Selkirk 4-Laning Project, ML/ARD Material Management Plan



PRESENTED TO

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ACRONYMS & ABBREVIATIONS

Acronyms/Abbreviations	Definition
ARD	Acid Rock Drainage
ACA	Average Crustal Abundance
AP	Acid Potential
BC WQG	British Columbia Water Quality Guidelines (for protection of aquatic life)
BTA	Blended Type A
CEMP	Construction Environmental Management Plan
cm/s	Centimetre per second
EM	Environmental Monitor (Contractor's)
PAG	Potentially Acid Generating
Non-PAG/NAG	Non-Potentially Acid Generating
m	Metre
mbgs	Metres below ground surface
mm	Millimetre
ML	Metal Leaching
ModNP	Modified Sobek NP
MoTI	Ministry of Transportation and Infrastructure
SFE	Shake Flask Extraction
STA	Station (as in project chainage station)
TARP	Trigger Action Response Plan
TCH	Trans Canada Highway
QA/QC	Quality Assurance and Quality Control

LIMITATIONS OF REPORT

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1.0 INTRODUCTION

Tetra Tech Canada Inc. (Tetra Tech) was engaged by the Ministry of Transportation and Infrastructure (MoTI) to develop a metal leaching (ML) and acid rock drainage (ARD) Materials Management Plan (MMP) for the Highway 1 Selkirk 4-Laning Project. MoTI is undertaking improvements to Highway No.1 at Selkirk Mountain. The Project area is located approximately 31 km northwest of Golden, BC. The proposed improvements include the 4-Laning for a 3.86 km section of the highway and construction of two wildlife underpass structures. The MMP informs the 100% Detail Design and Special Provisions for the Project. This work is carried out under the existing Contract No. 860 CS 5041 for As & When for Metal Leaching and Acid Rock Drainage Assessments and Material Management.

Materials to be excavated during the Project include Type A material which includes excavated bedrock and bedrock exposed on rock faces and Type D materials which includes all other overburden materials inclusive of till, organics, soils, and aggregates. Previous metal leaching and acid rock drainage (ML/ARD) assessment work on the highway has been completed by Lorax Environmental in 2018, and SNC Lavalin in 2020 and 2022.

Results of static testing and humidity cell kinetic testing indicated mixed potential for ML/ARD. However, mitigation of all Type A rock was deemed to be warranted due to the interbedded nature and distribution of rock with potential for acid generation. For the purpose of material management and handling, all Type A rock is considered the same in terms of geochemical classification for ARD potential and is managed as potentially acid-generating (PAG) classified rock.

The MMP is based on, and relies upon information from, studies completed by others provided in the following documents:

- Selkirk Passing Lane ML/ARD Assessment, Project No. A469-3, Lorax Environmental, 10 September 2018.
- Selkirk Mountain Four-Laning, Environmental Overview Assessment, Stantec Consulting Ltd., September 19, 2018.
- ML/ARD Assessment to Support Selkirk Mountain 4-Laning Project, Project 666768, SNC Lavalin Inc March 17, 2020.
- Highway 1 – Selkirk Mountain 4 Laning, Geotechnical Investigation Factual Report, Golder Associates Ltd., Prepared for Ministry of Transportation and Infrastructure, 15 January 2021.
- Highway 1 – Selkirk Mountain 4 Laning, 100% Detailed Geotechnical Design Report, WSP Canada Inc., Prepared for Ministry of Transportation and Infrastructure, 12 May 2023.
- Results of Humidity Cell Tests – Type A Materials for the Highway #1 Selkirk Mountain 4-Laning Project, Project 666768, SNC Lavalin Inc, March 10, 2022.

The MMP is specific to the design and Project details presented in:

- British Columbia Ministry of Transportation and Infrastructure, Project No. 24583-0000, Highway No.1 Selkirk Mountain 100% Detailed Design.

2.0 OBJECTIVE

The objective of the MMP is to describe how the Project will manage Type A material which have been characterized as having ML/ARD potential and the mitigation of the potential adverse effects resulting from Type A exposure and ML/ARD on the receiving environment. The management and mitigation pertain to potential sources of ML/ARD material during construction and post-construction for the life of Project.

ARD results from the oxidation of sulphide minerals when exposed to oxygen and water, resulting in the acidification of run-off water. It is part of the naturally occurring weathering process that can be exacerbated by rock disturbances, such as excavation and blasting. ML is the release of elemental constituents in solution as leachate from the rock mass and can occur under acidic and neutral drainage conditions. The potential for ML/ARD and its impact on the receiving environment depends on many site-specific components in addition to the geochemical characteristics of the excavated rock. This includes climate, material handling and storage, exposure areas and exposure times, and water management, among other items.

The MMP is a living document and may be updated in future stages of the Project to incorporate recommendations from any modifications to the engineering and highway design, construction sequencing and rock and water characterization.

The scope of the MMP includes the management of:

- Type A excavated rock from the Project area.
- Type A rock blended with gravels containing high carbonate contents from the Waitabit Pit to form a Blended Type A (BTA) material.
- Type A rock cut faces and associated contact drainage.
- Type A rock and BTA material stockpiles and associated contact drainage.
- Type D material specific to where it is used for management/encapsulation for BTA material.

The majority of Type A material to be excavated for the Project is classified as potentially acid-generating (PAG) with low potential for metal leaching. For the purpose of material management and handling, all Type A rock excavated in the project area is considered the same from a geochemical characterization perspective and is managed as PAG rock.

The MMP will inform PAG management for the Project and language for Special Provisions to accompany the 100% Detailed Design. The MMP uses a risk-based approach in consideration of the overall Project and potential impacts to the receiving environment.

The MMP will identify ML/ARD concerns associated with the Project, and present management and mitigation strategies for the use and disposal of potentially acid generating (PAG) materials. The MMP flags areas which may require further study or where engineered solutions may need to be considered.

The information presented in this MMP will inform the Project's Special Provisions, the Contractor's Construction Environmental Management Plan (CEMP) and the Contractor's Blending Plan. The Contractor will outline their commitment to PAG management, mitigation and monitoring in the CEMP.

3.0 PROJECT OVERVIEW

3.1 Material Types Excavated

For roadway and/or drainage excavations, MoTI classifies the excavated material into two material types:

- Type A – Solid Rock: Type A shall, without limitation, include all forms of "solid rock in place" including formations, masses, ledges, seams or layers of dense sedimentary, igneous or metamorphic material of sufficient hardness generally requiring drilling and blasting methods, very heavy ripping or equivalent methods, before excavation and removal. Type A shall also include detached masses or rock or boulders individually containing a volume of 2.0 m^3 or more.
- Type D – Common: Common material is all other excavation materials of a nature not included in the foregoing description of Type A, regardless of the nature or condition of the material, or the method used to excavate or remove. Type D material is all material below the stripping organics layer and above bedrock and includes all types of overburden in this zone.

Type A excavation is currently estimated to be approximately 12,000 m^3. A contingency amount of 1,000 m^3 is applied, and this report references an estimate of 13,000 m^3 for the purpose of blending discussions.

Type D excavation is currently estimated to be 140,000 m^3 going to embankment fill and 118,150 m^3 excavation identified for haul-away. This estimate of Type D embankment fill volume will be reduced given the proposed Type A material management and mitigation use as embankment fill.

As noted by WSP (2023) there are areas of the site where the Type D materials overlie Type A bedrock on moderately steeply sloping ground, and where highway widening occurs in these areas, the type, nature, and thickness of these materials needs to be determined to detail the cut/fill geometry and accurately determine the Type A and Type D fill estimates.

This MMP focuses on the excavation and material handling for Type A material. The design drawings indicate the construction will intercept Type A materials between approximately STA 164+45 and STA 169+70, STA 180+00 and STA 182+00 and STA 183+00 and STA 185+60. The most significant cut zone is from approximately STA 166+10 to STA 168+80, representing approximately 70-75% of the total Type A excavation.

Table 3-1 provides a summary of the rock cut locations and approximate excavation volumes. A dominant rock type is also noted based on field observations.

Table 3-1: Type A Rock Cut Locations and Estimated Quantities

Cut Location	Rock Type[1]	Excavation Volume (m^3)
164+45 to 169+70	Dominantly Quartzite, and interbedded Arkose and Pelite	9,687
180+00 to 182+00	Dominantly Arkose; and interbedded Arkose and Pelite	437
183+00 to 185+60	Dominantly Arkose; and interbedded Arkose and Pelite	1,852
Total		**11,976**

[1] Based on observations in existing rock cuts described in Section 5.1. Rock type may vary in areas outside of existing rock cuts and at depth.

3.2 Drainage and Surface Water Resources

The Project generally follows along the south side of the Columbia River valley. The Columbia River flows southeast to northwest in the area. Flowing surface water was observed during the SNC drilling investigation program (SNC, 2020), comprising a small unnamed creek flowing north near STA 182+60. A small swamp is located approximately 300 m north of the highway near STA 175+00. No creeks were observed flowing into the swamp and it is inferred that recharge is via overland flow and/or seepage from shallow groundwater. Wiseman Creek is located approximately 1.4 km west of the Project; surface water at this location was not assessed as it is considered part of MoTI's Quartz Creek Project.

3.3 Groundwater Levels

WSP, 2023 indicates that groundwater levels and groundwater flows in the Project area are expected to fluctuate significantly seasonally with varying precipitation and water flow in the surface water bodies, particularly during periods of heavy rain and snowmelt. They also note that the record water levels are from open test holes at the time of the investigation and may not represent the stabilized groundwater levels in all cases.

Standpipe piezometers were installed in May 2000 at four locations on the westbound fill side between approximate STA 188+90 to STA 190+80 and STA 193+90 to STA 196+10. Groundwater levels were measured between 6.0 and 14.0 meters below ground surface (mbgs) at these locations in later summer 2000 (WSP, 2023).

Four groundwater monitoring wells were installed during the 2021 investigation (WSP, 2023) on the eastbound cut side between approximate STA 187+00 and STA 193+00. The installation included dataloggers to evaluate groundwater levels on the Project site. Initial water level measurements in the four groundwater monitoring wells in these locations ranged from 0.64 to 3.04 mbgs, from installation through mid-June 2022. The data provided shows minimal seasonality and variability in groundwater water levels in this area. The groundwater levels in a given monitoring well are observed to vary between 1.1 to 4.7 mbgs from minimum to maximum recorded levels throughout the period of record from June 2021 to June 2022. WSP (2023) notes that cut slopes on the eastbound side within this area have historically been subject to significant groundwater seepage.

Groundwater measurements in 2019 and 2021 during the geotechnical investigations included measurements of standing water level in open boreholes and seepage observations during test pit excavations and site reconnaissance, groundwater levels measured between 0.2 and 8.0 mbgs (WSP, 2023). Seepage was observed on the fill slope on the north side of the highway at approximate STA 174+00, during the June 2019 site investigation that WSP completed.

In the area of the proposed blended Type A rock placement, detailed in Section 8.0, the two closest groundwater monitoring points are: TH19-208 (groundwater level 2.2 mbgs) which falls within the proposed embankment area near the toe; and the next nearest (to the west, outside of the proposed placement area) is TP19-413 with groundwater level 2.8mbgs. Groundwater levels measured by Ryan Edmonds, MoTI on May 23, 2023 site visit.

3.4 Climate

The project site is located between the Glacier National Park – Rogers Pass station (situated at 51°18'06.060"N, 117°31'00.000"W with elevation of 1330m) and the Golden Airport station (situated at 51°17'57.000"N, 116°58'56.000"W with elevation of 785 m). The proposed highway elevation at the project site ranges from approximately 1,050 to 1,085m.

The average daily temperature at the weather station in Golden, BC at the airport ranges from a low of -7.9°C in January to a high of 17.3°C in July. The average annual precipitation is 466.8 mm, with 325.2 mm of rain and 158.7 mm of snow (Government of Canada, 2022).

The average daily temperature at the weather station at Glacier National Park – Rogers Pass ranges from a low of -9.1°C in December to a high of 13.1°C in July. The average annual precipitation is 1,494.6 mm, with 630.0 mm of rain and 846.7 mm of snow (Government of Canada, 2022).

4.0 REGULATORY CONTEXT AND RESPONSIBILITIES

4.1 Requirements and Best Practice Guidelines

This MMP has been developed to be consistent with the MoTI requirements and ML/ARD best management practice and guidance documents summarized below.

The following MoTI document is relevant to ML/ARD management:

- Evaluating The Potential for Acid Rock Drainage and Metal Leaching at Quarries, Rock Cut Sites and from Stockpiled Rock or Talus Materials Used by the MoTI. Technical Circular T- 04/13. September 2013.

Best management practices and guidelines relevant to ML/ARD management include, but are not limited to:

- Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials, Mine Environment Neutral Drainage Program (MEND) Report 1.20.1, December 2009.
- Policy for Metal Leaching and Acid Rock Drainage at Minesites in British Columbia, Ministry of Energy and Mines and Ministry of Environment, Lands and Parks, July 1998.
- Guidelines for Metal Leaching and Acid Rock Drainage at Minesites in British Columbia, Ministry of Energy and Mines, August 1998.
- List of Potential Information Requirements in Metal Leaching/Acid Rock Drainage Assessment and Mitigation, MEND Report 5.10E, January 2005.
- The Global Acid Rock Drainage (GARD) Guide, Internal Network for Acid Prevention (INAP), 2018.

4.2 Water Quality Criteria

The BC Contaminated Sites Regulation, Schedule 3.2, and the BC Ministry of Environment water quality guidelines for the protection of freshwater aquatic life should be adopted for use in assessing the water quality of contact runoff associated with rock cuts and fill associated with the Project. The Fisheries Act will also apply on account of identifying potentially fish-bearing streams (Stantec, 2018). These guidelines are consistent with other MoTI highway construction Projects throughout the province.

- "Approved Water Quality Guidelines" British Columbia Ministry of Environment: Environmental Protection and Sustainability Branch.
- "Schedule 3.2" Contaminated Sites Regulation. BC Reg 375/96.
- Federal Fisheries Act, R.S.C., 1985, c. F-14 and BC Fish Protection Act.

Many of the guideline values vary based on ambient water hardness, pH, temperature, or chloride concentrations. Humidity cell and shake flask extraction tests are conducted in laboratory controlled neutral conditions, however, the results may vary with local ambient environmental conditions. The conclusions of the comparison to guideline values may be impacted by the above information and because the guidelines are intended to be applied in ambient waters rather than at the point of discharge.

4.3 Responsibilities

The Contractor must submit the CEMP a minimum of 15 days prior to mobilizing to site and the document will outline how the Contractor will address the requirements and recommendations presented in this MMP to manage waste rock materials, mitigate ML/ARD, and protect the environment.

The Contractor shall provide a Type A Material Blending Plan and submit this plan to the Ministry Representative for acceptance four (4) weeks before commencing Type A Excavation. The Contractor shall detail their approach to achieving the blending requirements that include a site preparation and maintenance work plan and a confirmatory monitoring program by the Contractor to verify that the proposed blending ratio specifications are achieved.

As part of the CEMP, the Contractor's Environmental Monitor (EM) will complete site inspections and provide reports on observations. This MMP plan presents items related to ML/ARD that the EM should include in the site inspections.

Tetra Tech will provide a Geoscientist of Record for the Project who will complete Construction Monitoring at assigned witness points during construction and will provide support to MoTI in reviewing and analyzing items related to ML/ARD during construction.

MoTI through the assigned Ministry Representative will be responsible for verifying that the Contractor has implemented the ML/ARD items agreed to in the CEMP and Special Provisions for the Project.

5.0 TYPE A BEDROCK

5.1 Project Geology

Mapping and visual inspection of currently exposed bedrock identified in the alignment noted by WSP, 2023 and SNC, 2020 are as follows:

- STA 161+30 to STA 163+00 – south side of highway and STA 166+50 to STA 168+70 – south side of highway
  - Rock types in these two rock cuts are described by SNC, 2020 as dominantly Quartzite and interbedded Arkose and Pelite. Visual observations of current outcrop show a greater exposure of Quartzite than the Arkose and Pelite.
- STA 180+20 to STA 182+20 – south side of highway and STA 180+40 to STA 181+20 – north side of highway
  - Rock types in the two rock cuts are described by SNC, 2020 as dominantly Arkose and interbedded Arkose and Pelite. Visual observations indicate a greater volume of Arkose than other rock types.

5.2 Geochemical Characterization

Geochemical characterization and ML/ARD assessment work on the highway was conducted by Lorax Environmental in 2018 (Lorax, 2018), and SNC Lavalin between 2019 and 2022 (SNC, 2020; SNC, 2022).

The Type A material to be excavated for the Project is variably classified as potentially acid-generating (PAG) and non-acid generating (Non-PAG) with low potential for metal leaching. As per SNC (2022), it is not possible to predict the final geochemical characteristics of the excavated Type A materials as the final volume will comprise a mix of the Hamill Group sedimentary rocks that vary in thickness and mineralogy across the Project. Each unit contains disseminated sulphides which contribute to the variable amounts of acid potential. The units also contain variable neutralization potential, from carbonate and non-carbonate sources.

For the purpose of material management and handling, all Type A rock is considered the same and is managed as PAG rock.

Details of the existing geochemical characterization test work is summarized below and provided in the referenced summary reports documented in Section 5.0. These investigation programs and reports evaluated and established the ML/ARD characteristics expected for the Type A materials. Table 5-1 presents an overview of sampling and geochemical data presented in the investigation programs.

Table 5-1: Summary of Geochemical Characterization Test Programs

Reference Report	Number of Samples	PAG samples (ModNP/AP <2)	NAG Samples (Mod NP/AP >2)	Total Element, elements > ACA	SFE, Elements >BC WQG	Other Analysis
Lorax, 2018	13	4	9	As (1); Mn (1); Mo (8); Sb (1)	Al (12), As (1), Cu (1), Hg (2)	6 XRD samples
SNC, 2020	11	6	5	Sb (3); As (1); Ba (1); Co (5); Mn (2)	Al (5); As (1) Cu (6);	3 Petrography samples; 4 XRD samples
SNC, 2022	5	2	3[1]			Humidity Cells

[1] Two of the three Non-PAG samples are blended samples of quartzite and Donald Hill carbonate rocks

Geochemical characterization included static and kinetic testing.

- Static testing includes acid-base accounting, trace element analysis, shake flask extraction, and mineralogy analysis (X-ray diffraction or petrography).
- Kinetic testing includes humidity cell analysis. Kinetic testing completed on one sample of Arkose, one sample of interbedded Pelite/Arkose, one sample of Quartzite, and two samples containing blended Quartzite and carbonate rocks from Donald Hill. The humidity cells operated for 64 weeks.
  - SNC noted in the 2020 and 2022 studies that sulphide minerals were disseminated in the sedimentary rocks at site, which can lead to heterogeneity in the distribution of minerals in the sample. As a result, there are observed differences in the pre-test and post-test geochemical characterization of the humidity cell samples. SNC, 2022 notes that their review of the data suggests there is heterogeneous mineral content in the humidity cell sample material, which is supported by the XRD testing in Lorax (2018) and SNC (2020).
  - SNC, 2022 reports estimates of Ca+Mg release rates, as presented below, to estimate potential onset of acidic conditions between 2 to 585 years for the non-acidic cells (Arkose and Quartzite). SNC points out

that these estimates assume the neutralization is only provided by reactive carbonates and/or silicate minerals within the Type A material and that NP deposition occurs at the indicated laboratory rates.

  - The well-flushed humidity cell test provides a measure of the rates of elemental release, acid generation, and acid neutralization under the geochemical conditions encountered in the test. Laboratory conditions in tests like the humidity cell analysis may enhance or depress rates of sulphide oxidation, carbonate and silicate dissolution, and metal leaching rates relative to field conditions.

