Giant Mine Underground Arsenic Trioxide Management Alternatives Workshop

June 11 & 12, 2001

Explorer Hotel
Yellowknife, NT

PARTICIPANT BINDER

June, 2001

Affaires indiennes et du Nord Canada
Indian and Northern Affairs Canada

Giant Mine Underground Arsenic Trioxide Management Alternatives Workshop

June 11 - 12, 2001

Katimavik Rooms "A" and "B", Explorer Hotel,
Yellowknife, Northwest Territories

Workshop Purpose and Objectives

Purpose

The *Giant Mine Underground Arsenic Trioxide Management Alternatives Workshop* is part of a continuing commitment to a broader management approach being led by the federal government to address the arsenic trioxide currently stored underground at Giant Mine. This workshop is a key element in advancing the engineering, scientific, human health, and ecological risk considerations associated with the management alternatives.

This workshop will contribute to strengthened understanding by participants of the underground arsenic trioxide problem at Giant Mine, provide a forum to present and discuss the work completed to date on management alternatives, as well as identify actions and considerations to further advance the analysis and ultimately to seek environmental assessment and regulatory approval to implement the selected management alternative.

Workshop Objectives

The *Giant Mine Underground Arsenic Trioxide Management Alternatives Workshop* is structured in three parts and is intended to achieve the following objectives:

Part One: The Underground Arsenic Trioxide Problem At Giant Mine and Efforts to Address It

1. Review the commitment to and elements of a broader Giant Mine Arsenic Trioxide Management approach being led by the federal government to address the arsenic trioxide currently stored underground. This includes outlining the process to complete the engineering, scientific and other work necessary to prepare for an environmental assessment and regulatory review based on a formal *Project Description*.

2. Provide an historical overview of arsenic trioxide management at Giant Mine and the chronology of events related to the work completed to date on underground arsenic trioxide management practices and options at Giant Mine, with particular emphasis on the engineering and scientific assessment work since the June 1999 technical workshop.

Part Two: Examination of Management Alternatives

1. Present an overview of the work completed by the Technical Advisor.

2. Provide the results of a screening level human health and ecological risk assessment of a case where no special measures are taken to manage the arsenic trioxide at the Giant Mine - referred to as an *unmanaged base case* for analysis purposes only.

3. Present the approach, methodology and conclusions from the group of management alternatives examined: (1) in situ management; (2) dust removal with arsenic and gold recovery; (3) dust removal with gold recovery; and, (4) dust removal with stabilization.

4. Present the evaluation to date of the four representative management alternatives.

Part Three: Development of Next Steps to Advance Management Options

1. Identify and discuss in break out groups what needs to be considered to further advance the management alternatives, including social, economic, environmental, and communication/consultation factors.

2. Identify and discuss in break out groups the potential roles of stakeholders and the public in the next stages, including the potential of establishing a multi-stakeholder advisory group to help guide the process.

Giant Mine Underground Arsenic Trioxide Management Alternatives Workshop

June 11-12, 2001
Katimavik Rooms " A" and "B", Explorer Hotel,
Yellowknife, Northwest Territories

Sessions Open to the Public & Media

Agenda Day 1: Monday, June 11, 2001

12:00 - 1:00 **Arrival and Registration**

1:00 - 1:25 **Welcome and Opening Remarks**

· Welcome	Andy Swiderski, Facilitator
· Opening Remarks	Dave Nutter, DIAND
· Introduction of Participants	
· Purpose, Objectives and Anticipated Workshop Results	Facilitator
· Roles & Responsibilities	Facilitator
· Overview of Logistics & Organization, Reference Materials and Displays	
· Keeping track and Recording of Discussions	Facilitator
· Review of Participant Reference Binder	Facilitator
· Agenda Review	Facilitator
· Questions/Discussion	

PART ONE: THE ARSENIC PROBLEM AT GIANT MINE AND EFFORTS TO ADDRESS IT

1:25 - 1:45 **Agenda Item No. 1: The Giant Mine Arsenic Trioxide Management Approach Being Led By the Federal Government** (Obj.1)

· 15 minute presentation by Dave Nutter, DIAND
· Questions/Discussion

1:45 - 2:10 **Agenda Item No. 2: An Historical Overview of Underground Arsenic Trioxide Management At Giant Mine and the Chronology of Events Related to the Work Completed To Date** (Obj.2)

· 20 minute presentation by Neill Thompson, DIAND,
· Questions/Discussion

PART TWO: EXAMINATION OF MANAGEMENT ALTERNATIVES

2:10 - 2:45 **Agenda Item No. 3: Overview of Work Completed by the Technical Advisor** (Obj. 3)

- 20 minute presentation by Daryl Hockley, SRK Consulting
- Questions/Discussion

2:45 - 3:00 Break

3:00 - 4:15 **Agenda Item No. 4: Results of the Screening Level Environmental and Human Health Risk Assessment** (Obj. 4)

- 60 minute presentation by Randy Knapp and Bruce Halbert, SENES Consultants
- Questions/Discussion

4:15 - 4 :45 **Agenda Item No. 5: Overview of the Management Alternatives** (Obj. 5)

- 20 minute presentation by Daryl Hockley, SRK Consultants
- Questions/Discussion

4:45 - **Public Questions & Discussions**
Day One Wrap Up and Instructions for Day 2 (Facilitator)

5:00 - **Media Briefing & Questions**

OPEN HOUSE/PUBLIC INFORMATION SESSION
7:00 to 9:00 pm, Katimavik Room "C"

Agenda Day 2: Tuesday, June 12, 2001

08:30 - 09:00 **Arrival and Registration**

09:00 - 09:15 **Welcome and Opening Remarks**

· Welcome	Dave Nutter, DIAND
· Review Workshop Purpose and Objectives	Facilitator
· Summary of Day 1	Facilitator
· Day 2 Agenda Review	Facilitator
· Questions/Discussion	

Continuation of.....PART TWO: EXAMINATION OF MANAGEMENT ALTERNATIVES

09:15 - 11:00 **Agenda Item No. 6: Presentation of Four Representative Management Alternatives** (Obj. 6)

· 90 minute presentation by Daryl Hockley, SRK Consultants, Grant Feasby, Lakefield Research, and Randy Knapp, SENES Consultants
· Questions/Discussion

10:15 - 10:30 Break

10:30 - 11:30 **Agenda Item No. 6:....CONTINUED**

· 20 minute presentation by Daryl Hockley, SRK Consultants on evaluations to date
· Questions/Discussion

PART THREE: DEVELOPMENT OF NEXT STEPS FOR PREPARATION FOR ENVIRONMENTAL ASSESSMENT

11:30 - 12:00 **Agenda Item No. 7: Development Of Next Steps for Preparation of Environmental Assessment: Break Out Group Tasks and Instructions** (Obj. 7)

· 15 minute presentation by Facilitator
· Questions/Discussion

12:00 -1:00 Lunch (Lunch is provided)

1:15 - 3:45 **Agenda Item No. 8: Development Of Next Steps for Preparation of Environmental Assessment: Break Out Groups** (Obj. 7 & 8)

3:45 - 4:45 **Agenda Item No. 9: Reports From Break Out Groups and Plenary Discussion Regarding Development Of Next Steps for Preparation of Environmental Assessment** (Obj. 7 & 8)

4:45 - **Public Questions & Discussions**
Closing Remarks (Dave Nutter, DIAND)
Workshop Wrap Up (Facilitator)

Hansard Friday June 8, 2001

Member's Statement on Options to Address the High Cost of Living

MR. NITAH: Mahsi, Mr. Speaker. Mr. Speaker, today I would like to speak about the high cost of living and what the government wants to do to help the citizens of the Northwest Territories with this. The honourable Minister responsible for Finance mentioned a tax credit yesterday in one of his statements, to help with the high cost of living.

I agree with anything that will put money back into the pockets of the people of the Northwest Territories, Mr. Speaker. I have to question the method the Minister would like to use to give money back to the people, to assist them with the cost of living.

When you introduce a tax that is based on salaries, I think it is discriminatory between low income earners and people who make a fairly good wage. What he is introducing will give $177 to every member of the community, or a person in the Northwest Territories who makes $66,000 or more. It is staggered as the salary goes down. Not to mention the fact that it does not help an individual who has four or five kids and one income earner in the home. It does not address the fact that the cost of living affects all people in the Northwest Territories.

It does not address the fact that there are two reserves in the Northwest Territories who do not pay taxes, and do not file claims. There are some aboriginal communities in my constituency, Treaty 8, which believe that they should not have to pay taxes. That is an arrangement between them and the federal government. They will not qualify for it. People on income support may not qualify for it.

There are too many outstanding questions. I do not understand why we have to rush this tax. The argument that Mr. Handley uses is to be able to implement with the federal government so that we can qualify for this year, and next year's tax return. The road toll, if it is approved, does not kick in until January. Mr. Speaker, I do not think we should rush this. I think we should give it a little more thought and possibly look at other methods of putting money back into people's pockets that is fair to everyone. That recognizes the different living conditions, the different political initiatives, and is basically a fair system. Mahsi, Mr. Speaker.

MR. SPEAKER: Mahsi, Mr. Nitah. Item 3, Members' statements. The honourable Member for Great Slave, Mr. Braden.

Member's Statement on Arsenic Remediation Efforts

MR. BRADEN: Thank you, Mr. Speaker. Mr. Speaker, a legacy of Yellowknife's gold mining history over the last six decades has been the production of arsenic trioxide and the adverse health risks which accompany this industry. Yellowknife residents, for many years, have had concerns about arsenic levels in the city, Mr. Speaker. I am pleased to note that progress is being made. on how to manage this serious issue.

I would like to recognize the ongoing work of the Yellowknife Arsenic Soil Remediation Committee, sometimes known as YASRC. It is a coalition, Mr. Speaker, of all levels of government, community, aboriginal and mining groups, whose task is to determine at what point arsenic levels pose real threats to our public health and environment.

The other day in this House, the Minister for RWED noted that the improvement in air quality of the city has greatly improved now that the Giant roster has ceased operation. This is good news. In fact, at the May public meeting hosted by YASRC, it was underlined that in regard to arsenic levels, the drinking water in the city of Yellowknife is not a problem, and ambient air levels are also not a problem.

This committee has retained Canada's leading expert in the field to determine the health risks from arsenic around the city and develop soil remediation guidelines for use for residential, recreational and industrial land uses. In fact, guidelines, according to the committee, will be presented to the public in September, Mr. Speaker.

Yellowknife MLAs have continued to draw to the attention of the federal government its obligation at the Giant Mine for the immense problem of some 265,000 tons of arsenic trioxide stored underground there. There is still a long way to go in this process. The federal government has identified resources to advance the planning and this is a positive step, not only for Giant, but for dealing with the environmental issues at Colomac as well.

Next week, stakeholders will be meeting to consider the approach for managing the arsenic problem at Giant Mine. Stakeholders and public have a vital interest in what is going on. I complement the governments and the stakeholders for opening the process to the general public.

Mr. Speaker, I applaud the efforts of these officials and the federal government, we must keep in mind, has been the major beneficiary of the development of our resources. It is their obligation to ultimately manage this environmental hazard. We must consider to continue to seek long-term commitment of federal resources to implement a permanent solution which addresses the arsenic problem to the satisfaction of residents. Thank you, Mr. Speaker.

-- Applause

MR. SPEAKER: Thank you, Mr. McLeod. The honourable Minister responsible for the Department of Education, Culture and Employment, Mr. Ootes.

Further Return to Question 35-14(4): Seniors Fuel Subsidy

HON. JAKE OOTES: Thank you, Mr. Speaker. Mr. Speaker, we can certainly undertake to look at that possibility. We are looking at that for income support, the food basket area, doing an annual adjustment and an annual survey. Thank you.

MR. SPEAKER: Thank you, Minister Ootes. Item 6, oral questions. The honourable Member for Yellowknife South, Mr. Bell.

Question 36-14(4): Impact of Proposed Tax Credit

MR. BELL: Thank you, Mr. Speaker. Mr. Speaker, my question today is for the Minister of Finance. It is about the tax credit he announced would be coming forward. I am concerned about the highway toll and the actual cost of it. Some groups are now starting to come out in support of it, thinking that the cost will be offset by the tax credit. I tabled a document the other day in which Mr. Handley says "The net increase for average citizens in the North should be nil." I am worried the department will move to a position of we recognize the credit will not entirely offset the cost, but it is reasonable to ask residents to contribute to this highway infrastructure because they will get the benefits. Will the Minister confirm that the net should be no increase for the average citizens of the North?

MR. SPEAKER: Mr. Bell, I regret to inform you that the question you are asking may be out of order because of the nature of it. It is apparently on the order paper for today. We will disregard that question. Item 6, oral questions. The honourable Member for Great Slave, Mr. Braden.

Question 37-14(4): Giant Mine Reclamation Plan

MR. BRADEN: Thank you, Mr. Speaker. In my statement, I addressed the concern citizens have about the arsenic situation in and around Yellowknife, specific to the Giant Mine work. I would like to ask the Minister responsible for Resources, Wildlife and Economic Development, what involvement and what initiatives this government is taking in terms of that long-term management process? Thank you, Mr. Speaker.

MR. SPEAKER: Thank you, Mr. Braden. The honourable Minister responsible for the Department of Resources, Wildlife and Economic Development, Mr. Handley.

Return to Question 37-14(4): Giant Mine Reclamation Plan

HON. JOE HANDLEY: Thank you, Mr. Speaker. Mr. Speaker, the responsibility for the arsenic situation at Giant Mine rests with the Department of Indian and Northern Affairs, with the federal government, as a condition of the sale of the mine. They hold the responsibility. The Government of the Northwest Territories participates primarily because as a government for this territory, we have great concerns about what the department may or may not be doing, what their plans are may be in the future and so on. We do not have an official role or responsibility. Thank you.

MR. SPEAKER: Thank you, Minister Handley. Supplementary, Mr. Braden.

Supplementary to Question 37-14(4): Giant Mine Reclamation Plan

MR. BRADEN: Thank you, Mr. Speaker. A point of clarification. My understanding is that indeed, it is the federal government's responsibility for the underground areas, but this government does have some involvement for managing things on surface and for reclamation there. This is where I would like to find out specifically what involvement and what processes this government has responsibility for? Thank you, Mr. Speaker.

MR. SPEAKER: Thank you, Mr. Braden. The honourable Minister responsible for the Department of Resources, Wildlife and Economic Development, Mr. Handley.

Further Return to Question 37-14(4): Giant Mine Reclamation Plan

HON. JOE HANDLEY: Mr. Speaker, this government's responsibility is for clean-up and reclamation on the lands that are not covered by the water license. There is still some debate between our department and DIAND on exactly where that begins and were it ends. We argue that, at minimum, DIAND is responsible for everything from the mill and its impact to everything that flows down from there, including the tailings ponds and reservoirs and so on. Our responsibility is for other structures that may be sitting on the mine property, but not directly connected with the water license. Thank you.

MR. SPEAKER: Thank you, Minister Handley. Supplementary, Mr. Braden.

Supplementary to Question 37-14(4): Giant Mine Reclamation Plan

MR. BRADEN: Thank you, Mr. Speaker. In relation to the mine, my understanding is that the Miramar Giant company still plans to continue mining until some time later this year when the plans are that mining at that property will stop for good, and then we can go into a reclamation process. I am wondering, at this stage, are there any specific moves that the GNWT has in relation to the complete stop of work at Giant Mine later this year? Thank you, Mr. Speaker.

MR. SPEAKER: Thank you, Mr. Braden. The honourable Minister responsible for the Department of Resources, Wildlife and Economic Development, Mr. Handley.

Further Return to Question 37-14(4): Giant Mine Reclamation Plan

HON. JOE HANDLEY: Mr. Speaker, it is my understanding that the arrangement between Miramar Giant Mine Limited and the Department of Indian and Northern Affairs expires at the end of December this year. At that time, Miramar Giant Mine Limited has the option of either negotiating an extension, and determining what the terms of that extension might be is something between them and DIAND, or simply saying no we do not intend to continue mining from that site any more.

I have spoken to the manager, and he has told me that they have not yet firmly made up their mind of exactly what they will do. Until we know that, it is very difficult for us to do more than simply continue to monitor what they and DIAND are doing. Thank you.

MR. SPEAKER: Thank you, Mr. Minister. Item 6, oral questions. The honourable Member for Range Lake, Ms. Lee.

Question 38-14(4): Class Size in Territorial Schools

MS. LEE: Thank you, Mr. Speaker. Mr. Speaker, my question today is for the Minister of Education, and it is with regard to the class size in our schools. Mr. Speaker, I have a letter from a concerned parent whose child attends the Range Lake North school, who is saying that the next year's class size could be up to about 30 students per class. Most of the classrooms at the Range Lake North school are built for 24 students, and not 31, suggesting possible problems regarding safety. My question to the Minister is, what is the department's responsibility in making sure that there are not too many kids in the classrooms? Thank you, Mr. Speaker.

MR. SPEAKER: Thank you, Ms. Lee. The honourable Minister responsible for the Department of Education, Culture and Employment, Mr. Ootes.

Return to Question 38-14(4): Class Size in Territorial Schools

HON. JAKE OOTES: Thank you, Mr. Speaker. Mr. Speaker, I should take a moment to explain the process of funding that we provide to education boards. We fund the district education councils throughout the Northwest Territories and

Break Out Sessions

LOCATION	KAT "A"	KAT "B"	KAT "C"
PARTICIPANT GROUP	A	B	C
FACILITATOR	Jim Micak	Ray Bethke	Andy Swiderski
DIAND REPRESENTATIVE	David Livingstone	Neill Thompson	Dave Nutter
TECHNICAL SUPPORT	Randy Knapp Stephen Schultz	Grant Feasby Bruce Halbert	Daryl Hockley Mike Royle

Group A	Group B	Group C
Richard Allan	Louie Azzolini	Jennifer Bellman
Peter Bengts	Pearl Benyk	Leo Betsina
Ron Breadmore	Bill Coedy	Alexandra Borowiecka
Ed Collins	Brad Colpitts	Gary Craig
Mark Davy	Bob Hauser	Noel Crapeau
Ken Hall	Erica Myles	Lena Drygeese, Translator
David Livingstone	Kevin O'Reilly	Jonas Fishbone
Stephen MacDonald	Steve Peterson	Lawrence Goulet
Maureen Marshall	Emma Pike	Joe Martin
Philip Wright	Robert Turner	Michel Paper
		Isadore K. Sangris
		Greg Smith
		Mary Rose Sundberg, Translator
		Isadore Tsetta
		Hugh Wilson

Agenda Item 4

SCREENING LEVEL ENVIRONMENTAL AND HUMAN HEALTH RISK ASSESSMENT

Randy Knapp
Bruce Halbert

SENES Consultants Limited

Why complete a Risk Assessment?

- To determine if humans or ecology are potentially at risk of adverse health impacts.
- To provide a benchmark or reference case with which to compare risk management alternatives (what dose or risk reduction may occur if an alternative is adopted).
- Allows for optimization of the future management plans.

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What is a Screening Level Risk Assessment?

- A conservative evaluation of potential effects on the human health and ecology of the area.
- Assess the contaminant loadings to the environment, determine levels in the environment and calculate dose or exposure levels.
- Compare these exposures to toxicity benchmarks (safe levels)
- For levels below benchmark, minimal risk. For levels above benchmarks, potential risk and further study warranted.

