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Memo

To:	John Roberts	**Client:**	TMAC Resources Inc.
From:	Kelly Sexsmith	**Project No:**	1CT022.002
		Date:	May 27, 2016
Subject:	AANDC-TC3 – Potential Effects of Flooding on Mine Water Quality and Doris Lake Water Quality		

During the Technical Meeting in January 2016, TMAC presented results of an analysis to show the potential effects of backfilled waste rock and tailings on water quality in the re-flooded mine and Doris Lake. The presentation slides are provided in Attachment A and summarized below:

- Slide 1 presents the issue and the status of responses.
- Slide 2 presents a conceptual model of the underground workings and Doris Lake, including:
  - Estimated groundwater flows from the underground mine into Doris lake (13,000 m^3/yr);
  - Surface water flows through Doris Lake (8,980,000 m^3/yr), which is 680 times more than groundwater flows;
  - The quantities of backfilled material, the time over which that material will be exposed to oxidation prior to flooding, and the amount of void space that will be filled with groundwater once the mine has flooded; and
  - A list of the potential geochemical processes occurring within the mine.
- Slide 3 is identical to Slide 2, but highlights the geochemical processes that were considered in the reflooded mine calculations, i.e. dissolution of stored contaminants and ferrihydrate. Processes not considered in the calculations, such as equilibrium with secondary minerals, attenuation to mineral surfaces, and precipitation of sulfides, are expected to greatly reduce concentrations of metals in the flooded mine water; accordingly, the predictions are considered conservative.
- Slide 4 explains how soluble loads in the backfilled material were calculated.
- Slide 5 explains how the incremental concentrations released from the backfill are calculated and how concentrations in Doris Lake are calculated.
- Slide 6 shows the results for parameters that are most likely to be present in the re-flooded mine. The results indicate that concentrations in Doris Lake are all below CCME guidelines for freshwater aquatic life. It is also noted that the predicted concentrations are very similar to background concentrations due to the high degree of dilution present in the system.

Although a limited suite of parameters was shown in the technical presentation, a broader suite of parameters was modelled. Results for the broader suite of parameters are shown in Table 1.

In summary, this evaluation shows that potential impacts to water quality in Doris Lake from re-flooding of the underground mine are negligible, despite a high degree of conservatism in the calculations.

Table 1: Estimated Concentrations in the Reflooded Mine and Doris Lake after Flooding of the Underground Mine Workings

Parameter	Groundwater (mg/L)	Incremental Backfill Conc. (mg/L)	Reflooded Mine Conc. (mg/L)	Background Conc in Doris Lake (mg/L)	Doris Lake Conc. with mine inputs (mg/L)	CCME (FWAL) (mg/L)
Sulphate	1900	5549	7449	3	14	-
Chloride	18000	-	18000	61	87	-
Aluminum Al	0.035	2.01	2.05	0.046	0.049	0.10
Antimony Sb	0.00095	0.0058	0.0067	0.00040	0.00041	-
Arsenic As	0.0024	0.021	0.024	0.00040	0.00043	0.005
Barium Ba	0.12	1.10	1.221	0.0033	0.0051	-
Beryllium Be	0.00086	0.0100	0.0109	0.0010	0.0010	-
Boron B	2.8	3.1	5.9	0.050	0.059	-
Cadmium Cd	0.00012	0.0068	0.0069	0.000010	0.000020	0.000058
Calcium Ca	2000	6094	8094	8.3	20	-
Chromium Cr	0.00086	0.056	0.057	0.0010	0.0011	-
Cobalt Co	0.0015	0.15	0.15	0.0020	0.0022	-
Copper Cu	0.0012	0.112	0.114	0.0014	0.0016	0.0020
Iron Fe	4.7	7.9	13	0.13	0.14	0.30
Lead Pb	0.00029	0.0086	0.0089	0.00010	0.00011	0.0010
Lithium Li	0.34	1.36	1.70	0.010	0.012	-
Magnesium Mg	1300	1215	2515	6.0	9.6	-
Manganese Mn	1.7	17	18	0.019	0.046	-
Mercury Hg	0.000049	0.00100	0.00105	0.000020	0.000022	0.000026
Molybdenum Mo	0.018	0.051	0.069	0.0050	0.0051	0.073
Nickel Ni	0.0018	0.14	0.14	0.0020	0.0022	0.025
Potassium K	240	306	546	2.1	2.9	-
Selenium Se	0.0019	0.19	0.19	0.00040	0.00068	0.0010
Silver Ag	0.000097	0.00026	0.00036	0.000020	0.000020	0.00025
Sodium Na	8700	4005	12705	29	47	-
Strontium Sr	27	2.1	29	0.040	0.082	-
Thallium Tl	0.000086	0.0030	0.0031	0.00010	0.00010	0.00080
Tin Sn	0.036	0.56	0.59	0.050	0.051	-
Titanium Ti	0.0049	0.065	0.070	0.0021	0.0022	-
Uranium U	0.000089	0.013	0.013	0.00010	0.00012	0.015
Vanadium V	0.00086	0.021	0.022	0.0010	0.0010	-
Zinc Zn	0.15	0.50	0.65	0.0040	0.0049	0.030

