CANADIAN ZINC CORPORATION

January 31, 2014

Julian Morse
Regulatory Officer
Mackenzie Valley Land and Water Board
7th Floor-4922 48th Street,
Yellowknife, NT
X1A 2P6

Dear Mr. Morse,

Re: MV2008L2-002, Prairie Creek Mine, Draft AEMP Design Plan

To fulfil the requirement of Part G, Condition 2 of Water Licence MV2008L2-0002, Canadian Zinc Corporation (CZN) is pleased to provide a Draft Aquatic Effects Monitoring Plan (AEMP) design document. The document is draft No. 2, and builds on the first draft produced during the permitting process. Two items are worthy of particular note:

- the triggers in Section 5 have been amended to reflect the discharge management conditions contained in the final Water Licence; and,

- AEMP locations were selected last year and baseline sampling was initiated in summer 2013. The resulting data, together with the results of the first Bull Trout Monitoring Program, are provided in Appendix A1 of the document.

If you have any questions, please contact us at 604 688 2001.

Yours truly,

David P. Harpley, P. Geo.
VP Environment and Permitting Affairs

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Hatfield
CONSULTANTS

Prairie Creek Mine
Aquatic Effects Monitoring Program
Draft No. 2

January 2014

Prepared for:

Canadian Zinc Corporation
Vancouver, British Columbia

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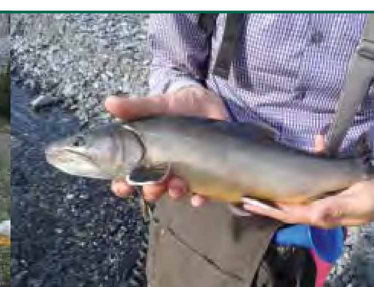

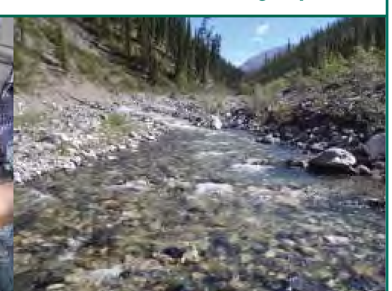

PRAIRIE CREEK MINE
AQUATIC EFFECTS MONITORING PROGRAM

DRAFT NO. 2

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JANUARY 2014

CZN6335.3

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LIST OF ACRONYMS

AANDC	Aboriginal Affairs and Northern Development Canada
AOC	Analyte of Concern
AEMP	Aquatic Effects Monitoring Program
BACI	Before/After/Control/Impact
BEAST	BEnthic Assessment of SedimenT
CABIN	Canadian Biomonitoring Network
CCME	Canadian Council of Ministers of the Environment
CZN	Canadian Zinc Corporation
DFO	Fisheries and Oceans Canada
EEM	Environmental Effects Monitoring
EPT	Ephemeroptera, Plecoptera, Trichoptera
EQC	Effluent Quality Criteria
FF-P	Farfield sampling location within the Park
FF-PB	Farfield sampling location at the Park boundary
GNWT	Government of Northwest Territories
IDZ	Initial Dilution Zone
LPL	Lowest Practicable Level
MMER	Metal Mining Effluent Regulations
MRP	Management Response Plan
MVLWB	Mackenzie Valley Land and Water Board
NBDB	Nahanni Butte Dene Band
NF	Nearfield
NTUs	Nephelometric Turbidity Unit
RCA	Reference Condition Approach
RIVPACS	River Invertebrate Prediction and Classification System
REF	Reference
SNP	Surveillance Network Program
SOPC	Stressors of Potential Concern
SSWQO	Site Specific Water Quality Objectives
TDS	Total dissolved solids
TGD	Technical Guidance Document

TK	Traditional knowledge
TSS	Total suspended solids
WRP	Waste Rock Pile
WSC	Water Survey of Canada
WSP	Water Storage Pond

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Name	Firm	Hardcopies	CDs	Email	FTP
David Harpley	Canadian Zinc Corp			✓	

1.0 INTRODUCTION

This document presents a draft plan for an Aquatic Effects Monitoring Program (AEMP). The final AEMP will be determined though discussions between Canadian Zinc Corp. (CZN), regulators and representatives from local communities, through an AEMP Working Group convened for that purpose.

An AEMP is an essential component of any development project in the Northwest Territories. It is designed and implemented with the intent of evaluating effects of industry on the aquatic environment.

Regulatory drivers for the aquatic monitoring programs at the Prairie Creek Mine (the Mine) include:

- A Water Licence, issued and administered by the Mackenzie Valley Land and Water Board (MVLWB); and
- The Metal Mining Effluent Regulation (MMER), associated with Section 36(3) of the federal Fisheries Act (administered by Environment Canada) and including requirements for effluent (discharge) quality monitoring and Environmental Effects Monitoring (EEM).

The purpose of this AEMP is to verify that mine activities do not cause significant deleterious environmental effects. Generally, the AEMP focuses on discharge quality and downstream water quality, ensuring that mine controls are adequate to prevent significant effects by the Mine's discharge on the aquatic ecosystem of Prairie Creek. As such, the AEMP serves as an operational confirmation of the efficacy of the Effluent Quality Criteria (EQC) defined in the Water Licence to regulate the mine's discharge.

Guiding principles for an AEMP program for the Prairie Creek Mine were outlined by Dubé (2010) and Hatfield (2011). The proposed AEMP builds upon baseline work by Spencer et al. (2008), Bowman et al. (2009) and Scrimgeour et al. (2010), and draws upon federal MMER guidance and guidance provided in the Aboriginal Affairs and Northern Development Canada (AANDC) AEMP guidance document (INAC 2009). Notable attributes of most AEMPs include the incorporation of aboriginal consultation and traditional knowledge (TK) into measurement end-points, and a management response plan (MRP). An MRP sets thresholds for individual measurement end-points, and clearly defines actions that must be implemented if thresholds are exceeded. Actions may include increased sampling frequency, the collection of additional types of data, or changes to discharge treatment/mill process.

AEMPs should be designed to assess both project-specific and cumulative effects. However, given the Prairie Creek Mine is located in a remote area with no other development activities in the area or Prairie Creek watershed, cumulative effects from stressors other than the Prairie Creek Mine are not expected.

Specific objectives of the AEMP, as stated in Part G and Schedule 6 of the Water Licence, are as follows:

- To determine the short- and long-term effects of the Project on the Receiving Environment;
- To test the predictions made in the Environmental Assessment and in other submissions to the Board regarding the impacts of the Project on the Receiving Environment;
- To test predictions that there will be no impacts to the ecological integrity of the aquatic ecosystem within the Nahanni National Park Reserve;
- To assess the efficacy of mitigation measures that are used to minimize the effects of the Project on the Receiving Environment;
- To identify whether there is any need for additional mitigation measures to reduce or eliminate Project-related effects; and
- To provide an early warning system where the results of aquatic monitoring are used to prevent or avoid adverse environmental effects through a Response Framework and regular evaluation of the AEMP.

This version of the draft AEMP is Draft No. 2 and incorporates additional baseline data collected from the following:

- Aquatic surveys performed by DFO and CZN in the area in July/August 2013;
- Additional upstream Prairie Creek water sampling since August 2013; and
- Re-activation of the Water Survey of Canada (WSC) continuous hydrometric (water-level) station on Prairie Creek upstream of the mine by WSC in early June, 2013.

Draft No. 1 was issued in December 2012 before the issuance of Prairie Creek's Water Licence (September 2013). New baseline data is presented in Appendix A1.

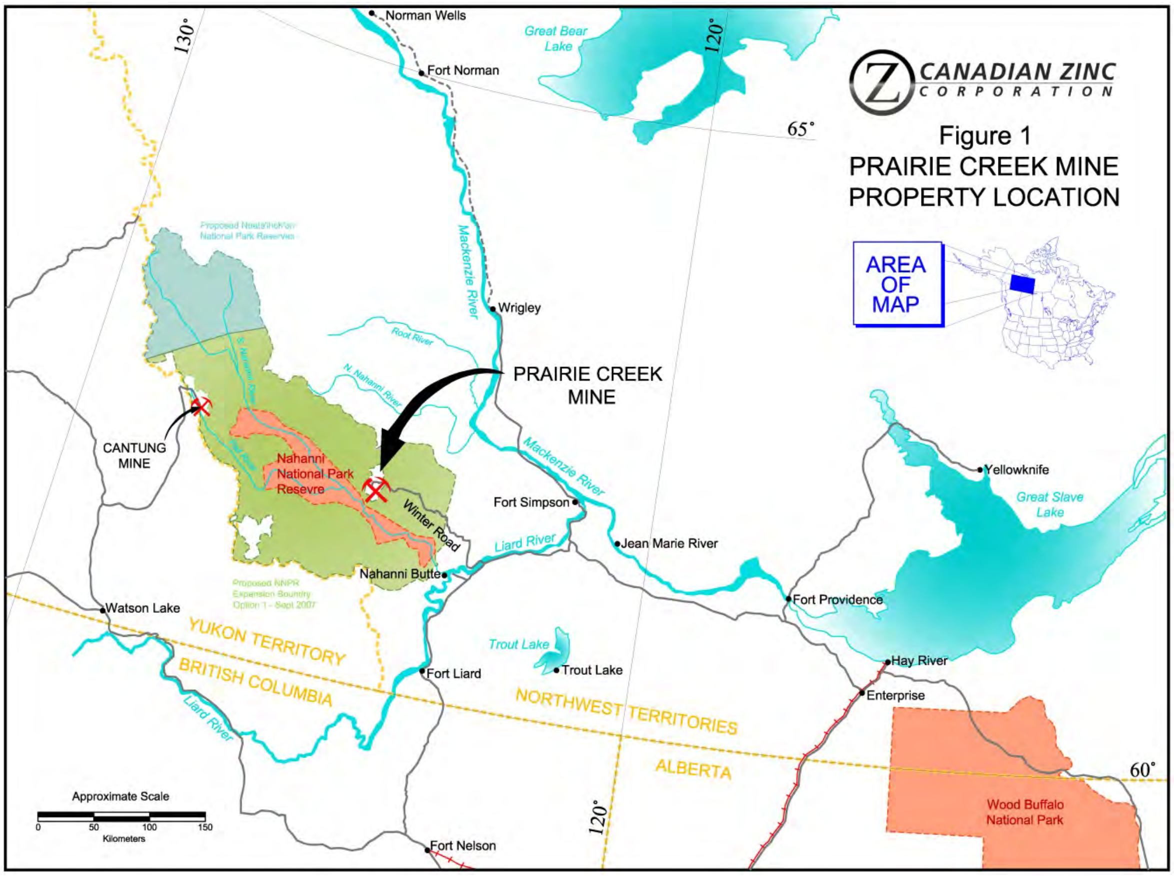
1.1 SITE DESCRIPTION

The Mine is located adjacent to Prairie Creek, a tributary of the South Nahanni River. The Mine is also upstream of, and surrounded by, the Nahanni National Park Reserve (Figure 1).

The catchment area of Prairie Creek upstream of the Mine is 506 km^2 (Map1 in Appendix A1). Harrison Creek, a tributary to Prairie Creek adjacent to the Mine and which also receives mine drainage, has a catchment area of 10.3 km^2 upstream of the Mine site, making a total upstream catchment area 515.9 km^2.

Natural surface runoff was modified somewhat historically by the construction of a flood-protection berm around the main site. Surface runoff now flows into the Catchment Pond and currently discharges into Harrison Creek. Prairie Creek has annual average precipitation of about 369 mm/year, and an annual average rainfall of 224 mm/year. Peak precipitation rates, and related flood events, occur between June and August. The yearly average daily temperature is 1.2°C (CZN 2010). Summers have a mean temperature of 9°C and winters have a mean temperature of -9.5°C (Environment Canada (EC) 1991).

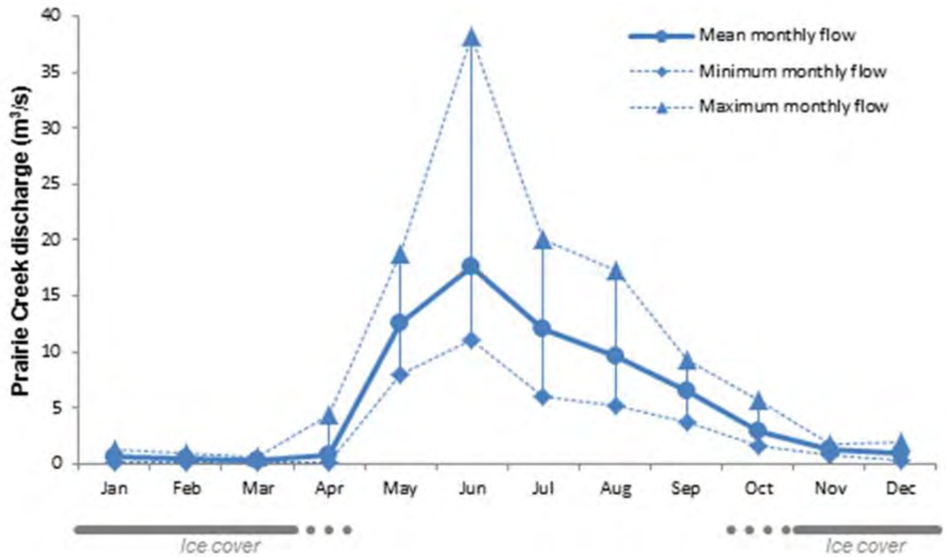
Figure 1 Location of the Prairie Creek Mine.



1.1.1 Water Quantity and Quality

Flows within Prairie Creek were continuously monitored by a hydrometric station operated by WSC from 1974 to 1990. The station was re-activated in June 2013, andis located at the Mine on the west side of Prairie Creek opposite the large pond. The highest monthly flows generally occur between May to September, with the highest flows occurring in June (coinciding with the freshet). The lowest flows occur in March and, based on average monthly flows, are approximately 2% of the maximum (17.6 to 0.32 m^3/s , CZN 2010).

Figure 2 **Range of mean monthly flows observed in Prairie Creek at Harrison Creek, 1976 to 1990.**



The pH in Prairie Creek naturally ranges between 8.0 and 8.6. Hardness and sulphate are relatively high, ranging between 147 to 341 mg/L and 27.6 to 114 mg/L, respectively. Total metal concentrations are typically very low, falling well below the Canadian Council of Ministers of the Environment (CCME) water quality guidelines, unless creek water is turbid. Using standard analytical detection limits of the time, many metals (e.g., arsenic, chromium, copper, mercury, nickel and silver) were often below detection limits in previous studies.

Analyte concentrations are similar between open-water seasons and under ice, except for some dissolved substances including selenium, sulphate, total dissolved solids (TDS) and dissolved zinc, which are often higher in winter. For dissolved selenium and sulphate, there is a distinct drop in concentrations during the high-flow season (specifically in May), followed by a gradual increase to the highest concentrations which occur in November (Hatfield 2012).

The seasonal high flows of Prairie Creek have generated primarily erosional substrates; soft sediments are uncommon. Sediment sampling conducted by Spencer et. al. (2008) did not find any substantial differences in metals concentrations between reference (upstream of the Mine), high-exposure and low-exposure (both downstream) sites they tested. They did report a slight increase in arsenic concentration at the nearfield site. However, given the small increase (17%) and small sample size (n=1), it is possible that this apparent increase is actually natural variation.

1.1.2 Fish Community

Studies have identified that both bull trout (*Salvelinus confluentus*) and mountain whitefish (*Prosopium williamsoni*) spawn in the Prairie Creek watershed upstream of the Mine location. Bull trout are known to spawn in Funeral Creek, a tributary of Prairie. Slimy sculpin (*Cottus cognatus*) inhabit the main creek (and therefore also likely spawn in the creek), along with some of the tributaries. Arctic graying (*Thymallus arcticus*) inhabit the lower portions of Prairie Creek, far downstream of the Mine near the creek's confluence with the Nahanni River. In all of the studies conducted in proximity to the Mine, only one grayling has been reported, adjacent to the airstrip. Many tributaries of Prairie Creek are steep and ephemeral, having low productivity (CZN 2010). Some algal and plant communities in Prairie Creek downstream of the Mine have indicated slight nutrient enrichment (Dubé 2010).

1.1.3 Regional Land and Water Use Patterns

The lower portion of the South Nahanni River is an historic travel route for the Naha Dehe Dene Band (NDDB). Traditionally, the route was travelled using moose-hide boats, rafts or spruce-bark canoes. Now, when water levels and flows permit, Band members occasionally travel up-river using power boats (CZN 2010).

Band members occasionally fish in Prairie Creek near where it enters the South Nahanni River, approximately 45 km downstream of the Mine. Because Prairie Creek is such a fast-moving, shallow stream, the NDDB is concerned that any potential spills could travel quickly and pollute the downstream areas (CZN 2010).

1.1.4 Existing Mine Infrastructure and Discharges

Significant infrastructure currently exists at the Mine site, erected in the early 1980's by Cadillac Explorations Limited, who previously owned the Mine. However, Cadillac declared bankruptcy just before mine operations were due to commence, and the Mine has never operated. Existing infrastructure includes a processing plant (the Mill), office buildings, workshops and accommodations. CZN intends to upgrade and modernize the existing buildings and add new facilities, including a kitchen/accommodation block, concentrate shed, power-generation units and an incinerator (CZN 2010). CZN has been treating water draining out of the Mine since 2006, primarily using sodium sulphide with ferric sulphate and flocculent addition as settling aids. The focus of water treatment has been zinc concentrations. The existing treatment scheme will be replaced with a full-size commercial treatment plant during the construction phase prior to full mine operations for the treatment of mine water and mill process effluent (D. Harpley pers. comm. October, 2012).

1.2 PREDICTED MINE INFRASTRUCTURE AND DISCHARGES

Over the Mine's operating life, vein and strata-bound deposits containing lead, zinc, silver and copper will be removed by underground mining, at a rate between 600 to 1,200 tonnes of ore per day. The ore will be crushed, and lead and zinc concentrates will be produced using flotation cells. The concentrates will be transported to market during winter when the access road is open (CZN 2010).

In the Mill, process water will be removed from residual tailings by filtration. The tailings will be sent to a paste plant where they will be mixed with gravel-size waste rock and cement, and placed as a paste into the underground voids created by ore extraction. Over the life of the operation, all of the tailings will be placed underground along with about a third of the gravel-size waste rock. The remaining waste rock will be placed in an engineered waste rock pile (WRP) located in a small valley on the north side of Harrison Creek (CZN 2010).

Once operational, the Prairie Creek Mine will produce approximately 32,400 L/day of domestic sewage, based on 120 people on site at any given time (270 L/day/person). Sewage treatment will utilize aerobic biological digestion and settling processes. Sewage wastewater will have a biological oxygen demand of <20 mg/L and total suspended solids of <20 mg/L. The wastewater will be sent to a water storage pond (WSP) and will ultimately either be used as processing water in the Mill, or treated to remove metals and discharged (Dubé 2010).

In addition to sewage, the WSP will store mine drainage, wastewater from the mill process, and WRP and stockpile seepage . A water treatment plant will be constructed to treat excess water before discharge to Prairie Creek. The treatment and discharge rate will be adjusted according to the flow in Prairie Creek to ensure the analyte loads discharged do not cause water quality objectives to be exceeded. This is a load-based management approach. Between January to March when Prairie Creek flows are at their lowest, there may be periods of no water treatment and, therefore, no discharge (CZN 2010).

Discharged wastewater will have elevated concentrations of several metals, including cadmium, copper, lead, selenium and zinc. In addition, hardness, chloride, sulphate, sodium, iron and conductivity may also be elevated (Dubé 2010).

1.3 PREVIOUS AQUATIC ENVIRONMENTAL EFFECTS STUDIES

Two comprehensive aquatic-effects studies have been undertaken in the vicinity of the Mine in recent years (Spencer et al. 2008, Bowman et al. 2009), which provide extensive background information on the biophysical characteristics and biological communities of Prairie Creek, and the potential influence of historical mine-site discharges on the creek. The end-points proposed in this AEMP document are similar to the approaches used in the previous studies.

Spencer et al. (2008) conducted a control-impact study to determine differences between reference (upstream), near-field (high-exposure) and far-field (low-exposure) sites in Prairie Creek, utilizing methods outlined in the MMER EEM Technical Guidance Document (EC 2012a). Study end-points included metals concentrations in water, sediment, and fish tissues (i.e., slimy sculpin liver and muscle); periphyton and benthic macro-invertebrate community composition; and fish-health indices. An increased richness of benthic invertebrate communities and increased sculpin condition was found downstream of the Mine site, suggesting a mild enrichment.

Bowman et al. (2009) performed a similar study that was more regional in nature. This study included 20 reference sites and one site each immediately downstream of Prairie Creek Mine and Cantung Mine, both in the South Nahanni River Basin. End-points included: metals in water, sediment and fish (slimy sculpin) tissue; fish health; and community composition of benthic algae and invertebrates. The results of this study were similar to those of Spencer et al. (2008), indicating mild enrichment immediately downstream of the mine sites. Bowman et al. (2009) also showed that federal and regional guidelines for metals (such as aluminum, copper and iron) may not be appropriate for this region, as many of the reference sites in the headwaters of the South Nahanni River are naturally metal-rich and exhibited metal concentrations in water exceeding CCME guidelines.

