INFORMATION REQUEST RESPONSE

EA No: 0809-001 **Information Request No: Review Board #01**

Date Received:

February 14, 2011

Linkage to Other IRs

Date of this Response:

May 31, 2011

Request

Preamble:
The DAR makes much reference to the ongoing Freeze Optimization Study (FOS), which was initiated in June 2009 to investigate and optimize the active / passive / hybrid freezing options. Objectives of the study are presented in DAR s. 6.2.9.1. However, in order to address various points listed in the ToR, the DAR states:

- "Advantages and disadvantages of the two approaches are being further investigated in the FOS that commenced in June 2009". (DAR s.6.2.3, p. 6-12)
- "A program to test methods for creating backfill plugs forms part of the FOS". (DAR s. 6.2.5.2, p.6-17)
- "The FOS is expected to result in improvements to the parameter estimates, which could lead to changes in pipe spacing, drillhole numbers and total lengths". (DAR s.6.2.5.3, p.6-22)
- "Surface drilling methods under investigation in the FOS include mud rotary, downhole hammer and coring". (DAR s.6.2.5.3. p 6-23)
- "An alternative hybrid system that is being tested in the FOS involves the delivery of primary coolant directly to the point of heat exchange with the carbon dioxide". (DAR s.6.2.5.5., p. 6-26)
- "Several instrument types are being tested in the FOS. […] Methods for handling the expected large volumes of monitoring data are also being tested in the FOS". (DAR s. 6.2.5.6., p 6-27)
- "The most effective methods to accomplish each step remain under investigation, principally through the ongoing FOS. […] However, results of the FOS are required before those estimates can be confirmed or improved. […] Results of the FOS will allow improved modelling of the freezing process. The target criterion of -5°C is not expected to change, but revisions to the modelling may indicate slower freezing rates". (DAR s.6.2.6, p 6-29 – 6-30)
- "As noted above, results of the FOS will be assessed to confirm or improve the parameters used in the 2006 modelling". (DAR s.6.2.7.2, p 6-31)
- "The ability to overcome these limitations is being tested in the FOS". (DAR s.6.2.8.3, p 6-39)

The freeze technology is extremely important to the success of the remediation program. One and a half years of data should now be available from the study.

Question:
Please present the initial results, findings and conclusions of the Freeze Optimization Study to date. It is understood that this is an ongoing study and not all questions may be answered at this point. However, the study is expected to provide important information relevant to many of the predictions in the DAR. Please apply the most recent data from the FOS in answering ToR s 3.3 (Arsenic Containment), points 1, 2 and 8.

Reference to DAR (relevant DAR Sections):

S. 6.2. Arsenic Trioxide Dust Storage Areas

Reference to the EA Terms of Reference

S.3.3 Arsenic Containment

Summary

Although construction of the Freeze Optimization Study (FOS) started in June, 2009, the freezing system was completed and turned on only in March, 2011. Due to the very limited duration of freezing so far, no conclusions can be drawn about the design or expected performance of the full-scale system. Interim data reports will be issued periodically with the first report expected in June, 2011.

Response

Points 1, 2 and 8 in ToR Section 3.3 deal with implementation of the frozen block method, saturation of the arsenic trioxide dust and the longevity of the cooling system, respectively. The results of the FOS are expected to inform design and implementation of the frozen block method. The current study plan does not include any testing of saturation, nor any investigations specifically targeted at system longevity.

Construction of the FOS began in June, 2009. The work completed in 2009 included surface preparation, drilling and installation of freeze pipes and thermosyphons from surface, development of access to the underground freeze pipe locations, and drift plugging trials.

Above-ground infrastructure and underground freeze pipes were installed in 2010 and early 2011. This work included the installation of freeze plants for the active and hybrid freezing systems, power supply, piping distribution systems to surface and underground freeze pipes, and a data collection and management system.

Installation and commissioning of the thermosyphons was completed at the end of February, 2011. Active freezing began following commissioning of the freeze plants in early March, 2011. Attached to this response are a selection of as-built drawings that detail the general layout and location of the freeze pipes and monitoring points. The following bullets list the key features that can be found in each drawing:

- Drawing C04 provides the layout of all of the surface drillholes, including locations of the freeze pipes and instrumentation drillholes.
- Drawing C05 indicates the freezing technology being tested in each group of drillholes. Groups B, F, and G consists of hybrid thermosyphons, each with a different pipe diameter ranging from 2.5 inches to 4 inches. All other groups consist of active freezing pipes, but with different connection arrangements in parallel or serial.
- Drawing U02 provides the layout of the horizontal freeze pipes and instrumentation installed in horizontal drillholes beneath the chamber.

The experience with system construction will assist the engineering team in scheduling and estimating costs for full scale implementation. For example, three drilling methods were tested and the results give a clear indication of the accuracy and advance rates that can be expected for each method.

No conclusions about the performance of the active or hybrid freezing systems are yet available. Passive ground cooling began only with the charging of the thermosyphons in February, 2011, and active and hybrid freezing only in March, 2011. Results from the study will be released on an ongoing basis. However, conclusions will only be possible once the study is complete. The current expectation is that the FOS will run until 2012 to provide a full year of data. Complete analysis of these data would take at least another couple of months.

INFORMATION REQUEST RESPONSE

EA No: 0809-001 **Information Request No: Review Board #02**

Date Received:

February, 14 2011

Linkage to Other IRs

Review Board IR #7

Date of this Response:

May 31, 2011

Request

Preamble:
The DAR makes reference to the FOS (see IR 1 above), but does not clearly state how the frozen block is created and controlled. In particular, the creation of a frozen (not sub-zero) curtain in the surrounding rock is still unclear. The DAR states:

"Step 1 Creating the Frozen Wall […]
The objective of the first step will be to create a frozen zone around each storage area that is wide enough to prevent any outflow of water or soluble arsenic trioxide when the chamber or stope is flooded".

"Step 2 Wetting the Dust
Complete […] saturation of the dust is not required; the "frozen block" concept only requires that a large mass of frozen water be developed somewhere within each chamber or stope. […] The dust is thought to be quite open, with porosity estimated at up to 60%. The high porosity and the high latent heat of freezing water means that if water at even 1 or 2°C is added to the dust, it will infiltrate before it freezes. On the other hand, tests to date indicate that the dust has a relatively low hydraulic conductivity, estimated at 7x10-7 m/s. Based on these estimates, simply adding water to the surface of the dust and allowing it to infiltrate would be feasible but slow, taking up to several months in the larger chambers".

Question:
1. The frozen wall concept appears to be based on the assumption that potential water will freeze in situ if it reaches the -10°C curtain as the chambers and stopes are wetted. Please clarify why the creation of the frozen wall appears to be based only on temperature and not on the existence of actual ground ice.

2. Please clarify why the "frozen block" concept only requires that a large mass of frozen ground, and provide any references to potential models, concepts or laboratory investigations that would support this statement. Please clarify the meaning of "large" in this context.

3. There seems to be a contradiction between the high porosity requirement for non-saturated conditions and the low hydraulic permeability. The DAR states that water will infiltrate before it freezes because of the latent heat effect, but on the other hand, the hydraulic conductivity is relatively low. Please present analytical data, numerical models or laboratory investigations to support this assumption.

Reference to DAR (relevant DAR Sections):

S.6.2.6 Initial Freeze

Reference to the EA Terms of Reference

S.3.3 Arsenic Containment, Point 2

Summary

Measurement of ground ice in bedrock with a low porosity is impractical, while temperatures can be monitored easily and reliably.

Thermal modeling initially presented in the Remediation Plan shows that complete and uniform saturation of the arsenic trioxide dust is not required. Requirements and methods for distributing water within the dust remain subjects of ongoing investigation and detailed design.

The calculations and supporting statements in the DAR regarding the rates of wetting and freezing are presented.

Response 1

Details of the initial freeze criterion can be found in Supporting Document J1 of the Remediation Plan - Conceptual Engineering for Ground Freezing (SRK, 2006).

The -10^{o}C frozen shell is situated in the bedrock around the chambers. This bedrock has a very low porosity, estimated to be in the range of 0 to 1% based on the recovered rock cores and available literature. Measurement of ground ice in a medium with such low porosity is impractical, while temperatures can be monitored easily and reliably.

Ground freezing projects commonly adopt a series of temperature criteria to determine when the ground is adequately "frozen". Water in the ground begins to freeze at 0^{o}C, but can remain unfrozen or partially unfrozen at several degrees lower, due to the effects of solutes in the water and the capillary forces exerted by matrix pores. For example, saline water with a NaCl concentration of 30% will freeze at -2°C instead of 0°C for pure water and the capillary force of a fissure of 1 micrometer will depress the freezing temperature by 0.05°C. Furthermore, it is impractical to monitor all of the frozen area, and allowance must be made for variability. Therefore, it is good engineering design practice to adopt temperature criteria that are significantly below 0°C, and to specify a distance over which such temperatures must be measured before the ground can be considered to be adequately frozen.

The initial frozen shell criteria of a -10°C temperature over a width of 10 m were selected to be conservative. They are the same criteria as were adopted at the McArthur River uranium mine in northern Saskatchewan, where ground freezing is used to provide a 'freeze curtain' that isolates the mine working from an adjacent rock layer containing high pressure groundwater. Section 3.2 of the Conceptual Engineering for Ground Freezing (SRK 2006) report provides a list of bullets comparing the McArthur River Mine to the Giant Mine providing additional rationale as to why the initial freeze criteria selected for the Giant Mine project are conservative.

Response 2

The wording in Section 6.2.6 of the DAR is intended to draw a distinction between "wetting" and "saturation" of the dust. Both the Remediation Plan and the DAR Terms of Reference had used the term "saturation", implying a complete and uniform distribution of water to fill all of the pore space within the dust. The use of the word "wetting" in the DAR is intended to imply that complete and uniform distribution of the water is not essential. That intent is clearer when the entire paragraph is quoted. For example, the last sentence clarifies the paragraph's intent by adding the caveat "However, it would be desirable to distribute the water as much as possible throughout each chamber and stope prior to freezing".

Similarly, the use of the term "large" in Section 6.2.6 is in the context of a plain English description, rather than an engineering specification of a particular size.

The basis for these statements is a series of modeling results such as were presented in Table 3.3 of Supporting Document J1 of the Remediation Plan - Conceptual Engineering for Ground Freezing (SRK, 2006). Those simulations provided predictions of thawing times assuming that the freezing system, either active or passive, is removed after 25 years. The table is repeated below. The second and third rows compare thawing times for cases where the dust in Chamber 12 is fully saturated and 10% saturated. Both rows indicate that it will take a very long time for the outer edge of the dust to reach 0°C. Complete saturation appears to provide little benefit in this analysis.

A similar pattern is expected in other cases. However, there are combinations of frozen zone distributions and thawing locations that show more rapid thawing. For example, the top surface of the dust is predicted to thaw more quickly in cases where the water is assumed to fill only the bottom 80% of a chamber than in cases where the water is uniformly distributed. These considerations are being taken into account in the later phases of design and will lead to a better definition of the "wetting" or "saturation" requirements.

Table 3.3 Time predictions of thawing

Area	Stope	Dust	Thaw Index n_t	Thawing time for outer edge of dust to reach threshold temperature after the removal of artificial freezing at year 25			
				-10 °C	-5 °C	-1 °C	0 °C
				Time (years)	Time (years)	Time (years)	Time (years)
1	12	saturated	1	4.5	14	> 50	> 50
		saturated	2	3.1	8.2	18.1	26
		unsaturated deg. sat. 10%	2	3	7.8	18	21
2	C212, 10	saturated	2	10	28	> 50	> 50
3	B230, B233, B234	saturated	2	12	27	> 50	> 50
4	B212	saturated	2	4.8	12	30	41

Response 3

Section 6.2.6 of the DAR clearly states that alternative methods of wetting the dust remain under consideration. Rather than trying to test or model the details of a particular implementation, the DAR seeks only to examine the fundamental limitations provided by the low hydraulic conductivity of the dust and the thermodynamics of freezing.

The section states that adding water to the surface of the dust and allowing it to infiltrate would be "feasible but slow, taking up to several months in the larger chambers". Table 1 provides the calculations for the chamber filling time assuming ponded infiltration for a range of different chamber sizes. The calculations assume that the water is injected uniformly across the top of the dust and infiltrates downward under a unit hydraulic gradient. The calculations indicate filling times ranging from 3-7 months. But it is recognized that the process of infiltration into an unsaturated medium is more complex than this simple calculation. So the DAR states only that the process would take "several months".

Table 1: Calculations of Chamber Filling Time Assuming Ponded Infiltration

Chamber dimensions			
Chamber	**10**	**B212**	**B230**
Length, (m):	26	52	23
Width, (m):	11	31	9
Total Volume, (m^3):	5700	25700	2800
Porosity:	0.59	0.59	0.59
Void Volume, (m^3):	3336	15040	1639
Darcy's Law assuming unit hydraulic gradient			
Hydraulic Gradient, (m/m):	1	1	1
Maximum Area, (m^2):	286	1612	207
Flow Rate, Q (m^3/s):	2.00E-04	1.13E-03	1.45E-04
Filling Time (s):	1.67E+07	1.33E+07	1.13E+07
Days:	**193**	**154**	**131**

Source: Arsenic_Dust_Wetting_Calculations.xlsx

Table 2 summarizes the calculations used to compare the amount of heat required to warm arsenic trioxide dust to the latent heat required to freeze the infiltrating water.

Scenarios 1 to 3 assume a range of dust heat capacity values, representing dry, saturated frozen and saturated unfrozen dust. Each of these scenarios assumes that the dust is initially at -10°C. Scenario 4 uses worst case properties for the dust: the typical dry bulk density is doubled, the porosity is lowered by half to 0.3, the highest heat capacity is assumed, and the initial temperature is set to -15 °C. Even under the extreme scenario 4 assumptions, the heat required to freeze the water is greater than the heat required to warm the dust to 0°C. These calculations indicate that the dust will warm before the water will freeze or, in other words, the dust is not cold enough to freeze the infiltrating water.

Once again it is recognized that a full analysis of the infiltration of water into unsaturated cold dust is more complex than the simple calculations indicate. A full treatment would require, amongst other things, laboratory testing of the dust's unsaturated hydraulic and thermal properties. The project team is not against embarking on such a program if the need is clear, but currently a number of wetting methods remains under discussion. The testing requirements associated with each method form part of that discussion.

Table 2: Numerical Comparison of Heat Required to Freeze Water Vs. Heat Dust

	Scenario 1: Dry Heat Capacity	Scenario 2: Saturated Frozen Heat Capacity	Scenario 3: Saturated Unfrozen Heat Capacity	Scenario 4: Extreme Worst Case	Units
Dust properties					
Bulk Dry Density, ρ_b	1402	1402	1402	2800	kg m^{-3}
Specific Gravity	3380	3380	3380	3380	kg m^{-3}
Porosity, ϴ	0.59	0.59	0.59	0.30	
Heat Capacity, c_g	0.6	1.06	1.71	1.71	kJ kg^{-1} $°C^{-1}$
Initial As Temperature, T	-10	-10	-10	-15	C
Heat required to raise dust to 0° C					
Heat	**8,412**	**14,861**	**23,974**	**71,820**	**kJ m^{-3}**
Heat required to freeze the water					
Saturated water content, γ_f	585	585	585	300	kg m^{-3}
Latent heat of freezing, L_f	-334	-334	-334	-334	kJ kg^{-1}
Heat reqd to freeze sat. dust	**-195,459**	**-195,459**	**-195,459**	**-100,200**	**kJ m^{-3}**

Source: Arsenic_Dust_Wetting_Calculations.xlsx

- In Table 2, the heat required to raise dust to 0°C is calculated as: $H = \rho_b \times c_g \times \Delta T$ where ΔT is the change in temperature from its initial temperature to 0°C.
- The heat required to freeze the saturated dust is calculated as: $H = \gamma_f \times L_f$

INFORMATION REQUEST RESPONSE

EA No: 0809-001 **Information Request No: Review Board #03**

Date Received:

February 14, 2011

Linkage to Other IRs

Review Board IR #8, #12 – 15
Environment Canada IR #4, 6

Date of this Response:

May 31, 2011

Request

Preamble:
The DAR provides some general comments on the long-term behavior of the frozen block:

- "[…] even after 100 years of sustained global warming, the currently assumed number of thermosyphons is likely to be adequate to counteract thawing."
- "[…] It is recognized that the developer's activities on site will continue in some form in perpetuity" (DAR, p. 3-6).

Based on the current DAR it is difficult to predict the potential effort required in the future to maintain the arsenic trioxide encapsulated in frozen block. No considerations, general sensitivity or hazard analysis were presented that would allow for a better assessment of the long-term risks associated with the assumption that the frozen block will exist for perpetuity.

Question:

1. Please provide results of sensitivity analysis, that, independent on any assumed climate change scenario,
   a. show the minimum air freezing index / average seasonal air temperatures required for the frozen block to remain frozen using the passive cooling method;
   b. provide information on the energy consumption required as a function of various air temperatures for an active / hybrid system; and
   c. provide estimates of thaw times as a function of various air temperatures, assuming that active, hybrid or passive systems fail.
2. Please present a series of graphs showing these trends.
3. Please provide electricity demands and related costs if active or hybrid freezing is required over the long term.

4. Please provide a best estimate on the sensitivity of these initial analyses based on current FOS findings. Because the final design strongly depends on the results of the FOS, it is recognized that the results will be initial estimates.
5. Please describe in detail the assumptions about groundwater volume, velocity, temperature and thermodynamics underlying the expectation that passive cooling will be adequate for the long term. Describe available management options should this be the case, and discuss their financial feasibility and implications.
6. Discuss the probability and consequence of a combination in increased groundwater, hydraulic connectivity by unidentified drill holes and voids, thermal loading from saturation water escaping from voids, leaked saline coolant from ruptured pipes, or other factors preventing the initial freeze.

Reference to DAR (relevant DAR Sections):

S.6.2.7 Long-term Freeze Maintenance
S.6.2.8.2 Thawing and Climate Change

Reference to the EA Terms of Reference

S.3.3.1 Arsenic Containment – Detailed Description of Frozen Block, Point 1 b/c
"With the best available information, a prediction of the amount of active freezing, the amount of passive freezing, power requirements, numbers and general locations of thermosyphons that will be necessary to achieve stability (referring here to a state where active management of the site is no longer necessary)."

"An illustration of the stability of the proposed system for a duration of at least 100 years after converting the active freezing system into a passive system."

Summary

Sensitivity analyses are presented for the effects of a range of mean annual air temperatures on:

- the number of thermosyphons required to maintain stability for Chamber 12;
- the time required for the edge of the chamber to reach 0^{o}C; and
- long-term annual energy consumption and power costs for an active freeze plant.

Results of the sensitivity analysis confirm that the thermosyphons provide more than adequate cooling power in the event of the worst case climate change scenario, as defined by the Intergovernmental Panel on Climate Change (IPCC).

A hypothetical scenario is analyzed to show that additional heat provided by groundwater flow, even through an entirely open drift, would be easily removed by the planned thermosyphons.

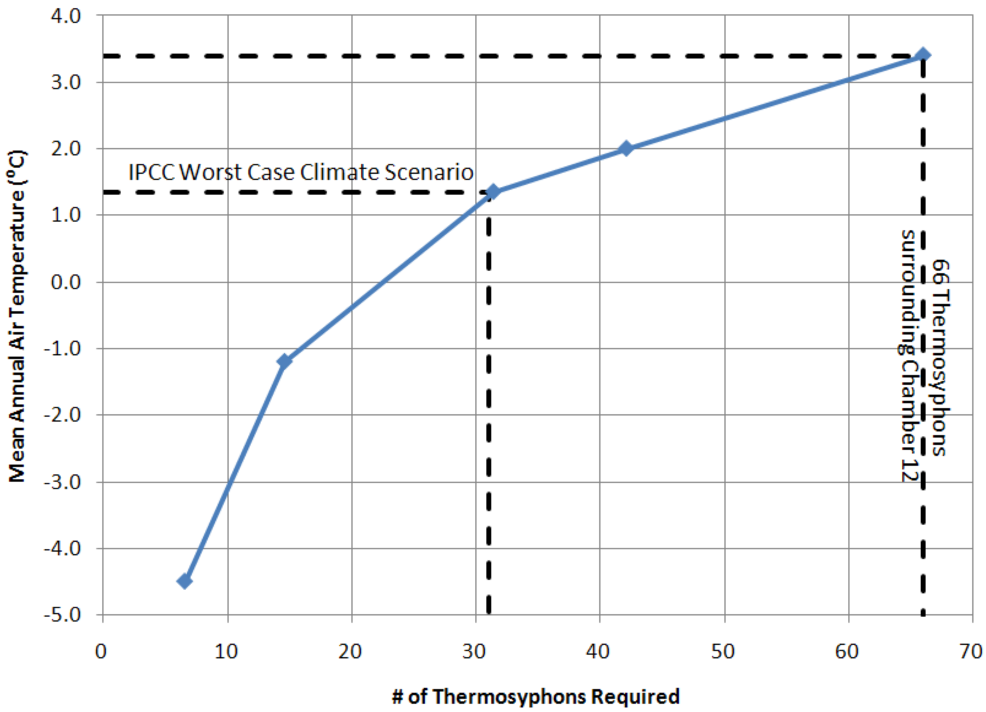
Response 1a

Section 6.2.8.2 of the Developer's Assessment Report (DAR) presents a simplified model for Chamber 12 that evaluates the theoretical number of thermosyphons required to maintain stability for various climate change scenarios. Chamber 12 was used in the calculations as previous model simulations have shown it to be the most sensitive to thawing due to its location in a prominent bedrock outcrop. The resulting number of thermosyphons ranged from 13 to 52 for the IPCC worst case global warming scenario. As the current plan includes 66 thermosyphons around the chamber, the simplified model concluded that there is adequate cooling capacity to keep Chamber 12 frozen. Further details of the model calculations are presented in Section 6.2.8.2.

The simplified model presented in the DAR assumed each thermosyphon had a radiator size of 19.5 m^2. The thermosyphons currently used in the FOS have 39 m^2 sized radiators. The figure below shows the results of the same calculations, using the revised thermosyphon radiator size and a wider range of climate change scenarios. The scenarios have mean annual air temperatures ranging from the current -4.5 ^oC to +3.4 ^oC.

Calculations using a mean annual air temperature of 3.4 ^oC resulted in 66 thermosyphons being required, matching the layout shown in the DAR. The DAR describes the simplifying assumptions used in the analysis. The limitations means the model should not be relied upon for design, but does show the robustness of the current concept.

Figure 1: Simplified Model Sensitivity Analysis for Thermosyphon Performance at Chamber 12



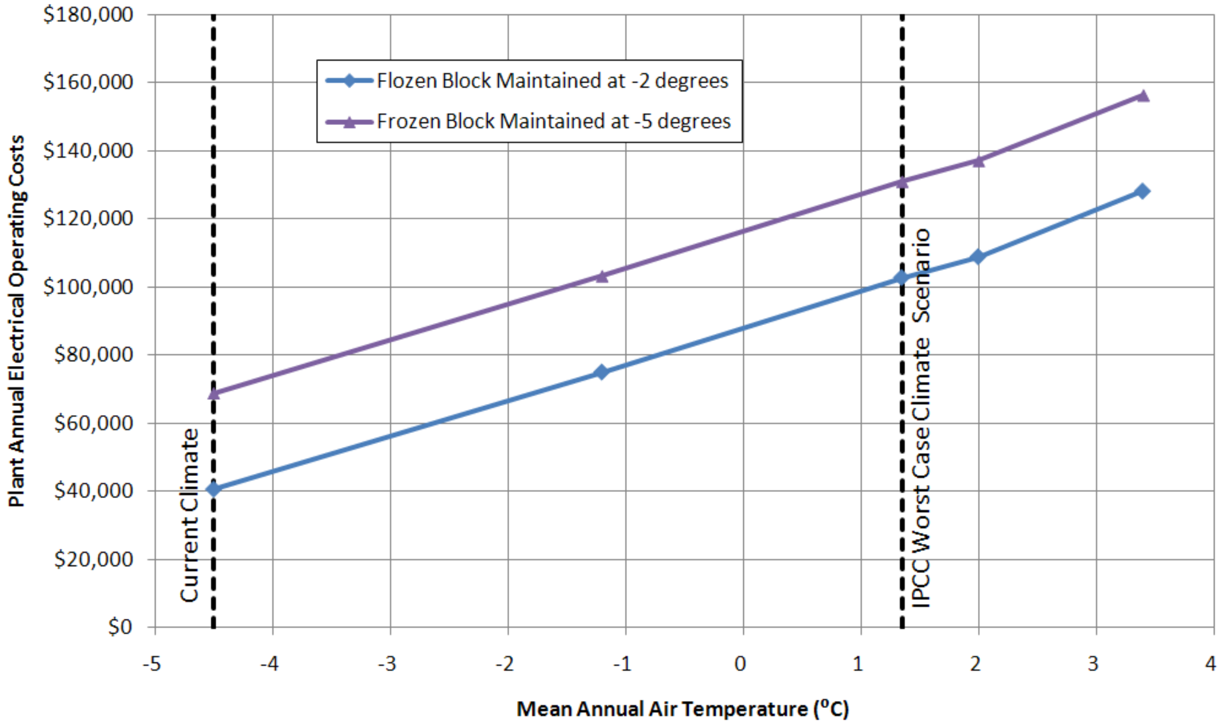
Response 1b

The same simplified model presented above and in Section 6.2.8.2 of the DAR was used to estimate electricity requirements for an active freezing system. Heat flux estimates into Chamber 12 were derived for the same range of temperatures and using the same methodology described in Section 1A (above). The resulting heat flux was then used to estimate the heat extraction per pipe for the entire site. This method is likely to be conservative as Chamber 12 has a larger in-flux of heat than other chambers due to its location on a bedrock outcrop.