Results for the Quartzite unit:

- The Quartzite unit contains disseminated sulphide and sulphide contents reported in the ABA analysis are moderate ranging from 0.28% to 0.88% by weight. The NP is low to moderate with contributions from carbonate and non-carbonate sources, including calcite noted in XRD analysis. The static test results characterize this unit as variable for ARD classification with six of twelve samples classified as PAG.
- The humidity cell analysis was completed on the quartzite sample with the highest reported sulphide sulphur content of 0.88 S%. The sample was classified as PAG with an NPR value of 0.3.
  - The two blended humidity cell tests also used this quartzite sample to evaluate using the highest sulphide sulphur, and associated acid potential of the samples tested.
  - As noted above, differences were observed in the pre- and post-test sample characterization. The post-test characterization shows a sulphide sulphur content of 0.16 S% and classification as Non-PAG with an NPR value of 3.1. Based on the low sulphate release rate, most of the difference in characterizations is attributed to differences in the amount of disseminated sulphide in the different sample fractions. Therefore, it may not truly reflect the actual highest sulphide sulphur content.
- The leachate pH in the humidity cell analysis remained above pH 7 through the duration of testing, except for one measurement at pH 6.07. The pH generally ranged from pH 7.0 to 8.44. Low sulphate release rate suggests a low rate of sulphide oxidation in the sample. The PAG classification indicates an acidic leachate could be generated from the sample given sufficient time, although under the aggressive lab based testing this was still estimated as hundreds of years. SNC, 2022 estimated that the time to depletion of the NP based on the Ca+Mg leach rate was 585 years.
- The humidity cell analysis indicated some potential for aluminum, iron and copper concentrations from Quartzite samples to report above the reference water quality criteria. These concentrations were not observed in the mixed sample of Quartzite and Donald Hill rock, except for the initial 10 weeks of testing.

Results for the Arkose unit:

- The Arkose unit contains disseminated sulphides and sulphide contents reported in the ABA analysis are low to moderate ranging from 0.01% to 0.27% by weight. The NP is negligible and the results show an absence of net-neutralizing reactive Ca/Mg carbonate minerals and the only minerals providing NP were silicates. This is supported by mineralogy and petrography results. The static test results characterize this unit as PAG overall, with four of five samples classified as PAG.
- The leachate pH was reported as neutral (around pH 7.0) for the last twenty weeks of humidity cell analysis. However, SNC, 2022 estimated that the time to depletion of the NP based on the Ca+Mg leach rate was 2 years, and that an acidic leachate would be generated given sufficient time.
- Some variability was noted in the humidity cell leachate with recorded concentrations of dissolved aluminum and copper that were at times greater than the reference water quality guidelines.

Results for the interbedded Pelite and Arkose unit:

- The interbedded unit contains disseminated sulphide and sulphide contents reported in the ABA analysis are low to moderate ranging from <0.01 % to 0.52% by weight. The NP is low to moderate with contributions from carbonate and non-carbonate sources. The static test results characterize this unit as Non-PAG overall with three of four samples classified as Non-PAG.
- The humidity cell analysis was completed on a sample with moderate sulphide content and the lowest reported NP from the static testing on this unit. This was the one sample classified as PAG. Leachate pH in the humidity cell analysis was acidic (pH<5) after 9 weeks of testing, and the average pH over the final 20 weeks of testing was pH 4.43.
- Dissolved iron and aluminium concentrations increased in the humidity cell leachate after nine weeks coincident with the decreasing pH, and concentrations reported as greater than the BC WQG reference values. Dissolved copper was also elevated above the reference water quality guidelines for all but three of the weekly leachates.

6.0 TYPE D COMMON BORROW

Type D material in the Project area has been identified as consisting of glacial sediments, including glacial drift, silt, alluvium, and alpine moraine. The material consists of non-cohesive sands and gravels with varying fines and cobble and boulder content (WSP, 2023). Golder notes that some cohesive silts and clays with a varying content of sand and gravel were also encountered, often interlayered between the coarse-grained deposits identified as the primary materials. In some locations, Type D material was not encountered at all due to bedrock directly below the organics topsoil layer (WSP, 2023).

7.0 WATER MANAGEMENT

7.1 Overall Surface Water Management

ML/ARD management benefits from minimizing the volume of surface water that comes in contact with PAG or ML rock. This may be achieved by managing the flow of water on site to reduce contact with excavated rock, including cut faces and fill material.

During site investigations for this Project there has been minimal surface water flows observed on the existing rock cuts and in the existing ditches. There is potential for groundwater seepage in areas where the groundwater table is above the elevation of the upslope side of the cut, however, there has not been significant flows from groundwater seepage observed on site within the existing rock cut slopes (pers. comm Ryan Edmonds, July 5, 2022). WSP (2023) confirms that seepage was not observed during the geotechnical rock outcrop mapping, but some joints were identified as possible locations of seepage during periods of high groundwater flow.

At present, design does not include cut off ditches or infiltration drains that would limit water contact with the exposed rock cut faces due to the limited evidence of surface water flows or groundwater seepage. In the event that flow and seepage are observed in greater volumes during construction, management of water to reduce contact with rock should be considered.

Stockpiles of Type A excavated rock should be isolated from contact with water prior to being blended and placed as fill in the construction area, as outlined below in Section 8.1.

7.2 Groundwater Levels and Management

WSP (2022) notes that seepage and high groundwater levels were observed at numerous locations across the Project site. The existing groundwater data is generally limited to water levels observed in monitoring wells which are installed in the eastern extent of the Project, with all wells located east of STA 187+00. Additional groundwater level measurements have been taken west of this area in open boreholes and seepage observations during test pit excavations, but the data is limited. Additional information on groundwater levels is needed in the sections proposed for placement of BTA rock as embankment fill.

8.0 MATERIAL HANDLING AND MANAGEMENT

The primary considerations for ML/ARD mitigation for Type A material during and post construction are guided by the following strategies:

- Reducing the exposure time of PAG material to ambient environmental conditions (air and oxygenated water) following excavation and prior to blending with Waitabit Pit gravels.
- Blending of excavated PAG material with a high carbonate gravel from Waitabit Pit in a manner to provide additional buffering capacity to offset the generation of acidic leachate.
- Placing the blended rock in the embankment fill with Type D cover to further minimize infiltration and generation of leachate.

The preferred option for material management is to achieve successful use of the material during construction, by blending the Type A rock with Waitabit Pit gravels and placing it as fill within the road prism design.

The details of the management strategies for handling of materials in differing design components are detailed below, including interim material stockpiling during construction, blending and placement as embankment fill. Additional management alternatives are presented below in Section 8.4 that were considered in early stages of the project but are not currently considered.

8.1 Temporary Stockpiling of Type A Material

Stockpiling of PAG materials should be avoided as it will increase the overall exposure time of materials to air and water, and the re-handling of material from the stockpile to end use presents another opportunity for increased exposure of the material to air and water. Humidity cell testing showed that interbedded Arkose and Pelite rock started to generate acidic leachate after nine weeks of humidity cell operation in the earliest case. Acid generation in a field setting, if it occurs, will be dependent on the size fraction of material, stockpile geometry, and numerous other factors.

Based on results of the analysis of the humidity cells, noting the rapid onset of acidic conditions in the interbedded Arkose and Pelite, SNC provided the recommendation that excavated Type A materials are placed and covered within a short period of time following their initial disturbance. If stockpiling of material is required to facilitate construction, then stockpiles should be protected from exposure to air and water.

The Type A material will be temporarily stockpiled based on the specifications outlined below:

- Stockpiles to be placed on a low permeability foundation, comprised of compacted soils high in fines, or placed directly on a tarp or poly sheeting that provides an impermeable barrier between the stockpile and the ground it is placed upon. The compacted foundation base or the tarp or poly sheeting, should be larger than the footprint of the stockpile and extend to the perimeter ditch surrounding the pile. Overlapping of the tarp or poly sheeting may be needed as per supplier specifications for the product.

- Compaction of stockpiled materials is recommended to mitigate against water and air contact with materials. All material shall be well compacted to achieve the density of the stockpile that will limit water and air contact with materials, and to the satisfaction of the Ministry Representative.
- The top of the stockpile should be graded to a minimum slope of 2% to promote drainage off the pile. Side slopes of the stockpile shall be designed at a stable slope to limit erosion and prevent materials from sliding down the pile.
- Construction of a perimeter ditch and berm to prevent surface water from contacting the stockpile and to collect any run-off from the stockpile may be required and can be determined by the Construction Contractor's EM with support from the Geoscientist of Record.
- If the temporary stockpile is exposed for 14 or more consecutive days without being covered with new Type A material, the Contractor's EM in coordination with MoTI should evaluate the need for a temporary cover solution. The need for the cover will be dependent on the time of the year, in terms of temperature and precipitation, and the construction timelines.
  - The stockpile should be covered by a temporary durable and impermeable liner within a minimum thickness of 4 mm, such as poly sheeting.
  - The stockpile cover is to be free of holes, punctures, or gaps in the cover material, and will cover the full stockpile, including top surface and sides.
  - The cover material should have sufficient overlap or folding of the seams between the placed segments to prevent water infiltration.

8.2 Blending of Type A Project Rock with High Carbonate Rock

The purpose of the blending is to provide additional acid neutralization potential to the Type A rock. The carbonate rich gravel from the Waitabit Pit has been identified to provide excess neutralization potential to mitigate acid generation potential from the Type A rock.

SNC (2022) identified that a blending option with carbonate rocks from the Donald Hill project may be possible to minimize the risk of ML/ARD at the Selkirk project area. The evaluation of the blending option included running two humidity cell tests with blended samples of quartzite rock from the project with carbonate rock from Donald Hill (SNC, 2022). One sample was blended at a ratio of 90% Type A and 10% carbonate rock and the second was blended at a ratio of 70% Type A and 30% carbonate rock. The humidity cell test results showed that blending the Donald Hill carbonate rocks was effective at raising the neutralization potential in the samples, and that the elevated calcium and magnesium release rates reported for the two humidity cell tests showed that the carbonate rocks were reactive and maintained neutral pH leachate conditions over the duration of humidity cell tests.

8.2.1 Waitabit Pit Deposit

Access to the Donald Hill project is no longer available. The gravel deposit at Waitabit Pit was identified as an alternative source of carbonates. Geochemical testing on the Waitabit Pit samples was completed and evaluated for suitability of blending from a geochemical characterization perspective. The results of the testing and blending concept are presented in the attached Appendix B memo and summarized below as applicable to the conclusions on the blending option.

The gravel from the Waitabit Pit consists predominantly of limestone and sandy carbonate. The acid-base accounting analysis demonstrates that it has high neutralization potential, provided almost entirely from carbonate mineralogy (dominantly calcite) which is expected to provide fast and effective neutralization potential. The ABA parameters are similar to the carbonate rocks tested from the Donald Hill project that were used as a blending material in the humidity cell analysis completed for the Selkirk Project (SNC, 2022).

The Waitabit Pit samples appear to be a suitable substitute for the Donald Hill carbonate rocks in terms of geochemical characteristics, and it is assumed that a blend with this gravel could produce similar results as observed in the humidity cell tests. The results of the humidity cell analysis indicate that the blending was successful at mitigating acid generation, as well as maintaining metal leaching concentrations at acceptable levels relative to the reference water quality guidelines.

Additional mapping and/or delineation drilling/test pitting is needed to confirm the extents and continuity of the Waitabit Pit carbonate gravels. Clear delineation in that area and confirmation of neutralization capacity is needed to ensure sufficient material is present for blending. The analysis presented herein is based on the samples collected for testing and analyzed to-date. The potential variability in the rock types and material characteristics of the Waitabit Pit gravels, as well as the extents of the gravel deposit, both laterally and vertically is not currently delineated.

The MoTI Aggregate Resource group should conduct additional sampling and delineation of the Waitabit Pit deposit to produce a Development Figure for the contractor which will outline the extents of the area where material can be sourced from. Confirmatory monitoring requirements for rock testing during construction are detailed in Section 9.2.

8.2.2 Blending Proportions

The blending concept presented in Appendix B suggest that a minimum blending proportion of 10% material from the Waitabit Pit would be needed to achieve an average NPR classification as Non-PAG (NPR > 2). The volume of Type A rock from the Selkirk project is estimated at 13,000 m^3. This suggests that a minimum volume of approximately 1,500 m^3 would be needed from the Waitabit Pit to achieve the desired BTA rock mix. The high blending ratio means that it may be difficult to achieve a consistent blending throughout the material, so it may be best to go to a lower ratio for easier mixing and to provide additional neutralization potential as a conservative measure for reduction of ARD potential. Increasing the required amount of Waitabit Pit gravel to a 4:1 ratio, which would require a minimum volume of Waitabit Pit gravel closer to 3,300 m^3, is recommended for the Special Provisions for the contractor.

8.2.3 Blending Specifications and Method

It is important that the two blending materials, Type A rock and Waitabit Pit gravels, are appropriately comingled to verify distribution of the neutralization potential throughout the BTA volume. Blending presents a risk of localized ML/ARD generation, where water contacts acid generating material without contacting the neutralizing material.

The idealized blend is achieved across all scales of the particle size distribution in the Type A and Waitabit Pit rock. The reason for this is to reduce the potential to have void spaces in the BTA rock mass where the different material types are not in contact. If void spaces are present it increases the potential for oxygen and water ingress into the BTA material which allows ARD reactions to proceed and limits the contact of neutralization potential from the Waitabit material to contact the potentially acid generating surfaces of the Type A rock. The idealized blend is challenging in practice due to physical characteristics of the project Type A rock (i.e., large particle size of produced rock) and Waitabit Pit gravels (i.e., smaller fraction sizes), costs associated with material handling, and specialized equipment needed for blending. The Waitabit Pit materials ideally would fill the void space in the Type A rock, however, there is some risk that material settles out leaving voids in the Type A rock. The Waitabit Pit materials do benefit from increased surface area to volume ratio on account of small fraction size, which does provide higher reactivity.

The proposed blending method is to stockpile the Type A project rock and Waitabit Pit gravels separately within the project area. A third stockpile area can then be established next to these two stockpiles, and the two rock sources will be placed in the additional stockpile area with a maximum ratio of 4:1 (Type A to Waitabit Pit gravels). Alternatively, the Type A project rock and Waitabit Pit gravels could be blended in place in the embankment fill design area. This will be contingent on the sequencing of material excavation and placement. The Contractor should outline their blending approach in the Blending Plan and submit to MoTI for approval, as per Section 4.3.

8.3 Encapsulation of Blended Material as Rock Fill

Blending as discussed above is the primary mitigation measure of ML/ARD. Tetra Tech maintains that the BTA rock material should still be used as embankment fill on the project. The application of blending with the carbonate rich Waitabit Pit gravels however means that engineered encapsulation is not required for ML/ARD management. The BTA rock can be placed in embankment fill areas where space allows and covered by Type D material as planned in the highway embankment fill design.

The purpose of the encapsulation is to reduce the exposure of the BTA rock to oxygen and water, which contributes to the ML/ARD reactions. Reducing the quantity of affected water is achieved by reducing the net percolation of meteoric water into the BTA rock, which in turn reduces the effluent seepage volumes and potential for contamination of groundwater and surface water resources. A reduction in seepage volume ideally limits peak concentrations of contaminants in receiving waters to levels that can be assimilated without adverse effects on the aquatic environment (INAP, 2017).

The current design indicates that there are several suitable sections for use of BTA rock as fill materials in the road prism design. Tetra Tech and MoTI have identified sections of the alignment that are preferred for placement of BTA rock fill. Tetra Tech considered multiple locations suitable for encapsulation and the geotechnical stability and hydrogeological assessments, highway design, including embankment capacity, and other components of the Project, which may dictate the suitability of embankment fill in various areas. Placement of BTA rock fill should avoid wetland areas or areas with sensitive environmental receptors, where possible.

The proposed sections for use of BTA material as fill materials in the road prism is:

- STA 176+10 to 177+60 (downslope embankment).

In the area of the proposed blended Type A rock placement, detailed in Section 8.0, the two closest groundwater monitoring points are: 1) TH19-208, which falls within the proposed embankment area (near the toe) and measured groundwater level at 2.2 mbgs; and 2) TP19-113, which is to the west and outside of the proposed placement area and measured groundwater level at 2.8 mbgs. Groundwater levels measured by Ryan Edmonds, MoTI on May 23, 2023 site visit. The groundwater levels measured do not indicate near-surface groundwater issues that would contact the BTA rock fill placement. Ryan Edmonds, MoTI (R. Edmonds, email May 18, 2023) indicated that TH19-015 and TH19-114 are within the roadway alignment, upgradient of the BTA rock placement area, and that both borehole logs do not indicate near-surface groundwater issues. The GW level was measured approximately 9.5mbgs in TH19-114 (Golder, 2021).

Pre-determining and prioritizing key sections for placement of BTA rock fill will allow for controlled management of materials. Placing the embankment fill in specific areas also limits the monitoring locations to these areas and promotes efficient and improved QA/QC for tracking Type A and BTA rock use on site.

The embankment fill design specifies that Type D material will be used on top of the placed BTA rock. Type D material is expected to be quite variable in terms of particle size as it is glacial till mixture with a wide range of particle sizes. From a ML/ARD perspective, there are no specific requirements for the Type D material and its handling. Screening of boulders, moisture content, and compaction will follow the geotechnical design requirements.

8.4 Alternatives Considered for Type A Excavation Management

8.4.1 Fill Material at Quartz Creek Rest Area and Snowmobile Staging Area

Fill material is required at the planned construction for the Quartz Creek rest area and snowmobile staging area. Not currently considered feasible given elevated groundwater table in this area.

8.4.2 Disposal at Old Man Pit

There is a pit within the highway right of way and is on Crown Land, referred to locally as “Old Man Pit”. MoTI has indicated that this former gravel pit may be a possible long-term disposal option for Type A material, however the preferred option is to keep the Type A material within the primary Project footprint to limit having a secondary site that requires monitoring.

The following items at a minimum would need to be considered:

- Formalize Right-of-way amendments as needed and application for extension;
- Geotechnical investigation and design;
- Environmental site assessment and mapping of potentially impacted water receptors;
- Develop monitoring plan for potential environmental impacts; and
- Develop a blending or encapsulation design including the sourcing and materials testing, geotechnical and geochemical, of the sourced cover materials.

9.0 TYPE A ROCK MONITORING PROGRAM

9.1 Project Type A Rock

The Type A rock monitoring program will verify that geochemical characterization from pre-characterization testing has accurately characterized materials. This is particularly important if new rock types or significant variations in the estimated proportions of the rock units is observed during Project construction. The existing information is based on surface mapping and surface and borehole sampling in discrete locations, and rock type may vary at locations outside of the reviewed areas.

If additional rock types not identified during characterization phase of the Project are identified during construction, static geochemical testing of these materials should be undertaken. Geologic mapping of all final rock cuts should be undertaken to document lithologies exposed in permanent bedrock exposures. Interim rock cut mapping will also be completed, when possible if the Geoscientist of Record is on site for construction monitoring.

Samples will be collected during construction by the Contractor's EM or MoTI's Ministry Representative during the site inspections to hold for potential testing under the discretion of the Geoscientist of Record. The Contractor's EM will complete a checklist of environmental observations during site inspection and sampling, as per the template in Appendix C. The Contractor shall collect Type A samples from the blasted rock in the temporary stockpile or from the blast rock face, one sample per 1,000 m^3 of excavation (approximately 15 Type A samples, based on estimated Type A excavation for project). Samples should be approximately 1.5 to 2.5 kg in mass. The sample should be placed in a plastic bag and tightly closed. The samples shall be delivered to the Ministry Representative on the day collected. The samples shall be labeled and photographed with the following information recorded:

- Unique Sample ID;
- Date collected;
- Location collected with GPS coordinates; and
- One photo of the sample and at least two photos of the area where the sample was collected.

All of the Type A rock is classified as PAG for the purpose of ML/ARD management on the site, so the results of the rock monitoring program are not expected to change the approach to ML/ARD for the Project. The identification of additional rock types and/or results of geochemical characterization from the rock monitoring program will not represent a hold point during construction, however the information may be useful for environmental monitoring and should the material management not prove successful.

The monitoring program also provides confirmation that the geochemical characterization for Type A rock used for the blending concept is consistent with field data during construction. Variations in the geochemical characterization should be reviewed by the Geoscientist of Record to determine if adaptive management is required, such as varying the blending proportions.

9.2 Waitabit Pit

The three samples collected from the Waitabit Pit show consistent mineralogy and acid-base accounting parameters to one another. All three samples reported calcite content over a narrow range of 48 wt.% to 50 wt.%, and dolomite content from 23 wt. % to 26 wt. %. The associated carbonate neutralization potential also varies over a narrow range of 560 to 600 kg $CaCO_3$/tonne.