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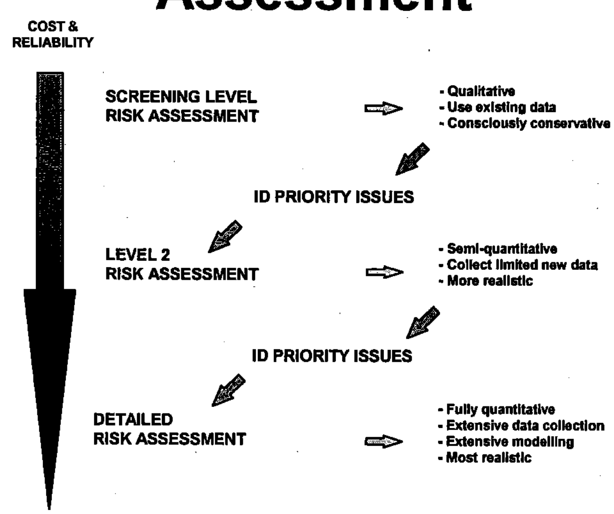
Staged Approach to Risk Assessment



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Steps in Risk Assessment

- Define system (sources, pathways and receptors of interest)
- Characterize contaminant sources
- Calculate contaminant transport and "pathways" to estimate intake by receptors
- Compare intakes to toxicological benchmarks

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Definition of Unmanaged Base Case

- Hypothetical analysis of what could happen in long term future if:
  - Mine is allowed to flood with no measures to manage the arsenic trioxide dust
  - Only minor clean-up and remedial works completed to minimize inflow and assure stability
- Only arsenic releases from mine are considered:
  - Arsenic released to groundwater that discharges to Baker Creek and Back Bay
  - Toxicity thresholds reduced to allow for other sources
- Considers all aquatic pathways to receptors:
  - aquatic species (fish and benthos)
  - animals
  - humans

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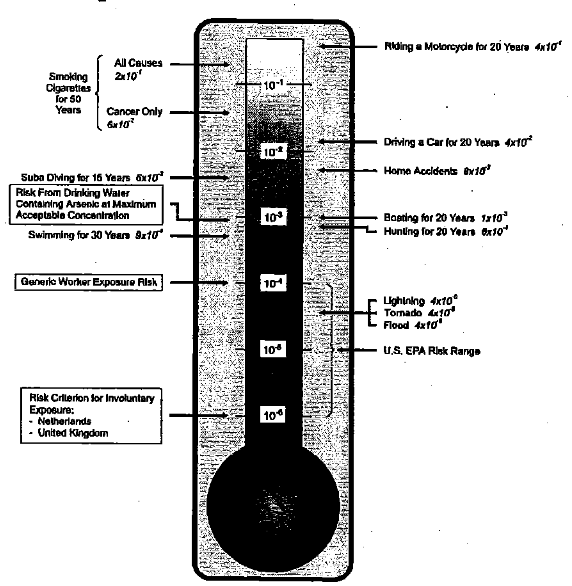
Toxicity Benchmarks

- Aquatic Biota
  - LC_{20} or EC_{20}, level at which 20% of population may be affected
- Benthos
  - PEL, Probable Effect Level, level frequently associated with adverse effects
- Terrestrial Biota
  - NOAEL, No Observable Adverse Effect Level
- Humans
  - RfD, Reference dose (for this study have used Health Canada tolerable lifetime daily intake)
  - SF, Slope Factor, Factor used to assess risk of cancer

Examples of Lifetime Risk



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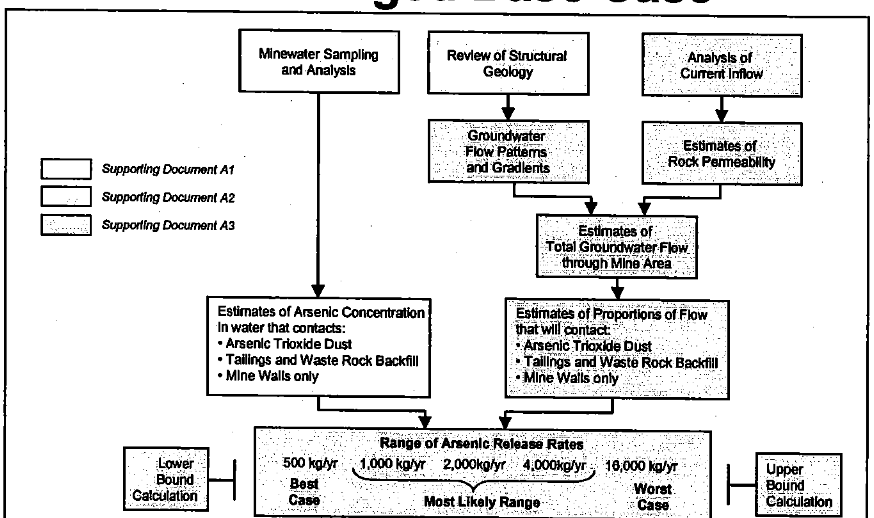
Source Characterization

- Investigation of arsenic sources and concentrations in the mine
- Hydrogeological assessment of potential range of flows and flow paths through the mine
- Bounding calculations of the potential releases of arsenic from the mine

Arsenic Releases in Unmanaged Base Case



Pathways Calculations Tools

- **LAKEVIEW dispersion model**
  - **Used to predict arsenic levels in water and sediment)**
  - **Model calibrated to historic database of water and sediment arsenic**
- **Pathways model**
  - **Used to determine uptake of arsenic and transfer among biota and humans**
  - **Considers all relevant exposure pathways (drinking water, eating plants and animals, contact with contaminants etc).**

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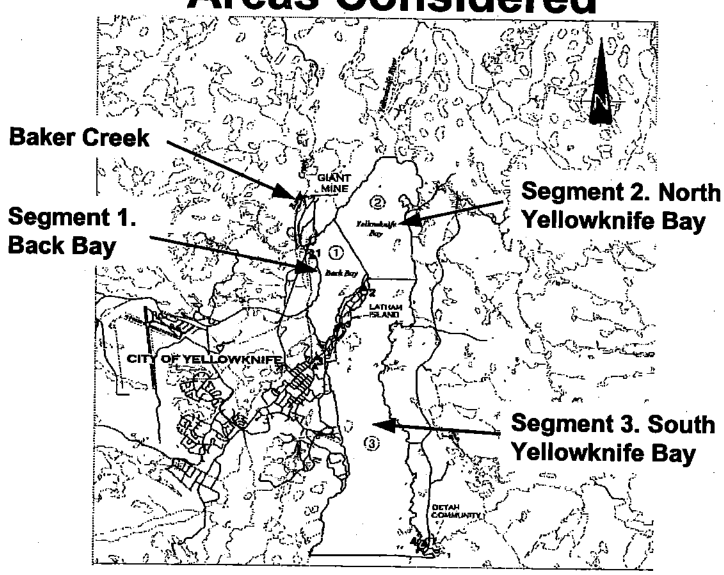
Areas Considered



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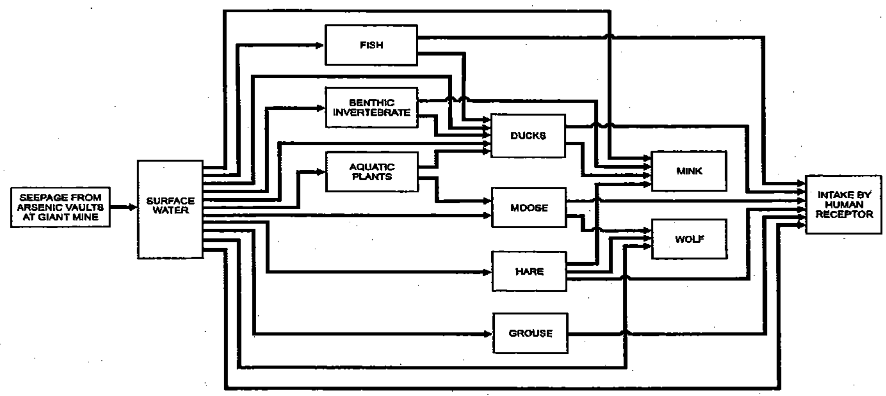
"Pathways" Considered



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Background Data on Water and Sediment Quality

- Large data file on water quality and sediments
- Data available for both immediate area and regional sources
- Data allows for calibration of models of arsenic transport and deposition in Back Bay and Yellowknife Bay

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Historical Arsenic Releases

- Reviewed historic data on water quality, sediments, arsenic releases.
- Estimated arsenic loading to Back Bay via Baker Creek:
  - 12,500 kg/yr before 1968
  - 8,000 kg/yr 1968 to 1980
  - 1300 kg/yr 1981 to 1993
  - 950 kg/yr 1994 to present

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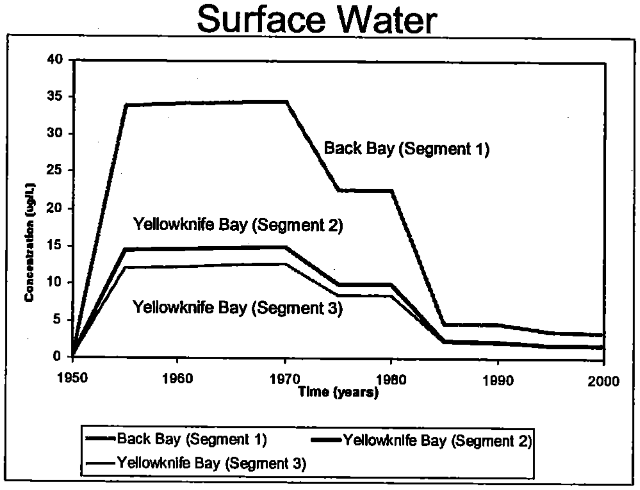
Predicted Arsenic Concentrations Between 1950 and 2000

Surface Water



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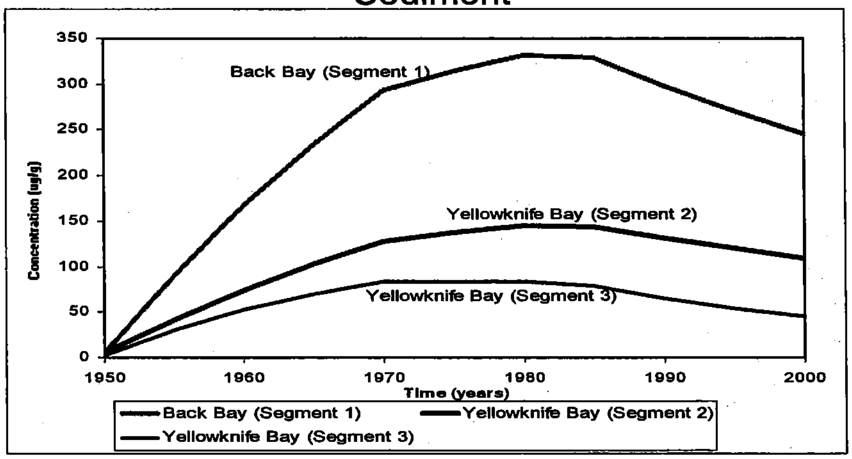
Predicted Arsenic Concentrations Between 1950 and 2000

Sediment



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Arsenic Release Rates Unmanaged Base Case Scenarios

Scenario	Arsenic Load (kg/yr)
Best Case	500 + 450
Base Case 1	1000 + 450
Base Case 2	2000 + 450
Base Case 3	4000 + 450
Worst Case	16,000 + 450

Background arsenic load of 450 kg/yr carried in Baker Creek

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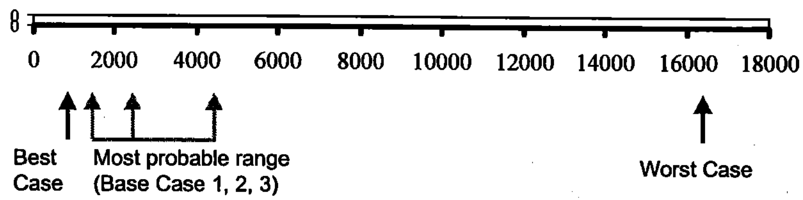
Range of Arsenic Release Rates (kg/year)



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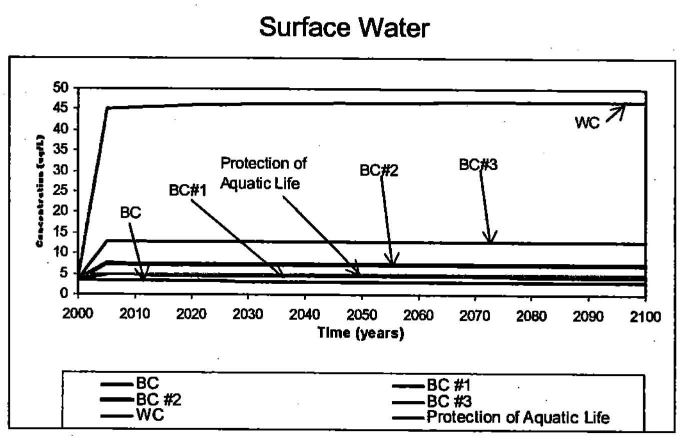
Predicted Arsenic Concentrations Back Bay – Segment 1 Between 2000 and 2100



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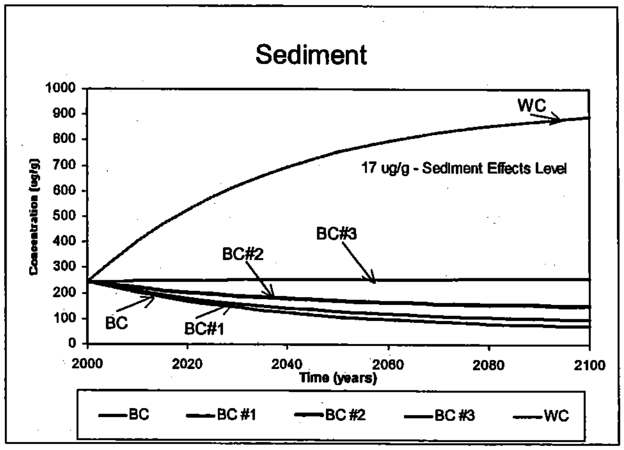
Predicted Arsenic Concentrations Back Bay – Segment 1 Between 2000 and 2100



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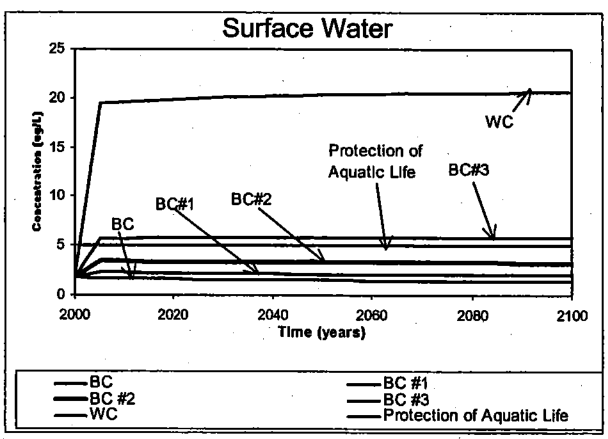
Predicted Arsenic Concentrations Yellowknife Bay – Segment 2 Between 2000 and 2100



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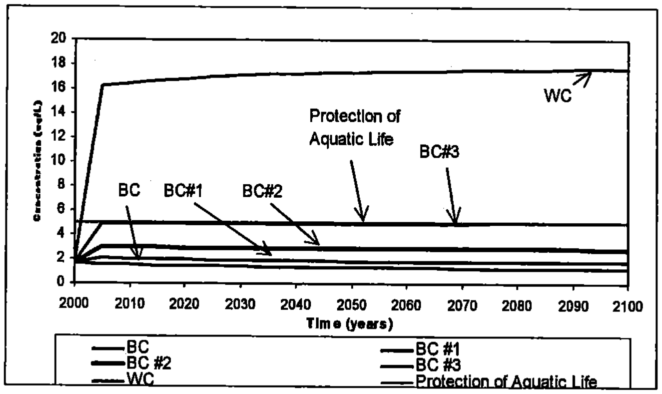
Predicted Arsenic Concentrations Yellowknife Bay – Segment 3 Between 2000 and 2100

Surface Water



Ecological Risk Aquatic Receptors by Location

Baker Creek	Segment 1	Segment 2	Segment 3
Pond Weed	Pond Weed	Pond Weed	Pond Weed
Benthic Invertebrates	Benthic Invertebrates	Benthic Invertebrates	Benthic Invertebrates
	Northern Pike	Northern Pike	Northern Pike
	Lake Whitefish	Lake Whitefish	Lake Whitefish
White Sucker	White Sucker	White Sucker	White Sucker

Ecological Risks
Terrestrial Receptors by Location

Baker Creek	Segment 1	Segment 2	Segment 3
Moose	Ducks	Ducks	Ducks
Spruce Grouse	- Merganser	- Merganser	- Merganser
Hare	- Mallard	- Mallard	- Mallard
Ducks (50%)	- Scaup	- Scaup	- Scaup
Wolf			
Mink			

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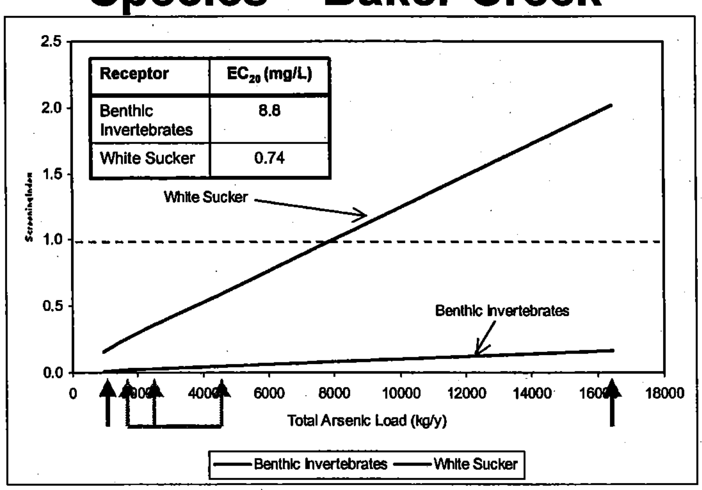
Screening Indices for Aquatic Species – Baker Creek



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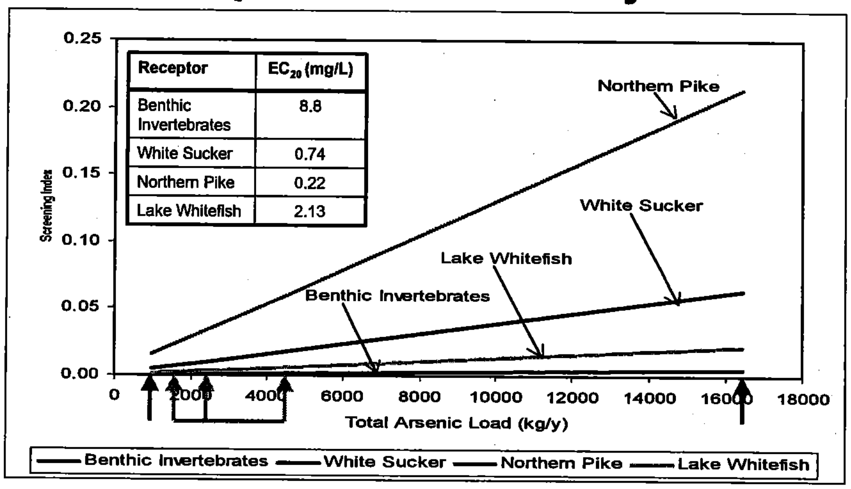
Screening Indices for Aquatic Species – Back Bay



Receptor	EC_{20} (mg/L)
Benthic Invertebrates	8.8
White Sucker	0.74
Northern Pike	0.22
Lake Whitefish	2.13

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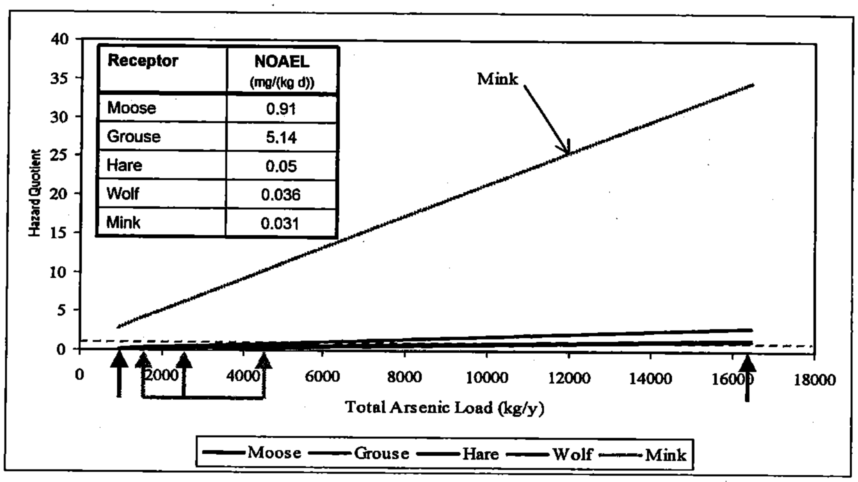
Hazard Quotients for Terrestrial Species – Baker Creek



Receptor	NOAEL (mg/(kg d))
Moose	0.91
Grouse	5.14
Hare	0.05
Wolf	0.036
Mink	0.031