Estimates of the annual electricity costs for all chambers and stopes are shown in Figure 2 (below). They were calculated using the methodology described in the report "Conceptual Engineering for Ground Freezing" and an assumed power cost of $0.12/kWh (2006). Costs are shown for two cases, one with the frozen blocks maintained at -5°C and the other with the frozen blocks allowed to reach -2°C. Allowing the frozen blocks to reach the higher temperature would reduce the temperature gradient between the ground surface and the frozen block, resulting in lower electricity costs.

The estimates in Figure 2 are for a fully active system. If a hybrid system were installed, electricity costs are expected to be significantly less.

Figure 2: Simplified Model Sensitivity Analysis of Long-Term Electrical Operating Costs for an Active Freeze Plant

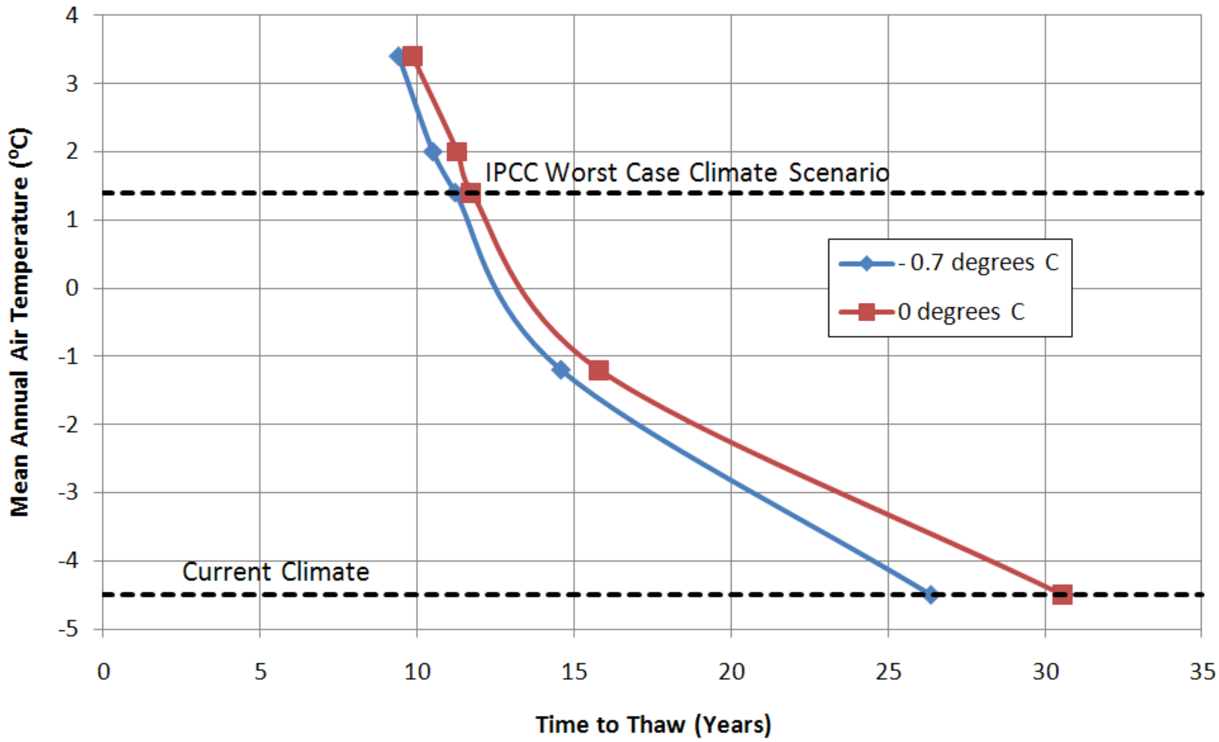


Response 1c

For the hypothetical scenario of a complete failure of all of the thermosyphons, the thaw times for Chamber 12 were estimated over the same mean annual temperature range presented in Section 1A (above). Thaw times are presented as the time required for the edge of the chamber to reach -0.7 °C (start of phase change for the arsenic dust) and 0°C (end of phase change). The model simulations were the same as those presented in Figure 3.13 of the "Conceptual Engineering for Ground Freezing" report.

The model simulations are similar to those reported in Table 3.3 of the "Conceptual Engineering for Ground Freezing" report which predicts a 26 year thaw time for the 0°C isotherm to reach the top of the chamber. The minor variation in results is due to the exact monitoring point for the model not being known. The variation in results would become smaller for higher mean annual air temperatures. The results show that for the worst case climate scenario, as defined by IPCC, the shortest thaw period for all of the chambers would be over 10 years.

Figure 3: Time for Ground Surface Thaw Zone to Reach Top of Chamber 12 for Case with No Thermosyphons and Various Mean Annual Air Temperatures



Response 2

See graphs in Section 1.

Response 3

If additional cooling capacity is required once the passive system is in place, it would most likely be to address a local area of deficiency and the most economical option would be to install additional thermosyphons within the localized area.

However, in the unlikely event that active or hybrid freezing is required over the long term, Section 1b above provides estimates of the annual electrical demands and power costs for freeze plant operation for various mean annual air temperatures. Other related costs include maintenance of the freeze plant. Maintenance for the long-term active freezing system would be similar to that for the initial active freezing system, which has been estimated at an average annual cost of $272,000. That cost is only about $62,000 per year higher than estimated long-term care and maintenance costs for the passive freezing system.

Response 4

The ground freezing system in the FOS was only turned on in March 2011. Data collected to date are preliminary only and do not change the sensitivity analyses presented in Section 1.

Response 5

The long-term groundwater level within the mine will be controlled by the year-round removal of minewater for treatment. Flooding of the mine to levels that would allow groundwater to contact the frozen blocks would only occur in the unlikely event of a failure of the pumping system. A long-term condition where groundwater contacts the frozen blocks would require that the pumping failure be completely un-mitigated over the long-term.

The extensive groundwater modeling reported in Supporting Document C6 of the Remediation Plan indicates that, even in that very unlikely scenario, the groundwater gradient in the mine area would be extremely low (0.0002 m/m), and that by far the majority of the flow would be through the drifts and other man-made voids. Flow within bedrock, including around the perimeter of frozen blocks, would be insignificant.

To address whether groundwater flow through an open drift or void could have an impact on passive cooling, a worst-case scenario was analyzed. The scenario assumes that a flooded and unplugged drift, 5m wide and 3m high, runs parallel to and along the full length of Chamber 12. (No such drift exists, the assessment is hypothetical only.) Heat from groundwater flowing in the drift then travels through the rock to the edge of the frozen block, which is assumed to be only 5 m away. The groundwater is assumed to be at +4 ^{o}C. The heat transferred to the frozen block can be estimated from:

$$Q = \frac{kAL(\Delta T)}{d}$$

where: Q is the heat flux (J day^{-1} m^{-1})
k is the bedrock thermal conductivity (300 kJ day^{-1} m^{2} ^{o}C^{-1})
A is the drift's surface area per linear m, i.e. its perimeter (30 m)
L is the length of Chamber 12 (62 m)
d is the distance between the drift and the frozen wall (5m)
ΔT is difference in temperature between the frozen wall (-5 ^{o}C) and water in the drift (+4 ^{o}C)

The resulting estimated heat transfer is 536 MJ/day. Using the simplified model presented in Section 6.2.8.2 of the DAR, one thermosyphon can remove 240 MJ/day of heat from a frozen block at -5^{o}C. The implication is that, even in this very unlikely scenario, all of the heat contributed by the groundwater could be removed by less than three "extra" thermosyphons. Figure 1 above shows that that the Chamber 12 area plan has over 30 thermosyphons more than the minimum needed to maintain the frozen block, even under the worst case climate scenario.

The management actions for mitigating scenarios like the above would start with mitigating the pumping failure that led to the loss of control over groundwater flow. That would be necessary in any case, in order to continue minewater extraction and treatment.

In the event that uncontrolled groundwater flow was allowed to continue, it would be necessary to review ground temperature monitoring data to identify if and where any thawing was occurring. At the rates of heat transfer estimated above, thawing would be very slow and there would be many years of time for any necessary further investigations.

Again continuing with the assumption that nothing is done to control the overall minewater level, local groundwater flows could be mitigated by constructing remote plugs within the drifts of other conductive features. The plan is to plug all such features prior to the initial freeze, when they are more easily accessible. But if necessary there are methods to remotely place plugs in flooded mine workings.

Another option would be to increase the local cooling capacity. That could be accomplished most simply by installing additional thermosyphons. The annual care and maintenance costs for the passive freezing system include an amount equal to 1% of the initial construction cost, which could easily pay for installation of the three additional thermosyphons required under the above scenario.

Response 6

The factors listed in the information request (groundwater, hydraulic connectivity, coolant leaks, and thermal loading) are either independent or occur during different stages of the freezing process.

During the initial stage of freezing, when the frozen shell is established, the minewater and groundwater levels will be well below the bottom of the lowest chambers and stopes.

The coolant currently being used during active freezing for the FOS is Dynalene HC-40. Any loss of fluid would be detected as a loss of pressure in the piping, and the affected portions of the freeze system would be shut down and assessed. As the bedrock conductivity is low, the loss of fluid within the bedrock would be small. Flow would further be impeded by frozen bedrock conditions.

Water will first be introduced into the stope and chamber areas during the wetting of the arsenic trioxide dust. Wetting will only be initiated after the frozen shells have formed a 10 m wide frozen zone at a temperature below -10^{o}C. The likelihood that an unidentified drill hole or void passing from the chamber to outside of the freeze wall will remain undetected and unsaturated is low. The possibility of water escape through such features is discussed in the response to the Review Board's IR08.

INFORMATION REQUEST RESPONSE

EA No: 0809-001 **Information Request No: Review Board #04**

Date Received:

February 14, 2011

Linkage to Other IRs

Date of this Response:

May 31, 2011

Request

Preamble:
Certain additional technical details are required to properly evaluate the freezing properties of the arsenic block and surrounding ground. This freezing is fundamental to the project. The frozen block concept requires that the ground is frozen, meaning that the all pore water in the ground is completely frozen and the hydraulic permeability is reduced to a very small value. The following values can be found in the DAR:

- "Thermal Conductivity, Frozen = 0.093 W/(mk); Unfrozen = 0.100 W/(mk)" (DAR, p. 5-3)
- "Freezing point of saturated solution -0.7ºC" (DAR, p. 5-3)
- "Thermodynamic considerations show that the most important component of that resistance would be the transition from about -1ºC to just above 0ºC (i.e., the point where the ice would have to be melted). Cooling of the block below that range provides little additional benefit. For that reason, the target of -5ºC has been selected as the criterion for declaring the chambers and stopes to be adequately "frozen" and "safe for the environment". (DAR, p. 6-30)

However, the DAR does not present a detailed assessment on temperature dependent hydraulic or thermal conductivities and does not seem to consider that the phase change is likely at a range different than the stated -1ºC to just above 0ºC. Laboratory tests presented by SRK (Memo entitled: "Physical properties of overburden, bedrock and arsenic dust", 5.9.2005) show that at temperatures of -8°C, the unfrozen water content can be as high as 8 Vol.-%, which affects its hydraulic permeability. In addition, a chemical rejection is to be expected, potentially changing the arsenic trioxide concentration as the chambers freeze, further affecting the freezing point of the ground.

This uncertainty is also reflected in the utilization of the term "thaw". It is unclear whether this means unfrozen conditions, i.e. >-0.7ºC, assuming the conditions in the ground are homogeneous everywhere and similar to the ones of the sample tested in the lab, or if thaw simply refers to >0ºC. E.g. in the long-term stability assessment the developer writes: "After 20 or more years of the above conditions, the dust at the top of some of the chambers would just be beginning to thaw" (DAR, p. 6-33). Further, natural changes in groundwater levels may, in combination with thaw of the frozen block (controlled or uncontrolled), result in hydraulic gradients that would allow seepage through the frozen wall and potential contamination of the environment. The temperature dependent, frozen hydraulic conductivity of the materials need to be known in order to assess the long-term behavior.

Question:

1. Please clarify

   a) the potential of change in freezing point depression as a function of freezing rate;
   b) the factor of safety associated with the -5ºC criterion and point of completely frozen conditions (no unfrozen water present);
   c) the change in hydraulic permeability as a function of negative temperature and degree of saturation;
   d) the assessment of the potential seepage through the frozen block assuming best estimates for the frozen hydraulic permeability; and
   e) the use of the term "thaw" within the DAR and a clear definition, which preferentially is defined on an acceptable hydraulic permeability, hence unfrozen water content

Reference to DAR (relevant DAR Sections):

S. 6.2.6 Initial Freeze
S. 6.2.8.2 Thawing and Climate Change
Various other locations in DAR

Reference to the EA Terms of Reference:

S.3.3 Arsenic Containment, Point 1

- "A detailed description of how the frozen block method will be done […]"

Summary

The Information Request preamble implies that the frozen block method is dependent on the arsenic dust providing a frozen hydraulic barrier. However, it is the frozen bedrock shell that provides the impermeable barrier. The ice in the arsenic dust provides an additional benefit as a 'cooling reservoir' in the form of stored latent heat, providing greater resistance to thawing.

Freezing rates during implementation will be on the order of months to form the frozen shell and changes in the freezing point depression are not a concern. The -5 ^{o}C criterion for the remainder of the frozen block was chosen as there is very little additional benefit gained by cooling the arsenic dust further as the unfrozen water content will not be significantly further reduced. No hydraulic conductivity tests were completed on the arsenic trioxide, but the potential seepage through the frozen block is estimated to be very, very low as the chambers are surrounded by the frozen bedrock. The term thaw refers to the transition between frozen and unfrozen conditions.

Response A

The freezing rate can cause a change in freezing point depression at very high freeze rates, for example, in the flash freezing of foods. The thermal model simulations in the Conceptual Engineering for Ground Freezing report (SRK 2006) show that freezing will be on the order of months, ex. Figure 3.4 in that report shows that it takes approximately 0.1 years (1.2 months) for the freeze front to advance 3 m from the freeze pipe. The freezing rate will also be lower further away from the freeze pipes, and within the dust material which has a lower thermal conductivity compared to the bedrock.

Freezing point depression can also result from solutes. The testing of saturated arsenic trioxide solutions reported in the DAR, showing that they freeze at -0.7 °C, is clear evidence of that effect and has been accounted for in analyses presented in the Remediation Plan and summarized in the Developer's Assessment Report (DAR).

The information request preamble also raises the question of chemical rejection, i.e. the tendency for solutes to be pushed out of freezing water and concentrated in the remaining unfrozen zones. In saline systems, very high solute concentrations can develop in these unfrozen zones and further depress the freezing point. In the arsenic trioxide dust, the negative effects of solute exclusion will be limited by the fact that the dissolved arsenic trioxide will be at its saturation point. In other words, any freeze concentration effects will cause a precipitation reaction that will remove arsenic from solution. The net result will be that increases in dissolved arsenic concentrations, and changes to the freezing point, will be limited. Other solutes, such as sulphate and magnesium, could be subject to chemical rejection but are present at much lower concentrations than arsenic.

Response B

Following establishment of the frozen shell at a -10^{o}C temperature over a distance of 10 m and wetting of the dust, efforts will then be shifted to the second stage which will target cooling of the arsenic trioxide dust to establish the frozen block. The criterion at that state is a temperature of -5^{o}C or colder within the dust.

Figure 1 of the 'Physical properties of overburden, bedrock and arsenic dust' memo, below, shows the unfrozen volumetric water content curves on arsenic trioxide samples for different degrees of saturation. Between temperatures of -5 ^{o}C and -8 ^{o}C (temperatures at which tests were completed), there was very little change in the unfrozen water content. The -5 ^{o}C criterion was chosen as there is very little additional benefit gained by cooling the arsenic dust below this temperature. It should be noted the unfrozen water content (ranging from 0 to 9% in the tests) will largely be bound by ice and immobile, in addition to being encapsulated by the frozen bedrock shell.

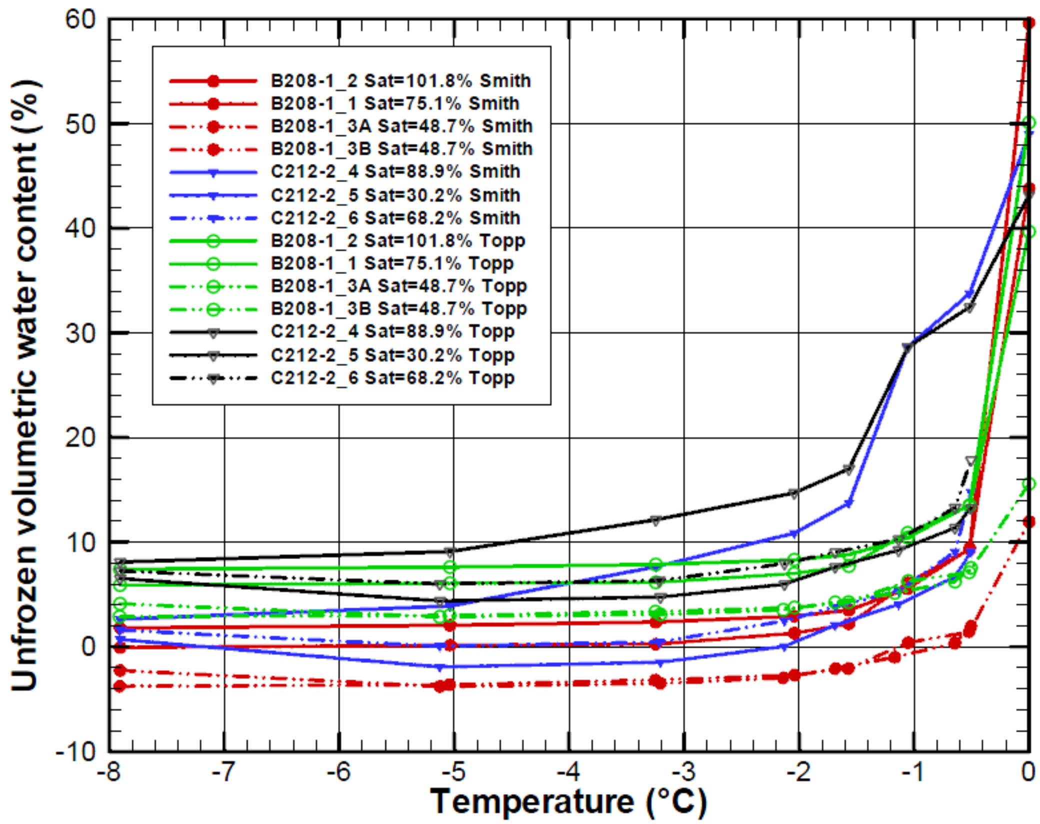


Figure 1 Unfrozen volumetric water content curves on arsenic trioxide samples for different degrees of saturation[1].

Response C

The hydraulic conductivity of the arsenic trioxide dust at negative temperatures was not tested. The frozen block method is not dependent on the low hydraulic conductivity of the arsenic trioxide dust. The frozen shell created during the initial freeze acts as the barrier to groundwater flow. The frozen shell will be created in the bedrock surrounding each chamber or stope, not in the dust itself.

The statement that the "temperature dependent, frozen hydraulic conductivity of the materials need to be known in order to assess the long-term behavior" is partially correct. If, for some reason, the frozen bedrock around a chamber or stope were to thaw completely, it is true that the low hydraulic conductivity of frozen arsenic dust would continue to present an impediment to groundwater flow. However, arsenic trioxide is so soluble that even groundwater flow along the dust-bedrock interface would create high concentrations of dissolved arsenic. For that reason we have conservatively neglected the benefits of the low frozen hydraulic conductivity of the dust, and based the design on keeping the surrounding bedrock frozen.

Response D

The hydraulic conductivity of the bedrock frozen shell will be extremely low. Mine water levels will be maintained below the chambers and stopes and, even in the unlikely event that the mine is subject to complete flooding, very low hydraulic gradients of 0.0002 m/m are expected. We conclude that there will be essentially no seepage through the frozen blocks. We believe the critical design question is how frozen blocks can be created and maintained, and that question is addressed in other part of the DAR and these responses.

Response E

The term thaw is used in the DAR to refer to the transition between frozen and unfrozen conditions. For the arsenic trioxide, as shown in the figure presented above, this transition largely occurs between -0.7 ^{o}C and 0 ^{o}C. For the bedrock material, no unfrozen water content testing was completed. In the thermal modeling simulations described in the Conceptual Engineering for Ground Freezing report, phase change was assumed to occur between temperature of -0.5 ^{o}C and -0.1 ^{o}C.

INFORMATION REQUEST RESPONSE

EA No: 0809-001 **Information Request No: Review Board #05**

Date Received:

February 14, 2011

Linkage to Other IRs

Review Board IR #7

Date of this Response:

May 31, 2011

Request

Preamble:
Any impacts of a controlled thaw, should it be required in the future, would potentially result from the proposed freezing. It may be necessary or desirable to thaw the frozen block at some point in the future, for example due to emergence of new remediation technologies or the development of different uses for arsenic trioxide. Item 2 of the Dec. 13th 2010 deficiency response generally suggests some of the existing risks, but does not examine these in sufficient detail. The response suggests that impacts of a controlled thaw would be the subject of a future environmental assessment. However, the risks of controlled thaw arise because of the proposed freezing, and must be assessed before it is frozen.

Because of the perpetuity conditions stated in the DAR, the possibility and potential consequences need to be assessed, particularly with regards to the thermal, mechanical, and hydraulic characteristics of the thawed arsenic trioxide and the stability of bulkheads and crown pillars.

Question:
1. Please provide a detailed description of the preferred methods for a controlled thaw of the frozen block should the need arise.
2. Please describe the risks of a controlled thaw, examining the probabilities and severity of associated impacts. This should include an assessment of risks of potential failure of crown pillars and bulkheads, and settlements associated with thaw consolidation, among others.
3. Please describe the potential opportunity costs of saturating the dust and filling in voids below crown pillars, in terms of limiting future options for arsenic removal (e.g., pneumatically, mechanically).

Reference to DAR (relevant DAR Sections):

S. 6.2.8.2 Thawing and Climate Change
S. 6.2 Arsenic Trioxide Dust Storage Areas

Reference to the EA Terms of Reference

S.3.3.1 Arsenic Containment – Detailed Description of Frozen Block

Summary

An example implementation of a controlled thawing program is presented and assessed. Assumptions about the context and conditions of the controlled thaw are based on extraction alternatives considered in the 2002 "Giant Mine Arsenic Trioxide Management Alternatives Final Report".

Before any controlled thawing would be initiated, the risks associated with each step in the thawing process would be thoroughly examined. Consideration of the example based on Alternative G1 from the 2002 report indicates that the thawing program would in fact offer opportunities to reduce risks versus extraction of unfrozen dust.

Previous studies have concluded that the dust would need to be wetted during extraction. So wetting the dust in the freezing program adds no cost to a future extraction. Backfilling the voids above the dust could add cost to a future extraction, unless the backfill is designed to withstand the future mining.

Response 1

Selection of a preferred method for controlled thawing would depend largely on the intended dust treatment, which would determine the rate, and conditions at which dust needs to be supplied, and therefore the required rate of thawing. Another consideration would be the duration of time since the initial freezing, which would determine the level of difficulty associated with accessing the underground drifts and re-using the underground part of the freezing system. These examples illustrate why, in order to address the information request, we need to make assumptions about the context and conditions of the controlled thaw.

Assumed Context and Conditions for the Controlled Thaw

For the purposes of responding to this Information Request, it is assumed that the future thawing of the dust would be undertaken in order to extract it from the stopes and chambers for some form of re-processing.

