SOCIO-ECONOMIC ANALYSIS OF PROPOSED CONTROL OPTIONS FOR ROYAL OAK'S GIANT GOLD MINE.

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BY:
Resource Futures International
1 Nicholas Street, Suite 406
Ottawa, Ontario
K1N 7B7

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EXECUTIVE SUMMARY

- **Introduction**

This report has been prepared to provide information to a Federal Government Task Force established to respond to the determination by the Ministers of Environment and Health that arsenic is a "toxic" substance under the *Canadian Environmental Protection Act,* and that atmospheric emissions of arsenic from gold mines are not currently adequately addressed.

This report focuses on the only gold mine currently emitting arsenic.

The study:

- estimates the human health and environmental effects arising from airborne arsenic emissions from Royal Oak's Giant Yellowknife Mine in the NWT; and
- evaluates three management options to control these emissions:
    1. a regulated performance standard under CEPA;
    2. a structured agreement between Environment Canada and Royal Oak Mines; and
    3. a covenant between Royal Oak Mines and the community.

Although this study does not address all of the social issues related to the Giant Gold Mine, and only addresses a narrow aspect of the overall environmental and human health related issues, it does emphasize the potential importance of accounting for this "bigger picture" when determining what action is appropriate.

- **Estimated benefits and costs of reducing atmospheric emissions of arsenic from the Giant Gold Mine**

Our ability to estimate the benefits of reducing atmospheric emissions of arsenic is significantly limited by a lack of data. Atmospheric emissions from the mine are currently approximately 26 to 29 kg./day at a concentration of 24 mg/m3. These emissions have and will continue to affect ambient levels of arsenic in air, water, soil and food, although we cannot predict the magnitude of this impact. The current average ambient levels are 0.006 to 0.015 µg/m3 for air; 1 to 70 µg/L for surface water, 0.3 for µg/L for drinking water, and are unknown for soil and food.

The Federal Government's Toxic Substances Management Policy suggests that arsenic is a "Track 2 toxic substance" and should therefore be reduced to the greatest extent practicable. Health Canada policy further suggests that these ambient levels are problematic, and should be "medium" to "high" priorities for reduction efforts.

The benefit in terms of reduced mortality due to inhalation may range from $350,000 to $7,200,000 over an average lifetime (i.e. approximately 70 years). These numbers probably underestimate the total benefits, since they do not account for the health related benefits of reduced ingestion or of reduced sub-mortality effects, nor do they account for potential environment related benefits.

By comparison, costs to the company alone to reduce emissions could range from $1.2 to $2.1 million in capital investment and between $168,000 and $206,000 in annual operating costs. The estimated annualized costs to the company thus range from $350,000 to $490,000 using a discount rate of 5%.

- **Management options**

Because each of the management options reviewed in this report offers considerable flexibility in terms of how environmental performance objectives will be achieved, they are roughly comparable with respect to likely impacts on emissions and in terms of the costs they will impose on the company. The costs to government of regulation and an SVA should also be similar, while a community based covenant could require less government investment.

Regulated Performance Standard

A regulated performance standard offers three main advantages. First, it would provide all stakeholders with certainty. Second, it would enhance government control over the final outcome. And third, it could be applied to a broader range of arsenic sources. The federal government could design the regulation to apply to all gold mines using arsenic, or to all industrial emitters of arsenic.

The primary challenge with respect to a regulated performance standard is whether it is possible to demonstrate that the overall benefits of a regulation outweigh the costs. The above analysis suggests that it may be difficult to demonstrate a positive benefit-cost result. The decision of whether or not a regulation is warranted to address emissions from the Giant Mine alone may therefore turn on the extent to which the government is willing to invoke the precautionary principle. In addition, the government will have to determine whether the added benefits of developing a regulation that might apply to other emitters of arsenic in the future tips the balance in favour of developing a regulation at this time.

A second problem with respect to the regulatory approach is that most stakeholders - including the Mine, the NGOs, the aboriginal community and the local government - view airborne arsenic as less important than other environmental issues involving the mine.

Community Covenant

Both negotiated agreement options offer the added potential to address other aspects of the problem rather than being restricted to air emissions. The key issue with respect to both options is whether the relevant parties can be expected to be willing to enter into an agreement.

Our preliminary interviews suggest that although some of the stakeholders might be interested in a covenant between community representatives and the mine, many have reservations about such an approach. The local ENGOs and the Yellowknives Dene Band are interested in addressing a wider range of issues with respect to the past and present operations of the mine than could be included in a regulation. A covenant might provide the opportunity for such a negotiation and could provide an opportunity for opening up lines of communication and restoring trust. It is not clear that any of the stakeholders would be satisfied with the lack of enforcement "teeth" that might be provided by a community covenant on its own, however. An additional concern articulated to us by a number of stakeholders is: which parties should participate in such an agreement. Who speaks for the community? And if the list of participants gets large in order to accommodate the diversity of interests, would the negotiations be manageable? The most significant problem with this option is that the mine does not appear to be interested in engaging in negotiations over these issues with community groups, and does not face any significant incentive to do so.

Structured Voluntary Agreement

An SVA could take one of two forms: a negotiated agreement between the mine and the federal government focused on atmospheric emissions of arsenic only, or an agreement among the mine, the NWT and the federal government. There are few prospects for the first model, since the mine is unlikely to be willing to negotiate atmospheric emissions alone due to the perceived lack of a credible threat of regulation.

The mine might, however, be interested in an SVA that addressed a wider range of environmental issues. The main reason the mine would be interested in such an agreement is the potential for developing a long-term integrated approach to its environmental issues. This raises two issues:

- would this incentive be sufficient to induce the mine to include atmospheric emissions of arsenic in the negotiations even though the threat of regulatory intervention on that particular issue may be low?
- in any event, what are the prospects of inter-jurisdictional cooperation with respect to such an approach?

Although we did not pursue these issues in detail, our preliminary observations suggest that the answer to both is positive. Although they did not indicate to us precisely which issues they would be willing to negotiate, officials from the mine suggested that they would be very interested in negotiating a comprehensive package of the environmental issues they face. And while the NWT intends to pursue the promulgation of the SO2 regulation, it would be interested in exploring the possibility of whether negotiations could help resolve outstanding issues such as the liability for the contaminated site upon closure of the mine.

In addition to addressing these two concerns, an SVA would have to address at least two additional issues in order to be effective. First, it would have to overcome concerns expressed to us by some members of the local community about the need for effective enforcement powers. More analysis is required in order to determine whether the community stakeholders would be satisfied with a non-regulated approach. Second, it will be important to ensure that the community trusts the government to negotiate on its behalf. Many of the local aboriginal groups and ENGOs have expressed concerns in a number of fora about the failure of the federal government to adequately address their historic concerns about the mine.

1. Introduction

1.1 Objective of this study

This report:

- estimates the human health and environmental effects arising from airborne arsenic emissions from Royal Oak's Giant Yellowknife Mine in the NWT; and
- evaluates three management options to control these emissions:
  1. a regulated performance standard under CEPA;
  2. a structured agreement between Environment Canada and Royal Oak Mines; and
  3. a covenant between Royal Oak Mines and the community.

1.2 Background

Arsenic is a naturally occurring element found most often in compounds with sulphur either alone or in combination with various metals. It enters the environment from natural sources and human activities including metal processing, the use of arsenical pesticides, operation of coal-fired power generation plants and the disposal of domestic and industrial waste material.

In 1994, the federal government concluded that arsenic and its inorganic compounds were "toxic" under section 11 of *the Canadian Environmental Protection Act* (CEPA). Under the government's *Toxic Substance Management Policy* (TSMP), arsenic is to be managed as a "Track 2" substance, with the goal of reducing releases to the environment "to the greatest extent practicable."

In 1995, the House of Commons Standing Committee on Environment and Sustainable Development released its report, *Its About Our Health! Towards Pollution Prevention.* Recommendation No. 107 of that report urges the Minister of the Environment and the Minister of Health "to conclude their determination of the measures they plan to apply to arsenic by December 1995."

In response to this recommendation, the federal Departments of Environment and Health reviewed the current management of arsenic releases in Canada. The departments concluded that arsenic releases to the environment from most anthropogenic sources are being adequately addressed by existing regulations or will be addressed by the Strategic Options Processes (SOPs) for base metal smelters, coal-fueled power plants, iron and steel mills and wood preservative facilities, but that arsenic releases from gold roasting operations are not covered by either existing regulations or current SOPs. Accordingly, in August 1995, Environment Canada assembled a Task Force to investigate possible management options that might be applied to gold roasting operations. The only gold roasting operation currently emitting arsenic in Canada is the Giant Mine in the NWT.[1] Accordingly, it is the focus of this study.

Although this study focuses only on the atmospheric emissions of arsenic from the Giant Mine, this section briefly describes the context in which the mine operates. The environmental regulatory context is quite complex. The mine is now subject to regulation by the G NWT (~~water, waste~~ land use, and some air emissions), DIAND (which ~~retains some jurisdiction over~~ is responsible for the *NWT Waters Act* ~~and over some land use decisions~~ Water Use, Waste Disposal), Environment Canada (under the *Fisheries Act*) and the City (solid waste). There is good reason to believe that this regulatory regime will become more complex in the future. In addition to existing regulations and whatever action is taken as a result of this study, the G NWT has announced its intention to control SOx emissions through a new regulation, ~~and to address~~

[1] Other Canadian mines which have employed a gold roasting process have either suspended operations (i.e. Golden Bear) or closed down completely (e.g. Campbell Red Lake Mines and Dickenson Mines). We are not aware of any plans for new mines using this process in Canada.

~~underground storage issues through the renewal of the mine's existing license under the~~ ~~*North West Territories Waters*~~ *Act*. Finally, since a number of different owners have operated the mine for over 40 years, there are difficult questions with respect to liability for the unremediated contamination that was caused by previous owners.

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The mine is also the subject of considerable local attention. It is the fourth largest employer in the City, and recently was the center of a protracted and violent labour strike that gained international attention. Local aboriginal residents have a number of long standing grievances against the mine. The local Yellowknives Dene band complains, for example, that the mine employs none of their members. And a number of aboriginal spokespeople made presentations to the Standing Committee in 1995 about the failure of the government and successive mine owners to respond to their historic concerns about the human health and environmental effects of the mine's operation.

Although this study does not address all of these social issues, and only addresses a narrow aspect of the overall environmental and human health issues, it does emphasize the potential importance of accounting for this "bigger picture" when determining what action is appropriate.

1.3 Organization of this report

This study is structured as follows:

- section 2 estimates the human and environmental impacts of the current air emissions of arsenic from the mine;
- section 3 describes the three management options and evaluates their potential effectiveness in reducing atmospheric emissions of arsenic; and
- section 4 concludes with a discussion of the relative merits of each of the options both with respect to air emissions and with respect to their capacity to address the broader set of issues faced by the mine and the community.

2. Human Health and Environmental Effects

In this section we examine the human health and environmental effects due to arsenic in the environment. Specifically, the objectives of this section are:

1) to characterize current ambient concentrations of arsenic and estimate the human health and environmental risks that may be associated with these ambient concentrations; and

2) to estimate the human health and the environmental benefits of reducing arsenic air emissions.

2.1 Human Health and Environmental Effects arising from current ambient conditions

The terms of reference for this study, asked us to assess the human health and environmental effects due to arsenic air emissions. To understand how we responded to this challenge, it is important to understand the link between arsenic emissions and human health and environmental effects.

