Atlantic Gold

Appendix P.3

draft Nitrogen Management Plan
Completed for the Updated 2021 Beaver Dam Mine EIS

DRAFT Nitrogen Management Plan

Beaver Dam Mine Project 2021
Environmental Impact Statement Amendment,
Marinette, Nova Scotia
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1 INTRODUCTION

1.1 Scope and Objectives

A Nitrogen Management Plan (NMP) has been prepared by Lorax Environmental Services Ltd. (Lorax) on behalf of Atlantic Mining Nova Scotia Corporation (AMNS) for the Beaver Dam Mine Project (the Project). The purpose of this NMP is to provide guidance for AMNS to minimize residual nitrogen from explosives and to minimize the release of nitrogen in Project effluent discharges. Nitrogen (N) is present as total ammonia (NH_3 + NH_4^+), nitrate (NO_3^-) and nitrite (NO_2^-) and elevated concentrations of these compounds may be harmful to the aquatic receiving environment. Ammonium nitrate explosives are widely used for mining and are recognized as a significant source of nitrogen at mining operations, therefore this NMP addresses the release of nitrogen associated with explosives use.

The scope of this NMP is limited to the environmental management of total ammonia (NH_3 + NH_4^+), nitrate (NO_3^-) and nitrite (NO_2^-) originating from explosives use and released as contact water. Legislation and regulations for explosives transport, handling, and storage are described and referenced to provide context for nitrogen management procedures, however this NMP is not intended to be used as a comprehensive plan for the transport, handling, storage and use of explosives.

The objectives of this NMP are as follows:

1) Protection of the receiving environment from excess nitrogen concentrations through the implementation of nitrogen source control measures, environmental monitoring, and establishment of preliminary management triggers; and,
2) Provide an overview of planned nitrogen management at the Project during mining operations.

1.2 Project overview

The Beaver Dam Mine Project (the Project) is a proposed surface gold mine owned by Atlantic Mining Nova Scotia Corporation (AMNS) and will operate as a satellite mine to the nearby operating Touquoy Mine owned by AMNS. The Project is located approximately 80 km northeast of Halifax, Nova Scotia, and approximately 20 km northeast of the Touquoy Mine. Low grade ore mined from the Project will be temporarily stockpiled at site prior to transfer to the Touquoy Mine ore processing facilities (Schulte, pers. comm., 2021). The Project will produce 36.8 Mt of Non-Acid Generating (NAG) and 2.1 Mt Potentially Acid Generating (PAG) waste rock which will be segregated and stored in separate Waste Rock Storage Areas (WRSAs) (Halas, pers. comm., 2020).

This NMP outlines the strategies to monitor and mitigate nitrogen from explosives in order to prevent receiving environment guideline exceedances attributable to effluent discharges from the Project. During operations surface runoff within the Project area (contact water) will be directed to three ponds, specifically the North Pond, East Pond and South Pond. Drainage and runoff from the WRSAs and mine pit dewatering will be directed to the North Pond whereas runoff reporting to the East and South Ponds will have minimal contact with blasted rock. The North and East Pond effluents will discharge separately to Cameron Flowage which forms part of the Killag River, and South Pond effluent will be directed to Tent Lake. The average monthly inflows to the North Pond at end of mine (EOM) are estimated to range from approximately 100,000 to 200,000 m^3/month (GHD, 2020). Water quality modelling has determined nitrite (NO_2^-) may exceed water quality guidelines in the Killag River during summer months (GHD, 2020). Therefore, AMNS retained GHD Limited (GHD) to conduct a preliminary assessment of nitrite (NO_2^-) treatment options for the Project (GHD, 2020). Nitrogen source control, as outlined in this NMP, is the primary mitigation measure to limit potential Project effects on nitrogen concentrations. Treatment is a secondary mitigation option and the need for treatment will be continuously assessed during mine operations using the trigger-response approach described in this NMP.

2 REGULATORY FRAMEWORK

2.1 Legislation and Guidance Documents

This section presents an overview of the regulatory framework under which the NMP was developed. Numerous Federal and Provincial Acts and Regulations, as well as guidance documents, address the handling and use of explosives as well as the release of nitrogen compounds to the freshwater aquatic environment from mining operations. Safety and transportation procedures for the handling, transport and use of explosives are outside the scope of this management plan. The regulatory documents relevant for the management of nitrogen compounds at mining operations include, but are not necessarily limited to:

- Federal Explosives Regulations (SOR/2013-211) which sets out the regulations under the Federal *Explosives Act* (R.S.C., 1985, c. E-17) for the manufacture, testing, acquisition, possession, sale, storage, transportation, importation and exportation of explosives;
- Federal *Transportation of Dangerous Goods Act, 1992* (S.C. 1992, c. 34) which regulates the transportation of explosives;
- Federal *Transportation of Dangerous Goods Regulations* (SOR/2019-101) which set out the regulations for the safe transportation of explosives and emergency response planning;
- Federal *Fisheries Act* (R.S.C., 1985, c. F-14, as amended) Section 36(3), which prohibits the discharge of a deleterious substance to waters frequented by fish;
- Federal *Metal and Diamond Mining Effluent Regulations* (SOR/2002-222) (MDMER), which regulates concentrations of certain parameters in water quality discharged from mine sites under Sections 34(2), 36(5), and 38(9) of the *Fisheries Act* and sets out requirements for water quality monitoring, reporting and emergency response planning. Regulations for ammonia are scheduled to come into force on June 1, 2021 in accordance with Federal *Regulations Amending the Metal Mining Effluent Regulations* (SOR/2018-99);
- Federal *Canadian Environmental Protection Act, 1999* (S.C. 1999, c. 33), which regulates pollution prevention and environmental protection;
- Nova Scotia *Blasting Safety Regulations* (N.S. Reg. 89/2008, amended N.S. Reg. 54/2013), which regulates explosives storage, transportation and use;
- Nova Scotia *Environment Act* (1994-95, c. 1, s. 1) and subordinate regulations which regulate pollution prevention and environmental protection;
- Nova Scotia *Environmental Emergency Regulations* (N.S. Reg. 16/2013), which sets out regulations for reporting the release, or impending release of explosives to the environment, as well as remedial and emergency measures to be implemented;
- Canadian Council of Ministers of the Environment (CCME) Water Quality Guidelines for the Protection of Aquatic Life which establish short- and long-term guidelines for ammonia, nitrate and nitrite; and
- British Columbia Ministry of Environment and Climate Change Guidance on Preparing Nitrogen Management Plans for Mines using Ammonium Nitrate Fuel Oil Products for Blasting (Version 1.0, 2018).

2.2 Effluent Limits and Water Quality Guidelines

Mine contact water is typically collected in a water management system and is directed to one or more discharge points where effluent waters enter the receiving environment. The Federal MDMER apply to mines that discharge a total of more than 50 m^3/day of effluent from final discharge points, and although nitrogen compounds were not previously regulated, ammonia effluent limits are scheduled to come into force on June 1, 2021, as noted above. Discharged effluent mixes with the receiving water body and regulators generally expect that water quality guidelines are met downstream of effluent discharges. Water quality guidelines for the protection of aquatic life have been developed by the CCME for total ammonia (NH_3 + NH_4^+), un-ionized ammonia (NH_3), nitrate (NO_3^-) and nitrite (NO_2^-). The general convention is that long-term guidelines must be met in the receiving water body, downstream of effluent discharges, at the edge of the initial dilution zone (IDZ), and short-term guidelines should not be exceeded in the effluent or within the IDZ (as per the *Fisheries Act*). It is expected that Beaver Dam Mine Project effluent and the water quality downstream of effluent discharges will be required to meet the limits and guidelines summarized in Table 2-1 and Table 2-2, respectively.

It is important to note that the CCME water quality guidelines for the protection of aquatic life summary table (CCME, 2021) express concentrations of total ammonia (NH_3 + NH_4^+) and nitrate (NO_3^-) as mg NH_3/L and mg NO_3/L, respectively, whereas nitrite (NO_2^-) is expressed as a nitrogen equivalent concentration (mg N/L). Laboratory test results for nitrogen compounds are typically reported in concentration units of nitrogen equivalents (mg N/L). It is important that lab test results be compared to effluent limits and guidelines using the same concentration units. Concentration unit conversion factors are 0.8224 for ammonia, and 4.43 for nitrate CCME (2010, 2012). For consistency, all nitrogen species concentrations presented in this NMP are expressed as nitrogen equivalents (mg N/L).

Table 2-1: 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) [2]	Maximum Authorized Concentration in an Effluent Grab Sample (mg N/L)
Ammonia, un-ionized (NH_3) (N) [1]	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 2-2: 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) (N) [1]	No guideline	0.0156
Ammonia, total (NH_3 + NH_4^+) (N) [2,3]	No guideline	39.5
Nitrate (N) [3]	124	3.0
Nitrite (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 = 6 and temperature = 20°C, based on the dataset maximum field pH and temperature measurements (19.9 ºC and pH 5.49) from baseline monitoring at station SW-1 on the Killag River (Atlantic Gold, 2017).
[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 ROLES AND RESPONSIBILITIES

Key personnel accountable for implementation and compliance with the NMP are the Mine Manager and the Environmental Manager, and their designated subordinates. Generic position titles are used in this NMP to identify and describe the key personnel and their responsibilities with respect to nitrogen management as outlined below:

Table 3-1: Roles and Responsibilities for Nitrogen Management

Generic Role	Responsibilities for Nitrogen Management
Mine Manager	Has ultimate responsibility to identify, implement and ensure continuous compliance to all regulatory requirements and corporate policies and procedures related to nitrogen management at the mine site. Provides sufficient personnel, equipment, training and other resources, as needed, for effective nitrogen management and implementation of the NMP. Ensures all subordinates involved with nitrogen management are qualified to complete delegated tasks related to nitrogen management.
Environment Manager	Provides the Mine Manager expertise and guidance regarding the protection of the environment as related to nitrogen management and leads the implementation of procedures for nitrogen management. Ensures all required NMP monitoring, audits, nitrogen source control investigations, management reviews and reporting are performed as required, and that all related records are maintained and current. Ensures subordinates have sufficient resources, training and qualifications to adequately complete delegated tasks related to nitrogen management.
Engineering Staff	Works with the Mine Manager to plan and track mine development and blasted rock movement for effective nitrogen management, and to prepare blast pattern designs based on industry good practices that minimize inefficient explosives consumption. Works with Blasting and Drilling Staff to ensure blast patterns are prepared as designed and that nitrogen management and source control procedures are implemented before, during and after explosives loading and blasting. Ensures that required nitrogen management records for explosives use, blasting, blasted rock movement and placement are maintained and current. Ensures subordinates have sufficient resources, training and qualifications to adequately complete delegated tasks related to nitrogen management.
Blasting and Drilling Staff	Works with Engineering Staff and the Environment Manager to ensure on-site explosives movement, handling, use and blasting are conducted to minimize the release of nitrogen from explosives and blasting residues to mine effluent. Implements industry good practices related to nitrogen management for explosives use, handling, transport and blasting. Ensures that nitrogen management records for explosives use and blasting are prepared for each blast. Communicates to the Mine Manager any deficiencies in their qualifications that would prevent competently conducting nitrogen management tasks and refrains from accepting tasks for which they are not qualified or sufficient oversight by a qualified individual is not provided.
Environmental Staff	Works with the Environment Manager to conduct assigned tasks for nitrogen management monitoring, auditing, reporting, and investigation tasks. Ensures that nitrogen management records for monitoring, auditing, investigation and reporting are collected and maintained. Conducts surface water quality and flow monitoring, and groundwater quality monitoring. Communicates to the Environmental Manager any deficiencies in their qualifications that would prevent competently conducting nitrogen management tasks and refrains from accepting tasks for which they are not qualified or sufficient oversight by a qualified individual is not provided.

4 EXPLOSIVES HANDLING AND BLASTING PRACTICES

4.1 Overview

Nitrogen-based blasting reagents are typically the primary source of waterborne nitrogen compounds released from pit walls and mine rock storage facilities at surface mining operations (Pommen, 1983; Ferguson and Leask, 1988). The nitrogen compounds ammonium (NH_4^+) and nitrate (NO_3^-) are the primary constituents of ammonium nitrate-based explosives, while nitrite (NO_2^-) is typically formed during and after blasting. These nitrogen species are very water soluble and will rapidly dissolve in water. Under ideal blasting conditions, ammonium (NH_4^+) and nitrate (NO_3^-) are converted to nitrogen gas (N_2) (Djerdjev et al., 2018). 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 rapidly leached from blasted mine rock by surface runoff (Revey, 1996; Mueller et al., 2015).

The release of nitrogen to the mine pit sump can occur prior to blasting or from residue on the blasted rock surfaces prior to excavation (Cameron et. al., 2007). However, a significant amount of the explosives residue remain within the blasted rock which is typically excavated from the mine pit within days or weeks of blasting. Therefore, nitrogen is also transferred to temporary or permanent stockpiles (e.g., WRSAs) where it can be mobilized by meteoric infiltration waters, or to the mill where it is transferred from ore to mill process water and tailings. The timing and magnitude of nitrogen leaching from blasted rock deposited within WRSAs is influenced by unsaturated hydrology processes where preferential and capillary flow paths can lead to variable and delayed flushing of nitrogen (Fala et al., 2003; Stockwell et al., 2006; Fretz et al., 2011). The nitrogen available for leaching is limited to the wetted areas of the pile and the type of flow through the pile, therefore nitrogen release from large rock piles can be delayed and subsequently persist for years after rock placement (Baily et al., 2013; Lorax, 2017).