The most thorough review of options for managing the arsenic trioxide dust was the "Giant Mine Arsenic Trioxide Management Alternatives Final Report" prepared by the Technical Advisor in 2002. That report considered several options that would involve taking the dust out of the chambers and stopes. After reviewing all available mining methods, a three-step dust extraction process was selected:

- The upper roughly 90% of the dust in each stope or chamber would be extracted by borehole mining. A borehole mining machine would be lowered into the dust from surface through a large borehole. These machines have a high pressure water jet that would be used to cut into the surrounding dust and create a water-dust slurry. The slurry would then flow back towards the machine, where it would be collected and pumped to surface.

- The complex geometry of drifts, cross-cuts and ore passes at the base of many of the chambers and stopes would make borehole mining impossible, and it was concluded that conventional mining methods would be needed to recover the last 5-10% of the dust. To minimize safety risks, the void created by the borehole mining would first be backfilled. Areas containing residual dust would then be accessed by remotely operated machines travelling via the original mine workings.

- Even at the time of writing the 2002 report, it was recognized that the stability of the lower areas of some of the stopes and chambers would not be sufficient to allow access. The extraction plan therefore included a third step whereby some of the stope and chamber bottoms would be completely “re-stoped”. In other words, the surrounding rock, the access tunnels and any contained arsenic dust would all be removed. The mixed material would then need to be washed to separate the arsenic trioxide, which would again be recovered as a water-dust slurry.

Based on the analysis from the 2002 report, it is estimated that a five-year period would be required to complete the extraction effort. This can be further broken down into three years to construct the “reprocessing facility” (as defined by the emergent technology) and prepare the chamber and stope areas for dust extraction, and two years to extract the dust.

The 2002 study also concluded that, once the dust extraction was completed, a period of intensive minewater collection and treatment would be needed to recover any arsenic trioxide that was left behind or that escaped the immediate areas during borehole mining. It was estimated that ten years of active pumping and treatment of high-arsenic water would be required.

Thereafter, the alternative would look very much like the frozen block option. To prevent arsenic release from the rest of the mine, water treatment would continue at the same rate as in the frozen block alternative. The site would continue to be managed in perpetuity.

Controlled Thaw for Dust Extraction
In the context of the extraction method described above, a thawing program could involve the following steps. In general, the approach would be to preserve the frozen shell as long as possible, in order to prevent escape of water during the borehole mining.

During the three-year preparation period, access to the underground workings would be re-established and the underground freeze pipes inspected and if necessary replaced. A small active freezing plant would be procured and the necessary piping, power and control systems re-established.

Immediately prior to initiation of the borehole mining in each stope or chamber, the small-scale freeze plant would be connected to the area’s underground freeze system and turned on.

Dust extraction would be initiated by drilling a large borehole into the top of the frozen dust. The borehole mining machine would be installed and the water jet initiated. Tests of borehole mining machines have shown that their water jets are capable of cutting through rock with strengths of 20-50 MPa, which is more than ten times the strength of most frozen soils. The machine should be easily capable of cutting through the frozen dust.

The cutting action would initially produce splinters or chunks of frozen dust. The water-dust-ice slurry would flow to the extraction ports on the mining machine and be pumped to surface. The temperature of the water used for the jetting would need to be controlled to ensure that the mixture did not freeze in the borehole machine or any of the surface pipes. Controlling the inlet temperature could also allow control of the thawing process. An optimal level of heating would need to be defined, but the thawing would probably begin in the stope or chamber and only reach completion once the slurry is on surface. It is worth noting that borehole mining machines can also jet air or steam, if for some reason more thawing was desired.

Once the top layer of dust, say 5-10 meters in thickness, was extracted, the machine would be lowered and the next cut initiated. This process would continue until the bulk of the dust was removed.

During the entire borehole mining process, the freeze plant would be used to cool the rock below the chamber or stope, and the perimeter thermosyphons would continue to cool the chamber or stope walls. In this manner, the initial frozen shell would be preserved and escape of any of the dust slurry would be prevented. There are many permutations of that approach. For example, it might be necessary to initiate active freezing in the thermosyphons or, conversely, monitoring might show that the rock is sufficiently cold that no active freezing is required even below the chamber or stope. (Here again, uncertainties about the actual conditions prevent us from defining the method details.)

At the end of borehole mining in a chamber or stope, the bulk of dust would have been removed and a basal layer of frozen material would remain. That layer would provide an ideal base for backfilling the void left by dust extraction. To facilitate subsequent mining of the remaining dust, some form of cemented backfill would be required.

Once the cemented backfill is in place, removal of the remaining dust could commence. For stopes and chambers that were shown to be stable enough to allow access through the original drifts, remote mining methods could be used. It would be necessary to remove the drift plugs constructed as part of the initial freezing. The mining equipment would then proceed along the drift, removing any arsenic dust that is encountered. Two options would need to be examined. One would require the entire area to be thawed prior to mining. That could be accomplished by disconnecting the active freezing plant and switching to a heating system that would pump hot water through the underground pipes. But a second option would be to keep the surrounding rock frozen and only thaw material immediately ahead the extraction. The thawing could be accomplished by installing small heating tubes into the mine face. For example, after each day's mining, the crew would use a jackleg drill to push several pipes into the frozen face, and then connect them to a hot water circulation system that would thaw the material overnight, making it ready for the next day's mining. (Again the details would vary depending on circumstances.)

For stopes and chambers where the rock was not stable enough to allow access, the re-stoping method would be used. In those cases, thawing might be unnecessary as the dust and surrounding rock could all be mined while frozen. In fact, there might be advantages to keeping the dust frozen. For example, it would reduce the risk of dust release when the surrounding rock was blasted. In that case, the thawing would take place on surface when the mined material was washed to remove the arsenic trioxide.

As discussed above, the next step in the dust extraction alternatives would be ten years of intensive water collection and treatment to recover any residual or escaped dust. Maintaining the frozen shell during the dust extraction process would allow complete control of the water-dust slurry, and minimize the escape of any dust into the surrounding rock. That might significantly reduce the time and costs associated with the intensive water collection and treatment. It might be possible to maintain the frozen shells during the intensive water collection and treatment. The pattern of water circulation around each chamber and stope would be much easier to control, perhaps resulting in a further shortening of the treatment period.

Response 2

Before any controlled thawing would be initiated, several phases of investigation, assessment and design would be required. That work would be similar in complexity to the ten years of study that have gone into the currently proposed freezing program, and the risks associated with each step in the thawing process would be thoroughly examined.

To continue with the example developed above, the general risks associated with the dust extraction alternatives were assessed in the 2002 report, which concluded that the proposed dust extraction method was entirely feasible, but that there would be elevated worker safety risks during the last two steps. The discussions above show that, although the thawing process would add to the complexity of the dust extraction process, it would also add opportunities to better control many of the steps. Worker exposure to arsenic dust, for example, would be significantly reduced if the dust were kept frozen during blasting and/or only extracted as a recently thawed slurry.

Other changes in the extraction risks would be traceable to the initial freezing. The freezing process could cause or enhance fracturing of the rock mass around the chambers and stopes, making it more likely to fail during dust extraction. Three failure modes can be envisaged, but all have reasonable mitigation options:

- Collapse within an access drifts. As noted above, there would be at least a three-year preparation period prior to the start of dust extraction. That would allow sufficient time for any underground access to be re-established and appropriately supported.

- Failure of a crown pillar during borehole mining. At least two options exist to mitigate that risk. The first would be to backfill each cut level immediately after mining. The second would be to cut from the bottom up, maintaining a zone of frozen dust between the extraction level and the crown pillar.

- Failure of a sill pillar during the remote mining. As noted in the 2002 report, this risk is already present and is the reason why re-stoping, which would be designed to take out all of the at-risk material, is included as an option. So the only consequence of freezing-induced weakness would be to increase the preference for re-stoping over remote mining. Again the three-year preparation period would allow the re-stoping geometry and methods to be defined. And backfilling of the void left by borehole mining dust extraction would provide a stable "roof" for the re-stoping.

We conclude 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. The ability to control the rate of thawing appears to allow some of the dust extraction risks to be mitigated, leading to an overall decrease in the risks that would be associated with any future re-processing of the arsenic dust.

Response 3

Wetting of the dust would not lead to additional costs in dust extraction.

- In all of the dust extraction methods analyzed in 2002, worker health and safety risk associated with exposure to arsenic dust was a significant concern. Prior wetting of the dust will help to reduce that risk.
- Mechanical removal of the dust could be accomplished by many methods. As noted above, a thorough review of dust extraction options in 2002 led to a conclusion that wet mining methods are preferred. Prior wetting of the dust would only simplify those methods.
- Pneumatic removal was ruled out of consideration early in the 2002 assessment of mining methods. It is only practical on dry materials, and portions of the arsenic dust are thought to be saturated already and other portions have become moist during the dust's many years in the humid underground environment.

The dust extraction plans developed in 2002 included backfilling of the void left by borehole mining of dust from the stopes and chambers. Backfilling of the upper voids prior to freezing could be beneficial to extraction if the fill is capable of withstanding the jet boring. If not, the fill would be mobilized along with the dust and mixed into the water-dust slurry.

If the dust was being removed for cement stabilization, the consequence would be an increase in the volume of material that would need to be cement stabilized. The unit cost of cement stabilization cost was estimated in 2002 at slightly less than $300 per tonne. Assuming 50,000 tonnes of backfill, the added cost would be $15,000,000. Other methods to treat the dust, for example, autoclaving, might require that the backfill be separated from the dust which could entail higher costs.

INFORMATION REQUEST RESPONSE

EA No: 0809-001 **Information Request No: Review Board #06**

Date Received:

February 14, 2011

Linkage to Other IRs

Review Board IR #3

Date of this Response:

May 31, 2011

Request

Preamble:
In order to assess the impacts of this project, the Review Board needs to understand the extent of saturation proposed for the underground arsenic before freezing. The concept behind the non-saturated frozen block needs clarification. The following statements presented in the DAR seem to be contradictory with respect to the role of the frozen block and the immobilization of the arsenic trioxide:

- "[…] Immobilization of arsenic trioxide through ground freezing (the frozen block method)" (DAR, p. 2-3)
- "[…] The frozen conditions will be maintained over the long-term, and the large volume of ice in the frozen block will provide additional protection against thawing" (DAR, p. 6-11)
- "[…] Complete and uniform saturation of the dust is not required; the "frozen block" concept only requires that a large mass of frozen water be developed somewhere within each chamber or stope." (DAR, p. 6-29)
- "[…] However, the primary role of the frozen block is to provide a mass of frozen water that will resist any future increases in temperature." (DAR, p. 6-29)

Question:
Please clarify the above and confirm that these unsaturated conditions have been considered in all the thermal analysis, describing how these varying conditions, which influence thermal and hydraulic ground parameters, have been duly considered in project design.

Reference to DAR (relevant DAR Sections):

S. 5.1.2.2 Physical Properties
S. 6.2.6 Initial Freeze

Reference to the EA Terms of Reference:

S.3.3.1 Arsenic Containment – Detailed Description of Frozen Block, Point 2
"A detailed explanation on the saturation procedure of the arsenic trioxide dust before freezing and a demonstration that the frozen dust will be compact and ice saturated, (i.e. no loose cold regions and frozen bridges occur that could jeopardize the stability of the system)"

Summary

The frozen bedrock surrounding the chambers and stopes provides complete isolation regardless of the saturation condition within the dust itself.

Response

The four statements from the DAR are not contradictory when one considers that the surrounding frozen bedrock is a significant component of the frozen block. The frozen bedrock forms an impervious barrier surrounding the arsenic trioxide dust, and provides complete isolation regardless of the saturation condition within the dust itself. The benefit of wetting and freezing the dust is only that the latent heat stored in the frozen water would slow down any possible future warming.

Unsaturated conditions have been considered in the thermal modeling. The response to question 2 of the Review Board's Information Request #2 provides a summary of that work.

INFORMATION REQUEST RESPONSE

EA No: 0809-001 **Information Request No: Review Board #07**

Date Received:

February 14, 2011

Linkage to Other IRs

Review Board IR #05

Date of this Response:

May 31, 2011

Request

Preamble:
SRK 2005(b) identified the possible failure of four crown pillars above arsenic containing stopes. The developers recognize the current instability of several of the bulkheads and crown pillars. This is reflected at various sections within the DAR:

- "[…] An initial review […] found that all chambers have relatively thick crown pillars, and failures appear to be unlikely. However, the crown pillars above the stopes are not as thick, and their stability is a concern […]" (DAR, p. 5-18)
- "[…] The long-term stability of these bulkheads is questionable and the short-term stability of some of them is also a source of concern […]" (DAR, p. 5-20)
- "A second and more immediate concern is the physical stability of the dust storage areas. Several of the bulkheads below the chambers and stopes have been identified as having moderate to high failure risks" (DAR, p. 6-5)
- "[…] All bulkheads will be incorporated within the frozen zone around each chamber and stope." DAR, p. 6-13)
- "[…] Following freezing, all crown pillars will be supported by the frozen dust, ice, or fill placed prior to freezing." (DAR, p. 6-15)

The DAR does not provide enough detail on the effect of this instability on the freezing, and the effects of the freezing on the unstable structures.

Question:
Please describe:

a) Potential effect on the stability of the crown pillars in the stopes due to saturation and freezing of the arsenic trioxide, assuming that the block will have to be thawed in the future for a different remediation measure.

b) Potential impacts and risks associated with the freezing of the bulkheads, such as risk of frost jacking or loss of strength of the bulkheads due to the freezing of the stopes.
c) Potential impacts and risks associated when freezing the tunnels outside the arsenic trioxide dust storage. Details on the saturation, the backfill and associated freezing front penetration are to be provided.
d) Potential impacts of crown pillars above arsenic containing stopes collapsing during initial freezing before dust saturation.

Reference to DAR (relevant DAR Sections):

S.5.1.4 Stability of Arsenic Trioxide Dust Storage Area Crown Pillars
S.5.1.5 Stability of Arsenic Trioxide Dust Storage Area Bulkheads
S. 6.2.4.1 Bulkheads
S. 6.2.4.2 Crown Pillars
S. 6.2 Arsenic Trioxide Dust Storage Areas

Dec. 13, 2010 Deficiency Response, reply to item 1, page 1
"The most potentially significant issues pertain to the stability of some of the bulk heads and certain crown pillars. However, these risks are associated with the site in its current condition (i.e., they are not caused by the Project) and the risks will be mitigated through the implementation of the Project".

Reference to the EA Terms of Reference:

S.3.3 Arsenic Containment

Summary

Freezing of the chambers may cause cracking of the bedrock resulting in some degradation of the rock quality. The crown pillars most at risk are located in the B1 Pit, where prior to freezing, the voids beneath the pillars will be backfilled and fill will be placed above the pillars. As a result, any cracking of the crown pillar will be supported, and the risk of collapse mitigated

Prior to freezing, all drifts leading to or from the base of the arsenic chambers and stopes will be plugged. Freeze pipes will be located through each plug and the plugs will be frozen as part of the initial development of a frozen shell. If a bulkhead fails during the subsequent freezing within the shell, the arsenic dust will be contained by the frozen plugs.

The risks of planned thaw, including failure of the crown and sill pillars, are discussed in Review Board Information Request #5 (IR#5).

Response A

Crown pillar stability in the event of a planned thaw is discussed in the response to IR#5.

Freezing of the chambers may cause cracking of the bedrock resulting in some degradation of the rock quality. This effect increases the risk of failure of both the crown and sill pillars during a planned thaw. The final design of the backfilling of the voids between the crown pillar and the voids is still to be determined and any planned thaw would include mitigation measures to minimize the risk of failure such as those described in IR#5.

During a planned thaw, the crown pillar would likely be thawed prior to the saturated arsenic (and the backfilled void). If the crown pillar failed, the risk of an arsenic dust release to the surface is unlikely as it would be supported by the backfilled void and overlying fill material.

The risk of a sill pillar failure is more likely to occur than a crown pillar collapse. If the mine is re-flooded, there is a risk of the movement of the backfill which supports the sill pillars due to fluctuations in the water level at depth. The mine level fluctuations would be caused by seasonal storage and during de-watering of the mine that would occur prior to the planned thaw. Further investigations of the sill pillar stability are planned prior to the final design to reduce the uncertainty. The risk of a sill pillar failure is further discussed in the response to IR#5.

Response B

Section 6.2.4.1 of the Development Assessment Report (DAR) (pg. 6-13) states that the long-term stability of these bulkheads is questionable and the short-term stability of some of them is also a source of concern. Due to the freezing process, a loss of bulkhead strength is possible. However, in order to complete the frozen shell around each chamber and stope, drift plugs will be installed. The design of the drift plugs has not yet been finalized. However, they are all located outside of the bulkheads. Freeze pipes will be strategically located to freeze the plugs, allowing them to be frozen during the development of the frozen shell, i.e. well before any freezing of the bulkheads. Any arsenic dust releases caused by subsequent failure of the bulkheads will be contained by the plugs with no escape of arsenic.

Response C

Freezing of the tunnels outside the dust storage areas may lead to some localized spalling of the bedrock, but not to the degree that will cause instability.

Details of the drift plugs and the backfill for voids between the dust and crown pillars are still under discussion as part of the design process. It is worth noting that drift plugging and void backfilling are common operations in underground mining, and a number of well-proven methods exist.

Response D

Table 5.1.7 of the DAR states that a crown pillar collapse for chambers B208, B212, B213, and B214 is possible. All of these chambers are located by B1 Pit that is to be backfilled prior to freezing. Before the pit is backfilled, Section 6.4.3 of the DAR states that the voids between the crown pillars and the arsenic trioxide dust are to be stabilized. Several materials are being considered for use as backfill material in the void, including coarse rock, cemented aggregate, and foam cement. Additional cost and constructability analyses are needed before a selection is made. In addition, Highway #4 will be relocated prior to freezing of the chambers near the present highway. As a result, there is no direct risk to public safety.

As a result of the stabilization and backfilling that occurs before the freeze begins, any cracking of the crown pillar will be supported, and the risk of collapse mitigated.

INFORMATION REQUEST RESPONSE

EA No: 0809-001 **Information Request No: Review Board #08**

Date Received:

February 14, 2011

Linkage to Other IRs

Date of this Response:

May 31, 2011

Request

Preamble:
Adequate monitoring is essential to adaptive management of the project to help mitigate future risks. As indicated in the DAR, the main parameter being monitored to assess the completeness of the frozen wall is temperature: "In general, these will be temperature monitoring devices." (DAR, p. 6-27) The proposed application of artificial ground freezing is unique with respect to technology (e.g. generating of a frozen wall in unsaturated conditions). It carries unique risks associated with potential non-closure of the frozen wall. Therefore, additional and improved monitoring measures should be considered.

Question:
1. Please present additional monitoring and QA/QC measures that consider the unique situation. These measures must make it possible to evaluate whether:
   a. the freeze pipes have been installed according to design (e.g. borehole depth / orientation) and,
   b. complete closure condition of the frozen wall has been achieved.
2. Please provide a detailed assessment of the risks if the frozen wall does not seal off completely.

Reference to DAR (relevant DAR Sections):

S.6.2.5.6 Instrumentation

Reference to the EA Terms of Reference

S.3.3 Arsenic Containment, Point 1e / Point 8c
- "A description of the monitoring and maintenance requirements of the thermosyphons, the conditions that would require their replacement, and the frequency of replacement."
- "A discussion of the challenges involved, monitoring systems employed, maintenance efforts required, and why some systems had failed in the past."

Summary

QA/QC procedures for the freeze pipes installations will likely be similar to the measures used during the construction of the Freeze Optimization Study (FOS). The design freeze pipe spacing was selected as being the most effective to achieve the temperature performance criteria. Freeze pipe deviations may affect the freezing time, but not the ability for the design criteria to be met. The water pressure sensors installed in the arsenic chambers will be used to track water levels during wetting of the dust and for any loss of water.

The risks and impacts of the freeze wall not sealing off completely due to a large crack in the bedrock material are presented. The risk of a continuous, open crack in the bedrock present from the chamber to the outside of the freeze wall is very low. If such a crack were present, there is a risk of a temporary increase in seepage rates of arsenic saturated water and release of arsenic trioxide sludge during the wetting of the dust. The quantity of seepage would be dependent on the chamber wetting method. Dissolved arsenic present in any seepage would be transported downward into the mine, collected in the mine-water system, and removed by the water treatment plant. As the rate of flow into the crack would be governed by the dust hydraulic conductivity (measured to be 7x 10^{-7} m/s), the slow-moving water would freeze quickly and seal the crack.

Response 1

We recognize the importance of ensuring that the frozen shells are complete. The freezing criteria specifying that the frozen shell reach -10°C over at least a 10 m width were selected after lengthy consultation with industry experts and the Independent Peer Review Panel. Stating the criteria in that manner allows for flexibility in the method of drillings and freeze-pipe installation. An alternative approach would have been to adopt less stringent criteria for the frozen shell, for example a much thinner width at a lower temperature. In that case, we agree that the problems arising from, for instance, inaccurate drilling and freeze pipe alignment could be acute and that more extensive QA/QC requirements would be needed.

Sensitivity analyses indicate that, at the currently assumed freeze pipe spacing of 4.0 m with a 7.0 m offset from the chamber walls, deviations in freeze pipe alignment affect only the overall freezing time. They do not affect the ability for the design criteria to be met. Furthermore, the same sensitivity analyses show the time to reach -10°C over a 10 m width is insensitive to local deviations in hole spacing, as long as the average spacing remains at the design value. The reason is that the space between freeze pipes cools very rapidly, and thereafter the freezing pipes act together as a “line source” of cooling.

Given the choice to adopt very conservative design criteria and the evidence of the sensitivity analyses, we expect QA/QC procedures for the freeze pipe installation to be similar to those used during the construction of the FOS. During drilling and freeze pipe installation, an inspector will be present to ensure that the design drill depth is achieved, periodic down-hole surveys will be completed during drilling to monitor for excessive drillhole deviation, and leak detection testing will be completed in accordance with the design criteria.

Three different surface drilling methods were tested during the FOS. Drilling deviation was typically less than 1 m for vertical holes of roughly 100 m depth. That level of deviation is well within the ranges that have been checked by sensitivity analyses. The FOS results also showed that at least one of the methods allowed efficient drilling at higher accuracy.

The deviations for the underground horizontal freeze holes were greater, with a maximum deviation less than 2.0 m over a length of only 20-30 m. However, the horizontal deviations tended to be parallel, with the average spacing remaining close to design.

As detailed in the DAR s. 6.2.5.6, temperature monitoring devices will be installed in drillholes located around the freeze pipes to monitor the progress of the cooling front into the surrounding dust and ensure that the 10 m wide, -10^{o}C frozen shell is achieved. Water pressure sensors will also be included in monitoring strings inserted into the arsenic chambers. The water pressure sensors will be used to track water levels during wetting of the dust and for any loss of water. The exact numbers, locations, and types of instruments will be determined in a later stage of design.

Response 2

The most likely reason for the frozen wall to not seal off completely would be the presence of an open fracture that is not water saturated during the development of the frozen wall. The risk of a fracture extending from the arsenic chamber and through 10 m of frozen wall is very low, as the chambers are located away from the major fault zones. However, let us assume for the sake of this assessment that such a fracture exists. After the initial freezing stage, the bedrock around the fracture will have a maximum temperature of -10^{o}C.

During the wetting of the dust, there is a potential for a release of soluble arsenic trioxide in seepage that escapes through the fracture. The quantity of seepage would depend on the method used to saturate the chamber. As discussed on Page 6-29 of the DAR, the wetting method remains in concept at this time and additional testing is planned as part of the final design process. One option is to add water to the top of the chamber and allow it to infiltrate down into the dust. In that case, the flow rate into the fracture would be limited by the dust hydraulic conductivity, measured to be 7x 10^{-7} m/s. The slow-moving water entering the crack would freeze quickly and ice buildup would seal the fracture. If a more energetic blending of the dust was used during the saturation process, there would be a short term potential for a larger quantity of seepage to pass through the crack. However, once the blending stops, the flow rate entering the crack would again be limited by the low hydraulic conductivity of the dust.

Dissolved arsenic present in any seepage that does escape the frozen shell would be transported downward into the mine, collected in the mine-water system, and removed by the water treatment plant, just as it is today. Any significant increase in soluble arsenic reporting to the treatment plant would be noticeable both in influent analyses and in increases in water treatment costs.

INFORMATION REQUEST RESPONSE

EA No: 0809-001 **Information Request No: Review Board #09**

Date Received:

February 14, 2011

Linkage to Other IRs

Review Board IR #12, 13
Alternatives North IR #20
City of Yellowknife IR #2.3

Date of this Response

May 31, 2011

Request

Preamble:
The stability of containment structures is important to evaluating and managing long-term risks. The DAR does not present an assessment for the long-term (in perpetuity) stability and potential remediation measures that may be required. The risk assessment (DAR s10) does not describe likelihood or severity of failures. The 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. Long-term stability of the tailings dam(s) and tailings cover are important aspects of the project.