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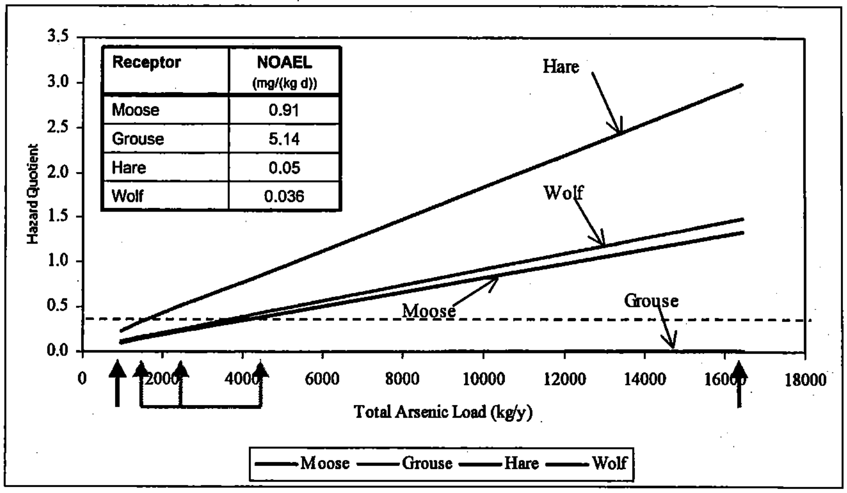
Hazard Quotients for Terrestrial Species – without Mink



Receptor	NOAEL (mg/(kg d))
Moose	0.91
Grouse	5.14
Hare	0.05
Wolf	0.036

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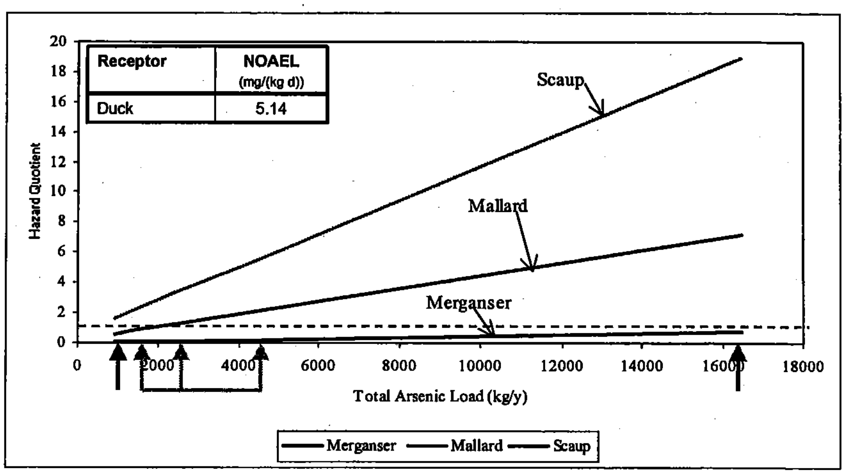
Hazard Quotients for Ducks – Baker Creek



Receptor	NOAEL (mg/(kg d))
Duck	5.14

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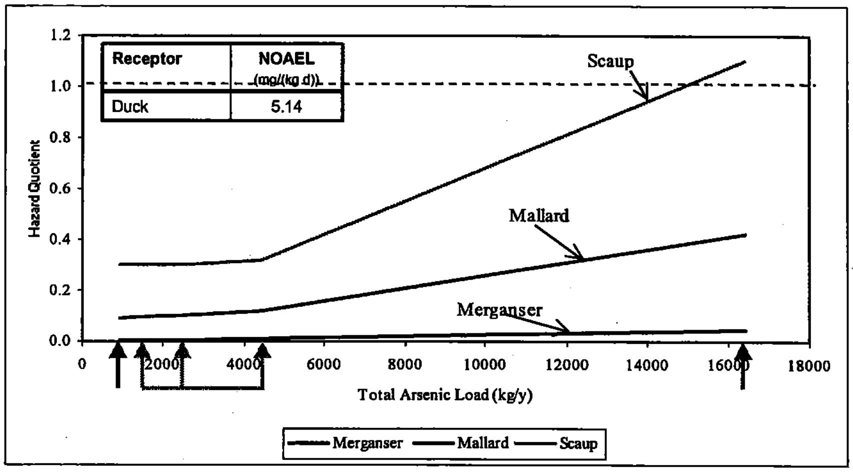
Hazard Quotients for Ducks – Back Bay Segment 1



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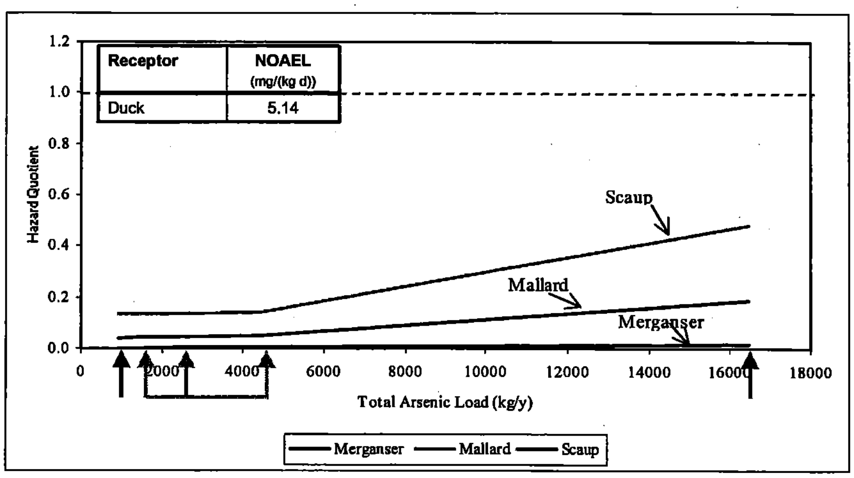
Hazard Quotients for Ducks – Yellowknife Bay Segment 2



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Summary - Aquatic Species at Risk

Location	Arsenic Release Rate (kg/yr)				
	500	1,000	2,000	4,000	16,000
Baker Creek	-	-	-	-	Pondweed, White Sucker
Segment 1 Back Bay	-	-	-	-	-
Segment 2 North Yk. Bay	-	-	-	-	-
Segment 3 South Yk. Bay	-	-	-	-	-

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Summary - Duck Species at Risk

Location	Arsenic Release Rate (kg/yr)				
	500	1,000	2,000	4,000	16,000
Baker Creek	Scaup	Scaup	Scaup, Mallard	Scaup, Mallard	Scaup, Mallard
Segment 1 Back Bay	-	-	-	-	Scaup
Segment 2 North Yk. Bay	-	-	-	-	-
Segment 3 South Yk. Bay	-	-	-	-	-

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Summary - Terrestrial Species at Risk

	Arsenic Release Rate (kg/yr)				
	500	1,000	2,000	4,000	16,000
Species at Risk	Mink	Mink	Mink	Mink	Mink, Hare, Wolf, Moose

Note: Mink assumed to live year round in Baker Creek area, and obtain all drinking water from Baker Creek, and all food from Baker Creek area.

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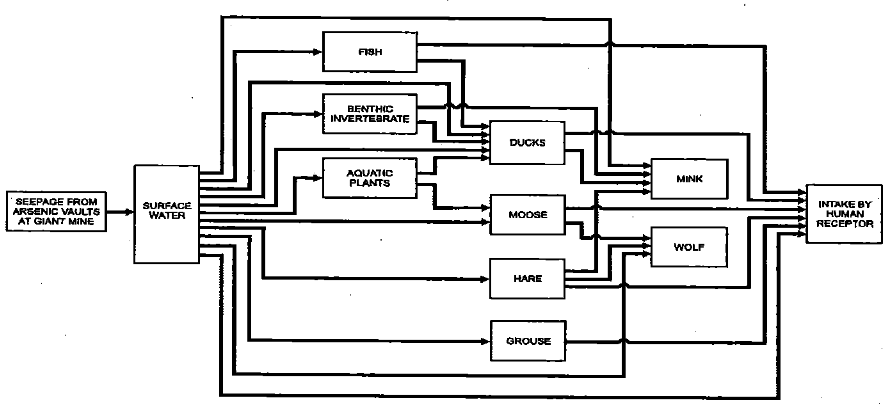
Human Exposure Pathways



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Human "Receptors"

- Assessed arsenic intake by four human "receptors"
- Receptor locations and diets chosen to result in wide range of arsenic intakes

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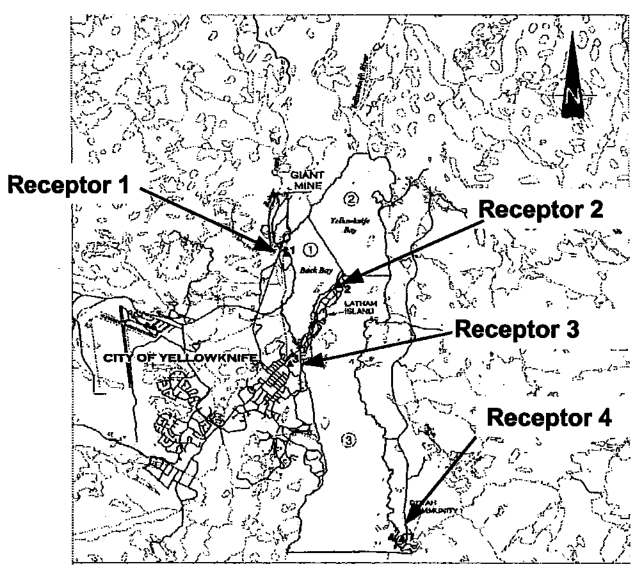
Human Receptor Locations



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Human Receptors - Assumed Diets

- Receptor 1- An adult working at the Marina at the Giant Town Site
- Receptor 2-An adult and child living in the community on Latham Island
- Receptor 3-An adult and child living in Yellowknife
- Receptor 4-An adult and child living in the Dettah community

	Receptor 2 and 4		Receptor 1 and 3	Receptor 3
	Adult	Child	Adult	Child
Water (L/d)	1.5	0.8	1.5	0.8
Meat (g/d)				
Caribou *	310.9	103.6	62.2	20.7
Moose	6.9	2.3	1.4	0.5
Hare	1.6	0.6	0.3	0.1
Poultry (g/d)				
Grouse	2.0	0.7	0.4	0.1
Ducks	2.8	0.9	0.6	0.2
Fish (g/d)	55.0	27.5	11.0	5.5
Berries (g/d) *	5.4	2.7	5.4	2.7
Total Protein (g/d)	378.9	135.6	75.9	27.1

* Not considered in the base case scenario

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Human Receptor Food & Water Sources Best and Base Case

Receptor Location	Mallard	Moose	Grouse	Hare	Fish	Water
1 Marina	BC				S1	YR
2 Latham Island	BC	BC	BC	BC	S1	S1
3 Yellowknife	S2	BC	BC	BC	S2	YR
4 Dettah	S3				S3	S3

BC – Baker Creek
S1 – Segment 1 (Back Bay)
S2 – Segment 2 (Yellowknife Bay)
S3 – Segment 3 (Yellowknife Bay)
YR – Yellowknife River

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Human Receptor Food and Water Sources Worst Case

Receptor Location	Mallard	Moose	Grouse	Hare	Fish	Water
1 Marina	S1				S1	YR
2 Latham Island	S1				S1	S1
3 Yellowknife	S2				S2	YR
4 Dettah	S3				S3	S3

BC – Baker Creek
S1 – Segment 1 (Back Bay)
S2 – Segment 2 (Yellowknife Bay)
S3 – Segment 3 (Yellowknife Bay)
YR – Yellowknife River

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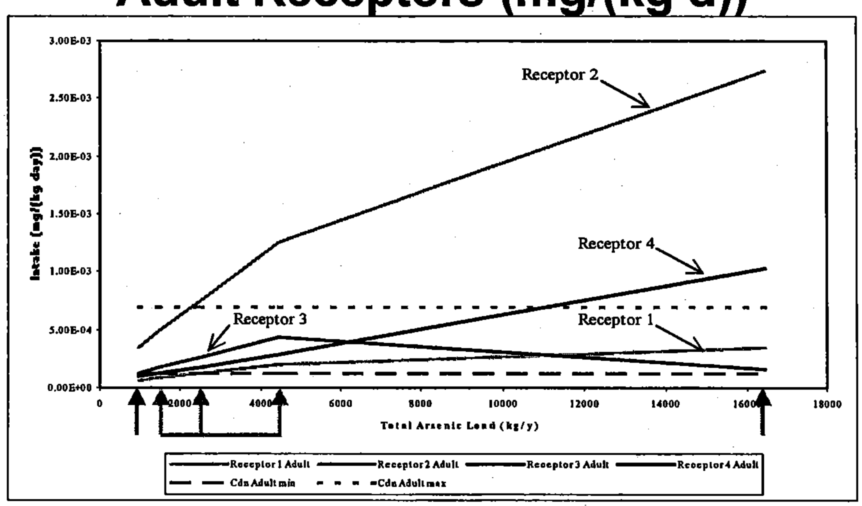
Estimated Intake of Arsenic by Adult Receptors (mg/(kg d))



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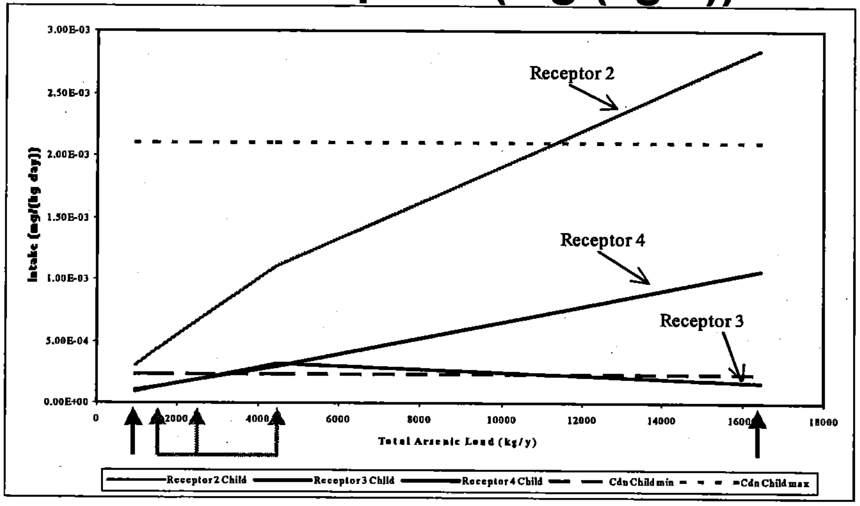
Estimated Intake of Arsenic by Child Receptors (mg/(kg d))



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Sources of Arsenic Intake by Human Receptors

Receptor	% Distribution of Intake						
	Mallard	Moose	Grouse	Hare	Caribou	Fish	Water
Receptor 1 - Adult	52	0	0	0	0	43	5
Receptor 2 - Adult	40	3.4	<< 1	<< 1	0.3	35	22
Receptor 2 - Child	30	2.6	<< 1	<< 1	0.2	41	27
Receptor 3 – Adult	6	13	<< 1	<< 1	1.2	62	17
Receptor 3 - Child	4	10	<< 1	<< 1	0.8	66	19
Receptor 4 - Adult	5	0	0	0	0	59	36
Receptor 4 - Child	3	0	0	0	0	58	39

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Arsenic Toxicity

- Has both carcinogenic and non-carcinogenic properties
- Typically, risks assessed using toxicity data (slope factor and reference dose) from USEPA Integrated Risk Information System
- In this study used slope factor from USEPA (1.5(mg/(kg d)) $^{-1}$) and reference dose from Health Canada (2 ug/(kg d)) since this was developed for Canadian populations
- In addition, compared intakes and risks for the seven different receptors to typical background intakes for the Canadian population provided by Health Canada to provide a prospective on the risks

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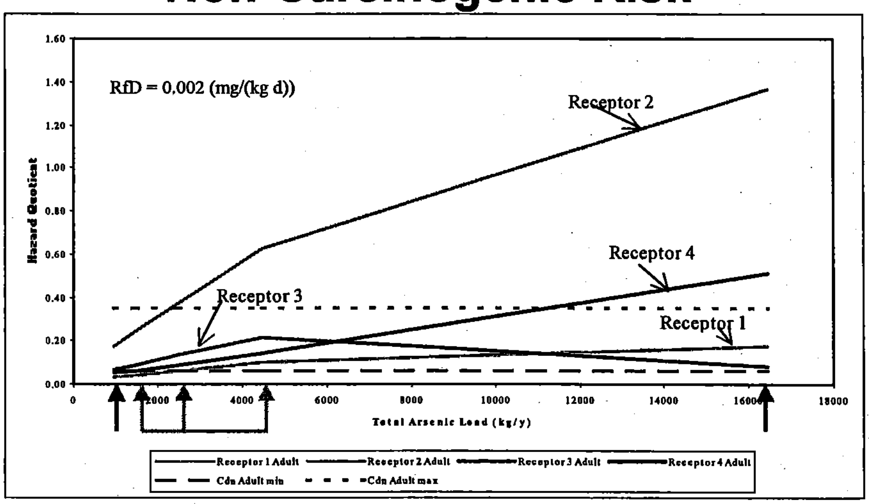
Adult Receptors Non-Carcinogenic Risk



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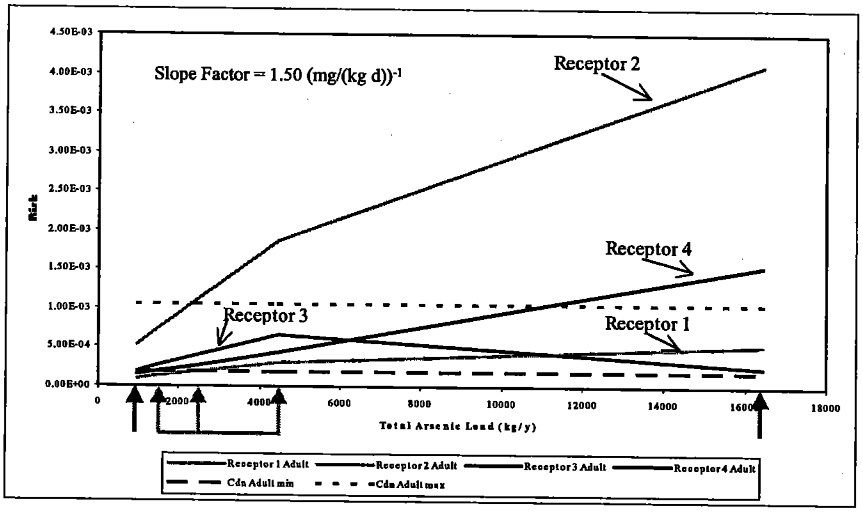
Adult Exposure Cancer Risk



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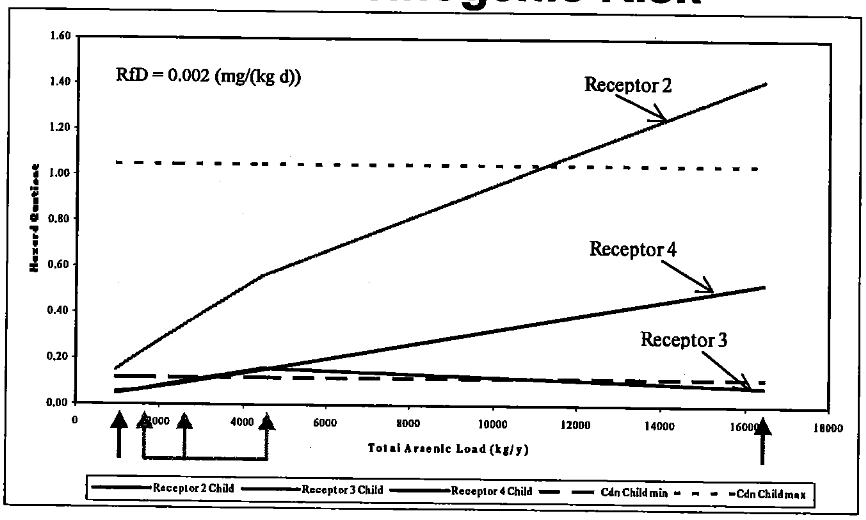
Child Receptors Non-Carcinogenic Risk



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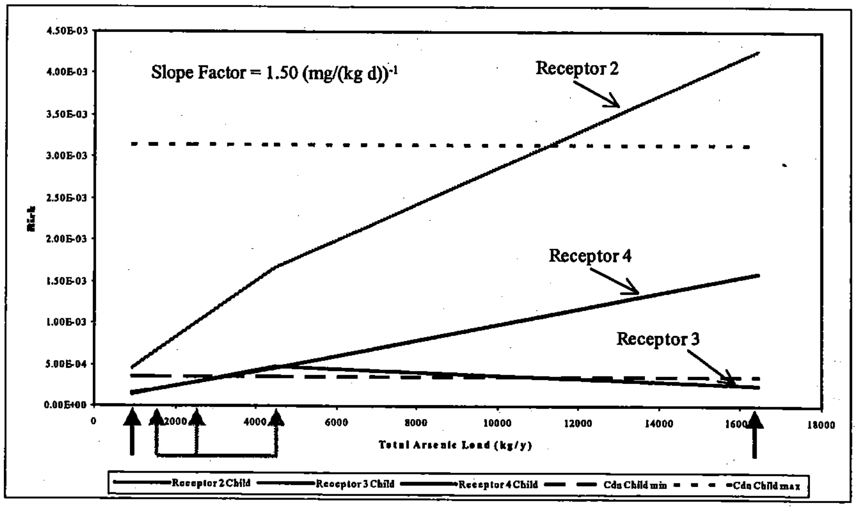
Child Receptors
Cancer Risks



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Summary - Human Receptors at Risk

Receptor	Arsenic Release Rate (kg/yr)				
	500	1,000	2,000	4,000	16,000
Receptor 1	-	-	-	-	-
Receptor 2	-	-	Adult	Adult, Child	Adult, Child
Receptor 3	-	-	-	-	-
Receptor 4	-	-	-	-	Adult, Child

Note: Receptor 2 assumed to obtain all drinking water from Back Bay and to eat duck and fish from Baker Creek and Back Bay.

