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Richard Dwyer

Manager of Licensing
Nunavut Water Board
P.O. Box 119
Gjoa Haven, Nunavut
X0B 1J0

September 10th, 2019

Re: Geochemical Criteria for Naartok East Crown Pillar Recovery at Madrid North.

Dear Richard Dwyer, the KIA has reviewed the geochemical criteria for Naartok East Crown Pillar Recovery at Madrid North.

The KIA's geoengineering consultant, BGC Engineering Inc. (BGC) has reviewed the proposed geochemical criteria of non-mineralized construction material from Naartok East Crown Pillar Recovery (NE CPR) at Madrid North, which is required for the Type "A" Water Licence 2AM-DOH1335, Part F, Item 12 for TMAC Resources Inc.'s (TMAC) Boston-Madrid Project.

KIA's consultant reviewed two documents which were:

- Attachment A: Classification of Waste Rock in Support of Segregating Construction Rock from Naartok East Crown Pillar Recovery, Madrid North, Hope Bay Project - SRK Consulting (Canada) Inc., 2019.

- Attachment B: NE CPR Site-Specific Waste Rock for Construction Flowchart – TMAC Resources Inc., 2019.

The former attachment provides the technical rationale for the proposed geochemical criteria to assess waste rock that may be appropriate for construction purposes. While the latter is the proposed site-specific flow chart to be implemented for the NE CPR during construction to segregate suitable construction material.

The following sections present KIA's consultant's review of these documents.

Technical Summary

SRK Consulting (Canada) Inc. (SRK) was engaged by TMAC Resources Inc. (TMAC) to conduct a geochemical characterization program to assess the metal leaching (ML) and acid rock drainage (ARD) characteristics of waste rock from NE CPR. Briefly, the geochemical program involved testing 43 waste rock samples from

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outcrop samples and drill hole coarse assay rejects (-2 mm) that intersected the NE CPR. Samples were comprised of the four lithologies found at NE CPR:

- Mafic metavolcanics (rock code 1)
- Mafic volcanics with sediments (rock code 1aj)
- Sedimentary unit (rock code 5)
- Early gabbro (rock code 7).

Samples were confirmed as waste rock and/or low-grade ore by applying TMAC's high grade ore cut off. Samples were submitted for trace metal analysis (using aqua regia digestion and 4-acid digestion methods) and acid-base accounting (ABA) at ALS Vancouver (ALS) and Maxxam Laboratories (Burnaby, BC). The two trace metal analysis methods were used to test the arsenic deportment between silicate and non-silicate mineral groups for NE CPR waste rock only.

In addition to the geochemical program, SRK tested the potential use of a portable X-ray fluorescence (pXRF) device (i.e., ThermoScientific Niton ZL3t GOLDD+).

The results of this program identified three main criteria to be used to identify material suitable for construction purposes, namely:

- Rock classified as mafic metavolcanics or early gabbro.
- An arsenic content of less than or equal to 70 ppm.
- A total sulphur content of less than or equal to 1%.

The latter two criteria are to be assessed in the field using a calibrated pXRF device.

In general, KIA's consultant, BGC, finds the geochemical program, material testing, quality assurance and quality control (QA/QC) and interpretation of the results to be partially valid. BGC identified eight comments following the review of the two attachments, which ranges in importance from low (n = 2), moderate (n = 2) to high (n = 4). The details of these review comments are provided in the following section.

Review Comments

Review Comment Number	KIA-NECP-1
Subject/Topic	Sample Selection Representativeness
Importance	Moderate

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References	Table 3-1 (Attachment A)
Summary	Validation of geochemical sample program datasets.
Detailed Review Comment	Expected volumes are a factor typically used to estimate an appropriate dataset size per lithology type to be included in a geochemical program. This information is not included in the report; however, Section 4.1.3. does qualitatively comment on projected volumes of the rock types sampled. Figure 3-1 provides an indication of sample location relative to the lateral extents of the surface of the crown pillar, but does not provide as much insight regarding the sample distribution at different levels below ground surface. Figures 4-3 to 4-7 (of Attachment A) do present vertical cross sections through the NE CPR quarry; however, the gap between NE-2 and NE-3 sections is large and it is difficult to assess the vertical spatial relationship of samples selected in this area in the NE CPR. If more detailed, or quantitative, information regarding projected volumes and spatial distribution of waste rock to be encountered at NE CPR is available, it should be presented to assess the adequateness of geochemical program's sample distribution and (hence) the appropriateness of sample results. Only 27 of the 43 samples tested were from the two rock units to which this program is to be applied.
Recommendation / Request	KIA requests that TMAC comments on the expected volumes of material to be excavated at NE CPR, as well as the vertical representation of the sample data set.