Question:

1. Please provide an assessment of the long-term performance of the tailings dam, and provide a risk assessment that includes any scenarios under which the tailings dams, tailings cover or both could fail, including a description of the likelihood and severity of failures over the long-term.

2. Please describe whether monitoring of chemical uptake by plants on the tailings cover will extend to include establishment of climax species that will dominate over the long-term, and describe what the Project Team will do if arsenic uptake is observed

Reference to DAR (relevant DAR Sections)

DAR, s. 5.5 Tailings and Sludge Containment Areas, p. 5-41 – 5-47
DAR Table 10.4.1 p10-11 Erosion of tailings cover or perimeter dams release tailings to surface water

Recent assessments of the tailings dam completed in 2004 showed no immediate safety concerns. “The detailed review identified no immediate safety concerns, but made recommendations to assess dam performance in more detail, and improve operating, maintenance and surveillance procedures.” (DAR, p.5-42)

“To prevent or mitigate reduced cover performance or deterioration (of tailings perimeter dams and tailings cover), the Project Team will require that covers and dams are monitored and maintained within the temporal scope as defined by regulatory authorizations”. (Table 10.4.1 p10-11)

“To prevent or mitigate vegetation penetrating the tailings cover, the Project Team will monitor the revegetation of the tailings and sludge areas, including the chemical uptake of the plants during the temporal scope as defined by the Review Board. (Table 10.4.1 p10-11)

Reference to the EA Terms of Reference

ToR 2.3 Temporal Scope
“(T)he Review Board has set a limit on the duration of **activities** that it can meaningfully assess... For the purposes of this EA, **the development activities** are those occurring within 25 years and extending to any further time required to stabilize the site. This assessment will not consider the **impacts of activities** occurring after that period”. *(emphasis added)*

ToR s. 3.2.4 Development Description, Point 8 “A detailed description of the proposed method(s) and location(s) of tailings disposal and/or containment, including a description of any technologies or materials that may be used, and any temporary or permanent measures to control fugitive dust from tailings disposal areas.”

Response 1 Summary

A 2004 Dam Safety Reviews and subsequent updates classified the dams at Giant Mine and demonstrated their compliance with stability criteria recommended by the Canadian Dam Association.

A risk evaluation or assessment identified a low risk of a failure for the tailings dams on site in the long term / post closure. The risk of a failure of the tailings covers is also low. Further examination of the likelihood and consequences of tailings dam and tailings cover failures are provided in the response to the Review Board’s Information Request #12.

Response 1

All dams at Giant Mine were subjected to a Dam Safety Review in 2004. Dam Safety Reviews are formal processes carried out according to the Canadian Dam Association *Dam Safety Guidelines* (CDA 1999). One of the results of that work was an interim classification of the dams based on the possible consequences of failure.

- Dams 1, 2 and the B2 Pit Dam were classified as “High” consequence, on the basis that their failure could result in the loss of tailings and fluid into the underground mine and possibly cause fatalities of people working underground.
- Dams 3, 11, 21 and 22 were classified as “Low” consequence. (BGC 2004)

The remaining dams did not fall into the CDA classification system.

- For Dams 8, 9 10 and 12 the review concluded their basins “are now filled with solids not prone to fluidization under static or earthquake conditions” and they “therefore do not fall under the CDA classification of dams”.
- Dams 3C, 3D, 7, 4, 5, and 6 are “minor water retaining dykes with limited storage used for water and seepage management and not subject to substantial flood flows” and “would not release water or fluidized tailings to the environment if they failed”. (BGC 200)

The *Dam Safety Guidelines* were updated in 2007 (CDA 2007). The revised *Guidelines* included a classification based on environmental damages, under which Dams 3, 11, 21 and 22 could also be classified as “High “ consequence on the grounds that their failure could result in damage to significant loss or deterioration of important fish or wildlife habitat.

The revised *Guidelines* also recommended that “High” consequence dams be assessed for stability under “Earthquake Design Ground Motions” equivalent to a 1:2500 year earthquake. Such an evaluation was carried out in 2008 and found that the dams would be stable under the 1:2500 earthquakes recommended by the Canadian Building Code (SRK 2008, Amini & Naesgarrd 2008).

A risk evaluation or assessment identified a low risk of a failure for the tailings dams on site in the long term / post closure. Thus, as the likelihood of a failure is low, the consequence is also low. The evaluation is based on the closure plans for the tailings management facilities (TMF) which proposes that all of the TMF areas at the mine will be drained. The tailings dams would then act as solid earth embankments that retain dry or drained tailings and the risk of a dam failure and release of tailings in this condition is low.

The risk of a failure of the tailings covers is also low. The final covers would be monitored for several years after the covers are completed during a monitoring phase (part of closure period) and before the post closure (long term) period would start. Thus, before the post closure period starts, settlement under the covers would have occurred and been corrected. The drainage channels would have been monitored for several years and any sites needing added material (ditch protection) would be up graded.

Further examination of the likelihood and consequences of tailings dam and tailings cover failures are provided in the response to the Review Board’s information request #12.

References

BGC Engineering Inc., *Giant Mine: 2004 Dam/Dyke Safety Review*, February 2005.

Canadian Dam Association (CDA) *Dam Safety Guidelines (1999).*

Canadian Dam Association (CDA) *Dam Safety Guidelines (2007).*

National Research Council of Canada, *National Building Code of Canada 2005*, Ottawa.

SRK Consulting Inc., *Giant Mine Remediation Plan: 2008 Seismic Studies Related to Tailings Dam Safety – FINAL*, Report Prepared for Giant Mine Remediation Project, Department of Indian Affairs and Northern Development, August 2008.

Amini, A., Naesgaard, E., *Giant Mine: Dam/Dyke Site Response and Liquefaction Triggering Assessment*, Report prepared for SRK, March 2008. Giant Mine Remediation Plan:2008 Seismic Studies Related to Tailings Dam Safety - FINAL Appendix C.

Response 2 Summary

The re-vegetation strategy for covers, as presented in the Developer's Assessment Report (DAR), is conceptual in nature and will be refined through future field studies, consultation and detailed engineering design. This process will include the development of a comprehensive monitoring strategy that is capable of detecting chemical uptake in vegetation species that will dominate over the long term. The approach to addressing the potential for uptake is necessarily one of risk-based adaptive management; selecting pre-defined action levels and actions is not appropriate due the wide variety of variables that could influence ecological exposures. Under this approach, all monitoring data will be evaluated as part of the State of Environment reviews to determine if uptake is occurring and to ascertain associated risks. Depending on the severity of any identified risks, consideration will be given to implementing additional remedial and/or risk management measures.

Response 2

As indicated in Table 2.7.1 of the DAR, 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 consultations (particularly with Aboriginal groups) to determine preferred approaches to re-vegetation, including long-term monitoring and adaptive management.

Studies to select vegetation species and define seeding, planting and fertilization requirements are still needed and are part of ongoing work on the site. A detailed plan for additional re-vegetation studies is being developed. It is envisioned that a mix of non-invasive agronomic and native species will be used but this is subject to change as additional consultations and assessments are conducted.

Regardless of the re-vegetation strategy that is selected, it will be based on an adaptive management approach and will include provisions to report to regulators and potentially affected communities. The process will be guided by the approaches described in the following sections of the DAR: Chapter 13 (Communication and Consultation) Chapter 14 (Monitoring and Evaluation)

As indicated in Table 10.4.1 of the DAR, to prevent or mitigate vegetation penetrating the tailings cover, the Project Team will monitor the re-vegetation of the tailings and sludge areas. This will include monitoring for chemical uptake in plants.

A key element of the monitoring approach will be to assess uptake of arsenic in species that are culturally important to local residents. Specifically, as stated in Section 13.2.1, there will be long-term monitoring of terrestrial vegetation which will include sampling of vegetation established on the covers. Monitoring is anticipated to focus on plant species such as medicinal plants with cultural significance (e.g., Labrador tea), berries and forage species. There will be opportunistic sampling of edible berries and sampling of plant species such as birch and willow which are known to accumulate inorganic contaminants from contaminated soils in terminal leaves and twigs, and may serve as exposure pathways to browsing wildlife.

As specified in Section 14.1.2, vegetation monitoring will be directed through a specific Environmental Management Plan (EMP). It is currently envisaged that monitoring will commence once successful re-vegetation is reported in remediated areas (tailings areas and contaminated soils areas). Follow-up monitoring would subsequently occur annually for five years or until vegetation is fully established.

With regard to what will be done if arsenic uptake in vegetation is observed, it is not possible to state definitively what actions will be taken. First, criteria for arsenic concentrations in terrestrial vegetation have not been proposed as effects concentrations are species-specific and assessment of the health of biota is most effectively accomplished through field investigations. Second, the approach to addressing the potential for uptake is necessarily one of risk-based adaptive management; selecting pre-defined action levels and actions is not appropriate due the wide variety of variables that could influence ecological exposures. Under this approach, all data will be evaluated as part of the State of Environment (SOE) reviews to determine if uptake is occurring and to ascertain associated risks. Depending on the severity of any identified risks, consideration will be given to implementing additional remedial and/or risk management measures.

INFORMATION REQUEST RESPONSE

EA No: 0809-001 **Information Request No: Review Board #10**

Date Received:

February 14, 2011

Linkage to Other IRs

Date of this Response:

May 31, 2011

Request:

Preamble:
To evaluate the proposed remediation of tailings ponds, the Board requires more information on their current state and predicted physical changes. No information on the current state of tailings consolidation or predicted additional future consolidation settlements of the tailings ponds was available in the DAR.

Question:
Please provide best estimates of current and future consolidation settlements, if any, of the tailings ponds that may also be relevant to surface water flow and pond cover integrity.

Reference to DAR:

S. 5.5 Tailings and Sludge Containment Areas

Reference to the EA Terms of Reference:

S. 3.2.4 Development Description, Point 8
"A detailed description of the proposed method(s) and location(s) of tailings disposal and/or containment, including a description of any technologies or materials that may be used, and any temporary or permanent measures to control fugitive dust from tailings disposal areas."

Summary:

The Project Team has not yet generated estimates of tailings consolidation. Design of the tailings cover and surface drainage system are currently conceptual only. Investigations to advance the design are ongoing.

Response:

Tailings consolidation estimates have not yet been completed.

Consolidation will be taken into account in further design of the tailings cover and its surface drainage system. The current conceptual design generally is not expected to be sensitive to consolidation, but does allow for varying thicknesses of material to be placed as needed. On the other hand, alignment of the surface drainage system is expected to be sensitive to predicted tailings consolidation. The current conceptual surface drainage design accounts for consolidation only in that it generally routes water from areas of coarse tailings towards areas of fine tailings. The latter are expected to consolidate more than the former.

Further work is needed to support design of the tailings cover. That work will include field investigations, development of grading plans that take consolidation into account, and alignment of surface drainage swales or channels. Golder Associates initiated further field investigations of the tailings in March 2011. The scope of the geotechnical investigation was filed with the Mackenzie Valley Environmental Impact Review Board in December, 2010 and is available on the public registry. The investigation report will be available prior to the technical hearings.

INFORMATION REQUEST RESPONSE

EA No: 0809-001 **Information Request No: Review Board #11**

Date Received

February 14, 2011

Linkage to Other IRs

Alternatives North IR #15

Date of this Response

June 17, 2011

Request

Preamble:
The feasibility of the proposed project depends in part on financial resources. The certainty of cost predictions and committed financial resources are important in evaluating project feasibility. The DAR mentions a fixed, and very precise, budget of the running costs (i.e. 1.91M$/yr). This figure is based on several assumptions, such as the adequacy of passive freezing to maintain the frozen block over the long term. However, in Document J and other texts there are numerous references to uncertainties and adaptation without ever estimating any variability in project costs.

Question:

1. Please describe the uncertainties linked to these costs estimates.

2. Is it possible to define an order of magnitude of variability?

3. Please describe how project financing will cope with possible variations in costs for perpetuity.

4. Please reconcile possibility of ever-increasing water treatment cost (Dec. 13, 2010 Deficiency Response, reply to item 1, page 4) with the very precise budget and scheduling defined in the report.

Reference to DAR (relevant DAR Sections)

s.6.13.6 Financial Resource Requirements
Dec. 13, 2010 Deficiency Response, reply to item 1 page 4

“Again assuming no response, the above situation would continue indefinitely, with ever increasing water treatment costs, but no uncontrolled release of arsenic into the surrounding environment.”

Reference to the EA Terms of Reference

s. 3.2.4 Development Description

Estimated capital, operating, monitoring and maintenance costs (the latter presented by year for the life of the development) of the approval process.

Response 1 Summary

Uncertainties in the cost estimates include the effects of inflation and escalation of cost inputs, changes to the design, and changes in management structure and/or contracting policies. Broader "project risks" also generate cost uncertainties.

Response 1

The cost estimates reported in Table 6.13.4 of the Developer's Assessment Report (DAR) were based on estimates generated in 2007 during preparation of the Giant Mine Remediation Plan (Remediation Plan). To reflect cost increases over the period 2007-2010, the original estimates were increased by 8% per year. With the effect of compounding, the estimates in the DAR are approximately 26% higher than the original estimates.

As Table 6.13.4 shows, the estimates include significant contingencies, ranging up to 50% of the estimated direct and indirect cost. The contingencies provide for uncertainties in the estimated quantities and unit costs.

There are other uncertainties in this class of cost estimate. They include the effects of inflation and escalation of cost inputs, changes to the design, and changes in management structure and/or contracting policies. Sources of "project risk" can also generate significant cost uncertainties. A list of "project risks" typical of projects of this scope includes the following (ICE 2005):

- Insufficiently defined objectives leading to scope drift;
- Hidden, unstated or untested assumptions;
- Timing and restrictions of regulatory approvals;
- Opposition from third parties;
- Improved construction or leading edge technology;
- Loss of key personnel;
- Insolvency of contractor;
- Disagreement amongst sponsors;
- Force majeure; and
- Obtaining finance.

Response 2 Summary

Cost estimates at this stage of planning are normally considered to be accurate to ± 30%. However, uncertainties in the Giant Mine Remediation Project, details, and implementation plans as well as "project risks" could result in changes beyond that range.

Response 2

Cost estimates at this stage of planning are normally assumed to be accurate to ± 30%. However, at the time the estimates were prepared, there remained significant uncertainties in the project details, and implementation plans. Uncertainties in the Remediation Project, for example the plans for Baker Creek, are expected to be resolved through the environmental assessment, community consultation and water licensing processes. Uncertainties about design details, for example the selection amongst active, passive and hybrid freezing methods, will be resolved through the further engineering studies that are currently in progress. Uncertainties about project implementation will be resolved through the project definition and procurement processes that will follow licensing and engineering. One or more of these processes could easily change the project details and/or schedule such that the final cost estimates could be more than 30% different from the DAR estimates.

Reference:

Institution of Civil Engineers, 2005. *Risk Analysis and Management for Projects (RAMP)*. 2nd Edition, November 2005, ISBN 978-0-7277-3390-0

Response 3 Summary

The budget estimates outlined in the DAR were established based on the best available information at the time and could be revised if required, based on changing circumstances or new information.

The Governments of Canada and the Northwest Territories (NWT), 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.

In INAC's view, the budgeting process and approval of expenditures, required for all government projects, are the appropriate mechanisms to address any possible variations in costs going forward.

Response 3

Table 6.13.4 of the Developer's Assessment Report (DAR) presents a summary of estimated costs for the implementation phase of the Giant Mine Remediation Project, and Table 6.13.5 presents a summary of estimated annual costs over the long-term. These estimates were established based on the best available information at the time. Going forward, these estimates could be revised if required, based on changing circumstances or new information. For example, as with any large engineering project the estimates will become more precise as plans are advanced and more detailed analysis is completed. This includes normal cost escalations associated with long-term operations (e.g., inflation, rising costs for labour, parts etc.).

The funding for the Remediation Project of the Giant Mine site is provided by the Federal Contaminated Sites Action Plan (FCSAP). As a part of FCSAP, all financial requirements for the Giant Mine Remediation Project will need to be outlined and defined. This definition of costs will be an opportunity to address or clarify any variations in cost that might be required. In addition, all government projects, including the remediation of the Giant Mine site, require detailed budgeting and the approval of expenditures. These required processes are the appropriate mechanisms to address and approve any variations in costs.

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 states clearly that several elements of the project will be required to be addressed in perpetuity. Long-term care, maintenance and monitoring are essential components of the remediation approach at the Giant Mine site that will protect human and environmental health and safety and ensure the integrity of Canada's investment.

In INAC's view, the budgeting process and approval of expenditures, required for all government projects, are the appropriate mechanisms to address any possible variations in costs associated with the Giant Mine Remediation Project.

Response 4 Summary

The "ever-increasing water treatment costs" referenced in this question are a part of an unlikely and improbable worst case scenario related to a complete failure of the operations, monitoring and governance related to the Frozen Block Method.

The budget estimates in the DAR were established based on the best available information at the time and could be revised if required, based on changing conditions or new information.

In INAC's view, the budgeting process and approval of expenditures, required for all government projects, are the appropriate mechanisms to address any possible variations in costs associated with the Giant Mine Remediation Project under any scenario.

Response 4

This question specifically references the possibility of ever-increasing water treatment costs that would be associated with a malfunction or failure of the Frozen Block Method as outlined in the December 13, 2010 Response to MVEIRB DAR Deficiency #1 (page 4). The "ever-increasing water treatment costs" here are discussed under a worst case scenario that would involve a complete failure of the frozen blocks over the long term. The chain of events required for this scenario to occur would include:

- Ineffective thermosyphons that would go unnoticed or unmitigated for at least 20 years;

- Unnoticed or ignored failure of the temperature monitoring devices;
- Lack of analysis or recognition of changes at the water treatment plant; and
- No response from the site operator and responsible authorities.

To reach this scenario, there would have to be a complete failure of operations and governance over many years. Given the length of time involved, it was considered reasonable to expect that any of the steps leading to this type of failure would be detected and corrective action would be taken. As a result, the likelihood of such an occurrence was judged to be very low.

Although very unlikely, there are mechanisms in place (i.e., requirements of all government projects), which would allow for variations in costs to be addressed. These processes described below would be utilized under all scenarios going forward, worst-case or otherwise.

The funding for the Remediation Project of the Giant Mine site is provided by the Federal Contaminated Sites Action Plan (FCSAP). As a part of FCSAP, all financial requirements for the Giant Mine Remediation Project will need to be outlined and defined. This definition of costs will be an opportunity to address or clarify any variations in cost that might be required. This would include normal cost escalations associated with long-term operations (e.g., inflation, rising costs for labour, parts etc.). In addition, all government projects, including the remediation of the Giant Mine site, require detailed budgeting and the approval of expenditures. These required processes are the appropriate mechanisms to address and approve any variations in costs.

The “precise budget and schedule” refers to Table 6.13.4 of the Developer’s Assessment Report (DAR) that presents a summary of estimated costs for the implementation phase of the Giant Mine Remediation Project, and Table 6.13.5 that presents a summary of estimated annual costs over the long-term. These estimates were established based on the best available information at the time. Going forward, these estimates could be revised if required, based on changing circumstances or new information. For example, as with any large engineering project the estimates will become more precise as plans are advanced and more detailed analysis is completed. Any changes would then be considered as a part of the budgeting and expenditures approval process described above.

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 states clearly that several elements of the project will be required to be addressed in perpetuity. Long-term care, maintenance and monitoring are essential components of the remediation approach at the Giant Mine site in order to protect human and environmental health and safety and to ensure the integrity of Canada’s investment.

In INAC’s view, the budgeting and approval of expenditures process, required for all government projects, are the appropriate mechanisms to address any possible variations in costs associated with the Giant Mine Remediation Project under any scenario.

INFORMATION REQUEST RESPONSE

EA No: 0809-001 **Information Request No: Review Board #12**

Date Received

February 14, 2011

Linkage to Other IRs

Review Board IR #08, 13, 14, 15
YKDFN IR #05, 10

Date of this Response

June 17, 2011

Request

Preamble:
The DAR section on accidents and malfunctions only examines failures of individual elements of the project in isolation. It describes what would happen assuming all design features, mitigation measures and emergency response plans are functioning ideally. It does not address likelihoods and severity of each risk. It provides no scenarios of larger events that could cause compound failures of several elements, or consequences of domino effects within overall systems. This includes the larger events described in section 9.

The risk assessment defines “credible” events as those that have a reasonable probability of occurring within the first 25 years, based on the temporal scope of the EA. However, the 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. The developer’s definition of “credible” appears to exclude all long-term risks and low probability events.

Question:

1. Please identify risks for the life of the project, beyond those occurring during initial development activities.

2. Please identify scenarios for events in short and long-term which could cause multiple failures of components of the project

3. Please evaluate probabilities and severities and consequences (including costs) resulting from those scenarios

4. Please describe how failures of individual components would affect the larger systems they are a part of

5. Please describe probabilities, severities and consequences (including costs) for the events discussed in section 19 plus any additional long-term risks identified (see point 1, above).

Reference to DAR (relevant DAR Sections)

s. 9Effects of the Environment on the Project
s. 10 Assessment of Accidents and Malfunctions

Reference to the EA Terms of Reference

s. 2.3Temporal Scope
s. 3.2.5 Accidents and Malfunctions

Response 1

Three risk workshops were arranged and at the first session, Failure Scenario Analysis (FSA) trees were developed which summarize failure scenarios relevant to this project. These FSA trees identify the initiating events for the overall project, as well as the impact a component failure has on an overall system. Appendix A of the attached report, "Failure Mode Effects Criticality Analysis (FMECA) - Giant Mine Remediation - Giant Mine Remediation – Mackenzie Valley Environmental Impact Review Board – Information Request 12 Response," presents these FSA trees for the various systems and evaluates risk in both the short and long term.

Response 2

Cascading Event Scenarios and Multiple Cause Scenarios were developed to assess how multiple failures of components would affect the Giant Mine Remediation Project (Remediation Project) in both the short and long term. A cascading event scenario refers to a series of accidents and malfunctions occurring because of one initiating event; which may cause another malfunction to lead to a series of other multiple malfunctions. The cascading event scenarios developed for both the short and long term of the Remediation Project are presented in Appendix B of the attached report. Multiple cause scenarios were also examined in preparing the response for Question 2. A multiple cause scenario is a specific fault scenario which includes two or more initiating events occurring simultaneously. These types of scenarios generally have a lower likelihood as they require two unrelated causes to happen simultaneously. In the evaluation of multiple cause scenarios, focus was placed on evaluating multiple cause scenarios for the freeze and water management systems. The multiple cause scenarios developed for both the short and long term are presented in Appendix C.

Response 3

To evaluate the probabilities, severities and consequences, experienced workshop participants reviewed the hazards and risks from the FSA Trees and further examined consequences, probabilities and severities through Failure Modes Effects Criticality Analysis (FMECA). The risks were broken down into detail and were given a rating for the likelihood of occurring, and a risk rating for public safety, environment and cost consequences. If the scenario posed risks at a level of moderate to high, mitigating measures/design elements were applied and the risk rating was re-evaluated. The FMECA tables for the major systems are presented in Appendix D of the attached report.

Response 4

The first of three risk workshops arranged developed Component FSA Trees which summarizes how a component failure can affect an overall system of the Remediation Project. Appendix A of the attached report presents these Component FSA trees for the various systems and looks at risk in both the short and long term.

Response 5

To evaluate the probabilities, severities and consequences discussed in section 10, the workshop participants reviewed the risks from the FSA Trees and further examined consequences, probabilities and severities through FMECA. The risks were broken down into detail and were given a rating for the likelihood of occurrence, and a risk rating for public safety, environment and cost consequences. If the scenario posed risks at a level of moderate to high, mitigating measures / design elements were applied and the risk rating was re-evaluated. The FMECA tables for the major systems are presented in Appendix D of the attached report.

INFORMATION REQUEST RESPONSE

EA No: 0809-001 **Information Request No: Review Board #13**

Date Received:

February 14, 2011

Linkage to Other IRs:

Review Board IR #12
Review Board IR #14
Review Board IR #9 (for question 2)

Date of this Response:

May 31, 2011

Request

Preamble: 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. Other parts of the same section of the DAR (9.2.2) specify that it considered risks only over a 25-year time period, the temporal scope of the assessment. However, the 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. Long-term stability is an important aspect of the project.

