PREDICTED VS. ACTUAL PERFORMANCE OF THREE MINES NEAR THE CARMACKS COPPER HEAP LEACH PROJECT

Prepared for:
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1.0 Qualifications

Bill Slater of Bill Slater Environmental Consulting reviewed the water licence application for Western Copper Corporation's Carmacks Copper Project (No. QZ08-084) on behalf of Little Salmon Carmacks First Nation (LSCFN). Bill Slater has worked with LSCFN as a technical advisor in relation to the Carmacks Copper project since 2005. He is a Whitehorse-based environmental consultant with a B.Sc. in engineering and more than 16 year of experience in environmental assessment and water management in relation to mining projects. Bill Slater has been involved in the evaluation of many proposed mining projects in Yukon as well as projects in other parts of Canada and overseas. He has been closely involved in the development and/or evaluation of most mine closure plans that have been considered in the past 15 years including the following roles:

- For more that five years, participation in the development of the Faro Mine Closure Plan, as a member of the overall technical advisor team providing advice to the federal, territorial and three First Nation governments.
- Technical advisor for the First Nation of Na-cho Nyak Dun for closure planning at the Keno Hill Mines
- Technical advisor for the Little Salmon Carmacks First Nation for closure planning at the Mt. Nansen Mine.
- Senior Program Scientist and technical consultant for Environment Canada during the assessment and licencing of the closure plan for the Brewery Creek Mine.
- Technical advisor for Selkirk First Nation in relation to the Minto Mine including mine development and closure planning.

Details of Bill Slater's education and work experience are described in the Appendix I, a resume for Bill Slater as well as a Company Profile and Project List for Bill Slater Environmental Consulting.

2.0 Context

LSCFN has significant concerns about the proposed Carmacks Copper project and has raised these concerns during earlier review processes including the assessment by the Executive Committee of the Yukon Environmental and Socio-economic Assessment Board. LSCFN considers some key issues, including issues that present significant long-term environmental risks, to be unresolved at the conclusion of those other processes.

Most significantly, LSCFN has always been concerned that the detoxification of the ore heap will prove much more challenging than predicted in the water licence application. Worldwide there is no proven record for detoxification of a copper/sulphuric acid heap leach, and no project of this type has ever operated in a climate similar to Williams Creek. Physical constraints, for example, may lessen the effectiveness of heap rinsing. These are expected to arise and worsen due to application of multiple lifts on the heap and repeated application over multiple years of leach solution as copper is leached from each subsequent lift. The Executive Committee concluded that uncertainty about these constraints could be addressed by an adaptive management approach, utilizing results of leaching (not detoxification) performance in the first heap cell – i.e. that if leaching works, then detoxification will too. However, it is clear that the leaching issues may arise over the longer-term, and also that operational changes may not be adequate to address the issues. If this is the case, then adaptive management will not be effective. LSCFN remains concerned because the proposed approach does not present a practical solution that will provide timely information about detoxification performance or that identifies proven adaptive responses that can address inadequate performance soon enough.

LSCFN's review team for the water licence application includes several advisors with a broad range of expertise. This report has been prepared as a component of LSCFN's overall review of the application. Other reports provide additional details about LSCFN's concern in relation to the above issue and many other technical issues. The information presented in this report must be considered within the context of LSCFN's overall review and the information provided by other members of LSCFN's review team.

3.0 Introduction

The information provided in the water licence application leaves some significant areas of high uncertainty about future performance of the mine and the potential effects that could easily arise from mining activities and after mining is completed. Some areas of potential uncertainty include:

- Performance of the proposed heap detoxification and the resulting long-term drainage water quality from the heap taking into consideration the potential physical constraints on rinsing (e.g. compaction, preferential flow paths), proposed reliance on leaching model cell as an indicator of detoxification performance, chemical constraints on rinsing/neutralization and chemical stability of water treatment sludge stored on heap surface.
- Performance of the proposed pad liner, recognizing that the long-term integrity of the pad liner is critical if water quality conditions are more adverse than predicted. The type of liner is not yet selected and some liners under consideration have no performance record with acidic and exothermic (potentially hot) conditions. Designs and operational conditions add to uncertainty: proposed liner thickness that appears low for industry experience, lack of comprehensive leak detection (e.g. upper pad, conveyance facilities), foundation conditions that are predicted to result in potential differential settlement that may approach the strain limits of liners and construction methods that may not be adequate to achieve proposed soil liner specifications (e.g. lift thicknesses, sub-grade preparation).
- Identification and differential handling of sulphide and oxide materials in the pit may prove more difficult than predicted leading to potential changes in geochemical performance of mine components.
- Physical stability of the waste rock dump if thermal conditions result in more thawing than predicted.
- Long-term drainage water quality from waste rock.