Review Comment Number	KIA-NECP-2
Subject/Topic	Sample Preparation
Importance	Moderate
References	Sections 3.1 and 5.3 (Attachment A)
Summary	Comparison of geochemical program sample preparation to the proposed field classification methods.

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Detailed Review Comment	The sample material in the geochemical program was comprised of coarse assay (-2 mm) rejects from TMAC's exploration drill program, whereby each assay sample represented approximately 1 m of core length (Section 3.1). The proposed field classification method (in Section 5.3) involves the collection and sieving (to -2 mm) of drill core cuttings from each blast round, prior to pXRF analysis. This approach assumes the field method is comparable to the geochemical program method and (therefore) materials are expected to have similar solid-phase and leaching characteristics. However, samples generated from crushing competent drill core may not be analogous to finer blast-segregated cuttings that are collected in the field. The role of particle size and differences in geochemical characteristics between friable and competent material can influence the relative abundance of sulphide and arsenic-bearing minerals, as well as mineral weathering rates or leachability.
Recommendation /Request	KIA requests that TMAC comment on the comparability of the proposed field method to the methods used as part of the geochemical program. Further clarity regarding these methods will help to assess the adequateness of the sample preparation methods included in the proposed field classification program.

Review Comment Number	KIA-NECP-3
Subject/Topic	Arsenic Criterion – 1
Importance	Low
References	Figures 4-9 and 4-10, and Section 5 (Attachment A)
Summary	Further discussion of the arsenic criterion basis.
Detailed Review Comment	The results shown in Figure 4-10 do not provide an adequate understanding of the appropriateness of the 70 ppm arsenic criterion. In contrast, the total sulphur criterion (of 1% total sulphur) can be comprehended based on the presentation and discussion of total sulphur versus

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	potentially acid-generating (PAG) or non-PAG classifications of the samples tested (Figure 4-9). KIA acknowledges that the basis of the arsenic criterion is found in Appendix A of Attachment A. However, the main report of Attachment A does not include a discussion as to the derivation of the criterion and presents this value for the first time in Table 5-1.
Recommendation/ Request	The main report of Attachment A should be revised to briefly summarize the technical basis of the arsenic criterion to afford better clarity for the reader.

Review Comment Number	KIA-NECP-4
Subject/Topic	Arsenic Criterion - 2
Importance	High
References	Appendix A (Attachment A)
Summary	Consideration for a lower arsenic criterion.
Detailed Review Comment	Review of the geochemical results used to develop the arsenic criterion had the following irregularities noted: a) The 30 kinetic test samples (Table 2-1) used to develop the 70 ppm arsenic criterion contained between 2 ppm to 630 ppm arsenic, with the exception of five samples without a recorded arsenic value. However, only three (of the 30) samples contained arsenic concentrations between 10 ppm and the arsenic criterion (i.e., HC-17: 11 ppm, HC-23: 27 ppm and HC-39: 64 ppm) and none from the two units deemed satisfactory for construction by the geochemical program (i.e., mafic metavolcanics and gabbro). b) Review of the initial humidity cell (i.e., first flush) and maximum field barrel arsenic concentrations shows a wide range of values (from 0.0008 mg/L to 2.4 mg/L), with the highest reported value from a field barrel (W6) containing mafic metavolcanics and a solid-phase arsenic concentration of 120 ppm. The relationship between

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	arsenic content and maximum concentrations from field barrels is shown in Figure 2-4 (in Appendix A); however, the number of samples shown in that figure is almost double the eight field barrels (i.e., labelled W2 – W4, W6 – W8, W11 and W14) shown in the previous Table 2-1. The relevance of the additional data used to develop this figure and potentially support the proposed 70 ppm arsenic criterion is not clear. c) In Section 3.1, the report states that "For barrel containing for NE CPR rock types (1, 7a, 5) with As < 30 ppm, average and maximum concentrations were <0.002 and <0.037 mg/L, respectively and were the lowest of the overall sample set. This statement indicates that material from rock types deemed suitable for construction (i.e., appropriate rock type and below the proposed arsenic criterion) could leach arsenic at concentrations above water quality guidelines of 0.005 mg/L. The dataset used to develop the arsenic criterion is limited in its distribution of material containing arsenic concentrations between 30 ppm and 70 ppm, as well as its consideration for initial flush concentrations that could substantially exceed water quality guidelines and would need to be managed. The 43-sample geochemical dataset described in the main report of Attachment A should have also considered soluble leach testing on the crushed drill core to expand the dataset on leachable arsenic.
Recommendation/ Request	KIA recommends that the arsenic criterion is lowered to <30 ppm until a larger dataset can be provided, as well as further consideration for initial flush chemistries that may contain elevated arsenic concentrations. It is worth noting that material containing 30 ppm arsenic reflects anomalous solid-phase concentrations in comparison to average crustal abundances of 2 ppm (Ronov and Yaroshevsky, 1972). Therefore, the use of anomalous or arsenic-enriched material for construction should be implemented with care to ensure environmental

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	protection.