Question:

1. Please provide seismic scenarios with earthquakes of various sizes (including Richter magnitudes of 5.0-5.9, 6.0-6.9 and 7.0 to 7.9) hitting the partially frozen system (*e.g.,* Cavities' perimeters are frozen with unfrozen dust; cavities perimeter frozen, saturated unfrozen dust; etc.) and the frozen system.
2. Please evaluate probabilities and consequences on natural geological features, manmade structures and their environment, with as well as buildings, pipes, etc.
3. Please provide possible drainage scenarios in the aftermath of an earthquake.
4. Please define "credible" seismic event over the duration of the project (Instead of the 25 year period considered elsewhere in section 9.2.2).

Reference to DAR (relevant DAR Sections):

S. 9.2.2.1 Potential Seismicity Effects
S. 9.2.3 Mitigation Measures
S. 7.2.2.7 Seismicity

Reference to the EA Terms of Reference:

S.2.3 Temporal Scope
S.3.3.9 ---

Response 1 Summary

Review of information on historical earthquakes occurring within a radius of 300 km from Yellowknife on the Natural Resources Canada web site (www//nrcan.gc.ca) suggests:

- Risk of occurrence of earthquakes of magnitude M5-M5.9 within a 300 km radius from Yellowknife – Low to Moderate.
- Risk of occurrence of earthquakes of magnitude M6-M6.9 within a 300 km radius from Yellowknife – Very Low to Low.
- Risk of occurrence of earthquakes of magnitude M7-M7.9 within a 300 km radius from Yellowknife – Very Low.

Yellowknife is in an area of low to moderate risk for earthquakes of M5 to M7.9 and the anticipated events would cause only minimal damage, if any consequences. The low accelerations anticipated would have a low risk of causing damage to the frozen rock shells around the dust stopes/chambers or to the piping installed to freeze the rock (frozen shells) or the opening areas around the arsenic dust stopes/chambers. The event may cause some minor settlement of the unsaturated dust but would not impact the wetting effort or unfrozen saturated dust.

Response 1

We have reviewed the information on the Natural Resources Canada web site (www//nrcan.gc.ca). The data provided on historical earthquakes (data from 1985 to present) suggests that:

- Risk of occurrence of earthquakes of magnitude M5-M5.9 within a 300 km radius from Yellowknife – Low to Moderate.
- Risk of occurrence of earthquakes of magnitude M6-M6.9 within a 300 km radius from Yellowknife – Very Low to Low.
- Risk of occurrence of earthquakes of magnitude M7-M7.9 within a 300 km radius from Yellowknife – Very Low.

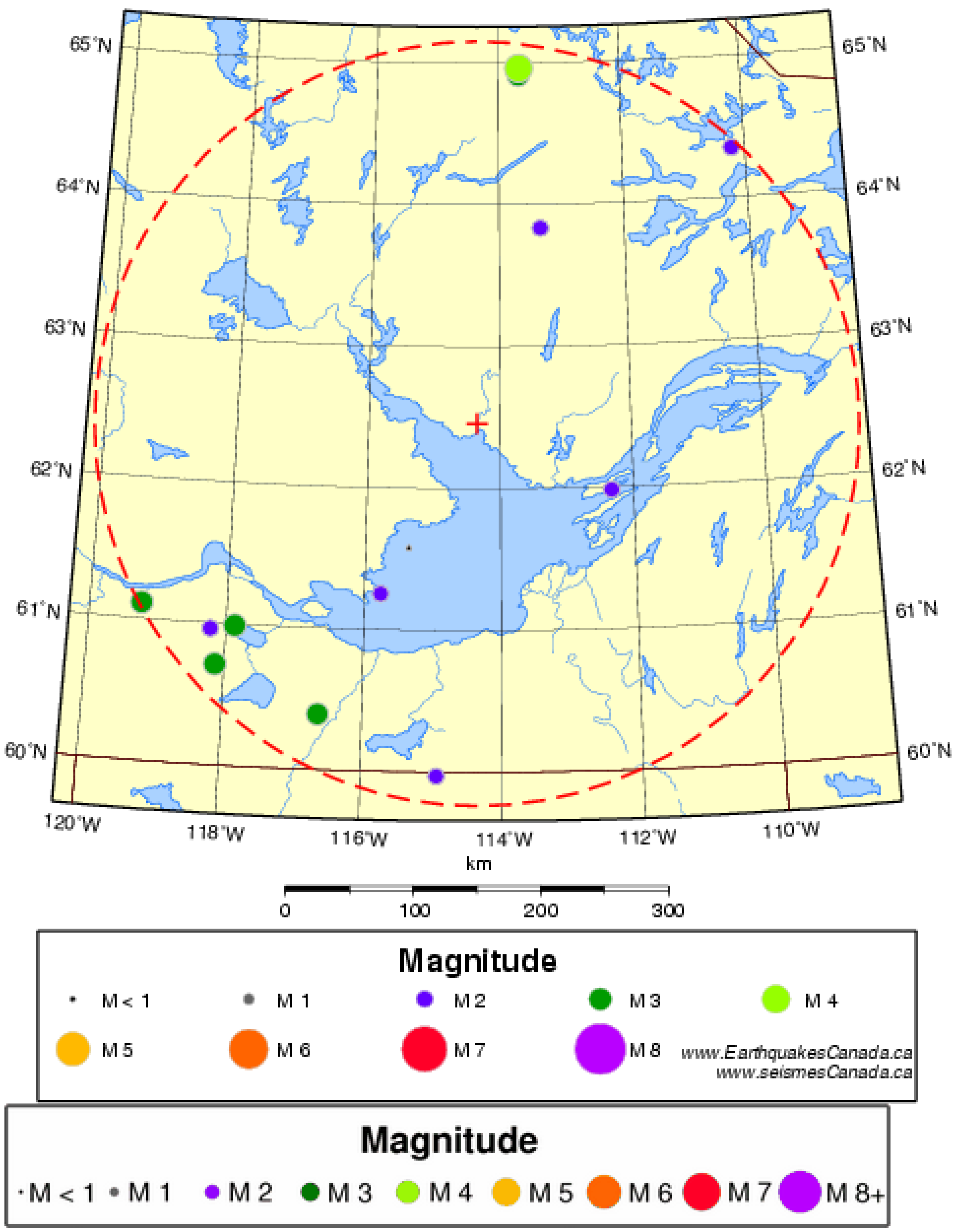
In addition, if needed, an Open File which contains all earthquakes from the database in or near Canada with a magnitude of 2.5 and greater for the time period of 1627 to 2008 can be downloaded from the GeoPub website:

Seismic Hazard Earthquake Epicentre File (SHEEF) used in the fourth generation seismic hazard maps of Canada. Halchuk, S. Geological Survey of Canada, Open File 6208, 2009.

The data used for this effort is:

```
Date       Time(UT)  Lat    Long    Depth  Mag   Region and Comment
----       -------- ---    ----    -----  ---   -------------------
2010/11/30  22:16:39  64.35  -110.21   5.0g  2.3ML 297 km ENE of Yellowknife
2008/06/12  18:38:50  60.99  -117.87  35.0g  3.8ML 115 km W   of Hay R
2006/01/01  19:48:12  60.38  -116.64  10.0g  2.9MN Southwest of Great Slave Lake
2005/11/08  03:47:56  60.71  -118.13  10.0g  3.1MN Near Great Slave Lake.
2005/03/08  17:00:43  61.25  -115.76  18.0g  2.7MN 50 km N from Hay River
2003/01/27  03:21:54  61.98  -112.33  18.0g  2.0MN 100 km SW from Snowdrift
2002/12/31  11:06:16  61.58  -115.36  18.0g  0.7MN 85 km N from Hay River
2002/12/12  08:19:21  63.83  -113.34  18.0g  2.6MN 160 km N from Yellowknife
2001/12/10  11:43:12  61.11  -119.24  15.0g  3.8MN West of Great Slave Lake
2001/11/28  04:18:39  64.96  -113.66  20.0g  4.5Mw Near Snare Lake
2001/11/28  04:11:14  64.91  -113.67  20.0g  3.9MN Near Snare Lake
2000/09/20  17:51:36  60.96  -118.22  10.0g  2.9MN Horn Mountain
1990/03/30  07:53:58  60.39  -116.63  18.0g  3.5MN SOUTHWEST of HAY RIVER
1989/04/04  03:13:40  59.97  -114.93  18.0g  2.8MN WOOD BUFFALO NATIONAL PARK
A total of 14 events found.
```

Magnitude	< 1	1	2	3	4	5	6	7	8	9
Total	1	0	7	5	1	0	0	0	0	0



Date Modified: 2011-02-23

Thus, based on data on historical earthquakes, Yellowknife is in an area of low to moderate risk for earthquakes ranging from magnitude M5 to M7.9. The anticipated peak horizontal ground acceleration for Yellowknife and the region nearby, for a return period of 2,475-yrs to be considered for the design of structures as per 2010 National Building Code of Canada, is predicted to be 0.036g. This peak acceleration has been downgraded from the 2005 Code, as the hazard map for the Yellowknife area has been updated in the 2010 Code.

Therefore, from the information collected, it is judged that for an event with a magnitude of M5 to M5.9, the peak horizontal ground acceleration for a probable seismic event in the Yellowknife area has a low risk of causing damage to the underground plugs or mine openings (cavities) but may cause minor damage to the freezing system. The damage might result in control systems being off line or a minor power outage, which would all be managed locally to return the system to normal. The low accelerations anticipated would have a low risk of causing damage to frozen rock shells at the dust sites or to the piping installed to freeze the rock (frozen shells) or the opening areas around the arsenic dust stopes/chambers. The event may cause some minor settlement of the unsaturated dust but would not impact the wetting effort or unfrozen saturated dust.

In consideration of the larger seismic events (M5 and larger), the documented evidence suggests that to cause damage to buildings or earth dams/embankments and liquefaction of soils as a result of ground shaking from earthquakes, the following pairs of "credible earthquake magnitude – distances" should be considered:

M_w 5 occurring within a distance of ~1 km from the mine site
M_w 6 occurring within a distance of ~7 km from the mine site
M_w 7 occurring within a distance of ~50 km from the mine site
M_w 8 occurring within a distance of some 165 to 340 km from the mine site

An earthquake of magnitude 8 (and larger) is generally associated with an inter-plate subduction event. Such an event is likely to be generated at the plate boundaries located offshore at distances in the order of about 1,300 km. An earthquake occurring so far away will have only a minimal impact with regards to ground shaking at the mine site and can be excluded for the purposes of engineering evaluations.

The remaining earthquake scenarios presented above will likely be crustal events and may be considered for the seismic assessment of the partially frozen and frozen systems during the detailed design of the facility components. The corresponding ground shaking levels should be established at that time for the assessment of seismic stability of the various mine structures, but would be managed within current design parameters.

Response 2 Summary

The 2010 National Building Code of Canada (NBCC) specifies a peak horizontal ground acceleration of 0.036 g for the Yellowknife area for a return period of 2,475-years. This intensity of shaking is equivalent to an earthquake that corresponds to MMI-V in the Modified Mercalli Intensity Scale that is based on the intensity of shaking felt by people and observed damage. The credible seismic events are of low intensity and would have minimal consequences to dams or new buildings on the mine site in the post-closure period.

Response 2

The 2010 National Building Code of Canada (NBCC) specifies a peak horizontal ground acceleration of 0.036 g (peak ground acceleration – PGA) for the Yellowknife area for a return period of 2,475-years. This intensity of shaking is equivalent to an earthquake that corresponds to MMI-V in the Modified Mercalli Intensity Scale that is based on intensity of shaking felt by people and observed damage. An MMI-V scale earthquake can be described as follows: "*Felt by nearly everyone, many awakened. Some dishes, windows, and so on broken; cracked plaster in a few places; unstable objects overturned. Disturbances of trees, poles, and other tall objects some-times noticed. Pendulum clocks may stop (Bolt, 1987)"*. The overall damage potential is assessed to be "very light" to structures that would be built for the post-closure period.

The seismic design ground motions in the 2010 NBCC have been downgraded from the 2005 NBCC due to refinements implemented to the seismic hazard models used to compute the parameters in low seismic hazard regions of Canada; *i.e.,* PGA in 2005 NBCC = 0.059 g vs PGA in 2010 NBCC = 0.036 g. Thus, the consequences of damage as a result of a credible seismic event in the area of Giant mine are minimal. Minor to no damage would be anticipated to pipes and buildings developed for the post-closure operation at the Giant mine.

The conservative design that has been selected for the site would anticipate that the dams on site would be reviewed and classified as "High Consequence" structures according to CDA Dam Safety Guidelines (2007). This would be considered a 'worst case condition' during the closure period (several key dams still operational). In post-closure, none of the existing dams will retain water. The dam structures would retain drained tailings. The existing buildings on the site would be removed and the new structures on site would be designed and built to the 2010 NBCC.

Response 3 Summary

It is anticipated that the dams on site would be classified as "High Consequence" structures, and considering the CDA Dam Safety Guidelines (2007), the previous dam safety reviews in 2004 indicated that there is a low likelihood of any significant damage to the tailings dam that will result in a risk of release of reservoir contents. Consequently, drainage of water from behind the dams in the post-closure period would be minor if at all.

The anticipated damage to the 'frozen shell' which is developed at start of the freeze program would be minor if any damage occurred. The new concrete plugs to be installed to support the existing bulkheads in the lower drifts at the arsenic chambers will be designed to withstand the predicted seismic events. There is a very low risk of leakage or drainage after a credible seismic event.

Response 3

It is assumed in the current preliminary closure design that the dams would be classified as "High Consequence" structures, and considering the CDA Dam Safety Guidelines (2007), the previous reviews indicated that there is a low likelihood of any significant damage to the tailings dam that will result in a risk of release of reservoir contents. Consequently, drainage water from the tailings areas behind or retained by the dams in post-closure would be minor and in time (plus 25 years into post closure period) it is anticipated that there would be limited water retained.

The anticipated damage to the 'frozen shell' which is the first stage of the freeze program would be minor. Concrete plugs to be installed in the lower drifts below the arsenic chambers will be designed to withstand the predicted saturated head for a fully wetted dust chamber. Thus, if a critical seismic event occurs when the freeze program was at a critical point, a low risk of leakage or drainage of dust or saturated water with arsenic dust would be predicted based on the current design being developed.

References

BGC Engineering Inc., Giant Mine: 2004 Dam/Dyke Safety Review, February 2004

Canadian Dam Association (CDA) Dam Safety Guidelines (2007)

SRK Consulting Inc., Giant Mine Remediation Plan 2008 Seismic Studies Related to Tailings Dam Safety – Final, August 2008

Response 4 Summary

A historical search of earthquakes occurring in the past 25 years within radii of 100 km, 200 km, and 300 km and centered at Yellowknife resulted in four M1 to M2 earthquakes and fourteen M1 to M4 earthquakes. This indicates that the mine site is in a region of low historical seismicity. A peak ground acceleration of 0.036 g for the 2,475-year return period confirms low levels of seismic activity and suggests that only minor credible seismic events could occur over the long term of the project. This should result in very low to low risk of damage to structures in post-closure.

Response 4

A historical search of earthquakes occurring in the past 25 years within radii of 100 km, 200 km, and 300 km and centered at Yellowknife resulted in four M1 to M2 earthquakes and fourteen M1 to M4 earthquakes. This indicates that the subject site is in a region of low historical seismicity.

The 4^{th} Generation Seismic Hazard Maps developed for the 2010 NBCC indicate a peak horizontal ground acceleration of 0.036 g for ground motions with a return period of 2,475-years for a credible seismic event in the Yellowknife area. The 4^{th} generation models consider both the historical and regional seismicity models and the acceleration values are provided for the worst case scenario. A peak horizontal ground acceleration of 0.036 g for the 2,475-year return period confirms low levels of seismic activity. This level of shaking is relevant for dams with a High Consequence classification. The resulting performance of the dams on the Giant mine, built using standard construction practices, is expected to be satisfactory in accordance the Dam Safety Guidelines updated in 2007 and given that the dams on site will not be retaining any water, the dam performance is anticipated to be satisfactory.

Extrapolation of seismic hazard data for longer return periods indicates that the peak ground acceleration should be close to 0.06 g for a longer 5,000-year return period. This level of shaking is applicable for Very High Consequence dams. The inferred level of shaking is unlikely to cause any significant damage to dams built at the Giant mine using the standard construction practices of the day.

Earthquakes of magnitude M_w 8 (or larger) are generally associated with inter-plate subduction events. These events are likely to be generated at the plate boundaries located offshore at distances of the order of about 1,300 km. Earthquakes occurring so far away will have only a very minimal impact with regards to ground shaking at the mine site and can be excluded for the purposes of engineering evaluations.

Other M_w 5 to M_w 7 earthquake scenarios will likely be crustal events and may be considered for the seismic assessment of the partially frozen and frozen systems during the detailed design of the facility components.

Reference
Canadian Dam Association (CDA) Dam Safety Guidelines, 2007

INFORMATION REQUEST RESPONSE

EA No: 0809-001 **Information Request No: Review Board #14**

Date Received

February 28, 2011

Linkage to Other IRs

Review Board IR #01, 02, 05, 07, 12, 13, 15, 16, 20

Date of this Response

June 17, 2011

Request

Preamble:
In evaluating risks or accidents and malfunctions, the Review Board must consider any stability issues arising from the proposed arsenic saturation and freezing method. The DAR raises the possibility of moving or agitating the water and arsenic dust during saturation while the perimeters of the chambers and stopes are already frozen, and may be swollen by the freezing.

Question:

1. Please provide a stability analysis to prove that cavities will remain stable during perimeter freezing, saturation of dusts, freezing of dust.

2. Please describe drainage scenarios and any other potential releases or arsenic in the event of a collapse or bulkhead failure.

Reference to DAR (relevant DAR Sections)

S. 6.2.6 Initial Freeze
S. 5.1.4 Stability of Arsenic Trioxide Dust Storage Area Crown Pillars
Dec 13, 2010 Deficiency Statement #1, 2.

Reference to the EA Terms of Reference

ToR 3.2.5

Response 1

Stability of the arsenic stopes/chambers cannot be 'proven' given the uncertainties in rock characterization and loading conditions. However, an evaluation of the existing stability analyses previously carried out is in progress. These analyses have assessed the likelihood of failure of the arsenic stopes and chambers, and adjacent non-arsenic stopes prior to freezing and saturation.

Preliminary results of the design evaluation suggest that the likelihood of failure of various arsenic stopes is similar to that outlined in Section 5.1.4 of the Developer's Assessment Report (DAR).

The current phase of design work will also include recommendations for future geotechnical investigations, stability analyses, and possible short-term performance monitoring requirements for specific arsenic stopes and chambers and nearby stopes. The need for mitigation of the risk of instability of nearby stopes will be considered where this has the potential to affect the implementation of the remedial design.

The design evaluations will consider the potential for the implementation of perimeter freezing, saturation of dusts, and freezing of dust to cause arsenic stopes and chamber failure. Preliminary comments on these issues follow.

Perimeter freezing

- Unsupported or under-supported rock wedges subjected to freezing may become detached from the rock mass but the effects are anticipated to be local and no major instabilities are expected. Freeze/thaw cycles would increase the potential for wedge stability issues and their magnitude but these are not anticipated under the proposed design.

- The lower bulkheads will be reinforced with drift plugs and drift backfilling prior to freezing and wetting. The impact of slabs falling off the arsenic stope or chamber walls and into the arsenic dust will be minimal.

Saturation of dust

- Saturation of the dust could result in settlement of the dust that would increase open stope hanging-wall, foot-wall, and end-wall spans. The potential impact of dust consolidation will be addressed in the final design, as required.

- During the wetting or flooding process some local rock wedges may be impacted by the changing groundwater pressures but the effects are anticipated to be local and no major instabilities are expected.

- The potential impact on pillars separating adjacent stopes of ground loads caused by saturation of the dust will be the subject of a future geotechnical assessment. The impacts are anticipated to be minimal as non-arsenic stopes separated by thin pillars from arsenic stopes will be backfilled and the pillars frozen prior to saturation.

Freezing of dust

- The final design will assess the optimum approach to freeze the added water in the dust to prevent significant increase in pressure that may impact the stability of the arsenic stopes and chambers or the lower arsenic drift plug / bulkhead combinations.

Response 2

The preliminary remediation design approach includes measures to reduce the probability of pillar collapse or bulkhead failure which could lead to drainage of contained arsenic contaminated water, saturated arsenic dust, or dry arsenic dust.

The closure/remediation design includes new drift plugs that will be installed in all drifts and raises connected to or adjacent to arsenic stopes or chambers to isolate them from the “clean” and/or non-frozen areas of the mine. New drifts will be excavated to gain access to currently inaccessible bulkheads for plug construction. The drift plugs will be built within the zone of rock to be frozen. Many of these new drift plugs will be built directly adjacent to the existing bulkheads and will be designed to withstand the pressure from the maximum possible column of saturated arsenic dust. The combined existing bulkhead /new plug structure will be designed to resist structural failure. In the few cases where the new lower arsenic drift plugs will be built away from existing bulkheads, the intervening drifts will be backfilled and frozen prior to saturation of the dust. Potential seismicity will be included in the designs.

The impact of frost pressure due to freezing on the combined bulkhead / drift plug structure is outlined in response to IR #14, Question 1, but information gained during the Freeze Optimisation Study (FOS) will be incorporated into the final designs.

However, any resulting leaks will be captured in the general mine pool and treated in the water treatment plant.

INFORMATION REQUEST RESPONSE

EA No: 0809-001 **Information Request No: Review Board # 15**

Date Received:

February 14, 2011

Linkage to Other IRs:

Review Board IR # 8, 12, 13

Date of this Response:

May 31, 2011

Request

Preamble:
The proposed project involves saturating and freezing chambers with water, despite the possible presence of many unidentified holes and open voids. The project description in the DAR suggests that although detected and pluggable holes will be filled with fine-granular material, pre-existing undetected or unpluggable holes will remain open until the caverns are saturated with water. It is unclear how this may affect the freezing process, and whether it may cause other potential impacts.

Question 1:
With respect to holes and voids in chambers during freezing:

- Please define scenarios which include the presence of variable number/section of undetected/unpluggable holes

Question 2:
With respect to holes and voids in chambers during freezing:

- Please verify that freezing will be possible under flow

Question 3:
With respect to holes and voids in chambers during freezing:

- Please describe potential impacts and implications, such as possible losses of contaminants, over-costs of pumping/treatment, etc.

Reference to DAR (relevant DAR Sections):

S. 6.2.8.1 Influence of Groundwater
S. 6.2.5.2 Underground Preparation
S. 5.2 Other Underground Mine Components
S. 5.2.6 Boreholes

Reference to the EA Terms of Reference:

S. 3.3.2 ---

Response 1 Summary

Unknown water pathways in the rock may be encountered during the execution of the freeze program. The plan is to backfill and plug known exits for water. If leaks are detected during drilling and the water flow is such that the frozen shell does not stop it, then additional measures will be considered such as grouting. A plan will be developed as part of future design phases for adding water to the chambers/stopes and will include a program for monitoring.

Response 1

Records show that attempts were made to plug drill holes into chambers prior to placing the arsenic trioxide dust. Current information indicates the rock around the arsenic chambers/stopes is generally competent with a low permeability. Known pathways for water to leave the chambers/stopes are drifts and raises. These exits will be backfilled and plugged prior to filling the chambers/stopes with water.

Undetected pathways for water to exit the chamber/stope may be identified during drilling for the freeze pipes. Possible scenarios might be old drill holes or fractures in the rock. However, the flow of water through these undetected pathways is expected to be limited; the rock within the freeze perimeter will be cooler than -10°C and water in any fracture would eventually freeze. If unexpected leakage is detected and the frozen shell does not stop the flow, additional measures such as grouting may be reviewed and evaluated as part of the response plan. Should water containing arsenic leak from a chamber/stope, it will report to the general mine water and be treated by the water treatment plant as is currently the case.

Response 2 Summary

Water is expected to freeze under flow.

Response 2

Once the frozen shell is in place, freezing is expected under flow. It is anticipated that the filling of the chambers/stopes will include a gradual increase in the head during flooding. As stated in Review Board IR #8, Response #2, if water seepage is not stopped initially by the frozen shell, the hydraulic conductivity of the dust will limit the flow rate of water into the fracture. With the rock at a temperature cooler than -10°C the slow moving water would quickly freeze and the ice buildup would seal the fracture.

Response 3 Summary

There will be a limited impact on pumping and treatment costs of leaks from the chambers/stopes because of the relatively small flow rate from such leaks compared to the overall mine drainage and treatment system.

Response 3

Water will be added to the chambers/stopes after the frozen shell is in place and the potential impact from water leaking out of a chamber or stope is considered low. During the time when water is added to the chamber/stope, monitoring in access drifts will be conducted until the frozen block is created. Water that may leak out of the frozen shell would not progress very far unless the leak intersects a drift. Once water from a leak intersects a drift, it will flow into the mine water drainage system and be treated by the water treatment plant. Given the relatively low flow volume from the leak and the relatively larger amount of water that will be treated by the water treatment plant, the overall impact on pumping and treatment costs is considered negligible.