In 2009, Scrimgeour and Bowman also conducted a field program on a regional scale. This study utilized Canadian Biomonitoring Network (CABIN) approaches for sampling and analyzing benthic invertebrate samples. The approach was intended to be simpler than the methods employed by Bowman et al. (2009), yet serve as an effective model for future biomonitoring programs (G. Scrimgeour pers. comm. October 2012).

Several authors have developed Site-Specific Water Quality Objectives (SSWQO's) for Prairie Creek. SSWQO's are numerical values for water quality analytes that are considered to be protective of aquatic life residing in a water body. SSWQO's are also used in the process of establishing EQC's in Water Licences. Dubé and Harwood (2010) considered various techniques to determine SSWQO's for Prairie Creek and compared them to CCME guidelines. For a limited set of metals, they recommended that objectives be based on a background reference approach as per CCME (2003), calculated as the mean + 2SD of natural background concentrations in Prairie Creek. In their final submission to the Water Board, CZN proposed SSWQO's for a more extensive list of metals and non-metals based on both toxicity-based values and the background reference condition approach (Hatfield 2012 a, b). The Water Board adopted CZN's proposed SSWQO's and included them in the Water Licence (see Table 1 below). A SSWQO for total phosphorous is outstanding, and must be provided by CZN to the Water Board three months prior to the discharge of treated wastewater.

Table 1 Site-Specific Water Quality Objectives provided in the Prairie Creek Mine Water Licence.

Water Quality Parameter	Water Quality Objective (mg/L)
Total Antimony	0.015
Total Arsenic	0.003
Total Cadmium	0.0002
Total Copper	0.0025
Total Iron	0.21
Total Lead	0.005
Total Mercury	0.000024
Total Selenium	0.002
Total Silver	0.00007
Total Zinc	0.035
Ammonia as N	0.2
Nitrate as N	2
Nitrite as N	0.02
Sulphate	200
Total Dissolved Solids	1000

2.0 PROBLEM FORMULATION

Problem formulation provides a framework upon which an AEMP can be based. In it, stressors, potentially impacted ecological components and the mechanism (pathway) of potential impact are defined and discussed. These are summarized in conceptual diagrams. From the conceptual diagrams, assessment end-points are defined, which are descriptions of individual environmental values to be protected (e.g., the maintenance of an Arctic grayling population suitable for consumption in lower Prairie Creek could be considered an assessment end-point). Measurement end-points (field or laboratory measurements) are then developed to assess the status of individual assessment end-points. For instance, a measurement end-point assessing the suitability of Arctic grayling in lower Prairie Creek for consumption might be mercury concentrations in fish tissue.

2.1 IDENTIFICATION OF STRESSORS OF POTENTIAL CONCERN

Metals, nutrients, ions and conventional variables are stressors of potential concern (SOPC) within Prairie Creek. The SOPC's, also referred to as analytes of concern (AOC's) can impact organisms via direct exposure or by dietary intake. However, impacts can also include secondary effects such as the reduction in food availability.

Low primary productivity makes Prairie Creek highly susceptible to changes in nutrient concentrations. Excessive enrichment of ultra-oligotrophic water, such as in Prairie Creek, could potentially lead to increased mercury methylation rates (and associated mercury accumulation) and depressed dissolved oxygen concentrations in overwintering pools (due to competing oxygen requirements of decaying organic matter).

The SOPC's for this AEMP are antimony, arsenic, cadmium, copper, iron, lead, mercury, selenium, silver, zinc, ammonia, nitrate, nitrite, sulphate, total dissolved solids, and total phosphorus. These analytes are listed in the Water License and represent those that are anticipated to be elevated in mine discharge water relative to Prairie Creek.

2.2 POTENTIALLY IMPACTED ECOLOGICAL COMPONENTS

Typical of swift-moving, oligotrophic, northern streams, Prairie Creek is characterized by having little periphyton growth and few depositional areas. Organic carbon concentrations in sediments are also very low. Macro-invertebrates typical of this sort of habitat have a large proportion of mayfly (Ephemeroptera), stonefly (Plecoptera) and caddisfly (Trichoptera) (EPT) organisms. EPT's tend to be more sensitive to changes in water quality than other macro-invertebrates. Slimy sculpin is the most abundant fish species found in Prairie Creek, and appears to be the primary resident fish species. Despite being the most abundant, the low productivity of the creek limits sculpin populations.

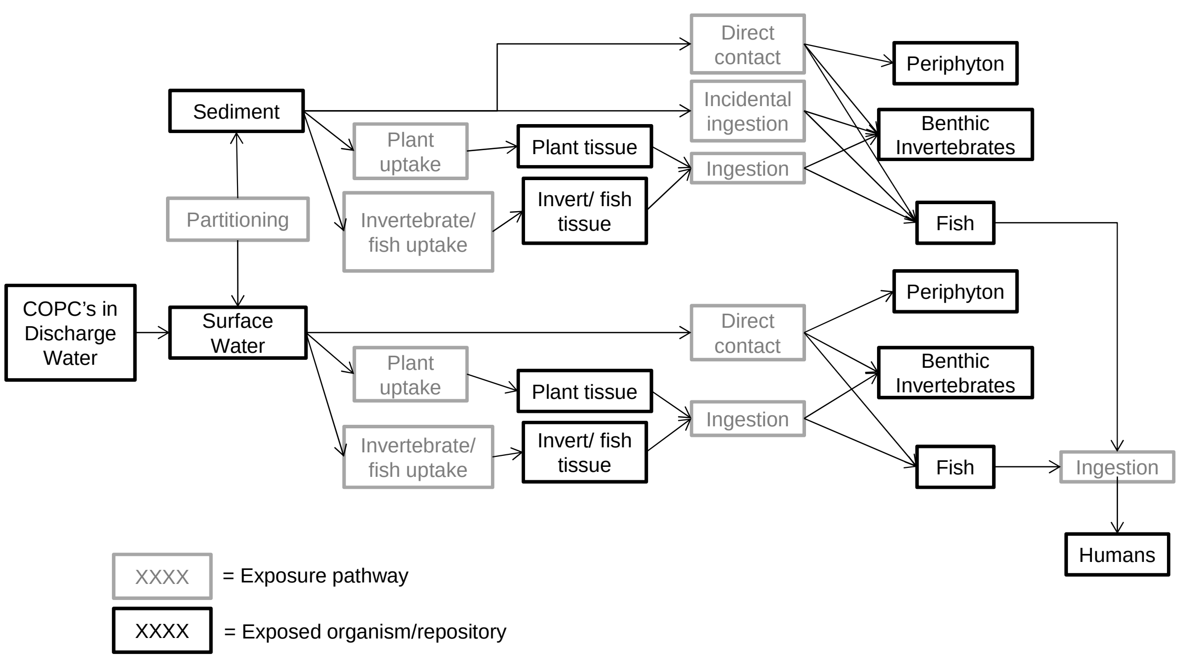
Bull trout are thought to migrate through Prairie Creek, possibly on their way to spawning grounds in Funeral Creek and other tributaries, although the trout population in Funeral Creek may be resident. Deeper pools in Prairie Creek several kms downstream of the Mine are believed to be important over-wintering sites for bull trout. Whitefish have also been observed in Prairie Creek adjacent to the Mine site; however numbers have generally been low. Arctic grayling populations exist in Prairie Creek near the confluence with the South Nahanni River. Aboriginal groups are reported to occasionally fish for grayling in this area.

Wildlife likely use Prairie Creek for drinking. However, fish populations are likely too small to be a significant source of food for piscivorous wildlife.

2.3 CONCEPTUAL DIAGRAM

The conceptual diagram in Figure 3 depicts chemical stressors, potentially impacted ecological components and the mechanism of potential impact. This figure only considers deleterious impacts related to chemical exposure. The primary sources of chemical exposure are expected to be water discharged from the Mine, and Harrison Creek water which could contain some waste rock leachate. Other possible impacts may be secondary or physical in nature. For instance, growth and subsequent decay of algae in downstream Prairie Creek could potentially lead to suppressed dissolved oxygen concentrations in over-wintering pools downstream of the mine.

Figure 3 Conceptual diagram of contaminant exposure to potentially impacted ecological components.



2.4 ASSESSMENT END-POINTS

As previously defined, assessment end-points are environmental values intended to be protected. For the Prairie Creek Mine, the following is a list of aquatic characteristics/values CZN intends to maintain in Prairie Creek:

1. Periphyton biomass characteristic of a northern oligotrophic creek;
2. Stable benthic invertebrate populations having a high proportion of taxa that would act as sentinels for aquatic effects (i.e., mayflies, stoneflies, caddisflies);
3. Populations of healthy fish (i.e., fish downstream of discharges with similar health to those upstream of discharges);
4. A functioning migratory corridor in Prairie Creek for fish moving upstream and downstream of the Prairie Creek Mine, particularly for bull trout; and
5. Avoidance of nutrient levels that could lead to significant algal enrichment, and in turn, depressed dissolved oxygen concentrations in Prairie Creek downstream of the Mine.

3.0 PROPOSED MEASUREMENT END-POINTS

Measurement end-points (field or laboratory measurements) are used to assess the status of individual assessment end-points. Measurement end-points have been grouped in three main categories:

1. **Physical:** data related to water and sediment quality, and water flow;

2. **Toxicological:** the results of toxicity tests using representative species and end-points to assess potential impacts to aquatic organisms; and

3. **Biological:** data related to populations, health and tissue chemistry.

Physical end-points proposed for measurement in receiving environments include:

- Chemical concentrations of metals in site discharge, Prairie Creek water and sediments, and Harrison Creek water;

- Flows of discharge and Prairie Creek; and

- Non-metal water quality measurements, including nutrients and dissolved oxygen.

Toxicological end-points include:

- Acute toxicity tests on discharge water; and

- Sub-lethal/chronic toxicity testing using Prairie Creek water collected at the edge of the initial dilution zone (IDZ, downstream of the Mine).

Biological end-points proposed are as follows:

- **Fish:** Calculated health indices, tissue metal concentrations, and population estimates;

- **Benthic macro-invertebrates:** population estimates (species assemblage indices), tissue metal concentrations; and

- **Periphyton:** taxa richness, biomass (as chlorophyll *a*) and potentially tissue metal concentrations.

4.0 DATA QUALITY OBJECTIVES

4.1 INTRODUCTION

Problem Statement

This AEMP is intended to confirm that discharges from the Mine do not significantly negatively affect aquatic life or human health from fish consumption (i.e., via accumulation of mercury).

Goals

This AEMP includes the collection and assessment of a range of aquatic environmental data, primarily from Prairie Creek, to allow conclusions to be reached and, where necessary, decisions made regarding the ecological condition of the creek and any potential influences or impacts from Mine activities. AEMP design also includes:

1. Using and building upon existing information collected at the site;
2. Incorporating TK where possible and appropriate;
3. Fostering an integrated research approach, in which local communities and Parks Canada are research partners; and
4. Content that also complements the requirements of the Water Licence Surveillance Network Program (SNP), and meets the requirements of a suitable EEM program.

Aboriginal Engagement and Involvement

CZN will endeavor to incorporate TK in future iterations of this design document, likely through the involvement of local aboriginal communities in the AEMP Working Group and EEM Technical Advisory Panel expected to be formed regarding this project.

Where possible, CZN will seek to involve local First Nations in field programs associated with data collection in support of this AEMP.

Analytical Approach

The recommended program contains aspects of a formal Before/After/Control/Impact (BACI) approach, as well as a Reference Condition Approach (RCA). For the BACI approach, conventional hypothesis testing will be followed, using either statistical probabilities or scientifically accepted affect sizes. For the RCA, clustering and discriminant functions following CABIN (EC 2012b) protocols will be applied.

Sampling Frequency

Proposed sampling frequencies vary depending on the type of program and information requirements. Those variables measured as part of the SNP will be measured as often as weekly. Variables normally included in EEM-type investigations may only be measured once every three years. More information on sampling frequency is provided in the "Proposed Information Inputs" section below.

Sampling Locations

The AEMP will generally use existing sampling stations established by previous studies, such as Spencer et al. (2008), Bowman et al. (2009) and Scrimgeour and Bowman (in press), so that existing baseline data can be incorporated, where possible, into on-going monitoring and used for comparisons with pre-development conditions. Specific station locations (see Table 2 or Map 5 in Appendix A1) were chosen after general AEMP content discussions with AANDC, Fisheries and Oceans Canada (DFO) and EC at a technical meeting held in Yellowknife on December 20, 2012. The locations of SNP sites for operations are shown in Figure 4.

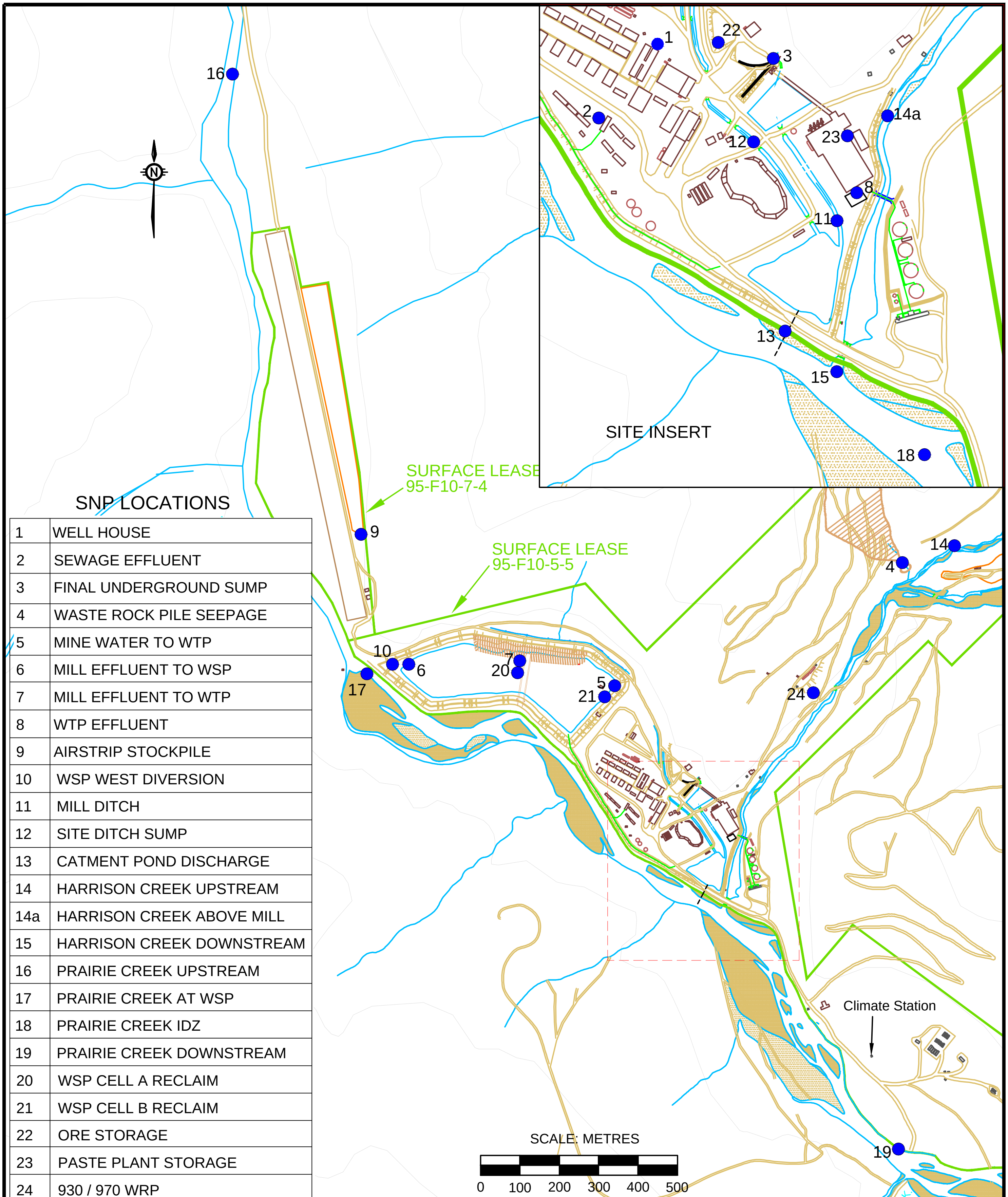
Table 2 Location of core EEM/AEMP sites on Prairie Creek.

Site Description	Site ID	Coordinates
Prairie Creek Reference	PC-REF	N61º34'19.2" W124º49'15.2"
Prairie Creek Near-field	PC-NF	N61º33'03.2" W124º47'40.1"
Prairie Creek Farfield at Park Boundary	PC-FF-PB	N61º31'28.0" W124º43'43.6"
Prairie Creek Farfield within Park	PC-FF-P	N61º21'51.3" W124º26'17.4"
Cathedral Creek Reference	CC	N61º47'06.6" W125º34'43.5"
Wrigley Creek Reference	WC	N61º46'49.5" W125º24'53.0"

Prairie Creek stations ordered from upstream to downstream.

4.2 PROPOSED INFORMATION INPUTS

Table 3 summarizes proposed AEMP components along with the discharge and receiving water quality that will be measured as part of the Mine's SNP.



SNP LOCATIONS

1	WELL HOUSE
2	SEWAGE EFFLUENT
3	FINAL UNDERGROUND SUMP
4	WASTE ROCK PILE SEEPAGE
5	MINE WATER TO WTP
6	MILL EFFLUENT TO WSP
7	MILL EFFLUENT TO WTP
8	WTP EFFLUENT
9	AIRSTRIP STOCKPILE
10	WSP WEST DIVERSION
11	MILL DITCH
12	SITE DITCH SUMP
13	CATMENT POND DISCHARGE
14	HARRISON CREEK UPSTREAM
14a	HARRISON CREEK ABOVE MILL
15	HARRISON CREEK DOWNSTREAM
16	PRAIRIE CREEK UPSTREAM
17	PRAIRIE CREEK AT WSP
18	PRAIRIE CREEK IDZ
19	PRAIRIE CREEK DOWNSTREAM
20	WSP CELL A RECLAIM
21	WSP CELL B RECLAIM
22	ORE STORAGE
23	PASTE PLANT STORAGE
24	930 / 970 WRP

Legend

Minesite Infrastructure
Watercourse
Property Roads
Lease Boundary

CANADIAN ZINC CORPORATION

Scale: As Shown
Drawn By: C. Reeves
File Name: SNP_2014.dwg
Date: January 2014

PRAIRIE CREEK MINE

Figure 4:
SNP LOCATIONS, OPERATIONS

Table 3 Summary of AEMP components, triggers and management responses.

Monitoring Program	Surveillance Network Program		AEMP		
Monitoring target	**Discharge Quality and Quantity**	**Water Quality and Quantity**	**Primary Productivity**	**Benthic Invertebrates**	**Fish**
Monitoring activity	Discharge flow rate Water chemistry Acute toxicity tests Sub-lethal toxicity tests	Flow rate in Prairie Creek Comprehensive Prairie Creek chemistry	Periphyton biomass Periphyton taxonomy (semi-quantitative)	Benthos community survey Tissue chemistry	Fish-health survey (sculpin) Fish-tissue chemistry (sculpin, grayling)
Monitoring location	Final discharge from Catchment Pond	Flow rate: Prairie Creek upstream at SNP station 17 (opposite WSP) Chemistry: Prairie Ck. REF and 100 m downstream (NF)	Prairie Creek upstream (REF), downstream (NF, FF-PB, FF-P)	Prairie Creek upstream (REF), downstream (NF, FF-PB, FF-P), and reference locations on Wrigley and Cathedral Creeks. Tissue chemistry at REF and NF only (anticipated to have sufficient mass of tissue for analysis)	Prairie Creek upstream (REF), downstream (NF, FF, FF-PB, FF-P); and near confluence with Nahanni River for grayling only.
Monitoring method	Flow meter, Grab samples	Hydrometric gauge Grab samples	Rock scrapings	Hess (EEM) or kick-net (CABIN) samplers	Electrofishing (health/tissue) and aboriginal collection (grayling tissue)
Monitoring frequency	Discharge rate: continuous Chemistry: weekly Acute toxicity: monthly (per MMER) Sub-lethal toxicity: bi-annually (per EEM)	Discharge rate: continuous Prairie Creek REF: monthly Prairie Creek NF: bi-monthly or monthly (analyte dependent) Harrison Creek: monthly	Harmonized with benthic invertebrates	Annual for the first three years of mine operations Following MMER EEM schedule after first three years	Fish-health: Following MMER EEM schedule
Management triggers	Excursion of EQC's Acute toxicity	Excursion of SSWQO	(None proposed)	Per MMER	Per MMER
Management response to triggers	See text	See text	Per AEMP working group decision	Per MMER guidance, AEMP working group	Per MMER guidance, AEMP working group

4.2.1 Physical Measurements

4.2.1.1 Mine Discharge

Site discharge quantity and quality monitoring are stipulated in the Water Licence SNP. Table 4 presents a summary, which constitutes a portion of the Mine's SNP.

Table 4 Discharge Monitoring Required by the Water Licence SNP and MMER.