A regular confirmatory rock testing program is not required if the material is sourced from the Development Area outlined by the MoTI Aggregates Group as discussed in Section 8.2.1. If the material is sourced from within the designated Waitabit Pit Development Area, the Contractor must collect three discrete samples from three unique locations per 1000 m^3 of Waitabit Pit material. These samples shall be provided to the Ministry Representative to hold for potential testing under the discretion of the Ministry's Geoscientist of Record.

If the material is sourced from outside of the Development Area, then the Contractor will be responsible for sampling and testing to confirm the characteristics of the material. In addition to requirements in SS 202, the Contractor must also complete the following tests on three samples per 1,000 m^3 of sourced material:

- XRD analysis by Rietveld method; and
- Acid base accounting test, with Modified Sobek NP, inorganic carbon content, total sulphur and sulphide sulphur.

The samples for this material must be taken by the Contractor during excavation works at the Waitabit Pit. Three discrete 2 kg samples from three unique locations will be collected. The Contractor will submit the lab data sheets to the Ministry. A minimum combined percentage of calcite and dolomite of 60 wt.%, with a minimum percentage of 40 wt.% calcite content is required for use. The calcite and dolomite wt% values shall be the median of the three samples. The mineral characteristics of the material will be determined by the X-Ray Diffraction by Rietveld method. The Contractor shall seek MoTI approval for gradation specs for the embankment if the material is sourced outside the Development Area.

10.0 CONSTRUCTION MONITORING

10.1 Temporary Stockpile

The Contractor's EM will monitor work activities and verify the stockpiling of Type A material are in accordance with the site CEMP. The EM will observe and record the work activities, including confirming the integrity of the covered stockpile, condition of the liner or cover, water seepage, and potential environmental impacts. A template for environmental monitoring observations is provided in Appendix C. In addition to a routine monitoring schedule, inspections and reporting should be completed following large rainfall events.

The following items related to temporary stockpiling are to be included in the environmental monitoring reports:

- Confirm that Type A rock is only placed in the designated areas for temporary stockpiling.
- Confirm that relocated Type A material is covered temporarily as needed as per the specification in Section 8.1 for cover materials and timing.
- Observe and record the Type A stockpile activities, including the integrity and condition of the liner or cover (free of holes, punctures, or gaps in the cover material), water seepage in the stockpiles and potential for environmental impacts.
- In addition to a routine monitoring schedule, inspections and reporting must be completed following significant rainfall events.
- Record observations of pooled water, upslope run-off or seepage, and whether the observed water has potential to infiltrate the Type A stockpile, and the BTA rock stockpile if a BTA stockpile is developed. Record the source location of the noted water. Record the colour and condition of the water, particularly with respect to signs of ML/ARD such as red/orange discoloration and white precipitates.
- Surface water management and drainage will be inspected by the Contractor's EM. The environmental monitoring must record observations of water management and seepage in pre- and post-construction monitoring until the temporary stockpile is exhausted and the embankment fill section of the highway construction is completed.
- Communicate issues noted to the Ministry Representative immediately to initiate corrective actions, including repairing and maintaining the cover if damage or deficiencies are observed and managing surface water at the stockpiles and/or the blended Type A embankment.

10.2 Blending and Fill Placement

Construction monitoring for development of BTA rock and placement of the BTA rock in the embankment fill design will be required by the Geoscientist of Record at established witness points in the construction schedule, as well as inspections by the Contractor's EM.

A confirmatory monitoring program is required to verify that the proposed blending ratio specifications are achieved. The Contractor will specify their approach to this verification process in their Blending Plan, which will be reviewed by MoTI prior to implementation. The Contractor's EM should complete documentation of the BTA stockpile development and placement as embankment fill.

The proposed witness points for review by the Geoscientist of Record including the following construction schedule milestones:

- After clearing and stripping of the area and prior to placement of BTA rock.
- During placement of BTA rock, once during the placement.
- After placement of BTA rock and before placing overlying Type D layer.
- At the completion of the embankment fill design.

The following items should be considered in the requirements for the Contractor's environmental monitoring site inspections and reports:

- Confirm that BTA rock is only placed in the designated areas assigned for embankment fill.
- Record observations of pooled water, upslope run-off or seepage, and whether the observed water has potential to infiltrate the embankment fill. Record the source location of the noted water. Record the colour and condition of the water, particularly with respect to signs of ML/ARD such as red/orange discoloration and white precipitates.
- Communicate issues noted to the MoTI Representative immediately to initiate corrective actions, including addressing damage or deficiencies in the encapsulation are observed and managing surface water.

The Contractor will be responsible for verifying and documenting that the BTA material is only placed within the designated area. In addition to the environmental monitoring, the Contractor will also need to complete daily monitoring during placement to provide survey data and volumes placed of BTA material and Type D (Appendix C). The Contractor will maintain a record of the source of the Type D material covering the BTA embankment fill.

11.0 WATER MONITORING PROGRAM

Construction and post-construction environmental monitoring by way of water quality sampling is used to document potential changes in drainage and water quality and to inform additional mitigation, as required. Locations for water quality monitoring will be dependent on rock cut locations and area of BTA rock placement as embankment fill.

11.1 Program Requirements and Documentation

The proposed water quality monitoring program discussed in this report shall be integrated into the overall surface water quality program for the site. The discussion below is specific to items of water quality relating to potential for ML/ARD from the temporarily stockpiled Type A material and the BTA rock embankment fill. The overall water quality monitoring program for the Project may include other components that are not detailed here and that are covered under the Standard Specifications from another MoTI group.

The water quality monitoring program is recommended to be run for a minimum time period of 12 months, to capture at least one full cycle of seasonality including summer precipitation, freshet, and snow melt. The duration of the monitoring program will be adjusted based on the results of analysis, and comparison to the water quality standards. Trend analysis indicating increasing contaminant load concentrations or exceedances of the water quality criteria will require a longer monitoring period. This decision will be evaluated by MoTI in consultation with the Geoscientist of Record.

The water quality monitoring plan should be documented in a Trigger Action Response Plan (TARP) report. The TARP provides monitoring triggers that require adaptive management responses and/or regulatory notification based on the results of the monitoring program. The TARP will include details such as:

- Roles and responsibilities;
- Quantitative triggers that lead to the implementation of specific action responses;
- Timelines for the action response for mitigation to be implemented; and
- Notification and reporting requirements.

Water quality samples should be analyzed for the following parameters at a minimum. Additional parameters may be requested as part of other components of the Project beyond the scope of the ML/ARD items.

- Dissolved metals (groundwater samples); Dissolved and Total Metals (surface water samples);
- Total Suspended Solids and Total Dissolved Solids;
- pH, Electrical Conductivity, Total Alkalinity, Hardness; and
- Anions (chloride, fluoride, sulphate, nitrate, nitrite).

The quantitative trigger values should be developed to conservatively identify water quality conditions that indicate potential for environmental impact. The trigger values should consider the background/baseline water quality and presence or absence of fish in the waterways.

The TARP should discuss adaptive management, which is a systematic, rigorous approach designed to link environmental monitoring to management actions. Adaptive management will help to evaluate the success of the geochemical characterization and assessment programs and confirm that disturbed and fill areas are performing as expected. The determination will include assessment of both the construction works and the downstream receiving environment.

11.2 Surface Water Management

Surface water management and drainage will be inspected by the Contractor's EM. The environmental monitoring will record water seepage in pre- and post-construction monitoring, that can be used by the Geoscientist of Record to identify areas where surface water management and mitigation is needed.

11.3 Establishing Baseline Water Quality

To determine representative background groundwater quality values, a summary 95th percentile value can be calculated (per BC MoE [1996] and CCME [2003]) from the 95th percentile values reported at each background station. This is a widely accepted approach to the identification of background concentrations in environmental media.

11.3.1 Surface Water Quality Characterization

Pre-construction surface water sampling was completed to inform the ML/ARD assessment and management/mitigation for problematic materials. Representative surface water samples were collected from accessible locations on relevant surface water bodies (Table 11-1) to assess chemistry in water bodies that may be affected by construction activities. This surface water quality characterization is considered suitable for establishing baseline surface water quality conditions in the select locations.

Sampling was completed on May 5, 2020 (SNC, 2022), at the same locations that were sampled in 2019 (SNC, 2020). Sampling was attempted on October 19, 2021, but no samples could be collected because either no flow was observed or there were safety access issues. Sampling was also conducted in October 2022 and June 2023 by MoTI. Results from the 2022 and 2023 were not available for review at the time of developing this MMP.

Field measurements of pH, temperature, electrical conductivity, dissolved oxygen, and oxidation-reduction potential were recorded for each location using a hand-held multi-parameter instrument. Details of the water quality characterization work and results of analysis are presented in SNC, 2020 and SNC, 2022.

Table 11-1: Surface Water Sampling Locations (adapted from SNC, 2022)

Station ID	Surface water body	Latitude	Longitude	Description	Access comments
CRUS	Columbia River (upstream)	51.514	-117.281	Upstream from the Project and approximately 2.5 km to the north.	Access to this location is challenging; one sample has been collected by travelling north of the Columbia River along back roads and walking down a very steep slope to the river.
CRDS	Columbia River (downstream)	51.508	-117.311	Downstream from the Project and approximately 2 km to the northwest.	Access to this location is challenging; one sample has been collected by travelling north of the Columbia River along back roads and walking down a very steep slope to the river.
SWMP	Wetland Area	51.495	-117.303	Downslope from the Project and upslope from the Columbia River.	Approximately 500 m of bushwhacking to access this location. Recommend bringing or wearing hip waders as there are sections where you can sink into the swamp very easily.
GULLY	Unnamed Creek	51.493	-117.291	A small creek that flows north through the Project. The creek flows under the TCH at approximately Stn. 18+250. The sample was collected south and upslope from the highway.	Access was uncomplicated. Parked in pullout and crossed the highway.

Table 11-1: Surface Water Sampling Locations (adapted from SNC, 2022)

Station ID	Surface water body	Latitude	Longitude	Description	Access comments
WS-WEST	Unnamed Creek	51.492	-117.304	A small creek that flows parallel to the TCH along the south side of the TCH (sample location), then S to N through a culvert under the TCH.	Access was uncomplicated. Parked in pullout and walked along the highway.
WS-EAST	Unnamed Creek	51.491	-117.283	A small creek that flows parallel to the TCH along the north side of the TCH.	Access was uncomplicated. Parked in Redgrave West pullout and crossed the highway.

The following general observations were noted about the previous water quality characterization from 2019:

- Data from each location suggests circumneutral conditions and oxygen saturation is indicated by field measurements of pH and dissolved oxygen.
- Total and dissolved metal concentrations in each sample were less than the BC WQG for the protection of freshwater aquatic life and for drinking water.
- Samples collected from the Columbia River in June 2019 during an ML/ARD assessment to support construction of the Donald Hill descending lane contained slightly elevated total chromium, iron, and zinc.
  - The Donald Hill samples were collected approximately 5.4 km and 11.9 km upstream from CRUS and the elevated metals were attributed to higher sediment load in the river during higher freshet flows.
  - These results suggest water chemistry in the area is seasonally affected, and this should be considered for interpretation of future surface water sampling results in the vicinity of the Selkirk project.

The following general observations were noted about the previous water quality characterization from 2020:

- Neutral to alkaline pH values were reported at the sampled stations.
- Dissolved aluminum concentration in the GULLY sample location exceeded the short-term maximum and long-term average concentration BC WQG for the protection of freshwater aquatic life.
  - SNC noted that the 2020 value was a order of magnitude greater than the 2019 sample at this location. The variability in results was inferred to be associated with seasonal effects.
- Total iron concentrations in samples from the downstream (CRDS) and upstream (CRUS) Columbia River locations were greater than the BC WQG for the protection of drinking water.
- Dissolved chloride at the SWMP location exceeded the BC WQG for protection of freshwater aquatic life.
  - SNC noted that the 2020 value was an order of magnitude greater than the 2019 sample at this location. The variability in results was inferred to be associated with seasonal effects.
  - The May 2020 sample was collected during spring conditions when surface water bodies were receiving runoff from snow melt. The source was attributed to salt from Highway 1; however this sample is located

300m from Highway 1 and therefore further sampling is needed to understand the potential for meltwater to transport chloride from the Highway 1 to the SWMP station.

- The concentrations of the other tested parameters were either non-detectable or were less than the BC WQG.

Wiseman Creek is located approximately 1.4 km west of the Project and within the MoTI's Quartz Creek Project. One sample event was conducted at this location on October 1, 2019. An alkaline pH of 8.0 was recorded and high alkalinity of 113 mg/L (total, as $CaCO_3$) was measured. Total and dissolved metal concentrations in each sample were less than the BC WQG for the protection of freshwater aquatic life.

11.4 Management of Rock Cuts and Project Ditches

Bedrock from rock cuts will remain exposed after construction of the Project is completed. The exposed rock faces are a potential source for geochemical load due to potential sulphide oxidation and subsequent liberation and mobilization of secondary reaction products like sulphate, acidity, and metals. However, it is expected based on current 100% design and available geologic and geochemical data, rock cut geometry and the relatively small overall cut volumes proposed, that covers, or surface treatments will not be required.

As discussed in Section 7.1, we are expecting limited surface water run-off from above the rock cut slopes and there are no plans for cut-off or infiltration drains to prevent water-rock contact.

Mitigation of potential ML/ARD leachate or PAG contact water from the rockcut slopes should consider the following:

- In the event that there is increased surface runoff during or post construction, reduction of surface runoff on any exposed rock cuts by means of directing clean water away from slopes.
- Characterization of natural downstream environments that will receive rock cut contact water and identification of potentially sensitive downstream receptors.
- A monitoring program should be developed for monitoring of flow in the ditch below rockcuts, either by in situ sampling for pH and/or laboratory sampling for water quality.

Although environmental impacts are not expected from flushing of the rock faces. If the monitoring identifies water quality issues resulting from exposed bedrock in the rock cuts such as acidic or metalliferous leachate, then MoTI will consult with the Geoscientist of Record and develop a mitigation strategy. One option to be considered is placing rock with excess neutralization potential or limestone in the ditchlines below the rock cuts to mitigate acid generation. Carbonate-rich source rock placed as rip-rap provides a surface area of available neutralization potential.

11.5 Groundwater for Encapsulated Fill Areas

Additional installation of monitoring wells in the area of the BTA rock fill placement will be required for groundwater monitoring of water levels and water quality prior to construction and during construction. Monitoring well design and locations will be discussed in consultation with MoTI during the detailed design stage and as required during post-construction. Potential locations of the groundwater monitoring wells will be evaluated based on hydrogeological conditions, access, safety, and final locations of placed BTA rock. Groundwater monitoring will be conducted upgradient and downgradient of the areas of BTA rock fill to evaluate baseline conditions and potential changes associated with the BTA rock fill placement.

Three monitoring events prior to construction is recommended to observe the potential for variability in the groundwater levels, particularly during periods of heavy rain and snowmelt which may be influenced by time of the year. MoTI anticipates that three sample events will be completed in fall, winter and spring, over two calendar years. MoTI may choose to task the contractor with installation of the wells and baseline water collection prior to construction, or request that the geotechnical drilling consultant take on this work.

11.6 Upgradient and Downgradient Streams and Channels

The pre-construction surface water sampling stations (Table 11-1) should continue to be sampled during construction, where possible. It is anticipated that some of the stations may be impacted by construction activities, and if so, new stations should be considered to sample upstream, at source and downstream of the Project.

12.0 LIMITATIONS OF REPORT

The MMP is based on and relies upon information and studies completed by others provided in the reports listed in Section 1. The MMP is based on a desktop review of the available information for the Project, a brief geological reconnaissance along the existing highway and review/interpretation of the results of geochemical characterization and geological mapping completed by others, and discussion with the MoTI Project team.

The scope of this MMP is limited to acid rock drainage and metal leaching conditions of the excavated Type A rock handling and management. The management and mitigation, including blending and placement as embankment fill, must also include consideration of geotechnical, hydrological, hydrogeological, archeological, highway design and other components that are outside of the scope of this plan.

This MMP and its contents are intended for the sole use of BC Ministry of Transportation and Infrastructure and their agents. Tetra Tech Canada Inc. (operating as Tetra Tech) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than BC Ministry of Transportation and Infrastructure, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this document is subject to the Limitations on the Use of this Document attached in the Appendix A or Contractual Terms and Conditions executed by both parties.

13.0 CLOSURE

We trust this document meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
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2023-11-09

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APPENDIX A

TETRA TECH'S LIMITATIONS ON THE USE OF THIS DOCUMENT

LIMITATIONS ON USE OF THIS DOCUMENT

GEOTECHNICAL

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The Client acknowledges that it has fully cooperated with TETRA TECH with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The Client further acknowledges that in order for TETRA TECH to properly provide the services contracted for in the Contract, TETRA TECH has relied upon the Client with respect to both the full disclosure and accuracy of any such information.

1.5 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

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While TETRA TECH endeavours to verify the accuracy of such information, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage.

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This Professional Document is based solely on the conditions presented and the data available to TETRA TECH at the time the data were collected in the field or gathered from available databases.

The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this document, at or on the development proposed as of the date of the Professional Document requires a supplementary exploration, investigation, and assessment.

TETRA TECH is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

1.7 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, TETRA TECH has not been retained to explore, address or consider and has not explored, addressed or considered any environmental or regulatory issues associated with development on the subject site.

1.8 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems, methods and standards employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. TETRA TECH does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

1.9 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

1.10 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historical environment. TETRA TECH does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional exploration and review may be necessary.

1.11 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

1.12 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

1.13 INFLUENCE OF CONSTRUCTION ACTIVITY

Construction activity can impact structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques, and construction sequence are known.

1.14 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, and the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

1.15 DRAINAGE SYSTEMS

Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function. Where temporary or permanent drainage systems are installed within or around a structure, these systems must protect the structure from loss of ground due to mechanisms such as internal erosion and must be designed so as to assure continued satisfactory performance of the drains. Specific design details regarding the geotechnical aspects of such systems (e.g. bedding material, surrounding soil, soil cover, geotextile type) should be reviewed by the geotechnical engineer to confirm the performance of the system is consistent with the conditions used in the geotechnical design.

1.16 DESIGN PARAMETERS

Bearing capacities for Limit States or Allowable Stress Design, strength/stiffness properties and similar geotechnical design parameters quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition used in this report. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions considered in this report in fact exist at the site.

1.17 SAMPLES

TETRA TECH will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the Client's expense upon written request, otherwise samples will be discarded.

1.18 APPLICABLE CODES, STANDARDS, GUIDELINES & BEST PRACTICE

This document has been prepared based on the applicable codes, standards, guidelines or best practice as identified in the report. Some mandated codes, standards and guidelines (such as ASTM, AASHTO Bridge Design/Construction Codes, Canadian Highway Bridge Design Code, National/Provincial Building Codes) are routinely updated and corrections made. TETRA TECH cannot predict nor be held liable for any such future changes, amendments, errors or omissions in these documents that may have a bearing on the assessment, design or analyses included in this report.

APPENDIX B

RESULTS OF WAITABIT PIT SAMPLES

TECHNICAL MEMO

ISSUED FOR USE

To:	Julie Sandusky, P.Geo.	**Date:**	January 17, 2023
c:	Ryan Edmonds, P.Eng.	**Memo No.:**	001
From:	Scott Kingston, P.Geo. Amy Hudson, Ph.D., CPG	**File:**	704-MIN.VMIN03121-05
Subject:	Summary of Waitabit Pit Sample Results and Blending Concept for Type A PAG Rock Management for Selkirk 4-Laning Project		

1.0 INTRODUCTION

Tetra Tech Canada Inc. (Tetra Tech) was engaged by the Ministry of Transportation and Infrastructure (MoTI) to develop a metal leaching (ML) and acid rock drainage (ARD) Materials Management Plan (MMP) for the Highway 1 Selkirk 4-Laning Project (the Project). MoTI is undertaking improvements to Highway No.1 at Selkirk Mountain. This work is carried out under the existing Contract No. 860 CS 5041 for As & When for Metal Leaching and Acid Rock Drainage Assessments and Material Management.