The existing remediation plan proposes a separate system to treat water that may have high concentrations of arsenic until the frozen blocks are all in place. After the blocks are frozen, arsenic concentrations in mine water should fall because the main source of arsenic in the mine water to be treated is seepage from the chambers/stopes that contain arsenic trioxide dust.

INFORMATION REQUEST RESPONSE

EA No: 0809-001 **Information Request No: Review Board #16**

Date Received

February 14, 2011

Linkage to Other IRs

Review Board IR #02, 05, 07, 12, 14

Date of this Response

June 17, 2011

Request

Preamble:
Stability of the chambers during freezing is an important part of the proposed project. The DAR identifies that possibility of crown pillar collapse in some chambers. The Board needs to evaluate the risks related to freezing and structural stability. Presumably expansion of the cavity by freezing saturated dust will exert pressure on the wall. Further description is required of the effects on unstable crown pillars and bulkheads during freezing and during possible thawing in the future. Further description is also required of potential changes to surface drainage patterns due to changes related to freezing.

Question:
1. Please verify possible deformations during the freezing process, such heave, differential freezing etc.
2. Please compare deformations to natural drainage patterns and check alterations.
3. Please describe potential impacts of instability or failure of crown pillars and bulkheads due to differential expansion and other changes that may occur during freezing.
4. Please describe potential impacts of instability or failure of crown pillars and bulkheads due to thawing and reductions of pressure.

Reference to DAR (relevant DAR Sections)

Document J (page 6) recognizes deformation of the rock mass, and states on page 34 “If necessary, water would be added in stages to control the effects of expansion caused by freezing.”

Reference to the EA Terms of Reference

S.3.2.5 Accidents & Malfunctions
"The developer is required to:
- Analyze risks for this development, including components, systems, hazards, and failure modes.
- Assess likelihoods and severity of each risk identified."

Summary

Freezing the ground around and within the chambers should increase the strength of the bedrock and overburden once frozen. However, the water present inside fractures and voids will expand when freezing and could increase the stresses along those fractures and voids. Such stress could propagate cracks within the bedrock, or trigger structural instabilities. The final methodology of wetting of the chambers will take into account the expansion effects of water during freezing.

The locations of the chambers are shown in relation to the current drainage patterns on site. All of the chambers with a possible risk of crown pillar collapse are located within a catchment reporting to the B1 Pit. Prior to freezing, the voids in these chambers are to be backfilled and the B1 pit filled.

The risks and impacts of freezing and thawing leading to failure of a crown pillar or a bulkhead is described in the response to the Review Board Information Request #07 and Review Board Information Request #05.

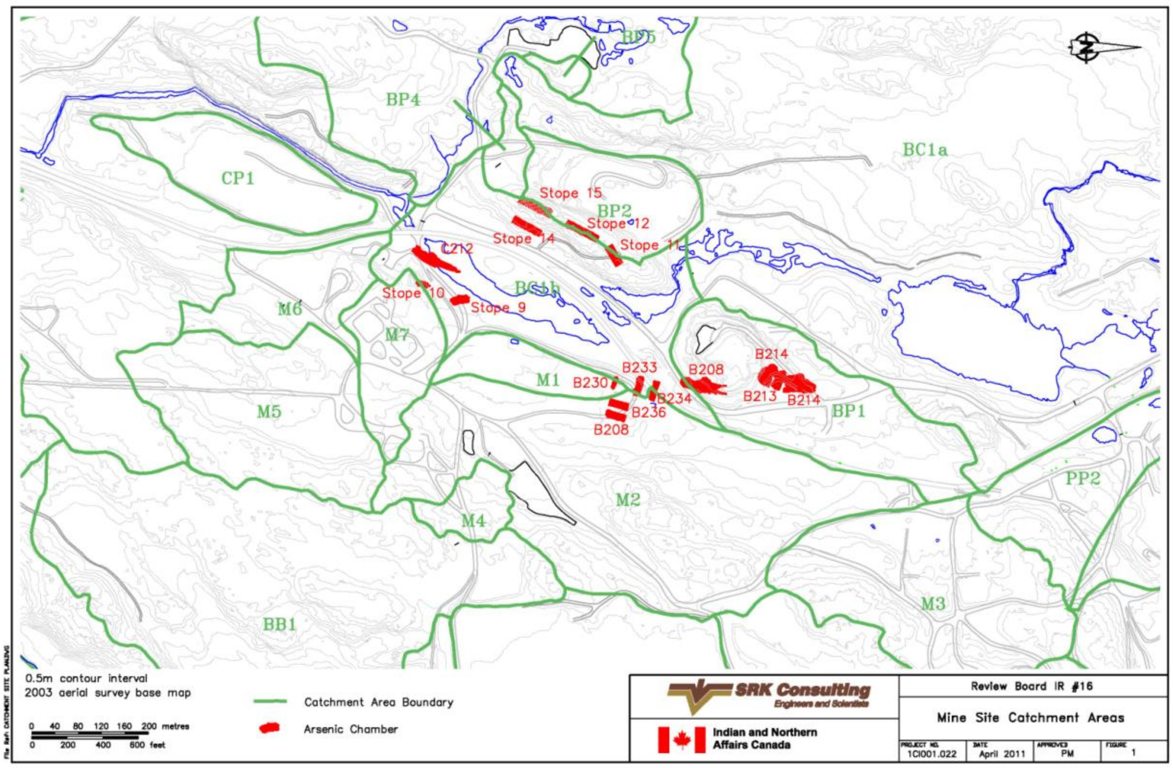
Response 1

The water present inside fractures within the bedrock will expand during freezing and could increase the stresses along those fractures. The increased stress could cause the fractures to propagate, potentially triggering local failures of crown pillars, sill pillars or access drifts. Local failures within access drifts, such as spalling of the drift walls, are not expected to be problematic because the drifts will be plugged prior to freezing. The potential for larger failures, for example of crown or sill pillars, will need to be considered in design. The current plan is to backfill voids below pillars that are questionable. The backfill would provide support in the event of a weakening of the bedrock. No upward heaving is expected in the bedrock.

Wetting of the dust is described in Section 6.2.6 of the Developer's Assessment Report (DAR) and is further discussed in the response to Review Board Information Request #02. Currently, the wetting method remains in concept and additional assessments are planned as part of further design. The importance of freeze expansion and the methods for dealing with it will depend on the wetting process. For example, if a "bottom-up" wetting method were used, freezing water would be free to expand upward into the dust, minimizing the pressure exerted on the wall.

Response 2

The figure below shows the location of the chambers in relation to the current drainage patterns on site. The catchment areas correspond to those used in the water and load balance reported in Supporting Document M1 of the Giant Mine Remediation Plan. Table 5.1.7 of the DAR discusses concerns about the stability of crown pillar over stopes B208, B212, B213 and B214. All of those stopes are located in the B1 Pit catchment area. Even a complete crown pillar failure would have no impact on drainage patterns outside this catchment area. Drainage patterns within the B1 Pit catchment will be significantly modified by the pit backfilling, and any required re-grading could be accomplished at that time. It should be noted however that the plan is to backfill the voids beneath the crown pillars in order to prevent crown pillar failure.



Response 3

The risks and impacts of the failure of a crown pillar or a bulkhead due to freezing is described in the response to the Review Board Information Request #07.

Response 4

Risks and impacts of the failure of crown pillars and bulkheads due to thawing are discussed in the response to the Review Board Information Request #05.

INFORMATION REQUEST RESPONSE

EA No: 0809-001 **Information Request No: Review Board #17**

Date Received

February 14, 2011

Linkage to Other IRs

NSMA IR #09

Date of this Response:

May 31, 2011

Request

Preamble:
To assess impacts on wildlife, the Board considers the effectiveness of proposed mitigations. The DAR and accompanying materials suggest that the treated water storage pond will be fenced to make it inaccessible

Question:
Please describe if the treated water storage pond will be covered with fencing to keep water birds from landing on it. If not, please describe if and how water birds will be kept away.

Reference to DAR (relevant DAR Sections):

S.7.5.3.1
"Birds that are "At Risk" are the common nighthawk and olive-sided flycatcher while the harlequin duck, yellow rail, rusty blackbird and American white pelican are classified as "May Be At Risk'".

S.7.5.4.4
"The survey showed that no duck broods were present on the disturbed sites during the summer, likely due to the lack of emergent vegetation along the shoreline. However, gulls and terns preferred disturbed sites over control sites. While no ducks were observed in Baker Creek Pond, shorebirds nested in the area. A breeding bird survey conducted as part of the study during the summer reported a total of 79 species present on site from mid-May to mid-October, most associated with the wetlands on the site, followed by the mesic forests".

S.7.1.4.3 and Fig. 7.1.7
"Sediments from Baker Pond had total arsenic concentrations in the range of a few hundred µg/g to over 3,500 µg/g".

Reference Supporting document N1 Tier 2 RA under 2.2.1 Potential Future Releases Associated with Remediation Case state:

"No surface ponds will be present on site with the exception of the treated water storage pond. The arsenic concentration in the pond is expected to average approximately 0.38 mg/L, but the pond will be fenced. Therefore, it will be inaccessible".

Reference to the EA Terms of Reference

S.3.5.4 (2)
"The effects of each development component on each wildlife and wildlife habitat component"

S.3.5.4 (3)
"The potential effects of the development operations on rare, threatened or endangered species including Peregrine falcon (anatum subspecies) and species listed by the Committee on the Status of Endangered Wildlife in Canada, including plans for monitoring species listed as "at risk" or "may be at risk" in the NWT General Status Ranks".

Summary

The water storage pond will contain clean water, and will have no habitat or vegetation. The pond will be small in comparison to other water bodies in the area, and will present no significant risk to birds.

Response

Storing treated water in a holding pond would allow the water quality to be monitored before discharge. Most of the water in the pond would be discharge quality, with only occasional exceedances of discharge criteria. Any treated water that fails to meet the discharge criteria, for example due to occasional plant upsets, would be recycled through the treatment plant or returned to underground storage.

An outdoor treated water storage pond would be within a fenced area to inhibit land access. It is not anticipated that the pond would be covered since the treated water storage pond would lack vegetation and aquatic life and therefore it would not attract water birds. The pond will be small in comparison to other water bodies in the area, and any birds that land on the pond would not stay long due to the lack of food and suitable habitat. The short exposure period and the fact that the pond would only contain water that had been treated to remove contaminants mean there will be no significant risk to birds.

INFORMATION REQUEST RESPONSE

EA No: 0809-001 **Information Request No: Review Board #18**

Date Received:

February 14, 2011

Linkage to Other IRs:

Date of this Response:

May 31, 2011

Request

Preamble:
The ecological benefits of creating attractive breeding habitat for fish and other wildlife in the form of enhanced wetlands (p6-88) in highly contaminated areas of Baker Creek are unclear. Wetlands in Baker Creek will likely attract fish, water birds, and semi-aquatic furbearers. The DAR recognizes that fish in Baker Creek may be unsafe to eat, and that muskrat and mink will likely exceed toxicity reference values (p8-80). The DAR states that superior habitat is locally abundant. The DAR predictions on terrestrial wildlife recognize that habitat is not as valuable when it poses a chemical risk to the species using it.

Question:
Please explain the reasoning behind creating wetland habitat that is attractive to fish, water birds and fur-bearers in the contaminated setting of Baker Creek.

Reference to DAR (relevant DAR Sections):

S.6.1.1 Remediation Objectives #5: Restore Baker Creek to a condition that is as productive as possible

S.6.1.2 Re: Baker Creek: "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. At 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.

S.6.9.3 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". INAC is considering creating or enhancing wetlands in Reach 5 and 6 of Baker Creek.

Baker Creek sediments contain thousands of parts per million arsenic, well over applicable criteria. Among the highest concentrations are in Reach 5 and 6 (DAR 7.1.4.3 p7-19 and Fig. 7.1.7). There is a potential for adverse effects from arsenic on both predator and forage fish within Baker Creek (DAR 8.9.4.2 p8-79). There is an abundance of superior habitat in the Local Study Area and Regional Study Area" (DAR 8.8.2.3).

Reference to the EA Terms of Reference

S.3.5.2 Fish and Aquatic Habitat: "Potential effects to fish and fish habitat were identified as issues of concern during the Review Board's scoping exercise. Public concern 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"

Summary

Remediation will result in important improvements to the chemical quality of Baker Creek and also presents opportunities for improvements in the physical habitat of the creek. Although some chemicals (particularly arsenic) will remain at concentrations that are elevated relative to natural conditions, significant adverse risks to most aquatic species are not anticipated to occur. On this basis, Baker Creek has the potential to serve as viable and productive habitat, without significant risks to aquatic species. Notwithstanding this conclusion, the Giant Mine Remediation Project Team (Project Team) believes that decisions regarding the remediation of Baker Creek should be informed by additional input from interested parties. This will include consideration of preferences to both encourage and discourage habitat use within the design process for Baker Creek.

Response

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 (e.g., to avoid surface and/or sub-surface flooding). A second priority of the Giant Mine Remediation Project (Project) is to manage potential risks to ecological and human receptors by reducing chemical loadings to the downstream aquatic environment (i.e., Great Slave Lake). This will be achieved through the remedial concepts presented in the following Sections of the DAR: 6.6 (capping of tailings and sludge areas), 6.8 (management of site waters – surface water and minewater), 6.9 (management of contaminated sediments in Baker Creek) and 6.10 (remediation of contaminated surficial materials).

In addition to the two priorities noted above, both of which are considered to be "mandatory requirements" of the Project, a third and optional priority for Baker Creek is the creation of new aquatic habitat. If desired, habitat creation could be achieved through the physical modifications that encourage the use of the creek by aquatic species during relevant life stages. Examples of such improvements include the creation of deeper pools, riffle areas, spawning/rearing areas and establishment of appropriate food sources (i.e., aquatic invertebrates and vegetation).

The realignment of Reach 4 in 2006 serves as a case study of potential habitat improvements that could be achieved elsewhere in Baker Creek. In that case, a diverse community of worms, snails, mayflies, caddis flies, beetles and flies have colonized the rehabilitated portion of the creek, indicating good forage for hatching grayling and sucker. The benthic community present in Reach 4 was observed to include both pollution-tolerant and pollution-sensitive species that provide very good forage for the fish community. Furthermore, studies conducted since the realignment of Reach 4 have shown that the modifications markedly improved the spawning success of Arctic grayling within the Creek.

The realignment of Reach 4 illustrates that a wide array of aquatic species can be encouraged to use the creek through improvements to the physical habitat. However, even after remediation, some parameters (particularly arsenic) will remain elevated relative to background concentrations. As a consequence, species using Baker Creek will be exposed to risks that are higher than in a similar but "pristine" environment. In addition, it is expected that the current catch and release policy for those who fish in Baker Creek will remain in effect for many years.

As described in Section 8.9 of the DAR, the Ecological Risk Assessment results showed that arsenic concentrations in Baker Creek post-remediation are not expected to result in adverse effects to most aquatic species and to wildlife that have aquatic-based diets. These findings were based in part on the results of field surveys that have shown fish to be present and successfully reproducing in Baker Creek and Environmental Effects Monitoring carried out on resident fish species at the mouth of Baker Creek which indicated little difference in the health of species caught in Baker Creek versus a reference area. Field evidence from muskrat surveys carried out in Baker Creek in 2003 and 2004 demonstrated that muskrat were present, reproducing and appeared in good health despite the fact the risk assessment indicated that they may be at risk. The primary effect of current contaminant concentrations is on the diversity and abundance of benthic invertebrate species in areas with elevated arsenic levels in sediments. Improvement of habitat conditions (such as demonstrated in Reach 4) and reduction of the arsenic level in the creek water and sediments is expected to result in reduced risks to all species.

While it is acknowledged that superior habitat is available elsewhere in the Great Slave Lake watershed, Baker Creek has the potential to serve as viable and productive habitat, without significant risks to aquatic species. This position has been supported by government agencies with regulatory authority (e.g., DFO) and has been integrated throughout the remedial planning process. The alternative to creating new habitat would be to actively discourage use of Baker Creek by aquatic species. Such a philosophy would presumably extend to areas of the creek that are already serving as effective habitat (e.g., Reach 4). It is expected that the elimination of such habitat would not be acceptable to regulatory authorities.

Notwithstanding the conclusions noted above, decisions regarding the remediation of Baker Creek should be informed by additional input from interested parties. This will include consideration of preferences to both encourage and discourage habitat use within the design process for Baker Creek, where appropriate. The mechanisms through which this input will be incorporated into the Remediation Project are described in Section 13.12 of the DAR. In addition, the approaches that will be used to monitor and confirm the health of the aquatic environment are presented in Chapter 14.

INFORMATION REQUEST RESPONSE

EA No: 0809-001 **Information Request No: Review Board #19**

Date Received:

February 14, 2011

Linkage to Other IRs

Alternatives North IR #07

Date of this Response:

May 31, 2011

Request

Preamble:
The DAR establishes that the project has thoroughly examined best available technologies, and that it is open to improvements if technologies advance. It is unclear how future technologies will be recognized and considered.

Question:
Please provide details on how emergent technologies will be considered in the future, and the frequency with which this will occur.

Reference to DAR (relevant DAR Sections):

DAR s.6.2.2.4 Future Re-Consideration of Alternatives

Reference to the EA Terms of Reference

ToR 3.3

Summary

The Giant Mine Remediation Project Team (Project Team) proposes that a review of emergent technologies be conducted every 10 years following full implementation of the Frozen Block Method, and that the result of the reviews be reported in the State of the Environment Report for that year. Emergent technologies that are identified in such a review will be submitted to the Independent Peer Review Panel for a more detailed technical examination of applicability to the specific situation at the Giant Mine.

Response:

As described in detail in the DAR, the Frozen Block Method is designed to be a robust and effective remediation solution for the complete life of the project. The conditions at the site prevent any "quick fix" or "walk away" solutions and therefore any approach to remediation of this site requires long-term care and monitoring.

Considering the long-term duration of this remediation solution, the Giant Mine Remediation Project Team (Project Team) proposes a periodic review of technology to ensure that the most effective and efficient solution is in place. This will form part of the adaptive management approach incorporated into the long term Monitoring Plan, which is currently under development. Emergent technologies that are identified in such a review will be submitted to the Independent Peer Review Panel for a more detailed technical examination of the applicability to the specific situation at Giant. Chapter 14 of the DAR introduces the commitment to preparing an Environmental Monitoring and Evaluation Plan (EMEP) and an Environmental Monitoring Strategy (EMS). The process for developing these documents and the role of stakeholders and public are described in the Response to MVEIRB IR #27.

The Project Team is proposing that a review of emergent technologies be conducted every 10 years following full implementation of the Frozen Block Method, and that the result of the reviews be reported in the State of the Environment Report for that year.

INFORMATION REQUEST RESPONSE

EA No: 0809-001 **Information Request No: Review Board #20**

Date Received: February 9, 2011

Linkage to Other IRs

Review Board IR #3
Review Board IR #12

Date of this Response:

May 31, 2011

Request

Preamble:
This project is proposed for perpetuity, but is not engineered for perpetuity. For example, important components such as the Baker Creek channel wall above the pits are only expected to withstand up to a one in 370 year flood event. Although infrequent, a major earthquake can be reasonably foreseen over the long term. A project intended for perpetuity must be engineered to withstand infrequent high consequence events.

Long-term impacts of climate trends on temperature and precipitation have not been considered beyond the initial 25 years. The temporal scope of 25 years 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. Stability of the project considering long-term climate projections is an important aspect of the project.

Question:
1. Please 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.
2. Please provide scenarios and describe the implications in terms of 1) effectiveness of passive freezing over the long term and 2) water management, with management options, funding implications and related risks.
3. Please describe the limits of project systems with respect to increased precipitation extremes. For example, suppose the pumping or water treatment systems fail during an extreme precipitation event, and that the same event causes increased surface water volume, increased groundwater and a channel wall failure above the C1 pit causing the creek to enter the pit. How long would it take for the water storage pond, underground water storage and pits to fill before contaminated water is released to the surrounding environment?

4. Please explain why INAC expects the project to last for perpetuity when it appears to be designed to shorter term tolerances.

Reference to DAR:

DAR s.6.9.1 Key Concerns
DAR s.9.2.2. Evaluation of Potential Effects of the Environment on the Project

In the event of a storm greater than 1 in 500 year event, channel wall failure alongside A2, B1 or C1 pits would likely cause Baker Creek to flow into a pit, causing uncontrolled flooding of the mine (p6-75). 1 in 370 year event would overtop A2 pit (p9-6). Ice and debris jamming could make this worse. The predicted high winter temperature increase is 4.8°C (p9-5) and the predicted general precipitation increase is a maximum 13% (p9-6) for the25 year period of initial development activity. Groundwater flow rates may increase as freezing shuts off other areas (p6-32).

DAR s.7.2.2.7
"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".

DAR s. 9.2.2.2
Temporal scope of climate change considered predicted climate changes over 25 years "for the 2050s period (2041-2070)".

Reference to the EA Terms of Reference

2.3 Temporal Scope
"(T)he Review Board has set a limit on the duration of activities that it can meaningfully assess... For the purposes of this EA, the development activities are those occurring within 25 years and extending to any further time required to stabilize the site. This assessment will not consider the impacts of activities occurring after that period".

3.1.2 Assessing the Impacts of the Environment on the Development
"Consideration should be given to the impact of the environment, such as the impact of extreme weather events or climate change, on the development in each of the sections of 3.2, where applicable.

3.3 (10) 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

Summary

Long term climate change, passive freezing, and water management risks are discussed in other responses.

Some of the items proposed in the Giant Mine Remediation Plan (Remediation Plan) will require monitoring, inspections, maintenance, repair and even complete replacement. But INAC is committed to meeting those requirements. That commitment means that the project as a whole is designed for the long term.

Response 1

The Giant Mine Remediation Project (Remediation Project) has not attempted to model long-term climate change in general. 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. Further details can be found in the response to the Review Board's Information Request #3.

The Remediation Plan as a whole attempts to maximize the use of methods and materials that require a minimum of long-term maintenance. Certainly, there will be components that do require maintenance and even complete replacement. The water treatment system, for example, will include pumps that require routine maintenance and periodic re-build or replacement. But 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 cost estimate for long-term operation of the frozen block system, for example, includes an allowance for occasional replacement of thermosyphons.

Response 2

The long-term effectiveness of the passive freezing system was discussed at length in the Developer's Assessment Report (DAR) Sections 6.2.7 and 6.2.8. The response to the Review Board's information request #3 provides further discussion.

Risks associated with long-term water management are discussed in the response to the Review Board's Information Request #12.

Response 3

During normal operations, the water management system will not be sensitive to changes in precipitation. The large volume of storage available in the underground mine will provide a buffer against fluctuations in normal inflows.

Extreme floods do pose a risk to the water management system if they lead to water levels high enough to overtop the banks of Baker Creek and then flood the underground mine. The remediation plan for Baker Creek recognizes that risk, and in fact minimizing the risk of bank overtopping is the primary objective of the plan. The risks associated with flooding the mine are discussed in the response to the Review Board's Information Request #12.

Response 4

Long-term stability of the Giant Mine site has been a central objective of the remediation planning since day one. Some of the items proposed in the Remediation Plan certainly will require monitoring, inspections, maintenance, repair and in some cases even complete replacement in order to continue functioning over the very long term. But INAC is committed to meeting those requirements. That commitment means that the project as a whole is designed for the long term.

There appears to be some confusion about the significance of the design return periods that are selected and used in the engineering design process. 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 consistent with other design objectives. For example, if every swale or channel over the tailings cover were designed only for the flow rates that occurs every two years, the cover would be at least lightly damaged every two years (on average). Furthermore, the swales, channels and cover would probably suffer very significant damage in larger floods, such as might occur once every ten years. The frequent light damage and periodic significant damage would expose tailings, probably leading to an increased risk of arsenic dispersion and surface water contamination, and certainly leading to very high maintenance costs. On the other hand, designing every swale and channel to survive a 1000-year flood would result in armored channels that would not fit into the landscape, and significantly increased construction costs. In all likelihood, of course, the tailings cover swales and channels will be designed for something between the 2-year flood and the 1000-year flood. The key point for the current discussion is that 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 (such as fitting in with the surrounding landscape).

The choice of design return period emphatically does not mean that ditches or swales will be irreversibly destroyed after *X* years. There will be requirements for inspection, maintenance and repair after events exceeding the design. As noted above, it is the Project Team's commitment to meeting those requirements that really ensures the long term performance of the project.

