Natural Resources Canada Technical Submission
Environmental Assessment of Canadian Zinc Corporation's Proposed Prairie Creek Mine

June 3 2011

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Non-Technical Summary

Natural Resources Canada (NRCan) has legislated responsibilities, under the federal *Explosives Act,* for facilities that manufacture explosives. For the proposed Prairie Creek Mine, Canadian Zinc Corporation (CZN) has considered having an explosives plant constructed at the mine site during the mine's production stage. NRCan has advised the Mackenzie Valley Environmental Impact Review Board (the Board) that the department may be a regulatory authority for the purposes of the environmental assessment under the *Mackenzie Valley Resources Management Act.*

NRCan is also an established leader in science and technology in the fields of energy, forests, and minerals and metals, and use our expertise in earth sciences to build and maintain an up-to-date knowledge base of Canada's landmass. Key scientific and technical experts from the department have been involved throughout the Government review of the technical reports submitted by CZN, submitting comments and information requests, and advising other regulators and the Board of our findings. A summary of these findings are described below:

- *Geology* - The proponent has a reasonable understanding of baseline geology at the site for the purposes of an environmental assessment.

- *Earthquakes* - In consideration of the earthquake history of the area, the proponent will be designing mine buildings and critical infrastructure to modern codes and standards.

- *Permafrost and Terrain Stability* - NRCan is recommending that the proponent conduct the recommended additional studies along the access road before finalizing its design and environmental management plans, which should include measures to protect the organic surface layer and reduce the potential for thawing.

- *Water Storage Pond Stability* - NRCan is recommending that the proponent conduct the recommended additional geotechnical studies to assist in the design of the water storage pond slopes to ensure its long term stability. NRCan also provides specific recommendations for the environmental monitoring and management plan for the Water Storage Pond.

- *Access Road Sinkholes* – NRCan concluded that the potential for sinkholes to develop under the access road was manageable, and did not identify any additional concerns with respect to changes to the karst terrain.

- *Landslides* – The terrain in certain areas of the project, such as the western part of the mine and the eastern end of the access road, is more susceptible to landslides. NRCan is recommending that, the proponent include more detailed geohazard and risk information in its final detailed design.

- *Waste Rock Management* - The proponent is planning additional studies to finalize the design for covering and managing the waste rock generated at the mine. NRCan is recommending that the proponent consider, in that design, how to minimize the contamination of water that flows through the waste rock and may be discharged to Prairie Creek.

- *Post-Closure Water Quality* - The proponent is planning to conduct monitoring studies during operation to better understand, post-closure, the flow paths for groundwater and their quality. NRCan has recommended a series of questions that should be answered in advance of those monitoring studies seeking information on the processes through which metals in groundwater may be naturally reduced.

NRCan is willing to respond to any questions regarding our technical review by the Board, the Proponent, and other parties involved in the project in support of the environmental assessment process.

1. Introduction

Natural Resources Canada (NRCan) has been involved in the review of the proposed Prairie Creek Mine both in the context of our role as a federal department with a regulatory role through the *Explosives Act* in relation to the manufacture and storage of explosives, and as an established leader is science and technology in the fields of minerals and metals and the earth sciences. Specific areas of expertise that have been engaged in the Proposed Prairie Creek Mine Environmental Assessment Review are:

- (Deposit) Geology;
- Earthquake Hazards;
- Geotechnical Science, Permafrost, Terrain Sensitivity;
- Carbonate Stratigraphy, Karst;
- Surficial Geology, geohazards and stratigraphy; and,
- Mine Waste Management,

NRCan has participated in:

1. Comments on Developer's Assessment Report (DAR) Draft Terms of Reference;
2. Initial Review of the DAR;
3. Draft of IRs Round 1;
4. Review of IR Responses;
5. Participation in Technical Meeting 1, Dettah, October 2010;
6. Draft of IRs Round 2;
7. Review of IR Responses;
8. Technical Meeting 2, Yellowknife, April 2011;
9. Submission of Technical Report; and,
10. Interdepartmental Coordination Meetings.

A preliminary assessment of the Developer's Assessment Report (DAR) for CZN's Prairie Creek Mine was conducted in June 2010 to determine whether any additional information was required for NRCan to conduct a technical review. Requests for additional information were submitted to the Mackenzie Valley Review Board regarding issues related to stability of project components and the baseline information utilized in the impact analysis. The information provided by CZN in its response and during the October 2010 Technical Meeting was found to be helpful in providing NRCan with a better understanding of how the conclusions in the DAR were reached. It was determined however, that additional information was required and this was requested during the second round of information requests (IR).

NRCan is appreciative of the additional information provided in response to round 2 IRs as well as that provided during the April 2011 Technical Meeting and in the Commitments Table.

NRCan, at this phase in the EA review process, has the necessary information to complete its technical review and offer the following comments and recommendations, outlined in the specific comments below, for consideration by the Mackenzie Valley Environmental Impact Review Board.

NRCan acknowledges that project design is an iterative process and that detailed engineering design may address many of the issues we have raised. The recommendations provided therefore largely provide further guidance on factors that should be considered in final design or subsequent monitoring and follow-up plans to ensure that environmental impacts are minimized.

2. Deposit Geology

2.1. Relevant section(s) of the Terms of Reference

Terms of Reference (TOR) for Environmental Assessment For Canadian Zinc Corporation's Prairie Creek Mine EA0809-002 Sections: 1 Introduction; 2 Scope Consideration; 3 Terms of Reference 3.2 General Information Requirements 3.2.3 Developer's Assessment Boundaries; 3.2.4 Description of the Existing Environment Biophysical Environment 11) Terrain, surficial geology, structural geology, mineralogy, bedrock geology (type, depth, composition, permeability), seismic activity records and risk factors, permafrost locations and types within the EA Study Area; 3.2.5 Development Description; 3.3 Impacts on the Biophysical Environment 3.3.7 Terrain

2.2. Documents Reviewed

- Prairie Creek Mine Project Description Report, pages 20 to 23 and pages 36 to 38.
- Prairie Creek Mine Developer's Assessment Report Volume 1 Sections: Executive Summary: Introduction, The Project (page 18); Section 1.0 Introduction (pages 49 to 59); Section 4.11 Geology (pages 123 to 135); and Section 6.0 Development Description (pages 160 to 200; especially 183 to 188).
- NRCan Information Requests Round 1 #4, pages 8 to 11**.**
- Canadian Zinc Corporation's Response to NRCan Information Requests Round 1 #4 to 11, pages 62 to 69.

2.3. Specific Issue/topic - feasibility study

A feasibility study usually precedes environmental applications and permitting. Such a study increases the understanding of the geology baseline as part of the description of the existing environment.

2.3.1.Developer's Conclusion

Canadian Zinc Corporation mentions in its project description report of May 2008 (p.20) that Kilborn Engineering (B.C.) Ltd. completed a feasibility study in 1980 for mining the "Main Zone" area, and that MineFill Services Inc. completed a National Instrument Standards 43-101 (NI43-101) report in 2007 (p.23).

2.3.2.NRCan Conclusion and Rationale

NRCan asked the Developer in its Information Request Round 1 #4 if a more recent feasibility study had been done since the NI43-101 (2007) report, or if the Developer had any plans to update the NI43-101 (2007) report. The Developer responded to NRCan's Information Request Round 1 #4 that studies remain in draft stage and will be finalized when more certainty exists regarding the parameters of the proposed Prairie Creek operation, such as the regulatory process and construction timeline, concentrate transport plan, and site/road construction/management requirements.

NRCan deems this to be reasonable in this phase of the process.

2.3.3.Recommendations

NRCan has no further recommendation pertaining to this issue within the context of this environmental assessment review.

2.4. Specific Issue/topic - regional and mine fault and fracture system

A good understanding of the regional and mine fault and fracture system is critical for the mine development and seismicity evaluation.

2.4.1.Developer's Conclusion

Canadian Zinc Corporation describes in the Prairie Creek Mine Developer's Assessment Report Section 4.11 Geology on pages 127 and 134 that the Prairie Creek area is folded and dissected by numerous faults and fracture zones.

2.4.2.NRCan Conclusion and Rationale

NRCan asked the Developer in its Information Request Round 1 #5 to provide any more information (if available) on the roles of the regional- and property-scale faults on the mineralization. The Developer responded to NRCan's Information Request Round 1 #5 that it believes that the mineralization is linked to steep N-S reverse fault structures formed in tensional axial-plane-type features related to N-S folds.

NRCan deems this information to be sufficient for this phase of the process.

2.4.3.Recommendations

NRCan has no further recommendation pertaining to this issue within the context of this environmental assessment review.

2.5. Specific Issue/topic - vein stockwork and mineralization

Detailed information (width, length, thickness) on the vein stockwork might improve underground ore delineation and identify other similar vein systems in the region. More detailed information on strata bound mineralization may improve the definition of sulphide ore potential towards the south (i.e. between 50,100mN and 49,800mN), where exploration drilling is presently limited.

2.5.1.Developer's Conclusion

Canadian Zinc Corporation describes on page 36 of the Project Description Report and page 128 of the Prairie Creek Mine Developer's Assessment Report Section 4.11 Geology the vein system that carries the mineral resource.

Canadian Zinc Corporation describes on page 38 of the Project Description Report and page 128 of the Prairie Creek Mine Developer's Assessment Report Section 4.11 Geology, the stratabound mineralization, including apparent thicknesses.

2.5.2.NRCan Conclusion and Rationale

Veins, by their geological nature, have a tendency to vary in width, thickness and length. NRCan asked, in its Information Request Round 1 #6, that the Developer provide if known, any more information on the true width of the vein system at Prairie Creek, as well as more information, if available on the continuity of the vein system known underground and on the surface i.e., in terms of its width, thickness, and length, including any information on changes towards the north and south, and with depth.