Materials to be excavated during the Project include Type A material, which are comprised of excavated bedrock and bedrock exposed on rock faces, and Type D materials, which are comprised of all other overburden materials inclusive of till, organics, soils and aggregates. Results of geochemical characterization indicate mixed potential for ARD in the Type A materials. Potentially acid generating (PAG) rock is interbedded with non-potentially acid generating (NAG) rock, and mitigation of Type A material is recommended on the project. For management and handling purposes, all Type A rock on the Project should be considered classified as PAG rock.

A draft MMP was issued to MoTI on August 20, 2022. The MMP focuses on the management of the Type A rock by encapsulating it in the road embankment. Subsequent review of the proposed design with MoTI and Golder Associates, the project's geotechnical consultant, identified concerns with the encapsulation option. Therefore, a possible blending option was proposed using carbonate gravel material from the Waitabit Pit.

The purpose of the blending is to provide additional acid neutralization potential to the Type A rock. The carbonate rich gravel from the Waitabit Pit has been identified to provide excess neutralization potential to mitigate acid generation potential from the Type A rock.

Three samples were collected by Julie Sandusky, P.Geo. (MoTI) from the MoTI Waitabit Pit that is located near Donald, BC to evaluate the potential of using this material in the blending. The samples were submitted for a suite of testing to determine the geochemical characteristics of the material, specifically the rock type, minerology and acid-base accounting parameters.

This memo bas been prepared to summarize the potential use of the Waitabit Pit aggregate material as a blending agent, based on the results of geological and geochemical testing completed to-date. Suitability of the material from a geotechnical or materials testing perspective is outside of the scope of this document.

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2.0 INITIAL CONCEPT - BLENDING WITH TYPE A ROCK FROM THE DONALD HILL PROJECT

SNC-Lavalin (SNC) conducted an ML/ARD assessment for the Donald Hill Descending Lane Project, approximately 8.8 kilometers (km) in the eastbound direction from the Selkirk project area (SNC, 2019). They noted that bedrock observed at that location included slate, dolomitic limestone, and limestone, with low sulphide content (i.e., low acid potential) and elevated neutralization potential, and thus inferred as low potential for ML/ARD. SNC (2022) identified that a blending option with carbonate rocks from the Donald Hill project may be possible to minimize the risk of ML/ARD at the Selkirk project area, by providing additional alkalinity to neutralize potential acidity and to aid in the precipitation of soluble metals at near neutral pH.

The evaluation of the blending option included running two humidity cell analyses with blended samples of quartzite rock from the project with 10-30% of the carbonate rock from Donald Hill (SNC, 2022). The humidity cell test results showed that blending the Donald Hill carbonate rocks was effective at raising the neutralization potential in the samples. The elevated calcium and magnesium release rates reported for the two humidity cell sample tests show that the carbonate rocks were reactive and maintained neutral pH leachate conditions over the duration of humidity cell testing.

Blending calculations based on humidity cell tests indicates that a 10% addition of Donald Hill to the Selkirk area Type A rocks would be sufficient to get to NPR 2.4 (non-acid generating classification), while a 15% addition of Donald Hill material to the Selkirk area Type A rocks results in NPR 3.9 (SNC, 2022). These were based on conservative values of minimum neutralization potential (NP) and maximum acid generating potential (AP) measured from the geochemical characterization test work.

Access to the Donald Hill project is no longer available so a new source of carbonate rock is being considered, and the gravel deposit at Waitabit Pit is the subject of this investigation.

3.0 WAITABIT PIT TESTING AND RESULTS

3.1 Petrographic Testing

3.1.1 Purpose of Test

Tetra Tech completed petrographic testing of samples L-1 WB22HS-01 and L-2 WB22HS-03 at the materials test lab in Calgary, AB. The petrographic testing was performed in accordance with the MoTI 2020 Standard Specification for Highway Construction (SSHC), Appendix 202-B Petrographic Analysis Test. The petrographic results and test report are presented as Appendix B.

The purpose of the Petrographic Analysis Test is to identify the various rock types and rock characteristics in the aggregate fraction of gravel deposit material retained on the 9.5-millimeter (mm) sieve. The petrographic analysis test is intended to determine the cause of the poor aggregate performance and to determine the extent of or contributing factors of specific rock types, such as the extent of deleterious materials or clay particles present.

3.1.2 Results of Petrographic Analysis

3.1.2.1 Weighted Average Petrographic Numbers

The weighted average petrographic numbers of 134 and 141 for Sample L-1 and L-2, respectively provide an overall sample rating of "Fair" in accordance with the MoTI 2020 SSHC, Appendix 202-B. The quality distinctions are relative estimates of a rock's physical and chemical condition and of probable engineering quality. A rating of "Fair" indicates that the "Particles are soft but sound and tough, medium hard, slightly to moderately weathered, have small to moderate capillary absorption, are relatively smooth and impermeable".

The petrographic number weighted average rating is dropped into the "Fair" category on account predominantly of the sandy carbonate content of 15.8% and 13.8% in samples L-1 and L-2, respectively. The limestone, calcite, and quartz/quartzite which make up the majority of the coarse aggregate samples, 80.3% of L-1 and 83.5% of L2, classify in the "Good" quality designation, representing that "Particles are hard, durable, free from fracture potential, little or no capillary absorption".

The the MoTI 2020 SSHC, Appendix 202-B provides the following categories for overall sample rating based on the Sample Petrographic Number (Table 3-1).

Table 3-1: Appendix 202B – Petrographic Number Sample Ratings

Sample Petrographic Number	Overall Sample Rating
100 to 125	Good
>125 to 140	Fair
>140 to 155	Poor
>155	Deleterious

3.1.2.2 Sample L-1 WB22HS-01

Sample L-1 WB22HS-01 – 20-5mm Coarse Aggregate:

- The material is composed predominantly of limestone, with some sandy carbonate, calcite, and a trace of quartz/quartzite, encrustation, and ochreous carbonate. The weighted average petrographic number is 134.

Sample L-1 WB22HS-01 – Fine Aggregate:

- The material is composed predominantly of limestone and sandy carbonate, with some calcite, quartz/quartzite, ochreous carbonate, and trace of chert, encrustation, and siltstone.

3.1.2.3 Sample L-2 WB22HS-03

Sample L-2 WB22HS-03 – 20-5mm Coarse Aggregate:

- The material is composed predominantly of limestone, with some sandy carbonate, calcite, and a trace of quartz/quartzite, encrustation, and ochreous carbonate. The weighted average petrographic number is 141.

Sample L-2 WB22HS-03 – Fine Aggregate:

- The material is composed predominantly of limestone, with some sandy carbonate, calcite, ochreous carbonate, quartz/quartzite, and a trace of chert and encrustation.

3.1.3 Historic Petrographic Analysis

MoTI provided Tetra Tech with results of petrographic analysis on two historic samples. The analysis was completed in February 1974. The lab results are provided in the attached Appendix C. The two samples are both identified as X-8440 and it is not clear what the difference between the two sample results presented are.

Sample X-8440 (Number 1):

- Lab sheet notes indicate analysis was completed on the minus 3/8”+8 mesh screen fraction.
- Sample consists predominantly of limestone or dolomite, with some quartzite and volcanics (Table 3-2).

Table 3-2: Historic Petrographic Analysis X-8440 (Number 1)

Rock Type	Quality Percent (%)			
	Excellent	Good	Fair	Poor
Limestone of Dolomite	-	67.4	-	4.2
Quartzite	-	16.7	-	-
Volcanics	11.7	-	-	-
Total	**11.7**	**84.1**		**4.2**

Sample X-8440 (Number 2)

- Lab sheet does include any comments on sample fraction tested.
- Lab sheet notes indicated that a “calcareous coating on many particles”.
- Sample consists predominantly of limestone or dolomite, as well as quartzite, and lesser amounts of volcanics, schist and chert (Table 3-3).

Table 3-3: Historic Petrographic Analysis X-8440 (Number 2)

Rock Type	Quality Percent (%)			
	Excellent	Good	Fair	Poor
Limestone of Dolomite	-	54.5	-	-
Chert	-	-	-	2.4
Quartzite	-	27.7	-	-
Schist	-	-	3.0	0.8
Volcanics	11.2	0.4	-	-
Total	**11.2**	**82.6**	**3.0**	**3.2**

3.2 X-Ray Diffraction – Mineralogy

3.2.1 XRD Analysis Method

Quantitive phase analysis of three pulverized samples using the Rietveld X-Ray Diffraction (XRD) method was completed at the University of British Columbia. The XRD report is presented in Appendix D.

3.2.2 Results of XRD Analysis

The three Waitabit Pit samples report relatively homogenous mineralogy between the three samples analyzed (Table 3-4). The samples are dominated by calcite, followed by quartz, dolomite-ankerite, and micas (illite and muscovite). The samples all contain plagioclase, clinochlore, and rutile in smaller amounts. Sample WB22HS-02-02 reports trace amounts of possible pyrite, as well as kaolinite clay.

The proportion of calcite and dolomite is similar between the Waitabit Pit and Donald Hill dolomitic limestone and limestone samples, ranging from approximately 60-70% in the five total samples reviewed. The Donald Hill limestone samples show distinct calcite and dolomite content, categorizing the samples as either limestone (i.e., calcite dominant sample) or dolomitic limestone (i.e., dolomite-ankerite dominant sample).

The source report for the Donald Hill samples (SNC, 2019) notes that the 0.2% pyrite sulphur reported in the RS19-06 XRD results is not supported by the ABA results, which reported no detectable form of sulphur. It is also noted that the XRD measurement is less than 5x the detection limit of 0.1 wt%, so the value is uncertain.

Table 3-4: Results of XRD Quantitative Phase Analysis

Mineral	Ideal Formula	Waitabit Pit			Donald Hill Samples		
					Slate	Dolomitic Limestone	Limestone
		WB22HS-02-01	WB22HS-02-02	WB22HS-02-03	RS19-04	RS19-06	RS19-09
Calcite	$CaCO_3$	47.8	48.6	49.5	15.2	25.9	67.8
Clinochlore	$(Mg,Fe^{2+})_5Al(Si_3Al)O_{10}(OH)_8$	1.8	1.7	1.7	12.2	0.5	0.9
Dolomite - Ankerite	$CaMg(CO_3)_2$ - $Ca(Fe^{2+},Mg,Mn)(CO_3)_2$	12.5	11.2	13.9	0.7	41.3	1.5
Illite/Muscovite 2M1	$\sim K_{0.65}Al_{2.0}(Al_{0.65}Si_{3.35}O_{10})(OH)_2$-$KAl_2(AlSi_3O_{10})(OH)_2$	7.6	8.2	7.4	23	3.4	1.1
Kaolinite	$Al_2Si_2O_5(OH)_4$	-	0.5	-	-	-	-
Plagioclase (albite)	$NaAlSi_3O_8$ – $CaAl_2Si_2O_8$	4.4	4.4	4	13	3.8	9.8
Pyrite	FeS_2	-	< 0.1 (?)	-	-	0.2	-
Quartz	SiO_2	25.6	25.1	23.2	35.9	25.0	18.9
Rutile	TiO_2	0.3	0.3	0.3	-	-	-
Total		**100**	**100**	**100**	**100**	**100**	**100**

3.3 Trace Element Analysis

The results of trace element analysis were compared to average crustal abundance values to provide an indication of element enrichment in the analyzed samples. Concentrations that are above the average crustal abundance values by an order of magnitude are flagged for further consideration. Average crustal abundance values for Carbonates – Sedimentary Rocks (Price, 1997) were referenced based on the rock type classification and XRD analysis results. The results were also compared to the average crustal abundance values for earth's crust as a reference point.

Elevated concentrations may not translate to increased potential for ML but are a useful tool to highlight elements of interest for review. The results of the trace element analysis and comparisons to average crustal abundance values are presented in the attached Tables 2a and 2b. The lab certificate is provided as Appendix E.

Selenium concentrations in the three Waitabit Pit samples range from 0.4 ppm to 0.6 ppm, which is above the average crustal abundance value of 0.08 ppm for carbonate rocks. These values are an order of magnitude above average crustal abundance for earth's crust. Cobalt concentrations are an order of magnitude above the average crustal abundance value for carbonate rocks, however the reference average crustal abundance value for this rock type category may be too low, as it is noted that the concentrations are well below the average crustal abundance value for earth's crust.

Calcium value range from 18.5% to 19.7% and magnesium values are in the range of 1.4% to 1.7%, consistent with XRD results showing an abundance of calcite and some dolomite.

3.4 Acid-Base Accounting Results

Table 3-5 summarizes the ABA parameters for the three samples collected from the Waitabit Pit, as well as results for the five humidity cell samples and the two limestone samples from the Donald Hill project area.

Paste pH values are similar for all limestone, dolomitic limestone, and blended humidity cell samples, with values ranging from pH 8.6 to 8.9. The three project humidity cells have paste pH of 8.2 to 8.5

Sample BH19-S4ML-02-SA2 is an interbedded perlite and arkose sample that was analyzed by humidity cell analysis. The pre-characterization ABA analysis indicated a sulphide sulphur content of <0.01 S%. However, the post-test residue ABA analysis on this sample reported a sulphide sulphur content of 0.33 S%.

The blended humidity cell samples, HC4 and HC5, used dolomitic limestone and limestone material from the Donald Hill project. Pre-characterisation ABA data is not available for the two samples used for the blending; however, it is assumed that the ABA parameters are well represented by the respective dolomitic limestone and limestone samples, RS19-06 and RS19-09, respectively.

Table 3-5: Summary of ABA Parameters

Sample ID	Source Area	Rock Type	Inorganic Carbon, C %	Total Sulphur, S%	Sulphide Sulphur, S%	Maximum Potential Acidity (kg CaCO3/tonne)	Modified Sobek NP (kg CaCO3/tonne)	Carbonate NP (kg CaCO3/tonne)	Sobek NPR (NP:MPA)	Carbonate NPR (Carbonate NP:MPA)
WB22HS-02-01	Waitabit Pit	Limestone	6.82	<0.01	0.02	0.6	575	568	920	909
WB22HS-02-02		Limestone	6.77	<0.01	0.02	0.6	563	564	901	903
WB22HS-02-03		Limestone	7.24	<0.01	0.02	0.6	602	603	963	965
BH19-S4ML-01-SA2	HC1	Arkose	-	0.17	0.17	5.3	1.4	-	0.3	-
BH19-S4ML-02-SA2	HC2	Pelite/ Arkose	-	<0.005	<0.01	<0.3	2.6	-	8.3	-
BH19-39	HC3	Quartzite	-	0.88	0.88	27.5	7.2	-	0.3	-
Mix 90% BH19-39 + 10% DH-MD-01	HC4	Quartzite / Dolomitic Limestone	1.17	0.13	0.13	4.1	81	98	19.6	24
Mix 70% BH19-39 + 30% DH-MD-02	HC5	Quartzite / Limestone	3.37	0.14	0.14	4.4	278	281	65.4	64
RS19-06	Donald Hill	Dolomitic Limestone	-	<0.01	<0.01	<0.3	644	-	2146	-
RS19-09		Limestone	-	<0.01	<0.01	<0.3	656	-	2188	-

4.0 HISTORIC AGGREGATE QUALITY TESTING

MoTI provided Tetra Tech with historic documents from 2009 containing limited aggregate quality test results on pit run samples. The results are summarized below for reference but a review of the material characteristics and associated geotechnical consideration are outside of the scope of the current memo.

- Micro-Deval values for five coarse aggregate samples range from 19.9% to 32.0%, with an average value of 27.8%.
- Bulk density on one sample is 2.63 g/cm^3 for coarse aggregate and 2.56 g/cm^3 for fine aggregate.
- Absorption on one sample is 1.39% for coarse aggregate and 2.45% for fine aggregate.

- Soundness of aggregate by use of magnesium sulphate values in five samples range from 0.2% to 1.5% (average 0.7%) for coarse aggregate and from 1.9% to 13.9% (average 5.0%) in the fine aggregate.

5.0 CONCLUSIONS

The gravel from the Waitabit Pit consists predominantly of limestone and sandy carbonate. The ABA analysis demonstrates that it has high neutralization potential, provided almost entirely from carbonate mineralogy (dominantly calcite) which is expected to provide fast and effective neutralization potential. The ABA parameters are similar to the carbonate rocks tested from the Donald Hill project that were used as a blending material in the humidity cell analysis completed for the Selkirk Project (SNC, 2022).

The humidity cell test results showed that blending the Donald Hill carbonate rocks was effective at raising the neutralization potential in the samples, and that the elevated calcium and magnesium release rates reported for the two humidity cell tests showed that the carbonate rocks were reactive and maintained neutral pH leachate conditions over the duration of humidity cell tests.

The Waitabit Pit samples appear to be a suitable substitute for the Donald Hill carbonate rocks, and it is assumed that a blend with this gravel could produce similar results as observed in the humidity cell analysis. The results of the humidity cell analysis indicate that the blending was successful at mitigating acid generation, as well as maintaining metal leaching concentrations at acceptable levels relative to the reference water quality guidelines.

For the blending estimates, we assume conservatively that the geochemical characteristics of the Selkirk Type A rock can be represented by the highest reported AP (27.5 kg $CaCO_3$/t) and the lowest NP (<0.8 kg $CaCO_3$/t). We also assume conservatively that the geochemical characteristics of the Waitabit Pit granular material can be represented by the lowest report NP (560 kg $CaCO_3$/t) and the highest AP (0.6 kg $CaCO_3$/t). These values are used to calculate estimated NPR values at different blending ratios as presented in Table 5-1. Note that these blended NPR values assume a perfectly comingled material which may be hard to achieve in practice, and therefore some isolated pockets of higher or lower NPR values should be expected at the different proportions. It also assumes the conservative cases for measured NP and AP values and assigns that to all material where natural variability is expected in the rock mass.

Table 5-1: Estimated NPR value of Potential Blended Materials

Acid-Base Parameter	% Waitabit Pit Gravel Addition			
	10%	15%	20%	25%
Neutralization Potential (kg $CaCO_3$/t)	56.0	84.0	112.0	140.0
Acid Potential (kg $CaCO_3$/t)	25.3	23.9	22.5	21.1
NPR (unitless)	**2.2**	**3.5**	**5.0**	**6.6**

The calculated NPRs suggest that a minimum blending proportion of 10% material from the Waitabit Pit would be needed to achieve an average NPR classification as NAG (NPR>2). The volume of Type A rock from the Selkirk project is estimated at 13,000 cubic meters (m^3). This suggests that a minimum volume of approximately 1,500 m^3 would be needed from the Waitabit Pit. The high blending ratio means that it may be harder to achieve a consistent blending throughout the material. It may be best to go to a lower ratio for easier mixing. For example, increasing the required amount of Waitabit Pit gravel to a 4:1 ratio, which would require a minimum volume of Waitabit Pit gravel closer to 3,300 m^3.

Tetra Tech maintains that the Type A material should still be used as embankment fill on the project. The application of blending with the carbonate rich Waitabit Pit gravels however means that an engineered encapsulation is not required for ARD/ML management. The blended material can be placed in embankment fill areas where space allows and covered by Type D material as planned in the design.

6.0 BLENDING CONSIDERATIONS

The following items are identified for consideration of the blending option:

- Idealized blend would be achieved across all scales. This is challenging in practice due to physical characteristics of the project Type A rock (i.e., large particle size of produced rock) and Waitabit Pit gravels, costs associated with material handling, and specialized equipment needed for blending. It is important that the two blending materials, Type A rock and Waitabit Pit gravels, are appropriately comingled to verify distribution of the neutralization potential throughout the blended volume.
- Blending presents a risk of localized ML/ARD generation, where water contacts acid generating material without contact with the neutralizing material.
- Confirmatory monitoring program is required to verify that the proposed blending is achieved. Confirmatory monitoring may impact the schedule if lab testing is delayed.
- The blending option may be considered in conjunction with a non-engineered encapsulation option in the road embankment fill to further minimize risk of ML/ARD.

