# Giant Mine Arsenic Trioxide Technical Workshop

***Final Summary Report***

**November 1999**

Department of Indian Affairs and Northern Development

98-5603-04

*Submitted by*

**Dillon Consulting Limited**

November 9, 1999

Department of Indian and Northern Development
P.O. Box 1500
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Attention: Neill Thompson,
Head of Regulatory Aprroval

**Giant Mine Arsenic Trioxide Technical Workshop Final Summary Report**

Dear Mr. Thompson;

On behalf of Dillon Consulting Limited and Terriplan Consultants Limited I am pleased to submit three (3) copies of the Giant Mine Arsenic Trioxide Technical Workshop Final Summary Report.

We have enjoyed working with you on this endeavour. We look forward to further projects with the Department of Indian Affairs and Northern Development in the future.

We trust this meets with your requirements but should you have any questions please don't hesitate to contact the undersigned.

Yours sincerely,
DILLON CONSULTING LIMITED

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Project Manager

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## *Executive Summary*

Dillon Consulting Limited along with Terriplan Consultants were retained by the Department of Indian Affairs and Northern Development to coordinate and conduct a technical workshop to discuss options for the management of arsenic trioxide bearing dust at Giant Mine in Yellowknife.

### Background

Giant Yellowknife Mines was incorporated in 1937 and after 11 years of exploration and construction, the first gold brick was poured in May of 1948. By 1949, an Edwards type hearth roaster had been brought on line to treat arsenopyrite gold bearing ores. From 1949 to 1951, approximately 7,400 kilograms of arsenic per day were released to the air from this roaster. In an effort to reduce arsenic emissions, the Sherrit Gordon leaching process was investigated in 1950 as an alternative to roasting the refractory ores. In October 1951, upon orders from the Government of Canada, a cold Cottrell Electrostatic Precipitator (ESP) was added to the process stream to remove a portion of the arsenic trioxide[1] from the roaster gases. The arsenic trioxide was placed in a mined out stope for storage.

In 1952, a two stage slurry roaster was installed to replace the hearth roaster. The new roaster allowed the milling rate to increase from an average of around 400 tons per day (tpd) to approximately 700 tpd. Data for arsenic releases to the air were not available for 1952 or 1953, but in 1954, 5,500 kg/day were being released. In 1955, a hot Cottrell ESP was installed in parallel with the cold Cottrell. Arsenic releases in 1956 are estimated at 2,900 kg/day. Also in 1956, Giant investigated the use of pressure leaching to treat the mill concentrate.

A higher capacity two stage fluidized bed slurry roaster was installed in 1958. Subsequently, the milling rate was increased to approximately 1,000 tons per day. A Dracco bag-house was added at the same time to improve the arsenic trioxide bearing dust collection efficiency. Arsenic releases dropped to 52 kg/day in 1959. In subsequent years, arsenic releases ranged between 75 and 880 kg/day.

The last significant physical change to the roasting/dust collection process occurred in 1962 when the cold Cottrell ESP was converted to a hot ESP. Since that time, the arsenic trioxide bearing dust control system has undergone operational modifications to improve collection efficiency, but the overall system today is essentially the same as it was in 1962. To date approximately 265,000 tons of arsenic trioxide bearing dust has been deposited underground.

### Workshop Purpose and Objectives

The *Giant Mine Arsenic Trioxide Technical Workshop* is a key part of a commitment to a broader *Giant Mine Arsenic Trioxide Management Strategy* being led by the federal government. The *Technical Workshop* is a key element in developing the engineering and scientific aspects and considering the public health and environmental safety issues of the broader Management Strategy. Other elements of this Management Strategy will address: public information and communication; future ownership and operations; and, legal liabilities. Taken together, the elements provide the basis for informing the public and addressing the issues related to the management of arsenic trioxide bearing dust.

The workshop helped to develop a common understanding of the arsenic trioxide problem at Giant Mine.

[1] *Arsenic trioxide bearing dust* is the correct technical term, as the dust also contains other elements such as antimony, iron and gold. However, in the interest of brevity, this report will use the term *arsenic trioxide dust* to describe the dust found at Giant.

provided a forum to develop and apply arsenic trioxide management options evaluation criteria and process, and collectively determined a series of action items to identify what needs to be done to more fully develop the most promising and appropriate option(s), including addressing data gaps, tasks, responsibilities, required resources and time lines. Appendix A contains the detailed workshop agenda.

The *Technical Workshop* was structured in three parts and was intended to achieve the following objectives:

*A. Developing A Common Understanding Of The Problem*
*B. Development & Application of an Evaluation Criteria and Process for the Options*
C. *Development Of An Action Plan For Detailed Options Exploration*

**Criteria Development Process**

In order to evaluate the options available at this time, a preliminary matrix was created prior to the workshop to be used as a starting point for the development of the final matrix. This matrix contained evaluation criteria which were based on:

- Current knowledge of technologies
- Output from the previous workshop
- Understanding of current Giant Mine operation
- Knowledge of regulatory process requirements.

The preliminary matrix proposed a two phase evaluation process.

Phase 1 Screening of options - determining if the options meet minimum required performance criteria.
Outcome: Pass/Fail

Phase 2 Comparative evaluation - for all options meeting the minimum performance criteria, a comparison of their ability to meet selected risk, service, impact and cost criteria.
Outcome: Numerical score.

**Matrix Scoring of Options**

There were 7 options for the treatment of arsenic trioxide presented at the workshop. They were:

- Pump and Treat - this is the process that is in use at Giant today. The arsenic dust is left undisturbed and the mine continues to pump and treat ground water from the stopes in perpetuity. A variation of this process presented at the workshop was to freeze the arsenic dust in place.

- Solidification - the arsenic dust is incorporated into another material and solidified, thereby making it unavailable to the environment.

- Autoclave - the arsenic trioxide is combined with haematite, oxygen and water in an autoclave under high pressure and temperature to create ferric arsenate ($FeAsO_4.2H_2O$), a stable compound.

- WAROX - this fuming process upgrades the arsenic trioxide to a 99% pure, marketable form.

- Hot Water Leach - this leaching process upgrades the arsenic trioxide to a 95-99% pure, marketable form.

- Microwave Technologies - this process uses microwave heating to convert arsenic trioxide into a stable glass product.

- Bio Leach - this leaching process is conducted with micro-organisms which produces ferric arsenate ($FeAsO_4.2H_2O$), a stable compound.

In order to evaluate the feasibility of these options, they were scored using the final evaluation matrix agreed upon by the participants. Participants scored each option individually and scores were collected and tabulated.

**Results**

Once the scores were tabulated the options were ranked in a series of weighting scenarios. The three options the participants agreed should be explored further at this time were:

Option 2: Solidification
Option 3: Autoclave
Option 4: WAROX

The other options may be explored at a later date.

**Key Action Items**

One of the objectives of the workshop was to develop an action plan for further exploration of the selected options. Due to time constraints on this group, the action plan was not developed. However, there were some questions put forth which provide some direction for further study. In answering these questions, the options will be explored further. The questions raised by the working groups and discussed were:

- What is an acceptable end product? What are the key questions regarding acceptable end products?
- What needs to be done further assess and arrive at a preferred solution?
- What needs to be done to manage the arsenic in the interim?

A copy of the working group notes including these discussion topics may be found in appendix D.

## 1. Introduction

### 1.1 Purpose of the Summary Report

The overall purpose of this report, titled *Giant Mine Arsenic Trioxide Technical Workshop: Summary Report*, is to provide a concise summary of proceedings from a three day workshop held in Yellowknife, Northwest Territories, on June 22, 23, 24, 1999. More specifically, the objectives of the summary report are to:

- outline the context, factors and circumstances which necessitated the holding of the workshop;
- document the approach, methods and results of the workshop; and
- provide the framework and action items to identify what needs to be done to more fully develop the most promising and appropriate options identified through the evaluation process during the workshop.

### 1.2 Structure and Organization of the Summary Report

Section 2 provides an overview of the workshop background, purpose and objectives.

Section 3 summarizes the development of a common understanding of "problem", including: an overview of arsenic trioxide management at Giant Mine and the chronology of events related to the work completed to date on arsenic trioxide management practices and options; the Giant Mine Arsenic Trioxide Management Strategy being led by the federal government; and, the development of the project description.

Section 4 presents the approach, principles and development of options evaluation criteria and process at the workshop. The results of the application of the evaluation matrix are included. This section also presents an outline of the options.

Section 5 presents the *Action Plan* developed at the workshop. The *Action Plan* provides a framework and identifies what needs to be done to more fully develop the most promising and appropriate options identified through the evaluation process during the workshop.

The "working" components of the workshop are included in a series of appendices. Appendix A includes the detailed workshop agenda. Appendix B lists the names and organizations of registered workshop participants and observers. Appendix C contains the presentations notes which were distributed to participants by presenters. Appendix D contains the verbatim flipchart notes from the two working groups respecting Agenda Item 6 - Evaluation Criteria and Agenda Item 12 - Action Plan Development. The details respecting the development of the evaluation matrix, definitions, rationale and scaling factors, and the evaluation scoring results are contained in Appendix E and F respectively. Selected bibliographies and technical references are listed in Appendix G.

## 2. Workshop Purposes and Objectives.

### 2.1 Background

The original Giant group of 21 claims were staked in July 1935 by C.J. Baker and H.M. Muir for Burwash Yellowknife Mines Ltd. Giant Yellowknife Mines was incorporated in August 1937 to develop the property. Frobisher Explorations took over management control in 1943 and between 1945 and 1947 three shafts were developed and the mine infrastructure were constructed. The first gold brick was poured at Giant in May of 1948.

By 1949, an Edwards type hearth roaster had been brought on line to treat arsenopyrite gold bearing ores. From 1949 to 1951, approximately 7,400 kilograms of arsenic per day were released to the air from this roaster. In an effort to reduce arsenic emissions, the Sherrit Gordon leaching process was investigated in 1950 as an alternative to roasting the refractory ores. In October 1951, upon orders from the Government of Canada, a cold Cottrell Electrostatic Precipitator (ESP) was added to the process stream to remove a portion of the arsenic trioxide from the roaster gases. The arsenic trioxide dust was placed in a mined out stope for storage.

In 1952, a two stage slurry roaster was installed to replace the hearth roaster. The new roaster allowed the milling rate to increase from an average of around 400 tons per day (tpd) to approximately 700 tpd. Data for arsenic releases to the air were not available for 1952 or 1953, but in 1954, 5,500 kg/day were being released. In 1955, a hot Cottrell ESP was installed in parallel with the cold Cottrell. Arsenic releases in 1956 are estimated at 2,900 kg/day. Also in 1956, Giant investigated the use of pressure leaching to treat the mill concentrate.

A higher capacity two stage fluidized bed slurry roaster was installed in 1958. Subsequently, the milling rate was increased to approximately 1,000 tons per day. A Dracco bag-house was added at the same time to improve the arsenic trioxide collection efficiency. Arsenic releases dropped to 52 kg/day in 1959. In subsequent years, arsenic releases ranged between 75 and 880 kg/day.

The last significant physical change to the roasting/dust collection process occurred in 1962 when the cold Cottrell ESP was converted to a hot ESP. Since that time, the dust control system has undergone operational modifications to improve collection efficiency, but the overall system today is essentially the same as it was in 1962.

Until 1977, there was very little market for arsenic trioxide, and the dust produced at roasting operations was generally stored in sealed stopes. Improving market conditions in the late 1970's provided an incentive for arsenic producing mines to market their by-product. In 1979, Giant began researching methods for producing a marketable grade of arsenic trioxide, and in 1980 signed a contract with Koppers Corp. of Pittsburgh, Pa. for sale of crude arsenic trioxide from the mine. Construction was begun on a transfer facility to accommodate Koppers transport vehicles. The completion date was early 1981.

Shipping of crude arsenic trioxide commenced in February of 1981. A total of 1,205 tons were shipped that year, and test work was begun to determine the feasibility of increasing production by accessing the arsenic trioxide stored in the underground stopes.

A total of 6,700 tons of arsenic trioxide were successfully sold from 1981 to 1986. At this time, Koppers stopped purchasing crude arsenic trioxide due to the falling prices of commercial grade arsenic trioxide and the high cost of disposing of their treatment residue. Giant began researching methods for producing commercial quality arsenic trioxide.

A fuming process, commonly called WAROX, was chosen as the purification method. The name WAROX is derived from the product of the process, White Arsenic Oxide. It was expected that the process would use a 50:50 combination of production dust and dust taken from the underground storage chambers. A production decision was expected in late 1990, and a 7,000 ton per year plant was to begin operation in 1991.

In November 1990, the Giant mine was purchased by Royal Oak Mines Inc. The WAROX program was discontinued shortly thereafter.

The Con mine roasted refractory ores in Yellowknife. In August 1949, a wet scrubber was added to the process to remove arsenic from the roaster gases. The resulting slurry was pumped to storage basins where it settled to produce an arsenic trioxide sludge. In 1970, Con began mining non-refractory ores and the roaster was shut down. Concern regarding the potential environmental health hazard associated with the arsenic storage basins prompted the NWT Water Board to attach a condition to the 1977 water licence requiring that the mine develop a plan to reclaim all arsenic trioxide storage areas on the property. In 1983, a hot water leach program was begun with the dual objective of purifying the arsenic trioxide sludge into a saleable product and recovering the entrained gold and silver values. Process difficulties were encountered, and ultimately treatment of the sludge was begun in an autoclave constructed in 1991.