Attachment A: Presentation Slides

Issue: Effects of Mine Reflooding

- **Issue (AANDC TC3):**
  - "The documents do not include discussion on mine flooding after operation of the mine is finished, potential impacts of mine flooding on groundwater quality, and potential for groundwater discharge to Doris Lake after mine closure."
- **December response**
  - Described potential effects of backfill on water quality in the reflooded mine and expected flow from the reflooded mine to Doris Lake.
- **Outstanding**
  - TMAC committed to provide further evaluation at the hearings.

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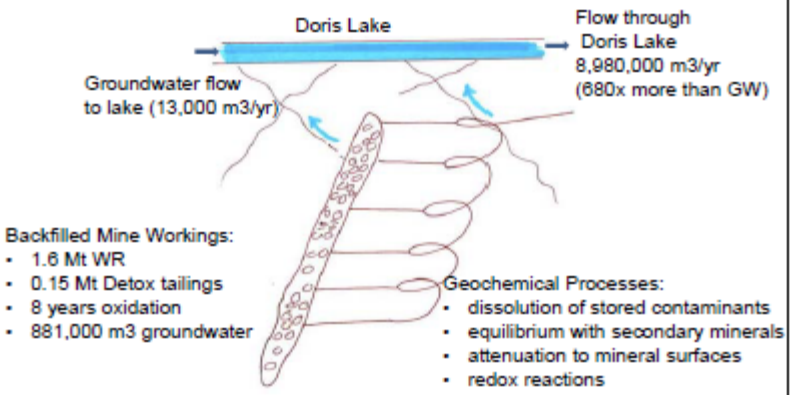
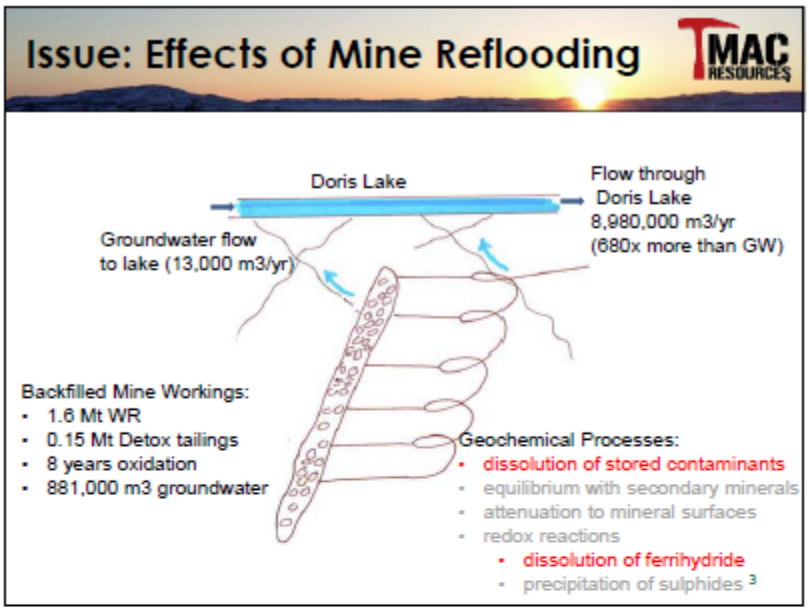
Issue: Effects of Mine Reflooding