The Developer responded to this Information Request Round 1 #6 that within the main defined mineral resource, the vein averages 2.5 metres in width and is exposed in all three existing underground levels (970, 930 and 870 levels). The vein, being a fault structure, contains variations both in width (0.1m to 10m true width), and dip (45°E to vertical). The vein structure (fault structure) can be readily followed over a 160 m strike length in 6 crosscuts within the 970 m level, in over 950 m of strike length in 32 crosscuts within the 930 m level workings, and over 560 m of strike length in 6 crosscuts within the 870 m level workings. A strike length of 2.1 km has presently been defined by diamond drilling within the Main Zone, however the structure remains open-ended to the north. On a more local scale, the vein-structure can be seen both underground and at surface to undergo en-echelon type structural development. At such locations, the vein-structure appears to be translated obliquely, generally into the hanging wall, across a few metres to upwards of tens of metres, then continues along its normal strike direction. In these locations, the vein can actually be doubled up on itself and have two parallel veins developed side-by-side for a short distance.

The vein structure has been drill tested in detail at the mine site within the upper 300 m panel, and this panel is the primary location of mineralization. The overlying Cadillac Formation and upper part of the Road River Formation, contain a high percentage of fine-grained material forming mostly shaly to laminated dolostones/siltstones that do not appear competent enough to host the vein structure and concentrate the mineralization. As evident in the 930 m level workings, the vein fault-structure becomes more dissipated within the upper units, which is attributed to the lithologies absorbing the stress and not inducing a brittle type response to deformation stress as the more competent underlying Whittaker units do. A few diamond drillholes at depth to the mineralization panel have still penetrated a quartz-carbonate bearing structure within the mid-lower Whittaker Formation siltstones and nodular dolomites. The structure contains a significant amount of quartz-carbonate material, however most intersections have only returned moderate to weak sulphide mineralization. Further delineation and definition of the vein at depth is required to properly assess its potential.

NRCan asked the Developer in its Information Request Round 1 #7 to provide any additional information (if available) on the stratabound zone, including the true thickness, its attitude and the structural relationship to regional faults, such as the HC and PC faults and other structures. The Developer responded to this Information Request Round 1 #7 that Strata-bound sulphide mineralization was originally discovered in 1992 in Zone 3 at Prairie Creek, and drill intersections of this style of mineralization have now been located along 4 kilometres of vein-type mineralization from the main zone down to Zone 6. Part of the exploration strategy at Prairie Creek has been to drill target the vein-type occurrence within a basal unit of the Upper Whittaker, which is host to the main strata-bound deposit, in hopes of intersecting strata-bound mineralization in addition to vein. Since this strategy has been employed, all strata-bound mineralization presently discovered is spatially proximal to the vein.

The largest strata-bound resource body has been defined in the immediate vicinity of the Prairie Creek Vein and contains a mineral resource estimated at 1.4 million tonnes grading 10.3% Zn, 5.0% Pb and 53 gpt Ag. The strata-bound resource is contained in a composite mass of sulphides up to several hundred metres in width, and 28 metres in thickness which includes numerous individual massive sulphide intervals, most often from 2-5 metres in thickness separated by the unaltered host Whittaker unit.

To date, exploration strategies for further strata-bound have focused on specific units of the Whittaker formation in the immediate vicinity of the vein-fault. From drill core, it appears that the vein mineralization cuts the strata-bound mineralization indicating the strata-bound is older.

Little is known about the lateral extent of the strata-bound mineralization since, at the minesite, the host unit Whittaker Formation dips steeply west and east down the flanks of the Prairie Creek antiform. Strata-bound mineralization appears to generally follow the primary bedding planes of the Whittaker Formation although some convolutions and flow patterns also are evident. It is unknown if there is any direct relationship of the strata-bound mineralization with the local or regional faults. There are, at this time, no underground workings which penetrate deep enough to intersect the strata-bound type mineralization. This would greatly assist in understanding its nature.

The mineralized vein occupies a fault structure itself called the "vein-fault" by Canadian Zinc Corporation. This vein-fault is an N-S reverse structure that developed in response to tectonic compression, and is related to the property wide N-S antiformal structure between two major N-S faults. Further delineation and definition of the vein at depth is required to properly assess its full mineralized potential.

The stratabound mineralization discovered so far is spatially associated to the vein-fault; however, little is known about its lateral and vertical extends, and its relationship to local and regional faults.

That said, NRCan deems the current level of information detail to be sufficient for this phase of the process.

2.5.3.Recommendations

NRCan has no further recommendation pertaining to this issue within the context of this environmental assessment review.

2.6. Specific Issue/topic – host rock and ore chemistry

A clear understanding of the chemistry of the host rocks and ores is important for the economic valuation of the property as well as a good understanding of potential challenges to handle waste and effluent.

2.6.1.Developer's Conclusion

Canadian Zinc Corporation provides information on the chemical composition of the host rock on page 130 of Prairie Creek Mine Developer's Assessment Report Section 4.11 Geology. A brief summary of the chemical composition of the host rocks is provided.

2.6.2.NRCan Conclusion and Rationale

NRCan was of the opinion that there was not enough information provided in the DAR on the chemistry of the sulphide ore and host rocks to have a clear understanding of the chemistry of the host rocks and ores.

Therefore NRCan asked the Developer in its Information Request Round 1 #8 to

(1). Provide a summary table with host rock and mineralization geochemistry and the range of values.

(2). Provide any information on the background Cu, Pb, Zn, Sb, Cd, Ag, As and W concentration values in the Road River Formation.

(3). Describe the results of the sulphide oxidation and redistribution from nearby ore into adjacent host rock in terms of Ag, Cd, Hg, Pb, Sb, As and Zn. Provide information on the mobility of As, Cd, Pb and Hg, including information on co-precipitation with secondary zinc minerals and if some of these elements stay behind.

(4). Provide the depth of the Pb/Zn oxidation level. Describe if this level is constant at the scale of the property.

(5). Provide a Table with the range of values characteristic of the Prairie Creek ores. Describe which minerals are responsible for anomalous chromium values.

The Developer responded to this Information Request Round 1 #8 that a report by Mesh Environmental Inc. for CZN entitled "Geochemical Characterization Report for the Prairie Creek Project, NWT" and dated April 2008 contains appropriate geochemical data. Summary Table 4.4 shows host rock and mineralization analysis by Aqua-Regia Digestion with ICP finish. Also, Figure 2.6 shows the Main Zone stratigraphy and rock descriptions that relate to Table 4.4. This report is filed on the Mackenzie Valley Review Board website on the CZN registry dated August 14th, 2008. However, the table and figure are reproduced in Appendix P."

NRCan deems this information detail to be sufficient for this phase of the process.

In summary, Canadian Zinc Corporation provided all the information requested by NRCan. It seems that the Developer has a fairly good understanding of the geology and mineral system within the mine site.

2.6.3.Recommendations

NRCan has no further recommendation pertaining to this issue within the context of this environmental assessment review.

3. Earthquake Hazards

3.1. Relevant section(s) of the Terms of Reference

Terms of Reference (TOR) for Environmental Assessment For Canadian Zinc Corporation's Prairie Creek Mine EA0809-002 Sections: 2 Scope Considerations; 3 Terms of Reference 3.1 Considerations 3.1.4 Assessing the Impacts of the Environment on the Development (p. 12); 3.2 General Information Requirements 3.2.4 Description of the Existing Environment *Biophysical Environment* 11) Terrain, surficial geology, structural geology, mineralogy, bedrock geology (type, depth, composition, permeability), seismic activity records and risk factors, permafrost locations and types within the EA Study Area; 3.3 Impacts on the Biophysical Environment 3.3.2 Key Line of Inquiry Mine Site Water Quality and 3.3.7 Terrain

3.2. Documents Reviewed

- Prairie Creek Mine Developer's Assessment Report Volume 1 Sections: Executive Summary: Introduction, The Project, Consultation and Impact Assessment (pages 18 to 23); Section 4.12.1 Seismic History (pages 136 to 137); Section 8.8 Accidents and Malfunctions (pages 278 to 280); Section 9.2 Unforeseen Events Geologic Instability (pages 287 to 288); and Section 10.4.2 Terrain Operations-Terrain Impacts Landslides (page 318)

- Prairie Creek Mine Developer's Assessment Report Volume 3 Appendix 11 Preliminary Design: Waste Rock Pile at Prairie Creek Mine NWT Golder Associates, February 2010 Section 5.1 Pseudo-Static (Seismic) Analysis (p. 12-13); and Appendix 12 Preliminary Design Water Storage Pond at Prairie Creek Mine NWT Golder Associates March 2010 Section 4.1 Pseudo-Static (Seismic) Analysis (p. 57).

- Prairie Creek Mine Developer's Assessment Report Volume 4 Appendix 25 Recent Seismic Data and Report on The 1985 Nahanni Earthquakes, Natural Resources Canada, 1987

- Prairie Creek Mine Developer's Assessment Report Addendum Section 7.0 Impacts on the Biophysical environment – 7.3 Terrain (pages 14 to 15)

- NRCan Information Requests Round 1 #3, pages 6 to 8

- Canadian Zinc Corporation's Response to NRCan Information Requests Round 1 #3, page 62
- Canadian Zinc Corporation's Response to NRCan Information Requests Round 1 provided by Golder Associates, September 2010 as Appendix D, responses to NRCan IR #3.1 to #3.10, and the IR Parks Canada 6 response referred to, pages 1, 2 and 10 to 12

3.3. Specific Issue/topic - Earthquake hazards at proposed minesite

3.3.1.Developer's Conclusion

A. The existing buildings will be upgraded and modernized. New facilities will include kitchen/accommodation block, concentrate shed, power generation units, and an incinerator (DAR Volume 1 page 20).