- Physical stability and collection/conveyance efficiency of diversion structures around the waste rock given permafrost conditions.
- Potential adverse pit water quality. The information suggests that all metals will precipitate out because pH will be neutral, however many metals will not precipitate at neutral pH and more adverse water quality is likely.

Each one of these uncertainties generates a serious risk to sound environmental protection. The combination of several of these hazards coming into play is not unrealistic and combinations of such outcomes have occurred at other Yukon mine sites in the past. As a result, the total risk presented to regulators by the Carmacks Copper project appears very consequential.

The potential environmental or financial outcomes of the above uncertainties for the Carmacks Copper Project may be more adverse because the proposed closure plan proposes only minimal land reclamation activities, leaving many slopes exposed permanently and providing minimal covers in other areas. The closure plan also appears to make optimistic assumptions about the time and effort required for heap detoxifications. The YESAA assessment identified this optimism and proposed that the uncertainty about detoxification could be resolved by a pilot test program, a solution that is unlikely to provide timely information and response, as described in the report by Mr. Jim Kuipers. The optimistic closure planning assumptions result in minimal estimates of closure liability that probably underestimate the costs that will eventually accrue. The report prepared by Mr. Jim Kuipers for LSCFN details some of the uncertainties inherent in proposed project, the mechanisms that are needed to resolve these uncertainties and the resultant challenges facing regulators for this project.

LSCFN's concern about uncertainties and risks with the Carmacks Copper project are heightened by experience with recent mining projects (e.g. Mt. Nansen Mine, Minto Mine, Faro Mine) where mine performance clearly failed to meet the predictions provided by proponents, accepted by regulators and expected by communities. This has created a common perspective that mining projects are oversold and under-delivered with respect to both environmental performance and local benefits. LSCFN's experience with the YESAA process for the Carmacks Copper project has further raised the level of concern because the outcomes failed to address some of their key concerns to their satisfaction.

Recognizing that significant environmental risks exist for the Carmacks Copper project and that these might eventually affect the environment, LSCFN sought to understand the potential implications if outcomes are not consistent with the predictions. This report identifies the scope and scale of potential environmental implications by evaluating nearby mining projects permitted and operated in the past twenty years, under what have been considered modern assessment and permitting legislation.

LSCFN's overall purposes in evaluating nearby projects as presented in this report are:

- To illustrate that Yukon has a weak record for permitting and establishing mining projects and having them operate in the manner anticipated once licenced. There have been some unacceptable outcomes arising from the current regulatory approach.

- To illustrate that inherent risks and uncertainties in the methods that proponents and regulators use to evaluate projects, and optimistic predictions about these uncertainties often lead to under-prediction of project effects on the environment.
- To learn from the experience with other projects and implement robust, precautionary regulatory approaches thereby minimizing the risk that unacceptable outcomes will arise with the Carmacks Copper project.

The following sections of this report discuss the results of some uncertainties that existed, whether recognized at the time or not, for nearby mining projects. In the cases of the Minto, Vangorda/Grum and Mt. Nansen mines, the predictions about performance and environmental effects of the mining projects all appear to have been overly optimistic in some key areas. These optimistic predictions have led to unexpected effects, overall project and regulatory management challenges and significant changes in closure cost estimates.

LSCFN considers these other recent and nearby experiences as important guidance in planning for the Carmacks Copper project. These, along with the experimental and unproven nature of the proposed project mean that this project cannot be permitted like others have been. Mechanisms must be in place to identify, understand and resolve the outstanding risks and uncertainties with this project in order to avoid unacceptable environmental, social and financial implications. To accomplish this, the regulatory framework established for this project will need to be precautionary, iterative, and provide for continuing scrutiny and engagement over the mine life and, quite possibly, beyond.

