

**Mackenzie Valley
Review Board**



Report of Environmental Assessment And Reasons for Decision

Giant Mine Remediation Project

EA0809-001

June 20th, 2013

Table of Contents

Review Board decision.....	i
Executive summary.....	ii
1 Introduction.....	1
1.1 Requirements of the Mackenzie Valley Resource Management Act.....	2
1.2 Regulatory history	2
1.3 Environmental setting	3
1.3.1 Biophysical setting.....	3
1.3.2 Traditional use	4
1.3.3 Giant Mine Remediation Project history	5
1.3.4 Existing infrastructure.....	6
1.3.5 Existing contamination	9
1.4 Description of development	10
2 Environmental assessment process	13
2.1 Parties to the environmental assessment	13
2.1.1 Participant funding.....	13
2.2 Environmental assessment phases.....	14
2.3 Decisions on significance.....	18
2.4 Scope of development	19
2.5 Scope of environmental assessment.....	20
2.5.1 Geographic scope of the Assessment.....	21
2.5.2 Temporal scope of the Assessment.....	21
2.5.3 Assessment of impacts	22
2.5.4 Giant Mine legacy issues	22
2.5.5 Net improvement and significance	23
2.6 The existing mine and cumulative effects.....	24
3 Public Concern	26
4 Engagement	28
4.1 Board analysis and conclusions: engagement	30

5	Perpetuity.....	32
5.1	Introduction	32
5.1.1	Perpetuity and the Project	32
5.1.2	The Temporal Scope of the Project and the EA	33
5.2	Evidence from Parties: Concerns about perpetuity	34
5.2.1	Conceiving of perpetuity.....	34
5.2.2	Perpetuity and future generations	36
5.2.3	Lessons learned, perpetual care planning and communication.....	37
5.3	Review Board analysis and conclusions: Concern and perpetuity.....	39
5.4	Evidence from Parties: Worst Case Scenarios, Project Design and Risk Assessment	41
5.4.1	Design for perpetuity	41
5.4.2	Worst case scenarios and perpetuity	45
5.4.3	The Developer’s risk assessment	48
5.5	Review Board analysis and conclusions: worst-case scenarios, design and risk assessment	52
5.6	Evidence from Parties: climate change and perpetuity	56
5.7	Board conclusions: Perpetuity and climate change.....	60
5.8	Reversibility	61
5.9	Financing and perpetuity.....	63
5.10	Research in Emerging Technologies	63
5.11	Review Board overall analysis and conclusions on perpetuity	66
6	Long-Term Funding	74
6.1	Evidence from the Parties: long-term funding	74
6.1.1	The Taylor and Kenyon funding report	75
6.1.2	The Kuyek lessons learned report.....	76
6.2	Review Board’s analysis and conclusions: long term funding	77
7	Oversight.....	81
7.1	Evidence from the Parties: public confidence in government as Developer.....	81
7.1.1	Multiple roles.....	82
7.2	Evidence from the Parties: Oversight.....	83
7.2.1	The Affolder Report on oversight at Giant Mine.....	84
7.2.2	Oversight working group	86
7.2.3	The Developer’s revised proposal for oversight.....	87
7.2.4	Oversight issues at the public hearing	88
7.3	Review Board analysis and conclusions: public confidence and oversight	91

8 Health Impacts94

8.1	Current contamination.....	94
8.2	Evidence from the Parties: Health Impacts	94
8.2.1	The Developer's human health risk assessment	94
8.2.2	Arsenic modelling.....	97
8.2.3	Cancer rates.....	98
8.2.4	Contaminants in food and drinking water.....	99
8.2.5	Contaminants in sediments and soils	100
8.2.6	Baseline health study	101
8.2.7	Public concerns over health	102
8.3	Review Board analysis and conclusions: Health Impacts	107
8.3.1	Conclusions on the human health risk assessment	107
8.3.2	Conclusions on health and public concern.....	113
8.3.3	General conclusions on human health assessment.....	114

9 Water Management116

9.1	Evidence from Parties: Baker Creek and flood risk	116
9.1.1	Worst-case flooding scenario for Baker Creek.....	116
9.1.2	Design criteria for Baker Creek flood management	117
9.1.3	Other potential causes of Baker Creek floods.....	118
9.1.4	Risks of Baker Creek to the underground mine after initial freezing	119
9.2	Board conclusions on risk from Baker Creek on frozen blocks.....	119
9.3	Evidence from Parties: Baker Creek as fish habitat.....	121
9.4	Review Board conclusions on impacts to fish habitat in Baker	129
9.5	Overall conclusions on Baker Creek.....	133
9.6	Evidence from Parties: Water Quality and the Diffuser	136
9.6.1	Arsenic loadings into surface waters	136
9.6.2	Overall impacts to water quality and aquatic life	137
9.6.3	Plant effluent, water quality objectives and the diffuser.....	139
9.6.4	Additional water treatment	140
9.6.5	Water quality concerns	141
9.6.6	Currents and the diffuser.....	143
9.6.7	Aquatic effects monitoring	145
9.6.8	Engineered wetlands for water treatment	146
9.6.9	The diffuser and ice thinning	146

9.6.10	Water treatment and outfall alternatives	147
9.7	Review Board analysis and conclusions: water quality	149
10	Freezing.....	155
10.1	Evidence from the Parties: freezing.....	155
10.1.1	Freezing design criteria.....	155
10.1.2	The freeze optimization study and the wetting study	155
10.2	Review Board analysis and conclusions: freezing	158
11	Surface Reclamation	161
11.1	Evidence from the Parties: surface remediation	161
11.1.1	Evidence from Parties: buildings and Infrastructure	161
11.1.2	Evidence from Parties: open pits and associated dykes.....	163
11.1.3	Evidence from the Parties: contaminated surface materials	166
11.1.4	Evidence from the Parties: waste management	171
11.1.5	Evidence from the Parties: site usability.....	173
11.2	Review Board analysis and conclusions: Surface Remediation.....	174
12	Traditional Use	181
12.1.1	The Developer's predictions	181
12.1.2	The evidence from the other Parties: traditional Use.....	182
12.2	Review Board analysis and conclusions: traditional use.....	185
13	Conclusions	188
	Appendix A: Summary of measures and suggestions	189
	Appendix B: Public registry index	197
	Appendix C: List of Developer's commitments	214
	Appendix D: Specific Risk Assessment Requirements.....	227
	Appendix E: Additional Health Risk Assessment Deficiencies	229
	Appendix F: Human Health Risk Assessment Requirements	232

List of Figures

Figure 1. Map of the Giant Mine location	4
Figure 2. Locations of arsenic chambers and stopes.....	7
Figure 3. Locations of open pits and tailings ponds.....	8
Figure 4. Aerial view of tailings ponds.....	8
Figure 5: Giant Mine Remediation Project environmental assessment process	15
Figure 6: Review Board members and staff conduct a site visit of surface and underground facilities	16
Figure 7: Members of the public at the Sept. 11, 2012 public hearing.....	36
Figure 8: Baker Creek North Diversion contingency.....	128
Figure 9: The freeze optimization study	156
Figure 10: Buildings and infrastructure at Giant Mine.....	162
Figure 11: Giant Mine roaster complex	163
Figure 12: Current access restrictions.....	164
Figure 13. Removing contaminated soils.....	167
Figure 14: Yellowknives Dene Elders Isadore Tsetta, Michel Paper and Métis Elder Ed Jones at the Sept. 10, 2012 public hearing.....	183

List of Tables

Table 1: Arsenic Loadings to Surface Waters.....	138
--	-----

List of abbreviations

AANDC	Aboriginal Affairs and Northern Development Canada
CCME	Canadian Council of Ministers of the Environment
DAR	Developer's Assessment Report
DFO	Department of Fisheries and Oceans
EA	Environmental Assessment
EMS	Environmental Management System
FMECA	Failure Mode Effects Criticality Analysis
GNWT	Government of the Northwest Territories
IR	Information Request
NSMA	North Slave Metis Alliance
YKDFN	Yellowknives Dene First Nation

Review Board decision

To make its decision in this environmental assessment, the Mackenzie Valley Environmental Impact Review Board (Review Board) has relied upon all the information on the Public Record. Having considered the evidence, the Review Board made its decision in accordance with section 128 of the *Mackenzie Valley Resource Management Act*.

Based on the evidence and submissions on the public record, it is the Review Board's opinion that the proposed Giant Mine Remediation Project is likely to cause significant adverse impacts on the environment, including cumulative impacts arising from the potential effects of the Project in combination with the effects of past activities. The Review Board also finds that significant public concern related to these impacts exists.

The Review Board has prescribed measures to mitigate these impacts, requiring that the Project timeframe be reduced from perpetuity to 100 years; facilitating ongoing research in emerging technologies towards finding a permanent solution; and requiring independent reviews of the Project every 20 years to evaluate its effectiveness and decide if a better approach can be identified.

Other measures prescribed by the Review Board include:

- a comprehensive risk assessment and human health risk assessment;
- human health monitoring;
- investigation of long-term funding options;
- independent oversight;
- diversion of Baker Creek;
- improvement of treated water quality to a drinking water standard;
- replacement of the proposed underwater diffuser near N'dilo with a near shore outfall immediately offshore of the Giant mine site; and,
- other measures to address the significant potential impacts of this Project.

It is the Review Board's opinion that the application of these measures will mitigate the causes of public concern.

The Review Board recommends, under subparagraph 128(1)(b)(ii) of the *Mackenzie Valley Resource Management Act*, that the Project be approved subject to the measures described in this report, which are necessary to prevent significant adverse impacts on the environment.


Richard Edjericon

Chairperson, Mackenzie Valley Environmental Impact Review Board

June 20th, 2013

Executive summary

This report describes the process, evidence, conclusions and decisions of the Mackenzie Valley Environmental Impact Review Board (Review Board) environmental assessment conducted on the Giant Mine Remediation Project (“the Project”) in the City of Yellowknife, Northwest Territories. The Developer of this Project is the Giant Mine Remediation Directorate and is led by Aboriginal Affairs and Northern Development Canada (AANDC) and the Government of the Northwest Territories (GNWT).

Proposed development

The Giant Mine site is located within the City of Yellowknife boundary, approximately 1.5 kilometers from the community of N’dilo and nine kilometers from the community of Dettah. The underground chambers and stopes of the site contain over 237,000 tonnes of water soluble arsenic trioxide, and there are 13.5 million tonnes of contaminated tailings spread over 95 hectares (equivalent to approximately 175 football fields) on the surrounding Giant Mine site. The proposed Project involves remediating the Giant Mine site, including:

- managing underground arsenic trioxide dust by ground freezing;
- remediating the surface, including covering tailings, managing the open pits, demolition of contaminated buildings, and management of contaminated soils, all to industrial standards for future land use
- managing site water;
- releasing treated water through a diffuser in Great Slave Lake;
- minimizing the release of contaminants to the surrounding environment; and
- improving the condition of Baker Creek.

The Project’s Remediation Plan has two phases: (1) site remediation and (2) long-term operation, monitoring and maintenance. The Developer has proposed the project for perpetuity, meaning that the project is required to work for an unlimited period of time, and requires ongoing management, maintenance and replacement of important components forever. The Developer has committed to review the Project after 100 years in order to determine the effectiveness of the remediation and to determine the approach to continue.

The Project is intended to protect human health, safety and the environment. The Developer has proposed design modifications to the remediation plan and mitigations to improve the Project. Some key design modifications include the Developer’s efforts to design the freeze system for stabilizing the arsenic trioxide dust to remain effective under “worst case” climate change scenarios using a combination of active and passive freezing. The Project has also been improved through commitments made by the proponent.¹ These commitments were considered as part of the Project in the Review Board’s decisions on the significance of adverse impacts.

¹ See Appendix C for a list of the Developer’s commitments.

The Review Board's findings

The Review Board has carefully considered the following issues, and provided a series of measures and suggestions that will mitigate the significant adverse environmental impacts and resulting public concern, and improve the monitoring and management of potential impacts.²

1) Perpetual Care

The Developer proposed this Project with a perpetual timeline, meaning that the Project as proposed would depend on active maintenance and replacement of key components forever. Parties and members of the public told the Review Board that this concerns them greatly. The Review Board has considered the evidence, and concludes that the Developer's analysis that the Project can be adequately managed in perpetuity was based on questionable assumptions and inadequate risk assessment of worst-case scenarios, climate change, and availability of funding. The Review Board concluded that there is significant public concern related to the proposed timeframe, and, that given enough time, the Project is eventually likely to cause significant adverse effects. It has prescribed measures that will likely make it possible to identify a better solution in the future, and reduce the probability of the significant impacts that would otherwise eventually happen. These measures:

- limit the Project to a maximum of 100 years;
- require periodic review of the Project every 20 years; and,
- facilitate ongoing research in emerging technologies towards finding a permanent solution.

The Board also prescribed a measure to require a thorough risk assessment to properly predict and prepare for risks within the 100 year timeframe.³

2) Funding

The proposed Project relies on annual government appropriations. Parties and members of the public are concerned with having to rely on future governments to ensure that the Project has sufficient funds to keep people and the environment safe for the 100 timeframe prescribed by the Review Board. The Review Board has included a measure requiring the Developer to investigate sustainable funding options, and suggests that it consider an independently managed self-sustaining trust fund for this Project.⁴

3) Oversight

Parties and the public described many issues regarding trust in the government as Developer, and in particular with the multiple roles of AANDC as Developer, inspector, enforcer, and Responsible Minister, among others. To help build public confidence, the Developer and Parties created a working group during this environmental

² Appendix A includes a full list of measures and suggestions.

³ See section 4 for details.

⁴ See section 6 for details.

assessment to discuss and draft a legally binding environmental agreement that would create independent oversight of the Project. After much apparent progress, the Developer instead proposed a committee that is not independent and is not based on a legally binding foundation. The Board finds that independent oversight is necessary to address significant public concern and that it may also address significant adverse impacts. It has prescribed a measure requiring the Developer and Parties to negotiate an environmental agreement for the creation of an independent oversight body for the Project.⁵

4) Health effects on people

Parties and members of the public described their concerns about health effects from the Project and from existing arsenic exposures. The Developer conducted a human health risk assessment in 2006 to evaluate the potential impacts of contaminants from the Project in combination with other sources of contaminants. The results of this assessment led the Developer to conclude that the Project would not cause significant adverse health impacts.

Health Canada identified problems with the Developer's health risk assessment, some of which do not appear to have been addressed since the health risk assessment's completion in 2006. The Board noted other shortcomings in the Developer's health risk assessment. In order to mitigate health effects and concerns, the Board has prescribed measures requiring the Developer to conduct a broad health effects monitoring program that includes people in N'dilo, Dettah and Yellowknife. The Board also prescribed a measure requiring an independent comprehensive human health risk assessment.⁶

5) Baker Creek

Some open pits are hydraulically connected to underground chambers that contain arsenic trioxide. When considering proposed water management for the site, the Review Board examined the potential risks to the containment of contaminants from Baker Creek flooding into open pits. The Board concludes that Baker Creek is unpredictable and poses unacceptable risks to important parts of the Project and to the downstream environment.⁷ Considering the flooding risks posed by Baker Creek and their potential effects on the freezing and containment of underground arsenic, the Board found that keeping Baker Creek on the mine site is not an acceptable risk. It has prescribed a measure that requires the Developer to divert Baker Creek around the mine site, and treat contaminated surface runoff that enters the former channel of Baker Creek.⁸

The Project proposes to rehabilitate Baker Creek to make it more attractive fish habitat. The Board considered the current and future importance of Baker Creek as fish habitat. Although used by fish now, the creek is highly contaminated, and will continue to be so for a very long time. The fish have elevated arsenic levels in their flesh, and after leaving Baker Creek, they mix with other fish in Yellowknife Bay where they may be caught by

⁵ See section 7.3 for details.

⁶ See section 8 for details.

⁷ See section 9.2 for details.

⁸ See section 9.5 for details.

people fishing, including traditional harvesters. The Board does not agree that the Developer should create habitat that will attract fish to a contaminated site.⁹

6) Treated water quality and the diffuser

The Developer proposes a water treatment process that would result in treated water containing 100 µg/L of arsenic going to Great Slave Lake through a pipeline to a diffuser approximately 300-400 meters north of the tip of N'dilo. The diffuser would mix and dilute treated effluent with lake water until it reached an arsenic concentration below 5 µg/L.

Many Parties expressed concerns about the Project relying on the mixing zone in the lake, and the proposed concentration of arsenic in already treated water which required further dilution in the lake. The Developer has not completed its modelling or studies of the currents in the lake. The effluent coming out of the diffuser would also contain heat, and Parties were concerned that this had the potential to affect ice thickness and human safety, particularly in spring and fall. Several other issues were identified related to water.

The Developer stated that water could be treated to a higher standard equivalent to drinking water quality, which would not require the diffuser. The Board requires the Developer to treat water to drinking water quality, and has prescribed other measures to ensure that the Project does not harm water quality or fish, including a comprehensive effects monitoring programme.¹⁰

7) Management of underground arsenic trioxide dust by ground freezing

The Board considers that the Developer's design for creating the frozen shell or blocks of underground stored arsenic trioxide appears to be sound, from an engineering perspective, for the Review Board's prescribed 100-year Project lifespan. Many aspects of the engineering design for freezing have not been completed, including some that may result in significant environmental impacts. For example, the Developer has not yet decided if it will be freezing the arsenic chambers, or freezing shells around them. The Board requires the Developer to conduct a comprehensive risk assessment on both options, and to not adopt any freezing method that is predicted to significantly reduce opportunities for other remediation by future technologies, including potential future arsenic removal.¹¹

8) Traditional Use

The Review Board heard from the Yellowknives Dene about the impacts and related concerns of the Giant Mine on traditional uses of the area. They were concerned that parts of the remediation work could combine with existing contamination to further affect traditional uses, either through direct cumulative impacts or through perceived contamination. The Board has recognized various ways that impacts from remediation could combine with the existing Giant Mine contamination to affect harvesting downstream. The Board has

⁹ See section 9.4 for details.

¹⁰ See section 9.7 for details.

¹¹ See section 10.2 for details.

prescribed measures that will help address these concerns and suggests the Developer engage in further consultation with Aboriginal groups on this subject.¹²

9) Engagement

The Review Board heard Aboriginal groups describe their concerns regarding the adequacy of the Developer's engagement efforts. They said that there was relatively little community engagement until the environmental assessment began, and even with the environmental assessment, most engagement has occurred during the past few years. Much of the main Project design, including selection of remediation methods, was completed with little apparent Aboriginal engagement. Surrounding communities have different views of the acceptability of different parts of the proposed Project. The Review Board does not believe it is sufficient to postpone important aspects of community engagement on the topic of acceptable Project design until after the environmental assessment is completed.¹³ The Board suggests further consultation with surrounding communities prior to finalizing the Project design.

Because of the uncertainties that resulted from a lack of information due to incomplete studies and designs, as well as problems with both the Developer's risk assessment and the human health risk assessment, and considering the scale of the hazard in proximity to a large population, the Board has taken a precautionary approach in its deliberations for some of the issues above.

Based on the above, the Review Board finds that the Project is likely to have significant adverse impacts on the environment, and that there is significant public concern related to these impacts.¹⁴ The Board has proposed measures that will mitigate these impacts and address the corresponding public concern.

To summarize some of the above, these measures include requirements to:

- limit Project life to 100 years instead of perpetuity
- do a more thorough risk assessment
- divert Baker Creek around the Project site to reduce risk of accidents and malfunctions
- conduct an independent revised health assessment and a health monitoring program
- create an independent monitoring body with a sound legal basis
- treat water to drinking water quality
- release treated water immediate adjacent to the mine site through an outfall, instead of through a diffuser off the tip of N'dilo

With these and other measures to mitigate identified impacts and related concerns, the Review Board has concluded that the Project should proceed to the regulatory phase for approvals.

¹² See section 12 for details.

¹³ See section 4 for details.

¹⁴ The full report includes specific findings of impact significance for each issue where measures are prescribed.

1 Introduction

This *Report of Environmental Assessment and Reasons for Decision* was prepared by the Mackenzie Valley Environmental Impact Review Board (Review Board, the Board) for the Giant Mine Remediation Directorate's (AANDC and GNWT) proposed Giant Mine Remediation Project. The purpose of this report is to:

- a) satisfy the reporting requirements of the *Mackenzie Valley Resources Management Act* (the *Act*) Sections 121 and 128;
- b) convey the Review Board's decision and reasons on whether the proposed development is likely to be the cause of significant adverse impacts on the environment or be a cause of public concern;
- c) summarize the relevant evidence on which the decision is based; and
- d) document relevant parts of the environmental assessment.

This Report of Environmental Assessment is organized as follows:

- **Section 1** provides background information on the regulatory history and referral of this development to the Review Board. This section also sets out the requirements of the *Act* and provides a brief description of the development proposal.
- **Section 2** describes the Review Board's environmental assessment process for this Project¹⁵. It provides information about the Parties to this assessment and the steps the Review Board took to identify any significant adverse impacts or public concern as required by section 128 of the *Act*. This section also describes the scope of the assessment and how the Board considered general topics that apply to several aspects of the development, such as cumulative effects, the legacy issues related to Giant Mine, and the net improvements in light of significance determinations.

The remainder of the document focuses on assessment of potential impacts and public concern,

- **Section 3** describes the Board's consideration and conclusions regarding public concern about the Project in general. Concerns about specific issues are addressed in their respective sections.
- **Section 4** describes issues related to community and stakeholder engagement.
- **Section 5** describes the evidence and Board conclusions about the perpetual timeframe proposed for the Project.
- **Sections 6 to 12** outlines selected subjects that the Review Board examined during the impact assessment, including potential impacts related to funding, oversight, health, water management, freezing, surface reclamation and traditional use. These sections each include a summary of the evidence, the Review Board's analysis and conclusions, and any mitigations and suggestions by the Review Board.
- **Section 13** summarizes the environmental assessment decision. It includes a general summary of conclusions and measures to avoid or reduce impacts.

¹⁵ In this report, the words "Development" and "Project" are used interchangeably. The *MVRMA* refers to "developments", while the Developer in this case refers to its proposed activities as the "Project".

The Review Board has considered all of the evidence on the public record.¹⁶ This Report of EA only addresses the issues that, in the Board's view, warranted further discussion.

1.1 Requirements of the Mackenzie Valley Resource Management Act

The Review Board derives its decision-making responsibilities in relation to the proposed development from Part 5 of the *Act*. The *Act* requires the Review Board to consider a proposed development's biophysical, socio-economic and cultural impacts on the environment, in accordance with Sections 114 and 115. The Review Board conducted this environmental assessment based on its *Rules of Procedure* and *Environmental Impact Assessment Guidelines*.

Under subsection 117(1) of the *Act*, the Review Board must decide on the scope of the development. The Review Board must also consider the factors set out in subsection 117(2), which are further described in Section 2 of this report. The Review Board is required to determine whether the proposed development is likely to cause a significant adverse impact on the environment or to be a cause of significant public concern.¹⁷ The *Act* also requires the Review Board to prepare a Report of Environmental Assessment.¹⁸

Once the federal Minister and Responsible Ministers accept the Review Board's Report of Environmental Assessment, the Developer¹⁹, government and regulatory authorities must ensure that any approved measure is carried out.²⁰

1.2 Regulatory history

AANDC submitted an application for a Type A Water License (MV2007L8-0031) to the Mackenzie Valley Land and Water Board on October 19, 2007. The Mackenzie Valley Land and Water Board (MVLWB) notified the Review Board and other interested Parties on October 26, 2007 that the application was complete and that it had commenced its preliminary screening of the development. On February 21, 2008, the MVLWB completed the preliminary screening and determined that it was unlikely that the proposed Project would have a significant adverse impact on the environment or be a cause of public concern.

Notwithstanding this decision, the City of Yellowknife referred the application to environmental assessment on March 31, 2008. The referral was based on the Project's potential to adversely impact the environment within municipal boundaries (PR#1). On April 7, 2008, the Review Board notified the Developer that it had initiated an environmental assessment of the Giant Mine Remediation Project.

The Developer of this Project is the Giant Mine Remediation Directorate and is led by Aboriginal Affairs and Northern Development Canada (AANDC) and the Government of the Northwest Territories (GNWT).²¹

¹⁶ The Public Record refers to the portion of the Public Registry that the Review Board relies on when reaching its decision. It contains all the evidence from the Parties submitted during the environmental assessment.

¹⁷ Subsection 128(1)

¹⁸ Subsection 128(2)

¹⁹ The "Developer" for this project refers to AANDC and the GNWT.

²⁰ Section 62 and subsection 130(5)

1.3 Environmental setting

1.3.1 Biophysical setting

The following description of the proposed development's biophysical setting is based on AANDC's Developer's Assessment Report (DAR).

The Project is situated on the northwest shore of Yellowknife Bay on Great Slave Lake, within the city limits of the City of Yellowknife, about 5 km north of the city centre. The region around Giant Mine is characterized by cool summers, very cold winters, and low humidity. In general, the terrestrial environment in the area has been degraded by industrial impacts and proximity to urban development.

The dominant hydrological feature in the site study area is Baker Creek. The creek originates upstream of Giant Mine and drains in a generally southward direction into Yellowknife Bay. The environmental quality of the creek has been adversely affected by historic mining operations. Great Slave Lake is drained by the Mackenzie River, which flows north to discharge into the Beaufort Sea. The terrestrial environment of the regional study area is broadly defined as the taiga shield, characterized by a heterogeneous distribution of jack pine and black spruce forests, discontinuous permafrost, Archean bedrock, and a large number of lakes and wetlands. The total area of lands covered by this project equals 949 hectares, or 9.49 km³ (PR#139 pp1.1, 1.7, 7.82).²²

The mean annual precipitation for Yellowknife is 281 mm, approximately 116 mm of which typically falls as snow. Average maximum temperatures in July are around 21.1° C. Average minimum temperatures in January are around -30.9 ° C (PR#139 p7.40). The catchment area of Baker Creek, running through the Giant Mine site, is estimated to drain an area of approximately 144-178 km². The largest recorded flood flow for Baker Creek was 8.5 m³/s, equivalent to about 70 L unit discharge per second per square kilometer of the watershed (PR#139 p7.4).

Wildlife that can be found near the Giant Mine Remediation Project site include a variety of fish species, muskrat, moose, caribou, local, migratory and aquatic birds, wolverine, and black bear. Northern pike, longnose sucker, white sucker, lake herring, burbot and grayling are now the most commonly found species in Baker Creek. Studies of fish communities in the lakes around Yellowknife show that the species present are typical of cold, northern lakes with low productivity. Twenty-four fish species have been identified in Great Slave Lake and the Yellowknife River (PR#139 pp7.65-7.88).

²¹ The Developer is also referred to as "The Giant Mine Remediation Team" and "the Project Team". For consistency, outside of quotations, the body of this report will refer to it as "the Developer".

²² This report references documents on the Public Registry with the initials PR followed by the registry number of the document and specific page numbers where appropriate. Appendix B provides a listing of the documents on the Public Registry by number.

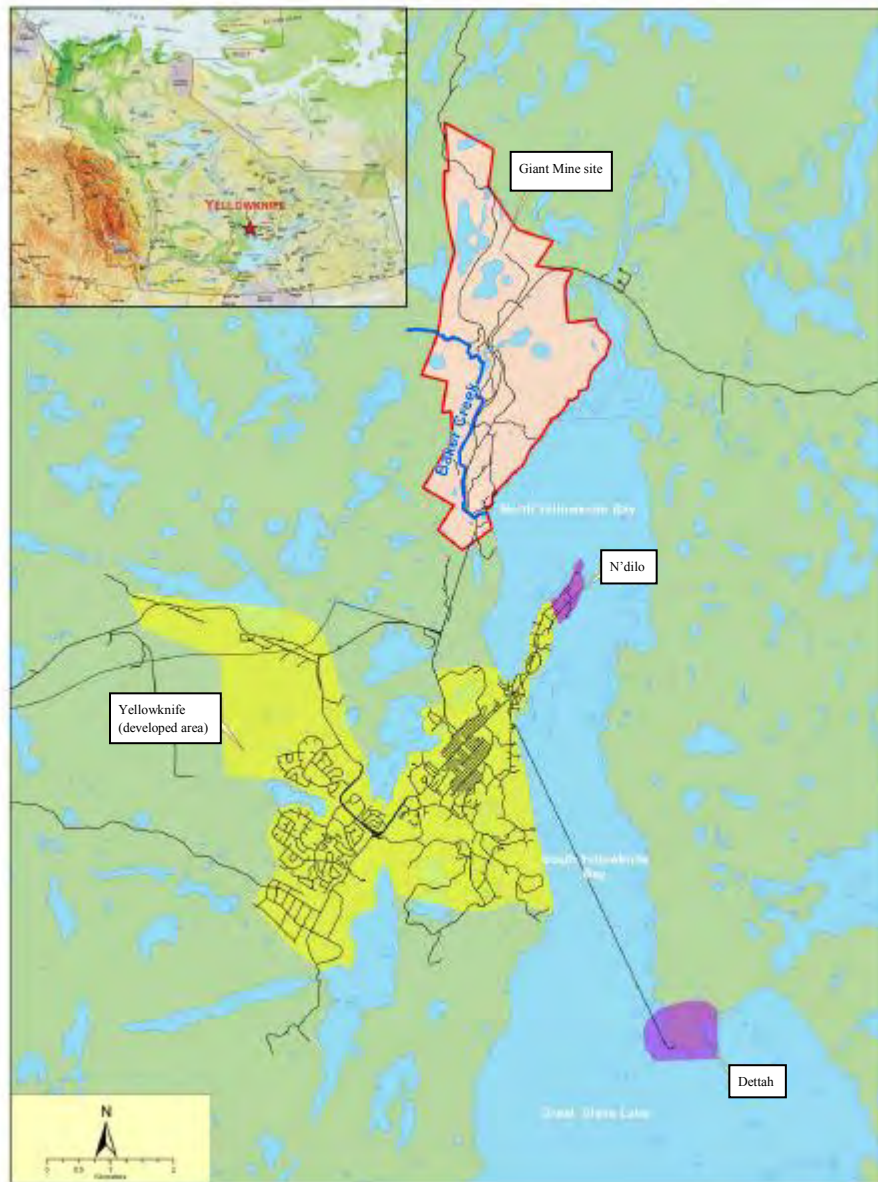


Figure 1. Map of the Giant Mine location
(Source: PR#139 fig.1.1.1)

1.3.2 Traditional use

The Tlicho, Akaitcho, and Métis have traditionally used the area around Yellowknife for traveling and camping while harvesting fish, berries and wildlife. The earliest written records of the area make reference to a semi-permanent fishing camp located across Yellowknife Bay, in the area now known as Dettah. Traditional land use activities within the Giant Mine lease boundary are currently restricted. While the remediation of the site might encourage traditional activities, the site will be within the boundaries of the City of Yellowknife and, as such, some restrictions will continue to be enforced. Since the mid-part of the 20th century, traditional use of the land and waters around Giant Mine has been curtailed due to a combination of habitat degradation associated with industrialization, increased human activity and concerns about contamination (PR#139 p8.96).

1.3.3 Giant Mine Remediation Project history

Giant Mine Development

The purpose of the Giant Mine Remediation Project is to mitigate the environmental risks that have developed over more than 50 years of industrial activity. The development at Giant Mine commenced in 1945 after nine years of exploration by Burwash Yellowknife Mines Ltd. Giant Yellowknife Gold Mines Ltd. was incorporated in 1937 after Yellowknife Gold Mines Ltd. acquired the assets of Burwash. After changing hands several times, Royal Oak Mines Inc. maintained operations from 1990 to 1999 when it went into receivership.

A court-appointed receiver transferred control of the property to AANDC²³ in December 1999. Immediately, Miramar Giant Mine Ltd. purchased Giant Mine from AANDC. Under the terms of the purchase agreement, AANDC indemnified Miramar Giant Mine Ltd. for existing environmental liabilities at the site. Concurrently, GNWT indemnified AANDC for certain liabilities associated with the surface of the mine. Until July 2004, Miramar mined a small amount of ore from Giant Mine, under the terms of a reclamation security agreement. This ore was processed at the Miramar-owned Con Mine on the west side of Yellowknife Bay. No processing of ore has taken place on the Giant Mine site since 1999. Giant Mine became ‘orphaned and abandoned’ when Miramar Giant Mine Ltd. was assigned into bankruptcy by the NWT court in 1999 (PR#139 pp4.2-4.7).

While in operation, three underground mining methods were employed, including cut and fill, shrinkage, and open stoping. By October 1950, cut and fill became the preferred mining method. Mine rock, natural surface gravel and tailings were used as the backfill material.

In 1974, once the known economic reserves were practically depleted, open pit mining began. A total of eight pits were developed until open pit mining ceased in 1990. After that, ore was exclusively extracted again from the underground workings (PR#139 p4.6).

Processing at Giant Mine

Roasting was the only efficient oxidation process available when Giant Mine was developed. An ore processing system was designed to concentrate the gold-bearing sulphide minerals using froth floatation, and then to roast the sulphide concentrate in preparation for cyanide leaching.

Ore processing began on May 12, 1948. Gold was recovered using both mercury amalgamation and cyanidation methods until 1959, at which time amalgamation was discontinued. Problems with the roaster resulted in arsenic trioxide deposits that tended to block the dust collector and emission stack. With the introduction of a new two-stage roaster in May 1952, mill tonnage was increased from 425 tons per day to 700 tons per day. Tonnage was again increased in 1958 to 1000 tons per day with the introduction of another new two-stage roaster which replaced the two older models. This roaster remained in operation until ore processing ceased in 1999 (PR#139 p4.7).

²³ At the time of the transfer AANDC was referred to as the Department of Indian Affairs and Northern Development (DIAND). To avoid confusion, this report of EA uses the current title of the department (AANDC). Where quotations are used, they include the name of the department used by the speaker (eg. INAC).

1.3.4 Existing infrastructure

The Giant Mine site has over 100 buildings associated with underground activities, the townsite, ore production and processing, and water treatment. Inspections carried out in 1998 by Royal Oak Mines identified asbestos containing materials, lead-based paints, and potential PCB contaminated materials, in addition to arsenic dust, as remediation concerns.

Progressive reclamation Projects conducted since 1999 include the demolition of some fuel storage tanks, electrical transformer stations, surface crusher and rock breaker structures, utilidors and other small buildings. Asbestos-containing materials were placed in sealed containers and buried in an on-site landfill. Other on-site infrastructure includes Northwest Territories Power Corporation power lines, various roads, fences and gates, and a number of equipment salvage and laydown areas (PR#139 pp5.67-5.68).

Thirteen arsenic trioxide dust chambers and stopes, 12 of which contain arsenic trioxide dust totalling approximately 237,176 dry tonnes remain underground at the Giant Mine site [Figure 2].²⁴ All of the chambers and stopes are located in the central area of the mine site, close to the processing plant where the dust was originally produced. The chambers and stopes are relatively close to the surface, with most of the excavations extending from about 20 m to about 75 m below the ground surface. All of the chambers and stopes are sealed by concrete bulkheads. Arsenic trioxide dust was distributed pneumatically through a series of pipes, most of which are still in place, likely containing residual arsenic trioxide dust. Some pipes have been moved to a location inside the perimeter of future freeze holes but many pipes are currently inaccessible (PR#139 pp5.1-5.7).

Other underground mine workings form a network of connected voids several kilometers in length, including horizontal drifts, inclined raises, vertical shafts, ramps, chutes, and ore stopes to a total depth of 610 m below the surface. There are currently 35 openings from the underground system to the surface that have been temporarily sealed or require inspection to determine adequacy. Additionally, there are approximately 27 000 known exploration and production drill holes, many thousands of which intersect the underground mine workings (PR#139 p5-24; p5-35).

There is a significant amount of remaining underground infrastructure and equipment. Most of the equipment and mine safety systems (ore and waste rock handling systems, ventilation systems, mine dewatering systems, and distribution systems for fresh water, compressed air and electricity) that remain in place are considered non-hazardous. Some facilities, however, in which hazardous materials were used or handled also remain. These include various maintenance shops, fuel and storage areas, explosives storage areas, and electrical systems (PR#193 pp5.24-5.30).

²⁴ Any references to “chambers” containing arsenic in this report refer to both chambers *and* stopes as described here.

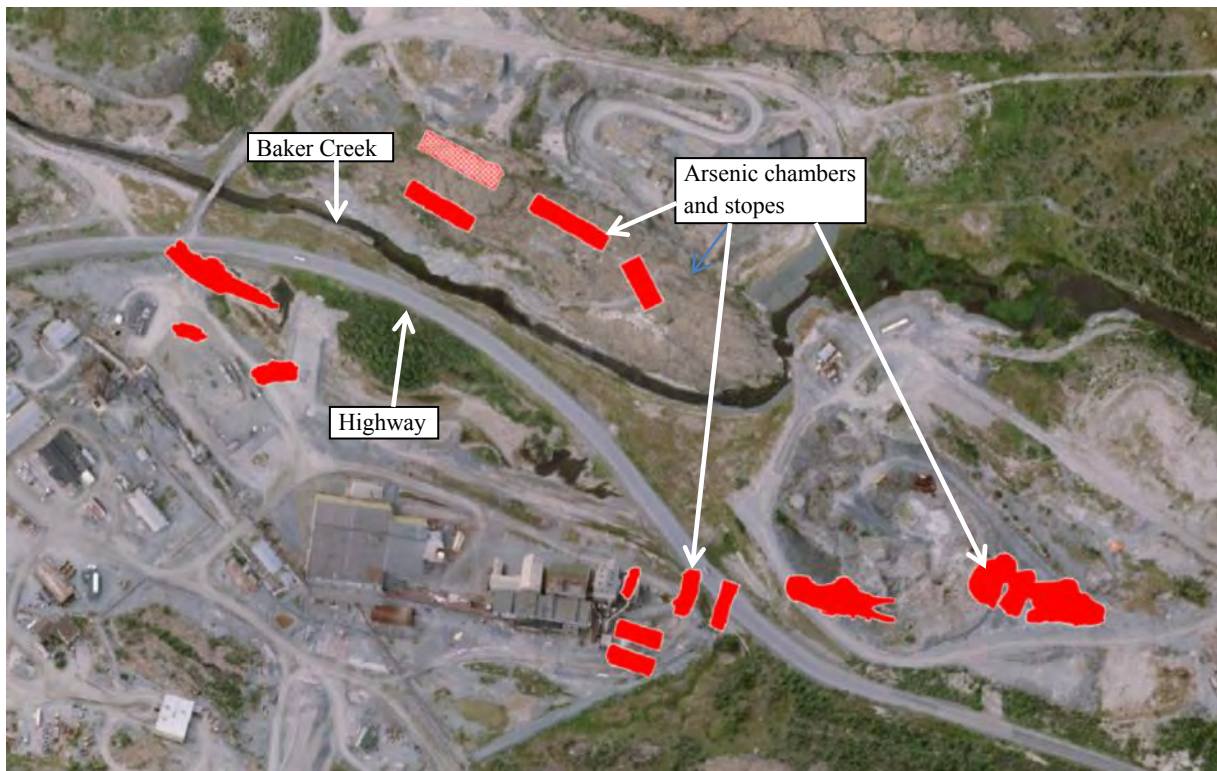


Figure 2. Locations of arsenic chambers and stopes.

[Modified from PR#348 p31]

There are a total of eight open pits on site which include numerous interactions with the underground mine workings (Figure 3). There is an existing dam at the B3 pit. In order to mitigate an uncontrollable leak from the B2 pit dyke in 2007, the B2 dam was built to prevent possible flooding of the mine. The A1, A2, and C1 pits have been backfilled with a total of approximately 66,000 m³ of till and waste rock. Tension cracks and subsidence are evident and the material is not considered stable for the long-term (PR#193 pp5.37-5.40).

Most of the waste rock produced from the mine was used as construction material in tailings dams and site roads. There are currently three small waste rock piles immediately south of the B2 pit containing approximately 12,000 tonnes of rock. There are also two overburden stockpiles on the site, located immediately north of the A1 Pit. There are few exposed quarries since mine rock was used for most construction activities (PR#139 p5.61).

Approximately 9.5 million dry tonnes of tailings were originally deposited in the North, Central and South Ponds (Figure 3, Figure 4). Between 1988 and 1990, 2.5 million tonnes of these tailings were reprocessed and transferred to the Northwest Pond in addition to the existing 4 million dry tonnes. The tailings in these ponds cover a combined surface area of 95 hectares, with a maximum tailings thickness of about 22 m. These tailings are impounded by a series of dams consisting of different combinations of waste rock, sand, clay, and gravel (PR#139 pp5.41-5.45).



Figure 3. Locations of open pits and tailings ponds
 [Modified from PR#348 p31]



Figure 4. Aerial view of tailings ponds

Aerial view facing NNW from above the southern end of the south tailings pond [Photo: PR#560 p13]

The northwest pond currently plays an important role in site water management, providing the majority of the capacity for storing contaminated water, holding about 900,000 m³. If required, the south pond could hold an additional 20,000 m³ and the north pond about 70,000 m³. Water reclaimed from the northwest pond and north pond is treated through an on-site water treatment plant, consisting of a primary and secondary circuit each

containing three agitator tanks. The settling and polishing ponds form another part of the current water treatment system. These ponds have had this function since 1981 when the first comprehensive treatment of mine water began. A rockfill dyke constructed on top of previously deposited tailings served to retain sludge produced by the water treatment plant in the settling pond, while allowing relatively clear water to seep into the polishing pond. The volume of sludge currently stored in these ponds is estimated to be between 250,000 and 450,000 m³ (PR#139 pp5.45-5.47). The maximum practical treatment rate for water through the settling and polishing ponds is approximately 7000 m³ per day.

Flooding of the lower levels of the mine was initiated in July 2005. Currently, water is pumped from the 750 Level Supercrest sump directly to surface and is discharged into the northwest pond at rates between 2000 and 4000 m³ per day (PR#139 pp5.51-5.52). Surface water runoff is managed using a series of diversion systems and sumps to avoid the collection of water in the open pits. Most water is directed to Baker Creek. Water with high arsenic content is pumped to the south pond or underground for storage and treatment (PR#139 p5.55).

1.3.5 Existing contamination

The mining area at Giant includes many contaminated areas with elevated levels of arsenic on the minesite, downwind and downstream, shown in various studies carried out from 1973 to 2004. Some of this is a result of releasing tonnes of airborne arsenic daily out the roaster for years. As described above, the chambers contain over 237 000 tonnes of water soluble arsenic trioxide, and there are 13.5 million tonnes of arsenopyrite contaminated tailings spread over 95 hectares. Soils, sediments in Baker Creek and Back Bay, fish and buildings are contaminated with arsenic, some of it at high, potentially hazardous concentrations, including the following:

- measured levels of arsenic in Baker Creek waters range to a maximum level of 12,600 µg/L;
- arsenic levels in Back Bay water reach a maximum of 740 µg/L;
- arsenic levels in south Yellowknife Bay reach 350 µg/L, and north Yellowknife Bay levels reach 83 µg/L (PR#139 p2.5);
- fish in Baker Creek and have elevated arsenic levels in muscle tissue up to 0.37 mg/kg (PR#139 p2.6). Some fish in Yellowknife Bay also have elevated arsenic levels;
- Sediment studies from Baker creek show measured arsenic levels reaching a maximum of 3,757 mg/kg (dry weight), and Back Bay measured arsenic levels in sediments attain a maximum of 3,140 mg/kg (dry weight).
- On site arsenic levels in soil reach a maximum of 87,000 mg/kg (dry weight), while arsenic levels in soil at the Giant Mine townsite reach 16,600 mg/kg (dry weight) (PR#139 p2-8). When soil arsenic content is more than 340 mg/kg, soil leachate arsenic concentrations ranged to 231 mg/L (PR#139 p5.65).
- Some soils in the City of Yellowknife were measured to contain 1 190 mg/kg (dry weight) of arsenic, soil arsenic levels on Latham Island reach 780 mg/kg (dry weight) and in Dettah soil arsenic levels reach 144 mg/kg (dry weight) (PR#139 p2.8);
- Arsenic concentrations in tailings range from 2000 to 4000 mg/kg with some samples attaining 5000 mg/kg. Dissolved arsenic is also found within tailings pore water. Release of arsenic from solid tailings combined with tailings pore water arsenic could cause arsenic levels to exceed effluent quality criteria (PR#139 p5.49). Large quantities of tailings and waste rock were used as backfill throughout the mine site (PR#139 p5.26);

- In the northwest pond arsenic levels in water average 15mg/L but can be as elevated as 20 mg/L (PR#139 p5.47);
- The mill and roaster areas harbor the highest arsenic concentrations (PR#139 p5.65). The estimated volume of soil with concentrations greater than 340 mg/kg of arsenic is 170,000 m³ (PR#139 p5.66). Surfaces in the mill and roaster are coated with dust containing arsenic and cyanide. There are approximately 700 tonnes of process residues with arsenic concentrations over 10 000 mg/kg. (PR#139 p5.67)

1.4 Description of development

The specific objectives of the Giant Mine Remediation Project are to (PR#139 p6.1):

1. Manage the underground arsenic trioxide;
2. Remediate the surface of the site to industrial guidelines under the NWT *Environmental Protection Act*;
3. Minimize public and worker health and safety risks;
4. Minimize the release of contaminants; and
5. Restore Baker Creek to a condition that is as productive as possible.

The Project is proposed to continue in perpetuity. In the first fifteen years the Developer proposes to install the freezing system, freeze the ground and immobilize contaminants. This will be followed by ten years of monitoring. This will be followed by periodic monitoring, maintenance and replacement of several components forever, such as thermosyphons, the water treatment system and diffuser and the water collection system. Some components require ongoing care and management for their continued operation in perpetuity.

Following initial implementation of the freezing, the arsenic storage areas will be fully frozen and the freezing system will be converted to a passive system designed to maintain the frozen state indefinitely (PR#139 p6.4). In total, the DAR proposes the installation of nearly 900 freeze pipes for a cumulative length of about 65,000 m (PR#130 p6.23). Application of the ground freezing is expected to take up to ten years. All arsenic distribution pipes outside of the frozen block will be dismantled and placed within a frozen block zone for long-term disposal and all mine drifts leading to a frozen block zone will be plugged (PR#139 p6.17).

If an active or hybrid freezing system is required, one or more freezing plants will be constructed. The currently preferred location for a single freeze plant is central to the four freezing areas, in close proximity to a new water treatment plant. Coolant distribution piping will tie the freeze plant to the freeze pipes (PR#139 p6.25).

The underground workings have a large inventory of arsenic contaminated materials that will release arsenic into the minewater once flooded. The concentrations of arsenic are expected to remain elevated over the long term beyond the 25-year temporal scope of the Project²⁵ meaning that minewater will continue to need to be contained and treated for the foreseeable future. Materials to be removed from the mine will include heavily contaminated arsenic materials from safely accessible underground workings, hydrocarbon products from maintenance shops and storage areas, and explosives. These materials will be brought to surface for disposal in

²⁵ See section 2.5.2 for details on the temporal scope.

accordance with procedures appropriate to the material type (PR#139 pp6.47-6.48). Finally, mine openings will be permanently sealed or controlled with a lockable gate or door.

As long as the mine water requires treatment for discharge, water levels in the mine workings will be maintained below the bottom of the open pits to prevent the formation of contaminated pit lakes. A combination of remedial action will take place with the open pits, ranging from remaining open with physical barriers to prevent access to completely backfilled with clean fill or a blend of clean fill, waste rock, and contaminated soils. Where possible, surfaces and slopes of the pits will be revegetated (PR#139 p6.51-6.55).

Tailings and sludge containment areas will be covered and re-graded to facilitate surface water run-off. The proposed tailings covers consists of a lower coarse protective layer of gravel, crush or quarry rock and an upper vegetation support layer of silt and clay. The settling and polishing ponds will be covered in a manner similar to that of the tailings. To minimize settlement of the cover, it may be underlain with a filter cloth or contaminated soils. The historic foreshore tailings area will be stabilized using geotextile and riprap below the lake surface (PR#139 pp6.65-6.67).

Surface waters from remediated areas that do not meet discharge criteria will be collected and directed underground to the mine water system for eventual treatment. A new mine water pumping system will be installed on the surface that will provide full control of the underground water levels (PR#139 p6.71). A new water treatment plant will be constructed and operated year-round, potentially in perpetuity. The discharge point for treated mine water will be moved from Baker Creek to Yellowknife Bay following the construction of a new outfall diffuser (PR#139 p6.4). This will be located in Great Slave Lake approximately 400m north of N'dilo (PR#576 p80, 130, 196; PR#562 p17). The estimated quantity of contaminated water that will be treated and discharged through the treatment process on an average annual basis is 540,000 m³ while the ground freezing is in progress and 345,000 m³ following freezing and tailings covering (PR#139 p6.75). Ongoing onsite disposal of sludge from the mine water will be required and might include a combination of disposal into mine voids (before they are frozen) and lined, engineered landfills that will eventually be covered (PR#139 p6.76).

With the exception of buildings that may be preserved for their heritage value, all existing structures will be removed. Existing roads will be reclaimed for use as fill or scarified and re-vegetated. Culverts will be removed and swales cut to facilitate surface water drainage. Hazardous materials will be placed in engineered facilities, and soils exceeding industrial soil contamination criteria will either be removed or covered with clean fill (PR#139 p6.4).

The Developer proposes to physically stabilize Baker Creek to improve both the quality and quantity of aquatic habitat. Sections of the Creek will be upgraded to decrease the risk of flooding the mine and some diversions may be introduced. Exact plans have not yet been identified and consultation activities continue (PR#130 p6-86).

All enclosed areas will remain under the control of AANDC and the GNWT (PR#139 p6.4).

The remediation implementation phase is expected to create almost 2.5 million person-hours of work and there is expected to be 16 long-term, full-time equivalent positions created for operations and maintenance post-remediation (PR#139 p6-106). The Developer's target is to have 60% of the Project's contract value and 60% of the person-hours of training to go to Northerners and Aboriginals (PR#595).

Certain aspects of Project design are as yet incomplete, including important decisions about tailings covers and monitoring (PR#354 pp185-225), remediation options for Baker Creek. (PR#139 p6-88; PR#577 pp17-18; PR#598 p2), whether to wet and freeze the chambers and stopes or instead create a frozen shell around the dry cold but unfrozen chambers (PR#561 pp193-207), and closure objectives (eg.PR#494; PR#575 p150). The Board has taken a precautionary approach in its deliberations for some of the issues in this report in response to these uncertainties that resulted from incomplete studies and design. This is reflected in the measures the Board has prescribed.

2 Environmental assessment process

This section describes the Review Board's environmental assessment process for this Project. It provides information about the Parties to this assessment and the steps of the process the Review Board took to identify any significant adverse impacts or public concern. This section also describes the scope of the assessment and the changes to the proposed development's design that occurred during the assessment.

2.1 Parties to the environmental assessment

Ten Parties participated in this environmental assessment. According to the Review Board's *Rules of Procedure*, the Developer is a registered party. The other registered Parties were:

- City of Yellowknife
- Kevin O'Reilly
- Environment Canada
- Department of Fisheries and Oceans Canada (DFO)
- GNWT Department of Environment and Natural Resources
- Yellowknives Dene First Nation (YKDFN)
- North Slave Métis Alliance (NSMA)
- Bob Bromley
- Alternatives North

During the environmental assessment process, representatives of government departments and other interested groups had the opportunity to identify their interests and to notify the Review Board of their intent to participate in the proceeding as an interested party. Parties to the environmental assessment had the opportunity to attend and actively participate in the process.

Though some Parties did not actively participate in all the stages, all information exchanges between the Developer and Parties can be found on the public registry. Kevin O'Reilly stopped participating as an individual and began participating on behalf of Alternatives North on December 6, 2010, when Alternatives North applied for party status (PR#155). All Parties actively participated in technical sessions and in final public hearings.

The *Terms of Reference* for the DAR outlined the Parties' roles and responsibilities. The Developer was responsible for producing the information necessary for the Review Board and the Parties to evaluate the potential impacts of the proposed Project on the environment.

2.1.1 Participant funding

An unusual aspect of this environmental assessment was the provision of general participant funding. This is the first time that AANDC has made participant funding generally available to Parties for an environmental assessment. AANDC made \$250,000 available to facilitate Parties' participation. The availability of such funding was advertised in local newspapers and by the Review Board on November 19th 2010. Funding was fully allocated by an independent decision-maker and awarded to Alternatives North, the North Slave Metis Alliance and the Yellowknives Dene First Nation on January 27, 2011. AANDC did this as the lead department responsible for the *MVRMA*, and not as the Developer.

The Board notes that Parties cooperated to maximize the value of the funding they received. Noteworthy examples of this are:

- The Yellowknives Dene and Alternatives North co-sponsored a perpetual care workshop in Dettah in September 2011 (PR#362)
- The Yellowknives Dene and Alternatives North co-sponsored an oversight workshop in Yellowknife in March 2012 (PR#412).
- The Yellowknives Dene, the City of Yellowknife and Alternatives North jointly commissioned a report entitled *Independent Environmental Oversight: A report for the Giant Mine Remediation Environmental Assessment*, referred to in the following sections as “the Affolder report”, from the University of British Columbia Faculty of Law (PR#185) and arranged for the lead author to present at the public hearing.
- The Yellowknives Dene, the City of Yellowknife and Alternatives North jointly commissioned the Taylor and Kenyon report on *Giant Mine Perpetual Care Funding Options* (PR#420) and arranged for the lead author to present at the public hearing.

The cooperation between the Parties is also reflected by their acceptance of each other’s positions and conclusions for issues of shared interest. For example, the YKDFN and Alternatives North have worked closely in this environmental assessment. Each of their technical reports draws on information from information requests by the other in reaching their conclusions (PR#482; PR#523), and the YKDFN has indicated that it accepts the conclusions of Alternatives North (PR#577 p386). The NSMA has also said that Alternatives North’s conclusions reflect theirs closely (PR#576 p270).

The Board notes that participant funding allowed for better input from the Parties, enabling them to hire technical expertise and to commission useful research applicable to the issues of the environmental assessment. These have brought relevant information to the Board’s consideration.

2.2 Environmental assessment phases

After the referral in March 2008 the Review Board conducted this environmental assessment in five broad phases: a start-up phase, a scoping phase, an analytical phase, a hearing phase, and a decision phase. See Figure 5 for tasks associated with each phase of the environmental assessment. A more detailed interactive summary of the actual EA timeline compared to the original timeline, showing detailed milestones and identifying causes of delays, is available Review Board’s website.²⁶

The Review Board issued the draft *Terms of Reference* to the distribution list for comment, in March 2009, and after considering all comments from Parties and issued the final *Terms of Reference* in May 2009. The Terms of Reference defined the scope of development, the scope of assessment and provided direction to the Developer and the Parties about their roles and responsibilities in the environmental assessment process.

On October 20, 2010, Review Board members and staff conducted a site visit [Figure 6].

²⁶ See http://reviewboard.ca/registry/project.php?project_id=69

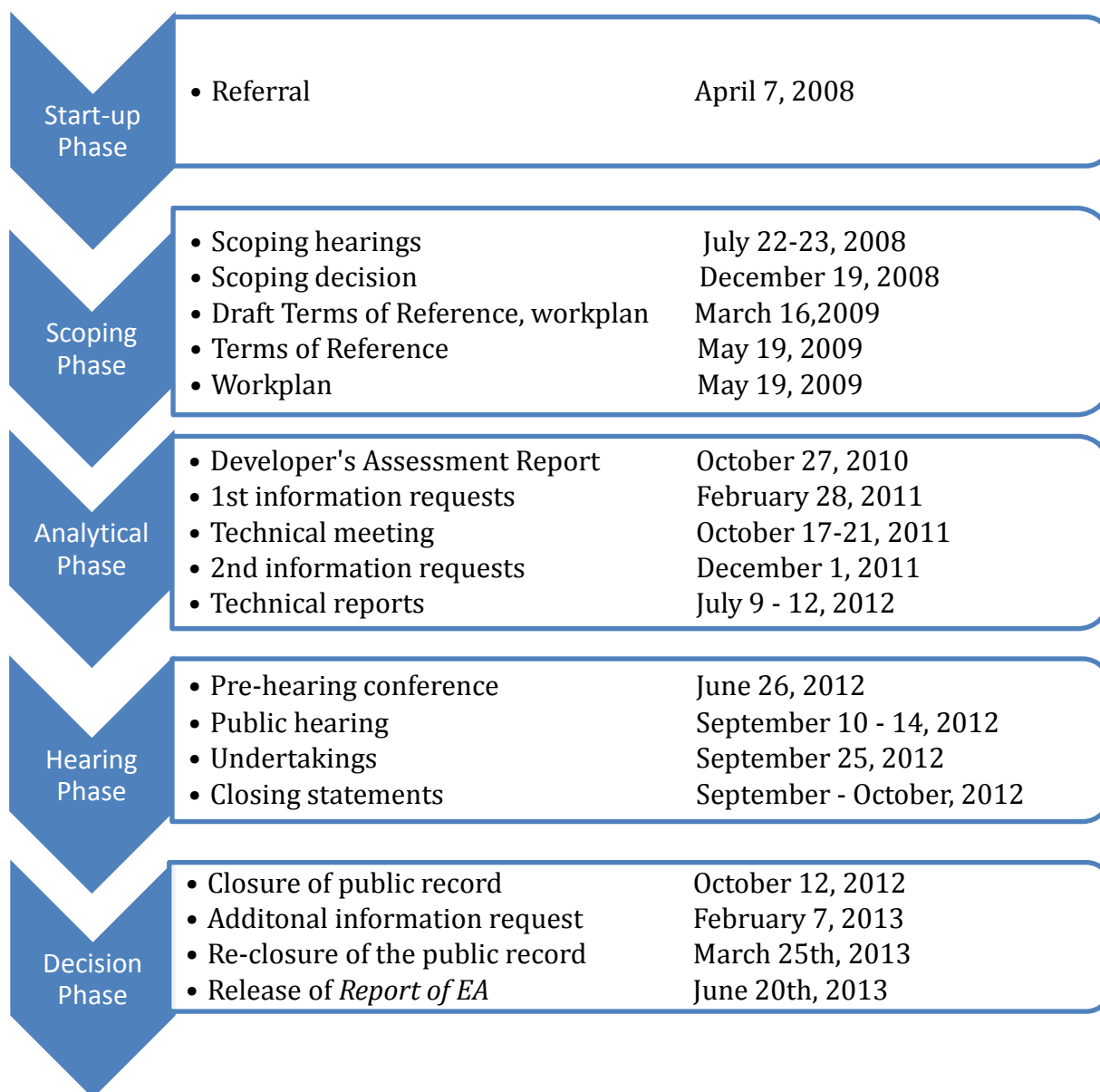


Figure 5: Giant Mine Remediation Project environmental assessment process

Development of Work Plan and Terms of Reference

The Review Board issued the first draft Work Plan in May 2008. This document established milestones and identified the Review Board's timelines and expectations for the completion of the environmental assessment. Parties to the environmental assessment submitted comments on this draft in June 2008. On July 22 and 23, 2008, the Board held a scoping hearing. After considering evidence and arguments from Parties and the public and deliberating on the scope, the Review Board issued the Draft Terms of Reference and a revised draft Work Plan in March 2009. Parties to the environmental assessment submitted comments on these drafts in April 2009. The Review Board considered these comments and issued the final Terms of Reference and the final Work Plan on May 12, 2009. The Work Plan was revised on Dec 10, 2010 and again on November 24, 2011 to

provide updated overviews of timelines for upcoming phases on the assessment. The nature of this development, in terms of the potential severity and scale of the adverse impacts and its close proximity to a large community, necessitated a more thorough and careful examination by the Review Board.



Figure 6: Review Board members and staff conduct a site visit of surface and underground facilities
(photo: Review Board)

Developer's Assessment Report (DAR)

The Developer submitted the *Developer's Assessment Report* (PR#139) according to the Terms of Reference in October 2010. On November 26, 2010, the Review Board issued a deficiency statement identifying four Terms of Reference items that were inadequately addressed. The Developer responded on December 13, 2010 and on December 21, 2010, the Review Board issued a conformity statement accepting that the Developer's Assessment Report and associated submissions were in conformity with the Terms of Reference.

Information requests and technical sessions

December 24, 2010, the Review Board asked Parties to provide their first round of written information requests for questions and clarifications on the Developer's Assessment Report. A deadline for responses of January 24, 2011 was set and subsequently extended to February 28, 2011. The Developer was requested to respond to the Parties' information requests and provide reasons to the Review Board in the event that they could not answer any given request. In May and June 2011, the Developer provided its responses to the Parties' first round of information requests.

On October 17-21, 2011 Review Board staff hosted a five-day technical session in Yellowknife so that Parties could seek clarification on responses to the information requests and discuss remaining issues face to face with the Developer's representatives.

Following the technical session, the Review Board gave Parties the opportunity for a second round of information requests, due November 30, 2011. The Developer responded to the Parties' information requests on February 17, 2012.

After the second round of information requests, the Review Board set a deadline of March 16, 2012 for Parties to submit their final technical reports. On March 12, 2012, the Developer informed the Board that it would not be prepared for a public hearing scheduled for mid-April until mid-May. As a result, the technical report submission deadline was extended to April 16, 2012.

Pre-hearing conference

Review Board staff hosted a pre-hearing conference on June 26, 2012 to discuss public hearing procedures and to set an agenda for public hearings in Yellowknife. Parties were invited to participate in person or by teleconference.

Public hearings

From September 10 to 14, 2012 the Review Board held public hearings in Yellowknife and included an evening session in Yellowknife on Sept. 11, 2012 and an evening session in Dettah, NT on Sept. 12, 2012. Radio, posters, newspapers and webpage announcements notified the public prior to the public hearing. The public hearing was an opportunity for the Parties and community members to raise concerns and to allow the Developer to share its views with members of the Review Board.

The Developer and other Parties gave presentations to the Review Board. All Parties had the opportunity to question both the Developer and the other Parties involved. The Parties highlighted direct and indirect impacts of the proposed development and presented final impact predictions and mitigation suggestions to the Review Board.

Public hearing follow-up, final submissions and closure of the public record

During the public hearings, the Review Board required the submission of undertakings from the Developer and other Parties. Responses to these undertakings were submitted to the Review Board on Sept. 25, 2012.

The Review Board accepted closing comments from Parties on Oct. 5, 2012 and final submissions from the Developer on Oct. 11, 2012. The Review Board closed the public record after receipt of the Developer's final public hearing submission.

Emergency exemptions and the scope of EA

On March 13th, 2012, the Developer notified the Review Board that it dismantling the mill conveyor because of its deteriorating condition and risk of harm to workers on site, among other risks (PR#403). The mill conveyor structure has not been maintained since the mine closed and recent inspections indicated structural degradation of the A-frame structure that supports the elevated conveyor. The Developer specified that it was proceeding with this as emergency work under subsection 119(b) of the *Mackenzie Valley Resource Management Act* (PR#415).

The Developer applied to the Mackenzie Valley Land and Water Board for a water licence related to demolition of the roaster complex²⁷ and underground stabilization activities on December 19th, 2012, stating this too was

²⁷ The Roaster Complex includes the Dorrco Building, Cottrell Building, AC Roaster/Pipe Shop, baghouse, calcine plant, fanhouse, arsenic silo and scale house, exterior roaster flues, and roaster stack.

being conducted as emergency work under subsection 119(b) of the *Act* (PR#629). On March 8th, 2013, the Developer further described the emerging conditions and “potentially catastrophic” threat to public and environmental safety under which it was applying for emergency exemption from part 5 of the *Act* (PR#630 p4). On March 13th, 2013, the Review Board indicated it was “... prepared to remove these particular aspects of the Project from the scope of the environmental assessment at this time, to facilitate emergency response, provided that it does not compromise or foreclose mitigative options for the remainder of the Project” (PR#617).

Deliberation and additional Information Requests

After the closing of the public record, the Review Board considered all submissions on the public record in its decision. After careful consideration of the evidence, the Review Board re-opened the public record and issued additional information requests to the Developer regarding alternative water treatment methods on February 7th, 2013. Developer responses and Party comments were received on March 14th, 2013 and March 25th 2013, respectively, and the record was subsequently closed.

Environmental assessment decision

The Board resumed its deliberations on March 25th, 2013. Based on these deliberations, the Review Board has prepared this Report of Environmental Assessment and Reasons for Decision for submission to the Minister of Aboriginal Affairs and Northern Development Canada as required by subsection 128(2) of the *Act*.

2.3 Decisions on significance

Section 128 of the *Act* requires the Review Board to decide whether or not in its opinion the proposed development will likely have a significant adverse impact on the environment or be a cause of significant public concern.

During the course of the environmental assessment, the Review Board asked the registered Parties to assist by providing their own views of the predicted impacts and their significance. The Review Board considered the following ‘significance characteristics’ of the environmental impacts identified:

- magnitude
- geographic extent
- timing
- duration
- frequency
- nature of the impact
- reversibility of the impact
- probability of occurrence
- predictive confidence level

Sections 4 to 12 of this report describe the Review Board’s analysis and the reasons for its decisions on the significance of the adverse impacts that are likely to result from the proposed development.

The proposed Project is unusual with respect to its proposed duration and the potential hazard, related in part to its scale and location. This Project involves risks of a different nature from those considered in most environmental assessments. Determination of the significance of potential impacts from this project will involve balancing both the potential likelihood and severity in significance characteristics described above. Effectively, this is an indicator of risk. In the case of this proposed Project, for some lower probability impacts where the potential severity is high (eg. “worst-case” type scenarios) there is potential for significant effects. For most

Projects the Review Board has dealt with in the past, the potential significance has arisen from more probable effects of lower severity than those considered for this particular Project.

The Board has carefully considered this in light of its statutory framework. Subsection 114 (c) of the *Act* states that one of the purposes of Part 5 is “to ensure that the impact on the environment of proposed developments receives careful consideration before actions are taken in connection with them”. Section 115 requires the process to have regard to “(a) the protection of the environment from the significant adverse impacts of proposed developments; and (b) the protection of the social, cultural and economic well-being of residents and communities of the Mackenzie Valley”. This is clearly intended to protect the environment and people from the adverse impacts of proposed developments that matter most.

In this report, likelihood must be read in the context of risk. In this case, dealing with low-probability high-consequence events, the significance of potential effects modifies the likelihood that is acceptable in the Board’s significance determinations. Where the Board identifies an unacceptable risk of impact likelihood and impact severity, the Board will identify it as likely to be a cause of significant adverse effects. It will do so based on its own determination of the risk, regardless of whether or not the impacts’ significance arises from a higher-probability lower-consequence risk or from a lower-probability higher consequence risk (such as a potentially rare but very severe impact).

2.4 Scope of development

The scope of development considered in this environmental assessment takes into account both principal and accessory development activities. It also outlines activities that will occur under the land use permit, water license or other regulatory instruments, as required. These activities cannot exceed the scope of environmental assessment without requiring further preliminary screening.

The scope of development was initially based on the water licence application submitted by AANDC to the Mackenzie Valley Land and Water Board during preliminary screening, and which was included in the Terms of Reference issued by the Review Board in May 2009. The scope of development identified here includes all relevant changes and, in the Review Board’s opinion, accurately reflects the Giant Mine Remediation Project as currently proposed. This includes the commitments included in the Developer’s Revised Commitments Tables for the Giant Mine Remediation Project - August 2012 (PR#489) (included in Appendix C of this report), additional commitments specifically identified by the Review Board in the following sections of this report (also summarized in Appendix C), and all other commitments made by the Developer on the public record.

The scope of the development includes all components listed in the Giant Mine remediation plan. This includes the following principle works and activities:

- Immobilization of arsenic trioxide through ground freezing (the frozen block or frozen shell method);
- On-going treatment of contaminated water to remove arsenic. This includes:
 - Construction of a new water treatment plant;
 - Treatment using additives to initiate the precipitation of arsenic from water;
 - Storage of treated water and eventual discharge to Great Slave Lake;
 - Storage and disposal of by-products of treatment;

- Removal of site infrastructure and materials, such as buildings, waste and contaminated material;
- Capping of tailings areas;
- Removal of contaminated soils from mine site and tailings areas;
- Rehabilitation of Baker Creek;
- Reclamation of open pits;
- Ongoing maintenance, monitoring, and management; and,
- Periodic replacement of components.

All of these components of the Project have been considered in the environmental assessment, including modifications identified by the Developer.

In its *Reasons for Decision* document of Dec. 19th, 2008 (PR#104), the Board decided that:

- The relocation of the Ingraham Trail highway is not within the scope of this Project.
- The Developer's Freeze Optimization Study is not part of the scope of this assessment, but does inform the assessment by refining the design of the proposed Project.
- Any activities conducted as emergency measures under section 119 of the MVRMA are not part of the scope of this Project.

2.5 Scope of environmental assessment

The scope of the environmental assessment identifies the issues and items the Review Board will examine during the process. The scope of assessment includes all potential impacts on valued components of the biophysical and the human environment (e.g. wildlife species or heritage resources) and public concern from the development, by itself and in combination with other past, present and reasonably foreseeable future developments as well as factors listed under subsection 117(2) of the *Mackenzie Valley Resource Management Act*.

To determine the scope of assessment, the Review Board reviewed AANDC's Project description summary and the relevant information available on the public registries of the preliminary screening and ongoing environmental assessment. The Review Board also conducted a scoping hearing in Yellowknife on July 22 and 23, 2008, where Board members heard directly from Parties on matters related to the scope. After considering the relevant information available on the public record, the Review Board issued a *Reasons for Decision* describing its determinations for the scope for this environmental assessment on Dec. 19th, 2008 (PR#104).

The Board decided that the issue of whether the site is remediated to an industrial or residential standard is not part of the scope of this assessment, but end land use of the site is within the scope.

The Board also made a decision dealing with specific alternatives to the proposed frozen block method. In 2002, the Developer struck an independent peer review panel with a wide range of technical expertise. That panel examined 56 alternatives, and identified the top three. After public sessions, Indian and Northern Affairs Canada ("INAC", now called Aboriginal Affairs and Northern Development Canada, or "AANDC") selected the current method. In 2008 the Review Board accepted that the Developer had done a thorough job of looking at alternatives, and that the current environmental assessment would focus on the proposed Project- that is, freezing the underground arsenic in place.

The Board does not rule out the idea that a better alternative may eventually exist, but excluded any discussions of specific alternatives from the scope of the current environmental assessment. The Developer has declared that the proposed method would be reversible, and that it would not prevent changing to a different method if a better technology emerges in the future.²⁸

In its decision on scope, the Review Board reserved the right to consider alternatives to the frozen block method “if compelling evidence that the review of alternatives was necessary was brought forward” (PR#104 p6).

The Review Board’s Terms of Reference stated that any issues related to arsenic trioxide (including its containment for an indefinite period underground and its contamination of the receiving environment) and questions related to monitoring and maintenance activities at Giant mine after the active freezing stage would be key lines of inquiry. The Terms of Reference specified that these would require the most attention during the environmental assessment and the most rigorous analysis and detail in the Developer’s Assessment Report. The Board’s consideration has included other issues that were progressively identified during the course of the environmental assessment.

As described in section 2, emergency work related to deconstructing the roaster complex and underground stabilization activities were removed from the scope this environmental assessment by the Review Board on March 13th, 2013 (PR#617).

2.5.1 Geographic scope of the Assessment

The geographic scope is limited to the area potentially affected by activities associated with the proposed Project. This area includes the Giant Mine site, the adjacent town site, a section of shoreline where historic tailings have been released, and the Cruising Club boat launch site.

The Review Board has assessed the potential impacts resulting from the Project proposed by the Developer and this Project, as proposed. This includes development activities that occur wholly within the Project areas identified in the Giant Mine remediation plan. While the Review Board has determined that the geographic scope is limited in this way, for the purpose of assessing potential impacts to valued components, such as impacts to water quality, it has considered a geographic scope that is appropriate to the valued component being assessed. For example, in the case of water quality, the Review Board considered potential downstream impacts in Great Slave Lake, not just impacts on waters within the Giant Mine site.

2.5.2 Temporal scope of the Assessment

The temporal scope of the Project, as described in the Terms of Reference (PR#116) includes five years of project initiation, the ten years predicted by AANDC for the ground freezing to be complete plus ten years of monitoring. The Review Board considers this 25-year period to be a reasonable timeframe of activities for which impact predictions can be made with a higher degree of certainty and confidence. The Terms of Reference specify that the development activities are those occurring within 25 years and extending to any further time required to stabilize the site. The Developer has since made it clear that contaminant levels on the site may take much longer than 25 years to stabilize. The temporal boundary refers to when development

²⁸ See sections 5.8 (Reversibility) and 5.10 (Research in Emerging Technologies) of this report.

activities occurred. It does not limit how long a period of impacts the Board will consider. The Board considered any relevant *impacts* arising from those activities, regardless of whether or not the impacts themselves occur within (or extend beyond) the first 25 years.²⁹

2.5.3 Assessment of impacts

Sections 4 to 12 of this Report of EA consider specific issues related to impacts that arose during the environmental assessment. The analysis in these sections is based on the public record. For each issue the Review Board describes:

- the evidence on the public record from the Parties and the Developer
- the analysis and conclusions of the Review Board pertaining to each issue; and
- any measures or suggestions by the Review Board.

