MEMORANDUM

To: John Perkins and Gregor Wilson; Sustainable Northern Nova Scotia (SuNNS)
From: Ann Maest, PhD; Buka Environmental
Date: 4 July 2018
Re: Initial Evaluation of Potential Water Quality Issues Related to Development of the Cobequid Highlands Project, and Recommendations for Additional Studies

Introduction

Interest in prospecting for gold in northern Nova Scotia has increased in the last several years after the discovery in 2011 of a low-sulphidation epithermal gold potential (Nova Scotia DNR, 2018a). The Nova Scotia Department of Natural Resources (DNR) has focused on a 70,000-acre parcel near Warwick Mountain with gold potential, referred to as the Cobequid Highlands Project (the Project). A Call for Proposals for Exploration is expected to be announced in late June 2018, and the successful proposal will be announced in October (Personal Communication, John Perkins discussion with DNR; Nova Scotia DNR, 2018a). The DNR has released digital maps, data, and reports (Nova Scotia DNR, 2018b). The information released is relevant for exploration but does not contain the type of studies needed to evaluate the potential environmental impacts of development of the Project, especially those related to water quality.

This memorandum presents an initial evaluation of the potential water quality effects of Project development, based on the limited available information on deposit type, mineralogy, nearby water quality, and information on the environmental effects of developing similar deposits. My work is conducted at the request of Sustainable Northern Nova Scotia (SuNNS),[1] a local citizen organization that is concerned about the effects of mining on their water supply, which is located in the French River watershed headwaters close to the Project. The memo discusses existing mining impacts in Nova Scotia, deposit type and baseline water quality, potential water quality impacts from mine development, and additional information needed.

Existing Mining Impacts in Nova Scotia

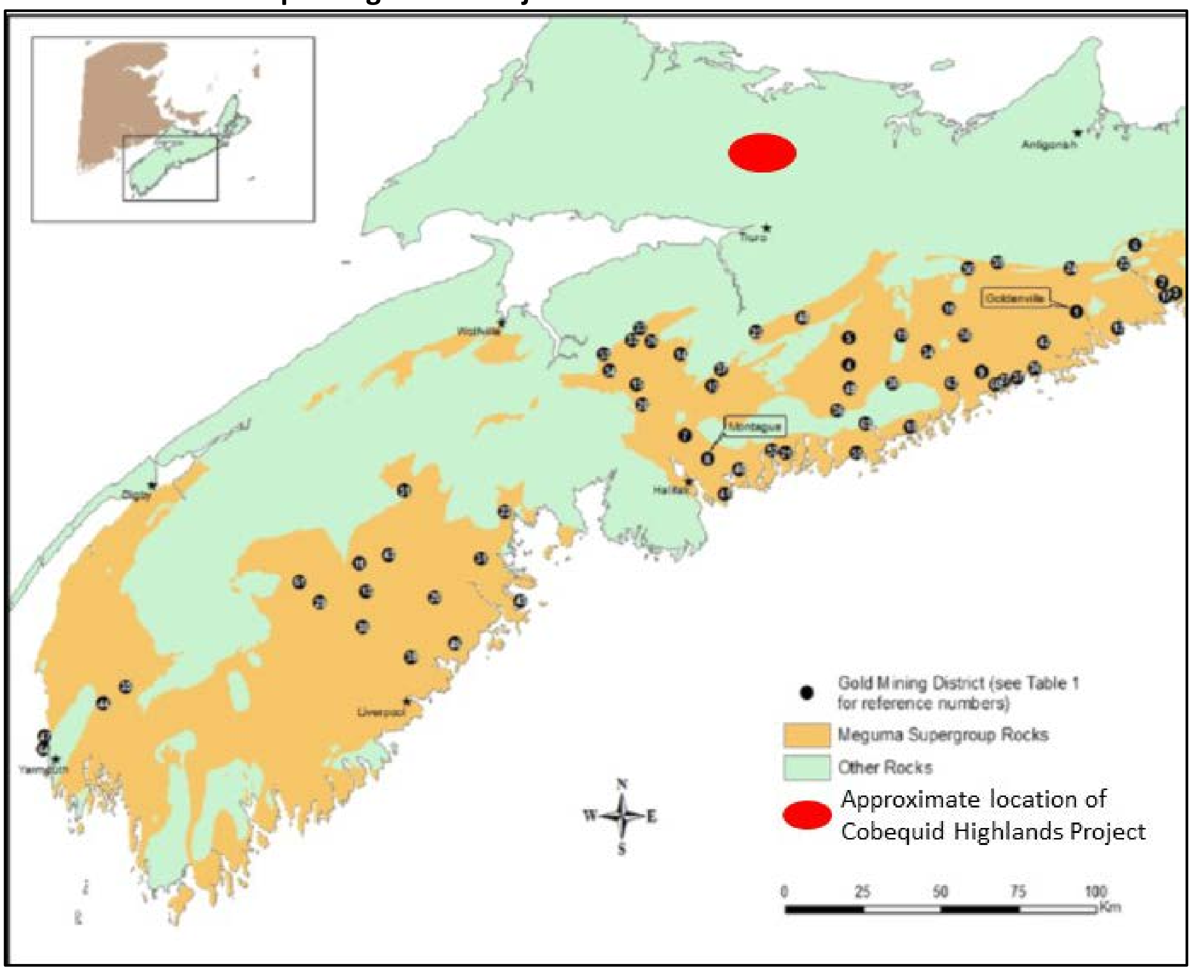
Gold mining in Nova Scotia started in the 1860s and has left a legacy of adverse effects to water quality, human health, terrestrial wildlife, and fisheries (Environment Canada, 2007; Drage, 2015). Most of the mining occurred in the southern portion of the province, while the Cobequid Highlands Project is in the north (Figure 1). The effects from historic mining examined to date relate largely to the uncontrolled release of mine tailings to streams, ponds, wetlands, land, and the ocean (Drage, 2015). The major contaminant of concern in the tailings is arsenic, but elevated concentrations of mercury, nickel, lead, antimony, and have also been measured in the tailings above Canadian Council of Ministers of the Environment (CCME) soil

