Controlling Arsenic Releases to the Environment in the Northwest Territories

Summary

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Environmental Protection
Environment Canada
P.O. Box 370
Yellowknife, Northwest Territories
X1A 2N3

Prepared by:

Donald D. MacDonald
MacDonald Environmental Sciences Ltd.
2376 Yellow Point Road, R.R. #3
Ladysmith, British Columbia
V0R 2E0

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Introduction

Arsenic is a naturally-occurring substance that is found most often in compounds with sulphur, either alone or in combination with various metals. Arsenic is present in the environment as a result of natural processes and human activities. The man-made sources of arsenic include metal processing, the use of arsenical pesticides, coal-fired power generation, and the disposal of domestic and industrial waste materials.

Metal production facilities are the principal sources of arsenic released into the Canadian environment from human activities. Based on release data from the National Pollutant Release Inventory (NPRI) for 1994, 45 facilities reported total arsenic releases of 47.2 tonnes to water, 132.9 tonnes to the air, 3800.0 tonnes to underground, and 0.3 tonnes to land.

In 1994, "Arsenic and its Compounds (Priority Substances List Assessment Report)" was released by the Government of Canada. The report concluded that arsenic and its inorganic compounds are "toxic" as interpreted under section 11 of the Canadian Environmental Protection Act (CEPA). As such, arsenic should be managed in a manner that prevents or minimizes its release into the environment.

Environment Canada assembled a technical task force in August, 1995 to examine options for controlling arsenic releases to the environment in the Northwest Territories. While reviewing the available technical information, the Task Force recognized the presence of some information gaps in the areas of technology and socio-economics, and engaged consultants to conduct studies and provide the required information.

This report summarizes the findings of the Task Force in the technical report "Controlling Arsenic Releases to the Environment in the Northwest Territories - Discussion of Management Options". The purpose of these documents is to facilitate public consultation in the Northwest Territories regarding the various management options for controlling arsenic releases. Interested individuals are encouraged to read the technical report for additional information and details.

Sources and Releases of Arsenic to the Environment

In the Northwest Territories, the mines and mills that extract and process arsenic-bearing rock represent the major man-made sources of arsenic. At present, there are eight metal mines and mills operating in the Northwest Territories. These operations include two base metal mines (Nanisivik Mine on Baffin Island and Polaris Mine on Little Cornwallis Island) and six gold mines (Colomac Mine at Steeves Lake, Lupin Mine at Contwoyto Lake, Mon Mine at Discovery Lake, and the Giant, Miramar Con, and Ptarmigan mines nearby Yellowknife).

Arsenic can be released to the environment during two stages of metal processing: milling and refining. During milling, the raw ore is processed to concentrate the target metals and remove many of the waste materials. When arsenic-bearing ores are processed, the waste products or *tailings* may contain arsenic. These tailings are typically stored on site in a tailings pond, where the solids are allowed to settle. Subsequently, the liquid effluent is discharged to surface waters, either with or without further treatment. All mines in the NWT mill the ore on site, and therefore have the potential to release arsenic into water.

While base metal mines in the NWT do not refine the concentrate on site, most of the gold mines do operate refineries to recover the gold. Refining activities produce additional wastes, which are usually disposed of on site. One refining process is smelting, which involves the use of heat to remove the unwanted substances from the concentrate. Smelting can result in the release of arsenic into the atmosphere.

Releases of Arsenic to Water

The discharge of water from the tailing ponds at operating metal and gold mines represents the primary source of arsenic to surface waters in the NWT . Other potential sources of arsenic to surface waters include runoff from contaminated soils and deposition (i.e., settling) of arsenic that is released into the atmosphere. The potential also exists for the arsenic trioxide (the main form of arsenic in gold roaster emissions), which has been stored in unused mine workings at the Giant mine, to enter Great Slave Lake (i.e., through the groundwater).