Air emissions are one of many sources of arsenic into the environment. Some of these are natural and some are the result of human activities. Natural sources are geological in origin. The Yellowknife region is underlain by mineral formations containing arsenic and associated metals such as copper, zinc, lead and nickel. Consequently weathering of the bedrock contributes to elevated levels of arsenic in the environment (DIAND, 1995).

Gold mining and the roasting of arsenic-containing ore is the most significant anthropogenic (human activity) source of arsenic. These activities have contributed past and present loadings to the environment via air, water and solid waste.

Human health and environmental effects arise when people and organisms are exposed to elevated ambient concentrations of arsenic. Therefore, to estimate human health and environmental effects, we need to know the ambient conditions and the ways in which humans and other organisms respond when exposed to these ambient concentrations. Emissions to air will contribute to these ambient conditions, but the link between emissions and ambient conditions is complex. Understanding this link demands information on: 1) the relative contribution of existing arsenic sources; 2) distribution and partitioning of these emissions between media; 3) remobilization of past arsenic emissions; and 4) movement and bioaccumulation of arsenic in the food web.

Despite our best attempts, it was not possible in this study to collect the information needed to link current air emissions to human health. We were successful in collecting information on air and water loading from the Giant Mine and a few other sources, but information on how arsenic reacts and moves between various media could not be found.

In the following section, we present the limited information on loadings that we were able to collect. We present this information because it contains some interesting emission trends, but we do not use this information in subsequent impact calculations. Instead, we estimate health and environmental effects using ambient conditions based on monitoring data collected in the region. We made no attempt to link these observed levels back the emissions.

2.1.1 Current Loadings

This section reports the limited information available on the magnitude of arsenic loading to water, air and solid waste from the Giant Mine.

Liquid effluent from the Giant Mine settles first in a tailings pond before it is treated and released into Baker Creek. Estimated total arsenic loadings are presented in Table 1 for 1991 - 1993. Annual loadings ranged from 956 - 1237 kgs, and the average annual effluent concentration ranged from .35 mg/L in 1993 to .58 mg/L in 1992. This latter concentration was below the NWT Water

Board's effluent quality criteria in place at that time (80 mg/L), but above the current criteria of .5 mg/L.

Air emissions from the gold roasters pass through a series of fabric filters before being emitted from the Mine's roaster stack (Hatch 1996). The arsenic-bearing dust from these emissions has been stored in underground chambers since 1951. Today there are approximately 236,000 tons of dust containing approximately 141,000 oz. of gold and 185 tons of arsenic trioxide. Current production at the mine adds approximately 5500 tons of dust to these underground storage chambers per year (Royal Oak 1993).

Figure 1 shows how airborne emission concentrations have reduced since the commencement of mining operations in the late 1940s. Although emissions have been reduced significantly since the 1940s and 1950s, total loadings to air have have remained relatively stable since 1980 (see Figure 2). Since 1990, six stack samples have been analyzed. Daily loading to air ranged between 3.2 and 37 kgs/day, with concentrations ranging from 3.2 to 34 mg/m^3. Values reported by an independent contractor between 1991-1993 indicate an average concentration of 24 mg/m^3 total inorganic arsenic (particulate and gaseous) over this period.

Table 1: Estimated arsenic loading to water and air from Giant Mine

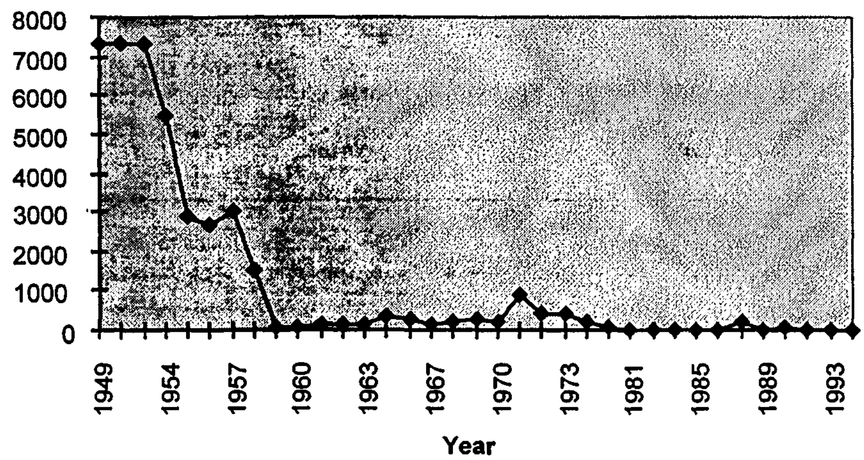
Year	Avg. Concentration (mg/L)	Total Loading (kgs)
1991	.39	956.75
1992	.58	1237.06
1993	.35	1098.64

Source: DIAND 1995.

In summary, arsenic loadings from the Giant Mine occur via three main routes: air, water and solid waste. Air emissions were formerly very high, were reduced significantly in the 1960s, and have remained relatively stable since the late

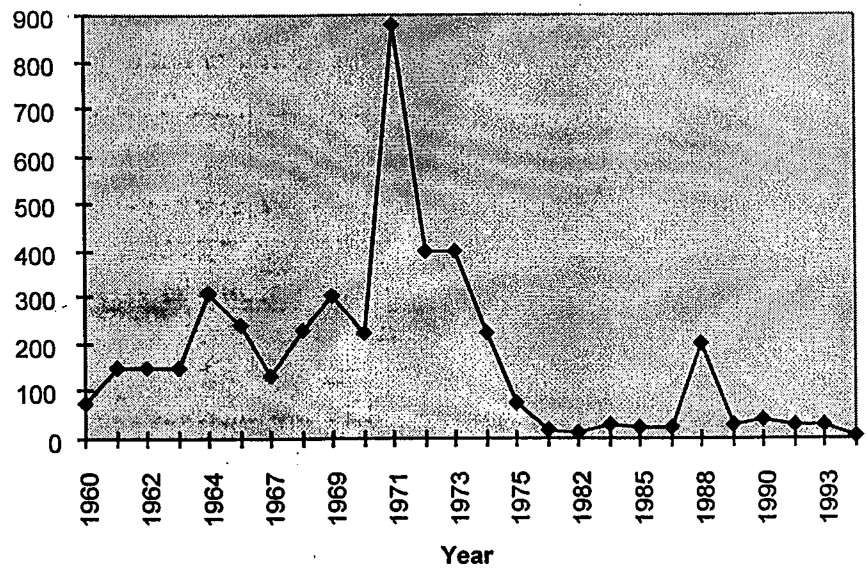
1970s. Limited water emissions data (1991-1993) indicate that effluent concentrations approach but do not exceed the limits stipulated by the mine's water license (NWT Water Board 1994). Arsenic-bearing dust is being produced at a rate of 5500 tons per year and is being stored in underground chambers. In 1993, the total amount of waste material in storage was estimated to be 236,000 tons.

Figure 1: Annual Arsenic Emissions to Air



Source: Hatch 1996 and GNWT 1993.

Figure 2: Arsenic Air Emissions Since 1960



Source: Hatch 1996 and GNWT 1993.

2.1.2 Ambient Conditions

In this section, we summarize the ambient concentrations of arsenic observed in Yellowknife air and water. We were unable to estimate concentrations of arsenic in Yellowknife soil, so concentrations measured in the vicinity of other industrial point sources were substituted. We were also unable to find any information on concentrations in Yellowknife food.

Table 2 summarizes the observed ambient concentrations in various media. This information will be used to estimate the potential human health and ecological impacts in Section 2.1.3.

Table 2 Estimated Ambient Arsenic Concentrations

Medium	Ambient Concentration	Location
Air	.006 - .015 µg/m³ average = .009 µg/m³	Downtown Yellowknife *
Surface Water	ind. samples ranged	Yellowknife-Back Bay

	from <.3 - 247 µg/L; site averages ranged from 1 - 70 µg/L	study area**
Drinking Water	.3 µg/L	Yellowknife municipal water intake***
Soil	3-500 mg/kg	Concentrations in vicinity of industrial sources****

* GNWT (1993, 1994, and 1995). Air quality monitoring results from 1991-1994.
** DIAND (1995)
*** Hamilton (1996) and Halliwell (1996)
****Government of Canada (1993)

We estimated airborne concentrations using monitoring data collected from a monitoring station located in downtown Yellowknife. Between 1991- 1994, average annual concentrations ranged from between .006 - .015 µg/m³ . The average annual mean over this period was .009 µg/m³. Surface water concentrations were obtained from the Yellowknife-Back Bay study (DIAND 1995). Annual averages at the 13 sites sampled in this study ranged from 1 - 70 µg/m³ . Drinking water concentrations were based on samples collected in 199? near the Yellowknife water intake on the Yellowknife river north of the Giant Mine site. Concentrations averaged .3 µg/L (Hamilton 1996, Halliwell 1996, Jamieson 1996). In emergency situations, the city of Yellowknife takes its raw drinking water from Back Bay, but this occurs less than seven days per year according to municipal officials (Jamieson 1996). Therefore, drinking water concentration of .3 µg/L should be considered accurate.

Soil concentrations for Yellowknife are based on concentrations measured near point sources elsewhere in Canada. The Giant mine has conducted surface soil investigations around the minesite, but these observations would not be characteristic of ambient concentrations likely to exist around Yellowknife. For this reason, soil concentrations in Table 2 describe concentrations measured in the vicinity of other industrial arsenic point sources.

2.1.3 Existing Human Health Effects

This section presents estimates of the human health effects arising from the ambient arsenic concentrations currently or most recently observed in the Yellowknife environment.

These estimates are based on comparisons of the currently observed conditions summarized in Table 2 (Section 2.1.2) with the results reported in the *Priority Substances List Assessment Report for Arsenic and its Compounds* (Government of Canada, 1993).

The PSL assessment report on arsenic reviewed the scientific literature and estimated the potency of arsenic via critical exposure routes. Health Canada (1994) defines potency ($TD_{0.05}$s) as the concentration or dose that induces a 5% increase in the incidence of tumours or heritable mutations considered to be associated with exposure. The PSL assessments also report an exposure/potency index (EPI) that measures the ratio between ambient concentrations and the 5% potency concentration. Therefore, as observed ambient conditions approach the 5% potency concentration, the EPI approaches one.

Health Canada does not convert the potency of a substance to an increased probability of tumours or mutations at low ambient concentrations because uncertainties become very large at the low end of the dose-response curve. We found it necessary to make this conversion and incorporated these estimates into our economic calculations. In doing so, we have assumed that the relationship between dose and response, as measured by the potency ($TD_{0.05}$s), is linear at doses below those used to calculate the potency. It is important to emphasize the large uncertainties surrounding these estimates of cancer risk at low concentrations.

The PSL assessment for arsenic is silent on the synergistic effect of exposure via more than one route. Thus, we cannot comment on the overall effect of total

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arsenic exposure, or on the relative contribution of inhalation to overall arsenic-related health effects. We must, therefore, evaluate the health effects of each exposure route independently, treating each route as if it were the only source of arsenic exposure.

According to the PSL assessment report, it was concluded that arsenic is carcinogenic by two routes of exposure in humans: inhalation and ingestion.