4.0 Minto Mine

The Minto Mine was initially assessed and permitted in the mid 1990s with a water licence issued in 1998. While some initial development activities occurred shortly after mine permitting, the mine did not begin operating until 2007. With this delay in mine development and a change of project proponent, there were some significant revisions and updates to mine plans. Many of the changes offered improvements over the original plans. Regardless, these new plans had implications of their own, many of which were not fully considered because regulators often approved the changes without further consideration under environmental and/or socio-economic assessment legislation and without formal public review (e.g. revised and relocated tailings management approach, changes in water management approaches and facilities, additional waste rock facilities, increased processing capacity). Ultimately the project is now facing significant water management challenges that result from a combination of revised mining plans, uncertainty arising from initial predictions about environmental conditions, and a less than robust regulatory regime.

At the time of mine permitting, the proponent predicted that water quality from tailings produced at the site would have very low contaminant levels: “Total copper was low in the supernatant (0.004mg/L)” and “the tailings supernatant met the guidelines for protection of aquatic life”[1]. This prediction was based on the testing of tailings supernatant from a laboratory metallurgical testing program in which the copper concentration of the final supernatant was lower than that in the water used to feed the test[2]. Therefore, the proponent predicted that mine effluent would have lower concentrations of copper than the surrounding creeks and would easily meet very stringent standards including a standard of 0.01mg/L for copper. They predicted that discharge of mine water would result in virtually no change in copper concentrations in Minto Creek, and in some circumstances predicted minor reductions in Minto Creek copper concentrations[3]. Assuming, as both proponent and regulators did, that final copper concentrations from mine effluent would be similar to tailings supernatant in test programs was overly optimistic because the copper concentration would have been artificially and temporarily depressed in such samples due to the copper recovery process and reagents used in the metallurgical testing program.

Other data available at the time of permitting indicated that conditions could be much worse. Special Waste Extraction Procedure (SWEP) tests resulted in copper concentrations of 0.171mg/L and 0.375mg/L[4] and Shake Extraction Tests using simulated rainwater (SWL) tests resulted in copper concentrations of 0.026mg/L and 0.866mg/L[5] (Note that the 0.866mg/L value is probably associated with solids because the dissolved copper concentration from the same test was very low). However, the proponent concluded that these data did not warrant concern and did not use them to refine the modeling assumptions even though the laboratory results suggested concentrations approximately 7 to 94 times the model assumption of 0.004mg/L (excluding the 0.866mg/L value). Instead they reached a general conclusion about the SWEP and SWL tests, suggesting they did not warrant concern:

- Tailings: “Concentrations are generally an order of magnitude lower than those which would be required to classify the leachate as special waste (in BC) or would result in contamination of the final discharge to Minto Creek”[6]
- Waste Rock: “Concentrations are generally an order of magnitude lower than those which would result in contamination of the final discharge to Minto Creek.”[7]

The proponent’s overall conclusion about water quality is stated as follows: “water quality modeling indicates that operation of the mine will not adversely affect water quality in lower Minto Creek.”[8] At the time, regulators failed to raise significant

[1] Minto Exploration Ltd. 1996. P. 5-14. Attached in Appendix II.
[2] Minto Explorations Ltd. 1996. Table 5.11. Attached in Appendix II
[3] Minto Explorations Ltd. 1996. Tables 9.8 through 9.13. Attached in Appendix II
[4] Minto Explorations Ltd. 1996. Table 5.9. Attached in Appenidx II
[5] Minto Explorations Ltd. 1996. Table 5.10. Attached in Appendix II.
[6] Minto Explorations Ltd. 1996. P. 5-13. Attached in Appendix II.
[7] Minto Explorations Ltd. 1996. P. 5-17. Attached in Appendix II.
[8] Minto Explorations Ltd. 1996. P. 9-6. Attached in Appendix II.

opposition to the predicted outcome, instead choosing to authorize the proposed effluent limits, which the mine has been unable to meet in many circumstances.

Not surprisingly given the data that were available during permitting, the mine effluent has proven much more difficult to manage than anticipated. Contaminant levels in tailings effluent are much higher than predicted. Also, additional sources have contributed to the effluent water quality even though the original modeling erroneously failed to consider these (e.g. historic and ongoing exploration disturbances, mill effluent, pit walls, waste rock, and widespread dust). Also, tailings runoff and seepage has contained contaminant concentrations much higher than the original predictions.

In comparison to the original prediction of 0.004mg/L copper for tailings effluent, data presented in Minto's recent project proposal for water management related licence amendments show copper concentrations in tailings effluent ranging from 0.196mg/L to 1.106 mg/L depending on the time of the year.[9] These values exceed the original predictions by 49 to 206 times and suggest that the most elevated concentrations encountered during testing (SWEP and SWL tests) offered more realistic predictions of actual site outcomes and that the assumptions used in 1996 modeling were overly optimistic.