B. The Prairie Creek Mine Site was constructed in 1980-1982 and did not appear to suffer any significant consequences of the 1985 seismic events, the M 6.6 and 6.9 earthquakes 80 km to the northeast of the mine site (DAR Volume 1 Section 4.12.1 page 136).

C. Earthquakes have occurred in the area previously (refer to Appendix 25), and since the Mine was originally built. No earthquake damage is evident in the berms and dykes. The structures have been inspected annually for 4 years and found to be stable. Recent geotechnical studies (see Appendices 12 and 18) by Golder Associates have confirmed the suitability of the structures for their purpose during normal conditions and during seismic events (DAR Volume 1 Section 8.8.3 page 280).

D. In addition to considering the potential for dyke and berm failures, it is also appropriate to consider the consequence of failures. If the flood protection berm failed, water from Prairie Creek could potentially flood the Mine site. There would undoubtedly be some damage to the accommodation block and other buildings, but there would be very limited impact in terms of contamination (DAR Volume 1 Section 8.8.3 page 280).

E. Future performance of the subject slopes during earthquake events cannot be determined with certainty, but the current evidence indicates that the likelihood of large rock slope failures occurring due to seismic activity is very remote (DAR Volume 1 Section 10.4.2 page 318).

F. Geotechnical designs for mine site structures account for potential seismic events, and stability should not be significantly comprised should such events occur. (DAR Addendum page 14)

G. During the 1985 earthquakes, significant vertical ground accelerations were measured (Wetmiller et al. 1988). A thorough review of the available seismic data should be undertaken to identify if additional considerations are warranted for final design and analysis (DAR Volume 3 Appendix 11 page 4).

H. For design options, the pseudo-static seismic analyses were completed using a ratio of horizontal pseudo-static acceleration to gravity (kh) of 0.125. This value represents roughly one half of the PGA determined for firm ground (NBCC 2005) (DAR Volume 3 Appendix 11 page 4).

I. During the 1985 earthquakes, significant vertical ground accelerations were measured. A review of the available seismic data should be undertaken to identify if additional remedial considerations are warranted during the detailed design (DAR Volume 3 Appendix 12 page 7).

J. For remediation and design options, the pseudo-static seismic analyses were completed using a ratio of horizontal pseudo-static acceleration to gravity (kh) of 0.125. This value represents roughly one half of the PGA determined for firm ground (NBCC 2005) (DAR Volume 3 Appendix 12 page 7).

3.3.2.NRCan Conclusion and Rationale

It is clear that the Developer is aware of the earthquake history of the region, the current National Building Code seismic provisions, and current seismic databases. There are numerous references to the 1985 Nahanni earthquakes (M 6.6 and 6.9) that occurred about 80 km from the mine site. The Developer notes that "mine site did not appear to suffer any significant consequences" during those earthquakes. This is important and valid information. However, stronger shaking (a larger or closer earthquake) cannot be ruled out in the future, and hence a thorough seismic hazard assessment should be performed at this site. Underground storage of all tailings from the mill is noted – this certainly minimizes any risk from future earthquakes in the long-term. In this proposal, seismic hazard during the operation phase of the Prairie Creek Mine and the stability of the "Water Storage Pond" will likely dominate the seismic risk assessment.

It was not entirely clear from the DAR if for example the flood protection berm failed, and if water flooded the mine site, will there be life-safety issues? Will the water retention system utilise the provisions in the 2005 Dam Safety Guidelines? Also, any site infrastructure the falls under the building code provisions should be designed to the current standards (2005NBCC or equivalent). NRCan expected further details on all aspects of the seismic hazard assessment and proposed mitigation measures. Therefore NRCan directed several information requests to the Developer in its Round 1 Information Request #3:

NRCan asked if any of the existing buildings were engineered structures and if any of the new facilities would be engineered structures, and if so, what building code standards have been used / or would be used. NRCan also asked what level of seismic hazard was utilized in the geotechnical design of mine site structures. The Developer's consultant responded that the existing Prairie Creek Mine buildings and structures were designed and constructed by Kilborn Engineering Ltd. to the National Building Code. All new facilities, both engineered or modular, will also be to the standards of the National Building Code.

NRCan asked what the ground shaking levels were estimated to be at the mine site during the 1985 events, and if there was any evidence for active faulting near the site. NRCan suggested that a deterministic hazard assessment (in addition to the standard probabilistic hazard assessment) should be considered. The Developer's consultant responded that the ground shaking levels at the mine site during the 1985 events cannot be estimated. As far as the Developer's consultant knew, ground acceleration was not measured in the vicinity of the mine site, only immediately adjacent to the epicentre of the events. There are a series of faults within the Prairie Creek Valley, but to the Developer's consultants' knowledge, there is no evidence of active faults near the mine site. Following customary practice, the preliminary design was based on seismic parameters from the standard probabilistic hazard assessment. During the detailed design phase, a deterministic hazard assessment (DHA) for the project site will be undertaken. Subsequently, all design and analyses will be based on parameters from the DHA.

NRCan asked what level of seismic design was used for the berms and dykes. The Developer's consultant responded that for remediation and design options, accelerations corresponding to a 2,475 year return period seismic event were considered (i.e., a 2% probability of exceedance in 50 years). Pseudo-static seismic analyses were completed using a ratio of horizontal pseudo-static acceleration to gravity (kh) of 0.125. This value represents roughly one half of the PGA determined for firm ground (NBCC 2005).

NRCan asked if there were life-safety considerations involved in the design for seismic events and if the Canadian Dam Association Guidelines (2005) would be utilized in the design of the flood protection berm. The Developer's consultant responded that it is considered highly unlikely that the flood protection berm will fail during a flood event. It is also expected that if the berm was to fail, given that the creek runs parallel to the berm, that there would be sufficient warning to evacuate the mine site prior to the failure. The Canadian Dam Association (CDA) Guidelines do not apply to 'flood protection / deflection berms', and as there is no reservoir, it is not technically considered a dam. CDA Guidelines will apply to the embankments of the Water Storage Pond.

NRCan asked what the estimated level of shaking was in these areas during the 1985 Nahanni earthquakes and how this compared to expected/possible levels of shaking during future earthquakes. The Developer's consultant responded that the design earthquake event that would be used for the analysis of specific natural slopes, if they are to be disturbed (to remediate the Water Storage Pond backslope, for example), should that be required at the final design stage, would depend on the consequences of failure and may be greater than or less than that which occurred in 1985. See also Response – Parks Canada 6.

NRCan asked for the waste rock pile design, if other potential seismic sources would be considered and if there was any evidence for active faults closer to the mine site. NRCan also asked for the water storage pond design, if other potential seismic sources would be considered and if there was any evidence for active faults closer to the mine site. The Developer's consultant responded that the Deterministic Hazard Assessment to be undertaken during detailed design will likely cover all possible seismic sources. To the

Developer's consultant's knowledge, there is no evidence of active faults near the mine site, besides that at the epicentre of the 1985 events.

NRCan asked for the waste rock pile design, for an explanation why a value that is one-half the PGA in code provisions was used. The Developer's consultant responded that the values for the horizontal pseudo-static coefficient used in analysis are chosen to reflect conditions applicable to the design. In engineering practice, a factor of one half the PGA is typically used for similar analysis. Once the deterministic hazard assessment is completed, the selected value may be revisited.

\NRCan asked for the water storage pond design, for an explanation why a value that is one-half the PGA in code provisions was used, if it was appropriate to use the same coefficient for the "Water Storage Pond" as for the "Waste Rock Pile", and if the material strength was comparable in both cases. The Developer's consultant responded with a reference to the response to 3.8 that it is appropriate to use the same coefficient for both structures for the preliminary design,, and as was noted previously, the coefficients would be revisited during final design. The material strength does not have a bearing on the selected coefficient.

NRCan deems the proponent's information on earthquake hazards satisfactory for this phase in the process.

A deterministic hazard analysis will be conducted and modern codes and standards will be utilised for design purposes (mine buildings and critical infrastructure).

3.3.3.Recommendations

NRCan has no further recommendations regarding earthquake hazards for this project at this time.

4. Geotechnical Science, Permafrost, Terrain Sensitivity

4.1. Relevant section(s) of the Terms of Reference

Terms of Reference (TOR) for Environmental Assessment For Canadian Zinc Corporation's Prairie Creek Mine EA0809-002 June 26, 2009

4.2. Documents Reviewed

- Prairie Creek Mine Project Description Report, Canadian Zinc Corporation. May 2008
- Prairie Creek Mine Developer's Assessment Report (DAR) – Main Report Volume 1, Canadian Zinc Corporation, Submitted to MVEIRB, March 2010
- Prairie Creek Mine Developer's Assessment Report (DAR) – Volume 2 Appendix 9, Canadian Zinc Corporation, Submitted to MVEIRB, March 2010