Releases of arsenic into water from operating mines and mills in the NWT are primarily controlled under the Northwest Territories Waters Act and, eventually, the Nunavut Waters Act. This legislation provides the NWT Water Board and the Nunavut Water Board with the authority to issue water licenses, which often specify acceptable levels of arsenic in liquid effluents. The Water Boards also have the authority to address other issues, that could affect water quality, such as underground arsenic storage.

Based on the information assembled, the Task Force determined that the releases of liquid effluent containing arsenic, as well as the associated issues, could be adequately addressed by the existing water licensing process in the NWT. Therefore, no further action on releases of arsenic to water was recommended.

Releases of Arsenic to Air

Of the six gold mines in the NWT, only the Giant and Miramar Con mines have utilized a smelting process to refine their ore concentrates. The Miramar Con mine began operating a gold roaster as part of its refining process in 1942. While the operation of this facility was suspended in 1943, roasting operations resumed in 1948 and continued until the roaster was decommissioned in 1970. The Giant mine has operated its roaster continuously since 1949.

Between 1942 and 1975, the releases of arsenic to the air from the gold roasters at the Giant and Miramar Con mines were not measured. Instead, arsenic emissions were estimated using information on the amount of arsenic present in the ore, in the concentrate, and in the tailings (i.e., using mass balance calculations). Since 1975, the concentrations of arsenic in the emissions from the gold roaster at the Giant mine have been periodically measured and used to estimate total releases to the atmosphere.

Examination of the data on arsenic releases to the air in Yellowknife leads to the following observations:

- From 1949 to 1951, approximately 7400 kilograms of arsenic per day were released to the atmosphere from the two roasters. Almost 99% came from Giant Mine.
- From 1954 until 1958, approximately 3300 kilograms of arsenic per day were released to the atmosphere from the roasters. Almost 95% came from Giant Mine.
- From 1959 until 1970, approximately 370 kilograms of arsenic per day were released to the atmosphere from the roasters. Approximately 50% came from each mine.
- From 1971 until 1977, approximately 350 kilograms of arsenic per day were released to the atmosphere from Giant Mine.
- Arsenic emission rates decreased substantially between 1975 and 1978 mainly as a result of changes that Giant Mine made to the operation and maintenance procedures for their air pollution control system in 1977.
- The average concentrations and daily release rates of arsenic in 47 tests since 1978 are 24.1 milligrams/cubic metre (mg/m^3) and 30.5 kilograms/day (kg/day) respectively.

Levels of Arsenic in the Atmosphere

The air in non-urban and non-industrial areas typically contains very low levels of arsenic (i.e., < 0.0005 µg/m^3). Urban areas can have somewhat higher levels of arsenic. A survey of 11 Canadian cites revealed that arsenic levels ranged between < 0.0005 and 0.017 µg/m^3 during the period 1985 to 1990. The mean annual concentration in Canadian cities is 0.001 µg/m^3 of arsenic, and levels have ranged between 0.0086 and 0.22 near industrial point sources.

Air quality monitoring has been conducted in the Yellowknife area between 1973 and present. Monitoring sites have included the Federal Building in downtown Yellowknife, the Fisheries and Oceans Canada warehouse in Old Town, and the Northland Trailer Park at the southern edge of the city. Analysis of the results of ambient air monitoring leads to the following observations:

- From 1973 to 1978, annual mean arsenic concentration in the ambient air fell by approximately 80% from 0.090 to 0.018 micrograms/cubic metre (μg/m^3).

- The annual mean concentration of arsenic in the ambient air from 1978 to 1995 has ranged from 0.006 to 0.023 μg/m^3 and has averaged 0.013 μg/m^3.
- The annual mean concentration of arsenic in the ambient air from 1989 to 1995 has averaged 0.009 μg/m^3.
- The highest concentration measured over a 24-hour period in Yellowknife since 1989 was 0.251 μg/m^3.