The combined effects of the under-prediction of copper concentrations are further illustrated by comparing the predicted and actual concentrations in the Water Storage Pond which has served as a repository for all loading from the site. Mean concentrations in the storage pond in 2008 and 2009 were approximately 11 times the predicted concentrations (0.01mg/L predicted[10] vs. 0.11-0.12mg/L actual[11]). This resulted in concentrations in Minto Creek that also exceeded the original predictions.

The unexpected water quality forced the regulators into an imprudent and non-precautionary course of action. On three occasions, the Water Board has authorized, on an 'emergency' basis, the effluent limits to allow discharge at levels up to 60 times the original effluent limit (0.3 to 0.6 mg/L of copper).

The quantity of water discharged during the 2008 emergency amendment[12] was approximately 335,000 m^3. Average effluent concentration during the discharge was reported as 0.1mg/L[13] leading to a copper loading of approximately 33.5kg of Copper to Minto Creek as opposed to the original estimate of 1.34kg if the same volume of water were discharged at the predicted concentration of 0.004mg/L. Average copper concentrations during the 2009 emergency amendments were 0.05 for amendment 5 and 0.02 for amendment 6, lower than the 2008 concentrations due to more effective water treatment.[14] Lower Minto Creek provides rearing habitat for juvenile Chinook salmon in

[9] Access Consulting Group. November 2009. Table 1. Attached in Appendix III
[10] Minto Explorations Ltd. 1996. Table 9.8. Attached in Appendix II
[11] Minto Explorations Ltd. August 2009. Table 9. Attached in Appendix IV
[12] Minto Explorations Ltd. August 2009. Appendix D, Table 1. Attached in Appendix IV
[13] Minto Explorations Ltd. August 2009. Appendix D, Table 3. Attached in Appendix IV
[14] Minto Explorations Ltd. 2009. Attached in Appendix V

the summer. Recent research has indicated that copper can inhibit the sense of smell in salmon at levels as low as 0.001mg/L and that the effects can occur in as little as 30 minutes. The sense of smell is considered important because of its relationship to several key aspects in the life history of pacific salmon: e.g. kin recognition, predator avoidance, homing.[15]

The water management outcomes at the Minto Mine emphasize the need to change the regulatory approach for mining projects including licencing, inspection and enforcement. Concerns about potential water quality effects could be partially addressed by adequate security requirements to address water quality uncertainties. Here too however, the regulatory system appears to be unable to take the hard positions needed to ensure that the security is available when needed.

In accordance with its *Yukon Mine Reclamation and Closure Policy* the Yukon Government has evaluated security for the Minto Mine and established requirements for posting security. The policy requires that security be adequate to address site liability at any point in time:

> "The mine owner must provide financial security for the full outstanding mine reclamation and closure liability. Outstanding reclamation and closure liability is based on the cost to reclaim and close the mine site in its current status, in accordance with the approved reclamation and closure plan. The outstanding reclamation and closure liability will be reassessed periodically (minimum every two years) to reflect the impact of operations and progressive reclamation."[16]

In 2007, Yukon Government estimated the closure liability at the end of two years of operation (2009) as approximately $3.9 million and requested $3.6 million in security, the estimated liability in 2007.[17] As of January 2010, Yukon Government holds approximately $3.8 million in security[18]. The September 2009 updated *Detailed Decommissioning and Reclamation Plan* for the Minto Mine provides the proponent's estimate of outstanding liability at the site at the end of two years of operation, slightly over $8 million.[19]. This indicates that both the proponent and regulators prepared extremely optimistic estimates in 2007 and/or that mine operations and plans have changed substantially and resulted in much greater liability than expected.

By issuing a screening report and water licence for the Minto Mine, government environmental assessment agencies and the water board accepted the optimistic predictions of environmental performance put forward by the proponent without adequate independent scrutiny. Subsequently, at the request of the proponent, regulators issued a variety of approvals for project changes, again based on the proponent's optimistic assumptions about performance. The actual effects of the mine are now different than expected but the project is underway and constraints that would limit the project to the originally predicted effects are no longer possible and regulatory actions are challenging.