7.0 ADDITIONAL INFORMATION REQUIREMENTS

The following items are identified as additional information requirements and next steps in detailing the blending option:

- This study is limited to the geochemical characterization information. No information is currently known for the physical stability or geotechnical material properties of the Waitabit Pit carbonate gravels or the blended Selkirk area-Waitabit Pit materials, except for preliminary information provided by the Petrographic Analysis. The result of the Petrographic Analysis should be shared with the Geotechnical Design team. Additional testing may be required to assess the construction suitability of this material and meet the aggregate testing requirements presented in the MoTI's SSHC.
- Additional mapping and/or delineation drilling/test pitting is needed to confirm the extents and continuity of the Waitabit Pit carbonate gravels. Clear delineation in that area and confirmation of neutralization capacity is needed to ensure sufficient material is present for blending. The analysis presented herein is based on the samples collected for testing and analyzed to-date. The potential variability in the rock types and material characteristics of the Waitabit Pit gravels, as well as the extents of the gravel deposit, both laterally and vertically is not currently delineated.
- Develop an operational plan for blending of the site Type A material with imported material from Waitabit Pit. The operational plan will outline the contractor's obligations for confirming the blending ratios, record keeping, documentation, and monitoring. This will be integrated in to a revised ARD/ML MMP.

8.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of BC Ministry of Transportation and Infrastructure and their agents. Tetra Tech Canada Inc. (Tetra Tech) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than BC Ministry of Transportation and Infrastructure, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this document is subject to the Limitations on the Use of this Document attached in the Appendix A or Contractual Terms and Conditions executed by both parties.

9.0 CLOSURE

We trust this technical memo meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
Tetra Tech Canada Inc.

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Enclosure: Tables
Appendix A – Limitations on the Use of this Document
Appendix B – Petrographic Analysis Report
Appendix C – Historic Petrographic Test Results from 2009
Appendix D – XRD Analysis Report
Appendix E – Laboratory Certificates from ALS for ABA and Trace Element Analysis

PERMIT TO PRACTICE
TETRA TECH CANADA INC.

PERMIT NUMBER: 1001972

REFERENCES

British Columbia Ministry of Transportation and Infrastructure. 2021. Standard Specifications for Highway Construction.

SNC Lavalin Inc., 2019. ML/ARD Assessment for Donald Hill Descending Lane, Project 665649, SNC Lavalin Inc., Prepared for BC Ministry of Transportation and Infrastructure, November 27, 2019.

SNC Lavalin Inc., 2020. ML/ARD Assessment to Support Selkirk Mountain 4-Laning Project, Project 666768, SNC Lavalin Inc., Prepared for BC Ministry of Transportation and Infrastructure, March 17, 2020.

SNC Lavalin Inc., 2022. Results of Humidity Cell Tests – Type A Materials for the Highway #1 Selkirk Mountain 4-Laning Project, Project 666768, SNC Lavalin Inc., Prepared for BC Ministry of Transportation and Infrastructure, March 10, 2022.

TABLES

Table 1: Acid-Base Accounting Testing Results

			Lab Reported Values											Calculated Values		ARD Classification	
Sample ID	Source Area	Rock Type	Paste pH	Inorganic Carbon, C %	Inorganic Carbon, CO_2 %	Total Sulphur, S%	Sulphate Sulphur (HCl Leachable), S%	Sulphide Sulphur, S%	Maximum Potential Acidity (kg CaCO3/tonne)	Modified Sobek NP (kg CaCO3/tonne)	Sobek NNP (kg CaCO3/tonne)	Fizz Rating	Sobek NPR (NP:MPA)	Carbonate NP (kg CaCO3/tonne)	Carbonate NPR (Carbonate NP:MPA)	Based on Sobek NPR	Based on Carbonate NPR
WB22HS-02-01	Waitabit Pit	Limestone	8.7	6.82	25	<0.01	<0.01	0.02	0.6	575	574	4 - Strong	920	569	910	NAG	NAG
WB22HS-02-02		Limestone	8.7	6.77	24.8	<0.01	<0.01	0.02	0.6	563	562	4 - Strong	901	564	902	NAG	NAG
WB22HS-02-03		Limestone	8.7	7.24	26.5	<0.01	<0.01	0.02	0.6	602	601	4 - Strong	963	603	964	NAG	NAG
BH19-S4ML-01-SA2	HC1	Arkose	8.5	-	-	0.17	<0.01	0.17	5.3	1.4	-3.9	1 - None	0.3	-	-	PAG	-
BH19-S4ML-02-SA2	HC2	Pelite/ Arkose	8.2	-	-	<0.005	<0.01	<0.01[a]	<0.3	2.6	3	1 - None	8.3	-	-	NAG	-
BH19-39	HC3	Quartzite	8.2	-	-	0.88	<0.01	0.88	27.5	7.2	-20	1 - None	0.3	-	-	PAG	-
Mix 90% BH19-39 + 10% DH-MD-01	HC4	Quartzite / Dolomitic Limestone	8.9	1.17	-	0.13	<0.01	0.13	4.1	81	77	4 - Strong	20	98	24	NAG	NAG
Mix 70% BH19-39 + 30% DH-MD-02	HC5	Quartzite / Limestone	8.9	3.37	-	0.14	<0.01	0.14	4.4	278	274	4 - Strong	65	281	64	NAG	NAG
RS19-06	Donald Hill Samples	Dolomitic Limestone	8.6	-	-	<0.01	<0.01	<0.01	<0.3	644	644	4 - Strong	2146	-	-	NAG	NAG
RS19-09		Limestone	8.8	-	-	<0.01	<0.01	<0.01	<0.3	656	656	4 - Strong	2188	-	-	NAG	NAG

Carbonate NP is calculated from Total Inorganic Carbon content.

Maximum Potential Acidity (MPA) is provided by lab based on total sulphur. The value here was recalculated based on the highest value of total, sulphide or sulphate sulphur as a conservative measure.

Sulphide Sulphur by sodium carbonate leach and Leco analysis

Sulphate Sulphur by HCl Leach

Samples classified based on NPR values in accordance with Price, 2009. NPR values greater than 2 are classified as non-acid generating (NAG), values of less than 1 are potentially acid generating (PAG), and values of between 1 and 2 are Uncertain

Table 2a: Comparison of Trace Element Concentrations to Average Crustal Abundance (Carbonates - Sedimentary Rocks)

Element	Units	WB22HS-02-01	WB22HS-02-02	WB22HS-02-03	BH19-SM4L- 01-SA2	BH19-SM4L- 02-SA2	BH19-39	Mix 90% BH19-39 + 10% DH-MD-01	Mix 70% BH19-39 + 30% DH-MD-02	Crustal Abundance	10x Crustal Abundance
		Waitabit Pit			HC1	HC2	HC3	HC4	HC5		
Ag	ppm	0.05	0.02	0.03	<0.5	<0.5	<0.5	-	-	0.0X	0.0X
Al	%	**0.54**	**0.56**	**0.52**	0.18	**0.439**	0.269	-	-	0.42	4.2
As	ppm	**3.3**	**3.2**	**2.7**	**39**	0.1	**1.9**	-	-	1	10
Au	ppm	<0.02	<0.02	<0.02	-	-	-	-	-	0.00X	0.0X
B	ppm	10	10	<10	0.7	1.3	0.5	-	-	20	200
Ba	ppm	20	30	20	12.7	46.7	11.1	-	-	190	1900
Be	ppm	0.2	0.2	0.18	<0.1	0.3	0.1	-	-	0.X	0.X
Bi	ppm	0.26	0.09	0.11	<0.5	<0.5	<0.5	-	-	D	D
Ca	%	18.6	18.9	19.7	-	-	-	-	-	30.23	302.3
Cd	ppm	**0.09**	**0.05**	**0.05**	<0.01	0.02	0.02	-	-	0.035	0.35
Ce	ppm	**18.45**	**17.5**	**16.5**	-	-	-	-	-	11.5	115
Co	ppm	**5.7**	**5.6**	**5.3**	**1**	**1.7**	**2.3**	-	-	0.1	1
Cr	ppm	8	8	6	**23**	8	6	-	-	11	110
Cs	ppm	0.19	0.2	0.17	-	-	-	-	-	0.X	0.X
Cu	ppm	**12.1**	**11.4**	**15.1**	0.9	0.6	0.6	-	-	4	40
Fe	%	**1.69**	**1.7**	**1.65**	**0.485**	**0.741**	**1.08**	-	-	0.38	3.8
Ga	ppm	1.52	1.56	1.45	-	-	-	-	-	4	40
Ge	ppm	<0.05	<0.05	<0.05	-	-	-	-	-	0.2	2
Hf	ppm	0.03	0.03	0.03	-	-	-	-	-	0.3	3
Hg	ppm	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	-	-	0.04	0.4
In	ppm	0.021	0.02	0.02	-	-	-	-	-	0.0X	0.0X
K	%	0.08	0.09	0.08	-	-	-	-	-	0.27	2.7
La	ppm	9.6	9	8.4	-	-	-	-	-	X	X
Li	ppm	**11.7**	**11.9**	**11.7**	<0.5	1.7	1.1	-	-	5	50
Mg	%	1.57	1.43	1.69	-	-	-	-	-	4.7	47
Mn	ppm	498	501	468	28	51	53	-	-	1100	11000
Mo	ppm	0.38	0.24	0.21	-	-	-	-	-	0.4	4
Na	%	0.01	0.01	0.01	<0.2	<0.2	<0.2	-	-	0.04	0.4
Nb	ppm	<0.05	0.05	<0.05	-	-	-	-	-	0.3	3
Ni	ppm	12.4	12.4	12.4	1.9	1.7	2.2	-	-	20	200
P	ppm	240	230	200	-	-	-	-	-	400	4000
Pb	ppm	**10.2**	**9.7**	9	1.7	1.1	1.6	-	-	9	90
Rb	ppm	**3.8**	**4**	**3.3**	-	-	-	-	-	3	30
Re	ppm	<0.001	<0.001	<0.001	-	-	-	-	-	D	D
S	%	0.01	0.01	0.01	-	-	-	-	-	0.12	1.2
Sb	ppm	0.2	0.15	0.15	<0.1	<0.1	<0.1	-	-	0.2	2
Sc	ppm	**3.2**	**3.2**	**3.1**	-	-	-	-	-	1	10
Se	ppm	**0.6**	**0.4**	**0.5**	<0.1	<0.1	**0.2**	-	-	0.08	0.8
Sn	ppm	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	-	0.X	0.X
Sr	ppm	575	595	610	3	4	13	-	-	610	6100
Ta	ppm	<0.01	<0.01	<0.01	-	-	-	-	-	0.0X	0.0X
Te	ppm	0.02	0.01	0.01	-	-	-	-	-	D	D
Th	ppm	**3.8**	**3.5**	**3.5**	-	-	-	-	-	1.7	17
Ti	%	<0.005	<0.005	<0.005	-	-	-	-	-	0.04	0.4
Tl	ppm	0.02	0.02	0.02	<0.1	<0.1	<0.1	-	-	0.0X	0.0X
U	ppm	0.38	0.48	0.39	<0.2	0.2	1.1	-	-	2.2	22
V	ppm	5	5	5	<1	<1	<1	-	-	20	200
W	ppm	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-	-	0.6	6
Y	ppm	9.64	9.42	9.57	-	-	-	-	-	30	300
Zn	ppm	**32**	**31**	**33**	1	3	<1	-	-	20	200
Zr	ppm	1.4	1.3	1.2	0.4	0.9	1.1	-	-	19	190

Crustal abundance values as reported in Appendix 4 (Price, 1997) - "Distribution of the elements in the Earth's crust for Carbonates Sedimentary Rocks
D: The data for these elements are misssing or unreliable
In some cases only an order of magnitude estimate for crustal abundance is available. These are indicated by the symbol X.
Metal concentrations exceeding the average crustal abundance are bold
Metal concentrations exceeding 10 times the average crustal abundance are bold shaded

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Table 2b: Comparison of Trace Element Concentrations to Average Crustal Abundance (Earth's Crust)

Element	Units	WB22HS-02-01	WB22HS-02-02	WB22HS-02-03	BH19-SM4L- 01-SA2	BH19-SM4L- 02-SA2	BH19-39	Mix 90% BH19-39 + 10% DH-MD-01	Mix 70% BH19-39 + 30% DH-MD-02	Crustal Abundance	10x Crustal Abundance
		Waitabit Pit			HC1	HC2	HC3	HC4	HC5		
Ag	ppm	0.05	0.02	0.03	<0.5	<0.5	<0.5	-	-	0.075	0.75
Al	%	0.54	0.56	0.52	0.18	0.439	0.269	-	-	8.23	82.3
As	ppm	**3.3**	**3.2**	**2.7**	**39**	0.1	**1.9**	-	-	1.8	18
Au	ppm	<0.02	<0.02	<0.02	-	-	-	-	-	0.003	0.03
B	ppm	**10**	**10**	<10	0.7	1.3	0.5	-	-	9.5	95
Ba	ppm	20	30	20	12.7	46.7	11.1	-	-	425	4250
Be	ppm	0.2	0.2	0.18	<0.1	0.3	0.1	-	-	2.8	28
Bi	ppm	0.26	0.09	0.11	<0.5	<0.5	<0.5	-	-	-	-
Ca	%	**18.55**	**18.85**	**19.7**	-	-	-	-	-	4.15	41.5
Cd	ppm	0.09	0.05	0.05	<0.01	0.02	0.02	-	-	0.15	1.5
Ce	ppm	18.45	17.5	16.5	-	-	-	-	-	66.5	665
Co	ppm	5.7	5.6	5.3	1	1.7	2.3	-	-	25	250
Cr	ppm	8	8	6	23	8	6	-	-	102	1020
Cs	ppm	0.19	0.2	0.17	-	-	-	-	-	3	30
Cu	ppm	12.1	11.4	15.1	0.9	0.6	0.6	-	-	60	600
Fe	%	1.69	1.7	1.65	0.485	0.741	1.08	-	-	5.63	56.3
Ga	ppm	1.52	1.56	1.45	-	-	-	-	-	19	190
Ge	ppm	<0.05	<0.05	<0.05	-	-	-	-	-	1.5	15
Hf	ppm	0.03	0.03	0.03	-	-	-	-	-	3	30
Hg	ppm	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	-	-	0.067	0.67
In	ppm	0.021	0.02	0.02	-	-	-	-	-	0.16	1.6
K	%	0.08	0.09	0.08	-	-	-	-	-	2.09	20.9
La	ppm	9.6	9	8.4	-	-	-	-	-	39	390
Li	ppm	11.7	11.9	11.7	<0.5	1.7	1.1	-	-	20	200
Mg	%	1.57	1.43	1.69	-	-	-	-	-	2.33	23.3
Mn	ppm	498	501	468	28	51	53	-	-	950	9500
Mo	ppm	0.38	0.24	0.21	-	-	-	-	-	1.2	12
Na	%	0.01	0.01	0.01	<0.2	<0.2	<0.2	-	-	2.36	23.6
Nb	ppm	<0.05	0.05	<0.05	-	-	-	-	-	20	200
Ni	ppm	12.4	12.4	12.4	1.9	1.7	2.2	-	-	84	840
P	ppm	240	230	200	-	-	-	-	-	1050	10500
Pb	ppm	10.2	9.7	9	1.7	1.1	1.6	-	-	14	140
Rb	ppm	3.8	4	3.3	-	-	-	-	-	90	900
Re	ppm	<0.001	<0.001	<0.001	-	-	-	-	-	0.0015	0.015
S	%	0.01	0.01	0.01	-	-	-	-	-	0.035	0.35
Sb	ppm	0.2	0.15	0.15	<0.1	<0.1	<0.1	-	-	0.2	2
Sc	ppm	3.2	3.2	3.1	-	-	-	-	-	22	220
Se	ppm	**0.6**	**0.4**	**0.5**	<0.1	<0.1	**0.2**	-	-	0.05	0.5
Sn	ppm	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	-	2.3	23
Sr	ppm	**575**	**595**	**610**	3	4	13	-	-	370	3700
Ta	ppm	<0.01	<0.01	<0.01	-	-	-	-	-	2	20
Te	ppm	**0.02**	**0.01**	**0.01**	-	-	-	-	-	0.002	0.02
Th	ppm	3.8	3.5	3.5	-	-	-	-	-	9.6	96
Ti	%	<0.005	<0.005	<0.005	-	-	-	-	-	0.565	5.65
Tl	ppm	0.02	0.02	0.02	<0.1	<0.1	<0.1	-	-	0.6	6
U	ppm	0.38	0.48	0.39	<0.2	0.2	1.1	-	-	2.7	27
V	ppm	5	5	5	<1	<1	<1	-	-	120	1200
W	ppm	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-	-	1.25	12.5
Y	ppm	9.64	9.42	9.57	-	-	-	-	-	33	330
Zn	ppm	32	31	33	1	3	<1	-	-	70	700
Zr	ppm	1.4	1.3	1.2	0.4	0.9	1.1	-	-	165	1650

Average crustal abundance values for all rock types. Multiple sources as compiled at https://en.wikipedia.org/wiki/Abundance_of_elements_in_Earth's_crust
Average crustal abundance is not provided for bismuth
Metal concentrations exceeding the average crustal abundance are bold
Metal concentrations exceeding 10 times the average crustal abundance are bold shaded

APPENDIX A

TETRA TECH'S LIMITATIONS ON THE USE OF THIS DOCUMENT

LIMITATIONS ON USE OF THIS DOCUMENT

1.1 USE OF DOCUMENT AND OWNERSHIP

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If any error or omission is detected by the Client or an Authorized Party, the error or omission must be immediately brought to the attention of TETRA TECH.

1.4 DISCLOSURE OF INFORMATION BY CLIENT

The Client acknowledges that it has fully cooperated with TETRA TECH with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The Client further acknowledges that in order for TETRA TECH to properly provide the services contracted for in the Contract, TETRA TECH has relied upon the Client with respect to both the full disclosure and accuracy of any such information.

1.5 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

During the performance of the work and the preparation of this Professional Document, TETRA TECH may have relied on information provided by third parties other than the Client.

While TETRA TECH endeavours to verify the accuracy of such information, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage.

1.6 GENERAL LIMITATIONS OF DOCUMENT

This Professional Document is based solely on the conditions presented and the data available to TETRA TECH at the time the data were collected in the field or gathered from available databases.

The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this report, at or on the development proposed as of the date of the Professional Document requires a supplementary exploration, investigation, and assessment.

TETRA TECH is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

APPENDIX B

PETROGRAPHIC ANALYSIS REPORT

November 29, 2022

ISSUED FOR USE
FILE: 704-MIN.VMIN03121-05
Via Email: julie.sandusky@gov.bc.ca

BC Ministry of Transportation & Infrastructure
Geotechnical Engineering Section
#200 – 940 Blanshard Street
Victoria, BC V8W 1E6

Attention: Julie Sandusky, P.Geo.

Subject: Petrographic Aggregate Analysis
Sample L-1 – WB22HS-01 – Sand and Gravel
Sample L-2 – WB22HS-03 – Sand and Gravel
Waitabit Pit near Donald, British Columbia

Pursuant to your request, Tetra Tech Canada Inc. (Tetra Tech) has completed petrography testing on the samples L-1 WB22HS-01 and L-2 WB22HS-03. The samples were identified as being sampled at the Waitabit Pit near Donald, British Columbia. The petrography was performed in accordance with 2020 Standard Specification for Highway Construction, Appendix 202-B Petrographic Analysis Test.

The summary of the petrographic analysis of the 20-5 mm coarse aggregate L-1 is presented in the enclosed Table 1. The material is composed predominantly of limestone, with some sandy carbonate, calcite, and a trace of quartz/quartzite, encrustation, and ochreous carbonate. The petrographic number is 134.

The summary of the petrographic analysis of the fine aggregate L-1 is presented in the enclosed Table 2. The material is composed predominantly of limestone and sandy carbonate, with some calcite, quartz/quartzite, ochreous carbonate, and trace of chert, encrustation, and siltstone. The material has a weighted average chert content of 2.5%.

The summary of the petrographic analysis of the 20-5 mm coarse aggregate L-2 is presented in the enclosed Table 3. The material is composed predominantly of limestone, with some sandy carbonate, calcite, and a trace of quartz/quartzite, encrustation, and ochreous carbonate. The petrographic number is 141.

The summary of the petrographic analysis of the fine aggregate L-2 is presented in the enclosed Table 4. The material is composed predominantly of limestone, with some sandy carbonate, calcite, ochreous carbonate, quartz/quartzite, and a trace of chert and encrustation. The material has a weighted average chert content of 1.4%.

Note that the samples were not processed and any aggregate beneficiation would reduce the petrographic number.