- Prairie Creek Mine Developer's Assessment Report (DAR) –Volume 3 Appendix 11, 12, 14, 16, 18A, 18B, 18C and 18D, Canadian Zinc Corporation, Submitted to MVEIRB, March 2010
- Prairie Creek Mine Developer's Assessment Report (DAR) –Volume 4 Appendix 20, 22 and 27, Canadian Zinc Corporation, Submitted to MVEIRB, March 2010
- Addendum to Developer's Assessment Report, May 2010, including Appendix C
- NRCan Information Requests Round 1 #10 to #13, pages 12 to 17
- Canadian Zinc Corporation's Response to NRCan Information Requests Round 1 #10, #13 pages 70 to 71
- Canadian Zinc Corporation's Response to NRCan Information Requests Round 1 provided by Golder Associates, September 2010 as Appendix D, responses to NRCan IR #11 to #13 pages 13 to16, Appendix I and II
- Canadian Zinc Corporation's Response to NRCan Information Requests Round 1 provided by Golder Associates, September 2010 as Appendix D, Figure II-4
- NRCan Information Requests Round 2, 2-1 to 2-3, pages 1 to 5
- Canadian Zinc Corporation's Response to NRCan Information Requests Round 2, 2-1 to 2-3, March 2011, pages 52 to 53, and the IR Response to Parks Canada Round 2-1 referred to, pages 5 to 18.
- Canadian Zinc Corporation's Response to NRCan Information Requests Round 2, March 2011, Appendix C, Proposed Access Route Plan and Profile 72 km to 136 and 136 km to 180 km
- Canadian Zinc Corporation's Response to NRCan Information Requests Round 2, March 2011, Appendix M
- Canadian Zinc Corporation's Response to NRCan Information Requests Round 2, March 2011, Appendix S
- Transcripts of Technical Meetings, Dettah Oct. 6-8 2010. Day 1 Oct 6. Day 2 Oct 7. Day 3 Oct 8.
- Summary Report, Technical Meeting, Yellowknife Apr. 12 2011
- Updated Commitments Table, Mar. 22 2011 and Appendix A

4.3. Specific Issue/topic - Impacts Related to the Access Road

Disturbance to vegetation and the ground surface related to construction of the access road re-alignments could potentially lead to terrain instability. This could include increased erosion or slope stability resulting in sediment inputs to streams at crossings or ground thawing, settlement and drainage changes in areas of permafrost, especially where soils are ice rich.

4.3.1.Specific documents referenced

- TOR: 3.2.4, 3.3.1, 3.3.7, 3.3.3
- DAR: Main Report section 4.12.3, 4.12.4, 9.2, 9.4.2, 10.1.2, 10.4.2, App 16, Addendum section 5.4, 6, 7.4
- Project Description Report: App. B
- Response to Round 1 IRs: NRCan IR 11, Parks Canada IR 8,10, 12, Transport Canada IR 3,5, Appendix D
- Transcripts Technical Meeting Oct. 7 2010 pg 140-221
- Response to Round 2 IRs: NRCan 2-1, PC 2-1, DFO 2-5 (including App. C)
- Updated Commitments Table

4.3.2.Developer's Conclusion

The Developer has acknowledged that there are locations along the access route where there is evidence of terrain instability. For potential route realignments, CZN has also indicated locations where there is a potential for instability. The proponent however has concluded (DAR vol. 1 section 10.1.2, 10.4.2) that the design and mitigation techniques to be utilized will result in a low risk of significant impacts and there is expected to be little disturbance of the terrain associated with access road construction and operation.

4.3.3.NRCan's Conclusion and Rationale

NRCan is in general agreement that with appropriate design and implementation of mitigation strategies, environmental effects associated with construction and operation of the access road can be minimized. NRCan raised concerns in IRs that removal of vegetation and disturbance of the ground surface during construction could lead to warming of the ground (due to loss of summer shading and insulating organic layer) in areas where ice-rich permafrost is present. This can lead to terrain instability, ground settlement and changes in drainage (ponding of water etc.).

Permafrost within in this area is likely sporadic and, based on observations made at Geological Survey of Canada field sites in the vicinity of Fort Simpson, is relatively thin (<10 m) and at temperatures close to 0°C (e.g. Smith et al. 2004, 2008, 2010a b). It is also likely that ice-rich frozen ground is largely restricted to areas with an organic cover. NRCan is in agreement there is potential for instability in sections of the realignments where ice-rich permafrost may be present. The Developer has indicated where these sections may be and further geotechnical investigations are required to determine the potential for instability and to determine whether mitigation, including aggregate fill, is required to reduce impacts.

NRCan is supportive of the recommendation by Golder (DAR App. 16) that further investigations should be conducted that may include borehole drilling and soil sampling and installation of temperature cables. Similarly, additional geotechnical investigations are supported for slopes and water crossings where instability and erosion could lead to increased sedimentation if not adequately considered in the access road design.

Excessive disturbance to the ground surface, including removal of the organic layer can lead to thawing of the ground (e.g. Smith et al. 2008). This could occur with blading and grading during road construction especially if snow cover is thin. This concern was raised in NRCan 2-1. The Developer has indicated the intention is to preserve the organic layer and outline in its response to NRCan 2-1, the plans to minimize the impacts on the surface if snow cover is thin. Initial clearing would be followed by watering and freezing of the ground which would reduce the reliance on snow cover and ensure preservation of the organic layer. This is a reasonable approach. Ensuring that there is no excessive blading during access road construction, is required to minimize disturbance to the organic layer.

NRCan and others (e.g. NRCan IR 2-1 PC IR 2-1) had raised concerns about the period during which ground conditions would be suitable for construction and operation of the access road.

In its response the Developer has indicated that extensive research conducted by the Developer and its consultants has given the Developer confidence in its plans for construction and operation of the access road. The plan is to begin construction activities in November at the northern (colder) end of the route with operation beginning in December. NRCan agrees than in most years the ground may be frozen by the end of October. Near-surface (3-5 cm depth) ground temperature data collected in the vicinity of Fort Simpson by NRCan (Geological Survey of Canada) since the late 1990s, does indicate that generally the ground surface has started to freeze and stays frozen by the end of October. However there have been some years where the ground surface temperatures do not drop below 0°C and stay there until mid November, and some times not until late November or into December. Early autumn snowfall for example could delay freezing of the ground and could result in softer conditions in early November which may not be suitable to support equipment for access road construction. The Developer does therefore need to be aware that extreme warm years or early establishment of a snow cover could lead to delays in ground freezing and possible reduction in the period for road construction and operation.

The Developer has provided (IR response PC 2-1, NRCan 2-1, DFO 2-5) some information on what techniques may be implemented for sections of the access road in areas of terrain sensitivity or potential including water crossings. Commitments have also been made regarding monitoring and mitigation and design techniques. NRCan is supportive of the approach to utilize techniques such as placement of aggregate fill, use of silt fences etc. to reduce potential for instability and to control erosion. Environmental management plans to be developed should include a decision tree or tool box which defines the criteria for selection and implementation of appropriate mitigation techniques should the monitoring program identify issues of concern.

4.3.4.Recommendations

- NRCan recommends that the Developer follow up on the recommendation made by Golder to conduct geotechnical investigation along the access road to better define the terrain conditions in particular in areas of potential instability such as ice-rich permafrost and at slopes and water crossings. The information obtained from these investigations should be incorporated into final design plans and environmental management plans for the access road.

- NRCan recommends that the Developer ensure that excessive blading and levelling of the ground surface is avoided to preserve the organic layer and minimize the potential for thawing of ice-rich ground and also to reduce the potential for erosion. NRCan suggests the proponent use as well as a contractor to construct the winter road, also a qualified and experienced QA/QC winter road engineer, to advise the proponent and contractor on technical issues pertaining to the winter road (e.g. geohazards, bearing capacity, surface preparation, environmental management and other issues).

- NRCan suggests that environmental management plans for the access road include a decision tree or toolbox that includes the available mitigation options and the criteria to be utilized to select from these options.

4.3.5.References

Smith, S.L., Burgess, M.M., and Riseborough, D.W. 2008. Ground temperature and thaw settlement in frozen peatlands along the Norman Wells pipeline corridor, NWT Canada: 22 years of monitoring. In Ninth International Conference on Permafrost. Edited by D.L. Kane and K.M. Hinkel. Fairbanks Alaska. Institute of Northern Engineering, University of Alaska Fairbanks, Vol.2, pp. 1665-1670.

Smith, S.L., Burgess, M.M., Riseborough, D., Coultish, T., and Chartrand, J. 2004. Digital Summary Database of Permafrost and Thermal Conditions – Norman Wells Pipeline Study Sites, Geological Survey of Canada Open File 4635.

Smith, S.L., Lewkowicz, A.G., Burn, C.R., Allard, M., and Throop, J. 2010a. The thermal state of permafrost in Canada - Results from the International Polar Year. In GEO2010, 63rd Canadian Geotechnical Conference and the 6th Canadian Permafrost Conference. Calgary, Sept 2010. GEO2010 Calgary Organizing Committee, pp. 1214-1221.

Smith, S.L., Romanovsky, V.E., Lewkowicz, A.G., Burn, C.R., Allard, M., Clow, G.D., Yoshikawa, K., and Throop, J. 2010b. Thermal state of permafrost in North America - A contribution to the International Polar Year. Permafrost and Periglacial Processes, **21**: 117-135. DOI 10.1002/PPP.690.

4.4. Specific Issue/topic - Stability of the Water Storage Pond (WSP)

The Water Storage Pond (WSP) is an essential component of the waste and water management strategy and its design must ensure containment to minimize potential risk for the environment. Instability that could result in impacts to the integrity of the structure could have impacts on water quality. Instabilities have been previously noted such as slumping of the back slope which could result in loss of integrity of the WSP resulting from tearing of liners for example. The design of the WSP must therefore be adequate to mitigate this instability to reduce potential impacts of the environment.

4.4.1.Specific documents referenced

- TOR: 3.2.4, 3.2.5, 3.3.1, 3.3.2, 3.3.7
- DAR: Main Report section 4.12.3, 4.12.4, 6.3.7, 6.16, 6.17, 8.7, 8.8.1, 8.8.3, 9.2, App. 12, 16, Addendum section 3, 7.3, App. B
- Response to Round 1 NRCan IR 12, INAC IR 2, Environment Canada IR 13, Parks Canada IR 41, App. D, Transcripts Technical Meeting Oct 8 pg 21-29; Response to NRCan IR 2-2 (including App. S), INAC IR 2-6; Apr 12 2011, Meeting Summary Report

4.4.2.Developer's Conclusion

The Developer has acknowledged that there have been instabilities associated with the original tailings pond in the past. Measures that will be incorporated into the design for the re-engineered Water Storage Pond will result in a stable structure that will perform as intended (e.g. DAR Vol 1, Executive Summary, sec 8.7.4, 8.8.1, 10.4.3, App.12). In the event there is a failure of the WSP and it is out of commission, milling operations would be stopped (e.g DAR vol. 1 sec 8.8.3, 9.2).