2.1.3.1 Inhalation

Based on human epidemiological studies, Health Canada estimated the respiratory cancer potency for inhaled arsenic to be between 7.83 and 50.5 $\mu g/m^3$. The potency ($TD_{0.05}s$) represents the concentration associated with a 5% increase in the incidence of lung cancer mortality. Comparing the average ambient arsenic concentrations measured in Yellowknife between 1991 and 1995 to this potency, the exposure/potency index for arsenic in Yellowknife ranges from 1.14×10^{-3} to 1.8×10^{-4}. Based on these results, Environment Canada/Health Canada criteria for further action suggest the priority for further action with respect to reducing overall arsenic exposure in the Yellowknife area is moderate to high.[2]

Assuming a linear dose-response relationship, we calculate an increased cancer risk ranging between and 9×10^{-6} and 5.74×10^{-5}. Put differently, if one million people were exposed to this range of airborne arsenic over an average 70 year lifetime, between 9 and 57 additional deaths due to lung cancer would probably be observed over what would otherwise occur. Since the population of the City

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[2] According to Health Canada (1994), the priority for further action is high for EPIs of approximately 2.0×10^{-4} or greater, moderate for EPIs between 2.0×10^{-4} and 2.0×10^{-6}, and low for EPIs less than 2.0×10^{-6}. Put differently, the priority is low when the estimated exposure is only a very small proportion of the concentration or dose that induces a 5% increase in tumours.

of Yellowknife is less than one million, this risk must be reduced proportionately. Assuming a population for Yellowknife of 15,175 (Statistics Canada 1993), this translates to between 0.14 and 0.86 additional deaths due to lung cancer attributable to exposure to airborne arsenic via inhalation over the 70 year lifespan of the exposed population. Table 3 summarizes the potency, exposure/potency index and the risk associated with arsenic inhalation.

We discuss the very important assumptions underlying these calculations in Section 2.1.3.3 below.

2.1.3.2 Ingestion

For ingestion, the PSL assessment report for arsenic considered a study of 40,421 individuals exposed to elevated levels of arsenic in drinking water to be the most appropriate for quantifying the potency of arsenic.[3] Based on this study, Health Canada estimated the drinking water potency ($TD_{0.05}$s) to be between 844 and 906 µg/L. Using Yellowknife's observed drinking water concentration of 0.3 µg/L, the exposure/potency index for arsenic in Yellowknife ranges from 3.3×10^{-4} to 3.6×10^{-4}. Based on these results, Environment Canada/Health Canada's criteria for further action suggests that the priority for reducing total levels of arsenic ingested in Yellowknife is moderate to high.

Assuming a linear dose-response relationship, we calculate an increased cancer risk ranging between 1.7×10^{-5} and 1.8×10^{-5} due to exposure to arsenic in Yellowknife drinking water. Put differently, if one million people were exposed to .3 µg/L of arsenic in their drinking water over their lifetime, we would expect to observe between 17 and 18 additional cases of skin cancer than would

[3] According to the PSL report, the intake of inorganic arsenic by the general population is greater in food than in drinking water, but insufficient data exists to estimate exposure/potency indices for food. Thus, we must rely on water indices, keeping in mind that this will underestimate the total exposure/potency.

otherwise occur. Assuming a population for the City of Yellowknife of 15,175, this translates to between .26 and .27 additional cases of skin cancer over the 70 year lifetime of the exposed population. Table 3 summarizes the potency, exposure/potency index and the risk associated with ingestion of arsenic from drinking water.

These estimates for ingestion are particularly problematic due to the fact that they do not account for exposure via food. The PSL assessment for arsenic reported that there was insufficient evidence to develop an exposure potency for food, so intake via ingestion is based solely on exposure via drinking water. The PSL report acknowledges that this likely under estimates the risks associated with ingestion since a larger portion of total arsenic intake will be attributable to food. This limitation creates a significant problem for our estimates since human health effects related to the consumption of country foods, in particular fish, by members of the local aboriginal community are a priority issue among members of the local aboriginal community around Yellowknife (Sangris 1996, MacKenzie Regional Health 1995).

The only available data concerning arsenic levels in country foods is from the Yellowknife Bay - Back Bay study (DIAND 1996) which analysed muscle samples from fish caught at six locations around the study area. Mean arsenic concentrations at the six sampling locations ranged from .015 to .43 μg As/g. In no case did the levels of arsenic in muscle exceed or even approach the limit of 5 μg As/g set for human consumption in the Food and Drug Regulations (DIAND 1995). Health Canada is currently assessing the health effects of fish consumption by aboriginals living in the Yellowknife region based on the fish muscle concentrations measured in the Yellowknife - Back Bay study. Results from this assessment are expected in the near future (Jackson 1996). Because of their preliminary nature, we have not factored this data into our numerical estimates.

Table 3: Summary of Estimated Potency and Risk Estimates

Medium	Potency	Exposure-Potency Index	Probability of increased tumours
Inhalation	7.83 - 50.5 μg/m^3	1.14 x 10^{-3} to 1.8 x 10^{-4}	9 x 10^{-6} and 5.74 x 10^{-5}
Ingestion	844 - 906 μg/L	3.3 x 10^{-4} to 3.6 x 10^{-4}	1.7 x 10^{-5} and 1.8 x 10^{-5}

In summary, according to the criteria established by Environment Canada and Health Canada, the existing conditions in the Yellowknife region pose a "moderate" to "high" health risk due to arsenic exposure via both inhalation and ingestion.

2.1.3.3 Assumptions underlying risk estimation

It is important to emphasize the assumptions inherent in these estimates. They do not take into consideration any additional or cumulative risk associated with other routes of exposure (Government of Canada 1993). Estimates for ingestion are based on drinking water only, and do not include the additional exposure via food because Health Canada could not estimate the uptake of arsenic from food via the stomach and intestines.

The estimates further assume that the current population has been exposed to currently observed levels of arsenic in air or drinking water for an entire 70 year lifetime. In actual fact, concentrations in Yellowknife have been much higher in past years. Moreover, most of the non-aboriginal population currently living in and around Yellowknife did not grow up there, and many will not live in the region for the rest of their lives. Their years spent in Yellowknife tend to be the healthier and more productive years of their lives, thus contributing to a healthy cohort. On the other hand, Yellowknives Dene band members are more likely to have been exposed to higher historical concentrations of arsenic in air, water and food, and are also likely to remain in the region for a larger proportion of their lives (Corveau 1996). All other things being equal, this should lead to a greater risk of arsenic-attributable impacts on members of this community. Unfortunately, insufficient demographic, health and/or exposure information exists to estimate a disaggregated risk for the Yellowknives Dene population (Corveau 1996).

2.1.4 Existing Environmental Effects

As with human health effects, environmental effects arise from exposure to arsenic via air, water, soil and food. This study focuses on the effects of arsenic released into air, but the airborne arsenic will contribute in some way to ambient concentrations in all four media. Although we cannot predict the relative contribution of airborne arsenic emissions to ambient concentration, in each medium, it is still important to understand the environmental effects arising those ambient conditions, and not restrict the analysis just to air.

DIAND (1995) identified several studies documenting the possible environmental effects of arsenic on the aquatic environment. Moore *et al.* (1979) observed that the density and diversity of benthic fauna increased progressively with increasing distance from the mouth of Baker Creek, finally showing signs of recovery 1000-1200 m into Back Bay. Baker Creek receives the treated tailings pond effluent from the Giant Mine, and is associated with elevated levels of arsenic and other heavy metals (DIAND 1995). Although Moore *et al.* (1979) further speculated that the reduction in density of bottom fauna probably reduced the food supply for bottom feeding fish such as lake whitefish, the actual impacts have never been investigated (DIAND 1995). According to Falk *et al.* (1973), mayflies were not present in the shallow portions of Back Bay, and their absence is likely related to their sensitivity to the pollutants present in the water column.

The Yellowknife - Back Bay study (DIAND 1995) attempted to document the effects of contaminant loading on the health of fish populations. The report concluded that the populations inhabiting the Yellowknife-Back Bay area appear "in good condition relative to other fish collected from selected other lakes in the

Northwest Territories" (DIAND 1995, p. 93). The report acknowledges, however, that information on the biology and ecology of these northern populations is limited and that further study would be required to assess the extent to which populations may be experiencing adverse effects.

With specific reference to arsenic, the Yellowknife-Back Bay study found elevated[4] levels of arsenic in muscle, kidney and liver tissue samples from most species collected from various locations around the study area. A review of the literature by the study's authors revealed that fish often accumulate arsenic in their liver and kidney and exhibit signs of sub-lethal toxicity. However, the authors did not check for sub-lethal indicators of toxicity and were, therefore, unable to conclude that such effects were taking place in Yellowknife-Back Bay populations.

The PSL assessment report for arsenic (Government of Canada 1993) developed two scenarios to determine if environmental levels of arsenic are adversely affecting wildlife. One of these scenarios is analogous to the situation being investigated in this study. That scenario considered the effect of elevated airborne arsenic concentrations around two base metal smelters and concluded that airborne arsenic has the potential to cause harmful effects in small mammals at concentrations above 0.13 $\mu g/m^3$ (Government of Canada 1993). Average annual ambient concentrations recorded at Yellowknife City Hall have ranged from .006 to .015 $\mu g/m^3$ between 1991 and 1994, indicating that harmful effects to small rodents are not likely to have taken place in the vicinity of the sampling station.

Air dispersion models run using existing stack and emission parameters estimate exceedance of this 0.13 $\mu g/m^3$ threshold within 2 kms. of the stack under certain wind conditions (McDonald and Murtha 1996). Thus, small

[4] Elevated in comparison to levels observed at a control site just outside Yellowknife Bay.

mammals living close to the mine may be experiencing harmful effects arising from airborne arsenic concentrations. No monitoring data exists, however, to confirm these model results outside of the City of Yellowknife. A monitoring station has been recently set up in the community of ~~Detah~~ Ndilo, but no data are available yet from this station.

The PSL assessment also reported adverse effects on pelagic organisms (amphibians and algae) exposed to arsenic in surface waters. Studies reported chronic responses at concentrations of 40 µg As(III)/L and 10 µg As(V)/L. Surface water concentrations of total arsenic ranged from .3 -247 µg/L in the Yellowknife/Back Bay Study (DIAND 1995). Mean concentrations ranged from 1 - 70 µg/L, with the highest concentrations measured at the mouth of Baker Creek which drains from tailings ponds used by the Giant Mine. Although it is difficult to compare total arsenic to chronic responses to As(III) and As(V), the high concentrations observed in selected samples suggest that adverse effects on pelagic organisms due to arsenic releases from the Giant Mine are possible in surface waters located near the mine.

The PSL assessment reported reduced growth in plants (green beans and spinach) grown in soils containing inorganic arsenic at concentrations of 10 mg As(V)/kg and 25 mg As(III)/kg. By comparison, concentrations of more than 10,000 mg/kg total arsenic have been reported in soil near two arsenic storage areas at the Miramar Con Minesite south of Yellowknife. Samples analyzed on the Giant Mine site ranged from 22 - 2380 mg/kg total arsenic (NWT Water Board 1996). The average concentration of the 57 samples analyzed in the Giant Mine study was 777 mg/kg, and all but two exceeded CCME's remediation criteria of 50 mg/kg. Clearly arsenic in these areas of elevated concentrations is likely having a harmful effect on terrestrial plants and invertebrates. We cannot, however, estimate the extent of this impact without more information on arsenic soil concentrations throughout the region and more information on the toxicity of arsenic to local vegetation.

In summary, comparing the findings in the literature with arsenic levels observed in the air, soil and water around the Giant Yellowknife Mine suggests that existing conditions are likely having an adverse effect on some of the terrestrial and aquatic organisms in the region. Unfortunately, we do not have sufficient information to estimate the magnitude and extent of this effect. Nor can we estimate the relative contribution to these effects from the air emissions from the mine.