This letter report and its contents are intended for the sole use of BC Ministry of Transportation & Infrastructure and their agents. Tetra Tech Canada Inc. does not accept any responsibility for the accuracy of the data, the analysis, or the recommendations contained or referenced in the letter report when the letter report is used or relied upon by any party other than BC Ministry of Transportation & Infrastructure, or for any project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this document is subject to the Limitations on the Use of This Document provided with this letter report or the Contractual Terms and Conditions executed by both parties.

Tetra Tech Canada Inc.
Suite 110, 140 Quarry Park Blvd SE
Calgary, AB T2C 3G3 CANADA
Tel 403.203.3355 Fax 403.203.3301

We trust this letter report meets your present requirements. Should you have any questions or comments, please contact the undersigned at your convenience.

Respectfully submitted,
Tetra Tech Canada Inc.

FILE: 704-MIN.VMIN03121-05
FILE: 704-MIN.VMIN03121-05
FILE: 704-MIN.VMIN03121-05

Prepared by:
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/mh

Enclosures (7): Sieve Analysis Report – Samples L-1 and L-2
Tables 1 and 3: Summary of Petrographic Analysis of Coarse Aggregate – Samples L-1 and L-2
Tables 2 and 4: Summary of Petrographic Analysis of Fine Aggregate – Samples L-1 and L-2
Tetra Tech's Limitations on the Use of This Document

PERMIT TO PRACTICE
TETRA TECH CANADA INC.

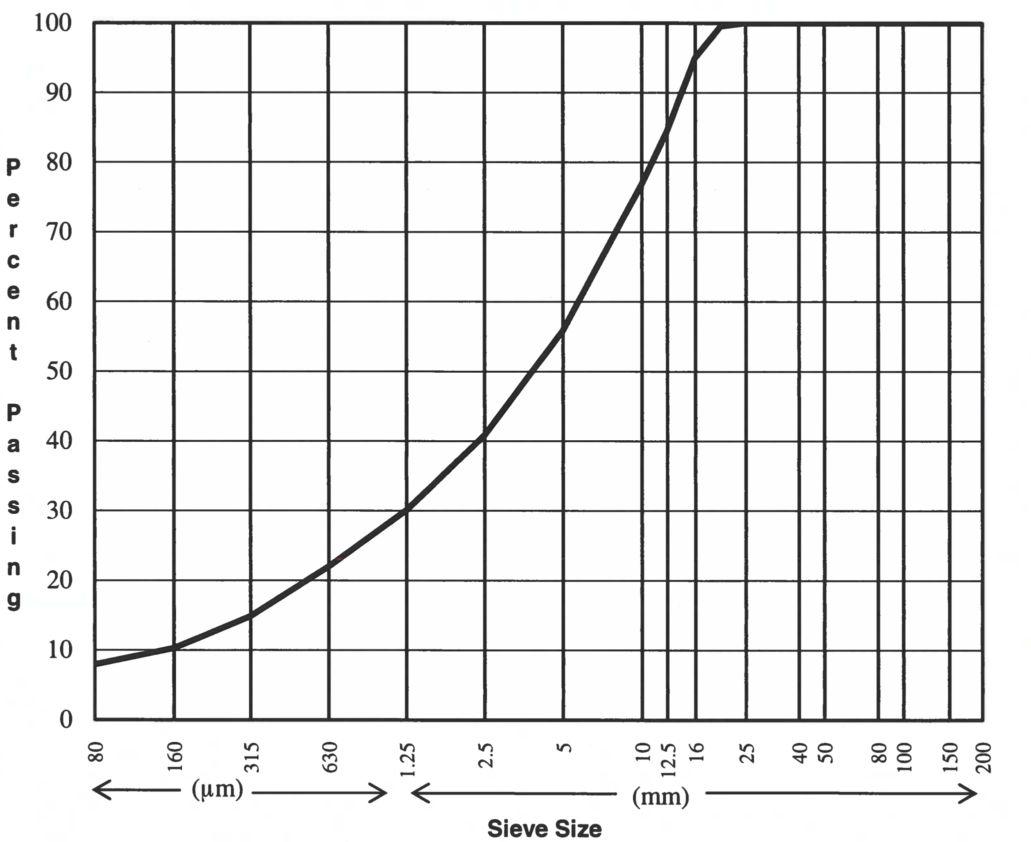
PERMIT NUMBER: 1001972

SIEVE ANALYSIS REPORT

ASTM C136, C117

Project:	Selkirk Hwy 1 Four-Laning-ARDML Management Plan	Sample No.:	L-1
Client:	Ministry of Transportation and Infrastructure	Date Sampled:	October 24, 2022
Project No.:	704-NIN.VMIN03121-05	Sampled By:	Client
Attention:		Date Tested:	November 4, 2022
Description:	SAND and GRAVEL	Tested By: JB	Lab: Clagary
Source:	WB22HS-01	No. Crushed Faces:	
Location:	Waitabit pit	Moisture Content:	1.8%
Specification:			

Sieve Size	Percent Passing
200 mm	
150 mm	
100 mm	
80 mm	
50 mm	
40 mm	
25 mm	100
20 mm	100
16 mm	95
12.5 mm	85
10 mm	77
5 mm	56
2.5 mm	41
1.25 mm	30
630 µm	22
315 µm	15
160 µm	10
80 µm	7.9



Remarks:

Reviewed By: ____________ P.Eng.

Data presented hereon is for the sole use of the stipulated client. Tetra Tech is not responsible, nor can be held liable, for use made of this report by any other party, with or without the knowledge of Tetra Tech. The testing services reported herein have been performed to recognized industry standards, unless noted. No other warranty is made. These data do not include or represent any interpretation or opinion of specification compliance or material suitability. Should engineering interpretation be required, Tetra Tech will provide it upon written request.

TETRA TECH

Table: 1

Summary of Petrographic Analysis of Coarse Aggregate Test Report

CSA A23.2-15A

Project: Selkirk Hwy 1 Four-Laning- ARDML Management Plan
Sample No.: L-1
Client: Ministry of Transportation and Infrastructure
Date Received: October 24, 2022
Project No.: 704-MI N.VMIN03121-05
Date Tested: November 22, 2022
Source: WB22HS-01
Petrographer: MS
Description: SAND and GRAVEL
Office: Calgary

Rock Type	Petrographic Multiplier	20 - 16 mm % in fraction	16 - 12.5 mm % in fraction	12.5 - 10 mm % in fraction	10 - 5 mm % in fraction	Weighted Average %
Good - High Strength						
Limestone	1	80.5	73.3	67.8	64.8	69.1
Calcite	1	0.0	9.8	11.5	13.2	10.6
Quartz/Quartzite	1	7.9	3.5	3.4	3.2	3.8
Fair - Medium Strength						
Sandy Carbonate	3	6.5	11.8	12.9	16.2	13.5
Calcite	3	5.1	1.6	1.8	1.4	1.9
Encrustation	3	0.0	0.0	2.7	0.6	0.8
Poor - Low Strength						
Ochreous Carbonate	6	0.0	0.0	0.0	0.6	0.3
Deleterious						
Petrographic Number :		**123**	**127**	**135**	**139**	
Percent of Fraction in Sample:		5.0	10.0	8.0	21.0	

Weighted Average Petrographic Number: **134**

Weighted Average Chert Content: **0.0 %**

Weighted Average Ironstone Content: **0.0 %**

Note: Petrographic evaluation of coarse aggregate suitability/acceptance should be confirmed by the suite of CSA Table 12 testing and AAR testing

Remarks:

CERTIFIED BY CCIL

Petrographer: ____________________ P.Geol.

Table: 2

SUMMARY OF PETROGRAPHIC ANALYSIS OF FINE AGGREGATE

CSA A23.2-15A

Project:	Selkirk Hwy 1 Four-Laning- ARDML Management Plan	Sample No.:	L-1
Client:	Ministry of Transportation and Infrastructure	Date Received:	October 24, 2022
Project No.:	704-MI N.VMIN03121-05	Date Tested:	November 28, 2022
Source:	WB22HS-01	Petrographer:	MS
Description:	SAND and GRAVEL	Office:	Calgary

Rock Type	5.0-2.5mm % in fraction	2.5-1.25mm % in fraction	1.25-630µm % in fraction	630-315µm % in fraction	315-160µm % in fraction	Weighted Average
Limestone	44.0	46.5	47.7	49.6	47.5	46.5
Sandy Carbonate	27.4	25.2	24.6	25.0	23.8	25.6
Chert*	1.9	1.8	1.5	1.7	2.0	1.8
Calcite	11.6	15.5	16.0	15.2	17.4	14.5
Encrustation	2.2	0.9	0.9	0.0	0.0	1.1
Siltstone	0.9	0.4	0.4	0.5	0.0	0.6
Quartz/Quartzite	3.1	4.9	6.3	8.1	9.3	5.5
Ochreous Carbonate	8.8	4.9	2.6	0.0	0.0	4.5

Percent of Fraction:	15.0%	11.0%	8.0%	7.0%	5.0%

Weighted Average Chert Content: **1.8%**

Weighted Total Ironstone Content: **0.0%** (Retained on the 2.5mm sieve)

Notes:

(1) Silica present in the above-identified rock types (*) has a potential for reaction with alkali compounds in Portland cement. The potential for alkali-aggregate reactivity (AAR) must be separately assessed.

(2) See CSA A23.1 and A23.2 for assessment of AAR in new concrete construction. In the absence of test results, this aggregate should be considered moderately reactive.

(3) Petrographic evaluation of fine aggregate suitability/acceptance should be confirmed by the suite of CSA Table 12 testing and AAR testing

Remarks: ______

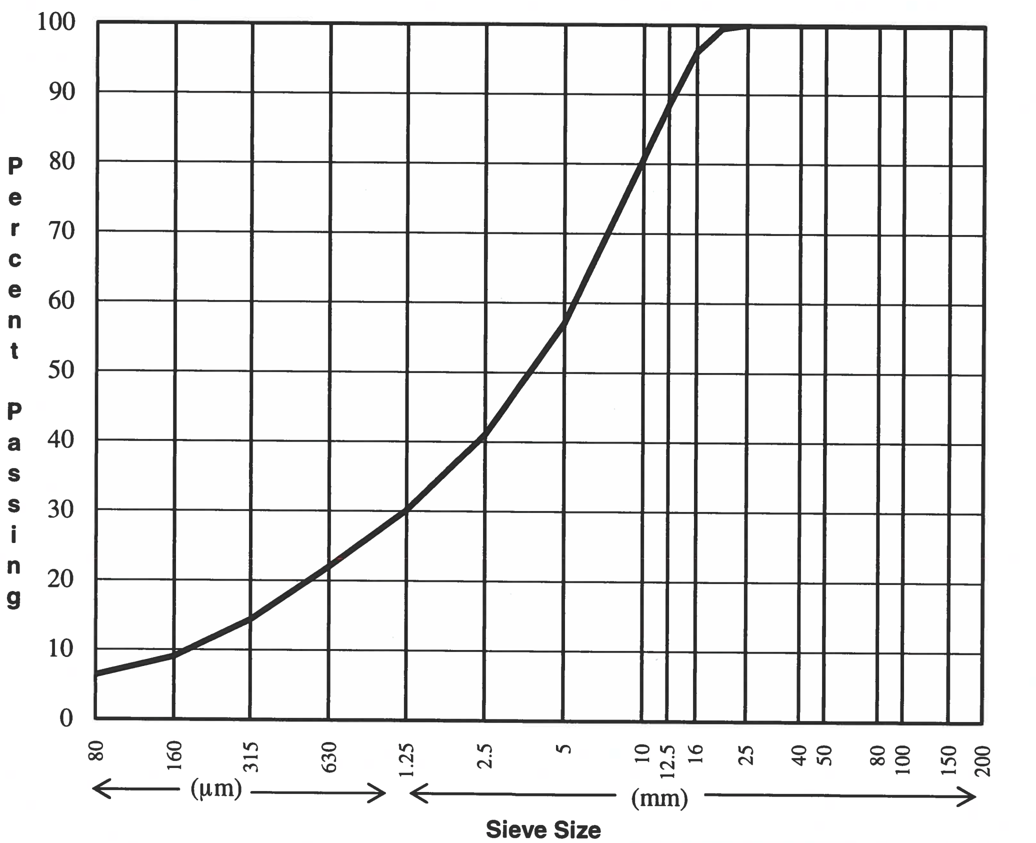
Petrographer: ______ P.Geol.

SIEVE ANALYSIS REPORT

ASTM C136, C117

Project:	Selkirk Hwy 1 Four-Laning-ARDML Management Plan	Sample No.:	L-2
Client:	Ministry of Transportation and Infrastructure	Date Sampled:	October 24, 2022
Project No.:	704-NIN.VMIN03121-05	Sampled By:	Client
Attention:		Date Tested:	November 4, 2022
Description:	SAND and GRAVEL	Tested By:	JB Lab: Clagary
Source:	WB22HS-03	No. Crushed Faces:	
Location:	Waitabit pit	Moisture Content:	1.9%
Specification:			

Sieve Size	Percent Passing
200 mm	
150 mm	
100 mm	
80 mm	
50 mm	
40 mm	
25 mm	100
20 mm	99
16 mm	96
12.5 mm	88
10 mm	81
5 mm	57
2.5 mm	41
1.25 mm	30
630 µm	22
315 µm	14
160 µm	9
80 µm	6.4



Remarks:

Reviewed By: ____________ P.Eng.

TETRA TECH

Table: 3

Summary of Petrographic Analysis of Coarse Aggregate Test Report

CSA A23.2-15A

Project:	Selkirk Hwy 1 Four-Laning- ARDML Management Plan	**Sample No.:**	L-2
Client:	Ministry of Transportation and Infrastructure	**Date Received:**	October 24, 2022
Project No.:	704-MI N.VMIN03121-05	**Date Tested:**	November 22, 2022
Source:	WB22HS-03	**Petrographer:**	MS
Description:	SAND and GRAVEL	**Office:**	Calgary

Rock Type	Petrographic Multiplier	20 - 16 mm % in fraction	16 - 12.5 mm % in fraction	12.5 - 10 mm % in fraction	10 - 5 mm % in fraction	Weighted Average %
Good - High Strength						
Limestone	1	63.4	72.2	70.8	57.6	63.0
Calcite	1	8.0	7.7	10.8	16.3	13.2
Quartz/Quartzite	1	5.7	2.9	3.2	4.5	4.1
Fair - Medium Strength						
Sandy Carbonate	3	10.7	14.5	12.1	18.0	15.8
Calcite	3	0.0	2.8	2.2	1.1	1.5
Encrustation	3	12.1	0.0	0.9	1.4	1.8
Poor - Low Strength						
Ochreous Cabonate	6	0.0	0.0	0.0	1.0	0.6
Deleterious						
Petrographic Number :		**146**	**135**	**130**	**146**	
Percent of Fraction in Sample:		3.0	8.0	7.0	24.0	

Weighted Average Petrographic Number: **141**

Weighted Average Chert Content: **0.0 %**

Weighted Average Ironstone Content: **0.0 %**

Note: Petrographic evaluation of coarse aggregate suitability/acceptance should be confirmed by the suite of CSA Table 12 testing and AAR testing

Remarks:

CCIL

Petrographer: ______________________ P.Geol.

TETRA TECH

Table: 4

SUMMARY OF PETROGRAPHIC ANALYSIS OF FINE AGGREGATE

CSA A23.2-15A

Project:	Selkirk Hwy 1 Four-Laning- ARDML Management Plan	Sample No.:	L-2
Client:	Ministry of Transportation and Infrastructure	Date Received:	October 24, 2022
Project No.:	704-MI N.VMIN03121-05	Date Tested:	November 27, 2022
Source:	WB22HS-03	Petrographer:	MS
Description:	SAND and GRAVEL	Office:	Calgary

Rock Type	5.0-2.5mm % in fraction	2.5-1.25mm % in fraction	1.25-630µm % in fraction	630-315µm % in fraction	315-160µm % in fraction	Weighted Average
Limestone	46.0	49.4	47.4	54.2	52.7	49.1
Sandy Carbonate	24.0	21.5	21.9	23.6	21.4	22.7
Chert*	1.1	1.7	1.1	1.4	1.8	1.4
Calcite	12.3	11.8	16.3	14.9	16.1	13.7
Encrustation	2.2	0.8	1.2	0.0	0.0	1.1
Quartz/Quartzite	3.9	3.8	4.6	5.9	8.0	4.8
Ochreous Carbonate	10.6	11.0	7.4	0.0	0.0	7.3
Percent of Fraction:	16.0%	11.0%	8.0%	8.0%	5.0%	

Weighted Average Chert Content: **1.4%**

Weighted Total Ironstone Content: **0.0%** (Retained on the 2.5mm sieve)

Notes:

(1) Silica present in the above-identified rock types (*) has a potential for reaction with alkali compounds in Portland cement. The potential for alkali-aggregate reactivity (AAR) must be separately assessed.

(2) See CSA A23.1 and A23.2 for assessment of AAR in new concrete construction. In the absence of test results, this aggregate should be considered moderately reactive.

(3) Petrographic evaluation of fine aggregate suitability/acceptance should be confirmed by the suite of CSA Table 12 testing and AAR testing

Remarks: ______

Petrographer: ______ P.Geol.

LIMITATIONS ON USE OF THIS DOCUMENT

CONSTRUCTION MATERIALS ENGINEERING AND TESTING

1.1 USE OF DOCUMENT AND OWNERSHIP

This document pertains to a specific site, a specific development, and a specific scope of work. The document may include plans, drawings, profiles and other supporting documents that collectively constitute the document (the "Professional Document").

The Professional Document is intended for the sole use of TETRA TECH's Client (the "Client") as specifically identified in the TETRA TECH Services Agreement or other Contractual Agreement entered into with the Client (either of which is termed the "Contract" herein). TETRA TECH does not accept any responsibility for the accuracy of any of the data, analyses, recommendations or other contents of the Professional Document when it is used or relied upon by any party other than the Client, unless authorized in writing by TETRA TECH.

Any unauthorized use of the Professional Document is at the sole risk of the user. TETRA TECH accepts no responsibility whatsoever for any loss or damage where such loss or damage is alleged to be or, is in fact, caused by the unauthorized use of the Professional Document.

Where TETRA TECH has expressly authorized the use of the Professional Document by a third party (an "Authorized Party"), consideration for such authorization is the Authorized Party's acceptance of these Limitations on Use of this Document as well as any limitations on liability contained in the Contract with the Client (all of which is collectively termed the "Limitations on Liability"). The Authorized Party should carefully review both these Limitations on Use of this Document and the Contract prior to making any use of the Professional Document. Any use made of the Professional Document by an Authorized Party constitutes the Authorized Party's express acceptance of, and agreement to, the Limitations on Liability.

The Professional Document and any other form or type of data or documents generated by TETRA TECH during the performance of the work are TETRA TECH's professional work product and shall remain the copyright property of TETRA TECH.

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1.2 ALTERNATIVE DOCUMENT FORMAT

Where TETRA TECH submits electronic file and/or hard copy versions of the Professional Document or any drawings or other project-related documents and deliverables (collectively termed TETRA TECH's "Instruments of Professional Service"), only the signed and/or sealed versions shall be considered final. The original signed and/or sealed electronic file and/or hard copy version archived by TETRA TECH shall be deemed to be the original. TETRA TECH will archive a protected digital copy of the original signed and/or sealed version for a period of 10 years.

Both electronic file and/or hard copy versions of TETRA TECH's Instruments of Professional Service shall not, under any circumstances, be altered by any party except TETRA TECH. TETRA TECH's Instruments of Professional Service will be used only and exactly as submitted by TETRA TECH.

Electronic files submitted by TETRA TECH have been prepared and submitted using specific software and hardware systems. TETRA TECH makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.

1.3 STANDARD OF CARE

Services performed by TETRA TECH for the Professional Document have been conducted in accordance with the Contract, in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Professional judgment has been applied in developing the conclusions and/or recommendations provided in this Professional Document. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of the Professional Document.

If any error or omission is detected by the Client or an Authorized Party, the error or omission must be immediately brought to the attention of TETRA TECH.

1.4 DISCLOSURE OF INFORMATION BY CLIENT

The Client acknowledges that it has fully cooperated with TETRA TECH with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The Client further acknowledges that in order for TETRA TECH to properly provide the services contracted for in the Contract, TETRA TECH has relied upon the Client with respect to both the full disclosure and accuracy of any such information.