Health Effects of Arsenic in the Environment

While arsenic is well known to be acutely toxic, that is, ingestion may lead to death, the levels of arsenic in the air in Yellowknife are of concern more from the long-term chronic exposure perspective. Arsenic trioxide, the main form of arsenic released to the air by Giant Mine, is readily absorbed into the body following inhalation or ingestion. As identified in the PSL Assessment Report, chronic inhalation exposure to arsenic has been associated with lung cancer in workers at three different smelting facilities. Although the exact association with the different forms of arsenic has not been completely resolved, inhalation of the arsenic released by these smelters is considered to present a risk of lung cancer. It is on the basis of the inhalation cancer risk that arsenic was declared "toxic" under Section 11(c) of the Canadian Environmental Protection Act.

To put this risk into perspective, an evaluation was conducted of the potential cancer risk associated with the arsenic released from the Giant Mine's roaster. Based upon the annual mean levels of arsenic in Yellowknife between 1989 and 1995 (0.009 μg/m^3), the estimated increased cancer incidence one might expect to see in the population of Yellowknife, if exposed at this level for a lifetime, would be approximately one cancer death.

Mineral Processing and Air Pollution Control Systems at Giant Mine

Mineral Processing

Ore from the mine is run through a series of crushers and grinders to reduce it to the size of sand or smaller. Water is added to produce a slurry, and this slurry is further processed by "flotation". In the flotation process, the desirable sulphide minerals are separated from the undesirable or waste materials. The waste materials are sent to the tailings pond and the sulphide minerals or "flotation concentrates" are collected for further processing.

The ore at Giant Mine is called "refractory", meaning that the gold is locked in pyrite and arsenopyrite minerals. In order to release the gold, the flotation concentrates are roasted at a temperature of 495 ^{o}C. The roasting process results in the production of gold-bearing "calcine", and releases arsenic trioxide and sulphur as gases. The calcine is sent for further processing to recover the gold and the tail gas from the roaster is directed to the air pollution control system.

Air Pollution Control

The tail gas from the roasters is sent through cyclones to remove coarse particulate (dust), and then passed through an electrostatic precipitator (ESP). Arsenious oxide in the vapour state passes through the ESP at a temperature of 315 ^{o}C. The dust settles in the collection hoppers for subsequent gold recovery. Tail gas from the ESP is cooled by dilution with ambient air causing arsenious oxide to condense as fine particulate. The tail gas is filtered in a baghouse to remove particulate arsenic trioxide. Arsenic trioxide shaken from the bags is collected in hoppers and discharged to underground storage vaults. The filtered gas is discharged to the atmosphere via an acid-brick lined stack that is 2.7 metres in diameter and 45.7 metres tall.

The efficiency of particulate collection in the baghouse is dependent on several variables, in particular, the shaking cycle, the temperature in the baghouse, and maintenance of the system. In 1977, changes to all of these variables were made at Giant Mine. The frequency of shaking was reduced from 32 to 4 cycles per day, reducing the amount of fine arsenic trioxide which passes through the bags during the shaking cycle. The temperature in the baghouse was reduced from 110 °C to 105 °C, increasing the amount of arsenic that was present as dust and therefore able to be collected by the bags. Finally, a program to regularly replace all of the bags was instituted, thereby reducing excess arsenic releases due to bag failure.

Emission Reduction Options

Arsenic control options are divided into three principal categories:

- processes which are alternative technologies to roasting;
- processes which treat the roaster tail gas; and
- improvements to the existing air pollution control system at Giant Mine.

Estimated costs for the alternative technologies for reducing arsenic releases to the air from Giant Mine are summarized in Table 1.

Alternative Technologies for Gold Recovery from Refractory Ore

<u>Background</u>

Releases of arsenic to the atmosphere could be virtually eliminated if alternative gold recovery technologies were used at the Giant mine. The following alternatives to the roasting of refractory minerals, which improve gold recovery and/or reduce atmospheric emissions of arsenic, have been investigated and reported.