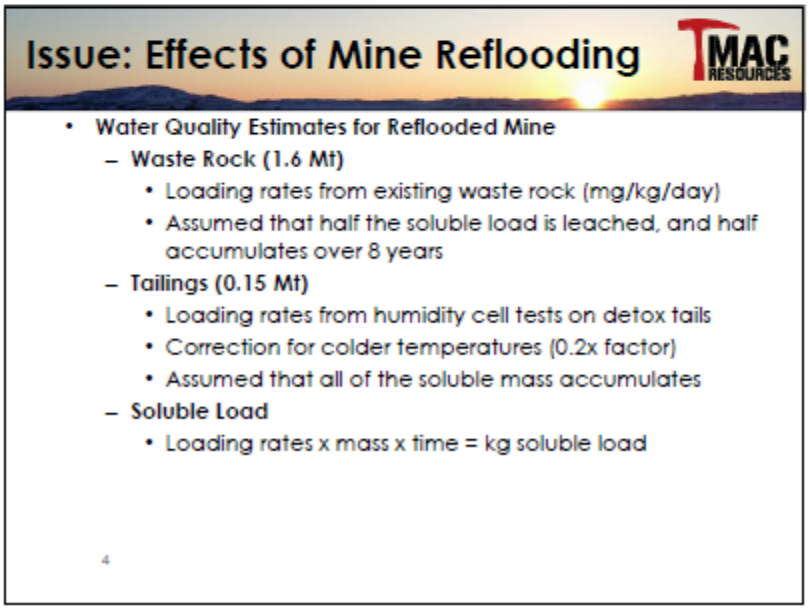


Backfilled Mine Workings:
- 1.6 Mt WR
- 0.15 Mt Detox tailings
- 8 years oxidation
- 881,000 m3 groundwater

Geochemical Processes:
- dissolution of stored contaminants
- equilibrium with secondary minerals
- attenuation to mineral surfaces
- redox reactions
  - dissolution of ferrihydride
  - precipitation of sulphides

2


Issue: Effects of Mine Reflooding
TMAC RESOURCES
Doris Lake
Flow through
Doris Lake
8,980,000 m3/yr
(680x more than GW)
Groundwater flow
to lake (13,000 m3/yr)
Backfilled Mine Workings:
• 1.6 Mt WR
• 0.15 Mt Detox tailings
• 8 years oxidation
• 881,000 m3 groundwater
Geochemical Processes:
• dissolution of stored contaminants
• equilibrium with secondary minerals
• attenuation to mineral surfaces
• redox reactions
• dissolution of ferrihydride
• precipitation of sulphides
3


Issue: Effects of Mine Reflooding
TMAC RESOURCES
• Water Quality Estimates for Reflooded Mine
– Waste Rock (1.6 Mt)
• Loading rates from existing waste rock (mg/kg/day)
• Assumed that half the soluble load is leached, and half accumulates over 8 years
– Tailings (0.15 Mt)
• Loading rates from humidity cell tests on detox tails
• Correction for colder temperatures (0.2x factor)
• Assumed that all of the soluble mass accumulates
– Soluble Load
• Loading rates x mass x time = kg soluble load
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Issue: Effects of Mine Reflooding

- Reflooded Mine Concentrations
  - Soluble load / volume of voids (881,000 m3) = incremental conc.
  - Add to concentrations in groundwater
  - Secondary mineral controls, attenuation and other chemical reactions were not considered (highly conservative)
- Doris Lake Concentrations
  - Calculated loads from reflooded mine plus background loads divided by flow through Doris Lake (680x dilution)

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Issue: Effects of Mine Reflooding

- Selected results:

Parameter	Groundwater (mg/L)	Incremental Backfill Conc. (mg/L)	Reflooded Mine Conc. (mg/L)	Background Conc in Doris Lake (mg/L)	Doris Lake Conc. with mine inputs (mg/L)
SO4	1900	5549	7449	3	14
As	0.0024	0.021	0.024	0.00040	0.00043
Cd	0.00012	0.0068	0.0069	0.000010	0.000020
Fe	4.7	7.9	13	0.13	0.14
Se	0.0019	0.19	0.19	0.00040	0.00068

- Change in water quality in Doris Lake is minor, even with conservative assumptions
- All results below CCME

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