EDI ENVIRONMENTAL DYNAMICS INC.
Natural Resource Consultants

MT. NANSEN TERRESTRIAL AND AQUATIC EFFECTS STUDY – *PHASE 1*

VOLUME 1 OF 2 - REPORT

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PREFACE

This report presents the findings of Phase 1 of the Mt Nansen Terrestrial and Aquatic Effects study as conducted during the fall and winter of 2005. Many of the patterns identified in Phase 1 will be confirmed or expanded upon in Phase 2 of the project. Phase 2 of the project is being conducted in 2006 and will be used to clarify specific questions raised during Phase 1 of the project (as outlined in the recommendations) as well as putting the results from Phase 1 into perspective. *As such, it is strongly recommended that the Phase 2 report (once produced) be viewed or used over this report.*

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1.0 INTRODUCTION

1

This study was completed to provide a better understanding of the Terrestrial and Aquatic effects of the Mt. Nansen minesite.

The terrestrial and aquatic effects of past mining activities associated with the Mt Nansen mine site are not clearly understood. The Little Salmon Carmacks First Nation (LSCFN) as well as the general Yukon community use the area for subsistence and recreational purposes. As the Yukon Government, Abandoned Mines Branch works towards reclamation of the minesite a better understanding of the Terrestrial and Aquatic effects is required to ensure that the works address the issues at the site. In August 2005, *EDI Environmental Dynamics Inc.* was retained to design and complete a Terrestrial and Aquatic Effects Study for the Mt. Nansen minesite. The objective of the project was to provide insight into past effects, current levels of contamination and ongoing contamination of various terrestrial and aquatic ecosystem components in the vicinity of the mine site.

1.1 Study Area

Mt. Nansen is located within the LSCFN Traditional Territory, 60 km west of Carmacks, YT.

The Mt. Nansen gold and silver mine site is located approximately 60 kilometres west of Carmacks. A gravel-surface road provides access to the site from Carmacks (Figure 1.1). The site lies within the watershed of Victoria Creek, a tributary stream to the Nisling River, a medium sized river in the Donjek/White Rivers drainage basin. The mine is located in an area of low mountains and rolling hills, composing the western part of what is broadly defined as the Yukon Plateau (central) Ecoregion. It is east of the Ruby Range Mountains, west of the Yukon River, south of the Klondike Plateau, and directly north of the Aishihik Lake area. The region is quite dry, and characterized by boreal spruce forest. Immediately west of the site, wide grassland valleys characterize much of the upper Nisling River drainage basin with spruce forests on the hillsides and low mountains. This area was also a part of a glacial refuge that did not undergo the impacts of the last ice age.

Many species of wildlife and fish are found within the general area.

The area is utilized heavily by a variety of wildlife, including woodland caribou (*Rangifer tarandus*), moose (*Alces alces*), wood bison *(Bison bison)*, grizzly bear *(Ursus arctos)*, black bear *(Ursus americanus)*, and a number of furbearers and small game. Low snow packs and the open grassland valleys provide important winter habitat for big game species, particularly to the west of the mine site. The Nisling River is a spawning stream for chinook salmon (*Onchorhynchus tshawytscha)*; however, most spawning activity occurs in the middle and lower portions of the River and not in the upper reaches near the Mt. Nansen area. Fish species utilizing water bodies near (downstream of) the mine site include Arctic grayling *(Thymallus arcticus)*, burbot (*Lota lota*), northern pike *(Esox lucius)*, round whitefish *(Prosopium cylindraceum*) and slimy sculpin *(Cottus cognatus)*.

The climate is reflective of the latitude (62^{o} N) and the elevation of the site (approx. 1,200 m). While weather data is incomplete, it is estimated that only May through September have average daily temperatures above freezing. Wind direction data recorded at Mt. Nansen indicate that winds are most prominent from the west, southwest, and east (Figure 1.2).

