APPENDIX H

MEMO

Date: May 9, 2011 **HCP Ref No.:** CZN1682

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To: David Harpley, CZN

Subject: Prairie Creek Mine – Additional Water Quality Issues (Memo 5)

1.0 INTRODUCTION

This document stems from technical discussions between regulators and CZN at Yellowknife on April 12, 2011.

In this memo, potential effects related to changes in Prairie Creek temperature, increased sediment loadings, pH and dissolved oxygen are assessed.

2.0 TOTAL SUSPENDED SOLIDS, WATER CLARITY AND DEPOSITED SEDIMENTS

Sediment plumes have the potential to disrupt fish migration by blocking migratory routes or by inhibiting the ability of fish to find migration routes (Westerberg *et al.* 1996). Sediment deposits also smother eggs by restricting egg respiration and the removal of metabolic waste.

The potential presence of contaminants of concern in suspended sediments discharged from the mine pose another potential concern, namely the possibility that these sediments may deposit and accumulate in depositional areas of Prairie Creek, posing a potential risk to benthic aquatic organisms or developing fish eggs.

The anticipated TSS concentration in discharged effluent is predicted to be <4 mg/L (based on laboratory treatment and an expectation that suspended sediment levels will be lower in an operational treatment plant with a clarifier and solids recycling). This concentration is well below the 90th-percentile TSS concentration of Prairie Creek (247 mg/L). Considering that the creek can have TSS concentrations as high as 359 mg/L (and possibly higher during significant rainfall events), and that no substrate finer than pebbles have been observed in the creek (IR2 reply, Appendix Q), the potential for any notable accumulation of fine sediment from the mine is very unlikely.

3.0 PH

The final step in the primary effluent treatment process includes the addition of lime. Final pH will be in the 9.0 to 9.5 range. The pH of the creek ranges from 7.8 to 8.6. The largest potential influence would occur in winter during low flow conditions. Assuming a 1:7 dilution and a pH of 7.8, predicted downstream pH is 7.9.

Consequently, acidifying effects in Prairie Creek resulting from the pH of the effluent are unlikely (note that University of Saskatchewan data were excluded because pH values were consistently lower than the other three sources and suggest problems with their pH meter).

4.0 TEMPERATURE

Magnuson *et al.* (1979) grouped temperate species into three thermal guilds defined by thermal niches:

- Warm water (summer temperatures between 27 and 31ºC);
- Cool water (21–25ºC); and
- Cold water (11–15ºC).

Following this approach, Reist (1994) further defined an Arctic Guild as fish distributed wholly or primarily in northern areas and adapted to extremely cold water (<10ºC) and adapted to short growing seasons, extensive ice presence, and long periods of darkness.

The three predominant fish species indicative of these Arctic cold-water ecosystems and known to inhabit Prairie Creek include: bull trout, mountain whitefish, and slimy sculpin. Bull trout will be of primary concern for potential impacts associated with effluent discharge considering its status as a "species at risk" in the NWT. Arctic grayling has been observed downstream of the Prairie Creek Mine near the confluence with the Nahanni River, but not in proximity to the Mine.

Bull trout are typically found in coldwater mountain streams with optimal densities occurring at temperatures of 12ºC to 13ºC (Dunham *et al.* 2003). In general, all bull trout (regardless of the life stage or life history strategy) are cold-water specialists and are seldom found in systems where water temperatures that exceed 15°C for prolonged periods (McPhail and Baxter 1999). Effluent discharge causing temperatures above 15°C in Prairie Creek should be avoided to avoid physiological stress to the resident fluvial bull trout population, as well as avoidance along this migration route to upstream Funeral Creek by adfluvial populations during fall spawning events.

Bull trout reportedly spawn in Funeral Creek in mid-August, with eggs incubating over-winter in gravel/cobble substrate (16 mm to 64 mm) to hatch in March to April. The incubating eggs require temperatures of less than 8°C to survive (Berry 1994), with optimum inter-gravel temperatures of 2°C to 4°C. It is during this winter incubation period that bull trout are most susceptible to changes in water quality and sedimentation; however, there is a lack of adequate spawning gravels near the exfiltration trench, and there is no record or indication of spawning in the Prairie Creek main stem. The general absence of fry or juvenile bull trout from catch records in the Prairie Creek main stem further supports the suggested absence of spawning. Therefore, impacts to developing embryos are not likely. Secondly, winter discharge of mine and process water is expected to be at a minimum during this winter incubation period, even if embryos are present.