Note: Receptor 4 assumed to obtain all drinking water from Yellowknife Bay and to eat duck and fish from Yellowknife Bay.

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SUMMARY

- Under current conditions, arsenic release from mine is controlled by treatment system. Arsenic concentrations in lake and sediments are steady or decreasing.
- There is a wide range of uncertainty in estimates of future arsenic release from the mine if no arsenic trioxide management measures are taken:
  - Probable range 1000-4000 kg/yr
  - Best case 500 kg/yr, Worst case 16,000 kg/yr
- Upper end of range is similar to release rates of 1960's
  - Allows predictive model of arsenic behaviour in lake and sediments to be calibrated against historic data
  - Even worst case future releases would be no worse than the historical releases
- Lower end of range is similar to today's release rates

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SUMMARY (cont'd)

- Screening level risk assessments with the range of arsenic release rates indicate:
  - Ecological risks are low for aquatic species in Back Bay and Yellowknife Bay. Fish and aquatic plants in Baker Creek could be impacted by worst case releases. Ecological risks are low for birds and mammals except for species feeding in Baker Creek.
  - Releases in the upper range potentially pose health risk for humans that obtain all their drinking water from Back Bay and eat fish and ducks from Baker Creek and Back Bay
  - Worst case releases could also cause health risks for humans that obtain all their drinking water and eat fish and ducks from Yellowknife Bay
  - Releases in the low range (<2,000 kg/yr of arsenic) pose no significant risk to human health

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SUMMARY (cont'd)

- Measures to limit arsenic release from the mine are prudent. The target arsenic release levels for any management alternative should be <2,000 kg/yr
- An integrated risk assessment should be completed to assess all sources and exposure pathways. It will be difficult for risk managers to make decisions without understanding the complete picture.

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TABLE OF CONTENTS

TAB

Giant Mine Underground Arsenic Trioxide Management Alternatives Workshop

June 11-12, 2001
Katimavik Rooms "A" and "B", Explorer Hotel,
Yellowknife, Northwest Territories

Sessions Open to the Public & Media

Agenda Day 1: Monday, June 11, 2001

12:00 - 1:00 **Arrival and Registration**

1:00 - 1:25 **Welcome and Opening Remarks**

· Welcome	Andy Swiderski, Facilitator
· Opening Remarks	Dave Nutter, DIAND
· Introduction of Participants	
· Purpose, Objectives and Anticipated Workshop Results	Facilitator
· Roles & Responsibilities	Facilitator
· Overview of Logistics & Organization, Reference Materials and Displays	
· Keeping track and Recording of Discussions	Facilitator
· Review of Participant Reference Binder	Facilitator
· Agenda Review	Facilitator
· Questions/Discussion	

PART ONE: THE ARSENIC PROBLEM AT GIANT MINE AND EFFORTS TO ADDRESS IT

1:25 - 1:45 **Agenda Item No. 1: The Giant Mine Arsenic Trioxide Management Approach Being Led By the Federal Government** (Obj.1)

- 15 minute presentation by Dave Nutter, DIAND
- Questions/Discussion

1:45 - 2:10 **Agenda Item No. 2: An Historical Overview of Underground Arsenic Trioxide Management At Giant Mine and the Chronology of Events Related to the Work Completed To Date** (Obj.2)

- 20 minute presentation by Neill Thompson, DIAND,
- Questions/Discussion

PART TWO: EXAMINATION OF MANAGEMENT ALTERNATIVES

2:10 - 2:45 **Agenda Item No. 3: Overview of Work Completed by the Technical Advisor** (Obj. 3)

· 20 minute presentation by Daryl Hockley, SRK Consulting
· Questions/Discussion

2:45 - 3:00 *Break*

3:00 - 4:15 **Agenda Item No. 4: Results of the Screening Level Environmental and Human Health Risk Assessment** (Obj. 4)

· 60 minute presentation by Randy Knapp and Bruce Halbert, SENES Consultants
· Questions/Discussion

4:15 - 4 :45 **Agenda Item No. 5: Overview of the Management Alternatives** (Obj. 5)

· 20 minute presentation by Daryl Hockley, SRK Consultants
· Questions/Discussion

4:45 - **Public Questions & Discussions**
Day One Wrap Up and Instructions for Day 2 (Facilitator)

5:00 - **Media Briefing & Questions**

OPEN HOUSE/PUBLIC INFORMATION SESSION
7:00 to 9:00 pm, Katimavik Room "C"

Agenda Day 2: Tuesday, June 12, 2001

08:30 - 09:00 **Arrival and Registration**

09:00 - 09:15 **Welcome and Opening Remarks**

· Welcome	Dave Nutter, DIAND
· Review Workshop Purpose and Objectives	Facilitator
· Summary of Day 1	Facilitator
· Day 2 Agenda Review	Facilitator
· Questions/Discussion	

Continuation of.....PART TWO: EXAMINATION OF MANAGEMENT ALTERNATIVES

09:15 - 11:00 **Agenda Item No. 6: Presentation of Four Representative Management Alternatives** (Obj. 6)

· 90 minute presentation by Daryl Hockley, SRK Consultants, Grant Feasby, Lakefield Research, and Randy Knapp, SENES Consultants
· Questions/Discussion

10:15 - 10:30 Break

10:30 - 11:30 **Agenda Item No. 6:....CONTINUED**

· 20 minute presentation by Daryl Hockley, SRK Consultants on evaluations to date
· Questions/Discussion

PART THREE: DEVELOPMENT OF NEXT STEPS FOR PREPARATION FOR ENVIRONMENTAL ASSESSMENT

11:30 - 12:00 **Agenda Item No. 7: Development Of Next Steps for Preparation of Environmental Assessment: Break Out Group Tasks and Instructions** (Obj. 7)

· 15 minute presentation by Facilitator
· Questions/Discussion

12:00 -1:00 Lunch (Lunch is provided)

1:15 - 3:45 **Agenda Item No. 8: Development Of Next Steps for Preparation of Environmental Assessment: Break Out Groups** (Obj. 7 & 8)

3:45 - 4:45 **Agenda Item No. 9: Reports From Break Out Groups and Plenary Discussion Regarding Development Of Next Steps for Preparation of Environmental Assessment** (Obj. 7 & 8)

4:45 - **Public Questions & Discussions**
Closing Remarks (Dave Nutter, DIAND)
Workshop Wrap Up (Facilitator)

Giant Mine Underground Arsenic Trioxide Management Alternatives Workshop

June 11 - 12, 2001

Katimavik Rooms "A" and "B", Explorer Hotel,
Yellowknife, Northwest Territories

Workshop Purpose and Objectives

Purpose

The *Giant Mine Underground Arsenic Trioxide Management Alternatives Workshop* is part of a continuing commitment to a broader management approach being led by the federal government to address the arsenic trioxide currently stored underground at Giant Mine. This workshop is a key element in advancing the engineering, scientific, human health, and ecological risk considerations associated with the management alternatives.

This workshop will contribute to strengthened understanding by participants of the underground arsenic trioxide problem at Giant Mine, provide a forum to present and discuss the work completed to date on management alternatives, as well as identify actions and considerations to further advance the analysis and ultimately to seek environmental assessment and regulatory approval to implement the selected management alternative.

Workshop Objectives

The *Giant Mine Underground Arsenic Trioxide Management Alternatives Workshop* is structured in three parts and is intended to achieve the following objectives:

Part One: The Underground Arsenic Trioxide Problem At Giant Mine and Efforts to Address It

1. Review the commitment to and elements of a broader Giant Mine Arsenic Trioxide Management approach being led by the federal government to address the arsenic trioxide currently stored underground. This includes outlining the process to complete the engineering, scientific and other work necessary to prepare for an environmental assessment and regulatory review based on a formal *Project Description.*

2. Provide an historical overview of arsenic trioxide management at Giant Mine and the chronology of events related to the work completed to date on underground arsenic trioxide management practices and options at Giant Mine, with particular emphasis on the engineering and scientific assessment work since the June 1999 technical workshop.

Part Two: Examination of Management Alternatives

1. Present an overview of the work completed by the Technical Advisor.

2. Provide the results of a screening level human health and ecological risk assessment of a case where no special measures are taken to manage the arsenic trioxide at the Giant Mine - referred to as an *unmanaged base case* for analysis purposes only.

3. Present the approach, methodology and conclusions from the group of management alternatives examined: (1) in situ management; (2) dust removal with arsenic and gold recovery; (3) dust removal with gold recovery; and, (4) dust removal with stabilization.

4. Present the evaluation to date of the four representative management alternatives.

Part Three: Development of Next Steps to Advance Management Options

1. Identify and discuss in break out groups what needs to be considered to further advance the management alternatives, including social, economic, environmental, and communication/consultation factors.

2. Identify and discuss in break out groups the potential roles of stakeholders and the public in the next stages, including the potential of establishing a multi-stakeholder advisory group to help guide the process.

GIANT MINE UNDERGROUND ARSENIC TRIOXIDE MANAGEMENT ALTERNATIVES WORKSHOP

June 11 & 12, 2001
Explorer Hotel
Yellowknife, NT

Participants List

NAME		POSITION	ORGANIZATION
Allan	Richard	V.P. Engineering	Manhattan Minerals Corp.
Azzolini	Louie	Environmental Assessment Officer	MV Environmental Impact Review Board
Baillargeon	Alfred		Yellowknives Dene First Nation
Bengts	Peter	Prevention Services, Mine Safety	Workers' Compensation Board
Benyk	Pearl	For Jake Ootes and other Yellowknife MLA's	(Assembly in session)
Betsina	Leo		Yellowknives Dene First Nation
Breadmore	Ron	Water Resources Officer, South Mackenzie	Water Resources
Borowiecka	Alexandra		Ecology North
Charlo	Judy		Yellowknives Dene First Nation
Collins	Ed	Chief, Environmental Engineering	Environment Canada
Colpitts	Brad	for Stanton Regional Health Board and the	Canadian Public Health Association
Craig	Gary		City of Yellowknife
Dahl	Julie		Department of Fisheries and Oceans
Davy	Mark	Senior Environmental Planner	Municipal and Community Affairs
Erasmus	Bill		Dene Nation
Fishbone	Jonas		Yellowknives Dene First Nation
Goulet	Lawrence		Yellowknives Dene First Nation
Hall	Ken	Manager, Environmental Protection	EPS, RWED
Hauser	Bob		Miramar Mining Ltd.
Hornby	Edward	District Manager, South Mackenzie District	Water Resources
Livingstone	David	Director	Renewable Resources and Environment
MacDonald	Stephen	Head, Toxic Substance Section	Health Canada, Ottawa
Mackenzie	Paul		Yellowknives Dene First Nation
Marcinkoski	Lionel	Industrial Specialist (Mining)	EPS, RWED
Marshall	Maureen	For Ethel Blondin-Andrew, MP	
Martin	Joe		Yellowknives Dene First Nation
Martin	Morris		Yellowknives Dene First Nation
Myles	Erica	Contaminants Consultant	Health Protection Unit, GNWT Health
O'Reilly	Kevin		Canadian Arctic Resources Committee
Paper	Michel		Yellowknives Dene First Nation
Peterson	Steve		Canadian Auto Workers Union
Pike	Emma	Regulatory Officer	Mackenzie Valley Land and Water Board
Riveros	Patricio		CANMET, Natural Resources Canada
Smith	Greg	Regulatory Officer	Mackenzie Valley Land and Water Board
Stard	John	General Manager	Miramar Mining Ltd.
Tsetta	Isadore		Yellowknives Dene First Nation
Turner	Robert		North Slave Metis Alliance
Wilson	Hugh	Manager, Environmental Affairs	Miramar Mining Ltd.
Wright	Philip	Mineral Economist	HQ, DIAND

GIANT MINE UNDERGROUND ARSENIC TRIOXIDE MANAGEMENT ALTERNATIVES WORKSHOP

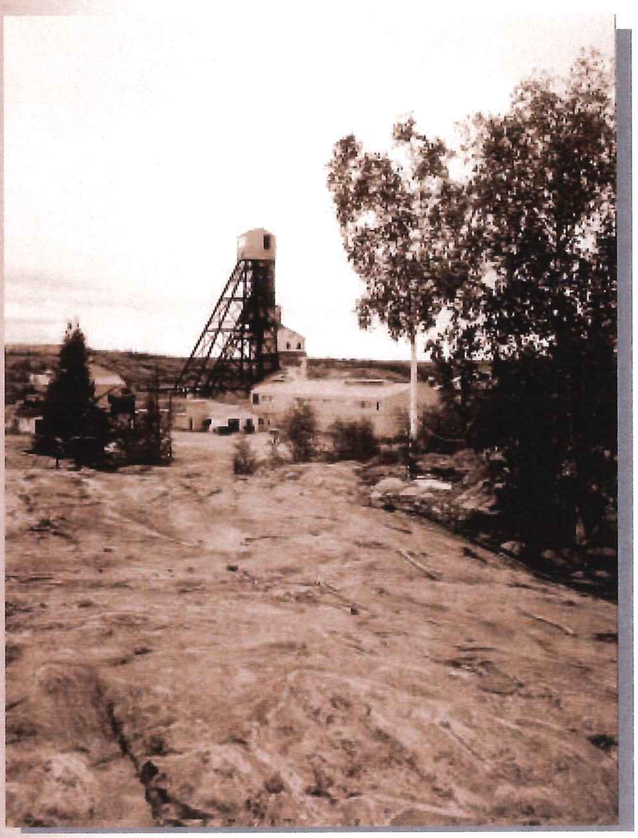
June 11 & 12, 2001
Explorer Hotel
Yellowknife, NT

Participants List

NAME		POSITION	ORGANIZATION
Project Team			
Bellman	Jennifer	Communications Officer	Royal Oak Project Team
Bethke	Ray	Facilitator	Terriplan Consultants Ltd.
Feasby	Grant		Lakefield Research
Ferguson	Margaret	Facilitator	Terriplan Consultants Ltd.
Halbert	Bruce		SENES
Hockley	Daryl	Senior Project Manager	SRK Consulting
Knapp	Randy		SENES
Martin	Berna	Translator	
Micak	Jim	Principal	IER
Nutter	Dave	Special Advisor	Royal Oak Project Team
Schultz	Stephen	Project Engineer	SRK Consulting
Sundberg	Mary Rose	Translator	
Swiderski	Andy	Partner	Terriplan Consultants Ltd.
Thompson	Neill	Project Manager	Royal Oak Project Team

Department of Indian Affairs
and Northern Development

Study of Management Alternatives
Giant Mine Arsenic Trioxide Dust
Executive Summary



Prepared for:

Department of Indian Affairs
and Northern Development
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X1A 2R3

Prepared by:

SRK Consulting
Engineers and Scientists

SENES Consultants Limited

HGE

Lakefield Research

May, 2001

PROJECT 1CI001.06

STUDY OF MANAGEMENT ALTERNATIVES FOR GIANT MINE ARSENIC TRIOXIDE DUST

Prepared for:

DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

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MAY, 2001

EXECUTIVE SUMMARY

INTRODUCTION

The Giant Mine, located just north of Yellowknife, NWT, has been producing gold since 1948. In the Giant Mine ore, the gold is associated with an arsenic-bearing mineral, and the process used to liberate the gold leads to the production of arsenic-rich gases. During the period 1951 to 1999, operators of the Giant Mine captured the arsenic-rich gases in the form of an arsenic trioxide dust. Approximately 237,000 tonnes of the dust was then stored underground in mined-out stopes or purpose-built chambers.

Royal Oak Mines Inc. operated the Giant Mine from 1990 to 1999. When Royal Oak Mines Inc. went out of business, the property was conveyed to the Department of Indian Affairs and Northern Development. In December 1999, DIAND sold the Giant Mine to Miramar Giant Mine Ltd. Liability of the Miramar parent group for environmental conditions at the mine was limited to the assets of Miramar Giant Mine Ltd. Through this transaction, the federal government effectively retained responsibility for pre-existing environmental liabilities on the property, including the arsenic trioxide dust.

The arsenic trioxide dust is approximately 60% arsenic. Although arsenic is a naturally occurring element, in sufficient concentrations it is known to be toxic to many organisms, and both toxic and carcinogenic to humans. Currently, the dust is contained in the underground stopes and chambers, and any escaped arsenic is captured by a drainage system within the mine. The concern is that, once the drainage system is shut off (and in the absence of other management measures), arsenic could escape the storage areas by dissolving in groundwater. The arsenic contaminated groundwater would then make its way to Baker Creek and Great Slave Lake, where it would present a hazard to both environmental and human health.

DIAND is currently following a phased approach to developing a management plan for the arsenic trioxide dust. This report and the supporting documents present results from the first phase. The specific objectives of the work reported herein were to:

- Quantify the environmental and human health risks that will arise in the absence of measures to manage the arsenic trioxide dust (i.e. the "unmanaged base case");

- Select representative management alternatives;

- Prepare pre-feasibility level designs and cost estimates for the management alternatives; and

- Analyze environmental, human health, technical and financial risks associated with each of the management alternatives.

Subsequent phases envisioned by DIAND include a program of public consultation and detailed study of a small number of long term management plans, leading to final selection of a preferred alternative; submission of a Project Description under the Mackenzie Valley Resource Management Act; environmental assessment and public hearings as required by the Act; licensing by regulatory authorities; and final design, contractor selection and implementation of approved management measures.

The authors of this report and the supporting documents are a team of mine environmental experts contracted by DIAND to act as Technical Advisor – Arsenic Trioxide Dust Management. The terms of the Technical Advisor contract specify that members of the team must provide independent technical advice to DIAND, and therefore must exclude themselves from participation in the implementation phase of the project. Although the Technical Advisor team will participate in the public consultation process, its primary role is to provide technical advice. Therefore, this report should be seen as independent technical input to the ongoing process of selecting and implementing arsenic trioxide management measures. The conclusions and recommendations expressed herein are subject to the review, and particularly the public consultation, anticipated in the remaining phases.

ASSESSMENT OF RISKS IN UNMANAGED BASE CASE

The environmental and human health risks that would arise from the arsenic trioxide dust, in the absence of management measures, were evaluated. The "unmanaged base case" was defined to include minimal underground rehabilitation prior to cessation of mine dewatering, leading to flooding of the mine (and the arsenic trioxide dust) by groundwater. Results of minewater quality studies carried out in 1999 and 2000 were reviewed to derive estimates of the arsenic concentrations that would result in the vicinity of the arsenic trioxide storage areas, and in other parts of the mine. Estimates of groundwater flowrates through the mine, and the proportion of flow through each contaminated area, were then developed and used to estimate the total flow of and average arsenic concentrations in groundwater that would discharge to Baker Creek and/or Great Slave Lake.

Dilution and transport of the arsenic in Back Bay and Yellowknife Bay were then estimated using a mathematical model. The model also considered historical arsenic discharges and the uptake or release of arsenic by the lake sediments.

The resulting estimates of arsenic concentrations in Baker Creek and Great Slave Lake were used as inputs to a series of calculations that estimate the uptake of arsenic by aquatic and terrestrial animals. Finally the intake of arsenic by humans, through drinking water and the consumption of fish and game from the area, was estimated and compared to toxicological benchmarks.

The key results were:

- Uncertainties about the patterns of water flow through the reflooded mine mean that there is significant uncertainty in the arsenic release rates estimated for the unmanaged base case. The range of estimated arsenic release rates extends from 500 kg/year to 16000 kg/yr. The most likely range is thought to be between 2000 and 8000 kg/yr.

- Current high arsenic concentrations in sediments in Baker Creek and Back Bay are due primarily to the high arsenic discharges (8000 – 12500 kg/yr) of the 1960's and 1970's. If future arsenic release rates remain below the historical levels, water quality will gradually improve. If future arsenic release rates are at or above 8000 kg/yr, arsenic concentrations in the sediments and water of Back Bay and Yellowknife Bay will either be maintained at current levels, or will increase.