The Review Board has considered all issues that Parties and the public raised in this environmental assessment, pursuant to the requirements of s.117 of the *Act*. The Review Board considered evidence from the public hearings as well as written evidence on the public record. This report does not discuss issues which the Review Board has decided are fully resolved by the material on the public record.

The only issues discussed in detail in this Report of Environmental Assessment are those that the Review Board decided warranted further consideration for the purposes of its decision under section 128 of the *Act*. The Board notes that within the framework of the *Act*, the significance determinations described in this report are not intended to limit regulators from drawing their own additional conclusions when carrying out their regulatory duties.

2.5.4 Giant Mine legacy issues

The Project is proposed at the Giant Mine site in response to the contamination caused by past mining activity. In the Review Board's *Reasons for Decision on Scope* (PR#104), the Board considered whether legacy issues would be considered as a part of the proposed development. After a scoping hearing and careful deliberation, the Board determined that the impacts of past mining activities are not part of the proposed development, saying (PR#104 p11):

The legacy impacts of mining, as described by the Parties, are unfortunate and regrettable. However, these mining activities were not conducted by the Developer in this EA. Also, they are not related to activities described in the GMRP, which is a reclamation project designed to improve environmental conditions at Giant Mine. It is the view of the Review Board that the scope of development be limited to the activities and work described in the Developer's application to the MVLWB for a water license (MV2007L8-0031). The remediation activities would be the cause of any direct impacts of this development and the scope of assessment will focus on any issues and concerns arising from those activities.

This decision that Giant Mine is not part of the proposed development does not mean that the Board will ignore the existence of Giant Mine or the contamination which resulted from the operation of this mine. Cumulative

²⁹ For further discussion of the temporal scope, see section 5.1.2.

effects are considered in the Board's environmental assessments. Appendix H of the Review Board's *Environmental Impact Assessment Guidelines* specify that this includes the impacts of a proposed development (in this case, the Project) with other past, present and reasonably foreseeable future developments.

The Giant Mine is a past development with impacts that potentially combine with those of the proposed Project. Parties spoke extensively to the Board about impacts from this Project in the context of past effects from Giant Mine. Potential changes in arsenic loads in people and the environment result from the proposed Project in addition to the existing loads, including from the largest industrial source of bioavailable arsenic in the vicinity, the Giant Mine. The combined result is an important consideration. The Board recognizes that Giant Mine was a separate project, and considers its effects in this assessment only in the cumulative context.³⁰

2.5.5 Net improvement and significance

A purpose of the proposed Project is to remediate contaminants. In the Developer's Assessment Report, the technical sessions and in the public hearing, the Developer has argued that compared to the current condition of the site as a baseline condition, the Project overall is an improvement of the environment (eg. PR#153 pES-8; PR#353 p91; PR#354 p159; PR#576 p148, p188-189, p222, p227). The Developer has emphasized this at several times during the environmental assessment when discussing the overall significance of impacts. The Board has considered, in light of this, whether this eliminates the possibility of significant adverse impacts resulting from the Project.

The intention for the Project to cause net benefits does not rule out the potential for it to result in significant effects. Even if the Project is beneficial overall, parts of the Project can cause significant impacts to certain valued components.

Assuming the entire Project proceeds exactly as planned, it will include:

- handling highly contaminated soils;
- disturbing arsenic-laden sediments;
- drilling into chambers of arsenic dust;
- demolishing and removing highly contaminated buildings; and,
- releasing contaminants from underground into surface waters via the diffuser;

These activities involve hazards of their own, to workers and to surrounding communities. These hazards are heightened by the location, which is:

- in the vicinity of the NWT's largest population;
- in the highly used setting of Back Bay;
- upstream of an area used for traditional harvesting; and,
- upstream of an area used by some as drinking water.

The proposed activities in that setting have the potential to cause significant impacts. It is possible for a project to cause significant impacts on specific areas even while causing a net improvement of a larger area.

³⁰ See section 2.6 (The existing mine and cumulative effects) for further discussion.

If the Project does not go as planned, many other potentially significant impacts could also occur. The potential for accidents and malfunctions, including worst-case type scenarios, raise the possibility of several other potentially significant impacts that must be considered for a proposal that depends on the storage and maintenance, forever, of 237 000 tonnes of a hazardous substance in a municipal area, using a new application of a complex technology at this scale.

Based on this, the Board concludes that the Project's intention to cause a net environmental improvement does not mean that the Project will not or cannot be a cause of significant adverse effects. The following sections consider the likelihood and significance of the Project's potential effects.

2.6 The existing mine and cumulative effects

The effects of this Project will not occur in isolation. From a cumulative effects assessment perspective, these must be considered in combination with the effects of other past, present and reasonably foreseeable future developments. In the case of the proposed Project, from a health perspective and from an environmental contaminants perspective, the Project may add to the historical and ongoing releases of arsenic from Giant mine and the mine site.

Proposed Project activities have the potential to disturb or relocate contaminants from areas affected by historical and ongoing releases, making them bioavailable. This includes the potentially hazardous activities described above in section 2.5.4 that may cause airborne dust contamination, such as handling highly contaminated soils, drilling into arsenic chambers and demolishing contaminated buildings. The proposed project also includes activities such as the proposed diffuser, which would release contaminants from underground into surface waters via the treated water. The DAR appears to recognize that these parts of the proposed Project could affect community well-being (PR#139 p8-94), but does not explicitly acknowledge the cumulative context.

The following are examples of Project activities have the potential to cause cumulative effects in combination with contamination that has resulted from past activities at the Giant Mine. For example, the proposed Project has the potential to:

- cause cumulative effects to water quality, sediment and fish;
- generate or release contaminated dust and volatiles, which may cause cumulative effects in combination with historical deposition of past contamination in the Giant Mine airshed; and
- contribute to cumulative body burdens of contaminants in people in addition to levels caused in part by past contamination.

The Review Board recognized that the Giant Mine was a separate development.³¹ However, for the reasons above, and considering that responsible cumulative effects assessment requires consideration of past activities, the Board has considered impacts from activities at Giant Mine where they are relevant to the assessment of cumulative impacts of the proposed project. Many participants in the environmental assessment expressed

³¹ See Section 2.5.4 for details

concerns about the potential for any arsenic released as a result of Project activities to combine with existing baseline levels of contamination caused by mining activities at Giant Mine.³²

³² See sections 3 (Public concern), 8.2.7 (Public concerns over health) and 12.1.2 (Traditional Use) for details.

3 Public Concern

The Board is required to consider public concern in its environmental assessments, and it does so in the following sections on specific issues. Some of the factors it considered when weighing the significance of public concern apply to all of the issues. Rather than repeat these in each of the following sections, these are presented here for later reference in this document.

In the *Review Board's Environmental Impact Assessment* (EIA) Guidelines, it describes attributes of projects that can cause public concern. Although this list is provided in the EIA Guidelines as a reference for Preliminary Screeners, the same list of attributes is useful for identifying potential public concern in other cases. These indicators are:

- development scale;
- proximity to communities;
- use of new technology;
- severity of worst case scenarios;
- proximity to protected areas; and,
- proximity to areas of known harvesting.

The Guidelines specify that where a project has any one of these attributes, the Preliminary Screener should be particularly careful to consider public concern. The Board notes that, in this case, the proposed Project has all but one of these attributes.

Many members of the public expressed their views during the public hearing, via letters, and in other submissions to the Review Board and expressed grave concerns about the proposed Project. None spoke in favour of the Project.

On Sept. 11, 2012, the Review Board held an evening hearing despite the occurrence of a storm and subsequent power failure prior to and during the public hearing session. Many members of the public made the effort to attend nonetheless and participated in the session until the Board closed the public hearing late at night. In the Board's view, the large number attendees that participated and their willingness to stay until late at night are indicators of their concern.

The demeanor of members of the public at the public hearing was observed by the Review Board. Members of the public were clearly describing serious concerns that were weighing upon them.

Similar concerns were voiced by Aboriginal Elders, residents of N'dilo and Dettah, MLAs, Aboriginal leaders, and urban non-Aboriginal residents of Yellowknife from many different walks of life. The Board also notes that public hearing participants included Chiefs, City of Yellowknife representatives, and two Yellowknife members of the Legislative Assembly of the Northwest Territories, Ms. W. Bisaro and Mr. B. Bromley, who would have heard concerns from their constituents, which include Yellowknife, N'dilo, and Dettah.

The Board has heard evidence that this Project, in combination with existing contamination, is a cause of widespread anxiety. Dene and Metis residents have emphasized that they are afraid (eg. PR#577 p366, p378). They have described their belief that arsenic is like a monster that is "killing us slowly" (eg. PR#264 pp346-

352, p391; PR#575 p117; PR#577 p346). Many non-Aboriginal residents also expressed their concern in strong terms, telling the Board “Don’t make us live with an anxiety of ‘what if’” (PR#576 p366). MLA Bob Bromley stated that “For residents, as we’ve heard, and indigenous people, awareness of this condition is psychologically pervasive and weighs on the mind” (PR#576 p372).

Based on the above, and many other strong statements made at the public hearing and in letters (eg. PR# 570; PR#584; PR#585), the Board concludes that this Project is a partly responsible for significant public concern that is widespread. The measures described in the remainder of this report will help to address this, by dealing with the otherwise significant adverse impacts that the concern is based on.

In the public hearing, the Developer has argued that the concern was not about the Project, but was actually about the historical activity that resulted in the enormous stores of arsenic trioxide at the mine (PR#560 p26). The Review Board has considered and rejects this argument. If there were no contaminants to contain, this public concern would obviously not exist. It is true that some of the concerns related to the decisions that allowed the present situation to develop over the course of more than 50 years of mining activity.

However, the concerns expressed by Parties went well beyond this. The Review Board is of the opinion that the concerns expressed related directly to project-specific and cumulative aspects of the proposed Project, and were not simply concerns about historical activities. In the public hearing, Chief Sangris specified that the YKDFN view both the historical contamination and the proposed clean up as separate wrongs (PR#575 p96).

This Report of EA focusses on the proposed Project, but must do so considering the setting in which it is proposed. Based on the concerns voiced in the public hearing, the Board is of the opinion that many participants are aware of the potential for arsenic released due to the proposed Project to combine cumulatively with existing the baseline levels of contamination caused by Giant Mine.³³ The Review Board finds that participants’ concerns are not only about the historical activity and current state of Giant Mine, but are about the proposed Project and its cumulative effects.

³³ See Section 2.6 for details.

4 Engagement

Throughout the technical reports, public hearings, and closing statements, several Parties, including Aboriginal Parties, told the Board that they were concerned that the Developer had not adequately engaged with them during Project design. The technical report of Alternatives North criticized the lack of public and Aboriginal involvement in the overall design of the proposed Project since 1999 (PR#482 p8). The same report criticizes more recent engagement effort by the Developer (PR#482 p10):

There is still no public demonstration of consent, let alone support, for the GMRP or the frozen block method from either the City of Yellowknife or the YKDFN. Recent performance by the Developers' on public engagement and work with the Parties to this Environmental Assessment does not bode well for the future. There is no 'social licence' for the GMRP to proceed and significant public concern lingers in the community.

In its closing statement, the Yellowknives Dene were also critical of the Developer's engagement efforts, saying "for far too long, this endeavour has been one-sided, with the proponent dictating to YKDFN and other Parties why the project is good for the people and the land without listening to very real concerns or addressing our needs" (PR#605 p1). The Yellowknives Dene's closing statement summarized the YKDFN view of engagement problems as follows (p9):

Moving forward, the first step the proponent needs to do is acknowledge that there are significant concerns with this project and embrace the Measures [proposed by YKDFN]. If the project were listening to the people, there would be no need to even state this- the Proponent would be proposing Measures to address the significant concerns. However, they continue to stand still- unmoving in their approach to this reclamation. That must change and they need to start listening to concerns. If the project approaches future operations that way- fighting every step, seeking to avoid obligation, failing to meaningfully respond, then this project will never succeed. We encourage the proponent to hear the message- to listen to the people. They must start working with us, in good faith, else the worst case that we all worry about will be at our doors.

The NSMA cited concerns about inadequate consultation in the public hearing and in its closing statement (PR#579 p59; PR#606 pp3-4).

The Kuyek report, entitled *The Theory and Practice of Perpetual Care of Contaminated Sites* and submitted by Alternatives North, discussed the subject of engagement, looking at examples elsewhere for applicability to the proposed Project. It observed that "There is a general consensus amongst all writers and case studies that local communities need to be involved in planning for long term care; in particular, the indigenous communities who have strong attachment to the very land upon which the waste repository sits" (PR#333).

Yellowknives Dene Chief Ed Sangris raised this issue at the public hearing (PR#575 p93):

My message to the government this morning, to the remediators, and to Board members, is a simple one: listen to the people and what they want. How they envision the future. Listen to the

people who were born here, who have lived here, and who use the land traditionally as part of their history and their culture. Listen to the people who will die here, and be buried here. And whose future generation will remain on the land forever.

In response to concerns voiced by Parties about a lack of engagement at the Developer's pre-hearing technical workshop in June 2012, the Developer committed to holding discussions with stakeholders at a later time, after receiving its water license, which will provide further details about operations on site (PR#516 p5).

The Developer described its public and Aboriginal engagement to date in its hearing presentation (PR#565). These included meetings from 1997 to present; in-person meetings; public sessions in Dettah, N'dilo, Lutsel K'e, Hay River and Yellowknife; sessions with the YKDFN and the Tlicho; the environmental management system working group of the Parties; the oversight working group; and the YKDFN Giant Mine Advisory Committee and Yellowknife Community Alliance. It recognized that current best practice in environmental management requires engagement of communities and citizens in the EMS (PR#579 p120), and said that "meaningful engagement is fundamental for the success of this project" (p122). The Developer, summarized saying it is "committed to working with the communities, the public and Aboriginal groups, to help achieve these goals, not only our goals, but the goals of the community moving forward" (PR#579 pp122-123).

The Parties raised contrasting views of past engagement by the Developer. In the public hearing, Parties described their concerns with the Developer's approach to engagement and the lack of public engagement to date on project design (PR#575 p178).

In response to similar concerns later in the public hearing, the Developer stated that its focus has been on managing the dynamic challenges of the site, and recognized that this focus has caused challenges related to community engagement (PR#579 pp138-139):

(W)e are challenged as the Developer, as the -- as the proponent, and as the organization trying to stabilize the site with the unfortunate situation that we have a site that's not waiting for all of us to get it together. That site is -- is doing it's own thing. It's -- it has a way of -- of morphing and evolving and changing. Our focus has been watching that while at the same time doing our very best to engage with communities, and incorporate the knowledge that exists in this community and -- and with the Aboriginal communities into that plan...

We're committed to [future engagement], but we're also committed at the same time to ensuring that the immediate problem, the arsenic trioxide and the rest of that site is stabilized and made safe, so that we have more time to engage and get the input from stakeholders on perpetual care on a number of issues that you've heard.

The City of Yellowknife told the Review Board that the September 2012 public hearing was... "the first time... there was authentic engagement with the public in terms of the socioeconomic interests and impacts, and particularly in the community of Dettah..." (PR#579 pp56-57). The City concluded that AANDC has not demonstrated authentic public engagement or a proper planning process on the real issues regarding the community interests.

In the public hearing, Parties told the Board that they were not sufficiently involved in the Developer's risk assessment (PR#575 p177), which the Developer has acknowledged (p179). The Developer said this would be part of the environmental management system, which is still under development.

In response to a question from the Review Board during the public hearing regarding engagement with Aboriginal communities, the Developer said "Our communication at times, fails" due to the challenges communicating about "a very complex site... at times across cultural divides, and across times with a long history" (PR#579 pp151-152). In the public hearing on the following day, during a discussion regarding ways of working with the City to examine options for controlling site use, the Developer reemphasized that its current focus is on stabilizing the site, and this may have detracted from its efforts on engagement but it would have "time to have a fully informed discussion going forward into the future" (PR#578 p116). At various other times in the public hearing, the Developer acknowledged that it had not engaged communities on various matters of interest to them, such as diffuser location, remediation objectives and Baker Creek, but planned to do so in the future (eg. PR#576 p235; PR#577 pp17-18, 51, 53, 96).

In its closing statement, Alternatives North described its concerns with the Developer's approach to engagement, including actions it believes were intended to avoid public scrutiny, and concluded that the Developer has never meaningfully engaged the Parties (PR#607 p2). Alternatives North sees an environmental agreement as an essential basis for a partnership that will help the Developer engage communities meaningfully. In its closing statement, Alternatives North says that "It is clear that past engagement activities have failed and the Developer should seriously consider a new approach and additional staff or expertise to carry out this important work, towards securing a social license to operate from communities" (pp3-4).

4.1 Board analysis and conclusions: engagement

The Review Board heard the Developer describe the numerous meetings and mechanisms it has undertaken for several years, and has heard Parties including Aboriginal groups describe their concerns with its adequacy. The Developer's presentations throughout the public hearing do not appear to reflect the full breadth of communities' concerns. There is an apparent gap between the Developer's view of community concerns and of the actual concerns expressed by community residents.

The Board acknowledges that conducting meaningful community engagement for a project like this is difficult. The Developer has described the challenges of discussing a technically complex project in a cross cultural setting, while simultaneously having to deal with emerging problems on site. The Board suspects that Aboriginal engagement has also been made more difficult by the lack of trust between Aboriginal Parties and the government, described below in section 7.1.

However, in the Board's opinion, meaningful engagement is particularly important for the proposed Project. The surrounding communities will have to live with the Project for many generations. Community members perceive risks to themselves and their families.³⁴ They see a large hazard upstream of the land they use traditionally.³⁵ The Board agrees with the Developer that meaningful engagement is fundamental to the success of this Project, which requires a social license to operate from the people that will have to live with it over

³⁴ See section 5.2 and 8.2.7 for examples.

³⁵ See section 12.1.2 for details.

multiple generations. The selection of alternatives and much of the main Project design was completed without much engagement.³⁶

Much of the Project appears to have been designed primarily from an engineering perspective. The Developer stated that its focus has always been on stabilizing the site (PR#578 p151). The Developer had indicated in the public hearing that it has not yet had community input on various parts of the Project including the diffuser location, and about Baker Creek. Similarly, when preparing the Failure Mode Effects Criticality Analysis (FMECA) risk assessment the Developer predicted certain risks, but never actually spoke with communities to find out their views on the acceptability of predicted risks.

In the Review Board's view, if the Developer had conducted thorough Aboriginal engagement about the proposed diffuser earlier in the Project design process, the Yellowknife's views of the importance of water quality with respect to the return of coney fish stocks to Yellowknife Bay and their cultural importance would have been heard.³⁷ The Developer would be in a better position to predict the Yellowknives' view of the acceptability of deliberately releasing arsenic from the diffuser into Great Slave Lake. Without early meaningful engagement, accommodating this difference was not given enough priority by the Developer during Project design.

The Board has concluded that additional consultation will help address the remaining concerns of surrounding communities, and makes the following suggestion:

Suggestion 1: The Developer should further consult with surrounding communities, including Dettah, N'dilo and the City of Yellowknife, prior to finalizing its Project design, so that design improvements may be incorporated to address any remaining concerns.

³⁶ Section 5.3 provides additional discussion on the importance of community engagement for the design of a project requiring long-term care. Engagement is also discussed in section 7.1.1

³⁷ See section 12.1.2 (Traditional use) for a discussion of the evidence from Yellowknives Dene related to the cultural importance of the return of the coney, and section 9.6.5 (Currents and the diffuser) for evidence regarding the return of the coney and YKDFN water quality concerns near the proposed diffuser.

5 Perpetuity

5.1 Introduction

The proposed Project requires perpetual care, meaning that its success depends on ongoing care and maintenance in perpetuity. This section examines the evidence regarding the perpetual nature of the Project, the implications of perpetual care in terms of risk prediction and assessment, Project design and public concern. The section also describes the Board's conclusions and recommendations.

5.1.1 Perpetuity and the Project

The Developer's Assessment Report (DAR) states that the Project's first objective is to, "Manage the underground arsenic trioxide dust in a manner that will prevent the release of arsenic to the surrounding environment, minimize public and worker health and safety risks during implementation, and be cost effective and robust over the long-term" (PR#139 pES-2). This indicates the Developer's intention to manage the arsenic to prevent its release over the "long term".

The Terms of Reference acknowledged the perpetual nature of the Project and identified several information requirements related to perpetuity (PR#116). The Developer was asked to:

- contrast the expected duration of the hazard against the expected lifespan of each component of its containment system
- discuss whether the frozen block method will protect the biophysical environment and the health and well-being of the human residents living nearby to the Giant Mine for as long as the contaminated materials persist at the site
- consider climate change and risk level over the long term, and
- describe any opportunity costs for future underground arsenic management and treatment options associated with the proposed development in terms of futures foregone.³⁸

In the DAR the Developer states that, "The Giant Mine Remediation Project has been designed to minimize the potential for environmental effects associated with current site risks. While some risks can be eliminated, others (e.g., arsenic trioxide) will remain on site indefinitely and will require long-term management" (PR#139 pES-11). Over the course of the environmental assessment, the Developer has clarified that several aspects of the Project will need to be actively monitored and replaced, and in some cases continuously operated, in perpetuity (eg. PR#139 p14-43). These include:

- the water collection system, including pumps, pumping and overland pipelines
- the thermosyphons (which require periodic replacement³⁹), freeze system⁴⁰ and monitoring devices

³⁸ ie. the costs of missed opportunities that could not be pursued because of the choice to use ground freezing.

³⁹ Maintenance of the thermosyphons is expected as their efficiency reduces with time (e.g., loss of charge gas pressure). Without maintenance, the frozen block could warm and thaw if the cooling system is not monitored and maintained in perpetuity.

- the tailings and sludge covers, dams, surface water spillways and collection ditches
- pit walls, crown pillars and closed mine entries
- the diffuser
- power supplies
- the fences around the pits
- arsenic uptake in vegetation
- the water treatment system

In the deficiency statement, the Review Board identified deficiencies in the Developer's DAR description of the hazard duration compared to the lifespan of the containment system. The Review Board noted that the DAR did not adequately describe the longevity of components of the freezing or water treatment system, and did not contrast the lifespan of components with the duration of the hazard (PR#153 p2). The Developer replied that, "the underlying hazard referred to in the Board's questions is the arsenic trioxide dust. Under the proposed management plan, the dust will continue to exist in perpetuity. But it will only become a significant risk to humans or the environment if there is a failure of the containment system" (PR#159).

The Developer also clarified the replacement schedule for:

- The water treatment system may be replaced or re-built every 25 years (PR#159 p4)
- Electrical and mechanical equipment related to water collection and treatment can last 10 to 25 years before major repair or replacement
- The diffuser would need replacement every 50 years or more (PR#159 p4)
- The thermosyphons would need periodic replacement (PR#139 p6-39).

5.1.2 The Temporal Scope of the Project and the EA

The Developer has proposed a perpetual time frame for the Project, meaning that the Project is proposed to last forever with ongoing maintenance. The perpetual timeframe caused concern among Parties to the EA and members of the public.⁴¹

In the Terms of Reference, the Review Board specified that the temporal scope of the activities would include "those occurring within 25 years *and extending to any further time required to stabilize the site*" (PR#116) [emphasis added]. It specifies that stability refers to "a state where active management of the site is no longer necessary" (PR#116 p16).

In the DAR the Developer states that, "the Review Board established a temporal scope of assessment of 25 years" (PR#139 p2-6). This is repeated in DAR section 3.4.2 which says, "the temporal scope assigned by the Review Board is a total 25 years" (PR#139 p3-6). The 25 year temporal boundary was used by the Developer throughout the DAR, with consideration of longer time frames "in a limited number of situations where the Review Board requested it" (p3-6).

⁴⁰ Eventually "components of the active or hybrid system would be "moth-balled" in a way that would allow the system to be reactivated as needed" (PR#159 p3)

⁴¹ See section 5.2.1 for further discussion.

In its first round of information requests, issued on February 9, 2011 the Review Board clarified the temporal scope, specifying that, “(t)he temporal scope defines the activities assessed, not the duration of effects of the Project to be considered. The Board assesses what happens because of development activities occurring within that time, not only the effects that happen during that time” (PR#178 p13). This includes long-term stability and risks resulting from the initial Project work of the first 25 years.

However, throughout the assessment, the Developer often used the phrase “long term” to describe the duration of the Project activities. This has been clarified in the technical sessions and during the public hearings. Although a *term* is a period of time with a beginning and an end, for rhetorical reasons the Developer is using the phrase “long term” to refer to perpetuity, with no end point (PR#352 p136; PR#578 p145).

5.2 Evidence from Parties: Concerns about perpetuity

Various Parties and members of the public described problems and difficulties understanding the perpetual care aspect of the Project. Further, Parties voiced concern about the implications of the Project and long term risk.

This section will review relevant evidence pertaining to public concern related to the proposed Project’s perpetual timeframe and:

- Parties’ difficulties conceiving of and accepting a perpetual timeframe (section 5.2.1)
- Concerns regarding the Project and future generations (s.5.2.2), and
- Concerns about perpetual care planning based on lessons learned from other perpetual care sites, including communication issues over the proposed Project lifespan (s.5.2.3).

The Review Board’s analysis, and conclusions for all of these sub-topics follow in section 5.3. Those conclusions form part of the Review Board’s overall analysis, conclusions and measures pertaining to the Project and perpetuity in section 5.11.

5.2.1 Conceiving of perpetuity

The Developer has proposed this Project for perpetuity. In the technical session on October 20, 2011, the Review Board’s technical advisor Doug Ramsay noted that the perpetual nature of this Project means it will have to keep working for much longer than the span of human history. In response, the Developer explained (PR#355 p163):

We have always presented this project as a project that requires perpetual care, or some presence onsite. We have never promoted this as a walk- away solution. Arsenic is an element, and, chemically, there's no way just to make it disappear. This will stay with us, there's no way to convert it into something else; that is never going to break down... There's always going to be a level of presence needed on site and a level of responsibility that we are passing down to future generations, and that is the nature of where we are at.

Participants in the environmental assessment have described their challenges in conceiving of this proposed duration of the Project. During the public hearing in Dettah, Elder and former YKDFN Chief Fred Sangris shared with the Review Board the Dene conception of perpetuity, and the concern that the government (as Developer) does not understand it. He said (PR#577 p367):

I think there's a word called "forever". For the Yellowknives Dene, that word "forever", we know what it means. You look beyond the moon and the stars, and you see nothing. You continue; that's forever. But for the federal government, "forever" means ten years. After that, they're hoping that people will forget the history here, turn the page and go on with their lives...

Dettah Band Counsellor Mary Rose Sundberg told the Board "...We need some kind of guarantee, because we're not going nowhere like some people said. We're living here forever and we have to live with that [the Project] forever. I just can't comprehend that, because it's way too long into the future" (PR#577 p351).

The Kuyek report noted that no one has ever built anything that has lasted for perpetuity, that most current discussion of post closure mining looks 100 years or less into the future, and that long-term stewardship requires a different kind of planning to deal with the centuries and millennia ahead (PR#333 p4).

Weledeh MLA Bob Bromley, a registered Party to the environmental assessment, spoke during the public comment period of the public hearing on Sept. 11 2012 (PR#579 p376):

The proponents have observed the need for perpetual care of this site, but I do not feel they have ensured the necessary operational mechanisms, in terms of a comprehensive plan, secured funding in perpetuity for the annual maintenance work required, and the commitment to continuously pursue ongoing research towards methodology that ultimately can resolve or largely address the various aspects, forms, and quantities of arsenic contamination that threaten the public and their environment.

Frame Lake MLA Wendy Bisaro also described her concerns about perpetuity and her doubts that the political will required to properly fund and maintain the Project will exist for the very long term, saying (PR#579 p382):

Who will enforce the monitoring, ensure the annual funding, be in charge? I greatly fear that an "out of sight, out of mind" mentality will prevail, and the contamination will be left untended, to revert to its original state and become an environmental liability that no one recognizes or deals with... To expect that bureaucrats in Ottawa will stay interested and engaged in this project after several hundred years is to fool ourselves.

Several members of the public described concerns regarding the perpetual aspect of this Project [Figure 7]. In the public hearing, member of the public Erin Suliak told the Board her reasons for believing that public concern related to the Project and its perpetual aspect is widespread throughout Yellowknife, and her disagreement with the Developer's view that the project is not a cause of significant public concern. She said (PR#576 p403):

It's hard to measure baseline anxiety for an entire public. I don't think there's anyone in Yellowknife who does not have grave concerns about this project, and in particular about the water issues associated with it. I -- I couldn't not come up here and say that I'm shocked and disappointed in the language around the term "public concern" in the Proponent's presentations. I -- I'm sorry, but I-- I find it insulting almost... 237,000 tonnes of poison aren't going away and neither is our concern.



Figure 7: Members of the public at the Sept. 11, 2012 public hearing
(photo: Review Board)

This view was reinforced in the closing statement of the North Slave Metis Alliance who state, “Given the public’s concern regarding the Giant Mine Remediation Project, particularly stemming from the fact that the Project is perpetual in nature, it would be difficult to conclude that this issue and concern is not significant” (PR#606 p7).

5.2.2 Perpetuity and future generations

The Review Board considers sustainability issues within the context of Section 115 of the *MVRMA*- “to have regard to the protection of the social, cultural and economic well-being of residents and communities in the Mackenzie Valley”. This includes intergenerational equity, and whether the proposed development “meets the needs of the present without compromising the ability of future generations to meet their own needs”.⁴² Concerns about the proposed Project’s potential effects on, and moral obligations to, future generations were raised by several Parties and members of the public, including Aboriginal and non-aboriginal participants.

Alternatives North described the idea of passing the responsibility for perpetual maintenance of the site to future generations as an absurdity (PR#355 p54). In the public hearing it stated that, “AANDC has really approached this frozen block as the full and final solution, which just shifts the onus for this to future generations to deal

⁴² As defined by the *Brundtland Report* of the United Nations World Commission on Environment and Development, 1987.

with” (PR#575 p111). On the same subject, the ANDRA (Nuclear Waste Management Organization of France) report, entitled *Making Nuclear Waste Governable* and submitted by Alternatives North, said of long-term care, “these hazardous repositories will require constant institutional monitoring, which not only represents a substantial burden for future generations, but also implies that they will be in a position to... monitor them over such lengthy time frames” (PR#452 p12).

In the public hearing at Dettah, band Councillor Mary Rose Sundberg told the Board that the Yellowknives are worried about the site and its perpetual care, and are worried about its effects on future generations, saying (PR#577 p345):

I'm here to represent my future generations, my grandchildren that are not yet born.... You talk about perpetual care, which means forever. What about our people? We need perpetual care forever because we're going to be worrying about this monster -- I call it a monster that's underground; that's going to be there forever. Every time we drive by there, we worry about it. So we worry about our health, and our safety. And our emotional well-being. That is forever. So have they thought about us Dene people, what we'll be living through.

This emphasis on impacts on, and responsibility to, future generations was also described by many other public hearing participants. In his closing statement YKDFN Chief Ed Sangris emphasized the importance of considering future generations and states, “Listen to the people who will die here, and be buried here. And whose future generation will remain on the land forever” (PR#575 p93). In the community hearing in Dettah on Sept. 12 2012, YKDFN Elders Isadore Tsetta (PR#577 p180, 182) and Elder Michel Paper ((PR#577 p191), expressed their concerns about environmental contamination and the health of future generations. The YKDFN closing statement spoke about the same subject, saying “We have a responsibility to future generations to provide a better world, and while YKDFN didn’t create this disaster, we will be part of the solution for our children and our own healing” (PR#605 p1).

The NSMA also emphasized the moral responsibility towards future generations (PR#578 p117).

The issue of future generations of Aboriginal peoples having to deal with repercussions was identified in the Kuyek report’s review of lessons learned for Giant from other perpetual care sites, which notes that perpetual care sites’ impacts on future generations “disproportionally affects indigenous peoples upon whose land the mine was built, usually without their consent” (PR#333 p54). The same subject arises in the Raffensberger report (PR#395).

As noted earlier, the ANDRA report described how making irreversible decisions about long-term care sites for hazardous substances can deprive future generations of the freedom to choose their own approach to the problem (PR#452 pp17-18).⁴³

5.2.3 Lessons learned, perpetual care planning and communication

Parties and the Review Board encouraged the Developer to look to other perpetual care sites for lessons learned about planning for perpetual care. The Kuyek Report (PR#333) identified many lessons from elsewhere that are

⁴³ See Section 5.8 for further discussion on reversibility.

applicable to the proposed Project on a number of relevant subjects including: community involvement, control of access, long term management, long term communication and record keeping, emergencies and failures, funding, intergenerational equity, and perpetual care planning.⁴⁴

During the technical sessions, Parties observed the need for development of future scenarios when planning for perpetuity, based on lessons learned from other perpetual care sites, citing examples from nuclear waste management, and the developer agreed to work on perpetual care scenarios within the next few months” (PR#355 pp84-86; PR#356 p22, p23). There is no evidence that this has occurred. In the round of information requests that followed the technical sessions, the Review Board asked in its IR#7 what lessons the Developer has learned from other perpetual care sites (PR#378 p9), and whether the Developer had considered the concerns and views voiced at the recent Perpetual Care Workshop organized by the YKDFN and Alternatives North in Dettah (PR#362). The Developer responded that it the “Project Team and its Technical Advisor are constantly examining similar projects throughout North America and beyond for lessons learned” (PR#390).

Many submissions from Parties emphasized the lack of perpetual care planning to date (eg. PR#459 p21; PR#461 p38, 40; PR#471 pp40-41; PR#578 p110; PR#605; PR#606). Several examples of perpetual care planning at other sites were provided or described by Parties (eg. PR#333 pp104-107; PR#362; PR#442; PR#443; PR#445; PR#446; PR#452; PR#453; PR#455).

In an undertaking resulting from an action item arising from the June 2012 technical workshop the Developer acknowledged that the lessons learned from other sites indicate deficiencies in its approach to perpetual care scenarios, because of the failure to include other stakeholders early on, and because it did not adequately consider effects that are important but difficult to quantify (PR#500 p2). On the same topic the Developer stated that parties have raised good points regarding the transition to perpetual care, and that it had “not yet given these matters a great deal of thought”, but would have time to do so engage public on the subject during future water licensing (PR#516 p5).

In the technical reports of the YKDFN and Alternatives north, both parties expressed concern that the Developer has not yet incorporated lessons from other perpetual care sites, leaving these for later when there may be less engagement of parties and asked the Board to address this in a measure (#459 p21; PR#471 p37; PR#605 pp7-8).

One part of planning for perpetual care was particularly problematic to the members of the public that spoke at the public hearing: communications with future generations. Considering the potential for changes in language, culture and society over millennia, many members of the public emphasized the challenge of designing Project communications to ensure that people in the distant future understand the threat the site presents if it is not managed as predicted (eg. PR#579 p313, p345, p391; PR#582). France Benoit, speaking at the public hearing, said (PR#579 p313):

I think we may be the first civilization that will have to design infrastructures and a communication plan that has to last forever. We have sent a man to the moon and are now exploring Mars, but we have never built for eternity and communicated through eternity. Here at

⁴⁴ Specific lessons from other perpetual care sites are cited in applicable sections throughout this report.

Giant Mine, we have not even begun this work. ... Eternity gives us a new scale to think about. ...It's mind boggling. Just how do you communicate to generations that will follow us thousands of years from now? How do we tell people that those thermosyphons are not to be tampered with? How do we convey the danger to human life that lies beneath us?

The Raffensberger report framed this as an issue of intergenerational rights, saying “Future generations have a right to the information they will need to address the legacy of waste left to them by this generation. They have a right to be warned of any danger, to know the history of their home, and to understand what has worked and failed at restoring the land to health” (PR#395 p10). Parties noted that that Dene oral traditions have withstood thousands of years, and that traditional knowledge could be part of the solution to the long term communications issue (PR# 333 p34; PR#576 p316). The YKDFN specifically requested a measure from the Review Board for a perpetual care plan with a “special focus on language and communicating with future generations” (PR#605 p8).

This subject was a focus of several other submissions from Parties at technical sessions, in information requests, at the Dettah perpetual care workshop, in the Raffensberger and Kuyek reports, in Alternatives North’s Designation Options report, in public hearings (eg. PR#390; PR#355 p99; PR#333 p104-107; PR#395; PR#362 pp10,14-15, 17; PR#417; PR#571 p91; PR#605 p8). In response, the Developer has said it will archive information electronically, draw on traditional knowledge, and examine approaches used by the nuclear waste industry to deal with this issue, and that it is open to discussing this issue further after the environmental assessment (PR#356 p172, p183; PR#390; PR#516 p5).

A discussion paper on designation options for the Giant mine was prepared by Avens Associated Ltd. for Alternatives North. It considers various formal designations as ways to institutionalize the memory of the site, to help future generations understand and remember the site (PR#417).

5.3 Review Board analysis and conclusions: Concern and perpetuity

Many members of the public expressed profound concern about the perpetual aspects of the Project during the public hearing, via letters and in other submissions, saying that the Project, as proposed for perpetuity, is inconceivable and unacceptable:

- “It’s mind boggling” (PR# 576 p313);
- “No one can understand the magnitude of this environmental liability” (PR# 576 p380);
- “We’ve got to think about forever... I can’t think what eternity is about... and that scares the hell out of me” (PR# 576 p348);
- The NSMA are “incredulous” about proposing the Project forever (PR#578 p116);
- In Dettah, Yellowknives Dene Elders described why they do not believe that the Developer truly understands what “forever” means (eg. PR#577 p367).

During the public hearing, the Board observed that members of the public exhibited a high degree of concern in their statements about the perpetuity aspects of the Project, including the issues concerning the perpetuity of the proposed Project, and the responsibility and challenges related to future generations.

A substantial part of the concern the Review Board heard from Parties and members of the public was related to the perpetual aspect of the Project. Considering the quantities of arsenic in proximity to a large population and two Aboriginal communities, the Review Board understands that the Parties and the public do not have any confidence that the Developer can be trusted to fund and actively manage the site forever as proposed. The weight of evidence before the Board indicates that the public does not accept that the challenges of perpetual care have been adequately considered by the Developer, and that the Project, as proposed, meets our society's moral responsibilities to future generations.

The Developer has explicitly stated that it views the proposed Project “as the long-term solution for Giant Mine arsenic trioxide, rather than as a temporary measure” (PR#139 s6.2.2). In contrast, the Review Board noted that several Parties and members of the public expressed their qualified and conditional support for the Project only if it were to proceed on an interim basis, instead of as a perpetual undertaking (eg. PR#575 pp96-98, pp118-121; PR#579 p354, p372; PR#579; PR#582; PR#585; PR#607).

Chief Edward Sangris summarized this view during the hearing, when he told the Review Board (PR#575 pp96-98):

The Yellowknives Dene do not view this plan as remediation. The problem is not being removed. (This) is a long-term management plan for the danger that will remain forever... We do not agree with the frozen block method.... But we realize the reality of our times... We understand technologies do not exist or (are) not cost- effective enough to achieve our goals. We understand that stabilizing the arsenic chambers by freezing them is maybe the best solution for today.

The YKDFN reiterated this sentiment in their closing statement saying, “we want to work with the proponent, to say that the Frozen Block method will be acceptable for now, our commitment is to making a better plan, a plan that we can live with for now while the solution is found in the future” (PR#605 p9).

It is clear to the Review Board from participants' comments that their concerns also are not only about the historical activity and current state of Giant Mine, but are about the proposed Project, including its perpetual aspect.⁴⁵ Parties are worried that the proposed Project will not work as described for the time for which it is proposed, and that this will result in harm to the people and the land. For the reasons described above, the Review Board concludes that there is significant public concern about the Project as proposed, and that some of this concern is due to the perpetual aspect of the proposal. The Board expects that the measures described in section 5.11 will help to address this significant concern.

Parties have provided the Developer with several reports and documents describing lessons from other perpetual care sites. The Developer has acknowledged their value, and shortcomings in its own approach, but there is no evidence that this information has had an effect on perpetual care planning for this Project to date. The Developer has stated that it plans to engage the public on these aspects later. The Developer seems to have

⁴⁵ See sections 2.5.4 and 2.6 for further details.

underestimated the importance of such a plan to this Project, the degree of public concern related to the long-term risk from the Project, and its importance and requirements in mitigating potential significant effects over perpetuity.

Accordingly, the Review Board accepts the arguments of Parties and the public that there has been a lack of proper perpetual care planning, including incorporating experiences from other perpetual care project and consideration about communicating with future generations. In the view of the Board, perpetual care planning is an essential part of managing a project such as this. It should have been a part of the Project, and has not been adequately done to date. This is likely to result in significant adverse impacts related to problems with land use controls, records and information management, funding, and communication. For example, without a plan to communicate important aspects of the Project to people in the distant future, they will likely lack the information that is a necessary to enable them to manage the Project properly. Over perpetuity, this lack of planning is likely to result in significant adverse impacts on the ground. The Developer's response to these concerns has been to say that perpetual care planning has not yet been done, but they will get to it.

Parties and members of the public have raised their concerns regarding the perpetual aspect of the Project repeatedly. They are prepared to accept the project only as an interim solution, not as an undertaking that must be continued by future generations in perpetuity. The Review Board has provided measures in section 5.11 below to address these concerns.

5.4 Evidence from Parties: Worst Case Scenarios, Project Design and Risk Assessment

This section will review relevant evidence pertaining to:

- The Project's design for perpetuity (section 5.4.1), including considerations of:
 - the chosen design standards and return periods (section 5.4.1.1),
 - the weighing of cost and risk in selecting design standards (section 5.4.1.2),
 - probabilities over perpetuity (section 5.4.1.3)
 - short-term vs. long term approaches (section 5.4.1.4)
- Worst-case scenarios and perpetuity, including flooding, seismic events and social instability (section 5.4.2)
- The Developer's risk assessment (section 5.4.3), and

The Review Board's analysis and conclusions for all of the above follow in section 5.5. Those conclusions form part of the Review Board's overall analysis, conclusions and related measures about the Project and perpetuity in section 5.11.

5.4.1 Design for perpetuity

The Terms of Reference required the Developer to "contrast the expected duration of the hazard against the expected lifespan of each component of its containment system" (PR#116 p17) and this issue was raised during several stages of the environmental assessment when dealing with specific Project design elements for perpetuity. . As described in sections 2.2 and 5.1.1 of this report, this was inadequately addressed in the DAR, and a more detailed request for this information was included in the deficiency statement that was later issued by the Review Board (PR#153 p2). The subject was raised again by the Board and parties in information requests. In the first round of information request the Review Board asked the Developer about Project

engineering to withstand infrequent high consequence events, and its consideration of long-term climate change (PR#177 p27).

5.4.1.1 Design standards and return periods

Important components of the proposed Project are designed to engineering standards for events with certain return periods.⁴⁶ For example, when the DAR was submitted, the engineered channel of Baker Creek was originally designed to withstand a one in 370 year flood. The DAR identified risks from flooding arising from very infrequent severe storms (PR#153 s. 9.2.2 p6-55, p9-6). Based on concerns identified during the environmental assessment, channel design was later improved to withstand a (larger) one in 500 year flood.

Because this Project is proposed for perpetuity, there is a virtual certainty that a flood this big will occur eventually. Similarly, given unlimited time, a large earthquake, although infrequent, could happen. The Developer acknowledged this in the DAR (PR#153 s.7.2.2.7). The Board asked the Developer to explain why it expects the Project to last for perpetuity when it appears to be designed to shorter term tolerances (PR#177 p27). In response the Developer emphasized, “the Remediation Plan as a whole attempts to maximize the use of methods and materials that require a minimum of long-term maintenance” (PR#211 p3), and that, “(l)ong-term stability of the Giant Mine site has been a central objective of the remediation planning since day one” (PR#211 p4).

The Developer acknowledged that components would require maintenance, monitoring, inspections and complete replacement to keep working over the long term, but noted that, “larger components, such as the frozen blocks and the tailings covers, are intended to require very little maintenance. Nonetheless, even those components are expected to be monitored and inspected, and maintenance will be undertaken as needed”. The Developer noted that this replacement is part of the cost estimate for the Project. It stated that “INAC is committed to meeting those requirements. That commitment means that the Project as a whole is designed for the long term” (PR#211 p3).

5.4.1.2 Weighing cost and risk when choosing design standards

Alternatives North quotes a submission by Kevin O’Reilly to the preliminary screening of the proposed Project raising concerns about how cost was weighted against risk acceptability for the Project, saying “In my view, the driving principle in developing the Remediation Plan was to minimize costs with some balancing of environmental and human health costs” (PR#471 p34-37). On this subject, the Developer stated (PR#211 p4):

In general, design return periods are selected to (a) reduce risks to acceptable levels (b) provide a reasonable balance between initial construction cost and future repair costs, and (c) be

⁴⁶ Part of the Review Board’s information request deals with return periods and design criteria. For any project, components are engineered to withstand a certain event. For example, a dam might be engineered to withstand a flood so big that it only occurs once every 200 years, or to withstand an even bigger flood, such as one that only occurs once every 500 years. The event return period describes how rare an event a component is designed to withstand. The longer the return period, the longer the component can be expected to work.

Most projects are designed for return periods that are much longer than their life cycle. For example, a mine with a life of 25 years might depend on a water channel designed for floods so big they only occur every 500 years (designed to a 1:500 year return period). This means that the chances of a flood so big it overcomes the channel happening in the first 25 years (the life of the project) is one in 20, or five percent.

consistent with other design objectives... The selection of design return periods for each item would be based on a careful balancing of risk, maintenance costs, construction costs and other design objectives.

When the same subject arose in the technical session on October 20, 2011, the Developer further emphasized the importance of economic considerations in selecting design criteria, saying “the selection of a design criteria is, essentially, an economic decision. One designs things because, in essence, if we built everything for the worst-case scenario we couldn't afford to build anything right. So, essentially, it's an economic decision. It's not a credibility decision” (PR#353 p217).

In the technical sessions the Developer acknowledged that designing the Project for the long term is important to it and to parties (PR#356 p25). The Developer described the urgency of short term work and the relationship between that work and the perpetual requirements that result, saying (PR#356 p32):

Today's priority must be on stabilizing and remediating the site. Of course, keep in mind... that today's decisions influence what we do under perpetual care. One observation... is the considerable tension that exists between wanting designs and guarantees that things will last and perform in perpetuity and the inability of current science and technology to provide those designs and guarantees.

Later in the technical session, Alternatives North voiced its concern over the idea of committing to maintain Project components forever, in the face of uncertainty and limited resources (PR#355 p54).

5.4.1.3 Probabilities and perpetuity

The Developer described the period considered in its risk assessment, including “the long term, which we define as a period of a hundred years after the steady-state period” (PR#355 p60). Alternatives North stated that its concerns were more the Project’s about long-term engineering for perpetual care than it was about the short-term engineering (PR#355 p86). In response, the Developer stated that the perpetuity aspect was considered during Project design, but said “It's impossible to quantify likelihoods unless you choose a period to consider... So the period that was considered was a hundred years... (W)e needed to say that hundred years just to make the math work” (PR#355 p87-88). The Developer specified that this represented the statistical odds of an event happening in any given 100 year period, and not necessarily in the *first* 100 years. Alternatives North identified that this contradicted the explicit definition of long term that is specified in the Developer’s risk assessment, which stated that the risk assessment was “limited to what the assessment team can envision for the **next** one hundred years” (PR#285 p3, as cited in PR#355 p160).

The Review Board’s expert advisor on mine engineering, Dr. Lukas Arenson, challenged the developer’s approach of dismissing risks on the basis of the low frequency of severe events for a perpetuity project. He noted that for a perpetuity project, the likelihood of a very infrequent event occurring over the life of the project is the same as that of any other event, because the project is expected to work forever and stated, “A one to ten year event has the same probability as a one to a hundred thousand event when you think of perpetuity. It has

basically a probability of one” (PR#355 p93).⁴⁷ The Developer agreed, and clarified that its intention was not to suggest otherwise, but only to provide “a sense of perspective on things that are likely to happen all the time and things that are -- that are likely to happen only under very rare and extenuating circumstances” (PR##355 p94).

In its second round of information requests, Alternatives North asked the Developer about the choice of design standards, how they were applied, and how they meet the perpetual care needs for the site (PR#381). The Developer replied with a list of guidelines, regulations and plans containing building codes the Project was designed to meet, and stated that, “continuous performance monitoring will be completed for each remediation component to measure actual versus specified design criteria to provide early warning of poor component performance” (PR#394 IR#6 p2).

At the public hearing, the Developer acknowledged that it is not possible to engineer any structure forever, and said (PR#581 pp130-131):

In lieu of the best perfect solutions that don't exist yet, we feel that it is our responsibility ... by using engineering proper structures and systems to obtain a long-term goal of containment. Our interest is to develop the most sustainable long-term project that we can at this time, recognizing that systems and knowledge and innovation change over time.

The Kuyek report examines case studies relevant to the Project from the uranium industry in Saskatchewan and cites key points from International Atomic Energy Association reports, such as “Any engineering solution has a finite life-span, which may be shorter than desirable from a radiological or toxicological safety point of view...” (quoted in PR#333 p56). Based on examples of containment failures, another states that “there is no such thing as ‘fail-safe’ facilities for tailings management”, and concludes that a combination of regulations, design specifications, and management systems must all be applied carefully and in combination for secure tailings containment (PR#333 p70).

The subject of Project lifespan compared to design criteria was explored further during the public hearing when the Developer was asked about the rationale for designing the Project for return periods that are less than the life of the Project. In reply, the Developer emphasized that it has chosen “pretty conservative design criteria”. The Developer was then asked whether it would have chosen the same design standard for the channel 20 years ago, before the recent problems with anchor ice in the channel which resulted in flooding. The Developer replied that a lower value might have been used, and that there was a “likelihood of exceedence” over the life of the Project, but expects to be able to manage such problems (PR#577 p80-87).

5.4.1.4 Short-term vs. long term approaches

In its technical report, on the subject of Project design and perpetual care, Alternatives North stated that, “much more can and should be done to properly consider the long-term remediation options for various mine components to reduce or eliminate perpetual care requirements and to work with natural processes rather than

⁴⁷ At the hearing, member of the public Shannon Ripley raised a similar point, saying that even a very small risk of something going wrong “becomes certain if you extend it over forever” (PR#579 p319). The ANDRA report describes similar conclusions about the eventual failure of engineered solutions over the course of perpetuity (PR#452 p11).

rely on engineered structures and solutions” (PR#482 p35). Alternatives North described several ways overall Project design would be different if minimizing perpetual care requirements was a priority and recommended that the Review Board create a suggestion that the Federal Contaminated Sites Action Program should develop a policy framework and guidance for the perpetual care and management of remediated contaminated sites (PR#482 pp36-37).

In its technical report, the YKDFN also voiced concerns about a lack of design for perpetuity, stating: “There is an apparent reliance on monitoring to identify failure instead of implementing a design that considers perpetual care. This reliance contradicts AANDC’s statement that sustainability is preferred over short-term solutions” (PR#459 p11).

Other evidence describes concerns of Parties and the public about the apparent short-term focus of the Project, with inadequate planning for the long-term aspects of perpetual care (eg. PR#471 p34-37). On this subject, the Yellowknives Dene technical report states (PR#459 p21):

The focus of the proponent’s submission to the Board has almost entirely been on the short term. Long term project planning is at best, disjointed and not committed to paper; at worst, absent and not a priority. Our experience with the EMS to date provides zero confidence that it will have the robustness or broad vision to address perpetual care issues.

In the Developer’s technical workshop of June 2012, the Developer states (PR#461 p38):

(O)ne of the things we considered in our frozen block studies was how do you determine failures over long timespans. For example...if war is declared and funding is redirected for ten years. Risks like this occur, and we considered these risks when looking at methodologies that will be most suitable for perpetual care. We selected an option that would best address these risks.

The Developer’s presentation at the public hearing addressed the issue of design for perpetuity, saying (PR#578 p44):

Perpetual care consists of two components: the physical systems... as well as the the long-term management and oversight of these systems. The physical systems, including the frozen block, have been designed for the long term. The frozen block was designed to be robust over the long term -- and easy to monitor. With constructive inputs from the Parties through the Review Board, through the environmental assessment, we have altered our thoughts or improved our planning on perpetual care and we made a commitment to develop a perpetual care management plan.

Alternatives North and others argued that the Project as proposed is at best an interim solution and is more a plan for stabilizing, not remediating, the site (eg. PR#579 p238; PR#585).

5.4.2 Worst case scenarios and perpetuity

During various stages of the environmental assessment, Parties and the Review Board asked the Developer about low frequency high consequence events. These are events that do not happen often but have major

consequences and often referred to as “worst-case scenarios”. However, because there are a range of events of this type, they are technically referred to more often as “low frequency high consequence” events.

A number of low frequency - high consequence events were considered throughout the environmental assessment, including earthquakes, floods, and social instability and were raised particularly in light of the perpetual nature of the proposed Project.

Flooding

Flooding was raised at several times, particularly as it relates to short and long term risks to arsenic containment. It is dealt with in other sections of this document, such as in section 9.1 regarding Baker Creek and in section 5.6 regarding long-term climate change. In the DAR, the Developer predicted that an uncontrolled discharge the completely flooded the mine would release an estimated 2,000 to 12,0000 kg of arsenic per year into Back Bay (PR#139 p8-14).

Seismic

In the DAR the Developer stated that, “it is anticipated that seismic events will not cause adverse effects that would compromise the overall performance of the Remediation Project” (PR#139 s.9.2.2.1). The Developer noted that it would conduct a geotechnical inspection of potentially vulnerable structures such as tailings covers, dams, and conveyance channels following earthquakes with magnitude 5.0 or higher. The DAR also stated that free standing structures will meet applicable earthquake standards in the National Building Code (PR#139 s.9.2.3).

The DAR states elsewhere that (PR#139 s7.2.2.7):

“Understanding of seismicity in the stable shield or core regions of continents has led to revised seismic values... This increased understanding has led to the assumption that a large earthquake could occur anywhere in the Canadian Shield, albeit rarely. The probabilistic hazard values correspond to a... 2% probability of exceedence in 50 years”

The Review Board’s first round information request asked the Developer, “Assessment of risk requires considering both probability and consequences of events. The earthquake scenario is dismissed because it is ‘highly unlikely’. However, the costs of consequences could be catastrophic especially during construction” (PR#178 p17). The IR asked for seismic scenarios with earthquakes of different sizes, particularly hitting the partially frozen system, the related probabilities and consequences, and drainage scenarios in the aftermath. It also requested a clarification of the Developer’s definition of a “credible” seismic event over the duration of the Project (PR#178 p18). Further, the Review Board IR IR#20 noted that “(a)lthough infrequent, a major earthquake can be reasonably foreseen over the long term”.

In response the Developer replied that the historical record of earthquakes since 1985 “...confirms low levels of seismic activity and suggests that only minor credible seismic events could occur over the long term of the project” (PR#206 p2). The Developer states that should result in “very low to low risk of damage to structures in post-closure...”, because large earthquakes generally occur at the edges of tectonic plates, which are far away.

Yellowknives Elder George Tatsiechele raised concerns regarding the proposed Project and earthquakes in the Perpetual Care workshop in Dettah on Sept. 26, 2011 (PR#362 p5). In the public hearing in Dettah on Sept. 12th 2012, Yellowknives Dene members expressed concerns about the effect of a future earthquake on the Project. In the public hearing in Dettah, Yellowknives Elder and Dettah resident Michel Paper described his concerns regarding the Project and rare, severe events, saying “Some day the earth will shake, a lot of things is happening. The climate change. There's a flood. And earthquake. It might get here some day. And once that earthquake, everything will break. And maybe at that time when it gets here it'll be too late for the people here and for our kids” (PR#577 pp190-191). Yellowknives Elder and band Councillor Peter Sangris expressed similar concerns (PR#577 p376), as did Mary Rose Sundberg, band Councillor for Dettah. She expressed doubts regarding the adequacy of an emergency response and the potential effects downstream, including on communities down the Mackenzie River (PR#577 p358-364). Member of the public Lorraine Hewlett also described concerns about catastrophic failures related to earthquakes elsewhere (PR#576 pp365-366).

The Kuyek report draws conclusions on catastrophic failure based on lessons from other perpetual care sites, particularly from the International Atomic Energy Association. The Kuyek report summarizes this as follows: “Catastrophic failure can be the result of neglect over time, of earthquake, fire, flood, or civil unrest, or all of these together. Or it can result from a series of minor, unrelated failures” (PR#333 p9). The report also examines causes of the Three Mile Island and the Space Shuttle Challenger disasters as examples of the combined effect of many small failures resulting in catastrophe (PR#333 p13) and identified other potential failures based on lessons from different perpetual care sites. It noted that most controls to keep people away from the site, such as fencing and warning signs, can be expected to eventually fail, so most organizations caring for the sites attempt redundant controls as backups. (PR#333 p6).

Social instability

A low frequency-high consequence issue that was particularly emphasized with respect to perpetuity and the need for ongoing active management and funding was the risk of the Developer being unable or unwilling to manage the project in the distant future due to a breakdown of governance or civil unrest. In the DAR the Developer described the chain of events that would have to go wrong before thawing of the frozen blocks would lead to a release of arsenic (PR#139 s.6.2.8.2). It concludes that, “this combination is conceivable only in the case of a complete breakdown of civil order. Such a breakdown would presumably entail more immediate risks to the environment and human health” (PR#139 p6-33).

In the technical sessions, this issue was raised by Parties and Review Board staff, noting that Canada is less than 150 years old, all societies and governments have changed over the time spans involved in the Project, and predicting the very distant future is extremely difficult (PR#354 p221; PR#356 p158). In reply, the Developer replied that while it cannot predict all the things that are going to go wrong in the future, “institutions of public government will likely still be in the business of protecting human health and safety” (PR#354 p223). The Developer stated that setting up a project that makes logical sense for generations to come is the best it can do when dealing with hypothetical future scenarios in the distant future (PR#356 pp160-161).

Alternatives North requested that the Developer's risk assessment should be redone with a focus on perpetual care, including the use of scenarios as has been done for nuclear waste sites requiring perpetual care in the US. This should include distant scenarios such as the breakdown of civil society (PR#355 p84). Alternatives North

noted that virtually no political institutions in the world have survived from a thousand years ago, and that 9000 years is beyond the span of human history (PR#355 pp161-162). The Yellowknives noted that from the perspectives of YKDFN Elders' the change of government here is a relatively recent event (PR#355 p103-104).

In an information request the Review Board asked the Developer 1) why it expects future governments in the very long term to have both the capacity and willingness to conduct the on-site management activities required to keep the arsenic safely contained, and 2) the assumptions the conclusions are based on (PR#422). The Developer replied (PR#433):

AANDC expects that future governments will have the capacity and willingness over the long-term to keep the arsenic at the site contained. It is expected that the government as a stable entity that has existed since 1867 will take all measures necessary to protect the human health and safety of Canadians.... based on two basic and highly probable assumptions. The first is that the government of Canada is as an entity will exist in the future.... The second assumption is that the future Government of Canada will protect the health and safety of Canadians, including taking the measures necessary to prevent harmful release of arsenic from the Giant Mine site.

An example of perpetual care planning that considers a breakdown of civil order is provided in the Kuyek report, which shows that one of the up to 10,000 year scenarios considered by the experts panel at the US Waste Isolation Pilot Project included a scenario with “devastating and long-lasting recession with famine, disease, population explosion, nuclear war, global warming, ozone depletion” (PR#333 p105). Alternatives North cited a report from the nuclear waste management authority of France that states “To scientists who are working on the tricky issue of nuclear waste disposal (over a 10 000 year period)... their oft-repeated view is that it would simply be crazy to gamble on the ‘stability of social institutions’ over such lengthy timescales” (PR#452 p12). This issue was raised by Parties and members of the public at many other times throughout this environmental assessment (eg. PR#90; PR#179; PR#355 p82; PR#452 p12; (PR#482 p40).

During the public hearing Developer stated in its presentation that “scenarios like a complete collapse of government were included in assessment of options by the project team” (PR#564 p15). The Developer provided an example of its consideration of collapse of civil order over long time periods, and said “The consideration of scenarios well outside the realm of “normal engineering risk assessments”, up to and including a complete collapse of civil order, is consistent with the best practices suggested by the most recent literature from other industries” (PR#500 p2).

5.4.3 The Developer's risk assessment

The Terms of Reference states, “the Developer is required to 1. Analyze risks for this development, including components, systems, hazards, and failure modes, and 2. Assess likelihoods and severity of each risk identified” (PR#178 p16).

The assessment of risks in the DAR and Developer's deficiency response

Section 8.9 of the DAR described the Developer's initial assessment of ecological and human health risks (PR#178 pp8-71 – 8-92). It is largely based on a 2006 study, which it reviewed and accepted, although it stated that it “likely over-estimates the risks” (PR#139 p8-71). The DAR examines post-remediation arsenic loadings to the following:

- water and sediment quality

- arsenic concentrations in soils
- garden vegetables and berries, arsenic concentrations in fish
- studies of the type of arsenic in fish to infer fish-derived arsenic in humans, and
- investigations of muskrat in Baker Creek

The Developer stated that the interaction between waterborne and sediment-bound arsenic are very important in determining the exposure of aquatic organisms, and it examined transport processes. These were simulated with a mathematical model (PR#139 p8-75). Regarding future concentrations, it states that, “only the predicted arsenic concentration in Baker Creek exceeds the CCME guideline for the protection of aquatic life and the Canadian guideline for drinking water”. It also stated that “sediment toxicity benchmarks would be exceeded in Baker Creek and Back Bay” (p8-76). The risk assessment considered arsenic intake by ecological receptors. It identifies potential adverse effects on both predator and forage fish in Baker Creek (p8-79). The assessment of potential effects identified intakes above toxicity reference values for hare, muskrat and mine (p8-80).

The DAR’s treatment of health risks from arsenic are described in section 8.2.1 of this report.

The DAR included fourteen pages on accidents and malfunctions (PR#178 s.10). This involved 1) identifying credible events; 2) screening them for potential impacts that warrant further consideration, and 3) further evaluating those “determined to potentially result in an adverse consequence” (PR#178 p10-1). The events that were selected for further assessment were lower bulkhead failure, mine water pipeline rupture, freeze pipe rupture, vehicle or equipment accident. The assessment included one to three paragraphs on each (PR#178 p10-13).

The DAR also included 11 pages related to risk assessment describing the effects of the environment on the Project (PR#139 s.9). It considered seismic events, severe weather and flooding, and identified mitigations for each.

In the Review Board’s deficiency statement, issued on November 26, 2012, unaddressed items from the Terms of Reference including issues related to risk of malfunctions were identified. The Review Board required an understanding of both likelihood and severity of worst case scenarios and other serious malfunctions to properly assess risk and asked for more description of the implications of a complete failure of the frozen block method and related impacts over the short, medium and long term (PR#153).

The Developer’s response to the deficiency statement reviewed the risk, and concluded that a complete failure of the Project (which the Developer considered highly improbable) (PR#157 p13):

...could conceivably result in gradual release of arsenic to the environment. The consequences of such an event would be increased arsenic levels in Baker Creek and Yellowknife Bay water, increased risk of adverse effects to aquatic and terrestrial species in the lower Baker Creek watershed, and increased risk to human health of those individuals who live off the land (i.e. harvest fish and game from the study area). Environmental effects would be expected to be limited to the study area and not result in adverse consequences to the Great Slave Lake ecosystem or people living outside the immediate study area.

The assessment of risks in the Developer's FMECA

In its first round information request the Review Board identified several shortcomings in the risk assessment presented by the Developer in the DAR and deficiency response and requested more information on the likelihood and severity of each risk, including scenarios of larger events that could cause compound failures or domino effects (PR#178 p16). In response, the Developer conducted three workshops in March, April and May of 2011 with Project staff and consultants. The purpose of these was to develop sequences of events that could lead to component failures, identify causes, and develop mitigations (PR#285 p1). The result is the risk assessment called the Failure Mode Effects Criticality Analysis (FMECA).

The FMECA starts with a Statement of Qualifications and Limitations. This includes the statement, "The information, data, recommendations and conclusions contained in the Report... in the case of subsurface, environmental or geotechnical conditions, may be based on limited testing and on the assumption that such conditions are uniform and not variable either geographically or over time" (PR#285). The document defines short term and long term timelines in which risk was considered. In its definition of "long term", it states (PR#285 p3):

The risk of events which could occur after steady state is achieved is defined as long term for the purpose of this assessment. The assumed endpoint of this timeline is 100 years, beginning after steady state is achieved. The identification and assessment of these risks is limited to what the assessment team can envision for the next 100 years based on the current remediation plan. This 100 year period is the time in which the remedial components are expected to function within specified parameters with ongoing maintenance. However, this time frame does include low probability events, such as a 1 in 500 year rainfall event. If the remediation plan is changed, or at some future point a new remediation technology is implemented, the long term risks would require reassessment.

The Failure Mode Effects Criticality Analysis (FMECA) defines a credible event as having "a reasonable probability of occurrence based on professional judgement in the context of Project-specific conditions" (PR#285 p4). It examines extreme weather, floods, forest fires, power failures, seismic events and climate change as initiating events that could cause other accidents and malfunctions. The document used a Failure Scenario Analysis approach to systematically examine the results of these initiating events, followed by the actual FMECA. It included cascading events and multiple cause events (PR#285 p13).

This allowed the Developer to evaluate large systems, identify risk mitigations, and rank the estimated risk in FMECA tables. Further, "Credible failure modes and their associated consequences" were identified (PR#285 p8). Public safety, environment and cost risk was estimated for each failure mode. The results were qualitative rankings of risk shown on tables indicating "likelihood" (from "more than once every five years" to "once every 1000 years"⁴⁸) and consequence ("low" to "critical") (PR#285 p10).

⁴⁸ The Developer used the following likelihood index: 1= once in 5 yrs; 2 = once in 15 yrs; 3 = once in 30 yrs; 4 = once in 100 years; 5 = once in 1000 years.

Risk assessment methodology issues

During the technical sessions of October 2011 the Board's technical expert Dr. Cesar Oboni noted that the Developer is describing impacts in terms of frequency, but over the proposed life of the Project, even low frequency events have the same likelihood of happening as do higher frequency events, because both are certain to occur given infinite time. Considering this, the Developer was asked if its focus on frequency instead of overall probability introduces a bias into its risk assessment, and whether this could be misleading to the public (PR#353 p213).

The Developer replied that it viewed its design criteria as sufficiently conservative, and that it was using an approach comparable to that of the Canadian Dam Association. When asked if Canadian Dam Association standards are appropriate for a perpetuity project, the Developer stated that it did not know, but they are routinely applied (PR#355 pp216-219). The Developer was later asked how the results of its FMECA compared to the Canadian Dam Association's acceptability criteria. The Developer specified that it has not compared its results to acceptability criteria, and that the FMECA has "not really defined acceptability at all" (PR#355 p216).

In the public hearing the Developer reiterated that its risk assessment used a "team of experts together to define credible events that were site specific and likely to potentially occur" (PR#578 p164). The Developer specified that this was the same qualitative evaluation applied by Aboriginal Affairs to all contaminated sites, including mines across the North. It describes risk in words and scenarios instead of numbers and allows Aboriginal Affairs to consider risks a broader variety of impacts than would a quantitative analysis (PR#578 pp164-166).

The Developer replied that the approach used is "based on an industry standard" and was reviewed by the peer review panel, and further stated (PR#578 p167):

I think the best way to establish credibility of INAC's risk management system for the purposes of the Board's review is to say that it was developed in consultation with Deloitte Canada who does risk assessment for probably hundreds of -- of government and -- and corporate entities. That it meets the standards of ISO 31000. In fact, ISO 31000 is an international standard for risk assessment that was developed after INAC had its program. And its program, in my opinion, meets those standards.

In the public hearing, the Board's technical advisor Dr. Franco Oboni noted that the INAC risk management approach includes an evaluation of which risks are acceptable, evaluated relative to the risk tolerance of the organization, and that residual risks should be as low as reasonably practical, to a numerical specification. However, the Developer's risk assessment did not establish any risk acceptability threshold to evaluate the risks identified in the FMECA (PR#285 p168). Oboni noted the Developer's earlier risk assessment stated "Consequences of the potential realization of a risk that should be considered go to human health and safety, legal obligations, environmental impacts, special considerations, including impacts on traditional land use, community, media, and reputation, and, finally, cost" but only public safety, environment and cost were actually carried forward to the FMECA (PR#578 p170).

In the same exchange, the Developer was also asked why the analysis of effects on health, environment and cost were never integrated in its risk assessment. The Developer emphasized that the method used for its risk assessment "allowed an integration of the results of three kinds of risk assessment, namely scenario assessment,

engineering risk assessment, and human health / ecological risk assessment, which is something that has not been achieved by any other approaches” (PR#500 p2, as quoted in PR#578 p171). However, results of the toxicological risk assessment are not used in the engineering risk assessment (PR#578 p174).

The Board’s technical advisor asked the Developer why FMECA was not used in conjunction with other analytical tools. The Federal Aviation Administration guidelines⁴⁹ state that, “FMECA is an excellent hazard analysis and risk assessment tools, but it suffers from other limitations... It also usually provides an optimistic estimate of reliability. Therefore, FMECA should be used in conjunction with other analytical tools when developing reliability estimates” (PR#578 p175). The NASA Engineering Handbook makes a similar point, stating that risk matrices are useful for discussing risk, but are not to be used for risk analysis with critical aspects (p176). The Developer responded saying that followed an approach is widely used, including by some perpetual care projects.

5.5 Review Board analysis and conclusions: worst-case scenarios, design and risk assessment

Parties have described to the Board their concerns about low probability – high consequence events. They have made it clear that this is particularly important in light of the potential hazard posed by 237 000 tonnes of arsenic trioxide in close proximity to an urban centre and a lake that is used for traditional harvesting. This is magnified by the likelihood of a low-probability high-consequence event occurring over the course of perpetuity.

Perpetuity and “Credible” events

Parties, including Aboriginal Elders and other members of the public, are concerned about what low-probability high-consequence events such as earthquakes and floods could do to the Projects’ containment of arsenic, the treatment of water, and the containment of tailings. Low-probability high-consequence events such as floods, earthquakes and fires have caused problems at other perpetual care hazardous sites, such as at the Zortman Landusky Mine in the US and at Cigar Lake in Saskatchewan (PR#333 p9, p 51, p62). The National Research Council 2003 Report, *Long-Term Stewardship of Department of the Environment Legacy Waste Sites* notes that floods may be infrequent but can unfold rapidly at unpredictable intervals, may alter landscapes, and can be associated with failures (PR#333 pp34-35). The earthquake that led to the Fukushima Daiichi nuclear disaster was raised by a member of the public (PR#576 pp365-366). YKDFN Elders Michel Paper and Peter Sangris both expressed concerns regarding risks related to earthquakes (PR#577 p191; p376). The Developer has made it clear that these events are extremely infrequent (PR#153 s7.2.2.7), that it has followed appropriate building codes (PR#153 s.9.2.3), and that it does not expect adverse effects from seismic events (s.9.2.2.1).

The Review Board notes that the frequency of earthquakes presented by the Developer was extrapolated over a relatively short period, but accepts that the very low frequency events such as earthquakes are unlikely to pose a threat to the Project over the short term. The same may be true for other sources of risk such as floods, fires, etc. Such events may be unlikely in a given year, but over the unlimited number of centuries and even

⁴⁹ *Federal Aviation Administration Research and Development Accomplishment*, 2004

millennia for which the Project is proposed, the probability becomes a certainty. The lessons learned from other perpetual care projects and examples from the public indicate that such infrequent events are relevant sources of risk to perpetual care projects. Given long enough, the unlikely becomes likely.

During the public hearing, the Developer specified that the risk assessment (the Failure Modes Effects Criticality Analysis [PR#285] considered only “credible” events, evaluated qualitatively based on site experience (PR#578 p163). The risk assessment specifies that “credible events” are events with a “reasonable probability of occurrence” (PR#185 p4). In the Review Board’s opinion, by looking only at “credible” events based on site experience the Developer failed to consider the extremely infrequent events that will, given enough time, occur and cause major problems with the Project as proposed. It is precisely the events like major seismic events and floods that are infrequent but can matter most in a worst-case-type scenario.

Focussing only on “credible” events eliminates consideration of the extreme scenarios under which failures occur and introduces a bias into the risk assessment. Considering such events, even if they are unlikely over a shorter period of time, is essential for a comprehensive risk assessment, especially one intended to serve for perpetuity. The Developer provided no rationale for this approach. The Aboriginal Elders, other members of the public and other participants are concerned about risk from the Project under extreme scenarios (PR#576 pp365-366; PR#577 p1981, p376). The Developer’s risk assessment has overlooked these potentially important but infrequent events, and as a result, there is no perpetual care plan to consider or manage them.

Further, the Developer’s risk assessment focussed on major components, but history has shown that major failures occur, such as the BP oil spill, Three Mile Island, or the space shuttle Challenger disaster, when long chains of apparently benign, sometimes minor, events are produced. As the Kuyek report states, “small multiple failures can defeat the most elaborate safety systems” (PR#333 p13). The opportunities for such alignments of small, collectively important problems increases over time.