[1] https://sunns.org/

and/or sediment quality guidelines (Parsons et al., 2012). Mercury was used to remove and concentrate gold from the ore.

High-arsenic groundwaters also exist, especially downgradient of tailings areas. Background (non-mining-impacted) arsenic concentrations in areas in or near the mining districts were examined by Parsons et al. (2012). Background arsenic concentrations were generally <25 μg/L, with a range of 5 to 100 μg/L. Water quality affected by mine tailings had much higher concentrations ranging up to 6,580 μg/L with a median value of 117 μg/L (Parsons et al., 2012). The CCME guideline for arsenic for the protection of aquatic life is 5.0 μg/L, and the federal Canadian drinking water standard is 10 μg/L (CCME, 2018; Government of Canada, 2018).[2] Background water quality is site-specific and depends on the extent of mineralization, the presence of non-mining releases, and local hydrogeochemical factors. Consequently, a Cobequid Highlands baseline water quality analysis, which would estimate water quality conditions in the absence of mining, must be site-specific and cannot use data from other areas.

Figure 1. Map showing location of 26 gold mining districts in Nova Scotia, with approximate location of the Cobequid Highlands Project in northern Nova Scotia.



Source: Drage, 2015, Figure 1, with approximate location of Cobequid Highlands Project.

[2] Nova Scotia has adopted the Guidelines for Canadian Drinking Water Quality as legally binding standards for regulated public drinking water supplies and recommended for private well owners. https://novascotia.ca/nse/water/waterquality.asp