Applicable Regulatory Device (Regulator)	Regulatory requirement	Proposed monitoring	Proposed/required frequency (routine)
Water Licence (MVLWB)	Discharge analyte loads (Flow x Quality) must be < Allowable Discharge Loads (ADL's) computed using Prairie Creek flow rate	Discharge rate	Continuous
		Chemistry: conductivity, pH measurement of major ions, temperature, nutrients, and total and dissolved metals	Weekly
Metal Mining Effluent Regulation (EC)	Reporting of discharge quality and quantity	Consistent with the Water Licence data presented above.	Consistent with above
	Discharge must not be acutely toxic to fish.	Acute toxicity testing: LC50 tests using rainbow trout and the water flea, *Daphnia magna*.	Monthly
	Required monitoring of sub-lethal toxicity	Sub-lethal toxicity testing: Larval salmonid *Ceriodaphnia* reproduction Algal reproduction Duckweed growth	Twice annually

Discharge Flow

The flow rate of the final discharge to Prairie Creek will be monitored continuously using an automated flow monitoring device.

Discharge Chemistry

Monitoring of discharge chemistry (major ions, nutrients, and total and dissolved metals) is required under the federal MMER. Routine discharge chemistry monitoring will be conducted weekly. If any of the regulated contaminants exceed EQC, this would trigger a management action.

The MVLWB has specified EQC's that the Mine's discharge will have to meet once the Mine becomes operational. The MVLWB has accepted, subject to related conditions being met, CZN's load-based approach of discharge management which is intended to ensure SSWQO' s are met.

Acute Toxicity Testing

Following MMER and Water Licence requirements, final discharge water will be sampled for acute-toxicity testing once per month using rainbow trout and the water flea *Daphnia magna*. Acute toxicity testing will include a 48-hr *Daphnia magna* mortality test, and a 96-hr rainbow trout mortality test, following Environment Canada protocols as stipulated in the MMER.

Sub-lethal Toxicity Testing

Final discharge water will be sampled for sub-lethal toxicity testing twice annually (summer and winter), as a part of MMER Environmental Effects Monitoring (EEM) requirements. Tests will include survival and development of larval salmonids (*Oncorhynchus mykiss*), survival and reproduction of the cladoceran *Ceriodaphnia dubia*, growth and reproduction of the green alga *Pseudokirchneriella subcapitata*, and growth of duckweed (*Lemna minor*). These tests will be done on a dilution series of final discharge.

QA/QC

QA/QC associated with SNP measurements will be provided in the QA/QC Plan submitted as required by Annex A of Water Licence MV2008L2-0002.

4.2.1.2 Receiving Water Quality and Quantity

Water quality will be measured routinely in the receiving environment as part of the SNP, which will also provide supporting data for biological monitoring components of the AEMP. Sampling will occur in the same reaches of Prairie Creek as fish, benthos and periphyton monitoring. The federal MMER also requires monitoring of receiving water quality; the proposed program would harmonize MMER requirements within the broader water licence requirements. Table 5 summarizes the receiving environment monitoring.

Table 5 Proposed water quality monitoring in Prairie Creek and Harrison Creek.

Applicable Regulatory Device (Regulator)	Waterbody/location	Proposed monitoring	Proposed/required frequency (routine)
Water Licence (MVLWB)	Prairie Creek upstream of mine discharge	Flow rate	Continuous (hydrometric station)
		Chemistry: Measurement of major ions, nutrients (low-level DL), and total and dissolved metals (CCME low DL, full scan).	Monthly
	Harrison Creek upstream of confluence with Prairie Creek	Measurement of in situ water quality (pH, conductivity, turbidity) and chemistry: major ions, nutrients (low-level DL), and total and dissolved metals (CCME low DL, full scan).	Monthly (when creek flowing)
	Prairie Creek, 100 m downstream of mine discharge (IDZ)	Measurement of in situ water quality (pH, conductivity, turbidity) and chemistry: major ions, nutrients (low-level DL), and total and dissolved metals (CCME low DL, full scan).	Monthly
MMER (EC)	Prairie Creek, 100 m downstream of mine discharge (IDZ)	Chemistry as for Water Licence, above.	4x per year (harmonized with Water Licence monitoring above)

4.2.2 Creek Flows

Flow will be measured in Prairie Creek continuously for mine-site water management planning. This will also provide supporting data to water quality and biological monitoring components for the assessment of possible physical impacts to fish and fish food species. The hydrology data will also provide an indication of natural physical processes that may confound mine monitoring programs throughout the year.

Prairie Creek flow will be continuously monitored upstream of the mine discharge using an automated monitoring device (i.e., a pressure transducer with attached data-logger). This was installed by the Water Survey of Canada at the beginning of June 2013.

Flow monitoring on Harrison Creek is not proposed. The Harrison Creek channel is steep and rocky upstream of the Mine, and a previous attempt to monitor flows was unsuccessful. Instead, CZN proposes to estimate flows using Prairie Creek flows and correlating the catchment areas of Harrison and Prairie creeks.

4.2.3 Creek Water Chemistry Monitoring

Creek chemistry will be monitored monthly at the downstream edge of the initial dilution zone (IDZ), 100 m downstream of the discharge and from the creek's left (mine-side) bank. Samples will be tested for a full suite of chemistry variables, consistent with (but not limited to) MMER requirements. In addition, monthly samples will be collected from Prairie Creek upstream of the mine discharge to capture seasonal changes in natural creek chemistry and potentially further refine SSWQO, defined in-part using upstream water quality. These samples will be sent to an accredited analytical laboratory on ice for analysis of water licence regulated analytes. QA/QC will be as per the SNP QA/QC Plan.

4.2.4 Biological Communities

4.2.4.1 Fish Health

Initial (Lethal) Fish Survey

After at least one year of full operations, a lethal survey of resident slimy sculpin in Prairie Creek will be conducted in upstream and downstream locations, which will match benthic invertebrate sampling reaches and be consistent with MMER-EEM technical guidance. The survey will use standard EEM end-points (also used by Spencer et al. [2008] and Bowman et al. [2009]), including size, condition, age, size-at-age, liver weight and gonad weight. Sacrificed fish also will provide tissues for metals analysis; the resulting metals data will be compared with baseline data collected previous to mine operations.

Data for fish from upstream and downstream sites will be compared to determine if there is any statistically significant difference in fish condition or tissue concentrations, which might be related to discharge from the Mine.

Because sculpins are territorial (have a small home range) and likely do not mature quickly or represent a large local population in oligotrophic Prairie Creek, frequent lethal surveys of sculpin populations from Prairie Creek could greatly impact the abundance and recruitment of sculpins in these sampling areas. Therefore, for this AEMP, a single, lethal sampling program within the first three years of mine operations is proposed (consistent with MMER EEM requirements), with subsequent fish-health surveys being non-lethal (see below), unless results of the initial, lethal survey suggest that further sacrifice of fish is warranted (e.g., if biologically significant changes in liver or gonad weight are observed).

For QA/QC purposes, a single duplicate fish muscle sample will be submitted for every ten tissue samples, and submitted to an accredited analytical laboratory. On 10 percent of fish, both otoliths will be assessed independently to assess laboratory precision.

Subsequent (Non-Lethal) Fish Surveys

In subsequent years, the intent is to change fish-health surveys from lethal to non-lethal sampling techniques. As such, monitoring of tissue metals will be shifted from analysis of fish tissues, to analysis of benthic-invertebrate tissues instead.

Fish condition and a visual survey of fish health will be assessed every one to three years using resident slimy sculpin and a non-lethal approach. Fish will be measured for length and weight, and be assessed for any physical abnormalities (e.g., lesions on the body, fin erosion, etc.). The condition of fish both upstream and downstream of the Mine will be compared to determine if there is a difference which could be a result of mine discharge. The frequency of these non-lethal surveys will be determined based on the results of the initial, lethal fish-health survey.

4.2.5 Stream Invertebrate Communities

The goal of the benthic-invertebrate component of the AEMP is to determine if any significant changes in the benthic community occur (considered representative of fish-habitat quality in EEM), and if they do, whether they are a result of exposure to discharges from the Mine.

Sampling will occur in upstream and downstream erosional areas in the fall, and will follow Environment Canada's CABIN (kick-net-based) protocols (EC 2012b). Although CABIN protocols typically involve collection of single kick-net samples within a sampled reach, MMER EEM technical guidance requires replication within sampling areas. Therefore, at least five kick-net samples will be collected in each sampling reach/area, so that the resulting data also satisfy MMER EEM requirements. Supporting CABIN habitat measures also will be sampled within each reach.

All benthic invertebrate samples will be collected using CABIN field procedures (EC 2012b). Samples will be collected with a 400µm mesh size kick-net, resulting in only material 400 µm and larger being sent for taxonomic analysis. Analysis will include processing, enumeration and identification. Organisms will be identified to the lowest practicable level (LPL) and samples will be retained for tissue analysis. Invertebrate taxonomy will be consistent with quality assurance/quality control requirements of both EEM and CABIN programs.

Quality assurance and quality control (QA/QC) will meet requirements for both CABIN and federal MMER programs, including EEM-compliant assessments of sorting efficiency (three samples) and sub-sampling efficiency (two samples), and CABIN-compliant re-identification and regrading of two samples. Increased taxonomic sub-sampling beyond prescribed CABIN/EEM protocols will be conducted for samples with high abundance, to reduce indirect effects of sub-sampling on taxonomic resolution.

Benthic Community Metric Analysis

Benthic community structure will be assessed using the following community metrics: density, richness, Simpson's diversity index, evenness and Bray-Curtis dissimilarity coefficient, per EEM technical guidance. Additional data-exploration and assessment techniques, as provided within the CABIN database (EC 2012b), i.e., BEAST [BEnthic Assessment of SedimenT] and RIVPACS [River Invertebrate Prediction and Classification System] will also be used. Unless otherwise stated, all of these indices will be calculated using Family-level data, per the MMER TGD (EC 2012 a).

Differences between the upstream and downstream sites will be compared using these community matrices to determine if differences exist between sampling areas that are statistically and/or biologically significant, as defined by MMER EEM guidance, and compared against regional CABIN data to assess their similarity with similar reference communities.

Two-tailed T-tests will be conducted to test for differences in benthic community metrics (i.e., density, richness, diversity and evenness) between the near-field and the reference locations. Data for T-tests will be analyzed visually using residual plots to ensure that assumptions of normality and homogeneous variance will be met. If data fails to meet these assumptions, T-tests will be conducted using natural log transformed variables. All tests will be conducted at the alpha=0.1 level of significance, consistent with MMER TGD (EC 2012a).

Benthic Invertebrate Tissue Analysis

Bulk samples of benthic invertebrates collected for community assessment from each sampling area in the first cycle of the AEMP and EEM will also be retained and analyzed for tissue metals. This will help augment data where only limited fish-tissue data are available. Analysis of metals in these small tissue samples will be made possible by utilizing sample micro-digestion methods recently introduced at some commercial laboratories.

4.2.6 Periphyton

Periphyton monitoring programs have been shown to indicate differences between impacted and reference sites more rapidly than other biological indicators. The short life span of periphyton allows for a quick turn over rate and a faster response to SOPC. Although periphyton sampling is not required as a core component of the EEM process, its usefulness as an indicator for nutrient enrichment has prompted the inclusion of this analysis within the AEMP.

Periphyton will be sampled from the surface of creek rocks at the same time and from the same reaches and stream depths as benthic invertebrate samples. In each sampling location, five composite samples of three 16-cm^2 rock scrapings will be collected into ash-free filter papers, preserved with $MgCO_3$, wrapped in tinfoil and frozen at the earliest possibility before being shipped to an analytical laboratory for analysis of total chlorophyll a (an indicator of algal biomass). Therefore, within a benthos sampling area with five CABIN sampling locations, a total of five composite periphyton samples would be collected.

Periphyton community structure also will be assessed by collection of a composite periphyton sample from each sampling location, with each sample preserved in the field in dilute Lugol's solution. Samples will be sent to an algal taxonomist for semi-quantitative analysis, i.e. enumeration of taxa present and their relative abundance as present (<5% of total sample), common (5-25%), or predominant (>25%).

5.0 MANAGEMENT RESPONSE PLAN

As outlined above, the following events will be considered triggers for additional monitoring and/or corrective action:

1. Measured loads(s) of permitted water quality variables in site discharge exceed those allowed to be discharged according to the rate of flow in Prairie Creek;

2. Site discharge is acutely toxic to rainbow trout or Daphnia magna;

3. Concentration(s) of one or more AOC in Prairie Creek downstream of mine discharge (measured at downstream edge of IDZ) exceed relevant SSWQO, and are not explained by upstream concentrations; or

4. Biological monitoring indicates an effect on fish, fish habitat, or fish tissue that exceeds significance criteria defined by the federal EEM program.

Details of these triggers, and proposed responses to them, are described below. Generally, these responses include the following elements:

- Confirm the trigger condition;
- Quantify the effects of the trigger event in the receiving environment; and
- Take corrective action.

5.1 TRIGGER #1: DISCHARGE LOADS EXCEED ALLOWABLE LOADS

Discharge quality will be monitored routinely (see Table 3) for a range of chemical end-points, as stipulated in the Water Licence.

The Water Licence specifies that a load-based approach will be used to regulate site discharge, subject to conditions being fulfilled by CZN.

In the event that routine discharge monitoring indicates that the discharge load for any analyte exceeds the allowable load based on Prairie Creek flow, then an additional discharge sample will be collected immediately and analyzed, and the discharge load re-calculated and compared again to the allowable load. If a continuing excursion is not confirmed, no further action will be taken.

However, if a continuing excursion is confirmed, the following actions will be taken:

- Mine staff will attempt to determine the cause of the problem, and to identify and take corrective actions to ensure compliance with permit conditions;

- The frequency of discharge chemistry sampling and analysis will be increased to every three days, until two consecutive tests show that discharge loads are less than allowable loads;

- Concurrently, a water sample will be collected from Prairie Creek downstream of the mine discharge (at the downstream edge of the IDZ), and analyzed for those water quality variables causing the load excursion (above); and

- The frequency of water-quality sampling in Prairie Creek downstream of the mine discharge will continue at the same frequency as discharge chemistry sampling.

If discharge quality testing over three consecutive sampling periods (i.e., nine days total) indicates on-going permit excursions, and corrective actions have been taken that should have rectified the problem (reduced treated process water discharge, for example), acute toxicity testing will be undertaken immediately using rainbow trout and *Daphnia magna*.

Results of toxicity testing will be considered along with downstream water quality data and knowledge of seasonal discharge mixing patterns in Prairie Creek, to assess the likelihood of biological effects in Prairie Creek using a deductive, weight-of-evidence approach.

If acute toxicity in discharge is observed, action triggers outlined in Section 5.2 will be followed.

In the event of on-going excursions, mine staff will continue to attempt to identify the causes of excursions and define corrective actions.

5.2 TRIGGER #2: DISCHARGE EXHIBITS ACUTE TOXICITY

Following MMER requirements, the Mine will routinely monitor discharge water for acute toxicity using rainbow trout and *Daphnia magna*, on a schedule that is initially monthly during mine operations.

5.2.1 Acute Toxicity - Rainbow Trout

If discharge water is found to be acutely toxic to trout, and this doesn't correlate with discharge load excursions, the Mine's response will follow and expand upon MMER Section 15 requirements, as follows:

- An additional discharge sample will be collected immediately and sent for toxicity testing using trout to confirm the toxicity observed in the initial test;

- Concurrently, a full characterization of discharge water chemistry will be conducted, including all routinely monitored effluent-quality variables; and

- The frequency of toxicity testing using trout will increase to twice monthly (per MMER), until three consecutive tests at this schedule have demonstrated no toxicity.

If the acute toxicity persists over more than one testing period, the Mine will examine possible corrective actions to identify and eliminate causes of the toxicity, in discussion with regulators.

If discharge water is found to be acutely toxic to trout, and this correlates with discharge load excursions, the Mine's response will be to significantly reduce the rate of process water treatment until the excursions and toxicity have been corrected.

5.2.2 Acute Toxicity - *Daphnia magna*

Following MMER requirements, acute toxicity of discharge water to *Daphnia magna* will also be assessed at the same time and frequency as tests with trout, including if frequency is changed because of recorded trout toxicity (described above), or consistent lack of toxicity (see below).

The MMER does not require any mine response to observed toxicity of discharge water using *Daphnia magna*.

5.2.3 Consistent Lack of Acute Toxicity

Consistent with MMER Section 16, if no acute toxicity using trout is observed over 12 consecutive (months), then the frequency of acute toxicity testing will be reduced to once in each calendar quarter.

5.3 TRIGGER #3: PRAIRIE CREEK WATER QUALITY EXCEEDS AN SSWQO

The site-specific water quality objectives (SSWQO's) defined in the Water Licence will be used to assess the potential for impacts on water quality in Prairie Creek. Water Licence conditions were derived to avoid downstream exceedances of SSWQO's.

Three levels of objective excursions, with different action triggers, have been identified below (i.e., minor, intermediate and major). Due to the confounding influence of high turbidity events on creek water quality, samples will not be collected from Prairie Creek when turbidity is greater than 20 Nephelometric Turbidity Units (NTU's). A turbidity meter, tube, or another suitable method will be used to determine turbidity in the field.

Downstream water samples refers to samples collected immediately downstream of the Initial Dilution Zone (IDZ).

5.3.1 Minor Objective Excursion

A minor excursion of an objective is defined as a downstream concentration for a given water quality variable that exceeds the SSWQO by less than 1.5 times, and is not explained by a similar increase in the upstream concentration.

Such a minor excursion will trigger the immediate collection of discharge, upstream and downstream water quality samples and analysis of the offending variable to assess the source of the observed objective excursion. Samples will continue to be collected each week for chemical analysis of the offending variable until downstream concentrations return to below the objective. If the results of three sequential tests indicate a concentration exceeding the SSWQO by less than 1.5 times (and the fourth test has yet to be received), the load in discharge of the offending variable will be reduced to 90% of the allowable discharge load (ADL). A weekly discharge sample will be collected immediately after reducing the load. The results of this sample will confirm that the adjusted load should result in the variable meeting the SSWQO, and if not, the load will be reduced by another 10% increment. Weekly sampling downstream will be continued until two subsequent weekly samples have no concentrations exceeding the SSWQO's.

5.3.2 Intermediate Objective Excursion

An intermediate excursion of an objective is defined as a downstream concentration for a water quality variable that exceeds the SSWQO by more than 1.5 times and up to three times, and is not explained by a similar increase in the upstream concentration.

An intermediate excursion of an SSWQO will trigger immediate collection of discharge, upstream and downstream water quality samples and analysis of the offending variable to assess the source of the observed objective excursion. From this point on, samples will be collected weekly and sent for rush chemical analysis of the offending variable.

After the second excursion, the load of the offending analyte in discharge water will be reduced to be less than 90% of the ADL. After the third excursion, the load of the offending analyte in discharge water will be reduced to be less than 80% of the ADL, and so on until all SSWQO's are met. Simultaneously, the discharge management process and load calculations will be re-evaluated. Weekly sample collection and rush chemical analysis of the offending variable will continue until downstream concentrations no longer exceed any SSWQO's in two sequential samples.

5.3.3 Major Objective Excursion

A major excursion of an objective is defined as a downstream concentration for a water quality variable that exceeds the SSWQO by more than three times, and is not explained by a similar increase in the upstream concentration.

A major excursion of a SSWQO will trigger immediate collection of discharge, upstream and downstream water quality samples twice per week, with samples sent for rush analysis of the offending variable. Simultaneously, the load of the offending variable in discharge water will be reduced significantly, up to an amount commensurate with the magnitude of SSWQO exceedance. The Mine will take immediate steps to understand the underlying cause of the exceedance and make any needed changes.

If the subsequent sample still indicates that the concentration downstream of the offending variable exceeds the SSWQO, then the Mine will lower the discharge load of that variable still further.Two samples will be collected each week until two sequential samples indicate an absence of all SSWQO exceedances.

5.4 TRIGGER #4: BIOLOGICAL COMMUNITIES SHOW EFFECTS

The federal EEM program provides regulatory guidance regarding how to assess the statistical and biological significance of biological effects observed through effects-based monitoring. If such effects are observed in Prairie Creek EEM monitoring, the frequency of monitoring will increase from every three years to every two years, and follow a tiered, investigative framework of: Confirmation of Effect, Investigation of Magnitude and Extent, Investigation of Cause, and, if the Mine discharge is identified as the cause of an observed effect, Investigation of Solutions.

Given previous EEM-type surveys undertaken by Spencer et al. (2008) and Bowman et al. (2009), and the absence of other human activities on Prairie Creek in the vicinity of the Mine, if effects are observed in an EEM study that appear to be related to the Mine, CZN will move immediately to a combined Investigation of Cause or Investigation of Solutions phase in the subsequent EEM cycle.

Triggers for tissue-residue effects (in fish or invertebrates) are not precisely defined in EEM guidance, particularly for emerging metals of concern such as selenium. As such, instead of prescribing pre-defined triggers, fish-tissue results will be reviewed on a study-by-study basis, with recommendations for future studies discussed among regulators and other experts.

6.0 REPORTING

Several reports will be created as part of the AEMP. The reporting frequency depends on the component of the AEMP. SNP reports will generally be small and frequent, and are outlined in the conditions of the Water Licence. Some reporting requirements will be tied to excursions and specific triggering events. EEM components of the AEMP will need to be reported every three years, as stipulated in the MMER. If no effect is indicated in two sequential three-year EEM cycles, the reporting frequency will switch to a six-year reporting cycle. All of the other AEMP information collected will be reported annually.

7.0 CLOSURE

We trust the above information meets your requirements. If you have any questions or comments, please contact the undersigned.