The Campbell Mine in the Red Lake district of Ontario has a similar history. Refractory ores were roasted from 1951 until 1973, during which period, approximately 3.1 tpd of arsenic trioxide was released to the air. In 1973, vegetation studies found that leaf damage attributable to arsenic trioxide was found on most aspen trees within approximately 6.5 km of the release point. An ESP and baghouse were installed in late 1973 and the collected arsenic trioxide dust was directed to former production stopes for storage. This procedure continued until 1991 at which point the roaster was replaced with an autoclave. From 1981 to 1987, the crude arsenic trioxide was sold as feedstock to other industries. The company currently has between 40,000 and 50,000 tons of arsenic containing dust stored underground.

In October,1997 the Giant Mine Arsenic Trioxide Management Technical meeting was held in Yellowknife. The meeting objective was to provide a venue for government agencies to develop a sound technical understanding of the situation at the Giant mine. As a first step towards developing a management plan for the arsenic trioxide, research was initiated by both Royal Oak Mines and DIAND to fill in the technical data gaps identified during discussions at the meeting.

In April 1999, Royal Oak was placed into receivership.

The mine site at Giant has been operating for over 50 years. During this period, steps were taken to control the arsenic according to the technology and understanding of the day. If construction of a treatment plant using the current level of technology were begun immediately, it would still be several years before it could begin operating. Due to the large volume of material to be processed, it may be another 10 or 20 years before the arsenic trioxide can be completely treated.

*Summary of Giant Mine Trioxide Management Technical Meeting - October, 1997*

A technical meeting was held October 28-30, 1997 which included participants from federal, territorial and municipal governments, along with representatives from the mining industry, health, various universities and the private sector. The focus of the technical meeting was to, first, develop a common understanding of the history of the mine, the gold processing, the by-product (arsenic trioxide) and current storage procedures. Secondly, technical experts in the fields associated with various aspects of arsenic trioxide provided an information base from which discussions and management options could be determined. The following is a summary of the key issues touched upon during the October 1997 workshop. The full proceedings and background materials are listed in Appendix G - Selected References.

*A. Extraction*

Giant Mine's current gold extraction method produces approximately 10-13 tons per day of arsenic trioxide containing dust from it's roasting process. This dust contains an average of 78% arsenic trioxide by mass and an average of 0.5 ounces of gold per ton. The product is pneumatically conveyed underground to a depth ranging from 75 to 250 feet below surface where it is stored in rock vaults. Five of the underground containment locations are former production stopes and are irregular in shape. All other storage vaults were constructed specifically for the purpose of storing the arsenic trioxide and have a more regular rectangular shape.

*B. Underground Storage*

The arsenic trioxide is currently stored in 15 underground storage vaults or chambers. Design of these chambers was to consider the following criteria: the chambers were to be developed in permafrost; chamber accesses or openings were to be bulk-headed in accordance with the Mine Safety Act; the storage areas were excavated in competent rock; the area was to be dry before arsenic trioxide storage proceeded.

If underground storage of the arsenic trioxide is considered an option, several operational refinements could be considered:

- move the arsenic trioxide to a deeper level
- treat in-situ
- provide a new underground area for storage
- consider developing preferential pathways for groundwater and relocate Baker Creek. This will require geotechnical, hydrologic and hydrogeologic studies.

*C. Transport and Handling of Arsenic Trioxide*

Should the decision be made to treat the arsenic trioxide, either for purification and further gold extraction or as a stabilization process, removal from the underground storage chambers to surface, surface transportation and temporary surface storage will be required. The challenges to be overcome in removing and transporting the dust to the surface include: confining the dust to prevent contamination during movement; minimizing worker exposure; applying removal techniques to variable stope geometries and material characteristics; and cleaning/securing the storage chambers for abandonment. Technologies under consideration include: vacuuming, slurry pumping, remote "clam" mining and drawpoint mucking. Surface transportation could be via truck or using an upgraded pneumatic system similar to what is currently being used. Surface storage could be carried out in a number of ways. The material could be stored in drums or bags, in existing decommissioned TRP storage tanks (80% usable capacity), or in a facility constructed specifically for the purpose.

*D. Material Processing/Upgrading for an Economic End Use*

Before arsenic trioxide can be successfully sold on the open market, it must be processed to a minimum of 97% and preferably to 99+% purity with contaminant concentrations in the range of:

- 0.05 - 0.30% Sb,
- 0.025 - 0.03%Fe
- 0.001 - 0.1% Cu.

There are several methods available to achieve these levels.

- The arsenic trioxide can be evaporated at a temperature of around 193 °C while impurities remain as solids until temperatures in excess of 1000 °C are reached. The purified arsenic can then be condensed out in brick cooling chambers, air-cooled condensers or a cold air quench.
- The arsenic trioxide can be dissolved using a solvent which solubilizes the arsenic at a higher level than the impurities. The arsenic trioxide is then crystallized out in a purified form. Hot water, ammonia and methanol have all shown promise for use as solvents in this process.
- In the late 1980's work on a variation of the evaporation method was begun at Giant Mine (WAROX filter). A sintered metal filter was used to remove impurities from the arsenic trioxide vapour exiting the baghouse. Difficulties were encountered meeting antimony and iron specifications, and the process was never fully developed.

All of these processes leave behind a residue which will probably contain some arsenic as well as the other contaminants, and consideration must be made for disposal of this material.

*E. Arsenic Trioxide Stabilization*

Due to the relative uncertainty of the world arsenic trioxide market and the presence of arsenic in waste streams from any purification process there may be a need to develop a process to stabilize arsenic trioxide for long term storage. Arsenic trioxide can be converted to less soluble arsenic compounds such as ferric arsenate or arsenic sulfide using an autoclave, a microwave reactor or, if the volumes were small enough, biological processes. Arsenic sulfide is considered stable on an indefinite basis if it can be kept under anaerobic conditions as it oxidizes and solubilizes in the presence of oxygen. Ferric arsenate, however, does not require specific storage conditions.

Arsenic trioxide can also be encapsulated in a cement medium to increase its stability. The use of Portland cement alone, however, does not allow for a very high loading rate (1% arsenic trioxide). On the other hand, when used in combination with additives such as zeolite capacity is considerably increased potentially providing a viable storage alternative. In order to encapsulate the amount of arsenic stored at Giant, however, an excessive amount of cement would be required.

### 2.2 Workshop Purpose

The *Giant Mine Arsenic Trioxide Technical Workshop* is a key part of a commitment to a broader *Giant Mine Arsenic Trioxide Management Strategy* being led by the federal government. The *Technical Workshop* is a key element in developing the engineering and scientific aspects and considering the public health and environmental safety issues of the broader Management Strategy. Other elements of this Management Strategy will address: public information and communication; future ownership and operations; and, legal liabilities. Taken together, the elements provide the basis for informing the public and addressing the issues related to the management of arsenic trioxide.

The workshop helped to develop a common understanding of the arsenic trioxide problem at Giant Mine, provided a forum to develop and apply arsenic trioxide management options evaluation criteria and process, and collectively determined an Action Plan to identify what needs to be done to more fully develop the most promising and appropriate option(s), including addressing data gaps, tasks, responsibilities, required resources and time lines. Appendix A contains the detailed workshop agenda.

### 2.3 Workshop Objectives

The *Technical Workshop* was structured in three parts and was intended to achieve the following specific objectives:

***Part One: Developing A Common Understanding Of The Problem***

1. Provide an historical overview of arsenic trioxide management at Giant Mine and the chronology of events related to the work completed to date on arsenic trioxide management practices and options at Giant Mine, including a summary of the legislative and regulatory regime, operational, geophysical, engineering & environmental parameters and the associated issues and challenges;

2. Outline the commitment to and elements of a broader Giant Mine Arsenic Trioxide Management Strategy being led by the federal government;

3. Confirm the proposed objectives of the Giant Mine Arsenic Trioxide Management Project Description.

This will include an outline of the planning, and anticipated environmental impact assessment and decision making processes;

***Part Two: Development & Application Of Options Evaluation Criteria and Process***

4. Present a detailed overview of the range of available engineering and scientific options explored to date, including existing issues, data gaps, and work (ie. research and technology development; marketing and feasibility studies) in progress related to the various options;

5. Present and discuss a comparative evaluation matrix to assess and rank the various options using engineering, scientific, public health, environmental safety, economic, and social criteria that need to be considered;

6. Amend (as necessary) the comparative evaluation matrix to achieve agreement on suitable and appropriate criteria for the evaluation of arsenic trioxide management options;

7. Based on objective application of the evaluation criteria determine which arsenic trioxide management option(s) are the most promising and appropriate;

***Part Three: Development Of An Action Plan For Detailed Options Analysis***

8. Identify and discuss what needs to be done to more fully develop the selected option(s), including the development of a detailed Action Plan identifying tasks, responsibilities, required resources and time lines; and,

9. Present the findings and results of the workshop to the public and interested organizations.

## 3. Developing a Common Understanding of the Problem

Developing a common understanding of the problem entailed addressing three areas:

- An historical overview of arsenic trioxide management at Giant Mine and the chronology of events related to the work completed to date on arsenic trioxide management practices and options at Giant Mine, including a summary of the legislative and regulatory regime, operational, geophysical, engineering & environmental parameters and the associated issues and challenges;
- Outlining the commitment to and elements of a broader Giant Mine Arsenic Trioxide Management Strategy being led by the federal government; and,
- Confirming the proposed objectives of the Giant Mine Arsenic Trioxide Management Project Description, including an outline of the planning, and anticipated environmental impact assessment and decision making processes.

### 3.1 Overview of Arsenic Trioxide Management at Giant Mine and the Chronology of Events.

Three presentations were made with respect to arsenic management at Giant Mine and the chronology of events related to the work completed to date on arsenic trioxide management practices and options. Selected highlights from each of the three presentations are provided below. Appendix C contains the complete presentation materials.

***Dr. Rick Allan - Giant Mine: History and Status of Arsenic Trioxide Management***

- Since the first production of arsenic trioxide bearing dust, resulting from the refining of refractory ores, Giant Mine has constantly re-evaluated and updated it's arsenic trioxide disposal practices.

- With the implementation of underground arsenic trioxide storage in the 1950's, the giant Mine was recognized as providing an environmentally sound disposal concept. This plan included placing the material underground, in specially designed storage chambers, as a final disposal procedure. The arsenic trioxide storage areas would be isolated by bulkheads and permanently frozen to minimize the potential for the material to leach into the groundwater.

- With a better understanding of arsenic chemistry, mine conditions, and emerging technologies it is apparent that the continued practice of underground storage is not a completely risk free disposal method.

***Neill Thompson - Chronology of Events Related to Work Completed on Arsenic Trioxide Management Practices.***

- Since 1997 the Department has been quite actively collaborating on a number of projects to assess the options for managing the arsenic trioxide stored underground at the Giant Mine. The main areas of focus are: current underground conditions, extraction methods, upgrading/re-processing the material to a commercial product and converting it into an environmentally stable material. Work has been conducted by the Department and in conjunction with other government agencies, consultants, the company itself, academics and mining and industry experts. To date the Department has spent approximately $750, 000 on 18 projects. A summary of these projects is available in appendix C, Neill Thompson's speaking notes.

Creek valley, and near the A2 open pit in particular. Consequently, mitigation by removal and treatment should necessarily include remedial measures to address the groundwater contamination issue, including the ongoing preliminary modeling (Phase 1), planned field activities (Phase 2), and final model simulations (Phase 3).

### 3.2 The Giant Mine Arsenic Trioxide Management Strategy

Dave Nutter, Senior Executive Advisor - Royal Oak, of DIAND made a presentation on the *Giant Mine Arsenic Management Strategy* being led by the federal government. The key elements of the presentation are summarized below.

- There is a significant amount of highly toxic arsenic trioxide dust stored undergound at the Giant Mine in Yellowknife. DIAND's number one priority is safeguarding public health and safety, and securing the environment, ensuring that this arsenic trioxide does not adversely impact on the lives of residents in the Yellowknife region.

- The Giant Mine is still in the hands of the private sector, and it is their responsibility to ensure that all laws are complied with. However, should the property be abandoned, DIAND, with other federal and territorial agencies, will ensure that all necessary steps are taken to keep the arsenic trioxide safely contained at the mine site until the best means of dealing with it over the long term is identified, assessed, approved and implemented.

- DIAND's current role in the process leading to the implementation of a long term arsenic trioxide management solution is that of a regulator. Strictly speaking, the development of this management solution is the private sector's responsibility. However, we all are well aware of the financial situation facing Royal Oak Mines Inc., the owner of the Giant Mine. DIAND believes that the public should not have to wait for this financial situation to be resolved before the arsenic trioxide issue is addressed; rather, actions must be taken now to come up with the long term plan for dealing with the arsenic trioxide. For this reason, DIAND has taken the lead in identifying the problems associated with the arsenic trioxide and finding the best long term solution. This week's technical workshop should make significant progress towards identifying that solution.