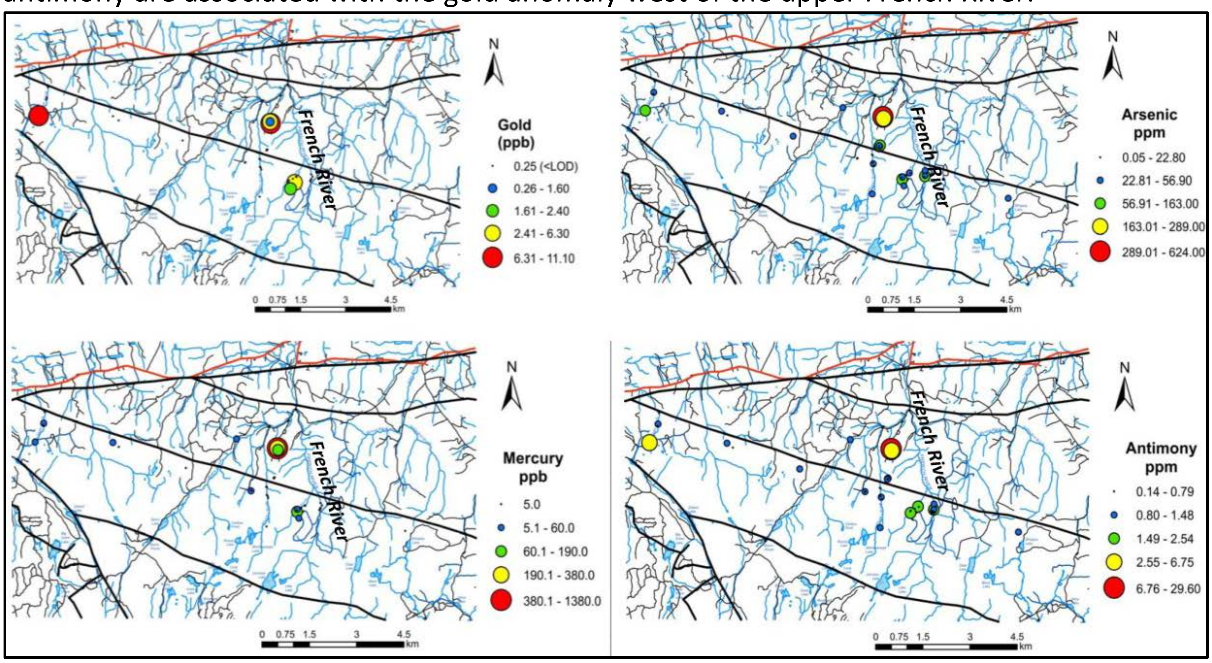
Overview of Geology, Mineralization, and Local Water Quality

Geology and Mineralization

The gold mineralization geology is in Carboniferous-age volcanic rocks of the Byers Brook and Diamond Brook formations (Nova Scotia DNR, 2018a). The Byers Brook Formation is the lower unit and is primarily rhyolitic and felsic volcaniclastic; the overlying Diamond Brook Formation is primarily basaltic (Baldwin, 2016). The upper part of the Byers Brook Formation has been hydrothermally altered and sulphidized, with silicic and potassic alteration. Byers Brook Formation rhyolites near the top of the formation in the Warwick Mountain area to the west of the French River are intensely brecciated and altered and contain large blebs of pyrite (Baldwin, 2016). The Diamond Brook Formation west of the French River is the most highly altered and contains zones of pyrite-calcite veining and intense potassic and silicic alteration. The presence of arsenopyrite (an arsenic-iron sulfide) and massive sulphide mineralization were also noted in the Warwick Mountain area (Mills and Fodor, 2016).

The Nova Scotia DNR reports are careful to not refer to the mineralization as a gold *deposit* and note that most samples had gold values below the detection limit of 0.5 ppb (Baldwin, 2016). However, the arsenic (As), mercury (Hg), and antimony (Sb) values are elevated, especially for As and Sb, with maximum values of 624 ppm As, 1.38 ppm Hg, and 29.6 ppm Sb (Figure 2). World average crustal abundance values for As, Hg, and Sb are 1.8, 0.08, and 0.2 ppm, respectively (Taylor, 1964). In addition to these elements, concentrations of lead, tungsten, and cadmium were elevated in Cobequid Highlands rock samples (MacHattie, 2013).

Figure 2. Maps showing location of rock samples with elevated concentrations of gold, arsenic, mercury, and antimony in the Warwick Mountain Upper French River area. Each map shows the same geographic area. Elevated concentrations of arsenic, mercury, and antimony are associated with the gold anomaly west of the upper French River.