2.2 *Effects of controlling Air Emissions*

2.2.1 Technological Options to Reduce Arsenic Emissions

Hatch (1996) lists four emission control options that would achieve between 90 - 95% removal of the remaining atmospheric arsenic emissions (i.e. less than 1.0 mg/m^3 residual arsenic in final emissions). Table 4 summarizes each of these options. Hatch (1996) also identified several non-arsenic producing alternatives to roasting. According to mine officials, pressure leaching using an autoclave represents the most practical alternative, especially given the GNWT's proposed SO2 regulations expected to be passed later this year. The Hatch study (1996) estimates capital costs for these alternatives in the neighbourhood of $23.6 million, but acknowledges that a thorough study of capital and operating costs would have to be carried out. Mine officials placed the capital costs closer to $30 million. Since the marginal benefit arising from reduced airborne arsenic emissions is small relative to the capital cost of these alternative processes, the following analysis focuses exclusively on emission control options.

Table 4: Cost summary of Technical Control Options

Equipment Description	As emissions mg/scm	Capital Costs $C x 10^6 ~~per year~~	Operating Costs $C x 10^3 per year
Scrubber	>1.0	1.181	198
Wet Electrostatic Precipitator (ESP)	>1.0	2.016	168
Alternative Wet	>1.0	2.044	169

ESP Activated Carbon	>1.0	2.206	206

(modified from Hatch 1996)

Environment Canada ran an air dispersion model incorporating meteorological data from Yellowknife and stack parameters from the Giant Mine. They ran the model using three scenarios: 1)current emissions; 2) predicted emissions following modification of existing technology; and estimated future emissions following installation of emission control technologies recommended by Hatch (1996). They validated the model results using currently observed ambient conditions. In the opinion of the modellers, this validation was satisfactory.

We used the model results to estimate future ambient annual average concentrations in downtown Yellowknife[5]. According to our calculations, the annual average concentration expected in downtown Yellowknife are lower than the average concentration observed in other cities across Canada (Dann 1990). Since at these very low concentration, model assumptions and variability become significant, we should assume that atmospheric arsenic in downtown Yellowknife are no different than those observed in other city locations. In effect, airborne concentrations would reduce to background levels if emission control measures were put in place.

2.2.2 Estimated benefits of control technologies on Human Health

If emission control technologies reduce airborne concentrations of arsenic to background levels as discussed in section 2.2.1, the estimated health benefit

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[5] Unfortunately, the model was set-up to calculate maximum concentrations, not annual average concentrations. Environment Canada modellers are attempting to re-run the model, but final results were not available in time for this draft. We estimated annual means based on these mximum values, assuming that the order of magnitude difference observed under current conditions would also hold under future emission rates.

would equal the number of cancers avoided due to reduced exposure to inhaled and ingested arsenic. Since we cannot calculate the effect of reduced air emissions on ambient drinking water conditions, however, we are only able to estimate the benefits due to reduced exposure from inhalation. Based on our calculations presented in section 2.1.3.1, implementation of control technologies could result in between 0.14 and 0.86 fewer deaths due to lung cancer over the 70 year lifespan of a population the size of Yellowknife.

The benefits of reduced illnesses and possible mortality resulting from arsenic exposure may be put into monetary terms. This approach assumes that people are willing to pay to avoid the pain and suffering associated with such illnesses[6]. The challenge is then to develop an appropriate estimate. Perhaps predictably, there is wide variation in the estimates that have been developed. Based on a survey of studies, Viscusi (1992) concluded that the most appropriate range for the value of a "statistical life" was $3 to $8 million (1994 U.S. dollars). The study on cleaner vehicles and fuels (Lang *et al.*, 1995) for the Canadian Council of Ministers of the Environment (CCME) used a range based on some of the same studies. In this analysis, we use the monetary values cited in the CCME study (See Table 5).

Table 5: Summary of Selected Monetary Values for Cancer Effects (C$1994)

[6] Some people object to any attempt to value illness (and human life) in monetary terms. The analysis in this report does not depend on this estimate. We present the numbers as a point of comparison and as a way of presenting as complete a picture as possible. Such numerical estimates have been made in many other contexts, including developing regulations for controlling ozone-depleting substances under CEPA (e.g. Abt Associates, 1989, 1993; Apogee Research, 1994), estimating the benefits of cleaner vehicles and fuels in Canada (e.g. Lang *et al.*, 1995) and assessing the effects of Clean Air Act Amendments for sulfate reductions in the United States (e.g. Chestnut, 1995).

Portion of Range	Dollars per Non-fatal Cancer Case	Dollars per Fatal Cancer Case	Average Dollars for All Cancer Cases	Lung Cancer Mortality (Sec. 2.1.3.1)	Monetized Value ($000)**
Low	$149,000	$2.5 million	$1.6 million	0.14 - 0.86	350 - 2,150
Central	$297,000	$4.2 million	$2.6 million	0.14 - 0.86	588 - 3,612
High	$594,000	$8.3 million	$5.2 million	0.14 - 0.86	1,162 - 7,138

*Based on the average survival rate for all cancers in Canada of 40%.

**lung cancer mortality x dollars per fatal cancer case.

Modified from Lang et al., 1995.

These estimates suggest that the monetary value associated with installing air emission control technologies and reducing lung cancer mortality due to inhalation of arsenic would be between $350,000 and $7.1 million[7].

For comparison, recent studies relied on by the Government of Canada to estimate the benefits of controlling ozone-depleting substances used figures of $10 million (1992 C$) for the value of a statistical life and $21,000 per incidence of melanoma (Abt Associates, 1993; Apogee Research, 1994).

2.2.3 Environmental Effects

Although we can estimate the change in ambient arsenic levels in the air resulting from reduced stack emissions at the mine, we cannot calculate the effect this change will have on future ambient concentrations in surface water, sediments, or soil levels because we have inadequate information on how arsenic loadings into one medium affect concentrations in other media. We also have no information on how arsenic moves and bioaccumulates in the food chain. Without this information we cannot quantify the change in total exposure

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[7] For information purposes, the monetary value associated with avoiding skin cancer due to ingestion of arsenic would be between 384,000 and $1.4 million. This figure, however, is not directly relevant to this analysis since we cannot estimate what effect, if any, air emission controls might have on ingestion and associated skin cancer.

and thus the environmental benefits that may arise from any of the three control options under consideration in this study.

2.3 Summary

Our ability to estimate the benefits of reducing atmospheric emissions of arsenic has been significantly limited by a lack of data. We do know that atmospheric emissions from the mine are currently in the order of 26 to 29 kg./day at a concentration of 24 mg/m^3. These emissions have and will continue to affect ambient levels of arsenic in air, water, soil and food, although we cannot predict the magnitude of this impact. The current average ambient levels are 0.006 to 0.015 μg/m^3 for air; 1 to 70 μg/L for surface water, 0.3 for μg/L for drinking water, and are unknown for soil and food.

The Federal Government's *Toxic Substances Management Policy* suggests that arsenic is a "Track 2 toxic substance" and should therefore be reduced to the greatest extent practicable. Health Canada policy further suggests that these ambient levels are problematic, and should be "medium" to "high" priorities for reduction efforts.

One of the factors typically accounted for by government in determining what reductions are appropriate are estimates of the costs and benefits of reductions. In this case, it is very difficult to estimate the precise value of possible reductions. We suggest that the value in terms of reduced mortality due to inhalation may range from $350,000 to $7,200,000 over an average lifetime (i.e. approximately 70 years). These numbers probably underestimate the overall benefits since they do not account for the health related benefits of reduced ingestion or of reduced sub-mortality effects, nor do they account for potential environment related benefits. We were unable to estimate these added benefits due to inadequate data.

The following section presents and evaluates three management options for reducing atmospheric emissions of arsenic from the Giant mine, and discusses a range of monetary and non-monetary considerations in addition to those estimated in this section.

3. Management Options

3.1 Overview of Management Options

The three management options under consideration in this study are:

1. a regulated performance standard under CEPA;
2. a structured voluntary agreement between Environment Canada and Royal Oak Mines; and
3. a covenant between Royal Oak Mines and the community.

This section briefly describes each option and presents criteria against which these options will be evaluated.

3.1.1 Regulated performance standard

Performance standards work like a speed limit. They generally specify the maximum emissions from a given stack or plant. There are several ways in which performance standards can be framed. Relevant options in this case include:

- emission rate (i.e. volume or mass of emissions per unit time);
- emission concentration - this will usually be adjusted to standard conditions (humidity, pressure and oxygen concentration); and
- total quantity of residuals per time interval (e.g. in kilograms per year) - also known as the loading;

These are the same

More than one standard may be set for the same substance (e.g. a maximum release per 24 hours and a maximum release per year). This may be designed to accommodate standard operating conditions, as well as upset conditions when brief larger releases may be permitted.

Although the analysis in this report focuses on the one gold ~~mine~~ or roaster emitting arsenic to the air currently in operation in Canada, such a regulation would probably be designed to apply more generally to all gold mines using ~~arsenic~~ roasters. In theory, it would also be possible to design a regulation to address all industrial atmospheric emissions of arsenic. This study does not further address this option since it was outside of the terms of reference.

3.1.2 Structured voluntary agreement

A structured voluntary agreement (SVA) is a formal negotiated agreement between government and industry which includes environmental goals, quantitative targets, timetables and recommended approaches to achieving environmental goals. The parties would include at least the federal government government and the mine, and could also include the GNWT and/or community representatives. The agreement could also describe the commitments of the government and the community representatives.

3.1.3 Community covenant

For the purpose of this project, a community covenant is defined as an agreement between the mine and the local community, but not the government. Again, the agreement should stipulate the environmental objectives, and may also include quantitative targets, approaches to achieve them, a description of the context of the agreement, definitions of important terms and guiding principles, and the commitments of each party. A key issue with respect to covenants is what parties can speak for the "community." We address this issue further in subsequent sections.

3.1.4 Legal issues with respect to the design of CVAs and covenants

Both an SVA and a community covenant would probably have the status of a contract. This has a number of important implications. First, the government may be limited in terms of what promises it can make. For example, the government requires explicit legislative authority to waive or alter an existing regulatory obligation. Moreover, government can probably not provide an absolute committment concerning future policy developments or future courses of action with respect to the implementation of laws and policies. At most, it can probably provide a best faith undertaking to take into account the contract in its future action.

A contract also has implications for government's enforcement-related issues:

- In most cases, the government can only sue for damages related to non-performance, and would have only a limited capacity to sue for "strict performance" (i.e. to compel the polluter to comply with the agreement and meet emission standards);

- absent a specific penalty clause, damages could be very hard to demonstrate, due to the long time required for many environmental damages to manifest themselves, the difficulty of disaggregating possible intervening causes, and the prospect that many effects may occur in other jurisdictions; and

- the inability of third parties to sue for breach of such a contract.

Addressing these limitations could be difficult. For example, in order for the government to enter into a contract providing for an effective civil penalty scheme, legislative amendments to either *CEPA* or the Department of *Environment ~~Canada~~ Act* may be required. This problem does not arise with respect to covenants, which would be between two private parties.

The concern about third party rights could be addressed either through adding them as parties to the agreement or by creating effective access to information and public reporting provisions into the agreement.

3.1.5 Comparison of options

Each of the options under review offers considerable flexibility in terms of its precise content. The final form of each option would depend in part on the resolution of the following issues:

- the precise level of emissions permitted;
- the basis for the standard - is it technology or risk based?;
- the timing of implementation;
- the monitoring protocol - i.e. end of stack; ambient; biomonitoring; health monitoring;
- the accountability process - i.e. which party is responsible for monitoring; how much self reporting is required; how much public access to information is provided for; and
- the enforcement process, including the type of sanctions available.