- Pressure Leaching
- Biological Leaching
- Atmospheric Leaching

<u>Pressure Leaching</u>

A number of gold mills employing roasting to treat refractory minerals have evaluated or switched to pressure leaching using autoclaves. As with roasting, the main purpose of pressure leaching is to break down arsenic-bearing sulphide minerals to permit conventional leaching of gold.

Capital costs relating to the installation of pressure leaching circuits are documented. The retrofit at Campbell Red Lake Mine in Ontario had projected capital costs of $23.6 million in 1990, including licensing and tailings area preparation. Capacity was rated at 71 tonnes of concentrate per day. Estimated capital costs for a pressure leaching plant at a facility such as Giant Mine are $35 million. Annual operating costs have not been estimated.

Biological Leaching

An alternative to chemical leaching is biological leaching, which employs bacteria to modify the refractory minerals for gold leaching. The bacteria behave as catalysts and, under ambient conditions, can accelerate the oxidation reaction by factors of several hundred thousand to a million.

The cost of a bio-leaching plant, to replace the existing roasting operation at a site such as Giant Mine, would be approximately $35 million. Operating costs are estimated to be similar to current costs plus the costs of tailings neutralization, which wouldincrease the pre-treatment cost by $20 per tonne.

Atmospheric Leaching

Low pressure or atmospheric leaching has been developed as an alternative to pretreatments previously discussed. Process equipment is simplified by avoiding, for example, the use of autoclaves. Examples of this pre-treatment approach are the Nitrox Process and the Redox (formerly Arseno) process. Both of these processes are based on the use of nitric acid as the leaching agent.

Capital costs for commercial plants have not been reported in the literature. Estimates suggest that the cost for a Nitrox plant for a facility such as Giant Mine would be $42 million. Annual operating costs have not been estimated.

Alternative Technologies for Treating Roaster Tail Gas

Treating the tail gas is a viable option for reducing arsenic emission. Current technologies designed to address the removal of residual amounts of contaminants from process gas streams are well established. The technologies investigated were:

- Scrubbing
- Gas conditioning followed by electrostatic mist precipitation
- Activated carbon adsorption

Scrubbing

Scrubbing cools the gas to precipitate the arsenic and collects about 80 percent of it on fine water droplets. The main energy consumer in this form of scrubbing is compressed air used for water atomization. The scrubbing step is followed by mechanical mist elimination. The process gas proceeds to the stack via a booster fan. A stack liner is required due to the reactive and corrosive nature of the gas. Information from manufacturers suggests that arsenic concentration released from the stack would be <1.0 mg/m^3 . Estimated capital costs for a scrubber are $1.2 million, with annual operating costs of approximately $200,000.

Electrostatic Precipitation

Significant tail gas arsenic removal is possible by cooling the gas in a low pressure drop venturi scrubber, followed by treatment in a wet electrostatic precipitator. Gases from the wet mist precipitators proceed to the stack using a booster fan. A stack liner is also needed in this type of system. Information from manufacturers suggests that arsenic concentration released from the stack would be <1.0 mg/m^3 . Estimated capital costs for this option are $2.0 million, with annual operating costs of approximately $170,000.

Activated Carbon Adsorption

By combining activated carbon with the electrostatic precipitation system, somewhat higher removal of arsenic gas can be achieved. Information from manufacturers suggests that arsenic concentration released from the stack would be <1.0 mg/m^3 . Estimated capital costs for this option are $2.2 million, with annual operating costs of approximately $220,000.

Improvements to the Existing Air Pollution Control System at Giant Mine

The existing air pollution control system and operating procedures at Giant Mine have not changed significantly since 1977. Only minor reductions in arsenic releases to the air would be possible using the existing equipment. With improvements in bag technology and management practices, arsenic concentrations could potentially be reduced to 20 mg/m^3. Stack emission testing would be required to confirm whether this concentration could be attained on a consistent basis.