Source: Baldwin, 2016; Figures 4 and 5.

The presence of pyrite has been noted in Baldwin (2016); Mills and Fodor (2016, also arsenopyrite); and MacHattie (2013). MacHattie (2017) is calling for high-resolution geochemical mapping of pyrite in the Cobequid Highlands Project area. Although the gold potential is referred to as a low-sulphidation occurrence, highly altered parts of the volcanic formations hosting the gold are referred to as sulphidized because they do contain noticeable amounts of sulfide minerals (MacHattie, 2017). The most promising area for gold mineralization is in the Warwick Mountain area (Baldwin, 2016), and the justification for reserving such a large area for exploration (70,000 acres) has not been presented.

Water Quality

Some limited information is available on the water quality in the Cobequid Highlands area. The disparity between sampling for mineral prospecting in northern Nova Scotia versus sampling for water quality and evaluating the potential environmental effects of mining is staggering. For example, between 1986-87 approximately 3,300 stream sediment samples from northern Nova Scotia were analyzed for 35 metals in heavy mineral separates and for 17 metals in the fine fraction. In contrast, stream water samples from these same areas were only analyzed for two elements: uranium and fluorine[3] (Nova Scotia DNR, 2006).

The only baseline water quality sampling in the area that determined metals in surface water was conducted by the Nova Scotia DNR on one sampling date in November 2016 (Drage, 2017). The sampling effort was aimed specifically at determining baseline water quality in the area that could be explored for mineral potential in the upper French River watershed. The watershed has a source water protection plan and is the drinking water source for the Village of Tatamagouche (Drage, 2017). Five of the eight samples were collected inside the area currently closed but that will later be opened to mineral exploration. The water chemistry analyses were performed on unfiltered water samples and were fairly complete in terms of measuring major cations and anions and total metals.[4] The sample handling methods and the laboratory detection limits were good, although an analytical method should be used for copper and zinc, which had detection limits of 2.0 and 5.0 μg/L, respectively, that would allow detection at 1.0 μg/L. Based on the information in Drage (2017), the sampling appears to be a good effort in terms of quality control and conceptualization.

The results from the 2016 DNR sampling effort show that the waters sampled in the upper French River watershed have very low solute concentrations, and most metals, including those that could be released from exploration and mining efforts, were below detection. Nutrient (nitrate, nitrite, ammonia, orthophosphate) and sulphate levels were also close to or below detection limits. Hardness (a measure of total calcium and magnesium) and alkalinity (a measure of the neutralizing ability of the water) were also low. Table 1 provides a summary of some of the more important parameter concentrations (mean and concentration ranges) for evaluating baseline water quality. In Drage (2017) the results were compared to drinking water standards but not aquatic life criteria. As noted in the Drage (2017) report, the sampling was a first step, and additional sampling is needed to capture seasonal and other temporal variability in water quality.

[3] I assume they mean fluoride rather than fluorine.

[4] Fluoride would be a good addition for future sampling efforts.

Table 1. Water quality summary (mean and range) for French River headwater streams sampled in 2017 and comparison to drinking water and aquatic life standards.

Parameter	Units	Mean	Range	Drinking Water Standard	Aquatic Life Criterion[1] (short term/long-term)
Bicarbonate Alkalinity	mg/L as $CaCO_3$	11.2	6.6 – 16	NA	NA
Hardness	mg/L as $CaCO_3$	13.1	8.2 – 18	NA	NA
Nitrate+Nitrate	mg/L as N	<0.05	<0.05 - <0.05	10	124/2.9
Ammonia (total)	mg/L as N	<0.05	<0.05 - <0.05	NA	NA/pH and temperature dependent
Total Organic Carbon	mg/L C	2.5	1.5 – 5.9	NA	NA
Sulphate	mg/L	1.7*	<2 – 2.6	≤500 AO	NA
Antimony	µg/L	<1	<1 - <1	6	NA
Arsenic	µg/L	<1	<1 - <1	10	NA/5
Cadmium	µg/L	0.017*	<0.01 – 0.028	5	1.0/0.09
Copper	µg/L	<1	<1 - <1	≤1000 AO	NA/2
Lead	µg/L	<0.50	<0.50 - <0.50	10	NA/1
Zinc	µg/L	<2.5	<2.5 - <2.5	≤5000 AO	NA/30