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[15] Environment Canada. January 2010. Section on Site Specific Water Quality Objectives.
[16] Yukon Energy Mines and Resources. June 2009. Website Page.
[17] Yukon Energy Mines and Resources. May 2007. Website document. Attached in Appendix VI.
[18] Yukon Energy Mines and Resources. January 2009. Website page. Attached in Appendix VI.
[19] Minto Explorations Ltd. September 2009. Attached in Appendix VII

5.0 Vangorda/Grum Mines at Faro

The Vangorda/Grum component of the Faro Mine Complex was assessed and permitted in the late 1980s and early 1990s. Curragh Resources Inc. began mining began in the early 1990s but ceased operation in late 1992 and sought bankruptcy protection. Anvil Range Mining Corp. restarted operations in 1994 and mined intermittently until 1998 when it sought bankruptcy protection. Since that time the site has been under care-and-maintenance while plans for permanent closure are developed. Government has funded care-and-maintenance and closure planning activities and so the public will pay the costs for closure, currently estimated as approximately $500million[20].

At the time of the initial permitting the proponent and regulators recognized potential future water quality concerns related to this lead/zinc deposit. As a result, the project information included predictions about water quality emanating from pits and waste rock, and the possible effects on local surface water. The project proposal described mitigation to address water quality concerns and a closure plan to ensure long-term chemical and physical stability at the site. The planning process recognized a potential need for perpetual treatment at the site and government established a security bonding requirement considered adequate to address the expected liabilities at the site.

A retrospective comparison of the predictions and initial closure plans to the actual outcomes demonstrates that the initial predictions grossly underestimated the scale and severity of issues that would arise from the Vangorda/Grum project. The corresponding security bond also proved inadequate to address the closure costs when the operators became financially insolvent.

Investigation of Predictions for Acidic Drainage at the Vangorda Plateau, Faro Mine Complex – Faro, YT[21], a research report prepared for the Mine Environmental Neutral Drainage (MEND) initiative, compares the water quality predictions completed for project permitting with the actual monitoring results and more recent predictions completed to support closure planning. The study focused on zinc, the primary contaminant of concern, and considered comparisons of loading from pits and waste rock as well as natural sources. It included consideration of predictions in the areas of hydrology, hydrogeology and geochemistry. Significant differences were identified for some major load sources.

- The proponent's 1989 predictions of zinc concentrations for seepage water on the Vangorda Pit walls ranged from 2mg/L to 10mg/L depending on rock types while surface runoff in the pit during operations was expected to have concentrations up to 40mg/L. Overall pit water was expected to reflect a combination of these inputs.

[20] Faro Mine Closure. January 2008. Website document.
[21] Moodie et al. April 2008.

Measured average pit water concentrations for 1998-2004 were 66mg/L with an increasing trend. Based on this actual data, 2004 predictions of zinc concentrations for seepage water on the pit wall ranged from 46mg/L to 780mg/L, 23 to 78 times the original predictions.[22] By 2008 the concentrations in pit water had reached 139mg/L[23] suggesting that the latter predictions are much more realistic.

- During project development, the proponent's proposed closure plan for the Vangorda Pit entailed re-diversion of Vangorda Creek into the pit and creation of a pit lake[24], with zinc load estimates of 792kg/yr. By 2004, this concept was no longer considered viable due to water quality concerns and load estimates in the pit were approximately 13,000kg/yr – approximately 16 times higher.[25]
- The proponent's pre-development predictions estimated contaminant concentrations from Vangorda waste rock as 15.7mg/L to 28.6mg/L depending on specific rock types. By 2008, measured seepage concentrations from Vangorda waste rock ranged from 564mg/L to 12,500mg/L – a remarkable 437 times higher than the predicted maximum[26].

In the conclusions, Moodie et al. identify the uncertainty in prediction of source concentrations as the greatest contributor to the significant underestimates of contaminant loading during initial project planning. Uncertainty in predictions of hydrogeological conditions in waste rock is also identified as a major contributor. Failure to carry out the mining in accordance with proposed plans is identified as another key contributor to underestimates about the effects arising from the project. For example, some reactive waste rock materials were to be isolated using till berms and covers, as part of waste rock dump development. This was only partially completed and varied in some cases because regulatory permits did not adequately constrain the project to the original designs or inspection/enforcement did not provide adequate oversight.

