TECHNICAL MEMORANDUM

To:	**Nettie Ore, KGHM Ajax**	**May 20, 2016**
From:	**Bruce Mattson**	**Project #: J933-5**
Subject:	**Response to SSN concerns regarding Geochemistry - SSN 888**	

The following memo provides a response to the concerns regarding the test methods used in the geochemical assessment of the Ajax mine rock and tailings. The specific request from the Stk'emlupsemc te Secwepemc Nation (SSN) is reproduced in italics below followed by the responses to issues raised in the presentation during the panel hearing.

Dr. Morin highlighted his concerns regarding weaknesses in the testing methods used by KGHM to predict geochemical source-water contamination. Can you respond to those concerns?

The concerns regarding the methods raised in the mine drainage assessment group (MDAG) presentation during the panel hearing were associated with the following headings that are discussed in turn below.

- Aqua-Regia leach test method.
- Kinetic test methods.
- Application of average annual concentrations in water quality model.

Aqua-Regia

A concern was raised that the aqua-regia digestion method was not appropriate. Although the aqua-regia leach method does not provide a complete digestion of a sample, this method is recommended to determine the leachable metal content of mine rock samples. Determining the leaching potential of mine rock is a primary objective of the Ajax geochemical characterization program. The aqua-regia digestion is referenced in the most recent guidance documents that describe best practices for geochemical practitioners assessing metal leaching / acid rock drainage (ML/ARD) issues. Three of these guidance documents that reference the aqua-regia procedure for Canada, European Union and the mining industry are listed below.

Price, William A. 2009. Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials. MEND Report 1.20.1, Natural Resources Canada, December, 2009, 579 p.

CEN. 2012. Characterization of Waste – Overall guidance document for characterization of waste from the extractive industries. Technical Report CEN/TR 16376 October, 2012, 136 p.

INAP. 2014. Global Acid Rock Drainage (GARD) Guide. Prepared for the International Network for Acid Prevention (INAP) Rev.1 December, 2014.

Kinetic Testing

A concern was raised that the kinetic tests were conducted at a smaller scale than the proposed mine facilities. The Ajax kinetic testing was carried out using best practices recommended by the three guidance documents referenced above. It is acknowledged that the tests contain less rock than a full scale facility. Thus, to make predictions for the mine site drainage the results from the kinetic tests were scaled to account for the size discrepancy. More importantly, the predicted scaled concentrations were validated with drainage chemistry from:

- the Ajax field bins,
- existing waste rock dumps at the Ajax site, and
- other copper porphyry mines in British Columbia.

Specifically, the predicted scaled concentrations for mine rock storage facilities were compared with the maximum value from the following sources:

- 90th percentile from Porphyry Copper mine site drainage chemistry;
- 95th percentile existing pore water from full scale Ajax mine rock; and
- 95th percentile from Ajax field bins.

Predicted scaled concentrations for tailings were compared with the maximum value from the following sources:

- 95th percentile of metallurgical testing supernatants
- 95th percentile of tailings field bin drainage;
- 95th percentile of saturated tailings columns; and
- 95th percentile of tailings pore water from historic Afton impoundment that holds Ajax tailings.

The use of full scale mine data to validate predicted concentrations is stated in both Appendix 3B of the Ajax Application document and the Lorax SSN Hearing Presentation. However, the MDAG consultant presentation did not acknowledge that this conservative approach was used and stated the opposite in his presentation that only small-scale tests were used. In actual fact, drainage chemistry from large scale facilities was used to develop the predicted geochemical source terms.

A concern was raised that "caps" were used to establish the maximum drainage concentrations from a mine facility. The development of maximum equilibrium concentrations or "cap" concentrations is a well known geochemical process that occurs due to the removal of metals from solution by the formation of secondary minerals. The Ajax geochemical source terms were assigned maximum "cap" concentrations based on drainage chemistry from both field tests, full scale waste rock dumps and tailings pore water. MDAG has acknowledge in technical papers and presentations that these caps can occur at several scales ranging from small laboratory tests to large mine facilities. This process is illustrated in the figure below, which is taken from a paper authored by Kevin Morin that is available on the MDAG website. It is unclear why this approach was questioned in predicting the maximum concentrations at the Ajax site, when this process is highlighted on the MDAG website.