Sources: Drage, 2017; CCME, 2018; Health Canada, 2017.
1 at a hardness of 25 mg/L as $CaCO_3$
** Used ½ detection limit for values below detection*
NA = not applicable (no standard exists)
AO = aesthetic objective

Potential Water Quality Impacts from Exploration and Mining of the Cobequid Project

Primary Threats to Water Quality

Although much more information is needed, the primary threats to water quality from exploration and development of the Cobequid Project are the formation of acid drainage and the leaching of arsenic, antimony, and mercury. Leaching of arsenic and antimony from rocks and mine wastes are enhanced at both acidic and alkaline pH values and are therefore not dependent on the formation of acid drainage. Adverse effects to water quality will affect drinking water and the sustainability of aquatic life.

Acid rock or mine drainage forms when iron-containing sulfides in rocks are exposed to oxygen and water. The most common minerals that form acid drainage are pyrite and pyrrhotite (iron sulfide minerals), but arsenopyrite (arsenic iron sulfide) and chalcopyrite (copper iron sulfides) can also produce acid drainage when exposed to oxygen. The formation of acid drainage is greatly enhanced by the presence of bacteria such as *Thiobacillus thiooxidans* and *Thiobacillus ferrooxidans,* which are ubiquitous in mine wastes. Although acid drainage can occur naturally (and is then referred to as acid rock drainage), mining greatly increases the surface area of minerals exposed to oxygen and therefore increases the rate of acid drainage formation and metal leaching (Nordstrom and Alpers, 1999). Acid waters can also develop from the dissolution of certain secondary sulfate salts that form from the weathering of primary sulfide minerals such as pyrite (Jambor et al., 2000; Maest and Nordstrom, 2017). Acid drainage can be neutralized by direct contact with carbonate minerals (primarily calcite and dolomite) and to a lesser extent by interaction with certain aluminosilicate minerals (Blowes et al., 2003).

The potential for development of acid rock drainage has been estimated for the southwestern part of Nova Scotia,[5] but the map does not extend into the northern or eastern portions of the province. Nova Scotia has Sulphide Bearing Materials Disposal Regulations (part of the Environment Act) that considers any material with ≥0.4 weight percent sulphur acid-producing (Tarr and White, 2016). A similar analysis should be conducted for the Cobequid Highlands area before mine disturbance begins.

Mineralogy and Deposit Type

Little is currently known about the types or percentages of sulfide and carbonate minerals in rocks of the Cobequid Highlands Project area. The rock types in the area are rhyolite and basalt, which do not contain notable amounts of carbonate minerals, except in veins. Extensive alteration[6] of these rocks has occurred in zones of interest for gold exploration (Baldwin, 2016). The mineralogy of the alteration is only generally known, but pyrite has been observed in the more altered areas. For example, Baldwin (2016) reports the presence of intense alteration and pyrite veining along Whirley Brook Road, where previous drilling has occurred. If pyrite-rich outcrops or near-surface exposures exist in the Cobequid Highlands area, it is possible that minor to moderate disturbance during exploration could generate acid drainage. Mills and Fodor (2016) note that arsenopyrite was found in a surface bedrock exposure at Warwick Mountain, as was massive sulphide mineralization. Arsenopyrite can form acid drainage and releases arsenic, and massive sulphide deposits are known to have high percentages of pyrite and other sulfides (Plumlee, 1999; Seal and Hammarstrom, 2003). If volcanigenic massive sulphide mineralization occurs in the Project area, the potential for acid mine drainage formation increases dramatically (Plumlee et al., 1999). In light of the known presence of pyrite, arsenopyrite, and intense alteration, it is critical that baseline water quality evaluations are completed before any additional prospecting or exploration begins. The advisability of allowing gold mining in an area containing a known drinking water resource must also be questioned.