4.4.3.NRCan's Conclusion and Rationale

NRCan agrees that the Developer has done much additional work to ensure that the re-engineered WSP is designed to maintain its integrity and perform as intended. Information has been provided on the preliminary design which outlines the various design features that will be utilized to ensure the stability of the WSP. However, as the Developer has acknowledged, additional information is still required prior to detailed design. NRCan has a number of comments and suggestions for consideration as the design of the WSP progresses.

Information provided by the Developer such as the report by BGC (1995, included in App. D of response to Round 1 IRs) indicates that slopes in the vicinity of the WSP have performed poorly in the past and instability in the back slope resulted in distortion in and tearing of the synthetic liner. Data obtained from slope inclinometers (SI) indicate that movement in the North Slope is continuing and in the case of one SI, movements have been large enough to make the casing unusable. The existing North Slope has been described as, at best, marginally unstable (DAR App. 12). The instability has been partially attributed to permafrost degradation. NRCan agrees that there is limited permafrost remaining and any effect its thaw has on instability may be diminishing. Slope movements were also observed to correspond to the depth of the clay layer (DAR App. 12).

The potential for further instability has necessitated modifications to be made in the back slope in design of the re-engineered WSP. Design of the WSP including the North Slope will require adequate information on the geotechnical properties of the underlying materials to refine the stability analysis and reduce uncertainty. A number of boreholes have been drilled to better characterize the material properties and to support stability analysis and preliminary design (DAR App. 12). Golder has suggested (DAR App. 12) that further investigations are required prior to final design to investigate the extent of a clay layer beneath the upper North Slope as well as the thickness of the colluvium layer. NRCan supports this given the association of the clay layer with past slope movements. The Developer indicated during the Apr. 12 Meeting that the stability of the clay layer is an important factor in the WSP design. The additional investigations will provide important information to determine the amount of excavation that will be required to stabilize the slope.

In its information requests, NRCan asked if extreme events had been incorporated into the stability analysis and design of dykes (Round 1 NRCan IR 12, NRCan IR2-2). Extreme events have been a factor in the poor performance of slopes in the past. BGC (1995) suggested that heavy precipitation and melting of a deeper than average snow pack led to continuous shallow failures upstream of the perimeter dyke in 1982. In response to NRCan IR 2-2, CZN has indicated that extreme events will be further considered in stability analysis and diversion ditch design during the detailed design phase. CZN indicates that they do not expect high rainfall or snowmelt events to significantly affect slope stability because after construction the slope will consist of a smooth even grade to divert runoff to diversion structures.

NRCan agrees that the slope design can lessen the effect of extreme events. However, it is suggested that the Developer consider incorporating a sensitivity analysis into the stability analysis prior to final design to ensure that the design of all elements associated with the WSP will perform as intended should these extreme events occur.

Another factor in the stability of the WSP back slope will be the water level. Information provided in DAR App. 12, indicates that a water level of 877 m is required to maintain an adequate factor of safety. The Developer expects the slope still to be stable at a water level of 876 m (Apr 12 meeting notes). The required operating levels are to be confirmed at final design. NRCan is aware that questions have been raised regarding the storage capacity of the proposed WSP design and the water balance. NRCan has not examined the information regarding the storage needs and the water balance. However, it would appear that storage requirements and components of the water balance need to be confirmed to determine the final slope and WSP design. Sensitivity analysis for variable water levels could be useful prior to final design to determine which of the suggested design options are preferable.

Some instrumentation such as slope inclinometers already exists in the North Slope. Golder (DAR App. 12) has also recommended that additional instrumentation including

SIs, piezometers and thermistor strings be installed after construction. Information obtained from this instrumentation can be used to determine whether there is any ongoing movement or increases in pore water pressure that could lead to instability and failure of the WSP. NRCan is supportive of the installation of this instrumentation as part of the environmental monitoring and management plan. The Developer has provided additional information in response to NRCan 2-2 (App. S) regarding how data obtained from SIs and piezometers will be utilized to determine if mitigation is required to deal with potential instabilities. CZN has also indicated that an action plan will be developed that will include the criterion for action and actions to be undertaken should these critical values be exceeded. Examples of actions that may be taken have also been provided. NRCan suggests that action plan will also need to include the criteria for selection of the mitigation options as well as a response that may be required should the monitoring data deviate from the predicted values but still remain below critical threshold values.

4.4.4.Recommendations

NRCan recommends the following be considered prior to final design:

- The Developer conduct, prior to final design of the WSP the additional geotechnical investigations suggested by Golder to better characterize the properties of the materials underlying the North Slope, including the extent of the clay layer. This information should be incorporated into the stability analysis and final design.

- The Developer conduct sensitivity analyses to include the effects of extreme events (high rainfall, snowmelt events) into the slope stability analysis and design of components of the WSP (slope, diversion ditches etc.)

- The Developer considers conducting sensitivity analysis to include effects of variable water levels into stability analysis and final design of the WSP to deal with uncertainties related to storage capacity and the water balance.

- NRCan recommends the following be considered as part of the environmental and management plan for the WSP and surrounding slopes:

    - The Developer installs additional instrumentation (as recommended by Golder) such as slope inclinometers and piezometers, as part of their environmental monitoring and management plan for the WSP and the surrounding slopes.

    - The environmental monitoring and management plan include the definition of critical values that will be utilized to determine when action is required (due to issues related to instability), the mitigation options and the criteria for selecting the mitigation technique (i.e. decision tree or mitigation toolbox). Also included should be the response required if monitoring data deviate from predicted values but still remain below critical values.

4.5. Specific Issue/topic - Flood data and climate data for mine design values

Design of flood protection structures requires consideration of extreme events such as high flows resulting from storm events or higher than normal snowmelt. However, design floods (e.g. 200 year event) are usually calculated through extrapolation of fairly short records that are often less than 30 years in length. This can lead to uncertainties in the determination of design floods.

4.5.1.Specific documents referenced

- TOR: 3.2.4, 3.3.2, 3.3.7
- DAR: Main Report section 4.3, 4.4, 8.7, 8.8, 9.2; App. 9, 11,12, 16 18, 20, 22
- Project Description Report: Section 3.1, 4.8.3 and App. B, C
- DAR Addendum: Section 2, 3, App. C
- Response to Round 1 NRCan IR 10, INAC IR 2, Parks IR 40, 42, Environment Canada IR 13, MVRB IR 3, 4, App. Q
- Transcripts Technical Meeting Oct. 8 pg 18-79
- Response to Round 2 NRCan IR 2-3 (including App. M)

4.5.2.Developer's Conclusion

The Developer has indicated (e.g. DAR sec. 8.8, 9.2) that the flood protection dykes have been designed and built properly and have performed well over 30 years. It is acknowledged that some damage has occurred to the armouring during high flow events such as that in 2006 and 2007 but this has been repaired. The Probable Maximum Flood (PMF) was re-evaluated and the projected levels are less than that assumed for berm crest design and the high flows in 2006 (estimated 200-400 m^3/s) were less than the PMF (e.g. App. C DAR Addendum, App. Q response to 1st round IRs, response to NRCan IR 2-3). Damage may occur to armouring during high flow events but complete failure of the flood protection dyke is unlikely.

4.5.3.NRCan's Conclusion and Rationale

Based on the information provided by CZN, NRCan agrees that flows to date for Prairie Creek, including the 2006 event, have been within the design values for the flood protection dyke. NRCan had raised some concerns regarding the uncertainties in the determination of the design value, given the limited data available for Prairie Creek. Short records may not adequately capture the range in conditions that may occur. NRCan had asked (NRCan IR2-3) whether incorporation of recent data such as the 2006 event may affect the design values since inclusion of more information could reduce uncertainty in the estimation of design floods. The 2006 event was the highest flow since 1978. The maximum flow gauged for Prairie Creek was 187 m^3/s in 1977. The Developer has indicated that the 2006 event was comparable to that in 1977 but the estimated flow for 2006 (200-400 m^3/s) suggests it could be somewhat higher than the 1977 peak. If a continuous record had existed for Prairie Creek from 1975 to 2006 a return period of 33 years would be calculated for the 2006 event which means that a flow of 400 m^3/s (the maximum estimated for 2006) could have a higher probability of occurrence than estimated from the shorter data record (and exceeds for example, the estimate for the 200 year flood of 250 m^3/s provided in DAR Addendum App. C). Incorporation of the 2006 event into the calculation of the design value therefore could result in a higher design flood than currently predicted. NRCan acknowledges that incorporation of the high (400 m^3/s) value for 2006 could also lead to over estimation for the real design value as the 2006 event may be a low frequency event that occurred during a shorter record. While NRCan notified the Developer that by considering the recorded flood events as normally distributed any potential trend would be neglected, NRCan also agrees with the Developer that there is no strong evidence for such a trend in the discharge records toward higher flows (response to NRCan *R 2-3 App. M).

The Developer appears to have taken a conservative approach with respect to design values in choosing a design value estimated to have a recurrence of more than 10,000 years and allowing a freeboard of at least 0.5 m. The Developer has also acknowledged that some damage may occur to the dyke armour during high flows and has initiated a monitoring plan to determine if erosion is occurring. The approach appears to be reasonable. The environmental monitoring and management plan associated with flood protection dyke stability and performance should include definition of the criteria to be utilized to determine if action is required as well as the options for action to be taken should these criteria be exceeded. These plans should also include the criteria used to select mitigation (maintenance and repair) options to ensure that flood protection dykes maintain their integrity and perform as intended.