- Significant impacts on aquatic and terrestrial wildlife are predicted to be limited to the area immediately around Baker Creek, except when arsenic release rates reach 16,000 kg/yr. In that case, impacts to species in Back Bay are also predicted. Impacts to scaup (a duck species) and mink are predicted even at background arsenic release rates, primarily due to the high levels of arsenic in Baker Creek sediments.

- Arsenic release rates at or below 2000 kg/yr are predicted to have no effect on human health. Arsenic release rates above 4000 kg/yr could create health risks for people who consume significant amounts of drinking water and significant amounts of duck and fish from Back Bay. The worst case arsenic release rate of 16,000 kg/yr could create health risks for people who consume significant amounts drinking water and significant amounts of duck and fish from Yellowknife Bay.

SELECTION & ASSESSMENT OF REPRESENTATIVE ALTERNATIVES

To assess possible management measures, a very long list of candidate methods was first developed. Complete alternatives were then selected to represent each group of management measures. The following "representative alternatives" were selected:

1. *In situ* management of the dust by ground freezing;
2. Extraction of the dust and reprocessing by fuming to recover high purity arsenic trioxide and gold;
3. Extraction of the dust and reprocessing by pressure oxidation to recover gold and stabilize arsenic; and,
4. Extraction of the dust and stabilization with cement.

Each of the representative alternatives was carried through engineering design, cost estimates and risk assessments. The engineering designs considered all aspects of each alternative, including extraction of the dust, the management of process residues, and the treatment of waste water.

Cost and revenue estimates were prepared to reflect capital costs, operating costs, long-term maintenance costs, and revenues from the sale of gold and/or high purity arsenic trioxide. The financial risks associated with each alternative were characterized by preparing upper and lower estimates of net costs.

Each alternative design was then reviewed to estimate the risks of short-term and long-term release of arsenic. Short-term releases could occur during the extraction or processing of the dust, for example by spills. Possible long-term releases include the escape of arsenic from facilities required to store processing residues.

The worker health and safety risks associated with each alternative were then evaluated. Human health risks due to air emissions from one of the alternatives were also evaluated.

Results of the assessments are summarized in the following table. It is clear from the table that Alternative 1, *in situ* management of the dust with ground freezing, is by far the lowest cost alternative. Alternative 1 also poses lower risks than any of the other alternatives.

Alternatives 2, 3 and 4 are similar in terms of risk, but differ in cost. Alternatives 2 and 4 are significantly less costly than Alternative 3. However, the net cost of Alternative 2 is strongly the dependent on the assumed market for high purity arsenic.

Assessment Item	**Alternative 1** ***In Situ*** **Management with Ground Freezing**	**Alternative 2 Extraction of Dust, Arsenic and Gold Recovery by Fuming**	**Alternative 3 Extraction of Dust, Gold Recovery and Arsenic Stabilization by Pressure Oxidation**	**Alternative 4 Extraction of Dust, Stabilization with Cement**
Costs (millions of $CDN)				
Capital	20.8	81.5	122.3	42.1
Operating	29.4	199.0	313.2	189.3
Revenue	-	95.1	35.6	-
Net	52.8 ~~50.2~~	185.4	399.9	231.4
Maximum Net	67	344	409	256
Minimum Net	37	143	319	186
Risks				
Probability of 1000 kg Short-term Arsenic Release	1 in 10,000	1 in 500	1 in 500	1 in 500
Probability of 1000 kg Long-term Arsenic Release	1 in 10,000	1 in 4000	1 in 3000	1 in 5000
Worker Health & Safety	Low	Medium to High	Medium to High	Medium
Air Emissions	n/a	Very Low	n/a	n/a

CONCLUSIONS AND RECOMMENDATIONS

The studies presented herein characterize the potential for the arsenic trioxide dust at the Giant Mine to cause environmental or human health problems if no management measures are taken, and assess representative management alternatives.

The implications of the risk assessment are that it is prudent to investigate measures to manage the arsenic trioxide dust, that dust management measures which would keep arsenic release rates at or below 2000 kg/yr would generally be sufficient to protect human and ecological health, and that other considerations will need to be considered to select among the alternatives that can meet that target.

Results of the alternatives analyses indicate that Alternative 1, *in situ* management of the dust through ground freezing, is by far the lowest cost alternative. Even the maximum costs for this alternative are significantly below the minimum net costs for the others. Alternative 1 also poses lower risks than any of the other three alternatives.

The studies reported herein have identified gaps in the current understanding of the site. Some of those gaps are critical for further decisions about management of the arsenic trioxide dust. Critical areas for further work to reduce uncertainties in the risk assessment have been identified.

The use of representative alternatives was not intended to rule out other options. Based on the good results obtained for ground freezing, further analysis of the other *in situ* management measures is warranted. Work on other groups of alternatives should be limited to areas that could lead to significant reductions in costs and risks.

As mentioned in the introduction, the studies reported herein consider technical issues only. The results should be considered as technical input to the process of public communication and consensus building around the management of arsenic trioxide dust at the Giant Mine.

GIANT MINE ARSENIC TRIOXIDE MANAGEMENT ALTERNATIVES WORKSHOP
Agenda Item No. 1

Federal Management Strategy

by Dave Nutter
Indian and Northern Affairs Canada

Yellowknife NT
June 11 and 12, 2001

Strategy

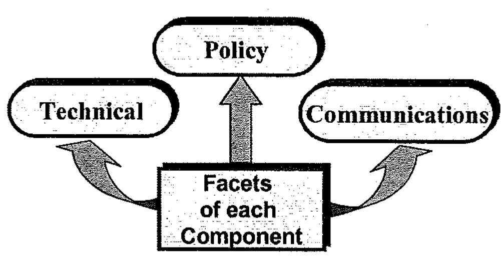
Arsenic Trioxide Management Options

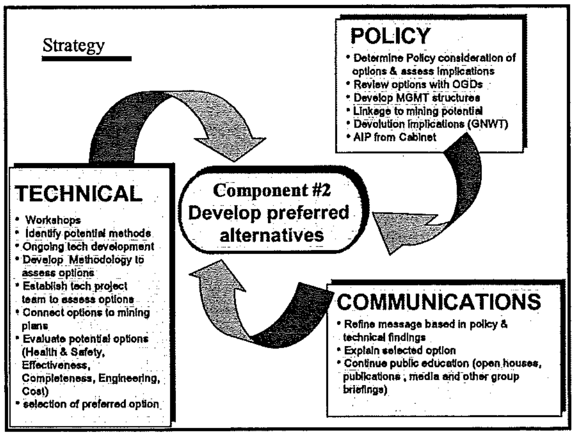
- Define the problem
- Develop options & select preferred alternative
- Complete Project Description
- Complete Environmental Assessment
- Complete regulatory approvals
- Implement

currently safest place for arsenic is in the vaults.

Strategy

STRATEGIC FRAMEWORK
3 Facets to each Component





Strategy

Proposed Strategic Framework and Timeline for Arsenic Management

Time	Component	Technical	Policy	Public Consultation
ongoing	Define the problem			
2001	Complete pre-feasibility study			
2002-03	Complete Project Description			
	Environmental Assessment			
2004-05	Complete regulatory approvals			
2005 +	Implementation			

GIANT MINE ARSENIC TRIOXIDE MANAGEMENT ALTERNATIVES WORKSHOP
Agenda Item No. 2

Historical Overview/ Summary of Activities

by Neill Thompson

Indian and Northern Affairs Canada

Yellowknife NT

June 11 and 12, 2001

Historical Summary

Historical Summary

MINE SITE

- Giant Mine operating since 1948
- Ore is arsenopyrite which requires special processing
- Ore was heated in a roaster to free the gold
- Process produced arsenic gas as a by-product collected as an arsenic trioxide bearing dust
- Over the life of the milling 237,000 tonnes (265,000 tons) of dust were produced

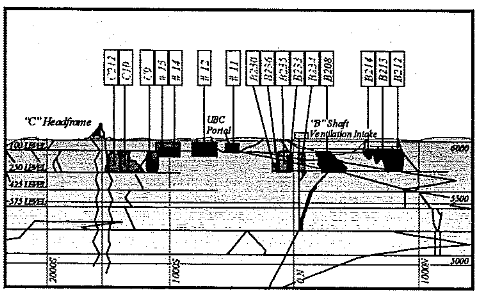
Historical Summary

ARSENIC STORAGE

- Dust was placed underground in 15 chambers (2 types: old stopes & purpose built)
- Chambers are located between 80' - 250' level of a 2000' mine 30'
- Underground storage was considered the most viable option
- Containment was based on permafrost, competent host rock and low groundwater flows
- In 1977 Canadian Public Health Association (CPHA) recommended underground storage be continued

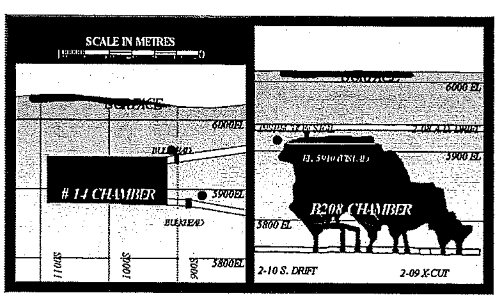
Historical Summary

Longitudinal section of arsenic chambers in mine



Historical Summary

Longitudinal section of #14 and 208

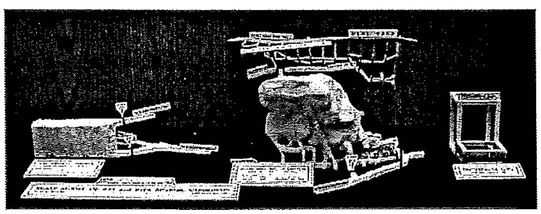


Historical Summary

Bulkhead

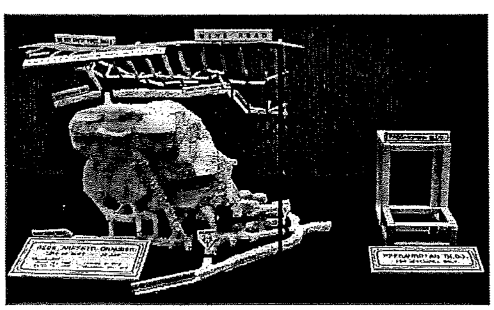
Historical Summary

Arsenic Chamber Model Overview



Historical Summary

Model Close-up of 208 & PreCambrian



Historical Summary

MINEWATER

- Pumping/dewatering of the mine has occurred over the last 50+ years of mine operations
- Water table in the mine area has been lowered
- Mine water is collected in the mine workings and pumped to the tailings ponds for treatment and discharge
- Local flows in the areas of the chambers are contained and collected in the mine water
- Ongoing ground water quality and quantity studies

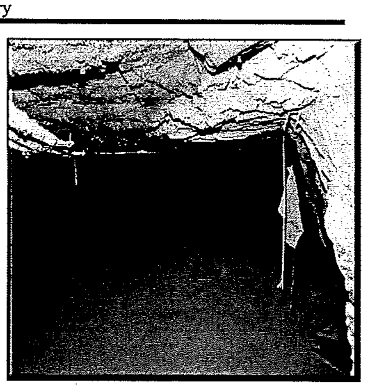
Historical Summary

ARSENIC DUST

- Key chemical components (in wt%)
  - Arsenic 36 - 67 %, average 60%
  - Arsenic trioxide average 79%
  - Gold 2 - 80 ppm (averages 0.5 OPT)
  - 138,000 ounces of gold
- Dust placed dry initially but has compacted and gained moisture

Historical Summary

Picture of arsenic in vault



Historical Summary

TOXICITY OF ARSENIC

- Toxicity varies depending on compound
- Arsenic trioxide is soluble in water
- Arsenic trioxide is toxic

Historical Summary

OWNERSHIP

- Royal Oak Mines amassed large debts and filed for court protection - February 1999
- Court transfer to DIAND representing the federal government - December 1999
- Sale to Miramar Giant Mine Ltd. (MGML) - December 1999

Historical Summary

TERMS OF SALE

- MGML to maintain property in environmental compliance
- Reclamation security trust established
- Limited liability for the pre-existing state of the property - Liability ultimately rests with DIAND
- Right of termination - December 14, 2001 (upon 6 months notice)
- Limited production - processing at Con Mine
- Permanent closure of roaster - no more production of arsenic trioxide

Historical Summary

DIAND SHORT TERM ACTIONS

- Ensure public health & safety and environmental protection
  - ongoing water monitoring program
  - ongoing monitoring of arsenic containment (bulkhead inspection)
  - underground rehabilitation (improved bulkhead access).
- Arsenic Trioxide Management Project Description - MVLWB for October, 2001

Summary of Activities

Summary of Activities

WORK TO DATE

- Workshops previously held in 1997 and 1999
- Work now directed at an Arsenic Trioxide Management Project Description
- Project List describing activities undertaken

Summary of Activities

SPECIFIC PROJECT AREAS

- Assessment of management options
- Hydrogeology - water quality, quantity and sources
- Bulkhead assessment and rock mechanics
- Underground mine rehabilitation
- Public information/consultation
- Surface Assessment & Rehabilitation

Summary of Activities

ARSENIC TRIOXIDE TECHNICAL ADVISOR

- RFPs sought through the competitive contracting process
- SRK Consulting was retained with Senes Consulting, Lakefield Research and HG Engineering on the team
- To act as an independent advisor to DIAND to provide us world class advice
- Main objectives of SRK are:
  - provide broad-based, neutral technical advice
  - identify and recommend, with rationale, preferred management option(s) to DIAND
  - assist DIAND in managing assessment & research
- Current status is the completion of the Pre-feasibility Study

Summary of Activities

OTHER PLAYERS

- Other activities/groups involved in arsenic in Yellowknife
  - MGML w/ Golder Consulting - developing mine A&R plan
  - YSARC w/ RMC and Risklogic - Yellowknife soil remediation criteria
  - RMC - long running arsenic research in Yellowknife area
  - GNWT, City of Yellowknife
- We are working with these groups to maintain contact

Summary of Activities

PUBLIC COMMUNICATION AND CONSULTATION

- DIAND is committed to ensuring the public is both informed and involved in developing this project.
- It is vital that the concerns and ideas of the public and interest groups be incorporated into developing the appropriate management options.
- Methods - 2 open houses 1999 and 2001, 3 Technical Workshops 1997, 1999 and 2001, a Public Registry and various publications.
- Looking at setting up a Multi-stakeholder Advisory Group.
- DIAND is committed to moving forward with confidence that the work is done right and that we have the appropriate information and support to move forward on the preferred options.

1999

Arsenic Management Plan

- Developing an action plan to address technical issues related to permanent disposal of the arsenic trioxide.
- Developed a group of technical advisors.

University of British Columbia Research

Research into the following long-term disposal options:

1) transforming arsenic trioxide into non-toxic forms such as ferric arsenate;
2) incorporating the arsenic trioxide into glass; and
3) immobilizing arsenic trioxide in cement.

The first two options evaluated the use of microwave technology as an alternative source of energy.

Canada Centre for Mineral and Energy Technology (CANMET) Research

Research and development of a hot water leaching process for purifying the arsenic trioxide dust so that it can be sold on the commercial market.

Hydrogeological Numerical, Flow and Transport Model

Development of a three-dimensional groundwater transport model of Giant Mine to understand and evaluate how water would flow through the mine and arsenic trioxide storage vaults if the mine pumps were shut off and the mine allowed to flood. Complements the hydrogeological work done in 1998.

Arsenic Market Study

An update of Royal Oak Mines 1996 arsenic trioxide market Study - Dillon.

Review of Mining Methods Applicable to the Recovery of Baghouse Dust Stored Underground

An update and summary on potential mining/extraction methods for the arsenic trioxide.

Underground Rehabilitation

Developed a plan for underground rehabilitation of mine workings to gain access to vaults where access was previously cut off.

Comparative Study of Refinement Techniques

Compares two processes (WAROX and El Indio) that could be used to refine the arsenic trioxide dust so that it can be sold on the commercial market and to recover the gold contained within it.

Arsenic Technology Review

Review and update on viable arsenic trioxide management options for the Crown as they relate to benefits, risks and associated costs.

Technical Workshop

The objective of this workshop is to build on the information we have determined from the previous workshop and research. Plus develop a common understanding. The workshop established assessment criteria, that no quick fix was available and that the management plan may be a combination of options.

First Public Information Open House

A four-day store front open house was held in September for public information with two evening presentations.

2000

Project Technical Advisor

DIAND retained the services of SRK Consulting, a firm of engineers and scientist to act as an overall technical advisor for the project. SRK is responsible for overseeing the major areas of arsenic trioxide assessment including: environmental, hydrogeological and geotechnical issues relating to the underground chambers and access workings; and potential methods for dust extraction, dust reprocessing and dust stabilization. Also, on the team are Senes Consultants Ltd., H.G. Engineering and Lakefield Research Ltd.

Cement and Bitumen Stabilization

An ongoing study using cement and bitumen for stabilizing the toxic mine dust, and monitoring the stability of bitumin stabilized dust.

Groundwater Monitoring Report

Surface water and mine water sampling was carried out at selected sites at the Giant Mine. The objectives of this water sampling program were to: characterize the late-summer chemical and isotopic composition of surface waters and groundwaters; compare current data to previous data; and establish the framework for continued monitoring of surface water and groundwater quality.

Hydrogeology Experts Meeting

A meeting of world class hydrogeologic experts convened in March 2000.The meeting was held to review existing work; to solicit expert opinion; and to provide directions for future work.

SRK Senior Technical Session, Giant Mine Arsenic Trioxide

The session reviewed the current state of knowledge about the arsenic trioxide dust; identified methods and develop alternatives for managing the arsenic trioxide dust; identified the information needed; and design & prioritize investigations to acquire the needed information.

A Review of Arsenic Disposal Practices for the Giant Mine

A literature review to obtain information about arsenic disposal practices in the mining-metals industry and about the long-term stability of the disposed arsenic compounds. The information was analysed and evaluated to determine the applicability of current arsenic technologies to the Giant Mine.

Recovery and Purification of Arsenic Oxide - Giant Mine

A production investigation of pure arsenic using water leaching-crystallization and re-sublimation techniques.

Environmental Study of Arsenic Contamination on the Giant Mine

A scientific study to assess the levels of arsenic found from the Giant Mine property.

2001

Underground Rehabilitation

An underground rehabilitation was carried out to provide safe access to the bulkheads that were not accessible. Also, installing water pumps and ventilation fan near the arsenic chambers.

Bulkhead Evaluation

SRK is currently assessing the physical strength of the bulkheads which seal off the arsenic storage chambers and stopes. Using the original bulkhead design information, as well as information collected during underground inspections, SRK is evaluating the stability of the structures under variable conditions. Recommendations have been made for a monitoring and stability program.

Hydrogeology

Work has continued conducting further monitoring and finalizing the hydrogeology information package. The mine water monitoring program has some additional sampling of new sites underground and detailed analysis of the data collected in 2000 and 2001. This has been done in conjunction with DIAND, SRK and Dr. Ian Clark.

SRK Senior Technical Experts Meeting

A meeting of technical experts on the SRK team was held at the end of March. The results of the various scientific, engineering and risk studies were presented and discussed. The alternatives were compared and ranked, according to varying evaluation criteria.

The SRK team is currently preparing a final report on the pre-feasibility study, which is anticipated to be completed in the second quarter of 2001.

Mine Tours

Surface and underground mine tours were provided on three separate occasions to the members of Yellowknife City Council, the local Media, and members of the Legislative Assembly.

Public Information Open House

A two-day open house was held in March 2001 to update the public about the progress of the Giant Mine's Arsenic Trioxide Management and Surface Reclamation. An evening of visual presentation, followed by questions and answers, concluded the event.

Public Registry

Initially started in 1999, a number of reports relating to the arsenic trioxide issue have been completed by DIAND contractors, a public registry is set up on the 5th Floor Precambrian Building as a means of making this information available to the public. Copies of all reports have been placed in the registry and are available for review.

Agenda Item No. 3

Overview of Technical Advisor Work to Date

Daryl Hockley
SRK Consulting Inc.