There are four main distinctions between the two negotiated measures and the regulated performance standard:

- application - the regulation would ~~probably~~ apply to any mine emitting arsenic from gold ~~smelting~~ roasting in Canada, whereas the negotiated agreements would be specific to the Giant Mine;
- scope of issues - both types of negotiated agreement can address issues that extend beyond the atmospheric emissions of arsenic;
- flexibility - the agreements provide greater flexibility to modify the terms of the agreement at some future date (this could be important, for example, in the case of sudden shifts in gold prices); and

- timing - while there is not necessarily a difference among the options on this, presumably a negotiated agreement could give greater weight to Royal Oak's current investment plans.

- The main difference among the two types of agreements is the role played by government, which is a party to an SVA, but not to a community covenant. This will influence the possible scope of issues that can be addressed, and the possible linkages that can be made to the regulatory regime.

3.2 Evaluation of Management Options

In this section we evaluate the management option according to five criteria:

- impact on emissions;
- impacts on the company;
- impacts on government;
- indirect economic impacts; and
- other community and stakeholder issues.

3.2.1 Impact on Emissions

Hatch (1996) estimates that the Giant Mine can achieve emission rates less than 1 mg/m^3 by installing technological control measures to scrub and filter the roaster tail gases. Each of the three management options can achieve the same results with respect to arsenic airborne emissions. Nothing in any option would restrict or enhance the company's ability to achieve any emission target, the government's ability to set a particular target, or the timing of implementation.

3.2.2 Impact on the Companies

The focus of this analysis is on the only currently functioning gold mine using a roasting process (the Giant Mine near Yellowknife). The mine will bear a large fraction of the total costs. Thus estimates of the direct costs associated with implementing the control options will be central to evaluating the overall impact of the management options. It is also important to go beyond the simple cost figures and to place them in the context of the operating environment for the companies to understand the implications of the added costs.

3.2.2.1 Costs to the Company

A recent analysis of the technical control options for atmospheric emissions of arsenic from the Giant Mine concluded that the mine could achieve significantly higher levels of control with commercially available technology. Hatch (1996) identified four emission control options that would achieve between 90 - 95% removal of the remaining arsenic (i.e. less than 1.0 mg/scm residual arsenic in final emissions). The capital costs range from $1.2 - 2 million, and annual operating costs range from $168,000 - $206,000 (Table 6). Hatch also identified several non-arsenic producing alternatives to roasting (e.g. autoclave), but concluded that all of these options would require significant capital expenditures and operating costs at least as expensive as those associated with roasting. As a result, we did not include these latter options in this analysis.

Table 6: Cost Summary of Technical Control Options

Equipment Description	Arsenic Emissions mg/scm	Capital Costs \$C x 10^6 ~~per year~~	Operating Costs \$C x 10^3 per year
Scrubber	>1.0	1.181	198
Wet Electrostatic Precipitator (ESP)	>1.0	2.016	168
Alternative Wet ESP	>1.0	2.044	169
Activated Carbon	>1.0	2.206	206

(Modified from Hatch, 1996)

For the purposes of the cost analysis, we assume that the capital cost would be amortized over ten years (Table 7).

Table 7: Annualized costs for technical control options

Equipment Description	Annualized costs at 0% discount rate (\$000)	Annualized costs at 5% discount rate(\$000)	Annualized costs at 10% discount rate(\$000)
Scrubber	316	351	390
Wet Electrostatic Precipitator (ESP)	370	429	496
Alternative Wet ESP	373	434	502
Activated Carbon	427	492	565

Note: Financing charges have not been included in this calculation.

Under each of the management options, we assume that the timing of the installation of the control equipment would be negotiated either informally in the case of the regulation, or formally in the case of the SVA and the covenant. The extent of the increase in costs will depend in part on the timing of implementation relative to the time of replacement for existing pollution control equipment. According to company officials, the current equipment can function indefinitely if properly maintained.

In addition to the costs of the control equipment and its operation, there would also be monitoring and reporting costs. Given that commercially available continuous emission monitors do not exist, we assume that the required monitoring program will consist of monthly grab samples. This sampling regime is similar to the *Secondary Lead Smelter Regulations* under CEPA. These costs are assumed to be XXXX **[Barbara, do you have any information on this?].**

As mentioned above, if the scope of the control effort under a covenant or structured voluntary agreement was expanded to include related environmental concerns (e.g. SO_2 emissions and arsenic releases through other media) the cost for the company would increase compared to controlling arsenic alone. It is possible, however, that this combined approach could lower the company's overall costs than for separate regulations for sulphur dioxide, atmospheric arsenic emissions and other arsenic-related emissions or storage issues.

3.2.2.2 Implications of costs

The implications for the company of implementing the management options will depend on the financial and regulatory context of the mine and the company. The additional capital and operating costs will reduce the operating margin of the mine. In the worst case scenario, the mine would suspend operations or shut down completely. This section addresses some of the factors that would shape the decision by Royal Oak's directors about the viability of the mine after implementing the options.

Financial context (Royal Oak)

Royal Oak Mines is one of Canada's top mining companies. The *Financial Post* (1996) ranked it in the top 500 of Canada's companies (at 440), with revenues of $208.3 million in 1995.

Royal Oak Mines is in sound financial condition. Net income for 1995 was $23.2 million and has been increasing steadily over the last few years. Of the top 500 companies in Canada in 1995, it ranked 45th in terms of its profit margin (at 11.1%) (Financial Post, 1996).

Financial context (Giant Mine)

The Giant Mine is an important asset in Royal Oak's total holdings of gold properties. In 1995, the Giant Mine represented 25% of Royal Oak's gold production and 8.9% of its mineable gold reserves.

Our understanding is that Royal Oak evaluates the viability of the mine independently of other Royal Oak operations. This means that the government should assess pollution control measures on the basis of the mine's operations, specifically its operating costs, rather than on the basis of the company's overall financial status.

The financial status of the Giant Mine will depend on four main factors:

1. the price of gold;
2. the size of reserves;
3. the grade of the reserves; and
4. operating costs.

The first factor influences the profitability and competitiveness of the industry overall. The next three affect the specific situation at the Giant Mine. We will address each of these in turn.

Price of gold

The price of gold may fluctuate dramatically in short periods of time in response to political and economic events. For example, in 1993, London gold prices ranged between $326 (US) and $406 (US) (American Metal Market, 1995). The short term fluctuations create uncertainty for the operation of gold mines, but affect all gold mines in the same way. Canada is a price taker for gold prices given its relatively small (approximately 7%) share of production.

Over the longer term, the price increased to a peak through the 1970's, but has settled at a relatively stable plateau in recent years (Figure 3). The latest figures (1995 and early 1996) indicate that gold prices are approximately 3% higher than in 1986. The factors driving the future price of gold are difficult to predict (e.g. Mackenzie and Gesing, 1987), however no drop in price is anticipated for the near future.

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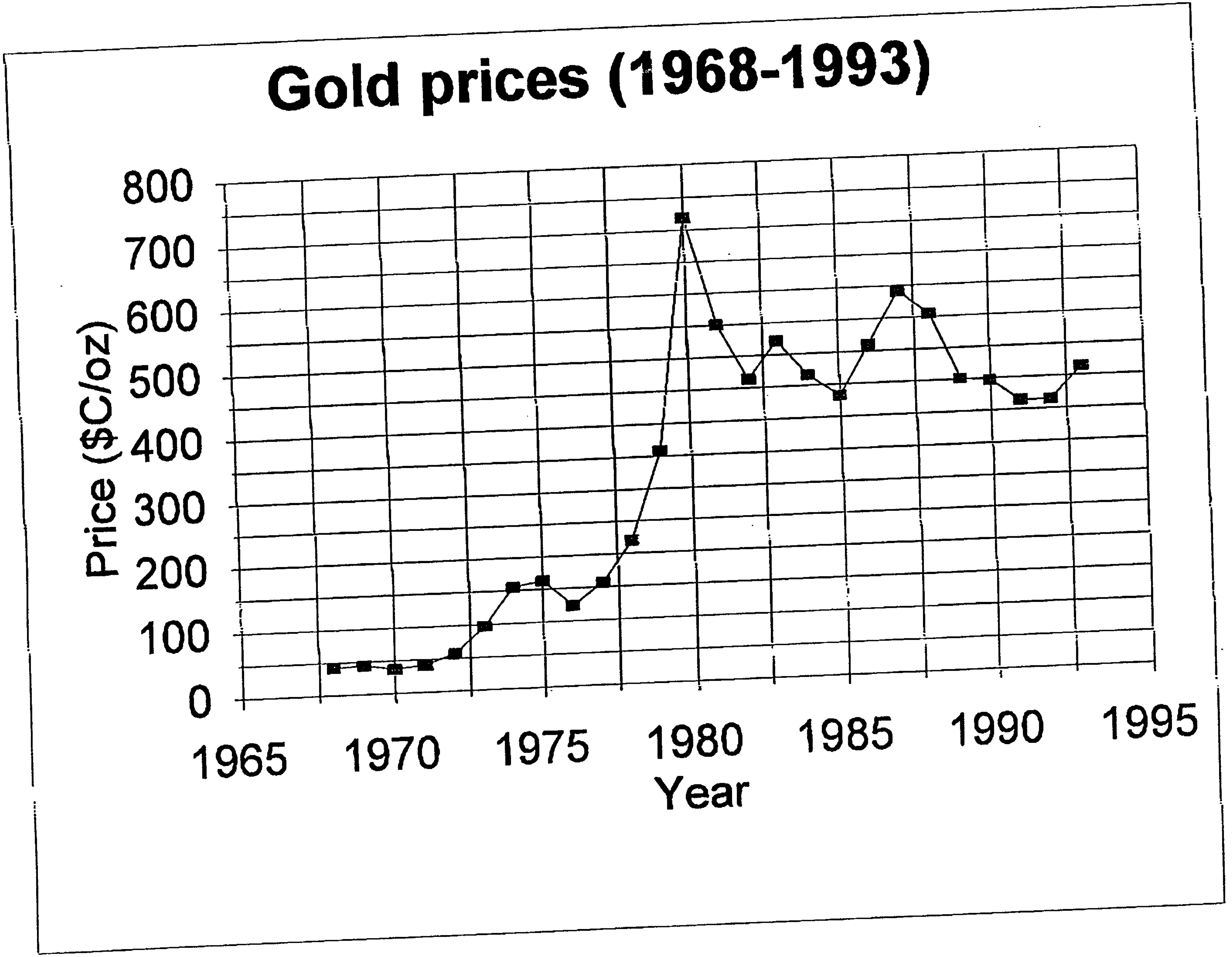

Gold prices (1968-1993)
Price ($C/oz)
800
700
600
500
400
300
200
100
0
1965
1970
1975
1980
1985
1990
1995
Year

Size of reserves

The size of the reserves will determine the expected lifespan of the mine, based on current prices and mining technologies. Mineable reserves at the Giant mine at December 31, 1994 amounted to 763,000 oz. of gold, compared with 840,000 oz. of mineable gold at December 31, 1993 (Giancola, 1996). The decrease at the Giant mine was due to an engineering review of mineability and production. The figures rose again (to 826,000 oz.) in 1995.

