Appendix E.10

Nitrogen Source Control Monitoring Plan for Touquoy Mine – March 14, 2021
Completed for the Updated 2021 Beaver Dam Mine EIS

TECHNICAL MEMORANDUM

To:	**Veronica Chisholm**	**Date:**	**March 14, 2021**
From:	**Patrick Mueller**	**Project #:**	**A591-3**
Subject:	**Nitrogen Source Control Monitoring Plan for Touquoy Mine**		

1. Introduction

Atlantic Mining Nova Scotia Incorporated (AMNS) has operated the Touquoy mine, located approximately 60 km northwest of Halifax, since 2017. As a result of a site-wide water quality model update (Minnow Environmental, 2020) for which Lorax Environmental Services Ltd. (Lorax) provided geochemical source terms (Lorax, 2020), nitrogen (N) species were identified as being a parameter of interest. To better constrain the sources, leaching behaviour, and speciation of nitrogen associated with blast residue, AMNS retained Lorax to prepare this N source control monitoring plan for Touquoy Mine. The plan focuses on source waters from the mine pit and waste rock storage area (WRSA). Waters in the tailings management facility (TMF) also contain N however these are not included in the present plan.

Monitoring conducted to date is summarized and a monitoring program is recommended. The records and data can be used for N source control investigations at Touquoy Mine and to study the release of N from blasted rock.Nitrogen-based blasting reagents are the primary source of N compounds from pit walls and mine rock storage facilities at surface mining operations (Pommen, 1983; Ferguson and Leask, 1988). The TITAN® XL1000 bulk emulsion explosive used for blasting at Touquoy Mine contains N almost evenly divided between ammonium (NH_4^+) and nitrate (NO_3^-). Nitrite (NO_2^-) is typically formed during and after blasting. Under ideal blasting conditions the NH_4^+ and NO_3^- are converted to nitrogen gas (N_2). However, in practice ideal blasting conditions are rarely if ever achieved and small proportions of the explosives remain as residue on blasted surfaces and are readily leached by infiltrating meteoric water.

The N containing residues on blasted rock surfaces are flushed by contact water (Revey, 1996; Mueller *et al.,* 2015) and accumulate in the pit sump. In unsaturated waste rock piles preferential and capillary flow paths develop and can lead to variable and delayed flushing of N (Fala *et al.,* 2003; Fretz *et al.,* 2011; Baily *et al.*, 2013) and although the N residues are finite N release from a large rock piles can persist for years after rock placement before diminishing as the preferential flow paths are flushed (Stockwell *et al.*, 2017).

2. Discharge Limits

Contact water from the Touquoy WRSA is collected in sediment ponds WRSP1 and WRSP2 with surplus waters pumped to the TMF at an annual average rate of approximately 600 m^3/day. Water accumulated in the pit sump (SW-OP) is also transferred to the TMF. The Federal *Metal and*

Diamond Mining Effluent Regulations (MDMER) apply to mines that discharge a total of more than 50 m^3/day of effluent to the environment from final discharge points. Water quality guidelines for the protection of aquatic life have been developed by the Canadian Council of Ministers of the Environment (CCME) for total ammonia (NH_3 + NH_4^+), un-ionized ammonia (NH_3), nitrate (NO_3^-) and nitrite (NO_2^-). The MDMER and CCME limits do not apply to SW-OP and WRSP2 waters and are presented for context only (Table 1 and

Table 2).

Table 1: MDMER Maximum Authorized Concentrations for Ammonia at the Final Discharge Point Coming into Force June 1, 2021 (Expressed as N)

Parameter	Maximum Authorized Monthly Mean Effluent Concentration (mg N/L)	Maximum Authorized Concentration in an Effluent Grab Sample (mg N/L)
Ammonia, un-ionized (NH_3) (as N) [1,2]	0.50	1.00

[1] The monthly mean concentration is the average of all samples collected a minimum of 24 hours apart each month and is typically based on weekly samples.
[2] The procedure for converting ammonia, total, reported by the lab to ammonia, un-ionized, for comparison to the effluent limits is provided in the *Metal and Diamond Mining Effluent Regulations.*

Table 2: CCME Water Quality Guidelines for the Protection of Freshwater Aquatic Life (Expressed as N)

Parameter	Short-Term Guideline (mg N/L)	Long Term Guideline (mg N/L)
Ammonia, un-ionized (NH_3) (as N) [1]	No guideline	0.019
Ammonia, total (NH_3 + NH_4^+) (as N) [2,3]	No guideline	0.10
Nitrate (as N) [3]	124	3.0
Nitrite (as N)	No guideline	0.060