Technical Advisor Team

SRK Consulting Engineers and Scientists

SENES Consultants Limited

Lakefield Research

HGE

Team Members Here Today

- Daryl Hockley (SRK)
- Randy Knapp (SENES)
- Bruce Halbert (SENES)
- Grant Feasby (Lakefield)
- Stephen Schultz (SRK)
- Michael Royle (SRK)

Other Senior Members of Team

- Dr. Chris Page (Mine Engineering)
- Jarek Jakubec, P.Eng. (Rock Mechanics)
- R. Christoph Wels (Hydrogeology)
- Dr. Chris Lee (Structural Geology)
- Lou Bruno, P.Eng. (Materials Handling)
- Phil Evans, P.Eng. (Pyrometallurgy)
- Dr. Hans van der Sloot (Waste Stabilization)
- Dr. Rob Bowell (Arsenic Geochemistry)
- Dr. Harriet Philips (Toxicology)
- Dr. Doug Chambers (Risk Assessment)

Technical Advisor Role

- "Develop and assess management measures for the arsenic trioxide dust"
- "Provide senior technical expertise and broad-based advice to DIAND ..."
- Contract excludes the Technical Advisor team from participation in the implementation phase of the project

Technical Advisor Activities

- Team selected in January 2000
- Senior Technical Session in March 2000
  - Reviewed available information
  - Identified dust management alternatives warranting consideration
  - Designed investigations to assess alternatives
- Project funding delayed and project suspended in June 2000

Technical Advisor Activities

- Project re-initiated in October 2000
- Focus on "Pre-feasibility study"
- Study completed in May 2001

Pre-Feasibility Study Objectives

- Based on available information:
  - Quantify environmental and human health risks associated with current dust storage
  - Define representative alternatives
  - Prepare defensible pre-feasibility level designs and cost estimates
  - Analyze environmental, technical and financial risks

Step 1 - Assess Base Case Risks

- Assess environmental and human health risks from the arsenic trioxide dust in the "*unmanaged base case*"
  - Hypothetical future condition where the mine is abandoned without any measures to manage the arsenic trioxide dust

Step 2 - Define Alternatives

- Define and prepare pre-feasibility level designs for "*representative management alternatives*"
  - Review of proposed methods
  - Selection of alternatives for further analysis
  - Engineering designs

Step 3 - Assess Alternatives

- Assess the representative management alternatives with respect to:
  - Risk
    - Arsenic releases during implementation
    - Arsenic releases over long term
    - Worker health and safety
    - Air emissions
  - Net Cost
    - Capital and operating costs
    - Revenue from sale of gold or arsenic
    - Cost uncertainties

Step 4 - Communicate Results

- Report issued in May 2001:
  - *"Study of Management Alternatives for Giant Mine Arsenic Trioxide Dust"*
- Presentation in Ottawa
  - June 7 & 8 2001
- Workshop in Yellowknife
  - June 11 &12, 2001

Following Presentations …

- Agenda Item No. 4
  - Risks associated with the unmanaged base case
- Agenda Item No. 5
  - Overview of dust management alternatives
- Agenda Item No. 6
  - Representative management alternatives and evaluations to date
    - Designs
    - Evaluation of risks
    - Cost and revenue estimates
    - Conclusions

Agenda Item 4

SCREENING LEVEL ENVIRONMENTAL AND HUMAN HEALTH RISK ASSESSMENT

Randy Knapp
Bruce Halbert

SENES Consultants Limited

Why complete a Risk Assessment?

- To determine if humans or ecology are potentially at risk of adverse health impacts.
- To provide a benchmark or reference case with which to compare risk management alternatives (what dose or risk reduction may occur if an alternative is adopted).
- Allows for optimization of the future management plans.

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What is a Screening Level Risk Assessment?

- A conservative evaluation of potential effects on the human health and ecology of the area.
- Assess the contaminant loadings to the environment, determine levels in the environment and calculate dose or exposure levels.
- Compare these exposures to toxicity benchmarks (safe levels)
- For levels below benchmark, minimal risk. For levels above benchmarks, potential risk and further study warranted.

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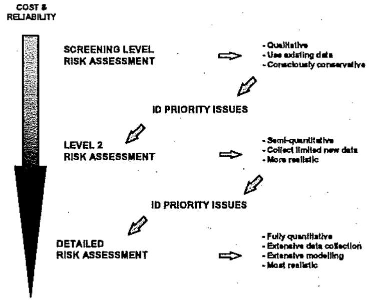
screening level

Staged Approach to Risk Assessment



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- uses existing data

Steps in Risk Assessment

- Define system (sources, pathways and receptors of interest)
- Characterize contaminant sources
- Calculate contaminant transport and "pathways" to estimate intake by receptors
- Compare intakes to toxicological benchmarks

SENES Consultants Limited

Definition of Unmanaged Base Case

- Hypothetical analysis of what could happen in long term future if:
  - Mine is allowed to flood with no measures to manage the arsenic trioxide dust
  - Only minor clean-up and remedial works completed to minimize inflow and assure stability
- Only arsenic releases from mine are considered:
  - Arsenic released to groundwater that discharges to Baker Creek and Back Bay
  - Toxicity thresholds reduced to allow for other sources
- Considers all aquatic pathways to receptors:
  - aquatic species (fish and benthos)
  - animals
  - humans

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Toxicity Benchmarks

- Aquatic Biota
  - LC_{20} or EC_{20}, level at which 20% of population may be affected
- Benthos
  - PEL, Probable Effect Level, level frequently associated with adverse effects
- Terrestrial Biota
  - NOAEL, No Observable Adverse Effect Level
- Humans
  - RfD, Reference dose (for this study have used Health Canada tolerable lifetime daily intake)
  - SF, Slope Factor, Factor used to assess risk of cancer

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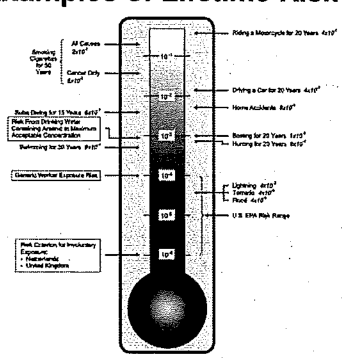
considered 40% of intake by humans –

Examples of Lifetime Risk



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Source Characterization

- Investigation of arsenic sources and concentrations in the mine
- Hydrogeological assessment of potential range of flows and flow paths through the mine
- Bounding calculations of the potential releases of arsenic from the mine

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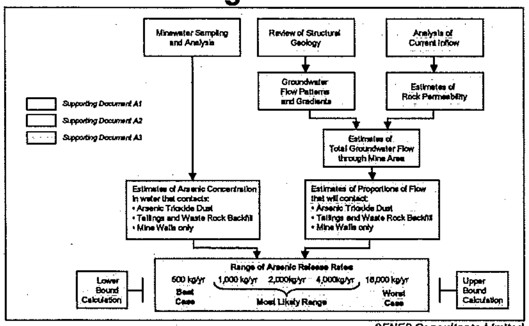
Arsenic Releases in Unmanaged Base Case



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Pathways Calculations Tools

- LAKEVIEW dispersion model
  - Used to predict arsenic levels in water and sediment)
  - Model calibrated to historic database of water and sediment arsenic
- Pathways model
  - Used to determine uptake of arsenic and transfer among biota and humans
  - Considers all relevant exposure pathways (drinking water, eating plants and animals, contact with contaminants etc).

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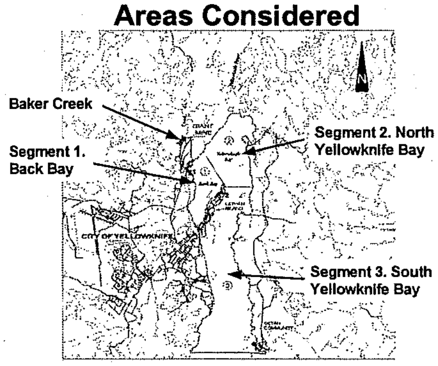
Areas Considered



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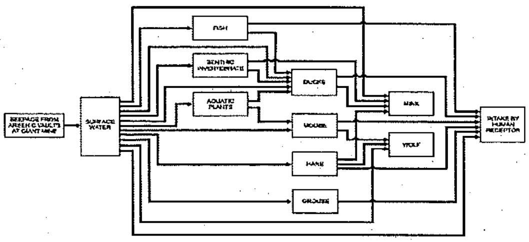
"Pathways" Considered



Background Data on Water and Sediment Quality

- Large data file on water quality and sediments
- Data available for both immediate area and regional sources
- Data allows for calibration of models of arsenic transport and deposition in Back Bay and Yellowknife Bay

Historical Arsenic Releases

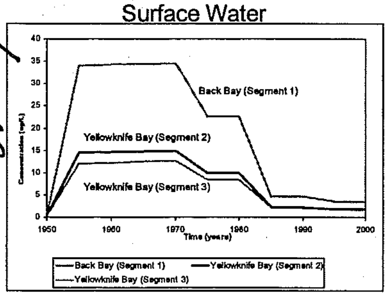
- Reviewed historic data on water quality, sediments, arsenic releases.
- Estimated arsenic loading to Back Bay via Baker Creek:
  - 12,500 kg/yr before 1968
  - 8,000 kg/yr 1968 to 1980
  - 1300 kg/yr 1981 to 1993
  - 950 kg/yr 1994 to present

summer only

June → Sept.

Predicted Arsenic Concentrations Between 1950 and 2000

Surface Water



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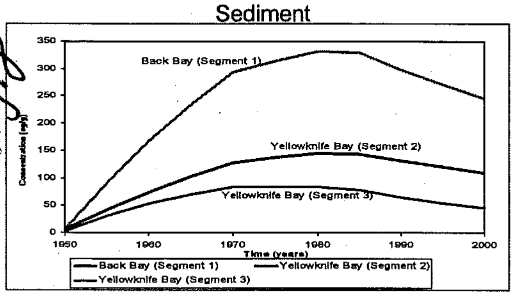
Refer to previous slide

Predicted Arsenic Concentrations Between 1950 and 2000

Sediment



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Arsenic Release Rates Unmanaged Base Case Scenarios

Scenario	Arsenic Load (kg/yr)
Best Case	500 + 450
Base Case 1	1000 + 450
Base Case 2	2000 + 450
Base Case 3	4000 + 450
Worst Case	16,000 + 450

Background arsenic load of 450 kg/yr carried in Baker Creek

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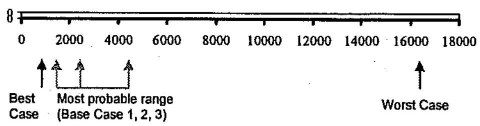
+ 450 accounts for runoff from historic watershed due to deposition, remobilization

Range of Arsenic Release Rates (kg/year)



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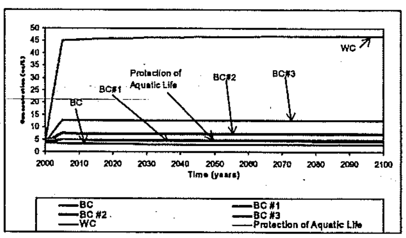
Predicted Arsenic Concentrations Back Bay – Segment 1 Between 2000 and 2100

Surface Water



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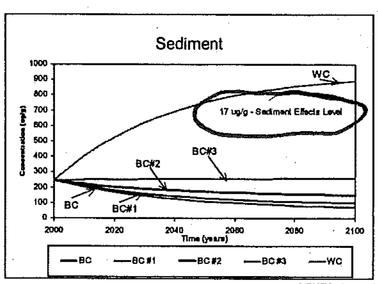
Predicted Arsenic Concentrations Back Bay – Segment 1 Between 2000 and 2100



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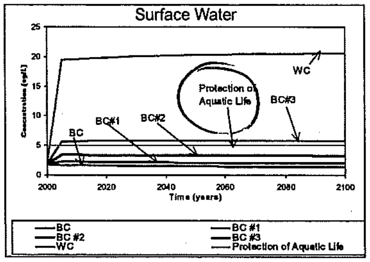
Predicted Arsenic Concentrations Yellowknife Bay – Segment 2 Between 2000 and 2100



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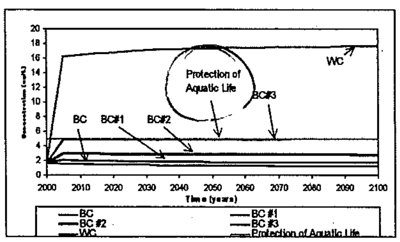
Predicted Arsenic Concentrations Yellowknife Bay – Segment 3 Between 2000 and 2100

Surface Water



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Ecological Risk Aquatic Receptors by Location

Baker Creek	Segment 1	Segment 2	Segment 3
	Pond Weed	Pond Weed	Pond Weed
Benthic Invertebrates	Benthic Invertebrates	Benthic Invertebrates	Benthic Invertebrates
	Northern Pike	Northern Pike	Northern Pike
	Lake Whitefish	Lake Whitefish	Lake Whitefish
White Sucker	White Sucker	White Sucker	White Sucker

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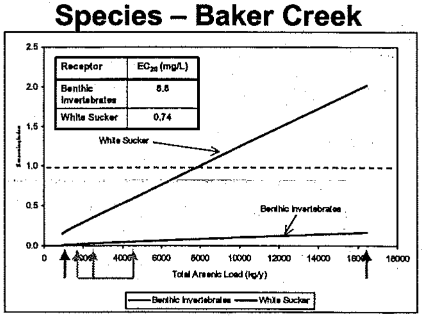
Baker - pond weed, benthic inverts, suckers

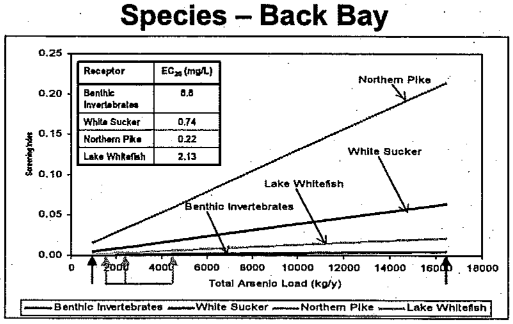
Ecological Risks
Terrestrial Receptors by Location

Baker Creek	Segment 1	Segment 2	Segment 3
Moose	Ducks	Ducks	Ducks
Spruce Grouse	- Merganser	- Merganser	- Merganser
Hare	- Mallard	- Mallard	- Mallard
Ducks (50%)	- Scaup	- Scaup	- Scaup
Wolf			
Mink			

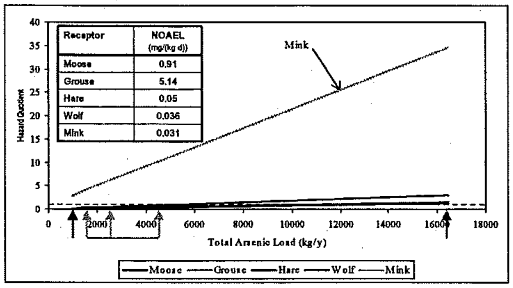
Screening Indices for Aquatic Species – Baker Creek



Screening Indices for Aquatic Species – Back Bay



Hazard Quotients for Terrestrial Species – Baker Creek



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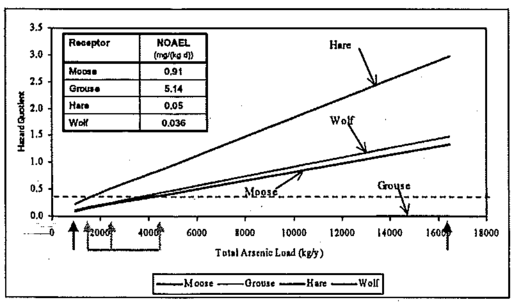
Hazard Quotients for Terrestrial Species – without Mink



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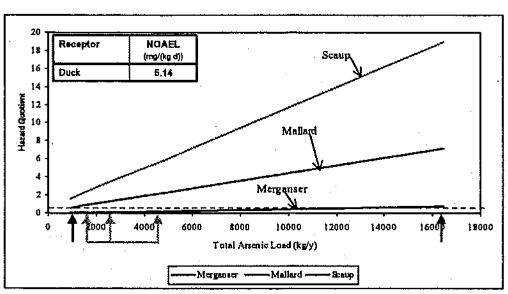
Hazard Quotients for Ducks – Baker Creek



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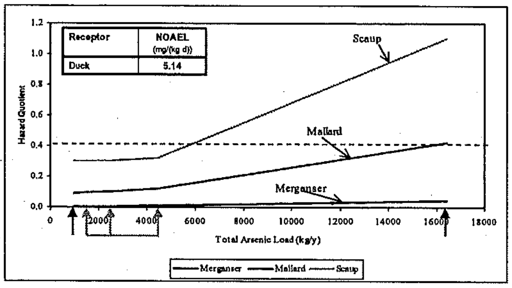
Hazard Quotients for Ducks – Back Bay Segment 1



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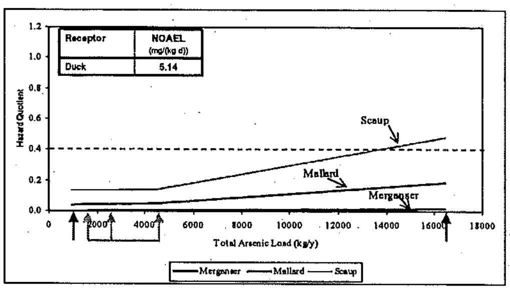
Hazard Quotients for Ducks – Yellowknife Bay Segment 2



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Summary - Aquatic Species at Risk

Location	Arsenic Release Rate (kg/yr)				
	500	1,000	2,000	4,000	16,000
Baker Creek	-	-	-	-	Pondweed, White Sucker
Segment 1 Back Bay	-	-	-	-	-
Segment 2 North Yk. Bay	-	-	-	-	-
Segment 3 South Yk. Bay	-	-	-	-	-

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Summary - Duck Species at Risk

Location	Arsenic Release Rate (kg/yr)				
	500	1,000	2,000	4,000	16,000
Baker Creek	Scaup	Scaup	Scaup, Mallard	Scaup, Mallard	Scaup, Mallard
Segment 1 Back Bay	-	-	-	-	Scaup
Segment 2 North Yk. Bay	-	-	-	-	-
Segment 3 South Yk. Bay	-	-	-	-	-

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Summary - Terrestrial Species at Risk

	Arsenic Release Rate (kg/yr)				
	500	1,000	2,000	4,000	16,000
Species at Risk	Mink	Mink	Mink	Mink	Mink, Hare, Wolf, Moose

Note: Mink assumed to live year round in Baker Creek area, and obtain all drinking water from Baker Creek, and all food from Baker Creek area.