4.5.4.Recommendations

- NRCan recommends that the Developer continue to monitor performance of flood protection structures to determine if maintenance and repairs are required.

- NRCan recommends that environmental monitoring and management plans associated with flood protection structures include definition of critical values to be utilized to determine when action is required, the options for action should critical values be exceeded and the criteria used to determine the action required.

5. Carbonate Stratigraphy, Karst

5.1. Relevant section(s) of the Terms of Reference

Terms of Reference (TOR) for Environmental Assessment For Canadian Zinc Corporation's Prairie Creek Mine EA0809-002, June 26, 2009 Sections: 1 Introduction; 2 Scope Considerations; Section 3.2 General Information Requirements 3.2.3 Developer's Assessment Boundaries; 3.2.4 Description of the Existing Environment *Biophysical Environment* 11) first bullet page 16; 3.3 Impacts on the Biophysical Environment 3.3.3

Ecological Integrity of the NNPR 4.d. page 25; 3.3.7 Terrain 2b page 29; 3.6 Cumulative Effects 1.e page 39

5.2. Documents Reviewed

- Developer's Assessment Report Main Report Volume 1 of 4, Sections: Executive Summary: Introduction, The Project (page 18 and page 20 Access Road); Impact Assessment Terrain and Stability (page 22); 1.0 Introduction (pages 49-59); 4.12.2 Karst Landform (page 137 and 138); 6.0 Development Description (page 160-177); 9.4.2 Impact Assessment - NNPR Terrain and Stability (page 295); 10.4.2 Impact Assessment - Other Terrain-Operations-Terrain Impacts Karst (page 317); 10.4.4 Impact Assessment - Other Mitigation and Monitoring (page 317 and 318); 13 Cumulative effects

- Developer's Assessment Report Appendices Volume 3 of 4, Appendix 16 Terrain Assessment Report Prairie Creek Mine Northwest Territories, Sections: Appendix I Executive Summary 10) and 11); Appendix II Ground Stability Overview 10) Appendix III Impact Assessment (NNPR) – Terrain and Stability Assessment Zones G, H, and I Table III-2 and Photographs; Appendix V recommendations 8 and 9

- Developer's Assessment Report Addendum, Section 7.3 Terrain (page 14)

- NRCan Information Requetés Round 1, Information Request #9, pages 11 and 12

- Canadian Zinc Corporation's Response to NRCan Information Requests Round 1 #9, page 70

- Canadian Zinc Corporation's Response to NRCan Information Requests Round 1 provided by Golder Associates, September 2010 as Appendix D, pages 12 and 13

- Parks Canada Agency Round 1 Information Requests #7, #8 and #9, pages 11 to 13

- Canadian Zinc's Response to PCA Round 1 Information Requests #7, #8 and #9, page 8

- Canadian Zinc's Response to PCA Round 1 Information Requests #7, #8 and #9, page 3 to 7

- Canadian Zinc's Response to PCA Round 1 Information Requests #7, #8 and #9,

- Canadian Zinc's Response to PCA Round 1 Information Requests #7, #8 and #9,

5.3. Specific Issue/topic – Sinkhole Development

The potential for sinkholes developing under and near the access road.

5.3.1.Developer's Conclusion

The Proponent included some useful background information on karst in DAR Volume 1 section 4.12.2. In DAR Volume 3 Appendix 16 a terrain inventory that includes known karst features and routing of the access road are given. A zone of intense karst terrain that exists in the vicinity of Km 56 will be avoided by re-routing the access route to the north of the karst valley (Polje by-pass route). The Proponent's consultant Golder Associates suggested in DAR Volume 3 Appendix 16 Appendix V that all karst features within 200 m of the access road should be identified and monitored.

According to the Proponent the risks to the proposed access route from the potential for renewed subsidence associated with karst features appear to be small. No evidence of subsidence at any location along the road was noted.

5.3.2.NRCan Conclusion and Rationale

NRCan agrees with the Proponent's consultant that all karst features within 200 m of the access road should be identified and monitored. It was however unclear to NRCan how, when and at what frequency this identification and monitoring would be done.

NRCan requested the Proponent to:

1. Provide a map of karst features along the proposed new route;

2. Provide an analysis of the size and orientation of the karst sinkholes;

3. Comment on the features that control sinkhole distribution (lithology and stratigraphy, faulting and fracturing?) and their bearing on road location;

4. Provide details of the geotechnical investigation that will examine these and other factors related to road stability (ice-rich permafrost; weak soils); and,

5. Provide a monitoring plan, including the methods that will be used to monitor karst-related subsidence.

The proponent's consultant responded in detail in Appendix D. No recent activity on the karst features was reported, the 200m limit explained, and a monitoring program outlined. The impact of changed drainage, load and vibration were discussed and the effect considered to be minimal

NRCan has no additional concerns regarding the potential effects of karst terrain on this proposed project, or potential effects of the project on the karst terrain. The risk of sinkhole development is considered manageable with a suitable baseline map of the karst features and the proposed monitoring program implemented.

5.3.3.Recommendations

No further recommendations are required regarding karst.

6. Surficial Geology, geohazards and stratigraphy

6.1. Relevant section(s) of the Terms of Reference

Terms of Reference (TOR) for Environmental Assessment For Canadian Zinc Corporation's Prairie Creek Mine EA0809-002, June 26, 2009 Sections: 1 Introduction; 2 Scope Considerations; Section 3.2 General Information Requirements 3.2.3 Developer's Assessment Boundaries; 3.2.4 Description of the Existing Environment *Biophysical Environment* 11) first bullet page 16; 3.2.5 Development Description; 3.3 Impacts on the Biophysical Environment 3.3.3 Ecological Integrity of the NNPR 4.d. page 25; 3.3.7 Terrain pages 28 and 29; 3.3.8 Air Quality 1. p. 30; 3.3.10 Biophysical Environmental Monitoring and Management Plans p. 31; 3.5 Closure and Reclamation and 3.6 Cumulative Effects 1., 2. and 5. pp. 39 and 40.

6.2. Documents Reviewed

- Developer's Assessment Report Main Report Volume 1 of 4, Section: Existing Biophysical Environment 4.12 Terrain (pages 136 to 139); Impact Assessment – NNPR 9.4.2 Terrain and Stability (page 295); Impact Assessment – Other 10.4 Terrain (pages 316 to 320)

- Developer's Assessment Report Appendices Volume 3 of 4, Appendix 16 Terrain Assessment Report Prairie Creek Mine Northwest Territories with appendices

- Developer's Assessment Report Addendum, Section 7.3 Terrain (page 14)

- NRCan Information Requests Round 1 Information Request #14, pages 17 and 18

- Canadian Zinc Corporation's Response to NRCan Information Requests Round 1 #14, page 71

- Canadian Zinc Corporation's Response to NRCan Information Requests Round 1 provided by Golder Associates, September 2010 as Appendix D, page 16

- Canadian Zinc Corporation's Response to NRCan Information Requests Round 1 provided by Golder Associates, September 2010 as Appendix D, Figure II-4

6.3. Specific Issue/topic - Surficial geology, slope stability

6.3.1. Developer's Conclusion

The Proponent's consultant Golder and Associates completed a terrain assessment report that was provided in DAR Volume 3 Appendix 16. The report contains a series of photographic plates that portray the terrain features from the Prairie Creek Mine site and along the access road. Appendix 16 also includes a description of the terrain landforms, stability and granular deposits.

A table describes terrain zones along the road with comments on ground characteristics, slope stability, potential effects of terrain on the road, and potential effects of the road on terrain.

Based on a review of available aerial photos, historic, large scale rock slope failures are not evident in the Prairie Creek valley in the vicinity of the Mine Site, nor along the access route within the Funeral Creek and Sundog Creek valleys.

Local areas around the site and parts of the access road are prone to active, small scale rock falls. These areas occur in the mountainous terrain at site and from Km 0 to 35 (Cat Camp area) along the road. Infrastructure at the Mine and Cat Camp is constrained by topography and is proximal to these local falls. Operational practices, such as on-going monitoring and maintenance, can mitigate the effects of these relatively small events.

Rocky debris flows with essentially no organics and derived from adjacent talus have accumulated on the slopes. Flow events are believed to be related to high run-off conditions, possibly due to intense precipitation events and/or to periods of rapid thaw. Evidence of past debris flow activity can be seen at the locations of many small lateral drainages along Prairie, Funeral and Sundog Creeks.

Large scale, historic soil slope instabilities were documented by Golder in the Km 39 and Km 60 areas of the access road. Generally, the instabilities do not appear to be active. A number of recent, small-scale soil slope failures were noted along the road. These appear to be located near the interface between the surficial glacial soils and the underlying Horn River Shale Formation.

Mud flows are defined as slope failures that involve generally fine-grained soils that move in liquid fashion normally with only ten's of metres of displacement. A relatively large recent mudflow was noted at the Second Polje (Figure 1 in Appendix 16) and the western slope of the Silent Hills. These failures appear to be related to degradation of ice-rich ground in the area of the failures, possibly along with increased seepage or surface run-off into the failed areas.

It is anticipated that ice rich ground will be encountered along the existing and proposed realigned sections of the road. Where possible, maintenance of the organic layers in a viable and un-compacted state will help to maintain the thermal status of these areas.

6.3.2.NRCan Conclusion and Rationale

The surficial geology and slope stability of the Prairie Creek Mine property and access road indicated that the terrain has a variety of materials some of which are affected by permafrost. The majority of these materials are local in origin (colluvium) developed from the underlain bedrock. The surfaces developed over this type of terrain are the most stable. The Prairie Creek valley sides in which the mine is located are affected by rock slides and bedrock rotational slides. The other deposits are derived from elsewhere and are mostly glacial and fluvial in origin. The slopes developed in these deposits are the most susceptible to landslides.