Baldwin (2016) appears to compare the Cobequid Highlands Project to volcanic gold deposits in the northern Great Basin of Nevada, yet not enough information exists to make these comparisons. If Baldwin is referring to the Carlin Trend mines in Nevada, which have high

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[5] Nova Scotia DNR. Acid Rock Drainage. https://novascotia.ca/natr/meb/geoscience-online/ard_about.asp

[6] "Alteration" is the modification of original minerals in rocks, primarily by circulating hot fluids, which often supply the gold and other metals of economic interest.

arsenic and mercury concentrations, the environmental behavior of those mines is not desirable, and the meteorologic conditions in Nevada are very different than those in Nova Scotia. The Carlin Trend mines are in sedimentary rocks and generally have low acid drainage potential, but acid mine drainage has occurred at the Rain, Hollister, and Gold Quarry Mines in Nevada (Bureau of Land Management, 2011).

Baldwin (2016) mentions the presence of paleosinter and sinter deposits on the contact between the Byers Brook and Diamond Brook formations. The presence of sinter and elevated concentrations of As, Sb, and Hg, such as has been found in the Cobequid Highlands rocks, are often associated with hot-spring gold deposits (Plumlee et al., 1999). Examples of hot spring gold deposits include the Leviathan Mine in California, the McLaughlin Mine in California, and the Round Mountain Mine in Nevada. Drainage waters from the McLaughlin Mine are highly acidic and have high dissolved concentrations of copper, cobalt, nickel, chromium, arsenic, and thallium (Plumlee et al., 1999).

The gold occurrence is labeled as a low-sulphidation epithermal deposit type, yet it is also described as sulphidized, and pyrite has been noted in several reports. It is clear that more information is needed to understand the deposit type, if in fact a deposit exists. Knowledge of the deposit type can help understand potential drainage water quality that could develop from excavation of the deposit. However, conducting geochemical testing of rocks in the Cobequid Highlands Project area to determine the acid generation and contaminant leaching potential over the short-term and longer term will produce more definitive results than simply knowing the deposit type.

Environmental Effects of Mineral Exploration

Relatively few peer-reviewed articles have been published on the environmental effects of mineral exploration. A study conducted on the Pebble site after exploration showed that exploration drilling and disposal of drill core caused contamination of soils and some water samples. The Pebble Project is a copper-molybdenum-gold ore body and a sulfide deposit. Exploration drill cuttings were consistently elevated in copper and molybdenum and had acidic pH values (Zamzow and Chambers, 2017). Some soils also contained petroleum hydrocarbons; while the company states these reflect biogenic (natural) conditions, soils and wetland sediment were found to have elevated concentrations of diesel and residual range petroleum organics (Zamzow and Chambers, 2016). These results suggest that mineral exploration activities need to be carefully regulated and remediated and that adverse impacts to water, sediment, and soil can easily occur.

Implications for Water Quality

The low alkalinity in the upper French River watershed indicates that the streams will have essentially no ability to neutralize any acid produced during exploration or mining (see Table 1). The very low hardness will also increase the toxicity of metals to aquatic life, especially for copper, cadmium, lead, and zinc toxicity to salmonids (e.g., salmon and trout) and other aquatic biota (Spry and Wiener 1991; Wang, 1987; Welsh et al., 1999). The measured hardness values (8.2 - 16 mg/L as $CaCO_3$) are below those recommended to be used to calculate water quality criteria for hardness-dependent metals. This means that the toxicity of metals such as lead, zinc, cadmium, and copper is not well known in the French River headwaters. The French River is a known Atlantic salmon spawning stream (Government of Nova Scotia, 2017). Site-specific testing of resident or representative fish with local surface waters is recommended to resolve this uncertainty. Using a hardness of 25 mg/L as $CaCO_3$, the long- and short-term standards are shown in Table 1. The chronic and acute values are a measure of the highest concentration that sensitive aquatic biota can be exposed to over longer and short periods of time, respectively, without causing adverse effects; therefore, chronic standards are lower (lower in concentration) than acute values. The presence of dissolved organic matter can ameliorate some of the effects of metal toxicity, but the measured values are not especially high (see Table 1), and more would need to be known about the type of organic matter and organic ligands present to estimate their effects on toxicity (Marr et al., 1999). Given the high uncertainty of metals toxicity in French River headwaters, the very clean water currently in the streams, and the potential for metals to be released from mine exploration and development, extraordinary care must be taken to understand baseline water chemistry, aquatic biological populations, and the toxicity of metals to local or representative aquatic species when added to headwater streams before any disturbance begins.