Cost Analysis

Detailed cost analysis was performed for only the options described as alternative technologies for treating roaster tail gas. The estimated annualized costs to Royal Oak for the installation and operation of these technologies at Giant Mine range from $550,000 to $707,000. This range of costs represents less than 2% of the average annual operating costs of the Mine, and approximately 9% of the net cash flow from Giant Mine to its owner, Royal Oak Mines.

TABLE 1

SUMMARY OF ALTERNATIVES FOR ATMOSPHERIC RELEASES OF ARSENIC AT GIANT MINE

ALTERNATIVE	PREDICTED RELEASE LEVEL (kg/day)	CAPITAL COST	ANNUAL OPERATING COST
Pressure Leaching	0	$ 35 million	Unknown
Biological Leaching	0	$ 35 million	Unknown
Atmospheric Leaching	0	$ 42 million	Unknown
Wet Scrubbing	1	$ 1.2 million	$ 200,000
Wet Electrostatic Precipitation	1	$ 2.0 million	$ 170,000
Wet Electrostatic Precipitation plus Carbon Adsorption	1	$ 2.2 million	$ 210,000
Improve Existing Control System	20	Unknown	Unknown
No Change	30	$ 0	$ 0

NOTES:

- Capital and operating cost estimates are rough order of magnitude.
- Cost estimates make no allowance for loss of production during conversion to new technologies.
- Annual Operating Cost represents the incremental cost in addition to the present cost for operation of the existing air pollution control system.

Effects of Pollution Control Measures on Air Quality

The various pollution control and gold recovery technologies that were investigated all have the potential to reduce or eliminate arsenic emissions into the atmosphere. However, evaluation of the health benefits associated with such reductions in arsenic emissions also requires information on the improvements in air quality that could result from operational changes at the Giant mine. For this reason, air quality modeling was undertaken to predict the levels of contaminants that could occur under a range of environmental and operational conditions.

The results of air quality modeling provide valuable information for assessing the potential implications of the various technological options for reducing arsenic emissions. Under existing operating conditions, the model predicts that average daily concentrations of arsenic in air contributed by Giant Mine's roaster can exceed 0.16 μg/m^3 near the gold roaster and 0.08 μg/m^3 in Yellowknife. Optimization of the existing pollution control system would likely yield modest improvements in air quality; however, arsenic levels contributed by Giant Mine's roaster could still exceed 0.13 μg/m^3 nearby the gold roaster and 0.06 μg/m^3 in Yellowknife. In contrast, further treatment of tail gas from the gold roaster is likely to have significant effects on air quality. Following treatment, average daily concentrations of arsenic contributed by Giant Mine's roaster nearby the roaster would probably be reduced below 0.03 μg/m^3, while levels in Yellowknife would likely be reduced to less than 0.02 μg/m^3.

Benefits of Reducing Arsenic Emissions

In recent years, an increasing level of concern has been expressed about the adverse health effects that could be associated with prolonged exposure to arsenic. Of great concern with respect to atmospheric arsenic is the risk of lung cancer associated with breathing arsenic-contaminated air. To address this concern, an evaluation of the health benefits associated with reduction of the levels of arsenic in Yellowknife air was conducted. Reducing the concentration of arsenic released from Giant Mine's roaster to <1.0 mg/m^3 could reduce mortality due to lung cancer from inhalation of arsenic, saving between 0.14 and 0.86 lives over the 70 year lifespan of a population the size of Yellowknife.

In addition to the benefits to human health, reduction in arsenic emissions from the Giant mine would likely have environmental benefits. While limitations on the available information make it difficult to estimate those benefits, it is likely that improvements in air quality would reduce the incidence and severity of effects on a variety of wildlife species. Moreover, reductions in atmospheric emissions would decrease inputs of arsenic to water and soils.