- At present, the safest location to store the arsenic trioxide is underground at Giant. It is securely contained there in vaults, and any seepage of contaminated groundwater is collected in the mine sumps and returned to surface for treatment.

- It is important to choose the right solution, not just pick what seems obvious off the shelf. There are a variety of proven technologies or processes which have dealt and are dealing with arsenic trioxide elsewhere in the world, including at the Con Mine in Yellowknife. However, each situation is unique, and Giant certainly is. The sheer volume of arsenic trioxide and its location underground at Giant place this management problem in a very challenging category of its own. Given its location on the outskirts of a major community and its proximity to a large water body which serves much of the NWT, there is a high degree of public interest and, understandably, public concern.

- We must ensure that the solution is the right one for the long term, primarily from the perspective of safeguarding the public's health and the environment. Also, because significant public expenditures may be required to deal with the problem, we must ensure a wise and effective use of public funds.

- Finally, it is very important that the process of selecting and implementing the long term arsenic trioxide management solution is a public one, so that the public accepts and supports this solution. An open and thorough environmental impact assessment can and will meet the need for public transparency and support.

- There has been a significant amount of work undertaken to date by DIAND and Royal Oak, in our attempts to fully understand the problems surrounding the underground storage of arsenic trioxide at Giant. Over the past 18 months, DIAND has invested close to one million dollars in gathering information which has put us much closer to finding the best long term management solution. Over the next three days, we will learn about and discuss the merits of and challenges inherent in a number of arsenic trioxide management options.

- DIAND has developed a strategic framework and estimated time line for the actual implementation of the arsenic trioxide management option which is ultimately chosen. The strategic framework consists of 6 components: Define the Problem; Develop Options for Solutions (to the problem); Complete the Project Description; Complete the Environmental Assessment; Complete the Regulatory Approvals, and Implementation. Each component is characterized by three facets: Technical; Policy and Communications, and DIAND has identified tasks which must be addressed within each of these facets.

- For example, as part of developing options for long term arsenic trioxide management, the technical facet includes the identification of all feasible options and their assessment against a standard set of evaluation criteria. We will develop these evaluation criteria at this week's workshop, and, through their application, be able to focus our attention on a short list of the most promising management options. This evaluation will also identify the knowledge gaps and show us where more research is required to confirm the most appropriate management solution.

- DIAND estimates that at least 4 years will be required before we will see full implementation of a long term arsenic trioxide management solution, and this is contingent upon the selection of this preferred option within the next 18 months. The following 2-3 years would be required to prepare a complete project description, submit this project proposal to rigorous environmental impact assessment and public review, and obtain the necessary regulatory approvals. Because this is a significant environmental issue within the community, DIAND is committed to a thorough public review of the proposed arsenic trioxide management option before we will authorize its implementation.

- This workshop is a cornerstone of DIAND's commitment to developing a broad arsenic trioxide management strategy.

**3.3 Development of the Giant Mine Arsenic Trioxide Project Description.**

David Livingstone, Director of Renewable Resources and Environment Division, DIAND, outlined the objectives of the Giant Mine Arsenic Project Description, including the associated planning, and anticipated environmental review and decision making processes. The key elements of the presentation are summarized below.

**Project Description Objective:** Find and implement a safe, permanent solution to the arsenic trioxide problem at Giant Mine.

**Performance Standards**
The performance standards set out for this project include:

- proven technology
- acceptable risk (safety)
- minimum maintenance upon closure (permanency)
- cost-effective

**Environmental Impact Assessment**
The environmental review process is likely to include a number of key issues, including:

- what's the setting?
- what are the objectives of the project?
- what are the options available to achieve the objectives?
- what are the preferred options and why?
- what is the preferred solution and why?

**Current Water Licence Requirements**
The water licence requirements set out the framework within which the project is to be developed. These requirements include:

- detailed description of proposed disposal methods
- rationale for the preferred method
- risk assessment for the preferred method
- detailed description of contingencies
- implementation of schedule and costs
- detailed description of management of residual and waste materials
- detailed monitoring plan

**The Steps Involved**
The anticipated process to develop, review and implement the project includes a number of steps.

- clear understanding of the current situation
- clear understanding of options for treatment
- ranking of these options, based on performance standards
- development of preferred option(s)
- development of preferred solution
- development of detailed project description, based on preferred solution
- development environmental assessment report
- preliminary screening
- referral to Mackenzie Valley Environmental Impact Review Board

- public review
- regulatory review
- implementation

## 3.4 Comments from the Honourable Ethyl Blondin-Andrew - Secretary of State, Children and Youth/Closing Comments from Dave Nutter.

**Ethel Blondin-Andrew's Comments**

I'd like to begin by thanking all of you who have come to this technical workshop in Yellowknife. I know there's probably concern about why the discussion is very narrow; it's intended to be narrow, it's supposed to be that way. We're looking for some options and we're looking at specifics, and I think that should be understood and appreciated. I also want to say that the statement I'm making is on behalf of the Government of Canada from the Minister of Indian Affairs and Northern Development, Jane Stewart. This particular issue is not one onto itself. It has far reaching implications for other contaminated sites across Canada, and it has implications for so many other things. I think you should know that this is my riding and it's a particular concern to myself; that it's a reflection of the concern that's out there by the other Northern residents. The work being done here is an important step to our developing an overall arsenic trioxide management strategy for Giant Mine. I'm pleased that the workshop is exploring management and disposal options and that it has been assessing how to proceed with further research into the challenge at hand. This is from Minister Stewart actually. I wish to reassure you that the priority of the Government of Canada is to ensure the health and safety of Northerners. The Department of Indian Affairs and Northern Development continues to monitor the arsenic trioxide at Giant Mine to ensure it remains stored safely. The department has also taken steps to our developing a long-term arsenic management plan. It is supporting research into arsenic trioxide disposal methods and it will continue to work with stakeholders until a permanent solution is found. That solution, when we find it, must be the safest possible for Giant Mine. It cannot simply be the cheapest, nor can it be the fastest, it must be the safest, and it must withstand the test of an environmental assessment. There can be no other choice in the matter of Giant Mine. The Government of Canada places the health and safety of Northerners ahead of all other concerns. I support what's happening here as a very good step in the right direction.

**Dave Nutter's Closing Comments**

Thanks to all of you. It's been quite fascinating and I think very productive, educational, great 3 days. Alot of work for everyone on the table, Ethel Blondin-Andrew was here yesterday, one of the comments that she stressed to me over and over again was that she personally is extremely interested in this. She's trying to be as knowledgeable as possible about this and be supportive. And she did ask that at the end of the day today I pass on her congratulations and her personal support for this, and her congratulations to all of you for what's been happening these three days. Our minister Jane Stewart is also following this very closely, and certainly is regularly asking questions about Giant, Royal Oak, and the arsenic. She's very interested in how this goes and very concerned that we find the right answers and right solutions and proceed as quickly as possible to implement them.

The responsibility for dealing with this arsenic currently rests in the private sector. Royal Oak is at receivership and there is an attempt to find another company to take over the property. If a new company does arrive on the scene and take over Giant Mine wholly, then that company will assume all of the responsibilities that are currently that of Royal Oak's, including those responsibilities and obligations that fit within the current Water Licence. That Water Licence would be signed over to the new company, and along with it, all obligations including coming up with a plan to deal with the arsenic and to move ahead with dealing with this arsenic situation. That solution, before it was implemented, would go through full environmental impact assessment and licensing procedures. If, on the other hand the property still continues to operate under new management, but as part of the deal of that new management coming in to take over the property, government agrees to assume a share of the responsibility for arsenic, and I won't say what level that share would be because that would have to be worked out, then we would be moving forward building on what has happened today. One of the requirements of that company would be that full access to the arsenic underground would be maintained And in the third scenario, if the property is closed and abandoned and becomes an orphan site, ultimately, government will have to take on the responsibility, the full responsibility of dealing with this and again, we will move forward to do so.

Where do we go from here? We have an extraordinary amount of information, knowledge, good knowledge from all of you and that shared over the last three days. In an extensive report, we have to really capture everything that's been shared the last three days. Each of the options that have been discussed has merits, each of the options have failings. We've identified a lot of knowledge gaps, certainly major questions will be applied to each of the options. We have to address those knowledge gaps. A number of studies have been identified that should be carried through with. The objective here is to find a solution. It's going to be a package of processes applied to the issue we have here, the problem we have at Giant in dealing with the arsenic. We've got a major job of sharing what we've learned, nothing's been pushed off the table. Every one of you have a lot to contribute to us coming up with the ultimate solution for Giant. D.I.A.N.D will be working in partnership with other federal and territorial agencies, and with the community. Everybody in this community has to be involved in coming up with that ultimate solution, and hopefully supporting what is ultimately determined needs to be done.

We have to find the resources to do all of this. This three days could have gone in a lot of ways and it could have ended up being far less successful than I think it has been. And I think it's congratulations and a tribute to everybody here in the room that it's been as successful, and that it has been and we've remained really focused to the task at hand. We will be convening some public meetings in the community to both share the results of this meeting but also to address many of the broader issues of Royal Oak and Giant.
In summary, thanks very much. I think it's been a great three days, time well-spent certainly from D.I.A.N.D.'s perspective, money well-spent, and I appreciate all of you.

## 4. Options Evaluation Process

**Purpose:** To identify, assess, evaluate and *select a group of options* which offer the greatest potential to best manage the Giant Mine's Arsenic Trioxide.

**Definition:** An evaluation process is a formal procedure for establishing an order of preference among options. It should provide a traceable, replicable and accountable means of arriving at decisions.

### 4.1 Principles and Approach

**Principles to Guide the Evaluation Process:**

An evaluation process should be:

- Traceable - the ability to follow, in a logical and systematic (i.e. consistent) manner, the path chosen by the evaluator in arriving at a preferred option(s) - the process is easy to follow and easy to understand.
- Replicable - another person using the same information and methods could be expected to arrive at the same or similar conclusions.
- Transparent - all assumptions, definitions, limitations and judgements are clearly stated and available.

**The Approach to the Evaluation Process:**

The approach that was developed and completed is consistent with the generally applied framework for valuation of options. The evaluation process had five steps:

| Step | Objective |
|---|---|
| 1. The Problem | Clearly define the problem that needs to be addressed. |
| 2. The Options | Identify and describe the different ways (the options) that the problem can be solved. |
| 3. The Criteria | Identify and describe items of importance or concern that assess the "ability" of the option to solve the problem (the criteria). |
| 4. The Assessment | Collect data and assess the performance of each option with respect to the criteria. |
| 5. The Evaluation | Evaluate the performance of each option against the criteria and produce an order or grouping of preference for the options. |

### 4.2 Criteria Development

In order to evaluate the options available at this time, a preliminary matrix was created prior to the workshop to be used as a starting point for the development of the final matrix. This matrix contained evaluation criteria which were based on:

- Current knowledge of technologies
- Output from the previous workshop
- Understanding of current Giant Mine operation
- Knowledge of regulatory process requirements.

The preliminary matrix proposed a two phase evaluation process.

Phase 1 Screening of options - determining if the options meet minimum required performance criteria.
Outcome: Pass/Fail

Phase 2 Comparative evaluation - for all options meeting the minimum performance criteria, a comparison of their ability to meet selected risk, service, impact and cost criteria.

Outcome: Numerical score.

The preliminary matrix as it appeared before the workshop follows.