In its Round 1 Information Request 14 NRCan requested the proponent to provide:

1. Surficial geology mapping at the scale of the aerial photographs (approximately 1:50.000 or more detailed); and,

2. Aerial photographs with the interpretation of landslide processes: karst, rock fall, debris flow, mudflow, snow avalanches, rotational slides, retrogressive thawflow slides etc.

While NRCan's view is that the proponent's response did not provide all the information on all types of terrain instability in the level of detail / scale requested, the information currently provided is sufficient for this phase of the process.

It is NRCan's opinion that proper mapping and inventory of landslides in a highly landslide susceptible terrain like the western part of Prairie Creek Mine and eastern reaches of the access road is important to properly evaluate past, present and future geohazards.

6.3.3.Recommendations

NRCan recommends that the Proponent conduct a more detailed / larger scale (1:50.000 or better) mapping, inventory or risk assessment of landslides in the highly landslide susceptible terrain such as the western part of Prairie Creek Mine and eastern reaches of the access road to properly evaluate past, present and future geohazards for mine facilities and access road, before final detailed design and construction of the project.

7. Mine Waste Management

7.1. Relevant Section(s) of the Relevant section(s) of the EIS Terms of Reference

Terms of Reference (TOR) for Environmental Assessment For Canadian Zinc Corporation's Prairie Creek Mine EA0809-002 Section 3.3.2 - KEY LINE OF INQUIRY: Mine Site Water Quality

7.2. Documents Reviewed

- Prairie Creek Mine Developer's Assessment Report
- DAR Appendices 22 and 27
- Response to Parks Canada IR 1-42
- Response to Round 2 IRs: NRCan 2-4.

7.3. Specific Issue/topic - Waste Rock Management

A clear understanding of the waste rock placement plan and cover design is needed to ensure long-term environmental protection. Although the waste units are classified as non-acid generating (NAG), geochemical characterization and modelling has identified that metal leaching and drainage, specifically of Zn, from these units at nearly neutral to slightly alkaline pH conditions would be an issue of long-term environmental concern.

7.3.1. Developer's Conclusion

The waste rock would be deposited in a designed waste rock pile (WRP) on the north slope of the Harrison Creek valley, approximately 400 m north of the 930 portal. The organic soil cover and overburden from the designated WRP area would be stripped to bedrock. Part of the overburden material would be used for construction of a lined seepage collection pond and berms for collecting drainages from the waste rock pile. At closure, the pile would be covered with a suitable cover material to minimize precipitation infiltration and, hence, drainage from the site.

7.3.2. NRCan Conclusion and Rationale

Clarification from the Developer was sought on the following items:

i. Prior to placement of the waste rock and other solid wastes in WRP, would the exposed WRP bedrock pad be cleaned and any major cracks sealed to minimize seepage loss to the Harrison Creek Alluvial Aquifer (HCAA) below?

ii. In the WRP cover model simulations for closeout (DAR Appendix #22), two cover systems consisting of a 2 m granular till and a combination of 0.5 m compacted clayey till and 1.5 m granular till were evaluated. The cover systems reduced the annual net percolation through the pile by approximately 34% – 40% and by 42 - 50%, respectively, with both ponding of water on the cover layer and without in comparison to the bare waste rock as cover. In the conceptual closeout scenario (DAR Appendix #27) placing of only a 20 cm soil amendment layer as a suitable growth media is considered. This discrepancy needs to be resolved in terms of cover selection criteria and the anticipated benefits in terms of overall improvement in the drainage water quality from WRP upon closure.

iii. Consideration should also be given to the predictive modelling of post closure drainage water quality from WRP in terms of both short term (5-10 y) and long term (10 y +) time frame and the need for collection and treatment of the WRP drainage, if any.

The developer responded as follows:

i. No, because the limited amount of seepage not reporting to the Seepage Collection Pond will infiltrate through the rock mass to the underground workings and be collected with other inflows. On closure, seepage will be effectively limited by the cover placed over the pile.

ii. The 20 cm soil amendment layer would be in addition to the underlying till layer.

iii. This has been done in conjunction with assessment of cover type and performance, and results demonstrate that infiltration and seepage can be effectively limited. CZN's plan is to collect representative geochemical data for waste rock during operations, and to re-assess closure seepage potential, and therefore closure requirements, well before actual closure. The intent of this work is to define a suitably conservative cover design (in terms of seepage) such that collection and treatment of drainage is not necessary.

The proponent provided no further clarification with respect to the waste rock pile management related to IR NRCan 2-4 (ii) with respect to post closure water quality scenarios.

At closure, the waste rock pile (WRP) would be covered with a combination of granular till, clay and organic soil materials, to a thickness of approximately 2 m, to significantly reduce precipitation infiltration by more than 50%. The reduced percolation through WRP would then migrate entirely via overburden and bedrock fissures to underground mine workings resulting in very little /or no seepage from the waste rock pile.

However, once the mine workings are flooded, post closure sub-surface seepage and mine water drainage may occur from WRP, and could constitute an additional contaminant mass load to Prairie Creek and impacting its post closure water quality.

7.3.3. Recommendations

- In keeping with the developer's commitment (May 6, 2011) to determine a final composition for the WRP cover based on monitoring during operation, and to re-construct, upgrade or decommission ditches and other water control facilities as required, the Developer's design consideration should include the need to minimize or avoid contaminant loadings to Prairie Creek.

7.4. Specific Issue/topic - Paste Backfill

Paste backfill is proposed for tailings disposal at the Prairie Creek Mine. As this is a relatively new application, a clear understanding is needed on both the structural characteristics (e.g. stability), and the geochemical processes (e.g. possible leaching of the paste and its impact on mine water quality).

7.4.1. Specific documents referenced

- Prairie Creek Mine Developer's Assessment Report
- DAR Appendix 15. Pre-Feasibility Engineering Study for Cemented Paste Backfill Plant for the Prairie Creek Project
- Response to Parks Canada IR 1-19, 1-21, 1-28, 1-35 and NRCan 1-2(8); Appendix I to the CSN IR Response; Technical Meeting Day 3 Transcript, pp. 48-61
- Response to Round 2 IRs: NRCan 2-5.

7.4.2. Developer's Conclusion

The Developer proposed disposal of a maximum of tailings underground for environmental reasons through the use of paste backfill. A number of studies were completed to examine the feasibility of this approach.

7.4.3. NRCan Conclusion and Rationale

Certain operation information was explained during the technical sessions in discussions between consultants to the proponent and consultants to the parties. Among the points of interest to NRCan, we are interested in the following areas:

Would the proposed paste backfill cement content (1-3 % cement) provide the required trafficability and/or load bearing strength for equipment mobility within a reasonable curing time? Would the designed solid content of 85% permit pumping of the paste to the desired location? Would there be any need to use booster pumps or back-up units and/or lowering of the solids content to meet pumping requirements?

The developer responded as follows:

> The trafficability/load bearing strength paste layer will not only have a 3% cement content, but will consist of a 50:50 tailings:DMS mix. This is expected to be suitable for traffic in a short time. Paste backfill can be prepared at varying strengths and varying densities to meet a wide range of mining needs. This includes bulk lower strength fill in cut and fill mining, or higher strength fill for trafficability. It may also require lower densities to reduce pumping pressures and pump maintenance, however with a resulting increase in binder costs. All measures are available. In addition, it is not necessary to place high strength paste on the floor for trafficability, since a bed of aggregate can provide good bearing pressure and rapid turnaround time, if so needed. These are day to day economic and operational decisions that would also include the effect of strength on cycle time and dilution from backfill, in addition to costs incurred.
>
> Trucking from the mill to the underground has been proposed to make use of returning trucks and to reduce or eliminate the need for expensive pumps in the paste backfill plant as well as booster pumps. Coupling trucks with mobile concrete-type paste pumps reduces the trucking of paste on ramps and levels, further improving the overall efficiency. Paste slump can be altered to suit the exact backfill needs. There are sufficient measures to provide adequate strength of backfill while maintaining control of costs.

7.4.4. Recommendations

NRCan has no further recommendations pertaining to this issue within the context of this environmental assessment review.

7.5. Specific Issue/topic: Effluent Treatment and Post Closure Water Quality

The post closure Prairie Creek water quality has been modelled under a variety of creek flow conditions with various ground water interactions. These include surface complexation on alluvial materials of Prairie Creek and Harrison Creek alluvial aquifers and Se redox reactions to attenuate Hg, Zn and other trace metals in the groundwater flow path. Metals would be further attenuated in the creek water with the precipitation of ferrihydrite under the prevailing pH-Eh conditions of the oxygenated creek water.

Selenium, cadmium and zinc are chemicals of concern, as they can have significant impacts to both aquatic and terrestrial biota. Metals and other chemicals of concern in the mine effluent should be at concentrations that will not negatively impact the receiving environment. Treatment processes may be required to reduce metal concentrations to acceptable levels.

7.5.1.Specific documents referenced

- Prairie Creek Mine Developer's Assessment Report
- DAR Appendix 6: Water Treatment Plant Operations: SNC Lavalin
- Responses to Parks Canada IR 1-21, 1-22, 1-23, 1-25, 1-26, 1-45, 1-46 and 1-47, and to INAC IR 1-07, 1-08, and 1-09
- Response to Round 2 IRs: NRCan 2-6.

7.5.2. Developer's Conclusion

The expected Se concentration in the treated process water is reported to be high at approximately 0.039 mg/L in comparison to both CCME and site specific SRC water quality objectives.