In the public hearing, the Developer acknowledged that, “That site is doing its own thing... It has a way of morphing and evolving and changing” (PR#579 p139). The Board accepts this and observes that four unpredicted and unprecedented events occurred on the mine site during the course of the environmental assessment:

- the discharge of arsenic trioxide dust from a chamber during drilling that was part of the freeze optimization study (PR#120);
- the appearance of *aufeiss* anchor ice which caused Baker Creek to create a new channel during freshet, resulting in a tailings spill into Great Slave Lake (PR#336; PR#353 p204);
- a halocarbon spill from the cooling plant; and,
- the sudden appearance of unanticipated large sinkholes near a pit and arsenic chamber (PR#355 p196).

In the opinion of the Board, these are the kinds of small accidents or malfunctions that are likely, over perpetuity, to eventually align to cause bigger failures.

There are other problems with the Developer’s risk assessment. The Board also notes that there has been a lack of public involvement in risk assessment to date, including in scenario analysis and in evaluating risk acceptability to potentially affected communities (PR#578 p175). In the Board’s view this is a relevant shortcoming. The failure of the risks assessments to adequately consider “worst-case” type events suggests that

the Developer was unaware of the kinds of risks that the public was concerned about, or that it greatly under-appreciated the risks of maintaining a hazardous site close to a large population in perpetuity.

The risk assessment did not adequately consider problems due to social instability and governance in the perpetual perspective.⁵⁰ The success of the Project, as proposed, depends on active site management forever. This depends on the government to manage the site on the ground, and to ensure that funding is always available. The Board accepts the Developer's arguments about the likely stability of government and its values for the foreseeable future. The proposed perpetual timeline creates a different context. Priorities of governments can be influenced by events they have little control over, for example in response to financial crises. History has demonstrated that priorities, governments, countries and entire civilizations have finite lifespans, while the proposed Project does not. It is unreasonable to depend on the eternal existence and willingness of the Government of Canada for a project requiring active management forever. However, in the Board's view, concern about this aspect of the proposed Project is significant and reasonable only in light of the perpetual lifespan of the Project. The Board expects that the measures described in section 5.11 will help to address this concern.

Other risk assessment concerns

The FMECA was an improvement over the previous efforts, and the Board recognizes the substantial risk assessment efforts made by the Developer at that point. However, there are still remaining problems with the risk assessment, such as:

- Its separation of engineering, long term and toxicological risks leads to a fragmented view of the risks. It does not let the Board, Parties or public understand the overall integrated risks of the Project over its proposed perpetual life. For example, in the event of a major arsenic release, the combined risks to human health, the environment and costs would occur together and therefore need to be considered together when evaluating severity and choosing appropriate mitigations.
- It does not provide any basis for the validity of the probabilities used in its predictions.
- The FMECA uses a likelihood index where 1= once in 5 yrs; 2 = once in 15 yrs; 3 = once in 30 yrs; 4 = once in 100 years; 5 = once in 1000 years (PR#333 p10). This scale of likelihoods leaves large gaps which effectively bias it towards optimistic results in the risk evaluation.

The Developer has followed design criteria used by the Canadian Dam Safety Association for flood design criteria and the National Building Code. The Board notes that these were never designed to apply to perpetual care projects. NASA and the Federal Aviation Administration have publicly identified serious problems with the application of FMECA as it was done by the Developer, without also applying quantitative analytical tools. The Federal Aviation Administration has concluded that the FMECA risk matrices, the type of risk assessment used by the Developer, "usually provides an optimistic view of reality" and needs to be used in conjunction with other analytical tools (PR#578 p175). This was not done. This was specifically identified at the public

⁵⁰ This issue was raised by Parties and members of the public at many other times throughout this environmental assessment (eg. PR#90; PR#179; PR#354 p221; PR#355 p82, pp103-104; PR#356 p158; PR#452 p12; PR#482 p40), and was given cursory consideration by the developer (eg. PR#500 p2 and PR#564 p15; PR#578 p158-160).

hearing, and the Developer was challenged to respond to this shortcoming. The Developer's response was not convincing to the Review Board.

Of particular importance is the Developer's failure to apply criteria to evaluate risk tolerability or acceptability. A risk assessment needs to compare the risk, in terms of likelihood and severity, against a normative model to weigh its social acceptability. The results of the risk assessment should have been superimposed against established tolerability thresholds. This is a relevant omission that reduces the value of the FMECA risk assessment.

The FMECA only examined long term risks for a 100 year period, although it later specified that this meant any 100 year period over the life of the Project. The Board is of the view that focussing on frequency of events within such a period risks giving a false impression to readers about the overall likelihood of those events over the course of perpetuity. It has addressed this earlier in this section.

The Developer asserts that it can predict risks for the site, which needs to function for longer than the oldest human structures have existed, but it does so based on a risk assessment with serious flaws. These were identified in the public hearing to the Developer, which offered a response that was not persuasive, in the Board's judgement. Based on the above, the Review Board finds that the evidence shows that inadequacies in the Developer's risk assessment limit its credibility for this type of project. These limits prevent adequately prediction and mitigation of the potential impacts of the Project.

The shortcomings of the risk assessment are further considered as part of the Review Board's overall conclusions on perpetuity in section 5.11 below.

Design criteria

The Developer selected design criteria for critical Project components. It is clear from the evidence that economic decisions were an important basis for this. The Developer has stated that the cost of designing for worst-case scenarios is prohibitive (PR#353 p217) and that it is impossible to engineer structures to last forever (PR#578 p131). It says it has used design criteria that are suitable for events with long return periods (such as infrequent large floods). It has described the building codes it will meet for earthquakes, and identified other projects that are designed to similar standards.

Design criteria of critical components are usually selected so that those components work for periods longer than the projects are expected to last, to ensure that critical components are unlikely to fail during project life. In the Review Board's view, the Developer's approach of relying on design for low return periods focuses on the relatively low frequency of worst-case type events, ignoring the probability of such events over the life of the Project. This Project is proposed to last forever, so the probability of worst-case type events is certain. Parties are correct that a very different design would be required if the main goal of the Project was perpetual environmental protection and perpetual public safety (e.g. PR#482 p36). This would involve remediating the site, instead of only stabilizing it, and would be very expensive to do safely in the short term.

The Developer is in the difficult position of having to balance limited funding with decisions about risk. Although it has made attempts to improve its risk assessment during the course of the environmental assessment, it has not yet identified Project risks, and particularly long-term risks, in a manner well enough to

reach an acceptable balance point. This requires better identification of long-term risks and evaluation against standards of acceptability that include more input from the Parties that have to live with the Project.

These conclusions are further considered as part of the Review Board's overall analysis, conclusions and related measures about the Project and perpetuity in section 5.11.

5.6 Evidence from Parties: climate change and perpetuity

The issue of confidence in climate change predictions for perpetuity recurred throughout the environmental assessment. Relevant evidence is described in this section, and the Review Board's analysis and conclusions regarding climate change considerations and perpetuity follow in section 5.7. Those conclusions form a part of the Review Board's overall analysis, conclusions and related measures about the Project and perpetuity in section 5.11.

The Terms of Reference recognized the potential importance of climate change to this Project and requested:

- “Consideration should be given to the impact of the environment, such as the impact of extreme weather events or climate change, on the development” (PR#116 p8).
- a timeline for freezing that specifically accounts for long-term climate change.
- the Developer to provide “an account of how climate change predictions and observations affect the risk level in the long term based on ‘best estimate’ and ‘high estimate’ scenarios, including discussion of risks in light of the current climate predictions as set out in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change” (PR#116 p18).

In the DAR the Developer provided its simplified model of climate change and heat flux (PR#139 6-38). In this model, the Developer considered only arsenic Chamber 12, which it considered “most sensitive to thawing due to its location in a prominent bedrock outcrop”. It simulated current, best and worst case estimates for temperature increases. The model result implied that, “even the worst case predictions of climate warming would shorten the 20 to 50-year thaw times ... by only about 15%” (PR#139 p6-36). The Developer noted that the three climate factors primarily affecting the effectiveness of the thermosyphons are the duration of cold periods, average air temperature when thermosyphons are operating and wind speed.

From this, the Developer concludes that (PR#139 p6-37):

- current climate conditions offer a “significant excess of thermosyphons ‘cooling power’
- even after 100 years of sustained global warming, the number of thermosyphons currently assumed to be needed for the Project is likely to be adequate
- if there is more warming, or if thermosyphons are less efficient than assumed, the number of thermosyphons could be increased

The DAR also examined climate change in its consideration of effects of the environment on the Project (PR#139 s.9.2.2.2). It provides one or two paragraphs about climate change effects over a 25 year period only on passive freezing, storage of contaminants and waste, and water management, and predicts no adverse effects on any (PR#139 p9-6).

Long-term climate change was raised again by the Board and Parties in information requests. In the preamble to its first round information request the Review Board noted that, “(s)tability of the project considering long-term climate projections is an important aspect of the project” (PR#178 p27). It asked the Developer to “describe how INAC can model long term climate change (including changes in temperature and precipitation, and systemic effects on groundwater), and for how long INAC can reasonably guarantee that the system and its components work... ” (PR#178 p29)

In response, the Developer replied that it “has not attempted to model long-term climate change in general”. It stated: “In assessing the viability of maintaining the frozen blocks with passive freezing, the effects of climate change were considered by adopting the long-term temperatures predicted by the Intergovernmental Panel on Climate Change” (PR#211 p3).

The Developer noted, in the technical session of October 18th 2011, that the anchor ice (*aufeiss*) event in Baker Creek that caused a tailings spill in Great Slave Lake that in the spring of 2011 was unanticipated by people who have been on the Giant site for decades. The Developer indicated this may have been due to a climate shift in the late 1990s (PR#353 p204).

In the technical sessions of Oct. 20, 2011, the Developer clarified that it was making its long term climate predictions for a one hundred year period following the first 25 years of construction and initial adaptation (PR#355 p60; p190), explaining: “This is deliberate. This reflects the fact that, although we expect society to live in perpetuity, any large remediation project similar to the built environment is subject to the constraints of engineering methods and materials” (PR#355 p61).

In the technical session of October 20th, 2011, on the subject of climate change and risk of flooding in the distant future in response to extreme precipitation beyond the current range, the Review Board’s expert advisor Doug Ramsay asked if the Developer considered climate change in water-related risk scenarios, and if it modified the extreme event design period for climate change. The Developer indicated that it did not. Asked if that was the product of formal analysis or “gut feel”, the Developer indicated it was based on expert judgement (PR#355 pp190-191). The Developer later clarified that “Potential climate change effects were not explicitly incorporated into the design basis for the Baker Creek remediation at the Giant Mine” (PR#390 p6).

In the technical session, the Developer stated that it has investigated the potential effects of the worst-case scenario of the Intergovernmental Panel on Climate Change Report #4 (PR#352 p50). Review Board technical advisor Doug Ramsay asked the Developer what was covered by that scenario, and for what period in the future was it considered (PR#352 p132). This became Technical Session Undertaking #2 (PR#353 p46). The Developer response to undertaking #2 was as follows (PR#366):

The climate change scenarios assumed in the various Giant Mine reports were all intended to represent conditions in the year 2100. ... For example, the graphs presented in the response to the MVEIRB’s Information Request 3 cover a mean annual temperature range from today’s values to an increase of 7.9 °C, which exceeds the 3.8 – 6.0 °C range of “worst case” temperature increases predicted by [the Canadian Climate Change Scenarios Network]’s ensemble-mean scenarios....

The two Canadian climate models discussed here both fail to accurately represent baseline conditions and yield very different results for future projections, in particular when monthly and seasonal precipitation values are considered.”

In the second round of information requests, the Review Board addressed the subject of climate trends and contingency measures. It asked the Developer for a description of potential long-term climate trends (i.e. more than 100 years from completion of the freeze implementation) (PR#378 p1). In its reply, the Developer clarified (PR#390 p3):

The climate system is complex and highly dependent on natural forcing mechanisms, such as ocean circulation and solar intensity, as well as anthropogenic factors such as population, economic growth, and fuel consumption. These complexities and uncertainties result in a high level of uncertainty in predictions of long term future climate change. As a result, the Intergovernmental Panel on Climate Change (IPCC) provides a wide range of climate change predictions only for the period up to 2099. Those predictions have been used in most of the climate change analyses reported in the Developers Assessment Report (DAR) and in responses to previous information requests...

For periods beyond 2099, the IPCC provides only “multi-century” projections covering a range of “stabilization scenarios”. The presumption is that global climate will stabilize into one of those scenarios over a period of up to several centuries. In addition to all of the assumptions behind the 21st century predictions, the stabilization scenarios require assumptions about the long-term concentrations of carbon dioxide and other greenhouse gases and aerosols, as well the timing and level of peak emissions.

Over 175 such scenarios have been analyzed and grouped into six categories. ...The IPCC Climate Change 2007 Synthesis report ... indicates global average temperature increases of 2.0-6.1 °C... Most importantly, however, the Project Team has developed a series of contingency measures and shown that these are well able to deal with any of the projected climate warming scenarios.

In its public hearing presentation of Sept. 10 2012, the Developer described its modelling results based on its worst-case climate warming scenario of 6.1°C over 100 years (PR#561 pp54-57). Assuming all thermosyphons stopped working, the Developer’s model indicates that it would take 20 years for the upper corners of the arsenic trioxide dust to thaw (PR#575 p157).

In response to a question from the Review Board’s technical advisor Lukas Arenson, the Developer specified that the worst-case climate scenario it considered was a 6.1°C increase in mean annual air temperature over 100 years, then remaining constant afterwards, based on the IPCC multi-century projections (PR#575 p201).

At the public hearing on Sept. 12th, 2012, in response to questions from Review Board staff regarding the adequacy of the design of the Baker Creek channel to prevent floods, the Developer stated that its design criteria for the Baker Creek channel and for the tailings cover and drainage ditches were based on historical climate data, and not climate trends or climate change predictions (PR#577 pp81-82). The Developer stated it was not able to find other examples of projects designed for increased probable maximum floods to

accommodate climate change. The Developer noted that it made its estimates based on the same techniques as the Bluefish Hydro project and stated further that it is using “a pretty conservative design criteria” (p85).

The Review Board’s round two information request IR#5 further examines the issue of the potential effect of the expected warmer conditions on the probable maximum precipitation in light of long-term climate change effects. It asked how climate change will affect probable maximum precipitation for the Project site, and how the proposed Baker Creek channel as designed will handle the potential future probable maximum precipitation flow (PR#378 p7).

In response the Developer replied that the future might not necessarily be wetter with more floods, and that, “the Project Team is unaware of any that have sufficiently long data sets to come to firm conclusions on the hydrological trends that accompanied 20th century warming” (PR#390 pp3-6). The Developer argues that the climate predictions are not definitive and offered the same argument earlier in its Undertaking #2 from the technical session, which said:

“The two Canadian climate models discussed here both fail to accurately represent baseline conditions and yield very different results for future projections, in particular when monthly and seasonal precipitation values are considered” (PR#366 p6).

In the same response, the Developer stated that the critical period between diverting Baker Creek and freezing the chambers and stopes is 20 -30 years, and that any spills of water to the underground will be managed after that period. It also described plans to re-evaluate flood design criteria, and said it did not design for a maximum precipitation happening at the same time as anchor ice because maximum precipitation would be expected in summer or early autumn, when there is no anchor ice.

As described earlier in this report, the issue of flooding and design criteria over perpetuity was discussed during the public hearing on Sept. 12, 2012 (PR#755 p80).⁵¹

In the public hearing, Elder and band Councillor Peter Sangris stated “Yellowknives Dene, they are worrying about frozen arsenic because the world is changed. Too warm -- too warm of weather. The frozen arsenic, some these days, they might melt it and go down to Yellowknife Bay, and then-- pollution” (PR#577 p376). Elder Michel Paper also described his concerns over the effects of climate change and floods, and the risks posed to the Project and residents (PR#577 p190).

MLA Bob Bromley and member of the public Lois Little expressed concerns regarding climate change in the context of the Project. Bromley emphasized the unpredictability of extreme climate events over the very long term (PR#576 p372). Lois Little told the Board “we're moving into a whole new world right now. We've got climate change happening so fast. Like who would have thought that the Northwest Passage would be ice free in a couple of years? You know, we would never imagine that five years ago, but that's what we're faced with (PR#576 p349).

⁵¹ See Section 5.4.1 for details.

Because of the perpetual duration of this Project, other extreme events were raised that would normally be well beyond the consideration of an environmental assessment. These include glaciation and shoreline change. Alternatives North submitted documents to the public registry showing how these subjects are considered for perpetual care projects elsewhere. The Nuclear Waste Management Organization considered glaciation in its planning for climate change (PR#443). It notes the uncertainty in predicting climate over long periods of time, and cites Natural Resources Canada's prediction that, "the Earth's present climate, if allowed to evolve naturally, might last an additional 20 000 years or so before glacial conditions return" (PR#443 p3). The Nuclear Waste Management Organization's work "includes the study of climate change scenarios to provide a way to think about the issues, development of siting factors to mitigate the risks, and planning in the design of facilities to minimize these risks" (PR#443 p4).

Alternatives North also submitted evidence demonstrating how the Deep Geological Repository Panel, assessing a perpetual care site of nuclear waste in Kincardine, Ontario, issued specific information requests on how the Project planned to deal with climate change and glacial cycles, and how it would deal with coastal changes to the shoreline of Lake Huron over geological time periods (PR#442 pp50-51).

In the Developer's technical workshop of June 27th and 28th 2012, the Developer was asked about how glaciation was considered. John Hull, on the Developer's behalf, indicated that it was not reviewed or evaluated, and would have to be looked at as post-closure moves forward (PR#461 p42). The technical report submitted by Alternatives North noted in that the Developer had not analyzed implications of long-term events such as glaciations or shoreline change, and identified it as a deficiency in the Developer's perpetual care planning (PR#482 p40).

5.7 Board conclusions: Perpetuity and climate change

The Developer presented its predictions of the effects of climate change on the Project. Using the *International Panel on Climate Change Report Four*, the Developer has predicted the effects of climate change using a conservative scenario up to the year 2100, including worst-case predictions up to an average annual increase of 7.9°C. Based on modelling of warming and heat flux, it predicted that warming would shorten the 20 to 50 year thaw times by only approximately 15%. The Developer has concluded that even after 100 year of sustained warming, the current number of thermosyphons is likely to be able to keep the shell frozen, and if not, it can increase the number of thermosyphons (PR#139 p6-37).

For periods beyond the first 100 years, the Developer indicated that there was a high level of uncertainty, and that best prediction cover a range of scenarios (PR#390 pp3-6). The Developer's mean annual temperature predictions assumed a worst case of 6.1°C in the first 100 years and remaining constant afterwards (PR#575 p201). In this case, it would still take 20 years before the uppermost corners of the frozen chambers and stopes would thaw.

The Review Board is satisfied that the Developer has done a professional job of predicting the Project's response to predicted worst-case temperature increases for the first 100 years. The Board is satisfied, for this initial 100 years, that increasing passive cooling by adding thermosyphons or increasing active cooling using a

refrigeration plant are viable options if the need arises to maintain freezing in unexpectedly warmer temperatures.

However, the Developer's evidence indicates that the passive cooling is dependent on cold winter conditions. Given the uncertainties identified by the Developer in the long term climate predictions (PR#366 p6; PR#390 pp3-6), the Board sees no compelling basis for the Developer's assumption that climate, after the initial 100 years, would be stable. Considering that keeping the chambers frozen is an important part of this project, the Board is not persuaded that the Developer has established that the Project will be viable for the climate beyond the initial 100 years.

Changes in precipitation are also relevant to this project. Parties are concerned about climate change and flooding potential. Yellowknives Dene Elder Michel Paper, MLA Bob Bromley and Back Bay resident Lois Little expressed their concerns about these issues during the public hearings (PR#577 p190; PR#576 p372).

Managing flood risk forever along the Baker Creek engineered channel is a challenge. Potential changes in precipitation events and anchor ice in the channel over time make this even more complicated. This problem was raised, but based on the Developer's judgement of the conservatism of its existing model, very long term changes in precipitation and extreme climate events did not affect the outcomes of its risk assessment (PR#355 p190-191). With respect to flood risk over time, the Developer has not incorporated changing risks from increased extreme precipitation events due to climate change into the channel design for Baker Creek (PR#390 p6). The Developer's estimates of probable maximum flood were estimated using the same techniques Developer used by Northwest Territories Power Corporation at the Bluefish Hydro project (PR#577 p83).

It appears to the Review Board that the Developer's consideration of climate change over the perpetual life of the Project did not adequately consider extreme precipitation events. In response to the Board's information request on climate and flooding, the Developer emphasizes the uncertainty of the distant future predictions (PR#366 p6; PR#390 pp3-6). How the Baker Creek channel and of the tailings cap perform are both important aspects of this Project that can potentially be affected by precipitation extremes. If either the containment of Baker Creek or the integrity of the tailings cap is compromised, it would likely cause significant adverse impacts. In the Board's view, it is not enough to claim the Project is designed to be effective for perpetuity while ignoring potential changes in extreme precipitation over the same time span.

The Board also notes that the Developer has used the same techniques for estimating the probable maximum flood as was done for the Bluefish Hydro project. However, the hydro project is not required to work forever. Predicting and planning for perpetuity required a broader kind of thinking, which does not appear to have been done for the Project as proposed.

These conclusions are further considered as part of the Review Board's overall analysis, conclusions and related measures about the Project and perpetuity in section 5.11.

5.8 Reversibility

In considering the subject of perpetuity, the issue of reversibility has been important to the Review Board and Parties throughout. Section 3.3.6 of the terms of reference required information on futures foregone (that is, alternatives that have been eliminated) in light of options that may be identified later. In the deficiency

statement issued on Nov. 26th, 2010, the Review Board identified that the Developer had not sufficiently described opportunity costs and futures foregone well enough. The DAR sections on future re-consideration of alternatives (section 6.2.2.4) and intentional thawing (section 6.2.8.5) did not provide any details regarding risks, impacts or even feasibility of intentional thaw. The Review Board asked, “Considering that Project design was not able to consider best available technology in the distant future, and that the Project requires active management in perpetuity... (w)ill it be possible to deliberately thaw the frozen block if adaptive management deems it desirable in the future? If so, how, and what are the risks and impacts of doing so?” (PR#153 p1).

The Developer’s deficiency response was that that it would be possible, although likely complicated, to deliberately thaw the frozen block, although it would require certain risks to be carefully managed (PR#158). The Developer later described a method for thawing the chambers and stopes, and concludes “that the thawing program, when put into the context of the dust extraction program defined in prior alternatives analysis, does not add any unmitigable risks” (PR#200 p6).

Based on a study of several perpetual care sites, one of the Kuyek report’s major conclusions is the need for flexibility if new remediation technologies are identified in the future, or if engineered structures eventually fail. Kuyek emphasized that it is crucial to be able to retrieve materials from sites or switch to a different remedy if necessary (PR#333 p10). The Raffensberger report raises a similar point (PR#395 p20). The ANDRA report concludes that irreversible disposal of nuclear waste deprives future generations of freedom of choice, making a reversible solution preferable ((PR#452 pp17-18). In its technical report (PR#471), Alternatives North notes that in France, the Radioactive Materials and Waste Planning Act requires that any nuclear waste disposal is now legally required to be reversible for a period of at least 100 years (see PR#453, 455, 452 for details)

The reversibility of this Project was reaffirmed later in the technical session of October 20, 2011. The Developer stated that it believed it was unlikely that there would be a “markedly superior” option in the future, because of the thoroughness of the Developer’s 2000-2003 investigation of alternatives, and because of the challenges inherent in excavating the arsenic even if a better treatment were available (PR#352 pp54-56). The Developer’s view is, considering the amount that would have been previously spent on the initial Project implementation, “the thresholds for any new options are going to be very high” (PR#352 pp54-56).

In the technical session, the Developer committed to re-review the Project in 100 years, and later indicated that it would expect this review to happen sooner (PR#355 p247; PR#578 p214). The Developer described the limitations of current science and the inability to forecast what emerging technologies will be available in 100 years, saying (PR#365 p32):

(C)onsiderable tension... exists between wanting designs and guarantees that things will last and perform in perpetuity and the inability of current science and technology to provide those designs and guarantees. It's just the reality under which we're operating. We cannot forecast what technology will be available in a hundred years or beyond that. All we can say is there will be improvements. We'll have more means at our disposal.

At the public hearing, on the subject of reversibility and future alternatives, the Developer noted that, “it would be very difficult to get the dust out of all these corners and tunnels. We would have to send people in there to mine toxic dust out of a fifty year-old excavation, and that would be extremely dangerous” (PR#578 p143). The

Developer noted that the more robust a solution was, the less easy it might be to reverse (PR#578 p136), and that there was no clear difference in the reversibility of a project with arsenic in a wet frozen block compared to a dry powder (PR#578 p139).

The Review Board's consideration of evidence pertaining to reversibility is included in its overall conclusions related to perpetuity, in section 5.11 below.

5.9 Financing and perpetuity

The subject of ensuring adequate financing for perpetuity arose several times on the public record. The Project will require approximately \$1.9M funding each year forever (PR#139 p6-107). The following is a brief summary of the evidence applying the funding questions to a perpetual context.⁵²

The Project needs to be funded forever, and the government is unable to guarantee funding forever. The Developer has stated that, "the nature of the Canadian Federal Government governance process does not allow INAC, or any existing parliament, to bind or guarantee the actions of a future parliament" (PR#236 p2). Considering this, the Developer was asked in the technical sessions on Oct. 21, 2011, "if this project requires people to be on the ground forever, and the current mechanism for funding it doesn't allow you to promise to be able to get the funds you need to do that, is that the right funding mechanism for this kind of project...?" (PR#365 p159). The Developer replied describing its expectation that future governments will continue to fund the project. It stated "(T)hat's the best we can do in a hypothetical. We don't know what's going to happen in a couple hundred or thousand years from now" (PR#365 p160).

In the Developer's technical workshop held before the public hearings, Alternatives North raised this issue, and indicated that an appropriate funding arrangement was needed and should be part of the perpetual care plan (PR#461 p41). In the public hearing in Dettah, Band Counsellor Mary Rose Sundberg told the Board of her concern that there is no guaranteed funding for perpetuity (PR#577 p345).

The Review Board's consideration of evidence pertaining to perpetual funding is included in section 5.11 below.

5.10 Research in Emerging Technologies

Throughout the environmental assessment process several Parties submitted evidence to the public record regarding future research towards technologies that could provide a better and permanent solution to the problems at Giant Mine.

During the July 2008 scoping hearing, then project manager Bill Mitchell described the Project's lack of authority to spend money on research since all Project funding comes from the Federal Contaminated Sites Action Plan, which is directed towards cleaning up of abandoned and contaminated sites in Canada, primarily in the North. Mitchell noted that there are federal arsenic-related research programs funded by Natural Resources

⁵² See Section 6 for further discussion of funding issues, and Section 6.1 for public concerns related to funding.

Canada (PR#68 p138). In the DAR the Developer emphasized that the proposed Project is not intended as a temporary measure, and views the frozen block method as the long-term solution for Giant Mine arsenic trioxide. The Developer added that it remains open to improvements in technologies but has no intention of adding a long-term search for a better solution to the Project (PR#139 p6-10).

In response to questions from the review Board (PR#178 p8, p26, p35), the Developer stated that the proposal is designed to be robust for the life of the Project (PR#210). It proposed a review of technology every 10 years “to ensure that the most effective and efficient solution is in place” as part of the adaptive management system, and which will be submitted to an Independent Peer Review Panel for a technical examination of the applicability of emerging technologies at Giant.

Alternatives North asked the Developer if it had any intention to initiate or fund active research on a more permanent solution for the underground arsenic (PR#180 p10). The Developer’s replied (PR#219):

Due to the detailed and exhaustive approach that was used to identify the remediation method, and the nature of the site (i.e., no quick fixes or walk away options), INAC is confident in the Frozen Block Method and has no intention to initiate or fund research and development into alternative approaches.... The Governments of Canada and the Northwest Territories, in selecting the preferred remediation option for the site, have recognized and accepted that the Giant Mine Remediation Project includes long-term care, maintenance and monitoring. The DAR also notes (Section 6.2.2.4) that INAC and the GNWT remain open to considering alternative emerging technologies in the future. The intention is to review advances in technologies rather than fund active research through the remediation project...

The Kuyek report on lessons from other perpetual care sites states that a key question to address in the management of such sites is “how does the long term stewardship plan drive innovation so that the site may eventually be neutralised?” (PR#333 p10). This question was explored at the technical sessions, in technical reports and in the public hearings.

During the October 2011 technical sessions the Developer recognized that improved technological options will develop in the future, but emphasized the need to move forward with currently available technology (PR#356 p32). The Developer committed to review emerging technologies every 10 years after the project implementation phase. The Developer confirmed that these periodic reviews would continue over the long-term, not just for the Project initiation phase, and would be independent and transparent (PR#352 p55; PR#356 p212).⁵³ The Developer later clarified how these reviews of emerging technology would be approached, including possibilities such as support for university research, engagement of experts to prepare a state of the science and technology report, and convening workshops of experts (PR#390, IR#6, p3). In the same response, the Developer committed to also examining emerging technologies each time an update is required to project elements such as the water treatment plant.

⁵³ This commitment was separate from the developer’s commitment to review best available technologies for water treatment on a twenty year cycle (PR#353 p250).

The Developer committed to carrying out a complete review of the Project that is fair, transparent and participatory at least every 100 years (PR#355 p247; PR# PR#390 IR#6, p3; PR#578 p214; PR#579 p168).⁵⁴

Research into new technologies was discussed in Alternatives North's technical report, which concluded delaying active research shifts the onus to future generations and is not consistent with sustainable development (PR#482 p31). In the public hearing, Alternatives North further emphasized the difference between actively facilitating research versus research reviews that may be occurring in other contexts, describing it as a strategic investment that can also reduce public concern (PR#575 p111; PR#579 p238).

In the public hearing Alternative North asked the Developer why it would not commit to an active research program to identify applicable emerging technologies (PR#575 p188). The Developer replied that when it evaluated alternatives for the Project in 2001 to 2003, it knew technologies would change, so it examined whole classes of methods instead of specific technologies. The Developer also described how it was staying abreast of new technologies and noted that if a new technology could remove ninety-nine percent of the arsenic dust, the remaining one percent would still be toxic, and that it would take a whole series of technological breakthroughs to solve the problem, concluding with saying it was better to do periodic review rather than an on-going review (PR#575 p189).

Later in the public hearing, the Developer stated that the ideal solution for Giant does not exist yet, and recognized the potential of technological innovation (PR#578 p130). The Developer said "given the way technology evolves, there will be lots of changes" (PR#581 p198) and that it was very likely that a better technical solution would be found within 200 years (PR#578 pp132-133). The Developer stated that if a better solution was found that made sense for the Giant site, it would implement it (PR#578 p134). In response to a question about committing one half of one percent of Project costs as seed money to promote active research, the Developer replied that it would not make such a commitment because it is outside its mandate, that it does want to look at the research that is ongoing, but, in the Developer's opinion fostering original research was not worthwhile (PR#578 pp142 -145). The Developer stated that the last major formal public review was based on technologies from 2001 to 2003 (PR#578 p184). The Developer said that it would research new technologies as components are replaced, that it would also be doing its review of existing technologies every ten years, and that this will definitely be with the input of stakeholders (PR#581 p193).

Bill Enge, President of the North Slave Metis Alliance addressed the issue of research during the public hearing. He said "What we want to see is the Crown go back to the drawing board and find a permanent right and proper solution to cleaning up the arsenic trioxide.... because the very survival of the North Slave Metis people is at stake" (PR#578 p117). Enge stated that the NSMA cannot support the proposal without commitment to research a permanent solution (PR#578 p121).

Many members of the public, including elected officials such as band councillors, expressed their concerns that active research to identify a permanent solution is a necessary requirement of the project. The evidence from the public included statements at community and public hearings and letters to the Board, including Dettah band Councillor Mary Rose Sundberg (PR#576 p348), Yellowknife residents Craig Yeo (PR#579 p344), Mike

⁵⁴ See Sections 5.8 (Reversibility), 5.11 (Perpetuity conclusions) and Measure 2 for additional details .

Mitchell (PR#607), Erica Janes (PR#585), and Wendy Lahey (PR#586), and Ingrahm Trail resident Laurie Sarkadi (PR#578 p233).

Carol LaFontaine wrote a letter to the Board describing why she does not expect research that is not specific to the problems of Giant Mine to find a solution. LaFontaine wrote “The Developer needs to commit to investment in research and development to actively find solution to the arsenic trioxide problem.... This is a unique problem to the NWT. We cannot assume that others will further the research when no one will ever deal with a similar problem” (PR#580).

The Review Board’s consideration of evidence pertaining to research in emerging technology is included in section 5.11 below.

5.11 Review Board overall analysis and conclusions on perpetuity

This section describes the Review Board’s overall analysis and conclusions regarding the perpetual aspect of the proposed Project. It draws on the Review Board’s subject-specific conclusions described above regarding concerns about perpetuity and the Project (section 5.3), Project design and perpetuity (section 5.5), climate change and perpetuity (section 5.7).

The Review Board has carefully considered the evidence regarding issues related to the perpetual aspect of this Project. The Developer has made it completely clear that the Project as proposed is intended to depend on ongoing monitoring, maintenance and management for perpetuity. Important components, such as the thermosyphons, require periodic replacement. Others, such as the water treatment plant, require constant care.

The Developer has been very clear that when it talks about the long-term, it is in fact referring to perpetuity. Parties and several members of the public have repeatedly expressed the difficulties in simply comprehending the eternal nature of the Project.

The Developer has asserted that the Project is designed to minimize maintenance requirements (PR#211), and is the most sustainable project currently possible (PR# 581 p131). However, elsewhere, the Developer has said its Project design reduced risks to “acceptable” levels, provides a reasonable balance between initial construction costs and future repair costs, and is consistent with other design objectives (PR#211 p4). In the technical session the Developer stated that the selection of design criteria is “essentially, an economic decision... not a credibility decision”. The Developer has also made it clear that its main priority has been the short term stabilization of the site (e.g. PR#356 p25; PR#581 p151). In the Board’s view, considering the complexity of the problem, its location and the potential for severe impacts, the Developer’s engineering team were correct to concentrate on stabilizing the site.

Parties have told the Board that the Developer’s long-term (perpetual) planning has not received the degree of care it should have because of this short term focus. The YKDFN conclusion in its technical report was that, “Long term project planning is at best, disjointed and not committed to paper; at worst, absent and not a priority. Our experience with the EMS (environmental management system) to date provides zero confidence that it will have the robustness or broad vision to address perpetual care issues” (PR#459 p21). Alternatives North reached a similar conclusion in its technical report (PR#471 p34).

It is apparent to the Review Board that the Developer has considered parts of Project design for the next 100 year period rather than for perpetuity. For example, as Parties noted and notwithstanding the Developer's statements to the contrary made in the technical session, the Developer's risk assessment explicitly states that it has identified risk and assessed those risks for the next 100 years (PR#285 p3). Similarly, the Developer has made clear its climate change scenarios represent conditions in the year 2100, and that future conditions beyond this cannot be represented accurately due to high levels of uncertainty (PR#366; PR#390 p3; PR#575 p201). The Developer's modelling results are based on a 100-year scenario (PR#561 pp54-57). This has provided the Board with greater confidence in the Developer's submissions regarding potential impacts for the next 100 year period than for perpetuity.

Earlier in this Report of EA, the Board noted that there are several problems with the Developer's approach to and work on aspects of this Project related to perpetual care.⁵⁵ The Review Board finds the following as fact, based on the evidence on the public record:

- The Developer's risk assessment has flaws resulting in an inadequate assessment of risks over perpetuity, including risks from "worst-case" type low-frequency high-consequence events. Deficiencies in its risk assessment prevent the Developer from adequately identifying and evaluating these risks.
- The Developer has not considered climate change over the full proposed Project time frame, and this too poses risks of significant impacts over the long term.
- Several aspects of the Project are not designed to withstand events that are likely to occur over the Project's timeframe as proposed, due to economic constraints and engineering realities.

Based on its careful review of the evidence on the record pertaining to perpetuity, the Review Board is of the view that the perpetual timeframe of the Project is likely result in significant adverse impacts, and that there is significant public concern related to this impact. Without an adequate risk assessment, the Developer is unable to identify and avoid or manage the impacts that are likely to arise over the course of perpetuity. This makes the Project likely to eventually cause significant adverse impacts. Similarly, without an adequate consideration of climate change over the full time frame for which the Project is proposed, the Developer is unable to identify and avoid or manage the impacts that are likely to arise over the course of perpetuity due to changes in temperature and precipitation. This too makes the Project likely to eventually be subjected to conditions that will cause significant adverse impacts. Engineering constraints over perpetuity also make eventual failures of important Project components probable over perpetuity. These too are likely to cause significant adverse impacts.

Learning from other perpetual care sites might help avoid significant impacts over the long term. Despite repeated concerns from the Parties and their submission of useful and applicable lessons learned from other perpetual care sites, the Developer has not produced a perpetual care plan that can address these risks. The

⁵⁵ See sections 5.3,

Developer has made no progress towards designing communications with people in the very distant future. The Review Board accepts the Parties' arguments regarding the Developer's consideration of and planning for perpetual care. Without a plan to communicate important aspects of the Project to people in the distant future, they will likely lack the information that is a necessary to enable them to manage the Project properly. Over perpetuity, this is likely to eventually result in significant adverse impacts.

Other issues arise from transferring the risks and costs related to this Project to future generations. The Developer has made assumptions about the capacity of government to manage the Project that are reasonable in the short term but unreasonable over eternity. The Developer has promised to take active care of the Project forever, but is not in a position to guarantee the funds this would require in the distant future. Without adequate funding, the Project cannot be properly maintained and managed. Over perpetuity, this is eventually likely to cause significant adverse impacts.

Each of these features of the Project and its design is likely to eventually cause significant adverse impacts given enough time, and the perpetual aspect of this Project ensures that there will be enough time. In combination, this is even more evident.

As described above in section 2.5.5, the Developer has argued that compared to the current condition of the site as a baseline condition, the Project overall is an improvement of the environment. In the Review Board's opinion, it is true that if the entire Project proceeds as planned in every respect for perpetuity, it will be an improvement overall. However, this does not prevent the proposed Project from being a potential cause of significant adverse impacts.⁵⁶ This is particularly true light of its perpetual aspect.

The perpetual aspect of the proposed Project introduces new kinds of risks that do not exist at present. For example:

- At present, there is no risk of everyone forgetting what is underground and what needs to be done to keep it there. This would not necessarily be true over the millennia for which the Project is proposed.
- If a major low-frequency high consequence event were to occur at present (described as “the Very Bad Day” by the Developers (PR#355 p131), the government would respond quickly with significant resources to manage the impacts and stabilize the site (PR#355 p140). However, in the distant future, priorities and funding could change. The response to an uncontrolled arsenic release in the future may not be as high a priority, and the actual impacts could be worse than if an uncontrolled arsenic release were to occur today.
- There is good reason to have more confidence that the Project is designed with tolerances suitable for the current climate, including extreme events. Decreasing predictive certainty over time means there will be greater chances that conditions in the distant future will exceed Project design tolerances.
- Risks from low-frequency high-consequence events increase over time, and are therefore much greater over perpetuity than they are in the short-term.

⁵⁶ See Section 2.5.5 (Net Improvement and Significance) for details.

The potential impacts of the Project must be considered in a cumulative perspective, which in many cases is in addition to the effects of the historical activities at Giant Mine and ongoing arsenic releases.

The Review Board accepts the Developer's evidence that there are risks to people and the environment posed by the site in its current condition, and that these need to be addressed in the short term. The Board notes that the risks associated with each of the issues related to perpetuity would be greatly reduced if the Project timeline was reduced to a finite period.

The Board accepts the evidence from the YKDFN and others that the proposed Project is not a remediation plan in the broad sense (eg. PR#575 p79; PR#579 p238; PR#585). With respect to the underground arsenic and tailings, the proposed Project does not remove the hazard; it only stabilizes it (PR#579 p24; PR577 p106; PR#578 p127, 151). This defers risk and costs to future generations.

The Parties have put forward compelling evidence that reversibility is an important aspect of a perpetual care project, that it is a necessary part of adopting future technologies, and that it is an essential part of freedom of choice for future generations (eg. PR#180; PR#452 pp17-18). The Developer has reaffirmed that the Project as proposed will be reversible, although this will pose its own engineering challenges (PR#158; PR#200; PR#355 pp54-56; pR#578 pp136-149).

The Developer has recognized that knowledge and innovation develop over time (PR#578 p131), committed to periodically review emerging technologies (PR#210), said it expects that a better solution will very likely be found eventually (p133), and has said that it would adopt such a solution (p134). The Developer has committed to ensuring that a complete Project review is carried out at least every 100 years, and has indicated that it may occur sooner (PR#355 p247; PR#578 p214; PR#579 p168).

The Review Board is of the view that reducing the Project's timeline to a finite period would mitigate the above significant adverse likely effects. Because the proposed Project is reversible, and because the Developer is open to adopting any better technologies that are identified in the future, the Board accepts that it is only as an interim solution that the Project is feasible without these significant adverse impacts. This would likely address the portion of public concern that is related to the issues resulting from the concept of perpetuity as it pertains to this project.

Based on the evidence on the record, the Review Board concludes that a 100-year period is an appropriate maximum timeframe for this Project. The measures in this section, in combination with the measures in other sections of this Report of EA, will mitigate the above risks to an acceptable level and will help address public concern, for the following reasons:

- The Developer's climate predictions are projected to a 100-year model, as described above;
- A 100-year period allows enough time for considerable technological progress to occur. In combination with the active research program described in Measure 3 below, this provides enough time to identify and implement better and/or permanent alternatives that require little or no active management;
- The Board accepts that the government will have the means, willingness and ability to manage the site over a 100-year period;

- The Board expects that this approach will address concerns regarding communication with future generations, because there will likely be relatively little change in culture or language to change so much over a 100-year period compared to over perpetuity;
- The design tolerances for the Project are inadequate for perpetuity, but are conservative enough to be relied on for a 100-year Project;
- Public concern over low-frequency high-consequence events like floods and earthquakes increases beyond the first hundred years;
- A 100-year period is, in the Board's opinion, a long enough period to provide substantial benefits, in terms of meeting the Projects' objectives, to make the initial implementation worthwhile.

Measure 1: To prevent the significant adverse impacts on environment and the significant public concern from the proposed perpetual timeframe, the Project will proceed only as an interim solution, for a maximum of 100 years.

The Review Board notes that, in the Developer's own words regarding those who follow us, we need to "have faith that they will do the right thing in the future" (PR#365 p32). The Review Board is of the opinion that decisions made now must facilitate this, that there are periodic opportunities to recognize and adopt any better solutions as technology advances over time. In combination with the research described in measure 3 (below), a public and transparent re-evaluation of progress and achievements of the Project should occur more frequently than the once in 100 years that the Developer has committed to.

The Board has carefully considered the evidence on the public record regarding future technologies, the shortcomings of public engagement to date, public anxiety and widespread concern. It concludes that the Project is likely to cause significant adverse social impacts related to ongoing anxiety and the mental wellbeing of people, among other impacts. The Board also concludes that this can be partially mitigated by an independent review of this Project once each generation (that is, every 20 years) for the duration of the Project as described in the above measure. This provides each future generation the opportunity to review the Project considering the values, setting and technologies of that time.

Measure 2: Every 20 years after the beginning of Project implementation, the Developer will commission an independent review of the Project to evaluate its effectiveness to date, and to decide if a better approach can be identified. This will:

1. consider results of the ongoing research
2. be participatory in nature
3. follow the requirements of procedural fairness and be transparent in nature.

If the periodic review identifies a better approach that is feasible and cost-effective, the Developer will further study it, and make the study and its results of the study public.

The Review Board expects that the above measure will ensure that any better approaches identified in the future are a matter of public discussion. In the Board's view, this will increase the likelihood of a better approach being adopted eventually, which will help mitigate the impacts likely to otherwise arise were the proposed Project expected to work for perpetuity.

Section 5.10 described evidence regarding research in emerging technologies. The Board accepts that the engineering of the frozen shell is based on the best available current technology and is adequate for a 100 year period.⁵⁷ The Board has heard Parties argue persuasively that the best available technology is likely to progress considerably over the many decades of Project life. Considering the progression of technology over the past 100 years, the Board accepts that there could be useful new technologies identified within the next 100 years.⁵⁸

In response to concerns voiced during the environmental assessment, the Developer has committed to undertake a review of emerging technologies that are related to permanently eliminating or treating the arsenic at Giant Mine. Parties and the public have argued that research for new applicable technologies should be actively facilitated with a funded program.

As required by Measure 1, the Project will proceed only as an interim solution, for a maximum of 100 years. A permanent alternative is necessary beyond that point. The search for that alternative should not wait. The Board is of the opinion that decisions made now must facilitate this, and agree with the evidence from the Parties and members of the public that active research is required. The Board is of the view that the Developer's commitment to periodically evaluate ongoing research elsewhere is commendable but is not enough to address the unique nature of the site, nor to address the public concern associated with the Project or the significant impacts described above that will likely occur given enough time despite the Developer's best efforts. The following measure, along with Measures 1 and 2, will help mitigate the significant impacts described above and address related public concern.

Measure 3: To facilitate active research in emerging technologies towards finding a permanent solution for dealing with arsenic at the Giant mine site, the Developer will create a multi-stakeholder research agency with potentially affected Parties. The ongoing funding for this research agency will be negotiated and included as part of the environmental agreement specified in Measure 7. This body will, on a periodic basis:

- 1. produce reports on relevant emerging technologies;**
- 2. identify research priorities**
- 3. administer research funding**
- 4. ensure the results of research are made public, and**
- 5. apply results of each cycle to the next cycle of these steps.**

Measure 4: The research agency will provide the results of the research to the periodic reviews of the Project described in Measure 2. If better technological options are identified in-between these periodic 20-year reviews, the research agency will report these publically to the Parties, the public and the Developer. The Developer will consider these technologies and make decisions regarding their feasibility. The Developer will make any such decisions public.

⁵⁷ As described in section 5.11 (Perpetuity) and Measure 1.

⁵⁸ One hundred years ago televisions, sliced bread, ballpoint pens, and penicillin had not yet been invented, and arsenic was still being added to food intentionally as a preservative (Hughes et al. *Arsenic Exposure and Toxicology: A Historical Perspective*. Toxicol. Sci. (2011) vol. 123 (2): pp305-332).

Measure 8 prescribes a role for the oversight body⁵⁹ with respect to considering and reporting on the adequacy of research funding to stakeholders and the public.

Section 5.5 above identifies concerns with the Developer's risk assessment. In the Board's view, this is a real problem, particularly in consideration of:

- the amount of hazardous contaminants on site
- the close proximity to communities
- the past emergence of unexpected problems on site
- the long timeline of the Project

The Board is of the opinion that unexpected events are likely to cause significant adverse effects. It needs to be mitigated to the extent possible by conducting a thorough, proper and objective risk assessment before beginning Project construction. This will help the Developer anticipate, prioritize and manage the unexpected as it unfolds to reduce the likelihood or severity of resulting potential impacts. The following measure and accompanying text below describe requirements for this.

Measure 5: In order to mitigate significant adverse impacts that are otherwise likely, the Developer will commission an independent quantitative risk assessment to be completed before the Project receives regulatory approvals. This will include:

- 1. explicit acceptability thresholds, determined in consultation with potentially affected communities**
- 2. an examination of risks from a holistic perspective, integrating the combined environmental, social, health and financial consequences.**
- 3. possible events of a worst-case/ low frequency high consequence nature**
- 4. additional considerations specified in Appendix D of the Report of EA**

From this, the Developer will identify any appropriate Project improvements and identify management responses to avoid or reduce the severity of predicted unacceptable risks.

The Board expects the risk assessment described in the above measure to obtain well balanced, transparent, understandable measures of holistic risks.⁶⁰ This understanding will help the Developer design and manage the Project to avoid or minimize adverse impacts for the Project now, during its construction and during its long-term operation. The Board also expects this risk assessment to guide future reviews (as described in Measure 2) with a progressively improved understanding of the dynamics of the Project as a system. This will likely help identify adjustments that will improve the current Project design. The Board expects the risk assessment described in the above measure to include the items identified in Appendix D.

The risk assessment will be periodically updated for consideration during periodic Project reviews as described

⁵⁹ described by Measure 7 in Section 7.3

⁶⁰ Holistic risk includes identifying the total risks from an event from the integration of the risks to human health, the environment, and financial costs, instead of considering these each in isolation.

in Measure 2 above, and will also be updated after any extreme events or changes to the Project as a system.

Considering the problems with the Developer's Failure Mode Effects Criticality Assessment described above, the Board also concludes that it is likely that significant impacts will occur resulting from unexpected events at some point within the 100 year period of operations. The Developer's risk assessment has failed to prove that these will not be significant within a 100 year period of operation. The Review Board expects that the measures above and the measures in sections 6 to 11 will mitigate these impacts.

The Board is of the view that the story of Giant Mine is important and should be widely known in Canada. Parties have proposed ways to do this (eg. PR#417 p20; PR#544 p66; PR#578 p228). The Board has considered these and suggests the following:

Suggestion 2: The Developer should create a monument as a memorial to the impacts of past contamination from Giant Mine on Aboriginal communities and the environment.

Suggestion 3: To encourage widespread learning from and remembering of the experiences of the Giant Mine, the Developer, in conjunction with the GNWT Department of Education, Culture and Employment, should:

- 1. develop an education resource unit on the impacts of Giant Mine on the land and on people, including impacts on Aboriginal peoples, and**
- 2. distribute this resource unit for use within the school curriculum across Canada.**

Alternatives North notes that there are no federal guidelines for perpetual care sites in Canada, and there is a need for them. The Board agrees and suggests the following:

Suggestion 4: The Federal Contaminated Sites Action Program should develop a policy framework and guidance for the perpetual care and management of remediated contaminated sites.

6 Long-Term Funding

The DAR identifies many elements of the Project that are to be managed in perpetuity. These elements include water treatment, hazardous waste management, and monitoring of thermosyphons and the frozen blocks of arsenic trioxide dust buried beneath the site (PR#433, p3).

Reviewers have expressed concerns about the availability of a long-term stable funding mechanism to support perpetual care and monitor the Giant Mine Site in perpetuity. For the duration of the environmental assessment, the Developer stated that government will maintain the site but did not commit to identifying long-term funding options.

6.1 Evidence from the Parties: long-term funding

In the Terms of Reference one of the key lines of inquiry for this assessment required the Developer to “(p)rovide ... a description of Project feasibility including financial feasibility. Include discussion of funding certainty for the development and related monitoring” (ToR 3.2.2(5)). The Developer’s Assessment Report did not adequately address this issue, and in the subsequent deficiency statement the Board asked how Project feasibility would be affected if government funding priorities change in the future and about the Developer’s confidence that it will always have secure funding for the necessary activities (PR#153).

The total cost for the Project is estimated to be \$903,535,080 (PR#639 p5). For the long-term following initial implementation, the Project will require approximately \$1.9M funding each year (PR#139 p6-107). The Developer stated that it has funds earmarked until 2020, that annual appropriations have been successful for managing the Giant Mine site in the past, that government funding has been stable and consistent to date, and it will rely on annual appropriations for the future. It has stressed that it cannot bind the decisions of future governments and that it expects that government priorities will remain (PR#160, p4; PR#230 pp2-4; PR#356 p148; PR#433 p3; PR#579 pp123-124). The Developer stated that a potential reconsideration of the funding mechanism may be more appropriate when the Project enters the final monitoring and maintenance phase (PR#433 p5), and that long-term funding will be a relatively small amount after initial implementation (PR#516 p5).

The Developer stated that the Project has been a high priority for government and that long-term funding will be available, because of known risks, historical funding, previous investment, and if this changes, it would be “open to considering the most effective and efficient funding mechanism that would maintain the integrity of the Remediation Project” (PR#230 pp2-3).

In its first round Information Request IR#22, submitted on May 11, 2011, Alternatives North asked the Developer if it was prepared to research and investigate options other than annual or occasional parliamentary budgetary approvals (PR#180). In the technical session held on Oct 21st, 2011, Kevin O’Reilly of Alternatives North described the above information request and the Developer’s response, and said (PR#356 p144):

I'm not sure that I want my kids or grandkids to be in the position of relying on people in Ottawa deciding to allocate money for this project forever... Is there a way in which we can get more creative with long-term funding that's going to make me and my grandkids feel more comfortable with what's happening out there than relying on some future parliament to approve money..?

The YKDFN voiced its agreement with Alternatives North's concerns on relying on the goodwill and priorities of future governments. It recommended in the interim that annual reporting of the budget be made to the Parties. The YKDFN stated that this would allow all Parties to know if there is a reduction in funding during the long-term period, and recommended this as a measure (PR#356 pp151-152).

The YKDFN, Alternatives North, MLA Bob Bromley and members of the public voiced their concerns at several times regarding the subject of the lack of long-term funding (e.g. PR#576 pp316, 338, 339, 404; PR#576 pp316, 378, 383 PR#579 p28; PR#583; PR#582; PR#584; PR#604 PR#576 p378; p383).

6.1.1 The Taylor and Kenyon funding report

In March 2012, the YKDFN and Alternatives North submitted a report entitled *Giant Mine Perpetual Care Funding Options*, jointly commissioned from the Pembina Institute, prepared by Amy Taylor and Duncan Kenyon (PR#420) and presented at the public hearing by co-author Duncan Kenyan (PR#579 p265). This report identifies and evaluates perpetual care funding options for the long-term care and maintenance of the Giant Mine site. The resulting evaluation of existing long-term funding programs suggests that establishing a trust fund for the perpetual care of the Giant Mine site would be the most appropriate option. The report considers the characteristics of the Project, and the strengths and limitations of funding approaches employed elsewhere in Canada and abroad for dealing with perpetual care sites. Taylor and Kenyon note that the time horizon for the Project is long in relation planning and budgeting cycles. The report states that the need for Project funding will exist regardless of the state of the economy and competing demands for competing demands (PR#420 p47).

The Taylor and Kenyon report recommends a trust fund as a possible solution. This would include contingencies, involves stakeholders in decisions, communicates regularly to stakeholders and is managed independently. It says (PR#420 p47):

These funds can be seeded with funds from government, industry, levies, non-government organizations, or some combination of the above. These funds can be self-sustaining and, with clear governance and objectives, can continue to deliver on stated goals for long periods of time. Thus, they can provide funds for the life cycle of a project and are protected from economic swings that make competing with other funding priorities increasingly difficult. Funding can be made available for contingencies and regular reviews of technologies and funding processes. As well, third-party expert and stakeholder engagement can be an important part of the governance of such funds. Reporting and verification of costs, revenues, liabilities and contingencies are possible with trust funds

The report concludes that establishment of a trust fund for the perpetual care of the Giant Mine would ensure a stream of revenue for the life cycle of the Project and avoid the need for annual appropriations from government which cannot guarantee the availability of funds in perpetuity (PR#420 p8). The Pembina report provides several recommendations and considerations for the establishment of a trust fund. The report does not actually recommend a trust fund be implemented, but it does suggest that it appears to be the best option for long-term funding of the Giant Project. It recommends additional research to assess the feasibility in this case, and to design such a fund that is appropriate for the Giant Project.

6.1.2 The Kuyek lessons learned report

The document “The Theory and Practice of Perpetual Care of Contaminated Sites” (PR#333) was prepared specifically for the Giant environmental assessment by J. Kuyek, for submission by Alternatives North. It provides a detailed study of lessons learned from other long-term care sites, noting that most case studies show difficulties in maintaining adequate funding when competing with politically more attractive projects, and that trust funds are recommended by several researchers on this subject, although discounting over perpetuity based on net present value can be problematic for trust funds (PR#333 pp9-10). The report describes the risks of projects having to continually compete with “politically more attractive projects”. On the subject of long-term funding, the Kuyek report (pp38-40, p44) included a summary of issues facing the US Department of the Environment dealing with the Hanford nuclear site⁶¹, which stated (PR#333):

The ultimate question is whether the resources needed for stewardship will be available once the spotlight on cleanup has been turned off.... a robust and reliable stewardship system will have to endure changes in property use and ownership, as well as changes in politics and government institutions. Assuring funding over such long time periods is an unprecedented and daunting problem—one that calls for innovative solutions

The report notes the importance of: financial security; clear rules, roles, and responsibilities; public information; enforceability; and, permanence, for a successful long-term funding program. Kuyek notes that at the Hanford site, the state government has reported that that, relying on annual appropriation depends on pressure from local and state governments and “only works if Congress honours long term stewardship obligations each and every year in perpetuity, or, if states are willing to litigate to enforce obligations (PR#333 pp44-45).

The Kuyek research report includes lessons learned regarding funding at problems at other major perpetual care sites (eg. PR#333 p53), indicating that indirect costs (eg. inflation, administration) can be much higher than assumed, that emergencies will continue to occur, and that “the geochemistry of solutions in leach pads, tailings impoundments and waste dumps may continue to evolve during reclamation, complicating treatment and increasing costs”. Of the Yukon’s Faro Mine, which is funded under FSCAP as is Giant, Kuyek concluded “Remediation and long-term care of mine sites like Faro require public engagement and activism in order to create the political will for the enormous funding that is required” (PR#460 p72).

Without a commitment or a plan that ensures funding for perpetual care requirements, Parties have expressed a lack of confidence in the Developer’s commitments and ability to manage the site indefinitely. In its technical report, the Yellowknives Dene First Nation recommends that the Crown establish a mechanism to ensure that the long term operation of this site is not compromised. At a minimum, YKDFN suggests that this should include the establishment of a reserve fund for the Project to access in the future if funding is not acceptable relative to operational demands, to ensure that the Project competes with other priorities (PR#460 p18). In the same report, the YKDFN recommend the Crown look at establishing of an endowment to create a reserve fund

⁶¹ Based on the US DOE *Resources for the Future* (2000) report *Long-Term Stewardship of Contaminated Sites: Trust Funds as Mechanisms for Financing and Oversight*

for the Project operations, and if funding is insufficient, consult with affected Parties including the YKDFN about the resulting environmental and socioeconomic impacts.

At the public hearing, the Developer described the timing of funding requirements, saying that there will be a gradual ramping-up of expenditures to the cost-intensive construction phase, and the long term will require a lower level of funding. The Developer states “(W)e anticipate that to be in the order of \$2 million annually. And that amount of money, while not negligible, is certainly within the Government of Canada's traditional kind of infrastructure spending” (PR#579 pp123-124).

On September 14th, 2012 during the public hearing, the Developer stated that the estimated cost of Project implementation was \$449,615,993 (PR#579). Through an Access to Information Request, Alternatives North acquired a document dated September 1st, 2012 from the Developer to the Treasury Board of Canada in which the Developer estimated the total cost for the Project to be \$903,535,080 (PR#639 p5). The same treasury Board submission states (PR#639 p6).

There is a potential for the total project cost estimates to increase over time. The increase in costs could occur due to the need to urgently address unanticipated risk events. Costs could also increase as a result of the completion of the engineering designs as these will provide significantly more detail for overall project planning.

6.2 Review Board’s analysis and conclusions: long term funding

In section 5.11 the Board has provided its considerations and conclusions regarding the issue of perpetuity. It has specified that this Project is only acceptable assuming that it is an interim solution, and not a perpetual solution. This has implications for the consideration of the evidence on funding. Assuming that this Project lasts 100 years, as an interim solution, the timeframe is very different from a perpetual care project. Reducing the length of the Project reduces the odds of failure due to funding issues. As discussed below, there remains a likelihood of significant impacts from the Project from risks related to funding.

The Board has heard considerable evidence on the subject of long-term funding from Parties and the public. They are concerned that the government has committed to maintain and manage the Project without evidence of a corresponding commitment to provide the funds on which the Project depends, for the time those funds will be required.

Section 5.1.1 of this Report of EA describes the components of this Project that require ongoing maintenance or periodic replacement such as the thermosyphons, pumps and the water treatment plant. These components will depend on the ongoing funding that makes their maintenance and replacement possible. The Board further notes that the \$1.9M ongoing cost per year over the life cycle of this Project would eventually add up to an unlimited financial commitment if the Project were to actually proceed in perpetuity as proposed. Even as an interim solution of only 100 years,⁶² if the Developer’s predicted costs are accurate, then the Project would

⁶² As required by Measure 1 in section 5.11

require \$190M for ongoing maintenance only, in addition to the \$903M cost specified by the Developer to the Treasury Board on Sept. 1st 2012 (PR#639 p5).

The Kuyek report presents numerous examples of problems arising at other long term care sites resulting from reliance on annual appropriations for long-term funding, including difficulties in competing with other political priorities, particularly after public attention to the Project has diminished (pp9-10, 44-45). The Review Board notes that actual costs of managing other long term care sites have varied widely beyond initial predictions and the Developer has acknowledged to the Treasury Board that the Project cost could increase (PR#639 p6). The Board notes that the Developer's prediction does not reflect the additional costs of accidents or malfunctions, even though the Developer has told Treasury Board that costs almost doubled in part due to "urgent and unforeseen risks" (PR#639 p6). Considering the amounts and types of contaminants and the time span of this Project even as an interim solution, unforeseen events have the potential to greatly increase the funds required beyond the 25-year initial implementation phase. For these reasons, the Board is of the view that the actual ongoing costs could be much higher than the Developer has predicted.

The risk assessment and impact predictions presented by the Developer assume that water treatment and freeze systems are being maintained and replaced as proposed. These are necessary parts of managing contaminants on site. If funding were not available, the Board is of the opinion that it is likely that serious problems would lead to significant adverse environmental impacts related to the release of contaminants. Over the 100-year life of this Project, neither funding needs nor government funding priorities are certain.

The Board notes that the *Giant Mine Perpetual Care Funding Options* report recommends a trust fund as likely a preferred option for several reasons, and recommends further research into this funding mechanism, recognizing that this needs to be a subject of discussion between the Developer and Parties. It stops short of actually recommending that the Review Board require a trust fund. In the report and during the public hearing, Taylor and Kenyon recommended up-front multi-year funding as a proven mechanism already used in other situations by the Government of Canada. In the Board's opinion, the arguments made on behalf of YKDFN and Alternatives North for establishing a trust fund, possibly with multi-year up front funding, have merit for an interim solution, and deserve to be considered thoroughly.

The Developer's overall response to the issue of secure long term funding has been that it has funds earmarked until 2020, that annual appropriations have been successful for managing the Giant site in the past, that government funding has been stable and consistent to date, and it will rely on annual appropriations for the future. It has stressed that it cannot bind the decisions of future governments and that it expects that government priorities will remain (PR#160, p4; PR#230 pp2-4).

The importance of stable funding has been raised in the Terms of reference, the deficiency statement, Board and party information requests, the technical session, in technical reports, and in both the Taylor and Kenyon and Kuyek reports. In the technical session of October 2011, the Developer indicated its openness to considering other approaches to long-term funding (PR#356 p156), and has stated that doing so "will be beneficial to decision makers in the future" (PR#582 p184), but there is no evidence that the Developer has begun investigate other means for long-term funding.

General Board conclusions on funding

The Developer has stated that government cannot bind future governments. However, the Board notes that the Taylor and Kenyon report provides several examples of government setting up up-front multi-year funding. The land claims that the MVRMA itself is based on are binding commitments from the government.

Adequate funding is essential for proper Project management, including ongoing maintenance and responding to problems. Without a suitably reliable long-term funding mechanism, there is a likelihood of significant adverse impacts over the 100 year duration of the Project. Funding shortfalls have been a problem at many other long-term care sites, and have resulted in impacts on the ground, and the Board expects this to be no less likely for this Project. The developer has presented no compelling evidence to contrary. The Board concludes that it is worth thoroughly investigating long-term funding mechanisms that match the life cycle of the Project.

However, the Review Board does not wish to overstep its mandate by being overly prescriptive of how the government should organize its financial affairs, and does not wish to require the Developer to implement a specific funding arrangement. The Developer has indicated that it is open to considering other approaches to funding. The following measure and suggestion are intended to ensure that the ideas put forth by the Parties receive due consideration in a way that engages stakeholders.

Measure 6: The Developer will:

- **investigate long-term funding options for the ongoing maintenance of this Project and for contingencies, including a trust fund with multi-year up front funding,**
- **involve stakeholders and the public in discussions on funding options; and,**
- **make public a detailed report within three years that describes its consideration of funding options, providing stakeholders with the opportunity to comment on the report.**

By identifying funding options and making them available for public discourse, the Board believes it likely that the government will implement any superior and feasible funding mechanism that is identified. This would acceptably reduce the likelihood of the Project causing significant adverse impacts resulting from its inadequate funding.

The evidence indicates that the funding described in the following suggestion has many advantages. The Review Board puts it forth as a non-binding suggestion instead of a measure in recognition that the investigation of funding options required by the above measure may identify a superior option.

Suggestion 5: To ensure long-term funding throughout the life of the Project, the Developer should create an independently managed self-sustaining trust fund with multi-year up-front funding for the ongoing maintenance of this Project and for contingencies. A third-party expert should independently manage this trust fund. Annual reports on the condition of the fund should be provided to stakeholders and the public.

In section 7.3 of this report, the Board has described the oversight body and its role. It is reasonable for the oversight body to consider adequacy of funding, and regularly communicate with stakeholders and the public to ensure that they remain aware of any potential issues. Measure 8 in section 7.3 prescribes such a role for the oversight body.⁶³

⁶³ described by Measure 7 in Section 7.3

7 Oversight

Parties and members of the public spoke of the multiple roles of AANDC as the Developer (co-proponent), inspector, Responsible Minister and more for this Project. This led many to call for independent oversight. This section examines issues such as public confidence, multiple roles of the Developer⁶⁴ and independent oversight.

7.1 Evidence from the Parties: public confidence in government as Developer

Many members of the Yellowknives Dene described their lack of confidence in government based on past experiences with the federal government and Giant Mine. For the current Project, they told the Board that this results in a lack of trust in government to: predict the potential impacts reliably; make decisions about the Project objectively; report problems accurately; respond to emergencies efficiently and effectively; and generally consider the concerns and needs of the Yellowknives Dene adequately.

Yellowknives Dene Chief Ed Sangris described the history that has caused this lack of trust. He told the Review Board (PR#575 p95-96):

Now back then, government knew what was happening because of the arsenic. And yet they allowed our lakes and our creeks to be contaminated. Why was that? When they knew people, animals, and plants were being harmed, why did they let it continue?... After all of that, do we still trust the government to take care of our land?

Numerous other members of the YKDFN, including former Chiefs and band Councillors expressed similar sentiments regarding past and ongoing impacts of past environmental management of Giant Mine on the YKDFN, and how this has reduced trust in government (PR#576 p357; PR#577 pp354-355; PR#577 p364).⁶⁵

YKDFN Chief Ed Sangris indicated that local decision making was an important part of building confidence in the Project. He said: “The Yellowknife Dene do not believe that Ottawa should be making decisions for this Project. Those decisions need to be made here, by the people living in the dark shadows of the mine and who are most impacted by its history and its future” (PR#575 p98). Other participants commented on the importance of local involvement and the fact that many members of the Project team do not live in Yellowknife (eg.PR#534; PR#575 p111; PR#579 p52, p145, p230).

Parties cited other concerns affecting their confidence in the government as Developer (PR#356 p74; PR#482 pp8-9; PR#428 p27; PR#486; PR#554; PR#459 pp4-5; PR#575 p108; PR#579 p216-219; PR#585; PR#639).

⁶⁴ Throughout this report, all references to the issue of the multiple roles of the “Developer” refer primarily to AANDC in particular as a part of the federal government. The Board heard no similar concerns regarding the GNWT.

⁶⁵ Other evidence regarding the Yellowknives Dene’s experiences and lack of confidence regarding health issues is presented in the health effects section (s. 8) of this document.

7.1.1 Multiple roles

Parties and members of the public expressed a particular lack of confidence due to the multiple potentially conflicting roles of AANDC as described below. In the Review Board's scoping hearing of July 2008, many participants noted the need for independent oversight and monitoring review for this Project (eg. PR#67 p65).

In its technical report, Alternatives North described issues relating to trust and community acceptance of the Project in terms of its social license to operate (PR#482 pp7-10):

It is necessary to go back in time and briefly review the approach to developing the GMRP to understand the deep public mistrust and sense of betrayal that pervades the Giant Mine... Giant Mine became a public liability in 1999. There is a deep and pervasive resentment in the community over the mismanagement and lack of regulatory oversight of the Giant Mine and the resulting environmental, social and cultural legacy...

Recent performance by the Developers' on public engagement and work with the Parties to this Environmental Assessment does not bode well for the future. There is no 'social licence' for the GMRP to proceed and significant public concern lingers in the community.

Supporting materials submitted with the Alternatives North technical report define a social license to operate as "existing when a project has the ongoing approval within the local community and other stakeholders, ongoing approval or broad social acceptance and, most frequently, as ongoing acceptance". It is granted by the community, is intangible and dynamic, and has to be earned and then maintained (PR#482 p105). In the public hearing, Alternatives North emphasized the lack of a social license to operate, saying (PR#575 p 108):

(U)nfortunately, after four years I have to report that we think there's been little progress made on this issue of trust... (T)here's no consent or support for this project from the Yellowknives Dene First Nation or the City of Yellowknife. We don't think there's actually a social licence to carry it out.

Parties and members of the public recommended independent oversight as a solution.⁶⁶

Several submissions and statements from Parties describe concerns about multiple roles of the government as Developer, inspector, enforcer, responsible authority and so on. These came from the Yellowknives Dene (PR#179 p19-20; PR#576 p252-3; PR#577 pp362-363 PR#575 p98), the NSMA (PR#183) and Alternatives North (PR#180 p2; PR#381 p21. PR#482 p26 PR#575 p111).

In response to the question about its consideration of the Report of EA, the Developer stated (PR#301 p3):

On an operational level, INAC employees are responsible for consulting with the INAC Minister on the Review Board's recommendations. This role is separated from the proponent role. INAC will document this process fully; and will be neutral in its approach so as not to fetter the INAC Minister's discretion. INAC will exercise its different roles in the Remediation Project in a manner that will meet the general principles of fairness, transparency and accountability. These roles within INAC are structured to avoid conflict of interest, bias or apprehension of bias. This

⁶⁶ See section 7.2.

will be ensured by each branch of INAC fulfilling its legislative roles and acting in a transparent manner...

7.2 Evidence from the Parties: Oversight

The general solution called for by Parties is the creation of an oversight body. As the Yellowknives Dene stated in its technical report, oversight is a way of creating confidence in the Project (PR#459 p5):

Secrecy, technocracy and an existing climate of mistrust means that an intermediary body is required to ensure that the Yellowknives Dene desire for a successful reclamation is implemented – the project cannot be relied on to implement best practices.... the only way forward is to develop a mechanism that creates confidence in the proponents plans. An independent environmental oversight body is the right tool for this job.... YKDFN are hopeful and optimistic that a negotiated accommodation to this concern can be arrived at but strongly believe that a strong and clear measure from the Board will make this a reality.

The requests for independent oversight from Parties and the public span several years. In the Board's scoping hearing of July 2008, participants talked about the multiple roles of the Developer and concerns were raised about the need for oversight (PR#67 p65; PR# 68 p137, p145). In response, the Developer stated it would be "willing to entertain independent oversight for the project in the future" (PR#68 p138).

In the July 2008 scoping hearing, then Project manager Bill Mitchell described an oversight committee that existed at the time (PR#68 pp24-25):

The oversight committee, equal members of GNWT and INAC in recognizing that the main interest groups are probably the City of Yellowknife and the Yellowknife Dene. We sort of deal with them and try and meet with them as much as possible, give them information as to where we are with the remediation plan.

In response, Kevin O'Reilly specified during the scoping hearing that Giant Mine Community Alliance was set up by the Developer as a communications liaison body that was not independent, possibly not inclusive, and does not serve an oversight role (PR#68 p65). MLA Bob Bromley shared his experience with the Giant Mine Community Alliance at the July 2008 scoping hearing, saying he decided not to participate further because of the "lack of commitment from the Proponent (and) regulators to public oversight" (PR#576 pp369-370).

Section 14.1.6 of the Developer's Assessment Report (p14-5) stated:

(I)np[ut] from Aboriginal communities and the public will continue to be sought throughout the life of the Remediation Project... As the implementation of the Remediation Project advances, and in response to monitoring results, the public and Aboriginal communities will be engaged in the review of monitoring results and the identification of adaptive management approaches needed to address any environmental issues identified through the monitoring program...

The Yellowknives Dene first round information request IR#25, stated that “Independent oversight is the only way for the community and First Nation to have confidence that the remediation is transparent and the concerns of the local people are being addressed rather than that of the current government” (PR#179 pp19-20). The Yellowknives Dene asked the Developer to complete its design of the aboriginal and government body proposed for oversight, and give a comprehensive rationale as to why co-management is inappropriate in this case.

The Review Board’s first round information request IR#27 asked the Developer about plans being considered for establishing an independent monitoring body (PR#178 p35). In response the Developer committed to develop and manage long term monitoring in a manner that is (PR#290 p3):

- adaptive
- objectives Based
- credible
- inclusive
- transparent
- cost effective
- accountable

The Developer noted that it will carry out a performance monitoring program to confirm objectives are being met, and an adaptive management plan “to adapt to changing conditions as required”. It stated that its Environmental Management System is a core part of planning, managing, monitoring, reporting and reviewing environmental issues, and is a central component of the Environmental Monitoring and Evaluation Framework.