Measurements taken before and after effluent treatment in the laboratory indicate that a temperature increase in the water coming into the treatment building will not occur

(SGS-CEMI, April 2011). It is anticipated that during the summer, the temperature of water in the holding ponds may increase above the temperature of Prairie Creek; however, the increase should not be more than a few degrees. NHC modelled potential changes in water quality in the creek, as a result of mixing and dilution. Using their coefficients, a temperature differential of 5°C would lead a temperature change in Prairie Creek downstream of the IDZ under low-flow, open-water conditions of less than 0.1 degrees. Therefore, no effects related to temperature are anticipated in the receiving environment.

5.0 DISSOLVED OXYGEN

Winter is a critical time for dissolved oxygen levels. While cold water can hold more dissolved oxygen than warm water, ice cover blocks contact with air and can reduce the potential for aeration through turbulence (Alberta 2002). Effluent addition during low winter flows can cause dissolved oxygen concentrations in many northern rivers to dip to near critical levels for many oxygen-sensitive organisms.

Oxygen loss through the water column can occur through several pathways, including: plants and animal respiration, chemical oxygen demand (COD) as elements oxidize to form complexes, and biological oxygen demand (BOD) as bacteria consume oxygen to break down decaying plant and animal matter. The amount of oxygen-demanding organic material, suspended solids, or dissolved metals released into a river system by natural or human sources is a significant factor in the oxygen level declines in many northern rivers (Alberta 2002).

Adequate dissolved oxygen levels are critical for fish in their early life stages. Many fish species in the northern river basins spawn following spring break-up or in summer (slimy sculpin), when water flows are elevated and dissolved oxygen levels are high. However, fall spawning species (including mountain whitefish and bull trout) produce eggs and young that must develop during winter low flow periods where ice-cover typically persists and dissolved oxygen levels may be lower. Studies concluded that mountain whitefish eggs took longer to hatch, and recently hatched bull trout were under-developed at low dissolved oxygen concentrations below 6 mg/L (Alberta 2002). Considering the riverbed is usually lower in dissolved oxygen than the water column, adaption of the CCME objective of 9.5 mg/L (CCME 1993) of Prairie Creek, for early life stage bull trout and whitefish would help to ensure that interstitial DO concentrations of 6.0 mg/L, or greater, are supplied to any developing eggs or winter emergent species in Prairie Creek.

Previous observations have indicated that dissolved oxygen concentrations in Prairie Creek are very high, as would be expected from a cold, fast-flowing, turbulent stream flowing predominantly over shallow riffles.

There are two potential mine related factors that could influence the concentration of dissolved oxygen in Prairie Creek: winter die-offs of algal biomass, stimulated by nutrients in effluent; or addition of effluent of high chemical oxygen demand (COD).

With regard to enrichment effects, incremental additions of nutrients are expected to stimulate algal biomass, but not to the extent that thick, algal mats are formed (see accompanying memo regarding enrichment). Additionally, in winter under ice, biological metabolism would be expected to be very low given very low river temperatures, and likely not lead to rapid decomposition of algal cells, or even substantial death of algal cells.

With regard to COD, ferric sulphate (or ferric chloride) is added as part of the effluent treatment process to remove any excess sulphide. Sulphide reduces the ferric iron to ferrous iron. Ferrous iron is often associated with chemical oxygen demand (and oxygen suppression) in the aquatic environment. However the treatment also involves the addition of lime (raising the pH) and aeration of the effluent for 60 minutes. Due to the oxygenation and high pH, there should be no ferrous iron present in the final effluent.

This assertion is supported by observations made during a recent *Daphnia magna* toxicity test with new simulated treated effluent (Nautilus Environmental, May 5, 2011). The 96-hr acute *Daphnia magna* toxicity test does not receive any aeration, and any oxygen suppression caused by a sample is readily observed. No oxygen suppression was observed, nor was there any sign of precipitated iron (ferric-iron) on the bottom of any of the containers, which would be observed if ferrous-iron was originally present in the simulated effluent sample.

6.0 REFERENCES

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