**Giant Mine Arsenic Trioxide Technical Workshop**
**Preliminary Evaluation Criteria and Matrix**

| Minimum Performance Criteria | Pass / Fail | Comparative Criteria | Option # |
|---|---|---|---|
| **Process Understanding:**<br>➡ Is the process a proven technology?<br>➡ Does the process provide a permanent solution to arsenic management?<br>➡ Can implementation of the process be completed within 50 years?<br>➡ Can the process be operated in the Yellowknife environmental conditions? | | **Risk**<br>➡Has this process been used at a commercial scale for $As_2O_3$ before?<br>➡Has it been used in similar environmental conditions?<br>➡What level of confidence is there based on the data/information regarding design?<br>➡What is the level of safety for workers during normal and upset conditions? | |
| **Public Health and Safety**:<br>➡ The routine operation of the process poses no known risk to public health.<br>➡ Has the end product been proven to be stable? | | **Service:**<br>➡What reagents are required, what is the source of these reagents?<br>➡Design flexibility: does it fit in current mill process and equipment already available?<br>➡What is the level of flexibility of the process to changes in feedstock quantity and quality?<br>➡Can this process replace the roaster?<br>➡What is the level of recovery of arsenic and gold?<br>➡How expediently would this process eliminate the $As_2O_3$ over the next 20 years? | |
| | | **Impact:**<br>➡Is the displacement/disruption of natural features minimal ?<br>➡Are the land/space requirements minimal?<br>➡Is the volume of the stored end product material minimal?<br>➡What number of jobs would be created by this option? (Annually, in total) | |
| | | **Cost:**<br>What are:<br>➡Capital costs?<br>➡O & M costs?<br>➡Closure costs?<br>➡Is there revenue recovery? | |

The participants of the workshop were divided into two working groups with the purpose of revising the preliminary matrix as they saw necessary. Please see Appendix D for flipchart notes from working group sessions. The revisions are as follows (changes appear in bold print):

**Giant Mine Arsenic Trioxide Technical Workshop**
**Final Evaluation Criteria and Matrix**

| Minimum Performance Criteria | Pass / Fail | Comparative Criteria | Option #: |
|---|---|---|---|
| Process Understanding:<br>➡ Is the process a proven technology for **Arsenic?**<br>➡ Does the process provide a **complete** solution to arsenic management?<br>➡ **Can the process be initiated in 7 years and substantially completed in 25 years**<br>➡ Can the process be operated in the Yellowknife environmental conditions **if it is to operate in Yellowknife?** | | Risk -<br>➡Has this process been used at a commercial scale for **Arsenic or other comparable hazardous material** before?<br>➡Has it been used in similar environmental conditions?<br>➡What level of confidence is there based on the existing data/information regarding design?<br>➡What is the level of **health** and safety risk for workers during normal and upset conditions?<br>➡ **What is the level of risk to the environment during normal and upset conditions and with respect to end products?**<br>➡**Can the option be implemented without the requirement for special worker training, procedures and equipment?** | Y N<br>Y N<br>H M L<br>L M H<br>L M H<br>Y N |
| | | Service:<br>➡**What are system requirements, availabilities and costs of these requirements?**<br>➡What is the level of flexibility of the process to changes in feedstock quantity and physical and chemical properties?<br>➡**Can this process eliminate or use current arsenic dust production as well as treating current stockpiled arsenic?**<br>➡How expediently and efficiently would this process treat the As over the next 20 years?<br>➡Can this process eliminate roaster **emissions?**<br>➡**Is post implementation monitoring required for less than 5 years?** | L M H<br>H M L<br>Y N<br>H M L<br>Y N<br>Y N |
| Public Health and Safety:<br>➡**Does this process meet the current occupational and public safety standards and pose no known and unmitigable risk to public health and worker safety?** | | Impact:<br>➡**Can the option be implemented without:**<br>**- Air emissions?**<br>**- Flora and fauna?**<br>**- Aesthetics?**<br>**- Surface/ground water?**<br>**- Socio-cultural?**<br>**- Heritage resources?**<br>➡**Is the end product sold or segregated for possible sale in future?** | Y N<br>Y N<br>Y N<br>Y N<br>Y N<br>Y N<br>Y N |
| | | Cost:<br>What are:<br>➡Capital costs?<br>➡O & M costs?<br>➡Closure costs?<br>➡Is there revenue recovery?<br>➡**What number of jobs would be created by this option?**<br>➡**Does the option allow for on-going or future mining at Giant?** | L M H<br>L M H<br>L M H<br>Y N<br>H M L<br>Y N |
| ***Matrix Criteria Legend***<br><br>**Left = Good**<br>**Right = Poor**<br><br>**Yes = Good**<br>**No = Poor** | | | |

This final matrix was then used by the participants to score each option as it was presented.

**4.3 Options** (See Appendix C for presentation notes)

### *4.3.1. Pump and Treat*

The process in operation at the mine today is Pump and Treat. The arsenic trioxide dust remains in storage underground and the chambers are prevented from flooding by pumping and treating any seepage. Currently the pumped sludge is disposed of in the tailings pond. During the discharge season the water from the tailings pond is pumped to a water treatment plant for removal of arsenic and other contaminants. Without another management strategy, pump and treat would be required for an essentially perpetual period.

A second leave-in-place process proposed at the workshop was to freeze the arsenic trioxide dust where it is. Again the dust would remain in storage underground where it would be contained and isolated by the establishment of a frozen barrier around the chambers. This freezing would be accomplished using thermoprobes which would remove heat from the ground in the winter and release it to the air.

### *4.3.2. Solidification/Stabilization*

The process of solidification involves incorporating the arsenic dust into a stable solid form. The most common forms of arsenic that have been used, or suggested for use, for longtime storage of arsenic trioxide are as follows. Metallic arsenic, arsenic trisulfide, calcium arsenate, ferric arsenate, and the mixture sometimes called "ferric arsenate" that results from the co-precipitation of arsenate with ferric hydroxide. Vitrification of the dust (incorporation into a glass), or incorporation of the dust into materials such as cement, amorphous ferric arsenate, bitumen and sulfur are other possibilities.

The arsenic trioxide dust is stored either in the form of a dry, free-flowing powder or as a slightly damp and compacted solid. The options are to handle it as such, or as a solution/suspension in water.

**Options for treating aqueous solutions of the mine dust.**

- Reduction to arsenic metal; precipitation as calcium arsenate; precipitation as arsenic sulfide ; precipitation with ferric hydroxide
- The solution/suspension could be mixed into cement with or without prior oxidation.

**Options for direct treatment of the mine dust**

- Conversion to metallic arsenic; conversion to arsenic trisulfide; conversion to ferric arsenate
- Incorporation of the dust into glass
- Incorporation of the dust into cement, bitumen or sulfur.

### *4.3.3. Autoclave*

The Autoclave is a process by which arsenic trioxide is combined with hematite ($Fe_2O_3$), oxygen and water in an autoclave under high pressure and temperature to create ferric arsenate ($FeAsO_4.2H_2O$), a stable compound. Both chemical theory and test results indicate that ferric arsenate residues can be de-stabilized by long term exposure to strong alkali, therefore disposal of the product of this reaction into a strongly alkaline environment is to be avoided.

### *4.3.4. WAROX/El Indio*

The WAROX Process is a fuming process for upgrading the arsenic trioxide content and recovering residual gold values from crude dust collected by bag-houses used in roasting operations, such as the one at Giant. The name WAROX is derived from the purified product of the process, white arsenic oxide. The process sublimes arsenic present in the feed dust within a fume reactor or sublimator, collects the non-volatile gold-containing component of the sublimator off-gas train by a hot metal filter bag-house and condenses the gaseous arsenic component of the gas train in a cold filter bag-house. The dust collected by the metal filter bag-house is subjected to cyanidation for gold recovery. The condensate from the cold filter bag-house, comprising greater than 99% $As_2O_3$, is marketable as a precursor wood preservative chemical.

A second fuming process known as the El Indio Process was discussed at the workshop. The fundamental difference in the flow sheets for the two processes is the manner in which fine dust in the fume reactor off-gas train is captured. The WAROX process employs novel hot metal filtration technology and the El Indio Process uses a hot electrostatic precipitator (ESP) for equivalent purposes. The characteristics of the crude baghouse dust at Giant, expected to be significantly different in composition and more importantly in particle size distribution than the product generated at El Indio, could favour one dust collection technology over another, from technical and/or economic perspectives.

### *4.3.5. Hot Water Leach*

During the Hot Water Leach process, the arsenic dust found at Giant is purified to a marketable 95-99% $As_2O_3$. A laboratory procedure has been devised and tested that consists of pressure leaching the arsenic dust for 2 hours at 150°C, cooling to approximately 100°C with pressure release, filtration at 95°C, and precipitation of pure $As_2O_3$ by cooling to room temperature. The results indicate that leaching at 125-150°C greatly improves the dissolution of $As_2O_3$ from the arsenic trioxide bearing dusts. The leaching of arsenic attained 93-99% of the total present, depending on the dust sample and the conditions used. Gold did not dissolve, but concentrated in the residues in amounts ranging from 30 to 55 ppm.

A hot water leach process was used at Con in the mid-1980s.

Research is being done to determine the potential for conversion of arsenic dust to scorodite, a stable ferric arsenate product. Further research is also needed to determine the potential for gold recovery.

### *4.3.6. Microwave Technologies*

Electro-Magnetic Radiation (EMR) Technology uses microwave heating to convert arsenic trioxide into a stable glass product. The bag-house dust is mixed with a glassy slag consisting of calcium oxide, silcon oxide and manganese oxide in a ratio of 1:1:2. The resulting slag is fed into an extrusion process unit where it is exposed to high levels of microwave radiation. The solid product is cooled and the result is a stable glass form which can be safely disposed of. Some problems with this process were: 1) The process description is poorly developed; 2) Tests produced poor leachate qualities.

### *4.3.7 Bio Leaching*

Bio Leaching is a technology in which stablization to ferric arsenate is conducted with microorganisms. Biological leaching of a suitable iron source would oxidize the arsenic into solution from the arsenic trioxide dust. The arsenic iron solution is separated from the dust, which would go to conventional cyanide treatment to recover the contained gold. The iron arsenic solution is neutralised in a controlled manner to produce a ferric arsenate solid ($FeAsO_4.2H_2O$), which would meet TCLP requirements. The process requires a significant iron sulphide source to ensure a stable ferric arsenate ($FeAsO_4.2H_2O$) product is formed. The iron oxidation process generates a significant amount of heat that would have to be removed even in the sub-arctic conditions of Yellowknife.

**4.4 Matrix Scoring Results.**

According to the two phase evaluation process agreed to by the participants, those options which did not meet minimum performance criteria were not passed through the second phase of the matrix. It was also agreed to by the participants that any option which was failed by more than 30% of the evaluators was considered to be unacceptable and were not to be considered further at this time. The options which were not supported were:

- Option 1: Pump and Treat - 38% failure rate
- Option 5: Hot Water Leach - 35% failure rate
- Option 7: Bio Leach - 43% failure rate

In order to assign a numerical score to those options which did pass the minimum performance criteria, the following scoring scheme was used.

High = 3
Medium = 2
Low = 1
Yes = 1
No = 0

From this, each cell of the matrix was given a numerical value. 2 sets of averages were calculated.

- Mean Score - the average score given to each cell. For example, for the criteria "What level of confidence is there based on the existing data/information regarding design?" for Option1:

  12 evaluators answered High
  11 evaluators answered Medium
  1 evaluator answered Low
  Total 24 evaluators

  12X3 +
  11X2 +
  1X1 =
  59

  59/24=2.4

  Therefore the average score for that cell was 2.4

- Mode score - the score which was given by the most number of evaluators. In the previous example the mode score was High, or 3 because the majority of the evaluators gave that criteria a High score.

Once these average scores had been calculated for each cell, these scores were run through a series of different weighting scenarios.

- The evaluators were asked to fill into their matrix the weights they felt were appropriate for each of the four categories (risk, service, impact, cost). The average of these weights were:
  - Risk 37
  - Service 25
  - Impact 23
  - Cost 15
  - Total 100

  The resulting ranking of the remaining options from this scenario was:

| Rank | Option |
|---|---|
| 1 | Option 3: Autoclave |
| 2 | Option 2: Solidification |
| 3 | Option 4: WAROX |
| 4 | Option 6: EMR |

- All categories weighted equally (25). The resulting ranking of the remaining options from this scenario was:

| Rank | Option |
|---|---|
| 1 | Option 3: Autoclave |
| 2 | Option 4: WAROX |
| 3 | Option 3: Solidification |
| 4 | Option 6: EMR |

- Cost weighted at 0, all others weighted equally (33.3). The resulting ranking of the remaining options from this scenario was:

| Rank | Option |
|---|---|
| 1 | Option 3: Autoclave |
| 2 | Option 4: WAROX |
| 3 | Option 2: Soldification |
| 4 | Option 6: EMR |

- Risk weighted at 60, all others equal (13.3). The resulting ranking of the remaining options from this scenario was:

| Rank | Option |
|---|---|
| 1 | Option 3: Autoclave |
| 2 | Option 2: Solidification |
| 3 | Option 4: WAROX |
| 4 | Option 6: EMR |

- Service weighted at 40, all others equal (20). The resulting ranking of the remaining options from this scenario was:

| Rank | Option |
|---|---|
| 1 | Option 4: WAROX |
| 2 | Option 3: Autoclave |
| 3 | Option 2: Solidification |
| 4 | Option 6: EMR |

- Unitized Average Weights. The resulting ranking of the remaining options from this scenario was:

| Rank | Option |
|---|---|
| 1 | Option 3: Autoclave |
| 2 | Option 4: WAROX |
| 3 | Option 2: Solidification |
| 4 | Option 6: EMR |

From these different scenarios, we can conclude that, in general, the options rank as follows:

| Rank | Option |
|---|---|
| 1 | Option 3: Autoclave |
| 2/3 | Option 4: WAROX |
| 2/3 | Option 2: Solidification |
| 4 | Option 6: EMR |

## 5. Key Questions - Action Items

It was the task of the working groups in agenda item number 13 to develop an action plan for detailed options analysis by outlining the approaches and key elements to be considered for the advancement of the options. While the working groups did outline many of the questions which need to be answered to further assess the available options for arsenic trioxide management, they were unable to reach a consensus on an action plan or to prioritize the action items due to time constraints. What follows is a summary of the action items as laid out by the working groups. Complete notes from these working sessions can be found in Appendix D.