Summary

Based upon the assembled information, the Task Force determined that releases of liquid effluent containing arsenic in the Northwest Territories, including issues related to the underground storage of arsenic trioxide at Giant Mine, could be adequately controlled through the water licensing processes of the NWT Water Board and the Nunavut Water Board.

Arsenic releases to the air in the Northwest Territories are not subject to regulatory control, and are not being examined by any other federal or territorial regulatory initiatives. Because of this, the Task Force has determined that, in the Northwest Territories, atmospheric releases of arsenic from gold roasting warrant the highest priority for federal action.

The gold roaster at Giant Mine in Yellowknife is the only man-made source of arsenic releases to the air in the NWT. Because the intent of CEPA is to control activities on a nation-wide or industry-wide basis, this examination of options for the reduction of arsenic releases considered releases from all gold roasters in Canada. Besides the gold roaster at Giant Mine, there is only one other gold roaster in Canada. It is located at Golden Bear Mine in British Columbia, and has been out of operation since 1994.

Voluntary control measures instituted at Giant Mine reduced arsenic releases from their gold roaster to the atmosphere from approximately 7300 kg/day in the early 1950's to approximately 30 kg/day by 1978. Atmospheric arsenic releases from Giant Mine have remained at this level since 1978. Also since

1978, the concentration of arsenic being released to the atmosphere has averaged 25 mg/m^3.

Arsenic levels measured in the ambient air in Yellowknife have improved substantially since 1975, and are now similar to the levels measured near arsenic point sources in other parts of Canada. The average ambient concentrations of airborne arsenic measured in downtown Yellowknife over the period from 1978 to 1995 ranged from 0.006 to 0.023 µg/m^3, averaging 0.013 µg/m^3 . This compares with an average annual concentration of 0.001 µg/m^3 measured in cities across the rest of Canada, and a range of between 0.0086 and 0.22 µg/m^3 measured near industrial arsenic point sources in Canada.

Although the health risk to the population of Yellowknife from exposure to current levels of airborne arsenic would be considered low relative to the risks encountered in day-to-day life, they are considered to be high in comparison with the risks generally associated with other environmental contaminants.

Alternative processing technologies which could replace roasting are commercially available and would completely eliminate atmospheric emissions of arsenic. Installation of one of these processes would require significant capital expenditures, and operating costs at least as expensive as those associated with roasting. These processes would also require significant development to ensure that acceptable gold recovery from the concentrates at a specific mine could be achieved. The costs of alternate technologies to completely eliminate airborne releases of arsenic greatly exceed the calculated health benefits. Officials of Royal Oak Mines Inc. have stated publicly several times that a requirement to spend the capital costs estimated in this report for alternate processing technologies would probably result in the closure of Giant Mine.

Roasting technology for treating refractory gold concentrates has been practised for over 50 years. Proven, commercially-available treatment technology could reduce atmospheric arsenic releases from Giant Mine from the present 30 kg/day to approximately 1 kg/day, by reducing arsenic concentration in the tail gas from 30 mg/m^3 to less than 1.0 mg/m^3. Operating costs are modest and would include the marginal costs associated with operating the existing tailings disposal facilities. Air dispersion modelling predicts that by reducing the concentration of arsenic released from the stack to 1.0 mg/m^3, average concentration of arsenic contributed by the Giant Mine in a 24-hour period would not exceed 0.030 µg/m^3, and would be less than 0.020 µg/m^3 in Yellowknife. The costs to reduce arsenic releases to 1 kg/day exceed the benefits to human health calculated from the limited evidence available, as defined by the specific cost/benefit analysis adopted for this assessment and recognizing that there are inherent limitations to any such analysis. There is not enough information to accurately quantify benefits to the environment. If environmental benefits could be quantified and added to the calculated health benefits, the benefits might exceed the costs. In any case, the additional costs would probably not place undue financial pressure on Giant Mine.