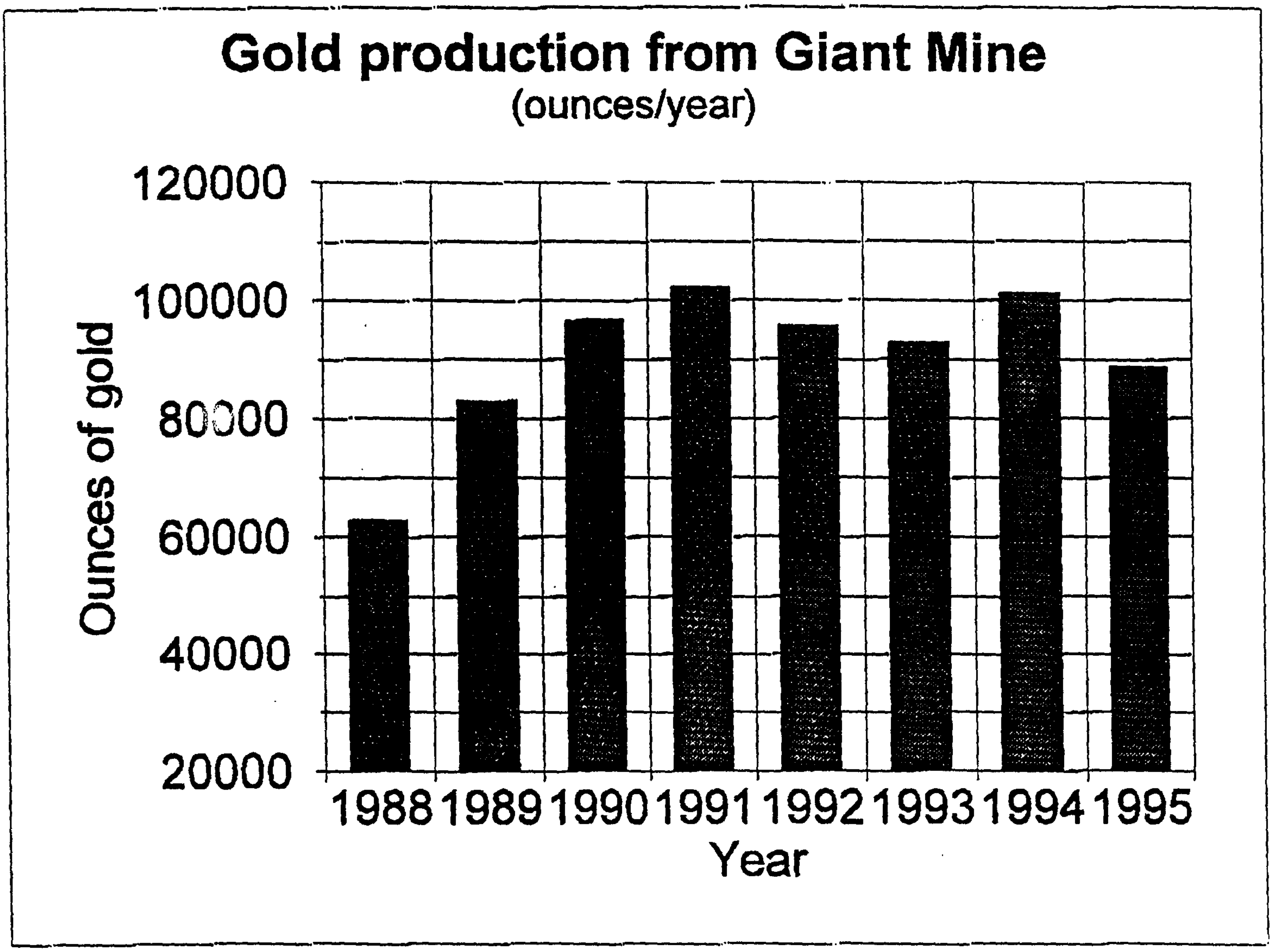
To be meaningful in this context, the reserves need to be compared to the production levels. Figure 4 shows that annual production has remained approximately in the range of 90,000 to 100,000 ounces over the last few years. (The 1995 value is 91,423 oz.) Based on current reserves, this gives a lifespan for the mine of approximately eight years. Mine officials estimated the lifespan of the current reserves to be closer to 5 years, but did not provide figures to substantiate their estimates.

The reserves are not a fixed amount, and may grow with exploration and development. For example, in 1989 the estimated reserves were 325,614 ounces, giving the mine a lifespan of just over three years at current production levels. Reserves also fluctuate due to improved extraction efficiencies. In fact, most of the current production came from areas of the mine that had been mined previously, utilizing ore that was considered unproductive in past years. Mine officials indicated that active exploration is underway.

Grade of the reserves

The grade of reserves has stayed relatively high for the Giant Mine over the recent past. The current (1995) level is 0.254 opt. compared to 0.264 for 1994 and 1993 and 0.286 for 1992, with a projected level of 0.262 for 1996.

Royal Oak's Supercrest mine project is located near the Giant Mine and is an advanced stage development project, where limited production commenced in late 1994. Mine officials stated that the higher grade mineable ore from Supercrest will offset the reduced quality expected elsewhere, maintaining the grade at its current level.


Gold production from Giant Mine
(ounces/year)
120000
100000
80000
60000
40000
20000
Ounces of gold
1988
1989
1990
1991
1992
1993
1994
1995
Year

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Thus the size and grade of reserves do not indicate any special financial difficulty for the mine.

Operating costs

The operating costs for the Giant Mine are documented in the latest annual report for Royal Oak and summarized in Table 8.

Table 8: Financial status of Giant Mine

	1991	1992	1993	1994	1995
Mine revenue *	$39.5	$38.8	$35.3	$41.0	$41.9
Costs	$31.1	$32.8	$30.7	$27.7	$33.7
Mine net cashflow	$8.4	$6.0	$4.6	$13.3	$8.2

* Figures are in millions of US dollars.

Operating costs for gold mines are frequently reported in terms of cost per ounce of gold. The cost figures for Giant Mine have been well below the selling price for gold over the last few years. In fact, there was a decline in operating costs from 1993 to 1994. Thus on the basis of these crude measures, there is scope for the Giant Mine to increase its operating costs and remain profitable. Using the annualized cost for the cheapest option at a 10% discount rate, the operating costs would rise by approximately 0.8%.

In this analysis, we were not able to address the relative competitiveness of the Giant Mine compared to other Royal Oak holdings or to other mining companies. It is difficult to compare mines operating in the NWT with those operating in the south because wages and other costs are significantly different.

Regulatory context

In addition to existing regulations applicable to the Mine, there is a good prospect of a number of additional regulatory measures in the near future. The government of the NWT is currently proposing to control the release of sulphur dioxide and other pollutants from gold roasters through *Gold Roaster Discharge Control Regulations* under paragraph 34(1)(b) of the Northwest Territories' *Environmental Protection Act*. The Department of Renewable Resources has prepared draft regulations and are now circulating them for public consultation. These draft regulations do not address arsenic emissions. A backgrounder released by the GNWT estimates Royal Oak's short-term capital costs of compliance with the regulations to be in the range of $2 million dollars. Longer term costs (i.e. beyond 2006) range from $30 - 50 million for alternatives to gold roasting, to $18 million capital and $4.4 million annual operating costs for end-of-stack systems.

As a result of the proposed GNWT regulations and the initiative of which this report forms a part, the Giant Mine could potentially face requirements to address two additional air pollution issues at the same time. Given that the proposed solutions to arsenic and sulphur dioxide are different, the costs would be additive, approximately double the costs for arsenic control alone in the short term.

The mine also requires a water license from the NWT Water Board for its water use, liquid effluent emission and waste disposal. The license specifies a maximum allowable concentration for arsenic in liquid effluent, and a series of requirements and studies to investigate long-term storage/disposal of arsenic-bearing dust collected by the emission control equipment. The current water license expires in April 1998, and increasing concerns over the underground storage issue may introduce additional financial demands on the mine when this license is renewed.

There also exists the issue of environmental clean-up and remediation in the event that the mine shuts down on a permanent basis. Once the mine is abandoned, water may seep back into these storage vaults, remobilizing the soluable arsenic trioxide and possibly contaminating the groundwater. The current water license demands that the company posts and maintains a $400,000 security deposit against clean-up costs deemed to be the responsibility of Royal Oak. Officials are currently contemplating imposing a much larger security deposit in the next water license which would have economic impact on Royal Oak. And, in any event, the GNWT Waters Act authorizes the government to order the Mine to pay any costs required to prevent or remedy risks to human health or the environment. The precise extent of the potential liability related to this issue is uncertain due to ongoing disputes concerning the degree to which Royal Oak is responsible for contamination caused by previous owners.

Summary of cost implications

On the basis of the data obtained in this analysis, it appears unlikely that financial considerations alone would justify closing the Giant Mine in the face of a requirement to control arsenic emissions. The combined effect with the SO_2 regulations proposed by the GNWT, along with liquid effluent controls and measures regulating underground arsenic storage that may arise during upcoming water licence renewals would create more serious financial challenges. Even together, however, these added costs should not significantly affect the profitability of the Mine.

3.2.2.3 Benefits to the companies

In general, the increase in costs due to implementation of arsenic control measures will have few accompanying benefits from the company's perspective. There are two possible ways in which the company could benefit. First, in theory, measures to control atmospheric arsenic emissions could reduce the requirements for control of emissions of sulphur dioxide. As discussed above, this probably *not* the case.

The second way the company could benefit is through generation of a marketable commodity, arsenious trioxide, by diverting it from their waste stream. This also appears to be unlikely. According to Hatch (1996), As_2O_3 has sold for $2.20 per kg to preservative producers, but this appears to be based on a 1969 reference. The Hatch study further notes that supply has often exceeded demand and only the highest purity arsenic compounds have found a market. A 1981 paper on *Gold Roasting At Giant Mine* indicates that As_2O_3 prices were unstable leading to a growing inventory of baghouse dust containing As_2O_3. The GNWT 1991 report also mentions the As_2O_3 market and the fact that this substance is largely in storage. No arsenious trioxide was commercially sold in Canada in 1992, 1993, or 1994 (Mining Association of Canada, 1995).

3.2.2.4 Added impact of negotiated options

Both an SVA and a covenant could address issues in addition to atmospheric emissions of arsenic. This opportunity could be attractive to the company.

In particular, an SVA could be developed to address all of the environmental issues relevant to the mining operation. This approach could offer a number of benefits to the mine relative to a regulated approach:

- the opportunity to identify and discuss more complete aspects of the problem, allowing the agreed upon measures to reflect a multi-media, "ecosystem approach" perspective, and to be based on systematic trade-offs among all possible issues;
- increased flexibility in terms of how and when to address an issue;
- some assurances concerning long term certainty in terms of how government policy will develop and be applied;
- a new relationship with government, in which they are treated as equals; and
- an improved public image.

Our preliminary research confirmed the company's potential interest in this approach. Faced with the prospect of a number of costly additional environmental control measures, mine officials indicated their preference in informal interviews with us for a management option that ensures an integrated approach to environmental management, and one that allows greater flexibility in terms of implementation. Specifically, the company would prefer a management option which permits an integrated (and hence lower cost) resolution of the atmospheric arsenic, underground storage and sulphur dioxide issues. A covenant could allow the company to address other aspects of the local community's concerns. In particular, it could provide a vehicle for the company to address and resolve community complaints by addressing additional dimensions of the issue such as the need for risk communication and remediation. At minimum, it could establish a process whereby these parties can work out issues face-to-face, provided the parties believe that such a dialogue would be fruitful. As we discuss further, below, the company is less interested in this approach. ?

3.2.2.5 Summary of differences among management options

In theory, each of the management options should impose the same costs on the company to reduce atmospheric emissions of Arsenic. Each option can be structured to provide the company with considerable flexibility in terms of how to achieve a prescribed reduction. Similarly, the timing of each could be structured so as to provide for a realistic investment period for the company. In practice, however, the negotiated options may provide more opportunities for the company to ensure that the timing requirements do not impose undue costs.

