APPENDIX E

MEMO

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

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To: David Harpley, CZN

Subject: Prairie Creek Mine – Initial Dilution Zone Characteristics (Memo 2)

1.0 INTRODUCTION

Stemming from technical discussions between regulators and CZN at Yellowknife on April 12, 2011, this memo defines an initial dilution zone (IDZ) for the Prairie Creek mine. In a subsequent memo, water quality predictions for the IDZ will be discussed.

This memo also discusses the safe passage of migrating fish past the exfiltration trench.

2.0 INITIAL DILUTION ZONE CHARACTERISTICS

2.1 PROPOSED INITIAL DILUTION ZONE

An Initial Dilution Zone (IDZ), also called a "mixing zone", was defined as "an area adjacent to the effluent outfall within which waste is discharged and first mixes with water in the receiving environment" by the Mackenzie Valley Land and Water Board (MVLWB) in *The Final Draft Water and Effluent Quality Management Policy* (MVLWB *et al*. 2010).

In that document, MVLWB does not provide any guidance on defining IDZs, but states that "…establishment of an initial dilution zone (IDZ) will be considered by the Boards on a case-by-case basis such that the water quality standards for the receiving environment will need to be met outside of the IDZ."

CCME (2003) define an IDZ as "the area contiguous with a point source (effluent) where the effluent mixes with ambient water and where concentrations of some substances may not comply with water quality guidelines or objectives." CCME also provides 14 factors that should be considered while setting an IDZ. The planned outfall will meet all of CCMEs requirements.

Briefly, treated effluent discharge from the Prairie Creek Mine will be discharged to Prairie Creek via one of two pipes buried in exfiltration trenches (see Northwest Hydraulics Co. [NHC], December 22, 2010 and February 11, 2011, April 29, 2011). Use of exfiltration trenches rather than a simple pipe discharge will result in very rapid mixing of effluent into Prairie Creek, so that effluent concentrations are typically less than 2% of release within tens of metres downstream of the discharge point. This substantially alleviates the concerns related to IDZ's and aquatic impacts. Most effluent

mixing will occur in a small zone of vertical mixing, immediately downstream of the discharge point. Effluent concentrations at complete vertical mixing will be similar to those occurring further downstream at complete, transverse (cross-channel) mixing.

Two exfiltration pipes (rather than the previously proposed one) have been proposed for two reasons: (1) to provide a back-up if one of the pipes requires servicing; and (2) to provide greater cross-channel width for uninterrupted fish passage under ice-covered conditions via a shorter pipe.

In addition to the very efficient mixing, the specifications of the revised outfall scenario are considered to address the 14 CCME factors mentioned above as follows:

- *The dimensions of an IDZ should be restricted to avoid adverse effects on the designated uses of the receiving water system (i.e., the IDZ should be as small as possible);* The adoption of an exfiltration trench over a pipe outfall greatly reduces the mixing zone, thus minimizing the area of possible effect;

- *Conditions outside the IDZ should be sufficient to support all of the designated uses of the receiving water system (i.e., there should be no environmental impact, meaning no guideline/objective excursions or sub-lethal toxicity);* Modelling of the dispersing effluent plume from either short or long trenches indicate very little difference in effluent concentrations at the edge of the proposed IDZ, with predicted water quality meeting water quality objectives, and concentrations ensuring no whole-effluent toxicity;

- *Conditions within the IDZ should not cause acute or short-term chronic toxicity to aquatic organisms;* Acute toxicity testing using simulated final effluent indicates no acute toxicity to *Daphnia magna* or rainbow trout at full effluent concentrations;

- *The IDZ should not impinge on critical fish or wildlife habitats (e.g., spawning or rearing areas for fish; over-wintering habitats for migratory waterfowl);* The proposed IDZ is small (100 m downstream), and in an area with no record of spawning or rearing of game fish, and no overwintering habitat for these fish. Spawning migrations of mountain whitefish and bull trout have been documented passing past the mine site.

- *Wastewaters that are discharged to the receiving water system must not be acutely toxic to aquatic organisms;* Acute toxicity testing using simulated final effluent indicate no acute toxicity to *Daphnia magna* or rainbow trout;

- *Conditions within an IDZ should not result in bio-concentration of contaminants of potential concern (COPC) to levels that are harmful to the organism, aquatic-dependent wildlife or human health;* The IDZ is an erosional, riffle zone, with little potential for deposition and accumulation of any contaminants in sediments;

- *A zone of passage for migrating aquatic organisms must be maintained;* Safe passage is addressed separately below; briefly, the shorter exfiltration trench ensures passage for fish even during low flow (winter) conditions;

- *Placement of mixing zones must not block migration into tributaries;* The mixing zone contains the confluence of Harrison creek, an ephemeral creak that has low fish habitat potential and does not support fish;