HATFIELD CONSULTANTS:

Approved by:

John Wilcockson
Project Manager

Date

Approved by:

Martin Davies
Project Director

Date

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APPENDICES

Appendix A1

Supplementary Baseline Data Collection, 2013

APPENDIX A1
SUPPLEMENTARY BASELINE DATA COLLECTION, 2013

A1.0 WATER QUALITY

Five water quality samples were collected upstream of the mine in 2013. Four of these were collected at the existing Surveillance Network Program (SNP) upstream monitoring station 3-11. An additional sample, collected further upstream at the site of benthic community sampling, is also included. Samples were collected on the following dates: August 1, August 3, September 25, October 25 and November 20, 2013.

With the exception of the August 1 and August 3 samples, samples were collected by mine staff. No field filtering or field preservation was performed by mine staff; filtering occurred at the contracted laboratory.

The concentrations of key metals of concern (both in dissolved and total form) are presented in Figure A1.1. Sampling dates are plotted on the hydrograph for the period since the re-activation of the hydrometric station.

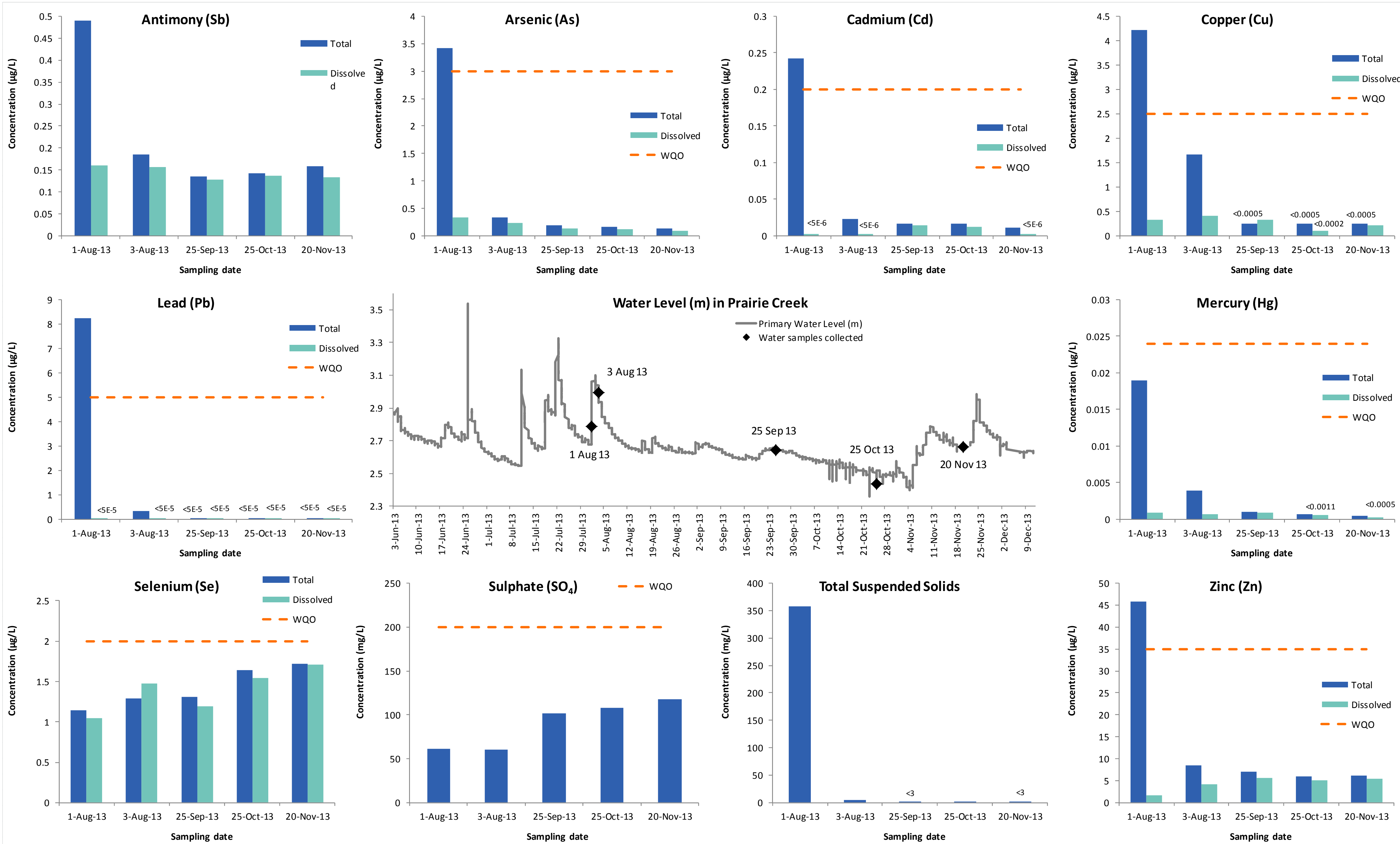
Total metals concentrations are highly dependent on suspended sediment levels, which are in turn controlled by high runoff events. At the time of sampling on August 1, 2013, there had been heavy precipitation for two days prior and water was visibly turbid. The hydrograph indicates that the water level at the time was increasing, but had not peaked. Observations from a helicopter of Prairie Creek upstream of the Mine on the morning of August 1, 2013 indicated that the suspended sediment load was originating from Fast Creek (Figure A1.).

Figure A1.2 Prairie Creek at confluence with Fast Creek showing Access Road and turbid waters of Fast Creek, August 1, 2013 Baseline Program.

All metals with the exception of selenium had much higher total concentrations when the water was turbid. Dissolved metals concentrations were generally very similar to periods of low water turbidity. However, dissolved arsenic was at its highest during the high total suspended solids (TSS) period. Other dissolved metals (i.e., antimony, copper and nickel) peaked two days later, possibly indicating a shallow localized groundwater input.

The above results indicate that water sampling at the edge of the initial dilution zone (for total metals analysis) should not be conducted during periods of high turbidity. There appears to be little difference between the August and November sampling dates, suggesting little effect of seasonal differences during this period. The August to November period falls within the open water low flow period.

Figure A1.1 Upstream Prairie Creek water chemistry and water levels, chemistry samples collected between August 1 and November 20th, 2013.



A2.0 EEM/AEMP AND BULL TROUT BASELINE INVESTIGATION

A2.1 INTRODUCTION

A baseline investigation was carried out in the summer of 2013. The purpose was to fill in pre-operational data gaps, add to the existing pool of aquatic ecosystem data, and to provide insights as to where the Aquatic Effects Monitoring Program (AEMP) may need to be refined. All fieldwork was conducted by David Harpley (CZN) and John Wilcockson (Hatfield Consultants) between July 26 and August 6, 2013.

There were two main components to the work:

- A core Environmental Effects Monitoring (EEM)/AEMP study; and
- A juvenile bull trout occupancy and rearing study.

A third component, an adult grayling fish tissue study, was originally planned for the 2013 field program. However, the study was not carried out because a similar study was carried out in 2012. Also, it was felt that conducting another tissue study so soon, when it wasn't really necessary, would provide little incremental information and cause undue impacts on the resident fish population.

The study area includes several sub-drainages to the South Nahanni River: Prairie Creek and the four adjacent basins to the west; Vera Creek, Wrigley Creek, Cathedral Creek and Clearwater Creek. Wrigley and Cathedral creeks were also used as CABIN reference stations (see Map 1 in Attachment A1-1).

A2.2 METHODS

A2.2.1 Core Program

The core EEM/AEMP study consists of an investigation of small-bodied fish health, benthic invertebrates (sampling and taxonomic analysis following Canadian Biomonitoring Network [CABIN] protocols), periphyton (for biomass and taxonomic analysis), and supporting habitat information (i.e., sediment and water quality [concentrations], substrate type, gradient, cover, and flow velocity). Four sampling sites were established on Prairie Creek: up-stream reference (REF), near-field (NF), far-field station at the Nahanni National Park Reserve (the Park) boundary (FF-PB), and a location further downstream within the Park (FF-P) near the old Park boundary (see Map 5 in Attachment A1-1).

In addition to Prairie Creek sites, benthic community (CABIN) and water quality samples were collected at two reference sites located outside the Prairie Creek drainage. One of these was located on Wrigley Creek (WC), and the other on Cathedral Creek (CC). Both sampling sites were CABIN reference sites used by Scrimgeour in 2008 and/or 2009.

Small-bodied Fish (Sculpin)

The non-lethal slimy sculpin study was carried out at the four core EEM/AEMP sampling locations on Prairie Creek (Table A1.1).

Table A1.1 Slimy sculpin electrofishing, reach coordinates and catch numbers.

Location ID	Catch numbers	Latitude	Longitude
13PCRA (Prairie Creek reference)	24 (13 adults)	61º34'19.2" N	124º49'15.2" W
13PCNF (Prairie Creek near-field)	14 (12 adults)	61º33'04.0" N	124º47'40.9" W
13PCFF-PB (Prairie Creek just upstream of Park boundary, 5km downstream of mine)	26 (11 adults)	61º31'28.0" N	124º43'43.6" W
13PCFF-P (Prairie Creek in Park, 28km downstream of mine)	50 (21 adults)	61º21'51.3" N	124º26'17.4" W

EEM guidance for non-lethal surveys specifies that 100 fish need to be caught at each sampling location, unless a power analysis can be done a-priori. Given the low productivity of Prairie Creek, Spencer et al. required up to 3.5 hours of electrofishing time in order to catch 40 fish (20 females and 20 males). Electrofishing time represents the time that the electrofisher is energized. Total staff time in the water while fishing was estimated to be four times greater. Consequently, we estimated that more than two days per location would be required to collect 100 fish.

A pre-fieldwork power analysis using Spencer et al. (2008) condition data (reported as means and standard deviations) indicated that 10-20 fish should provide the required power. We expected that the subsequent power analysis conducted with the new 2013 data would be an improvement over the pre-fieldwork analysis since raw data would be available (i.e., instead of just mean and standard deviation). Power analysis results based on 2013 data are provided in Section A2.3.1.

Length (± 0.1cm) and weight (± 0.1g) were measured on all fish caught, as well as a qualitative assessment of external abnormalities (e.g., lesions on the body, fin erosion, etc.). Size measurements were used to calculate fish condition and size distribution at each location.

ANCOVA

Analysis of Covariance (ANCOVA) was conducted using R statistical software (R Development Core Team 2008) to test for differences in fish condition (body weight vs. fork length) between the reference site and each of the near field and far field sites. A significance level of $\alpha=0.1$ (EC 2012) was used to evaluate statistical significance. If a significant result is obtained, the direction and magnitude of the effect is calculated. Environment Canada recommends using effect sizes of 10% for fish condition (EC 2012). Therefore, if the measured effect is greater than a 10% change in the adjusted reference station mean, then a critical effect has occurred.

An assumption of the ANCOVA model is that the slopes of the body weight vs fork length regression lines are equal for all areas. Therefore, statistical differences in slope (α =0.1) were tested prior to conducting each ANCOVA. Other assumptions of ANCOVA (normality of residuals and homogeneity of variance) were checked using residual plots. If assumptions were not met, analyses were conducted using $\log_{10}$ transformed variables.

Data were initially screened for potential outliers using studentized residuals. Observations with studentized residual value greater than 4 were removed from the analysis. No observations were removed in this way.

Post Hoc Power Analyses

Post hoc power analyses were used to evaluate the possibility of false negative results (i.e., results that conclude that no difference in fish condition exists when in fact one does). Accordingly, power analyses for the current study were conducted to evaluate whether the ANCOVA analyses had sufficient power to detect a 10% change in body weight as a function of length. Sufficient power was considered to be a value above 0.9 (EC 2012).

Power analyses were also conducted using data from this study to determine the sample size required to detect a 10% critical effect size with 90% power in subsequent studies. All power analyses were conducted using G*Power 3.1 (Faul et al. 2009). Results are presented in Appendix A1 Section A2.3.1.

Benthic Invertebrates

The benthic invertebrate (following CABIN methodology) and periphyton studies were carried out at each of the slimy sculpin study locations, but were also conducted at reference locations located on Wrigley and Cathedral Creeks (Table A1.2).

Table A1.2 Benthic invertebrate reference creek sampling reaches, Wrigley and Cathedral Creeks, summer 2013.

Location ID	Latitude	Longitude
13WC (Wrigley Creek, Waypoint 101, Parks #60)	61º46'49.5" N	125º24'53.0" W
13CC (Cathedral Creek, Waypoint 121, Parks #59)	61º47'06.6" N	125º34'43.5" W

13WC was sampled by Parks Canada in 2008 and 2009; 13CC was sampled by Parks Canada in 2008 (Scrimgeour 2013).

A 400µm mesh kick-net travelling for three-minutes was used at each location. Samples were preserved immediately after collection using 10% formalin.

In order for kick-net sampling to be compliant with EEM benthos requirements, five replicate samples were collected at the Prairie Creek reference and near-field locations. At the remaining sites (the two Prairie Creek far-field downstream samples, and two reference locations on neighbouring drainages), only a single sample was collected following CABIN requirements.

At the time of writing this report, taxonomic analysis was still in progress. Once raw data become available from the taxonomist, benthic community structure will be assessed using the following community metrics: density, richness, Simpson's diversity index, evenness and Bray-Curtis dissimilarity coefficient, per EEM technical guidance. CABIN online tools will also be used to compare the core sites to applicable local reference stations.

Periphyton

Periphyton is not required as a core component of the EEM process; however, its usefulness as an indicator for nutrient enrichment has prompted the inclusion of this analysis within the baseline program (and AEMP).

Periphyton was sampled from the surface of creek rocks at all core sites. Following Spencer et al. (2008), nine 15-25 cm diameter cobbles were selected randomly from each sampling site. For chlorophyll-a analysis, one 16 cm^2 scraping was collected from each rock. Scrapings from individual rocks were grouped into composites, each representing scrapings from three rocks; therefore, three composite samples were submitted for analysis from each core sampling site. Samples were collected into ash-free filter papers, preserved with $MgCO_3$, wrapped in tinfoil, frozen and then shipped to ALS Environmental (Burnaby, BC) for analysis of total chlorophyll-a, an indicator of algal biomass.

Periphyton community structure was also assessed. A composite periphyton sample was collected from each sampling location. Each sample was immediately preserved in the field in dilute Lugol's solution. Samples were provided to Ms. Karen Munro (Stantec Inc., Vancouver, BC). for semi-quantitative analysis (i.e., enumeration of taxa present and their relative abundance as present [<5% of total sample], common [5-25%], or predominant [>25%]).

Supporting Variables

At each of the core sampling sites and the two additional benthic invertebrate sampling sites, single water and sediment samples were collected for analysis. Sediment samples were collected from isolated depositional zones. At least three sub-samples were composited to make up each sample.

The purpose of sediment chemistry data is to support biological observations (i.e., provide context). However, sediment chemistry will also support the assessment of trends in metals concentrations over time once the Mine is operational.

Immediately after collection, water and sediment samples were put on ice. Water samples requiring preservation were preserved immediately, except for samples requiring filtration. Samples collected for dissolved metals, dissolved mercury and dissolved organic carbon were filtered later by the analytical laboratory. All water and sediment samples were shipped on ice to ALS Environmental (Burnaby, BC).

Sediment samples were sieved in the laboratory to retain the ≤63µm fraction for metals analysis. The <63µm fraction represents the most bioavailable fraction of metals in sediments, and normalizing to a specific size range facilitates comparison between areas and over time. Two whole-sediment samples (Prairie Creek reference and near-field) also were assessed against Canadian Council of Ministers of the Environment (CCME) sediment quality guidelines (CCME 2013).

A2.2.2 Juvenile Bull Trout Occupancy and Density

A juvenile bull trout occupancy and density study was conducted as part of the baseline program. The intended field design consisted of defining trout occupancy and density in two tributaries of Prairie Creek upstream of the Mine, and two tributaries of other sub-basins of the South Nahanni (reference locations). The Prairie Creek tributaries are referred to as exposure sites, which would need to host trout whose migration could potentially be negatively affected by discharges from the Mine. The tributaries of other sub-basins of the South Nahanni (i.e., other than Prairie Creek) are referred to as reference sites, which would also need to host trout and whose occupancy and density could not be affected by the Mine. The two reference sites provide control for any natural regional influences on bull trout behavior unrelated to the Mine.

In discussions with Neil Mochnacz (Fisheries and Oceans Canada [DFO]), two tributaries to Prairie Creek upstream of the Mine were selected: Funeral Creek ("patch 40"; see Maps 2 and 6 in Attachment A1-1), and a tributary approximately 6.5 km further upstream on Prairie Creek ("patch 45", see Maps 2 and 7 in Attachment A1-1). Funeral Creek was known to host a juvenile Bull trout population. DFO confirmed the presence of a similar population in the Patch 45 creek prior to CZN's survey. DFO had not identified suitable reference patches (creeks) prior to CZN's work. DFO identified, Wrigley Creek, Cathedral Creek and Clearwater Creek as drainages that may contain suitable reference tributaries and noted that Parks Canada had found adult Bull Trout in the main stem creeks of one or more of these drainages (see Map 1 in Attachment A1-1). Therefore, CZN was tasked with the identification of suitable reference creeks.

Prior to the field program, suitable candidate reference creeks were screened by identifying first to third order streams with gradients less than 15% (and thus likely to be accessible to trout) and catchment areas greater than 400 hectares (and thus more likely to have sufficient flow year-round), properties similar to that of Funeral Creek. Using these criteria, five to seven candidate creeks were identified using GIS on each of Wrigley and Cathedral Creeks.

Following DFO methodologies, once suitable exposure and reference creeks had been defined, the intention was to electro-fish ten to 15 reaches approximately 90 m long on each creek, with the reaches on each creek spanning a creek length of approximately 5 km. It was expected that the subject reference creeks would be identified during the summer 2013 field program (Mochnacz 2012). Fishing was to target juveniles and young of the year, and fork length was to be measured on each fish caught. Photographs were to be taken at the downstream end of each sampling reach to record general habitat features. Fishing in patches 40 and 45 were done in reaches previously defined and fished by DFO staff.

Initial scouting and fishing of the pre-screened tributaries of Wrigley and Cathedral Creeks did not identify any significant potential for suitable reference sites. At that point, investigations for reference sites changed from specific creek baseline surveys to creek potential reconnaissance. Four days of helicopter time was logged in the evaluation of the Wrigley, Cathedral, Clearwater and Vera watersheds in terms of their potential to host creeks with a significant juvenile bull trout population. Aerial surveys, combined with spot electrofishing of candidate streams, were conducted. All sites assessed during the reconnaissance were assigned a waypoint number, which are shown on Maps 2, 3 and 4 (in Attachment A1-1). An accompanying annotated waypoint list provides descriptions of each waypoint (Attachment A1-2). A few patches with some potential were identified (way points 113 and 120 on Map 3; and waypoint 131 on Map 4). These require additional investigation, and will need the clearing of landing pads to facilitate access. Electrofishing of patches 45 and 40 (the exposure creeks) was done on one occasion each, on August 1 and 4, respectively (Maps 6 and 7 in Attachment A1-1). Photographs associated with the bull trout occupancy study are provided (Attachment A1-3)

A2.3 RESULTS

A2.3.1 Slimy Sculpin Condition Study

Histograms of sculpin length indicate that size follows a bimodal distribution, a split occurring between 5 and 6 cm. This observation suggests that fish less than 5cm are likely young-of-year, i.e., juveniles, and fish longer than 5cm are adults. The focus of the slimy sculpin assessment was on adult fish.

There was no statistically significant difference in fish condition between the reference and near-field sites, and between the reference with far-field within park sites (Table A1.3). However ANCOVA detected a significant difference (16%) between the reference and far-field at park boundary sites. The results suggest a mild enrichment effect at the park boundary, but not at the near-field or within the park sites.

Post-hoc power analysis indicated that a power of 0.9 (as required for EEM programs) was almost obtained. A low power indicates that the t-tests performed may not have been able to identify significant differences actually occurring. The power analysis on the ANCOVA indicates that a minimum of 22 adult fish need to be caught in order to obtain a power of 0.9.

Catch per unit effort was greatest at the Prairie Creek reference site and lowest at the far-field at park boundary site (Figure A1.), indicating that despite the fish showing higher condition at the latter site, they may be less abundant. The benthic community data, once available, should provide more context to the potential for enrichment.

Figure A1.3 Slimy Sculpin condition (K), Prairie Creek, July/August 2013.