### Group A

### *QUESTION 1: WHAT IS AN ACCEPTABLE END PRODUCT?*

A) Purified Arsenic
B) Stable form of Arsenic
C) Solidification of Arsenic

**A) Purified Arsenic:**

We need to learn:
1) Product specification
- Arsenic grade
- antimony
- iron
- particle sizing (form)
- crystal form of $As_2O_3$

2) Market Security
- market survey
- buyer for 10K tons/year (issue of supply and demand)
- options for agreement
- advance existing work

3) What is the fall back option (ie. Disposal/storage strategy if product can't be sold?)
4) What are environmental issues associated with the end product and all elements of the process?
5) Who makes the decisions on these issues?

**B) Stable Arsenic** (2 products)
1) Scoradite / Ferric Arsenate
2) Amorphous Ferric Arsenate
C) Need to summarize the existing data on stability under various conditions and identify preferred storage options and cement stabilization.

Product B

Yes — Meets Current Standards — No

Look at process options — REJECT
Look at disposal options

Ponding — Stabilization

**C) Solidification of Arsenic**

Solidify in:
1) Cement (loading capacity)
2) Glass (how to make it without vapourization)
3) Bitumen (hygiene, safety, fire problems)
4) Arsenic metals (oxidizes easily)

**General concerns:**

- need to address data gaps (to confirm / verify viability)
- ratio/volume, loading - cement, glass and bitumen
- environmental standards, testing protocol
- relevance of TCLP vs own procedure
- identify other residual contaminents
- solidification is not to be confused with encapsulation (which is unacceptable)

- If these 4 options address the above general concerns adequately, the next step is what are storage options for product and disposal options for residuals ( to be done based on toxic waste criteria). The next step is to decide go or no go.
- If any option does not address the above concerns it is rejected.

## *QUESTION 2: WHAT IS TO BE DONE TO FURTHER ASSESS /ADVANCE OPTIONS 2, 3 &4?*

**Option 2: Solidification**

Bitumen must be looked at:

- does it dissolve or encapsulate the $As_2O_3$
- polysection?
- stability of bitumen itself
- surface vs subsurface placement options
- loading levels
- Logistics (process; how much; where to get it) + cost issues

* Generic issue for all solidification product options: What about the residuals (look at transforming residual in stopes)

**Option 3: Autoclave**

Need to know, look at, address, research:

- assess operational detail from Con Mine
- size and location
- mix of feed
- how soon do you want to consume Arsenic?
- placement of waste material
- consider other (flexibility of feed from other processes running elsewhere)
- energy cost
    - source of iron
    - source of sulphide for heat
- mini plant pilot project
- study and grade ores in the mine
- lime source - cost for neutralization
- residue subject to leachate test
- recycling of solutions (water balance considerations)
- what to do with bleed stream

**Option 4: WAROX/El Indio**

Depends on market survey

- Economic cost/benefits analysis
- Run test: put filter system in place in run - to produce a marketable product (which is not available for sale now)
- Longevity of filter (look at Con data)
- Treatment of the residue bed (future option to be considered)
- $1.5M replacement of existing with conversion
- Ultimate handling and storage considerations (volume/time)

**Option 6: EMR**

- Is microwave heating the way to do this?
- What other "furnace" options can be considered?
- How much fuming results?
- Size of the operation.
- How to granulate the SLAG?
- Loading is a key issue
- Leachate test performance
- Feed volume (operational problems)
- Feed stock requirements (type/availability/cost)
- Where to put it in the end.

## *QUESTION 3: WHAT TO DO IN THE INTERIM?*

- Existing stockpile & Current production
  - No permit / option to handle / store it other than in existing stopes
  - Use of metal filter (resulting in small volume) $1.5M installation cost
  - Shut mine down
  - Stockpile ore (do not roast)
  - Leakage problem
  - Capture the leachate to address plume under stopes (50 year old plume)
  - Use of drain holes (to characterize... possibly drain) (Part of monitoring program)
  - Send float (existing) to autoclave (but distant location)
- If potential new owner purchased on condition of shut down roaster and use autoclave - permitting time lag?
- Public information / communication is a key point.
- Little choice about what to do in the short term.

## Group B

### *QUESTION 1: WHAT NEEDS TO BE DONE TO MANAGE THE ARSENIC UNTIL A SOLUTION IS SELECTED?*

1) Must keep water away from the vaults - continue to intercept and treat.
2) Concern that compromised stopes need to be addressed
   - consider "freeze" option as an interim measure - could serve as a pilot study

2a) Pilot study to prove if "freeze" is effective (OH&S) and feasible. Assess if pilot study is warranted given current pump & treat.

3) Study and better understand the hydro-geological regime.
   - Should the storage of current production continue underground or on the surface?
4) Nature of current pump and treat operations examine economics / logistics and imprint of long term solution.
   - Need more information on geometries of chambers rock formation (stability drifts, openings etc. and range of physical/technical property of the chambers)
5) Complete access to "B" area stopes.
   - Contingency plan.

### *QUESTION 2: WHAT ARE THE KEY QUESTIONS REGARDING END PRODUCTS?*

1) Need to know economics of end product re: markets.
2) If inert - how and where should it be disposed?
3) Define inert.
4) Upgrade vs. stabilized product.
5) Approach the market players.
   - those that use/sell
   - specifies re: market
6) Offsite transportation risks and costs.
7) The nature of end products stable or not and related storage requirements.
8) Consider the future risks the end products represent.

**The key questions to consider**

1) What are the reasonable, feasible methods to take material out of the stopes?
2) What % removal is reasonable?
3) What options are available for various amounts of residual?

3a) What are the volume considerations? What process is best?

4) Can the end product be disposed of (sold) in an acceptable manner? What are the markets/demand? How is this determined?
5) What are the transportation risk issues?
6) Who decides?

### *QUESTION 3: WHAT NEEDS TO BE DONE TO ARRIVE AT A PREFERRED SOLUTION(S).*

1) **Market Studies.**
   - To increase understanding of the true potential of markets.
   - Determine price of reagents / shipping cost / supply.
   - Look at options that survive for further analysis.
2) **Additional details of performance of options against evaluation criteria.**
   - Develop to same level of detail to enable a full/complete evaluation of option to option as equals.
3) **Fill in the gaps.**

- Paper study - a full paper conceptual solution.

**4) Underground Extraction.**

- Identify methods and equipment to recover the product.
- More information on geometry of chambers, rock formation, drifts, range of physical / chemical properties of chambers.
- Better understanding of hydro-geological regime.
- Check and reassemble as new data is available.
- Detailed mining plan for each stope.
- Assess residue (waste product from) stability - re: disposal.

**5) Options**

*Option 4: WAROX*

- Place and update into a pre-feasibility level of detail.
- Small pilot on current roaster production.
- Assess transportation risks.
- Better info on gold recovery.

Consultation

- Open / public clear well written.
- Layman's language
- Consider multi-interest steering committee & public rep - to balance engineering / technology committee.
- Define objectives for consultation roles / responsibilities / time line expectations.

*Option 2: Solidification*

- Assessment of feasibility of in-situ placement (does it work?)
- Conceptual engineering of cement bitumen processing.
- Additional bench (big) testing of bitumen encapsulation.
- Assess surface and underground logistics of placement.
- More detailed costing (consumables).
- Assess regulatory regime.

*Option 3: Autoclave*

- Assess transportation aspects to Con.
- Additional tests at Giant to assess autoclave.
- Determine availability of Con.

**6) Develop detailed Action Plan timelines.**

**7) Disclosure / sharing of information to public - NO surprises.**

***OTHER***

- Consider combination of technologies as a system.
- Take an immediate final step to show action.
- Develop management option for residuals in the mine.
- How can all technologies assist in providing a response?

# *Appendix A: Agenda*

# Giant Mine Arsenic Trioxide Technical Workshop

*June 22 - 24, 1999*
*Katimavik Room "B" (Plenary Session Location), Explorer Hotel,*
*Yellowknife, Northwest Territories*

## Agenda Day 1: Tuesday, June 22, 1999

## Sessions Open To The Public & Media For Observation

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

09:00 - 09:30 **Welcome and Opening Remarks**
· Welcome ( Andy Swiderski, Facilitator)
( Dave Nutter, DIAND)
( Bob McLeod, GNWT)
· Introduction of participants
· Purpose, Objectives and Anticipated Workshop Results (Facilitator)
· Roles & Responsibilities and workshop *"ground rules and procedures"* (Facilitator)
· Overview of Logistics & Organization, Reference Materials and Displays (including a *"reading and resource room"* located in the Frobisher Room
· Keeping track and recording of discussions (Facilitator)
· Review of Participant Reference Binder (Facilitator)
· Agenda Review (Facilitator)
· Questions/discussion

### PART ONE: DEVELOPING A COMMON UNDERSTANDING OF THE PROBLEM

09:30 - 10:10 **Agenda Item No. 1: Overview of Arsenic Trioxide Management At Giant Mine and the Chronology of events Related to the Work Completed To date On Arsenic Trioxide Management Practices and Options** (Objective 1)
· 30 minute presentation by Rick Allan, Manhattan Resources; Neill Thompson, DIAND, and John Gale, FracFlow
· Questions/discussion

10:10 - 10:45 **Agenda Item No. 2: The Giant Mine Arsenic Trioxide Management**

| | | |
|---|---|---|
| | | **Strategy Being Led By The Federal Government: Commitment and Action** (Obj. 2) |
| | · 20 minute presentation by Dave Nutter, DIAND.<br>· Questions/discussion | |
| 10:45 - 11:00 | Break | |
| 11:00 - 11:30 | **Agenda Item No. 3:** | **Development Of The Giant Mine Arsenic Trioxide Project Description: Objectives & Performance Standards, Environmental Review & Decision Making Processes** (Obj. 3) |
| | · 20 minute presentation David Livingstone, DIAND<br>· Questions/discussion | |
| 11:30 - 12:00 | **Agenda Item No. 4:** | **Environmental Impact Assessment Process, Criteria, Factors and Considerations To Ensure Public Health and Environmental Safety.** (Obj. 3) |
| | · 20 minute presentation by Heidi Klein, MVEIRB<br>· Questions/discussion | |
| 12:00 - 1:00 | Lunch (lunch will not be provided) | |

## *PART TWO: DEVELOPMENT & APPLICATION OF OPTIONS EVALUATION CRITERIA AND PROCESS*

| | | |
|---|---|---|
| 1:15 - 2 :30 | **Agenda Item No. 5:** | **Framework For Assessing The Options: Preliminary Evaluation Criteria & Comparative Matrix** |
| | · 15 minute presentation on evaluation approach, principles & methods by Jim Micak, Facilitator<br>· 30 minute presentation on the development and application of performance screening criteria and introduction to the preliminary evaluation criteria by Gary Strong, Dillon<br>· Questions/discussion<br>· Instructions for *Task 1 Working Groups* | |
| 2:30 - 2:45 | Break | |

| | | |
|---|---|---|
| 2:45 - 4:30 | **Agenda Item No. 6:** | **Task 1 Working Groups: To Discuss Evaluation Criteria** (Objective 5 and 6) |

· Working Group A: Katimavik "A", ( Andy Swiderski, Facilitator)
· Working Group B: Katimavik "C", ( Jim Micak, Facilitator)
· Designated Recorders in each working group

| | | |
|---|---|---|
| 4:30 - 5:30 | **Agenda Item No. 7:** | **Plenary Session On Task 1: Working Towards Consensus On The Options Evaluation Criteria** (Objective 5 and 6) |

· 10 minute presentations by Working Group A and B on Task 1
· plenary open discussion
· Questions/discussion
· Instructions for *Task 2 Working Groups (Day 2 activity)*

| | |
|---|---|
| 5:30 - 6:30 | ***Public* Questions & Discussions** |
| 6:30 - 7:00 | ***Media* Questions** |
| 7:00 - | **Day One Wrap Up and Instructions for Day 2** |

# Giant Mine Arsenic Trioxide Technical Workshop

*June 22 - 24, 1999*
*Katimavik Room "B" (Plenary Session Location), Explorer Hotel, Yellowknife, Northwest Territories*

## Agenda Day 2: Wednesday, June 23, 1999

## Sessions Open To The Public & Media For Observation

08:30 - 8:45 — ***Arrival, Welcome and Opening Remarks***
- Purpose, Objectives and Anticipated Workshop Results (Facilitator)
- Day 2 Agenda Review (Facilitator)
- Roles & Responsibilities (Facilitator)
- Questions/discussion

### PART TWO: DEVELOPMENT & APPLICATION OF OPTIONS EVALUATION CRITERIA AND PROCESS (Continued from Day 1)

8:45 - 3:15 — **Agenda Item No. 8: Engineering & Scientific Options Explored To Date: Minimum Performance Criteria, Issues, Data Gaps and Work In Progress** (Obj. 4)

8:45 - 9:30 — ***Option Number 1: Storage in Place***
- 30 minute presentation by John Brodie
- 15 minute questions/discussion

9:30 - 10:15 — ***Option Number 2: Stabilization/Solidification***
- 30 minute presentation by Bill Cullen
- 15 minute questions/discussion

10:15 -10:30 — Break

10:30 -11:15 — ***Option Number 3: Autoclave***
- 30 minute presentation by Rodney McElroy
- 15 minute questions/discussion