The Developer stated it does not intend to establish an independent monitoring agency such as those used for diamond mines. It asserted that its approach will be a credible, will incorporate Traditional Knowledge, and that it is prepared to work with potentially affected groups to develop an adaptive, transparent approach that meets their needs and is appropriate for such a large-scale, publically funded remediation project (PR#290 pp3-4).

7.2.1 The Affolder Report on oversight at Giant Mine

On Feb. 28th, 2011, the Yellowknives Dene, the City of Yellowknife and Alternatives North submitted a report (PR#185) undertaken at their combined request for this environmental assessment. Prepared by Dr. Natasha Affolder, Katy Allen and Sascha Paruk at the University of British Columbia Faculty of Law, the report (herein referred to as ‘the Affolder report’) analyzes the roles of independent oversight agencies and their challenges and strengths, specifically for relevance to the proposed Project. It examines the setup and effectiveness of ten different Canadian oversight bodies, including all three independent monitoring agencies in the NWT, and six international examples.

In summary, it notes key concepts about independent oversight agencies (p10-14):

- Independent oversight bodies do not have an inherent interest in seeing the original management system succeed, and are well suited to dispassionate evaluation of environmental management on an ongoing basis.
- This independence requires guaranteed existence, in terms of guaranteed tenure and funding.
- Composition is one of the determinants of how independent an oversight agency is.

- Oversight agencies need access to information in order to ‘oversee’.
- Accountability matters when oversight agencies hold organizations responsible for their actions.
- Motivations for independent oversight bodies often stem from fears about conflict of interest.
- Independent oversight bodies can act as a go-between for the public and the proponent. By including communication of complex scientific aspects of a project to the public in its mandate, an oversight body promotes greater transparency for and understanding by the affected community.
- When a project creates the potential for harm to human health or the environment, an independent oversight body can help prevent harm or reduce a proponent's liability should harm occur.
- An independent oversight body that represents and responds to the needs of affected Aboriginal groups could contribute to the Crown fulfilling its duty to consult.

The Affolder report derives fourteen key lessons from the numerous case studies it examines (pp86- 95):

- Independent oversight agencies have numerous potential drivers, many of which are relevant to Giant Mine.
- Not all bodies bearing the label “independent oversight agency” are necessarily independent, nor do they necessarily provide oversight functions.
- The primary role of an oversight body needs to be determined prior to choosing an appropriate form and structure.
- Composition should follow function.
- Access to information is paramount.
- Guaranteed funding is necessary.
- Proponents should be obliged to respond to recommendations from oversight bodies.
- Oversight bodies should have a legal base.
- Independent oversight bodies can promote effective environmental management through identifying gaps in environmental monitoring and management.
- The meaningful involvement of Aboriginal groups in oversight and monitoring requires careful attention and committed funding.
- The impacts of natural resource projects are differentially experienced. Ensuring community participation requires attentiveness to the different impacts on men and women from resource development.
- Ensuring an oversight body’s independence can be critical to ensuring public confidence.
- Long term projects require long term oversight and continuity of knowledge.
- Independent oversight can play an important role in emergency response planning.

The Affolder report states that “Overall, due to the unique risks posed by the arsenic trioxide dust, the multiple roles played by INAC, and the fact that the project will require monitoring forever, independent oversight may play a key role in ensuring the health and wellness of affected communities and the environment” (PR#186 p8).

The report concludes (p96):

Oversight is a mechanism that can ensure the shared goals of effective environmental management and ensuring public trust and support for a remediation project. It is about both creating and preserving public confidence in the Remediation Plan... The key is to create a body that will ensure the levels of public support and public confidence necessary to make the Remediation Plan a success.

To date, many good intentions about monitoring, participation, and consultation have been included in the Developer's Assessment Report. One can applaud, for example, numerous commitments already made... But the real challenge comes in translating these good intentions into sufficiently funded and staffed mechanisms of effective oversight that are up to the task of meeting public demands and ensuring public confidence in the Remediation Plan. This demands the creation of effective and responsive institutional mechanisms, backed up by formal structures and legal commitments that will withstand funding cycles, policy shifts, and changes in leadership. Nothing less.

The report and the subject of oversight were discussed during the October 2011 technical sessions. The Developer emphasized that it was of the view that the regulatory context satisfies and important oversight function (PR#356 p47). The Yellowknives Dene expressed that although they have confidence in the EA process, they do not have equal confidence that the regulatory process will necessarily ensure that its concerns are met (p70). The Yellowknives Dene expressed concern that the Aboriginal Government Body referred to in the DAR is not independent, because it is going to be “subject to the whims of funding... to the whims of capacity, which are affected through INAC funding mechanisms. And we have seen these slowly being eroded over the last couple of years” (PR#356 p74).

On March 6th and 7th, 2012, the Yellowknives Dene and Alternatives North co-sponsored a workshop on oversight of the proposed Project. The workshop report (PR#412), titled *Building Public Trust and Confidence; Report of a Workshop on Oversight of the Giant Mine* was submitted to the public registry. Several representatives of the Developer attended and participated, and people with direct experience in existing independent oversight agencies in the NWT shared their experiences and views. All participating Parties committed to form a working group towards developing oversight responsibilities for the proposed Project prior to the completion of the environmental assessment hearings (p23).

7.2.2 Oversight working group

The working group made up of the Developer and Parties met from March through May 2012. Following a consensus-based approach, the working group identified “sufficient common ground regarding the need for an arms-length environmental monitoring committee” to continue its discussions and agreed that such a committee would “fill an important role in gaining public trust in the remediation Project, something that AANDC and the GNWT, given their multiple roles, would be challenged to deliver” (PR#599 p.i). It noted that public concern about multiple roles and the need for arms-length monitoring has been and continued to be a central issue in the environmental assessment. The resulting discussion paper stated “The working group has concluded that it is in the individual and collective best interests of the Parties and the public that a Giant Mine Remediation Project Environmental Monitoring Committee be established prior to the initiation of the Project” (PR#599 p.iii). This Committee would be representative of the public and would monitor how environmental aspects of the Project.

The discussion paper describes the result of the consensus-based deliberations of the working group. It describes its mandate and functions. It specifies that the authority to make operational decisions would remain with the developer, and that the Environmental Monitoring Committee would be (PR#599 p.iv):

- *established pursuant to a binding agreement among the signatory Parties;*

- *independent of the Parties;*
- *advisory to the Parties; and*
- *established as a registered non-profit society in the NWT.*

This committee would have secure, adequate long-term funding provided by government, by project phase and as those phases are approved; and “secure tenure for the life of the Project, recognizing that changes to the Environmental Monitoring Committee’s mandate and budget may be appropriate as the Project moves from site remediation to long-term operation and maintenance (perpetual care)” (PR#599 p.iv). The discussion paper provided budget predictions, and described composition as follows:

The Environmental Monitoring Committee would be composed of five independent members. They would be residents of the Yellowknife area, including N’dilo and Dettah, and be selected through a public process. Selection of Committee members would be based on knowledge of the Project, the concerns of the residents and the technical and environmental issues associated with the Project, objectivity regarding the Project, and an understanding of the positions and interests of affected groups, particularly the YKDFN.

The paper recommended that Parties advise the Review Board collectively of the status of their discussions and next steps, and, if there is agreement to move forward, “confirm with the Review Board at the September 2012 public hearing their firm commitment to establish a Giant Mine Remediation Project Environmental Monitoring Committee and to ensure that it will be fully operational prior to the initiation of the Project” (PR#599 p.iv).

During the public hearing, the Developer characterized the above discussion paper as “an important piece of work” and “a foundational document” (PR#579 p112).

Alternatives North submitted two external reviews of the Independent Environmental Monitoring Agency for the Ekati diamond mine demonstrating the effectiveness of independent oversight mechanisms (PR#519). In the public hearing, Alternatives North noted that “AANDC has supported and signed agreements for oversight for the Northern diamond mines, but they’re not prepared to do it for this project” (PR#575 p111).

On May 7, 2012, the Review Board issued additional information request IR#3, which asked the Developer to describe areas of agreement and disagreement regarding oversight and its rationale for areas where there is disagreement (PR#422 pp5-6). The response (PR#422), dated June 11, 2012, was a joint letter on behalf of the Developer, the Yellowknives Dene, Alternatives North and the City of Yellowknife describing the oversight workshop of March 2012 and the progress of the oversight working group since that time. It said that the working group “quickly determined that there was sufficient common ground regarding the need for arms-length environmental oversight body to continue exploratory discussions” (p1), and it said that all the organizations involved “generally concur with the recommendations of the working group and have directed it to pursue discussions on an agreement to establish the committee” (p3).

7.2.3 The Developer’s revised proposal for oversight

On August 31, 2012, the last day prior to the closing of the public record before the public hearing, the Developer submitted a letter to the Review Board on the further development of its proposed oversight body

(PR#566). Unlike the June 11th, 2012 letter, this was signed only by the Developer. It introduced the Environmental Monitoring Advisory Committee. It described the proposed committee (see details below), and stated that the Developer was proposing to work with all interested and affected government and organization to have the committee in place prior to the commencement of the remediation.

In the public hearing, the Developer's presentation emphasized the various layers of existing oversight with government and regulatory mechanisms, the independent peer review panel, the environmental management system, the Aboriginal Government Body and the Giant Mine Advisory Committee. Based on the "excellent progress" of the working group following the March 2012 oversight workshop, the Developer proposed an Environmental Monitoring Advisory Committee. The Developer indicated that it accepted the working groups' conclusion about the need to establish an environmental monitoring advisory committee (PR#579 p113).

The Environmental Monitoring Advisory Committee's mandate will be "to provide arm's length advice to the Giant Mine Remediation Project team as it implements the environmental management system", including advice on adaptive management, best practices, perpetual care and communications. It is intended to "increase public confidence through regular engagement with the both the proponent and the community", and to "provide input to develop and implement the Environmental Management System engagement plans in perpetual care, and advise on the long-term operations and maintenance" (PR#579 p113).

The Developer described how the committee would have full access to all appropriate information, and how the Project team would consider and respond to the committee's recommendations (PR#579 p114). The Developer specified that the Giant Mine Advisory Committee would be composed of independent qualified members, and will exist throughout the Project implementation and monitoring phases. It will have a terms of reference to be reviewed every five years, will report annually and as needed, and will include a dispute resolution mechanism (PR#565 p12).

In the public hearing, Alternatives North asked if this committee would be based on a legally binding environmental agreement (PR#579 p134). This question was not directly answered, but the Developer later noted that there are examples of oversight groups that are not based on a legally binding agreement that have been effective, and that legally binding approaches takes more time to develop (p182). The Yellowknives Dene indicated that it has a definite preference for a legally binding agreement similar to those used for existing independent oversight agencies (p222).

In response to a question from DFO about the relationship of the committee to the environmental management system working group, the Developer stated that "these are both temporary structures that are in place during this stage of the Project... It's hoped that the oversight working group will continue the conversation... with a recommendation for a permanent body" (PR#579 p161).

7.2.4 Oversight issues at the public hearing

Chief Sangris related the Yellowknives' views on trust and confidence in the Project to the establishment of an oversight agency. On this, Chief Sangris said that the developer's unilateral rejection of the agreement produced by the working group was "proving there's no desire to enter into a binding agreement with the Yellowknife Dene or to establish a meaningful arm's-length oversight regime" (PR#575 p95-96). Sangris re-

emphasized the importance of oversight for the Yellowknives Dene, saying “(T)he only way that we can ensure that the government will keep the promises they have made for us to the Board is to assign a clear measure requiring the establishment of the oversight entity” (PR#575 p96).

The Yellowknives noted the Developer’s apparent commitment on oversight from the scoping hearing of July 2008, and said “it didn’t take long for that commitment to disappear, or sort of disappear”, and that was why it was requesting measures from the Board instead of just commitments by the Developer (PR#579 p215).

The Yellowknives Dene described the potential for an oversight agency as a builder of trust between the Developer and the Yellowknives. It noted that the Ekati mine wins awards for environmental stewardship, and said it was being pushed to excel by the regulators receiving interventions from its independent oversight body. The YKDFN noted that this helps build community trust in the Developer. For the proposed Project, it states that independent oversight “is not a negotiable part of the YKDFN forward. This is one of the accommodations that's required to the Yellowknives' concerns” (PR#579 p220).

The Yellowknives noted that the letter submitted by the oversight working group (PR#422) was submitted jointly, but the end product was a unilateral letter by the Developer (PR#566). The Yellowknives stated that the August 31, 2012 letter proposing the Giant Mine Advisory Committee did not go far enough and was not sufficiently binding, and that the YKDFN want a binding environmental agreement (PR#579 p221). The YKDFN asked the Board for a measure requiring the establishment of an independent oversight panel developed by agreement amongst the Parties, building on work already done. It stated that this would ensure independence and effectiveness (PR# 579 p225).

In Alternatives North’s public hearing presentation on oversight, it noted that there is evidence that the independent oversight agencies for diamond mines, which AANDC has supported and for which it has signed agreements, are performing satisfactorily (PR#542; PR#575 p111). It notes that the oversight working group that resulted from the March 2012 workshop held twelve meetings, that the discussion paper (PR#422) went through six drafts, and that the working group went through eight drafts of an environmental agreement (PR#579 p232). It described this as progress but noted that the Developer had not committed to independent oversight. Alternative North asserted that the commitment is not sufficient, and that there is significant public concern. It requested a binding measure for a mutually agreeable public oversight body before the Project proceeds.

Alternatives North noted there is no evidence of duplication or overlap between existing independent agencies and existing regulatory bodies, and requested that a legally binding and enforceable environmental agreement be negotiated to formalize the commitments on oversight to date from the Developer, and serve as a basis for independent oversight, among other things (PR#579 p234). It suggested possible provisions for an environmental agreement, including provisions for dispute resolution, and specified that the agreement should be for the life of the Project (PR#579 p236).

When asked for their views on the main areas of difference between the position of the Yellowknives Dene and Alternatives North compared to the position of the Developer regarding an environmental agreement, both Alternatives North and the Yellowknives said they have not been given any indication what the Developer’s

issues were with the draft environmental agreement. Alternatives North indicated it was not sure, but the differences appeared to be based on whether it should be based on a legally binding arrangement, dispute resolution and funding (PR#579 p247).

David Livingstone was the facilitator of the oversight working group. Livingstone specified that he was participating as a member of the public, and endorsed the comments by the Yellowknives and Alternatives North about the effectiveness of existing independent monitoring agencies, stating (PR#579 pp281-282):

Industry, I think, has seen the benefit in having third-party oversight, third-party comments, expert comments. Certainly the communities by and large have been reassured by the presence of these monitoring agencies as a voice that they can go to and hear from a neutral perspective whether the operators of the mines are doing their job as had been anticipated.

And I think government has generally been satisfied with the performance of those monitoring agencies as well. And I'd point out that government has been a signatory to each of those agreements. Each of those agreements is a legally binding agreement, and it's enabled the Parties to move ahead with the implementation of the projects, with some degree of a social licence.

So I think it's a useful model. I think that northerners, residents of the NWT, are familiar with those models, or that model, are comforted by the notion that somebody is looking out for their interest in addition to the normal cast of regulators and government agencies, and I think it's -- frankly, it's a small price to pay for that kind of reassurance.

The Yellowknives Dene expressed its concerns and recommendations regarding the Project oversight in its closing statement. It noted that much of the work has already been done collaboratively between the Developer and parties to develop a model for oversight specifically for this project, although the Developer chose to not proceed with it. It asked the Board for a measure for an independent oversight board “*along the terms established in the discussion paper and during the working group*” (PR#605 p5).

In its closing statement, the NSMA also asked the Review Board to create an independent monitoring agency for the Project that would (PR#606 p5):

...would be directed by a Board of appointees representing each of the Metis and First Nations whose territory includes Great Slave Lake, with one appointee for the City of Yellowknife. The Agency would have a mandate, with an adequate and secure budget, to commission its own research, including traditional knowledge research.

The City of Yellowknife stated its support for an environmental agreement and oversight in the public hearing (PR#579 p74).

In the Developer's closing statement (PR#611), it recognized that Project oversight has been a consistent theme throughout the EA, and said that it has been working collaboratively with Parties on this. It noted that the Project is subject to high levels of scrutiny within government and from regulatory bodies. It said (p9):

The Project Team believes the existing oversight mechanisms are effective and robust. Nonetheless, based on input from Parties and the public, the Project Team has concluded that establishment of an Environmental Monitoring Advisory Committee would be an effective mechanism to foster ongoing community engagement, public and independent input into the remediation process, and generate and maintain public confidence in the Project. Working with the Parties we have reviewed the options for additional oversight, and we are committed to establishing and resourcing a multi-stakeholder Environmental Monitoring Advisory Committee, formalized through a documented Terms of Reference.

We have researched and reviewed the options available for establishing an oversight body and presented this research into best practices at the Alternatives North/YKDFN sponsored Workshop on Independent Oversight. Based on this research, we believe the approach the Project Team is proposing will serve the community well and help build trust over the coming years.

The Developer notes that it has made commitments on accountability and oversight as part of the Environmental Management System working group of the Parties, the Giant Mine Advisory Committee of the YKDFN, an independent engineer who will report to the management board (primarily in the area of value for money [PR#597 p111]), and the Environmental Monitoring Advisory Committee.

At the public hearing and in written submissions, several members of the public told the Board that they want an independent oversight agency for the proposed Project to build public trust and confidence (PR#327; PR#576 p330, 337, p343, p354, p380, p386, p388; PR#581; PR#582; PR#583; PR#584; PR#604).

MLA and registered Party Bob Bromley told the Review Board that he viewed independent oversight as an important part of the Project. He said (PR#576 p374):

I just wish the public had been given the opportunity for independent oversight back when the community raised serious health concerns in the '50s and the '60s and when Ecology North raised it to a national level in the early '70s. Our only response was, 'Rest easy, your federal Government has it in hand'.

7.3 Review Board analysis and conclusions: public confidence and oversight

The Review Board notes that public confidence is an important recurring theme raised by many environmental assessment participants. The Yellowknives Dene have described their lack of trust in government based on their experiences of effects on their land, traditional practices, and wellbeing. The Review Board notes that Parties and members of the public have been particularly concerned about the multiple and potentially conflicting roles played by the government with respect to this Project, ranging from Developer, responsible minister, inspector, and so on.

In the Review Board's opinion, the acceptance of this Project by surrounding communities depends on public confidence. The Board believes it is essential that government fulfill its roles properly, and that surrounding communities recognize it is doing so and is acting in the broad public interest. Because of the nature of the Project, the potential hazard and the sensitivity of Aboriginal concerns based on their experiences, a high degree of trust is necessary for them to accept this Project. The Yellowknives Dene and others are concerned that the Project will not function as the developer has predicted and will not be managed properly with objective decision making that will keep people in surrounding communities and the environment safe from the risks of contamination. For these reasons, the Project as proposed is likely to cause widespread anxiety, particularly among the Yellowknives Dene.⁶⁷ This is an adverse social impact in itself, arising from a public concern that is significant.

Many Parties and members of the public have told the Review Board that they see independent oversight of the Project as a solution, because with it, they would not have to rely exclusively on the Developer to keep them informed and to provide critical oversight to ensure that the Project is working as intended. There is ample evidence on the record that in other instances in the NWT, across Canada and internationally, independent oversight agencies have been effective at achieving their intended goals, including increased public confidence. The Board notes that the same government that is proposing this Project was supportive of these to help address concern and build public confidence for the diamond mines.

The Developer has said that the regulatory system provides adequate oversight for the Project. The Board notes that the independent agencies that exist in the NWT do not serve the same function as regulatory agencies, and have not resulted in unnecessary duplication. The requests for an independent oversight agency by the Parties and public indicate their general satisfaction of the existing agencies. An independent oversight agency for the proposed Project would, in the Board's view, not duplicate existing regulatory mechanisms, but complement them.

Parties, particularly the Yellowknives Dene and Alternatives North, have made notable efforts to encourage progress towards developing a workable model for Project oversight. The Developer has made a real effort to work with Parties to identify a mutually suitable model. This was demonstrated by the oversight workshop, discussion paper, and joint response on oversight submitted to the Board in May 2012. The Board notes there was progress on multiple drafts of an environmental agreement and sees this as encouraging. This effort deserves recognition.

The Review Board is of the opinion that the commitment ultimately offered by the Developer contains encouraging elements, as Parties have observed, but accepts the evidence by the Parties that it is not sufficient. The Giant Mine Advisory Committee lacks the clear independence, legal basis, and dispute resolution required to address the public concern. The Board accepts the views of the Parties that independence is a critical part of ensuring public confidence, and that oversight bodies with a legal basis are better able to oversee and improve

⁶⁷ See sections 8 (Health) and 12 (Traditional Use) for further discussion of cultural and health aspects of this impact.

environmental management. The Board believes that a clear dispute mechanism to ensure compliance with the legal basis improves the credibility and effectiveness of oversight.

The Board has described above its conclusion that the Project, as proposed, is likely to cause significant adverse social impacts. By increasing public confidence in the proposed Project, independent oversight is likely to mitigate this impact and help address significant public concern. Independent oversight will also improve Project management and operation, and help compensate for the otherwise likely significant adverse impacts that will result from deficiencies in the predictions of the Developer's risk assessment.⁶⁸ This will help reduce the likelihood of significant impacts overall.

Measure 7: The Developer will negotiate a legally-binding environmental agreement with, at a minimum, the members of the Oversight Working Group, and other appropriate representative organizations, to create an independent oversight body for the Giant Mine Remediation Project. These negotiations will build on the existing discussion paper and draft environmental agreement of the Giant Oversight Working group. This oversight body will be in place before major Project activities begin on site, and will exist for the life of the Project. The environmental agreement will include a dispute resolution mechanism to ensure compliance with the agreement and a stable funding mechanism for the oversight body.

Measure 8: The activities of the oversight body will include:

- keeping track of monitoring activities by the Developer and the results of those activities, including water quality and aquatic effects monitoring, health monitoring and other monitoring
- considering the adequacy of funding for the Project and ongoing research
- providing advice to the Developer, regulators and government on ongoing improvements in monitoring and Project management to prevent risks and mitigate any potential impacts
- sharing the oversight body's conclusions with the general public and potentially affected communities in a culturally appropriate manner

The Board expects discussions towards the independent oversight body to build on the work already done by the Developer and Parties. The Board does not intend the above oversight body to duplicate the work of regulators, but instead to compliment it, bringing an integrated perspective of all aspects of the Project.

Suggestion 6: To reduce public concern about the multiple roles of AANDC in this Project and to increase public confidence, AANDC should produce guidelines to clarify reporting structures to ensure that Project inspectors, advisors and managers employed by the federal government can perform their duties objectively and without undue pressure from within the federal government. These should be made available to the public within six months of Ministerial acceptance of this Report of Environmental Assessment.

⁶⁸ described in section 5.5 and 5.11 of this report

8 Health Impacts

This section describes the evidence regarding potential impacts from the proposed Project on human health. This includes direct and indirect impacts and cumulative impacts. Section 8.2 reviews evidence from the Developer's human health risk assessment, additional evidence from the Parties, and concerns from the public. The Review Board's analysis of the Developer's human health risk assessment is presented in Section 8.3.

The Terms of Reference (s3.3(3)) required the Developer to examine whether the frozen block method will protect the health and well-being of the human residents living near the Giant Mine for as long as the contaminated materials persist at the site (PR#116 p16). Section 3.4.2 of the Terms of Reference focused on human health and safety and the protection of people in Yellowknife, N'dilo and Dettah. The Terms of Reference required the Developer to identify all potential pathways for contaminant exposure for local residents, and to assess all risks to human health and impacts to quality of life related to exposure to arsenic trioxide, with consideration of chronic exposure as well as to short-term high level exposure that might result from a catastrophic malfunction of the development leading to a large release of arsenic (PR#116).

8.1 Current contamination

Existing contamination on and around the Giant Mine site is briefly discussed above. In summary, the Giant mine site contains highly contaminated soils. Sediments and water in Baker Creek and Back Bay contain elevated arsenic levels. Fish in Baker Creek, and some in Yellowknife Bay, have elevated arsenic in muscle tissue. Some soils in Yellowknife and N'dilo are contaminated with arsenic. Some buildings on site are highly contaminated.⁶⁹

8.2 Evidence from the Parties: Health Impacts

8.2.1 The Developer's human health risk assessment

The Developer's Assessment Report specifies that the first objective of the Project is to manage the underground arsenic trioxide dust to minimize public and worker health and safety risks (PR#139 pES.2).

The Developer submitted a Tier II human health risk assessment conducted in 2006, as Appendix B supporting document N-2 of the Developer's Assessment Report⁷⁰ (PR#139b). It characterizes the site and arsenic receptors (including people), looks at exposure pathways, and models exposure. Section 8.9 (PR#139 pp8.71-8.92) of the Developer's Assessment Report describes the Developer's initial assessment of ecological and human health risks, largely based on the 2006 study. The Developer's Assessment Report uses the 2006 study to examine the type of arsenic in fish to infer fish-derived arsenic in humans. It considers exposure via food (including traditional foods), vegetation, medicinal tea, water, air, and soil. It also considers exposures for children and adults at the Giant townsite, on Latham Island, in the City of Yellowknife and in Dettah. It considers exposure of a toddler at the townsite, but does not include toddlers in the sensitivity analysis when determining effects.

⁶⁹ See Section 1.3.5 for a more detailed summary of existing contamination, including references.

⁷⁰ In this report, this document submitted in an appendix to the Developer's Assessment Report (PR#139) will be referenced as "PR#139b".

Assumptions and Uncertainty

The Developer modelled arsenic exposure for hypothetical receptors of different ages, diets, and residence locations and included a hypothetical 11-year old child and an adult (PR#139 p8-83). The DAR recognized some uncertainties, and described means by which conservative assumptions were used. For example, it assumed that receptors get a relatively large proportion of their food from local sources, and spend their entire lives in the vicinity of the mine.

The Developer noted recent studies suggesting that some forms of organic arsenic could be more toxic than previously thought (PR#139 pp8-82 to 8-84) and identified the classification of potential human health effects, as a particular challenge (PR#139 p8.87):

Perhaps the greatest source of uncertainty in the risk assessment process is in the relationship between arsenic intakes and potential health effects... The most difficult question surrounds whether health effects such as those described above [skin cancers, cancers of the bladder, lung, kidneys and prostate] can be expected to result from long-term exposure to low levels of arsenic.

Developer's predictions

The Developer's human health risk assessment notes that water quality predictions for Back Bay, North Yellowknife Bay and South Yellowknife Bay are expected to meet the *CCME Arsenic Guideline for the Protection of Freshwater Aquatic Life* and the proposed *Canadian Arsenic Guidelines for Drinking Water*, while Baker Creek is predicted to exceed both of these (PR#139b p7.3).

The Developer's assessment of all risks from arsenic trioxide includes chronic exposures and short-term high level exposures that might result from a complete failure of the Project with respect to arsenic containment. The Developer specified that even complete failure of the Project was not predicted to result in widespread human health effects (PR#139 p6-35). The deficiency statement issued by the Review Board required the Developer to provide more information on the potential health effects of a failure of the frozen block method (PR#153). In response, the Developer concluded that a complete failure of frozen block (PR#157 p13):

...could conceivably result in... an increased risk to human health of those individuals who live off the land (i.e. harvest fish and game from the study area). Environmental effects would be expected to be limited to the study area and not result in adverse consequences to the Great Slave Lake ecosystem or people living outside the immediate study area.

The Developer's Assessment Report indicates that, for a resident at Giant townsite a daily arsenic intake of 0.001 mg as a daily dose over a lifetime,⁷¹ the Project would increase that person's lifetime risk of getting cancer by roughly 12 in 10,000. It concludes that the predicted cancer risks from the Project are well below the lifetime incidence cancer rate of 3 in 10 for the NWT. It states (PR#139 p8-92):

The estimated total arsenic intakes for Yellowknife area residents, inclusive of individuals with traditional food diets, were found to generally fall within the range of typical arsenic intakes

⁷¹ i.e. 0.001 mg/(kg d)

estimated for other Canadians. Even though arsenic levels in the area are higher than found in most Canadian communities, the human health risk assessment results suggest that there would be no measurable change in cancer risk to people in the study area.

In its conclusions, the DAR predicts that “measurable elevation of cancer prevalence would not be expected” and that predicted arsenic intakes are (PR#139 p7.6):

- *within the range of risk levels associated with typical exposure of the general Canadian population living in communities across Canada;*
- *well below incidence rates of cancer in the Northwest Territories; and,*
- *similar to exposure levels in communities with elevated arsenic levels in the local environment. Communities ... with similar high levels of arsenic do not report elevated prevalence of cancers related to arsenic exposure.*

Reviewers’ comments

The 2006 Tier II human health risk assessment was reviewed by Environment Canada, DFO and Health Canada in 2010. The Developer submitted the DFO and Environment Canada reviews (PR#145; PR #146) to the Review Board on November 5th, 2010. This 2010 review by Health Canada (PR#591) was submitted by the Developer on September 14, 2012, as a requirement of a hearing undertaking (PR#576 p233).

On December 15, 2009, Environment Canada noted that there have been many additional studies on fish and benthic invertebrates that both support and refute the results of the 2006 human health risk assessment. For example, Environment Canada references a study which indicates a greater proportion of bioavailable arsenic in Yellowknife Bay than that which was used in the Developer’s 2006 study (PR#146). Environment Canada also noted that field studies deserve more weight than modelled results, and it suggested that incorporating these new studies into the human health assessment will inform more accurate conclusions and suitable remedial options at the site (PR#146). DFO comments support Environment Canada’s suggestion through its recommendation to augment the health risk assessment to reflect new information (PR#145).

Health Canada reviewed the health risk assessment on Feb. 19, 2010 (PR#591). It identified that Health Canada has lowered the cancer slope factor reference from 2.8 to 1.8 mg/kg day, based on updated toxicology related to internal cancers of multiple organs. It recommended “a conservative approach in using acceptable cancer slope factors to more accurately reflect emerging information related to arsenic toxicology and potential for increased susceptibility from early-life exposure to carcinogens” (PR#591 p1).

The 2010 review by Health Canada included its previous review comments, sent to the Developer in 2005, as an attachment. In these, Health Canada notes (PR#591 p5) that the health risk assessment concludes that “[p]eople living in the study area are not at risk of adverse effects from arsenic exposure even though arsenic levels in the area are higher than found in most communities. The estimated total arsenic intakes for Yellowknife area residents are below the Health Canada Toxicity Reference Value...”. However, section 6.3.7 of the same report states that the highest predicted total arsenic intakes for all child receptors were above the toxicity reference value. Similarly, the highest predicted total arsenic intakes for the most exposed adult receptors were above the toxicity reference value in one of the remediation scenarios.

In March 2010, on behalf of the Developer, the authors of the 2006 Tier II risk assessment reviewed the assumptions and inputs that were used in that assessment to determine whether the conclusions remain valid. The March 2010 review considered the results of the more recent studies and concluded that the findings of the 2006 risk assessment should remain unchanged (PR#147).

Although Health Canada's comments suggest that the Tier II health assessment underestimated the risks, the Developer's Assessment Report stated that it "likely over-estimates the risks" (PR#139 p8-71). In the public hearing on Sept. 13, 2012, the Developer summarized the 2006 risk assessment, saying "we've done an exhaustive account of the possible human health effects of this project". The Developer noted that the risk assessment included traditional foods and water, and said "[i]t's a highly site specific document... So we think we've done as much as possibly can be done on human health risk assessments" (PR#578 p172).

The role of Health Canada in the environmental assessment

Public hearing participants, among them the Yellowknives Dene, noted the absence of Health Canada in the proceedings (PR#576 p191, p223). The Developer suggested that the Yellowknives Dene's health concerns should be brought up with Health Canada outside of the EA process (PR#576 pp191-192). It clarified that Health Canada is not part of the Giant Team, but that it is part of the Federal Contaminated Sites Action Plan secretariat and had reviewed baseline studies of fish tissue analysis and some of the key risk assessment documents (PR#576 p224). The Developer told the Board that Health Canada has had no recent involvement and committed to submit the results of the fish tissue sampling to a regional contaminants body which Health Canada is part of, for its consideration with respect to fish consumption advisories (PR#576 pp225, 227).

8.2.2 Arsenic modelling

During the public hearing, Katherine Enns, the Review Board's technical advisor, cited section 7.4.3 of the Developer's Assessment Report, which states that "[t]aking into consideration mixing within Baker Creek and downstream within Great Slave Lake, Golder concluded that sub-lethal toxicity effects are likely to occur throughout Baker Creek and marginally into Great Slave Lake". The Board's technical advisor observed that the concentrations used in the models of the toxicological risk assessment were not compared to actual effects in the field. The Developer recognized that, as in any assessment, there was uncertainty⁷² and has tried to reflect this by conducting probabilistic assessments (PR#577 p119).

The following day, Ms. Enns asked how the Developer can model arsenic loading when it has not sampled arsenic distribution offsite (PR#578 p181). The Developer was questioned as to why it didn't examine humans living in the vicinity to establish current health conditions related to arsenic, considering the previous deaths described by the YKDFN. Ms. Enns also asked why there was such a reliance on modelling instead of measuring actual human hair concentration or urine analysis, considering the huge amount of arsenic and the vulnerable population (p185).

⁷² There is no indication that the Developer attempted to address uncertainties by using relevant data, such as the 2008 environmental effects monitoring, which the Developer's Assessment Report identified as a relevant study (PR#139b pR-6).

At the public hearing. Dr. Ian Gilchrist criticised the Developer's reliance on averages and general standards such as those of the International Standards Organization. He told the Board (PR#579 p37):

[A]rsenic exists in many forms, people exist in many forms, environments are different from place to place, and everything falls on a bell curve. So by using averages and standards from elsewhere without looking at who we are here, who the people are, who the people have been, what the people's health is like, it seems to me that you really are not able to achieve the final objective which is people's health.

The Developer stated that measured data were used, to a large part, although actual intakes are calculated through a model (PR#578 p189).

In its supporting documentation, Health Canada noted that the Developer's health risk assessment only presents risks for two life stages (adult and child), while Health Canada and CCME say that five life stages should be used for human health risk assessments, including infants, toddlers and teens, in addition to the child and adult models used by the Developer. Health Canada said "it is particularly relevant that the toddler be evaluated, consistent with advice and guidance proffered by Health Canada, CCME, and most provinces/territories, as they often represent the critical receptor for residential land use scenarios" (PR#591 p3).

The Tier II health risk assessment of toddlers at the townsite had an average arsenic exposure of 2.7×10^{-3} mg/(kg day) and a 95th percentile exposure of 4.3×10^{-3} mg/(kg day) but did not interpret the significance of this range of exposures except to say that toddler exposures would be highest at the townsite. Health Canada asked the Developer to clarify whether the sensitivity analysis for toddlers was incorporated in the final risk assessment, stating that "[i]t appears that the final calculations and summary conclusions were based on adult and child and a composite receptor risk estimates" (PR#591 p2).

8.2.3 Cancer rates

Health Canada commented on the Developer's comparisons of general cancer rates with predicted increases from the Project. It said that "these types of general comparisons may not truly reflect site specific risks that may be associated with specific contaminants exposure" and that the actual risk may be "a little bit higher". Health Canada also expressed concern that the health risk assessment uses the mean instead of the upper 95% confidence interval with respect to bioaccessability of arsenic in soils.

Health Canada considered it inappropriate that the Developer's health risk assessment blended in lifetime cancer risk from Giant Mine, a single source, with lifetime cancer risks from lung and skin cancers. These are usually associated with voluntary actions such as smoking and sun-bathing, while a child living with his or her parents in a community which has been contaminated by industrial pollution has not made a voluntary decision to live there.

In its first round information request IR#22 (PR#178) the Review Board requested more information on predicted distribution of cancer rates from Project exposures compared to general NWT cancer risks clarifying additional risks for smokers and non-smokers, maximum predicted arsenic toxic intakes, and a comparison of cancer risk levels compared with the incremental lifetime risk of developing internal cancer for receptors with the highest arsenic intake in the Yellowknife area (PR#178 p30). The Developer replied (PR#288) that it was unable to provide the distribution for arsenic exposure in Canadian adults, and that it was also unable to analyze cancer rates for smokers versus non-smokers because the information was not available (PR#288 p2, p5). It

acknowledged that the maximum arsenic intakes were approximately twice the mean intakes reported for receptors by the Developer in its Developer's Assessment Report (PR#288 p3).

Health Canada recognized the difficulty in distinguishing the development of cancer from a single source (such as Giant Mine) from the background of other cancers. It stated (PR#591p6):

This distinction becomes even more difficult when the exposed population is small, and therefore one would need several generations of data to be able to detect a significant pattern of cancer caused by a particular source. If a population is sufficiently small, it is possible that a significant pattern of cancer will not be able to ever be determined. Failure to definitively distinguish increases in cancer occurrence, does not in itself signify negligible or inconsequential cancer risks.

8.2.4 Contaminants in food and drinking water

During the public hearing, on September 11, 2012, Katherine Enns, the Review Board's technical advisor observed that the Developer studied arsenic body burdens in fish and arsenic sediment concentrations but did not study fish health effects beyond measuring the concentrations of arsenic in muscle tissue. She noted that such high concentrations of existing arsenic would usually result in an effects assessment, but there was no evidence that these studies were conducted. The Developer was asked if it looked for any other evidence of health problems in fish, such as sclerotic livers, malformations or skin diseases (PR#576 pp135-136). The Developer indicated that it did not.

The Board's technical advisor later stated that actual fish health measures are a better indication of fish health than fish tissue concentrations (PR#576 p141). Enns noted that the Developer's Tier II human health risk assessment identified hazards and resulting effects to invertebrates and fish in Baker, but also noted that the Developer used geometric means, which are low in comparison to the distribution of concentrations of arsenic in the environment (PR#576 p137). She said that the Developer did not appear to have taken the steps that would be required in other jurisdictions to prove there are no significant effects to fish, wildlife, and other receptors, and indicated that establishing a baseline before implementing the Project was one such step.

The Developer did not counter or challenge these assertions, but did commit to establishing a baseline. It described a plan to do more baseline research on fish in Yellowknife Bay near the mouth of Baker Creek and in the vicinity of the diffuser (PR#576 p141). The Developer described other studies on arsenic and summarized (PR#576 p140):

In general, the results we're showing for fish is that we don't see evidence of negative effects... The evidence we've seen so far on fish and arsenic levels in fish is that they're not unusually high. They are comparable to what we've seen in other systems elsewhere. They are elevated somewhat in some species within Baker Creek, but outside of that they are pretty typical. And there's very little evidence of health effects, from what I've read in the biological reports.

The Developer specified that fish are adaptable enough to be healthy despite exposure to high arsenic levels, however the Developer's studies examined arsenic concentrations in fish only, and did not examine fish health (PR#577p149):

Fortunately, arsenic doesn't accumulate to a high level in -- typically within fish species, and they will adjust over time to their new surroundings. So even if a fish is in, let's say, Baker Creek for a month and is exposed to higher levels of arsenic than it would be back in Great Slave Lake it will adjust -- the body burden, if you will, adjust over time as it migrates. So it's not just the fish are -- you used the word as "healthy". We're not talking about a health issue with respect to fish. We're talking about arsenic levels within the fish tissue itself and what that means to other species who eat the fish which is ourselves.

In the Dettah public hearing on Sept. 12, 2012, Yellowknives Dene Elder Peter Sangris told the Board that the Yellowknives Dene are afraid of pollution in water as it relates to fish health, and that he wants this to be studied (PR#577 p378):

No more pollution in Yellowknife Bay. It is enough. Dene people, they know Yellowknife Bay fish are sick from last fifty years... from the Giant Mine north territory. And all the fish, the stomach were all red. The meat is too soft to eat. Before last fifty years ago, the fish good to eat. Today we're scared to eat a fish. Somebody has to look into it.

8.2.5 Contaminants in sediments and soils

The Developer's 2006 Tier II health assessment described arsenic levels in sediment, saying (PR#139b p7.3):

Arsenic levels in sediments in Baker Creek, Back Bay and Yellowknife Bay have been shown to be elevated above background due to historic activities. Sediment quality predictions showed decreasing trends with time in all water bodies for the remediation case. However, arsenic levels in sediment remain elevated. Only in South Yellowknife Bay is the sediment arsenic concentration predicted to approach background conditions by 2100.

The Review Board's technical advisor asked why "the 2006 risk assessment results indicated that, in addition to arsenic, antimony, lead, and nickel also presented risks to the environment and to human health", but that lead and nickel were eventually ruled out (PR#576 pp135-136). The Developer stated that other contaminants, such as antimony, were screened out of the risk assessment because they were generally associated with the arsenic, and occurred in the same soils (PR#576 p139).

The Board's expert advisor observed that the sediments of Baker Creek, Back Bay and Yellowknife Bay have very high maximum arsenic concentrations ranging from 90 - 3757 ppm (PR#576 p142) and asked the Developer how it would be known if sediments were disturbed when the plans were to look at fish only every two to three years, and how it would be known that arsenic was not accumulating in the bay because of the diffuser, instead of being flushed out to Great Slave Lake.

The Developer replied that the arsenic has been there for decades, and that the system has been recovering, although arsenic concentrations change more gradually in sediment than they do in water. The Developer predicted that some pore water from the sediment would be released during diffuser installation, but that this would be a small release for a short duration and would be mitigated by the use of silt curtains and upward-angled nozzles on the diffuser. The Developer notes that the sediment the diffuser is going into is likely contaminated with 100 ppm arsenic, and does not expect further arsenic build-up in sediments (PR#576 p145).

The Developer later noted that half of the arsenic in sediments is in an inert form, that pore-water chemistry exerts toxicity effects, and that this has been quantified in the risk assessment (PR#576 p149).

The Board's technical advisor stated that the bay is shallow and the water in it may not be as mobile as expected (PR#576 p146). and asked the Developer how it plans to monitor arsenic accumulation in sediments. The Developer replied that it expects an overall improvement in the system, saying it was certain that, from a water quality perspective, there would be no residual issues in Yellowknife Bay (PR#576 p148):

Certainly from a water point of view, there's -- there are no residual issues within Yellowknife Bay. Sediments, granted, are -- have elevated arsenic. There is some effect certainly on the benthic communities that are there. And that's going to take many decades probably to rectify.

A study of cumulative human health impacts was conducted for the federal government in 2001 to distinguish between natural and anthropogenic inputs of arsenic in the Yellowknife area. During the environmental assessment scoping, the YKDFN submitted this study to the public record (PR#65). The report states that parks and playgrounds in Yellowknife, N'dilo and Dettah were of particular interest. It also provided the following information:

- The average concentration of arsenic in N'dilo soils is 286 ppm, plus or minus 240 ppm, although the actual range was as high as 645 ppm (p27).
- Concentrations of arsenic in Dettah soils is lower, averaging 50 ppm plus or minus 56 ppm, with a maximum of 144 ppm.
- The average concentration of arsenic in Yellowknife soils is 32 ppm, plus or minus 34 ppm, with a maximum of 148 ppm (p27).
- The study found average arsenic concentrations in Baker Creek surface sediments of 2024 ppm, plus or minus 1101 ppm.
- In Great Slave Lake outside the Baker Creek outflow breakwater, 3140 ppm of arsenic was recorded in sediments.
- The concentration in sediment up to a kilometer away remained as high as 1193 ppm.

The researchers concluded that there was not enough information to reach a decisive plan of action for dealing with arsenic in soils, and began work on risk assessment models that incorporate arsenic speciation (different kinds of arsenic with different toxicities), measures of its bioavailability and resulting risk.

8.2.6 Baseline health study

In the public hearing, the YKDFN expressed their strong interest in a baseline health study as follows (PR#576 p186):

People...want to be reassured that conditions continue to improve for them health-wise in the environment, and in the water, and in the air... Has there been any effort put towards some sort of baseline health studies that would [or] could reassure the Yellowknives Dene that the future is perhaps a little brighter when it comes to the environment that they live in?

In response the request from the YKDFN for a baseline health study, the Developer refused to commit to doing a health study because it has done them in the past and because it expects the Project to be an improvement over the existing situation (PR#576 p188-189).

Later in the public hearing, the NSMA also requested a health effects study to examine arsenic levels (PR#579 p156). The Developer again refused, replying that it was beyond its authority to do so and was not within its mandate (PR#579 pp156-157). In response to a later question from the Review Board's technical advisor, the Developer repeated that conducting a health study to monitor arsenic levels in people was not within its mandate (PR#579 p187). The Developer also emphasized that the Project is intended to cause an overall improvement to the environment (PR#576 p222).

Dr. Ian Gilchrist provided his views on the last day of the public hearing. He told the Review Board that it has been approximately 40 years since the Canadian Public Health Association studied health effects from arsenic in Yellowknife. He expressed concern that medical input was absent on the Developer's team. Dr. Gilchrist also emphasized to the Board that the understanding of arsenic and health effects is evolving. Dr. Gilchrist explained (PR#579 p36):

I think that just guessing how arsenic might affect people here by monitoring the food, water, et cetera doesn't quite go far enough. The amount of arsenic that will have gotten into people's bodies over the past eighty years will have certainly gone up and down and it's probably going down now... There is a need to look back at people's health. There is a need to look forward and do some projections about people's health. And if in your system of monitoring you are looking at everything else except the final goal, people's health, then it seems to me that it fails.

8.2.7 Public concerns over health

Concerns over health effects were raised many times by Aboriginal participants and other members of the public during the public hearing sessions in Yellowknife and was one of the primary themes of presenters in the public hearing in Dettah. In several cases, speakers were very emotional when they mentioned their fears concerning arsenic exposure, both historic and continuing exposure from the water, from a traditional diet of locally-obtained fish, caribou and berries and from the dust in the air.

These concerns have been documented earlier in this REA in the sections covering public concern, engagement and oversight, and so will not be repeated here. Suffice it to say that the Yellowknives in particular, and local area residents in general, have expressed strong concerns during this environmental assessment about the potential for ongoing and even severe health effects from arsenic exposure and a general distrust that the federal government was listening to and would respond to these concerns.

In addition to information about public concern regarding health matters, this section also contains a brief historical account of some of the issues the Yellowknives have dealt with as a result of mining operations at Giant follows.⁷³

⁷³ Section 2.6 describes the cumulative relevance of past effects of mining to this environmental assessment.

In its closing statement, the Yellowknives Dene provided its conclusions regarding health issues (PR#605 p4):

YKDFN have been impacted by this mine for decades, with little outside work undertaken to establish what the likely impacts are. Health Canada and the GNWT have not sought to establish the levels of contamination in our people to date - we don't need more models or risk analyses undertaken. We have an entire community of people who were exposed to unacceptable levels of arsenic for years. There was work undertaken during the 1980's by the Dene Nation and the Steelworkers using hair and fingernails to establish what the levels were in the people. This work should be recovered and extended to today.

A measure should be developed that directs Health Canada to repeat the studies previously undertaken and complete a more thorough analysis of the results to understand what the ongoing impacts to the people of N'dilo and Dettah are. In addition, a public apology must be made for the lives lost and continued harm that came to the people of Dettah and N'dilo as a result of mining at Giant.

YKDFN Chief Ed Sangris described to the Board the historical contamination and illnesses attributed to arsenic, including the deaths of young children (PR#575 p95):

When Giant began producing gold in the late '40s, it started releasing arsenic into the air and into the water. In 1951, Dene children died and other Dene started getting sick. But the government let Giant Mine continue to pollute the air, the land, and the water. There has never been the official inquiry into the causes of those deaths. Our people, whose children's mothers have never been given answers for the loss that was suffered.

Many other presenters raised the arsenic related deaths of Dene children (eg. PR#573; PR#576 p246; PR#577 pp354, 381, p394, p 397), which Elder Fred Sangris describes as “one of the worst things to ever happen to us” (PR#576 p246).

The historical summary of Giant Mine prepared by John Sandlos and Arn Keeling at Memorial University provides more details, and quotes the 1951 ruling from the coroner’s inquest that a two-year old boy died from “acute gastroenteritis caused by arsenical poisoning administered by unknown means” (PR#525 p8). The report states that “beyond April 1951, it is not clear from existing records how many other Yellowknives Dene were sickened by arsenic”, but describes additional cases that appear to be arsenic related.

Elder Fred Sangris described to the Board the connection between water quality and future health concerns based on the traditional role of fish in the Dene diet (PR#577 p364). He told the Review Board of the lack of government response in the past to studies dealing with health concerns of the Yellowknives Dene (PR#576 p254). The following day at the public hearing, Sangris further described to the Board how the past experiences of the YKDFN inform current health fears, describing deaths from particularly high cancer rates in the 1970s and 1980s cancer due to Giant Mine and the current inability of the Yellowknives to safely drink water from Yellowknife Bay (PR#577 p354, 366).

In the public hearing in Dettah, Band Counsellor Mary Rose Sundberg told the Board of that the Yellowknives are worried every day about health impacts from Giant, and regularly drive on the highway between

Yellowknife and Dettah through dust from the tailings ponds. Sundberg said “We don't know it, but it is killing us slowly” (PR#577 p346).

George Tatsiechele emphasized the ongoing nature of Yellowknives Dene’s current health to the Board, saying “there's a monster down there. And that monster, it's -- it's creating something in us because we're eating the fish, we're eating the animals. So we're -- we're like a walking time bomb, dying slowly because we -- we eat all that- - we eat the fish. We eat the caribou” (PR#577 p391).

Chief Ed Sangris, Elder Alfred Baillargeon and former Chief and Elder Fred Sangris characterized the concern in ongoing terms, in the context of the traditional diet, safety of drinking water from Yellowknife Bay and concerns about the exposure of children to contamination in the lake while swimming (PR#575 p95, p103; PR#576 p254). Fred Sangris specified that the proposed diffuser adds to this concern (PR#576 p253).

Former Chief and Vice Chief of Dene Nation Gerry Cheezie told the Review Board that he had great concern related to contamination in N’dilo and in sediment, particularly in terms of the safety of children living in N’dilo and Latham Island and said “The water that's going to be discharged into the Back Bay under this plan, the water has got to be drinking water quality, because if you don't, then you're just asking us to poison ourselves... There must be another way, and the experts have got to go back and rethink it and come up with another system” (PR#576 p359).

Several other Elders, including Michel Paper, Peter Sangris, former Chief Peter Liske others described similar concerns regarding health impacts from past and current contamination (eg., PR#362 p4; PR#572 , PR#575 p247).

In Dettah, former Chief Peter Liske presented the Board with a 1973 letter from the late Michael Sikyea, Dettah resident, to then Minister of Indian Affairs Jean Chretien, which described health concerns ranging back to the 1950s from arsenic at Giant and about drinking lake water. The letter asked the government for help (PR#573). Liske expressed his disagreement with the Developer’s conclusions about the impacts of the proposed Project on the health and well-being of the Yellowknives Dene, and said that the Yellowknives’ satisfaction would depend on the health studies being done by doctors and consultants hired by the Yellowknives themselves, instead of by the Developers (PR#577 pp379-386).

Former Chief and Elder Fred Sangris summarized the impacts of arsenic contamination on the Yellowknives Dene, and described his conclusions on the priorities of government, saying (PR#576 pp251-252):

For us, this great beautiful bay which used to support our lives, give us all the resources in our culture and our way of life, it's all gone, because the mine was so important to some people that it didn't really matter. Give them the permit. Give them water licence. Jobs are more important. But the Indian people who live here, took its toll, devastated. And we're still like that today.

Bill Enge, President of the North Slave Metis Alliance, described the similarities between the health impacts on Métis and those described by the Yellowknives Dene. He said “our people have seen the changes that have happened here, and have been subjected to the poisoning of our people, just like our Yellowknives counterparts have.... the Developer just hasn't done enough work to ensure the safety and health of the Aboriginal and non-Aboriginal people and northerners around here” (PR#576 pp269-270).

The Kuyek report (PR#333) describes why Aboriginal people are particularly vulnerable to health concerns from contaminants. It notes that in North America, the toxic effects of mines “disproportionally affects indigenous peoples upon whose land the mine was built, usually without their consent” (PR#333 p54). Kuyek notes that the experiences and related concerns have had important repercussions on the entire community, not just on those who worked at the mine. Drawing on a workshop report from the Deline-Canada Uranium Table, the author says (PR#333 p93):

The concerns are particularly related to human health but also to the health of their environment. The Dene rely strongly on their environment for their survival and their connection with the land is strongly reflected in their language and spiritual culture: "If the land, the water, the fish, the caribou are healthy, us Dene people will be healthy".

Several members of the public in Yellowknife told the Review Board of their concerns during the public hearing. Lorraine Hewlett spoke of the large amount of arsenic that would drain from Baker Creek annually into Back Bay. She asked the Board to “Protect public health. Keep people safe. Don't make us live with the anxiety of the ‘what if’” (PR#576 p366). Erica Janes, in her letter of September 23, 2012 to the Review board, described her health concerns as follows (PR#582):

There are still too many unknowns about the extent of the contamination: where is it, and will it be safe in Yellowknife to pick berries? Swim? Tap birch trees? Drink the lake water? Eat fish? Nobody knows the answers to these kinds of questions, and no work appears to be planned to answer them, although they are all important considerations in cleaning up this particular contaminated site. Aboriginal or non-aboriginal, all residents of this community deserve to trust that our health and interests are looked after by the responsible entities, and that the land and water will not poison us.

MLA Bob Bromley described to the Board his involvement with sampling human hair and fingernail tissue for contaminant analysis related to Giant Mine, saying (PR#576 p369): “This subsequent report concluded that Yellowknife had some of the highest human and environmental samples for arsenic, mercury, and possibly other -- other contaminants, such as antimony, in Canada”. On the subject of public concern, Bromley told the Board that the concern is “psychologically pervasive and weighs on the mind” of Aboriginal people and Yellowknife residents (p372).

The subject of health impacts related to widespread anxiety was discussed in the public hearing. On September 13, 2012, Dr. Frano Oboni, the Board’s technical advisor, noted that there are established models of evaluating changes in disease due to stress because of other life changes, such as the Holmes and Rahe stress scale which has been widely used since the 1960s. He asked why these has not been applied, considering the health concerns described by the Yellowknives Dene in the September 12, 2012 public hearing in Dettah. The Developer was asked, more generally, why “human health in a broad spectrum [had] not been brought in as a consequence in the risk assessment” (PR#578 p171). The Developer did not directly reply to the question, but stated that the human health risk assessment is “an exhaustive account of the possible human health effects of the project” (p171).

The Kuyek report (PR#333) includes an examination of available literature that included health issues of long-term and perpetual care sites. It summarizes these saying (p5):

In all the communities studied, risk assessments concluded that there was no provable relationship between the contaminants of concern and the shockingly poor health of the local people, except for psychological reactions.... 'The standard of proof for causality is set at such a high level that even if a near perfect correlation exists between local health problems and proximal levels of pollution or contamination, many communities still cannot prove causality'. (Rosa 2008, Guth 2010, Edelstein 2008, CHEJ)

Health effects on surrounding communities are common major issues of concern in the case studies examined in detail in that report. One of the conclusions from the case study of the Zortman-Landusky abandoned mine sites, which is alleged to have caused numerous health effects on four surrounding First Nation tribes, is that “health effects will be minimized by government and will be subject to political interpretation” (PR#333 p47).

On the subject of widespread anxiety associated with contaminated sites, the Kuyek report considers the experience of uranium mining in Deline and states (PR#333 p95):

Community-based health studies demonstrated that fear and anxiety about the human health and environmental impacts of Port Radium have severely affected the community of Deline. Analysis of collected oral histories showed that the majority of significant past and present health problems within the community continue to be strongly associated with perceived environmental threats. The perceptual link between exposure to mining activities and illness and death has affected people's sense of harmony with nature, which is a crucial component of their cultural identity.

In the Developer's public hearing presentation of September 14, 2012 (PR#565), it noted that “[t]he goal of this project is protecting the environment and the health and safety of the people of Yellowknife, Dettah and N'dilo” (PR#565 p24) and that “timely implementation of the remediation plan along with the described environmental management system and oversight mechanisms will ensure that health and safety is protected and that public concerns are addressed and minimized”.

A particular subset of the public concerns regarding health focussed on the Developer's chosen balance of cost and health in Project design. As described above, the Developer's Assessment Report states that the first objective of the Project is to: “Manage the underground arsenic trioxide dust in a manner that will minimize the release of arsenic to the surrounding environment, minimize public and worker health and safety risks during implementation, and be cost effective and robust over the long-term” (PR#139 p1-5).

In its technical report, Alternatives North expressed concern about how the Developer has balanced the need for minimizing safety risks against costs, as did Yellowknives Dene Elder and former Chief Fred Sangris during the public hearing (PR#471 p35; PR#576 pp255-256). During the public hearing, the Developer reinforced the priority of health considerations as a Project rationale, saying “[t]he project that's put before the Board is here to immediately address human health in the environment. By its very design, it's built to immediately improve the local environment and start -- and improve human health and protect human health” (PR#576 p227).

8.3 Review Board analysis and conclusions: Health Impacts

The Developer has made it clear through its health risk assessment and responses to questions in the public hearing, that it does not believe that the proposed Project is likely to cause any significant effects on health, or to be a cause of public concern. The Developer has reminded the Review Board that its first objective of the Project is “to manage underground arsenic to minimize health and safety risks”. It points to the predicted reduction in the amount of arsenic to be released and its health risk assessment.

8.3.1 Conclusions on the human health risk assessment

The Developer has responded to public concerns with its health risk assessment, which modeled arsenic intakes from food (including traditional foods), vegetation, medicinal tea, water, air and soil. The Developer has said that its health risk assessment was exhaustive, and that it has “done as much as can possibly be done on human health risk assessment” (PR#578 p172). It’s most thorough health assessment, the Tier II risk assessment, as reported in the DAR (PR#139 p8-92), was that estimated total arsenic intakes for Yellowknife area residents “generally fall within the range of typical arsenic intakes estimated for other Canadians”. It predicts “no measurable change in cancer risk to people in the study area”. However, the Board notes that Health Canada and the Board’s technical advisor found this study to be flawed for reasons described below.

8.3.1.1 Evaluating increased health risk

The conclusions of the human health risk assessment are not presented in a way that allows for a meaningful understanding of increased risks from the Project. The Developer’s health risk assessment is lacking a well explained, conservative, understandable conclusion with potential health risks identified and ruled out, where feasible.

Assessing health risks to toddlers

The Developer’s Tier II human health risk assessment modelled effects on an 11 year old child and on an adult, as a composite receptor but failed to include the most potentially vulnerable group - toddlers. Toddlers eat more in proportion to their body weights in comparison to children and adults, and they ingest more soil directly (a potentially potent source of arsenic). Toddlers are also at a more vulnerable point in their development than older children or adults. Even though the report identified (PR#139b p6-42) that “the toddler was anticipated to experience higher exposure than either the adult or child receptors” at the Giant townsite, Health Canada noted that toddlers were excluded from Developer’s sensitivity analysis (PR#591 p2).

The use of composite receptors has the effect of averaging out the more serious potential risks to toddlers and fetuses and has special significance to the potentially affected communities in this environmental assessment. The deaths of young children are still fresh in the minds of the Yellowknives Dene (eg. PR#576 p246).

Health Canada’s review of the Developer’s 2006 risk assessment note that guidance from Health Canada and CCME requires that risk assessments should include toddlers. Health Canada advises that “[i]t is particularly relevant that the toddler be evaluated, consistent with advice and guidance proffered by Health Canada, CCME, and most provinces/territories, as they often represent the critical receptor for residential land use scenarios”. Even though the Giant site is not proposed for residential use following remediation, this guidance still presents a good reason to consider effects on toddlers thoroughly.

The Developer did not provide a rationale for excluding fetuses, infants or toddlers but two factors should have modified this exclusion; even if remediation proceeds as planned, contamination sources will continue to affect soils, which are the main exposure pathway for very young children; and historical emissions are part of the cumulative effects of emissions from the Giant Mine.

While the Project may be defined as the immediate vicinity of Giant Mine, the plume from the Project (including past present and future deposition) extends into Yellowknife Bay, the City of Yellowknife, N'dilo and Dettah. These areas are included in the environmental assessment but excluded from a critically important modelling and measurement exercise that should⁷⁴ form the basis for a human health management plan for Yellowknife, N'dilo and Dettah. Further, the Developer proposes that people, including children, will use the site, on educational tours and possibly for recreation. Toddlers, infants and fetuses should have been included in the health assessment and the Developer should also have conducted modelling of the widely accepted 25 – 60 gram soil ingestion exposure pathway for toddlers.⁷⁵

The past deposition of arsenic from the roaster, which was only a few kilometers away from N'dilo, accumulated in playground and yard soils to result in high concentrations. Given that emissions will continue and may actually increase during the development phase, further accumulation may occur in soils in N'dilo, Yellowknife and Dettah. The Developer's health risk assessment has effectively placed an artificial boundary on the assessment of risk, but, as Health Canada has pointed out, there are problems with the data collection, analysis and conclusions in this assessment. In the Board's view, arsenic is a known toxin and a carcinogen and there are, known high concentrations in soils within city limits. This artificial boundary is not acceptable.

Suggestion 7: Based on the results of the health risk assessment described in Measure 10, the appropriate government authorities should remediate garden and playground soils where arsenic concentrations exceed current guidelines for urban soils in Canada.

The Board observes that the Developer submitted the 2010 reviews of the 2006 Tier II risk assessment, by DFO and Environment Canada, in November of 2010. The Developer submitted Health Canada's review to the record in September 2012, in response an undertaking from the public hearing. As a result, Health Canada's comments were not known by Parties, and were not considered by them during the information requests, technical sessions, or when they were producing their technical reports. This may have limited Parties' opportunities to thoroughly explore health issues.

8.3.1.2 Arsenic modelling

Focusing on means instead of maximums

The Review Board does not share the Developer's complete faith in the 2006 Tier II human health risk assessment, and observes that it relies heavily in on mean arsenic levels, which average the measured levels, and does not consider the maximum levels identified, even though these are, in many instances, much higher than the means. Although the methods are not clear, the analysis used to form the conclusions from the health

⁷⁴ Per Health Canada *Guidance on Human Health Detailed Quantitative Risk Assessment for Chemicals*, or Government of Alberta Hopkins D and D. Williams. 2011. *Guidance on Human Health Risk Assessment for Environmental Impact Assessment In Alberta*

⁷⁵ For example, as in Calabrese, E.J. E.J. Stanek and S.M. Roberts. 1997. *Soil ingestion: a concern for acute toxicity in children*. *Env. Health Perspect.* 105 (12): 1354-1358

risk assessment are based on a geometric mean and not the 95th percentile.⁷⁶ Geometric means are typically very low, and may include data from sites far from the Project. The use of the geometric mean may substantially mask very high values in the exposures.

Regarding the Developer's use of the lower 95% confidence limits on benchmark dosages using site specific concentrations, the Board notes that much of the current guidance on human health risk assessments where the toxin is a carcinogen stipulates that the 95% confidence limit should be modelled and explained.⁷⁷ Modelling using a geometric mean, which is modified by sampling in cleaner areas outside population exposures, is not acceptable in most human health risk assessments guidance documents especially if the contaminant is a toxin and a carcinogen. A cautious approach would have explained and ruled out risks to human health, on the basis of data that are reliable and conservative.

Cancer rates

Health Canada cautioned the Developer that it is difficult to distinguish the development of cancer from a single source such as Giant Mine against the background of other forms of cancers, particularly due to small population size. This would require several generations of data to detect a significant pattern of cancer caused by a particular source. Health Canada said "[i]f a population is sufficiently small, it is possible that a significant pattern of cancer will not be able to ever be determined. Failure to definitively distinguish increases in cancer occurrence, does not in itself signify negligible or inconsequential cancer risks" (PR#591p6). This implies that the failure to detect patterns in cancer in the population should not preclude or take the place of management for prevention of exposure and cancer risk.

Describing increased cancers rates against all Canadians, while ignoring the effects of smoking on that average, is misleading, because it risks masking effects behind highly variable other factors affecting cancer rates. This has been raised by the Review Board (PR#178 p30) and by Health Canada, which advised the Developer that this "can lead to confusion and is not appropriate for a contaminated site risk assessment" (PR#591 p5). The Review Board has said that this "does not meaningfully evaluate the actual risk for most people" (PR#178 p30). The Developer was not able to provide any better information.

The Kuyek report reached a similar conclusion based on research on other contaminated sites, citing "The standard of proof for causality is set at such a high level that even if a near perfect correlation exists between local health problems and proximal levels of pollution or contamination, many communities still cannot prove causality"⁷⁸ (PR#333 p5).

This suggests caution in accepting the Developer's health assessment conclusion for the proposed Project that "[e]ven though arsenic levels in the area are higher than found in most Canadian communities, the human health risk assessment results suggest that there would be no measurable change in cancer risk to people in the study area" (PR# 139 p8-92). In the Board's opinion, this suggests that causality would be hard to identify, but this does not mean that there is no effect.

⁷⁶ The geometric mean defines an average of numbers based on the product of their value, not their arithmetic sum.

⁷⁷ Such as the Canadian, Albertan, BC and CCME guidelines

⁷⁸ Cited from a quote of Martyniak in Edelstein (2008), p76.

Regarding assumptions about background and incremental cancer risks, the Developer's Tier II human health risk assessment appeared to show that the predicted cancer risks are well below the lifetime incidence cancer rate of three in ten for the NWT (PR#139 p8-92).

Health Canada notes that this conclusion is based on the least susceptible members of the human population, and that they do not reflect the site specific risks. Further, the conclusion that health risks are not, nor will be, significant based on a risk of 12 in 10,000, as stated in the health assessment, does not compare fairly to other benchmarks. The Developer notes that the Alberta Government's guidance document for human health risk assessment in environmental impact assessments sets a benchmark of 1 in 100,000 to be an "essentially negligible" risk and this back-calculates to a concentration of 0.4 µg/L arsenic in drinking water.⁷⁹

The Developer appears to have decided on the acceptability of its cancer risks starting with the CCME water quality guideline concentration of 5µg/L at the edge of the diffuser mixing zone and calculating backward to identify the risk. Consultation with potentially affected people to identify an acceptable risk level may have achieved better results, and then the project could be designed to achieve it. The Developer appears to presume that its predicted risk is acceptable or negligible for the NWT, even though it is an order of magnitude higher than what is "essentially negligible" in Alberta.

8.3.1.3 Contaminants in food and drinking water

The Board observes that some cases of arsenic measurements submitted by the Developer as a base case exceed toxic reference values for sediments, soils, moss, lichens and mushrooms, fish muscle tissue, benthic invertebrates, aquatic vegetation, waterfowl and game birds, and muskrats. Aboriginal Parties are concerned that traditional foods, particularly fish, are unhealthy due to arsenic contamination. The Developer's fish studies focussed on contaminant levels, and did not adequately examine fish for health effects such as abnormalities associated with contaminants but noted that fish can adapt to high body burdens of arsenic and remain healthy (PR#577 p149).

The Board does not accept that this is a reason for focussing solely on arsenic concentrations without considering overall health, particularly in light of the fact that fish are part of the traditional diet (PR#577 p378). Studies of fish health would have added to the credibility of the health risk assessment and may have helped to address concerns. The Board notes that concentrations of arsenic in surface water and in fish tissue from the study area are similar to those arsenic concentrations in water and fish tissue with subsequent immune response deficiencies and other abnormalities.

The Developer stated that arsenic levels in fish were not unusually high (PR#576 p140). The Board notes that this does not correspond with published literature. The concentrations in fish tissue are very high in Baker Creek and sporadically very high in Yellowknife Bay compared to published literature. The Developer's studies have provided no indication of how arsenic varies over time in fish in this environment, how much accumulates in resident fish at various distances, and how much arsenic in local fish accumulates in people who consume them. Only the modelling has indicated the extent to which transfer of arsenic occurs from fish to

⁷⁹ Hopkins D. and D. Williams. 2011. *Guidance on Human Health Risk Assessment for Environmental Impact Assessment In Alberta: Alberta Health and Wellness*. Government of Alberta

humans, and the risk assessment, although somewhat vague, indicates risk of accumulation of arsenic from fish could be relatively high and could possibly present an unacceptable risk to human health.

The Board notes that while the Developer describes its health risk assessment as “a highly site-specific document” (PR#578 p172), it does not use site-specific data regarding traditional foods, but relies on data on contaminants in traditional foods from across the NWT and even the Yukon (PR#139 SD p2-9 to 2-10). The Board is of the view that more site-specific data for other components of the traditional diet should have been obtained and used in the modelling.

With respect to fish, the Developer suggested that the Yellowknives Dene’s health concerns should be brought up with Health Canada outside of the EA process (PR#576 pp191-192). The Developer said it plans to submit the results of the fish tissue sampling to a regional contaminants body for its consideration with respect to fish consumption advisories (PR#576 p227). However, the Developer’s Tier II health risk recognized that for Latham Island residents, fish was a more important source of arsenic exposure than drinking water was (PR#139b appendix B p6-44), which appears to indicate that arsenic in fish could have a significant and negative effect on human health.

The Board notes that this potential source of arsenic exposure was incompletely evaluated in the Developer’s human health risk assessment. Further, this assessment appears to consider tap water as the only source of drinking water which is not accurate and makes the comparison of fish and tap water as arsenic sources somewhat misleading. Yellowknife Bay is a direct source of drinking water for some residents of Yellowknife (PR#604) and has much higher concentrations of arsenic than the tap water originating from Yellowknife River. It should have been better included in the health risk assessment.

The Board notes that the Developer’s arguments regarding arsenic loading and re-suspension of existing arsenic in sediment (PR#576 p145-149) emphasized that arsenic has been there for decades and that the system is recovering. However, long term exposures to arsenic, even at low concentrations are considered to be a potential hazard to human health, and there is little or no evidence in the public record that the system has been either declining or recovering.⁸⁰

The Board notes that the City of Yellowknife was considering changing its drinking water source to a location downstream of the Giant Mine site and the proposed diffuser. The Board ruled on Feb. 20, 2012 that the replacement of the city water line from the Yellowknife River was not part of the proposed Project because the city supply line was originally installed in response to historical arsenic in Yellowknife Bay (PR#386; PR#392).

8.3.1.4 Baseline effects studies and health effects monitoring

The Developer’s human health risk assessment is based largely on an exposure that is modelled. Even though some of the inputs were actually measured, these too feed into the probabilistic model applied by the Developer. This necessarily involves many assumptions, including that our current understanding of the toxicity of arsenic is accurate, and that the model accurately simulates the real world. In the Review Board’s view, this has not been supported or validated by enough real-world effects monitoring that measures actual levels of arsenic.

⁸⁰ See Section 9.6 (Water quality and the diffuser) for further discussion of potential sediment loadings.

Considering the evidence in an integrated manner, the Board has taken particular note of:

- the severity of the concern
- the lack of trust between the Aboriginal and other residents and the Developer
- problems and uncertainties of the Developer's health risk assessment and modelling
- the changing understanding of the health risk of arsenic
- the need for a precautionary approach, and
- the potential addition of arsenic from the proposed Project to the broadly distributed arsenic from past activities at Giant, including:
 - airborne contaminants in dust, and
 - contaminants in water, including those resulting from possible accidents and malfunctions.⁸¹

The Review Board finds as fact that the human health risk assessment does not provide an adequate basis for identifying, evaluating and avoiding impacts to human health from the proposed Project. The human health risk assessment's conclusions are inadequately supported to rule out increased health risk. The Review Board agrees that an effects study focussing on baseline arsenic in people and its changes over time is necessary.

It is not enough for the Developer to say that health effects studies are "beyond its mandate" (PR#579 pp156-157, p187). The Developer bears responsibility for ensuring that the Project does not cause significant adverse effects and significant public concern. Parties are asking for a baseline health study as a part of identifying and mitigating any potential cumulative effects from this development, and the Review Board agrees that a baseline health study is required as a part of identifying and mitigating the effects of the Project. Without a proper baseline there is a greatly reduced ability to successfully identify and mitigate any significant cumulative health impacts of the proposed Project.

Measure 9: The Developer will work with other federal and territorial departments as necessary to design and implement a broad health effects monitoring program in N'dilo, Dettah and Yellowknife focussing on arsenic and any other contaminants in people which might result from this Project. This will include studies of baseline health effects of these contaminants and ongoing periodic monitoring. This will be designed with input from:

- **Health Canada, GNWT Health and Social Services and the Yellowknife medical community; and**
- **The Yellowknives Dene and other potentially affected communities.**

⁸¹ For clarity, this consideration is not contingent on the proposed effluent from the water treatment plant containing 100 µg/L, nor is it contingent on sedimentation from the diffuser. Even if water treatment plant effluent was much cleaner than proposed, there are numerous other ways this project is likely to cause arsenic to enter surface water, including from surface drainage, from airborne particulates being depositing into water and from accidents and malfunctions.

The organization conducting the monitoring will provide regular plain language explanations of the monitoring results in terms that are understandable to lay people, and communicate this to potentially affected communities in a culturally appropriate manner.

This health effects monitoring program will help give people confidence that their health and wellbeing are not being adversely affected by the proposed Project in combination with past exposures. It will also help the Developer identify any unpredicted changes to health due to the Project and manage the Project accordingly. In the view of the Review Board, this is a necessary part of mitigating the significant adverse effects and concern that are likely to cumulatively result from the proposed Project adding to the effects of past activities at Giant Mine.