[1] The procedure for converting ammonia, total, reported by the lab to ammonia, un-ionized, for comparison to the guideline is provided in CCME (2010) and is identical to the procedure described in the *Metal and Diamond Mining Effluent Regulations.*
[2] Ammonia, total, guideline is pH and temperature dependant, and decreases as temperature and pH increase, therefore the applicable guideline is derived for each sample collected (CCME, 2010). The long-term guideline shown in the table is derived assuming pH = 8.5 and temperature = 25°C, based on the dataset maximum field pH and temperature measurements (26.8 ºC and pH 8.22) from monitoring data collected 2016 – 2020 at station SW-21 on Scraggy Lake.
[3] Ammonia and nitrate concentrations listed in CCME water quality guidelines for the protection of aquatic life summary table (CCME, 2021) are expressed as mg/L NH_3 and NO_3, respectively. Concentrations have been converted to nitrogen equivalent concentrations (mg N/L) using conversion factors of 0.8224 for ammonia, and 4.43 for nitrate (CCME;2010, 2012).

3. Nitrogen (N) Speciation

At the Touquoy Mine, the monitoring data indicate that N is almost evenly divided between NO_3^- and ammonia (NH_3 + NH_4^+) in the pit sump water. Conversely, NO_3^- is the dominant species in WRSA drainage (Figure 1). The pit sump waters are likely influenced by non-detonated explosives residues rinsed from blasted rock surfaces. The WRSA drainage may be influenced by NH_4^+ oxidation (*i.e.,* nitrification processes) or ion-exchange processes within the WRSA.

The stability of inorganic N compounds in natural systems is shown in Figure 2 (Stumm and Morgan, 1981) and indicates that the accumulation of NO_3^- is favoured under oxidizing conditions. It is speculated that oxidizing conditions in the pit sump and WRSA drainage can promote the conversion of NH_4^+ to NO_3^-, however Small *et al.* (2013) have noted that NH_4^+ oxidation can occur slowly in cold natural waters with annual nitrification rates in Lake Superior ranging from 0.1 to 0.2 mg N/L. Since pit sump samples are collected within days of contact with blasted rock surfaces, ammonia conversion is considered negligible at this monitoring station. However, residence time within the WRSA may be on the order of months to a year or more, allowing time for conversion of NH_4^+ to NO_3^- .

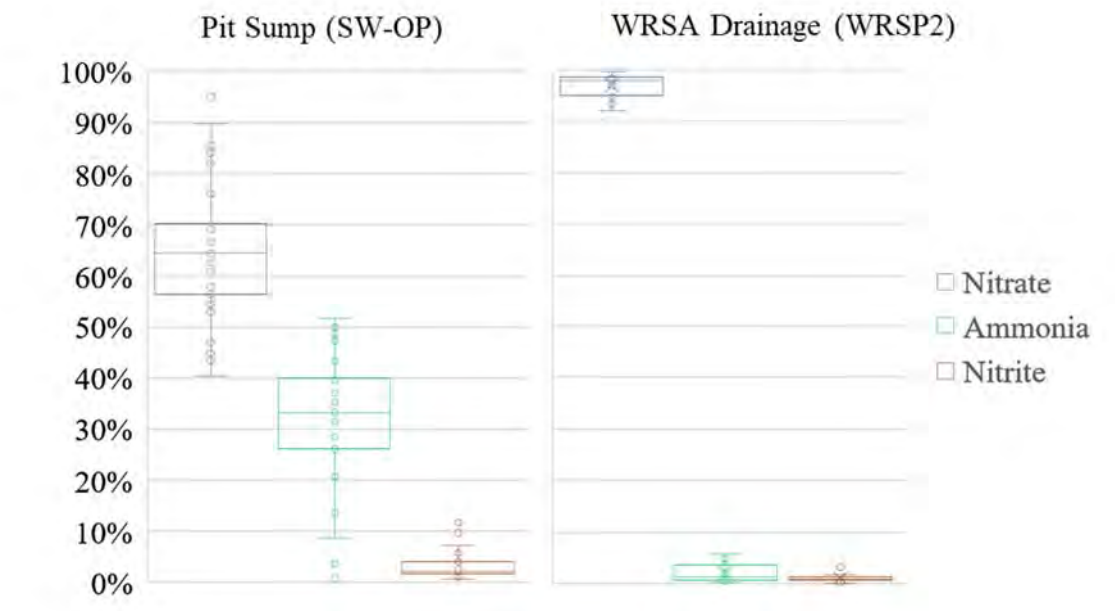

Figure 1: Nitrogen (N) species in pit sump and WRSA drainage as a percentage of total nitrogen. The box plot contains the 25th to 75th percentile of the data set, bisected by the median value. Individual measurements are plotted as dots.