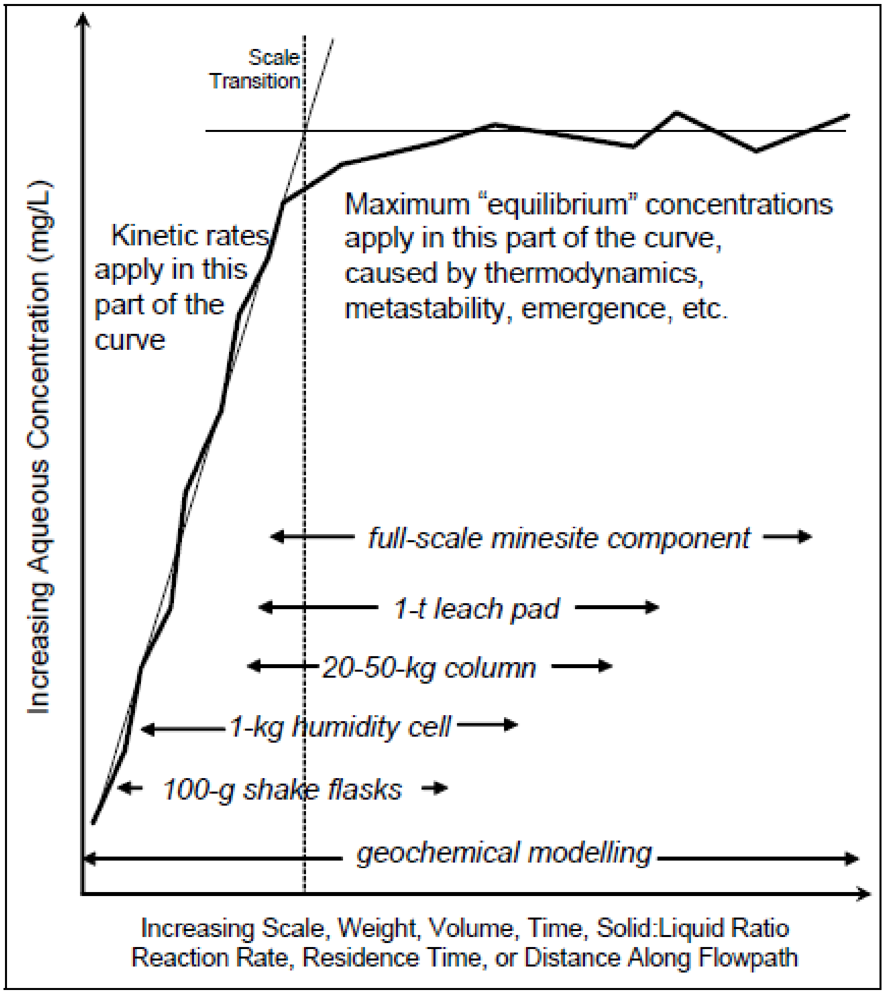

Figure 2. The conceptual model for scaling minesite-drainage chemistry, with general ranges of scale for various types of geochemical testwork and models.

Figure from - Morin, K.A. 2015. Nonlinear Science of Minesite-Drainage Chemistry. 1-Scaling and Buffering. MDAG.com Case Study #41.

Average Annual Concentrations

A concern was raised that average annual concentrations used as input into the water quality model would not account for peak contaminant concentrations. The geochemical source terms were calibrated and capped using the 90th or 95th percentile values from existing mine site water chemistry monitoring data (i.e. 95th percentile is the value below which 95% of the observations occur). As a result, the source terms correspond to the highest mine drainage concentrations that would be expected to discharge from the mine facilities, which is illustrated as a value near the blue dashed line on the figure below. It is this upper value that is used as input into the water quality model and conservatively assumed to be the average annual concentration. Using this conservative approach, the water quality model is more likely to overestimate concentrations 95% of the time, rather than under estimate the concentrations.

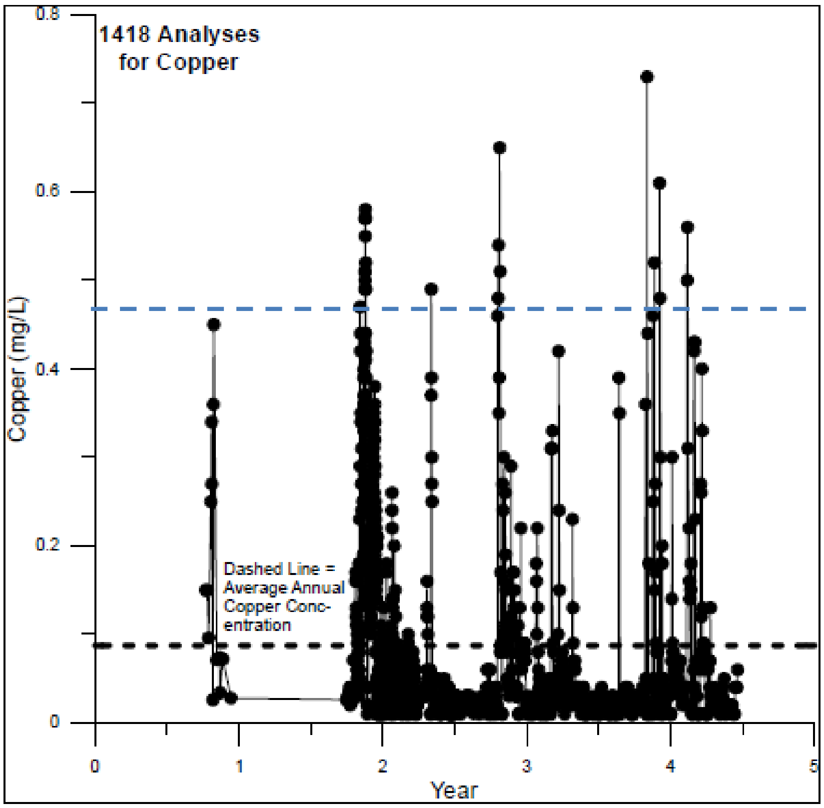

Figure 4-3. Aqueous concentrations of copper (mg/L) draining from waste rock at a copper minesite in British Columbia, showing that the average-annual value (dashed line) provides no information on toxic peaks that can persist for weeks or months; the average-annual approach was used for all source-term predictions of water contamination in the Ajax EIS.