- *Mixing zones for adjacent wastewater discharges should not overlap with each other;* There are currently no other dischargers within Prairie Creek, nor are any planned;
- *Mixing zones should not unduly attract aquatic life or wildlife, thereby causing increased exposure to COPC;* There is no likely reason why aquatic life or wildlife would be attracted to the effluent;
- *Mixing zones should not be used as an alternative to reasonable and practical pollution prevention, including wastewater treatment (pollution prevention principle);* Best-available treatment technologies are planned to treat wastewater that cannot be recycled before discharge from the mine;
- *Mixing zones must not be established such that drinking water intakes are contained therein;* There are no known drinking water intakes within the mixing zone;
- *Accumulation of toxic substances in water or sediment to toxic levels should not occur in the mixing zone;* No accumulation of toxic substances, through sedimentation or other processes, is anticipated within the mixing zone (the potential for bioaccumulation of mercury or selenium in Prairie Creek is more broadly addressed elsewhere); and
- *Adverse effects on the aesthetic qualities of the receiving water system (e.g., odour, colour, scum, oil, floating debris,) should be avoided.* No effect on creek aesthetics is anticipated within or downstream of the mixing zone due to effluent discharge.

Following CCME guidance on IDZ definition, the IDZ should extend from the discharge point to a downstream location between the exfiltration trench and somewhere shortly downstream of the point of complete vertical mixing. Based on plume modelling, the point of complete vertical mixing can occur anywhere from 1.6 m to 31 m downstream of the exfiltration trench. Given compliance water quality sampling in Prairie Creek should occur at the downstream edge of the IDZ, logistical considerations are also important in defining the IDZ. **Therefore, we propose that the IDZ extend approximately 100 m downstream of the exfiltration trench.** At this location, the creek enters a narrower, unbraided riffle zone which is shallow and therefore convenient and safe to access and sample year round. It will also allow the sampler to avoid any possible confounding influences of sampling directly downstream of the confluence with Harrison Creek. Modelling suggests that the difference in effluent concentrations between the downstream point of vertical mixing and 100 m will be small (see Northwest Hydraulics Co. [NHC], April 29, 2011).

2.2 SAFE FISH PASSAGE

A key tool for assessing sub-lethal effects on fish species and other aquatic organisms is avoidance responses to environmental stressors. To date, very little scientific analysis has been conducted on the effects of metal toxicants on fish behaviour. However, there has been some testing on the 'lowest observed effect concentration' (LOEC) based on full or partial life cycle tests or early life stage tests.

Avoidance is a key response to an individual's survival and is a 'flight' behavioural response to a contaminant. This 'flight' response can lead to the alteration of the aquatic community through emigration of affected species (Atchison *et al*. 1987).

A summary of related literature for the LOEC of environmental stressors on fish avoidance is outlined below (Atchison *et al.* 1987):

- Cadmium - Avoidance (rbt) at 52 µg/L @ 112 mg/L $CaCO_3$ hardness and 7.6 pH
- Copper - Avoidance (rbt) at 6.4 µg/L @ 28 mg/L $CaCO_3$ hardness and 7.3 pH
- Copper - Avoidance (rbt) at 0.1 µg/L @ 90 mg/L $CaCO_3$ hardness and 8.0 pH
- Copper - Avoidance (lw) at 6.3 µg/L @ unknown hardness and 7.7 pH
- Copper - Avoidance (as) at 2.3 µg/L @ 18 mg/L $CaCO_3$ hardness and unknown pH
- Copper - Avoidance (gf) at 5.0 µg/L @ 5 mg/L $CaCO_3$ hardness and 8.4 pH
- Iron - Avoidance (cs) at 4.3 µg/L @ 15 mg/L CaCO3 hardness and 7.7 pH
- Nickel - Avoidance (rbt) at 24 µg/L @ 28 mg/L $CaCO_3$ hardness and 7.3 pH
- Zinc - Avoidance (rbt) at 5.6 µg/L @ 14 mg/L $CaCO_3$ hardness and 7.2 pH
- Zinc - Avoidance (rbt) at 47 µg/L @ 112 mg/L $CaCO_3$ hardness and 7.6 pH
- Zinc - Avoidance (as) at 53 µg/L @ 18 mg/L $CaCO_3$ hardness unknown 7.6 pH

* Abbreviations: as = Atlantic salmon; cs = coho salmon; gf = goldfish; lw = lake whitefish; rbt = rainbow trout.

As outlined above, avoidance responses to metal stressors can vary greatly with fish species, water quality variables (i.e., hardness, pH, metal concentration), physical variables (i.e., shading), and simply between tests. The normal sensory processes of fish that respond to chemical signals in the water can also be affected by metal alteration of the water column. Chemical cues are important to many species for activities such as feeding, mate selection, migration, and predator avoidance (Kamchen and Hara 1980).

Although more tests of avoidance than any other behaviours have been conducted with metals, comprehensive testing has not been done to examine the effects of different metals, fish species, or water quality on the sensitivity of fish to various metal toxins (Atchison *et al.* 1987). The shortage of laboratory analyses, and high documented variation of avoidance behaviour/tolerances to date highlights the need for a safe passage corridor for migrating fish around the Prairie Creek mine discharge.

In response to this concern, CZN will use a shorter exfiltration trench during ice-covered conditions, and also during the predicted bull trout and whitefish spawning migrations if needed (i.e., from August to October). At a minimum, a safe migratory channel of (35% of the total wetted width, or 4.3 m, will be maintained during low Prairie Creek flows).

3.0 REFERENCES

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