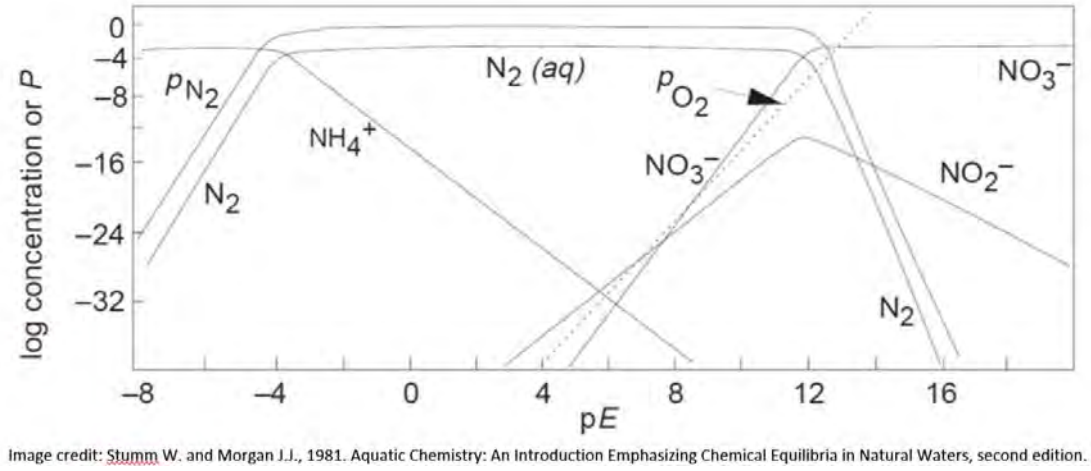

Image credit: Stumm W. and Morgan J.J., 1981. Aquatic Chemistry: An Introduction Emphasizing Chemical Equilibria in Natural Waters, second edition.

Figure 2: N species distributions based on the oxidation-reduction potential (pE) in aquatic environments (from Stumm and Morgan, 1996).

4. Monitoring Results 2016 to 2020

The climate at Touquoy Mine is temperate and a mean annual precipitation (MAP) of 1350 mm has been observed at the nearby Halifax Climate Station (Environment and Climate Change Canada Station No. 8202251). Mine development commenced in 2016 and the monthly explosives usage expressed as a powder factor (kg explosives per tonne of blasted rock) ranged from 0.11 to 0.38 kg/t from July 2016 through July 2020 as shown in Figure 3. The WRSA has been receiving waste rock since October 2017. Monthly cumulative totals are plotted in Figure 4 and a cumulative total of 11.4 Mt waste was stockpiled in the WRSA at the end of October 2020.

The WRSA is in the catchment of collection ponds WRSP1 and WRSP2. Drainage from the WRSA accumulates within the ponds. Surplus water in the ponds is directed to the TMF by transferring water from WRSP1 to WRSP2, and then from WRSP2 to the TMF. Discharge from WRSP2 has been directed to the TMF since January 2018 and flows have been measured since April 2019. The total nitrogen (T-N) ranged from 1.7 to 17.1 mg N/L and measured monthly discharges ranged from 2,101 to 62,997 m^3 (Figure 4).

Since monitoring commenced in August 2017 the pit sump (SW-OP) water quality has been variable and has trended towards balance between NO_3^- and NH_4^+ with concentrations frequently above 10 mg N/L in 2020 (Figure 5). A maximum of 2.4 mg N/L NO_2^- was observed in the pit sump in 2020. At WRSP2, the WRSA drainage elevated to 17 mg N/L NO_3^- however concentrations of NH_4^+ and NO_2^- have remained generally below 0.1 mg N/L.