In any event, the negotiated options could also address different issues and therefore result in a different overall impact on the company. For example, if a community covenant addressed issues of concern to the community in addition to current arsenic emissions (e.g. risk communication, compensation or remediation), it could cost more to implement than a regulation, but could provide the added benefits of reducing the currently high tension between certain elements of the community and the mine.

In theory, an SVA could be structured to address all of the environmental issues that are currently - or will be regulated - by the NWT, DIAND, and Environment Canada (e.g. SO_2 emissions, underground storage, atmospheric arsenic, etc.). Such an integrated approach might allow for a cheaper overall resolution of these issues than the current approach, and is therefore attractive to the company.

3.2.3 Impacts on Government

3.2.3.1 Regulated performance standard

The costs to government of designing, promulgating, administering and enforcing a regulation are fairly well understood, albeit difficult to predict with any precision. These costs would include:

- further technical analysis;
- consultations;
- legal drafting;
- Gazetting and further consultation;
- training of enforcement personnel;
- promulgating information to the regulated community;
- monitoring (e.g. reviewing self reported information);
- enforcement (including regular inspections and inspections and investigations in response to public complaints or perceived violations);
- response to public requests for information; and
- administration (such as providing information to CEPA annual reports, Minister's briefing notes, etc.).

Because the regulation need not be complex, the actual scientific analysis and drafting work required to develop a regulation will not be high. Similarly, because Environment Canada officials are already in regular contact with the Giant Mine, the incremental monitoring, administration and enforcement costs may not be high. The main expenses are likely to be consultation and process costs incurred to present a credible justification to the regulated community and to meet the governments own process demands for any new regulation.

3.2.3.2 SVA

The government costs with respect to an SVA would probably be roughly equivalent to those for a regulation. The negotiation costs would probably be higher, particularly if multiple jurisdictions were involved. Since one of the main benefits of such an agreement is assumed to be increased industry "ownership" of the objectives, the enforcement costs would probably be lower.

3.2.3.3 Community covenant

The costs to the federal government of a community covenant depends to a large degree on the investment required to create a credible threat to regulate. If the parties, in particular the mine, chooses to come to the table early in the regulation-setting process, the costs of a community covenant would likely be lower than for the other two options. The further regulation has to be pushed through the regulatory process, the higher the costs. If the regulation has to be in place before negotiations can begin, the government could still gain some economic benefits from lower enforcement or monitoring costs, but the size of these savings would depend on the outcome of the negotiations and could not be pre-determined.

In the short term, government would incur some costs in stimulating the negotiations. Government could also offer to play a role in facilitating the negotiations. In any event, government would have to monitor the negotiations and the performance under the agreement in order to ensure that it retains the capacity to intervene in the event of an unsatisfactory outcome either of the negotiation process or of performance under the agreement.

3.2.4 Indirect Economic Impacts

The impacts from implementing the management options will include indirect economic impacts at three levels: the local level for Yellowknife itself, the regional level for the Northwest Territories, and the national level. For the purposes of assessing these impacts, we have considered two scenarios: (1) the mine does not change its operations significantly and implements the management option; and (2) the worst case in which the mine closes. Some of the analysis in this section draws an early study which looked at the effects of the anticipated closure of the Giant and Con-Rycon mines in 1974 (St. Pierre, 1972).

3.2.4.1 Yellowknife

The indirect impacts on the community of Yellowknife are a function of the way the mine is linked to the community. There are three main economic links:

1. employment and related payroll;

2. purchase of goods and services; and

3. payment of taxes, water bills, electricity and other fees.

In addition to these links, there may be other flows such as contributions by the mine to community initiatives. We consider each of these links below.

In the situation where the technical controls are implemented and the mine continues operation, there will be a small positive impact on the economy of Yellowknife. This will have two aspects. First, there will be the temporary increase in economic activity due to construction of the pollution control equipment. The magnitude of the effect on the local economy will depend on the extent to which equipment, labour and supplies are purchased locally.

Second, there will be a small increase in employment associated with operation and maintenance of the equipment once it is installed. Hatch (1996) estimated that an additional 0.5-0.6 person-years would be required for operation and maintenance.

In the worst case scenario where the mine shuts down, this will lead to a significant negative impact on the local economy. The duration and magnitude of the impact will depend in part on the availability of alternative employment and the associated income. For example, with the potential development of the BHP diamond mine, a loss of employment at the Giant Mine may be reflected in a slower growth rate in aggregate employment rather than an actual increase in unemployment.

Employment and payroll

a fourth ?

The Giant Mine is the fifth largest employer in the region. It employs approximately 300 workers in the Yellowknife area. In comparison, the Miramar-Con mine employs approximately 370 workers and the federal and territorial governments combined employ roughly 2,300 people. The total labour force in 1991 was 9,730.

Thus the employment situation in Yellowknife is significantly more diversified and more stable than in many small communities in Canada which are dominated by a single employer. For such communities, the effect of closing a mine would be more devastating than in Yellowknife (e.g. Canadian Employment and Immigration Advisory Council, 1987). Yellowknife is also probably better able than many communities to take advantage of the increase in demand for goods and services associated with the installation and operation of the pollution control equipment.

The short term effect of the worst case scenario would be a substantial increase in the unemployment rate for men in Yellowknife. Using the 1991 census information with 5,225 men in the labour force, and recognizing that mine employment is overwhelmingly weighted towards men, the unemployment rate for men would rise from the base of 4.3% to 11.0%. The unemployment rate for women would not change significantly.

Over the longer term, the unemployment rate would come down as mine workers obtained jobs in other mines, shifted to other kinds of work, or moved to other communities. Although the mobility between different employers in Yellowknife may be relatively limited given the heavy emphasis on the public sector, the mobility of the Yellowknife work force[8] could facilitate a relatively speedy recovery for the community. This should be put in the context of the long term downward trend in employment in metal mining in Canada (from 69,000 in 1975 to an estimated 34,000 in 1994) (Mining Association of Canada, 1995) which suggests that there may be surplus of labour.

The second dimension of the potential employment impact is the wage impact. Assuming the mine continues to operate, the aggregate wage impact (i.e. total wages paid by the mine to the community) of the installation and operation of the pollution control equipment will be small and positive. With only an additional 0.5-0.6 person-year associated with operation of the equipment, the net effect will be difficult to detect.

For the worst case scenario, the adverse impacts will be significant in the short run. In many small communities with a single large employer, alternative employment when it is available, is only available at a reduced wage. The average per capita income in Yellowknife in 1994 was $25,600, 43% above the national average. The metal mining industry contributes to the high wages, but in Yellowknife it is not the only source of high wages. The average weekly wage for workers in primary industries in January 1996 ($1000) was only slightly higher than the average for territorial government employees ($957).

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[8] In the 1991 Census, only 23% of the residents of Yellowknife had lived in the community for more than five years.

Thus under the scenario where the mine continues to operate, there will be a small positive impact on the total personal income in Yellowknife. Under the worst case scenario, the short term impact of total income loss would be disproportionately greater than the number of jobs lost.

Purchase of goods and services

During installation of the pollution control equipment, there would be a pulse of capital spending. Based on the estimates in Hatch (1996) the largest fraction of this spending would be on the equipment itself, which would be imported to Yellowknife. The amount that might be spent locally could be on the order of $300,000, primarily related to construction activities. The annual operation of the equipment would require $18 to $33 thousand worth of supplies depending on the control option chosen. These requirements would have a small beneficial impact on the Yellowknife economy.

In the worst case scenario, the ongoing purchases by the Giant Mine would stop. In 1979, the mine was estimated to make purchases worth $2.6 million in the Yellowknife area. We were unable to obtain more recent estimates.

Changes in the purchases of goods and services could affect small businesses in Yellowknife in particular.

Payment of taxes and other fees

The addition of new pollution control equipment to the mine will increase the requirements for water and electricity by a small amount. It will not affect the other taxes and fees the mine pays to the community (property tax, business tax, and school tax). Only in the hypothetical worst case scenario, would these latter taxes be affected.

If the mine closed, the community would lose a significant source of revenue. In 1995, Royal Oak Mines was the third largest taxpayer, paying $683,934 in municipal and school property taxes (4% of the total). This could lead to an increase in taxes and charges for other users of the infrastructure and social services.

Indirect effects

In addition to the direct impacts of the changes in employment and purchases, there will also be indirect or "spinoff" effects. Such estimates need to be treated with caution to avoid possible double counting, however it is important to recognize the full scope of linkages of the mine into the community.

Indirect effects can be looked at in two ways. First, from the perspective of employment, the spouses and dependents of workers in the mine will be affected by changes in the operations of the mine. The figure estimated in 1979 was that as a result of 300 people working in the mine, 900 people were dependent on the mine. This ratio of 3:1 has probably dropped since 1979 with the greater participation of women in the labour force.

The employment effect can be extended by calculating an employment multiplier to estimate the number of indirect jobs which depend in the short term on the mine's operations. An early study (St. Pierre, 1972) estimated a value of 0.35 for Yellowknife (i.e. for the 300 Giant Mine workers there would be 105 indirect jobs).

The second way of describing indirect effects is through a multiplier for economic activity overall. St. Pierre (1972) estimated a value of 1.25, implying that for each dollar of activity generated by the mine, $1.25 of activity in indirect and induced activity would result.

These estimates are crude and should be treated very carefully, but they do underscore that the impact of the potential changes in economic activity resulting from the control measures under consideration will probably extend beyond the simple direct impacts.

3.2.4.2 Northwest Territories

The Northwest Territories as a region has higher unemployment and lower wages than in Yellowknife. Thus adverse impacts on the Yellowknife economy may extend to other parts of the territory. For example, in the hypothetical worst case scenario where the mine is forced to shut down, there may be impacts on the rest of the NWT through lower tax revenues, and through lower levels of economic activity. Both personal income taxes and corporate taxes might be affected.

The regional economic impact of the costs associated with changes in operations at the Giant Mine would be noticeable, but not large. To put the Giant Mine in perspective, we have summarized the role it plays in the overall gold mining industry in Canada (Table 9). Overall, mining is very important to the economy of the NWT, accounting for about 47% of total economic output (Van Geest and Corrigan, 1996). Gold is not the only highly valuable mineral; zinc is roughly comparable in terms of the value mined each year. Thus policies and options which affect the perceived economic attractiveness of mining in the NWT will have strong effects on the territory's economic outlook.

Table 9: Summary of gold mine activity in Canada

	Giant Mine	Yellowknife	Northwest Territories	Canada
Number of gold mines (January 1995)*	1	2	4	50
Gold production (kg) (1993)	3,517 *		13,205 **	153,129 **
Value of gold production ($000) (1993)	52,480 *		197,043 **	2,284,991 **

* from Royal Oak Mines 1995 Annual Report

** from Mining Association of Canada (1995)

3.2.4.3 Canada

The socio-economic effects at a national level of implementing the management options are small. There would be no detectable effect on national indicators such as inflation, employment, balance of payments, or national competitiveness, even with the worst case scenario.

For example, Canada is a net exporter of gold. In 1992, we exported a net amount of 168,402 kilograms of gold worth $2.37 billion (Natural Resources Canada, 1994). Of this the Giant Mine's production was 3,627 kilograms (or 2.2%).