1.5 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

During the performance of the work and the preparation of this Professional Document, TETRA TECH may have relied on information provided by persons other than the Client.

While TETRA TECH endeavours to verify the accuracy of such information, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage.

1.6 GENERAL LIMITATIONS OF DOCUMENT

This Professional Document is based solely on the conditions presented and the data available to TETRA TECH at the time the data were collected in the field or gathered from available databases.

The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this report, at or on the development proposed as of the date of the Professional Document requires a supplementary investigation and assessment.

TETRA TECH is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

1.7 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, TETRA TECH has not been retained to investigate, address or consider and has not investigated, addressed or considered any environmental, regulatory, or sediment and erosion issues associated with construction on the subject site.

1.8 VARIATION OF MATERIAL CHARACTERISTICS AND CONDITIONS

Observations and standardized sampling, inspection and testing procedures employed by TETRA TECH will indicate conditions of materials and construction activities only at the precise location and time where and when Services were performed. The Client recognizes that conditions of materials and construction activities at other locations may vary from those measured or observed, and that conditions at one location and time do not necessarily indicate the conditions of apparently identical material(s) at other locations and/or times.

Services of TETRA TECH, even if performed on a continuous basis, should not be interpreted to mean that TETRA TECH is observing, verifying, testing or inspecting all materials on the Project. TETRA TECH is responsible only for those data, interpretations, and recommendations regarding the actual materials and construction activities observed, sampled, inspected or tested, and is not responsible for other parties' interpretations or use of the information developed. TETRA TECH may make certain inferences based upon the information derived from these procedures to formulate professional opinions regarding conditions in other areas.

1.9 SAMPLING, OBSERVATION & TEST LOCATIONS

Unless specifically stated otherwise, the Scope of Services does not include surveying the Site or precisely identifying sampling, observation or test locations, depths or elevations. Sampling, observation and test locations, depths and elevations will be based on field estimates and information furnished by the Client and its representatives. Unless stated otherwise in the report, such locations, depths and elevations provided are approximate.

1.10 CONTRACTOR'S PERFORMANCE

TETRA TECH is not responsible for Contractor's means, methods, techniques or sequences during the performance of its Work. TETRA TECH will not supervise or direct Contractor's Work, nor be liable for any failure of Contractor to complete its Work in accordance with the Project's plans, specifications and applicable codes, laws and regulations. The Client understands and agrees that Contractor, not TETRA TECH, has sole responsibility for the safety of persons and property at the Project Site.

1.11 NOTIFICATION AND LEVEL OF SERVICE

Unless the Client requests or the building code requires full-time services, the Client understands that services provided by TETRA TECH are on an "On-Call" basis. The Client shall assume responsibility for adequate notification and scheduling of TETRA TECH services. TETRA TECH will make every reasonable effort to meet the Client's schedule, but will not guarantee service availability without direct confirmation from with the Client or their agent.

1.12 CERTIFICATIONS

The Client will not require TETRA TECH to execute any certification regarding Services performed or the Work tested or observed unless: 1) TETRA TECH believes that it has performed sufficient Services to provide a sufficient basis to issue the certification; 2) TETRA TECH believes that the Services performed and Work tested or observed meet the criteria of the certification; and 3) TETRA TECH has reviewed and approved in writing the exact form of such certification prior to execution of the Service Agreement. Any certification by TETRA TECH is limited to the expression of a professional opinion based upon the Services performed by TETRA TECH, and does not constitute a warranty or guarantee, either express or implied.

1.13 WEATHER AND PROTECTION OF MATERIALS

Performance of the Services by TETRA TECH and/or its designated subcontractor may be delayed or excused when such performance is commercially impossible or impracticable as a result of weather events, strikes, shortages or other causes beyond their reasonable control which may also impact cost estimates.

Excavation and construction operations expose materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations, and stockpiles, must be protected from the elements, particularly moisture, desiccation, frost action and construction activities.

1.14 CALCULATIONS AND DESIGN

Where TETRA TECH has undertaken design calculations and has prepared project specific designs in accordance with terms of reference that were previously set out in consultation with, and agreement of, TETRA TECH's client. These designs have been prepared to a standard that is consistent with industry practice. Notwithstanding, if any error or omission is detected by TETRA TECH's Client or any party that is authorized to use the Design Report, the error or omission should be immediately drawn to the attention of TETRA TECH.

1.15 INFLUENCE OF CONSTRUCTION ACTIVITY

There is a direct correlation between construction activity and structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques are known.

1.16 SAMPLES

The Client will provide samples for testing (at the Client's expense). TETRA TECH will retain unused portions of samples only until such time as internal review is accomplished for intended purpose. Further storage or transfer of samples can be made at the Client's expense upon written request, otherwise samples will be discarded. The duration of sample retention must be discussed in advance.

1.17 GEOTECHNICAL CONDITIONS

A Geotechnical Report is commonly the basis upon which the specific project design or testing has been completed. It is incumbent upon TETRA TECH's Client, and any other authorized party, to be knowledgeable of the level of risk that has been incorporated into the project design, in consideration of the level of the geotechnical information that was reasonably acquired to facilitate completion of the design.

If a Geotechnical Report was prepared for the project by TETRA TECH or others, it will be referenced in the Construction Materials or Materials Design Report. The Geotechnical Report contains General Conditions that should be read in conjunction with these General Conditions for this Report.

APPENDIX C

HISTORIC PETROGRAPHIC TEST RESULTS FROM 2009

H-175

District: Golden

Project:

Pit Name: Wait-a-bit

GEOTECHNICAL AND MATERIALS BRANCH

PETROGRAPHIC ANALYSIS

Sample No.: X-8440

Date: February 4, 1974

Analyst:

ROCK TYPES	DESCRIPTION	Weight in Grams	Weight %	Factor 1	Factor 2	Wtd. Value 1	Wtd. Value 2
SEDIMENTARY							
LIMESTONE or DOLOMITE	HARD, SOUND	426.4	64.5	1.2		77.4	
	SLIGHTLY WEATHERED, SOFT	19.5	2.9	1.5		4.4	
	INTENSELY WEATHERED, FRIABLE, CLAYEY or SHALEY	27.5	4.2	4.0		16.8	
SHALE	SOFT, GREY to BLACK, MAY BE LIMEY			5.5			
SANDSTONE, CONGLOMERATE & BRECCIA	HARD, SOUND			2.0			
	SCRATCHES EASILY, SOUND			3.0			
	VERY SOFT, FRIABLE			4.5			
GREYWACKE SILTSTONE	HARD, FINEGRAINED, GREY			2.0			
	SOFT WEATHERED			3.0			
TUFF	HARD, WHITE, POROUS			4.0			
CHERT	EXTREMELY HARD, SOUND			5.0	1.0		
CLAY	BALLS or FRAGMENTS, EXTREMELY SOFT, FRIABLE			6.0			
METAMORPHIC							
QUARTZITE	VERY FINE GRAINED	63.1	9.5	1.6	1.2	15.2	
	COARSE GRAINED (Greater than 1mm)	47.3	7.2	1.2		8.6	
GNEISS	HARD, SOUND, FRESH			1.3			
	MODERATLEY WEATHERED, HARD			2.0			
	BADLY DECOMPOSED			5.0			
SLATE	MEDIUM HARD, SOUND			1.3			
	SOFT, WEATHERED			2.0			
SCHIST	HARD, SOUND, FRESH			3.0			
	SOFT, WEATHERED			4.0			
SERPENTINE	HARD, FRESH			2.0			
	SOFT, WEATHERED			5.0			
IGNEOUS							
GRANITICS incl. Granite, Syenite, Diorite, Gabbro	HARD, SOUND, FRESH			1.0			
	SLIGHTLY WEATHERED, MINOR IRON OXIDATION			1.5			
	DECOMPOSED, INTENSE IRON OXIDATION			5.0			
VOLCANICS incl. Basalt, Felsite Obsidian, Porphyry	HARD, SOUND, FRESH	77.5	11.7	0.9		10.5	
	SLIGHTLY, WEATHERED			1.5			
	VESICULAR, VERY POROUS, FRESH			2.0			
	INTENSELY WEATHERED, SOFT			4.0			
NOTE: 1 SURFACING, 2 NON SURFACING	TOTAL	661.3	100%			132.9	

ROCK TYPES	QUALITY PERCENT Excellent	Good	Fair	Poor
Limestone or Dolomite		67.4		4.2
Quartzite		16.7		
Volcanics	11.7			
TOTAL %	11.7	84.1		4.2

NOTE: Factor less than or equal to 1-Excellent; 1.2 to 1.6-Good; 2.0 to 3.0-Fair; Greater Than 3.0-Poor

REMARKS:

Analysis done on Minus 3/8" + 8 mesh screen fraction

3MG-7-52

H-175.

GEOTECHNICAL AND MATERIALS BRANCH

PETROGRAPHIC ANALYSIS

District: Golden
Project:
Pit Name: Wait-a-bit

Sample No.: X-8440
Date: February 1, 1974
Analyst:

ROCK TYPES	DESCRIPTION	Weight in Grams	Weight %	Factor 1	Factor 2	Wtd. Value 1	Wtd. Value 2
SEDIMENTARY							
LIMESTONE or DOLOMITE	HARD, SOUND	933.7	52.8	1.2		63.4	
	SLIGHTLY WEATHERED, SOFT	30.3	1.7	1.5		2.6	
	INTENSELY WEATHERED, FRIABLE, CLAYEY or SHALEY			4.0			
SHALE	SOFT, GREY to BLACK, MAY BE LIMEY			5.5			
SANDSTONE, CONGLOMERATE & BRECCIA	HARD, SOUND			2.0			
	SCRATCHES EASILY, SOUND			3.0			
	VERY SOFT, FRIABLE			4.5			
GREYWACKE SILTSTONE	HARD, FINEGRAINED, GREY			2.0			
	SOFT WEATHERED			3.0			
TUFF	HARD, WHITE, POROUS			4.0			
CHERT	EXTREMELY HARD, SOUND	43.0	2.4	5.0	1.0	12.0	
CLAY	BALLS or FRAGMENTS, EXTREMELY SOFT, FRIABLE			6.0			
METAMORPHIC							
QUARTZITE	VERY FINE GRAINED	361.4	20.5	1.6	1.2	32.8	
	COARSE GRAINED (Greater than 1mm)	128.0	7.2	1.2		8.6	
GNEISS	HARD, SOUND, FRESH			1.3			
	MODERATLEY WEATHERED, HARD			2.0			
	BADLY DECOMPOSED			5.0			
SLATE	MEDIUM HARD, SOUND			1.3			
	SOFT, WEATHERED			2.0			
SCHIST	HARD, SOUND, FRESH	52.7	3.0	3.0		9.0	
	SOFT, WEATHERED	14.5	0.8	4.0		3.2	
SERPENTINE	HARD, FRESH			2.0			
	SOFT, WEATHERED			5.0			
IGNEOUS							
GRANITICS incl. Granite, Syenite, Diorite, Gabbro	HARD, SOUND, FRESH			1.0			
	SLIGHTLY WEATHERED, MINOR IRON OXIDATION			1.5			
	DECOMPOSED, INTENSE IRON OXIDATION			5.0			
VOLCANICS incl. Basalt, Felsite Obsidian, Porphyry	HARD, SOUND, FRESH	198.3	11.2	0.9		10.1	
	SLIGHTLY, WEATHERED	6.4	0.4	1.5		0.6	
	VESICULAR, VERY POROUS, FRESH			2.0			
	INTENSELY WEATHERED, SOFT			4.0			
NOTE: 1 SURFACING, 2 NON SURFACING	TOTAL	1768.3	100%			142.3	

ROCK TYPES	QUALITY PERCENT Excellent	Good	Fair	Poor
Limestone or Dolomite		54.5		
Chert				2.4
Quartzite		27.7		
Schist			3.0	0.8
Volcanics	11.2	0.4		
TOTAL %	11.2	82.6	3.0	3.2

NOTE: Factor less than or equal to 1-Excellent; 1.2 to 1.6-Good; 2.0 to 3.0-Fair; Greater Than 3.0-Poor

REMARKS:

Calcareous coating on many particles

APPENDIX D

XRD ANALYSIS REPORT

QUANTITATIVE PHASE ANALYSIS OF THREE POWDER SAMPLES USING THE RIETVELD METHOD AND X-RAY POWDER DIFFRACTION DATA

ALS Workorder #: VA22308263

Proj: 704-MIN.VMIN03121-05

Client Services CANW
Katerina Paley
ALS Geochemistry
2103 Dollarton Highway
North Vancouver, BC, V7H 3B1

Jacob Kabel, B.Sc.
Edith Czech, M.Sc.
Jenny Lai, B.Sc.
Lan Kato, B.A.

Dept. of Earth, Ocean & Atmospheric Sciences
The University of British Columbia
6339 Stores Road
Vancouver, BC V6T 1Z4

November 29, 2022

EXPERIMENTAL METHOD

The 3 samples of **WO# VA22308263, project 704-MIN.VMIN03121-05** were reduced to the optimum grain-size range for quantitative X-ray analysis (<10 μm) by grinding under ethanol in a vibratory McCrone XRD Mill (Retsch GmbH, Germany) for 10 minutes. Continuous-scan X-ray powder-diffraction data were collected over a range of 3-80°2θ with CoKα radiation on a Bruker D8 Advance Bragg-Brentano diffractometer equipped with an Fe filter foil, 0.6 mm (0.3°) divergence slit, incident- and diffracted-beam Soller slits and a LynxEye-XE detector. The long fine-focus Co X-ray tube was operated at 35 kV and 40 mA, using a take-off angle of 6°.

RESULTS

The X-ray diffractograms were analyzed using the International Centre for Diffraction Database PDF-4 and Search-Match software by Bruker. X-ray powder-diffraction data of the samples were refined with Rietveld program Topas 4.2 (Bruker AXS). The results of quantitative phase analysis by Rietveld refinements are given in Table 1. These amounts represent the relative amounts of crystalline phases normalized to 100%. The Rietveld refinement plots are shown in Figures 1 to 3.

Table 1. Results of quantitative phase analysis (wt.%)

Mineral	**Ideal Formula**	**#1 WB22HS-02-01**	**#2 WB22HS-02-02**	**#3 WB22HS-02-03**
Calcite	$CaCO_3$	47.8	48.6	49.5
Clinochlore	$(Mg,Fe^{2+})_5Al(Si_3Al)O_{10}(OH)_8$	1.8	1.7	1.7
Dolomite - Ankerite	$CaMg(CO_3)_2$ - $Ca(Fe^{2+},Mg,Mn)(CO_3)_2$	12.5	11.2	13.9
Illite/Muscovite 2M1	$\sim K_{0.65}Al_{2.0}(Al_{0.65}Si_{3.35}O_{10})(OH)_2$- $KAl_2(AlSi_3O_{10})(OH)_2$	7.6	8.2	7.4
Kaolinite	$Al_2Si_2O_5(OH)_4$		0.5	
Plagioclase (albite)	$NaAlSi_3O_8$ – $CaAl_2Si_2O_8$	4.4	4.4	4.0
Pyrite	FeS_2		< 0.1 (?)	
Quartz	SiO_2	25.6	25.1	23.2
Rutile	TiO_2	0.3	0.3	0.3
Total		**100.0**	**100.0**	**100.0**

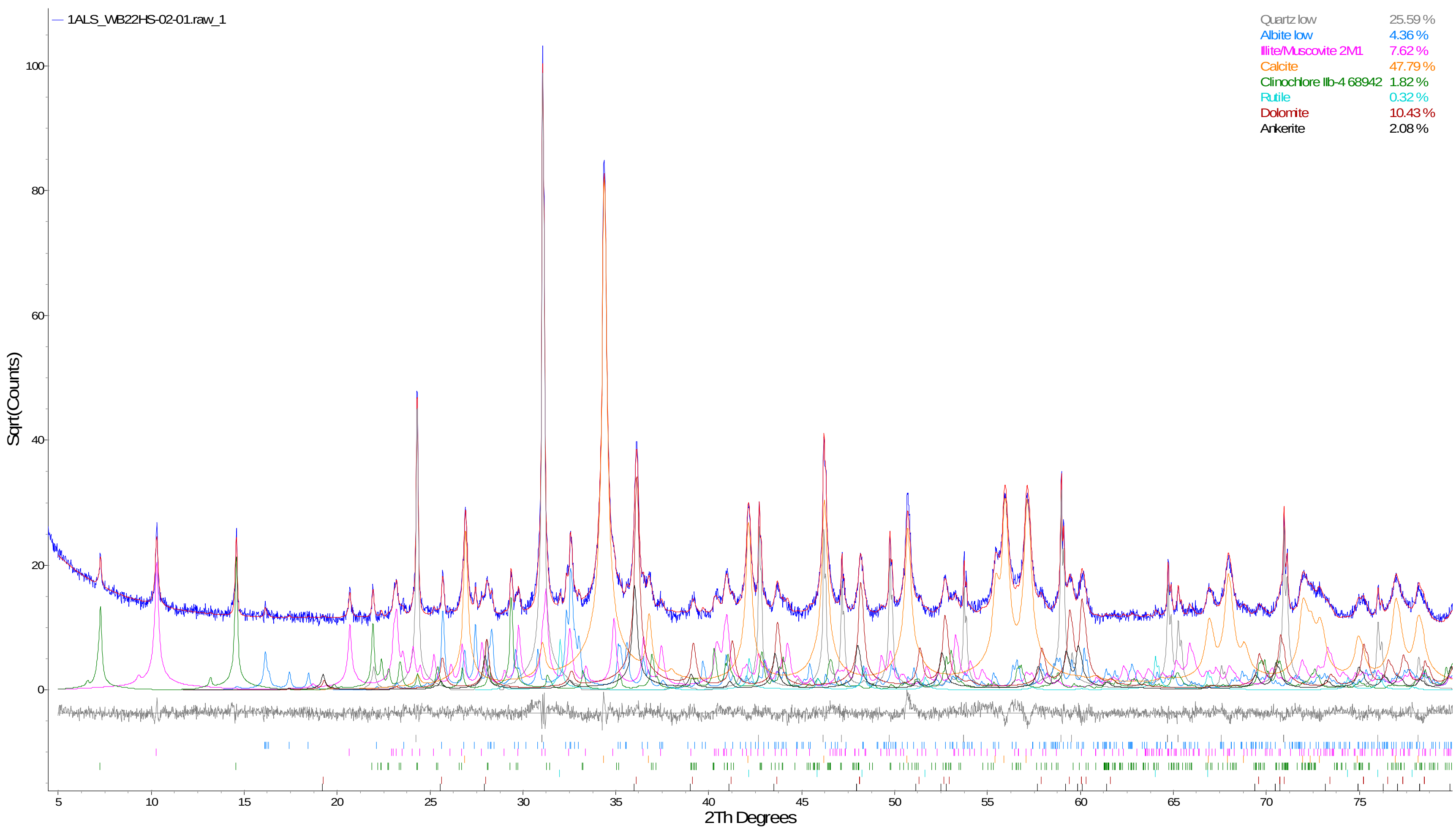

Figure 1. Rietveld refinement plot of sample **ALS Geochemistry #1: WB22HS-02-01** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below – difference between observed and calculated intensities; vertical bars - positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

