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.

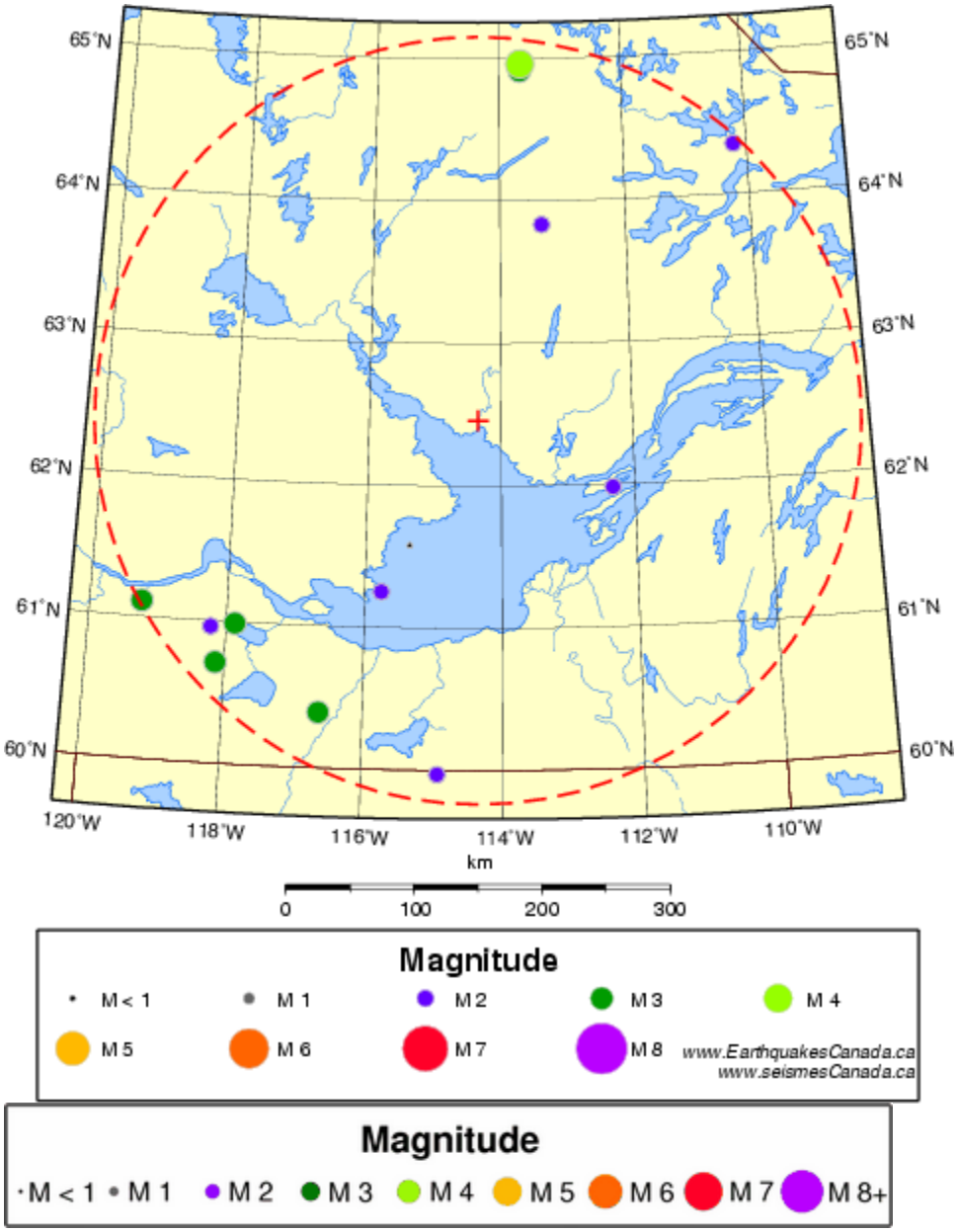
In addition, if needed, an Open File which contains all earthquakes from the database in or near Canada with a magnitude of 2.5 and greater for the time period of 1627 to 2008 can be downloaded from the GeoPub website:

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



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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 4th 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 4th 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