Measure 8 in section 7.3 prescribes a role for the oversight body⁸² with respect to the health effects monitoring program prescribed in the measure above. For clarity, the oversight agency is not expected to conduct health monitoring, but is expected to help communities understand the outcomes, and make recommendations to help identify and avoid potential health risks based on the health effects monitoring program.

Suggestion 8: The Developer should consider the Trail Human and Environmental Health Committee as a model for the development of the health program.

8.3.2 Conclusions on health and public concern

The testimony of public hearing participants indicates that Parties and the public do not accept the Developer's assessment of health risks from the proposed Project. The Yellowknives Dene particularly described to the Board that their worries are informed by decades of health impacts from arsenic contamination due to Giant Mine and related suffering. Numerous members of the Yellowknives Dene, including current and former leaders and Elders with first-hand knowledge, have described past and current health impacts and concerns. They described how arsenic harmed them their health physically, psychologically and affected their wellbeing in several other ways, and have also described the government's lack of response.

In the Review Board's opinion, these were not raised purely as a historical account.⁸³ The Yellowknives Dene are concerned about the health effects that they expect from the proposed Project, not just about historical arsenic on their land. They are worried that the proposed Project will not keep them or their land safe enough. As Yellowknives Dene Chief Ed Sangris said, the proposed plan to keep the arsenic frozen on the mine site means that contamination is "the danger that will remain forever" (PR#575 p96).

Section 2.6 of this report described in general terms the potential for effects from this Project to add to historical and ongoing the effects of Giant Mine and the minesite. Many participants in the EA are concerned about the potential for arsenic released due to proposed Project activities to combine cumulatively with existing baseline levels of arsenic caused by Giant Mine.

⁸² described by Measure 7 in Section 7.3

⁸³ See section 2.5.4 for details.

Section 7.3 describes some of the Board's conclusions based on evidence that indirect effects on health and well-being result from stress related to widespread anxiety. Section 3 has described the high degree of concern of the Yellowknives Dene, much of which relates to health (e.g PR#577 pp346-352, 391).

The Board accepts the evidence that the stress and anxiety about arsenic affects the health and wellbeing of the surrounding communities, as supported by the Kuyek report and noted in the public hearing (PR#333 p95; PR#578 p171). Considering this, the Review Board concludes that the proposed Project is likely to be a cause of significant concern to residents of the surrounding communities, particularly to Aboriginal residents.

The Developer has stated that implementing the remediation plan, environmental management system and oversight mechanism will address and minimize public health concerns (PR#565 p24). The Board does not accept that the Project, as proposed, would be enough to satisfy existing health concerns. The concerns will remain until there is more public confidence in the Developer⁸⁴ and until some of the concerns about the proposed Project itself, including its potential cumulative effects,⁸⁵ are more adequately addressed.

8.3.2.1 The evolving scientific understanding of arsenic health risks

Evidence on the record indicates that the scientific understanding of the risks posed by arsenic is changing. As Dr. Ian Gilchrist told the Board, until 25 years ago it was considered safe to treat wood in children's playgrounds with arsenic, and now it is not (PR#579 p35). The Developer's Assessment Report identified changes in our understanding of risks posed by organic arsenic during the course of the environmental assessment (PR#116 p8-84). Health Canada noted that the toxic reference values for arsenic changed in the short time between the Developer's 2006 risk assessment and Health Canada's 2010 review of the same assessment. Health Canada also warns that even very low concentrations of arsenic in drinking water are considered to be a serious risk to human health, primarily from cancers, but also many other illnesses.

The Board concludes that it is reasonable to believe that the understanding of the health risks of arsenic is likely to continue to develop in the future. Considering this, the uncertainties inherent in any ecological risk assessment, and the degree of concern related to health impacts described above, the Review Board is of the opinion that a precautionary approach is warranted.

8.3.3 General conclusions on human health assessment

The Developer's March 2010 review considered the results of the more recent studies and concluded that the findings of the 2006 risk assessment should remain unchanged (PR#147). This implies that Health Canada's advice to address shortcomings in the human health risk assessment was ignored by the Developers. It would have been more acceptable to correct the errors identified by Health Canada, to be clear about the results of each part of the risk assessment. This should have been the basis for the Developer to carefully rule out risk, or at least identify ways that risk could be managed, if possible.

It is very important to ensure that the proposed Project does not contribute to cumulative health effects, particularly in combination with the past contamination from Giant Mine. In the Board's view, there are several problems with the Developer's Tier II human health risk assessment, which can be found in Appendix E.

⁸⁴ as described in section 7.1 of this report

⁸⁵ as described in section 2.6 of this report

Based on this and a wide review of the available evidence, the Board concludes that the proposed Project, in combination with existing arsenic from past activities, may result in significant adverse impacts on the wellbeing of people. This is because of the cumulative potential health impacts from planned or unplanned arsenic releases in addition to existing effects from past activities. These are significant adverse impacts with an unacceptable likelihood that the human health risk assessment has not adequately addressed.

The Board is of the opinion that this impact can be mitigated by ensuring that a proper and comprehensive human health risk assessment is conducted, including a review of the Developer's Tier II human health risk assessment, and if appropriate, a Tier III human health risk assessment, with considerations including but not limited to those described in the measures and accompanying text below.

Measure 10: The Developer will commission a comprehensive quantitative human health risk assessment by an independent, qualified human health risk assessor selected in collaboration with Health Canada, the Yellowknives Dene, the City of Yellowknife, and the Developer. This human health risk assessment will be completed before the Project receives regulatory approvals. It will:

- 1. Include a critical review of the 2006 Tier II human health risk assessment and the previous screening reports;**
- 2. Consider additional exposures and thresholds (as specified in Appendix F of the Report of EA);**
- 3. Decide whether a Tier III risk assessment is appropriate;**
- 4. Provide a plain language explanation of the results in terms that are understandable to the general public, and communicate this to potentially affected communities in a culturally appropriate manner;**
- 5. Provide interpretation of results and related guidance; and**
- 6. Inform the broad health effects monitoring program (described in Measure 9 above).**

Based on the results of this human health risk assessment, and on the results of the health effects monitoring program (described in Measure 9 above), the Developer will, if necessary in response to this information, identify, design and implement appropriate design improvements and identify appropriate management responses to avoid or reduce the severity of any predicted unacceptable health risks.

For clarity, the Board expects that the human health risk assessment described in the above measure will, at a minimum, include the items listed in Appendix F of this report.

9 Water Management

This section examines the evidence dealing with water management on site. It includes a consideration of fish habitat in Baker Creek and the flood risks posed by Baker Creek to underground freezing. It also examines evidence related to the potential impacts of the diffuser in Great Slave Lake, with respect to treated water quality and potential ice thinning around the mixing zone.

9.1 Evidence from Parties: Baker Creek and flood risk

Baker Creek passes directly through the Giant Mine site. It drains a total area of 140 square km, and has a mean annual flow of approximately 7 million m³. Its peak median annual flow is below 2 m³/s (PR#353 p55). The spring melt (or ‘freshet’) typically occurs in late May. At this time, the flow in Baker Creek increases from a maximum of 0.25 m³/s to over 8m³/s (PR#563 p7), an approximately a 32 fold increase within one month. The highest recorded flow since 1968 is 8.45 m³/s (PR#349 p5).

9.1.1 Worst-case flooding scenario for Baker Creek

The Developer noted in the DAR that for storms greater than the 1 in 500-year event, inflow to a pit would be likely. Such an inflow could cause uncontrolled flooding of the mine and possibly release arsenic to the environment (PR#139 p6-85).

In the technical sessions of Oct. 2011, the Developer elaborated on the risks posed by Baker Creek to the proposed underground arsenic containment. The existing creek may flood when flow rates are extremely high. It also may not convey lower flows under anchor ice, rockfall or creek bank failure conditions and could result in spillage to A2, B1 and C1 pits if it is not addressed (PR#349 p3; PR#353 p52, 132). These pits are hydraulically connected to arsenic chambers and therefore flooding could overwhelm water storage and pumping capacity and cause a large release of contaminants. On this basis, the Developer characterized Baker Creek as “one of the greatest risks at the mine” (PR#353 p207).

The Developer was asked to describe the worst-case scenario with Baker Creek flooding. It described how this “very bad day” would unfold (PR#355 p133):

Your current pumping systems would be lost due to the inundation. You would have to reconstruct those pumping systems. The Northwest Pond, if you were to assume that this scenario happened at freshet, would be over half full from receding water all year round from the pumping operations, you may have 400,000 cubic metres of capacity in the Northwest Pond. So even if you could dewater the mine, you have nowhere to put it to feed it through the water treatment plant. You have a significant challenge. You would be multiple years trying to build or mobilize a temporary water treatment plant, new pumping systems, and you would be treating, in my opinion, for some period of time to recover the mine.

Another representative of the Developer indicated that the impacts of this might not be so severe, saying (PR#355 p137-139):

In the short time that this event is likely to happen, and we're not talking this being -- lasting for, I don't think for weeks or months necessarily, I would expect to see a short-term, if you will, blip going through the system and the system would adjust itself again.... It would adjust itself fairly quickly, but it's going to have some consequence... So I don't think we would end up, in all likelihood with a -- a fish kill, but we certainly would have an effect on some of the ecosystem. And the -- the question beyond that is a longer term question of how long it takes to remediate itself, if you will, over time...

In the technical session, DFO asked the Developer what the initiating event for the worst-case scenario would be based on current probabilities (PR#355 p195). The Developer replied:

It's what keeps some of us up at night... I speak for the engineering team and I believe my information is current. The situation that keeps this team up at night is the C1 pit. The diversion channel has some uncertainties in it. It is a rock cut channel. We're not absolutely certain that there is a continuous rock wall on the pit side of that diversion channel. It does seep in high water events every spring when the water is on top of the ice. We are undertaking additional investigations to try to understand where that dip, if you will, in the rock exists, and if there is something we can do about it. But that, in my opinion... is the single largest risk to loss of containment to Baker Creek at this point in time.

Another member of the Developer's engineering team responded to the same questions, saying (PR#355 p196):

I think the one word is, "underground instability." I think if -- if we lost -- if we lost the bottom of Baker Creek, that's a really bad day. We've got lots of things to do, right, so it's -- probably -- most of it would be the underground instability allowing that hydraulic connection into the underground.

The Developer specified that the recently emerged sinkhole near the B1 pit is an example of this underground instability, citing this as evidence that other unexpected occurrences may happen along Baker Creek (PR#355 p196):

The B1 sinkhole was one of those (events). We weren't expecting that, and it reminds us that there may be more of those particular situations along the Baker Creek corridor. At this time, the engineering team does not believe the B1 sinkhole will become a really large issue that we can't manage, but it certainly suggests there are things along the creek line that we simply aren't aware of right now.

9.1.2 Design criteria for Baker Creek flood management

The Developer's public hearing presentation described its intention to engineer Baker Creek to minimize flood risk so that it provides flow conveyance through the site without spillage underground (PR#563). The Developer stated that "Remediation eliminates flood risk" (PR#563 p14).

The Developer's presentation stated that the current dikes along Baker Creek are designed to withstand only a 1 in 200 year flood event⁸⁶ (PR#577 p13). Current design criteria for the proposed Project considers the 1 in 500-year flood event, with an additional two meters of anchor ice, plus 1 m freeboard (PR#563 p12; PR#577 p13). During the technical sessions the Developer describes the design criteria as conservative with the Baker Creek Channel being designed to contain a flow of 25 m³/s (PR#353 p55). The design also requires that groundwater seepage to the underground workings is minimized (PR#353 p54; 577 p13).

In the technical session, the Developer describes the design features of the Baker Creek Channel to be six metres wide with 3:1 side slopes and a bank full depth of about one metre, located in a flood plain 32 meters wide to provide extra flood conveyance, and to accommodate ice accumulation. The Developer described the allocation for two metres of ice and 1:500 year flow with an additional metre of freeboard as a conservative flood design (PR#353 p57; PR#577 p98). In the public hearings, the Developer told the Review Board that the proposed design for the Baker Creek channel focuses on the bank overtopping and flood protection to protect the mine in consideration of the Developer's FMECA risk assessment (PR#577). The design features are intended to reduce anchor ice formation and reduce risk of flooding from Baker Creek entering the mine. It said that underground stabilization will reduce the risk of inundation of the mine due to a Baker Creek spill, and that a "prime objective during all this work was [to] keep the water out of the underground" (PR#577 p98). Based on its risk assessment and consideration of failure modes, the Developer believes "unequivocally" that it has adequately managed the Baker Creek risks (PR#576 p100).

9.1.3 Other potential causes of Baker Creek floods

Other potential causes of Baker Creek flooding were discussed in the technical sessions and public hearing. Icing events, when anchor ice builds up on the bottom of the creek and causes the creek to re-route unpredictably, was a problem during the freshet of May 2011. This resulted in a spill of contaminated tailings into Great Slave Lake (PR#281; PR#330; PR#336; PR#563 p7; PR#577 p15, 16).

The Developer also noted that beavers have been an unpredicted and ongoing problem on site for Baker Creek. Beaver dams have caused blockage and bank instability. At other sites, beaver dams upstream have caused hazards when they break and release sudden volumes of water (PR#355 pp200-203).

It is stated in the DAR that "experience with ground freezing projects elsewhere has shown that groundwater is the most common source of problems" (PR#139 p6-31). Groundwater is also a consideration in the proposed design of Baker Creek. At the McArthur Mine in Saskatchewan a freeze curtain was used to isolate high pressure groundwater from the mine workings and problems with the use of thermosyphons resulted in mine flooding and closure for three months (PR#139 p6-38). At Giant, the groundwater pressures are expected to be much lower than at the McArthur Mine. The Developer does not expect similar problems.

With respect to Baker Creek as a groundwater source, the DAR states that groundwater from the creek has been seen to infiltrate the underground during high water periods, although it does not do so across most of the site.

⁸⁶ See section 5.4.1 of this report for an explanation of event return periods as design criteria.

At the north end of the C1 Pit the creek does infiltrate the upper fill section into the pit during high water periods (i.e., during spring freshet and periods when ice blockage causes water levels to rise) (PR#139 p5-59):

9.1.4 Risks of Baker Creek to the underground mine after initial freezing

In the public hearing, the Board's technical advisor Lukas Arenson noted that a diversion of Baker Creek could virtually eliminate flood risks to the underground mine from Baker Creek in the future. Arenson questioned whether the Developer has considered the potential for moisture migration into the frozen chambers and stopes as a result of the moisture gradient that occurs with the thermal gradient (PR#577 p88). In response, the Developer said that the environmental risk exists but is greatly reduced once chambers and stopes are frozen, because a flood would have less arsenic to wash out of the mine, and water is likely to freeze before it gets through the zone of frozen rock surrounding the arsenic chambers. The duration of floods would likely be a few weeks or months of uncontrolled water. The Developer said "(W)e agree there's a theoretical possibility of that effect, but we think, in practice, it's quite unlikely" (PR#577 pp90-93).

The Review Board's advisor noted that flooding on the surface could also have detrimental effects such as thermal erosion and mechanical erosion in permafrost areas, and asked the Developer about potential erosion depths and effects on the frozen blocks or frozen shells below (PR#577 p93). The Developer replied that there would be pads around frozen blocks that are higher than the flood level, so no floods could overtop a chamber (PR#577 p94).

9.2 Board conclusions on risk from Baker Creek on frozen blocks

The Board has considered the evidence regarding the potential risks from Baker Creek to the frozen blocks or frozen shell proposed and the environment, and has considered the Developer's proposed mitigations to manage those risks, including the improved flood design criteria for Baker Creek.

The Board notes that the flow of Baker Creek varies dramatically over the course of the year, particularly during the freshet, when water flow has increased 32 times within a month.⁸⁷ The Developer has described its median annual flow as less than two cubic meters per second. Considering the tremendous seasonal variability, the actual flow at any given time is often far from the median annual flow described by the Developer. At the peak of freshet, Baker Creek moves a large amount of water. When the creek is at its peak it can also be affected by *aufeis* (that is, anchor ice), which is a relatively recent occurrence in Baker Creek. This has recently caused the creek to reroute resulting in the release of contaminated tailings into Great Slave Lake.

The magnitude of freshet is influenced by precipitation (including snow depth and spring rains), by temperature and by the timing of changes in these, which are hard to predict.⁸⁸ Anchor ice is apparently related to climate changes in fall temperatures and precipitation over the last decade. For the 100 year term of this Project, projections of climate change, and its effect on *aufeis* and flow rates in Baker Creek are highly uncertain. The

⁸⁷ as described by the Developer and summarized in section 9.1 above

⁸⁸ Uncertainties regarding climate projections for perpetuity are described by the Board in section 5.7 of this report.

Developer has told the Board that the recent anchor ice incident was not predicted by anyone, including those with many years of experience on the site. The Developer has also told the Board, based on the unexpected sinkhole near Baker Creek "...it certainly suggests there are things along the creek line that we simply aren't aware of right now" (PR#355 p196).

Baker Creek passes near open pits that are hydraulically connected to arsenic chambers. At the north end of the C1 Pit groundwater flow from the creek infiltrates the upper section of the pit during high water periods (i.e., during spring freshet and periods when ice blockage causes water levels to rise) (PR#139 p5-59). This is the same pit that the Developer identifies uncertainties about with respect to the current channel, which it called the "single largest risk to the containment of Baker Creek" during the technical sessions (PR#355 p195). The Developer has described the seriousness of the problems that would occur in a sustained high flow, such as during freshet, if water were to enter the pits, even after backfilling, for a sustained period. It described how existing pumps could be lost due to inundation, how water storage may be inadequate to contain all the contaminated water, and how building or mobilizing a temporary water treatment plant could take years (PR#355 p133). The Developer has recognized that such a scenario may result in a fish kill in Great Slave Lake.

The Board is not convinced that, if a large amount of water were to enter the pits, the Developer would be able to adequately manage the problem. In the DAR, the Developer estimates that if the mine were completely flooded, uncontrolled discharge of contaminated mine water could release up to 12 000 kg/year of arsenic. The Board is of the view that this would have serious consequences for surrounding communities, that the impacts would extend much further than the immediate vicinity of the Project, and result in a variety of other significant impacts on ecosystems and social impacts on communities downstream, some of which would last a long time.

The probability of flooding exceeding the design selection is influenced by external events and by the Developer's design standards for the creek, in terms of the slopes of the engineered banks, depth and width. In the technical session the Developer described Baker Creek as "one of the greatest risks at the mine" (PR#353 p207). The Developer has proposed to design the creek to withstand a projected 1 in 500-year flood event, plus an additional two meters of depth to accommodate anchor ice plus a one meter freeboard, with which the Developer believes "unequivocally" that Baker Creek risks and failure mode risks are adequately managed (PR#353 p57; PR#576 p100).

The Board notes that a 1 in 500-year event calculates to mean that there is a 0.2% chance of occurrence in any given year; in other words, there is effectively a 1 in 5 chance that the creek will flood during the first 100 years of this Project as proposed. During the technical sessions, the Developer recognized that under the above assumption there is a 5% probability of such a flood occurring before the arsenic chambers are frozen, the time with the greatest consequence for uncontrolled flooding. The Board notes that this means there is a one in 20 chance that the flood will occur before freezing of the arsenic chambers is complete.

The Board observes that the Developer has recognized that flood predictions were extrapolated based on historical climate trends, and not on the projected trends reflecting changing climate, and that even projected trends involve various uncertainties for the 25 to 100 year period as described above. Given this uncertainty, the Board is of the view that the Developer's one in 500 year flood calculation could underestimate the

frequency and severity of flooding events over the 100 year life of this Project. Therefore, the re-engineering of the channel may not be enough to safely contain the creek during a particularly high freshet. Considering the severity of what could happen in a worst-case flooding event even if the one in 500 year flood design reflects the actual probabilities during the course of the Project, the Board is of the opinion that the remaining impact, if it did occur, would be so severe that it presents a risk with an unacceptable likelihood of significant adverse impacts. It meets the test for a likely significant adverse impact described in section 2.3 above.

The Board also notes that even if arsenic chambers are frozen, uncontrolled flooding presents numerous relevant risks to the Project and environment. This involves, but is not limited to, the following scenarios:

- Transport of unremediated surface contaminants into Yellowknife Bay due to the complex nature of a potential flood flow path. The Developer has not presented any such flood models, hence the potential impacts are unknown.
- Potential lack in freezing capacity (passive and/or active) due to the warmer water accumulating in the ground on top of the frozen block/shell, which may require most of the available energy to be frozen.
- Potentially insufficient design of the pad heights around the frozen blocks and ground water flow. This could affect freezing ability of the tops of the chambers and may result in risks to the arsenic containment.
- Potential inundation of unfrozen underground workings and pumps, allowing for the release of unremediated underground contaminants outside of frozen chambers to Yellowknife Bay.
- Potential groundwater contamination due to dissolution of arsenic as old pits, which are backfilled with contaminated soils, saturate with water after a flood.

The Board concludes that the design of the engineered creek channel is inadequate considering the risk posed by the creek to the Project. The Developer stated in an information request response that "One priority for any modifications to Baker Creek is to ensure that its hydrological characteristics are ideal for the long-term management of the site" (PR#209 p2). In the Board's opinion, Baker Creek is a bad fit with the Project site. Baker Creek is a source of water in a setting with arsenic that is highly water soluble. It transports heat to a Project where considerable effort is being made to remove heat. It has energy to carry contaminated water to Great Slave Lake, which is immediately downstream.

Considering what could go wrong, and the probabilities in light of channel design criteria, compounded by uncertainties in the predictions on which the engineering is based, the Board does not believe that the hydrological considerations of Baker Creek are ideal for the long-term management of the site. On the contrary, the Board is of the view that the creek poses unacceptable risks to important parts of the Project and to the downstream environment. This is considered further in the Board's overall analysis, conclusions and related measures regarding Baker Creek in section 9.5 of this report.

9.3 Evidence from Parties: Baker Creek as fish habitat

This section reviews the evidence on the Developer's plans for Baker Creek and its current use by fish and potential improvements as an objective of the project and includes Other Parties evidence on this subject. Section 9.4 describes the Review Board's analysis and conclusions with respect to Baker Creek as fish habitat.

The Terms of Reference addressed fish and aquatic habitat, saying: “(In scoping,) public concern (about effects on fish and habitat) focused on the development’s potential to contribute to the contamination of local fish stocks and aquatic habitat, including concerns about health impacts on traditional harvesters and other harvesters of fish” (PR#116 p22).

9.3.1.1 Existing Contamination in Baker Creek

The Developer’s Assessment Report notes that tailings effluent discharged to Baker Creek in 1960s had toxic effects on fish resulting in reduced survival rates and the elimination of benthic invertebrate communities until the 1980s. Until 1981, mine water was pumped and discharged directly into Baker Creek without treatment (PR#139 p4.9). The creek currently has high levels of arsenic, antimony, nickel and zinc in its benthic communities (PR#139 p7.75). A 2008 study concluded that “sub-lethal toxicity effects are likely to occur throughout Baker Creek” (PR#139 p7-80).

The Developer’s Assessment Report and other evidence as follows indicate that Baker Creek is highly contaminated:

- Studies from the 1990s show an average sediment arsenic content of 2,340 µg/g (PR#139b p6-5);
- Sediment arsenic concentrations in Baker Creek range from 82.8 µg/g (dw) to 7,600 µg/g (dw) with a mean concentration of 2,020 µg/g (dw) throughout the site study area, far exceeding applicable criteria such as the CCME Probable Effects Level (17 µg/g; PR#139 p7-19). Reach 5 and 6 are among the highest concentrations (PR#139 p7-19, Fig.7.1.7).
- Surface water arsenic concentrations range from 60 µg/L to almost 500 µg/L during treated water discharge and 17 µg/L to 280 µg/L without discharge (PR#139 p7-12);
- Flow-weighted average arsenic concentrations are 120 µg/L and 68 µg/L, respectively. Surface water arsenic concentrations in Baker Creek therefore exceed the CCME water quality guideline⁸⁹ (5 µg/L) and the chronic toxicity threshold for algae (50 µg/L);
- An extraction study conducted by the Developer concluded that although only 5% of the total arsenic is environmentally available, the high concentrations represent a significant source for potential arsenic remobilization and distribution through Baker Creek and into Yellowknife Bay (PR#139 p7-19).

The Developer indicated that very little of the original channel of Baker Creek remains, and that it has been modified several times (PR#353 p51; PR#139 p5.59); PR#563 p5; PR#577 p14). In the technical sessions, the Developer stated that “the existing channel alignment includes alterations and diversions that really don’t provide acceptable or adequate fish habitat” (PR#353 p53).

9.3.1.2 Baker Creek contamination in the proposed Project scenario

The Developer’s Assessment Report states that arsenic loading to Baker Creek is currently 800 kg/yr (PR#139 p8.14, Table 8.4.3). By discharging treatment plant effluent directly into Yellowknife Bay instead of into the creek following the proposed remediation activities, annual loading to Baker Creek is expected to be reduced by

⁸⁹ From the CME *Canadian Water Quality Guidelines for the Protection of Aquatic Life*

320 kg/yr to 480 kg/yr (PR#139 p8-14, Table 8.4.3).⁹⁰ An additional 30 kg/yr reduction is estimated to result from surface remediation which is expected to reduce the arsenic loadings to the creek from 220 kg/yr to 190 kg/yr. Loading from upstream sources, such as the Baker Creek watershed and the west tributaries, is expected to remain the same at 220 kg/yr and 67 kg/yr, respectively (PR#139 p8-14, Table 8.4.3). In the technical sessions, the Developer stated that “shifting the discharge point for the treated mine water to a new outfall location in Yellowknife Bay, combined with other remediation activities on the site, will effectively reduce the arsenic loading from an estimated 800 kilograms per year at the outlet at Baker Creek, to 480 kilograms per year, which represents approximately a 40 percent reduction (PR#353 p90).

The Developer’s 2006 human health risk assessment predicted that by the year 2011 arsenic levels in Baker Creek sediment would have reduced from current levels to approximately 1600 µg/g.⁹¹ This exceeds the severe effect level of 346 µg/g (PR#139b p6.7 Fig. 6.1.5). The Developer’s Assessment Report supporting documents state that after Baker Creek is realigned and some sediments removed, parts of the creek will still have arsenic concentrations of up to 2,200 mg/kg (PR#139b p2-4).

The Developer’s presentation at the technical session indicated that the Project, as proposed, will exceed toxicity reference values for predatory fish and forage fish in Baker Creek (PR#349 p67). Participants noted that the Developer’s Assessment Report predicts arsenic concentrations over the long term in Baker Creek to be 118 µg/l (PR#349 p66), this is over 20 times the CCME water quality guideline.⁹² This was discussed with the Developer during the public hearing. The Developer pointed out that some arsenic contamination enters the mine site from upstream sources already in excess of CCME guidelines (PR#577 p124):

We expect that the arsenic level in Baker Creek will be in the range of 100 micrograms per litre, at least for some period of time.... the inflow coming into the site from upstream is running 20 to 60 micrograms per litre. That's certainly above the CCME guideline of five. But don't forget that guideline is designed to be protective of all aquatic species and has a factor of safety built into it. So we can get into a debate about what's an acceptable criteria. But from a toxicity point of view, the level of arsenic in that system is below toxicity effects for most species.

In response, the Board’s expert advisor noted that the safety criteria built into CCME is usually a factor of 10, and the predicted toxicity level exceeds this by a factor of 20.

During the public hearing, Dave Tyson, the Board’s technical advisor, asked if it is appropriate to construct fish habitat in what is essentially degraded water quality. The Developer replied that the field evidence shows that the system is recovering, that several fish species now use Baker Creek, and that arsenic levels will decrease in the future (PR#577 p126). The Board’s technical advisor noted that the projected high arsenic levels presented by the Developer extended to the year 2100, and the arsenic concentrations by that time were still projected to be more than twenty times CCME *Canadian Water Quality Guidelines for the Protection of Aquatic Life* threshold.

⁹⁰ See Section 9.6.1[arsenic loadings] below for the entire table and further details on current vs proposed arsenic loadings of Baker Creek and Yellowknife Bay.

⁹¹ For reference, the CCME *Canadian Water Quality Guidelines for the Protection of Aquatic Life* threshold value is 5 µg/L.

⁹² CCME *Canadian Water Quality Guidelines for the Protection of Aquatic Life*

On this basis, the Board's expert asked the Developer if CCME guidelines were not applicable to this Project. The Developer said: "The answer simply is that we're not applying specific guidelines to Baker Creek. We're looking at doing the best we can, as far as remediating the site, to improve conditions. And I don't think it's appropriate in this particular instance to look at application of the CCME guidelines" (PR#577 p127).

9.3.1.3 Fish use of Baker Creek

The Developer's Assessment Report states that there is a potential for adverse effects from arsenic on both predator and forage fish within Baker Creek (PR#139 p8.79). With respect to fish habitat, the Developer's Assessment Report notes that "there is an abundance of superior habitat in the Local Study Area and Regional Study Area" (PR#139 p8-67). It also states that "The selected approach... will improve both the quality and quantity to habitat... expected to result in a gradual increase in numbers and diversity of fish, animals, wildlife and native vegetation in the drainage area of the creek" (PR#139 p?). At present, fish cannot move from Baker Creek Pond (also known as 'Reach 6') on the mine site into reaches of Baker Creek upstream of the minesite (PR#353 p61).

In its discussion of the current fish habitat in Baker Creek, the Developer's Assessment Report states (PR#139 p6.88):

Contaminated sediments are present throughout the creek, but there is evidence that reaches are biologically productive. The extent and severity of effects to the existing aquatic life in the creek from current contaminated sediment levels is unknown... A final determination has yet to be made whether removing and/or covering contaminated sediments will outweigh the disruptions to current biological functions.... Baker Pond contains tailings and contaminated natural sediments, but is also believed to be an important source of nutrients and food for fish.

Despite the existing contamination, fish use new habitat in Baker Creek for migration and spawning (PR#353 p95). In the technical sessions, the DFO described the use of habitat in Baker Creek by arctic grayling to spawn, but that it had not studied the importance of Baker Creek to the overall grayling populations in Yellowknife Bay. DFO further stated that Baker Creek provides some valuable habitat and it is limiting based on our knowledge right now in the context of Yellowknife Bay (PR#353 p235). The Review Board asked DFO for any actual studies that indicate the regional importance of Baker Creek as grayling habitat. DFO replied that there has been no study done of the importance of Baker Creek to regional grayling populations (PR#353 p235).

In its first round information request IR#18, the Review Board questioned the value of creating attractive habitat that is contaminated (PR#178 p25). In response, the Developer stated that "Baker Creek has the potential to serve as viable and productive habitat, without significant risks to aquatic species. Notwithstanding this conclusion, the Developer believes that decisions regarding the remediation of Baker Creek should be informed by additional input from interested Parties" (PR#209 p2). The Developer noted that arsenic will remain elevated in Baker Creek, but that "significant risks to most aquatic species are not anticipated".

In the Review Board's second round information request IR#8 to DFO, the Review Board asked DFO if it had conducted any studies using defensible methods that support its statements regarding the regional importance of fish habitat in Baker Creek and the availability of habitat in other water bodies such as Yellowknife River (PR#378).

In response to the first question, DFO described how parts of Baker Creek have not been realigned and how it maintains some of its natural characteristics. DFO replied that despite prior changes to Baker Creek, it still provides a variety of habitats for fish and wildlife (PR# 398 p2). In the public hearing, DFO said Arctic grayling use Baker Creek for spawning, rearing and feeding habitat, and other fish such as northern pike and nine-spined stickleback use the creek year-round. Additionally, lake whitefish, slimy sculpin, white suckers and shiners all use Baker Creek (PR#577 pp243-245).

Regarding the predicted habitat value of Baker Creek after remediation, DFO said that the proposed plan will *reduce productivity within the new creek channel until all the natural system recovers*, affecting habitat in Baker Creek, but this may be acceptable with an approved restoration plan to offset losses and improve habitat quantity and quality (PR#577 p245). For Baker Creek, DFO recommends that the Developer complete the sediment assessment and remedial options, develop a restoration plan as part of creek design, develop its environmental management plan to outline mitigation and monitoring, complete commitments about community engagement (PR#577 p246).

In the public hearing, the Developer described how fish are able to adapt to contaminated sites. It said “Fortunately, arsenic doesn't accumulate to a high level typically within fish species, and they will adjust over time to their new surroundings. So even if a fish is in, let's say, Baker Creek for a month and is exposed to higher levels of arsenic than it would be back in Great Slave Lake it will adjust the body burden...” (PR#577p149).

9.3.1.4 Baker Creek fishing and fish consumption

In the Developer's Assessment Report, the Developer states that “[a]t the discretion of DFO, catch and release fishing could continue. Food fisheries may need to be discouraged, depending on the level of residual arsenic concentration” (PR#139 pES-9, p6-4; PR#577 pp289-294).

In the technical session, DFO was asked if the same grayling using Baker Creek may be caught by subsistence harvesters and recreational fishers in Yellowknife Bay. DFO replied in the affirmative, noting that grayling are a migratory species and stay in Baker Creek for about a month before returning to Yellowknife Bay (PR#353 p238).

In the public hearing, Review Board members asked DFO representatives if they would eat fish from Baker Creek post-remediation (PR#577 p289). DFO replied it would not because the area would be closed to fishing. On further questioning, asking DFO representatives to hypothetically disregard the fishing closure, the Board asked “[i]f it's put in front of you and it's cooked, yes or no?” One representative replied “no”, and the other replied that it would not if there was a consumption advisory issued for fish in Baker Creek. Neither indicated they would eat the fish without more information, such as results of a human health assessment.

The YKDFN expressed concerns in its technical report that people catch fish in Yellowknife Bay, some of which are likely to come from Baker Creek and be affected by contaminants. They perceive this as a risk to human health (PR#459 p20). This potential for contaminated fish from Baker Creek to return to Great Slave Lake to mix with fish that have not been exposed to similar contamination was noted in the public hearing (PR#577 p148).

In the public hearing, the Review Board noted that perceptions about contaminants in traditional foods affect people's harvesting and the consumption of traditional foods. It asked DFO how important it thought this issue was. DFO replied:

I think everyone has a concern with the contamination and potential contamination of fish in the bay related to Giant Mine. I mean, we've heard it from the community, we've heard it from the Board staff and other members of the public who've come up. It's an important issue... DFO does view that perception as important, and it's one of the reasons that we do recommend ongoing consultation with communities.

9.3.1.5 Project objectives and designs for Baker Creek

One of the Project objectives described in the Developer's Assessment Report is to "restore Baker Creek to a condition that is as productive as possible, given the constraints of hydrology and climate" (PR#139 p1-5). It clarified, in its response to the Review Board's first round IR#18, that "[o]ne priority for any modifications to Baker Creek is to ensure that its hydrological characteristics are ideal for the long-term management of the site" (PR#209 p2). In its public hearing presentation, the Developer described priorities for Baker Creek to include addressing habitat and contamination issues, maintaining a low flow channel for fish passage and habitat and enhancing and restoring fish habitat (PR#349 p4).

In the Developer's Assessment Report, the Developer notes that it has not decided whether to remove contaminated sediments. It stated that "a final determination has yet to be made regarding whether removing and/or covering contaminated sediments will outweigh the disruptions to current biological functions. The feasibility of removing and/or covering contaminated sediments will also be a factor in evaluating the options. Additional studies are planned to assess these unknowns" (PR#139 p6-88). By the time of the hearing in September 2012, almost two years later, the Developer had not yet produced final designs for Baker Creek, and has not yet engaged Parties on suitable remediation objectives. The Developer told the Board that many steps are required before it is ready to present its sediment study, including input from three federal departments before public comment (PR#577 pp17-18). The Developer was not prepared to describe the schedule for these steps but in response to a hearing undertaking on this subject the Developer later indicated that multiple rounds of public input may be necessary over 2013 (PR#598 p2).

In the technical session, the Developer indicated the type of basic decisions about rehabilitating Baker Creek that had not yet been made. It said: "Is it acceptable to leave [sediments] there? Do we need to cap them in place or do they need to be removed completely? ...That's the decision that needs to be made" (PR#353 p54).

In its public hearing presentation the Developer stated that the objective for Baker Creek was to improve it so that although it would not be the same as it was before the mine, it would be rehabilitated (PR#577 p51). Stakeholders, including DFO, Environment Canada and the Yellowknives Dene had not yet been engaged in determining design details (p53).

The Yellowknives Dene expressed concern over the objectives for Baker Creek, and recommend that the Developer must "ensure that the water and sediment quality of the reclaimed area is of a quality equal to a site that has not been impacted by industrial development" (PR#459 p21).

In the technical session the Developer told Parties that it plans to monitor fish in Baker Creek to assess fish health and fish tissue chemistry and to conduct benthic invertebrate, aquatic vegetation, and sediment monitoring, all done every three years, to determine how recovery is occurring within that system (PR#353 p97). In the same technical session, Environment Canada noted that the *Metal Mining Effluent Regulations* apply (PR#353 p195).

In its public hearing presentation, Environment Canada told the Board that while the mine remains under *Metal Mining Effluent Regulations* the frequency of toxicity testing is determined through that process and EC has no concerns. If the mine opts out of *Metal Mining Effluent Regulations* and adopts Recognized Closed Mine Status then Environment Canada recommends a) whole effluent toxicity testing be done quarterly, with increased frequency to monthly during periods where a change in water quality may be expected (e.g. flooding) or b) if more than 30% mortality is observed in the fish bioassay, test until the effluent quality stabilizes (PR#545 p 4).

9.3.1.6 Consideration of the North Diversion route for Baker Creek

The Developer stated in the Developer's Assessment Report that it had examined the possibility of rerouting Baker Creek to avoid the mine site. It said (PR#139 p6-86):

The option of rerouting Baker Creek around the mine site entirely was examined as part of the method selection analysis. However, this option was discounted due to the fact that the mine site catchments would continue to drain to the current channel and a creek would continue to exist, albeit with significantly reduced flow.

During the technical sessions in October 2011, the Developer indicated that it was once again considering the diversion of Baker Creek off the mine site using a diversion channel to the north (referred to as the "North Diversion"). This would divert Baker Creek through Gar Lake and Shot Lake into Yellowknife Bay (see Figure 8 below). This could be done using a steep channel that would convey floods, or by a more winding route using existing topography to provide fish passage. Such a diversion would enter Yellowknife Bay downstream of the existing water intake to prevent concerns about drinking water quality (PR#353 p62).

In its public hearing presentation, the Developer stated (PR#349 p11):

The feasibility of an off-site diversion of Baker Creek has now been evaluated as a contingency to provide a basis for an additional risk-based evaluation of diversion alternatives:

- *Looking at diverting Baker Creek around the Site to the north;*
- *Based on Digital Elevation Data from City of Yellowknife;*
- *Flood-only diversion was previously assessed by SRK;*
- *Fish-friendly diversion limited to 2% valley slope;*
- *Multiple alternatives examined to minimize excavation volumes.*

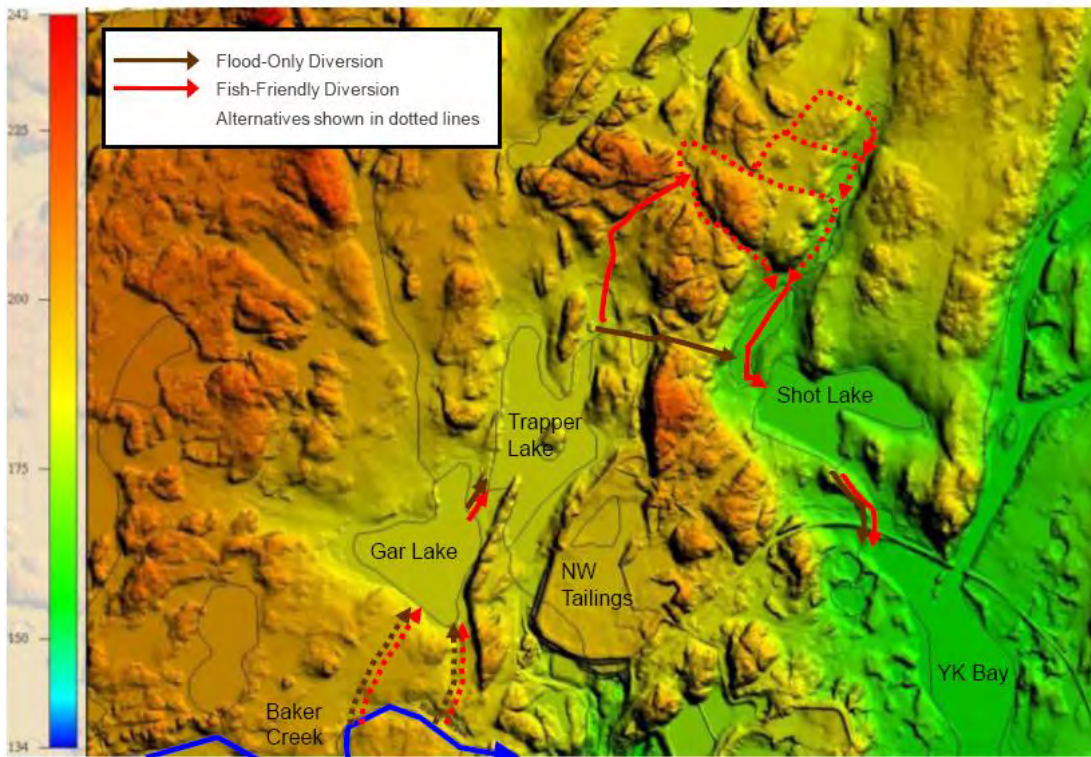


Figure 8: Baker Creek North Diversion contingency

[Source: PR#349 p13]

The Developer specified that this was at a preliminary stage, and that “if anything goes forwards on this, there's going to be a lot more work, both on the engineering side and also on the regulatory side, that would need to be done, but we just wanted to introduce this to people as something that we are looking at kind of behind the scenes” (PR#353 p62).

Review Board round 2 IR#8, directed to DFO, notes that much of Baker Creek is a human-constructed diversion channel for which the Project proposed additional engineered habitat features. It noted that the importance of Baker Creek to Yellowknife Bay grayling populations had not been studied. It asked (PR#378):

The Review Board is interested in the views of Fisheries and Oceans Canada in reconciling the habitat value of Baker Creek against the risks to the project from creek flooding or overtopping, and related contingencies regarding the diversion of Baker Creek.... Taking into consideration the risk analyses in the first round of information responses and the discussions at the Technical Session, in DFO's opinion, what level of risk to the project from Baker Creek would be enough to justify diverting it?

DFO replied (PR#398 p3):

(U)ntil a conceptual design is provided with an effects assessment, both for the new channel as well as the permanent or temporary loss of Baker Creek, DFO does not have enough information to assess the potential impacts of the construction and operation of the North Diversion on fish

and fish habitat.... (T)he determination of a threshold of risk to mine infrastructure that would warrant a large scale diversion/ re-construction of Baker Creek would be outside of DFO's mandate and expertise.

In its second round information request IR#3, the Review Board asked the Developer to compare habitat value of Baker Creek if it was left on the mine site against habitat value of the North Diversion (PR#378 p4). In response, the Developer stated that it was no longer considering the North Diversion. It said it was previously considering the North Diversion to mitigate flood risk, but is instead focussing on short term on-site mitigation measures to address these risks (PR#390 IR3p2).

In the public hearing, the Developer repeated that it is not proposing to remove Baker Creek from the mine site as part of the Project. It said of the diversion: "It's not in the scope of the project that we've proposed, for a good reason. We believe Baker Creek is a productive habitat and can be made a better habitat. We believe it can be made something of value to the community, and we think that's an essential part of mine closure" (PR#577 p123).

9.4 Review Board conclusions on impacts to fish habitat in Baker

Current and future contamination in Baker Creek and arsenic loading

It is evident to the Review Board that Baker Creek is heavily contaminated, and will remain contaminated following the completion of the proposed Project activities. The Developer predicts the mean surface water arsenic concentration in Baker Creek water after the proposed remediation activities will be 118 µg/L, more than 20 times the CCME *Canadian Water Quality Guidelines for the Protection of Aquatic Life* threshold (5 µg/L) and more than twice the chronic toxicity threshold for algae (50 µg/L) with little reduction over the following 100 years (PR#161 p6.1; PR#349 p66).

The Developer's Assessment Report does not adequately describe how contaminated sediments will be remediated and the Developer has been clear that the basic decisions regarding contaminated sediments have not yet been made (PR#577 pp17-18). The Developer indicated it had not yet completed its examination of sediments and remediation options (PR#577 pp17-18; PR#598 p2), which includes fundamental decisions such as whether to remove contaminated sediments (PR#139 p6-88).

The Developer predicts that sediment arsenic concentrations will be much lower following the yet to be detailed sediment remediation activities but also recognizes that transport of arsenic from upstream sources as well as residual releases onsite will have the potential to re-contaminate the creek sediments over the long-term (PR#139 p6.89; PR#577 pp17-18). The sediment will remain contaminated with arsenic, which will not be actively remediated but will instead be allowed to attenuate through dilution over time into Great Slave Lake. As this occurs, arsenic levels in Baker Creek sediments will drop, but by 2100 these will still be approximately 90 times higher than the probable effects level, and over four times higher than the severe effects levels identified in the Developer's Tier II health effects study (P139b p5-3).

The Board notes that arsenic loading to Baker Creek is currently 800 kg/yr (PR#139 p8.14, Table 8.4.3). Baker Creek releases most, if not all, of this into Yellowknife Bay.⁹³ The Developer currently releases 290 kg/yr of arsenic into Baker Creek from the existing treatment plant. The Project proposes to change this so that arsenic in effluent from the water treatment plant will be released directly into Yellowknife Bay, instead of into Baker Creek as it is today. The Board notes that the majority of loading reduction to Baker Creek from the proposed Project (290 kg/yr) is due to the relocation of treated mine water discharge from Baker Creek directly into Yellowknife Bay.⁹⁴

The Developer has emphasized the reduction of arsenic entering Baker Creek (eg. PR#353 p90). The Developer expects the upstream arsenic sources, resulting from historic mine activities, to diminish over time as arsenic is flushed from the upstream sources (PR#139 p7-10, p6-84). This process is anticipated to take hundreds of years through natural processes as there is currently no known practical means of accelerating the process (PR#139 p6-84). Baker Creek will remain a source of arsenic loading to Yellowknife Bay for a long time.

The Board concludes that Baker Creek will remain contaminated following the implementation of proposed remediation activities. Further, if the Developer does choose to remediate the sediments, there is potential for them to become re-contaminated over time.

Effects on Baker Creek aquatic life and habitat use by fish

The Developer's objective for Baker Creek is to "[r]estore Baker Creek to a condition that is as productive as possible, given the constraints of hydrology and climate" (PR#139 p1-5). The Board notes that, compared to the other Project objectives, this is vague and would be hard to verify using objective criteria. The Yellowknives Dene have identified this as a concern (PR#459 p21).

The Board notes that fish and fish habitat in Baker Creek have been affected by historic Giant Mine operations and that these impacts continue into the present. Baker Creek was re-aligned on several occasions during historic mining operations (PR#139 Fig.5.8.1) to facilitate mining operations while managing surface water drainage and transport across the site. Except for the re-alignment of Reach 4 conducted by the Developer in 2006, there was no evidence presented that the prior re-alignments considered impacts on fish habitat.

It is also evident that water quality and aquatic life in Baker Creek has been affected by previous and current activities at the site. Aerial deposition of arsenic, contaminant releases, surface drainage, sediment contamination, and tailings and mine effluent have affected Baker Creek and its ability to support aquatic life. Although arsenic concentrations in Baker Creek water have diminished since mining operations ceased, ongoing arsenic loading from upstream sources, surface drainage, sediments, and treated effluent discharge continue.

The remediation proposed by the Developer are predicted to reduce arsenic loading to Baker Creek primarily through the relocation of the site where treated effluent is released to Yellowknife Bay, but also through surface

⁹³ See section 9.6.1 for more details on arsenic loadings.

⁹⁴ The measures in section 9.7 will further reduce the amount of arsenic in water from the treatment plant.

drainage diversions and some surface remediation. Although the Developer predicts that there will be an improvement in the Baker Creek water quality as a result of the proposed remediation activities, Baker Creek will remain contaminated with arsenic concentrations above 20 times the CCME *Water Quality Guidelines for the Protection of Aquatic Life* threshold for the foreseeable future (PR#161 p6-1).

It is evident through the studies presented by the Developer that fish use Baker Creek. The degree of use has historically fluctuated with changes in water quality. Since mining operations ceased, fish from Great Slave Lake have spawned in Baker Creek (PR#577 p243-245). The Developer plans to re-align Baker Creek and to improve the quality and availability of physical fish habitat to re-establish a resident fish community as well as to increase the use of the creek by Great Slave Lake fish.

Although physical habitat improvements are likely to increase use of the creek by Great Slave Lake fish, the creek water will remain contaminated for the foreseeable future. Arsenic concentrations in Baker Creek will remain above the chronic toxicity concentrations for algae, which is likely to limit the productive capacity of the fish habitat.

DFO has suggested that Baker Creek may be regionally important as grayling spawning habitat, although it could produce no actual studies to support this assertion (PR#353 p235; PR#378). In terms of toxicity, the Developer provided evidence that existing arsenic concentrations in Baker Creek water are not likely to have acute (immediately lethal) toxicity effects. For larger adult fish, the high arsenic levels do not appear to have had an acute effect. The Board notes that, compared to adults, the other life stages for these fish are less mobile, more vulnerable, and less able to avoid effects. The Board notes that no evidence was presented regarding the potential effects of chronic, longer term exposure of arsenic to the vulnerable fish life stages such as eggs, fry, and juveniles. Any effects on the survival of eggs, fry, and juveniles would further limit the productive capacity of Baker Creek fish habitat. Neither the Developer nor DFO appear to have examined this potential impact.

The Board notes that the aquatic life in the creek is already affected by arsenic, but does not accept the Developer's argument that increasing use by fish demonstrates its quality as habitat. Even though fish are predicted to continue to use Baker Creek, this demonstrates the tolerance of fish to contaminated environments, not the quality of the habitat in Baker Creek. The Developer has indicated that fish are quite adaptable with respect to arsenic body burdens.

In light of the existing contamination, the Board views current fish use of Baker Creek as evidence that the instincts that cause fish to enter Baker Creek are strong and persistent, not that Baker Creek is good or healthy fish habitat. The Board concludes that attracting fish to Baker Creek, where they will be exposed to elevated levels of contaminants, is likely to cause elevated contaminant levels in fish. This may be a cause of significant adverse impacts on fish themselves, particularly at sensitive life stages. The Board is of the view that this is counterproductive and should not be done. Fish should be protected from contamination, not enticed into contaminated environments.

The following section examines the potential for significant public concern among people who eat fish that may have been so exposed.

Consumption, concerns and harvesting

The Board finds that there is significant public concern regarding the safe consumption of the fish that use Baker Creek. Most large-body fish using the creek are resident only during the spawning season and then return to Great Slave Lake, where they may be harvested by local resource users (PR#353 p238). There was significant concern expressed by Aboriginal Parties and the general public as to whether these fish are safe to consume.⁹⁵ The Developer indicated that there are ongoing studies examining the arsenic concentrations in fish, but posted no evidence from these studies to the public record.

The Developer predicts that the fish that will use Baker Creek will adapt to high body burdens of arsenic from their time in the creek. The Board notes that the Developer's studies have looked at arsenic levels but not at other indicators of fish health such as abnormalities.⁹⁶ Fish use the area, but the evidence indicates they may not be safe for people to eat (e.g. PR#139b). The DAR states that Baker Creek could be opened for fishing, but the Developer and DFO have expressed caution and uncertainty as to whether fish harvested from Baker Creek would be safe for consumption even after the proposed remediation activities have been completed (PR#139 p6-4; PR#577 pp289-294).

The same fish that spawn in Baker Creek also move through Yellowknife Bay, where they could be caught and eaten by traditional harvesters and recreational fishers. As with the fish in Baker Creek, the Developer's fish studies show that some fish in Yellowknife Bay have very high arsenic levels (PR#139 p7-71), consistent with expectations of fish from Baker Creek moving out into Great Slave Lake, as DFO described (PR#353 p238).

The Yellowknives Dene have told the Board in detail of their concerns about exposure to arsenic through traditional foods, including fish. As DFO and others have recognized, even if the actual amount of contaminants in traditional foods in total is not likely cause health effects, the perception of contamination has the real effect of reducing traditional harvesting.

The Developer's objective of making Baker Creek as productive as possible is likely to increase its attractiveness as fish habitat. Considering the very high contaminant levels, both existing and predicted, in creek sediments and in untreated surface drainage entering the creek, the Board does not agree that the Developer should be trying to attract fish into it. In the opinion of the Review Board, attracting fish to Baker Creek is likely increase exposure of fish to contaminants, and to increase harvesters' perceptions that the fish are contaminated. This is likely to cause the significant adverse impact of reduced traditional harvesting.

In the Board's opinion, maintaining Baker Creek on the mine site and designing and promoting fish habitat in the creek would not be in the best interest of human health and the environment.

⁹⁵ See Section 8.2.7 [Health] and section 12.1.2 [Traditional Use] for further discussion of concerns related to the contaminants in traditional foods.

⁹⁶ See Section 8.2.4 [Health] for further discussion.

Surface runoff

The Board notes that the Developer plans to direct surface runoff, including runoff from the 13.5 million tons of contaminated tailings on the surface, to Baker Creek without treatment. The Developer has predicted that surface runoff will contain high levels of arsenic. As noted above, almost all of this arsenic will enter Great Slave Lake via the creek.

The Developer has gone to considerable length to use what it describes as “state of the art technology” (PR# 576 p117) to make a proposal that it states will ensure that CCME concentrations for the protection of aquatic life for arsenic are met at the edge of the mixing zone in Yellowknife Bay.⁹⁷ It says it chose this threshold to provide a healthy environment for all aquatic life, to protect a potential source of drinking water, and to protect the recreational uses of Yellowknife Bay (PR#576 p71). However, the Review Board observes that the Developer is currently releasing arsenic contaminated water into a creek that is already over 20 times the same threshold-- water which will end up in Yellowknife Bay. Effectively, the creek is being used to discharge highly contaminated water without treatment.

The Developer is relying on the creek to dilute the contaminants. The Board observes that much of the widespread contamination on and around Giant Mine happened because of past reliance on air and water to disperse and dilute contaminants. Parties and members of the public have repeatedly told the Board their concerns about this practice and its harmful effects. They do not view dilution into the surrounding environment as an acceptable way of managing arsenic at Giant for this Project (eg. PR#459 p13-14; PR#605 p3). The Board agrees.⁹⁸

9.5 Overall conclusions on Baker Creek

The Board accepts the Developer’s statement that a priority for any modifications to Baker Creek is “to ensure that its hydrological characteristics are ideal for the long-term management of the site” (PR#209 p2). However, the weight of the evidence indicates that the current route of Baker Creek is not ideal for the long-term management of the site. Baker Creek presents unacceptable risks to the Project, and to the environment. Maintaining an unpredictable and potentially harmful contaminated creek in such a setting is not prudent, even if some fish are able to tolerate the high levels of arsenic and other contaminants in the water and sediments. The Board is of the view that the unsubstantiated regional benefits of the creek as fish habitat do not justify the unacceptable likelihood of significant risks involved in keeping Baker Creek on site.

The Board notes that DFO’s mandate requires it to consider habitat loss, and risks to fish habitat, but DFO has indicated that it does not weigh risks posed by fish habitat, such as flood risks from Baker Creek. It is able to consider only one side of balancing the possible benefits of Baker Creek habitat value against the risk of Baker Creek flooding.

⁹⁷ See section 9.6.2 for details.

⁹⁸ See section 9.7 for further discussion.

The Developer's proposed approach of improving habitat in the creek, if effective, will keep attracting fish to a heavily contaminated site, presenting an unacceptable risk to arsenic containment and to other aspects of the Project. Efforts to create habitat are better directed elsewhere.

The Developer considered diverting Baker Creek to the north of the site but later dismissed the idea on the basis of its improved engineering design for the channel. The Board also notes that the Developer identified that the north diversion could be engineered with low slopes that could provide new fish habitat. Although a north diversion of the creek would still contain arsenic from upstream sources from historical aerial depositions from the Giant Mine stack, the Board observes that the creek would not receive the additional arsenic from surface drainage and tailings seepage, as it would if the creek were left on the mine site. The Board considers this an improvement. The Reach 4 diversion constructed in 2006 on the mine site suggests that viable habitat can be constructed in a new channel.

In the past, the Developer has used Baker Creek to dilute untreated surface drainage, which the creek then transported off the mine site to Great Slave Lake. The Developer plans to continue using Baker Creek to dilute untreated surface drainage from the mine site, allowing an estimated 190 kg of arsenic each year to enter Baker Creek. For the proposed Project, the majority of the arsenic loading to Baker Creek from the mine site comes from surface runoff.

If Baker Creek is diverted to the north, it will no longer be available to dilute untreated surface drainage, and the contaminants in surface runoff and tailings seepage that would have gone via Baker Creek into the lake would likely require treatment before discharge. Although there would be some increase in loading once this effluent is treated and released via the diffuser, the much higher arsenic loading from the creek would be considerably reduced. In addition, the water quality in the new diversion channel would be much improved over Baker Creek as proposed. The Board considers the reduced pollution of Yellowknife Bay from mine site surface runoff via Baker Creek to be an improvement.

The Board is not convinced that the Project's engineering design is adequate to justify the risks presented by flooding from Baker Creek. Nor does it consider the dubious benefit of attracting fish to a highly degraded environment to be worth the risks, particularly noting that the same fish may be harvested traditionally in other parts of Great Slave Lake. Baker Creek is likely to add risk to the Project, while increasing contaminants in fish, increasing perceptions of contaminants in traditional foods, and reducing traditional harvesting. The Board is of the opinion that these adverse impacts are individually and collectively significant, and prescribes the following measure to mitigate them.

Measure 11: Within five years of receiving its water license, the Developer will divert Baker Creek to a north diversion route previously considered by the Developer, or another route that avoids the mine site and is determined appropriate by the Developer.

Suggestion 9: During its review of the diversion of Baker Creek, the Department of Fisheries and Oceans should consider the habitat loss of the existing Baker Creek and decide on any habitat design requirements for the diversion to the extent it deems appropriate. Any resulting habitat compensation requirements should be applied on the new diversion.

The Board finds that the surface runoff entering Baker Creek is likely to cause significant adverse effects unless it is treated prior to release. The measure above reduces dilution of any contaminated runoff in the channel by creek water from upstream. The two measures below deal with impacts from contaminants from surface runoff in the former channel of Baker Creek.

Measure 12: To prevent significant adverse impacts on Great Slave Lake from contaminated surface waters in the former channel of Baker Creek, the Developer will ensure that water quality at the outlet of Baker creek channel will meet site-specific water quality objectives based on the CCME *Guidance on the Site-Specific Application of Water Quality Guidelines in Canada*.

Measure 13: The Developer will design and, with the applicable regulators, manage the Project to ensure that, with respect to arsenic and any other contaminants of potential concern, the following water quality objectives are achieved in the vicinity of the outlet of the former Baker Creek channel excluding Reach 0:

- a) Water quality changes due to discharge from the former channel of Baker Creek will not reduce benthic invertebrate and plankton abundance or diversity;
- b) Water quality changes due to discharge from the former channel of Baker Creek will not harm fish health, abundance or diversity;
- c) Water quality changes due to discharge from the former channel of Baker Creek will not adversely affect areas used as drinking water sources,
- d) Water quality changes due to discharge from the former channel of Baker Creek will not adversely affect any traditional or recreational users; and,
- e) There is no increase in arsenic levels in Great Slave Lake due to discharge from the former channel of Baker Creek beyond the parameters described in Measure 12.

For clarity, the above measure excludes Reach 0 as part of the former Baker Creek channel, not from the water quality objectives.⁹⁹

Measure 8 prescribes a role for the oversight body¹⁰⁰ with respect to water quality monitoring.

In the public hearing the idea of building an engineered wetland to improve water quality was discussed (PR#576 pp101-106).¹⁰¹ Based on this, and considering other proposals to use such wetlands to treat arsenic in a similar climate,¹⁰² the Board offers the following suggestion:

Suggestion 10: The Developer should investigate the potential advantages and disadvantages of adding an engineered wetland to the Project to reduce arsenic in surface drainage. This investigation should

⁹⁹ Reach 0 (PR#139 Fig. 7.4.4) was part of Great Slave Lake until a breakwater was added, and is periodically diluted by Great Slave Lake water, unlike the rest of Baker Creek. Reach 0 is also excluded by the Developer in the DAR Table 7.4.7 description of Baker Creek reaches (PR#139).

¹⁰⁰ described by Measure 7 in Section 7.3

¹⁰¹ See Section 9.6.7 [Engineered wetlands for water treatment] for details.

¹⁰² See the Review Board's 2013 *Report on Environmental Assessment and Reasons for Decision: Fortune Minerals Limited NICO Project* for details.

include possible locations in the channel that formerly contained Baker Creek and in the Baker Creek diversion. On completion, the Developer should make a public report of the results of this investigation and of any resulting changes to Project design. This should be completed before a water license is issued for the Project.

9.6 Evidence from Parties: Water Quality and the Diffuser

Water quality was a recurring theme throughout this assessment. This section focusses particularly on arsenic loadings into Great Slave Lake from the Project, the proposed water treatment objectives and water treatment plant effluent. It also examines the proposed diffuser and the potential ice thinning above the diffuser, and alternatives methods for treating and releasing water.

The Terms of Reference identifies water as a key valued component, and required the Developer to consider impacts on water quality and quantity, with special attention on arsenic levels over time, in contaminated surface water, mine water, and treatment plant outflows (PR#116 s.3.5.1).

9.6.1 Arsenic loadings into surface waters

Arsenic loading in this section refers to the total amount of arsenic released to surface waters. The Developer summarized historical estimated arsenic loadings of Yellowknife Bay since 1950. It said that for the first twenty years, the arsenic loading into the lake was approximately 25 000 kilograms per year, eventually dropping to 1 700 kilograms per year in the 1983 to 1993 period (PR#355 p186).

In the DAR, the Developer predicted that the Project would reduce arsenic loading to sediments in Great Slave Lake and have a subsequent positive influence on the quality of sediment by reducing the rate at which arsenic is transferred from water to sediment. The Project will also isolate contaminant sources that could otherwise continue to contribute contaminant loads to surface waters and sediment through erosion and/or leaching. (PR#139 p8-24).

The DAR (PR#139 p8-14) , the Tier Two Risk Assessment DAR (PR#139 app. B p2-4) and the Developer's hearing presentation on water management (PR#562 pp5-6) describe current arsenic loadings into surface water and compares this to loadings after the Project is fully implemented (see Table 1 below).

At present:

1. Baker Creek currently receives 290 kg per year from "background sources", with 220 kg of those coming from runoff upstream of the mine and 70 kg from tributaries entering the minesite.
2. On the minesite Baker Creek now receives arsenic from surface runoff and from the existing treatment plant, which discharges its effluent directly into the creek (not into the lake via the diffuser as proposed):
 - a. Runoff going directly into Baker Creek adds 220 kg per year.
 - b. The treatment plant effluent currently releases 290 kg of arsenic into Baker Creek each year.
3. Additional surface runoff from the site directly into Yellowknife Bay adds 110 kg of arsenic per year.

The total amount of arsenic entering Yellowknife Bay at present is approximately 910 kg per year. At the public hearing the Developer said roughly a third of the arsenic comes from upstream of the mine, a third from the treatment plant, and a third from surface runoff (PR#578 p24).

Once the proposed project is fully implemented, the Developer predicts the following loadings of arsenic into surface waters:

1. The amount already in Baker Creek and tributaries reaching the minesite will remain at 290 kg per year.
2. On the minesite, Baker Creek will still receive runoff from surface facilities, but due to surface improvements, such as the capping of the tailings ponds, instead of 220 kg per year it will receive 190 kg per year.
3. Additional surface runoff from the site directly into Yellowknife Bay will be reduced from 110 kg of arsenic per year to 69 kg per year.
4. The treatment plant is expected to release 140 kg of arsenic per year¹⁰³, but instead of releasing into the lake via Baker Creek, it will be released directly into the lake via the diffuser.

With the proposed Project in place, the total amount entering Yellowknife Bay will be reduced from the current 910 kg down to 610 kg of arsenic per year.

These estimates assume no water released from the underground mine without going through the treatment plant. In the DAR the Developer stated that an uncontrolled discharge if the mine was completely flooded would release an estimated 2000 to 12 000 kg of arsenic per year into surface waters (PR#139 p8-14). Without any care, including current and proposed activities, the site would release approximately 7,717 kg of arsenic, 7,100 kg of which would come from underground. In the public hearing, the Developer stated that the untreated minewater load was 20 400 kg/yr (PR#562 pp5-6). The Developer expects reduced loadings to result in better water quality in Baker Creek and Yellowknife Bay (PR#353 p91).

9.6.1 Overall impacts to water quality and aquatic life

The Developer predicts no significant effects from its proposed discharge of minewater, due in part to diffuser design. The Developer states it will not result in an increase of human exposure to arsenic, and will not pose either a safety risk to human well-being, or impair the ecological function of Yellowknife Bay (PR#139 pp12-12, 12-13). The DAR also states that post-remediation arsenic releases do not pose a risk of adverse effects to aquatic plants and fish in Back Bay and Yellowknife Bay (PR#139 p8-92).

¹⁰³ The Developer's hearing presentation of Sept. 11 2013 (PR#562 p5) later stated that the treatment plant is expected to release 150 kg of arsenic per year.

Table 1: Arsenic Loadings to Surface Waters

Sources	Estimated Arsenic Releases to Water (kg/year)		
	Current	Post-Remediation	No-Remediation
Inputs to Baker Creek			
Baker Creek Upstream of Giant Mine	220	220	220
Tributaries from West of Giant Mine	67	67	67
Current Water Treatment Plant	290	n/a	n/a
Runoff from Surface Facilities to Baker Creek	220	190	220
Underground Mine to Baker Creek	0	0	7,100
Total Inputs to Baker Creek	800	480	7,607
Inputs to Yellowknife Bay			
From Baker Creek	800	480	7,607
Direct Runoff to Yellowknife Bay	110	69	110
New Water Treatment Plant	n/a	140	n/a
Total Inputs to Yellowknife Bay	910	690	7,717

(Source: PR#139 p8-14 table 8.4.3)

Potential impacts to water quality can arise from effluent and from disturbance by the diffuser, including the disturbance of existing contaminants in sediment. In the DAR, the Developer described why it does not expect adverse effects from its releasing contaminants in treated water, saying (PR#139 p8-17):

(A)lthough the Project will result in an overall improvement of water quality, the point discharge from the new outfall may have an effect on water quality in the immediate vicinity. The release of contaminants to surface waters could, in theory, lead to adverse effects on aquatic and terrestrial biota (via the surface water pathway). However, the long-term historic mobilization of contaminants within the surface water environment (e.g., during the operational period of the mine) is expected to dominate effects of this nature.

In contrast, the short-term incremental effects of contaminant mobilization caused by the Remediation Project are anticipated to be negligible relative to baseline conditions. On this basis, while localized and short-term contaminant mobilization may occur during implementation of the Project, adverse effects on species interacting with surface waters are not anticipated. This includes aquatic species, wildlife and vegetation.

In the public hearing, DFO noted the potential for physical changes to fish habitat within the proposed mixing zone of the diffuser. DFO stated that it did not have enough information on the diffuser to predict potential impacts to fish, and recommended the completion of a fish habitat assessment in Yellowknife Bay, along the outfall route and at the diffuser location. It stated that it would require the final diffuser design to inform its later regulatory review pursuant to the Fisheries Act (PR#577 p240).

9.6.2 Plant effluent, water quality objectives and the diffuser

In the public hearing, when describing the concentration of arsenic it planned to release into Great Slave Lake from the effluent coming out of the water treatment plan, the Developer told the Review Board that its approach to water treatment was based on protecting Yellowknife Bay “to support all beneficial uses” (PR#562 pp5-6). These include providing a healthy environment for all forms of aquatic life, for a source of drinking water, and for recreational pursuits such as boating and swimming.

Water treatment volumes and freezing are related. Freezing the chambers and stopes will reduce the volumes of minewater that requires treatment. In an average year, the amount of water needing treatment will be reduced from 630 000 L to 404 300L. In a wet year, the amount of water needing treatment will be reduced from 822 200 L to 517 500L (PR#562 pp5-6).

The Developer proposes to treat mine water so that effluent from the treatment plant will meet the Canadian Council of Ministers of the Environment Guidelines for the Protection of Aquatic Life once it has been diluted with lake water in the mixing zone above the diffuser. To do this, the water must have a concentration of 5 µg/L or less at the edge of the mixing zone. The quality untreated minewater entering the treatment plant varies up to a maximum of 280 mg/L (280 000 µg/L) of arsenic. Water leaving the treatment plant is normally expected to contain 200 µg/L or less, with peak short-term levels up to 400 µg/L (PR#562 pp5-6). The proposed water treatment process can achieve a lower arsenic concentration of 100 µg/L (PR#637 p3; PR#638 p4).

To reduce this concentration to the above guideline, the Developer has designed the diffuser to dilute the effluent from the water treatment plant with 100 parts lake water for each part of effluent (a 100:1 dilution ratio) (PR#562 pp5-6).

Health Canada’s 2012 *Guidelines for Canadian Drinking Water Quality* state that the maximum allowable concentration for arsenic is 10 µg/L (PR#139 p7-7), but also state that levels should be kept as low as reasonably achievable.

The Developer proposes to use a diffuser to ensure mixing of treated mine water with lake water within 15 meters (PR#353 p99). The steel diffuser will release effluent from 28 nozzles or ports above the bottom of the lake to prevent re-suspension of contaminated sediments (PR#353 p89). Effluent would flow to the diffuser from the water treatment plant via a three kilometer plastic pipeline, half on land and half in Great Slave Lake, to the diffuser for discharge and dispersion. The total extent of the mixing zone is 80 metres by 15 metres (PR#576 p150). The diffuser will require periodic replacement. The Developer described the diffuser as “state of the art technology” (PR#576 p117).

Three initial locations in Back Bay and Yellowknife Bay were considered in the DAR (PR#139 p6-76). In October 2011, the Developer selected a location “just north of Latham Island”, approximately 400m north of the tip of N’dilo, at a location selected on the basis of depth (PR#576 p80, 130, 196; PR#562 p17). The Developer indicated that it could move the diffuser, but move would be minor and the diffuser would remain in the same general area (PR#576 p91).

In the public hearing, the Review Board noted that the diffuser is going to release treated water, arsenic, other contaminants, and heat, and that the Developer has control over water treatment and the amount of arsenic in effluent entering the lake. The Developer replied that the effectiveness of the mixing zone is limited not only by effluent quality but also by hydraulic considerations affecting mixing (PR#576 p115, 119).

9.6.3 Additional water treatment

In its presentation during the technical session of October 18th, 2011, the Developer emphasized that the water treatment plant is designed with room for additional capacity and treatment if necessary, saying (PR#353 p80):

We have several contingency plans in place, the first of which is to provide extra capacity at the new plant. And how this is done, we estimated that our peak flows are -- earlier we estimated that our peak flows were 30 litres per second. What I did not mention was that this included a 10 percent downtime, and a 20 percent contingency. We also have room to install a third treatment train if this is found necessary. We have provided backup equipment, and multiple injection points for our oxidant as the process will be less effective without oxidization.

The YKDFN suggests in its closing comments that the Developer decided how thoroughly it would treat water by relying on dilution in Great Slave Lake until it meets its chosen objective. It said (PR#605 p3):

The project has taken a backwards approach to setting water quality objectives. The project acknowledged this on page 22 of the June Technical Workshop Report. The project looked at what they could easily achieve through their existing treatment plan and then how much dilution would be required to meet a particular 'guideline'. Thus, you have the mixing zone and a false higher standard, without actually having to meet a higher water quality objective.

(The Developer) stated that the project was going to meet a higher bar - but in reality it will be more or less the same as today, just measured in a different way. The same Metal Mining Effluent Criteria standards that existed during the mines operation will be the Effluent Quality Criteria - the solution is still dilution.

During questions regarding the relationship between effluent quality and mixing zone size, the Developer emphasized that additional water treatment would be required to lower arsenic concentration in the effluent, saying “ The plant has been designed to achieve a certain level at the end of the plant, end of pipe... If you want to achieve less arsenic in that end of plant, then we have to add plant process” (PR#576 p120).

In its closing comment, the YKDFN cites the *Second National Assessment of Environmental Effects Monitoring Data from Metal Mines Subjected to the Metal Mining Effluent Regulations*, by Environment Canada. This study concluded that the Metal Mining Effluent Regulations were not protective enough of the environment. It identified cases where fish showed significantly reduced condition and that the aquatic ecosystem as a whole showed less diversity even though these regulations were followed. Considering this, the Yellowknives Dene state: “Already the project has plans for an additional 'bank' of reactors within the future water treatment plan. The project could use this to provide additional treatment time or methods to improve water discharge to an acceptable point prior to release” (PR#605 p3).