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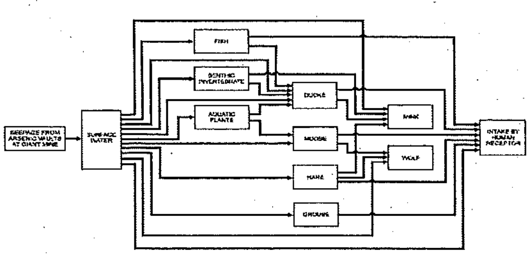
Human Exposure Pathways



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Human "Receptors"

- Assessed arsenic intake by four human "receptors"
- Receptor locations and diets chosen to result in wide range of arsenic intakes

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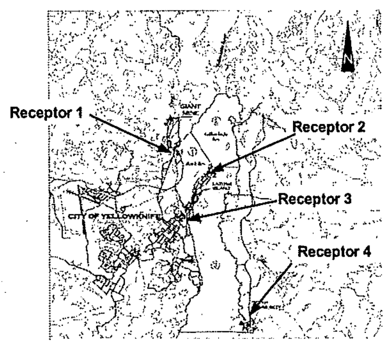
Human Receptor Locations



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Human Receptors - Assumed Diets

- Receptor 1- An adult working at the Marina at the Giant Town Site
- Receptor 2-An adult and child living in the community on Latham Island
- Receptor 3-An adult and child living in Yellowknife
- Receptor 4-An adult and child living in the Dettah community

	Receptor 2 and 4		Receptor 1 and 3	Receptor 3
	Adult	Child	Adult	Child
Water (L/d)	1.5	0.8	1.5	0.8
Meat (g/d)				
Caribou *	310.9	103.6	62.2	20.7
Moose	6.9	2.3	1.4	0.5
Hare	1.6	0.6	0.3	0.1
Poultry (g/d)				
Grouse	2.0	0.7	0.4	0.1
Ducks	2.8	0.9	0.6	0.2
Fish (g/d)	55.0	27.5	11.0	5.5
Berries (g/d) *	5.4	2.7	5.4	2.7
Total Protein (g/d)	378.9	135.6	75.9	27.1

* Not considered in the base case scenario

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Human Receptor Food & Water Sources Best and Base Case

Receptor Location	Mallard	Moose	Grouse	Hare	Fish	Water
1 Marina	BC				S1	YR
2 Latham Island	BC	BC	BC	BC	S1	S1
3 Yellowknife	S2	BC	BC	BC	S2	YR
4 Dettah	S3				S3	S3

BC – Baker Creek
S1 – Segment 1 (Back Bay)
S2 – Segment 2 (Yellowknife Bay)
S3 – Segment 3 (Yellowknife Bay)
YR – Yellowknife River

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Human Receptor Food and Water Sources Worst Case

Receptor Location	Mallard	Moose	Grouse	Hare	Fish	Water
1 Marina	S1				S1	YR
2 Latham Island	S1				S1	S1
3 Yellowknife	S2				S2	YR
4 Dettah	S3				S3	S3

BC – Baker Creek
S1 – Segment 1 (Back Bay)
S2 – Segment 2 (Yellowknife Bay)
S3 – Segment 3 (Yellowknife Bay)
YR – Yellowknife River

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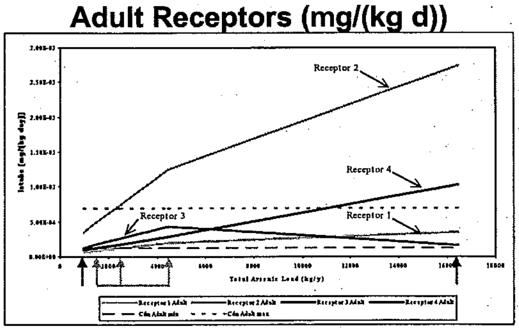
Estimated Intake of Arsenic by Adult Receptors (mg/(kg d))



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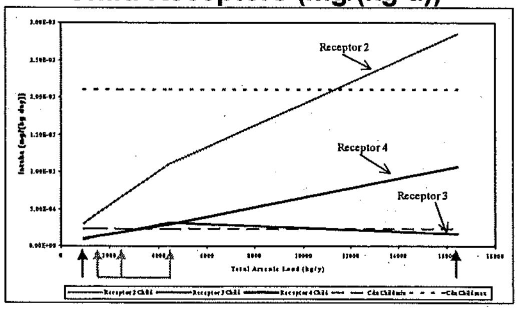
Estimated Intake of Arsenic by Child Receptors (mg/(kg d))



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Sources of Arsenic Intake by Human Receptors

Receptor	% Distribution of Intake						
	Mallard	Moose	Grouse	Hare	Caribou	Fish	Water
Receptor 1 - Adult	52	0	0	0	0	43	5
Receptor 2 - Adult	40	3.4	<< 1	<< 1	0.3	35	22
Receptor 2 - Child	30	2.6	<< 1	<< 1	0.2	41	27
Receptor 3 – Adult	6	13	<< 1	<< 1	1.2	62	17
Receptor 3 - Child	4	10	<< 1	<< 1	0.8	66	19
Receptor 4 - Adult	5	0	0	0	0	59	36
Receptor 4 - Child	3	0	0	0	0	58	39

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Arsenic Toxicity

- Has both carcinogenic and non-carcinogenic properties
- Typically, risks assessed using toxicity data (slope factor and reference dose) from USEPA Integrated Risk Information System
- In this study used slope factor from USEPA (1.5(mg/(kg d)) $^{-1}$) and reference dose from Health Canada (2 ug/(kg d)) since this was developed for Canadian populations
- In addition, compared intakes and risks for the seven different receptors to typical background intakes for the Canadian population provided by Health Canada to provide a prospective on the risks

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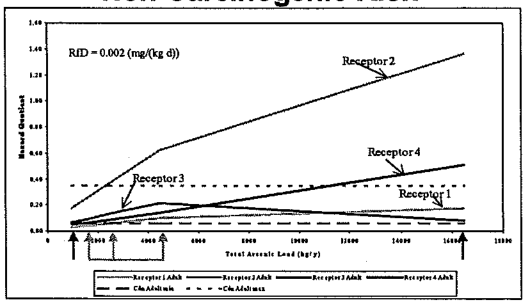
Adult Receptors Non-Carcinogenic Risk



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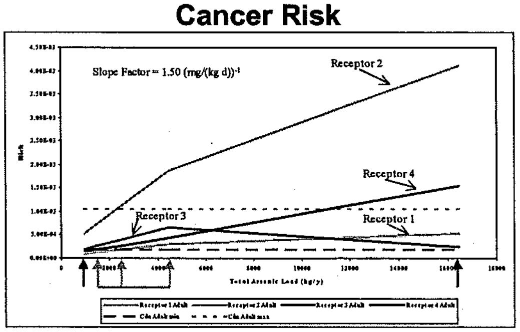
Adult Exposure Cancer Risk



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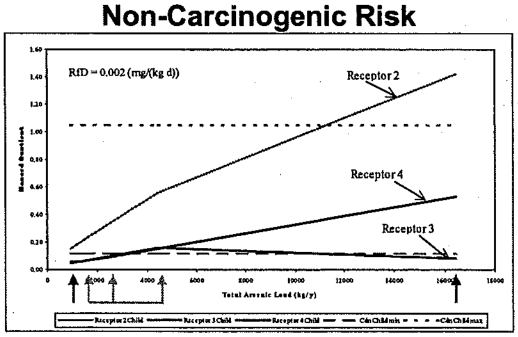
Child Receptors Non-Carcinogenic Risk



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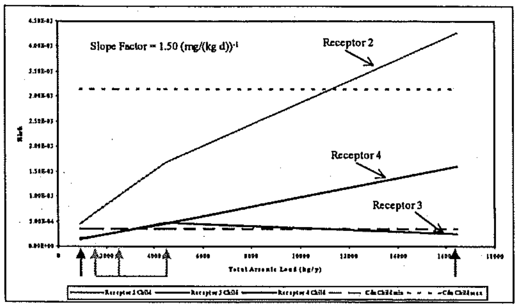
Child Receptors Cancer Risks



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doesn't include +450 ie. runoff from watershed

Summary - Human Receptors at Risk

Receptor	Arsenic Release Rate (kg/yr)				
	500	1,000	2,000	4,000	16,000
Receptor 1	-	-	-	-	-
Receptor 2	-	-	Adult	Adult, Child	Adult, Child
Receptor 3	-	-	-	-	-
Receptor 4	-	-	-	-	Adult, Child

Note: Receptor 2 assumed to obtain all drinking water from Back Bay and to eat duck and fish from Baker Creek and Back Bay.

Note: Receptor 4 assumed to obtain all drinking water from Yellowknife Bay and to eat duck and fish from Yellowknife Bay.

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SUMMARY

- Under current conditions, arsenic release from mine is controlled by treatment system. Arsenic concentrations in lake and sediments are steady or decreasing.
- There is a wide range of uncertainty in estimates of future arsenic release from the mine if no arsenic trioxide management measures are taken:
  - Probable range 1000-4000 kg/yr
  - Best case 500 kg/yr, Worst case 16,000 kg/yr
- Upper end of range is similar to release rates of 1960's
  - Allows predictive model of arsenic behaviour in lake and sediments to be calibrated against historic data
  - Even worst case future releases would be no worse than the historical releases
- Lower end of range is similar to today's release rates

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SUMMARY (cont'd)

- Screening level risk assessments with the range of arsenic release rates indicate:
  - Ecological risks are low for aquatic species in Back Bay and Yellowknife Bay. Fish and aquatic plants in Baker Creek could be impacted by worst case releases. Ecological risks are low for birds and mammals except for species feeding in Baker Creek.
  - Releases in the upper range potentially pose health risk for humans that obtain all their drinking water from Back Bay and eat fish and ducks from Baker Creek and Back Bay
  - Worst case releases could also cause health risks for humans that obtain all their drinking water and eat fish and ducks from Yellowknife Bay
  - Releases in the low range (<2,000 kg/yr of arsenic) pose no significant risk to human health

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SUMMARY (cont'd)

- **Measures to limit arsenic release from the mine are prudent. The target arsenic release levels for any management alternative should be <2,000 kg/yr**
- **An integrated risk assessment should be completed to assess all sources and exposure pathways. It will be difficult for risk managers to make decisions without understanding the complete picture.**

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Agenda Item No. 5

Overview of Management Alternatives

Daryl Hockley
SRK Consulting Inc.

Methods vs. Alternatives

- Over 90 "methods" identified in previous workshops, e.g.:
  - WAROX process, bitumen stabilization, dust extraction by dry vacuum
- But need to evaluate on the basis of complete alternatives, e.g.:
  - Extraction of the dust by vacuum followed by reprocessing by WAROX including waste disposal by ??? and waste water treatment by ???

"Representative Alternatives"

- After reviewing methods, was clear that four groups could be identified:
  - In situ management of the dust
  - Dust extraction and reprocessing to recover arsenic and gold
  - Dust extraction and reprocessing to recover gold only
  - Dust extraction and reprocessing to make a stabilized waste
- Many variants within each group, therefore needed to define representative variants

Evaluation Matrix

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Risk				
Short term arsenic release				
Long term arsenic release				
Worker health & safety				
Air emissions				
Cost				
Net cost				
Max / Min				
Public Consultation				

Evaluation of Alternatives - Risk

- Assessment of risks associated with each alternative
  - Short term risk of arsenic release by accidents or spills during implementation
  - Long term risk of arsenic release from residue disposal facilities and/or maintenance failures
  - Worker health and safety risks
  - Risks from air emissions

Evaluation of Alternatives - Cost

- Method selection and pre-feasibility level engineering design
- Wastewater / residue quantities and treatment / disposal designs
- Cost and revenue estimates
  - Capital costs
  - Operating costs
  - Closure and long term maintenance costs
- Sensitivity to design assumptions

Agenda Item No. 6

Presentation of Representative Management Alternatives

Daryl Hockley
Grant Feasby
Randy Knapp

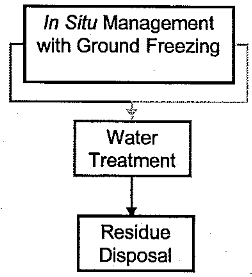
Four "Representative Management Alternatives"

1. Dust management *in situ* with ground freezing
2. Dust extraction and fuming to recover gold and arsenic
3. Dust extraction and pressure oxidation to recover gold and stabilize arsenic
4. Dust extraction and stabilization with cement

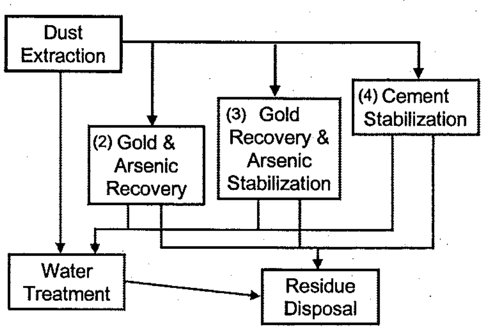
Supporting Studies

- Each alternative involves several methods
- Engineering studies by specialists in each area are presented in Supporting Documents B1 to B9 of the report
- Presentation in main report (and today) focuses on complete alternatives

Alternative 1



Alternatives 2, 3 and 4



Alternative 1

In Situ Management by Ground Freezing

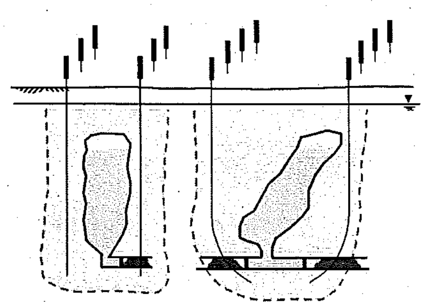
Alternative 1 - Ground Freezing

- Yellowknife is in area of discontinuous permafrost
- From 1950's to 1970's, all dust storage areas were in permafrost
- Later became clear that permafrost was degrading, probably due to warm ventilation air pumped through mine

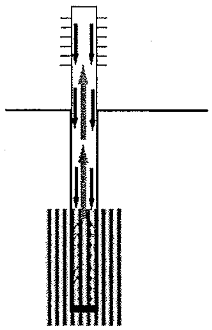
Design Concept

- Use "thermosyphons" or active freezing systems to cool the ground and restore or establish permafrost around arsenic trioxide chambers and stopes
- Frozen ground would prevent flow of groundwater through dust areas
- Would be *in situ* and perpetual

Design Concept



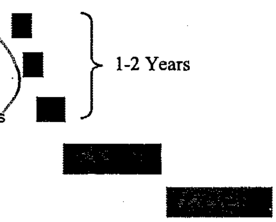
Thermosyphons



- Passive ground cooling system
- Takes heat out of ground and releases it into cold air
- Common use in NWT, and as far south as Winnipeg
- Would need approx. 800 thermosyphons at 2-4 m spacing

Alternative 1 - Implementation

- Backfill drifts
- Backfill pit
- Install thermosyphons
- Freezing period
- Flooding period



Alternative 1 - Water Treatment

- Need to treat minewater during freezing & flooding
  - Estimate 800 m^3/d at 35 mg/L arsenic
  - Duration about 20 years
- May also need long term collection and treatment of minewater
  - Assume 10 mg/L arsenic
  - Assume 80 to 90 years

Alternative 1 - Solid Residues

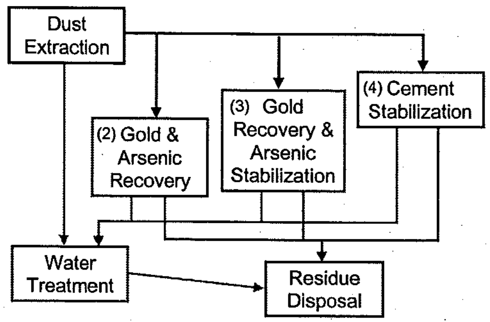
- Water treatment sludge:
  - 1200 tonnes in first 20 years
  - 1400 tonnes in next 80 years

Alternative 1 - Cost Estimate

Activity	Capital $ Million	Operating $ Million	Subtotal $ Million
Backfilling	2.7		2.7
Thermosyphons	17.0	2.4	19.3
Minewater Pumping	0.1	0.8	0.8
Water Treatment	3.5	21.5	25.0
Waste Disposal	0.3	0.1	0.4
Site Management		4.6	4.6
Totals	23.4	29.4	52.8

Alternatives 2, 3, 4

Alternatives 2, 3 and 4

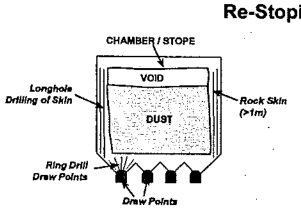


Review of Extraction Methods

- SRK study of geotechnical concerns indicated significant risks and costs, especially in stopes
- Review of sixteen mining and material extraction methods
- Qualitative risk assessment

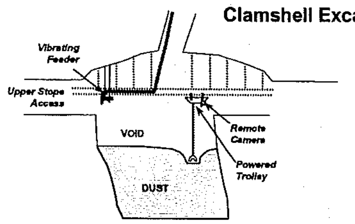
Dust Extraction Methods

Re-Stoping of Dust



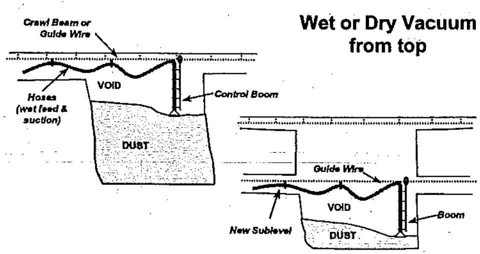
Dust Extraction Methods

Clamshell Excavation



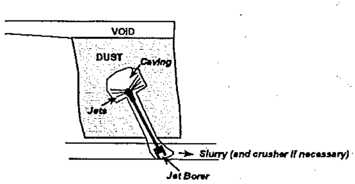
Dust Extraction Methods

Wet or Dry Vacuum from top



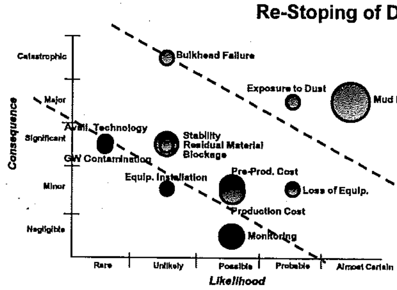
Dust Extraction Methods

Jet Boring



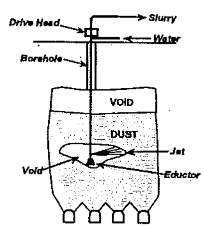
Dust Extraction Methods

Risk Bubble Chart for Re-Stoping of Dust



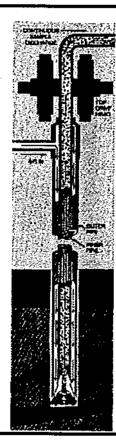
Dust Extraction Methods

Borehole Mining

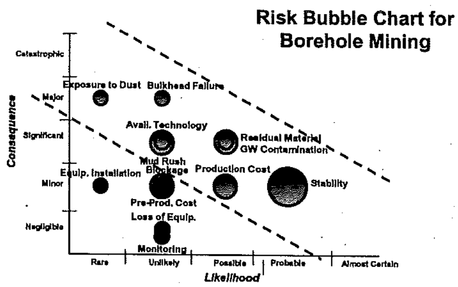


Borehole Mining

- Developed by USBM
- High pressure jet boring tool and slurry air lift system
- Tested in coal & kimberlite by Layne Drilling

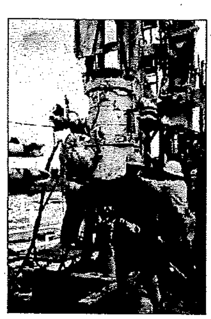


Dust Extraction Methods



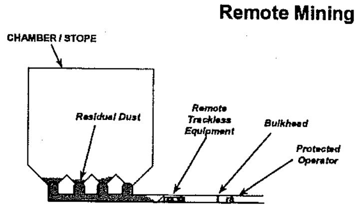
Borehole Mining

Borehole Mining



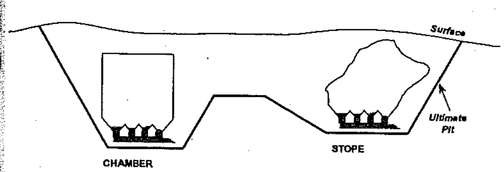
Residual Dust Extraction

Remote Mining

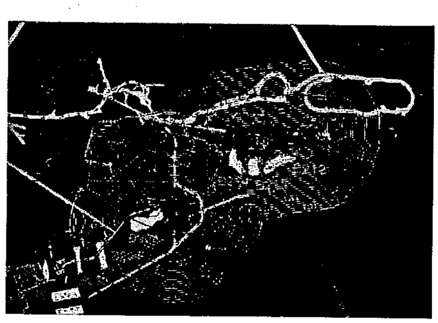


Residual Dust Extraction

Open Pit Mining



Open Pit Mine Outlines



Dust Extraction Cost Estimates

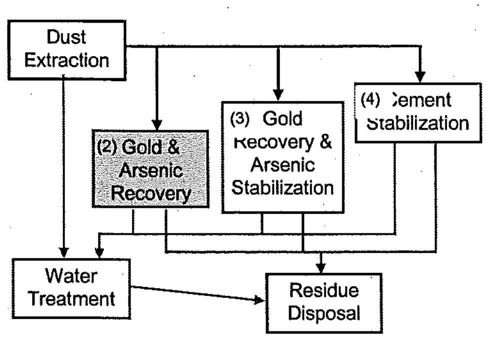
Alternatives 2 and 3 - Fifteen Years

Borehole mining	$ 28,600,000
Underground residual	$ 4,300,000
Open pit mining	$ 17,900,000
Net cost (NPV 3%)	**$ 50,800,000**

Alternative 2

Gold and Arsenic Recovery by Fuming

Alternatives 2, 3 and 4



Arsenic Dust Inventory

Dust Production	Dry Tonnes	Contents				Contained (Value $C)	
		% As	% As_2O_3	%Sb (est)	Oz/tonne Gold	Tonnes As_2O_3 (@ $0.50/kg)*	Oz Gold ($400/oz)
Pre- March 1962	59,400	46.5	61.4	3.5	1.38	36,500 ($18.3M)	82,000 ($32.8M)
Post-March 1962	179,600	64.7	85.5	1.5	0.318	153,400 ($76.7M)	57,100 ($22.8M)
Total	239,000	60.2	79.5	2.0	0.582	189,900 ($95.0M)	139,100 ($55.6M)

Challenges of Inventory

- Higher grade (in arsenic) in more accessible mine locations
  - Best for starting up a process
  - Lowest levels of trash
- Lower grade has 4 times gold value/tonne
- Strategy:
  - Blend material from mine for average grade

Arsenic Trioxide Dust Slurry

- 0.01 mg/m³ arsenic in ambient air restricts dry handling from mine
- some dust already wet
- slightly soluble in cold water - ~~[illegible]~~ 9.0 g/L
- dry dust hydrophobic
  - wetting agents and energy to mix in