It may be possible to slightly reduce arsenic releases from the roaster at Giant Mine using the existing pollution control system. This would involve using different filter bags and changing some operating procedures. Increased costs would be low, but arsenic reductions would probably be small. Air dispersion modelling predicts that even with optimization of the existing pollution control system, average concentration of arsenic contributed by the Giant Mine roaster in a 24-hour period can exceed 0.130 µg/m^3 near the roaster stack, and can exceed 0.060 µg/m^3 in Yellowknife. Considering the errors inherent in the model, the small relative change indicates that simply changing the operations in the facility would not greatly improve the regional ground-level concentrations of arsenic measured at Yellowknife.

Options for Future Action

There is a wide range of options that could be considered for managing arsenic releases to the environment in the NWT. The options described below are proposed as the starting point for discussion at public consultation sessions. There are other options which may be considered. The purpose of the public consultation is to develop recommendations for future actions by the government of Canada.

Option 1 Maintain the Status Quo

Arsenic releases to the air and water in the NWT should continue to be controlled as at present.

Option 2 Conduct Further Studies

The Government of Canada should conduct further studies on the environmental effects of the existing releases of arsenic to the air in the Yellowknife area to address the lack of data regarding environmental impacts. The studies should have a fixed time for completion and, if the studies determine that there are measurable environmental effects, action should be taken to reduce arsenic releases.

Option 3 Control Arsenic Releases

3A Regulated Performance Standard for Air Releases

Environment Canada should draft a regulated performance standard (Regulation) controlling the release of arsenic to the air from gold roasters. When promulgated, this Regulation would specify a limit on the concentration of arsenic in airborne releases from gold roasters, set a time frame for complying with the specified limit, and require appropriate testing and reporting of emissions from roaster stacks.

3B Negotiated Agreements

3B(i) Structured Voluntary Agreement (SVA) on Air Releases

The Government of Canada should initiate negotiation of a "Structured Voluntary Agreement" with Royal Oak Mines to reduce atmospheric releases of arsenic to a specified level. All quantitative reduction targets and the schedule for achieving them would be clearly stated in the agreement. The signatories to the SVA would be the Government of Canada and Royal Oak Mines.

3B(ii) Multi-faceted Structured Voluntary Agreement

The Government of Canada should initiate negotiation of a "Structured Voluntary Agreement" with Royal Oak Mines to address several environmental issues facing the Mine. Possible issues that could be considered include the underground storage of arsenic trioxide, atmospheric releases of arsenic and sulphur dioxide, releases of liquid effluent, and site remediation. The SVA would include clear quantitative reduction targets and schedules for achieving them. The federal government cannot waive or alter existing regulatory requirements with respect to these issues, however, it could take them into account when negotiating the terms of the agreement. The parties to the agreement would be the Government of Canada and Royal Oak Mines. The Government of the Northwest Territories may also need to be a signatory to the agreement given the jurisdictional nature of some of the issues. In the event of an unsatisfactory outcome either of the negotiation process or of performance under the agreement, the federal government could intervene to pursue an alternative course of action.

3B(iii) Covenant

The Government of Canada should initiate negotiation of a Covenant to address several environmental issues facing the Mine. The Covenant would include clear quantitative reduction targets and schedules for achieving them. Possible issues that could be considered include the underground storage of arsenic trioxide, atmospheric releases of arsenic and sulphur dioxide, releases of liquid effluent, and site remediation. The federal government cannot waive or alter existing regulatory requirements with respect to these issues, however, it could take them into account when negotiating the terms of the agreement. The Parties to the agreement would be the Government of Canada, Royal Oak Mines, and the affected communities (e.g. municipal government, aboriginal organizations, environmental organizations) The Government of the Northwest Territories may also need to be a signatory to the agreement given the jurisdictional nature of some of the issues. In the event of an unsatisfactory outcome either of the negotiation process or of performance under the agreement, the federal government could intervene to pursue an alternative course of action.