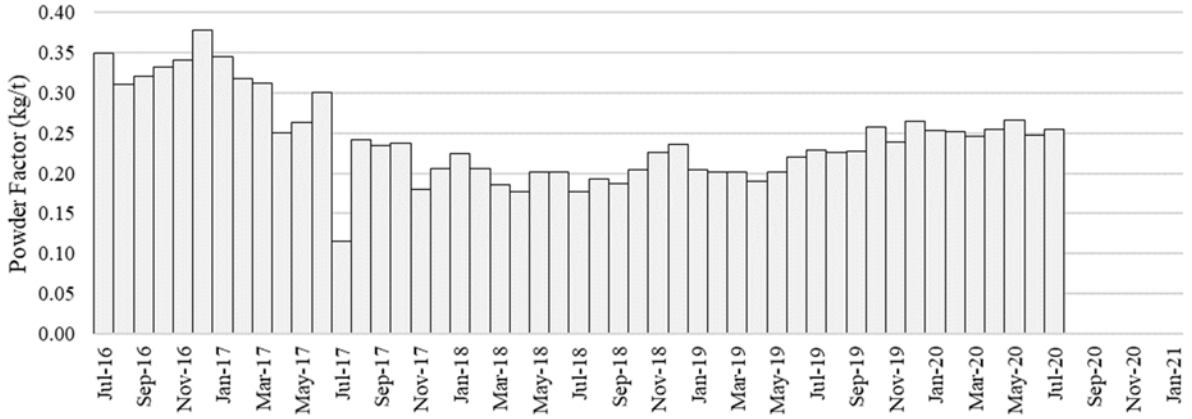

Figure 3: Monthly powder factor at Touquoy Mine from July 2016 to July 2020.

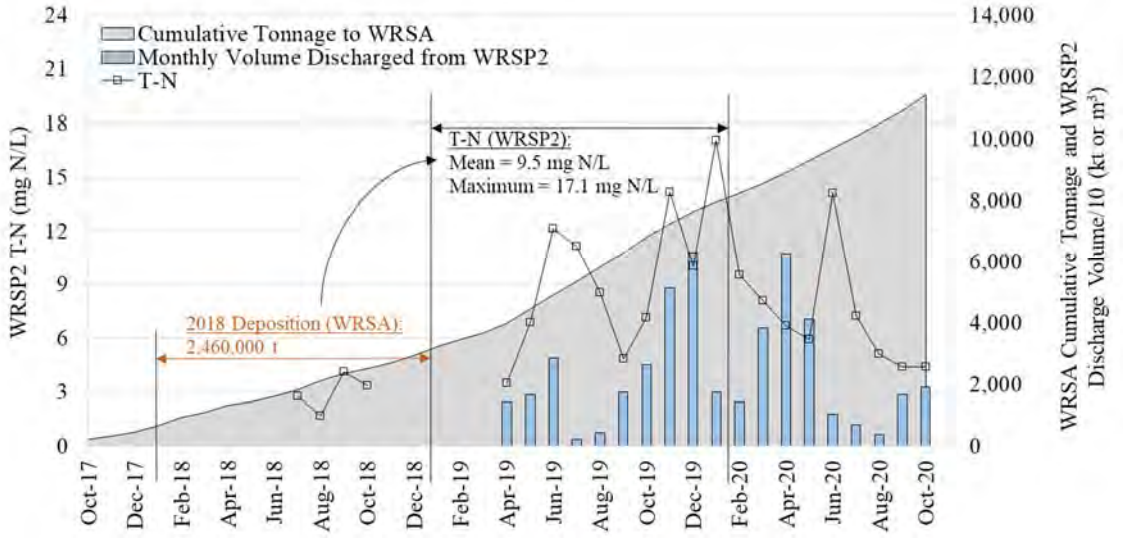

Figure 4: Touquoy WRSA cumulative monthly waste deposition, monthly WRSP2 discharge and monthly T-N concentration.