The Touquoy Mine is a proxy for nitrogen release from Project facilities due to similarities in ore and waste production volumes, planned blasting practices and climate. Empirical observations at Touquoy Mine suggest the Project NAG and PAG WRSAs, and temporary ore stockpile will begin to release nitrogen to infiltration water less than one year following deposition during the initial years of mining (Lorax, 2021). At other mines, the release of nitrogen from waste rock stockpiles has been observed to lag deposition by 1 to 3 years in locations with low precipitation (e.g., Diavik Mine) or mines with large waste stockpiles (e.g., Trend Mine) (Baily et al., 2013; Stockwell et al., 2017). This may be partially attributable to water retention within the waste stockpile. Therefore, it is likely that lag time between waste deposition and nitrogen release increases with the size of the stockpile.

The Project is expected to release nitrogen compounds from the following facilities:

3) Mine Pit Sump
4) NAG WRSA,
5) PAG WRSA
6) Temporary Ore Stockpile

4.2 Explosives Products, Storage and Handling

Blasting will be conducted using TITAN® XL1000 bulk emulsion product, a water-resistant ammonium nitrate explosives product manufactured by Dyno Nobel. Explosives loaded into blast holes can be spoiled by water originating from surface runoff or groundwater infiltration. The saturation of undetonated explosives can result in the leaching of ammonium (NH_4^+) and nitrate (NO_3^-) from explosives to the water and may also prevent proper explosives detonation. For example, ammonium nitrate fuel oil (ANFO) can spoil within minutes of contacting water, preventing proper detonation. Incomplete explosives detonation will increase the amount of nitrogen on blast rock surfaces or in the mine pit sump water, as well as leading to poor fragmentation of the blasted rock. Emulsion explosives are designed to encapsulate the explosive components (*e.g.* ammonium nitrate and other nitrate salts), shield them from the effects of water, and prevent their spoiling prior to detonation. Emulsion-based explosives are designed to mitigate the challenges of wet blasting conditions and thereby reduce the release of nitrogen to mine contact waters.

Other explosives products used for blasting such detonators and boosters also contain nitrogen, however during routine mining operations relatively small masses of these products are used compared emulsion. Therefore, nitrogen source control procedures are focused primarily on the handling and use of the emulsion products.

Spoiled explosives with be disposed by detonation or off site by returning the waste explosives to the manufacturer for disposal.

Explosives products will be handled, transported, and stored in accordance with Federal and Provincial regulations. The TITAN® XL1000 constituent product will be shipped to site as an ammonium nitrate solution and will be blended on site with a density control agent prior to use. The constituent and blended emulsion products will be stored in a secured Emulsion Area, with access restricted to authorized personnel only. The Emulsion Area will have an emulsion storage silo with a 40,000 kg capacity and chemical containers for the blending process. Other explosives will be similarly secured and stored in the Magazines Area with separate magazines for detonators and boosters. The magazine pad will contain storage trailers for 50,000 detonators and up to 8,500 kg of boosters. Both storage facilities will be gated and surrounded by a berm to prevent vehicle access except by designated blasting personnel.

4.3 Blasting Practices

Residual nitrogen from blasting is directly related to the type and quantity of explosives used for blasting a volume of rock (also known as a powder factor, or PF) and the blasting methods used. Blasting conditions (and PF) may vary daily due to conditions beyond the control of the personnel involved in blasting. The export of N is controlled by implementing good blasting practices to minimize non-detonated explosive losses within the pit prior to detonation, and to minimize non-detonated explosive and blast residues on blasted rock surfaces after blasting (Ferguson and Leask, 1988; Forsyth et al.; 1995; Revey, 1996; Cameron et al., 2007). Key considerations that are addressed for each blast pattern to maximize blast efficiency and minimize nitrogen residues are outlined in Table 4-1. Good explosive consumption efficiency is achieved by implementing good blasting practices, and these will minimize the nitrogen residues arising from explosives use.

Surface mining at the Project will progress from the ground surface to depth at 10 m elevation intervals, referred to as benches, to develop the mine pit vertically and laterally and to an approximate depth of 90 m below ground surface. Each blast is tailored to the rock type being blasted (*e.g.,* ore or waste) and other conditions that may be unique to the rock and area being blasted. The plan for each blast (known as the blast pattern) is developed by the Mine Engineer and implemented by Blasting and Drilling Staff. Explosives are loaded by pumping into boreholes that are drilled to a spacing and depth indicated in the blast pattern design. The explosives in each loaded borehole are referred to as the powder column. Blasting will be conducted by qualified personnel several times a week. The basic pattern design and explosive use rate planned for each blast is outlined in Table 4-2.