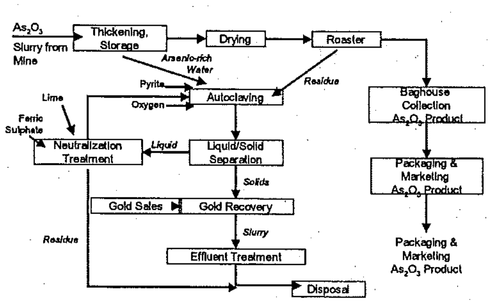
Methods

Method	Products for Sale	Pro	Con	Evaluate
Hot Water Leaching	Arsenic Trioxide Gold	Known process	Tried at Con Mine	Concept only
Ammonium hydroxide	Arsenic Trioxide Gold	Selective for Arsenic	Environment issues	No
Methanol	Arsenic Trioxide Gold	Selective for Arsenic	Cost, unproven	No
Sodium hydroxide	Arsenic Trioxide Gold		Environment issues	No
Sublimation/ fuming	Arsenic Trioxide Gold	Known process	Dry feed Autoclave residue	Yes
Autoclave New facility	Gold	Wet feed Process known High Gold Rec.	Cost Volume of residue	Yes
Con Autoclave	Gold	Existing facilities	Slow, Small capacity	Concept only

Alternative 2 - Gold and Arsenic Recovery by Fuming

- Extensive testing by Giant
  - proven process
- Basis:
  - Arsenic trioxide more volatile than impurities
  - Sale for wood preservation (CCA)
  - Arsenic, gold recovery each 90%
  - Autoclave residue
  - Complete new plant at Giant Mine site
  - 15 years to complete

Alternative 2 - Design Flowsheet



Alternative 2 - Design Values

Process	Rate	Basis
Processing	2.1. tonnes/hr	result
Days operating	310 (85%)	design
Total time	15 years	design
Arsenic recovery	91%	tests
Gold recovery	90%	assumption
Arsenic trioxide production	11,500 tonnes/yr	result
Gold production	8,239 troy ounces/yr	result

Alternative 2 - Water Treatment

- Treatment plant #1
  - Process waters
    - 1,300 m^3/d at 250 mg/L As during extraction (15 years)
  - Minewater
    - 1000 m^3/d at 35 mg/L As during extraction (15 years)
    - 1000 m^3/d at 10 mg/L As - up to 100 years
- Treatment plant #2
  - Stope/Chamber flushing water
    - 650 m^3/d at 1,000 mg/L As for 12 years

Alternative 2 - Solid Residues

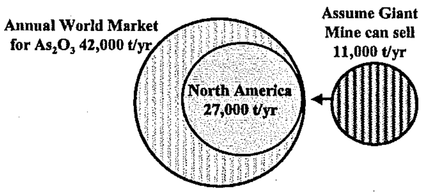
- Process residues
  - 200,000 tonnes of tailings containing several percent arsenic
- Water treatment sludge:
  - 24,000 tonnes in first 20 years
  - 1,400 tonnes in next 80 years

fuming

Ati .001 mg/m³ air emissions

Alternative 2 - Revenues

- Gold sales
  - $375 Cdn. per troy ounce
- Arsenic sales
  - $450 Cdn. per tonne As_2O_3



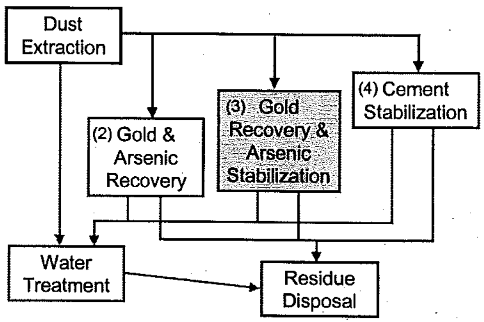
Alternative 2 - Cost Estimate

Activity	Capital $ Million	Operating $ Million	Subtotal $ Million
Extraction	4.0	46.7	50.8
Dust Processing	65.0	104.3	169.3
Minewater Pumping	0.1	0.8	0.8
Water Treatment	6.9	40.5	47.4
Waste Disposal	3.6	3.9	7.5
Project Closure	2.0		2.0
Site Management		2.7	2.7
Totals	81.5	199.0	**280.5**
Revenue			
Gold			35.6
Arsenic Trioxide			59.5
Net Cost			185.4

Alternative 3

Gold Recovery and Arsenic Stabilization by Pressure Oxidation

Alternatives 2, 3 and 4



Alternative 3 - Gold Recovery and Arsenic Stabilization

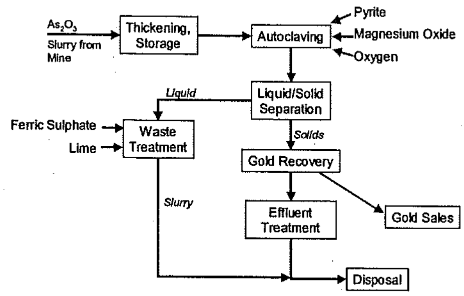
- Basis
  - New processing facility at Giant Mine site
  - Arsenic converted to stable iron arsenate
    - high temperature, pressure autoclave
  - Gold recovery from autoclaved residue
    - standard cyanidation process
  - Water treatment
  - Residue disposal in secure landfill
- Autoclaving for arsenic stabilization
  - current, proven technology

Alternative 3 - Gold Recovery and Arsenic Stabilization

Stable Forms of Arsenic:

Chemical Description	Solubility in TCLP Tests mg/L	Acceptability for Disposal
Calcium Arsenate	1000-3000	No
Arsenical Ferrihydrite	<1	Yes, but requires high Fe:As ratio
Arsenic Sulphide (various formulae)	variable	No, unstable in oxidizing environment
Scorodite ($FeAsO_4.2H_20$)	<1	Yes

Alternative 3 - Design Flowsheet



Alternative 3 - Design Values

Process	Rate	Basis
Processing	2.1. tonnes/hr	result
Days operating	310 (85%)	design
Total time	15 years	design
Gold recovery	90%	assumption
Gold production	8,239 troy ounces/yr	result

Alternative 3 - Autoclave Design Criteria

- Temperature: 210 °C
- Pressure: 3000 kPa (420 psig)
- Oxidation: Gaseous oxygen
- Iron/Arsenic ratio: 1.2:1
- Retention Time: 1.5 hours
- Autoclave Volume: 120 m^3

Alternative 3 - Process Needs

Item	Purpose	Tonnes/day
Raw Dust	Feed material	51
Pyrite Concentrate	Iron source to stabilize arsenic	68
Oxygen	Oxidize iron and arsenic	77
Magnesium oxide	Substitute for lime	15
Lime	Neutralize acid	40
Ferric sulphate	Precipitate As	2

Alternative 3 - Sources of Iron

Material	Availability	Cost $/t	Pro	Con
Pyrite	good	200	available	High acid production
Pyrrhotite	good	300	Lower acid production	Transport Ni contam.
Hematite	good	250	No acid produced	Low reactivity
Steel mill scale	good	150 + acid	Easy to transport	Need to oxidize
Ferric sulphate	good	>500	Lower autoclave size	Very high cost, handling

Alternative 3 - Water Treatment

- Treatment plant #1
  - Minewater
    - 1000 m^3/d at 35 mg/L As during extraction
    - 1000 m^3/d at 10 mg/L As - up to 100 years
- Treatment plant #2
  - Stope/Chamber flushing water
    - 650 m^3/d at 1,000 mg/L As for 12 years

Alternative 3 - Solid Residues

- Process residues
  - 1,000,000 tonnes of "scorodite"
  - Need secure disposal facility:
    - 500 m x 200 m
    - 14 m high
- Water treatment sludge
  - 22,000 tonnes in first 20 years
  - 1400 tonnes in next 80 years

Alternative 3 - Cost Estimate

Activity	Capital $ Million	Operating $ Million	Subtotal $ Million
Extraction	4.0	46.7	50.8
Dust Processing	95.6	219.9	315.5
Minewater Pumping	0.1	0.8	0.8
Water Treatment	6.6	27.4	34.0
Waste Disposal	12.9	15.6	28.6
Project Closure	3.1		5.8
Site Management		2.8	2.8
Totals	122.3	313.2	**438.2**
Revenue			
Gold			35.6
Net Cost			402.6

Alternative 4

Stabilization with Cement

Alternative 4 - What is stabilization?

- The modification of the physical and chemical properties of a waste material to allow for improved conditions for long term waste storage
- Key properties include:
  - physical stability
  - permeability
  - rate of leaching

Alternative 4 - Options

- Literally hundreds of stabilization methods
- Primary options for Giant include:
  - Conversion to a stable compound
  - Additives to improve properties (options include cement and bitumen) ≈ asphalt
  - Vitrification (encapsulation and or waste conversion in a glass matrix)

Alternative 4 - Evaluation Process

- International expert in waste stabilization (Netherlands Energy Research Institute):
  - Confirmed that bitumen, cement and vitrification are reasonable options
  - Insufficient data to select a preferred option
  - Therefore reviewed data on stabilization all other arsenical and highly soluble wastes to provide basis for design
- Secure disposal will likely be necessary, regardless of stabilization method

Alternative 4 - ECN Recommendations

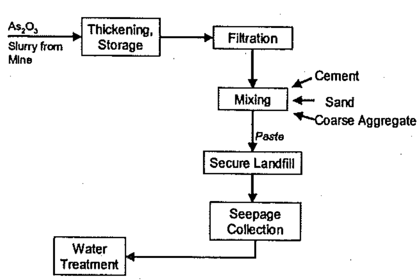
- Select cement addition as the representative stabilization alternative:
  - Can be applied to slurry (no drying)
  - No heating and release of arsenic gases
  - Produces a consisted consistent and physically stable product proven at field scale
  - Full-scale experience allows for good cost estimates and assessment of operating risks

Alternative 4 - Stabilization with Cement

- Process where arsenic dust in a slurry form is mixed with cement to form a solid cemented mass
- Mass has low matrix permeability, low surface area and long term mechanical stability
- Suitable for storage in a lined repository (secure landfill)
- Arsenic remains leachable albeit at lower concentrations than in dust.

Covered as well?

Alternative 4 - Design Flowsheet



Alternative 4 - Design Values

- Dust extraction at 50,000 t/yr (for a five year processing period)
- Pretreatment includes grinding and thickening to produce uniform product and adjust water content
- Mix: 15% dust, 18% Portland cement, 15% sand, 40% coarse aggregate and 12% water
- Pump stabilized waste (like concrete) to secure landfill for long term management
- Storage requirements 1,600,000 tonnes

Alternative 4 - Water Treatment

- Treatment plant #1
  - Minewater
    - 1000 m³/d at 35 mg/L As during extraction
    - 1000 m³/d at 10 mg/L As - up to 100 years
- Treatment plant #2
  - Stope/Chamber flushing water
    - 650 m³/d at 1,000 mg/L As for 12 years

Alternative 4 - Solid Residues

- Process residues:
  - 1,600,000 tonnes of "stabilized waste"
  - Secure disposal facility
    - 350 m x 200 m
    - 10 m high
- Water treatment sludge:
  - 22,000 tonnes in first 20 years
  - 1400 tonnes in next 80 years

Alternative 4 - Cost Estimate

Activity	Capital $ Million	Operating $ Million	Subtotal $ Million
Extraction	4.3	53.5	57.8
Dust Processing	28.6	98.2	126.7
Minewater Pumping	0.1	0.8	0.8
Water Treatment	7.3	29.8	37.1
Waste Disposal	0.7	3.4	4.1
Project Closure	1.2		1.2
Site Management		3.6	3.6
Totals	42.1	189.3	**231.4**

Results of Alternative Evaluations

Evaluation Matrix

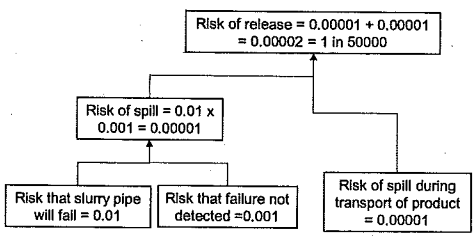
	Alternative 1 Freezing	2 Fuming	3 P.Ox.	4 Cement
Risk				
Short term As release				
Long term As release				
Worker Health/Safety				
Air Emissions				
Cost				
Net Cost				
Max / Min				
Public consultation				

Risks of Arsenic Release

- Environmental risk of each alternative:
  - Estimated probability of 1000 kg/year arsenic release during implementation
  - Then estimated probability of 1000 kg/yr arsenic release over long term

Risks of Arsenic Release

- Fault tree method example:



Risks of Arsenic Release

- Findings of fault tree analysis:
  - Considered major failure modes for all steps in each process
  - Can identify key risks:
    - During implementation risks of release generally related to spills during dust transfer or handling or product storage and handling
    - Over long term risks are dominated by release from residue disposal facilities

Risks of Arsenic Release

- Fault tree estimates of total probability of arsenic release for each alternative:

	Alternative			
	1 Freezing	2 Fuming	3 P.Ox.	4 Cement
Risk				
Short term	1 in 10,000	1 in 500	1 in 500	1 in 500
Long term	1 in 10,000	1 in 5000	1 in 3000	1 in 5000

Worker Health and Safety Risks

- Qualitative assessment of worker health and safety risks for each alternative
  - Conventional risks
  - Arsenic exposure risks
- Results:

	Alternative			
	1 Freezing	2 Fuming	3 P.Ox.	4 Cement
Worker Health and Safety Risk	Low	Med-high	Med-high	Medium

Risks from Air Emissions

- Human health risk assessment
  - Considered release from fuming process
  - Pathway model similar to unmanaged base case
- Results:

	Alternative			
	1 Freezing	2 Fuming	3 P.Ox.	4 Cement
Risk from air emissions	n/a	Very low	n/a	n/a

Summary of Risks

	Alternative			
	1 Freezing	2 Fuming	3 P.Ox.	4 Cement
Risk				
Short term releases	1 in 10,000	1 in 500	1 in 500	1 in 500
Long term releases	1 in 10,000	1 in 5000	1 in 3000	1 in 5000
Worker health/safety	Low	Med-high	Med-high	Medium
Air emissions	n/a	Very low	n/a	n/a

Cost and Revenue Estimates

	Alternative			
	1 Freezing	2 Fuming	3 P.Ox.	4 Cement
Capital Cost	23.4	81.5	122.3	42.1
Operating Cost	29.4	199.0	313.2	189.3
Total Cost	52.8	280.5	435.5	231.4
Revenue	-	(95.1)	(35.6)	-
Net Cost	52.8	185.4	399.9	231.4

All values in $ Million

Cost Estimate Uncertainties

- Alternative 1
  - Need for active freezing
- Alternative 2
  - Risk of collapse of arsenic market
- Alternative 3
  - Reagent costs
- Alternative 4
  - Mix proportions and reagent requirements/costs
- All Alternatives
  - Need for long term minewater treatment

Cost Estimate Min and Max

	Alternative			
	1 Freezing	2 Fuming	3 P.Ox.	4 Cement
Total Cost	52.8	280.5	435.5	231.4
Revenue	-	(95.1)	(35.6)	-
Net Cost	52.8	185.4	399.9	231.4
Maximum Net	69	344	409	256
Minimum Net	39	143	319	186

All values in $ Million

Completed Evaluation Matrix

	Alternative			
	1 Freezing	2 Fuming	3 P.Ox.	4 Cement
Risk				
Short term release	1 in 10,000	1 in 500	1 in 500	1 in 500
Long term release	1 in 10,000	1 in 5000	1 in 3000	1 in 5000
Worker H&S	Low	Med-high	Med-high	Medium
Air Emissions	-	Very low	-	-
Cost ($ millions)				
Net Cost	52.8	185.4	399.9	231.4
Max - Min	69 - 39	344 - 143	409 - 319	256 - 186
Public consultation				

Part 3

Conclusions

Conclusions - Alternatives

- Alternatives representing four very different approaches to management of the arsenic trioxide dust have been investigated
- Pre-feasibility level engineering designs have been completed for each alternative
- All four alternatives are likely to keep arsenic releases to less than about 2000 kg/yr, as derived from the unmanaged base case risk assessment

realistic alternatives

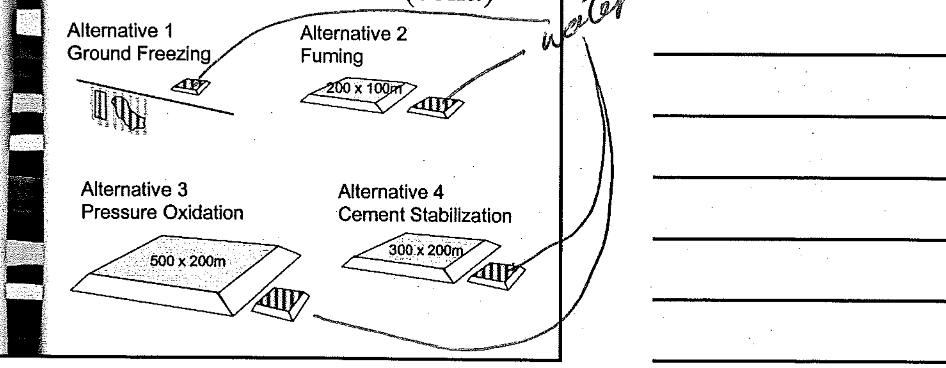
Conclusions - Water Treatment

- Short term water treatment will be needed for all alternatives
- More complex treatment needed when dust is extracted
- Long term water treatment may be needed for all four alternatives
- All water treatment processes generate arsenic rich sludge that needs to be managed

Conclusions - Residues

- All of the alternatives generate residues that will require long term management:
  - Alternative 1 - 3600 tonnes (+237,000 t dust)
  - Alternative 2 - 225,000 tonnes tailings + sludge
  - Alternative 3 - 1,025,000 tonnes scorodite
  - Alternative 4 - 1,625,000 tonnes stabilized dust

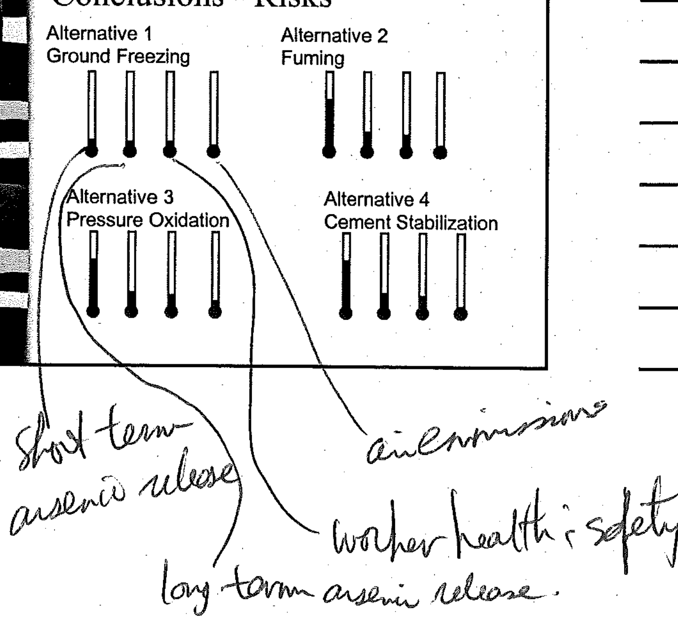
Conclusions - Residues (cont.)

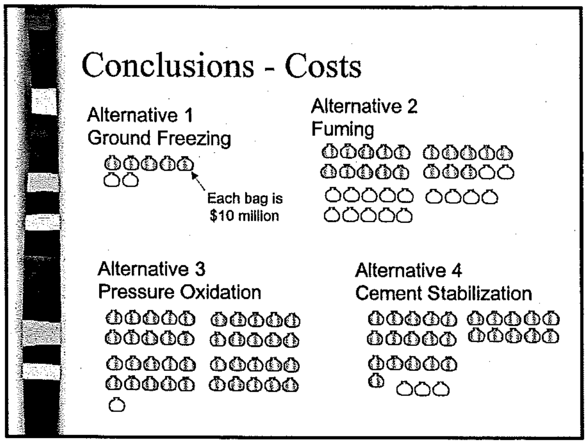


Conclusions

- Alternative 1, in situ management by ground freezing, has the lowest risk and lowest cost
- The remaining Alternatives 2, 3 and 4:
  - Are similar in terms of risk of arsenic release and worker health and safety risks
  - Alternative 2 and 4 have similar net cost, both much lower than Alternative 3
  - But the net cost of Alternative 2 is dependent on arsenic sales
  - Therefore Alternative 4 is probably lowest cost
- Still need to consider other evaluation factors, especially stakeholder acceptance

Conclusions - Risks





Conclusions

- Need stakeholder feedback before final decisions can be made
- Based on the good results obtained for ground freezing, work on other *in situ* management measures is warranted
- Further work on other alternatives should be limited to changes that will significantly decrease costs or risks