INFORMATION REQUEST RESPONSE

EA No: 0809-001 **Information Request No: Review Board #21**

Date Received

February 14, 2011

Linkage to Other IRs

City of Yellowknife IR #11
YKDFN IR #20

Date of this Response

May 31, 2011

Request

Preamble:
It is assumed that the assessment of human health risks is based partly on surface water quality. The project proposes to release arsenic through a diffuser year round into Yellowknife Bay or Back Bay. People swim in many locations in those bays. Ingestion of water by users of the bays is not limited to clear water, but includes sediment in turbid water. Arsenic loading of sediment in Back Bay and Yellowknife Bay is recognized in the DAR. This should be reflected in the assessment of human health risks.

Question:
1. Does the measurement of surface water quality in the LSA include arsenic on sediment in turbid water, to indicate total arsenic in the water column, or was analysis conducted only after particulates from sediment had settled?

2. Do the health and human safety assessments include accidental ingestion of, and topical exposure to, sediments in Ndilo, Latham Island, Back Bay, Yellowknife Bay (houseboat community) and Dettah? If not, please include it in a revised assessment.

Reference to DAR (relevant DAR Sections):

DAR 7.1.2.3 p7-9 Surface water quality-Local study area
DAR 8.9.5 Arsenic Intakes by Human receptors

Reference to the EA Terms of Reference

ToR 3.4.2 Health and Human Safety

ToR 3.5.1 Water
ToR 3.5.2 Fish and Aquatic Habitat

Response 1 Summary

The sampling and analytical techniques follow standard protocols for collection and analysis of surface water samples.

Response 1

The sampling and analytical techniques for surface water follow standard protocols for collection and analysis. Surface water samples were not collected from areas where bottom sediments were deliberately disturbed and suspended in the water column. Rather, samples were collected from locations with ambient conditions at the time of sampling. The water samples were not filtered to remove any suspended solids (i.e., sediments) before analysis, and therefore any potential contribution of suspended sediments to the resulting total arsenic concentration would have been accounted for in the analysis.

Response 2 Summary

In addition to the risk assessment, a supplementary exposure assessment was conducted in which various pathways were assessed to evaluate dermal exposure and inadvertent ingestion of sediment solids. These pathways will contribute negligibly to the total arsenic intake and will not result in any increased risk and therefore a revised assessment is not necessary.

Response 2

The risk assessment considered ingestion of drinking water and medicinal teas, consumption of fish and wild game, berries, and garden produce, incidental ingestion of soil, and inhalation. Incidental ingestion of and topical exposure to sediments were not included. In all cases, the drinking water source was assumed to be the City of Yellowknife municipal drinking water supply. The assessment results showed that ingestion of water and consumption of soil only accounted for 1% and 0.5% to 3%, respectively, of total arsenic intake. Ingestion of wild game and supermarket food was estimated to account for a majority (i.e., 67% to 90%) of arsenic exposure.

In preparing the response to this information request, a supplementary exposure assessment was undertaken for an individual who was assumed to come in contact with sediments in Back Bay. The analysis was done for both dermal exposure and inadvertent ingestion of sediment solids. For the analysis, a mean arsenic concentration of 875 mg/kg in Back Bay sediment was used to determine the reasonable maximum exposure that an individual would experience. For the dermal exposure assessment it was assumed that the individual spends 2 hours per week over a 3 week period each summer in Back Bay. The calculated dermal exposure to 875 mg/kg arsenic in sediments was estimated to result in a risk of 9×10^{-7} (i.e. 9 people in 10 million), which is well below the Health Canada "negligible" risk value of 1×10^{-5} (1 in 100 thousand). Assuming that the individual inadvertently ingests approximately 20 mg of sediment (equivalent to the amount of soil an adult is assumed to ingest daily), the risk from exposure to arsenic in the sediments was estimated to be approximately 1.8×10^{-8} (i.e. 1.8 people in 100 million) which again is well below the Health Canada "negligible" risk value of 1×10^{-5} (1 in 100 thousand). In conclusion, the risks from direct and indirect exposure to lake sediments (solids and porewater) to an individual from the Yellowknife area (e.g. someone from N'dilo, Latham Island, or the City of Yellowknife) would be expected to be negligible. Hence, there is no justification for redoing the risk analysis.

INFORMATION REQUEST RESPONSE

EA No: 0809-001 **Information Request No: Review Board #22**

Date Received

February 14, 2011

Linkage to Other IRs

Date of this Response

June 17, 2011

Request

Preamble:
Arsenic is carcinogenic. The health impact of the project on people is an important consideration for the Review Board. The DAR attempts to show how project would affect cancer rates of people in the project area. More details on arsenic exposure are needed to compare arsenic uptakes with averages, and to contrast cancer risks with general cancer risks in the NWT. The figures in the DAR present average cancer rates for the NWT. However, cancer risks for smokers and non-smokers differ by up to an order of magnitude. Statistically, the large standard deviation from averaging the two groups, with their very different risk levels, does not meaningfully evaluate the actual risk for most people. Presenting cancer risks controlling for this variable will allow a more meaningful comparison of any increased risks from the receptors identified in the DAR.

Question:

1. Please provide the curve showing the statistical distribution for typical arsenic exposure in Canadian adults (indicated as a section on Fig. 8.9.5). The current graphic only indicates the range of values, not their distribution.

2. Table 8.9.2 shows the mean toxic arsenic intakes by receptors 1-4. What are the maximum estimated arsenic levels for the receptors?

3. Please provide figures that graphically illustrate relative cancer risk of study receptors (as per Fig.8.9.6) that separately indicates cancer risks for smokers and non-smokers. Describe how these separate cancer risk levels compare with the incremental lifetime risk of developing internal cancer for receptors with the highest arsenic intake in the Yellowknife area.

Reference to DAR (relevant DAR Sections)

Table 8.9.2 Estimated Intake of Arsenic by Human Receptors
Fig. 8.9.6 Comparison of Arsenic Intakes
Fig 8.9.6 Comparison of Cancer Risks

Reference to the EA Terms of Reference

S.3.4.2 Health and Human Safety

Response 1 Summary

There is no published information available to develop a statistical distribution of arsenic intakes for Figure 8.9.5.

Response 1

The information provided in Figure 8.9.5 was obtained from Table 3 of the Priority Substances List Assessment of Arsenic, prepared by Environment Canada and Health Canada in 1993. This table represents the best available data on estimated intakes of arsenic by a typical Canadian resident. The information was obtained directly from the report and is provided below in its original format. The report only provides a range of values and not distributions. To the best of our knowledge, similar information is not available from other sources and thus a distribution of arsenic exposure cannot be developed.

Estimated Average Daily Intake of Inorganic Arsenic by Canadians					
Medium	**Estimated Daily Intake (µg/kg-bw/day)**				
	0-0.5 yr[a]	**0.5-4 yr[b]**	**5-11 yr[c]**	**12-19 yr[d]**	**20-70 yr[e]**
Water[f]	0.08	0.3	0.2	0.1	0.1
Food[g]	< 0.04-2.4	< 0.05-2.0	< 0.03-1.9	< 0.02-1.2	0.02-0.6
Air[h]	0.0003	0.0004	0.0004	0.0004	0.0003
Soil/Dirt[i]	0.03-0.08	0.02-0.05	0.006-0.02	0.002-0.005	0.001-0.004
Total	0.1-2.6	0.3-2.4	0.2-2.1	0.1-1.3	0.1-0.7
Tobacco Smoking[j]	--	--	--	0.01-0.04	0.01-0.03

a. Assumed to weigh 6 kg, breathe 2 m^3 of air per day and drink 0.1 L of water per day (EHD, 1988). Amount of soil ingested per day is estimated to be 35 mg, based on data from van Wijnen *et al* (1990), in which 0-1 year olds ingested approximately 70% as much soil as 1-4 year olds (50 mg/day).
b. Assumed to weigh 13 kg, breathe 5 m^3 of air per day, drink 0.8 L of water per day (EHD, 1988) and ingest 50 mg of soil per day based on average of values reported by Binder *et al*., 1986; Calabrese *et al.,* 1989; Clausing *et al.,* 1987; van Wijnen *et al.,* 1990).
c. Assumed to weigh 27 kg, breathe 12 m^3 of air per day and drink 1.1 L of water per day (EHD, 1988). Due to insufficient data, soil intake estimated to be midpoint between value for 1-4 year olds (50 mg/day) and that for adults (20 mg/day), i.e., 35 mg/day.

d. Assumed to weigh 55 kg, breathe 21 m^3 of air per day, drink 1.1 L of water per day (EHD, 1988) and ingest 20 mg of soil per day (assumed to be similar to adults).
e. Assumed to weigh 70 kg, breathe 20 m^3 of air per day, drink 1.5 L of water per day, and ingest 20 mg of soil per day (EHD, 1988).
f. Based on a mean concentration of 5 µg/L; levels in most Canadian surface drinking-water supplies are considerably less than this value, although concentrations in ground water often exceed 5 µg/L (Environment Canada, 1989a; 1989b; 1989c; 1989d; OME, 1989; Manitoba Environment, 1989).
g. Estimates for age groups 0-0.5, 0.5-4, 5-11 and 12-19 years based on concentrations in various food groups presented in Dabeka *et al.* (1987) and food consumption patterns data (Nutrition Canada, 1977). Estimated intake for 20-70 year olds from Dabeka *et al.* (1987). It is estimated that 37% of the arsenic content of food is inorganic; although the percentages of total arsenic which is inorganic were available for several food groups, it was not possible to determine the contribution of each food group to total dietary intake of inorganic arsenic, as these groups did not match the composites analyzed in the duplicate diet survey of Dabeka *et al.* (1987). Insufficient data were identified to estimate intake of arsenic by infants in breast milk.
h. Based on the mean airborne arsenic concentration of 0.001 µg/m^3 in most Canadian cities surveyed (Dann, 1990).
i. Based on range of mean arsenic levels in various Canadian soil types of 4.8 to 13.6 ppm (Kabata-Pendias and Pendias, 1984). It was assumed that all of the arsenic present in soils is inorganic.
j. Based on estimated arsenic content of mainstream cigarette smoke ranging from 40 to 120 ng per cigarette (U.S. DHHS, 1989) and 20 cigarettes smoked per day.

Response 2 Summary

In addition to the mean, the maximum arsenic intakes were calculated in the risk assessment and are approximately twice the mean intakes.

Response 2

The human health risk assessment was done in a probabilistic fashion and mean, median, 5th percentile and 95th percentile arsenic intake values were calculated. The 95th percentile of the distribution is considered to be a reasonable maximum estimate of arsenic exposures and essentially represents the maximum intake. From the values presented below, it can be seen that the 95th percentiles are approximately double the mean values.

Receptor	Total Arsenic Intake(mg/kg/d)			
	5th	Mean	Median	95th
1a.Townsite - adult	3.7×10^{-4}	8.8×10^{-4}	8.1×10^{-4}	1.6×10^{-3}
1c.Townsite - child	8.4×10^{-4}	1.6×10^{-3}	1.5×10^{-3}	2.7×10^{-3}
2a.Latham Is. - adult	4.0×10^{-4}	7.7×10^{-4}	6.7×10^{-4}	1.5×10^{-3}
2c.Latham Is. - child	7.0×10^{-4}	1.3×10^{-3}	1.1×10^{-3}	2.5×10^{-3}
3a.Yellowknife - adult	2.3×10^{-4}	6.7×10^{-4}	6.1×10^{-4}	1.3×10^{-3}
3c.Yellowknife - child	6.2×10^{-4}	1.3×10^{-3}	1.2×10^{-3}	2.3×10^{-3}
4a.Dettah - adult	3.3×10^{-4}	5.6×10^{-4}	4.8×10^{-4}	1.1×10^{-3}
4c.Dettah - child	5.7×10^{-4}	1.0×10^{-3}	8.3×10^{-4}	2.0×10^{-3}

Response 3 Summary

The information required to complete an analysis of cancer for smokers versus non-smokers is not available.

Response 3

The general cancer risk values that are presented in Figure 8.9.6 of the Developer's Assessment Report were obtained from Statistics Canada for the general population. To the best of our knowledge, smoking prevalence data are rare and therefore the age-adjusted rates that would be necessary to develop risks for smokers and non-smokers, and to compare with the lifetime risk for receptors with the highest arsenic intake, are not available.

INFORMATION REQUEST RESPONSE

EA No: 0809-001 **Information Request No: Review Board #23**

Date Received

February 14, 2011

Linkage to Other IRs

Date of this Response

June 17, 2011

Request

***Preamble*:**
In reaching its predictions about the significance of impacts, the developer considered whether the magnitude, duration, or spatial extent were ranked "low". If any one was, the developer did not consider the frequency, probability, reversibility, VC ecological importance, or VC social value for any predicted impacts. These are latter criteria are not necessarily secondary considerations. For example, with the method used, a highly probable impact on a highly valued component, with high magnitude and high spatial extent would automatically be considered "not significant" if duration is low.

Question:
1. Please explain the detailed reasoning behind using only three of seven criteria to evaluate the significance of most predicted impacts.
2. Please provide an updated Table 12.3.1 in which a ranking of "high" in any of the "Primary Criteria" results in consideration of the remaining criteria.

Reference to DAR (relevant DAR Sections)

S.12.2.2 Significance Determination
"If any of the Primary Criteria (magnitude, spatial extent or duration) was assigned a "low" ranking, then the residual effects would immediately be considered a minor adverse effect (not significant)".

Reference to the EA Terms of Reference

S.3.1 Considerations
"… the developer must apply the impact prediction criteria in the Review Board's EIA Guidelines…. The developer will provide its views on the significance of predicted impacts…"

Response 1 Summary

The evaluation of significance was conducted as a two-step process to ensure that a focus was placed on those evaluation criteria that have the greatest potential to influence the significance of a residual effect.

Response 1

Environmental Assessment (EA) specialists use a variety of methodologies to assess significance. While none of the methodologies have been universally accepted as the standard approach, the methodology used in the Developer's Assessment Report (DAR) has been applied extensively as an effective tool for screening significant effects. For example, the approach has been used by SENES on high profile nuclear and uranium mining projects.

The rationale for using a two-step screening process is that some criteria are implicitly more important than others in determining significance. The selection of these "primary" criteria, which include *Magnitude, Spatial Extent* and *Duration,* was based on the degree to which they influence the significance of an effect. All other criteria were classified as "secondary". The first step in the evaluation of significance is, in essence, a preliminary screening to determine if the rankings for the primary criteria are sufficiently high to potentially result in an adverse effect. In situations where such a potential exists, the ratings for the secondary criteria are evaluated to determine whether the effect is likely to be significant. However, if the ratings are not sufficiently high for the primary criteria, there are no scenarios in which a significant effect would occur, regardless of the ratings for the secondary criteria.

Notwithstanding the fact that only three of the seven criteria were classified as primary, Table 12.3.1 provides an evaluation of every residual effect against all seven criteria. While the two-step process was not required based on the methodology outlined in Section 12.2.2, the other criteria have already been evaluated.

Response 2 Summary

None of the identified residual effects is considered to be significant.

Response 2

In determining significance, it is necessary that at least one of the three primary criteria be rated as "high" in order for there to be any possibility for a significant adverse effect. In addition, the methodology specifies that the other two primary criteria would need to be rated as either a "medium" or "high" to be advanced to the second step of the evaluation. In other words, if any one of the primary criteria is rated as "low" the residual effect would automatically be classified as being not significant.

The Review Board has requested that the methodology be adjusted to require that any residual effect be advanced to the second stage of the evaluation if only one of the primary criteria is rated as "high". This was based on an example involving a residual effect with high magnitude and high spatial extent being classified as "not significant" if the duration of the effect is low. Although such an effect may be perceived as significant due to the influence of magnitude and spatial extent, a low duration effect indicates that the system would rapidly recover. Fundamentally, the rapid recovery of the environment implies that the effect is not significant.

Based on the above, the Giant Mine Remediation Project Team (Project Team) is not aware of circumstances under which a residual effect could be significant if one or more of the primary criteria are rated as low. Nonetheless, in response to the Review Board's request, we have revisited the evaluation presented in Table 12.3.1 and identified the following eight residual effects that were assigned a rating of "high" for one or more of the primary criteria:

I. Treated minewater discharged from the diffuser will exceed the CWQG –FAL guideline for arsenic within a small volume of water.
II. The discharge of treated minewater will alter the thermal conditions of the water column in the vicinity of the diffuser.
III. Mobilization of contaminated soils, sediment and pore water during earthwork activities.
IV. Mobilization of contaminants during construction of the diffuser/outfall.
V. Increased contaminant loadings in the vicinity of the diffuser in Yellowknife Bay (Great Slave Lake).
VI. Localized loss of permafrost
VII. The demolition of existing surface infrastructure and buildings may eliminate existing terrestrial habitat.
VIII. Buildings and surface infrastructure that have heritage value may be demolished as part of Project implementation.

It is important to note that the following primary criteria ratings were assigned to every one of residual effects identified above:

Magnitude = Low

Spatial Extent = Low

Duration = High

Although each of the residual effects was rated as having a high duration, the magnitude and spatial extent of each effect was also determined to be low (i.e., low, low, high). The Project Team cannot conceive of a situation in which an effect of low magnitude, low spatial effect but high duration would be significant. On this basis, the previous conclusion that the Remediation Project will not have significant effects on the environment has not changed.

In addition to the above, it should be emphasized that the assessment of significance presented in the DAR evaluated individual residual effects in isolation, without acknowledging the "net effect" of the project as a whole. This is particularly challenging for remediation projects which are intended to achieve positive effects. Instead of considering the contributions of these positive effects, assessments of significance focus exclusively on adverse effects that are, in relative terms, inconsequential. For example, with regard to the new treated water outfall in Great Slave Lake, this change represents a significant improvement in the overall environmental conditions relative to baseline conditions (i.e., the discharge of treated mine water to Baker Creek). Unfortunately, EA methodologies for the assessment of significance are not amenable to looking at the overall net benefit of the project.

INFORMATION REQUEST RESPONSE

EA No: 0809-001 **Information Request No: Review Board #24**

Date Received:

February 14, 2011

Date of this Response:

May 31, 2011

Request

Preamble:
The DAR lacks details necessary to understand the effects of the diffuser outflow on public concern, safety and water quality.

Question:

1. For each diffuser location, please describe and illustrate the currents in the bay in the various seasons, at a scale that encompasses the local study area, to identify where effluent ultimately travels. Does this water go to Ndilo, Latham Island, Back Bay, Yellowknife Bay (houseboat community) or Dettah? Describe the potential, over the long term, for this to result in arsenic sediment loading in any of these areas.

2. Please provide the model, if any, that is the basis for conclusion that "thermal loading is not expected to be an issue", considering currents during ice conditions. IF there is no model, please provide a detailed analysis.

3. Is INAC able to restrict access to the surfaces of frozen water bodies, as identified as a possible mitigation in Table 8.4.5? If so, please describe how.

Reference to DAR (relevant DAR Sections):

Figure 6.8.4
S 8.10.1 Evaluation Criteria
S. 8.10.2 Aboriginal Communities
Table 14.2.4.1

Reference to the EA Terms of Reference:

S.3.4.2 Human Health and Safety
S.3.5.1Water
S.3.5.2 Fish and Aquatic Habitat

Response 1 Summary

Water currents in Yellowknife Bay are primarily driven by wind conditions (open water period only) and by the flows from the Yellowknife River (open water and ice cover period). The diffuser will be located within the main area of influence of the Yellowknife River within the Bay, to promote the conveyance of the effluent toward Great Slave Lake and reduce the potential of effluent accumulation within the bay.

Response 1

A mapping of water currents in the Yellowknife Bay will be established during the detailed design phase of the diffuser. Currents in the bay are primarily driven by wind conditions during the open water period (*i.e.,* with no ice cover), with inflows from the Yellowknife River providing an added contribution. A wind rose for the period from May to October is provided below. During the ice cover period, currents in the bay are primarily affected by inflows from the Yellowknife River.

During the open water period, from May to October, winds recorded at Yellowknife Airport station are often coming from the east (45% of wind occurrences for the combined north-east, east and south-east directions), with frequent occurrences from the South (18%) and North (15%). However, winds have been observed in all major directions. Consequently water currents in the bay can be directed in any direction at any given time, depending on prevailing wind conditions. Flows from the Yellowknife River induce water currents to be directed towards Great Slave Lake.

Current velocity and direction are variables that impact effluent dilution and are considered as inputs to the assessment of effluent mixing within the Bay. The assessment of effluent mixing for this design study will include modelling scenarios for a range of expected current velocities, from near stagnant conditions to high velocities due to extreme winds, and a range of current directions (i.e., co-flowing and cross-flowing effluent). The selected final location and configuration of the diffuser will consist of the option that meets the required water quality criteria over these ranges of water current velocities and directions in the Bay.

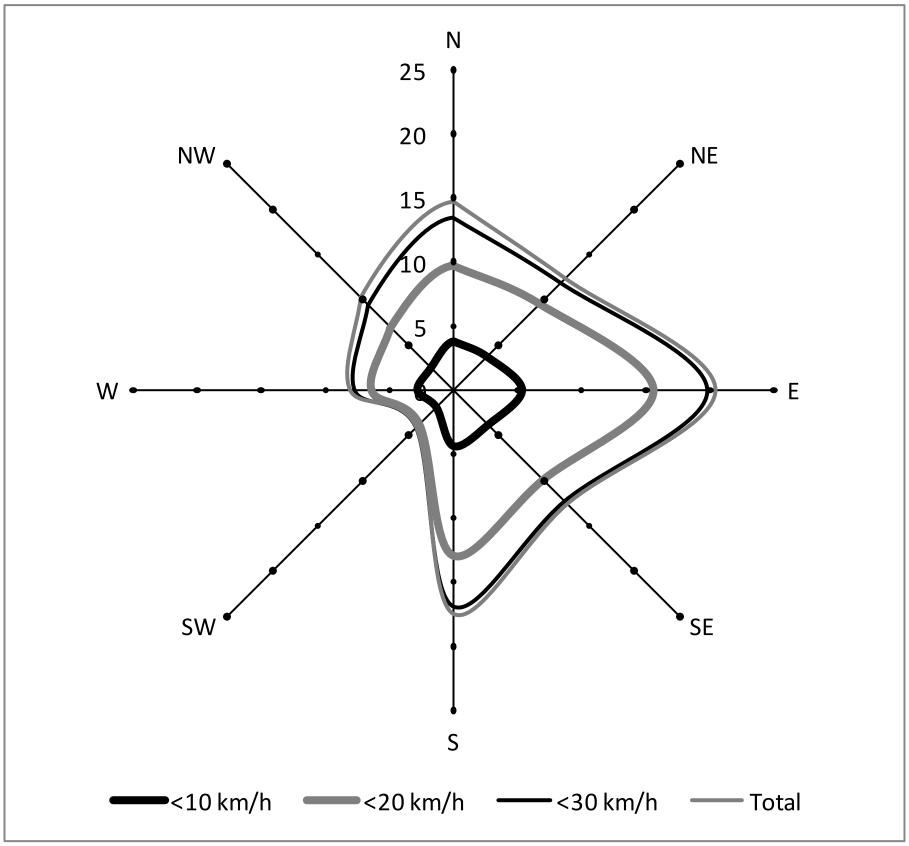


Figure 1: Wind Occurrences (in percent) for Major Directions at Yellowknife Airport Station, for the Period from May to October.

The water quality criteria to be met by the effluent consist of drinking water quality criteria and CCME criteria for the protection of freshwater aquatic life, or being within 10% of ambient water concentrations (i.e., when ambient concentrations of a given substance is above drinking water and CCME criteria). These criteria incorporate arsenic. The diffuser is being designed to meet the water quality criteria within the mixing zone defined based on existing guidelines, including those recently produced in the Northwest Territories (MVLWB 2011), while minimizing the size of that zone. The mixing zone will be at an appreciable distance (e.g. 150 m) from shorelines. Furthermore, the proposed diffuser location will be located within the main area of influence of the Yellowknife River within the bay, in order to promote the conveyance of the diluted effluent towards Great Slave Lake and reduce the potential of effluent accumulation within the bay.

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.

Mackenzie Valley Land and Water Board (MVLWB). 2011. Water and Effluent Quality Management Policy. MVLWB, Yellowknife, March.

Response 2 Summary

It is expected that the effects on ice thickness will be minimal primarily due to the low temperature of the effluent during the winter months.

Response 2

The treated mine effluent is anticipated to have negligible impact on the ice cover thickness. The currents under the ice are anticipated to provide a continuous source of ambient water from the bay for the dilution and heat dispersion of the effluent, and consequently erosion of the ice cover from the effluent discharge is not expected.