Table 4-1: Key Elements that Influence Blasting Efficiency

Element	Consideration
Pattern design	The blast pattern is designed to meet rock fragmentation objectives considering specific pattern geometry and geo-mechanical rock properties. The target powder factor is based on the minimum amount of explosive required to meet the fragmentation objectives.
Wet site conditions	The presence of water in the blast pattern creates challenging site conditions that may affect the amount of nitrogen released to the environment. Water resistant explosives are used (*i.e.*, emulsion). Water is managed to direct surface flows away from blast holes and to drain groundwater from the pattern. Flooded boreholes should be dewatered prior to loading explosives.
Explosive quality	Poor explosive quality (*i.e.*, out of specification composition) may cause inefficient consumption, and in extreme cases failure to detonate, leading to poor blast performance and increased nitrogen residue. Routine monitoring of explosives quality is required to confirm specifications are met.
Powder column contamination	This occurs when water or sediment (*i.e.,* drill hole cuttings) are mixed into explosives as they are loaded. Sediment and water can prevent propagation of the explosion reaction (*i.e.,* bridging) when one part of the powder column is separated from the remaining powder column. Bridging can result in partial detonation and residual nitrogen.
Fractures and voids	Loading explosives into boreholes with fractured rock or voids will result in explosives loading of empty spaces adjacent to the borehole. Explosives connected to the powder column but confined to small spaces will deflagrate, leading to the formation of yellow/orange smoke (nitrogen oxides). Decking or other strategies are used to avoid loading explosives into fractures and voids.
Detonation Failure	The powder column will not detonate if the detonator and booster are outside of the explosive or if the detonator is cut prior to detonation.
Spills	Spills may occur between blast holes due to leakage from the transfer hosing/connections, or by dripping out of the hose as the hose is moved away from the loaded blast hole. Good explosives loading practices are used to prevent spills. All spills are removed prior to blasting.
Stemming	Stemming material should be angular coarse crush with a size approximately 1/10th of the blast hole diameter in order to effectively contain the blast energy. Insufficient stemming or use of improper material for stemming (*i.e.,* borehole cuttings) will fail to contain the blast energy within the blast hole. Proper stemming material is used to minimize loss of blast energy.
Decking	Decking aids with the propagation of the blast energy through the blast pattern and can also be used to isolate the powder column from void spaces and fractured rock. Poorly formed seals will allow the leakage of explosive into empty spaces below the seal, with the seal forming a bridge in the powder column and preventing detonation of the leaked explosive below the seal.

Table 4-2: Blast Pattern Design for Blasting Ore and Waste at Beaver Dam Mine Project

Design Parameter	Units	Ore	Waste
Drillhole Spacing/Burden	m	3.5	3.9
Drillhole Diameter	mm	140	140
Explosive % ANFO		0%	0%
Explosive % Emulsion		100%	100%
Explosive Density	g/cc	1.15	1.15
Bench Height	m	10	10
Subdrill	m	0.8	0.8
Collar/Stemming	m	4	4
Charge per Hole	kg/hole	120	120
Tonnes Blasted per Hole	t/hole	334	415
BCM Blasted per hole	BCM/hole	123	152
Powder Factor (PF)	kg/t	0.36	0.29
	kg/BCM	0.98	0.79

5 NITROGEN DISTRIBUTION IN THE AQUATIC ENVIRONMENT

Although the forms of nitrogen in explosives is almost equally distributed between ammonium (NH_4^+) and nitrate (NO_3^-), their relative proportion in effluent discharges and in the receiving environment are altered by several processes including microbially-driven oxidation and/or reduction processes as well as ion-exchange processes within the WRSAs. Microbial processes can convert nitrogen from one chemical form to another within the Project water management system and in the waterbodies affected by discharges from the Project area.

Nitrogen may exist in the aquatic environment as total ammonia (NH_3 + NH_4^+), nitrate (NO_3^-) and nitrite (NO_2^-) as well as dissolved nitrogen gas (N_2). The relative distribution of nitrogen between total ammonia (NH_3 + NH_4^+), nitrate (NO_3^-) and nitrite (NO_2^-) is primarily governed by the reduction-oxidation potential (pE) of the aqueous system (Figure 5-1) and the presence of microbial communities that catalyze the conversion reactions. Oxidizing conditions (positive pE) favour conversion of total ammonia (NH_3 + NH_4^+) and nitrite (NO_2^-) to nitrate (NO_3^-), whereas reducing conditions (negative pE) favour conversion of nitrate (NO_3^-) and nitrite (NO_2^-) to nitrogen gas (N_2). The ammonium ion (NH_4^+) and dissolved ammonia gas (NH_3) are in equilibrium with each other and the distribution between ammonium ion (NH_4^+) and ammonia gas (NH_3) is primarily controlled by pH and temperature. Oxidizing conditions typically occur in oxygenated (oxic) waters, whereas in the absence of oxygen (anoxic) reducing conditions can develop. The WRSAs are unsaturated, oxic environments that tend towards positive pE and favor the oxidation of total ammonia (NH_3 + NH_4^+) and nitrite (NO_2^-) to nitrate (NO_3^-). In practical terms, measurement of the redox condition is typically described as the oxidation-reduction potential (ORP) and is measured using an electrochemical probe.