11:15 - 12:00 — ***Option Number 4: Sublimation (WAROX & El Indio)***
- 30 minute presentation by Serena Domvile & Kent Morton
- 15 minute questions/discussion

| | |
|---|---|
| 12:00 - 1:00 | Lunch (lunch will not be provided)<br>*(* Progress dependent there is the option to serve lunch for 30 minutes and continue with presentations to allow more time for Working Groups )* |
| 1:00 - 1:45 | ***Option Number 5: Hot Water Leach***<br>· 30 minute presentation by Patricio Riveros<br>· 15 minute questions/discussion |
| 1:45 - 2:30 | ***Option Number 6: EMR Technologies***<br>· 30 minute presentation by Jim Tranquilla<br>· 15 minute questions/discussion |
| 2:30 - 3:15 | ***Option Number 7: Bio Leaching***<br>· 30 minute presentation by Simon Purkiss<br>· 15 minute questions/discussion |
| 3:15 - 3:30 | Break |
| 3:30 - 4:30 | **Agenda Item No. 9: Task 2 Working Groups: To Discuss The Application Of The Comparative Evaluation Matrix To The Options** (Objective 5 and 6)<br>· Working Group A: Katimavik "A", ( Andy Swiderski, Facilitator)<br>· Working Group B: Katimavik "C", ( Jim Micak, Facilitator)<br>· Designated Recorders in each working group |
| 4:30 - 5:30 | **Agenda Item No.10: Plenary Session On Task 2: Working Towards Consensus On The Application Of The Comparative Evaluation Matrix To The Options** (Objective 5 and 6)<br>· 10 minute presentations by Working Group A and B on Task 2<br>· plenary open discussion<br>· Questions/discussion |
| 5:30 - 6:30 | ***Public* Questions & Discussions** |
| 6:30 - 7:00 | ***Media* Questions** |
| 7:00 - | **Day Two Wrap Up and Instructions for Day 3** |

# Giant Mine Arsenic Trioxide Technical Workshop

*June 22 - 24, 1999*
*Katimavik Room "B" (Plenary Session Location), Explorer Hotel, Yellowknife, Northwest Territories*

## Agenda Day 3: Thursday, June 24, 1999

## Sessions Open To The Public & Media For Observation

*08:30 - 08:45* **Arrival, Welcome and Opening Remarks**

- Purpose, Objectives and Anticipated Workshop Results (Facilitator)
- Day 3 Agenda Review (Facilitator)
- Roles & Responsibilities (Facilitator)
- Questions/discussion

*08:45* - 10:30 **Agenda Item No.11:** **Review of Ranking of Options and Confirmation of Selection of Preferred Options** (Objective. 6 and 7)

- presentation by Andy Swiderski, Facilitator
- open plenary discussion
- Questions/discussion
- Instructions for *Task 3 Working Groups*

10:30 - 10:45 Break

## *PART THREE: DEVELOPMENT OF AN ACTION PLAN FOR DETAILED OPTIONS ANALYSIS*

10:45 - 12:00 **Agenda Item No.12:** **Task 3 Working Groups: Development Of An Action Plan For Detailed Options Analysis: Strategic Considerations, Approaches and Key Elements** (Objective. 8)

- Working Group A: Katimavik "A",
  ( Andy Swiderski, Facilitator)
- Working Group B: *Cumberland Room*,

( Jim Micak, Facilitator)
· Working Group C: ***(If Required)***, Location TBD,
( Craig Thomas, Facilitator)
· Designated Recorders in each working group

| | | |
|---|---|---|
| 12:00 - 1:00 | Lunch (lunch will not be provided) | |
| 1:15 - 2:30 | **Agenda Item No.13:** | **Task 3 Working Groups: Development Of An Action Plan For Detailed Options Analysis: Strategic Considerations, Approaches and Key Elements (Continued from the morning)** (Objective. 8) |
| 2:30 - 2:45 | Break | |
| 2:45 - 4:30 | **Agenda Item No.14:** | **Plenary Session On Task 3: Working Towards Consensus On The Action Plan For Detailed Options Analysis** (Objective 8) |

· 10 minute presentations by Working Group A, B and C (if required) on Task 3
· plenary open discussion
· Questions/discussion

4:30 - 5:00 **Agenda Item No.15: Findings and Results Of The Workshop: Next Steps** (Objective. 9)
· presentation by Facilitator
· Questions/discussion

5:00 - 6:00 ***Public* Questions & Discussion**

6:00 - 6:30 ***Media* Questions**

6:30 **Workshop Closing Comments and Wrap Up**
· Dave Nutter, DIAND

# *Appendix B: List of Participants*

# *Invited Participants*

*Note - Participants who were invited but did not to attend are stroked out.

| Name | Organization |
|---|---|
| Allan, Rick | Manhatten Minerals Inc. |
| Baillargeon, Alfred | Yellowknives Dene Band |
| Beaulieu, Darrell | Yellowknives Dene Band |
| Bengts, Peter | WCB |
| Borden, Mike | Miramar Con |
| Breadmore, Ron | DIAND - Operations |
| Brodie, John | Brodie Consultants |
| Chouinard, Sylvan | Dept of Health - GNWT |
| Colpitts, Brad | Health - Yellowknife |
| Connell, Larry | Viceroy Minerals Corporation. |
| Coughlin, Jim | GNWT - MACA |
| Craig, Gary | City of Yellowknife |
| Cullen, Bill | UBC |
| Dahl, Julie | DFO |
| Domvile, Serena | Domvile and Associates |
| Dutrizac, John | Canmet |
| Dyer, Lisa | GNWT - RWED |
| Edwards, Richard | Pricewaterhouse Coopers |
| Gaeton, Raymond | Canmet |
| Gale, John | FracFlow |
| ~~Hall, Ken~~ | ~~GNWT, RWED~~ |
| Harbicht, Steve | Environment Canada |

| | |
|---|---|
| Johnston, Laura | Environment Canada |
| Klein, Heidi | MVEIRB |
| Livingstone, David | DIAND - Water Resources |
| McElroy, Rod | Fluor Daniel Wright |
| ~~McIvor, Elaine~~ | ~~DIAND~~ |
| Milburn, Dave | DIAND - Water Resources |
| Morton, Kent | Royal Oak Mines |
| Nutter, Dave | DIAND - Minerals |
| Peterson, Steve | Canadian Autoworkers |
| Purkiss, Simon | Pacific Ore Technologies Ltd. |
| Quiring, Annette | MVLWWG |
| Rippin, Allison | Dene Nation |
| Riveros, Patricio | Canmet |
| Schultz, Stephen | Royal Oak Mines |
| ~~Spalding, Andrew~~ | ~~CARC/Ecology North~~ |
| ~~Stard, John~~ | ~~Royal Oak Mines~~ |
| Thompson, Neill | DIAND - Water Resources |
| Tranquilla, J.M. Dr. | EMR Technologies |
| Tsetta, Isadore | Yellowknives Dene Band |
| Turner, Bob | North Slave Metis |
| Vincent, Andre | Dept. of Health - Federal |

# *Public, Media and Other Observers*

| Name | Organization |
|---|---|
| Aldous, Judy | CBC Radio |
| Ballantyne, Michael | EAN North |
| Blondin-Andrew, Ethel, Hon. | Government of Canada |
| Bohnet, Sevn | DIAND - WRD |
| Bryan, David | Price Waterhouse Coopers Inc. |
| Clark, John | Vista Engineering |
| Clarke, Sharon | DIAND |
| Coedy, Bill | DIAND - Taiga Environmental Laboratories |
| Dallner, Jennifer | Mix 100/CJCD |
| Fishbone, Jonas | Yellowknife Dene Band |
| Francois, Mike | Yellowknife Dene Band |
| Gibson, Dane | Northern News Services |
| Gilday, Cindy | MVEIRB |
| Goulet, Lawrence | Yellowknives First Nation |
| Hagar, Peter | Camillus Engineering Consultants |
| Hawke, Laura | DIAND |
| Huot, Daniel | l'Aquilon |
| Jewison, Cathy | DIAND |
| Jones, Paul | RWED |
| Kennedy, Matt | |
| Kent, Ron | Ferguson, Simek, Clark |
| Konda, Balesh | DIAND - HQ |
| Liske, Doreen | Yellowknife Dene Band |

| | |
|---|---|
| Mackenzie, Paul | Yellowknife Dene Band |
| Miyagishima, Wayne | Envirogold Technologies Inc |
| Murphy, Brent | EBA Engineering |
| Murzyn, Henry | Nishi - Khon / SNC - Lavalin |
| Nickerson, Dave | |
| Ollson, Chris | ESG - Royal Military College |
| Paquin, Emery | GNWT - RWED |
| Peckford, Brian | Peckford Consulting Ltd. |
| Rasmussen, Blake | Deton Cho Corporation |
| Reimer, Ken | ESG / RMC |
| Robb, Malcolm | DIAND - Mineral Development |
| Semple, Paul | Kilborn (SNC - Lavalin) |
| Shaw, Penelope | |
| Sobey, Kirk | |
| Stephens, Glen | DIAND - Contaminants Division |
| Stewart, Bernadette | Gartner Lee Limited |
| Thomas, Craig | Dillon Consulting Limited |
| Vaydick, Mike | NWT Chamber of Mines |
| Watt, Bill | Arctic Foundations of Canada |
| Wilson, Leslie | Roy Erasmus' Office (MLA) |
| Wright, Philip | DIAND - Hull, QC |

# *Appendix D: Flip chart Notes*

Notes appear verbatim.
Dotted line denotes new flip chart page.

**Agenda Item 6**
**Group A: Task 1**

**Comparative Criteria**
**(Short term vs. long term risk)**

- Arsenic Trioxide means Arsenic

Risk Group

1. Ok
2. "HAS" Ok
3. Ok
4. (Safety vs. risk)

New (Environmental Risk? To be discussed)

What is the level of risk to the environment during normal and upset conditions?

**SERVICE**

1. (Reagents)

- reagents (to include emergency)
- What are the system requirements and their availability and their associated risks?

2. Design flexibility: ? delete
3. Ok
4. Replace or mitigate the effects of the roaster? (assume 5 year mine life)
5. Ok
6. Ok expediently and efficiently to be discussed (data gap?)

**IMPACT**

1. Are the receiving environment impacts minimal? (Environmental Standards)
2. Ok
3. Applies mostly to "surface" storage.

- Is the end product amenable to environmentally sound segregation? and available for reprocessing.

(Add new)

| New |
|---|
| • Is there a transportation risk? |

Option to move to "RISK" Category.

Jobs: Retain as criteria but weighted low

---

**COST**

✔ agreed (with existing cost groupings)

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**Minimum Criteria**

Process Understanding

- For Arsenic Trioxide
  vs.
  (add) Arsenic (clarification)

  **(EMERGENCY TECHNOLOGY)**

- potential proven technology
  (add) "if it looks promising".
- "Removed" ... permanent solution based on existing standards (base flow cannot exceed drinking water standards)

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**(Min. Criteria)**

- does the process result in a stable material which meets or exceeds the regulatory criteria today.
- ADD
  Time required for actual implementation
  (inversely prop. to time) point allocation (in the evaluation criteria)

---

Minimum.

- Can the process consume all the materials (stockpile and current products) within 20 years. (plant life). (ie. no arsenic left underground)
- Plant must be able to "process" within 5 years.
- OK in Yellowknife environment.

Public Health Risk

- meets or exceeds occupational and public health standards of the day!

**Agenda - Item 6**
***Group B: Task 1***

- Review and Discussion of the performance criteria

Process understanding
- is the process a proven technology?
- "proven" maybe too restrictive - eliminating promising technology
- long time line to implement - perhaps emerging tech. Can be incorporated over time
- reasonable probability of resolving the problem
- confidence that it will work

Use as the criterion proposed modification

"Proven technology having published data that technology can be run at a production scale."

(Recognize scale/magnitude)

Environmental soundness

The process provides a complete solution to arsenic management
Definition:
A treatment for arsenic that does not result in adverse biological effect.

Can the process be initiated within a target 5 years?
And substantially completed within 25 years?
(Strong feeling 50 years too long)
(A commitment / recognition to on-going management/implementation)

If the process is to be implemented in Yellowknife it must be able to operate in Yellowknife environmental conditions.

**Public Health & Safety**

- the routine operation of the process poses no known or unmitigable risk to public health

Definition:

- health risk assessment & health risk benefit analysis studies

Additional Criteria

- address the occupational health and safety. Demonstrate commitment to avoid / minimize risk to workers

(More appropriate at comparative level? )

Has the end product been proven to be stable (safe).

Drop - included /addressed in earlier criteria.

**Comparative Criteria**

Risk

- Has the process been used at commercial scale for arsenic or other comparably hazardous materials before?
- Has it been used in similar env. Conditions.
- Ok
- What level of confidence is there based on existing data/information regarding the option.
- What is the level of health & safety risks for workers during normal & upset conditions.

Additional Criteria

- Is there a requirement for special workers training procedure, equipment & proceed.
- What are the potential environmental impacts related ~~contaminants~~ released residual products following process implementation.

Service

What consumables are required? What is the source of these consumables?

Design flexibility, does it fit in current mill process and is implementation already available?

Ok

What is the level of flexibility of the process to changes in quantity?

And physical & chemical properties?