Post closure drainages from WRP, vein fault zones and backfilled mine are expected to have elevated Zn concentrations of ~ 30,000 µg/L, 1,185 µg/L and 1,300 µg/L, respectively, with estimated average discharge flow rates of ~ 0.14 L/s, 2.9 L/s and 2.1 L/s.

7.5.3. NRCan Conclusion and Rationale

NRCan requested further information on these elements of concern:

> Are these Se concentrations expected to remain elevated through both operational and closure periods, or if better treatment technologies, if any, would be implemented to lower them to meet the stated water quality objectives?
>
> i. What is the expected time frame for these elevated Zn levels to continue and the anticipated treatment requirements, if any?
>
> ii. What are the management and disposal plans for the effluent treatment sludge generated during both operational and post closure phases?
>
> iii. CZN is proposing a different regulatory approach for the water license to include the expected water quality exceedences during both operational and post closure phases. What is the expected timeframe for post closure collection and treatment of effluents from all sources, and the cut-off water quality requirements for no further treatment?
>
> iv. Zn and Cd levels in the Prairie Creek are reported to be further reduced by the natural attenuation processes in the creek. Have these natural attenuation processes/ compartments been identified and what are the expected overall and seasonal removal efficiencies? Any supporting documents or test results to these effects should be provided.

The developer responded as follows:

Operational Se concentrations were provided in Hatfield Consultants Inc. Memo "Prairie Creek Mine – Water Quality Benchmarks and Assessment of Potential Aquatic Effects." (March 2 2011). Closure Se concentrations are addressed in Robertson Geoconsultants Inc. Memo "RGC Responses to Second Round of Information Requests, Prairie Creek Mine, NWT - REV 0" (March 2, 2011).

i. pHase Geochemistry/Robertson Geoconsultants have indicated that the source term concentrations are considered to be applicable to the early mine closure period, and that they will reduce with time. However, since zinc is a conservative metal, an elevated concentration might persist for an extended period. An assessment of water quality after mine closure has indicated that the magnitude of the sources (WRP, Vein Fault, backfilled mine) is unlikely to lead to zinc concentrations in Prairie Creek higher than those predicted to have occurred before any site development. Therefore, a need for water treatment is not expected. The intent of post-closure monitoring would be to confirm this, with appropriately selected triggers for response actions if conditions are not as expected (see reply to INAC IR 2-3, point 4).

ii. During operations, water treatment sludge will be combined with the backfill mix and taken underground. Water treatment is not expected to be required after mine closure. All mine openings will be backfilled. In the unlikely event that monitoring and assessments during operations indicate that a period of water treatment needs to continue after mine closure, any sludge will be stabilized with cement and taken to a suitable disposal location. This might be a mine portal that has not been completely backfilled in order to accommodate the sludge, or part of the Waste Rock Pile before cover placement.

iii. The regulatory approach proposed for the Water Licence is explained in Appendix P. This applies to the operating period and mine decommissioning period. It is expected that water treatment will cease soon after, if not before, mine closure. Mine voids will have been backfilled. Closure activities will include backfilling of the access tunnels, starting with the lowest elevations. Water treatment would continue while pumping from underground is required, but at some stage, pumping will stop and so will water treatment. Post-closure monitoring will then continue until conditions have reached an equilibrium and stabilized, and it has been conclusively determined that no further closure activities are required (see reply to INAC IR 2-3, point 4).

iv. The attenuation of metals in the natural environment by a range of processes is a well established geochemical fact (for example, put 'natural metal attenuation' into Google and review results). Overall and seasonal removal efficiencies have not been quantified because they are not being relied on. However, there is no question that attenuation will occur, although to different degrees depending on the parameter.

In follow-up discussions with Parks Canada, post closure leaching and mobility of Se, As, Zn, Hg and other trace metals from the cemented paste backfill under the resulting high pH conditions of the cemented fill was noted as an area of potential concern, as it may add to long-term water quality impacts of mine water discharge to Prairie Creek.

NRCan has advised Parks Canada that the proponent could be requested to undertake laboratory humidity cell and column leaching studies of the cemented paste backfill under both sub-aerial and sub-aqueous placement conditions using natural or synthetic mine water to determine both source term loadings of, and pathway interactions within the backfill materials. The impacts of the float rock on the pore water flow within the backfill as well as interactions of contact zone mine rock could also be investigated.

In its May 6, 2011 commitments, the developer identified that hydrogeological and geochemical date will be collected routinely during operations in order to "update predictions of the behaviour of the backfill and groundwater and surface water quality after mine closure", and recognizes that "further study will be required, during the operation period, to better understand the flow-path and attenuation mechanisms".

7.5.4. Recommendations

Prior to operation, as part of planning for hydrogeology and geochemistry data collection and the further studies of attenuation mechanisms, the developer should document and resolve the following questions:

a. What would be the coupled redox drivers in the mine water for Se reduction and precipitation of Hg as tiemannite (HgSe)? Dissolved Se is also known to be precipitated as elemental Se under alkaline pH and reducing conditions, thus, competing directly with the above HgSe precipitation process. Under what conditions would the former reaction be favoured?

b. Are the surface complexation and adsorption processes for metal attenuation in the two aquifers capacity limiting in the long-term such that a breakthrough would eventually occur?

c. Would the above scenario impact long-term, post closure Prairie Creek water quality?

d. Would the precipitation of ferrihydrite through groundwater discharge in the oxic environment of Prairie Creek impair its aesthetic as well as chemical water quality?

e. Would these processes gradually impact the sediment quality and its toxicity level in Prairie Creek?

f. Would there be any surface or shallow sub-surface discharge from the backfilled mine workings directly to Prairie Creek.

8. Summary of NRCan Recommendations

1. NRCan recommends that the Developer follow up on the recommendation made by Golder to conduct geotechnical investigation along the access road to better define the terrain conditions in particular in areas of potential instability such as ice-rich permafrost and at slopes and water crossings. The information obtained from these investigations should be incorporated into final design plans and environmental management plans for the access road.

2. NRCan recommends that the Developer ensure that excessive blading and levelling of the ground surface is avoided to preserve the organic layer and minimize the potential for thawing of ice-rich ground and also to reduce the potential for erosion. NRCan suggests the proponent use as well as a contractor to construct the winter road, also a qualified and experienced QA/QC winter road engineer, to advise the proponent and contractor on technical issues pertaining to the winter road (e.g. geohazards, bearing capacity, surface preparation, environmental management and other issues).

3. NRCan suggests that environmental management plans for the access road include a decision tree or toolbox that includes the available mitigation options and the criteria to be utilized to select from these options.

4. The Developer conduct, prior to final design of the WSP the additional geotechnical investigations suggested by Golder to better characterize the properties of the materials underlying the North Slope, including the extent of the clay layer. This information should be incorporated into the stability analysis and final design.

5. The Developer conduct sensitivity analyses to include the effects of extreme events (high rainfall, snowmelt events) into the slope stability analysis and design of components of the WSP (slope, diversion ditches etc.)

6. The Developer considers conducting sensitivity analysis to include effects of variable water levels into stability analysis and final design of the WSP to deal with uncertainties related to storage capacity and the water balance.

7. NRCan recommends the following be considered as part of the environmental and management plan for the WSP and surrounding slopes:

    a. The Developer installs additional instrumentation (as recommended by Golder) such as slope inclinometers and piezometers, as part of their environmental monitoring and management plan for the WSP and the surrounding slopes.

    b. The environmental monitoring and management plan include the definition of critical values that will be utilized to determine when action is required (due to issues related to instability), the mitigation options and the criteria for selecting the mitigation technique (i.e. decision tree or mitigation toolbox).

Also included should be the response required if monitoring data deviate from predicted values but still remain below critical values.

8. NRCan recommends that the Developer continue to monitor performance of flood protection structures to determine if maintenance and repairs are required.

9. NRCan recommends that environmental monitoring and management plans associated with flood protection structures include definition of critical values to be utilized to determine when action is required, the options for action should critical values be exceeded and the criteria used to determine the action required.

10. NRCan recommends that the Proponent conduct a more detailed / larger scale (1:50.000 or better) mapping, inventory or risk assessment of landslides in the highly landslide susceptible terrain such as the western part of Prairie Creek Mine and eastern reaches of the access road to properly evaluate past, present and future geohazards for mine facilities and access road, before final detailed design and construction of the project.

11. In keeping with the developer's commitment (May 6, 2011) to determine a final composition for the WRP cover based on monitoring during operation, and to re-construct, upgrade or decommission ditches and other water control facilities as required, the Developer's design consideration should include the need to minimize or avoid contaminant loadings to Prairie Creek.

12. Prior to operation, as part of planning for hydrogeology and geochemistry data collection and the further studies of attenuation mechanisms, the developer should document and resolve the following questions:

    a. What would be the coupled redox drivers in the mine water for Se reduction and precipitation of Hg as tiemannite (HgSe)? Dissolved Se is also known to be precipitated as elemental Se under alkaline pH and reducing conditions, thus, competing directly with the above HgSe precipitation process. Under what conditions would the former reaction be favoured?

    b. Are the surface complexation and adsorption processes for metal attenuation in the two aquifers capacity limiting in the long-term such that a breakthrough would eventually occur?

    c. Would the above scenario impact long-term, post closure Prairie Creek water quality?

    d. Would the precipitation of ferrihydrite through groundwater discharge in the oxic environment of Prairie Creek impair its aesthetic as well as chemical water quality?

e. Would these processes gradually impact the sediment quality and its toxicity level in Prairie Creek?

f. Would there be any surface or shallow sub-surface discharge from the backfilled mine workings directly to Prairie Creek.

9. Closing

NRCan is willing to respond to any questions regarding our technical review by the Board, the Proponent, and other parties involved in the project in support of the environmental assessment process.