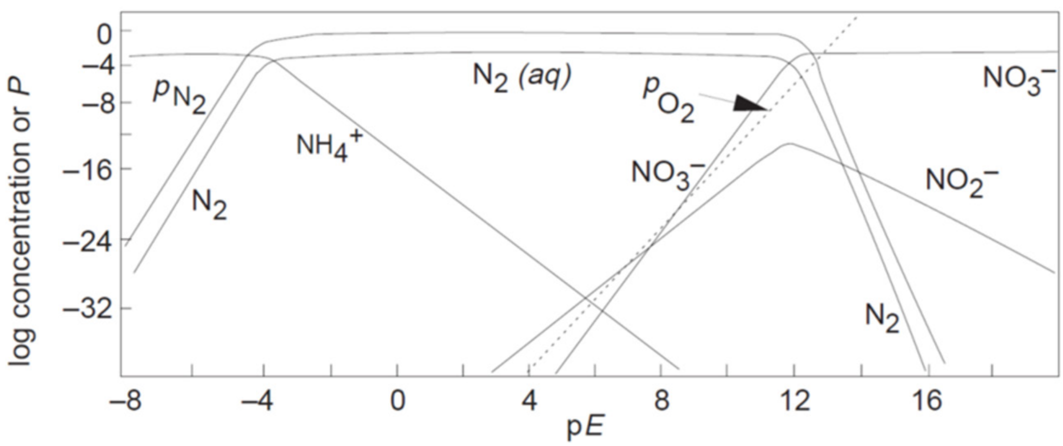

Image credit: Stumm W. and Morgan J.J., 1981. Aquatic Chemistry: An Introduction Emphasizing Chemical Equilibria in Natural Waters, second edition.

Figure 5-1: N Species Distributions Based on the Reduction-Oxidation Potential (pE) in Aquatic Environments

6 WATER QUALITY MODEL NITROGEN SOURCE TERMS

A water quality model was developed by AMNS to estimate possible changes to water bodies impacted by Project discharges. Inputs to the model include, but are not limited to, the site water balance and parameter concentrations at end of mine (EOM) for mine influenced source waters (*i.e.,* source terms) such as the mine pit sump, and drainage from the WRSAs and temporary low-grade Ore Stockpile. The operating Touquoy Mine was used as a proxy to develop the Project source terms for total ammonia (NH_3 + NH_4^+), nitrate (NO_3^-) and nitrite (NO_2^-) and these were derived using Touquoy water quality monitoring data for WRSA drainage and pit sump water. Source terms were developed for Base Case and Upper Case model scenarios. For WRSA and Ore Stockpile drainage, Base Case and Upper Case source terms were derived using annual average and maximum concentrations, respectively. Median and 90th percentile values were used to model the mine pit sump water quality. The monitoring data from Touquoy Mine will be periodically evaluated to determine if revisions to the Project nitrogen source terms are required.

Nitrogen source terms for the Project are also based on the Project mine schedules for blasting, excavation and deposition of blasted rock, as well as the water balance for associated mine facilities Lorax (2021). Nitrogen source terms are concentration-based estimates of the nitrogen species in the mine pit sump and drainage from the NAG WRSA, PAG WRSA, temporary Ore Stockpile at EOM (Table 6-1). The Base Case source terms are based on well-managed explosives use as described in Section 4.3. The Upper Case represents the influence of challenging blasting conditions that may reduce blasting efficiency and increase nitrogen transfer to contact water. The total ammonia (NH_3 + NH_4^+), nitrate (NO_3^-) and nitrite (NO_2^-) source terms and mine schedule assumptions are summarized in Table 6-1 and Table 6-2 below. The annual drainage volumes used for nitrogen source term derivations are shown in Table 6-3.

Table 6-1: Nitrogen Source Terms used for Water Quality Modelling

Facility/Model Condition	Total Ammonia (NH_3 + NH_4^+) (mg N/L)[1]	Nitrate (NO_3^-) (mg N/L)[1]	Nitrite (NO_2^-) (mg N/L)[1]
NAG WRSA			
Base Case	0.41	25.7	0.22
Upper Case	0.73	46.1	0.40
PAG WRSA			
Base Case	0.16	10.4	0.089
Upper Case	0.30	18.6	0.16
Temporary Ore Stockpile			
Base Case	0.066	4.1	0.036
Upper Case	0.12	7.4	0.064
Mine Pit Sump			
Base Case	2.4	5.4	0.19
Upper Case	8.7	15.4	1.6

[1] Concentration units are expressed as nitrogen equivalent (mg N/L). Values can be converted to species specific concentrations (*e.g.,* mg NO_3/L and mg NH_3/L) by applying conversion factors of 0.8224 for ammonia, and 4.43 for nitrate (CCME;2010, 2012).

