MEMO

Job **A new ruby mine at Aappaluttoq**

Customer **True North Gems**

Date **24/08/2013**

From **Rambøll, Michael Olesen**

Nitrogen load to the environment by mine blasting

Date 24/08/2013

Ramboll
Hannemanns Allé 53
DK-2300 Copenhagen S
Denmark

T +45 5161 1000
F +45 5161 1001
www.ramboll.com

1. Conclusion

The impact of waste nitrogen from blasting on the lake ecosystem can be assessed as negligible.

2. Background and preconditions

Nitrogen is one of the main components (about 1/3) of the explosives that will be used for the extraction of ore by the ruby mine at Aapaluttoq. Since nitrogen is one of the key components of living tissue, the release of nitrogen from mining to the environment could affect the ambient life. As Arctic regions usually are poor in nutrient, they will be relatively vulnerable to the influence of nitrogen load.

The following assessment has been carried out for estimating the potential effect of nitrogen load on the lake Ukkaata Qaava from mine blasting. Basic assumptions - as shown in the table below - have been used for a simple calculation of the mass balance of the mining area and for the lake.

2.1 Impact and implications of N-load

Related to the planned extraction of ruby ore an excavation of total 2.8 10^6 t bedrock is expected. According to LNS-Greenland /2/ 0.6 kg explosives of type ANFO is used for the blasting of each m^3 rock, equivalent to 200 grams per tonne (density set to 2.75t/m^3.) The nitrogen content is about 1/3 of the explosives quantity (possible excipients contain no or only insignificant amounts of nitrogen).

The waste resulting from undetonated material comprises typically 1-2% of the explosive /3/. The including nitrogen of this waste will mainly consist of nitrate (NO_3^-) and ammonia (NH_4^+/ NH_3). The spill

Rambøll Danmark A/S
DK reg.no. 35128417

Member of FRI

varies according to whether the mining takes place in the underground or in open pit mines or whether the explosives are water covered or not. In case of water in the drilling holes, the amount of spill increase significantly /3/ increase. A maximum wastage of 3% is used to calculate the potential impact of nitrogen salts to the environment. This fit to the experience of a similar open mining in Canada /4/. Nitrogen compounds in the explosives are highly water soluble, and would therefore quickly be washed out to the surroundings. A spill of 3% will result in up to 2.2 g of nitrogen salts per tonne blasted bedrock to the environment.

Table 1 Key ratios for calculating the mass balance of nitrogen for Lake Ukkaata Qaava. Most of the figures are extracted from the environmental baseline report /1/. References on the quantities of explosives and waste are given in the text.

AN (ammonium-nitrate): NH_4NO_3, molar weight (g/mole):	80
Nitrogen/AN (weight/weight, %):	35.0
AN/ANFO (EXAN) (weight/weight, %):	94.5
Explosive (ANFO) used per m^3 rock (kg/m^3):	0.6
Rock density (t/m^3):	2.75
Explosive consumption per t rock (g/t)	218
Waste of explosive (non-detonated, %):	3
N-residual per t excavated rocks (g/t):	2.2
Excavated rock in total (t):	2,800,000
Excavation period (year)	8
Excavated per year (t/y):	350,000
N-load from blasting total (t):	6.1
N-load per year (t/y):	0.76
Waste rock (%):	94.0
Tailings (%):	6.0
Ore process-water (m^3/t):	10
N-conc. process water (mg/l):	0.216
Lake volume (m^3):	19,600,000
western basin (m^3):	10,000,000
Outlet (m^3/y):	5,100,000
Inflow western basin (m^3/y):	5,100,000
Increase of N-conc. western basin (due to annual N-supply, mg/l):	0.050
Equivalent N-load (mg/l)	0.149

Waste rock pile and tailings is planned dumped in the lake's western basin. The total excavation will be 2,800,000 tonnes of ore corresponding to an annual mining of 350,000 tonnes. This will with the above assumptions correspond to a maximal waste of nitrogen-salts of 0.76 t / year. A distribution of this amount in the water body of the western basin will result in a maximum increase in N concentration of 50 µg N / l on average. The existing nitrogen levels in the lake has not been measured, but judging by the measured Secchi depth of more than 20 m (and from chlorophyll a's specific absorption coefficient of 0,015 mg/m^2), the total N in the lake water can be stipulated to between 50 and 100 ug N / l. This is not far from the typical levels of low arctic inland lakes between 100 and 200 µg / l. The importance of nitrogen input due to the blasting is therefore quite limited.

The annual water supply to the western basin corresponds to approximately half of its water volume. As the left-over bedrock is planned to be deposited continuously in the lake's western basin, the associated nitrogen load could be coupled to water supply. This will equate an inlet concentration of approx. 150 ug / l (annual N input / annual water supply). According to the Greenland Water Quality Guidelines /5/ the upper limit for discharge concentration of nitrogen to aquatic systems is set to 8 mg / l. Also in this relation the impact of the waste nitrogen for the lake ecosystem can be assessed as negligible.

3. Summary

The impact of waste nitrogen from blasting on the lake ecosystem can be assessed as negligible.

References

/1/ Rambøll 2011. Aapppaluttoq Environmental Study. Baseline 2007-2009. Report to True North Gems. Appendix 1, January 2011.
/2/ Peter Madsen (LNS-Greenland) - mail corr. August 9th 2013
/3/ Jørgen Schneider (Orica) – mail corr. August 8th 2013.
/4/WLWB 2007. Wek'èezhii Land and Water Board. Diavik Diamond Mine Ammonia Management Plan – Review Panel Report. Wekweèti, Canada, 2007.
/5/ Bureau of Minerals and Petroleum, 2011. Greenland Water Quality Guidelines *in* BMP guidelines – for preparing an Environmental Impact Assessment (EIA) Report for Mineral Exploitation in Greenland. 2nd Edition January 2011.