9.6.4 Water quality concerns

In the DAR (PR#139 s8.10.1,s8.10.2, p8-93, Table 8.10.2) the Developer recognized that “the discharge of treated mine water into North Yellowknife Bay may generate concern among traditional land users who fish there” is one of the “certain types of remediation activities (that) have the potential to generate concern which, in turn, may lead to adverse effects on community well-being”. The DAR identified “community perceptions of environmental health” as an evaluation criterion for adverse effects on Aboriginal communities. It noted that these perceptions may occur “regardless of the positive effects of the remediation project” (s.8.10.2.1 p8-94).¹⁰⁴ In the public hearing, in response to questions from the Review board, the Developer confirmed that no one in N’dilo was involved in choosing the proposed diffuser location (PR#576 p235).

The NSMA supported the City’s request to have AANDC accept financial responsibility for ensuring the drinking water supply for the City of Yellowknife is not contaminated by mine waste of any type (PR#578 p62).

Parties disagreed with the Developer about whether the proposed treatment plant effluent was acceptable, and expressed many concerns that the treated mine water contains levels of contaminants that make the water in Yellowknife Bay not safe for people, fish, and other aquatic life (PR#459 p13-14; PR#482 p15). Alternatives North challenged the Developer to “prove to the Water Board that the waters in Back and Yellowknife Bay will be safe for people and fish, and pay the City for any extra costs to make the water drinkable if the Giant Mine causes problems” (PR#482 p.iii).

The City of Yellowknife told the Board of its concerns regarding the standard of water treatment proposed by the Developer and its interest in additional water treatment. At the public hearing, it emphasized the importance of safe drinking water, and requested an outfall adjacent to the mine site instead of the diffuser, saying (PR#578 p38, p45):

Why can't the water be treated to such a level that it provides zero impact as it enters the Bay, and what would the need be for a diffuser? The real reason they need a diffuser and the reason they picked that location is because -- and something they emphasized over and over the last couple of days, it provides the best area for mixing. Well, why do you need to mix the water if the water entering the Bay has zero to no impact?

They’re proposing to install a pipeline at a cost of anywhere by -- on the diffuser a cost of one point five to \$2 million. That's money that could be better spent if they came up with a better design, a simple outfall located adjacent to the shoreline in the Giant Mine area. This could be monitored, maintained and wouldn't provide a risk to the residents of the Yellowknife Bay area.

...We want to assure this community can thrive in the future, and as such, such things like ensuring we have proper clean drinking water is an essential service that we must maintain.

¹⁰⁴ See section 2.5.5 (Net improvement and significance) for related discussion.

The City of Yellowknife encouraged the Review Board to request a better Project design because the Developer had no justification for installing the diffuser (PR#576 p40).

Alternatives North recommended in its technical report that the Developer commit to pay for any incremental costs for municipal water treatment costs caused by the Project (PR#482 p16).

The City of Yellowknife indicated that Yellowknife Bay is a possible drinking water source and asked the Developer to commit “to cover expenses associated with treatment processes to address potential spills in Yellowknife Bay to ensure that drinking water standards are achieved if the City chooses to use Yellowknife Bay as its potable drinking water source”. The Developer did not agree to this, but later specified it had previously committed to covering costs associated with accidental spills (PR#576 p97-98).

During the technical sessions (PR#353 p250), the Yellowknives Dene First Nation expressed its dissatisfaction with the proposed water treatment. It asked if the Developer was willing to commit to review best available technologies for water treatment every ten years, as part of its commitment (PR#210) to review emerging technologies for arsenic remediation.¹⁰⁵ The Developer replied that it would review best available technologies for water treatment on a twenty-year cycle (PR#353 p250).

In its technical report, the YKDFN stated that it disagrees with the Developer’s proposed standard of water treatment. It stated that rather than applying best available technology to produce the lowest achievable contaminant levels in effluent, the Developer instead is treating only to the degree that will achieve its desired outcome at the edge of the mixing zone. The YKDFN recommended that “at a minimum, the water quality objective at ‘end of pipe’ should be Health Canada’s Guidelines for Canadian Drinking Water Quality, meeting the protection of freshwater aquatic life at some point outside that” (PR#459 p13-14).

As described in above,¹⁰⁶ many residents of Dettah and N’dilo, and Yellowknife expressed concerns related to arsenic concentrations, drinking water from the lake and human safety. Former Chief and Vice Chief of Dene Nation Gerry Cheezie summarized these, telling the Review Board that he was not satisfied with the proposed quality of effluent. He told the Developer to produce a different water treatment method that would release effluent of drinking water quality. Cheezie said (PR#576 p359):

The water that's going to be discharged into the Back Bay under this plan, the water has got to be drinking water quality, because if you don't, then you're just asking us to poison ourselves. And for me and my family I don't think that's an option. There must be another way, and the experts have got to go back and rethink it and come up with another system, because I sure as heck don't like that idea. But I'm no -- I'm no engineer, I'm no scientist, but anything that goes into the water has far-reaching effects.

The Yellowknives Dene second round information request IR#1 asked the Developer for detailed water quality objectives (PR#380). The Developer replied that “at this stage of the design process (i.e., Preliminary Design)

¹⁰⁵ See section 5.10 for details.

¹⁰⁶ See section 8.2.7 for many other concerns related to arsenic concentrations, drinking water from the lake and human safety.

there is insufficient characterization data on the ambient conditions in Yellowknife Bay and Back Bay to allow for a detailed quantification of water quality objectives” (PR#389 p4).

On the subject of the Developer’s chosen objectives for water quality, the YKDFN technical report notes that aquatic organisms, sediment quality, and water quality in Back Bay and Yellowknife Bay have been significantly impacted over years, and further states that this has caused cultural impacts and affected the exercise of Treaty rights, asserting that “(t)his project needs to reverse that trend”. The YKDFN are not satisfied that the Developer plans to present water quality objectives once the Project is in the water licensing process, and plans to “confirm the appropriateness” of applying CCME guideline values for use as site specific water quality objectives for this Project. In the view of the Yellowknives Dene, “(t)he proponent is effectively saying that if it can’t meet the guidelines, then it will consider whether the guidelines are appropriate – essentially just moving the goalposts” (PR#459 p14-15).

The Developer has described the diffuser as being “consistent with industry practice” (PR#562 p16). In its technical report, the YKDFN disagreed with the proposed reliance on the mixing zone to lower contaminant concentrations in this location. The YKDFN state dilution may be a common approach for operating mines, but is not appropriate for a water body used as a drinking water source (PR#459 p13-14).

The NSMA specified that its members are concerned about significant issues with regard to water treatment and management, including the “ongoing threat to drinking water... to the Aboriginal and non-Aboriginal northerners, especially those resident in the Yellowknife area” (PR#576 p60). It stated that “AANDC must accept financial responsibility for ensuring the drinking water supply for the City of Yellowknife is not contaminated by mine waste of any type, be it effluent discharge, dust, disturbed sediment, et cetera” (p62).

9.6.5 Currents and the diffuser

In the DAR, the Developer identified three possible locations for the diffuser in Yellowknife Bay and Back Bay (PR#139 p6-76, Fig 6.8.4). In its first round information request IR#24, the Review Board requested a description of the currents in various seasons at these locations to identify where effluent would ultimately travel. The Board asked the Developer to describe the potential, over the long term, for this to result in arsenic sediment loading at N’dilo, Latham Island, Back Bay, Yellowknife Bay (including at the houseboat community) or Dettah (PR#178 p32). The Board also requested modelling or a detailed analysis of thermal loading with respect to ice conditions.

In its response, the Developer described how its prediction about arsenic loadings was based on the expected currents, but did not actually describe or illustrate the currents in the bay. The Developer said “Since substances within the diluted effluent, including arsenic, will be mostly in a dissolved form, they are expected to travel within the water column towards Great Slave Lake, with little or no settling to the bay bottom occurring. The effluent is therefore not expected to contribute any loadings to the sediment in any area of the bay” (PR#213 p3).

In the technical session of October 18, 2011, the Developer predicted that “the proposed outfall to Yellowknife Bay will not adversely impact the arsenic level in the bay, beyond the initial mixing zone” (PR#353 p99). The Developer recognized the importance of currents, and described its plans to model and study currents in the

lake, including under ice conditions, in January and March of 2012. The Developer said it would take temperature profiles, look for currents during freshet, and create a model to define the currents and predict how the diffuser would work with minimal impact on the water quality (PR# 353 pp128-129).

The Developer said in the public hearing that it expected the arsenic concentration to drop towards the ambient arsenic concentration of 0.9 µg/L in Yellowknife Bay as the plume from the mixing zone drifts away in the lake (PR#576 p93). However, the Developer had not completed its study and modelling of the currents as planned, and results were not available during the September 2012 public hearing.

In its technical report, Alternative North noted that an understanding of currents is necessary for far-field modelling of effluent mixing and currents in Yellowknife Bay, including under ice conditions, and disagreed with the Developer's conclusions regarding the potential for significant impact, particularly considering this lack of far-field modelling to date. It concluded that there is the potential for significant adverse environmental effects from the diffuser discharge into Back and Yellowknife bays (PR#482 p16).

In the public hearing, the Developer emphasized that it expects the diffuser to cause effluent to rapidly mix with the water in Yellowknife Bay, but acknowledged that additional modelling was required to prove this would result in no adverse effects. The Developer said the water from the treatment plant would "have no adverse impacts on arsenic levels in the bay beyond a very small initial mixing zone and... will have no adverse effects on aquatic biota, and will have minimal impact on the ice thickness, to be proven, of course, by detailed modelling yet to be undertaken" (PR#576 p89). The Developer emphasized that this would result in an overall improvement in the quality of surface water, and would not result in significant adverse impacts on the aquatic environment.

The Yellowknives described a specific cultural concern related to the diffuser. The Developer noted in the public hearing that the diffuser location has been selected based on depth, due to the presence of a suitable trench on the lake bottom. In the public hearing, the Yellowknives Dene told the Board how that the cultural identity of the Yellowknives Dene was tied to the inconnu or coney (*Stenodus leucichthys*), and described the cultural importance of the gradual return of the coney to Yellowknife Bay following years of avoidance during Giant Mine operations (PR#576 p242).¹⁰⁷

In Dettah, Elder and former Chief Fred Sangris described traditional knowledge specifying that fish move in "valleys", migrating along channels in the lake bed, to and from the Yellowknife River and Great Slave Lake. He expressed concern about the effects of disturbances such as sediment or contaminants in those channels on the fish that use them, and on the people that harvest those fish. The following day in the Dettah public hearing, Sangris described how the coney, namesake of the Yellowknives Dene as Weledeh people, were driven off since the start of industrial activities in the area, and predicted that the diffuser would affect their return to the Yellowknife River (PR#577 p365). On this basis and for other reasons, Sangris disagreed with the diffuser (PR#577 p360, 364).

¹⁰⁷ Other evidence related to the cultural importance of the coney is presented in section 12.1.2.

In the public hearing on September 12th, 2012, DFO said “With respect to the outfall and the diffuser, DFO has noted that there is a potential for physical changes to fish and fish habitat use associated with the construction of the outfall and diffuser, as well as within the mixing zone of the diffuser” (PR#577 p239). DFO told the Board that that the Developer’s assessment:

“... identified potential effects to surface water and sediment quality due to physical disturbance and mobilization of contaminants, as well as physical disturbance to the aquatic environment, including sediment, benthic invertebrates- those critters that are living on the bottom -- and aquatic vegetation... DFO has also noted that there is a potential for physical changes to fish habitat and fish use within the mixing zone of the diffuser, which requires further assessment into the future.

Based on the existing information, construction and final design of the outfall and diffuser may alter habitat. But additional information is still required in order to make a final determination on the potential impacts from the outfall and diffuser on fish and fish habitat”.

DFO recommended the completion of a fish habitat assessment in Yellowknife Bay, along the outfall route and at the diffuser location before it could predict potential impacts to fish. It stated that it would require the final diffuser design to inform its later regulatory review pursuant to the Fisheries Act (PR#577 p240).

9.6.6 Aquatic effects monitoring

In its technical report, YDFN recommends that the Board require an environmental effects monitoring program, which focuses on assessing effects on aquatic biota (e.g., benthic communities and fish) in the exposure area on a periodic basis (PR#459). Similarly, Alternatives North recommended in its technical report that the Developer prepare a comprehensive aquatic effects monitoring program for the approval of regulatory authorities. It specified that this monitoring program should include an adaptive management or response framework where thresholds are identified and tied to specific actions for key contaminants of concern including arsenic (PR#482 p16).

Environment Canada similarly indicated that “there remains a gap in understanding the immediate receiving environment in the diffuser location”, that it has not had results of winter water sampling, including for worst-case conditions. It recommends that the diffuser location be fully characterized to help understand the risks of re-suspending sediments, and to provide baseline data for future comparisons. Environment Canada also recommends monitoring for ammonia, sulphate and major ions (PR#460 p9).¹⁰⁸

If the diffuser tips over, the water being released from its nozzles could disturb and re-suspend contaminated sediment. The Developer proposes to monitor the diffuser quarterly for stability and sediment disturbance. Environment Canada recommended that the stability and performance of the diffuser be continuously monitored during initial commissioning, and at a higher frequency than the currently proposed for the first year (PR#460 p10).

¹⁰⁸ See section 8.2.5 for further discussion of sediments.

The Developer noted that it would implement a comprehensive environmental monitoring program to confirm its conclusions and identify any adaptations that may be required, including aquatic effects monitoring every three years to evaluate the effects of the treated mine water discharge to Yellowknife Bay (PR#353 p97,99; PR#576 p89). In the public hearing, the Developer specified that it would, every three years, conduct fish monitoring in Baker Creek and Yellowknife Bay to assess fish health and fish tissue chemistry, and conduct aquatic effects monitoring to evaluate effects of the treated minewater discharge to Yellowknife Bay (PR#562 p23).

9.6.7 Engineered wetlands for water treatment

In the public hearing on Sept. 11, 2012, the Review Board's expert Katherine Enns asked the Developer whether it had considered the use of an engineered wetlands in conjunction with the water treatment plant to reduce concerns about the outfall. Enns noted that using wetlands for bioremediation has been very successful at other sites (PR#576 p99,102). The Developer replied that it had chosen an option that requires year-round water treatment, partly to reduce potential hazards associated with ponding of surface water. Storing water in the mine lends itself better to year-round treatment and increases employment benefits and local participation (PR#576 p101). The Developer later specified that the northern climate would limit wetland effectiveness, and that it did not see any viable opportunity in using wetlands for year-round treatment, and did not consider it as an initial option. The Developer later expresses openness to looking at wetlands in principle as a possible technology, despite the constraints (PR#576 p 104-106).

In its response to the Review Board's February 2013 information request, the Developer submitted a table on the viability of constructed wetlands as a water treatment technology (PR#641). This included a synopsis of the technology and a summary of potential applications to Giant Mine, including advantages and disadvantages. It concludes:

For the Giant Mine, there is no evidence to suggest that constructed wetlands alone would be capable of achieving the effluent quality objectives that could otherwise be achieved by conventional treatment technologies. Constructed wetlands could be used to polish the effluent from a conventional treatment system. However, there are a number of disadvantages with the use of such an approach, the most notable of which is the performance uncertainty (i.e., there is currently insufficient information concerning the arsenic removal efficiency of constructed wetlands, particularly in situations similar to the Giant Mine). The overall conclusion is that proven treatment technologies are currently the most appropriate approach to achieve desired effluent quality characteristics.

9.6.8 The diffuser and ice thinning

The Terms of Reference required an examination of effects of the diffuser on water temperature and impacts of active freezing activities on normal seasonal freeze and thaw cycles in nearby water bodies (PR#116 s.3.5.1). The Developer addressed this in the DAR, saying no impact was anticipated because of the placement of the diffuser, depth of the water it was to be placed in, and the temperature of the effluent that would be going through it (PR#139 p12-12 to 12-13; PR#353 p88; PR#389 pp2-3). The Developer identified possible mitigations of potential ice thinning effects, including signage (PR#213 p5; PR#353 p88, pp111-114). PR#475, p.11; PR#576 p91)

Over the course of the EA, several documents posted to the public registry, IRs and presentations made in meetings and the public hearing were devoted to the issue of thermal loading in the vicinity of the diffuser that would have an impact on ice thickness potentially reducing it to an unsafe level. As a number of Parties pointed out, the area proposed for placement of the diffuser is about 400 m offshore of the tip of N'Dilo where there is a high amount of use by snowmobile traffic, dog sledding and other recreational uses in the fall after freeze-up, in winter and in spring before break-up (PR#179; PR#482, pp16-18; PR#605 pp4-5). Thinning ice could pose a safety risk, especially in the spring and fall, and Parties, including the Yellowknives Dene and the City of Yellowknife, objected to this placement of the diffuser (eg. PR#578 p40).

The developer stated that it has not completed thermal modelling against measured ice thicknesses and that the diffuser was in a preliminary stage of design (PR#353 p100; PR#389 pp2-3; PR#576 p122; PR#598 p2). Parties expressed concerns that the ice modelling was incomplete (PR#213 pp4-5; PR#353 p101, p104; PR#459 p12; PR#475, p11; PR#482 p14, pp16-18); PR#576 pp164-165; PR#605 pp4-5).

In response to an information request from the Review Board some months after the public hearing, the developer identified project alternatives that do not require a diffuser. These are discussed in sections 9.6.9 and 9.7.

9.6.9 Water treatment and outfall alternatives

9.6.9.1 Water treatment alternatives

After deliberating on the available evidence, the Review Board re-opened the public record on February 7th, 2013 to issue an additional information request regarding the diffuser and water treatment alternatives (PR#614). It noted that the Developers' studies of currents in the vicinity of the diffuser had not been completed by the public hearing, that diffuser design was not yet complete, and that the Developer had not yet conducted community engagement on the diffuser with potentially affected communities. It noted that this has resulted in several uncertainties about the potential for the diffuser to contribute to arsenic loadings in Yellowknife Bay, and about other effects resulting from the release of arsenic in the water treatment plant effluent.

The Board requested more information from the Developer on alternative methods of water treatment and management that do not rely on the diffuser or on Yellowknife Bay. Specifically, the Board asked the Developer for a description of the relationship between water treatment costs and arsenic in treatment plant effluent for a range of concentrations, and for the cost at which treatment would not be feasible for the next 100 year period. It also asked for a description of the best three alternative technologies for water treatment and management, including costs, implications to the overall Project and potential impacts (PR#614 p3).

The Developer submitted its response on March 15th, 2013, identifying ion exchange, reverse osmosis and mechanical evaporation as three alternative water treatment alternatives (PR#637, PR#638). These alternatives and the current proposal were described from the perspectives of effectiveness, cost and impacts.

The currently proposed water treatment option, using the diffuser to release water with 100 µg/L of arsenic and a mixing zone in Great Slave Lake for further dilution, costs approximately \$89M. Alternatives are summarized as follows:

Ion exchange: The Developer described ion exchange as an addition to the currently proposed water treatment which would result in effluent that would contain 10 µg/L of arsenic, which is equivalent to drinking water. The cost of the water treatment using this process was estimated to be approximately \$104M. (PR#638 p12) , The effluent would be clean enough to not need dilution via a diffuser, but could instead be released with a near shore outfall close to the mine site.

The Developer stated that for this option, “the discharge meets Health Canada’s drinking water quality guidance of 10 µg/L for arsenic and would therefore pose a very low risk of adverse health effects to people who might come in contact with the effluent, drink the treated water or catch and consume fish that come in contact with the effluent” (PR#637 p6).

Reverse osmosis: Using reverse osmosis would further lower the arsenic concentration to 5 µg/L. This would meet the Canadian Water Quality Guideline for the protection of freshwater aquatic life. This method would generate a large volume of contaminated brine, which could either be piped back down the mine for a total cost of apx. \$154M, or be evaporated mechanically, for a total cost of \$583M (PR#638 pp11-12). As with ion exchange, no diffuser would be needed because this effluent could be safely released near shore at the mine site (PR#637 p6).

Mechanical evaporation: This is a zero discharge option, which could be done without releasing any effluent into the lake, but it requires roughly two tanker trucks of fuel per day, generating considerable atmospheric pollutants and carries an estimated cost of \$1.5 billion (PR#638 p7, p12).

The Developer’s evaluation of the current option and three alternatives above found that “all four of the potential water treatment and disposal options, including the current proposal, do not pose a risk of significant adverse effect to ecological species or to people” (PR#637 p6). Reverse osmosis is not considered a viable option because it is not consistently reliable and involves significant financial costs and mechanical evaporation is not environmentally or financially feasible.

The Developer considers ion exchange to be “...a viable option that meets drinking water standards and can be implemented in a manner that addresses public concerns” (PR#637 p6). In later correspondence with the Yellowknives Dene, the Developer stated that it “would support a measure to meet drinking water quality of arsenic for discharge from the water treatment plant at the end of pipe” (PR#640).

9.6.9.2 Outfall alternatives to the diffuser

The response to the Review Board’s February 2013 information request considered alternatives to the diffuser for different water treatments. The Developer considered solar evaporation and several alternative outfall types, including near, shore, on shore, Baker Creeks, nearby lakes (PR#638 pp15-18). Of these, it recommended two: the current diffuser or a near shore outfall immediately adjacent to the mine site.

The near shore outfall was only recommended for effluent containing 5-10 µ/L of arsenic. The advantages of a near shore outfall included less disruption of sediments during construction, less capital cost, and a location immediately adjacent to the mine site that is easier to define and indicate to the public via signage. The disadvantage is that the lack of current could increase the effect of treated water temperature on the ice above it (PR#638 p17).

In related correspondence responding to YKDFN questions, the Developer stated that a near shore outfall would not impact recreational opportunities or use of the ice. The Developer proposed a workshop to identify a specific location, begin design on a breakwater that identifies where the ice is safe, possibly design pre-cooling for the effluent, design a monitoring program for ice thickness, and develop a communication plan. The Developer wrote that “the intent at Giant Mine is to consider a breakwater structure that is a permanent feature that forms part of the outfall structure design and cannot be readily accessed by the public” (PR#640).

In its comments on the Developer’s response, Alternatives North recommends a more detailed examination of reverse osmosis because ion exchange would still require mixing to reach the CCME guideline for the protection of aquatic life (PR#639 p5). Alternatives North stated that “the Developer should carry out a Site-Specific Risk Assessment and/or develop a Site-Specific Water Quality Objective based on the aquatic species found in Yellowknife Bay or design a water treatment system to meet the CCME arsenic guideline for the protection of aquatic life” (PR#639 p6).

Alternatives North acknowledges that ion exchange would improve arsenic levels over the current proposal, but do not accept the Developer’s conclusion of no significant effects because of the lack of far field and thermal modelling, or any site-specific ecological risk assessment using the species present in Yellowknife Bay (PR#639 p6,7). Alternatives North also expressed concern regarding the lack of public engagement on the above alternatives. It identified areas where the Developer committed to consulting Parties as part of a public hearing undertaking but had not done so (PR#639 pp6-7).

9.7 Review Board analysis and conclusions: water quality

Parties, and particularly the Yellowknives Dene, are deeply concerned about water quality in Great Slave Lake, and about the proposed Project deliberately releasing water, heat and contaminants including arsenic into the lake via the diffuser. They are concerned that this will adversely affect aquatic health, including the movements and health of fish, and human health.

The Board notes that a Project objective was reducing the amount of arsenic released from the Giant minesite and upstream sources from the current total of 910 kg per year, and the Project as designed would reduce arsenic to 690 kg per year. The Board agrees that the total reduction of 220 kg of arsenic per year is helpful. The Board notes that the whole Project as proposed will reduce the amount of arsenic currently entering the bay by approximately 25%.

The Developer has stated that the water at the point of release of the diffuser will contain 100-200 µg/l of arsenic, one hundred to two hundred times the ambient water quality in Back Bay, which is itself already affected by past mining. The level may reach as high as 400 µg/l of arsenic on occasion (PR#576 p73). The Developer proposes to use a portion of Back Bay 81m long by 15m wide as a mixing zone. At the edge of this area, after the treatment plant effluent has been diluted 100:1, the water is predicted to contain 2.9 µg/l of arsenic. The Developer proposes to locate the diffuser approximately 400m north of the Yellowknives Dene community of N’dilo, although the exact location still needs to be determined. It expects the plume to be diluted into Great Slave Lake by currents until it matches the background levels. The Developer has not yet studied far-field currents in the lake.

People are worried that the arsenic may not disperse but could instead accumulate in water and sediment in Back Bay. In response to the Developer's expectation that the sediment which may be disturbed by the diffuser is likely contaminated with 100 ppm arsenic, the Board notes that the concentration of arsenic in sediments varies over distance from the shore and in some parts of the proposed path of the diffuser is much higher than 100 ppm. The Developer has stated that half the arsenic in sediments is in an inert form. The Board notes that this is only true under anoxic conditions, but disturbance could change that. Arsenic levels in sediments are already high, and this could add to them and pose direct health risks to water users, and indirect risks related to fish. The proposed Project poses the potential for arsenic accumulation and loading in sediment, and Board notes that sediment can be a source of contaminants to surface waters for long periods of time. The Board concludes that the Developer may well have underestimated the potential of the diffuser to increase the amount of bioavailable arsenic in Yellowknife Bay.

The Developer has described the use of the mixing zones in other industrial settings. The Board notes that none of the examples provided were as close to communities, located in water used directly by communities, or in proposed drinking water sources. People swim in Yellowknife Bay (PR#576 p355, 369), eat fish from it, and some people continue to get their drinking water from it directly (PR#604).

The function of the diffuser is to mix lake water with water treatment plant effluent to dilute concentrations of arsenic and other contaminants. The Developer has stated that at the edge of the mixing zone, the water will meet the CCME criteria for the protection of aquatic life. Throughout the EA, the Developer's discussions on arsenic in effluent have focussed on arsenic concentrations. The Board notes that the Developer has put much more effort into predicting *concentrations* than it has to looking at the potential *loading* of arsenic in the bay. In the Board's opinion, even very low concentrations of arsenic can cause a problem if the arsenic accumulates, for example, in water, sediments, fish or people. Besides its initial modelling of arsenic releases in the DAR, the Developer has done very little to examine the potential for arsenic to build up in the bay.

The Board also notes that the functioning of the diffuser without causing the accumulation of arsenic in the sediment of Yellowknife Bay depends on the characteristics of the currents in the bay. The Developer was advised to complete its studies of far-field currents about a year before the public hearings, and has not yet done so. The Developer has therefore not proven to the Board's satisfaction that the diffuser will not result in arsenic accumulation in sediments and will not result in related impacts on the environmental and on people.

At the public hearing, the Developer and Parties described the role of the mixing zone related to the standard of water treatment proposed at the end of the pipe at the water treatment plant. The Board recognizes that the size of the mixing zone is partly limited by hydraulic considerations, but also concludes that the size of the mixing zone is largely determined by amount of mixing required to allow the treated effluent to meet CCME standards. This is based on the level of water treatment at the treatment plant. The Developer has described that there could be less arsenic at the end of the plant if additional processing was added, and that there is space in the proposed plant for additional treatment facilities. The Yellowknives Dene and the City of Yellowknife have asked that additional treatment be added to the current proposal.

Additional treatment involves additional cost, and the Developer has described how costs were one of the primary drivers for Project design. Considering this, it is fair to say that, to a large extent, the size of the mixing zone is related to effluent water quality, which is related to cost; In the Board's view, the mixing zone is an example of how the proposed Project involves a trade-off between cost and water quality.

In this case, considering the extensive public concern related to water quality, the Board believes that the people living in the area surrounding the Project have a fundamentally different view about how to strike the right balance for this trade off. To the Parties, the Yellowknives Dene and the public, it is important that water contamination is avoided as much as possible, even if it costs more. They do not agree with the Developer about how clean the water leaving the treatment plant and diffuser should be. They are also concerned about the possibility of stirring up contaminated sediments and about potential accidents regarding the effluent pipeline and diffuser.

The Board notes that DFO has identified potential effects to sediment and surface water related to sediment disturbance from the diffuser, and potential changes to fish habitat and fish use, but stated that it needs additional information to make a final determination on the potential impacts from the outfall and diffuser on fish and fish habitat.

The Developer says that the Project will cause a general improvement in the aquatic environment compared to the current situation. The Board's views on potential net improvement, cumulative impacts and accidents and malfunctions are discussed further in other parts of this report.¹⁰⁹

The Yellowknives Dene and other Parties have indicated that they do not agree with the Project design, including the diffuser, and do not agree with the mixing zone and dilution as a solution. However, the Yellowknives Dene reluctantly accept the diffuser as a compromise for the time being, only under the condition that the released water meets drinking water standards¹¹⁰ (PR#459 pp13-14; PR#576 p359; PR#605 p3), and with stringent measures to address ice safety issues. The City has also expressed its interest in improving water treatment so that the effluent does not require a diffuser, and has asked the Board to require an alternative to the diffuser (PR#578 p38).

As described above, Health Canada's 2012 *Guidelines for Canadian Drinking Water Quality* state that the maximum allowable concentration for arsenic is 10 µg/L (PR#139 p7-7), and amount determined to be low enough so as not to cause cancers of the lung, bladder, liver and skin, and other skin and vascular neurological effects. The Board observes that this amount is ten to twenty times lower than that proposed for the treatment plant effluent (100- 200 µg/l), and twice that at the edge of the proposed mixing zone.

Both the City of Yellowknife and the Yellowknives Dene do not agree with the standard chosen for the treatment plant effluent. The Developer has stated "we are going to meet a standard that is supporting the community's interests, which we've heard back from the community" (PR#576 p121). The Developer has recognized that it is possible to reduce the amount of arsenic in the effluent with additional treatment plant processing (PR#576 p120), and has identified that it has additional room in its proposed treatment plant for expansion (PR#562 p14).

The onus is on the Developer to prove that the proposed water treatment is not likely to cause significant adverse impacts. The Board is of the opinion that the Developer has failed to provide sufficient evidence to do so, for a number of reasons which include the following:

¹⁰⁹ See sections 2.5.5 and 2.6 for further discussion.

¹¹⁰ 10 µg/L of arsenic instead of the proposed treatment effluent containing 100 µg/L or more

- It has not established that releasing effluent of 100 µg/L will not result in arsenic loading of the bay, particularly in cumulative combination with arsenic from upstream sources, surface drainage, and sediments.
- It has not chosen a water quality objective that addresses the water quality concerns of those who will live closest to the Project, specifically the Yellowknives Dene and the City of Yellowknife.
- It has not completed far-field modelling of currents to proven that the effluent plume from the mixing zone will disperse as is expected.
- It has not provided sufficient site-specific information to establish that that the diffuser installation, operation and periodic replacement will not re-suspend sediments making existing arsenic in those sediments biologically available.
- It has not established that the near-field impacts on water quality will not affect the channels that Traditional Knowledge holders state are important to the return of coney to the bay, and it has not provided DFO with sufficient information for it to review site-specific physical disturbances and to evaluate the potential for impacts.

In the Board's view, these findings individually and collectively indicate that the Project will cause significant adverse impacts on water quality and the environment of Back Bay. Consequently, the Board determines that the Project is likely to be a cause of both significant adverse impacts to water quality and public concern. This results from the proposed level of water treatment coupled with the corresponding need for the diffuser and mixing zone and the effects of releasing this treated water over the life of the Project.

Without completed diffuser design and results of the far-field currents, the Developer has not proven to the Board's satisfaction that arsenic loading in Great Slave Lake has been adequately addressed. The Board concludes that a precautionary approach is appropriate in this case.

The Developer has indicated that adding ion exchange to the water treatment process is a feasible alternative. In the Board's view, this technology would likely to address these impacts and public concerns satisfactorily. The Developer has indicated it would support a measure requiring the Developer to meet drinking water quality guidelines for discharge from the water treatment plant.

The combination of the measures below is required to mitigate the above impacts to water quality from the water treatment plant effluent and the impacts described below regarding the diffuser, and address the related significant public concern regarding arsenic in water.

Measure 14: The Developer will add an ion exchange process to its proposed water treatment process to produce water treatment plant effluent that at least meets Health Canada drinking water standards (containing no more than 10 µg/L of arsenic), to be released using a near shore outfall immediately offshore of the Giant mine site instead of through the proposed diffuser. The Developer will achieve this concentration without adding lake water to dilute effluent in the treatment plant.

For clarity, this measure is intended to replace the proposed water treatment effluent of 100-200 µg/l of arsenic, the proposed diffuser, and the proposed release location near the northern tip of N'dilo, with the water treatment described as Option Two in the Developer's March 2013 information request response (PR#637 p6) and the outfall described under s.4.6 point 2 of the accompanying report (PR#638 p16).

The Board notes that the Developer has committed to review best technologies for water treatment every 20 years (PR#353 p250).

Regarding the proposed diffuser, the Review Board observes that ice thinning and human safety is clearly a concern to the Yellowknives Dene, the City of Yellowknife, Alternatives North and members of the public. It is apparent that many people use the ice in Yellowknife Bay, including during the “shoulder seasons” shortly after fall freeze-up and before spring break-up. This likely includes use during travel related to traditional harvesting by Yellowknives Dene and others, as well as recreational use.

In the Board’s opinion, the Developer has not done enough to prove that heat in the effluent released through the diffuser will not cause ice thinning, particularly the shoulder seasons. In October of 2011, the Developer said that it recognized the importance of the issue, saying “This has been one of the number one issues that has been given to the design team (PR#353, p101). However, it did not complete the studies and modelling it said it would when it said it would, and these were not even complete by the public hearing in September of 2012. This does not appear to be treating this issue as a priority. Without the completed studies, the Developer has not proven that the heat from the diffuser will not cause ice thinning and will not be a threat to the safety of people using the ice. In the Board’s view, a precautionary approach is warranted.

The Board accepts the City of Yellowknife’s point that thin ice rescue at the diffuser location would be difficult indeed, and notes that the Developer did not identify any mechanism for restricting access to the frozen surface of the lake when asked.

The Review Board is of the opinion that the diffuser as proposed is likely to be a cause of significant adverse impacts on human safety and generate public concern. However, the Developer stated that the need for the diffuser was to mix effluent with lake water. This was necessary because of the concentration of arsenic in the effluent leaving the water treatment plant. The Developer has indicated that the diffuser would not be required if the effluent was treated with the ion exchange process described in the above measure, because the effluent would be of a quality that would not require further dilution (PR#637 p4). The above measure makes it possible to replace the diffuser with a near shore outfall in the immediate vicinity of the mine site. This location is much further from N’dilo and areas of high ice use, and makes it possible to construct a breakwater around the outfall to warn ice users of possible hazards (PR#640).

The Board notes that even with the considerable reduction of arsenic in the effluent due to the measure above, effluent dispersal has not been examined, the Developer has not completed its study of currents, and the potential exists for gradual arsenic loading in Back Bay. The measures below are partly intended to ensure that this does not occur over time. Given the location of the Project relative a large population and upstream of areas used for traditional harvesting, the Review Board views a comprehensive aquatic effects monitoring program as essential to prevent significant adverse environmental impacts and significant public concern that is otherwise likely.

Measure 15: The Developer and regulators will design and manage the Project so that, with respect to arsenic and any other contaminants of potential concern:

- 1. Water quality at the outfall will meet the Health Canada Guidelines for Canadian Drinking Water Quality; and,**
- 2. The following water quality objectives in the receiving environment are met:**
 - a) Water quality changes due to effluent discharge will not reduce benthic invertebrate and plankton abundance or diversity beyond 200 metres of the outfall;**
 - b) Water quality changes due to effluent discharge will not harm fish health, abundance or diversity;**
 - c) Water quality changes due to effluent discharge will not adversely affect areas used as drinking water sources; and,**
 - d) There is no increase in arsenic levels in Yellowknife Bay water or sediments beyond 200 metres of the outfall.**

Measure 16: Before construction, the Developer will model re-suspension of arsenic from sediments and resulting bioavailability in the vicinity of the outfall. If the modelling results indicate that the outfall may re-suspend arsenic from sediments, the Developer will modify the outfall design until operation does not cause re-suspension of arsenic from sediment.

Measure 17: Before operating the outfall, the Developer will design and implement a comprehensive aquatic effects monitoring programme that is sufficient to determine if the water quality objectives listed in Measure 15 are being met. This programme will:

- 1. at a minimum, be able to identify any accumulation of arsenic over time in the water, sediment or fish in the receiving environment**
- 2. include appropriate monitoring locations near N'dilo, in Back Bay and in Yellowknife Bay, with a focus on areas in the vicinity of the outfall and areas used by people.**
- 3. include the establishment of a baseline for aquatic effects in Back Bay before beginning Project construction and installation of the outfall.**
- 4. be developed according to AANDC *Guidelines for Designing and Implementing Aquatic Effects Monitoring Programs for Development Projects in the Northwest Territories, June 2009*, with corresponding action levels and management response framework.**

Measure 8 prescribes a role for the oversight body (described by Measure 7 in Section 7.3) with respect to the aquatic effects monitoring prescribed in the measure above.

10 Freezing

10.1 Evidence from the Parties: freezing

The Terms of Reference required a detailed description of how the frozen block method will be done including the saturation procedure, risks and effects related to thaw, potential impacts of an intentional thaw, and risks and consequences accidents and malfunctions. It also asked for a thorough analysis of scenarios that could lead to partial or complete failure (PR#116 s.3.3).

The frozen block concept proposed by the Developer is presented in section 6.2 of the DAR (PR#139). The Developer identifies three steps for the frozen block concept (PR#139 s6.2.6 pp6-27 to 6-30):

1. Creating a frozen wall;
2. Wetting the dust; and
3. Freezing the block.

The DAR, as well as presentations and discussions held during the technical sessions in 2011, resulted in the submission of various information requests on the subject of freezing methods and objectives from different Parties (eg. PR#178; 348; PR#352 to PR#356). The Developer provided several additional documents before the public hearing and provided more details during these public hearings as a response to previous IRs (e.g., PR#561 and PR#575).

10.1.1 Freezing design criteria

Supporting document J1 in Appendix B of the DAR (PR#139) includes the Developer's conceptual design to date of the frozen block. In this document, the design criterion for the frozen block was formulated as follows (pp23 to 24):

The criterion for the initial containment is to lower the ground temperature to -10°C over a distance of at least 10 m around and below all mining workings where arsenic trioxide dust is present. The 10 m zone at -10°C will be extended to the top of the chamber and slope following the saturation of the arsenic trioxide... (T)he criterion would then be shifted to the second stage, where it will target specifically the arsenic trioxide dust. The proposed criterion in that stage is to maintain the temperature within the dust to -5°C or colder.

By the public hearing stage of the environmental assessment, success criteria to evaluate the performance of the frozen block had not yet been finalized (PR#494). In particular, the long-term criteria, such as changes that would require a management response, were still lacking (PR#561 p37; PR#575 p150). Parties have been concerned about the lack of definitive criteria throughout the EA process (eg. PR#582 pp19-21; PR#605 p7).

10.1.2 The freeze optimization study and the wetting study

The Developer initiated but has not yet completed a Freeze Optimization Study and a Wetting Study (PR#475; PR#495) [Figure 9]. The results of these studies suggest that the optimal detailed design may differ from the conceptual design assessed in this environmental impact assessment. For example, wetting the dust may not be the best option, as discussed below.



Figure 9: The freeze optimization study
(photo: Review Board)

The preliminary results from the Freeze Optimization Study and the Wetting Study were presented in the months leading up to the public hearing (PR#475; PR#495). As stated by the Developer during the public hearing in September 2012, both of these studies are still ongoing and only initial results were available at the time of the public hearing (PR#575; PR#561 p66).

The major findings of the Freeze Optimization Study as presented by the Developer to date can be summarized as follows:

- Ground freezes (cools down) faster than anticipated (PR#561 p47). Hence, the conceptual design presented in the DAR is conservative;
- Freezing is fast enough that full passive cooling might be reasonable (assuming today's climate conditions). Active freezing with an energy intensive refrigeration unit may not be required (PR#561 p54); and
- There are challenges with the data management system that need to be resolved (PR#561 p54).

The Developer suggests that these initial findings may result in changes to the conceptual design because (PR#561):

- Thermal conductivities are higher than used in the conceptual design;
- Bedrock has a higher thermal diffusivity (i.e., it cools more rapidly) than assumed in the efficiency and energy assessments;
- Higher thermal conductivity values indicate better performance; and

- A freeze pipe spacing of 5 m will be able to achieve the initial freeze criteria within 12 months.

During the course of the environmental assessment, the Developer suggested a number of potential changes to the Project (PR#561 pp193-207):

- Only a frozen shell may be required instead of a completely frozen chamber;
- It is possible that the vertical pipes to freeze the bottom of the mine stopes could be extended so that no horizontal pipes at the bottom would be required; and
- A special ceiling freezing may be required.

Based on the Freeze Optimization Study, the Developer concluded that ground freezing is much more efficient and occurs much quicker than initially calculated; only one year for the initial freeze is required instead of three years as projected and presented in the DAR (PR#139 p6-28). The Developer has indicated that three-dimensional geothermal modelling will have to be carried out for detailed design using data from the FOS for calibration.

The Developer has recognized that a better understanding of the likelihood of bulkhead collapse would be of benefit to further engineering and design (PR#575 p141).

The Wetting Study was a theoretical assessment of potential wetting methods for the arsenic trioxide dust in the chambers and stopes. Although not complete at the time of the public hearing, results up to that point indicate (PR#495; PR#575 pp148-149):

- Wetting of the arsenic trioxide dust from the top down can lead to several problematic phenomena;
- Wetting of the arsenic trioxide dust from the bottom up may require no additional mixing energy;
- Available data does not currently support a definitive conclusion about the extent of the settlement/collapse potential in the chambers;
- The initial purpose of the wetting (the ice would provide thermal inertia to keep the chamber cooler longer) is no longer needed, as the design criteria for freezing refer to the whole chamber and not only parts of it; and
- In general, the Developer considers wetting of the arsenic trioxide dust as a higher risk option compared to keeping the arsenic trioxide dust dry.

The Developer has not yet begun substantive discussions with Parties comparing the wet and dry methods, but will be in a position to begin these discussions by the spring of 2013 (PR#598 p2).

As additional data from the Freeze Optimization Study and the Wetting Study become available, the Developer may consider changing some aspects of the design that were presented and used during the environmental impact assessment (e.g., PR#575 p150, 157). For example, water infiltration can change when the chambers are not wetted and only the shell is frozen. The Freeze Optimization Study shows higher than anticipated thermal

conductivities, which the Developer claims can eliminate the need for horizontal freeze pipes at the bottom of the chambers. Considering this, the Developer believes that the whole chamber will freeze eventually (PR#575 p158 / PR#561 p59). However, uncontrolled water infiltration from top down¹¹¹ may result in an uncontrolled wetting in the very long term (perpetuity). The risk of uncontrolled water infiltration during a flood event is higher during the initial stages of the Project when the chambers may still be unfrozen.

With time, and as the shell and the arsenic trioxide dust cools down, the hydraulic conductivity is reduced, hence reducing potential water flow. As described by the Developer, this may result in severe problems caused by voids of unfrozen arsenic trioxide dust potentially forming in the chambers (PR#495 p3, Table 1).

Geothermal modeling has been used extensively by the Developer to assess the effectiveness of the ground freezing system. To date, only two-dimensional modeling has been carried out (PR#561 p55). However, in reports and responses to IRs the Developer acknowledges that there are limitations to the 2D models, and committed to do three-dimensional geothermal modelling to better assess the ground thermal regimes of the complex geometries. Recent results from the Freeze Optimization Study will be used to calibrate the three-dimensional models, but these were not available for the public hearing. The Developer was therefore unable to present potential changes to the freezing plan resulting from more sophisticated geothermal modeling which will be conducted in the future.

10.2 Review Board analysis and conclusions: freezing

Based on the above, the Review Board is of the opinion that the Developer's design for creating the frozen shell or blocks appears to be sound for the 100 year maximum lifespan of the Project.¹¹² The Freeze Optimization Study has proven a valuable tool for helping to understand and calibrate the functioning of the proposed freeze system. In combination with the measures required by the Review Board elsewhere in this document and below, this is likely suitable for the 100 year maximum Project lifespan.

Although the Developer has described other Projects that have used thermosyphons for ground freezing, the Board notes that none of these have been used to create frozen blocks of, or frozen shells around, such large chambers and stopes of contaminants, and all have been applied in a different setting. In this application and setting, this is a new technology. The Board has no evidence of similar projects.

In the Board's view, the engineering approach appears to be resilient and tolerant of existing and predicted conditions for the 100 year life of the Project. The Board notes the long chain of events that would be required to cause a failure. Although there are many such possibilities over the course of perpetuity, these are much less likely over the 100 year lifespan, particularly with the benefit of independent oversight¹¹³ to encourage best management practices. The Board also notes that maintenance of the thermosyphons will be required as their efficiency reduces with time (e.g., loss of charge gas pressure). It is therefore important to realize that without maintenance, the frozen block could warm and thaw if the cooling system is not monitored and maintained over

¹¹¹ such as after a Baker Creek flooding event (see Section 9.1 for details on Baker Creek and flood risks).

¹¹² As described in section 5.11 (Perpetuity) and Measure 1.

¹¹³ As described in section 7.3 (Trust and Oversight) and Measure 7.

the long term. This long-term dependence on ongoing maintenance is partially reduced by Measure 1 above¹¹⁴. In the maximum 100 years of the Project, the Board hopes that a permanent remediation strategy that does not require monitoring and maintenance can be implemented.

Regarding the possible optimizations to the freezing design that the Developer described, the Board notes that these may themselves have relevant effects on the impacts as freezing mechanisms and the effect of water infiltration at a later stage will likely change. As those mechanisms were not identified in the Developer's Failure Mode Effects Criticality Analysis (FMECA) risk assessment (PR#372), their potential impacts are currently unknown.

The Developer has stated in the public hearing that if a better solution was found, it would be adopted. The Developer's openness to identifying future treatments based on emerging technologies implies that it will consider a different remediation technique in the future, (eg. PR#390 IR#6, p3; PR#578 p168) such as excavation-and-removal or ex-situ treatment of the arsenic trioxide, assuming such technologies become available. Therefore, the application of future remediation, which may require removal such as thawing or excavation of the frozen blocks, needs to be considered in the initial freezing design.

For example, a partially-wet chamber, which also only freezes locally, may be more difficult to excavate if it is not known which sections are frozen, compared to a completely frozen, saturated block. Such scenarios were not considered in the assessment of the suggested method. It is also important to note that the Terms of Reference (PR#116 s.3.3) required saturation of the arsenic trioxide dust, i.e., no loose, unsaturated sections that would jeopardize the stability of the frozen block.

The Developer has not presented sufficient data to conduct a quantified risk assessment on all aspects of the Project, including the initial freezing phase, short-term and long-term maintenance requirements and potential removal if new technologies become available (PR#575 p198, p217). For example, no detailed wetting study has been carried out that would, in combination with a detailed risk assessment, provide input to decide what risks are associated with keeping the arsenic trioxide dust dry (and cold), versus wet and frozen.

Similar to the arguments by the Developer that dry dust could result in less risks to the Project (PR#575 p196-197), it can be argued that wet might be a better option both in terms of potential moisture migration into the dry chambers in the long-term, and also with respect to potential excavation of frozen material for future ex-situ treatment of the contaminated ground. No data exist that would help quantify the risks associated with the different options.

For these reasons, the Board concludes that deciding to either wet the chambers or not without carefully examining the risks of each is likely to cause an unacceptable risk of significant adverse impacts. The Board acknowledges that the Developer is continuing to collect information (e.g. through the Freeze Optimization Study and three-dimensional modelling) to better inform the detailed design. However, these changes may alter the Project compared to the conceptual design to date. Therefore, the Developer must conduct a quantitative risk assessment of wet and dry options, and must consider the implications of the selected method on potential

¹¹⁴ See section 5.11

future remediation, as described in the measures below. This will acceptably mitigate this risk by anticipating any relevant freezing risks and potential impacts and allowing the Project design to address them appropriately.

Measure 18: Prior to preparing chambers and stopes for freezing, the Developer will conduct a comprehensive quantitative risk assessment evaluating both wet and dry methods for the initial freezing design, with respect to current risks and implications for future removal. This will include an evaluation of potential effects of the proposed freezing and wetting method on the thawing or frozen excavations, and potential impacts of ongoing design changes prior to implementing the Project. The Developer will release a plain language report to the public describing its considerations and the resulting design.

The Review Board expects that the risk assessment described in the above measure will enable the Developer to systematically predict and avoid the significant adverse impacts that are otherwise likely to occur with either wet or dry method if no such risk assessment were done.

Measure 19: Considering the results of the risk assessment described in Measure 18, the Developer will not adopt any method of freezing that significantly reduces opportunities for future arsenic removal or other remediation by future technologies.

11 Surface Reclamation

This section examines the evidence on the potential impacts and changes to surface features and conditions resulting from reclamation activities associated with the Giant Mine Remediation Project. Below is a short summary of proposed surface remediation activities designed to address:

- the 100+ remaining buildings associated with the mining activities,
- the Townsite
- ore production, processing, and water treatment
- the 8 open pits and associated dams
- the 35 openings to the underground system and 27 000 drill holes that intersect the workings
- the 960,000m³ of contaminated soils
- and 13.5 million dry tonnes of tailings and associated infrastructure;
- the settling and polishing ponds; and,
- the waste rock piles, overburden stockpiles, exposed quarries, and site roads.

Following the summary of the evidence available for existing site surface features, this section will examine surface infrastructure that the Developer proposes to construct and maintain onsite in support of the long-term monitoring and maintenance associated with the perpetual care scenario. This includes waste management facilities and the water treatment plant.

Finally, this section will describe the Review Board's conclusions regarding surface reclamation. Other impacts to surface features including water management and infrastructure associated with freezing are examined in other sections of this report.¹¹⁵

11.1 Evidence from the Parties: surface remediation

11.1.1 Evidence from Parties: buildings and Infrastructure

Reviewers and the Review Board have expressed concerns about the decommissioning of some of the more contaminated buildings (Figure 10, Figure 11), specifically the roaster complex and mill, which contain large amounts of arsenic trioxide dust and asbestos. The Developer has made commitments to ensure that conditions are such that decommissioning does not contribute adverse impacts on the environment (PR#354 p227).

During remediation, all processed ores from the crusher, conveyor, and buildings will be placed into the tailings ponds. An onsite commercial/industrial waste landfill is proposed within the Central Tailings Pond to manage the non-hazardous material, debris and asbestos from building and structure demolition (PR#577 pp27-28). Stable non-hazardous demolition waste will be placed in B1 pit outside the frozen zone. Materials with soluble arsenic will be placed in a frozen zone, and asbestos will be buried in tailings in the northwest pond. Other items with hazardous substances, such as mercury and PCBs, will be shipped to off-site facilities. The mill and tailings reprocessing facility will be decontaminated prior to demolition (PR#139 p6-91, 6-92).¹¹⁶

¹¹⁵ See sections 9 and 10 for details.

¹¹⁶ The dismantling of the mill conveyor and roaster complex as emergency work under subsection 119(b) of the *Mackenzie Valley Resource Management Act* is described in section 2.2 of this report of EA.



Figure 10: Buildings and infrastructure at Giant Mine

(photo: Review Board)

Environment Canada recommended the avoidance of demolition activities during the nesting season. If for some reason, this is not feasible, it recommended that thorough inspections for active nests should be carried out a maximum of 4 days before destruction with appropriate buffers in place for any active nests identified (PR#577 p232). The Developer agreed with Environment Canada's recommendations and committed to avoid migratory birds and other wildlife using the structures as habitat, especially during the spring breeding season (PR#461 p12).

Contaminated Dust

The removal of buildings and other on-site features and infrastructure, including activities such as drilling and site/road construction will continuously contribute to the overall air emissions, especially through the re-suspension of dust, arsenic, and other contaminants. In the Developer's Assessment Report, the Developer suggested several ways to control dust and contaminant deposition in the demolition of the Roaster Complex:

- 1) Maintain negative pressure and exhaust air treatment with high efficiency particulate arrestor (HEPA) filters, and
- 2) Apply an adhesive to potential sources of loose contamination to reduce emissions during demolition activities (PR#139 p6.92).

During the technical sessions, the Developer committed to complete the asbestos and arsenic abatement processes under negative air and in favourable wind conditions, avoiding sensitive nesting seasons. The Developer stated that adherence to these commitments should ensure that the buildings are securely enclosed so that dust cannot enter the environment (PR#354 p227).

This level of protection has not been explicitly proposed for the demolition or construction of other facilities which may also disturb large quantities of dust and contaminants. The DAR states that the Developer will clean and decontaminate construction materials and equipment as much as possible prior to demolition (PR#139 p6-91). However, demolition and other on-site activities have the potential to introduce dust and other contaminants into the air.



Figure 11: Giant Mine roaster complex
(photo: Review Board)

11.1.2 Evidence from Parties: open pits and associated dykes

In the Developer's Assessment Report, AANDC and the GNWT acknowledge that the open pits and associated dykes represent a physical hazard to people using the site in the future (PR#139 p6.51). As a result, a combination of remediation activities has been proposed to stabilize the pits in terms of public health and safety, the environment, and sensitive infrastructure.

Open Pits

Figure 3 in section 1.3.4 of this Report of EA shows open pit locations and Table 11.1 below summarizes the planned disposition of open pits. Referencing the NWT Mine Health and Safety Act and Regulations, the Developer indicated that there is no intention to rehabilitate the open pit sites to meet future recreational use or public access standards. The Developer does not propose to completely backfill all of the open pits because there is not enough low point building material available to fill them. The Developer has stated that all available fill is needed for more high value uses, such as tailings covers.

Table 11.1 Summary of Open Pit Disposition

Pit	Disposition	Backfill	Safety Measures
A1	Remains open	no	Physical barrier around pit perimeter
A2	Remains open	no	Physical barrier around pit perimeter
B1	Backfilled	~330,000 m ³ Comprised of clean rock and contaminated soil	Security fence
B2	*Minor backfilling	*	Physical barrier around pit perimeter
B3	Maintained as surface water collection point	no	Physical barrier around pit perimeter
B4	Regrade pit slopes, cover and revegetate	no	None required
C1	Remains open	potentially	Physical barrier around pit perimeter
Brock	Backfilled	~6,000 m ³ Local clean material	None required

*Changes referenced in the technical session (PR#354 p98) which differ from the DAR (PR#139 p6.52).



Figure 12: Current access restrictions

Fencing, gates and signage are examples of current access restrictions (photo: *Review Board*)

The Developer has accepted that there will be a restriction on future land use at the open pit sites. It has committed to restrict access to most of the pits by erecting physical barriers (Figure 12), and inspecting them on a quarterly or monthly basis (PR#242). Others will be integrated into the reclamation design in order to provide waste disposal space and insulation for the installation of the freeze system, described in section 1.4 (PR#354 p90).

The Yellowknives Dene First Nation is not satisfied by the Developer's proposal to keep some of the pits open. The YKDFN believe that all pits should be filled to reduce risk to human health and maximize future land use options. The YKDFN feel that this short-sighted planning show that this remediation Project was designed around the frozen block idea rather than broader, site-wide, reclamation objectives and feel that "[f]encing and berming when adjacent to a city [is a] recipe for tragedy" (PR#577 p170).

In its final submission, the Yellowknives Dene First Nation reiterated their concern with the Developer's plan to leave some of the open pits unfilled. In addition to public safety concerns, which have already been identified, the YKDFN point out that filling the pits may provide increased options for future land use on a larger, more contiguous plot of land. The YKDFN recommend that the Review Board include a measure which requires the proponent to fill all open pits prior to the completion of the remediation phase (PR#605 p 5).

Dykes

Some of the proposed pit stabilization and modification activities aim to mitigate the potential of overflow from Baker Creek to the open pits and underground workings. At this time, there is no plan to allow for complete flooding of the underground workings since pit flooding would cause infiltration of pit water into the mine workings and vice versa (PR#354 p176). Various related issues, such as risks from flooding, seismic activity and climate change risks are described in previous sections of this report.¹¹⁷

According to the DAR, the B1 pit, some of which is within the freezing zone, will hold approximately 58,000m³ of contaminated soil. This will include metals and machinery containing total or soluble arsenic above the industrial land use criterion, soil and waste rock fill, and other process residues from the roaster and mill complexes (GNWT, 2003). In general, soils with higher levels of arsenic contamination will be placed within the frozen zone of the B1 pit. Surficial waste rock that contains total arsenic above the industrial land use criterion will be backfilled into the unfrozen section of the B1 Pit, with the remainder of the pit filled with quarry rock, stable non-hazardous demolition waste and other clean fill. Any other high arsenic material that is encountered will be excavated and deposited within one of the planned freeze zones, possibly including the frozen section of the B1 Pit above stopes B208 and B213. A protocol for site wide sampling to manage the movement of the various types of contaminated soil and to confirm remediation success has not yet been developed (PR#243).

Because of the proposed deposit of arsenic-contaminated materials into the B1 pit, reviewers expressed some concerns about the design, goals and performance of the pit cover. The majority of the B1 pit cover will be designed to provide a separation between the arsenic-contaminated materials and people working on the surface. Most of the B1 pit is expected to end up behind security fencing constructed to protect the long-term freezing system and prevent human and wildlife interactions with the pit itself. The southwest portion, outside

¹¹⁷ See sections 9.1 (flooding risk), 4.4.3 (seismic) and 5.6 (climate change) for details.

the security fence, will have a cover designed similar to that of the tailings ponds. Monitoring plans have not yet been developed (PR#241).

Boreholes

There are currently an estimated 27,000 boreholes, most of which are potential pathways for movement of groundwater through the site (PR#139 pp5-35 and PR#182 p5). Currently, there are no plans to seal all boreholes in the mine area but all known boreholes around the arsenic chambers and stopes have been sealed with grout. Any new holes in the vicinity will be sealed once activities in the area are complete. If an unidentified borehole is present, there may be a risk of a temporary increase in seepage rates of arsenic saturated water and arsenic trioxide sludge during the wetting period. Dissolved arsenic present in any seepage would be transported and collected in the mine-water system, and removed by the water treatment plant. Any slow-moving water in the boreholes should freeze, quickly sealing the borehole (PR#269).

11.1.3 Evidence from the Parties: contaminated surface materials

Soils

Surficial materials around the mine infrastructure show impacts of 50 years of industrial activity. Evidence on the record indicates that 13.5 million dry tonnes of tailings at the Giant Mine site contain arsenic - dominantly in the form of arsenopyrite and up to 960 000 m³ of contaminated soils containing various concentrations of arsenic, other metals, and hydrocarbons are presently onsite (PR# 354 p104).

Investigations have indicated that, because of the depth of contamination in some areas, approximately 317 000 m³ of contaminated soils will remain in place with engineered caps to facilitate local runoff. Marginally affected material, soils with less than 3,000 parts per million arsenic, totalling about 75 000 m³, can be reused for landfill construction (Figure 13). A small volume, 2000 m³, of exclusively hydrocarbon contaminated materials can be land-farmed onsite and there is room for approximately 58 000 m³ of contaminated soil in the B1 Pit. During the public hearings the Developer indicated that the remaining (over 500 000 m³) contaminated soils may be used as fill to support equipment and trafficability (to allow vehicles to travel over it) in the placement of tailings covers (PR#577 p25, p131).

For soils at the Giant Mine site, the Developer proposes to meet industrial level remediation standards. Through information requests and presentations at the technical sessions, the City of Yellowknife emphasized the need to remediate, at least the area of the Townsite, to residential standards. The reasons it provided were threefold:

1. The Townsite has been traditionally used for residential purposes since the mine was established;
2. There is already an overcapacity of industrial land in the City; and
3. The City would like to reclaim the land for future residential development.



Figure 13. Removing contaminated soils
[PR#348 p32]

The Review Board's *Reasons for Decision* describing its determinations for the scope for this EA on Dec. 19, 2008 (PR#104) decided that it the issue of whether the site is remediated to an industrial or residential standard is not part of the scope of this assessment, but end land use of the site is within the scope. The Developers have committed to work further with the City, outside the scope of the environmental assessment, to determine achievable remediation standards for the Giant Mine Townsite. The City of Yellowknife has an existing land use plan for the Giant Mine Site which it believes should be used to stimulate discussion for developing a collaborative land use strategy for the entire Giant Mine site (PR#354 pp135-147).

In response to information requests regarding the probability and impacts of arsenic minerals in contaminated soils or tailings reacting with carbon dioxide to form highly mobile arsenite (PR#178 p34), the Developer recognizes that such oxidation of different forms of arsenic will occur. The neutral pH conditions of arsenic contaminated areas at the Giant Mine site can generate low to moderate concentrations of arsenic being released as seepage and runoff. No mitigations measures have been proposed to address this release, but site drainage will be designed so that most, but not all, contaminated water is captured and treated prior to release into the environment.¹¹⁸

Remediation of the tailings ponds is not designed to restrict the movement of gas and the Developer therefore does not expect any changes to the rates of oxidation and release of arsenic relative to current conditions. The Developer has said that the only exception to the current release of arsenic from the tailings might be a reduction in total loadings from runoff once the engineered covers are in place.

¹¹⁸ For further discussion on untreated surface drainage and related measures, see sections 9.4 and 9.5.

All sources of arsenic trioxide dust in the chambers are to be completely isolated through freezing and should therefore not be affected by changes in redox conditions. Tailings and waste rock used to backfill some underground workings will interact with water and contribute sources of arsenic to underground water. This water will be pumped and treated over the long term (PR#215).

Tailings Ponds

There are 13.5 million tonnes of contaminated tailings on the mine site, spread over an area equivalent to approximately 175 football fields. These tailings containment areas consists of the Northwest Pond and the North, Central and South Ponds – all of which will be capped with approximately 0.4m of gravel and 0.7m of silty sand and revegetated (PR#139). The specific tailings cover design has not yet been confirmed but the main objective of the cover is to isolate the tailings and reduce infiltration. The Developers have identified several onsite bore areas that should provide approximately one million cubic meters of cover material, Baker Creek diversion excavation materials, and several rock quarry areas that can be used to create spillways for the drainage of the covered Northwest, North, Central, and South Ponds (PR#577 pp21-22).

The key concerns with the tailings ponds in their current state are seepage, surface overflow, dust, and human and wildlife health and safety (PR#139 pp6-63). During the technical sessions, technical experts for the Review Board asked about the long-term behaviour of the tailings, particularly the potential for settling and how this might affect remediation planning and monitoring (PR#354 p179). The Developers anticipate that sequential regrading and maintenance will be required for several years before final grading and contouring of tailings covers are complete (PR#354 p180).

The Developers propose to grade the surface of the tailings ponds so that all drainage and runoff from these areas will be directed into Baker Creek. Some tailings from the South and Central Ponds may be used in backfilling part of the underground stopes beneath the open pits and in the area of the arsenic chambers to improve stability and safety (PR#354 p111). The Central Pond has also been proposed as the location for disposal of non-hazardous waste, described further below (PR#139 p6-58; PR#354 p114).

Two of the four cover test plots suggest successful establishment of vegetation at the Northwest Pond and at Jo Jo Lake near Baker Creek. The Developer expects that further testing will determine levels of moisture migration, movement between the layers, and identify whether the thickness of the proposed zones are adequate (PR#462 p45). Part of the detailed design will also define whether or not there is a need for a geotextile layer between the capillary break and the vegetative layer. The Developer indicated that if used, a geotextile will only be required for the construction phase and is not anticipated for long-term performance considerations (PR#577 pp78-79).

During the June 2012 technical meetings, Alternatives North noted that two of the four existing test plots for cover testing were completely submerged in the Northwest Tailings Pond (PR#471 p21). They are concerned that the submerged plots for the study have limited value and are unsure whether the remaining two plots will provide enough information to inform future cover design (PR#471 p20).

Alternatives North also requested in its technical report and at the public hearings that the Developer prepare a comprehensive air quality monitoring program to test the performance of tailings covers with regard to dust control. It recommends that this program set triggers for actions and contingencies for management (PR#471 p21, PR#577 p197). More information about the proposed air quality monitoring program is provided below.

Alternatives North is concerned that without a proper design or defined objectives for the cover, it will not be possible to measure performance or determine the success of this mitigation. It has recommended that the Developer submit a final cover design including objectives and performance criteria for approval by regulatory authorities prior to the construction of tailings pond covers (PR#471 p21).

At the pre-technical workshop and public hearings, the Review Board asked about monitoring for chemical uptake in plants on the vegetated covers and the cover's resistance to weathering in the long-term. There is concern that, since this remediation plan is intended for perpetuity, chances of interaction between layers as time progresses may increase.

Environment Canada also addressed its concerns about the depth of the proposed tailings covers. Environment Canada is not convinced that the proposed cover will provide sufficient protection against metals uptake and water infiltration through time. As a result, Environment Canada recommended in its technical report and at the public hearings that the Developer design a thicker tailings cover (around 1.5 m dependent on the depth of the roots of the native vegetation in the area)) or provide evidence to support their assumptions that a 110cm cover will adequately protect vegetation and prevent infiltration. During the course of the environmental assessment, specific concerns about the potential future use of all-terrain vehicles (ATVs) on the reclaimed tailings pond covers were also identified by Review Board staff. Environment Canada further recommend that a monitoring plan be implemented to ensure the success of cover performance over time (PR# 461 p14, PR#577 p234).

Environment Canada reiterated its recommendations in its final comments. Environment Canada is not confident that the proposed 0.7m vegetative layer and 0.4m gravel layer will prevent the eventual penetration of vegetation through the tailings cap. If the gravel layer is breached by vegetation roots, the integrity of the tailings cover will be compromised. The barrier between tailings and surface will be broken and groundwater, people and wildlife may be at risk of exposure (PR#610 p2). In order to determine the success of the tailings cover, Environment Canada argued that a monitoring plan should test for all design specifications, including infiltration (PR#610 p2).

During the course of the environmental assessment, the Developer committed to develop a re-vegetation strategy for the site during the development of detailed designs for the tailings covers and other areas. The Developer has committed that it will include additional community engagement to determine preferred approaches to re-vegetation, including long-term monitoring and adaptive management for its revegetation strategy (PR#394 p3).

During technical meetings, the Yellowknives Dene First Nation expressed concern about the Developer's ability to measure the success of the tailings covers in reducing infiltration (PR# 461 p14). The YKDFN is adamant that the land and vegetation at the Giant Mine site should be remediated to a clean and productive state and it argues that freezing the arsenic and capping the tailings will not hide their community's concern about the hazards at the site. During the public hearings, the YKDFN emphasized the importance of implementing a strong research and technology review program that can address perpetuity issues at the Giant Mine site in a more direct way (PR#577 p164).

Foreshore Tailings

The historical foreshore tailings located on North Yellowknife Bay have already been covered above the waterline using riprap and geotextile (see Figure 3 in section 1.3.4). Studies undertaken in the area have shown

that submerged tailings have been carried and redistributed along the western side of North Yellowknife Bay, exposing the benthic invertebrate community to elevated levels of arsenic (PR#563 p247).

The proposed remediation plan aims to extend the riprap and geotextile cover over the submerged tailings. The objective is to reduce tailings erosion, minimize the amount of arsenic leaching into the water column, and create suitable fish and benthic invertebrate habitat. The Yellowknives Dene First Nation expressed some concern regarding a lack of detail provided for the cover design and whether the cover is an appropriate place for fish habitat to be established.

DFO responded to one of the YKDFN's information requests supporting the Developer's proposed cover extension proposed for the foreshore tailings. Based on previous studies, it has been shown that the existing cover has helped reduced the levels of erosion, exposure of the tailings, and arsenic contamination of the water. DFO believes that expanding the geotextile and riprap cover would serve to further reduce the exposure of aquatic organisms to contaminants, thereby providing improved environmental conditions and habitat in North Yellowknife Bay. DFO qualify this support by indicating that monitoring will be required to measure the effectiveness of the cover in achieving erosion control and providing suitable habitat (PR#342).

During the public hearings, DFO further recommended that the Developer complete a fish habitat assessment in Yellowknife Bay in the area of the historic tailings and outline measures to mitigate any adverse impacts to fish and fish habitat during construction of the cover through the environmental management plan. They requested that all final design, monitoring programs and mitigation measures be provided for review prior to approval (PR#577 p248). DFO reiterated these recommendations in its final statement (PR#608 p4).

Detailed design objectives and quantitative performance criteria of tailings covers, including monitoring and mitigation plans, have not yet been identified by the Developer. During the technical sessions Parties indicated that such gaps in the Project description provides a loose basis from which to express concern and, therefore creates a certain lack of confidence. Parties suggested that the Developer should provide clearly stated, and where possible measurable, closure goals so that at the end of the day the Parties, the public and inspectors knows what is expected at closure (PR#354 p185-225).

Air Quality

Air quality assessments using the CALPUFF/CALMET modelling package have been completed under a conservative "maximum working scenario". The assessment was undertaken for exposure to the public both onsite and offsite. The model was run on an hourly basis over a full year. Results showed that air quality measurements were low compared to the Canadian guidelines in most instances for total suspended particulate (TSP), NO_x, SO₂, and arsenic. Offsite, no exceedances have been predicted for TSP (PM₁₀), SO₂, or arsenic but a very low probability exceedance of the one-hour criterion for NO_x and the 24-hour criterion for TSP (PM_{2.5}) near Niven Lake. Proposed mitigation measures include reducing power requirements at critical times to reduce demand.

Particles belonging to the PM_{2.5} and PM₁₀ fractions pose a health concern because they are easily inhalable and can penetrate deep within the respiratory system. Through this process, particulate matter can aggravate asthma and other respiratory disorders. Adverse effects can also occur when particulate matter settles on plant surfaces and soils, serving as a contaminant pathway. Nitrogen dioxide (NO₂) is one of the main precursors of ground level ozone, which can also affect breathing, damage vegetation, and cause acidification and eutrophication of surface water bodies (PR#139 p7.44).

Onsite, PM_{2.5} was predicted to fall below the incremental exposure criterion but there was a very low probability of exceeding the arsenic exposure criterion for non-carcinogenic effects. Proposed mitigation measures include the shutdown of activities under very high wind conditions (PR#577 p31-38). During the pre-technical report meeting, the Developer acknowledged that until the tailings are capped, there is very little they can do to completely eliminate the impacts of dust on people using the area around the Giant Mine site (PR#461 p29).

During the public hearings, the YKDFN asked the Review Board to consider including a measure within the report of environmental assessment to enforce the commitments made by the Developer regarding air quality (PR#577 p175). The currently proposed air quality monitoring program includes site-specific monitoring throughout the course of remediation and for three years after completion. The Developer committed to develop activity-specific monitoring programs in relation to specific remediation components such as tailings cover construction and roaster demolition (PR#577 p129). The Developer has committed to modify the existing air quality monitoring program to identify action levels that trigger additional management activities through the development of the Environmental Management Plan prior to undertaking remediation activities (PR#577 p31-38).

Environment Canada recommended that the off-site ambient air quality monitoring program (SENES 2011) also continue throughout remediation activities up to at least one year after work is completed. EC stressed the importance of verifying model predictions so that responsible regulatory authorities can consider mitigation options, if necessary (PR#577 p231). In its final comments, Environment Canada restated its recommendation that the Review Board require the Developer to continue its ongoing ambient air quality monitoring for PM_{2.5} and NO_x, especially in the Niven Lake area (PR#610 p1).

Waste Rock, Quarries, Stockpiles and Roads

In general, remaining quarries, borrow pits and overburden piles will be re-sloped for improved drainage and stability. Where appropriate or necessary they may be further rehabilitated. The Developer has indicated that minimizing impacts on permafrost and terrestrial habitat loss remains one of the goals of this remediation project (PR#389). The Developer has also committed to manage archaeological artefacts or sites in accordance with the Mackenzie Valley Land Use Regulations.

11.1.4 Evidence from the Parties: waste management

The management of waste at the Giant Mine site will have to account for approximately 67,000 m³ of non-Hazardous waste including 23 service debris and equipment storage areas and the building demolition debris from 100+ buildings. All non-hazardous waste will be disposed of at an onsite landfill constructed within the Central Tailings Pond. This location was chosen because of its central location on site and proximity to major mine infrastructure which will minimize haul distances for disposal. The Central Tailings pond provides a single location with enough area to be able to accommodate the volume of waste requiring disposal that could blend into the natural topography and provide adequate drainage pathways (PR#354 p123-125).

Management of the landfilled wastes will include routine inspections of the containment berms, landfill cap and the surrounding drainage ditching. If deficiencies are noted, repairs and improvements will be completed in areas that show signs of erosion or settlement. In order to confirm that there is no detrimental impact to the

environment, the Developer committed to install groundwater monitoring wells. Upon completion of the final design the location of monitoring wells, the monitoring frequency, and the monitored parameters will be determined (PR#354 p125-127).

Landfill Design

Waste will be placed inside a bermed area within the Central Tailings Pond. Intermediate fill consisting of granular material, mine waste rock or contaminated soil will be used between each layer and to fill voids in the placed material. Lifts of waste will not exceed 2 m and will be compacted. Surface water run-off from the landfill cap will be directed to ditches surrounding the landfill. Surface water in general will be directed away from the landfill by the use of permanent ditching and berms to prevent flooding of the landfill development area. Surface water run-off and run-on will be handled in the same ditch system. Final engineering design will determine the size and capacity of the ditch system, ditch slopes as well as areas requiring armouring to prevent erosion (PR#139; PR#577).