3.2.4.4 Comparison among management options

There are few differences among the options, except that options which reduce the likelihood of the worst case scenario would be preferred. If options with higher levels of flexibility and options which are broader in scope have a greater probability for success and can provide a more cost effective solution to the company, they will help to avoid the worst case scenario and will be more likely to maximize net social benefits. Moreover, to the extent to which such options are perceived by the industry as less confrontational, they could help bolster the perceived attractiveness of the NWT to other mining ventures.

3.2.5 Stakeholder Issues

There are several "stakeholders" with an interest in how the federal government manages arsenic emissions from the Giant Mine. From a limited series of interviews conducted with government and non-government representatives in Yellowknife, six key government agencies and non-governmental stakeholder groups have emerged:

- the Federal government (DIAND, Environment Canada);
- the Territorial government ;
- the NWT Water Board;
- Royal Oak;
- the local aboriginal community (Yellowknives Dene Band); and
- the local municipal government.

This section describes some of the concerns and comments communicated to us by these groups. Since the federal government's position is already well known to the Task Force members, this section discusses the issues of concern for each of the other five stakeholder groups. In some cases these concerns are directly relevant to airborne arsenic and the control options. In other cases, they may not be directly relevant, but may nonetheless influence the likelihood of success of the management options and should therefore be taken into consideration.

We emphasize that the following are observations based on informal discussions with interested individuals. Analysis of these issues was well beyond the terms of reference for our study. Accordingly, we present these concerns as possible issues to be addressed in subsequent analysis if deemed appropriate by the Task Force. We have not attributed comments to any specific individuals.

3.2.5.1 GNWT Department of Renewable Resources

The GNWT Department of Renewable Resources main concern with respect to the mine at present relates to SO_2 emissions. The Department has prepared a draft regulation to control SO_2 and has circulated it for public comment. According to GNWT officials, the government has attempted, without success, to convince officials at the Giant Mine to comply voluntarily with SO_2 guidelines and believes that regulation is required to achieve their emission objectives. When asked whether the GNWT would consider participating in a broader discussion of management options applied to the mine, perhaps in the form of an SVA or community covenant, officials replied in the affirmative but emphasized that they would not consider delaying the regulations to accommodate such a process.

3.2.5.2 NWT Water Board

We did not meet with representatives of the Water Board, but it is clear from discussions with other stakeholders and from a review of the Giant Mine's water license, that this body and the process it administers play a central role in the overall regulatory regime applied to the mine. All parties expressed concern over the arsenic trioxide storage issue. The chief concern has to do with who will be responsible for what are likely to be very high costs of cleaning up the site once the Mine closes. At present, the water license requires Royal Oaks to conduct a study of the issue and to amend its Abandonment and Restoration Plan based on the results of this study. Some Members of the Water Board Technical Advisory Committee (TAC) are apparently dissatisfied with Royal Oak's progress to date on this issue. It is difficult to predict what effect this issue may have on the upcoming license renewal in 1998.

3.2.5.3 Municipal Government

Municipal government officials are concerned about the health effects of arsenic and about the public's concern over these health effects. But it is their opinion that the negative effects of airborne arsenic are more perceived than real. They are also aware of the economic benefits flowing from the Giant Mine in terms of both direct tax contribution and indirect economic effects. They made it clear that they would not want to see the mine close, and that the majority of the population of the city felt the same way. Although relations between the mine and the community were certainly been better under previous owners, animosity toward the mine has lessened considerably since the end of the strike to the point where current relations can best be described as "indifference".

3.2.5.4 Yellowknives Dene Band

Yellowknives Dene Band members are concerned about human health effects arising from past and present operation of the area's two gold mines. They do not generally make a distinction between arsenic and other contaminants. Rather, they are concerned about the health effects from exposure to chemical contaminants in general. They believe that their water is unsafe to drink, that their food (in particular the fish from ~~Yellowknife~~ Back Bay) is unsafe to eat, and that the air is unsafe to breathe. They base their concerns on the historical observations of the elders, and on the fact that the incidence of cancer appears to be rising in recent years. In particular, they noted that over the last winter, two elders who have continued to fish in ~~Yellowknife~~ Back Bay died of cancer. The community attributes these deaths to exposure to chemical contaminants from fish, and see this as further evidence of a significant health risk.

According to Yellowknives Dene representatives, relations between the band and the mine have never been good. They believe that a verbal commitment was made by the original mine officials to pay royalties to the Yellowknives Dene family who fist discovered gold in the region and reported this find to members of the non-aboriginal community in the late 1940s. The community still believes that the family should receive these royalties. At present, no members of the Yellowknives Dene community is employed by the mine.

When asked about any preference between the three management options, Band officials expressed no strong opinion. They did, however, say that they have made several attempts to open lines of communication with mine officials without success, and that the community covenant might be an excellent way to improve relations.

When asked what issues they would like to negotiate, band officials listed the following:

1. redirect surface water effluents out of Back Bay and allow the Bay to recover;
2. control stack emission;

3. control dust from the tailings area;
4. solutions to the underground storage issue since the community sees this as a long term threat to the entire Yellowknife Bay;
5. compensation for water bills, since the community can no longer drink the water from the Back Bay;
6. compensation for additional fishing and food gathering costs, since community members now have to travel greater distances to reach fishing and gathering areas; and
7. resolution of the royalty dispute between the mine and the family who first discovered gold in the area.

3.2.5.5 Royal Oak Giant Yellowknife Mine

Royal Oak officials acknowledged to us that their relationship with the community is poor and they take partial responsibility for this fact. Their view is that the community assumes that a lack of regulations for SO_2 and arsenic means that the company is emitting pollutants in an uncontrolled fashion. The company has made few attempts to publicize their environmental control efforts or the fact that their compliance record is extremely good. They further acknowledge that relationships between the company and the community have soured over the last several years, although they did not elaborate as to possible reasons for this.

Mine officials expressed considerable interest in SVA without hesitation. The main reason for their interest was the opportunity to deal directly with government agencies within a single management process. They expressed concern over a potential lack of coordination between SO_2 and arsenic control options, and hoped that a one-window approach would lead to a more integrated regulatory regime; one that created an opportunity to set priorities among issues.

3.2.5.6 Local Non-governmental Organizations

Note: I have arranged to speak with Kevin O'Reilly in Ottawa on June 24th and will incorporate his comments in the final draft.

4. Discussion of management options

Because each of the management options reviewed in this report offers considerable flexibility in terms of how environmental performance objectives will be achieved, they are roughly comparable with respect to likely impacts on emissions and in terms of the costs they will impose on the company. The costs to government of a regulation and an SVA should also be similar, while a community based covenant could require less government investment.

The main differences between these three options lie in the their ability to address or respond to many of the concerns, issues, relationships and dynamics that revolve around the stakeholders and arsenic. The better they respond, the greater the likelihood that the government's objectives regarding arsenic in particular and the environment in general will be met. We review each option below.

4.1 Regulated Performance Standard

A regulated performance standard offers three main advantages. First, it would provide all stakeholders with certainty. Second, it would enhance government control over the final outcome. And third, it could be applied to a broader range of arsenic sources. The ~~federal~~ government could design the regulation to apply to all gold mines using arsenic, or to all industrial emitters of arsenic.

The primary challenge with respect to a regulated performance standard is whether it is possible to demonstrate that the overall benefits of a regulation outweigh the costs. The analysis presented in this paper indicates that it is may be difficult to demonstrate a positive benefit-cost result. Section 2 presented estimated health benefits from reduced mortality due to inhalation of arsenic range from $.35 to $7.1 million over an average life span (i.e. approximately 70 years). These estimates are probably low since they do not account for reduced ingestion or reduced sub-lethal impacts, nor do they account for potential environmental benefits. Costs to the company could range from $1.2 to $2.1 million in capital investment and between $168,000 and $206,000 in annual operating costs. The estimated anualized costs to the company thus range from $350,000 to $490,000 using a discount rate of 5%.

Those estimates focus on the costs and benefits *vis à vis* a single mine. From that perspective, the decision of whether or not a regulation is warranted may turn on the extent to which the government is willing to invoke the precautionary principle. In addition, the government will have to determine whether the added benefits of developing a regulation that might apply to other emitters of arsenic in the future tips the balance in favour of developing a regulation at this time.

A second problem with respect to the regulatory approach is that most stakeholders - including the Mine, the NGOs, the aboriginal community and the local government - view airborne arsenic as less important than other environmental issues involving the mine.

4.2 Community Covenant

As we have observed above, both negotiated agreement options offer the added potential to address other aspects of the problem rather than being restricted to air emissions. The key issue with respect to both options is whether the relevant parties can be expected to be willing to enter into an agreement.

Our preliminary interviews suggest that some of the stakeholders might be interested in a covenant between community representatives and the mine. In particular, the local ENGOs and the Yellowknives Dene Band are interested in addressing a wider range of issues with respect to the past and present operations of the mine than could be included in a regulation. A covenant might provide the opportunity for such a negotiation. Aside from the actual substantive issues it addresses, a covenant should also provide an opportunity for opening up lines of communication and restoring trust.

Notwithstanding these potential benefits, however, the prospects for this option appear to be low. It is not clear that any of the stakeholders would be satisfied with the lack of enforcement "teeth" that might be provided by a community covenant on its own. An additional concern articulated to us by a number of stakeholders is: which parties should participate in such an agreement. Who speaks for the community? And if the list of participants gets large in order to accomodate the diversity of interests, would the negotiations be manageable? The most significant problem with this option is that the mine does not appear to be interested in engaging in negotiations over these issues with community groups, and does not face any significant incentive to do so.

4.3 Structured Voluntary Agreement

An SVA could take one of two forms: a negotiated agreement between the mine and the federal government focused on atmospheric emissions of arsenic only, or an agreement among the mine, the NWT and the federal government. There are few prospects for the first model, while the second model could be explored further.

The key issue with respect to either model is whether the company would be willing to enter into an agreement. In theory, there are three factors that might induce the mine to consider negotiating an agreement focused only on arsenic:

- significant community concerns with respect to airborne arsenic that are likely to impair the company's ability to continue to operate profitably;
- market pressures that might compel the mine to want to "green" its image; or
- sufficient concern on the part of the company about maintaining good will with the community.

Although this study has not addressed these considerations in great detail, our preliminary observations suggest that none of these conditions exist in this case.

The mine might, however, be interested in an SVA that addressed a wider range of environmental issues. The main reason the mine would be interested in such an agreement is the potential for developing a long-term integrated approach to its environmental issues. This raises two issues:

- would this incentive be sufficient to induce the mine to include atmospheric emissions of arsenic in the negotiations even though the threat of regulatory intervention on that particular issue may be low?

- in any event, what are the prospects of inter-jurisdictional cooperation with respect to such an approach?

Although we did not pursue these issues in detail, our preliminary observations suggest that the answer to both is positive. Although they did not indicate to us precisely which issues they would be willing to negotiate, officials from the mine suggested that they would be very interested in negotiating a comprehensive package of the environmental issues they face. And while the NWT intends to pursue the promulgation of the SO_2 regulation, it would be interested in exploring the possibility of whether negotiations could help resolve outstanding issues such as the liability for the contaminated site upon closure of the mine.

In addition to addressing these two concerns, an SVA would have to address at least two additional issues in order to be effective. First, it would have to overcome concerns expressed to us by some members of the local community about the need for effective enforcement powers. More analysis is required in order to determine whether the community stakeholders would be satisfied with a non-regulated approach. Second, it will be important to ensure that the community trusts the government to negotiate on its behalf. Many of the local aboriginal groups and ENGOs have expressed concerns in a number of fora about the failure of the federal government to adequately address their historic concerns about the mine.

5. Conclusion

We would appreciate guidance from the Task Force about the tone and content of this section.

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