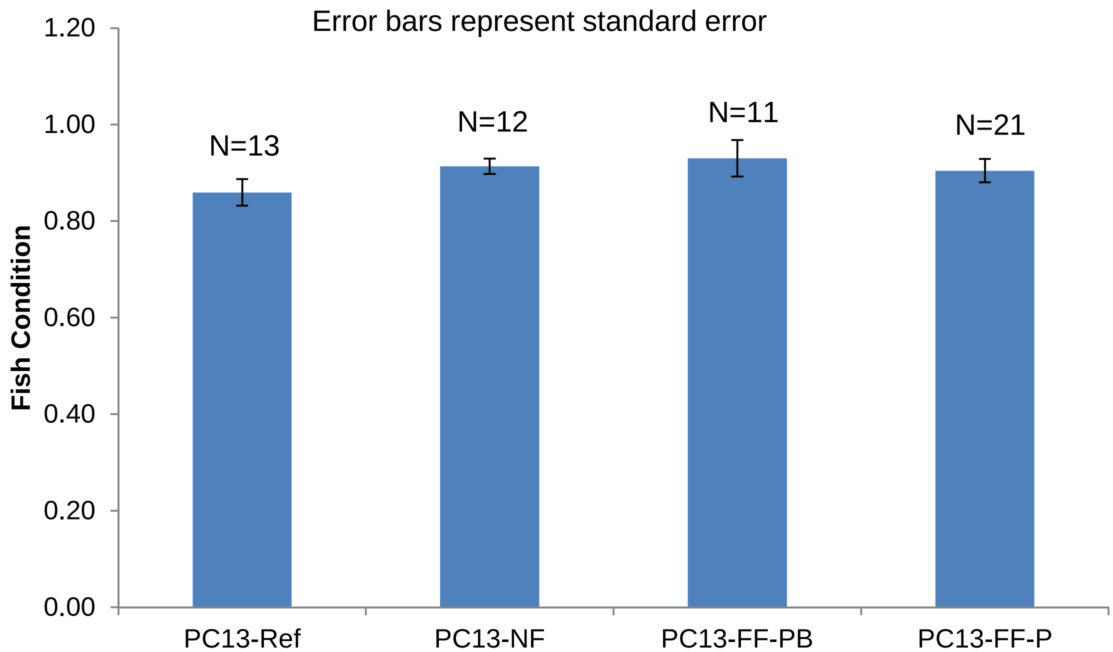


Figure A1.4 Slimy Sculpin catch per unit effort, Prairie Creek, July/August 2013.

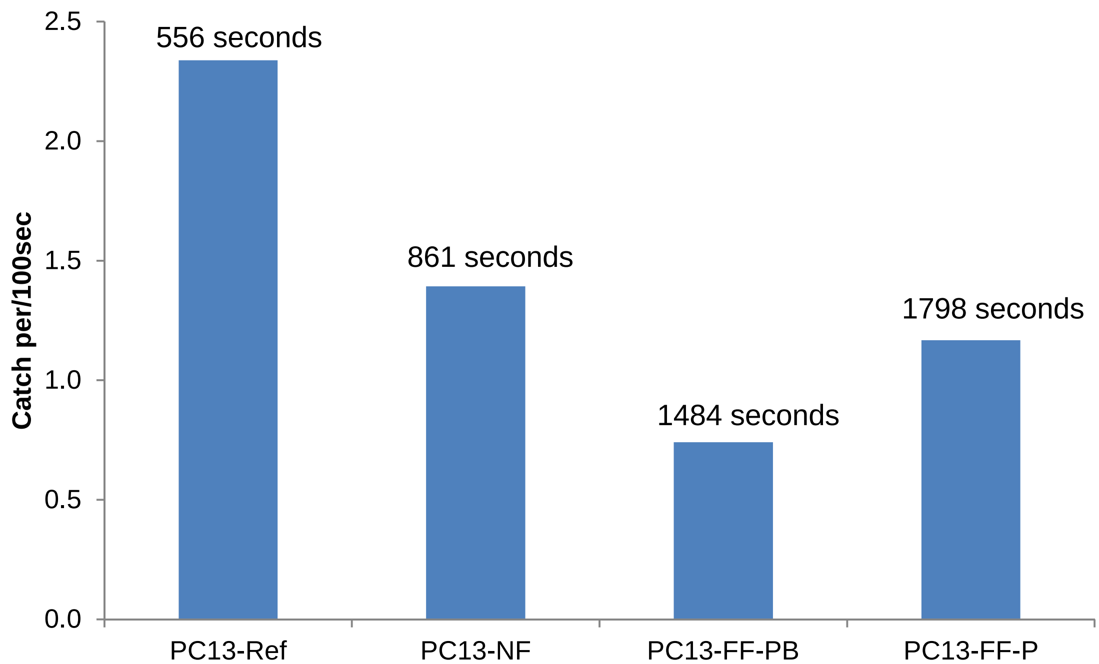


Table A1.3 Slimy sculpin, ANCOVA results and Post Hoc Power analysis of condition (k), Prairie Creek, Summer 2013.

Site Comparison	Slope (P)[1]	Intercept (P)[2]	% Difference	Post Hoc Power	N required for 90% power
Ref. vs NF	0.35	0.17		0.8	18
Ref. vs FFPB	0.63	<0.01	16%[4]		14
Ref. vs FFP[3]	0.22	0.42		0.82	22

1. The Slope P value should be greater than 0.1, indicating that the length-weight relationships are similar and therefore comparable.
2. The Intercept P value indicates if there is a Y-intercept shift, indicating a possible change in fish condition if P<0.1.
3. ANCOVA performed on logged data to ensure that the equal variance assumption was upheld.
4. Since a significant difference was observed, presenting the post hoc power (probability of not detecting a difference when there is one) is not useful.

* Post hoc power calculated using G Power 3.1.5.

A2.3.2 Benthic Invertebrate Community

Benthic invertebrate samples are currently being analyzed by the taxonomic laboratory. It is anticipated that this data will be available by mid-February.

A2.3.3 Sediment Quality

The chemistry of fine sediment fractions was similar among stations (Table A1.4). The highest metal concentrations occurred at the far-field at park boundary station. These results are in contrast to those of Spencer et al (2008), which found decreasing concentrations of most metals at the reference station. The only exceptions in Spencer et al., were arsenic, which was higher at the near-field station, and cadmium and zinc, which were similar between stations.

It is possible that the Mine has had some influence on the distribution of sediment chemistry, but if it has, it would appear to be minor. It is also possible that the results represent natural variability only. A slight increase in metals concentrations downstream of the Mine would not be unexpected considering that the Mine is located in a mineralized area. It is likely that natural erosion and depositional patterns in the creek may account for much if not all of any perceived differences in creek sediment concentrations.

Whole-sediment samples were also collected at the reference and near-field locations (Table A1.5). Individual concentrations were compared with CCME's sediment quality guidelines for the protection of aquatic life (CCME 2003). There were small exceedances of the arsenic, cadmium and zinc interim sediment quality guidelines (ISQG's) at both locations. The highest exceedance was 1.7 times the associated guideline (for cadmium). There were no exceedances of CCME's Probable Effect Levels (PEL), which represent higher thresholds of potential toxicity.

Whole-sediment concentrations were similar between this study and results reported by Spencer et al. (i.e., within two times of each other).

Measured concentrations were more than 10 times respective detection limits, with the exception of mercury and selenium, which were both within five times of their detection limits (DL). Therefore, the reported concentrations of mercury and selenium may have slightly greater inherent error.

Table A1.4 Sediment chemistry of samples collected from Prairie Creek, fine fraction (<63µm).

	PC13-R (reference)	PC13-NF (near-field)	PC13-FF-PB-2 (far-field park boundary)	PC13-FF-P (far-field within park)
Distance from future mine discharge	-2.5 km	0.3 km	5.0 km	29 km
Organic / Inorganic Carbon				
Total Organic Carbon	0.39	0.93	0.31	0.70
Metals				
Antimony (Sb)	1.16	1.21	1.39	1.01
Arsenic (As)	6.48	6.54	7.18	4.85
Barium (Ba)	227	176	252	175
Beryllium (Be)	0.56	0.55	0.46	0.38
Bismuth (Bi)	0.11	0.1	<0.10	<0.10
Boron (B)	5.8	6.3	<5.0	5.1
Cadmium (Cd)	0.778	0.815	0.884	0.673
Chromium (Cr)	11.4	11.1	10.1	7.8
Cobalt (Co)	6.78	6.45	6.26	4.08
Copper (Cu)	12.2	12.5	12.2	7.91
Lead (Pb)	15.4	16.5	19.2	17.5
Lithium (Li)	8.3	8.5	6.8	5.5
Manganese (Mn)	267	262	255	202
Mercury (Hg)	0.0475	0.0588	0.0592	0.0412
Molybdenum (Mo)	4.86	4.55	5.07	3.63
Nickel (Ni)	27.5	26.8	26.6	18.4
Selenium (Se)	0.46	0.41	0.48	0.41
Silver (Ag)	0.074	0.078	0.094	0.059
Strontium (Sr)	479	455	407	298
Thallium (Tl)	0.185	0.187	0.163	0.134
Tin (Sn)	0.58	0.46	1.45	0.45
Titanium (Ti)	22.7	25.1	24.4	23.9
Uranium (U)	1.15	1.14	1.2	1.39
Vanadium (V)	32.3	31.9	31.6	25.6
Zinc (Zn)	128	148	131	101
Speciated Metals				
Methyl Mercury	<0.000050	<0.000050	<0.000050	<0.000050

All concentrations provided as mg/kg (dry weight)

[shaded box] = key metals

Table A1.5 Chemistry of sediment collected from Prairie Creek, whole samples and CCME sediment quality guidelines.

	PC13-R (reference)	PC13-NF (near-field)	CCME SQGs ISQG	CCME SQGs PEL
Metals				
Antimony (Sb)	1.32	1.31	5.9	17
Arsenic (As)	***6.46***	***6.43***	5.9	17.0
Barium (Ba)	124	114		
Beryllium (Be)	0.39	0.43		
Bismuth (Bi)	<0.20	<0.20		
Boron (B)	-	-		
Cadmium (Cd)	***1.01***	***1.01***	0.6	3.5
Chromium (Cr)	9.2	10	37.3	90
Cobalt (Co)	5.32	5.65		
Copper (Cu)	10.9	11.1	35.7	197
Lead (Pb)	16	13.6	35	91.3
Lithium (Li)	6.9	7.3		
Mercury (Hg)	0.034	0.043	0.17	0.486
Molybdenum (Mo)	3.72	3.86		
Nickel (Ni)	24	25.4		
Selenium (Se)	0.38	0.41		
Silver (Ag)	<0.10	<0.10		
Strontium (Sr)	452	442		
Thallium (Tl)	0.131	0.159		
Tin (Sn)	<2.0	<2.0		
Titanium (Ti)	30.8	35.7		
Uranium (U)	1.14	1.09		
Vanadium (V)	30.8	30.8		
Zinc (Zn)	***124***	***133***	123	315

All concentrations provided as mg/kg (dry weight)

= Exceeds ISQG

= Exceeds PEL

A2.3.4 Periphyton Community

Biomass as Chlorophyll-a

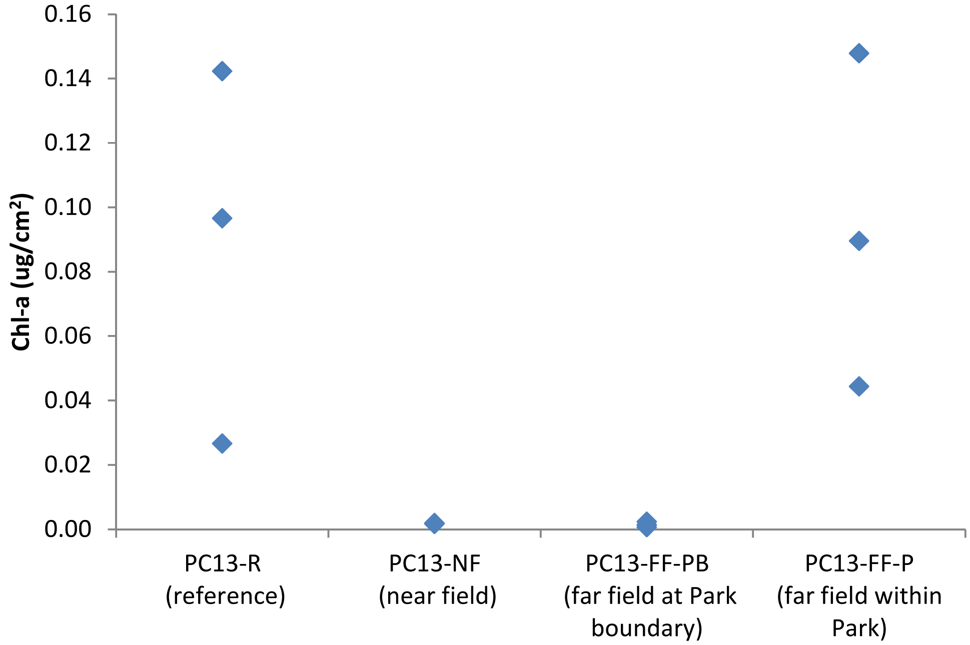
Chlorophyll-a (Chl-a) densities were highly variable between replicates (Figure A1.). The highest densities were 0.15 µg/cm^2, which were about half of what were observed by Spencer et al. (2008). The densities in both Spencer et al. and reported here are very low and confirm the nutrient poor state (i.e., oligotrophic) of Prairie Creek. For comparison, New Zealand uses chl-a densities of less than 0.17 µg/cm^2 (17mg/m^2) to identify oligotrophic streams.

At low densities, measurement error increases, both during sampling (i.e., more difficult to scrape the majority of sample off of rock) and during analysis (i.e., the closer a measurement is to the detection limit, the greater the measurement error). The densities of chl-a at the near-field and far-field at park boundary sites were within three times of the DL.

Periphyton densities were highest at the reference and far-field in park sites. Spencer et al. found little difference in densities between reference, near-field and far-field sites. Our results appear to indicate one of a number of potential conditions:

1. The water quality downstream of the Mine is limiting the growth of periphyton at NF and FF-PB. Current discharges from the Mine (treated mine water) enter Prairie Creek via Harrison Creek, and there is little immediate mixing laterally. Therefore, mixing of the mine discharge occurs gradually with distance downstream of the Mine, and the highest analyte concentrations would appear along the left bank, assuming discharge concentrations are higher than upstream concentrations. The left bank is where periphyton sampling was conducted. However, it is likely that complete lateral mixing occurs by the time the water reaches the far-field at park boundary sampling location. The short-coming of this explanation is that both chemistry and toxicity testing of treated mine water suggest that there is currently nothing in the mine discharge which should result in an effect on periphyton communities.
2. There are differences between sites. It is possible that, due to channel morphology, a recent scouring flood may have removed periphyton mass off of rocks in the near-field and far-field at park boundary sites. There could also be localized natural nutrient inputs via groundwater from the banks of Prairie Creek. There might also have been differences in flow rates or depths at which the samples were collected, despite a rock collection process to control these factors. These factors may significantly influence periphyton growth.
3. Tributaries immediately upstream of the REF and the FF-P sites are rich in organic matter.

Figure A1.5 Periphyton biomass as chlorophyll-a, Prairie Creek, summer 2013.



Periphyton Community Assemblage

The periphyton at the reference and far-field within park samples were both dominated by blue-green algae species, although species assemblages were quite different (Figure A1.). The reference location consisted of 95% blue-green algae representing five different species. The far-field within park sample consisted of 85% blue-green algae representing two different species. These observations are in contrast to Spencer et al, whose reference sample consisted of diatoms only, and whose far-field sample consisted primarily of diatoms.

The near-field samples had a very small amount of periphyton material, consisting primarily of three diatom species. Spencer et al. observed periphyton dominated by blue-green algae at this location. The far-field at park boundary sample had insufficient material for analysis. Comments by the taxonomist indicated that periphyton samples collected from these two areas consisted primarily of silt and detritus.

Richness was similar at the reference and the far-field within park sites (16 and 14 taxa, respectively). The richness at the near-field and far-field at park boundary were low, primarily due to the lack of periphyton at these locations. Spencer et al. observed a slight increase in richness (number of families) downstream of the Mine, while our results indicate no clear spatial trend downstream of the Mine.

Figure A1.6 Taxonomy of Prairie Creek periphyton samples (Proportion of algal classes present).

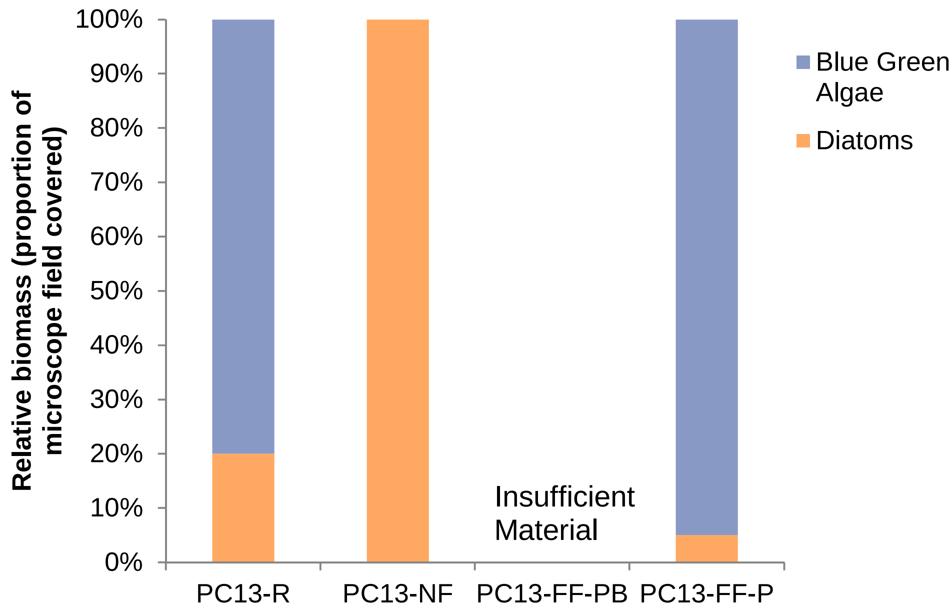
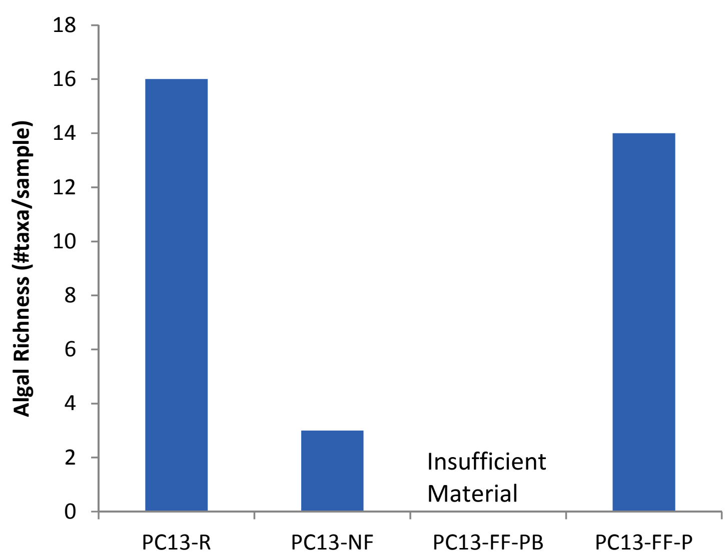


Figure A1.7 Periphyton algal richness (number of taxa identified/sample).



A2.3.5 Bull Trout Occupancy Study

A juvenile bull trout occupancy study was carried out in two tributaries to Prairie Creek: one just upstream of the Mine (the exposure creeks of Funeral Creek, and an unnamed creek located at 61º39′10.8″N 124º52′38.2″W [DFO patch 45]). We also performed an extensive reconnaissance survey of potential reference creeks.

Prior to the field program, a GIS pre-screening of potential reference patches identified five to seven candidate creeks on each of Wrigley and Cathedral Creeks. One of the Wrigley creeks, identified as "W5" (N61 48 14.7 W125 23 56.7) was assessed by electrofishing nine reaches, spanning from the confluence with Wrigley Creek main stem to 5 km upstream. Low abundance of juvenile grayling was found in the first 2 km, and two small adult bull trout, but no juvenile bull trout were observed. Due to the lack of juvenile bull trout at this location, the stream is not a suitable reference location.

Helicopter reconnaissance of the other GIS-identified candidate creeks indicated that many had obstructions to fish passage (14 creeks) or had insufficient flow within the first few kilometers from their mouths (10 creeks). Approximately 5 km of continuous creek length is required for sampling. A few candidate streams did not have safe locations to land a helicopter (2 creeks). However, these creeks were in areas where other creeks had a low potential for juvenile bull trout presence. In total, four days was spent assessing approximately 35 candidate creeks, mostly from the air. At a sub-set of these creeks, reconnaissance-level electrofishing was conducted to determine if juvenile bull trout were present. Of nine locations that were fished, five either yielded no fish or yielded only grayling. All sites assessed were provided gps waypoints, and are shown on Maps 2, 3 and 4 (Attachment A1-1) and descriptions of each waypoint are provided in an annotated waypoint list (Attachment A1-2).

Tributaries to Vera Creek and Wrigley Creek mostly hosted grayling if any fish were present. Candidate creeks in the Cathedral Creek drainage often have lower gradients, highly stained and turbid waters, and drain wetland topography. The morphology of these creeks is markedly different from the two DFO-recommended (and previously sampled) "exposure" sites on Prairie creek, which are considered to be mountain streams. However, potentially suitable reference creeks were found in the lower Clearwater and upper Wrigley catchments. Three potential reference patches were identified (i.e., having demonstrated the presence of bull trout) and require further investigation (Table A1.6). The Clearwater creeks are considered to represent the best potential because the streams are approximately 5 km long or greater, no obvious migration barriers were noted, and juvenile bull trout were found.

Table A1.6 Possible reference creeks for bull trout occupancy study, summer 2013.

Location	GPS coordinates	Observations during reconnaissance-level electrofishing.
Lower Clearwater (Waypoint 112)	61º41'59.0"N 125º40'15.4"W	2 juvenile bull trout and 1 juvenile grayling.
Lower Clearwater (Waypoint 120)	61º45'39.3"N 125º50'09.7"W	Juvenile bull trout.
Upper Wrigley (Waypoint 130)	61º58'02.2"N 125º19'42.7"W	Large mature bull trout and 9 adult grayling.