Can this process replace the roaster? Climate or use the current arsenic dust product as well as renting current stockpile.
ADD
Can this process eliminate arsenic trioxide roaster emissions & reduce other emissions?

What is the level of recovery of arsenic to gold?

Remove addresses under cost criteria Rev. recovery.

How expediently would the process treat arsenic trioxide over the next 20 years

Additional service criteria
What level of post implementation care and maintenance and monitoring.
Impacts
Is the displacement / disruption of natural features minimal?
What is the Environmental Impact?
- plants/animals
- air impact
- aesthetics
- water
- social/cultural/archeological
- heritage resources
- # of jobs

---

Does the option allow for on-going mining / does it limit future mine production.

Does the option bring associated environmental impacts (e.g. as wastes by-products)

**Agenda Item 12**
***Group A: Task 3***

THE NEXT STEPS
Developing an Action Plan: Key Questions
Q1 Stand Still
Q2 End Products
Q3 Advantages/Disadvantages
Q4What needs to be done to arrive at a preferred solution?

Considerations:
- Strategic/Management
- Technical Studies/Work
- Consultation/Communications
- Resource Requirements
- Time lines

- Who?
- How?

Q2. What needs to be done to advance the "identified" preferred options?
Grouping of options: Option 2 (stabilization) + Option 6
Option 3 (Autoclave)
Option 4 (Sublimation: WAROX/EL Indio)

- Rationale/Reasons for "Rejection" (Parking) of Options which were supported by less than 2/3 of evaluators: Option 1, 5, 7.

- What needs to be done to arrive at a preferred solution?

- What is an acceptable end product.
- What do we want to achieve?

Acceptable End Products

A Purified form of As
B Stable form of As
C Solidification of As

**Purified Arsenic**

1. Product specification
   - arsenic grade
   - antimony
   - iron
   - particle sizing (form)
   - crystal form of $As_2O_3$
2. Market Security
   - market survey
   - buyer for 10 K tons/year. (Issue of supply and demand must be addressed)
   - options for "agreement"
   - fall back options (if no market). Problem succession is not desirable
   - advance existing work

3. What is the fall back option *(ie. Disposal/storage strategy if product can't be sold)

Filter for all potential "end products":

- What are the environmental issues associated with the end product and all elements of the process?

Who makes the decisions on this/these issues?

OPTION A:

Market results

Yes - Consider further

No - Reject

Product B "Stable"

(2 products made)

1. Scorodite / ferric arsenate
2. Amorphous ferric arsenate

- Need to summerize the existing data on stability under various conditions and identify preferred storage options and cement stabilization.

## Product B

Decision Tree

Product B

Yes — Meets Current Standards — No

Yes: Look at process options; Look at disposal options → Ponding, Stabilization

No: REJECT

Product C: Solidification of As

1. Cement
2. Glass (How to make it without vaporization)
3. Bitumen (hygiene/safety/fire problem)
4. Arsenic metals?

General concerns:

- need to address data gaps (to confirm / verify viability)
- Ratio/volume, loading - cement, glass and bitumen
- Environmental Standards, testing protocol
    - relevance of TCLP vs own procedure
- identify other residual contaminents
- solidification is not to be confused with encapsulation (which is unacceptable)

- If these 4 options address the above general concerns adequately, the next step is what are storage options for product and disposal options for residuals ( to be done based on toxic waste criteria). The next step is to decide go or no go.
- If any option does not address the above concerns it is rejected.

Working Group A: (afternoon Day 3)
Q2. What is to be done to further assess/advance options:2, 3, and 4.

**Option 2**

Bitumen must be looked at:

- does it dissolve or encapsulate the $As_2O_3$?
- polysection?
- stability of the bitumen itself
- surface vs. sub-surface placement options need to be assessed.
- loading levels need to be assessed
- logistics (process; how much; where to get it) + cost issues.
- generic issue for all solidification product options:
  "What about the residuals (look at transforming residual in stopes )"

**Option 3: Autoclave**

- assess operational detail from Con Mine
- size & location
- mix of feed
- how soon do you want to consume
- placement of waste material
- consider other (flexibility of feed from other processes ... running elsewhere)
- energy cost (depends on source of iron & sulphide source)
  - source of iron?
  - source of sulphide source for heat?
- mini plant pilot project (or batch test) Look at gold recovery from actual operation
- study the low grade ores in the mine (iron & sulfide)
- lime source - cost for neutralization (prior to gold removal)
- the residue to be subject to a leachate test
- recycling of solutions (water balance considerations). What to do with the bleed stream?

**Option 4: WAROX** (Depends on market survey results)

- economic (Cost/Benefit analysis)
- run test: ? put filter system in place
  - to produce a marketable product (which is not available for sale now)
- longevity of filter (look at Con data)
- treatment of the residue bed (future option to be considered)
- $1.5M replacement of existing x with conversion
- ultimate handling & storage considerations (volume / time)

**Option 6** - Part of 2B

- is microwave heating the way (linked to manganese) to do this (currently small scale)
- what other "furnace" options can be considered?
- how much fuming results?
- size of the operation
- how to granulate the SLAG?
- loading is a key issue
- leachate test performance
- feed volume (operational problems)
- feed stock requirements (type/availability/cost)
- where to put it in the end

---

**Additional Discussion Related to Option 1 (A and B): Storage in Place**

| * this is an encapsulation solution ... not a transformation solution |
|---|

Option 1a:

- necessary short term option
- not a permanent solution

Does not allow for site reclamation

Option 1b:

- not a permanent solution (life expectancy concerns)
- partial solution only (4 stopes not addressed)
- heat load from ground water

How to handle transfer of exist. material from stopes.

- vacuum system
- first 50% is easy
- access issue

---

**Option 5** (not supported based on evaluation results)

- not "proven"
- limited experimental data (no operational/pilot data)
- market dependancy
- same marketability problems as WAROX option
- question of solubility (advantages of a wet system)
- need for a back-up system if no market
- possible product of ferric arsenate (problem succession)

---

**Option 7:**

- 3.5 M tons of stock
- source of inputs
- viability of bacteria in cold weather
- proven for gold but no data for showing it works for arsenic
- unknown rate of solution (not really a proprietary issue)
- patent only on DNA of bacteria (GENCOR)

---

- What to do in the interim?

2 PARTS

- Existing Stockpile
- Current Production
  - no permit/option to handle/store it other than in existing stopes
  - use of metal filter (ESP) (resulting in small volume) ($1.5 million installation cost)
  - shut mine down
  - stockpile ore (& do not roast)
  - leakage problem to be addressed
  - capture the leachate to address plume under stopes (50 year old plume)
  - use of drain holes (to characterize ... possibly drain) (part of monitoring program)
  - send float (existing) to autoclave (but distant location)

OTHER ISSUES:

- If potential new owner purchased on condition of shut down roaster & use autoclave - permitting time lag?
- Public information / communication is a key point.
- Little choice about what to do in the short term.

---

**Agenda - Item 12**
*Group B - Task 3*

Issues to address

1. What needs to be done to manage the arsenic - until a solution is selected.
2. What are the key questions on the type of end product.
3. Advantages/disadvantages of options set aside.

QUESTION #1

1. What needs to be done during the interim?
2. Concern that compromised stopes need to be addressed consider - "freeze" option as an interim measure - could serve as a pilot study

- Must keep water away from the vaults. Continue intercept & treat

- Re: two stopes

2. Pilot study to prove if "freeze" is effective (H&S) "feasibility, not complete. Assess if pilot study is warranted given current pump & treat.
3. Study and better understand the hydrogeological regime.

- Should the storage of current production continue underground or on surface?

4. Nature of current pump & treat operations examine economics/logistics & imprint on long term solution

- need more info on geometries of chambers rock formation/stability drifts, openings etc. & range of physical/technical property of chambers.

- Complete access "B" area stopes
  Contingency plan mining plan

QUESTION #2

What are the key questions Re: End Product?

- need to know economics of end product re: markets
- if inert - How & where should it be disposed?
- define what inert is
- upgrade vs. stabilized product

---

- approach the market players - those that use/self
  - specifies re: market
- off-site transportation risks & costs
- the nature of end products stable or not and related storage requirements
- consider the future risks the end products represent

---

The key questions to consider

1. What are the reasonable feasible methods to take material out of the mines?
2. What % removal is reasonable?
3. What options are available for various amounts of residual?

---

Are the stabilized end products acceptable.

3a. What are the volume considerations? What process is best?

4. Can the end product be disposed of (sold) in an acceptable manner? What are the markets/demand? How determined?

5. What are the transportation risk issues?

6. Who decides?

---

Advantages/disadvantages of those options set aside.

Options 2, 3, 4

| Option #1 - The freeze |
|---|

Advantages

- quick & dirty / inexpensive
- no risks from disturbing material
- eliminated OHS concerning
- potential for retrievability over the long term
- no transportation issues

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- little need for consumables
- relatively well-developed (proven)
- use local labour force, no retooling/retraining ( not as high tech)
- 100 % of material is addressed in chambers accessed.
- Canadian company

Disadvantages

- public perception/material still underground
- global warming concern
- not a complete solution
- water table challenge when mine floods (unknown)
- no revenue recovery
- no reduction on current emission
- remove land from future use

OPTION 5 - Hot Water Leach

Advantages

- flexibility to meet alternate objectives
- enables the recovery of gold ($)
- a proven technology
- at Giant - minimize transport risks
- can take local scrap metal

- Real, site specific data that's reliable
- processing simplicity
- potential to use Con Mine Autoclave (different perspectives)
- public perception risk communication

Disadvantages (Hot Water Leach)

- needs large volume of water & high energy
- possible need to bring in large volumes of consumables
- inherent OH & S problems in handling & need for training
- water trt. Requirements
- need for more R&D (but H.W.L. PL & in YK)

Hot Water Leach (continued)

- on-site storage (problem?)

OPTION 6 - EMR

Advantages

- minimal transport
- physical size of plant as proposed
- efficient energy use

OPTION 6

Disadvantages

- unproven end product
- un-engineered (vis avis - ceramics)
- substantial output volume (4 - x tonnage in reagents)
- no recovery of end product
- need for lots of water
- problems of emissions to air & water (stream)

- water treatment.
- concern over safe operation
- public perception of "microwaves"
- no info re: "iron vs. manganese"

OPTION 7 - Bio Leach

Advantages

- bye bye roaster - no air emissions
- proven - works at mine sites
- low energy requirements
- stable end product
- low cost - capital
- use of local scrap metal
- gold recovery

Disadvantages
- not proven in Yellowknife environmental conditions
- needs large surface area
- need for water trt.
- import of consumables ($) - different to set to sources
- no data re: treatment of $As_2O_3$

---

What needs to be done to arrive at a preferred solution(s)
- MARKET STUDIES
- to increase understand the time potential/market
- determine price of reagents/shipping cost/supply
- look at options that survive - for further analysis

---

- additional details of performance of options against evaluation criteria - develop too same level of detail to enable a full/complete evaluation of option to option as equals
  - fill in gaps
  - (paper study)
- a full paper conceptual solution

---

UNDERGROUND EXTRACTION
- identify methods & equipment to recover the product
- more info needed on geometry of chambers, rock formation, drifts, range of physical chemical properties of chambers
- better understanding of the hydrogeological regime
- check & reassemble as new data is available
- detailed mining plan for each stope
- assess residue ~~sludge~~ (waste product from) stability - re: disposal

OPTION 4 - WAROX
- place & update data into a pre-feasibility level of detail
- small pilot on current roaster production
- assess trans. risks
- better info gold recovery

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Consultation
- open / public, clear and well written
- layman's language
- consider multi-interest steering committee & public rep - to balance eng./tech. committee
- define objectives for consultation roles / resp / time lines expectations

OPTION #2
- assessment of feasibility of in-situ placement (does it work?)
- conceptual eng. Of cement bitumen (tal?) processing
- additional bench (big) testing of bitumen. Encapsulation
- assess surface & underground logistics of placement
- more detailed costing (consumables)
- (assess regulatory regime)

OPTION #3 - Autoclave
- assess transportation aspects to Con
- additional tests at Giant to assess autoclave
- determine availability of Con
- Develop Detailed Action Plan Time lines
- Disclosure/sharing of information to public - NO surprises

OTHER
- consider combination of technology as a system
- take a immediate final step to show action
- develop management option for residuals in the mine
- How can all technologies assist in providing a response?

# *Appendix E: Matrix Development*

**Giant Mine Arsenic Trioxide Technical Workshop**
**Preliminary Evaluation Criteria and Matrix**
**Information Package**
**Workshop Agenda Item #5**

***DEFINITIONS IN THE CONTEXT OF THIS MATRIX:***

**Proven Technology:** A technology which has published data that shows the technology can be run at a production scale for recognized or emerging technologies..

**Complete Solution:** A treatment for the Arsenic dust which will not result in adverse biological effects.

**Environmental Conditions:** Those conditions which predominate in Yellowknife such as low humidity and extreme range in yearly temperatures (from high 20°C to low - 40°C).

**End Product:** The Arsenic product which is generated by the process.

**Level of Confidence:** The confidence held by experts in the field in the design with respect to reliability, stability and efficiency.