In addition to metals, nitrate and ammonia can be released during exploration and mining. The most commonly used blasting agent at mines is ANFO (ammonium nitrate-fuel oil), and its use will release nitrate, ammonia, and petroleum organics to water resources. Even if no ore is processed on site, blasting of the underground workings or open pits will release these contaminants to groundwater and surface water. The Buckhorn Mine, an underground gold mine in Washington State, USA, is a relatively small mine that is currently beginning closure and that has been in violation of its Clean Water Act discharge permit since it began mining eight years ago (Washington State Department of Ecology, 2014). Nitrate and ammonia concentrations decrease after blasting stops, but during exploration (if blasting is used), construction, and operations – and into closure – elevated nitrate concentrations can persist. Measured concentrations of nitrate and ammonia were below detection in 2017 (see Table 1), and increases can adversely affect water quality and lead to eutrophication of lakes or ponds in the area (Mueller and Helsel, 1996). Because of its presence in blasting agents, the baseline water quality evaluation should also include petroleum hydrocarbons in the list of analytes.

Groundwater in Nova Scotia has been contaminated with arsenic in areas affected by historic mining. The seriousness of the problem led to establishing the Historic Gold Mines Advisory Committee in 2005 (Parsons et al., 2012). As shown in Figure 2, high concentrations of arsenic, antimony, and mercury have been found in rocks in the Cobequid Project area, and the potential exists for leaching of these elements to groundwater and surface water. The surface water sampled in 2017 (see Table 1) has low concentrations of arsenic, antimony, and mercury, but groundwater has not been sampled. A baseline water quality evaluation of groundwater in the Cobequid Highlands area should be conducted before additional disturbance is allowed.

Areas with close proximity to groundwater and surface water, like the Cobequid Highlands area, are more susceptible to water quality impacts from mining, especially if the mined materials have a moderate to high potential to release acidity and metals (Kuipers et al., 2006). Mines with shallow groundwater always need to pump groundwater and discharge it to streams because of the positive water balance (precipitation exceeding evaporation). The Cobequid Highlands area is clearly an area with abundant water. If the ore is not processed on site, no pumped groundwater will be used in mine processes, and essentially all water pumped will need to be discharged. The pumped water will be affected by blasting and dissolution of sulfides and other minerals and will require treatment to adjust the pH and remove nitrate, ammonia, metals, sulfate and other mine-related contaminants to very low levels before it is discharged to avoid adverse impacts to water quality. Groundwater levels will be lowered during mining and will affect groundwater-surface water interactions and the availability of water for other uses. The close proximity to water, the expected elevated concentrations of arsenic, antimony, and mercury that will likely be leached from the mined materials, and the purity of the water under baseline conditions lead to the preliminary conclusion that water quality in the Cobequid Highlands area has a high risk of being adversely affected by mining activity.