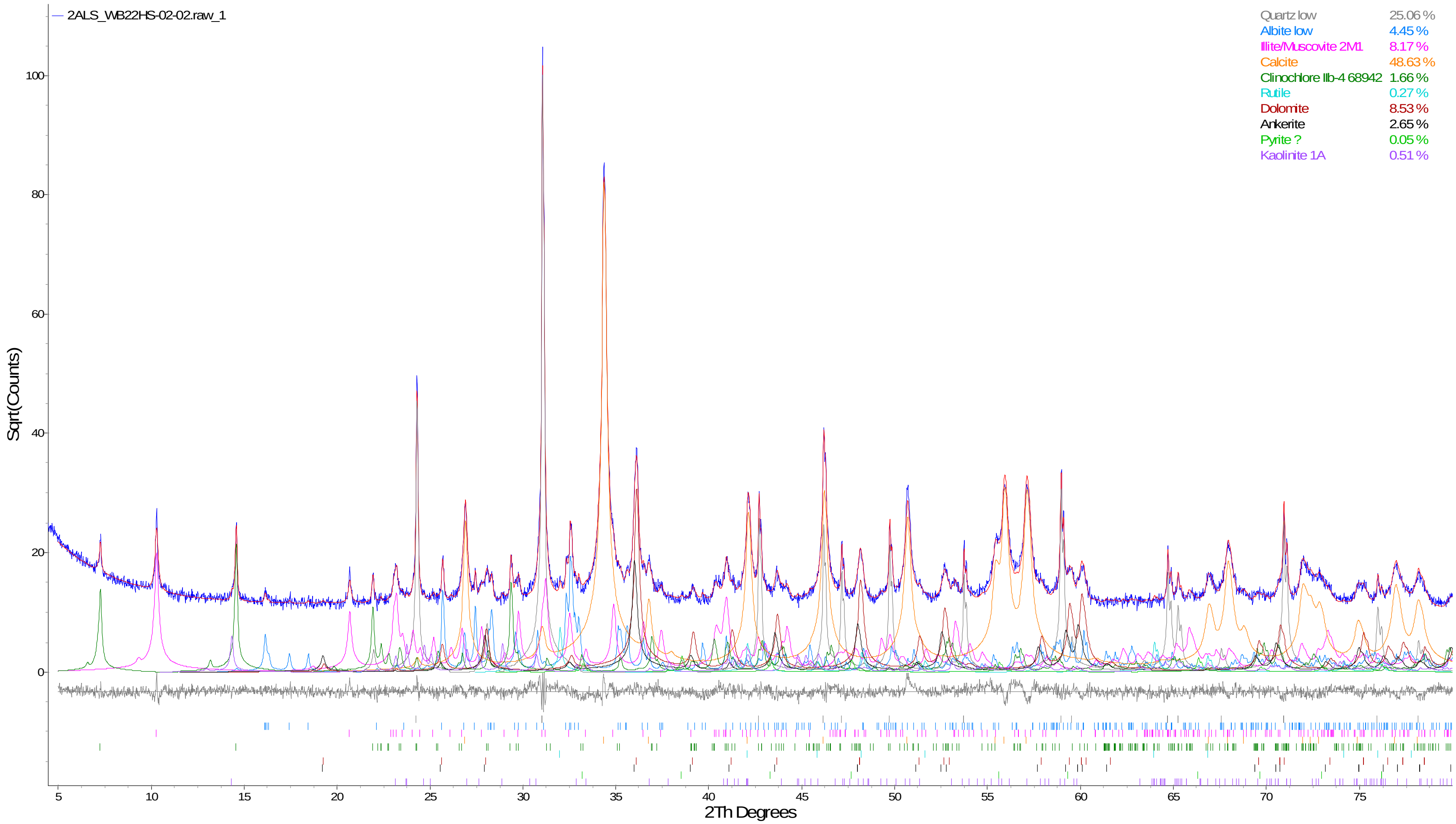

Figure 2. Rietveld refinement plot of sample **ALS Geochemistry #2: WB22HS-02-02** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below - difference between observed and calculated intensities; vertical bars - positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

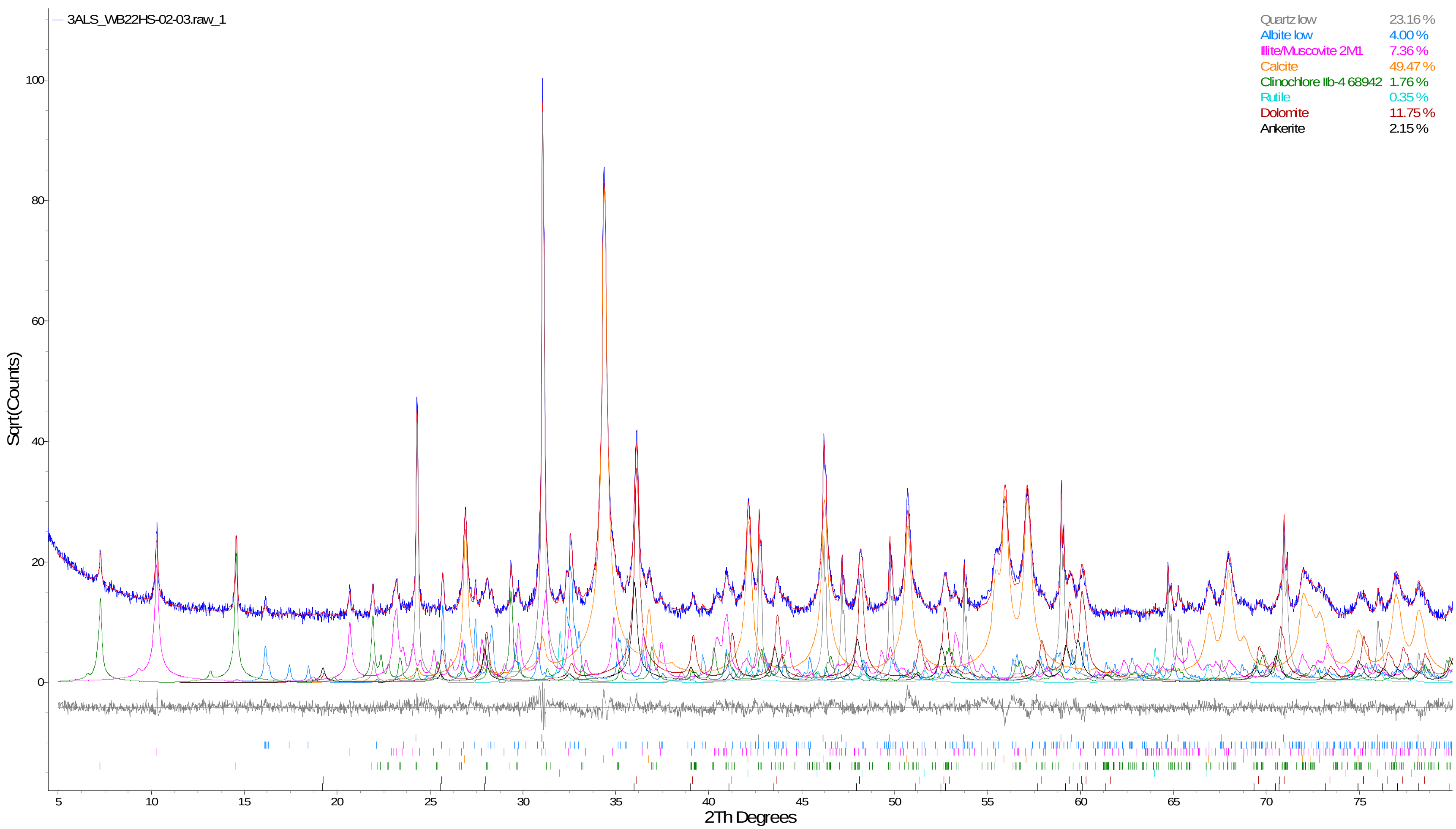

Figure 3. Rietveld refinement plot of sample **ALS Geochemistry #3: WB22HS-02-03** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below - difference between observed and calculated intensities; vertical bars - positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

APPENDIX E

LABORATORY CERTIFICATES FROM ALS FOR ABA AND TRACE ELEMENT ANALYSIS

ALS Canada Ltd.
2103 Dollarton Hwy
North Vancouver BC V7H 0A7
Phone: +1 604 984 0221 Fax: +1 604 984 0218
www.alsglobal.com/geochemistry

To: TETRA TECH CANADA INC.
885 DUNSMUIR STREET
VANCOUVER BC V6C 1N5

Finalized Date: 30-NOV-2022
Account: TGM

CERTIFICATE VA22308263

Project: 704-MIN.VMIN03121-05

This report is for 3 samples of Rock submitted to our lab in Vancouver, BC, Canada on 26-OCT-2022.

The following have access to data associated with this certificate:

S. KINGSTON	JULIE SANDUSKY	

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI-21	Received Sample Weight
LOG-22	Sample login - Rcd w/o BarCode
CRU-31	Fine crushing - 70% <2mm
SPL-34X	Pulp Split - For send out
SPL-21	Split sample - riffle splitter
PUL-31	Pulverize up to 250g 85% <75 um
SND-01	Send samples to external laboratory

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	INSTRUMENT
OA-VOL08m	Modified NP	
S-IR08	Total Sulphur (IR Spectroscopy)	LECO
OA-ELE07	Paste pH	
S-CAL06a	Sulfide Sulfur (calculated*)	
S-GRA06a	Sulfate Sulfur (HCl leachable)	WST-SEQ
C-GAS05	Inorganic Carbon (CO2)	
S-IR07	Sulphide Sulphur by Na2CO3 leach	LECO
ME-MS41	Ultra Trace Aqua Regia ICP-MS	

This is the Final Report and supersedes any preliminary report with this certificate number.Results apply to samples as submitted.All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:
Saa Traxler, Director, North Vancouver Operations

ALS Canada Ltd.

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North Vancouver BC V7H 0A7
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885 DUNSMUIR STREET
VANCOUVER BC V6C 1N5

Finalized Date: 30-NOV-2022
Account: TGM

Project: 704-MIN.VMIN03121-05

CERTIFICATE OF ANALYSIS VA22308263

Sample Description	Method	WEI-21	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41
	Analyte	Recvd Wt.	Ag	Al	As	Au	B	Ba	Be	Bi	Ca	Cd	Ce	Co	Cr	Cs
	Units	kg	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm
	LOD	0.02	0.01	0.01	0.1	0.02	10	10	0.05	0.01	0.01	0.01	0.02	0.1	1	0.05
WB22HS-02-01		1.52	0.05	0.54	3.3	<0.02	10	20	0.20	0.26	18.55	0.09	18.45	5.7	8	0.19
WB22HS-02-02		2.21	0.02	0.56	3.2	<0.02	10	30	0.20	0.09	18.85	0.05	17.50	5.6	8	0.20
WB22HS-02-03		1.95	0.03	0.52	2.7	<0.02	<10	20	0.18	0.11	19.70	0.05	16.50	5.3	6	0.17

***** See Appendix Page for comments regarding this certificate *****

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885 DUNSMUIR STREET
VANCOUVER BC V6C 1N5

Finalized Date: 30-NOV-2022
Account: TGM

Project: 704-MIN.VMIN03121-05

CERTIFICATE OF ANALYSIS VA22308263

Sample Description	Method Analyte Units LOD	ME-MS41 Cu ppm 0.2	ME-MS41 Fe % 0.01	ME-MS41 Ga ppm 0.05	ME-MS41 Ge ppm 0.05	ME-MS41 Hf ppm 0.02	ME-MS41 Hg ppm 0.01	ME-MS41 In ppm 0.005	ME-MS41 K % 0.01	ME-MS41 La ppm 0.2	ME-MS41 Li ppm 0.1	ME-MS41 Mg % 0.01	ME-MS41 Mn ppm 5	ME-MS41 Mo ppm 0.05	ME-MS41 Na % 0.01	ME-MS41 Nb ppm 0.05
WB22HS-02-01		12.1	1.69	1.52	<0.05	0.03	<0.01	0.021	0.08	9.6	11.7	1.57	498	0.38	0.01	<0.05
WB22HS-02-02		11.4	1.70	1.56	<0.05	0.03	<0.01	0.020	0.09	9.0	11.9	1.43	501	0.24	0.01	0.05
WB22HS-02-03		15.1	1.65	1.45	<0.05	0.03	0.01	0.020	0.08	8.4	11.7	1.69	468	0.21	0.01	<0.05

***** See Appendix Page for comments regarding this certificate *****

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Finalized Date: 30-NOV-2022
Account: TGM

Project: 704-MIN.VMIN03121-05

CERTIFICATE OF ANALYSIS VA22308263

Sample Description	Method Analyte Units LOD	ME-MS41 Ni ppm 0.2	ME-MS41 P ppm 10	ME-MS41 Pb ppm 0.2	ME-MS41 Rb ppm 0.1	ME-MS41 Re ppm 0.001	ME-MS41 S % 0.01	ME-MS41 Sb ppm 0.05	ME-MS41 Sc ppm 0.1	ME-MS41 Se ppm 0.2	ME-MS41 Sn ppm 0.2	ME-MS41 Sr ppm 0.2	ME-MS41 Ta ppm 0.01	ME-MS41 Te ppm 0.01	ME-MS41 Th ppm 0.2	ME-MS41 Ti % 0.005
WB22HS-02-01		12.4	240	10.2	3.8	<0.001	0.01	0.20	3.2	0.6	<0.2	575	<0.01	0.02	3.8	<0.005
WB22HS-02-02		12.4	230	9.7	4.0	<0.001	0.01	0.15	3.2	0.4	<0.2	595	<0.01	0.01	3.5	<0.005
WB22HS-02-03		12.4	200	9.0	3.3	<0.001	0.01	0.15	3.1	0.5	<0.2	610	<0.01	0.01	3.5	<0.005

***** See Appendix Page for comments regarding this certificate *****

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Account: TGM

Project: 704-MIN.VMIN03121-05

CERTIFICATE OF ANALYSIS VA22308263

Sample Description	Method	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-ELE07	S-IR08	S-CAL06a
	Analyte	Tl	U	V	W	Y	Zn	Zr	FIZZ RAT	MPA	NNP	NP	Ratio (N	pH	S	S
	Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm	Unity	tCaCO3/1Kt	tCaCO3/1Kt	tCaCO3/1Kt	Unity	Unity	%	%
	LOD	0.02	0.05	1	0.05	0.05	2	0.5	1	0.3	1	1	0.01	0.1	0.01	0.01
WB22HS-02-01		0.02	0.38	5	<0.05	9.64	32	1.4	4	<0.3	575	575	3680.0	8.7	<0.01	<0.01
WB22HS-02-02		0.02	0.48	5	<0.05	9.42	31	1.3	4	<0.3	563	563	3603.2	8.7	<0.01	<0.01
WB22HS-02-03		0.02	0.39	5	<0.05	9.57	33	1.2	4	<0.3	602	602	3852.8	8.7	<0.01	<0.01

***** See Appendix Page for comments regarding this certificate *****

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885 DUNSMUIR STREET
VANCOUVER BC V6C 1N5

Finalized Date: 30-NOV-2022
Account: TGM

Project: 704-MIN.VMIN03121-05

CERTIFICATE OF ANALYSIS VA22308263

Sample Description	Method Analyte Units LOD	C-GAS05 C % 0.05	C-GAS05 CO2 % 0.2	S-GRA06a S % 0.01	S-IR07 Sulphide % 0.01
WB22HS-02-01		6.82	25.0	0.01	0.02
WB22HS-02-02		6.77	24.8	0.01	0.02
WB22HS-02-03		7.24	26.5	0.01	0.02

***** See Appendix Page for comments regarding this certificate *****

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VANCOUVER BC V6C 1N5

Finalized Date: 30-NOV-2022
Account: TGM

Project: 704-MIN.VMIN03121-05

CERTIFICATE OF ANALYSIS VA22308263

CERTIFICATE COMMENTS

ANALYTICAL COMMENTS

Gold determinations by this method are semi-quantitative due to the small sample weight used (0.5g).

Applies to Method: ME-MS41

LABORATORY ADDRESSES

Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.

Applies to Method:

C-GAS05	CRU-31	LOG-22	ME-MS41
OA-ELE07	OA-VOL08m	PUL-31	S-CAL06a
S-GRA06a	S-IR07	S-IR08	SND-01
SPL-21	SPL-34X	WEI-21	

APPENDIX C

ENVIRONMENTAL MONITORING OBSERVATIONS TEMPLATES

APPENDIX - Daily Survey Data Checklist for the Blended Type A Embankment (BTA) for both Type A and Type D.

Date (dd-mmm-yr) & Time: ____________________

Personnel: ____________________

Weather: ____________________

Temperature: ____________________

Precipitation amount today:
(mm; from weather station) ____________________

Was there rain in the last 7 days? (Y/N) ____________________

For each Station of BTA Embankment placement fill out the following table:

BTA Embankment Placement	Notes and Observations
1. Confirm that BTA material is only placed within STA 176+10 to 177+60 and in the designated BTA embankment area.	
2. Volume of Placed Material Today: Type A: Waitabit Pit Material: Type D:	
3. Station Chainage of Placed Material today (include material type placed):	
4. Location Coordinates (latitude and longitude) of the two end points of placed material.	

Confirm that that Blended Type A material is being managed as per the accepted Blending Plan and as per the Contract. If NO, please contact Ministry Representative immediately to initiate corrective actions. Note corrective actions that need to be taken below. Describe ongoing activities related to blending and BTA Placement.

____

____

____

____

____

____

____

____

ARD/ML Management Notes and Observations	Yes, No, or, N/A and Description Notes
1. Is there any discolouration from alteration or weathering? Describe discolouration	
2. Are there areas of water pooling around the material placement?	
3. Do pooled areas have a different colour (e.g. yellow/orange/red)? (If yes, please notify Ministry Rep. immediately)	
4. Is there upslope surface run-off infiltrating the embankment material? (If yes, please notify Ministry Rep. immediately) If so, where? Is it point source or diffuse?	
5. Is there water seepage from the embankment material? If Yes, include notes on water seepage point source and where does it go.	

INSERT PHOTO(S) WITH DESCRIPTIONS

Ministry of Transportation and Infrastructure

APPENDIX – Weekly Environmental Monitor Checklist

Weekly Inspection Checklist for Type A Rock Cuts, Stockpiling, and Blending.

Date (dd-mmm-yr) & Time: ____________________
Personnel: ____________________
Weather: ____________________
Temperature: ____________________
Precipitation amount today:
(mm; from weather station) ____________________
Was there rain in the last 7 days? (Y/N). If so, how much? ____________________

Is the Type A or Blended Type A material being temporarily stockpiled? If yes, describe the nature of the stockpiling and location and confirm that Temporary Stockpiling is being completed as per the Contract.

____
____
____
____
____
____
____
____

Confirm that Blended Type A material is being managed as per the accepted Blending Plan and as per the Contract. If NO, please contact Ministry Representative immediately to initiate corrective actions.

____
____
____
____
____
____
____
____

For each Type A Rock Excavation, Type A Stockpile or BTA Stockpile – please print one of the following sheets and fill in relevant details. Please also take photos to provide in the report along with a description of the photos.

Ministry of Transportation and Infrastructure

Type A Excavation (rock face, rubble, etc.) - Station Chainages for exposed Type A.

Chainage from/to: ___________________________

ARD/ML Management Notes and Observations	**Yes, No, or, N/A and Description Notes**
1. Is the Type A wet or moist?	
2. Does Type A in moist/wet areas have a different colour (e.g. yellow/orange/red)?	
3. Are there areas of water pooling around the rock cut?	
4. Do pooled areas have a different colour (e.g. yellow/orange/red) or sheen? (If yes, please notify Ministry Rep. immediately)	
5. Is there upslope surface run-off infiltrating the Type A rock? (If yes, please notify Ministry Rep. immediately) If so, where? Is it point source or diffuse?	
6. Is there water seepage from the Type A cut face? If Yes, include notes on water seepage point source and where does it go.	
7. Are there any observed precipitates (white, yellow, orange) on any of the rock or soil surfaces?	

INSERT PHOTO(S) OF TYPE A EXCAVATION AND PHOTO DESCRIPTIONS

Type A or Blended Type A Stockpile Observations

Stockpile Type (Type A or Blended Type A): ____

PAG Type A Management Notes and Observations	Yes, No, or, N/A and Description Notes
1. Location Coordinates of Stockpile	
2. Describe date of placement and time before covering.	
3. Is there any discolouration from alteration or weathering? Describe discolouration	
4. Are there areas of water pooling around the stockpile	
5. Do pooled areas have a different colour (e.g. yellow/orange/red)? (If yes, please notify Ministry Rep. immediately)	
6. Is there upslope surface run-off infiltrating the stockpile? (If yes, please notify Ministry Rep. immediately) If so, where? Is it point source or diffuse?	
7. Is there water seepage from the Stockpile? If Yes, include notes on water seepage point source and where does it go.	
8. Is the stockpile covered? Describe condition of cover - cover intact, any rips, tears, or gaps in the panels?	
9. Estimated volume (or height and diameter) of pile	

INSERT PHOTO(S) OF STOCKPILE AND PHOTO DESCRIPTIONS