**Data/information:** Any data collected in testing, research or operation of the process.

**Reagents:** Any material inputs required to complete the process.

**Displacement/Disruption:** Any actions which change the natural features of the area to any degree.

**Capital Costs:** All costs from the time that the project received Environmental Assessment approval through to the end of commissioning. Includes design, procurement, construction and commissioning.

**O & M Costs:** Operation and Maintenance: the cost of maintaining production from commissioning until the Arsenic dust is consumed through the process.

**Closure Costs:** The cost of decommissioning the plant once production has ceased and completing such works as to verify the closure does not pose a residual liability.

**Scoring:** Yes -is always Good
Left side of scale -is Good
No -is always Poor
Right side of scale -Poor

***JUSTIFICATIONS:***
*Minimum performance criteria:*

**Why is it important that the technology be proven?**
- Roughly 20 years of technology development has gone on
- There are proven technologies that are currently used to address this issue in other locations. Some of these have over 5 years of production records
- Need to move forward, toward a solution.
-

**Why does the solution need to be complete?**

- Need to eliminate problem succession. This workshop is to work towards the final solution. Intermediate steps, although important in the overall management, are not the focus.

**How did you arrive at the number 35 years to completion?**
- 2 years to develop a complete project description.
- 2 years for E.A. process.
- 2 to 3 years design and construction.
- 20 to 25 years production.
- 2 years decommissioning.
- 35 years

*Comparative Criteria:*
***Risk***
**Where does the data/information come from? How can we trust it's credibility?**
Order of Confidence from greatest to lowest: 3rd party, independent, published data, proprietary data.

***Service***
**Why does the process need to be flexible?**
Feedstock will change as it will come from both the chambers and the mill process at the mine. Chambers content has been shown to vary widely and there are head grade changes.

**Why is it important that this process replace the roaster?**
- To prevent the creation of more Arsenic.
- Increase the likelihood of Giant site sale and future operation
- Removes Arsenic / $SO_4$ air emissions as side benefit.

**Why is the recovery level of Arsenic and Gold for market important?**
- Au recovery is reported to be worth $25million
- Additional $ recovery may be possible as head grades in old stopes are higher than the current production head grades.
- Removal of 100% of Arsenic impossible - but we need to move towards this.

***Cost***
**Why is cost a factor? Shouldn't we be trying to clean up the arsenic, no matter what the cost?**
Yes, however, where 2 or 3 competing technologies can provide a permanent solution, it is imperative that the socioeconomic factors be taken into account. Waste of money, either government or private, does not add to the reliability or security of the process. We need to find the *best value solution* not the most expensive or the cheapest solution.

***<u>SCALING FACTORS:</u>***

***Risk***
**What level of confidence is there based on the data/information regarding option?**

High: High level of confidence in data available based on a proven record of 5+ facility years of operation
Information regarding design has been widely proven on the full scale commercial industrial process applied on the same streams and in the similar environment
A data base containing full set of design data is in existence and is in compliance

with regulatory (licencing) reporting

Moderate: Limited confidence in data available, based on a record of 1-4 years of operation
Design information is proven, but with certain modifications and/or process restrictions
Limited design data are available

Low: Little confidence in data available, based on a record of less than 1 facility year of operation
Unproven information. Process was not used for the same streams and/or in similar environment
Process was never fully developed to a commercial production scale in the past
Lack of certain design data (data gaps)

**What is the level of health and safety risks for workers during normal and upset conditions?**

Low: Exposure expected during both normal and upset conditions is minimal or limited and controllable
Exposure through contact only
Automatic control eliminates risk
Regular maintenance requirements and conditions do not pose a risk to workers safety

Moderate: Exposure expected is substantial
Exposure during normal operating conditions is limited and controllable, but during upset conditions is substantial or unpredictable
Exposure through chemical hazards (by contact, inhalation, ingestion and noise)
Risk is mitigable with effective installation and operational housekeeping measures, including hygiene and PPE, adherence to certain procedures, and with education/training
Automatic control partially eliminates risk
Regular maintenance requirements and conditions pose a moderate and mitigable risk to workers safety

High: Exposure expected during either normal or upset operating conditions is high and uncontrollable, or unpredictable
Exposure through chemical (by contact, inhalation, ingestion, noise) and physical hazards (temperature, pressure) through breakdown of equipment
Automatic control does not eliminate risk
Regular maintenance requirements and conditions pose significant risk to workers safety, or are unknown

**What is the level of risk to the environment during normal and upset conditions and as a result of the process end or by-products?**

High: Low risk.
High confidence in operational process based on 5+ years of full scale operational data.
End products are known to be stable

Moderate: Minimal risk.
Confidence in operational process is based on 1 to 5 years of process data.

Some end products are unknown and/or known to need specific closure methods.

High: Known risk, or unknown operational process.
Some end products are known to be of concern.

***Service***
**What are system requirements, availability and risk?**

Low: Energy requirements comparable to current mill requirements.
Quantities of all consumables required are significantly less than the quantity of Arsenic dust
Consumables are readily available or relatively easy to obtain
Availability of consumables in the future is not expected to differ from their current availability, and is certain and predictable
Providing of consumables in sufficient quantities is not associated with significant difficulties and costs
No consumables are required

Moderate: Quantity of at least one of the consumables required is comparable with the quantity of Arsenic dust
Availability of consumables is limited
Availability of consumables is likely to decrease in the future
Providing of consumables in sufficient quantities is associated with moderate difficulties and costs

High: Quantity of at least one of the consumables required is significantly higher than the quantity of Arsenic dust
Consumables (in sufficient quantities) are not easily available
Availability of required quantities of consumables in future is uncertain or unknown
Providing of consumables in sufficient quantities is associated with high costs or is difficult
Energy requirements 75X current mill requirements

**What is the level of flexibility of the process to changes in feedstock quantity and physical and chemical properties?**

High: Good flexibility (or process insensitivity) to fluctuation in both feedstock quantity and quality
Process operates at 0-100% of design range

Moderate: Moderate sensitivity (some restrictions/problems) to fluctuations in feedstock quantity and quality
Process sensitivity to variations in feedstock quantity but not quality and vice versa
Flexibility is achievable with reasonable modification of the process (acceptable trade-offs)

Low: Process is highly sensitive (serious restrictions/problems) to variation in feedstock quantity and/or quality
Flexibility is achievable by serious modifications of the process (non-acceptable trade-offs)
Poor flexibility over design range
Flexibility of the process to changes in feedstock quantity or quality is not known

**How expediently would this process treat the Arsenic dust within 20 years?**

| | |
|---|---|
| High: | The most (80, 90%? - depending on the process conversion rates) of Arsenic is converted to a less soluble, environmentally inert form that does not require specific storage conditions<br>Small quantity of residue containing Arsenic dust and/or other contaminants requiring disposal is left behind (less than 10, 20% of initial volume?) |
| Moderate: | Limited amounts of Arsenic dust are converted (50-80%?)<br>Limited quantities of residues requiring disposal are left behind |
| Low: | Small amounts of Arsenic dust are eliminated (less than 50%?)<br>Big quantities of residue containing contaminants (including As) requiring disposal are left behind<br>No Arsenic dust is eliminated<br>Expedience of elimination of Arsenic dust is unknown |

*Impact*
**What number of jobs would be annually created (employment impact)?**

| | |
|---|---|
| High: | Continual employment for a large number of people of all educational profiles<br>More than a thousand person years of employment |
| Moderate: | Intermittent employment of a large number of people<br>Employment for smaller number of high profile workers<br>Between a hundred and a thousand person years of employment |
| Low: | No new employment provided<br>Short term duration (during construction and start-up) of high level of employment, followed by a continual employment of a small number of people<br>Less than a hundred person years of employment<br>Employment impact is unknown |

*Costs*
**What are capital costs?**

| | |
|---|---|
| Low: | Costs Less than $10,000,000 |
| Moderate: | Costs are between $10,000,000 and $50,000,000 |
| High: | Costs are more than $50,000,000 |

**What are O & M costs?**

| | |
|---|---|
| Low: | Costs Less than $1,000,000 per year |
| Moderate: | Costs are between $1,000,000 and $5,000,000 per year |
| High: | Costs are more than $5,000,000 per year |

**What are closure costs?**

| | |
|---|---|
| Low: | Costs Less than $1,000,000 |
| Moderate: | Costs are between $1,000,000 and $5,000,000 |
| High: | Costs are more than $5,000,000 |

# *Appendix F: Matrix & Score Results*

**Giant Mine Arsenic Trioxide Technical Workshop**
**Preliminary Evaluation Criteria and Matrix**

| Minimum Performance Criteria | Pass / Fail | Comparative Criteria | Option #: |
|---|---|---|---|
| **Process Understanding:**<br>➡ Is the process a proven technology for Arsenic?<br>➡ Does the process provide a complete solution to arsenic management?<br>➡ Can the process be initiated in 7 years and substantially completed in 25 years<br>➡ Can the process be operated in the Yellowknife environmental conditions if it is to operate in Yellowknife? | | Risk -<br>➡Has this process been used at a commercial scale for Arsenic or other comparable hazardous material before?<br>➡Has it been used in similar environmental conditions?<br>➡What level of confidence is there based on the existing data information regarding design?<br>➡What is the level of health and safety risk for workers during normal and upset conditions?<br>➡ What is the level of risk to the environment during normal and upset conditions and with respect to end products?<br>➡Can the option be implemented without the requirement for special worker training, procedures and equipment? | Y N<br>Y N<br>H M L<br>L M H<br>L M H<br>Y N |
| **Public Health and Safety.**<br>➡Does this process meet the current occupational and public safety standards and pose no known and unmitigable risk to public health and worker safety? | | Service:<br>➡What are system requirements, availabilities and costs of these requirements and costs?<br>➡What is the level of flexibility of the process to changes in feedstock quantity and physical and chemical properties?<br>➡Can this process eliminate the or use current arsenic dust production as well as treating current stockpiled arsenic?<br>➡How expediently and efficiently would this process treat the As over the next 20 years?<br>➡Can this process eliminate roaster emissions?<br>➡Is post implementation monitoring required for less than 5 years? | L M H<br>H M L<br>Y N<br>H M L<br>Y N<br>Y N |
| | | Impact:<br>➡Can the option be implemented without<br>- Air emissions?<br>- Flora and fauna?<br>- Aesthetics?<br>- Surface/ground water?<br>- Socio-cultural?<br>- Heritage resources?<br>➡Is the end product sold or segregated for possible sale in future? | Y N<br>Y N<br>Y N<br>Y N<br>Y N<br>Y N<br>Y N |
| | | Cost:<br>What are:<br>➡Capital costs?<br>➡O & M costs?<br>➡Closure costs?<br>➡Is there revenue recovery?<br>➡What number of jobs would be created by this option?<br>➡Does the option allow for on-going or future mining at Giant? | L M H<br>L M H<br>L M H<br>Y N<br>H M L<br>Y N |
| ***Matrix Criteria Legend***<br><br>**Left = Good**<br>**Right = Poor**<br><br>**Yes = Good**<br>**No = Poor** | | | |

The results of the matrix scoring completed by participants were tabulated as follows:

While all results were calculated, those options which received an absolute failure rate higher than 30% are not to be considered further at this time. The absolute failure rates are:

| Absolute Failure Rate | Option Number |
|---|---|
| 11% | 3 |
| 14% | 4 |
| 19% | 2 |
| 24% | 6 |
| 35% | 5 |
| 38% | 1 |
| 43% | 7 |

For those options that were scored, average scores were calculated for each response. The scores used in calculating these averages were:

High = 3
Medium = 2
Low = 1
Yes = 1
No = 0

Each cell was tabulated and averaged using the responses received for that cell. For example, for the criteria "What level of confidence is there based on the existing data/information regarding design?" for Option1:
12 evaluators answered High
11 evaluators answered Medium
1 evaluator answered Low
Total 24 evaluators

12X3+
11X2+
1X1
59

59/24=2.4

Therefore the average score for that cell was 2.4

These averages were then placed into six different weighting scenarios. The six weighting scenarios and the options ranking are presented below.

## Weighting Scenarios and Option Ranking Results

(Those options which failed to meet minimum performance criteria are not to be considered further at this time and are not included)

| Weighting Factor | RANK | | | |
|---|---|---|---|---|
| | **1** | **2** | **3** | **5** |
| Average of weights submitted | 3 | 2 | 4 | 6 |
| All weights equal (25) | 3 | 4 | 2 | 6 |
| Cost weighted at 0, all others equal (33.3) | 3 | 4 | 2 | 6 |
| Risk weighted at 60, all others equal (13.3) | 3 | 2 | 4 | 5 |
| Service weighted at 40, all others equal (20) | 4 | 3 | 2 | 6 |
| Unitized Average Weights | 3 | 4 | 2 | 6 |

Options Index

1. Pump and Treat
2. Solidification
3. Autoclave
4. WAROX/El Indio
5. Hot Water Leach
6. EMR Technology
7. Bio Leach

### Alternative Rank Order Proposal

The option was given to the participants to complete a ranking of the options on the third day of the workshop. The group consensus was to not complete a separate rank order but to work with the initial results from the evaluation.