Upper Wrigley may have a migration barrier just upstream of the reach investigated, and the stream length may be insufficient.

The occupancy study results for the two "exposure" sites are provided in **Figure A1.** and **A1.9**. Maps 2, 6 and 7 in Attachment A1-1 show waypoints associated with each sampling reach. For simplicity, only the downstream waypoint of each sampling reach is provided in Maps 6 and 7. Both the DFO coordinates (starting with either "40-" or "45-") and our actual reach start point waypoints are provided). Both creeks had juvenile bull trout in multiple reaches. In Patch 45, trout appear to be constrained to the first 3 km, with greater abundances in the first 1 km. In Patch 40 (Funeral Creek), both juvenile and adult bull trout were observed up to 5 km from the downstream confluence with Fast Creek, itself a tributary of Prairie Creek. The greatest densities of juveniles occurred at Km marker 4.9. At about Km marker 5.3, the creek splits into three fingers. The topography of each finger is significantly steeper, consisting of dynamic step pool morphology, and electrofishing in each finger failed to detect any fish. Unlike all other reaches, the sampling reaches on the three fingers upstream of 5.3 km did not correspond to previously sampled DFO locations. However, we believe DFO's results were similar. We conclude that the three fingers have very little potential to host fish.

Figure A1.8 Bull trout catch number in Patch 45, with distance from confluence with Prairie Creek, summer 2013.

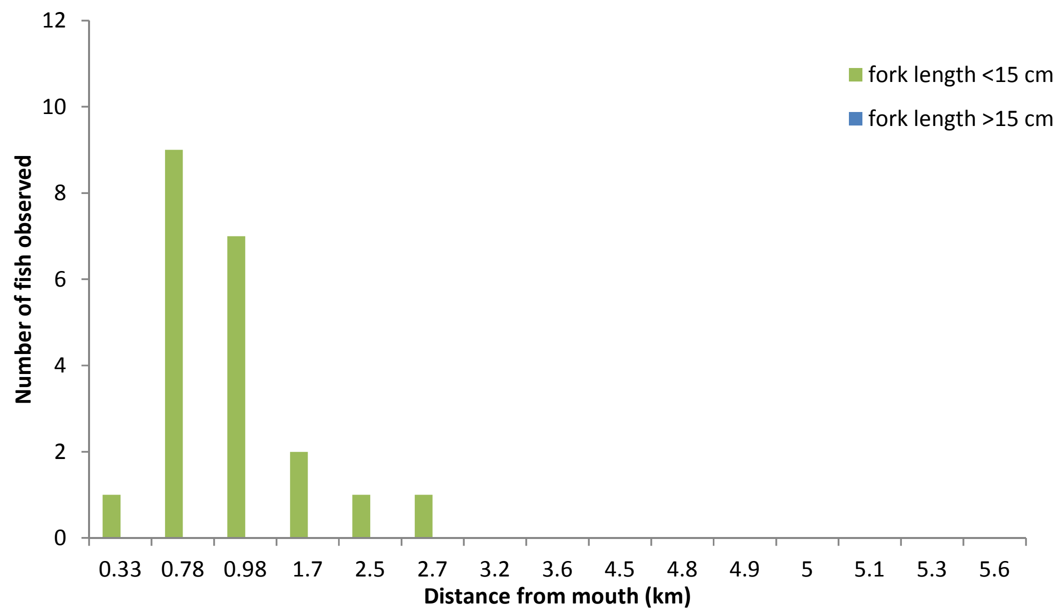
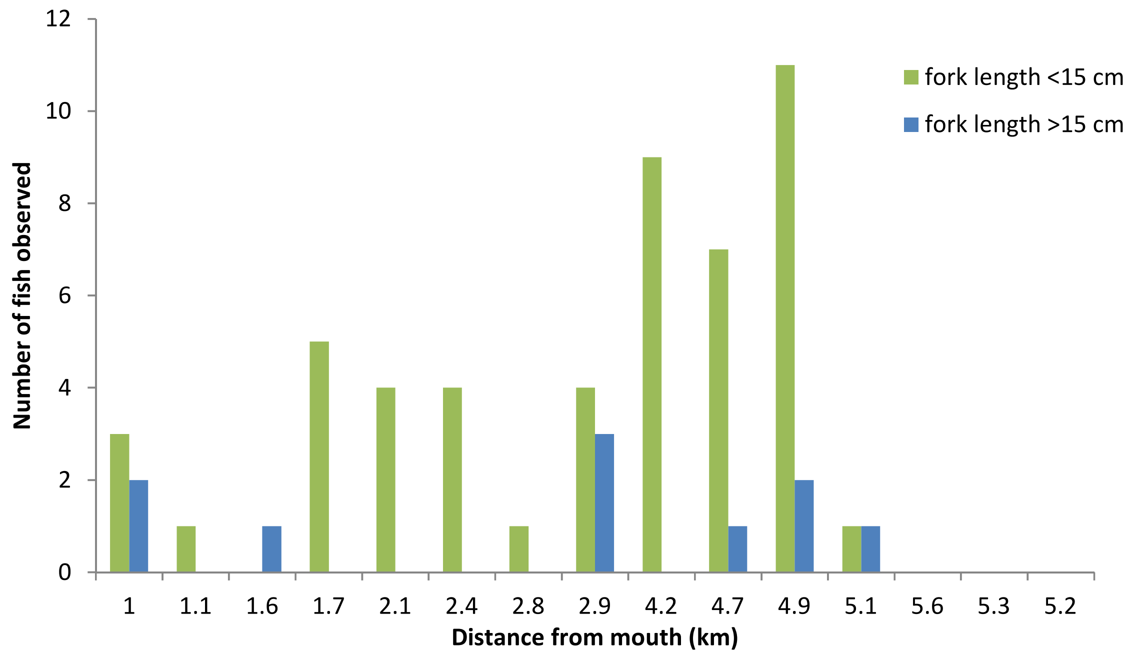


Figure A1.9 Bull trout catch number in Patch 40 (Funeral Creek), with distance from confluence with Fast Creek, summer 2013.



A2.4 2013 BASELINE PROGRAM CONCLUSIONS

The following conclusions are made based on the 2013 baseline sampling program:

1. A small, yet significant increase in fish condition was noted at the far-field at park boundary site, which is consistent with previous observations of mild enrichment downstream of the Mine. Other downstream locations did not show any significant effect (10% effect size) at a power of 0.8 or higher.

2. Sediment quality appeared to be similar upstream and downstream of the Mine. Concentrations of metals were typically slightly higher at the far-field at park boundary location. Arsenic, cadmium and zinc were the only metals to exceed the CCME interim sediment quality guidelines. Exceedances were small (<1.6) and similar for the reference and near-field locations. There were no exceedances of CCME's probable effects level (PEL);

3. Periphyton mass was small at all locations sampled, confirming the low nutrient status of Prairie Creek. There was a decrease noted in near-field and far-field at park boundary locations. The significance of this is unknown. Future surveys will likely need to include collecting more samples at each location, and possibly expanding the reach length at each station; and,

4. A four-day helicopter reconnaissance investigation identified three potential reference creeks for juvenile bull trout; two in the lower Clearwater Creek catchment and one in the upper Wrigley Creek catchment. These creeks either contained juvenile or large, mature adult bull trout. The two "exposure" creeks located upstream of the Mine both contained juvenile bull trout. Patch 45 contained only juvenile bull trout, and only from the mouth to the 2.7 km mark. Patch 40 (Funeral Creek) contained both adult and juvenile bull trout, and bull trout were captured from near the confluence with Fast Creek to all the way upstream to the 5.1 km mark.

Benthic invertebrate data were not available at the time of writing this report. It is anticipated that this data will be available in mid March.

A3.0 REFERENCES

Faul F, Erdfelder E, Buchner A, Lang A-G. 2009. Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. Behavior Research Methods, 41, 1149-1160.

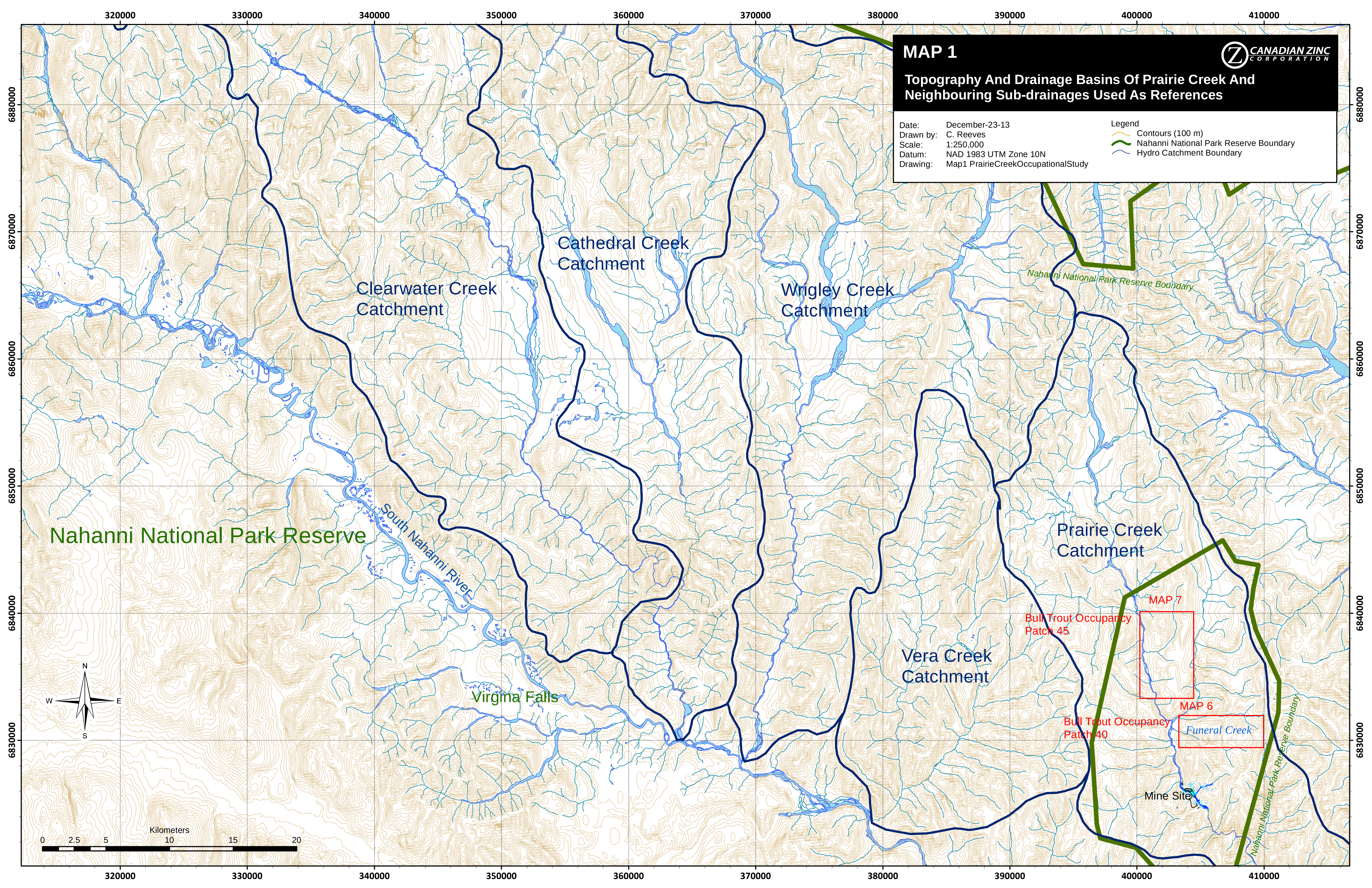
Parker BR, Levesque LM, Gue A, Perry L, Dessouki T, Halliwell D, Haggarty DR. 2010. Nahanni National Park Reserve Water Quality Status and Trends. Water Quality Monitoring and Surveillance, Prairie and Northern, Environment Canada. March 2010.

R Development Core Team. 2008. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org.

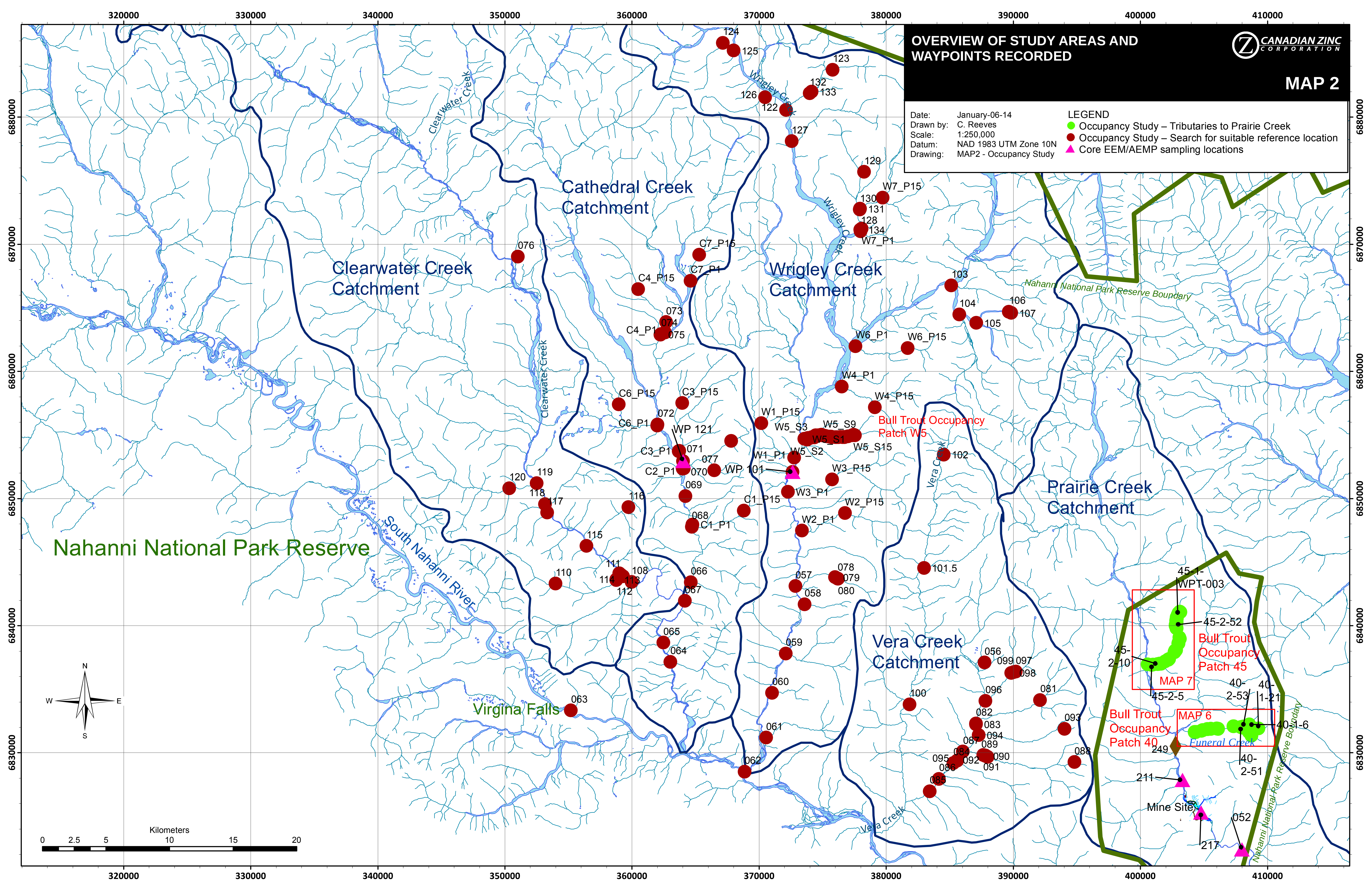
ATTACHMENTS

Attachment A1-1

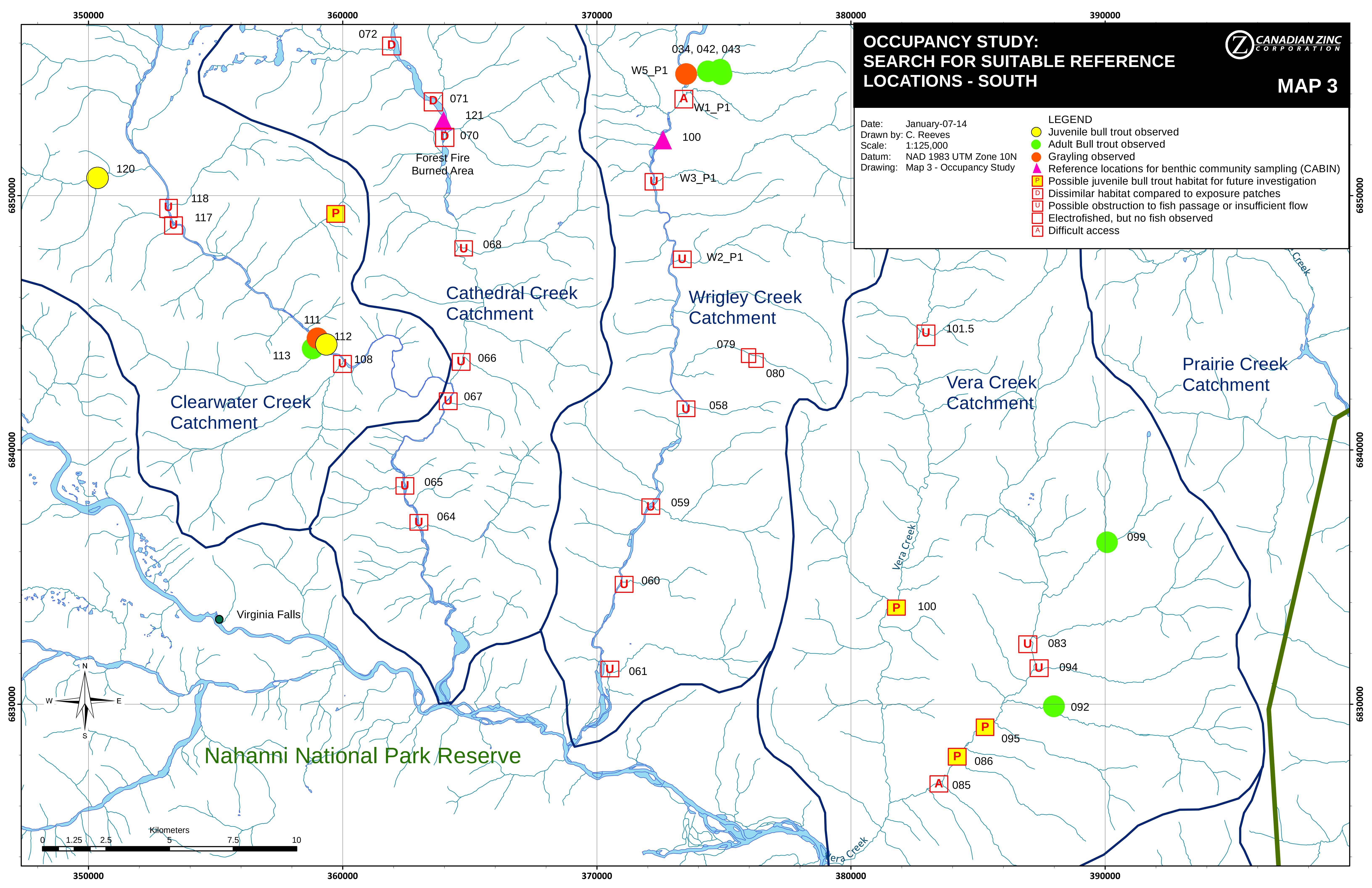
Maps



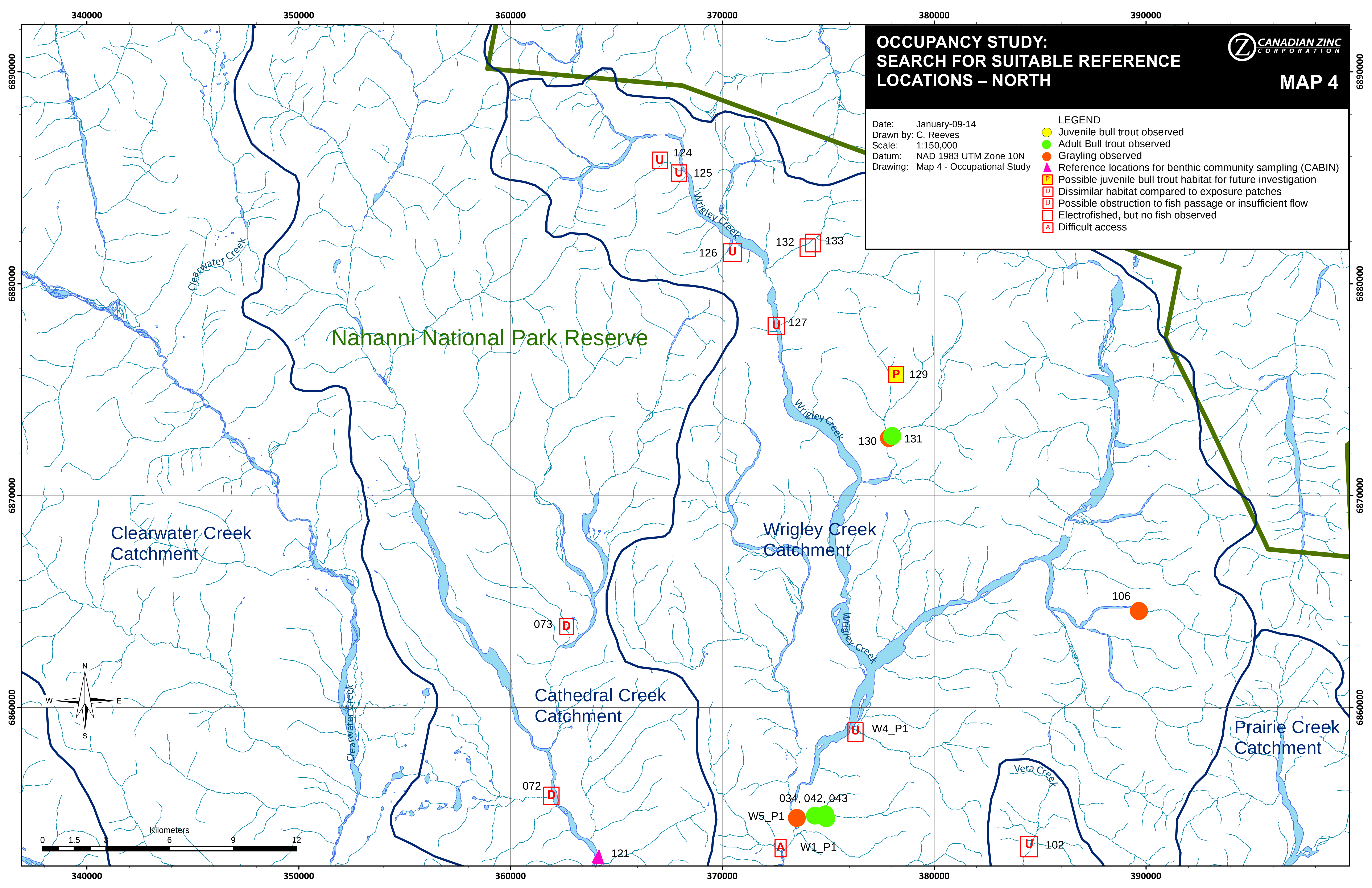
MAP 1
CANADIAN ZINC CORPORATION
Topography And Drainage Basins Of Prairie Creek And Neighbouring Sub-drainages Used As References
Date: December-23-13
Drawn by: C. Reeves
Scale: 1:250,000
Datum: NAD 1983 UTM Zone 10N
Drawing: Map1 PrairieCreekOccupationalStudy
Legend
Contours (100 m)
Nahanni National Park Reserve Boundary
Hydro Catchment Boundary
Clearwater Creek Catchment
Cathedral Creek Catchment
Wrigley Creek Catchment
Prairie Creek Catchment
Vera Creek Catchment
Nahanni National Park Reserve
South Nahanni River
Virgina Falls
Nahanni National Park Reserve Boundary
MAP 7
MAP 6
Bull Trout Occupancy Patch 45
Bull Trout Occupancy Patch 40
Funeral Creek
Mine Site
Kilometers
0 2.5 5 10 15 20
N
S
E
W
320000 330000 340000 350000 360000 370000 380000 390000 400000 410000
6880000 6870000 6860000 6850000 6840000 6830000