Table 6-2: Ore and Waste Excavation and Deposition Schedules used for Nitrogen Source Term Derivation (from Halas, pers. comm., 2020; Schulte, pers. comm., 2021)

Table Header	Ore Excavation (t)	Temporary Ore Stockpile (t)	NAG Excavation and Deposition to WRSA (t)	PAG Excavation and Deposition to WRSA (t)
2022	693	250,000	5,539,000	487,000
2023	2,160	250,000	13,506,000	806,000
2024	1,225	250,000	10,009,000	346,000
2025	1,600	250,000	5,899,000	329,000
2026	1,500	250,000	1,758,000	134,000
2027	656	250,000	124,000	23,000
Total	7,834	-	36,835,000	2,125,000

Table 6-3: Estimated Annual Drainage Volumes used for Nitrogen Source Term Derivation (from Lorax, 2021)

Table Header	Temporary Ore Stockpile	NAG WRSA	PAG WRSA
Annual Drainage Volume (m^3)	101,924	887,996	131,379

7 NITROGEN MANAGEMENT AND MITIGATION

7.1 Overview

Nitrogen management for the Project will be achieved through the implementation of best practices for explosives use and blasting, tracking of key metrics for blasting and rock movement, monitoring of water quality and flows, regular audits of explosives handling and blasting practices, and the establishment of threshold values for triggering additional action to maintain water quality objectives. The mining metrics, monitoring data and audit results will be used to trigger management response and inform management decisions. Collectively, the following activities will be conducted to support nitrogen management:

1) NMP training for all staff that have a role in nitrogen management and mitigation (Section 3);
2) Implementation of best practices for explosives use and blasting (Section 4);
3) Monitoring, recordkeeping and auditing (Section 7.2);
4) Establishment of management triggers to initiate management response (Section 7.3); and
5) Management reviews, implementation of actions identified and evaluation of their effectiveness (Section 7.6).

7.2 Monitoring, Recordkeeping and Auditing

The data and records that will be collected and evaluated for nitrogen management are outlined below. These metrics are compared to management triggers to determine when further investigation or action are warranted. A monthly time step is used for most metrics, except water quality and flow monitoring at final discharge points which require weekly monitoring as described in the *Metal and Diamond Mining Effluent Regulations*. An overview of the planned monitoring, recordkeeping and auditing is presented in Table 7-1.

Table 7-1: Monitoring, Recordkeeping and Audits for Nitrogen Management

Type	Parameters[1]	Locations	Frequency
Mining records	Powder factor, excavation and deposition tonnages	Mine Pit Sump, NAG WRSA, PAG WRSA, Ore Stockpile	monthly
Surface water quality	Total nitrogen (T-N) Total ammonia (NH_3 + NH_4^+) Nitrate (NO_3^-) Nitrite (NO_2^-) Field pH, Field Temperature	All final discharge points as defined by MDMER	weekly
		Sediment ponds, mine pit sump	monthly
		Toe seepage from NAG WRSA, PAG WRSA, Ore Stockpile	quarterly
Groundwater quality	Total nitrogen (T-N) Total ammonia (NH_3 + NH_4^+) Nitrate (NO_3^-) Nitrite (NO_2^-)	Downgradient and upgradient of WRSA and Ore Stockpile	monthly
Surface water flows	Discharge	Sediment pond discharges and all final discharge points (as defined by MDMER)	continuous
Audit of explosives use and blast practices	Explosives use and blasting practices	Mine pit and explosives facilities	monthly

[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) by applying conversion factors of 0.8224 for ammonia, and 4.43 for nitrate (CCME;2010, 2012).

7.3 Management Triggers and Response

Management triggers are used to initiate investigation and corrective action for nitrogen source control and mitigation. If the Project NMP monitoring metrics are below the trigger threshold values, then nitrogen source control measures are considered to be effective and additional mitigation is not required. Management triggers will be set at threshold values that provide sufficient advance warning to allow time for implementation of mitigation to prevent effluent limit or guideline exceedances at water quality compliance stations. If a trigger is activated, then the Mine Manager and Environment Manager will be immediately notified, and additional investigation and response will be initiated. The monitoring locations, metrics and initial threshold values shown in Table 7-2 will be reviewed and adjusted in consultation with a Qualified Professional, prior to or during the first year of mining.