The proponent's initial predictions of environmental performance for the Vangorda/Grum Mine relied heavily on empirical data from the adjacent Faro Mine property that had been operating for approximately 20 years at the time. Data from the Faro Mine was supplemented by additional investigations and laboratory studies including humidity cell test work to support geochemical predictions. Both Faro Mine data and humidity cell results provided indications that conditions could be substantially worse than the estimates used for predictions, but the proponent considered these results to be unreasonably severe.[27] Humidity cells produced concentrations up to 70mg/L while Faro Mine seepage data at the time showed concentrations as high as 300mg/L.[28] While these values seemed unreasonably high at the time, the current evidence suggests even these would have been optimistic estimates for some sources.

[22] Moodie et al. April 2008. Table 18. Attached in Appendix VIII.
[23] Deloitte and Touche Inc. February 2009. Section 4.2.3.
[24] Curragh Resources Inc. July 1989. Section 4.3.
[25] Moodie et al. April 2008. Table 18.
[26] Deloitte and Touche Inc. February 2009. Section 4.2.4.1.
[27] Moodie et al. April 2008. Section 6.0
[28] Moodie et al. April 2008. Section 4.2.7.

6.0 Mt. Nansen Mine

The Mt. Nansen gold mine was assessed by Indian and Northern Affairs Canada and permitted by the Water Board in the mid 1990s. The mine operated from late 1996 until early 1999.[29] The *Initial Environmental Evaluation* proposed mining of the upper, oxidized layer of the Brown-McDade deposit, with gold recovery in a mill using cyanidation. Once approved, the operation was plagued with construction difficulties, gold recovery challenges, environmental concerns and licence violations. The operators eventually sought bankruptcy protection and government assumed care-and-maintenance responsibility for the site in 1999. Since that time, the site has been under care-and-maintenance while permanent closure plans are developed. Care-and-maintenance and closure costs will again be borne by taxpayers despite the initial establishment of a security bond that the company and the Water Board considered adequate, at licencing, to complete the necessary closure requirements. Hindsight indicates that the environmental assessment, permitting and security bonding requirements failed to recognize the degree of uncertainty and potential effects associated with the project.

The mine design was based on mining and processing of oxide ores. As a result, long-term implications associated with storage of sulphide-bearing waste materials were not seriously considered in the mine design. During operations however, segregation of sulphide materials did not occur as planned and was not constrained in the water licence, resulting in processing of some sulphide ore materials and generation of some sulphide tailings and tailings with an overall net acid generating potential. Because the proponent's initial plan did not envision mining of sulphides, these tailings ended up exposed to ongoing weathering in upper tailings beaches, creating the least desirable conditions for mitigating potential effects.

The *Initial Environmental Evaluation* proposed a water treatment system capable of meeting effluent limits that would provide effective environmental protection for downstream aquatic resources. However, the treatment system did not perform as expected and frequently failed to meet many of the established effluent limits. The monitoring results presented in the *1998 Annual Report, Water Licence QZ94-004* provide some examples comparing results[30] with effluent limits[31]. It should be noted that some of the reported results for 1998 were from samples that included dilution with clean water from Dome Creek, a practice that BYG Natural Resources conducted for an unknown amount of time before the Water Board ruled this practice inadmissible.[32] Without this dilution, maximum concentrations and number of samples exceeding effluent limits would likely have been higher.

[29] Yukon Energy Mines and Resources. May 2008. Website page.
[30] BYG Natural Resources Inc. February 1999. Appendix 11, Water Quality Data, Station E7, Effluent to Dome Creek. Attached in Appendix X.
[31] BYG Natural Resources Inc. November 1994. Table 7-1. Attached in Appendix XI.
[32] BYG Natural Resources Inc. July 1998. P. 7. Attached in Appendix IX.

- Total Cyanide – 4 of 38 samples failed to meet the effluent limit of 0.3mg/L The maximum concentration of 4.56mg/L was 15 times the effluent limit and more than 50 times the predicted treatment plant performance of 0.09mg/L[33]
- Copper – 13 of 37 samples failed to meet the effluent limit of 0.2mg/L. The maximum concentration of 5.24mg/L exceeded the effluent limit by 26 times.
- Iron – 12 of 39 samples failed to meet the effluent limit of 1.0mg/L. The maximum concentration was 34.5 times the effluent limit.
- Cadmium – 5 of 38 samples failed to meet the effluent limit of 0.02mg/L. The maximum concentration of 0.07mg/L was 3.5 times the effluent limit, but over 4000 times the stringent CCME Guideline of 0.00017, indicating that the effluent limit of 0.02 may have been unprotective for the downstream aquatic environment.
- Arsenic – 3 of 38 samples failed to meet the effluent limit of 0.05mg/L. The maximum concentration of 0.7mg/L was 14 times the effluent limit.