Most inflows to the proposed new water treatment plant will be from the underground workings of the mine, where the water temperature is expected to be relatively cold. Resulting water temperature is anticipated to be on the order of 2 to 8 °C, while temperature in the Bay are expected to be on the order of 2 to 4 °C. The difference between effluent and ambient water temperature is relatively small. This difference will be further reduced from the mixing of the effluent and ambient waters by the diffuser, before the effluent reaches the elevation of the ice cover.

The mixing model used to assess effluent dilution in the bay (*i.e.,* CORMIX) includes a module for the assessment of heated discharges. This module will be used to further assess the effect of the effluent on the ice cover in the mixing zone.

The CORMIX model system (Doneker and Jirka 2007) is one of the most extensively used models for predicting plume mixing and dilution of substances in surface water bodies. The model also includes modules for the assessment of heated discharges, and has been used for a wide range of applications in estuaries, rivers, reservoirs and lakes (including bays). Effluent dilution and heat dispersion are calculated in CORMIX from semi-empirical formulas that have been considered reliable within applicable ranges, and are based on simplified governing equations for conservation of mass and momentum and on physical laboratory and field modelling data.

Doneker, R.L., Jirka, G.H. 2007. CORMIX User Manual: A Hydrodynamic Mixing Zone Model and Decision Support System for Pollutant Discharges into Surface Waters. Report EPA-823-K07-001, U.S. Environmental Protection Agency, Washington, DC.

Response 3 Summary

The effects of the effluent on ice thickness are expected to be negligible (see question #2); however warning signs to users of the bay may be used as mitigation, if required.

Response 3

The effects on ice thickness are expected to be negligible, primarily due to the low temperature of the effluent during the winter months. Ice thickness will be monitored and the resulting information will be made available to the public. If required, signs can be installed on the bay ice surface to warn users from passing through zones potentially affected by the discharge of the diffuser (*i.e.,* zones with a potentially thinner ice cover). Signs may also be posted on the shoreline year-round to provide additional warnings to the users of the bay.

INFORMATION REQUEST RESPONSE

EA No: 0809-001 **Information Request No: Review Board #25**

Date Received:

February 14, 2011

Linkage to Other IRs:

Date of this Draft

May 31, 2011

Request

Preamble:
The release of mercury into aquatic food chains by the project could be relevant to the Review Board. In addition to the arsenic contamination of the Giant Mine it is important to consider the mercury amounts in the area as large quantities of the element were used in the mercury amalgamation process in the early history of the mine. The remediation project could remobilize the mercury by exposing it to the weather conditions. This may be relevant in of itself, or cumulatively in addition to other sources of mercury in food chains.

Question:
1. Please describe the fate of on-site mercury contamination in light of the rehabilitation project.

2. Please describe the potential effects of mercury on the aquatic environment and human health.

3. Please describe any efforts to measure mercury concentrations in the local aquatic food chain, and the results of these studies.

4. Please describe the potential of the remediation project to remobilize mercury by exposing it to weather conditions.

Reference to DAR (relevant DAR Sections):

DAR 4.3.3 Ore processing included mercury amalgamation.
DAR 7.4.2.2 Effluent from Giant Mine contributed elevated levels of mercury in Yellowknife Bay.
DAR 14.2.3 Fish tissue samples will be analyzed for mercury.
DAR 14.2.4.1 Vegetation and soil samples will be analyzed for mercury.

Reference to the EA Terms of Reference

ToR s 3.5.2 Fish and Aquatic Habitat
ToR s 3.4.2.1 (1) Human Health and Safety

Response 1 Summary

Although mercury was used at the Giant Mine during the early years of operation, assessments of the environment indicate that mercury is typically present at concentrations that are well below levels at which adverse effects to humans and the environment might occur.

Response 1

Mercury amalgamation was used for the first decade of the Giant Mine's operational life (i.e., up to 1959). While significant effort would have been expended to recover mercury from process wastes (due to its high cost as a metallurgical input), some mercury would have been released to the environment, primarily in association with tailings. During this period, tailings were discharged to the area now referred to as the Historic Foreshore Tailings in Great Slave Lake (until 1951) and subsequently to land-based tailings containment areas. Mercury was also used in other industrial applications such as electrical equipment but this source is expected to be very small relative to mercury amalgamation.

Although mercury is known to have been released to the environment, initial Human Health and Risk Assessment studies conducted as part of remediation planning screened out mercury as a potential contaminant of concern. As a result, mercury has not been a focus of monitoring efforts. Nonetheless, mercury concentrations have been determined in a limited number of cases and were found to be generally low relative to applicable environmental quality standards. For example, comprehensive sampling within Yellowknife Bay (Golder 2005) determined that mercury concentrations in sediment are consistently below the Canadian Council of Ministers of the Environment (CCME 1999 and updates) Interim Sediment Quality Guidelines (ISQG) of 0.17 mg/kg and Probable Effect Level (PEL) of 0.486 mg/kg. The only exceptions were three samples collected from the Historic Foreshore Tailings area where maximum mercury concentrations were found to be 0.24 mg/kg. For reference, this maximum concentration is less than half of the concentration at which the most sensitive aquatic species are anticipated to show adverse effects (i.e., the PEL of 0.486 mg/kg). In surface water, groundwater, minewater and seepage samples, mercury concentrations have been found to be consistently lower than applicable guidelines for drinking water (1.0 µg/L) and protection of freshwater aquatic life (0.026 µg/L). Similarly, for surface soils on the Giant site, mercury concentrations are typically a small fraction of the most stringent land-use criteria (6.6 mg/kg for residential or parkland use) published by the Canadian Council of Ministers of the Environment (CCME 1999 and updates).

To summarize, the vast majority of data collected to date suggests that concentrations of mercury present in the environment on and near the Giant Mine are below levels at which adverse effects would occur.

Response 2 Summary

Concentrations of mercury in the environment are typically well below levels at which adverse effects to humans and the environment might occur. The only potential exception is a relatively small area in the vicinity of the Historic Foreshore Tailings. However, such effects (if any) are anticipated to be relatively minor and localized.

Response 2

As noted in the response to Question 1, concentrations of mercury are consistently lower than applicable environmental quality guidelines for virtually all media and all locations. Research suggests mercury is not having an adverse effect on the aquatic environment or human health.

Response 3 Summary

There has been no monitoring of mercury within the local aquatic food chain.

Response 3

Based on the absence of mercury contamination in all relevant media (i.e., water and sediment) there has been no monitoring of mercury within the local aquatic food chain.

Response 4 Summary

The implementation of the Giant Mine Remediation Plan is not anticipated to result in measurable changes to mercury concentrations within the environment. This will be verified through a monitoring program of applicable media.

Response 4

As indicated in the responses to Questions 1, 2 and 3, the Giant Mine Site is not considered to be a significant source of mercury. This is supported by low concentrations observed in soils (which are below the most stringent criteria for land use) and low concentrations in downstream receiving environments. Based on the low concentrations at source, the implementation of the remediation plan is not anticipated to have any measureable effect on the concentrations of mercury in the receiving environment (i.e., any releases of mercury would be minor and no adverse impacts are expected). This assumption applies regardless of the extent to which weathering might occur.

Notwithstanding the above conclusion, long-term monitoring of the site and surrounding environment will involve analysis of relevant media to confirm that potential risks associated with mercury are not occurring. This will include sampling and analysis of treated mine water (DAR 14.2.2.1), treatment plant effluent (DAR 14.2.2.3), fish (DAR 14.2.3) as well as vegetation and soil (DAR 14.2.4.1).

INFORMATION REQUEST RESPONSE

EA No: 0809-001 **Review Board Information Request #26**

Date Received:

February 14, 2011

Linkage to Other IRs:

YKDFN IR #15
City of Yellowknife IR #2.3

Date of this Response:

May 31, 2011

Request

To evaluate the impacts of the project, the Board needs to ensure that all sources of arsenic have been duly considered. Arsenic trioxide reacts easily with carbon dioxide to form highly mobile arsenite. Any arsenic trioxide in wastes that have been covered or capped with soil can become mobilized by reacting with carbon dioxide in soil gas. Some evidence for this phenomenon comes from the fact that the arsenic levels in pore waters of Baker Creek marsh and pond are much higher than the concentration of arsenic in tailings decant used in loading estimates.

1. Provide an analysis of the redox sensitivity of arsenic minerals in the environment and the related mobility of arsenic after remediation.
2. Describe how this affects future loading estimates.

Reference to DAR (relevant DAR Sections):

ES1 Introduction
The site contains approximately 16 million tonnes of tailings containing arsenopyrite on the surface.

S.5.5.5.1 Tailings
Tailings contain arsenopyrite and soluble arsenic.

Reference to the EA Terms of Reference
S.3.4.2 Human Health and Safety,
S.3.3 (3) Arsenic containment point
S.3.5.1 (3) Water

Summary

Forms of arsenic that are susceptible to reducing conditions are present in the calcines, mixed tailings, treatment solids and creek sediments. Appreciable changes in redox conditions are only expected to occur during reflooding of the underground mine. The effects of these changes were considered in assessing the potential loadings from the underground mine workings and led to the conclusion that ongoing treatment of water from the underground workings would be required. None of the other remediation activities are expected to result in changes in redox conditions or arsenic loadings.

Response

Arsenic is present in a number of different mineral forms in different materials and storage facilities at the Giant Mine. As a result, the effects of changes in redox conditions will vary. We have prepared a summary explaining the dominant forms of arsenic in the various source materials, and have then reviewed how the remediation plans may affect each of them.

Prior to mining, the ore and surrounding rock contained arsenic bearing sulphide minerals, primarily arsenopyrite ($FeAsS$) and arsenian pyrite (FeS_2 with trace amounts of arsenic substituting for the sulphur). These minerals are still the primary forms of arsenic present in the mine rock and tailings.

Sulphides present in the ore were concentrated through a flotation process, and were roasted to enhance recovery of the gold. The roasting process oxidized most of the arsenic and released it as a gaseous phase. This eventually precipitated as arsenic trioxide (As_2O_3) in the dust collection system, or as atmospheric fallout, affecting soils, lake sediments and stream sediments in the surrounding area.

Some of the arsenic would have remained in the roaster solids (calcines) either as residual sulphide minerals, or in association with maghemite (Fe_2O_3), an iron oxide mineral that formed following roasting of the concentrates. Subsequent leaching of the calcines to recover the gold may have further liberated some of the iron and arsenic, and resulted in co-precipitation of ferric arsenate minerals (e.g. $FeAsO_4$) and iron oxyhydroxides ($Fe(OH)_3$), and/or sorption of arsenate to iron oxyhydroxides.

Small amounts of sulphides would also have remained in the flotation tailings. At various times, the flotation tailings and calcines were stored separately or as mixed tailings. Flotation tailings and mixed tailings were stored in the surface impoundments or were used as backfill in the underground mine.

The majority of the arsenic released to the underground mine is from contact with the arsenic trioxide dust. Some arsenic is also released during oxidation of sulphides present in the backfilled waste rock and tailings. The underground water is collected and this arsenic reports to the treatment plant. The treatment process involves the addition of ferrous sulphate, which results in co-precipitation of ferric arsenates and iron oxyhydroxides, and/or sorption of arsenate to oxyhydroxides. The treatment solids (sludges) are currently allowed to settle from solution in the settling and polishing ponds.

Sediments in Baker Creek also contain elevated amounts of arsenic from historical tailings spills, residual suspended solids from the treatment process, and from direct interactions of the native sediments with residual arsenic present in the water column. This arsenic occurs in a variety of forms, including sulphides, maghemite, ferric arsenate, iron oxyhydroxides and arsenic that has been adsorbed on the surface of the solids.

A summary showing the dominant forms of arsenic present in the different source materials and where they are found at the Giant mine site is provided in Table 1.

Table 1: Dominant Forms of Arsenic Present in Different Waste Materials at the Giant Mine

Source	Storage Area	Arsenic trioxide	Sulphides	Maghemite	Ferric arsenates	Sorbed to iron oxyhydroxides	Sorbed to other minerals
Mine Rock	• Underground backfill • Underground wall rock • Three waste rock piles by B2 pit • Surface pads or road fills		x			*	
Arsenic trioxide dust	• Underground chambers	x					
Roaster Solids (Calcines)	• Calcine storage Area • Tailings impoundments • Underground backfill		x	x	*	*	
Flotation Tailings	• Tailings impoundments • Underground backfill		x			*	
Treatment sludges	• Settling pond • Polishing pond				x	x	
Stream sediments	• Baker Creek		*	*	*	*	*

Notes: x – dominant forms, * present in trace amounts

The sensitivity of each of these minerals to changes in redox conditions and the specific changes that can be expected as a result of the remediation activities can be summarized as follows:

- Arsenopyrite and arsenian pyrite are stable under reducing or oxygen limited conditions. In the presence of oxygen, these minerals will slowly oxidize, releasing sulphate, acidity, ferrous iron and arsenite to the aqueous phase. The ferrous iron and arsenite will further oxidize forming ferric iron and arsenate. Under neutral pH conditions, the ferric iron will precipitate as an iron oxyhydroxide mineral, and some of the arsenate will be co-precipitated with or sorbed to this mineral. Depending on the iron to arsenic ratios, low to moderate concentrations of arsenic may be released in seepage and runoff that is in contact with these minerals. Under acidic conditions, oxidation rates typically increase, and iron oxyhydroxides are no longer stable, often leading to increased rates of arsenic release and much higher arsenic concentrations. However, at Giant, results of acid base accounting tests have shown that there are sufficient amounts of carbonate minerals to maintain neutral pH conditions in all of the source materials.

Oxidation of sulphide minerals is expected to occur in unsaturated portions of the flotation tailings, mixed tailings, and calcines. As part of remediation activities, the tailings impoundments will be covered by a simple soil cover and areas re-vegetated, and the calcines will remain encapsulated within the overburden pile. These efforts are not expected to limit the exchange of gas, and will not reduce the amount of oxygen reaching any of these materials. Therefore, remediation activities are not expected to result in any changes in the rates of oxidation and release of arsenic relative to current conditions. However, in some areas, they may result in a reduction in the amount of flow that is in contact with these materials and therefore the total loading from these areas.

Oxidation of sulphides is also expected to occur in mine rock deposits left on surface, and in underground mine wall rock or backfill that remains above the water table. The low surface area of these materials make them relatively small sources of soluble arsenic.

- Arsenic trioxide is extremely soluble over a wide range of pH, redox and temperature conditions, reaching concentration of 4,000 to 10,000 mg/L. The remediation plan is intended to completely isolate the arsenic trioxide storage areas from any interaction with surface or groundwater flows. Therefore, the arsenic trioxide storage areas will not be affected by changes in redox conditions. Historically, arsenic trioxide was also dispersed from the roaster stack and soluble arsenic may now be present in contaminated soils, particularly in the mill area. These will be excavated and placed in the B1 pit, where they will be frozen and again isolated from any further interaction with surface or groundwater. The removal of contaminated soil that was affected by historical deposition of arsenic trioxide is also expected to result in reduced concentrations and loadings in some areas of the site, particularly in the mill area.

- Forms of arsenic that occur as co-precipitates of ferric arsenates and iron-oxyhydroxides, sorbed to iron oxyhydroxides or associated with maghemite are known to be susceptible to changes in redox conditions, particularly in settings where organic substrates are present. Some examples of this process in the literature include tailings at the Campbell Mine in Ontario (McCredie *et al* 2000, Stichbury *et al*. 2000) and Cheni Mine in France (Roussel et al. 2000) where tailings with these types of minerals were deposited on top of peat. Microbial activity associated with these processes is also expected to result in the release of carbon dioxide.

  As summarized in Table 1, arsenic associated with these secondary iron minerals are the dominant forms of arsenic found in the calcines, mixed tailings, and treatment sludges. Trace amounts may also be present in flotation tailings and waste rock that have been exposed to oxidation and weathering.

- The only materials that will be subjected to a major change in redox conditions are the backfilled tailings and waste rock in the parts of the underground mine that have been or will be flooded. The potential for reductive dissolution of arsenic associated with iron oxide minerals in the underground mine was considered in predictions of arsenic concentrations from other sources of arsenic in the underground workings, as documented in "*Giant Mine – Geochemical Characterization of Other Sources"* (SRK 2005). The potential for ongoing release of arsenic from these materials is the main reason why the remediation plan assumes that water in the underground workings would continue to be pumped to surface and treated over the long term.

- As discussed previously, the tailings impoundments will be closed in place with a soil cover, and some areas will be re-vegetated. The soil cover is not expected to limit the amount of oxygen reaching the tailings, the amount of carbon dioxide released from the tailings, or the redox conditions in the tailings. Therefore, arsenic concentrations in the tailings porewater are not expected to change as a result of these processes. However, arsenic loadings will be reduced as a result of decreased flows through these materials.

- The treatment sludges in the settling and polishing ponds will be closed in placed and will be covered with a soil cover. These sludges are currently saturated with water, and are expected to remain close to saturation once these remediation measures are implemented. Therefore, redox conditions are not expected to change appreciably from current conditions.

- The remediation plan for Baker Creek is being developed in consultation with other stakeholders, and include a variety of options to reduce arsenic concentrations in the sediments. If any of the contaminated stream sediments are left in place, they would continue to be susceptible to seasonal changes in redox conditions, as is currently observed in some areas of the creek during low flow conditions. However, the future estimates of arsenic loading from this area of the site are conservatively based on the current loadings from these areas which reflect the current sediment quality and the current range of redox conditions in the creek.

In conclusion, the only location where appreciable changes in redox conditions and therefore loadings are expected to occur are the flooded mine workings. The effects of changing redox conditions in the underground mine on mine water quality have been considered in the assessment of long-term treatment requirements.

References:

McCreadie, H. D.W. Blowes, C.J. Ptacek, J.L. Jambor, 2000. Influence of Reduction Reactions and Solid-Phase Composition on Porewater Concentrations of Arsenic. *Environmental Science and Technology*, Vol. 34. no 15. pp. 3159-3166.

Stichbury, M., J.G. Bain, and D.W. Blowes, 2000. Microbial-mediated reductive dissolution of arsenic-bearing minerals in a gold mine tailings impoundment. *In*: Proceedings of ICARD 2000, 5th International Conference of Acid Rock Drainage, Denver, CO., May 21-24, 2000.

Roussel, C., H. Bril, and A Fernandez, 2000. Arsenic Speciation: Involvement in Evaluation of Environmental Impacts Caused by Mine Wastes. *Journal of Environmental Quality*, Vol 29, No.1, Jan-Feb 2000.

INFORMATION REQUEST RESPONSE

EA No: 0809-001 **Information Request No: Review Board # 27**

Date Received

February 14, 2011

Linkage to Other IRs

Alternatives North IR #02

Date of this Response

June 17, 2011

Request

Preamble:
Considering the multiple roles of INAC and the public concerns expressed regarding this project, the Review Board is interested in INAC's views on establishing an independent monitoring agency for the duration of the Giant Mine Remediation Project, to provide stakeholder involvement in overseeing environmental management.

Question:

1. Please describe any plans being considered for establishing an independent monitoring agency for the duration of the Giant Mine Remediation Project, specifying who might participate, and in what capacity.

2. How might such [an} agency be engaged in any future examination of emerging technologies (as per IR#19 above)?

Reference to DAR (relevant DAR Sections)

14.1.6, Aboriginal and Public Input and Engagement
"(I)nput 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".

S.6.2.2.4 Future Re-Consideration of Alternatives

"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".

Reference to the EA Terms of Reference

ToR 3.6 Monitoring, Evaluation and Management
The continued surveillance of the environment at and around the Giant Mine site was a source of interest for participants throughout the scoping phase of the environmental assessment. To address this concern the developer shall provide:
1. A detailed description of the monitoring program proposed by the developer, including at a minimum a description of:

- Plans to periodically review of the efficacy of the proposed monitoring program and technologies used and a re-evaluation of the goals and benchmarks of the monitoring program
- Plans to engage with local communities in the development, implementation and review of monitoring activities

Summary

The Giant Mine Remediation Project Team (Project Team) is committed to developing and managing the long term monitoring in a manner that is:

1. Adaptive
2. Objectives Based
3. Credible
4. Inclusive
5. Transparent
6. Cost Effective
7. Accountable

The response below to Question 1 speaks to each of these principles and how the Project Team plans to undertake its commitment to developing and implementing an Environmental Monitoring and Evaluation Framework (EMEF) and an Environmental Management System (EMS). The EMS will describe the core approach to managing, monitoring and reporting on environmental issues – it is a central component of the EMEF. As the Government of Canada holds financial responsibility for the Giant Mine Remediation Project (Remediation Project), it is essential that it retain ultimate authority for the expenditure of funds. This speaks to the last of the seven principles listed above - accountable. In terms of plans to establish an Independent Monitoring Agency as used for example with the NWT diamond mines, we do not intend to establish such an independent agency.

For the response to Question 2 on future examination of emerging technologies, the reader is respectfully directed to the Response to Review Board Information Request #19.

Response 1

Monitoring is a fundamental and essential component of the Remediation Project. The Project Team is committed to developing and managing the long term monitoring program in a manner that is:

1. Adaptive
2. Objectives Based
3. Credible
4. Inclusive
5. Transparent
6. Cost Effective
7. Accountable

The principles of the Remediation Project monitoring approach includes: a performance monitoring program to confirm that the objectives are being met; and the development of an adaptive management plan to allow the Remediation Project to adapt to changing conditions as required.

As part of the EMEF, an Environmental Management System (EMS) will describe the core approach to planning, managing, monitoring, reporting and reviewing environmental issues – it is a central component of the EMEF. An EMS is used by governments and companies worldwide to achieve environmental goals through consistent control of operations. This includes the establishment of objectives, targets and environmental management plans to achieve the objectives and targets, the monitoring and evaluation of performance, and the implementation of corrective action where targets are not being met (towards continuous improvement), and regular evaluation to assess compliance with regulatory requirements and the overall functioning of the management system. The approach will build in a periodic review or evaluation of the efficacy of the proposed monitoring program and technologies used, as well as a re-evaluation of the goals and benchmarks of the monitoring program.

It will be a credible approach, in part by including best available technology and scientific information as well as Traditional Knowledge and undergoing regular re-assessment and re-evaluation.

As there are a variety of options to operationalize these operating principles, the Project Team is prepared to work with potentially affected groups to develop an approach that will meet the needs of the parties. This applies to developing and implementing the EMEF and the EMS as describe d in Chapter 14 of the DAR. The proponent is committed to establishing an EMEF to monitor and evaluate environmental protection and regulatory responsibilities throughout the remediation of Giant Mine. The proponent will use the EMEF to establish the blueprint for how environmental protection and regulatory responsibilities will be monitored and evaluated throughout the stages of remediation[1].

The Project Team is committed to involving the public in the design and implementation of the monitoring program in a manner that is inclusive. It will be done in a manner that is transparent and

[1] As defined in the Mackenzie Valley Resource Management Act (MVRMA), 'Environment' includes air, land, water and all living organisms, which includes socio-economic and health and safety issues.

meets the other principles listed above, including accountable, adaptive and credible. It will involve an effective approach to long term monitoring that is appropriate to such a large-scale, publically funded remediation project. It will involve stakeholders in design and implementation and will provide the public with a transparent and timely view of monitoring plans and results.

As described in Section 14 of the Developer's Assessment Report (DAR), the Project Team will be developing the EMEF and the EMS over the next year or two and will be engaging stakeholders throughout on their development. The intent of the engagement regarding the EMS and its adaptive management programs include:

- developing agreed upon environmental targets and criteria, and Environmental Management Plans (EMPs) to achieve these;
- developing a monitoring program;
- developing mitigation measures and strategies; and
- providing a coordinated approach to analysis and interpretation of monitoring data where applicable, facilitating collaboration with First Nations, Yellowknife public, regulators and others.

Engagement is a core element of the EMEF and transparency will be part of the approach to monitoring taken by the Project Team. Aboriginal communities and the public have provided important input into the design of the Giant Mine Remediation Plan, and continue to provide input through the EA process. The Project Team intends to regularly engage with Aboriginal communities and the public on this EMEF, on the development and implementation of the EMS and EMPs, on shaping specific environmental monitoring activities, and in response to monitoring results throughout the life of the project.

The format and content of the Giant Mine Remediation EMEF, EMS and EMPs is not presently developed. They will be developed and finalized in response to the detailed project design (which is currently under development); pursuant to direction from the Review Board; and in conjunction with the requirements of relevant regulatory instruments. Drafts will be shared as they become available throughout the EA and regulatory review process.

As the Government of Canada holds financial responsibility for the Remediation Project, it is essential that it retain ultimate authority for the expenditure of funds. The Project governance and management structure must be designed to incorporate this important factor. This speaks to the last of seven principles listed above - accountable.

In terms of plans to establish an Independent Monitoring Agency as used for example with the NWT diamond mines, we do not intend to establish such an independent agency.

Response 2

For the response to the question of future examination of emerging technologies please refer to the Response to Review Board Information Request #19.