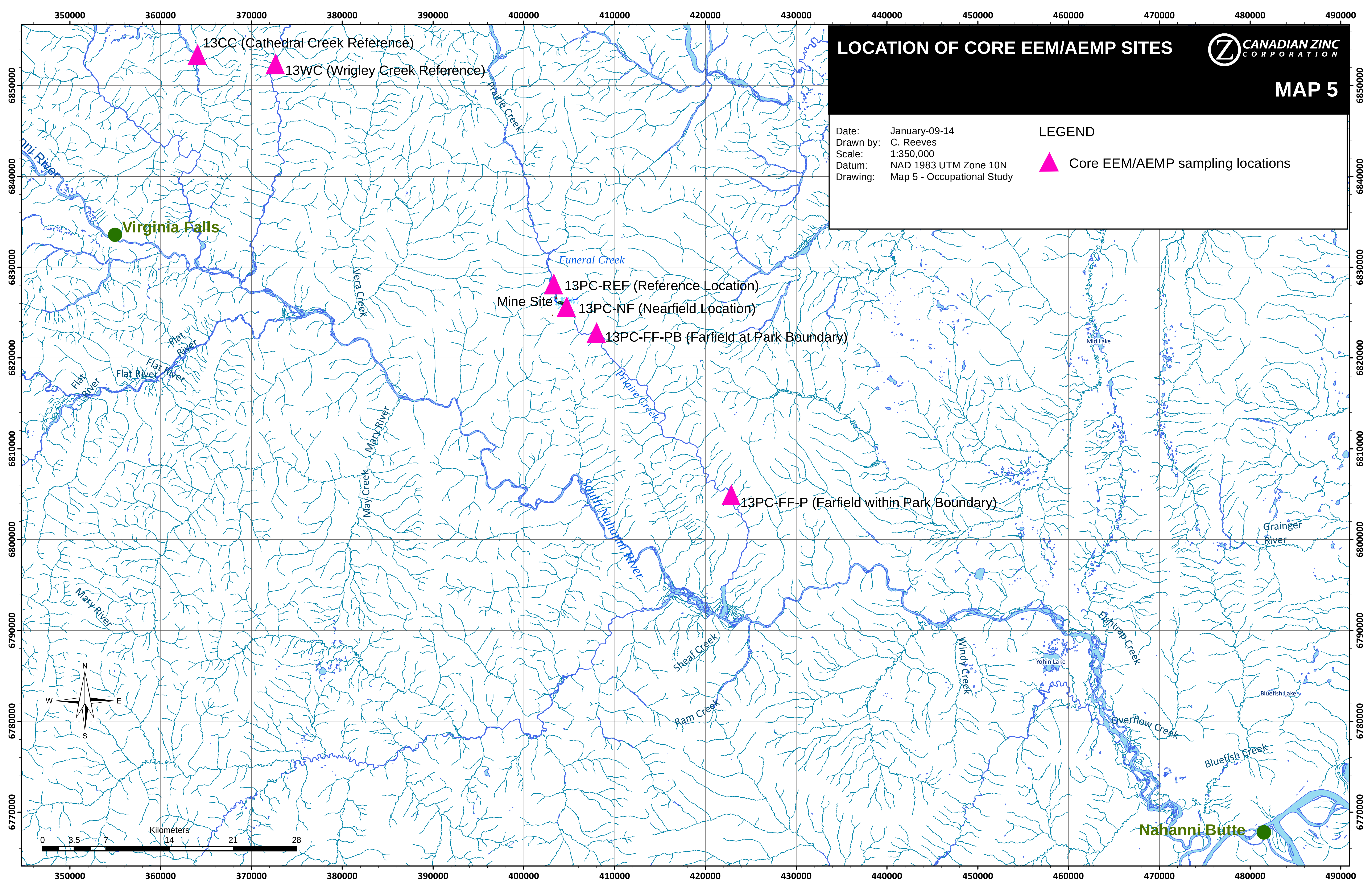


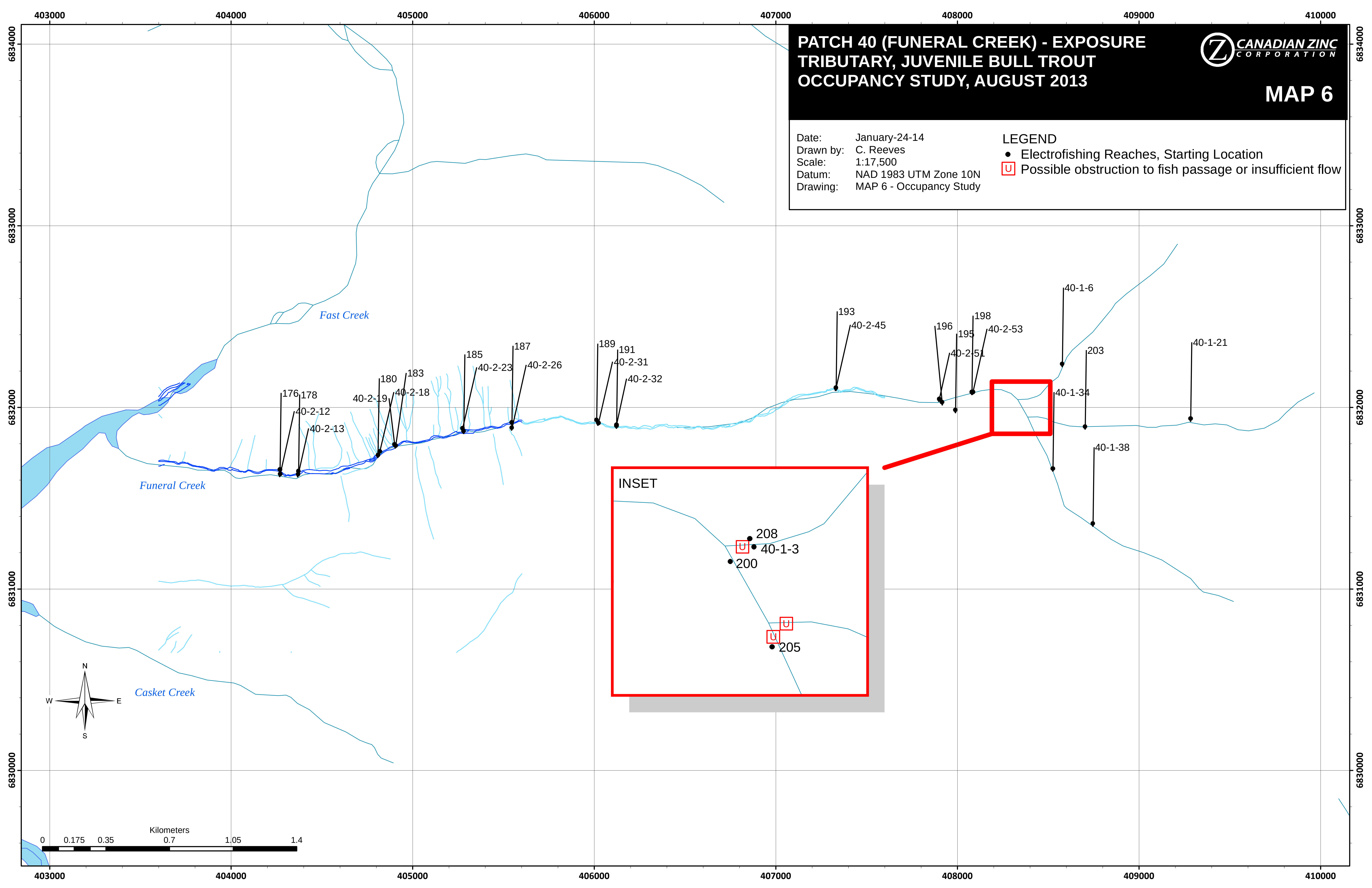
OVERVIEW OF STUDY AREAS AND WAYPOINTS RECORDED
CANADIAN ZINC CORPORATION
MAP 2
Date: January-06-14
Drawn by: C. Reeves
Scale: 1:250,000
Datum: NAD 1983 UTM Zone 10N
Drawing: MAP2 - Occupancy Study
LEGEND
Occupancy Study – Tributaries to Prairie Creek
Occupancy Study – Search for suitable reference location
Core EEM/AEMP sampling locations
Cathedral Creek Catchment
Clearwater Creek Catchment
Wrigley Creek Catchment
Prairie Creek Catchment
Vera Creek Catchment
Nahanni National Park Reserve
Nahanni National Park Reserve Boundary
South Nahanni River
Clearwater Creek
Wrigley Creek
Vera Creek
Funeral Creek
Virgina Falls
Mine Site
Bull Trout Occupancy Patch W5
Bull Trout Occupancy Patch 45
Bull Trout Occupancy Patch 40
MAP 6
MAP 7
Kilometers
0 2.5 5 10 15 20

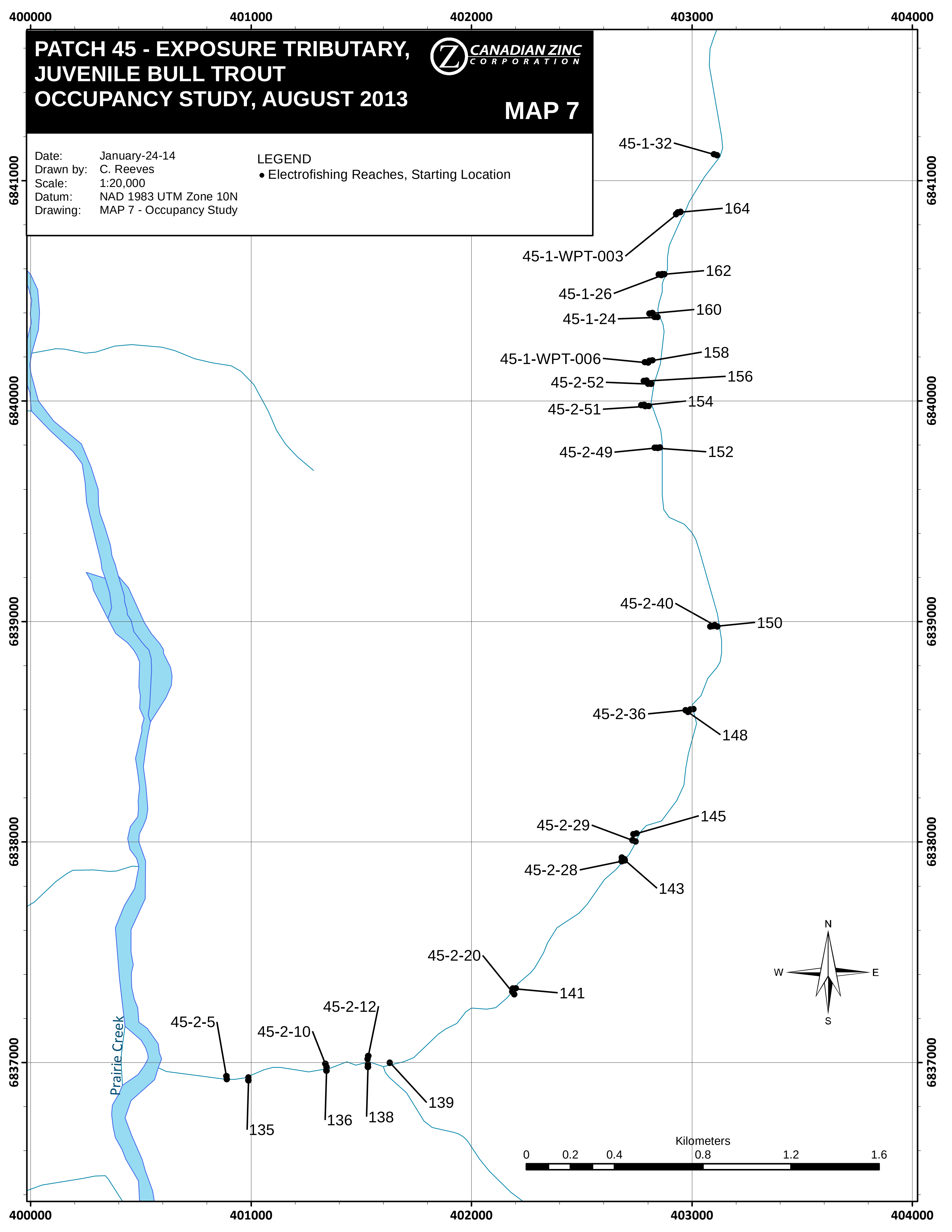


OCCUPANCY STUDY:
SEARCH FOR SUITABLE REFERENCE
LOCATIONS - SOUTH
MAP 3
CANADIAN ZINC CORPORATION
Date: January-07-14
Drawn by: C. Reeves
Scale: 1:125,000
Datum: NAD 1983 UTM Zone 10N
Drawing: Map 3 - Occupancy Study
LEGEND
Juvenile bull trout observed
Adult Bull trout observed
Grayling observed
Reference locations for benthic community sampling (CABIN)
Possible juvenile bull trout habitat for future investigation
Dissimilar habitat compared to exposure patches
Possible obstruction to fish passage or insufficient flow
Electrofished, but no fish observed
Difficult access
Cathedral Creek Catchment
Wrigley Creek Catchment
Clearwater Creek Catchment
Vera Creek Catchment
Prairie Creek Catchment
Nahanni National Park Reserve
Forest Fire Burned Area
Virginia Falls
Vera Creek
Kilometers
0 1.25 2.5 5 7.5 10
350000
360000
370000
380000
390000
6850000
6840000
6830000
034, 042, 043
W5_P1
W1_P1
W3_P1
W2_P1
072
071
121
070
100
120
118
117
068
111
112
113
108
066
067
065
064
101.5
079
080
058
059
060
061
099
083
094
092
095
086
085


OCCUPANCY STUDY:
SEARCH FOR SUITABLE REFERENCE
LOCATIONS – NORTH
CANADIAN ZINC CORPORATION
MAP 4
Date: January-09-14
Drawn by: C. Reeves
Scale: 1:150,000
Datum: NAD 1983 UTM Zone 10N
Drawing: Map 4 - Occupational Study
LEGEND
Juvenile bull trout observed
Adult Bull trout observed
Grayling observed
Reference locations for benthic community sampling (CABIN)
Possible juvenile bull trout habitat for future investigation
Dissimilar habitat compared to exposure patches
Possible obstruction to fish passage or insufficient flow
Electrofished, but no fish observed
Difficult access
Nahanni National Park Reserve
Clearwater Creek Catchment
Cathedral Creek Catchment
Wrigley Creek Catchment
Prairie Creek Catchment
Clearwater Creek
Wrigley Creek
Vera Creek
124
125
126
127
129
130
131
132
133
106
073
072
121
102
W4_P1
W5_P1
W1_P1
034, 042, 043
Kilometers
0 1.5 3 6 9 12
N
S
E
W
340000 350000 360000 370000 380000 390000
6890000 6880000 6870000 6860000


LOCATION OF CORE EEM/AEMP SITES
CANADIAN ZINC CORPORATION
MAP 5
Date: January-09-14
Drawn by: C. Reeves
Scale: 1:350,000
Datum: NAD 1983 UTM Zone 10N
Drawing: Map 5 - Occupational Study
LEGEND
Core EEM/AEMP sampling locations
13CC (Cathedral Creek Reference)
13WC (Wrigley Creek Reference)
13PC-REF (Reference Location)
Mine Site
13PC-NF (Nearfield Location)
13PC-FF-PB (Farfield at Park Boundary)
13PC-FF-P (Farfield within Park Boundary)
Virginia Falls
Nahanni Butte
Funeral Creek
Prairie Creek
Vera Creek
Flat River
Mary River
May Creek
South Nahanni River
Sheaf Creek
Ram Creek
Windy Creek
Fishtrap Creek
Overflow Creek
Bluefish Creek
Grainger River
Mid Lake
Yohin Lake
Bluefish Lake
Kilometers
0 3.5 7 14 21 28
N S E W


PATCH 40 (FUNERAL CREEK) - EXPOSURE TRIBUTARY, JUVENILE BULL TROUT OCCUPANCY STUDY, AUGUST 2013
CANADIAN ZINC CORPORATION
MAP 6
Date: January-24-14
Drawn by: C. Reeves
Scale: 1:17,500
Datum: NAD 1983 UTM Zone 10N
Drawing: MAP 6 - Occupancy Study
LEGEND
Electrofishing Reaches, Starting Location
Possible obstruction to fish passage or insufficient flow
Fast Creek
Funeral Creek
Casket Creek
INSET
208
40-1-3
200
205
176
178
40-2-12
40-2-13
180
40-2-19
183
40-2-18
185
40-2-23
187
40-2-26
189
191
40-2-31
40-2-32
193
40-2-45
196
195
198
40-2-51
40-2-53
40-1-6
203
40-1-21
40-1-34
40-1-38
Kilometers
0 0.175 0.35 0.7 1.05 1.4
N
S
E
W
403000
404000
405000
406000
407000
408000
409000
410000
6834000
6833000
6832000
6831000
6830000


PATCH 45 - EXPOSURE TRIBUTARY, JUVENILE BULL TROUT OCCUPANCY STUDY, AUGUST 2013
CANADIAN ZINC CORPORATION
MAP 7
Date: January-24-14
Drawn by: C. Reeves
Scale: 1:20,000
Datum: NAD 1983 UTM Zone 10N
Drawing: MAP 7 - Occupancy Study
LEGEND
Electrofishing Reaches, Starting Location
400000
401000
402000
403000
404000
6841000
6840000
6839000
6838000
6837000
45-1-32
164
45-1-WPT-003
162
45-1-26
160
45-1-24
158
45-1-WPT-006
156
45-2-52
154
45-2-51
152
45-2-49
45-2-40
150
45-2-36
148
45-2-29
145
45-2-28
143
45-2-20
141
45-2-5
45-2-10
45-2-12
135
136
138
139
Prairie Creek
N
W
E
S
Kilometers
0
0.2
0.4
0.8
1.2
1.6

Attachment A1-2

Annotated GPS Waypoint List

Attachment A1-2 Annotated GPS waypoints - Prairie Creek Baseline Aquatic Biomonitoring Program, July August 2013.