Review Comment Number	KIA-NECP-5
Subject/Topic	Gabbro Sample Dataset Representativeness
Importance	High
References	Section 4.1.3 (Attachment A)
Summary	High arsenic content and release rate from kinetic test HC-41.
Detailed Review Comment	As discussed in Section 4.1.3, the nine gabbro samples tested contained uniformly low arsenic contents (i.e., <10 ppm) and geological interpolation of this unit suggests it may reflect a volumetrically significant waste rock type. A review of the humidity cell data provided in Appendix A of Attachment A (Table 2-1) indicates one (of two) Madrid North gabbro kinetic tests contained a high arsenic solid-phase content (i.e., HC-41: 270 ppm) and presented a correspondingly elevated (stable) arsenic release rate of 0.27 mg/kg/wk. For comparison, the other gabbro kinetic test of Madrid North material (HC-40) had 7.1 ppm arsenic content and a substantially lower release rate (i.e., 0.0022 mg/kg/wk). Given these results and the potential for a significant waste volume, it is not clear if the sample size of nine gabbro samples (with only two leaching rate values) is considered suitable to assess the ML potential of this rock type to be used as construction material.
Recommendation/ Request	KIA request that TMAC comment on the representativeness of the gabbro dataset used to develop the construction criteria and if the results from HC-41 suggest gabbro material has a higher potential to host elevated arsenic contents? Performing soluble leach tests on the -2mm crush for the nine drill core gabbro samples may help generate a more robust dataset.

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Review Comment Number	KIA-NECP-6
Subject/Topic	Flow Chart Revision - 1
Importance	High
References	Figure 5-1 (Attachment A) and Attachment B
Summary	Additional pXRF steps to be included in construction flow chart.
Detailed Review Comment	The flow chart presented in Figure 5-1 (Attachment A) and Attachment B does not include the recommended step of taking replicate pXRF measurements if arsenic values are between 50 ppm and 90 ppm, as discussed in Section 5.2.1. This additional step mitigates the possibility for miscalculation by the field arsenic measurement method, as noted by the QA/QC results from the geochemical program. As well, the flow chart should describe an appropriate QA/QC protocol for pXRF measurements (similar to the discussion in Section 3.3.2, page 8 of Attachment A), to support the use of this field method and valid results.
Recommendation/ Request	The construction flow charts should be revised to include additional pXRF measurement steps, as identified as part of the geochemical QA/QC program, for verification of field measurements.

Review Comment Number	KIA-NECP-7
Subject/Topic	Flow Chart Revision - 2
Importance	High
References	Attachment B
Summary	Corrections to the sulphur criterion presented in the flow chart.
Detailed Review Comment	The flow chart in Attachment B details the total sulphur criteria in two spots, Step 3 and Step 4. Sulphur species can be measured as total, sulphide-sulphur or -sulphur. In Step

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	3, the "total" descriptor is omitted and should be included to be consistent with the findings of the geochemical study in Attachment A and the terminology used in Step 4. In Step 4, a total sulphur value of 0.1% is noted as a criterion to be applied as part of confirmatory sampling. It is not clear what this criterion is based on or if it is an error.
Recommendation/ Request	Revise the construction flow chart in Attachment B to contain consistent sulphur terminology and criterion values.

Review Comment Number	KIA-NECP-8
Subject/Topic	Drilling Brines and Blasting Concentrations
Importance	Low
References	Section 6.3 (Attachment A)
Summary	Validation of proposed blasting methods.
Detailed Review Comment	The report recommends that quarry development does not employ drilling brines and lower amounts of explosives are to be used. These actions will minimize the release of chloride and ammonia from excavated material, which are two leachable constituents of concern noted from waste rock at a nearby area.
Recommendation/ Request	KIA requests that TMAC confirms this recommendation will be implemented as part of construction for the NE CPR.

Thank you

John Roesch

John Roesch, P.Eng.

Senior Hope Bay Project Officer
Kitikmeot Inuit Association, Department of Lands and Environment

Cc Geoff Clark, Director, KIA, Department of Lands and Environment