By 1998, water quality data identified some instances in which the water in Dome Creek downstream of the tailings had contaminant concentrations that exceeded the mine's effluent limits, which themselves were well above the CCME guidelines for the protection of aquatic life.

Parameter	Effluent Limit	CCME Guideline	No. Samples Exceeding Effluent Limit	Maximum Value in Dome Creek[34]
WAD Cyanide	0.1	0.005	5 of 7	6.10
Copper	0.2	0.002 – 0.004	5 of 7	5.24
Iron	1.0	0.3	6 of 7	28.6
Manganese	0.5	None	7 of 7	13.1

Note: All values in mg/L

In addition to the failure to meet specific effluent discharge concentrations, the water treatment system also frequently failed to meet overall effluent toxicity requirements. Despite many efforts to address this, the operators were generally unable to produce non-toxic effluent. As a result, contaminated water accumulated on the site as the operators tried to avoid discharge of non-compliant water, leading to "four requests for Water License amendments to suspend non-toxicity requirements."[35] Toxicity was likely due to cyanide breakdown products including thiocyanate and ammonia[36] both of which had concentrations well above toxic values in treatment plant effluent and Dome Creek.

The *Initial Environmental Evaluation* proposed management of water in the tailings impoundment to minimize concentrations of contaminants. For example, a maximum

33 BYG Natural Resources Inc. November 1994, Appendix VI of Appendix IV. Attached in Appendix XI.
34 BYG Natural Resources Inc. February 1999. Appendix 11, Water Quality Data, Station D3. Dome Creek Downstream of Tailings. Attached in Appendix X.
35 Yukon Energy Mines and Resources. May 2008-2. Website page.
36 BYG Natural Resources Inc. July 1998, p. 11. Attached in Appendix IX.

allowable total cyanide concentration of 10mg/L was identified[37]. Operational difficulties however, led to significantly higher contaminant concentrations in the pond. The *1998 Annual Report* provides results from 42 samples for total cyanide of which 38 failed to meet the 10mg/L concentration with a maximum reported concentration of 101mg/L, more than 10 times the limit.[38] The high levels of total cyanide in the pond through 1997 also resulted in seepage concentrations up to 20mg/L of total cyanide in 1998,[39] more than 60 times the effluent limit of 0.3mg/L.

The Mt. Nansen project included a valley fill dam for tailings containment. Based on thermal analysis, BYG anticipated a frozen-core dam that would virtually eliminate seepage and be stable under earthquake conditions. "In the most probably event that the permafrost front moves up into the dam to a height higher than the pond level, seepage will be reduced to near zero."[40] "In the [frozen] case, seepage is effectively eliminated, and the structural strength of the dam is high."[41]

In reality, the anticipated frozen conditions never materialized and, in fact, the foundation beneath the dam has thawed resulting in liquefiable loose sands making the dam susceptible to failure under earthquake conditions. "Under the design seismic condition, the risk of the dam failure along the liquefied foundation soil is considered to be high. The post liquefaction static factor of safety was calculated to be about 0.70 indicating an unstable slope condition."[42] Seepage values were also substantially higher than anticipated and led to the emergency construction of a toe berm in 1997 to control piping activity at the toe of the dam[43].

The inadequate performance at the Mt. Nansen Mine ultimately led to several enforcement actions as well as emergency amendment of the water licence to relax water quality conditions so that water could be released from the site and reduce the physical risks to water management structures. But, the enforcement actions could only address already inadequate performance, not prevent it from happening. The enforcement process is also slow and cumbersome. As a result, environmental effects arising from the inadequate and unexpected performance could not be avoided.