Table 7-2: Nitrogen Management Trigger Threshold Values

Monitoring Location	Metric	Initial Trigger value
Mine Pit	Powder factor	Deviation from planned PF
Mine Pit	Blasted tonnage	Deviation from nitrogen source term modelled tonnage
Mine Pit Sump	Pit sump water quality	30% of Base Case water quality model source term for nitrogen species
NAG WRSA, PAG WRSA, Ore Stockpile	Deposition tonnage	Deviation from modelled tonnage
NAG WRSA, PAG WRSA, Ore Stockpile – toe seepage	Seepage water quality	30% of Base Case water quality model source term for nitrogen species
North, East and South Sediment Ponds	Pond water quality	30% of Base Case water quality model prediction for nitrogen species
	Discharge volume	Deviation from nitrogen source term assumption
Final discharge points (as defined by MDMER)	Pond water quality	10% of MDMER effluent limit for un-ionized ammonia (NH_3) 10% of CCME short-term guideline for nitrate (NO_3^-)
Water quality guideline compliance points	Receiving environment water quality	10% of CCME long-term guidelines for nitrogen species
Mine Pit and explosives facilities	Compliance with NMP requirements	Subjective assessment by Mine Manager and Environment Manager

The appropriate response to an activated management trigger will depend upon the outcome of the initial investigation and may include, but is not limited to, the following:

- Adjustment of the trigger threshold value;
- Additional training to improve implementation of NMP source control procedures;
- Expanded monitoring to inform further decision making;
- Updated nitrogen source terms, water quality modelling and environmental effects assessment;
- Identification of mitigation options, as well as timelines and permits needed for implementation; and,
- Revisions to the NMP.

7.4 Mitigation

Implementation of the nitrogen source control and monitoring procedures identified in this NMP is the primary nitrogen management strategy for the Project. Mitigation using water treatment is a secondary strategy that will be implemented if needed. An assessment of nitrite treatment technology and possible implementation at the Project site indicates total ammonia (NH_3 + NH_4^+), nitrate (NO_3^-) and nitrite (NO_2^-) concentrations will meet effluent limits and water quality guidelines for the Base Case (*i.e.*, expected) mining conditions (GHD, 2020). However, Upper Case model results indicate nitrite (NO_2^-) may exceed water quality guidelines in the Killag River during summer months (GHD, 2020). The initial management trigger values are set at conservative levels to ensure there is sufficient lead time to select, procure and commission treatment, if needed, in order to minimize the risk of exceeding CCME water quality guidelines. The conceptual approach for treatment of nitrite in North Pond effluent includes UV-peroxide or biological nitrification technology (GHD, 2020). If treatment is necessary, additional technology evaluations through engagement with vendors and bench testing will be required prior to final technology selection.

7.5 Reporting and Management Review

Formal reporting of NMP monitoring results and comparison to management trigger values will be conducted in monthly reports that are distributed for review to the Mine Manager and Environmental Manager and other staff responsible for N management, as needed. Records and reports of NMP monitoring will be maintained and provided for regulatory review if requested by an applicable regulatory agency. An annual summary of the NMP management and monitoring results will be reported externally as a component of the Industrial Approval Annual Report.

The overall implementation and effectiveness of this NMP will be reviewed quarterly by the Mine Manager and Environment Manager, with the review led by the Environment Manager. Reviews will include monitoring records, nitrogen audits and an evaluation of the implementation of the NMP. Action items arising from the review process will be assigned to the appropriate individuals and tracked for future evaluation.

7.6 Nitrogen Management Plan Revisions

This NMP will be reviewed and revised, if necessary, during the first year of mining, and periodically thereafter, to ensure that NMP procedures remain appropriate to meet the performance objectives as mine facilities are developed. During mining, and in the context of continuous improvement, the NMP procedures are expected to be revised and refined based on the NMP monitoring data, N source control audits and source control investigations. Proposed revisions will be reviewed by a Qualified Professional prior to implementation. In addition, the document will be revised if any of the following occur:

- The mine plan changes significantly, affecting the water quality model predictions for nitrogen compounds;
- The NMP monitoring results for total ammonia (NH_3 + NH_4^+), nitrate (NO_3^-) and nitrite (NO_2^-) are significantly elevated compared to predicted values; or
- There are changes or additions to the regulatory limits outlined in Section 2.

8 CLOSURE

In preparing this report, the authors have relied upon the written information provided by Atlantic Mining Nova Scotia Incorporated and GHD. The authors accept no responsibility for any deficiency, misstatement, or inaccuracy contained in this report as a result of omissions, misinterpretations, or inaccuracies in the information relied upon or data that were not made available for review. The report is provided for the exclusive use of Atlantic Mining Nova Scotia Incorporated subject to the terms and conditions of its contract with Lorax Environmental Services Limited. The authors accept no responsibility for the implementation of the plan, or any other use of, or reliance on, this report by any third party.

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