Summary and Recommendations for Additional Studies

- Mineral exploration activities need to be carefully regulated and remediated because of the potential for adverse impacts to water, sediment, and soil. In light of the known presence of pyrite, arsenopyrite, and intense alteration, it is critical that baseline water quality evaluations, discussed in more detail below, are completed before any additional prospecting or exploration begins.
- It is clear that more information is needed to understand the deposit type, if in fact a deposit exists. Knowledge of the deposit type can help understand potential drainage water quality that could develop from excavation of the deposit. However, conducting geochemical testing of rocks in the Cobequid Highlands Project area to determine the acid generation and contaminant leaching potential over the short-term and longer term will produce more definitive results than simply knowing the deposit type. This can be accomplished at a preliminary level using the existing rock samples and cores before exploration drilling is undertaken.
- Little information on metal toxicity to aquatic biota exists at the very low hardness and alkalinity values measured in the French River headwaters. Given the high uncertainty of metals toxicity in French River headwaters, the very clean water currently in the streams, and the potential for metals to be released from mine exploration and development, extraordinary care must be taken to understand baseline water chemistry and aquatic biological conditions before any disturbance begins. Site-specific testing of resident or representative fish with local surface waters is recommended to resolve this uncertainty.
- A detailed baseline water quality evaluation of groundwater and surface water is needed for the Cobequid Project area. My understanding is that groundwater quality has not been sampled in the area and only one sampling of surface water that included metals analysis was conducted in 2017. In addition to the major cations and anions, metals, metalloids, and dissolved organic carbon determined in samples collected in 2017, the baseline water quality evaluation should also include petroleum hydrocarbons in the list of analytes because of its presence in blasting agents.
- The close proximity to water, the expected elevated concentrations of arsenic, antimony, and mercury that will likely be leached from the mined materials, and the

purity of the water under baseline conditions lead to the preliminary conclusion that water quality in the Cobequid Highlands area has a high risk of being adversely affected by mining activity.

The Nova Scotia DNR has been heavily involved in evaluating the potential of the Warwick Mountain area for mining, but no effort has been expended on examining the geochemical characteristics that would indicate the potential to adversely affect the environment, especially water quality. The following information is needed to improve the understanding of the potential effects of mining on water quality:

- Evaluation of background As, Sb, Hg, Pb, Cd, Ni, and possibly other potential mine contaminant concentrations and variability (temporal for water quality, and geographic) in area groundwater and surface water, sediment, soils, aquatic and terrestrial biota, vegetation. Background water quality sampling should be conducted for a minimum of two years to evaluate seasonal variability, and available data should be gathered to evaluate longer term inter-annual variability.
- Evaluation of groundwater elevations in the mineral withdrawal area, groundwater-surface water-wetland interactions, and modeling of the effect of groundwater lowering during mining (groundwater pumping) on area groundwater levels and availability, including to private wells. The effects on the drinking water source for the Village of Tatamagouche must be examined.
- Major element chemistry, including major cations (sodium, calcium, magnesium, potassium) and major anions (alkalinity [bicarbonate and carbonate], chloride, sulfate, fluoride] of area groundwater and surface water.
- Geochemical characterization of the deposit for whole rock chemistry, acid-generation and neutralization potential; short-term leaching potential; long-term leaching potential; percent total sulfur and sulfide sulfur. For a summary of the types of testing needed, see Maest et al. (2005) and INAP (2009).
- Detailed mineralogy of the samples with anomalous gold, arsenic, mercury, and antimony values, including primary and secondary minerals, with a focus on sulfide and carbonate mineralogy.
- Acid rock/mine drainage assessment of the Cobequid Highlands area.

Biographical Sketch for Ann Maest

Ann Maest is an aqueous geochemist with Buka Environmental in Boulder, Colorado, USA. She has over 25 years of research and professional experience and specializes in the environmental effects of hardrock mining, the fate and transport of natural and anthropogenic contaminants, and geochemical testing methods for mine wastes. She has evaluated more than 150 Environmental Impact Statements for large-scale mines in the United States, Latin America, Asia, and Africa and provides training to government agencies and communities on EIS evaluation, the environmental effects of mining, and best practices. The results of her research have been published in peer-reviewed journals including *Applied Geochemistry*, *Canadian Journal of Fisheries and Aquatic Sciences*, *Chemical Geology*, *Applied and Environmental Microbiology*, and *Environmental Science and Technology*. After completing her PhD, Dr. Maest was a research geochemist in the U.S. Geological Survey's National Research Program, where she conducted research on metal-organic interactions, metal and metalloid speciation, and redox geochemistry in surface water and groundwater

systems. She has served on several National Academy of Sciences committees and a Board related to earth resources and has been an invited speaker at universities and national and international fora, including presenting on technical challenges and solutions for the mining sector at the United Nations. Ann holds a PhD in geochemistry and water resources from Princeton University.
Website: www.buka-environmental.com [best viewed on Firefox]

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