The combination of more adverse water quality conditions, excess water on the site and physical stability issues with the dam created substantially more severe risks to the downstream environment than the company or regulators considered during project planning. Both the consequences and likelihood of failure events were much higher than planned for by INAC in the assessment or the Water Board in licencing. Many of the

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[37] BYG Natural Resources Inc. November 1994. Table 7-1. Attached in Appendix XI.
[38] BYG Natural Resources Inc. February 1999. Appendix 11, Water Quality Data, Station E1. Attached in Appendix X.
[39] Natural Resources Inc. February 1999. Appendix 11, Water Quality Data, Station E2. Attached in Appendix X.
[40] BYG Natural Resources Inc. November 1994. P. 54. Attached in Appendix XI.
[41] BYG Natural Resources Inc. November 1994. P. 49. Attached in Appendix XI.
[42] EBA Engineering Consultants Ltd. May 2002. P. 42. Attached in Appendix XII.
[43] EBA Engineering Consultants Ltd. May 2002. P. 8. Attached in Appendix XII.

potential outcomes were identified during the review processes and the water licence directly incorporated a number of plans and studies intended to resolve some of the outstanding uncertainties. However, the plans and studies in the licence were not necessarily clear about specific requirements, and the company failed to meet the expectations in delivering and implementing the findings of these programs. Security bonding requirements established by the Water Board failed to consider the scope of uncertainties with the project.

7.0 Summary and Conclusions

For the Minto, Vangorda/Grum and Mt. Nansen mines, comparison of project planning assumptions and predictions, made by proponents and accepted by regulators, against the actual outcomes highlights the importance of understanding project uncertainties and establishing appropriate and robust mechanisms for resolving them. All three of these mines were reviewed and authorized under modern assessment and permitting regimes. In each case, test program results and initial reviews indicated that conditions could be more adverse than predicted, but these adverse conditions were not considered thoroughly in the planning or conservatively in the licensing by either companies or regulators.

At the Minto Mine, water quality predictions optimistically assumed that mine sources (tailings, pit, mill, waste rock) would not add any copper load to the creek and that, if needed, contingency water treatment could address this. Testing suggested that loading was possible, but the proponent discounted these results because the test conditions were considered more adverse than those which would occur on site. Government environmental assessment agencies and the Water Board accepted the predictions and granted approvals accordingly. Current water quality from tailings is more consistent with the results of the adverse tests.

Similarly, at Vangorda/Grum Mine the proponent's water quality modeling and evaluation negated actual adverse water quality conditions from the nearby Faro Mine and adverse results from humidity cell tests. The proponent considered these results to be unreasonably adverse and relied instead on more optimistic results and assumptions. Government assessment agencies and the Water Board granted approvals based on these non-conservative assumptions, but recognized a potential need for perpetual water treatment at the site. Water quality results and updated modeling now confirm that even those adverse conditions severely underestimated water quality outcomes.

At Mt. Nansen Mine the project proposal overestimated the performance of water management structures and facilities. Water treatment facilities could not meet the expected performance. Thermal predictions for the dam resulted in erroneous expectations for its performance. The combination of more adverse water quality, greater quantities of contaminated water and poor performance of the dam resulted in completely unacceptable risks at some stages of mine operation. The regulatory regime was unable to respond in a timely manner to prevent and resolve these risks and conditions.

Avoiding similar types of outcomes for the Carmacks Copper project is critical. LSCFN has expressed a strong desire to protect the environmental integrity of its traditional territory including the area that would be affected by mining activity at the Carmacks Copper project. LSCFN has also recognized the long-term social and cultural effects that have arisen as a result of the unacceptable risks and environmental conditions that occurred at Mt. Nansen due to inadequate consideration and resolution of project uncertainties through regulatory approvals and subsequent enforcement. Traditional use in the Mt. Nansen area has diminished as a result of the mine activities and continues to be affected. These effects on traditional use are expected to continue well beyond implementation of a closure plan. The outcomes at Mt. Nansen, when compared with the predictions and community expectations, have created a general mistrust of mining in the community.

The process to-date for the Carmacks Copper project has done little to resolve LSCFN's discomfort with mining projects. Two assessments have been completed for the project, one under Yukon's *Environmental Assessment Act* and one under YESAA. Following this, Yukon Government has issued a Quartz Mining Licence for the project. In LSCFN's view, none of these processes has adequately addressed substantive issues and uncertainties raised by LSCFN and the issues and unknowns have simply been passed on to subsequent regulatory processes. These issues are now reiterated in the report by Mr. Jim Kuipers.

This report highlights the importance of understanding and reducing the substantial risks and uncertainties for the Carmacks Copper project, either before the project is authorized or with innovative and demonstrably robust mechanisms within regulatory instruments. Key areas that need resolution are described in Mr. Kuiper's report. This is a novel, untested technology, in a sensitive environmental location of significant importance to LSCFN, and requires regulatory care and control well beyond business-as-usual.

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