All non-hazardous lead painted debris will be placed in a dedicated portion of the landfill. To prevent infiltration through this area, a geo-membrane will be utilized as part of the landfill cap design to help prevent the migration of water into this area. Once all the waste is placed within the landfill it will be capped. The landfill cap will consist of a minimum of 1m of granular material and will tie into the top of the surrounding berms. The final capped elevation will be limited to fit into the existing surrounding topography (PR#139; PR#577).

The City of Yellowknife recommends that the Giant Mine Remediation Directorate aim to achieve, at a minimum, the same standards for the onsite non-hazardous landfill as is currently used for the City of Yellowknife landfill. This includes the installation of liners and leachate collection systems as described in the *New Solid Waste Facility Preliminary Design Report* (PR#354 pp148-154). The Yellowknives Dene First Nation supported this recommendation at the public hearings stating that City engineers should approve the final design, construction, and deposition of the onsite landfill (PR#577 p174).

Hazardous wastes will generally be transported and disposed of offsite according to applicable regulations. Some exceptions are asbestos, which will be double-bagged and deposited in the onsite landfill at the Central Tailings Pond (PR#577 p27) and arsenic trioxide dust which will be collected for underground disposal. The quantities of underground hazardous wastes have not yet been completely inventoried (PR#354 p124). Hazardous materials from the roaster complex and other arsenic trioxide wastes will be placed underground and in the B1 pit where it will be frozen (PR#577 p27).

During the public hearing, the Yellowknives Dene First Nation argued against the Developer's proposal to retain and deposit waste at the Giant Mine site. The Yellowknives Dene do not agree with the use of development sites as landfills and have urged the Review Board to consider the proximity of the City of Yellowknife's landfill in its assessment of this Project and the determination of significance on Chief Drygeese Territory. The Yellowknives Dene requested that, at a minimum, the Review Board require City approval on the final design of any landfill that is to remain on the Giant Mine site. The Yellowknives Dene are of the opinion that doing so will provide some efficiency to the Project and at least provide some assurance that the land and water is being protected in a consistent manner (PR#605 p4).

As part of the water treatment process, an outdoor treated water storage pond will be required. The holding pond will be fenced to limit access but not completely covered. It will have an expected average arsenic concentration of 0.38 mg/L. During the information request phase, the North Slave Metis Alliance expressed concerns about the potential impact on birds accessing the holding pond. The Developer anticipates that the small pond should not attract birds since there are larger water bodies in the area with vegetation in the littoral zone providing more suitable food and habitat. Water quality in the pond should mostly meet discharge quality criteria and the Developer concludes that short exposures to the pond will not present a significant risk to birds (PR#208).

Sludge containing iron hydroxides with ferric arsenate, ferric antimonite, and calcium sulphate will also be generated. This waste material will be pumped into the freezing zone until frozen and inaccessible and then deposited in a separate stand-alone facility or in a separate cell located within the on-site engineered landfill. The detailed design of this cell will be completed once the characteristics of the waste material are confirmed (PR#312).

During the public hearings, the Developer estimated that the water treatment plant would initially produce approximately 6.3 m³ of sludge per day. The volume of sludge is expected to be reduced as the water quantities requiring onsite treatment decreases. The need for additional landfill space to accommodate sludge as the remediation and care and maintenance phases of the program continue was recognized by the Developer but the scope of these requirements remain unknown. The Developer suggested that advances in water treatment technologies could potentially deal with the problem of sludge disposal (PR#577 p133).

11.1.5 Evidence from the Parties: site usability

The City of Yellowknife has expressed concerns about the adequacy of future land use studies and plans for the Giant Mine Site. The concern is that without an integrated approach to addressing the remediation, restoration, land use and future redevelopment of the site, the communities will bear the responsibilities, costs, and liabilities of inadequate remediation and infrastructure improvements (PR#181 p6).

From the City's perspective, integration of the historical and traditional land uses should be reflected in the remediation plan, heritage preservation plan, and future use planning for the site in order to benefit from possible Giant Mine legacy opportunities (PR#181 p7). During the public hearings, the City of Yellowknife presented a conceptual land use plan for the future use of the Giant Mine site. They maintain that the Giant Mine Remediation Plan should be integrated into the City's Smart Growth Development and Harbour Plans which have undergone an extensive consultation process (PR#581 p47).

The Developer responded that the proposal could conceptually be accommodated given various conditions, suggesting that future discussion would be necessary. The Developer committed to meet with the City and other stakeholders to discuss new infrastructure needs (i.e. roads) that may be required for the Project and possibilities that would allow remediation work to contribute to future use plans. The Developer also committed to work with the City to help delineate the environmental impacts and liabilities of plans to construct a marina at the current mooring facility (PR#577 p42-47). To conclude the subject, the City of Yellowknife requested that the Review Board require the Developer to include and implement the City's land use plans as part of the Project (PR#581 p50).

Concerns about future usability of the marina were expressed by the City of Yellowknife and the Yellowknives Dene First Nation. The Developer's Assessment Report indicates that contaminated soils in the area will be removed or capped and in response to the YKDFN information request, the Developer implied that it will work with interested Parties to minimize impacts on the continued use of the marina and Townsite during remediation (PR#249).

The City of Yellowknife has expressed an interest in preserving and restoring 4-5 heritage buildings within the Giant Mine Townsite. The Project does not include structural assessments of the buildings and does not contemplate reuse of the Townsite for residential occupancy as part of its remediation plan (PR# 238). Should no arrangements be made with the City of Yellowknife or other Parties to transfer environmental and/or safety risks to other institutions, the Developer will:

- Work with interested Parties to carry out photo documentation prior to demolition;
- Allow for the removal of contents that may be of heritage value (safety permitting); and
- Work with interested Parties to facilitate the relocation of buildings off site (PR#237).

11.2 Review Board analysis and conclusions: Surface Remediation

The Review Board recognizes the threats and challenges posed by the remaining surface features and infrastructure on the Giant Mine site. Remediating 13.5 million tonnes of contaminated tailings spread over a surface area of approximately 175 football fields is challenging because of the enormity of the physical scale and because of the long-term nature of the solution that is required. The number of contaminated buildings is very large, and the contaminants they contain present a health hazard people in nearby. This section will describe the Board's conclusions on different aspects of the proposed surface remediation.

Remaining Buildings and Infrastructure

Alternatives North, the City of Yellowknife and Environment Canada provided comments and concerns regarding the proposed demolition of existing Giant Mine-related buildings and infrastructure, and the Developer made various commitments during the course of the environmental assessment to carry out demolition of the buildings and infrastructure so as to minimize impacts. Because of the close proximity of the site to large populations, airborne releases of fine particulates including arsenic and other contaminants could expose people to health risks. In the technical sessions, the Developer was asked if it would deconstruct buildings "when the wind is not blowing towards the City of Yellowknife" (PR#354 p227). In response, the Developer committed to do so, saying "...yes, we will ensure that conditions are right and that they do not add to any impacts that could occur during the demolition of a building" (PR#354 p228). In an effort to ensure consistency and to prevent or reduce the potential for adverse environmental impacts as a result of major construction or demolition activities, the Review Board requires the following:

Measure 20: The Developer will conduct all major demolition and construction activities with the potential to release large amounts of dust or contaminants into the air when wind directions will minimize the chances of dust and contaminants blowing into the City of Yellowknife, Dettah and N'dilo.

Although the emergency work on the roaster complex and mill conveyor are no longer within the scope of this assessment (PR#629), demolition activities for many contaminated structures, including the tailings reprocessing facility and others, remain within the scope.¹¹⁹ The Board notes that other jurisdictions have examples of guidance from other sectors on considering wind conditions for works involving hazardous plumes.¹²⁰

Suggestion 11: To manage the risks of airborne exposure of contaminated dust from deconstruction of buildings or other structures on site, the Developer should:

- **prepare a dispersion model of dust plume given typical wind direction and speed**
- **define the meteorological window of opportunity to describe acceptable wind conditions to eliminate the potential for a dust cloud release and transport of surrounding communities.**
- **consult a meteorologist to develop a sound model of weather conditions, to indicate when winds are steady and not gusting, blowing to the north**
- **stop if winds change or any dust controlling equipment fails**

Suggestion 12: To prevent impacts on people from potentially harmful contaminant releases from deconstruction of buildings or other structures on site at the Giant Mine site, the Land and Water Board should specify allowable wind directions and wind speeds in degrees, to ensure that contaminated structures are not demolished during blustery multi-directional winds at ground level.

In addition to preventing the ongoing accumulation of dust as a result of construction and demolition activities, the Review Board notes the importance of documenting background dust levels and arsenic concentrations in the soils and vegetation within and surrounding the Giant Mine site. These pre-remediation numbers can act as a baseline so that any future exceedences can be monitored and adaptively managed, as necessary. If baseline levels of dust and other contaminants are not clearly identified, it will be difficult to measure and manage any adverse impacts that remediation activities may introduce. Understanding whether demolition is mobilizing contaminants is important to the adaptive management of further demolitions on site, and may help identify whether further mitigations are needed. Considering the amount of proposed construction and demolition activities with the potential to generate dust, the range of contaminant concentrations across the site, and the proximity to communities, the Board is of the view that this is likely to otherwise cause significant adverse impacts.

In order to prevent or minimize any adverse environmental impacts as a result of increased levels of dust and other contaminants in the vicinity of remedial activities, the Review Board requires the following:

Measure 21: The Developer will collect dust and contaminant level data from soil and vegetation in the vicinity of major reclamation activities before and after major demolition or construction activities to serve as a baseline for any related adaptive management activities that may follow.

¹¹⁹ See section 2.2 for details regarding the exemption of emergency work under subsection 119(b) of the *Mackenzie Valley Resource Management Act*.

¹²⁰ For example, see the *British Columbia Oil and Gas Commission Sour Well Gas Flaring guideline*.

Tailings Ponds

The Board notes that the proposed tailings cover design consists of a 0.7m vegetative support layer and a 0.4m gravel or coarse layer to act as a barrier between the tailings and the vegetative cover, to create a physical barrier between the tailings and the surrounding environment and minimize erosion and sediment issues (PR#354 p112).

Environment Canada is not convinced that the tailings cap is thick enough to function as intended. The Review Board agrees with Environment Canada's concerns about the thickness of the tailings covers. During the course of the environmental assessment, the Developer has not supplied the evidence required to convince the Board that a 110cm cover will adequately prevent the uptake of tailings by vegetation or exposure of tailings over time. Considering the amount of tailings and the long period for which the cap function over such a large area, the Board is of the opinion that this is likely to be a cause of significant adverse effects. The following measure will ensure proper design of tailings cap depth, and will mitigate related impacts.

Many of the concerns regarding the remediation of the tailings pond covers also apply to the B1 pit cover. The B1 pit is one of the two pits planned to be backfilled as part of the remediation plan. During the course of the environmental assessment, reviewers expressed some concerns about the design, goals and performance of the pit cover. The southwest portion of the B1 pit, outside the proposed security fence, is designed to have a cover similar to that of the tailings ponds (PR#241).

The Review Board notes the Developer's commitments to install fencing around part the B1 pit to protect the long-term freezing system and to prevent human and wildlife interactions with the pit itself. The Review Board also recognizes the plan to store and freeze hazardous waste, including arsenic contaminated materials within the B1 pit. The majority of the B1 pit cover will be designed to provide a separation between the arsenic-contaminated materials and people working on the surface. The Board is of the opinion that significant adverse impacts are likely if the B1 pit cover is inadequate or compromised. The measures below therefore include both the B1 pit cover and the tailings cover.

Measure 22: The Developer will conduct a study to determine appropriate depth of the tailings cap and B1 pit cover, in consultation with Environment Canada and responsible regulators, to verify that the depth proposed will ensure the tailings cap and B1 pit cover are not compromised by vegetation growth. The Developer will provide a report of this study to the Mackenzie Valley Land and Water Board before it issues a water license for the Project.

The Developer has stated that a monitoring program will be established to assess the success of the tailings reclamation activities and to adjust or modify reclamation efforts where necessary to ensure:

- erosion control and slope stability;
- revegetation and sustainability of disturbed areas;
- site-specific reclamation measures;
- optimum species performance;
- noxious and restricted weed control; and

- re-establishment of habitat (PR#232).

In order to determine the success of the tailings cover, Environment Canada argued that a monitoring plan should test for all design specifications, including infiltration (PR#610, p. 2). The tailings cap is intended to function effectively over the long term, and will require maintenance activities over the long term. A detailed mitigation plan, in case the tailings covers fail is also required in order to reduce any potential impacts to the surrounding environment. Without careful monitoring and management, the Board is of the opinion that significant adverse impacts on the environment are likely. In order to prevent or reduce the potential for adverse impacts as a result of tailings failure, the Review Board requires the following measure.

Measure 23: The Developer will work cooperatively with responsible regulatory authorities and interested Parties in the development and submission of a Tailings Monitoring and Management Plan prior to receiving regulatory approvals. This plan will not only identify potential issues for the management of tailings but will also identify mitigation measures to prevent problems related to the tailings cap failure, and will include consideration of the B1 pit cover as applicable.

During the course of the environmental assessment, specific concerns were raised about the potential for ATVs to damage the reclaimed tailings pond covers. Because of the proximity to town, and the popularity of ATV use, the Board believes it is likely that residents will use ATVs on the site. Preventing access by vehicles designed cross obstacles is challenging, and physical prevention is more likely to be effective than other means. The Board is of the opinion that ATV use on the tailings cap is likely to cause significant adverse impacts related to compromising the tailings cover. In an effort to prevent this, the following measure is prescribed.

Measure 24: The Developer will physically prevent all-terrain vehicle access to the tailings cap and B1 pit cover to prevent the surface from being eroded or otherwise compromised. The Developer will monitor the effectiveness of this prevention, and will take any additional management measures as necessary to prevent all-terrain vehicle access.

Open Pits and Associated Dykes

At least five, and possibly six, of the existing eight open pits will remain unfilled according to the proposed remediation plan (PR#139 p6-52). The Review Board recognizes the YKDFN concerns and agrees that filling the pits may be the preferred alternative, provided that it does not add additional risks to other important parts of the Project. The Review Board acknowledges the difficulties and challenges identified by the Developer in enough sourcing fill material to fill the pits. The Review Board observes that other options besides leaving the pits open may be available to the Developer. In an effort to address the risks of the open pits the Review Board suggests the following:

Suggestion 13: The Developer should investigate options for filling in the pits, in consultation with the City of Yellowknife and YKDFN.

Foreshore Tailings

Having reviewed the evidence on the record regarding the reclamation plans for the historic foreshore tailings, including the technical report, public hearing evidence and closing statement by DFO, the Review Board is of the opinion that significant adverse impacts may occur unless appropriate design, monitoring and mitigation plans are developed and reviewed prior to construction of the proposed foreshore tailings cap. Baseline information and appropriate construction and monitoring plans will help ensure the proposed cover adequately prevents erosion and exposure of submerged tailings. In order to prevent any adverse impacts on fish, fish habitat and the benthic invertebrate community in North Yellowknife Bay, the Review Board requires the following:

Suggestion 14: The Developer should consider the baseline conditions for existing fish habitat in Back Bay (including a fish habitat assessment in the area of the foreshore tailings and the aquatic effects baseline required in Measure 17) and develop a foreshore tailings cover design and foreshore tailings monitoring and mitigation plan for review by the Department of Fisheries and Oceans pursuant to habitat provisions of the *Fisheries Act*.

Air Quality

The Review Board notes that the proposed air quality monitoring program does not include the ongoing monitoring of off-site receptors used in the Developer's air quality assessment, including the people who live closest to the Project site at the Niven Lake residential subdivision, and at the private property immediately adjacent to Fault Lake and the Yellowknife Ski Club's ski trails and which is closer to the mine site. During the environmental assessment, results of the air quality modelling indicated the possibility of exceeding Ambient Air Quality Criteria in the area. The Review Board finds that ongoing monitoring should continue to ensure that Ambient Air Quality Criteria are not being exceeded in the residential areas.

The Review Board accepts the predictions that air quality on the site will improve substantially following remediation as a result of covering or eliminating sources of contaminants and establishing a vegetative cover throughout the site area. Despite this finding, the Review Board believes that a precautionary approach is appropriate in order to safeguard the health and wellbeing of residents in the Niven Lake area.

In the Board's view, there is an unacceptable risk of exposing residents to nitrogen oxides and fine particulate matter that is easily inhalable and can penetrate deep within the respiratory system. The Board is of the opinion that even infrequent exposures of this nature would be significant and adverse. It is important that the Developer's predictions be verified and that the Developer take appropriate action in the event of any exceedances. The Review Board, therefore, requires the following measure:

Measure 25: The Developer will work cooperatively with responsible regulatory authorities and interested Parties in the development and submission of an Air Quality Management Plan which incorporates an ongoing air quality monitoring program. This ongoing monitoring program will include all previously identified on-site air quality monitoring stations and one off-site air quality monitoring station near Niven Lake. At a minimum, ambient concentrations of NO₂ and PM_{2.5} will be monitored at the Niven lake site. Total suspended particulate and metal concentrations will be monitoring at the on-

site locations. This air quality monitoring program will identify action levels and trigger additional management and mitigation activities, if required.

Waste Management

Waste management at the Giant Mine site will include approximately 67,000 m³ of non-hazardous waste including 23 service debris and equipment storage areas and the building demolition debris from over 100 buildings. All non-hazardous waste will be disposed of at an onsite landfill constructed within the central tailings pond.

The Review Board has considered the Yellowknives Dene First Nation requests to manage the placement of waste at the Giant Mine site. The Review Board agrees that there may be efficiencies in the collaboration of the Developer and the City of Yellowknife in the design of any onsite landfill(s). The City of Yellowknife has recently completed a water licence renewal with the Mackenzie Valley Land and Water Board and is familiar with new available technologies and water licencing requirements. In an effort to make the most of such efficiencies, the Review Board makes the following recommendation:

Suggestion 15: The Developer should consult with the City of Yellowknife in the design of any landfill on the Giant Mine site.

Site Usability

The Developer proposes to remediate the site according to the GNWT industrial standards following the GNWT *Environmental Guidelines for Contaminated Site Remediation* (PR#26). The specific standards are not part of the scope of the environmental assessment. The Developer has indicated that it is willing to provide information and participate in discussions during the creation of future land use plans (PR#234). Limitations on future use will be consistent with those set out in the Guidelines and soil arsenic concentrations on site following remediation. Future land use will also be restricted to those activities that will not interfere with or affect remediation efforts on site or any engineered remediation structures such as tailing cap covers, freeze infrastructure and water treatment infrastructure (PR#322).

The Developer has indicated that even though it is remediated to industrial standards, portions of the site may be open for future recreational or residential use. The Yellowknives Dene First Nation has asked the Board to require a collaborative planning process to include such negotiations. The Yellowknives Dene are concerned about the lasting effects of waste left onsite and believe that the consideration of alternatives focuses on more permanent solutions (PR#577 pp170-173).

The Review Board notes potentially conflicting ideas between the City, the YKDFN, and recognizes the importance of the consultation process with respect to the work that the City of Yellowknife has done for its Smart Growth Development and Harbour Plan. The Developer has committed to continue discussions with the YKDFN and the City to find ways in which remediation activities can support existing and future land use plans.

The Review Board notes that some of the future land uses may involve arsenic exposures that have health implications to the most sensitive receptors, specifically toddlers. As described above, Health Canada has advised the Developer of the particular importance of evaluating impacts on toddlers, and toddlers were

excluded from the Developer's sensitivity analysis (PR#591 pp2-3). This health impact is discussed in detail in the health section of this report.¹²¹ On the same basis, the Board concludes that some proposed uses of the site are likely to cause an unacceptable risk of significant adverse impacts on human health. This can be mitigated by the following measure:

Measure 26: In conjunction with Measure 10 above, the Developer will consider the results of the comprehensive human health risk assessment, and consult with the YKDFN and City of Yellowknife when determining suitable end uses of the site, to ensure that those proposed uses do not pose a health risk to people, including toddlers.

¹²¹ See sections 8.2.1, 8.2.2 and 8.3.1 for details.

12 Traditional Use

Section 115 of the MVRMA requires the Review Board to consider the protection of the cultural well-being and the importance of conservation to the well-being and way of life of Aboriginal peoples. This section describes some of the evidence pertaining to the effects of the Project on the traditional use of the Project area and downstream.

12.1.1 The Developer's predictions

The DAR considers potential effects on aboriginal interests. It states (PR#139 pp8-94 to 8-95):

The implementation of the Remediation Project may improve the well-being of Aboriginal persons living in the LSA. The starting point for these positive effects is the current baseline of concern among Aboriginal people regarding the historic and on-going effects of mining on their environment and traditional lifestyles. One of the most commonly expressed concerns by community members is the fear of contaminants and their potential to impact the health of wildlife and people. It is expected that, by immobilizing existing sources of contaminants, the Project may help to reduce the level of anxiety that the mine site has provoked among members of local Aboriginal Communities.

The DAR acknowledges that the Project may cause concern, stating “regardless of the positive effects of the Remediation Project, the implementation of individual remedial activities has the potential to cause concern that could affect Aboriginal Community well-being” (PR#139 p8-94). It identifies specific Project activities that could affect Aboriginal Community well-being including:

- capping of tailings
- excavation of contaminated soils
- Baker Creek Rehabilitation
- construction of the diffuser
- demolition of surface infrastructure
- discharge of treated minewater to Great Slave Lake, and
- storage of contaminants and waste.

The DAR notes that many non-Aboriginal residents share these concerns (PR#139 p8-94). The Developer appears to recognize the importance of perceptions as a potential cause of real impacts, such as reduced harvesting. The DAR states (PR#139 p8-95):

(A)n adverse effect on local Aboriginal Communities may occur if community well-being is perceived as being affected by Project activities that are deemed to be injurious to the land and people. A positive effect would occur if the implementation of the Project leads to an improved sense of community well-being by fostering restoration of the linkage between the land and Aboriginal people...

(T)he direct discharge of treated minewater to Great Slave Lake may result in a reduction of fishing activity in Yellowknife Bay by Aboriginal residents. By extension, changes in Traditional Land Use (e.g., fishing) has the potential to result in an effect on community wellbeing.

The DAR restates the role of perceptions saying that “Traditional Land Use after remediation has occurred will be strongly influenced by the historical use of Giant Mine and the perception of environmental quality post-remediation” (PR#139 p8-96). It notes that “the discharge of treated minewater directly into North Yellowknife Bay may generate concern among Traditional Land users who fish there”, and that this could cause harvesters to avoid the area (PR#139 p8-99).

In its response to the Review Board’s deficiency statement, the Developer concluded that a complete failure the Project “...could conceivably result in... an increased risk to human health of those individuals who live off the land (i.e. harvest fish and game from the study area)” (PR#157 p13).

Despite these recognitions of potential impacts, when predicting the residual effects the Developer concludes that “the project is not anticipated to cause adverse effects to Traditional Land Use relative to baseline conditions”, because the Project will lead to an overall improvement in environmental quality (PR#139 p8-96) but notes that “further consultation will be conducted to determine the validity of this conclusion” (p8-99).

12.1.2 The evidence from the other Parties: traditional Use

The Kuyek report, prepared on behalf of Alternatives North, presents and analyzes research and lessons learned from many perpetual care sites around the world (PR#333). It describes why many case studies of long-term care sites indicate that Aboriginal peoples are disproportionately affected by long-term hazardous sites. It notes that Aboriginal peoples are closer to the land in many ways; that the land often involves spiritual elements; that they often lack resources to defend their interests; and that recognition of impacts is an important part of community recovery and healing (PR#333 p55).

The applicability of this is demonstrated in the testimony of many of the Aboriginal participants in the public hearings [Figure 14]. Several members of the Yellowknives Dene described their experience of the Giant Mine affecting their traditional land use. This forms a baseline for the proposed Project.

In the Perpetual Care Workshop held in Dettah in Sept. 2011, Elder Eddie Sikeya emphasized that “It is important to show what the land was like before Giant Mine. The people need to know that the land was healthy even though it is dead now” (PR#362 p15).

Past traditional uses

Chief Eddie Sangris reflected on the past traditional use of the area and the inability of remediation to replace it. He described it to the Review Board in terms of greed and loss, saying (PR#577 pp354-355):

Remediation of this mine started quite a while ago, although it may be a little too late because I have to say that what we enjoyed one time, it's all gone. It's all gone. Everything we -- we had. [Baker Creek was] a place where our ancestors, and my family and my grandfathers, where they used to go and many of us Yellowknives, we used to go there to enjoy. There is a rock in the middle of a creek. There is a beautiful hill probably the size of this room, and the old ladies used to go up there and sit there while the men are hunting in the background of the creek. And along

there we were told that there were so many blueberries, all types of berries grew there. Medicine plants. And even burial sites in that area.

But all that is gone. We've lost it all. We'll never get it back. No matter how much remediation takes place, how much you try to scrub and clean that on your knees, you'll never get it back. It's -- it's gone forever, you know. It's -- it's something that -- it's really sad how -- how greed has gone beyond. Greed has really gone beyond the destruction of such people and lands, it's unbelievable. It's probably going to be a classic story for Canada and Canadian citizens to read one day, that this is something that happened to us, but it never -- never in our wildest dreams we thought it would go this far.



Figure 14: Yellowknives Dene Elders Isadore Tsetta, Michel Paper and Métis Elder Ed Jones at the Sept. 10, 2012 public hearing
(photo: Review Board)

In his closing statements in the Dettah public hearing, Chief Eddie Sangris recounted the numerous stories from his mother and grandfather about the use of the Giant Mine area. He told the Board how the public is concerned partly because they would not traditionally use an area where arsenic is being perpetually stored as proposed (PR#577 p398).

Other members of the Yellowknives Dene described traditional uses of the Project site. For example, Elder Eddie Sikyea recalled travelling by dog team on Baker Creek to fish in the area in 1945 (PR#577 p394). Elder Alfred Baillangeon described moose hunting along Baker Creek, and expressed frustration at the loss that

cannot be repaired by the Project. He said “It's not going to be the same like before, even though you -- you do the remediation work. Nothing will be the same” (PR#577 p371).

Elder Fred Sangris told the Board of his involvement with a research project with McGill University indicating that that past airborne contamination has broadly affected berries up to 24 kilometers away. Sangris said contamination has affected the traditional harvesting of the Yellowknives Dene, including harvesting of medicinal plants and mussels (PR#576 pp252-253). Sangris submitted to the record a 1999 letter he co-wrote as Chief along with then Chief Jonas Sangris to the Jane Stewart, Minister of the Department of Indian Affairs and Northern Development (now known as AANDC). It described the impacts of Giant Mine on the Yellowknives Dene, including losses to traditional harvesting due to arsenic contamination (PR#572).

Dettah Band Councillor Mary Rose Sundberg described this state of the Project site, saying “We can't use that land anymore, everyone knows that, how dead it is. If you look in that photos it looks so ugly and dead, because that monster underneath has killed the land.... When I say the "loss of land," I don't mean only the vegetation. Our ancestors had trails all over in that area. Those we don't use anymore” (PR#577 pp349-350). In this context, Sundberg disagreed with the desirability of the future recreational use proposed by the Developer (PR#577 p351).

Former Chief and Vice Chief of Dene Nation Gerry Cheezie described the importance of water and the traditional way of life in terms of treaty rights, and related this to risks from the proposed Project, saying “all this could be lost if we're not careful about how this plan is going to be implemented” (PR#576 p359).

Traditional fishery

One of the uses of Yellowknife Bay downstream of the proposed Project is as a traditional fishery. The subjects of socio-cultural impacts from perceptions of contaminants in fish and health impacts related to contaminants in traditional foods are examined elsewhere in this report.¹²²

In the public hearing, DFO recognized the importance of community perceptions of contaminants in fish (PR#577 p252). Several members of the Yellowknives Dene described their perceptions of contaminants in traditional foods in relation to Giant Mine and the proposed Project. These statements are summarized below.

Former Yellowknives Dene Chief and Elder Fred Sangris predicted impacts from the proposed diffuser on fish based on traditional knowledge about fish movements and migrations in valleys on the lakebed (PR#577 p360). At the public hearing on Sept. 11, 2012, Sangris described the lack of consultation about the diffuser despite its relevance to the observed recovery of fish in the area used for fishing, and shared Traditional Knowledge on the response of fish to subtle sensory disturbances. He told the Review Board “The diffuser will be right in their path. And, again, they will leave the Yellowknife Bay, and maybe this time forever” (PR#576 p252).

In the public hearing, Elder Fred Sangris and YKDFN representative Randy Freeman described the traditional use of Yellowknife Bay and specified that the cultural identity of the Yellowknives Dene was tied to the inconnu or coney (*Stenodus leucichthys*), namesake of the Yellowknives Dene as Weledeh people. They described the cultural importance of the gradual return of the coney to Yellowknife Bay following years of

¹²² See section 9.3.1.4 [Baker Creek] for discussions of the effects of perceptions of contamination on traditional harvesting, and see section 8.2 for discussions of health concerns related to fish.

avoidance during Giant Mine operation. Freeman described reports of early anthropologists who saw “coney drying racks that covered the entire side of a hill and hundreds and hundreds of Yellowknives Dene there drying fish, getting ready to head north in the fall to meet the caribou”, and emphasized how their cycle of life has been based on the productivity of Yellowknife Bay and Yellowknife River fisheries for thousands of years. Sangris described how the coney were driven off since the start of industrial activities in the area but are beginning to return. He predicted that the proposed diffuser would affect the recovery and return of coney to the Yellowknife River (PR#576 p184, pp242-244; PR#577 pp184, p365).

12.2 Review Board analysis and conclusions: traditional use

The Review Board recognizes the important role that Aboriginal cultures, values and knowledge play in its decision-making. In accordance with the requirements of subsection 115.1 of the *Act*, the Review Board considered all traditional knowledge, including knowledge of traditional use and related issues, which Parties provided during the environmental assessment.

The Aboriginal Parties, and particularly the Yellowknives Dene, described to the Board the nature of the loss they suffered to their traditional use of the land because of the Giant Mine. They have told the Board how the area, was close to communities and used for fishing, hunting, trapping, harvesting berries, traditional teas, medicinal plants, traditional trails and burial sites. In their statements to the Board, it was clear that they believe impacts of Giant Mine continue to affect them. The Yellowknives Dene recognize that much of the damage is likely irreparable, and that the mine site is never going to be used in the same way in the future as it was before Giant Mine. The Yellowknives Dene reflected on what the land provided in the past, and the little benefit they received from Giant Mine. They remain concerned that water flowing to N’dilo and Dettah cannot be safely drank, leaving them to pay for delivery of drinkable water. They bear the weight of recent history, and want an apology and compensation from the federal government.

The Board recognizes that Giant Mine has eliminated many pre-existing traditional uses of the mine site, and that current contamination continues to cause a drastic reduction in traditional use of the areas downstream such as Yellowknife Bay. Parties presented evidence about the impacts on traditional use including the effects of the Giant Mine, rather than about the proposed Project in isolation. After careful consideration, the Board notes that the Yellowknives have indicated that they believe the proposed Project will combine cumulatively with existing contamination. The Board concludes that concerns that include existing contamination were deliberately raised in the context of an assessment of a proposed development because of concerns about potential cumulative effects.¹²³

Examples of impacts of the proposed Project with the potential to combine with the impacts of Giant Mine to affect harvesting include the following:

- If the proposed diffuser were to cause, or was perceived to cause, loading of arsenic in water, sediment or fish, this could reduce harvesting levels downstream.¹²⁴

¹²³ See section 2.6 [Existing Mine and Cumulative Effects] for further discussion.

¹²⁴ See section 9.4 and 9.5 for further discussion and measures related to Baker Creek and impacts on consumption of fish by traditional harvesters.

- If the proposed Project causes dispersion of arsenic in dust from the handling of soils, capping of tailings or demolishing of contaminated structures, this could combine with historical contamination, or be perceived to do so. This could affect traditional use, by widening the zone which harvesters now avoid.
- If fish were attracted to highly contaminated Baker Creek as proposed, the same fish caught traditionally in Great Slave Lake would have higher contaminant levels. This possibility would likely affect traditional harvesting, by making harvesters fish further away to avoid the area, possibly reducing harvesting levels.

The Developer's list of components that could affect community well-being was similar to the one above. The Developer recognized that the Project could affect perceptions of contaminants in traditional foods, that discharging treated mine water of the land "may" generate concern among users who fish there traditionally, and that this could affect harvesting. Despite this, the DAR predicts no adverse effects, even though it notes that "further consultation will be conducted to determine the validity of this conclusion" (p8-99).

The Developer has not engaged Aboriginal communities on the subject of impacts to traditional land use. The Board believes that the Developer has a responsibility to conduct its community engagement on such subjects, as a fundamental part of making credible impact predictions. The Developer has made its predictions largely uninformed by discussions with the potentially affected communities. The Board heard directly and repeatedly from traditional land users in the public hearing that their views of the acceptability of the impacts clearly conflicted with the Developer's predictions. The Developer's lack of engagement resulted in inaccurate conclusions.

AANDC is a federal department with responsibilities for Aboriginal affairs and chairs the committee that manages the Northern Contaminants Program, so the board expects that AANDC should have a good understanding of Aboriginal concerns regarding contaminants and traditional foods. AANDC also leads fiduciary consultation and accommodation, so it should understand the benefits of early Aboriginal engagement. Considering these facts, it is not clear to the Board why AANDC did not consult communities regarding potential impacts to traditional use, and why it reached impact predictions that were so far from the evidence presented by the traditional land users themselves.

The Review Board concludes that this Project has the potential to affect traditional harvesting. However, while the Board accepts the Parties' views that much of the effects from Giant Mine on traditional use of the area are irreparable, many of the contributions from the proposed Project can be mitigated. The suite of measures the Board has prescribed in this report will largely address this Project's contribution to the cumulative reduction of traditional use.

The required measures include actions that will:

- build trust through independent monitoring¹²⁵
- greatly reduce the arsenic entering the lake beyond what is proposed, to the level the YKDFN described as acceptable¹²⁶
- eliminate attraction of fish to contaminated habitat¹²⁷
- more thoroughly consider and monitor potential health effects¹²⁸, and,
- encourage research and periodic review towards a better permanent solutions¹²⁹

The Board has deliberately ensured that the Yellowknives Dene have a strong involvement in many of the measures. The Board expects that the suite of measures in this report will go a long way to satisfy concerns about this Project's cumulative contribution to impacts on traditional uses, and the related concerns. The Board is of the opinion that further consultation may help to address any remaining impacts to traditional use, and offers the following suggestion:

Suggestion 16: The Developer should consult with Aboriginal groups with respect to reduced traditional use cumulatively resulting from the proposed Project in combination with contamination from Giant Mine. This should occur prior to finalizing Project design, so that design improvements may be used to address any remaining concerns.

¹²⁵ See Section 7.3 (Trust and oversight)

¹²⁶ see Section 9.7 (Water quality)

¹²⁷ see Section 9.5 (Baker Creek)

¹²⁸ see Sections 8.3.1.4 and 8.3.2.1 (Health)

¹²⁹ see Section 5.11 (Review Board overall analysis and conclusions on perpetuity)

13 Conclusions

The Board has carefully considered all of the evidence on the public registry. The above sections have described the basis and reasoning for the Review Board's findings that the proposed Project is likely to cause significant adverse ecological and social impacts. These impacts are generating public concern.

The Review Board has prescribed measures to mitigate these impacts, requiring that the Project timeframe be reduced from perpetuity to 100 years; facilitating ongoing research in emerging technologies towards finding a permanent solution; and requiring independent reviews of the Project every 20 years to evaluate its effectiveness and decide if a better approach can be identified. These measures will likely make it possible to identify a better solution in the future, and reduce the probability of the significant impacts that would otherwise eventually happen.

Other measures prescribed by the Review Board include:

- a comprehensive risk assessment and human health risk assessment;
- human health monitoring;
- investigation of long-term funding options;
- independent oversight;
- diversion of Baker Creek;
- improvement of water treatment to a drinking water standard;
- replacement of the proposed diffuser near N'dilo with a near shore outfall immediately offshore of the Giant mine site;
- facilitating active ongoing research into applicable emerging technologies; and
- other measures to address the significant potential impacts of this Project.¹³⁰

The Review Board believes that this combination of measures will mitigate the significant adverse impacts it has identified, and will address the public concern. These measures will:

- help the Developer better understand the current situation in terms of human and ecological health;
- help the Developer better predict, anticipate and manage currently unknown risks;
- reduce known risks on site;
- prevent the accumulation of contaminants from the Project in Great Slave Lake;
- give surrounding communities improved confidence that the Project is not harming traditional practices downstream; and
- make it possible to identify and implement a better permanent solution as technology emerges over the next century.

By addressing the significant adverse impacts in these ways, the Project will be improved, and meaningful actions will help address the concerns of the public and surrounding communities.

¹³⁰ Appendix A includes a full list of measures and suggestions.

Appendix A: Summary of measures and suggestions

Engagement (section 4.1)

Suggestion 1: The Developer should further consult with surrounding communities, including Dettah, N'dilo and the City of Yellowknife, prior to finalizing its Project design, so that design improvements may be incorporated to address any remaining concerns.

Perpetuity and overall risks (section 5.11)

Measure 1: To prevent the significant adverse impacts on environment and the significant public concern from the proposed perpetual timeframe, the Project will proceed only as an interim solution, for a maximum of 100 years.

Measure 2: Every 20 years after the beginning of Project implementation, the Developer will commission an independent review of the Project to evaluate its effectiveness to date, and to decide if a better approach can be identified. This will:

1. consider results of the ongoing research
2. be participatory in nature
3. follow the requirements of procedural fairness and be transparent in nature.

If the periodic review identifies a better approach that is feasible and cost-effective, the Developer will further study it, and make the study and its results of the study public.

Measure 3: To facilitate active research in emerging technologies towards finding a permanent solution for dealing with arsenic at the Giant mine site, the Developer will create a multi-stakeholder research agency with potentially affected Parties. The ongoing funding for this research agency will be negotiated and included as part of the environmental agreement specified in Measure 7. This body will, on a periodic basis:

1. produce reports on relevant emerging technologies;
2. identify research priorities
3. administer research funding
4. ensure the results of research are made public, and
5. apply results of each cycle to the next cycle of these steps.

Measure 4: The research agency will provide the results of the research to the periodic reviews of the Project described in Measure 2. If better technological options are identified in-between these periodic 20-year reviews, the research agency will report these publically to the Parties, the public and the Developer. The Developer will consider these technologies and make decisions regarding their feasibility. The Developer will make any such decisions public.

Measure 5: In order to mitigate significant adverse impacts that are otherwise likely, the Developer will commission an independent quantitative risk assessment to be completed before the Project receives regulatory approvals. This will include:

1. explicit acceptability thresholds, determined in consultation with potentially affected communities
2. an examination of risks from a holistic perspective, integrating the combined environmental, social, health and financial consequences.
3. possible events of a worst-case/ low frequency high consequence nature
4. additional considerations specified in Appendix D of the Report of EA

From this, the Developer will identify any appropriate Project improvements and identify management responses to avoid or reduce the severity of predicted unacceptable risks.

Suggestion 2: The Developer should create a monument as a memorial to the impacts of past contamination from Giant Mine on Aboriginal communities and the environment.

Suggestion 3: To encourage widespread learning from and remembering of the experiences of the Giant Mine, the Developer, in conjunction with the GNWT Department of Education, Culture and Employment, should:

1. develop an education resource unit on the impacts of Giant Mine on the land and on people, including impacts on Aboriginal peoples, and
2. distribute this resource unit for use within the school curriculum across Canada.

Suggestion 4: The Federal Contaminated Sites Action Program should develop a policy framework and guidance for the perpetual care and management of remediated contaminated sites.

Long term funding (section 6.2)

Measure 6: The Developer will:

- investigate long-term funding options for the ongoing maintenance of this Project and for contingencies, including a trust fund with multi-year up front funding,
- involve stakeholders and the public in discussions on funding options; and,
- make public a detailed report within three years that describes its consideration of funding options, providing stakeholders with the opportunity to comment on the report.

Suggestion 5: To ensure long-term funding throughout the life of the Project, the Developer should create an independently managed self-sustaining trust fund with multi-year up-front funding for the ongoing maintenance of this Project and for contingencies. A third-party expert should independently manage this trust fund. Annual reports on the condition of the fund should be provided to stakeholders and the public.

Oversight (section 7.3)

Measure 7: The Developer will negotiate a legally-binding environmental agreement with, at a minimum, the members of the Oversight Working Group, and other appropriate representative organizations, to create an independent oversight body for the Giant Mine Remediation Project. These negotiations will build on the existing discussion paper and draft environmental agreement of the Giant Oversight Working group. This oversight body will be in place before major Project activities begin on site, and will exist for the life of the Project. The environmental agreement will include a dispute resolution mechanism to ensure compliance with the agreement and a stable funding mechanism for the oversight body.

Measure 8: The activities of the oversight body will include:

- keeping track of monitoring activities by the Developer and the results of those activities, including water quality and aquatic effects monitoring, health monitoring and other monitoring
- considering the adequacy of funding for the Project and ongoing research
- providing advice to the Developer, regulators and government on ongoing improvements in monitoring and Project management to prevent risks and mitigate any potential impacts
- sharing the oversight body's conclusions with the general public and potentially affected communities in a culturally appropriate manner

Suggestion 6: To reduce public concern about the multiple roles of AANDC in this Project and to increase public confidence, AANDC should produce guidelines to clarify reporting structures to ensure that Project inspectors, advisors and managers employed by the federal government can perform their duties objectively and without undue pressure from within the federal government. These should be made available to the public within six months of Ministerial acceptance of this Report of Environmental Assessment.

Health impacts (sections 8.3.1.4 and 8.3.3)

Suggestion 7: Based on the results of the health risk assessment described in Measure 10, the appropriate government authorities should remediate garden and playground soils where arsenic concentrations exceed current guidelines for urban soils in Canada.

Measure 9: The Developer will work with other federal and territorial departments as necessary to design and implement a broad health effects monitoring program in N'dilo, Dettah and Yellowknife focussing on arsenic and any other contaminants in people which might result from this Project. This will include studies of baseline health effects of these contaminants and ongoing periodic monitoring. This will be designed with input from:

- Health Canada, GNWT Health and Social Services and the Yellowknife medical community; and
- The Yellowknives Dene and other potentially affected communities.

The organization conducting the monitoring will provide regular plain language explanations of the monitoring results in terms that are understandable to lay people, and communicate this to potentially affected communities in a culturally appropriate manner.

Suggestion 8: The Developer should consider the Trail Human and Environmental Health Committee as a model for the development of the health program.

Measure 10: The Developer will commission a comprehensive quantitative human health risk assessment by an independent, qualified human health risk assessor selected in collaboration with Health Canada, the Yellowknives Dene, the City of Yellowknife, and the Developer. This human health risk assessment will be completed before the Project receives regulatory approvals. It will:

1. Include a critical review of the 2006 Tier II human health risk assessment and the previous screening reports;
2. Consider additional exposures and thresholds (as specified in Appendix F of the Report of EA);
3. Decide whether a Tier III risk assessment is appropriate;
4. Provide a plain language explanation of the results in terms that are understandable to the general public, and communicate this to potentially affected communities in a culturally appropriate manner;
5. Provide interpretation of results and related guidance; and
6. Inform the broad health effects monitoring program (described in Measure 9 above).

Based on the results of this human health risk assessment, and on the results of the health effects monitoring program (described in Measure 9 above), the Developer will, if necessary in response to this information, identify, design and implement appropriate design improvements and identify appropriate management responses to avoid or reduce the severity of any predicted unacceptable health risks.

Baker diversion (section 9.5)

Measure 11: Within five years of receiving its water license, the Developer will divert Baker Creek to a north diversion route previously considered by the Developer, or another route that avoids the mine site and is determined appropriate by the Developer.

Suggestion 9: During its review of the diversion of Baker Creek, the Department of Fisheries and Oceans should consider the habitat loss of the existing Baker Creek and decide on any habitat design requirements for the diversion to the extent it deems appropriate. Any resulting habitat compensation requirements should be applied on the new diversion.

Water in Baker Creek channel (section 9.5)

Measure 12: To prevent significant adverse impacts on Great Slave Lake from contaminated surface waters in the former channel of Baker Creek, the Developer will ensure that water quality at the outlet of Baker creek

channel will meet site-specific water quality objectives based on the CCME *Guidance on the Site-Specific Application of Water Quality Guidelines in Canada*.

Measure 13: The Developer will design and, with the applicable regulators, manage the Project to ensure that, with respect to arsenic and any other contaminants of potential concern, the following water quality objectives are achieved in the vicinity of the outlet of the former Baker Creek channel, excluding Reach 0:

- a) Water quality changes due to discharge from the former channel of Baker Creek will not reduce benthic invertebrate and plankton abundance or diversity;
- b) Water quality changes due to discharge from the former channel of Baker Creek will not harm fish health, abundance or diversity;
- c) Water quality changes due to discharge from the former channel of Baker Creek will not adversely affect areas used as drinking water sources,
- d) Water quality changes due to discharge from the former channel of Baker Creek will not adversely affect any traditional or recreational users; and,
- e) There is no increase in arsenic levels in Great Slave Lake due to discharge from the former channel of Baker Creek beyond the parameters described in Measure 12.

Suggestion 10: The Developer should investigate the potential advantages and disadvantages of adding an engineered wetland to the Project to reduce arsenic in surface drainage. This investigation should include possible locations in the channel that formerly contained Baker Creek and in the Baker Creek diversion. On completion, the Developer should make a public report of the results of this investigation and of any resulting changes to Project design. This should be completed before a water license is issued for the Project.

Treatment plant effluent and water quality (section 9.7)

Measure 14: The Developer will add an ion exchange process to its proposed water treatment process to produce water treatment plant effluent that at least meets Health Canada drinking water standards (containing no more than 10 µg/L of arsenic), to be released using a near shore outfall immediately offshore of the Giant mine site instead of through the proposed diffuser. The Developer will achieve this concentration without adding lake water to dilute effluent in the treatment plant.

Measure 15: The Developer and regulators will design and manage the Project so that, with respect to arsenic and any other contaminants of potential concern:

- 1. Water quality at the outfall will meet the Health Canada Guidelines for Canadian Drinking Water Quality; and,
- 2. The following water quality objectives in the receiving environment are met:
 - e) Water quality changes due to effluent discharge will not reduce benthic invertebrate and plankton abundance or diversity beyond 200 metres of the outfall;
 - f) Water quality changes due to effluent discharge will not harm fish health, abundance or diversity;

- g) Water quality changes due to effluent discharge will not adversely affect areas used as drinking water sources; and,
- h) There is no increase in arsenic levels in Yellowknife Bay water or sediments beyond 200 metres of the outfall.

Measure 16: Before construction, the Developer will model re-suspension of arsenic from sediments and resulting bioavailability in the vicinity of the outfall. If the modelling results indicate that the outfall may re-suspend arsenic from sediments, the Developer will modify the outfall design until operation does not cause re-suspension of arsenic from sediment.

Measure 17: Before operating the outfall, the Developer will design and implement a comprehensive aquatic effects monitoring programme that is sufficient to determine if the water quality objectives listed in Measure 15 are being met. This programme will:

1. at a minimum, be able to identify any accumulation of arsenic over time in the water, sediment or fish in the receiving environment
2. include appropriate monitoring locations near N'dilo, in Back Bay and in Yellowknife Bay, with a focus on areas in the vicinity of the outfall and areas used by people.
3. include the establishment of a baseline for aquatic effects in Back Bay before beginning Project construction and installation of the outfall.
4. be developed according to AANDC *Guidelines for Designing and Implementing Aquatic Effects Monitoring Programs for Development Projects in the Northwest Territories, June 2009*, with corresponding action levels and management response framework.

Freezing (section 10.2)

Measure 18: Prior to preparing chambers and stopes for freezing, the Developer will conduct a comprehensive quantitative risk assessment evaluating both wet and dry methods for the initial freezing design, with respect to current risks and implications for future removal. This will include an evaluation of potential effects of the proposed freezing and wetting method on the thawing or frozen excavations, and potential impacts of ongoing design changes prior to implementing the Project. The Developer will release a plain language report to the public describing its considerations and the resulting design.

Measure 19: Considering the results of the risk assessment described in Measure 18, the Developer will not adopt any method of freezing that significantly reduces opportunities for future arsenic removal or other remediation by future technologies.

Surface reclamation (section 11.2)

Measure 20: The Developer will conduct all major demolition and construction activities with the potential to release large amounts of dust or contaminants into the air when wind directions will minimize the chances of dust and contaminants blowing into the City of Yellowknife, Dettah and N'dilo.

Suggestion 11: To manage the risks of airborne exposure of contaminated dust from deconstruction of buildings or other structures on site, the Developer should:

- prepare a dispersion model of dust plume given typical wind direction and speed
- define the meteorological window of opportunity to describe acceptable wind conditions to eliminate the potential for a dust cloud release and transport of surrounding communities.
- consult a meteorologist to develop a sound model of weather conditions, to indicate when winds are steady and not gusting, blowing to the north
- stop if winds change or any dust controlling equipment fails

Suggestion 12: To prevent impacts on people from potentially harmful contaminant releases from deconstruction of buildings or other structures on site at the Giant Mine site, the Land and Water Board should specify allowable wind directions and wind speeds in degrees, to ensure that contaminated structures are not demolished during blustery multi-directional winds at ground level.

Measure 21: The Developer will collect dust and contaminant level data from soil and vegetation in the vicinity of major reclamation activities before and after major demolition or construction activities to serve as a baseline for any related adaptive management activities that may follow.

Measure 22: The Developer will conduct a study to determine appropriate depth of the tailings cap and B1 pit cover, in consultation with Environment Canada and responsible regulators, to verify that the depth proposed will ensure the tailings cap and B1 pit cover are not compromised by vegetation growth. The Developer will provide a report of this study to the Mackenzie Valley Land and Water Board before it issues a water license for the Project.

Measure 23: The Developer will work cooperatively with responsible regulatory authorities and interested Parties in the development and submission of a Tailings Monitoring and Management Plan prior to receiving regulatory approvals. This plan will not only identify potential issues for the management of tailings but will also identify mitigation measures to prevent problems related to the tailings cap failure, and will include consideration of the B1 pit cover as applicable.

Measure 24: The Developer will physically prevent all-terrain vehicle access to the tailings cap and B1 pit cover to prevent the surface from being eroded or otherwise compromised. The Developer will monitor the effectiveness of this prevention, and will take any additional management measures as necessary to prevent all-terrain vehicle access.

Suggestion 13: The Developer should investigate options for filling in the pits, in consultation with the City of Yellowknife and YKDFN.

Suggestion 14: The Developer should consider the baseline conditions for existing fish habitat in Back Bay (including a fish habitat assessment in the area of the foreshore tailings and the aquatic effects baseline required in Measure 17) and develop a foreshore tailings cover design and foreshore tailings monitoring and mitigation plan for review by the Department of Fisheries and Oceans pursuant to habitat provisions of the *Fisheries Act*.

Measure 25: The Developer will work cooperatively with responsible regulatory authorities and interested Parties in the development and submission of an Air Quality Management Plan which incorporates an ongoing air quality monitoring program. This ongoing monitoring program will include all previously identified on-site air quality monitoring stations and one off-site air quality monitoring station near Niven Lake. At a minimum, ambient concentrations of NO₂ and PM_{2.5} will be monitored at the Niven lake site. Total suspended particulate and metal concentrations will be monitoring at the on-site locations. This air quality monitoring program will identify action levels and trigger additional management and mitigation activities, if required.

Suggestion 15: The Developer should consult with the City of Yellowknife in the design of any landfill on the Giant Mine site.

Measure 26: In conjunction with Measure 10 above, the Developer will consider the results of the comprehensive human health risk assessment, and consult with the YKDFN and City of Yellowknife when determining suitable end uses of the site, to ensure that those proposed uses do not pose a health risk to people, including toddlers.

Traditional Use (section 12.2)

Suggestion 16: The Developer should consult with Aboriginal groups with respect to reduced traditional use cumulatively resulting from the proposed Project in combination with contamination from Giant Mine. This should occur prior to finalizing Project design, so that design improvements may be used to address any remaining concerns.

Appendix B: Public registry index

PR#	Document	Date Received	Source
0	DFO comment re IR response	22-Mar-13	Parties/Public
1	Letter of Referral from the City of Yellowknife	07-Apr-08	Parties/Public
2	Notice of Referral	07-Apr-08	Review Board
2	Request to be on the Distribution List	07-Apr-08	Review Board
3	Notice of Referral to the Developer	07-Apr-08	Review Board
4	Giant Mine Remediation Plan (Figures)	01-Jul-07	Developer
4	Giant Mine Remediation Plan	01-Jul-07	Developer
5	List of Supporting Documents	16-Jun-08	Developer
6	Final Report: Arsenic Trioxide Management Alternatives	01-Dec-02	Developer
7	Request for Submissions	17-Apr-08	Review Board
7b	EA Roles Identification Form	17-Apr-08	Review Board
8	Letter from MVEIRB to CARD-INAC re: Clarification	22-Apr-08	Review Board
9	Letter from CARD-INAC to MVEIRB re: Clarification	18-Apr-08	Developer
10	Note to File	22-Apr-08	MVEIRB
11	Draft Workplan	26-May-08	Review Board
12	Invitation to Scoping Hearing	03-Jun-08	Review Board
13	MVLWB Preliminary Screening Report	20-Feb-08	Other
14	MVLWB Reasons for Decision	21-Feb-08	Other
15	MVLWB Staff Report on Giant Mine Remediation Project	13-Feb-08	Other
16	INAC Water Licence application for the Giant Mine	18-Oct-07	Developer
17	Compiled Preliminary Screening Comments	16-Jun-08	Other
18	Port Radium Action Plan, December 2002	23-Apr-08	Parties/Public
19	Mine Site Reclamation Guidelines for the NWT	23-Apr-08	Parties/Public
20	Environmental Agreement for the BHP Billiton Ekati Diamond Mine	23-Apr-08	Parties/Public
21	Letter from Kevin O'Reilly to MVEIRB re: Submission to the record	24-Apr-08	Parties/Public
22	Giant Mine Abandonment & Restoration: Preliminary Identification of the Issues & Potential Impacts on the City of Yellowknife	23-Apr-08	Parties/Public
23	Giant Mine Lease Area Land/Water Use Plan	23-Apr-08	Parties/Public
24	Giant Mine Lease Area Land-Water Use Plan OPTIMIZED	23-Apr-08	Parties
25	Giant Mine Lease Area Land-Water Use Plan REDUCED	23-Apr-08	Parties
26	Environmental Guideline for Contaminated Site Remediation Nov 2003.	23-Apr-08	Parties/Public
27	Mine Site Reclamation Policy for the NWT	23-Apr-08	Parties/Public
28	The Mining Reclamation Regime in the NWT: A Comparison with Selected Canadian and US Jurisdictions	23-Apr-08	Parties/Public
29	Letter from Kevin O'Reilly to the MVLWB re: Concerns over Giant Mine Remediation	23-Apr-08	Parties/Public
30	Application for a Type "A" Water License	19-Oct-07	Developer
31	Comments from Environment Canada	12-May-08	Parties/Public

PR#	Document	Date Received	Source
32	Email from NSMA re: Documents	17-Jun-08	Parties/Public
33	Comments on workplan	18-Jun-08	Parties/Public
34	Comments on workplan from NSMA	19-Jun-08	Parties/Public
35	Attachment to K. O'Reilly's Letter of June 18, 2008	19-Jun-08	Parties
36	Comments from INAC regarding workplan	18-Jun-08	Developer
37	Comments on the draft workplan from YKDFN-LMD	19-Jun-08	Parties/Public
38	Presentation from INAC for scoping meeting	17-Jun-08	Developer
39	Presentation from INAC for site visit	20-May-08	Developer
39	Presentation from INAC for site visit	20-May-08	Developer
40	Sign in sheet from scoping meeting June 17, 2008	17-Jun-08	Review Board
41	Meeting notes from Giant Mine Remediation Project EA scoping session - June 17 2008	20-Jun-08	Review Board
42	Letter from MVEIRB re: Scoping hearing requirements	27-Jun-08	Review Board
43	Audio from Giant Mine Scoping Meeting June 17 2008	20-Jun-08	Review Board
44	HydroQual Study-CD	30-Jun-08	Developer
44	HydroQual Consultant Study from 1985	02-Jul-08	Developer
45	Letter from MVEIRB re: Workplan & Party Status	02-Jul-08	Review Board
46	Initial Workplan for Giant Mine Remediation	14-May-08	Review Board
58	A Partial Annotative list of the Giant Mine Remediation Plan Process	09-Jul-08	Developer
59	Reminder re: public issues scoping hearing dates and times	15-Jul-08	Review Board
60	Agenda for Scoping Hearing July 22-23, 2008.	17-Jul-08	Review Board
61	Letter from MVEIRB requesting EC and DFO send reps to hearing	23-Jul-08	Review Board
62	Giant Mine Arsenic Management Workshop Summary Report July 2003	18-Jul-08	Developer
63	City of Yellowknife special meeting minutes - GMRP referral march 18 2008	18-Jul-08	Parties/Public
64	Prioritization of Issues from City of Yellowknife	18-Jul-08	Parties/Public
65	Document on Arsenic Levels in Yellowknife - Exhibit 1	23-Jul-08	Developer
66	Posters from July 2008 scoping hearing	22-Jul-08	Developer
67	Transcript from July 23, 2008	23-Jul-08	Review Board
68	Transcript from July 22, 2008	22-Jul-08	Review Board
69	Presentation from NSMA	23-Jul-08	Parties/Public
70	Presentation from YKDFN	23-Jul-08	Parties/Public
71	Presentation from Kevin O'Reilly	23-Jul-08	Parties/Public
72	Presented by the City of Yellowknife	23-Jul-08	Parties/Public
73	Presentation from INAC	22-Jul-08	Developer
74	Letter from the Native Women's Assn. Training Centre	31-Jul-08	Parties/Public
75	Letter from G. Vaillancourt, resident of Yellowknife	23-Jul-08	Parties/Public
76	Letter from Kevin O'Reilly to MVEIRB re: Follow-up to scoping hearing	08-Aug-08	Parties/Public
77	Con Mine Reclamation Status Report	08-Aug-08	Parties/Public
78	Sustainability-Based Assessment & Frameworks	23-Jul-08	Parties/Public

PR#	Document	Date Received	Source
79	GNWT Response to Undertaking #2	08-Aug-08	Parties/Public
80	YKDFN Medicinal Plant Study Report	05-Jun-08	Parties/Public
81	Letter from Private Citizen-Bruce MacLean	14-Aug-08	Parties/Public
82	City of Yellowknife Response to Undertakings 6-8	06-Aug-08	Parties
82	City of Yellowknife Response to Undertakings 6-8	06-Aug-08	Parties/Public
83	INAC's Response to Undertaking #1 - Freeze Optimization Study	15-Aug-08	Parties/Public
84	INAC's Response to Undertaking #3	15-Aug-08	Developer
85	INAC Request for extension re: Undertaking #4	18-Aug-08	Developer
86	INAC Undertaking #5 - MVRMA s. 118	15-Aug-08	Developer
87	EC's Response to Undertaking #9 - Expertise from government departments	18-Aug-08	Parties/Public
88	YKDFN response to Undertaking #10	18-Aug-08	Parties/Public
89	Letter from MVEIRB to INAC re: Request for Extension	19-Aug-08	Review Board
90	A submission by Warren Heath to MVEIRB	19-Aug-08	Parties/Public
91	Response to Undertaking #4	21-Aug-08	Developer
92	Sign-in Sheet for Giant Mine Scoping Hearing	22-Jul-08	Review Board
92	Sign in Sheet - Scoping Hearing	23-Jul-08	Review Board
93	Email from Lois Little re: Intervenor funding	03-Sep-08	Parties/Public
94	Discussion Paper on Colomac Mine Remediation	03-Sep-08	Parties/Public
95	Letter from Kevin O'Reilly to MVEIRB re: Comments on responses to undertakings	22-Sep-08	Parties/Public
96	DFO Comments on Giant Mine EA Scope	15-Jul-08	Parties/Public
97	Mining Heritage Society Letter to MVEIRB Regarding Society Property	01-Oct-08	Parties/Public
98	Email exchange from INAC to MVEIRB between Oct 6 and Oct 9	06-Oct-08	Developer
99	Current Distribution List for Giant Mine	12-Nov-08	MVEIRB
100	RE: URGENT October 9, 2008 e-mail from DIAND to MVEIRB on the Giant Mine Environmental Assessment	20-Nov-08	Review Board
101	Letter from INAC to MVEIRB re: Additional Information	17-Oct-08	Developer
102	Request for Proposals -Provision of Expert Services	20-Nov-08	Review Board
103	Letter from INAC Regarding Posting Information on the Public Registry	19-Nov-08	Developer
104	Reasons for Decision on Scope	19-Dec-08	Review Board
105	Letter from INAC to MVEIRB re: Comments on RfD	15-Jan-09	Developer
106	Letter from INAC Clarifying Concerns over Request for Proposals	21-Jan-09	Developer
107	Letter to INAC re: Expert Advisors	23-Jan-09	Review Board
108	Support from INAC for Technical Experts	03-Feb-09	Developer
109	Draft Terms of Reference	16-Mar-09	Review Board
110	Draft Work Plan	20-Mar-09	Review Board
111	CV of Dr. Franco Oboni	20-Mar-09	Review Board
111	CV of Jerome Nriagu	20-Mar-09	Review Board
111	CVs of BGC Engineering's team	20-Mar-09	Review Board

PR#	Document	Date Received	Source
111	Notification of expert advisory services	20-Mar-09	Review Board
112	K. O'Reilly Comments on Draft ToR	09-Apr-09	Parties/Public
113	INAC Comments on Draft ToR for Giant EA	09-Apr-09	Developer
114	DFO Comments on Draft ToR- Giant EA	09-Apr-09	Parties/Public
115	Covering Letter- Giant Mine Terms of Reference + Workplan	12-May-09	Review Board
116	Terms of Reference- Giant EA	12-May-09	Review Board
117	Workplan- Giant EA	12-May-09	Review Board
118	Freeze Optimization Study- progress and steps	29-May-09	Developer
119	Letter re: current activities at Giant	16-Sep-09	Parties/Public
120	Letter re: arsenic discharge at Giant	29-Oct-09	Parties/Public
121	Letter to INAC re: Funding of Parties	09-Nov-09	Parties/Public
122	E-mail and letter re: authorizations for freeze optimization study	09-Nov-09	Parties/Public
123	E-mail from Kevin O'Reilly Regarding Funding Requests for Independent Oversight	24-Nov-09	Parties/Public
124	Letter from B. Bromley, MLA, to INAC	08-Dec-09	Parties/Public
125	INAC Letter- Revised DAR Submission Date: April 2010	17-Dec-09	Developer
126	INAC request for meeting w YKDFN	25-Jan-10	Developer
127	YKDFN letter re: INAC meeting request	03-Feb-10	Parties/Public
128	Reply from INAC to Bob Bromley, MLA	04-Feb-10	Developer
129	Note to File- Temporary Contact Info	05-Feb-10	Review Board
130	UBC Faculty of Law Research Proposal	03-Mar-10	Parties/Public
131	INAC Meeting Request to YKDFN	30-Mar-10	Developer
132	INAC letter to YKDFN re: Information sessions	01-Apr-10	Developer
133	INAC 2010 Summer Workplan for Giant	16-Apr-10	Developer
134	Letter from INAC- Revised submission date	05-May-10	Developer
135	YKDFN letter re: Meetings on Giant Remediation	06-May-10	Parties/Public
136	O'Reilly submission re: participant funding for Giant EA	25-Jun-10	Parties/Public
137	Correspondence from INAC regarding the DAR	02-Jul-10	Developer
138	O'Reilly e-mail re: participant funding	21-Sep-10	Parties/Public
139	Giant DAR	27-Oct-10	Developer
139	Giant DAR Figures (Chapters 1 through 5)	28-Oct-10	Developer
139	Giant DAR Figures (Chapters 7 through 14)	28-Oct-10	Developer
139	Giant DAR Figures (Chapter 6 Figs. 6.1.1- 6.11.1)	27-Oct-10	Developer
139	Giant Implementation Schedule	27-Oct-10	Developer
139b	Tier II Risk Assessment- 2006 (DAR supporting doc N-2)	28-Oct-10	
140	Note to File: Giant DAR distribution and conformity check	29-Oct-10	Review Board
141	Giant DAR covering letter	27-Oct-10	Developer
142	Giant DAR on Board's FTP site	01-Nov-10	Review Board
143	INAC request re: Round 1 IRs	05-Nov-10	Developer
144	YKDFN e-mail to INAC re IR round 1	09-Nov-10	Parties/Public
145	DFO review- Human Health and Ecological Risk Assessment	05-Nov-10	Developer
146	EC Review- Human Health and Ecological Risk Assessment	05-Nov-10	Developer

PR#	Document	Date Received	Source
147	SENES Review- Human Health and Ecological Risk Assessment	05-Nov-10	Developer
148	BBCA e-mail re: Giant assessment	12-Nov-10	Parties/Public
149	Response to BBCA e-mail	12-Nov-10	Review Board
150	Participant Funding letter from INAC	24-Nov-10	Federal Minister
151	Public Notice- Participant Funding	24-Nov-10	Federal Minister
152	Participant Funding guide and application forms	24-Nov-10	Federal Minister
153	Deficiency Statement- Giant DAR	26-Nov-10	Review Board
154	Giant EA Participant Funding Guide and Application Forms	01-Dec-10	Federal Minister
155	Alternatives North party status application	06-Dec-10	Parties/Public
156	Deficiency response covering letter	15-Dec-10	Developer
157	Deficiency response item 1	15-Dec-10	Developer
158	Deficiency response item 2	15-Dec-10	Developer
159	Deficiency response item 3	15-Dec-10	Developer
160	Deficiency response item 4	15-Dec-10	Developer
161	Deficiency response item 1 supporting document	15-Dec-10	Developer
162	Alternatives North Party Status	21-Dec-10	Review Board
163	Conformity Letter	21-Dec-10	Review Board
164	Giant geotechnical study 2011	17-Dec-10	Developer
165	Revised Giant EA Workplan, Dec 2010	23-Dec-10	Review Board
166	Note to File- Information Requests by Parties	24-Dec-10	Review Board
167	INAC Request for Amendment to Workplan	14-Jan-11	Developer
168	INAC request re: postponing IRs	14-Jan-11	Developer
169	YKDFN support for INAC request re: IR deadline	17-Jan-11	Parties/Public
170	Alternatives North support for INAC request re: IR deadline	17-Jan-11	Parties/Public
171	Lessons Learned on Community Involvement in Remediation	17-Jan-11	Parties/Public
172	NOAMI Policy Framework Guidance Document	17-Jan-11	Parties/Public
173	NSMA support for INAC request re: IR deadline	18-Jan-11	Parties/Public
174	Alternatives North re: participant funding, IRs	05-Jan-11	Parties/Public
175	Letter from Review Board Re: IR deadline and process	20-Jan-11	Review Board
176	Participant funding decision and letter	27-Jan-11	Federal Minister
177	INAC Request for IR deadline extension	03-Feb-11	Developer
178	Review Board IRs, Revised Party Deadline	09-Feb-11	Review Board
179	YKDFN Round 1 IRs	28-Feb-11	Parties/Public
180	Alternatives North Round 1 IRs	28-Feb-11	Parties/Public
181	City of Yellowknife Round 1 IRs	28-Feb-11	Parties/Public
182	Environment Canada Round 1 IRs	28-Feb-11	Parties/Public
183	NSMA Round 1 IRs	28-Feb-11	Parties/Public
184	Cover letter- UBC Independent Environmental Oversight Report	28-Feb-11	Parties/Public
185	Independent Environmental Oversight Report	28-Feb-11	Parties/Public
186	Clarification of IRs 3.6 and 7c	21-Mar-11	Review Board
187	YKDFN IR clarification to INAC	21-Mar-11	Parties/Public
188	DFO Letter re: Giant IRs	28-Feb-11	Parties/Public
189	INAC Request for Extension on IR responses round 1	31-Mar-11	Developer

PR#	Document	Date Received	Source
190	Note to File- IR extension for INAC	01-Apr-11	Review Board
191	EC response to YKDFN IR#26	31-May-11	Parties/Public
192	Covering letter for INAC IR Responses	31-May-11	Developer
193	RB IR 01 Response	31-May-11	Developer
194	RB01_2-C05_Downhole Freeze Pipes-C5-FreezePipes_4-27-2011_60	31-May-11	Developer
195	RB01_3-U02_Underground Drillhole Layout_4-27-2011_60	31-May-11	Developer
196	RB01_1 -C04_Drillhole Layout and Methods-C4-Drilling Layout_4-27-2011_558	31-May-11	Developer
197	RB IR 02 Response	31-May-11	Developer
198	RB IR 03 Response	31-May-11	Developer
199	RB IR 04 Response	31-May-11	Developer
200	RB IR 05 Response	31-May-11	Developer
201	RB IR 06 Response	31-May-11	Developer
202	RB IR 07 Response	31-May-11	Developer
203	RB IR 08 Response	31-May-11	Developer
204	RB IR 09 Response	31-May-11	Developer
205	RB IR 10 Response	31-May-11	Developer
206	RB IR 13 Response	31-May-11	Developer
207	RB IR 15 Response	31-May-11	Developer
208	RB IR 17 Response	31-May-11	Developer
209	RB IR 18 Response	31-May-11	Developer
210	RB IR 19 Response	31-May-11	Developer
211	RB IR 20 Response	31-May-11	Developer
212	RB IR 21 Response	31-May-11	Developer
213	RB IR 24 Response	31-May-11	Developer
214	RB IR 25 Response	31-May-11	Developer
215	RB IR 26 Response	31-May-11	Developer
216	AltNrth IR 02 Response	31-May-11	Developer
217	AltNrth IR 04 Response	31-May-11	Developer
218	AltNrth IR 06 Response	31-May-11	Developer
219	AltNrth IR 07 Response	31-May-11	Developer
220	AltNrth IR 08 Response	31-May-11	Developer
221	AltNrth IR 09 Response	31-May-11	Developer
222	AltNrth IR 10 Response	31-May-11	Developer
223	AltNrth IR 13 Response	31-May-11	Developer
224	AltNrth IR 14 Response	31-May-11	Developer
225	AltNrth IR 15 Response	31-May-11	Developer
226	AltNrth IR 16 Response	31-May-11	Developer
227	AltNrth IR 17 Response	31-May-11	Developer
228	AltNrth IR 20 Response	31-May-11	Developer
229	AltNrth IR 21 Response	31-May-11	Developer
230	AltNrth IR 22 Response	31-May-11	Developer

PR#	Document	Date Received	Source
231	CityYK IR 01 Response	31-May-11	Developer
232	CityYK IR 02 Response	31-May-11	Developer
233	CityYK IR 05 Response	31-May-11	Developer
234	CityYK IR 07 Response	31-May-11	Developer
235	CityYK IR 08 Response	31-May-11	Developer
236	CityYK IR 09 Response	31-May-11	Developer
237	CityYK IR 10 Response	31-May-11	Developer
238	CityYK IR 12 Response	31-May-11	Developer
239	YKDFN IR 02 Response	31-May-11	Developer
240	YKDFN IR 03 Response	31-May-11	Developer
241	YKDFN IR 04 Response	31-May-11	Developer
242	YKDFN IR 05 Response	31-May-11	Developer
243	YKDFN IR 06 Response	31-May-11	Developer
244	YKDFN IR 07 Response	31-May-11	Developer
245	YKDFN IR 08 Response	31-May-11	Developer
246	YKDFN IR 13 Response	31-May-11	Developer
247	YKDFN IR 14 Response	31-May-11	Developer
248	YKDFN IR 15 Response	31-May-11	Developer
249	YKDFN IR 17 Response	31-May-11	Developer
250	YKDFN IR 18 Response	31-May-11	Developer
251	YKDFN IR 20 Response	31-May-11	Developer
252	YKDFN IR 21 Response	31-May-11	Developer
253	YKDFN IR 26 Response EC	31-May-11	Developer
254	YKDFN IR 26 Response	31-May-11	Developer
255	NSMA IR 05 Response	31-May-11	Parties/Public
256	NSMA IR 06 Response	31-May-11	Parties/Public
257	NSMA IR 07 Response	31-May-11	Parties/Public
258	NSMA IR 08 Response	31-May-11	Parties/Public
259	NSMA IR 09 Response	31-May-11	Parties/Public
260	NSMA IR 10 Response	31-May-11	Parties/Public
261	NSMA IR 11 Response	31-May-11	Parties/Public
262	NSMA IR 12 Response	31-May-11	Parties/Public
263	NSMA IR 13 Response	31-May-11	Parties/Public
264	NSMA IR 16 Response	31-May-11	Parties/Public
265	NSMA IR 17 Response	31-May-11	Parties/Public
266	NSMA IR 19 Response	31-May-11	Parties/Public
267	EC IR 01 Response	31-May-11	Developer
268	EC IR 02 Response	31-May-11	Developer
269	EC IR 04 Response	31-May-11	Developer
270	EC IR 05 Response	31-May-11	Developer
271	EC IR 06 Response	31-May-11	Developer
272	EC IR 07 Response	31-May-11	Developer
273	EC IR 09 Response	31-May-11	Developer