Waypoint	Notes	Date	Selected coordinates
23	PCFF-PB - Prairie Creek Far Field at Park boundary - helicopter landing site	26July'13	
24	PCFF-PB - electrofishing start	26July'13	
25	PCFF-PB - electrofishing end - 856 seconds	26July'13	
26	PCFF-P - Prairie Creek Far Field within Park - helicopter landing site	27July'13	
27	PCFF-P - old electrofishing start	27July'13	
28	PCFF-P - electrofishing start	27July'13	
29	PCFF-P - electrofishing end	27July'13	
W3_P1	Wrigley Tributary #3 -mouth -deeply incised , several water falls (likey impassible to fish)	28July'13	
W3_P15	Wrigley Tributary #3 - 5 km	28July'13	
W1_P1	Wrigley Tributary #1 -mouth -Lots of deadfalls lots of tall forest. Water looked turbid, no where to land.	28July'13	
W1_P15	Wrigley Tributary #1 -5 km	28July'13	
W4_P1	Wrigley Tributary #4 -mouth -water appears to go to ground	28July'13	
W4_P15	Wrigley Tributary #4 -5 km	28July'13	
30	W5_P1 - start	28July'13	
31	W5_P1 - end - 307 seconds - three juvenille greyling	28July'13	
32	W5_P2 - start	28July'13	
33	W5_P2 - end - 218 seconds - no fish	28July'13	
34	Two adult bull trout caught, one above a log, other right below. No waypoint collected site was between P2 and P3	28July'13	10 V 374163 6854826
35	W5_P3 - start	28July'13	
36	W5_P3 - end - 149 seconds - no fish	28July'13	
37	W5_P4 - start	28July'13	
38	W5_P4 - end - 148 seconds - no fish	28July'13	
39	W5_P5 - start	28July'13	
40	W5_P5 - end - 274 seconds - no fish	28July'13	
41	W5_S7 - start	28July'13	
42	W5_S7 - location of adult bull trout	28July'13	10 V 374842 6855001
43	W5_S7 - end - 126 seconds - one adult bull trout	28July'13	
44	W5_P7 - start	28July'13	
45	W5_P7 - end - 125 seconds - no fish	28July'13	
46	W5_P8 - start	28July'13	
47	W5_P8 - end - 147 seconds - no fish	28July'13	
48	W5_P9 - start	28July'13	
49	W5_P9 - end - 153 seconds - no fish	28July'13	
50	Obstruction to fish passage (?) W5-P10 just upstream. Endpoint for W5	28July'13	
51	PCFF-PB - day two electrofishing - end 628 seconds	29July'13	
52	PCFF-PB - day two electrofishing - start	29July'13	
53	DFO Patch 45 - 5km	29July'13	
54	DFO Patch 45 - mouth	29July'13	
55	Prairie Creek, confluence with Fast Creek	29July'13	
56	Possible bull trout reference trib on Vera to come back to	29July'13	
W2_P1	W2 not good - tight canyon at mouth, several large drops near mouth and at about km 2 goes to ground.	29July'13	
57	Possible canditate Wrigley bull trout reference creek, no large drops some good pools, flow less than funeral <<tried fishing later in same day, no fish caught>>	29July'13	
58	Wrigley Trib no good - Very steep wooded and narrow, could not see surface flow	29July'13	
59	Wrigley Trib no good - good plung pool habitat for first 1km in steep canyon. Flattens out mostly riffle. Good landing spot ~4km up. However ~2 m drop waterfall about 1km from mouth!	29July'13	
60	Wrigley Trib no good - small, no pools, too short and very low flow	29July'13	
61	Wrigley Trib no good - water turbid and two large drips in first km	29July'13	
62	Confluence of Wrigley with South Nahanni	29July'13	
63	Virginia Falls	29July'13	
64	Clearwater Trib no good - first 1km has good pools and landing spots. Large water fall ~1km from mouth >2m drop	29July'13	
65	Clearwater Trib no good - too small and large fall at mouth	29July'13	
66	Cathedral Trib no good - just north on east side of lake - waterfall + small flow + very steep.	29July'13	
67	Cathedral Trib no good - small trib on east side - waterfall near mouth, very steep	29July'13	
68	Cathedral Trib "C1" no good - large water falls at mouth - fish obstruction	29July'13	
69	Forest fire area quite new - no fresh undergrowth yet.	29July'13	
70	C2_P1 - Cathedral Trib "C2" turbid looking water. Shallow riffle between 3-4km. Some pools, but not many…possible candidate	29July'13	
C2_P15	5km from mouth of C2	29July'13	
71	C2_P1 - Cathedral Trib "C3" turbid looking, topography flatter, meandering, depositional looking in areas	29July'13	
72	Cathedral Trib "C6" - turbid for first km than tannin-y. Topography fairly flat. Very few pools.	29July'13	
73	Cathedral Trib "C4" -Topography fairly flat, water tinted brown, few pools (first coordinate about 1km from mouth).	29July'13	
74	Cathedral Trib "C4" - mouth	29July'13	
75	Cathedral Trib "C4" - mouth	29July'13	
76	Fuel cache on Clearwater	29July'13	
77	Big burn	29July'13	
78	Landing spot upstream of WP57	29July'13	
79	Wrigley trib -Electrofishing Start (DS)	29July'13	
80	Wrigley trib - Electrofishing End (US), 505 seconds, no fish	29July'13	
81	Vera trib - Vera east branch - looked too large	29July'13	
82	Vera trib - Vera east branch -Fork in Vera trib (DS of WP81)	29July'13	
83	Vera trib - Vera east branch -Fork in Vera trib (DS of WP81), water fall ~3km US of confluence with Vera	29July'13	
84	Vera trib - Vera east branch -	29July'13	
85	Vera trib - Vera east branch - looks possible, but no place to put helicopter, not very steep, few pools, looks like creek W5.	29July'13	
86	Vera trib - Vera east branch - more slope, few more pools and falls, some places to land.	29July'13	
87	Vera trib - Vera east branch -some pools, more flow. Long stretch of good looking habitat, saw one very deep looking pool <<returned later WP91-92>>	29July'13	
88	Vera trib - Vera east branch -~ 10km from mouth upward extent of trib WP87.	29July'13	
89	Vera trib- Vera east branch -mid point on trib WP87/88 (from day before) - electrofished - landing spot	30July'13	
90	Vera trib - Vera east branch -WP87/88 -	30July'13	
91	Vera trib - Vera east branch -WP87/88 - DS extent of electrofishing	30July'13	
92	Vera trib - Vera east branch -WP87/88 - US extent of electrofishing - 764 sec, caught 10 greyling	30July'13	10 V 387962 6829671
93	Vera trib - Vera east branch -to north of WP87 - ~ 10m US of mouth (WP94) very little flow beyond 1km from mouth, v. few pools	30July'13	
94	Vera trib - Vera east branch -mouth of WP93	30July'13	
95	Vera trib -- Vera east branch - further mouth of WP93 - more flow, but less than WP89.	30July'13	

Attachment A1-2 Annotated GPS waypoints - Prairie Creek Baseline Aquatic Biomonitoring Program, July August 2013.

Waypoint	Notes	Date	Selected coordinates
96	Vera trib -- Vera east branch - looked similar to greyling stream WP87/88, but a little smaller and goes to ground near 5km. Stopped to fish ~3.1 km good spot to land, large gravel bar, Riffle habitat.	30July'13	10 V 387806 6834071
97	Vera trib -east - helicopter landing spot	30July'13	
98	Vera trib - Vera east branch -DS extent of electrofishing-	30July'13	
99	Vera trib - Vera east branch -US extent of electrofishing -408 seconds - 9 greyling observed, 6 shocked.	30July'13	10 V 390034 6836343
100	Vera trib - Vera east branch - looks promising, some cascades about 1 km US of mouth, I felt that fish could pass	30July'13	
101	Parks 60 - CABIN sampling on Wrigley	30July'13	
101.5	Vera trib - Vera west branch - central - No good - goes to ground at 1.2 km	30July'13	
102	Vera trib -- Vera west branch - north - No good - water falls starting around km 3.	30July'13	
103	Wrigley trib - (upper wrigley east, north of Vera)	30July'13	
104	Wrigley trib - (upper wrigley east, north of Vera)	30July'13	
105	Wrigley trib - (upper wrigley east, north of Vera)	30July'13	
106/107	Wrigley trib - (upper wrigley east, north of Vera) - DS extent of electrofishing and helicopter landing spot	30July'13	
107	Wrigley trib - (upper wrigley east, north of Vera) - US extent of electrofishing - Pool with lots of greyling - water fall above is an obstruction.	30July'13	10 V 389841 6864592
108	Clearwater trib - no good - both branches go to ground within the first 3km	31July'13	
109	Clearwater trib - mouth	31July'13	
110	Clearwater trib - 5km up wp109	31July'13	
111	Clearwater trib - wp109 greyling caught here	31July'13	10 V 359113 6843999
112	Clearwater trib -wp109 juvenile bull trout caught here	31July'13	10 V 358757 6843628
113	Clearwater trib - wp109 furthest upstream extent - adult bull trout found in pool - 183 seconds	31July'13	10 V 358752 6843593
114	Clearwater trib - wp109 helicopter landing spot	31July'13	
115	Clearwater trib - mouth	31July'13	
116	Clearwater trib -5km from mouth - possilbe trib for future investigation.	31July'13	
117	Clearwater trib - no good - south side - dry	31July'13	
118	Clearwater trib - no good - north side -dry	31July'13	
119	Clearwater trib - no good - too big, appears to be 4rth order - too big. Waterfall in first 500m , may be an obstruction to fish passage	31July'13	
120	Clearwater trib - landing spot, captured bull trout within 5 minutes of fishing (10 seconds ef time)	31July'13	10 V 350327 6850810
121	Parks 59 - CABIN site on Wrigley Creek. Was originally going to use Parks 56, but large burn downstream may be influencing invertebrate community there.	31July'13	
122/123	Wrigley trib (upper wrigley west) - lots of gravel bars and walls. Some small falls, but generally looks good - electrofished later (wp132/133, no fish)	31July'13	
124/125	Wrigley trib (upper wrigley west) - No good - big fall close to mouth	31July'13	
126	Wrigley trib (upper wrigley west) - No good - very little flow, goes to ground	31July'13	
127	Wrigley trib (upper wrigley west) - No good - water fall (large) near mouth - box canyon	31July'13	
128/129	Wrigley trib (upper wrigley west) - Site "W7" - looks very promising, lots of pools, cool box canyon, would be great to sample	31July'13	
130/131	Wrigley trib (upper wrigley west) - Site "W7" - electrofished started at wp131 and up 200m - 9 adult greyling + one adult bull trout (30cm+) in 293sec ef time -	31July'13	10 V 377942 6872791
132/133	Wrigley trib (upper wrigley west) - electrofished from wp132 to 133 - No fish despite nice looking pools and periphyton on rock. Less flow than W7 - 194 seconds ef time	31July'13	
134	Wrigley trib (upper wrigley west) - visual check of canyon at bottom of W7	31July'13	
135	Prairie trib - DFO patch 45-2-5 to wp135 - ~9cm juvenile bull trout - fish escaped - 208 seconds	1Aug'13	10 V 400989 6836932
136/137	Prairie trib - DFO patch 45-2-10 -8 juventile bull trout - 334 seconds	1Aug'13	10 V 401342 6836976
138/139	Prairie trib - DFO patch 45-2-12 -5 juvenile bull trout, additional 2 escaped capture - 353 seconds	1Aug'13	10 V 401530 6836991
140	Prairie trib - DFO patch 45 temperature sensor	1Aug'13	
141/142	Prairie trib - DFO patch 45-2-20 - no fish captured, but 2 escaped -345 seconds	1Aug'13	10 V 402187 6837336
143/144	Prairie trib - DFO patch 45-2-28 - one fish captured - 226 seconds - location just DS of temperature logger station	1Aug'13	10 V 402682 6837930
145/146	Prairie trib - DFO patch 45-2-29 - one fish captured - 226 seconds - location just DS of temperature logger station	1Aug'13	10 V 402735 6838034
147/148/149	Prairie trib - DFO patch 45-2-36 - No fish captured -176 seconds	1Aug'13	
150/151	Prairie trib - DFO patch 45-2-40 - No fish captured -164 seconds	1Aug'13	
152/153	Prairie trib - DFO patch 45-2-49 - No fish captured -177 seconds	1Aug'13	
154/155	Prairie trib - DFO patch 45-2-51 - No fish captured -133 seconds	1Aug'13	
156/157	Prairie trib - DFO patch 45-2-52 - No fish captured -193 seconds	1Aug'13	
158/159	Prairie trib - DFO patch 45-1-WPT-006 - No fish captured -213 seconds	1Aug'13	
160/161	Prairie trib - DFO patch 45-2-24 - No fish captured -161 seconds	1Aug'13	
162/163	Prairie trib - DFO patch 45-2-26 - No fish captured -179 seconds	1Aug'13	
164/165	Prairie trib - DFO patch 45-1-WPT-003 - No fish captured -184 seconds	1Aug'13	
166	Prairie trib - DFO patch 45-pickup point	1Aug'13	
167	Compensation channel mouth - photo	2Aug'13	
168	Compensation channel mouth - photo - potential location for stop net?	2Aug'13	
169	Compensation channel mouth - photo - pool at bottom of steeper riffle	2Aug'13	
170	Compensation channel - location of stop net	2Aug'13	
171	Compensation channel - upstream end of electrofishing - first pass - 477 seconds - 73 Sculpin, 5 Bull Trout	2Aug'13	10 V 402798 6830732
172	Compensation channel - test pit	2Aug'13	
173	Compensation channel - natural pool	2Aug'13	
174	Casket trib adjacent to compensation channel - location releasing salvaged fish.	2Aug'13	
175	13PC-NF - Prairie Creek CABIN nearfield site - collecting water sample	2Aug'13	
176/177	Prairie trib - Funeral Creek - DFO patch 40-2-12 - 5 juv. bull trout -290 seconds	4Aug'13	10 V 404268 6831645
178/179	Prairie trib - Funeral Creek - DFO patch 40-2-13 - 1 juv. bull trout -435 seconds	4Aug'13	10 V 404370 6831636
180/181/182	Prairie trib - Funeral Creek - DFO patch 40-2-18 - 1 bull trout -403 seconds	4Aug'13	10 V 404809 6831725
183/184	Prairie trib - Funeral Creek - DFO patch 40-2-19 - 5 juv. Bull trout -342 seconds	4Aug'13	10 V 404904 6831778
185/186	Prairie trib - Funeral Creek - DFO patch 40-2-23 - 4 juv. Bull trout -380 seconds	4Aug'13	10 V 405281 6831858
187/188	Prairie trib - Funeral Creek - DFO patch 40-2-26 - 4 juv. Bull trout, caught additon two juv bull trout escaped - 236 seconds	4Aug'13	10 V 405546 6831905
189/190	Prairie trib - Funeral Creek - DFO patch 40-2-31 - 1 juv. Bull trout -191 seconds	4Aug'13	10 V 406012 6831918
191/192	Prairie trib - Funeral Creek - DFO patch 40-2-32 - 5 juv. Bull trout, caught additon two juv bull trout escaped - 327 seconds	4Aug'13	10 V 406122 6831885
193/194	Prairie trib - Funeral Creek - DFO patch 40-2-45 - 9 juv. Bull trout, caught additon 7 juv bull trout escaped -400 seconds	4Aug'13	10 V 407331 6832095
195	Parking location for access to 40-2-51	4Aug'13	
196/197	Prairie trib - Funeral Creek - DFO patch 40-2-51 - 4 juv. Bull trout, caught additon 3 juv bull trout escaped + one adult -270 seconds	4Aug'13	
198/199	Prairie trib - Funeral Creek - DFO patch 40-2-53 - 7 fry (?) +3 juv. Bull trout caught + excapted 1 juv + 2 adult bull trout -428 seconds	4Aug'13	
200/202	Prairie trib - Funeral Creek - DFO patch 40-1-3 - 1 adult and 1 juv bull trout -346 seconds	4Aug'13	
201	possible obstruction to fish passage, no fish found above waterfall.	4Aug'13	

Attachment A1-2 Annotated GPS waypoints - Prairie Creek Baseline Aquatic Biomonitoring Program, July August 2013.

Waypoint	Notes	Date	Selected coordinates
203/204	Prairie trib - Funeral Creek - New reach ~200 m from confluence on middle branch - no fish - 169 seconds	4Aug'13	
205/206	Prairie trib - Funeral Creek - New reach south branch - no fish - 201 seconds	4Aug'13	
207	Possible obstruction to fish passage - north branch	4Aug'13	
208/209	Prairie trib - Funeral Creek - New reach north branch - no fish - 191 seconds	4Aug'13	
210	13PC-NF - Prairie Creek CABIN nearfield site -CABIN sampling	5Aug'13	
211	13PC-R - Prairie Creek CABIN reference site -CABIN sampling	5Aug'13	
212	13PC-NF - Prairie Creek CABIN nearfield site -CABIN sampling	5Aug'13	
213	13PC-R - Prairie Creek CABIN reference site -CABIN sampling - electrofishing for sculpin - 556 seconds	5Aug'13	
214	13PC-R - Prairie Creek CABIN reference site -CABIN sampling - electrofishing for sculpin - 461 seconds	5Aug'13	
215	13PC-NF - Prairie Creek CABIN nearfield site -CABIN sampling - electrofishing for sculpin - 129 seconds - returned to productive riffle area to get more fish	5Aug'13	
216	13PC-NF - Prairie Creek CABIN nearfield site -CABIN sampling - electrofishing for sculpin - top part of fishing area	5Aug'13	
217	13PC-NF - Prairie Creek CABIN nearfield site -CABIN sampling - electrofishing for sculpin - bottom part of fishing area	5Aug'13	
218 - 225	Compensation channel - stakes to define proposed new compensation habitat pools - upper pool	6Aug'13	
226-234	Compensation channel - stakes to define proposed new compensation habitat pools - second pool	6Aug'13	
235-241	Compensation channel - stakes to define proposed new compensation habitat pools - optional third pool	6Aug'13	
242-249	Compensation channel - stakes to define proposed new compensation habitat pools - optional fourth pool	6Aug'13	

Legend

Yellow	Juvenile bull trout observed (and possibly adult BT and greyling)
Green	Adult Bull trout observed (and possibly greyling)
Orange	Greyling observed
Blue box	Difficult access
Red box	Possible obstruction to fish passage or insufficient flow

Attachment A1-3

Photographs of Bull Trout Occupancy Study Areas

Photo 1 Lower Reaches of W5 (Tributary to Wrigley Creek)

Photo 2 Middle Reaches of W5 (Tributary to Wrigley Creek)

Photo 3 Upper reaches of W5 (Tributary to Wrigley Creek).

Photo 4 Reach W5-10 Possible Obstruction to Fish Passage.

**Photo 5	Waypoint 79 – Tributary to Wrigley. Photo looking east.**

**Photo 6	Waypoint79 - Tributary to Wrigley. Photo looking east.**

Photo 7 Waypoint 92 – Tributary to east branch of Vera Creek. Photo looking east.

Photo 8 Waypoint 92 – Tributary to east branch of Vera Creek. Photo looking west.

Photo 9 Waypoint 99 – Tributary to east branch of Vera Creek. Photo looking east.

Photo 10 Waypoint 99 – Tributary to east branch of Vera Creek. Photo looking west.

Photo 11 Waypoint 107- Northeastern tributary to Wrigley Creek. Photo looking east.

Photo 12 Waypoint 107 Northeastern tributary to Wrigley Creek. Arctic Greyling

Photo 13 Waypoint 107 Northeastern tributary to Wrigley Creek. Photo looking east..

Photo 14 Waypoint 111. Tributary to Clearwater Creek. Photo looking south.

Photo 15 Waypoint 111. Tributary to Clearwater Creek. Photo looking north.

Photo 16 Waypoint 112. Tributary to Clearwater Creek. Photo looking east. Juvenile bull trout caught here.

Photo 17 **Waypoint 113. Tributary to Clearwater Creek. Photo looking south. Adult bull trout caught here.**

Photo 18 **Waypoint 113. Tributary to Clearwater Creek. Adult bull trout.**

Photo 19 Waypoint 120. Tributary to Clearwater Creek. Photo looking west.

Photo 20 Waypoint 120. Tributary to Clearwater Creek. Photo looking southwest.

Photo 21 **Waypoint 130. Tributary to North Wrigley "W7", Adult bull trout caught. Photo looking south.**

Photo 22 **Waypoint 130. Tributary to North Wrigley "W7" Photo looking southeast.**

Photo 23 Waypoint 132. Tributary to North Wrigley. Photo looking northeast.

Photo 24 Waypoint 132. Tributary to North Wrigley. Photo looking southwest.

Photo 25 **Waypoint 136. Tributary to Prairie Creek "Patch45" near mouth. Photo looking east.**

Photo 26 **Waypoint 136. Tributary to Prairie Creek "Patch45" near mouth. Photo looking west.**

Photo 27 Waypoint 164. Tributary to Prairie Creek "Patch45" near 5km mark. Photo looking east.

Photo 28 Waypoint 180. Tributary to Prairie Creek, Funeral Creek near mouth. Photo looking east.

Photo 29 **Waypoint 187. Tributary to Prairie Creek, Funeral Creek about 3km from mouth. Photo looking east.**

Photo 30 **Waypoint 187. Tributary to Prairie Creek, Funeral Creek about 3km from mouth. Photo looking west.**

Photo 31 Waypoint 207. Tributary to Prairie Creek, Funeral Creek, North branch (about 5.8km from mouth). Photo looking North.