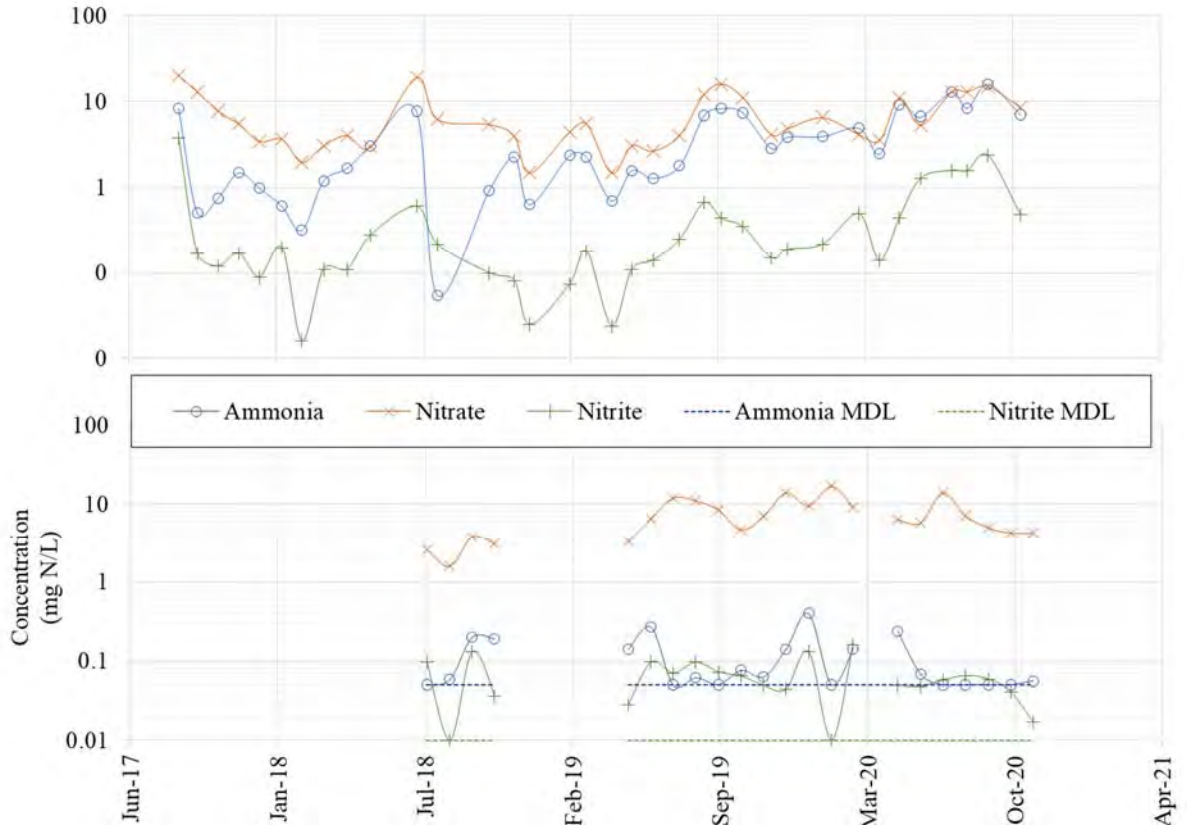

Figure 5: Nitrogen (N) species concentrations, logarithmic scale, in the Touquoy pit sump (SW-OP, top plot) and WRSA drainage (WRSP2, bottom plot).

5. Nitrogen (N) Source Control Monitoring Program

Mine development commenced in 2016 and mine facilities were subsequently developed in 2017. Monitoring commenced when the facilities were completed, and it is recommended that monitoring for N source control continue for the parameters and at the frequency indicated in Table 3. The primary modifications to the current program include the addition of field parameters (pH, temperature, ORP and DO), the lab test for total nitrogen and the monitoring frequency increase of the WRW-5A groundwater monitoring well from quarterly to monthly.

It is recommended the monitoring results be compared to the source term values used for the water quality model (Lorax, 2020). Deviation of observed values from planned or assumed values may indicate a revision in the water quality model is warranted. If nitrogen levels increase beyond the values measured from 2017 to 2020 then additional management measures may need to be implemented which may include additional monitoring or the implementation of source control strategies (*i.e.,* review and revision of blasting practices, blast practice audits, training).

Table 3: Recommended nitrogen (N) source control monitoring and recordkeeping.

Recordkeeping and Monitoring	Parameters[1]	Locations	Frequency
Mining records	Powder factor Excavation tonnage Deposition tonnage	Mine Pit, WRSA	Monthly
Surface water quality	Total nitrogen (T-N) Total ammonia ($NH_3 + NH_4^+$) Nitrate (NO_3^-) Nitrite (NO_2^-) Field pH, Field temperature Field ORP Field DO	WRSP2, SW-OP	Monthly
		Toe seeps from WRSA	Monthly
Groundwater quality		WRW-2A (upgradient of WRSA)	Quarterly
		WRW-5A (downgradient of WRSA)	Monthly
Surface water flows	Discharge	WRSP2 discharge, pit dewatering flow	Monthly (Totalizer)

[1] The concentration units for lab reported nitrogen species results may be expressed as a nitrogen equivalent (mg N/L) or as a species-specific concentration (*e.g.,* mg NO_3/L and mg NH_3/L), it is important to ensure test results and compliance targets are expressed in the same concentration units prior to comparison. Values can be converted to species specific concentrations (*e.g.,* mg NO_3/L and mg NH_3/L) or nitrogen equivalent (mg N/L) by using conversion factors of 0.8224 for ammonia, and 4.43 for nitrate CCME (2010, 2012).

6. Closure

This technical memorandum is for the exclusive use of Atlantic Mining Nova Scotia Inc. The preparation and review of this document was completed by Lorax Environmental Services Ltd. staff identified below.

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7. References

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