PR#	Document	Date Received	Source
274	EC IR 10 Response	31-May-11	Developer
275	EC IR 11 Response	31-May-11	Developer
276	EC IR 12 Response	31-May-11	Developer
277	EC IR 13 Response	31-May-11	Developer
278	EC IR 15 Response	31-May-11	Developer
279	EC IR 16 Response	31-May-11	Developer
280	EC IR 17 Response	31-May-11	Developer
281	Baker Creek Overflow Report	08-Jun-11	Developer
282	INAC covering letter for remaining IR responses	17-Jun-11	Developer
283	RB IR 11 Response	17-Jun-11	Developer
284	RB IR 12 Response	17-Jun-11	Developer
285	RB IR 12 Response Attachment	17-Jun-11	Developer
286	RB IR 14 Response	17-Jun-11	Developer
287	RB IR 16 Response	17-Jun-11	Developer
288	RB IR 22 Response	17-Jun-11	Developer
289	RB IR 23 Response	17-Jun-11	Developer
290	RB IR 27 Response	17-Jun-11	Developer
291	YKDFN IR 01 Response	17-Jun-11	Developer
292	YKDFN IR 09 Response	17-Jun-11	Developer
293	YKDFN IR 10 Response	17-Jun-11	Developer
294	YKDFN IR 11 Response	17-Jun-11	Developer
295	YKDFN IR 12 Response	17-Jun-11	Developer
296	YKDFN IR 16 Response	17-Jun-11	Developer
297	YKDFN IR 22 Response	17-Jun-11	Developer
298	YKDFN IR 23 Response	17-Jun-11	Developer
299	YKDFN IR 27 Response	17-Jun-11	Developer
300	NSMA IR 01 Response	17-Jun-11	Developer
301	NSMA IR 02 Response	17-Jun-11	Developer
302	NSMA IR 03 Response	17-Jun-11	Developer
303	NSMA IR 04 Response	17-Jun-11	Developer
304	NSMA IR 11 Response	17-Jun-11	Developer
305	NSMA IR 14 Response	17-Jun-11	Developer
306	NSMA IR 15 Response	17-Jun-11	Developer
307	NSMA IR 18 Response	17-Jun-11	Developer
308	NSMA IR 20 Response	17-Jun-11	Developer
309	AltNrth IR 01 Response	17-Jun-11	Developer
310	AltNrth IR 01 Q3 Attachment	17-Jun-11	Developer
311	AltNrth IR 03 Response	17-Jun-11	Developer
312	AltNrth IR 05 Response	17-Jun-11	Developer
313	AltNrth IR 11 Response	17-Jun-11	Developer
314	AltNrth IR 12 Response	17-Jun-11	Developer
315	AltNrth IR 18 Response	17-Jun-11	Developer
316	AltNrth IR 19 Response	17-Jun-11	Developer

PR#	Document	Date Received	Source
317	CityYK IR 03 Response	17-Jun-11	Developer
318	CityYK IR 04 Response	17-Jun-11	Developer
319	CityYK IR 06 Response	17-Jun-11	Developer
320	CityYK IR 11 Response	17-Jun-11	Developer
321	CityYK IR 13 Response	17-Jun-11	Developer
322	EC IR 03 Response	17-Jun-11	Developer
323	EC IR 08 Response	17-Jun-11	Developer
324	EC IR 14 Response	17-Jun-11	Developer
325	IR round 1 responses to Alternatives North	24-Jun-11	Developer
326	IR round 1 responses to the City of Yellowknife	24-Jun-11	Developer
327	IR round 1 responses to Environment Canada	24-Jun-11	Developer
328	IR round 1 responses to the NSMA	24-Jun-11	Developer
329	IR round 1 responses to the Review Board	24-Jun-11	Developer
330	Baker Creek Overflow Final Report	07-Jul-11	Developer
331	Note to File re: subsidence of the B1 pit wall	18-Jul-11	Review Board
332	AN covering letter and perpetual care study summary	20-Jul-11	Parties/Public
333	Perpetual Care of Contaminated Sites: Theory and Practice	20-Jul-11	Parties/Public
334	Letter from INAC re: Technical Sessions for Giant Mine	03-Aug-11	Developer
335	Cover Letter re: Jo Jo lake tailings work	03-Aug-11	Developer
336	Jo Jo Lake reclamation Plan for Giant Mine-document	03-Aug-11	Other
337	AN email to AANDC re: Jo-Jo Lake tailings work	05-Aug-11	Parties/Public
338	Note to File- tech session planning (w. parties' correspondence)	11-Aug-11	Review Board
339	Sept. 6 2011 letter from YKDFN- Giant Scope Clarifications	15-Sep-11	Parties/Public
340	Giant Tech Session agenda	06-Oct-11	MVEIRB
340	YKDFN IR 26 response from DFO	31-May-11	Parties/Public
341	Letter to parties re: Giant Technical Session	06-Oct-11	MVEIRB
341	Covering letter- YKDFN IR 19 Response from DFO	31-Mar-11	Parties/Public
342	YKDFN IR #19 Response by DFO	31-Mar-11	Parties/Public
343	Clarification of EA Scope - YKDFN	07-Oct-11	Review Board
344	Technical session agenda	07-Oct-11	Review Board
345	Letter to Parties- Giant Technical Sessions	07-Oct-11	Review Board
346	Note to File- Venue change for technical sessions	07-Oct-11	Review Board
347	AANDC's GIANT Remediation Project's Surface Remediation Presentation - Tech Session	11-Oct-11	Developer
348	Day 1 Freeze and Underground	13-Oct-11	Developer
349	Water-Baker Creek Day 2	13-Oct-11	Developer
350	Risk Assessment Day 4 Presentation	13-Oct-11	Developer
351	Long Term Monitoring Evaluation & Management Day 5 Presentation	13-Oct-11	Developer
352	Tech session transcript- Oct. 17	18-Oct-11	Review Board
353	Tech session transcript- Oct 18 2011	19-Oct-11	Review Board
354	Tech session transcript- Oct. 19 2011	20-Oct-11	Review Board
355	Tech session transcript- Oct. 20 2011	21-Oct-11	Review Board

PR#	Document	Date Received	Source
356	Tech session transcript- Oct. 21 2011	24-Oct-11	Review Board
357	Roaster report- tech session undertaking #7	28-Oct-11	Developer
358	Estimated roaster waste volumes + pictures- undertaking #7	28-Oct-11	Developer
359	MSDS Fact Sheet- SUVA	28-Oct-11	Developer
360	MSDS Fact Sheet- Dynalene HC	28-Oct-11	Developer
361	MSDS fact sheet- Ammonia	28-Oct-11	Developer
362	AN Giant Perpetual Care Workshop Report	17-Oct-11	Parties/Public
363	Giant Mine Technical Session Undertaking 1(a)	15-Nov-11	Developer
364	Giant Mine Technical Session Undertaking 1b	15-Nov-11	Developer
365	Giant Mine Technical Session Undertaking 1c	15-Nov-11	Developer
366	Giant Mine Technical Session Undertaking 2 and 4	15-Nov-11	Developer
367	Giant Mine Technical Session Undertaking 3 and 9	15-Nov-11	Developer
368	Giant Mine Technical Session Undertaking 5	15-Nov-11	Developer
369	Giant Mine Technical Session Undertaking 7	15-Nov-11	Developer
370	Giant Mine Technical Session Undertaking 8	15-Nov-11	Developer
371	Giant Mine Technical Session Undertaking 10	15-Nov-11	Developer
372	Giant Mine Technical Session Undertaking 11	15-Nov-11	Developer
373	Giant Mine Technical Session Undertaking 12	15-Nov-11	Developer
374	Cover letter for Giant Mine Tech Session undertakings	15-Nov-11	Developer
375	Revised Giant EA Workplan, Nov 2011	24-Nov-11	Review Board
376	Reminder- Round 2 IR deadline	24-Nov-11	Review Board
377	Covering Letter- Review Board IRs, Round Two	01-Dec-11	Review Board
378	Review Board IRs, Round Two	01-Dec-11	Review Board
379	DFO Round 2 IRs	01-Dec-11	Parties/Public
380	YKDFN Round 2 IRs	02-Dec-11	Parties/Public
381	Alternatives North Round 2 IRs	30-Nov-11	Parties/Public
382	Giant EA Note-to-File regarding Temporary Alternate Contact 11-Jan-12	11-Jan-12	Review Board
383	E-mail (10-Jan-12) and attachment from Kevin O'Reilly regarding Giant Mine Remediation Project and Highway #4 Realignment	10-Jan-12	Parties/Public
384	Letter from AANDC to the Review Board Regarding a Submission Date Extension Request	18-Jan-12	Developer
385	Letter from Review Board to AANDC Regarding Information Request Response Submission Date	19-Jan-12	Review Board
386	Letter to Review Board from City of Yellowknife Regarding Revised Scope for Giant Remediation EA	17-Jan-12	Parties/Public
387	Technical Report deadline and instructions	03-Feb-12	Review Board
388	Environment Canada response to Alt North IR #13	07-Feb-12	Parties/Public
389	Rnd 2 Responses to YKDFN IRs	17-Feb-12	Developer
390	Rnd 2 Responses to Board IRs	17-Feb-12	Developer
391	Rnd 2 Responses to DFO IRs	17-Feb-12	Developer
392	Letter to City of YK re: water pipeline and EA scope	20-Feb-12	Review Board
393	IR round 2 covering letter	17-Feb-12	Developer

PR#	Document	Date Received	Source
394	Rnd 2 responses to Alt North IRs	17-Feb-12	Developer
395	Principles of Perpetual Care- Report from Alt North	07-Feb-12	Parties/Public
396	Agenda- Workshop on Independence and Oversight at Giant Mine	23-Feb-12	Parties/Public
397	Long term funding option study- Statement of work	23-Feb-12	Parties/Public
398	Rnd 2 Responses from DFO to Board IRs	16-Jan-12	Parties/Public
399	City of YK tech session undertaking #6	06-Feb-12	Parties/Public
400	Note to File- Hearing no sooner than mid-May	05-Mar-12	Review Board
401	Alternatives North Concerns Following Round Two IR Responses	08-Mar-12	Parties/Public
402	Regulatory Process Concerns	08-Mar-12	Parties/Public
403	Letter re: Dismantling Mill Conveyor	13-Mar-12	Developer
404	Alternatives North letter re: mill conveyor	14-Mar-12	Parties/Public
405	Technical Report further deadline extension	15-Mar-12	Review Board
406	YKDFN request to delay tech reports, hearings	15-Mar-12	Parties/Public
407	YKDFN letter re: BacTech tailings remediation	15-Mar-12	Parties/Public
408	BacTech infosheet and report	15-Mar-12	Parties/Public
409	Letter to Parties re YKDFN extension request	23-Mar-12	Review Board
410	Letter to Giant Team re: Legal basis for site work	26-Mar-12	Review Board
411	YKDFN letter re: Mill Conveyor	26-Mar-12	Parties/Public
412	Report from Alternatives North-Yellowknives Dene First Nation Workshop on Oversight of Giant Mine Remediation Project	30-Mar-12	Parties/Public
413	Alternatives North letter re YKDFN extension request	02-Apr-12	Parties/Public
414	Request from NSMA regarding hearing notification	26-Mar-12	Parties/Public
415	Letter from Giant Team re: legal basis for dismantling mill	03-Apr-12	Developer
416	Attachments to Giant Mar 13 letter re mill conveyor	21-Mar-12	Developer
417	Giant Mine Designation Options discussion paper	13-Apr-12	Parties/Public
418	Board decision- YKDFN request for extension	13-Apr-12	Review Board
419	Into Eternity- Perpetual care documentary	25-Apr-12	Parties/Public
420	Giant Mine Perpetual Care Funding Options	24-Apr-12	Parties/Public
421	Alternatives North e-mail to City re: conveyor approvals	20-Apr-12	Parties/Public
422	Additional IRs + covering letter May 7 2012	07-May-12	Review Board
423	Hanford Long Term Stewardship Plan	07-May-12	Parties/Public
424	Environmental Management System update cov letter	27-Apr-12	Developer
425	Environmental Management System update summary notes	27-Apr-12	Developer
426	Environmental Management System presentation	27-Apr-12	Developer
427	Commissioner for the Env. 2012 Spring Report	09-May-12	Parties/Public
428	Regulator Meeting Materials- Giant SSP	18-May-12	Developer
429	Temp contact until June 4, 2012	23-May-12	Review Board
430	Email correspondence from Kevin O'Reilly to AANDC- May1, 2012	01-May-12	Parties/Public
431	Email correspondence from Kevin O'Reilly to AANDC -May 4 2012	04-May-12	Parties/Public
432	AN letter to Commissioner of Environment	05-Jun-12	Parties/Public
433	Additional IR Responses	11-Jun-12	Developer

PR#	Document	Date Received	Source
434	AN letter re: IR response on stable long-term funding	18-Jun-12	Parties/Public
435	AN e-mail requesting AECOM reports	12-Jun-12	Parties/Public
436	Giant workshop for parties- June 27, 28- agenda	19-Jun-12	Developer
437	AN e-mail re: June 27-28 2012 session expectations	18-Jun-12	Parties/Public
438	CALPUFF dispersion modelling final draft report	19-Jun-12	Developer
439	AECOM report- Structural condition of Mill Conveyor	19-Jun-12	Developer
440	AN e-mail re: Deep Geological Repository documents	24-Jun-12	Parties/Public
441	NWMO: Financial Surety Backgrounder	24-Jun-12	Parties/Public
442	NWMO: Planning for Climate Change backgrounder	24-Jun-12	Parties/Public
443	OPG responses to DGR CEAA panel IRs	24-Jun-12	Parties/Public
444	AN e-mail re: UK Nuclear Decommissioning Authority reports	24-Jun-12	Parties/Public
445	Nuclear Decommissioning Authority- Operational Safety Case	24-Jun-12	Parties/Public
446	Nuclear Decommissioning Authority- Environmental Safety Case	24-Jun-12	Parties/Public
447	AN e-mail - meeting summaries, oversight meetings	27-Jun-12	Parties/Public
448	AN e-mail- Halocarbon spill	04-Jul-12	Parties/Public
449	Halocarbon spill report	04-Jul-12	Parties/Public
450	Halocarbon Material Safety Data Sheet	04-Jul-12	Parties/Public
451	AN e-mail re: perpetual care in France	02-Jul-12	Parties/Public
452	ANDRA- Making Nuclear Waste Governable	02-Jul-12	Parties/Public
453	French law- management of radioactive materials and wastes	02-Jul-12	Parties/Public
454	ANDRA- Disposal Facilities: Preserving a Collective Memory	02-Jul-12	Parties/Public
455	ANDRA- Radioactive Materials and Waste Planning Act	02-Jul-12	Parties/Public
456	AN e-mail re: roaster complex	02-Jul-12	Parties/Public
457	Letter to Parties- Upcoming dates and reminders July 6 2012	06-Jul-12	Review Board
458	Resume of K.A. Enns	06-Jul-12	Review Board
459	YKDFN Technical Report- Giant EA	09-Jul-12	Parties/Public
460	Environment Canada Technical Report	09-Jul-12	Parties/Public
461	Pre-Technical Report Workshop Report	17-Jul-12	Developer
462	September 2011 AECOM Memo Regarding Integrity of Various Giant Site Buildings	06-Jul-12	Developer
463	Memo from Golder on Stability of Stopes B2-12, -13, and -14 and Surface Access Controls - GRMP	06-Jul-12	Developer
464	Golder Memo on Conceptual Mitigation Plans for High Risk Underground Workings - GMRP	06-Jul-12	Developer
465	Golder Memo on Crown Pillar B2-08 Stability Assessment	06-Jul-12	Developer
466	Memo from Golder Regarding Stope 2-01 Complex Crown Pillar Stability Assessment	06-Jul-12	Developer
467	Independent Risk Assessment of Various Giant Mine Components - GMRP	06-Jul-12	Developer
468	January 2006 Site Wide Crown Pillar Stability Investigation – GMRP	06-Jul-12	Developer
469	May 2005 Risk Ranking Summary Table for Crown Pillar Failure	06-Jul-12	Developer
470	Fisheries and Oceans Canada's Giant Mine EA Technical Report	11-Jul-12	Parties/Public

PR#	Document	Date Received	Source
471	Baker Creek Presentation – June 2012 Giant Remediation Workshop	13-Jul-12	Developer
472	CALPUFF Air Quality Modeling – June 2012 Giant Remediation Workshop	13-Jul-12	Developer
473	Diffuser Presentation – June 2012 Giant Remediation Workshop	13-Jul-12	Developer
474	Failure Modes Risk Assessment – June 2012 Giant Remediation Workshop	13-Jul-12	Developer
475	FOS Update – June 2012 Giant Remediation Workshop	13-Jul-12	Developer
476	Monitoring Maintenance and Management – June 2012 Giant Remediation Workshop	13-Jul-12	Developer
477	Water Quality Criteria – June 2012 Giant Remediation Workshop	13-Jul-12	Developer
478	Water Treatment Presentation – June 2012 Giant Remediation Workshop	13-Jul-12	Developer
479	NSMA supporting materials for tech report	12-Jul-12	Parties/Public
480	Pre-hearing conference letter and agenda	25-Jul-12	Review Board
481	Giant Mine pre-hearing conference - call in numbers	26-Jul-12	Review Board
482	AN Giant Mine EA Technical Report (Final)	11-Jul-12	Parties/Public
483	AN e-mail re: PHC, hearing info needs, issues and timing	27-Jul-12	Parties/Public
484	AN e-mail July 25- re: Commitments Table	25-Jul-12	Parties/Public
485	Draft hearing agenda and letter	03-Aug-12	Review Board
486	Letter from Lois Little re: concerns, recommendations	07-Aug-12	Parties/Public
487	Alternative North Questions for FCSAP on Perpetual Care	09-Aug-12	Parties/Public
488	Cover Letter for Giant Mine Responses to Parties' Recommendations	10-Aug-12	Developer
489	Giant Mine Remediation Project Updated Commitments Table	10-Aug-12	Developer
490	Letter re: Late submission of NSMA technical report	13-Aug-12	Review Board
491	Closure of Public Record	13-Aug-12	Review Board
492	Response to Technical Report Recommendations	10-Aug-12	Developer
493	Cover Letter for Giant Mine Responses to Parties' Recommendations	10-Aug-12	Developer
494	Success Criteria for Ground Freezing	10-Aug-12	Developer
495	Frozen Block Wetting Studies Report	10-Aug-12	Developer
496	Baseline Data Collection	10-Aug-12	Developer
497	Bench Scale Testing Report	10-Aug-12	Developer
498	Giant Mine Project Team Structure	10-Aug-12	Developer
499	AANDC Recordkeeping Directive	10-Aug-12	Developer
500	Consideration of Long Term Risks	10-Aug-12	Developer
501	Giant Mine Tailings Cover Trials 2010 Data Summary	10-Aug-12	Developer
502	Exposure to Public on Ingraham Trail	10-Aug-12	Developer
503	Progress Report on Giant Mine Remediation Project EMS	10-Aug-12	Developer
504	GMRP Definitions	10-Aug-12	Developer
505	Giant Mine EMS Working Group Final Terms of Reference	10-Aug-12	Developer
506	EMS Working Group Meeting Minutes March 5, 2012	10-Aug-12	Developer

PR#	Document	Date Received	Source
507	EMS Working Group Meeting Minutes April 25, 2012	10-Aug-12	Developer
508	EMS Working Group Meeting Minutes June 20, 2012	10-Aug-12	Developer
509	Site Stabilization Plan for the Giant Mine Remediation Project	10-Aug-12	Developer
510	Baker Creek Fish Monitoring Results - Reach 4 - Spring 2007	10-Aug-12	Developer
511	INAC Baker Creek Grayling Project Report	10-Aug-12	Developer
512	Baker Creek Aquatic Studies	10-Aug-12	Developer
513	Baker Creek Habitat Maps	10-Aug-12	Developer
514	Baker Creek Reach 7 Overflow Fish Monitoring Program	10-Aug-12	Developer
515	Giant Mine Procurement Strategy	10-Aug-12	Developer
516	Long-term Stewardship of the Giant Mine	10-Aug-12	Developer
517	NSMA Technical Report Plain Language Summary	10-Aug-12	Parties/Public
518	Submission Date Request for FOS Findings Update	13-Aug-12	Parties/Public
519	Effectiveness of Independent Oversight	13-Aug-12	Parties/Public
520	IEMA External Review March 2009	13-Aug-12	Parties/Public
521	IEMA External Review March 2000	13-Aug-12	Parties/Public
522	Good Neighbor Agreements Evaluation Report	13-Aug-12	Parties/Public
523	YKDFN recommendations for Giant	13-Aug-12	Parties/Public
524	Giant Mine Historical Summary Submission Cover Letter	13-Aug-12	Parties/Public
525	Giant Mine: History Summary	13-Aug-12	Parties/Public
526	Temporary contact change for Giant	13-Aug-12	Review Board
527	Giant EA Hearing Agenda	13-Aug-12	Review Board
528	Letter to Review Board on Redactions to Site Stabilization Plan	16-Aug-12	Parties/Public
529	E-mail Re: Redactions Made to the Site Stabilization Plan	16-Aug-12	Parties/Public
530	Bioleaching Remediation of the Giant Mine Tailings Memo	16-Aug-12	Developer
531	Request for Comments - Giant Mine Geotechnical Program	10-Aug-12	Other
532	MVLWB Draft Land Use Permit Conditions	10-Aug-12	Other
533	Draft Closure and Reclamation Guidelines	17-Aug-12	Parties/Public
534	Questions on Organizational Structure for Giant Mine	20-Aug-12	Parties/Public
535	Socio-Economic Impacts of Gold Mining in the Yellowknife Mining District	19-Aug-12	Parties/Public
536	2010 Giant Air Quality Monitoring Baseline Report	21-Aug-12	Developer
537	Questions on Giant 2010 Air Quality Monitoring Report	21-Aug-12	Parties/Public
538	Giant Mine Procurement Strategy	22-Aug-12	Parties/Public
539	Giant Mine Project Description	22-Aug-12	Parties/Public
540	City of Yellowknife Technical Report	22-Aug-12	Parties/Public
541	Cover Letter for AN Public Hearing Submissions	22-Aug-12	Parties/Public
542	Alternatives North Public Hearing Presentations	22-Aug-12	Parties/Public
543	Alternatives North Expert Public Hearing Presentations	22-Aug-12	Parties/Public
544	Alternatives North Expert CVs	22-Aug-12	Parties/Public
545	Environment Canada Public Hearing Presentations	22-Aug-12	Parties/Public
546	Department of Fisheries and Oceans Public Hearing Presentations	22-Aug-12	Parties/Public

PR#	Document	Date Received	Source
547	Update on Alternatives North Giant Mine EA Participant Funding 2012-13	22-Aug-12	Parties/Public
548	Giant Mine EA Schedule Delays	26-Aug-12	Parties/Public
549	YKDFN Note on Giant Public Hearing Submissions	29-Aug-12	Parties/Public
550	Giant Mine Air Quality Monitoring Baseline Study- 2005	28-Aug-12	Developer
551	Giant Mine Air Quality Monitoring Baseline Study - 2006	28-Aug-12	Developer
552	Giant Mine Air Quality Monitoring Baseline Study - 2008	28-Aug-12	Developer
553	Giant Mine Air Quality Monitoring Baseline Study - 2009	28-Aug-12	Developer
554	Collection of Giant Mine Media Coverage	29-Aug-12	Parties/Public
555	Giant Mine Brochure	29-Aug-12	Parties/Public
556	Extension for developer's hearing presentation	29-Aug-12	Review Board
557	City of Yellowknife Hearing Presentations	30-Aug-12	Parties/Public
558	Bactech e-mail and memo	30-Aug-12	Parties/Public
559	Note to File + email re: YKDFN hearing presentations	31-Aug-12	Parties/Public
560	Developer's project overview hearing presentation	31-Aug-12	Developer
561	Developer's freeze + underground hearing presentation (Day 1)	31-Aug-12	Developer
562	Developer's hearing presentation- water (day 2)	31-Aug-12	Developer
563	Developer's hearing presentation- Surface (day 3)	31-Aug-12	Review Board
564	Developer's hearing presentation- Perpetual care (day 4)	31-Aug-12	Developer
565	Developer's hearing presentation- Oversight (day 5)	31-Aug-12	Developer
566	Letter from developer re: Oversight	31-Aug-12	Developer
567	EC responses to AN questions	30-Aug-12	Parties/Public
568	GIANT Mine Remediation Project Hearing and Shuttle Schedule	06-Sep-12	Review Board
569	Freeze Optimization Study Update- Aug 2012	31-Aug-12	Developer
570	Concerns Regarding the Giant Mine Remediation Project	27-Aug-12	Parties/Public
571	Concerns Regarding the Giant Mine Remediation Project	29-Aug-12	Parties/Public
572	Letter - YKDFN to DIAND, Minister Stewart - April 8, 1999	12-Sep-12	Parties/Public
573	Letter - YKDFN to DIAND Minister J. Chretien - Sept 1973	12-Sep-12	Parties/Public
574	Background on Alternatives North	12-Sep-12	Parties/Public
575	Giant Mine hearing transcripts - September 10, 2012	17-Sep-12	Review Board
576	Giant Mine hearing transcripts - September 11, 2012	17-Sep-12	Review Board
577	Giant Mine hearing transcript - September 12, 2012	17-Sep-12	Review Board
578	Giant Mine public hearing transcript - Sept 13, 2012	17-Sep-12	Review Board
579	Giant Mine public hearing transcript - September 14, 2012	17-Sep-12	Review Board
580	Letter from Caroline Lafontaine, Yellowknife resident	14-Sep-12	Other
581	Letter from Carol Lafontaine	14-Sep-12	Parties/Public
582	Letter from Erica Janes	23-Sep-12	Parties/Public
583	Letter from Wendy Lahey	23-Sep-12	Parties/Public
584	Letter from Erin Suliak	24-Sep-12	Parties/Public
585	Letter from Leslie Wakelyn	19-Sep-12	Parties/Public
586	Alternatives North Backgrounder	12-Sep-12	Parties/Public
587	Contaminated Sites Program Performance Report 2007-2008	14-Sep-12	Review Board
588	Contaminated Sites Program Performance Report 2008-2009	14-Sep-12	Developer

PR#	Document	Date Received	Source
589	Contaminated Sites Program Performance Report 2009-2010	14-Sep-12	Developer
590	Contaminated Sites Program Performance Report 2010-2011	14-Sep-12	Developer
591	Undertaking #2: Health Canada comments	14-Sep-12	Developer
592	MVLWB Water and Effluent Quality Management Policy	14-Sep-12	Developer
593	Guidelines for the Discharge of Treated Municipal Wastewater in the NWT	14-Sep-12	Developer
594	Response to AN IR#10 round 2	14-Sep-12	Developer
595	Undertaking #1 and cover letter	25-Sep-12	Developer
596	Undertaking #3: Identifying water treatment plant BAPT	25-Sep-12	Developer
597	Monitoring in Perpetuity article	27-Sep-12	Review Board
598	Undertaking #4: Design schedule and steps	25-Sep-12	Developer
599	Discussion paper on Giant oversight considerations	22-Sep-12	Parties/Public
600	Comparison of diffusers and mixing zones	14-Sep-12	Developer
601	Report on Yellowknife Water Supply Line (1968)	13-Sep-12	Parties/Public
602	Community hearing presentation- Terry Pamplin	01-Oct-12	Parties/Public
603	Hearing presentation my Bob Bromley, MLA	13-Sep-12	Parties/Public
604	Letter from Mike Mitchell	04-Oct-12	Parties/Public
605	Closing comments- YKDFN	05-Oct-12	Parties/Public
606	Closing comments- NSMA	05-Oct-12	
607	Closing comments- Alternatives North	26-Sep-12	Parties/Public
608	Closing Statement- DFO	05-Oct-12	Parties/Public
609	Note to File re: participation of Board member John Curran	09-Oct-12	Review Board
610	Environment Canada Final Comments Giant Remediation EA	09-Oct-12	Parties/Public
611	Closing comments- Developer	11-Oct-12	Developer
612	YKDFN IR 24 Response	17-Jun-12	Developer
613	YKDFN IR 25 Response	17-Jun-12	Developer
614	Information Request re: Diffuser Feb 2013	07-Feb-13	Review Board
615	Request for extension for IR response	06-Mar-13	Developer
616	Board letter granting extension	08-Mar-13	Review Board
617	Letter re: roaster, s119, EA scope	13-Mar-13	Review Board
618	AQMP for Roaster 22Oct2012	22-Oct-12	Developer
619	Draft Combined WL Application Form 22Oct2012	22-Oct-12	Developer
620	Draft Roaster Detailed Project Description (Figures Removed) 22Oct2012	22-Oct-12	Developer
621	Draft UG Detailed Project Description (Figures Removed) 22Oct2012	22-Oct-12	Developer
622	Draft UG Waste Management Plan (Figures Removed) 22Oct2012	22-Oct-12	Developer
623	FTP Site Instructions	22-Oct-12	Developer
624	Giant Mine Dist List (MVLWB).docx	22-Oct-12	Developer
625	Arsenic Procedures	22-Oct-12	Developer
626	Draft Roaster Waste Management Plan (Figures Removed) 22Oct2012	22-Oct-12	Developer
627	Emergency Spill Response Plan	22-Oct-12	Developer

PR#	Document	Date Received	Source
628	SSP WL Cover Letter to Parties	22-Oct-12	Developer
629	AANDC - CARD - Letter to MVEIRB - Jan25-13	23-Jan-13	Developer
630	Letter to MVLWB re: roaster, EA scope	13-Mar-13	Review Board
631	Letter to parties- Comments on March 2013 IR responses	15-Mar-13	Review Board
632	AANDC Mar. 8 2013 letter to MVLWB re: roaster underground work	12-Mar-13	Developer
633	Attachment A - Responses	12-Mar-13	Developer
634	Draft WL Conditions - Suggested Changes	12-Mar-13	Developer
635	Section 119 Comment Summary Table - 8Mar2013	12-Mar-13	Developer
636	WL Comment Summary Table	12-Mar-13	Developer
637	Developer responses to February 2013 IRs	15-Mar-13	Developer
638	Giant Mine Water Disposal- IR Response Report	15-Mar-13	Developer
639	Letter from Alternatives North on 2013 IR on Water Treatment	24-Mar-13	Parties/Public
640	Additional info re: water treatment alternatives	25-Mar-13	Developer
641	Constructed Wetland Viability Summary Table	25-Mar-13	Developer
642	2011 Baker Creek Assessment	15-Mar-13	Developer
643	Giant Mine 2008 EEM-Report and Appendices	15-Mar-13	Developer

Appendix C: List of Developer's commitments

The scope of development described in section 2.4 describes how the Review Board considered the Developer's commitments. For reference, this appendix includes tables A to C of the Developer's *Revised Commitments Tables for the Giant Mine Remediation Project - August 2012* (PR#489), followed by a list of additional commitments specifically identified by the Review Board in the Report of Environmental Assessment. In addition to the commitments listed here, the Review Board also considered all other commitments made by the Developer on the public record.

Part 1: Revised Commitments Tables for the Giant Mine Remediation Project

August 2012m Tables A-C (PR#489)

1 DAR Commitment Tables

#	Commitment	Reference
1	INAC will prepare a comprehensive procurement strategy that optimizes employment, business and training opportunities for Aboriginal, local and northern residents.	DAR Chapter 1, Section 1.4.4, DAR Chapter 8, Table 8.11.3, Table 8.11.5
2	A detailed design for the remediation of Baker Creek will be prepared with active involvement from Aboriginal communities, Yellowknife residents, and government departments. The detailed design for the rehabilitation of Baker Creek will be based upon, among other things, flood carrying capacity, habitat creation, erosion resistance and the restoration of a natural hydrograph.	DAR Chapter 8, Table 8.4.2, Table 8.7.2
3	Results of the freeze optimization study will be used as input to the detailed engineering and design process.	DAR Chapter 6, Section 6.2.9.1
4	A detailed revegetation plan, which includes studies to select species and define seeding, planting and fertilization requirements will be produced.	DAR Chapter 6, Section 6.6.6 DAR Chapter 8, Table 8.8.2
5	Design of a new water treatment plant that will be based upon Best Available Technology for the separation of arsenic precipitates from the treated water.	DAR Chapter 6, Section 6.8.5
6	An engineering study of alternative on-land and offshore outfall and diffuser installation methods will be completed. The detailed designs for the outfall and diffuser will be based on the findings of this study.	DAR Chapter 6, Section 6.8.6 DAR Chapter 8, Table 8.4.5
7	Plans will be developed for the demolition of buildings and handling of waste, based on current industry best practises that meet local requirements for protecting the safety of site workers and the public, and protection of the environment.	DAR Chapter 6, Section 6.11.1
8	Environment, Health and Safety Plans for implementation of the Project will be developed, which include details regarding:	DAR

	• Emergency/spill response; • Erosion and sedimentation controls; • Dust management; • Building demolition; • Fuel management; • Protocols for vegetation surveys; and • Measures to respond to potential transportation incidents.	
9	Plans will be developed for the collection and management of contaminated water generated during remedial works (e.g., excavation water contaminated with arsenic or hydrocarbons).	DAR Chapter 8.4.5
10	A Wildlife Management Plan will be developed.	DAR Chapter 8, Table 8.8.2
11	Habitat surveys will be conducted in any areas that are to be disturbed to confirm that rare or endangered species are not present.	DAR Chapter 8, Section 8.8.2.4
12	Pre-demolition audits will be conducted to determine if structures to be demolished are being used as wildlife habitat.	DAR Chapter 8, Table 8.8.2
13	A protocol for the management and reporting of archaeological artifacts and sites will be developed.	DAR Chapter 8, Table 8.10.3
14	Memoranda of Understanding (or similar types of arrangements) will be developed with key emergency response services providers.	DAR Chapter 8.11.3
15	A Traffic Management Plan will be developed.	DAR Chapter 8, Table 8.11.4

Table 2a. DAR Commitments - Mitigation, Monitoring and Other Commitments (DAR Table 15.3.2)

A) In-design Mitigation Features

#	Commitment	Location in DAR
16	The freeze system (active and passive) will be designed to remain effective under “worst case” climate change scenarios.	DAR Chapter 9, Section 9.2.3
17	Mine openings to surface will be sealed with structures requiring minimal maintenance to remain stable and effective in the long-term.	DAR Chapter 6, Section 6.3.4
18	Physical barriers will be established around the perimeter of the A1, A2, B2, B3 and C1 Pits; the B1 and Brock Pits will be backfilled.	DAR Chapter 6, Section 6.4.3, Table 6.4.1
19	Only demolition material from buildings that can be decontaminated of hazardous materials will be disposed in a non-hazardous waste facility.	DAR Chapter 6, Section 6.12.1
20	Process residues from the Roaster and Mill complexes, as well as any other materials or machinery contaminated with soluble arsenic, will be disposed within one of the freeze zones.	DAR Chapter 6, Section 6.12.2
21	The footprint of areas requiring disturbance of vegetation is to be minimized.	DAR Chapter 8, Table 8.4.2 & Table 8.6.7 & Table 8.11.2
22	To the extent feasible, disturbance of areas known to possess permafrost will be avoided.	DAR Chapter 8, Table 8.5.4
23	New borrow sources will only be used in situations where insufficient material is available from previously disturbed areas.	DAR Chapter 8, Section 8.8.2.4

24	Free standing structures will be designed and built to meet applicable earthquake standards in the National Building Code.	DAR Chapter 9, Section 9.2.3
25	Surface drainage (including spillways and conveyance structures) in remediated tailings areas will be designed to convey the selected PMP event. Designs will also accommodate increased surface flows associated with climate change (if any).	DAR Chapter 9, Section 9.2.3
26	Any spills of arsenic dust encountered during underground preparation will be cleaned up and deposited in the nearest accessible arsenic chamber or stope.	DAR Chapter 6, Section 6.2.5.2
27	Temperatures in the frozen wall around each chamber or stope will be monitored throughout the initial freezing to ensure that the design criteria are met before dust saturation.	DAR Chapter 6, Section 6.2.6
28	During dust saturation, water addition rates and levels will be monitored within each chamber and stope, and any seepage into the surrounding drifts will be monitored.	DAR Chapter 6, Section 6.2.8.1
29	Where concentrated sources of arsenic contaminated materials are encountered in stable underground workings, such as the main tunnels, they will be removed to a secure underground disposal site.	DAR Chapter 6, Section 6.3.2
30	Hazardous material in the underground mine workings will be brought to surface for disposal in accordance with procedures appropriate to the material type.	DAR Chapter 6, Section 6.3.3
31	Earthworks activities will be conducted using standard operational practices to control erosion and sedimentation. The sediment control works will be maintained and operated until the areas have been stabilized (e.g., through revegetation) and erosion is reduced to levels typical of natural areas.	DAR Chapter 6, Section 6.6.9
32	Soils that are co-contaminated with petroleum hydrocarbons and arsenic will be deposited in a frozen zone. .	DAR Chapter 6, Section 6.10
33	PCB-contaminated soil will be excavated, handled and disposed of in accordance with the <i>Guideline for the General Management of Hazardous Waste in the NWT</i> .	DAR Chapter 6, Section 6.10
34	Hazardous materials, from building demolition, or other activities will be handled and disposed of according to industry best practices and the <i>Guideline for the General Management of Hazardous Waste in the NWT</i> .	DAR Chapter 6, Section 6.11.3 DAR Chapter 6, Section 6.12.2
35	Waste asbestos materials that are not contaminated with arsenic will be bagged and buried in the Northwest Pond in a designated hazardous material (HAZMAT) area.	DAR Chapter 6, Section 6.11.3
36	Hazardous materials other than asbestos waste and arsenic trioxide contaminated waste will be disposed in an approved facility.	DAR Chapter 6, Section 6.12.2
37	Bulk quantities of fuel will be stored in double-walled containers. The fuel dispensing area will be lined and a sump will be dug to collect any spills that may occur.	DAR Chapter 8, Table 8.4.5 Table 8.5.2, Table 8.5.3
38	Spill kits will be available at fuel storage and dispensing facilities.	DAR Chapter 8 Table 8.4.5, Table 8.5.2, Table 8.5.3
39	Spill response training will be provided to personnel.	DAR Chapter 8, Table 8.4.5, Table 8.5.2, Table 8.5.3

40	Daily inspection of vehicles and fuel storage facilities will be carried out.	DAR Chapter 8 Table 8.4.5, Table 8.5.2, Table 8.5.3
41	Silt curtains will be employed during construction of the outfall to minimize the area affected by dispersion of sediment solids disturbed during placement of the outfall pipe and diffuser.	DAR Chapter 8, Table 8.4.5
42	The in-stream rehabilitation of portions of Baker Creek will be carried out while the reach is dewatered whenever possible. In creek reaches where realignment is planned, remediation work can be carried out under dry conditions after creek flows have been diverted or during periods approved by DFO.	DAR Chapter 8, Table 8.4.6
43	If permafrost areas cannot be avoided, excavations will be regraded/sloped, armoured and vegetated to promote permafrost development.	DAR Chapter 8, Table 8.5.4
44	Clean-up kits will be kept at drilling sites in the event of a release of arsenic trioxide dust.	DAR Chapter 8, Table 8.6.7
45	During the unfrozen period, haul roads and earthworks work areas will receive an application of a chemical suppressant or light watering to control dust.	DAR Chapter 8, Table 8.6.7
46	All motorized remediation vehicles will be maintained in good condition in accordance with applicable regulations.	DAR Chapter 8, Table 8.6.7
47	All heavy equipment will be equipped with standard industrial noise suppression devices.	DAR Chapter 8, Table 8.6.8, Table 8.8.2
48	Consideration will be given to implementing remedial works during periods that avoid key life stages of resident and migrating species. Regulatory authorities are to be informed of specific activities that are anticipated to cause a disturbance.	DAR Chapter 8, Table 8.8.2
49	The Project Team commits to working with the Yellowknives Dene First Nation to identify and preserve any graves and additional Aboriginal Heritage Resources that may be present within the SSA.	DAR Chapter 7, Section 7.6.6.1
50	All areas that have the potential of being subjected to new surface disturbances will be evaluated by the Prince of Wales Northern Heritage Centre prior to the initiation of remediation to determine archaeological heritage potential.	DAR Chapter 8, Table 8.10.3
51	Borrow sources will be regraded, contoured and, where possible, re-vegetated to encourage conformity with the surrounding landscape.	DAR Chapter 8, Table 8.11.2
52	During extreme rainfall events, work stoppages will be implemented when remediation activities that could threaten water quality or the aquatic environment are being carried out.	DAR Chapter 9, Section 9.2.2.3
53	The Project Oversight Committee will be supported by a GNWT – Government of Canada Giant Mine Remediation Intergovernmental Working Group as described in Chapter 14. The role of the Working Group will be to ensure that the activities of federal and territorial departments contributing to the remediation of the Giant Mine site are integrated to the greatest extent possible, and that information is shared to support overall due diligence in the remediation of the site.	DAR Chapter 13, Section 13.11
54	Both INAC and the GNWT are committed to developing an Environmental Management System (EMS) that will be central to the ongoing monitoring and performance improvement of the Giant Mine remediation Project.	DAR Chapter 14, Section 14.1.1

55	An audit protocol, including third-party auditing, and review process will be an integrated part of the EMS.	DAR Chapter 14, Section 14.1.1
56	The assessment of environmental performance, and compliance with the objectives and targets of the EMP's will be carried out through a regular program of monitoring and evaluation set out in the EMS.	DAR Chapter 14, Section 14.1.3
57	Where activities on site are governed by specific authorities, for example protection of fish habitat under the <i>Fisheries Act</i> as enforced by DFO, the Project Team will work with such authorities to achieve compliance.	DAR Chapter 14, Section 14.1.5
58	As the project advances, and in response to monitoring results, Aboriginal communities and the public will be engaged in the review of monitoring results and the identification of adaptive management approaches needed to address any environmental issues identified through the monitoring program.	DAR Chapter 14, Section 14.1.6
59	To establish Aboriginal involvement throughout the life of the project, INAC will work with local Aboriginal communities and organizations to create the mechanisms to support a direct and distinct Aboriginal role in the planning and implementation of monitoring and evaluation activities for the Project, including the formation and funding for a joint Aboriginal and government body in cooperation with Aboriginal communities.	DAR Chapter 14, Section 14.1.6.1
60	INAC and the GNWT will continue to support the Community Alliance in its role of sharing information about the remediation project with the Yellowknife community and relaying public concerns and issues about the remediation of Giant Mine back to INAC.	DAR Chapter 14, Section 14.1.7
61	To ensure the effectiveness of efforts to manage risks, and to ensure that of themselves remediation actions do not contribute significant environmental effects, a long-term monitoring program will be developed and implemented.	DAR Chapter 14, Section 14.2
62	Annual Report(s) will be prepared annually to summarize and review all operational and environmental data collected in the 1-year reporting period.	DAR Chapter 14, Section 14.2
63	Status of the Environment (SOE) Reports will be prepared every three years during the initial 15-year remediation period and every five years thereafter, to summarize, review and interpret the operational and environmental data collected in the reporting period and to provide recommendations for modification to the monitoring program or site operations that may be affecting environmental quality.	DAR Chapter 14, Section 14.2
64	To address concerns about the effects on the Project and other projects on the receiving environment, a cumulative effects monitoring program will be developed as part of project implementation.	DAR Chapter 14, Section 14.2.8
65	Water draining from the tailings containment areas will be directed to the minewater collection system for treatment until such time that water quality meets the arsenic concentration discharge criterion. Direct discharge (e.g., to Baker Creek) of surface drainage that does meet the arsenic discharge criterion will be permitted.	DAR Chapter 6, Section 6.6
66	Monitoring wells will be installed within the sludge and tailings containment areas to permit long-term water level measurements and collection of pore water samples for analysis.	DAR Chapter 6, Section 6.6.7
67	Water levels in the mine will be maintained significantly below the local static water level until such time that monitoring indicates it is suitable for release to the environment without treatment.	DAR Chapter 7, Section 7.2.3
68	The occurrence of an earthquake with a magnitude of 5.0 or greater will prompt a geotechnical inspection of the tailings covers, dams, conveyance	DAR Chapter 9, Section 9.2.2.1

	channels and other potentially vulnerable structures.	
69	The Project Team remains open to improvements in the frozen block method, and will re-evaluate alternatives if technologies advance or if monitoring data indicate unforeseen emerging risks to the environment and/or humans.	DAR Chapter 6, Section 6.2.2
70	INAC's Giant Mine Project Office will provide direct oversight of the project implementation, and continue to act as the lead for regulatory affairs, communications, and consultation.	DAR Chapter 6, Section 6.13.1
71	The Project Team will secure the input of government wildlife regulators and traditional knowledge holders during work schedule planning in order that remediation activities consider the presence and key life stage of sensitive species in a work area.	DAR Chapter 8, Section 8.8.2.4
72	The Project Team will maintain effective lines of communication with community organizations using land adjacent to the Giant Mine to encourage awareness of all Parties of land uses that might be disturbed during the Remediation Phase.	DAR Chapter 8, Table 8.11.2
73	The Project Team will continue to have dialogue with Parties interested in preserving the Giant Mine's heritage buildings.	DAR Chapter 8, Table 8.11.2
74	Remediation activities will be carried out within a regulated work environment under the authority of the Workers' Safety and Compensation Commission.	DAR Chapter 8, Table 8.11.4

Table 1a. Information Request – Round 1 Commitments

A) Water and Regulatory

#	Commitment	Reference
R1IR1	The Project Team commits to working with City of Yellowknife regarding the construction of the outfall/diffuser to avoid any periods in which the City of Yellowknife would also be constructing a new drinking water intake.	Round One: Information Request: - North Slave Métis Alliance #08
R1IR2	In addition, the Project Team will develop an Aquatic Effects Monitoring Program for operations at Giant Mine, utilizing INAC's 2007 "Guidelines for Designing and Implementing Aquatic Effects Monitoring Programs for Development Projects in the Northwest Territories."	Round One: Information Request – Yellowknives Dene First Nation #12

Table 1b. Information Request – Round 1 Commitment

B) Surface

#	Commitment	Reference
R1IR3	The re-vegetation strategy for the site will be determined during the development of detailed designs for the tailings covers and other areas. The decision-making process will include the implementation of additional community engagement to determine preferred approaches to re-vegetation, including long-term monitoring and adaptive management.	Round One: Information Request - Review Board IR #09
R1IR4	Giant Mine Remediation Project Team (Project Team) will continue to work with interested Parties to minimize impacts on the continued use of the marina and town site.	Round One: Information Request - City of Yellowknife #01 Round One: Information Request - Yellowknives Dene

		First Nation #17
--	--	------------------

Table 1c. Information Request – Round 1 Commitments

C) Monitoring

#	Commitment	Reference
R1IR5	The Project Team is committed to developing a monitoring program in a manner that is inclusive. It will be done in a manner that is transparent and meets the principles listed in IR Response to Review Board #27 in the first Round of IRs, including accountable, adaptive and credible.	Round One: Information Request - Review Board #27 Round One: Information Request - Environment Canada #15
R1IR6	Subject to limitations set out in ATIP, the Project Team is committed to providing all final research and data regarding monitoring, environmental management plans, spills and any information required by legislation, regulation, policy and guidelines.	Round One: Information Request - Alternatives North #19
R1IR7	Summaries of Public Consultations including issues raised and responses will be made publicly available.	Round One: Information Request - Alternatives North #20

Table 1d. Information Request – Round 1 Commitments

D) Roles and Responsibilities

#	Commitment	Reference
R1IR8	The Project Team will participate with the City of Yellowknife and other Parties during the creation of Land Use and Transportation Plans for the Giant Mine Site.	Round One: Information Request - City of Yellowknife #07

Table 1e. Information Request – Round 1 Commitments

E) Other

#	Commitment	Reference
R1IR9	The Project Team has committed to holding further Industry Day information sessions in the DAR, Table 13.13.2 Looking Forward: The Consultation and Engagement Plan. Additional community meetings, public sessions and information sessions will be held to inform Aboriginal, local and northern businesses, as well as business at large, about the opportunities the Remediation Project has and inform the Project Team about local resources. (Please note that the Project Team held this Industry Day on August 1, 2012)	Round One: Information Request - City of Yellowknife #13

Table 2a. Commitments Arising from 17 – 21 October 2011 Technical Sessions

A) Compensation / Apology

#	Commitment	Location within Technical Sessions Transcripts
TS1	The Giant Mine Remediation Project Team commits to arranging a meeting between YKDFN and RDG (Please note that this meeting was held on June 4, 2012).	Day 1 – 17 October 2011 110: 4-10

Table 2b. Commitments Arising from 17 – 21 October 2011 Technical Sessions**B) Perpetual Care**

#	Commitment	Location within Technical Sessions Transcripts
TS2	The GMRPT to review the project after 100 years to determine whether the remediation plan is doing what it is supposed to and whether it is the correct approach to continue.	Day 4 – 20 October 2011 247: 8-25; 248: 1

Table 2c. Commitments Arising from 17 – 21 October 2011 Technical Sessions**C) Future Land Use / Marina Expansion**

#	Commitment	Location within Technical Sessions Transcripts
TS3	The GMPT to work with the City of Yellowknife on maintaining access to the boat launch and marina.	Day 2 – 18 October 2011 255: 15-21
TS4	The GMPT will participate in a public workshop on future land use for Giant Mine.	Day 3 – 19 October 2011 147: 8-10

Table 2d. Commitments Arising from 17 – 21 October 2011 Technical Sessions**D) Independent Monitoring**

#	Commitment	Location within Technical Sessions Transcripts
TS5	To have a workshop/meeting on independent oversight with the Parties to the Environmental Assessment. On March 6-7, 2012, the Project Team participated in Alternatives North (AN) and the Yellowknives Dene First Nation (YKDFN) jointly hosted a workshop to explore definitions and concepts for arms length monitoring of the Giant Mine Remediation Project.	Day 5 – 21 October 2011 142: 1-3

Table 1a. Information Request – Round 2 Commitments - DRAFT

#	Commitment	Reference
R2IR1	A review of emergent technologies will occur every ten years following the full implementation of the Frozen Block Method and the results will be reported in the State of the Environment Report for that year. The exact details on how this will be conducted will be determined as part of the development of the Environmental Management System (EMS), however it will include an organization or similar body that will oversee this review. The review will take place using public and private organizations and all emergent technologies identified in the review will be submitted to an Independent Peer Review Panel for applicability to the Giant Mine.	Round Two: Information Request - Review Board #06 Round Two: Information Request - Review Board #07
R2IR2	Please note that the commitments tables have been developed based the knowledge currently available and changes may arise due to the outcomes of the	Round Two: Information Request – Alternatives North #01

	Environmental Assessment, the final project design, or during project implementation. As a consequence, this list of commitments may be altered to reflect those outcomes. Any such changes will be communicated.	
R2IR3	The closure and reclamation of the Giant Mine site will be consistent with the goals set out in the Guidelines consistent with the life cycle stage of the mine. Due to the complexity of the Giant Mine site, and the need for very long-term monitoring of some components, it is likely that EMPs will be developed by aspect, not as a single closure plan document. Much of the detail requested in the IR will be addressed in the detailed design and EMP stages of the project. Engagement on the development of EMPs will be in the context of the larger consultation and engagement plan for the Project. It is anticipated that primary engagement on the development of EMPs will be through workshops with an Environmental Management System (EMS) working group composed of affected Aboriginal groups and interested Parties. Workshops will be structured to share and solicit input as well as to validate progressive work in the development of EMPs. Please see the August 10, 2012 letter from the EMS Chair, Erika Nyssonen outlining the existing status of EMS working group and path forward.	Round Two: Information Request – Alternatives North #03
R2IR4	Technology reviews will be conducted on a 10 year basis following remediation. Results will be made public with an opportunity to comment.	Round Two: Information Request – Alternatives North #04
R2IR6	NTPC has adequate generating capacity to meet the Giant Mine requirements. At such times during the year that there are localized increases in demands to the system, the proponents will limit usage for short periods of time at the request of the NTPC.	Round Two: Information Request – Alternatives North #09
R2IR7	The Giant Mine Remediation Project Team (Project Team) will comply with City regulatory requirements as applicable.	Round Two: Information Request – Alternatives North #15
R2IR8	The meeting summaries from the Oversight Committee will continue to be made public via the Giant Mine Public Registry.	Round Two: Information Request – Alternatives North #19
R2IR8	The Giant Mine Remediation Project Team (Project Team) is in the process of expanding on the approach laid out in Chapter 14 and is committed to working with the Parties to define the approach further. This applies to developing and implementing the Environmental Management System (EMS) and the Environmental Management Plans (EMPs) as described in Chapter 14 of the DAR. Through the EMS and EMPs the Project Team is committed to establishing criteria and to monitoring and evaluating environmental protection success and the meeting of regulatory responsibilities throughout the remediation of Giant Mine. As discussed at the technical sessions, the Project Team is committed to working with the Parties to improve the proposed monitoring of Giant Mine and will be actively involved in the	Round Two: Information Request – Alternatives North #22

	Oversight Workshop hosted by the Yellowknives Dene First Nation and Alternatives North.	
--	---	--

Table 1a. Information Request – Round 2 Commitments - DRAFT

#	Commitment	Reference
R2IR9	Based on comments from meeting with the stakeholders during the October 2011 Technical Sessions, the Project Team committed to conduct a risk workshop at a future date. The scope and schedule for a workshop is still being developed and stakeholders will be notified as to the nature of the workshop and how stakeholders will be involved. Materials developed during the course of the workshop will be made available to the public. A revised Failure Modes Effects Criticality Analysis will be submitted to the Review Board should a change occur.	Round Two: Information Request – Alternatives North #25
R2IR9	In the Developers Assessment Report (DAR), and in more detail at the October 2011 Technical Session, the Project Team presented plans for stakeholder participation in the development of environmental management plans. The Project Team is committed to sharing information with interested Parties on the progress of this effort. The Water Licensing process is expected to include a more detailed consideration of engineering designs and implementation methods for many components of the proposed Remediation Plan. The Project Team anticipates that further details of the proposed sequence of freezing and wetting process, including any variants that remain under consideration, will be available by that time.	Round Two: Information Request – Alternatives North #27

Table 1b. Information Request – Round 2 Commitments (Additional from Review Board) - DRAFT

#	Commitment	Reference
R2IR10	Aboriginal Affairs and Northern Development Canada (AANDC) remains committed to the existing funding mechanism over the short and medium term phases of the project... AANDC remains open to considering the most effective and efficient funding mechanism in order to maintain the integrity of the project. AANDC expects that future governments will have the capacity and willingness over the long term to keep the arsenic at the site contained. It is expected that the Government as a stable entity that has existed since 1867 will take all measures necessary to protect the human health and safety of Canadians.	Round Two (Part B): Information Request - Review Board #01
R2IR11	The working group has concluded that it is in the individual and collective best interests of the Parties to the working group and the general public that a Giant Mine Remediation Project environmental monitoring committee be established prior to the initiation of the Project. The Committee would be representative of the public, advisory in nature and would monitor implementation of the environmental aspects of the Giant Mine Remediation Project. The Giant Mine Remediation Project environmental monitoring advisory committee would not make decisions with respect to the operations of the project. Operational responsibilities and decisions would remain with the Developer. The working group will report back to the Parties and will update the Review Board on the progress of the discussions and any outstanding issues prior to the July 11, 2012 deadline for technical submissions.	Round Two (Part B): Information Request - Review Board #03

Part 2: Additional Commitments

The following are selected commitments are on the public record that are not included in the above table, or commitments with additional details that are lacking in the above table.

Commitment and reference document	Reference document
1. The Developer has committed to developing a “Comprehensive Perpetual Care Plan” (PR#564 p17) and pursuing improvements in perpetual care subjects including records management, communicating with future generations, and scenario analysis (PR#565 p11).	PR#564 p17 PR#565 p11
2. The Developer committed to develop and manage long term monitoring in a manner that is adaptive; objectives based; credible; inclusive; transparent; cost effective; and accountable (PR#290 p3):	PR#290
3. The Developer committed to submitting the results of the fish tissue sampling to a regional contaminants body which Health Canada is part of, for its consideration with respect to fish consumption advisories	PR#576 p227

(PR#576 p227).	
4. In response to the City of Yellowknife request for the Developer to commit “to cover expenses associated with treatment processes to address potential spills in Yellowknife Bay to ensure that drinking water standards are achieved if the City chooses to use Yellowknife Bay as its potable drinking water source”, the Developer specified it had previously committed to covering costs associated with accidental spills. (PR#576 p97-98).	PR#576 p97-98
5. The Developer committed to doing three-dimensional geothermal modeling to better assess the ground thermal regimes of the complex geometries related to freezing.	PR#561 p55
6. The Developer committed to review emerging technologies every 10 years after the project implementation phase. The Developer confirmed that these periodic reviews would continue over the long-term, not just for the project initiation phase, and would be independent and transparent (PR#352 p55; PR#356 p212). The Developer committed to also examining emerging technologies each time an update is required to project.	PR#352 p55 PR#356 p212 PR#390 p3
7. The Developer has committed to review best technologies for water treatment every 20 years (PR#353 p250).elements such as the water treatment plant.	PR#353 p250
8. The Developer agreed with Environment Canada’s recommendations and committed to avoid migratory birds and other wildlife using the structures as habitat, especially during the spring breeding season (PR#461 p12).	PR#461 p12
9. During the technical sessions, the Giant Mine Team committed to complete the asbestos and arsenic abatement processes under negative air and in favourable wind conditions, avoiding sensitive nesting seasons. The Developer stated that adherence to these commitments should ensure that the buildings are securely enclosed so that dust cannot enter the environment (PR#354 p227).	PR#354 p227
10. The Developer has accepted that there will be a restriction on future land use at the open pit sites. It has committed to Access to restrict access to most of the pits by erecting physical barriers, and inspecting them on a quarterly or monthly basis (PR#242). Others will be integrated into the reclamation design in order to provide waste disposal space and insulation for the installation of the freeze system, described in section (PR#354 p90).	PR#242 PR#354 p90.
11. The Developer has committed to work further with the City, outside the scope of the environmental assessment, to determine achievable remediation standards for the Giant Mine Townsite (PR#354 pp135-147).	PR#354 pp135-147
12. The Developer committed to develop activity-specific monitoring programs in relation to specific remediation components such as tailings cover construction and roaster demolition (PR#577 p129).	PR#577 p129
13. The Developer committed to modify the existing air quality monitoring program to identify action levels that trigger additional management activities through the development of the Environmental Management Plan prior to undertaking remediation activities (PR#577 p31-38).	PR#577 p31-38
14. The Developer committed to work with the City to help delineate the environmental impacts and liabilities of plans to construct a marina at the current mooring facility (PR#577 p42-47).	PR#577 p42-47
15. In the technical sessions, the Developer was asked if it would deconstruct buildings “when the wind is not blowing towards the City of Yellowknife”, in consideration of health risks from airborne releases of fine particulates including arsenic and other contaminants, of the close proximity of the site (PR#354 p227). The Developer committed to do so, saying “...yes, we will	PR#354 p228

ensure that conditions are right and that they do not add to any impacts that could occur during the demolition of a building” (PR#354 p228).	
16. The Developer has committed to continue discussions with Parties and the City to find ways in which remediation activities can support existing future land use plans.	PR#234, PR#577 p49
17. In response to concerns voiced by Parties about a lack of engagement at the Developer’s pre-hearing technical workshop in June 2012, the Developer committed to holding discussions with stakeholders at a later time (PR#516 p5).	PR#516 p5
18. Recognizing that current best practice in environmental management requires engagement of communities and citizens in the EMS (PR#579 p120), and that that “meaningful engagement is fundamental for the success of this project” (p122), The Developer committed to working with communities, the public and Aboriginal groups, to help achieve both its goals and the communities goals” (PR#579 pp122-123).	PR#579 pp122-123

Appendix D: Specific Risk Assessment Requirements

The Board expects the risk assessment described in the above Measure 5 to include:

- The compilation of a proper glossary containing a description of all the terms used in the Project and its development, especially those that might have a common use which differs from the technical meaning (such as “risk”, “crisis”, “hazard”) in compliance with ISO 31000.
- The definition of the Project context in compliance with ISO 31000, including all the assumptions on the Project environment, chronology etc.
- A properly defined hazard and risk register covering:
 - a clearly defined system of macro and subsystems/elements and their links describing for each one of them:
 - expected performances,
 - possible failure modes and
 - quantification of the related ranges (to include uncertainties) of probabilities¹³¹ evaluated as numbers in the range 0-1 (mathematical characterization) with a clear explanation of the assumptions underlying their determination, and,
 - associated magnitude of the hazards and related scenarios.
- An independent analysis of failure/success objectives.¹³²
- A holistic consequence function integrating all health and safety¹³³, environmental, economic and financial direct and indirect effects.
- Applicable published correlations¹³⁴ and information.

The Board expects the risk assessment to use a unified metric showing consequence as a function of all health and safety, environmental, economic and financial direct and indirect effects. This will be done in a manner that allows transparent comparison of holistic risks with the selected tolerability threshold (see below).

Consequences will be expressed as ranges, to include uncertainties. When evaluating the consequences, the risk assessment will:

- Explicitly define Risk Acceptability/Tolerability thresholds, in compliance with ISO 31000 international code. These will be determined in consultation with potentially affected communities, using a unified metric compatible with the one described above for consequences.

¹³¹ For the determination of the probabilities the assessors will use a selection of methods taken from ISO 31010 international code.

¹³² For example, see NASA's 2002 *Fault Tree Handbook with Aerospace Applications*. This should model success and failure with various pre-selected criteria.

¹³³ Including inference of casualties and pathologies deducted from health studies described in Measure 9.

¹³⁴ For example, using Holmes and Rae empirical correlation between “life changing units” and the likelihood to become ill due to external changes, stress, Societal Willingness to Pay, etc.

- Risks¹³⁵ and tolerability or acceptability will be developed separately, in such a way not to influence or bias judgment of the assessors or evaluators. Risks will then be grouped into “tolerable” and “intolerable” classes. The risks in the intolerable group will be ranked as a function of their intolerable part. Mitigation efforts will be allotted proportionally to that ranking.

¹³⁵ Risks = (probability (range) * Consequence (range))

Appendix E: Additional Health Risk Assessment Deficiencies

Section 8 of the evidence portion deals with the DAR and the following section deals with the Developer's 2006 Human Health Risk Assessment (HHRA) (PR#139b). The following list includes statements made in the DAR that appear to be derived from the 2006 report, but are not included in the report, as such. (A numbered summary of errors and omissions from the HHRA report is included following the section, below.)

Errors and Omissions in the DAR are as follows.

1. Use of drinking water piped from Yellowknife River as the only surface water exposure pathway for human receptors is not an accurate or sufficiently conservative approach to risk assessment (PR#139 Table 8.9.2). This results in several receptors exposures being less than what is realistic through the drinking water pathway. Some people do use the Yellowknife Bay for drinking water (eg. PR#604) and this use pattern may increase over time. Even very low concentrations of arsenic in drinking water are associated with health effects which may take decades to appear (see Item 2 below).
2. The DAR questions if long term exposure to low levels of arsenic will cause health effects (PR#139 p8-87). The DAR did not include any reference to the examples in the literature of long term exposures causing health effects, even though the studies were abundant in the literature on human health response to low levels of arsenic in drinking water from the year 2000 onward (see citations below).¹³⁶ Some of the concentrations in Yellowknife Bay are equivalent to those concentrations causing long term adverse health effects and increased mortality from cancer. A portion of the Yellowknife population still uses Yellowknife Bay as a source of drinking water. The potential for continued low to moderately high concentrations of arsenic in Yellowknife bay is a fundamental consequence of the proposed remediation case. People may begin to use drinking water from the bay in the future, especially if they are ill informed regarding risk. The literature cited in this section is being inaccurately quoted and evidence in the public domain ignored.¹³⁷
3. Despite advice from Health Canada, the uncertainty analysis does not recognize the uncertainty of including only a composite of the 11 year old and an adult in the risk evaluation, and of excluding pre-

¹³⁶ For example, West Bengali / Bangladeshi people exposed to low levels of arsenic in drinking water and the subsequent long term consequences of increased morbidity and mortality in the population, effecting thousands of people at a huge cost to human life and experience (Vahter 2008, Ferrecio 2000, Smith et al. 1992, Smith et al. 2000, Hassan and Argos 2007).

¹³⁷ The following references explain low concentration exposures in drinking water and subsequent long term health risk, at concentrations projected for surface water in the remediation case:

Vahter, M. (2008), Health Effects of Early Life Exposure to Arsenic. Basic & Clinical Pharmacology & Toxicology, 102: 204–211

Ferreccio et al. 2000. Lung cancer and arsenic concentrations in drinking water in Chile. Lippincott Williams and Wilkins. Page 673 –

Smith et al. 1992. Cancer risks from arsenic in drinking water. Environmental Health Perspectives. 97 p. 259-267.

Smith et al. 2000. Contamination of drinking-water by arsenic in Bangladesh: a public health emergency. Bulletin of the World Health Organization. 78 (9) p 1093-

Hassan and Argos. 2007. Arsenic and Cancer: a crisis in Bangladesh. Cancer Prevention. NewYork-Presbyterian Hospital News Letter. Spring 2007. Issue 9.)

born, toddlers and teens as independent receptors. The potential for pica episodes in toddlers was not included. This has potential for serious harm to human health, in the cumulative context of the remediation case, unless soil removal in yards with high concentrations of arsenic is undertaken. As there is currently no plan to remove soils that toddlers could be exposed to in N'dilo, Dettah and Yellowknife, in the future, this is an uncertainty regarding cumulative effects.

4. As pregnant women may be working on the Project, this is a direct uncertainty when pre-born are not included in the model and workers will be handling highly contaminated soils and sediments.
5. Downplaying the risk of cancer as curable and therefore not serious is inappropriate (PR#139 p8-87).¹³⁸ Comparisons of modelled data on risk from exposures to arsenic from Yellowknife versus Wawa, Ontario and Deloro, Ontario in terms of incidences of cancer in the population (PR#139 p8-87) is irrelevant, and creates the impression that actual human health data on the incidences of cancer in Yellowknife were compared to Wawa and Deloro when in fact they were not. Health Canada had advised (Mohapatra 2010, Health Canada 2007) that this was not an acceptable comparison, but the DAR retained it in the text.
6. Downplaying the risk of high arsenic concentrations that are to remain unmitigated in portions of Baker Creek in the remediation case (There *may* be the *potential* for adverse effect at upper bound concentrations" [PR#139 pp 8-79]), or to say (PR#139 s.6.8.8) "The extent and severity of effects to existing aquatic life in the creek from current contamination is unknown" when there is evidence in their own documents (Environmental Effects Monitoring studies) is potentially misleading and an omission. The DAR should have been plain in stating that there *are* adverse effects predicted to upper bound concentrations. Those concentrations are definitely high enough to cause adverse effects and do cause effects. Whole faunal assemblages are not only adversely effected, but are missing. The evidence of effects of arsenic on faunal assemblages is ignored within the documents cited.
7. The remediation case does not promise an improvement in surface water concentrations in Baker Creek. (PR#139 p8-10): the Project "will reduce the potential for water discharges to underground mine workings" only, and not remove that potential completely, therefore the potential for mine water discharges are still and eventual occurrence. Limited or restricted improvements to surface water concentrations in Baker Creek are subsequently limited or restricted improvements to surface water concentrations in Yellowknife Bay. As the construction phase of the project is expected to cause discharges, the increase in arsenic in surface water over the construction phase is a risk that should have been more completely examined and mitigated.
8. The reference to store-bought foods having higher arsenic concentrations than local country foods (PR#139 p8-84) is true if shellfish is the only food consumed. If shellfish and other marine fish are removed from the store bought diet, the local country foods diet is higher, especially for truly local sources.

¹³⁸ The DAR states "Evidence from many studies shows that long term intake of arsenic at sufficiently high rates results in some cancers. The skin cancers predominantly occur as squamous cell and basal cell carcinomas, which are highly treatable if detected in time. Ingestion of inorganic arsenic has also been reported to increase the risk of cancer in the bladder, lung, liver, kidney and prostate and other health related effects of a of less serious nature" (PR#139 p8-87).

Shortcomings in the 2006 HHRA are as follows:

1. Drinking-water exposures are based on tap water originating from the Yellowknife River, and not from Yellowknife Bay. This is inaccurate for that proportion of the population that uses water from south of N'dilo / Latham Island, or for occasional use of water from the bay in future (PR#139b Table 2.3-1). This is an error and an omission.
2. All media concentrations except water concentrations are presented in the Appendices of the DAR, and many are based on sources older than a decade from potentially non-comparable data sources.
3. More recent surface water data were not used, and the 2006 human health risk assessment [PR#139b] claims there is no difference between the two data sets, but does not show the test for this lack of significant difference. The older water data from various sources was used, but the data are not provided. This is an omission, and possibly an error.
4. Use of a composite receptor (adult plus 11 year old) (PR#139b p6-54) that does not include toddlers or pre-born results in an underestimate of the potential risk to the most vulnerable and susceptible age group.
5. The analysis and interpretation of large chunk of soil ingestion as potential pica episodes was not considered for toddlers (*Calabrese et al*).
6. The analysis does not evaluate a range of slope factors, despite advice from Health Canada to do so. The analysis does not include entirely site specific, local risks from exposures-- it uses country food concentrations from all of NWT. (PR#139b p2-9). It used arsenic concentrations from terrestrial animals from the Yukon and NWT wide studies. Bird tissue concentrations were sourced as from the Canadian Arctic (PR#139b p2-10). Conversely it recognizes that local fish tissue can have an impact on exposure (p6-40) but does not elaborate on what risk is presented from this exposure. As local fish are a large proportion of Dene diets, this is a statement that should have been elaborated on. Given that some of the local tissue arsenic concentrations are likely over guideline levels for exposures, and potentially present risk to consumers, more site specific data for other components of the country foods diet should have been obtained and used in the modelling.
7. Although the methods are not clear, the analysis used in the conclusions from the human health risk assessment was based on a geometric mean and not the 95th percentile. The use of the geometric means substantially masks some very high spiking values in the exposures. The 95th percentile should have been examined, data displayed, and risk identified and ruled out, if reasonable to do so.
8. The acceptance and planning for a 340 ppm remediation case in soil presents future risk to human health, especially if any use of the site is allowed in the future, but also from wind borne dust deposition and exposures into the future.

Appendix F: Human Health Risk Assessment Requirements

For clarity, the Board expects that the human health risk assessment described in the above measure will, at a minimum:

1. Include a critical review of the 2006 Tier II risk assessment [PR#139b] and the previous screening reports, and based on this, consider the valid results of the Tier II risk assessment in its recommendations or discussions;
2. Consider baseline historical data (CPHA 1977), current Canadian Guidelines for human and environmental exposures to arsenic, and baseline studies
3. Review the existing distribution of concentrations of arsenic in various media effecting humans and the environment of Yellowknife and surrounding communities and compare these with the range of concentrations and exposures in the current literature on human and environmental health impacts;
4. Conduct a Risk Assessment Sensitivity Analysis that completes the evaluation of pre-born, toddler, child, teen and adult receptors in all four localities of the mine site (N'dilo / Latham Island, Yellowknife and Dettah) without combining these receptors into a composite receptor (PR#139b);
5. Evaluate impacts on toddlers considering potential soil pica episodes and acute arsenic toxication (per *Calabrese, et al.* 1997). The results of this component of the risk assessment should be used to inform and assist the health effects monitoring program described below;
6. Consider a range of current cancer slope factors to evaluate and explain the results of the analysis. This will:
 - a. use the most conservative approach to most accurately reflect potential increased susceptibility from early life exposures to carcinogens;
 - b. include a particular focus on the Yellowknives Dene and lifetime Yellowknife residents, who are most likely to reside within the realm of exposure to arsenic from the Giant Mine Remediation Project for their entire lifetime; and
 - c. consider long term cumulative exposure from pre-born to adult stages.
7. Use data that reflect site-specific local concentrations that people are exposed to, instead of regionally or territorially averaged measures, for any of the consumed items in the models. This must consider:
 - d. concentrations in local soils, sediments, drinking water, traditional foods and store-bought food as well as local aerial emissions. In the case of wide ranging animals used as food such as caribou, it is permissible to use data that are relevant to the local hunting patterns of the receptors;
 - e. worst case scenario exposures as well as local (not regional or territorial) averaged exposures.
8. Compare the identified arsenic levels with thresholds from a range of guidance available for the use of various Toxicological Reference Values and their equivalents (HC 2010¹³⁹), identifying where Toxicological Reference Values and equivalents are exceeded, and interpreting the importance of any such exceedances;

¹³⁹ Health Canada 2010. Federal contaminated site risk assessment in Canada, Part V: Guidance on human health detailed quantitative risk assessment for chemicals. ISBN: 978-1-100-17926-1

9. Consider potential impacts of soil concentrations on receptors, and apply the results to the human health monitoring program.
10. Use recently collected water data to reflect current conditions, instead of the surface water data from the late 1990s in some localities used in the 2006 Tier II study.
11. Provide guidance and interpretation of the current and predicted exposures, subsequent human health risk, and risk management to the health effects monitoring program. This will include exposure data with ambient concentrations in soil, water and air, geographically displayed and interpolated if feasible, to indicate where risk is presented to human populations; and
12. Evaluate indirect effects of potential exposures to arsenic on wellness, including stress effects.