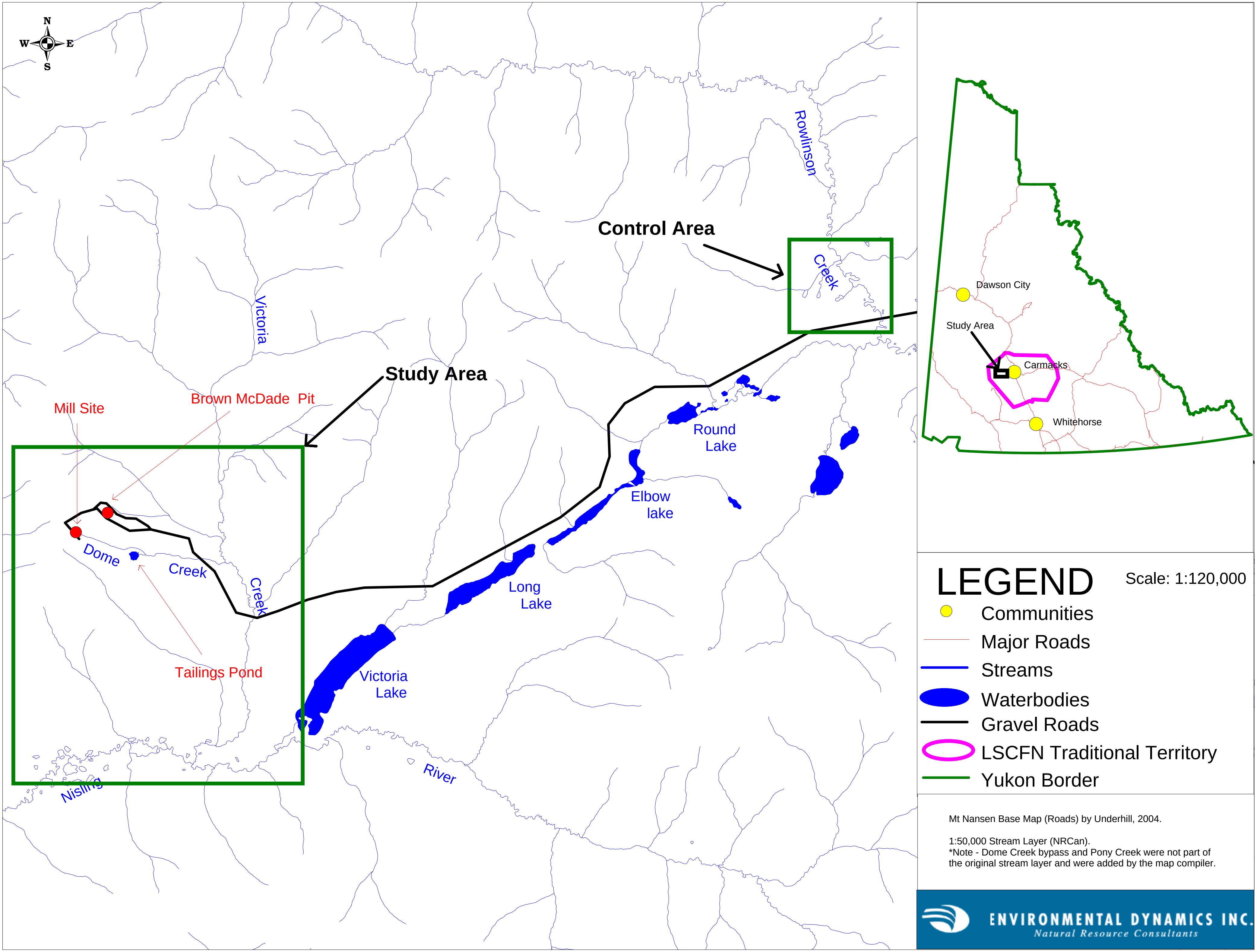


Figure 1.1. Map of study area.

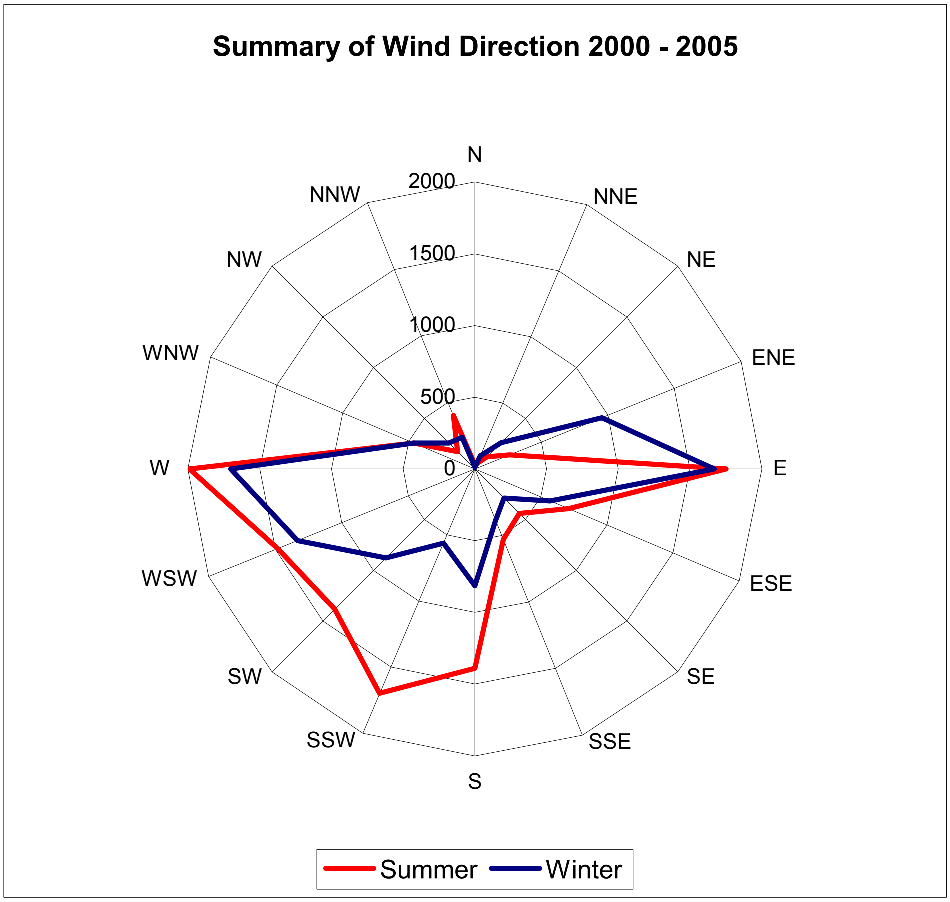


Figure 1.2. Occurrences of wind from specific directions at the Mt Nansen site 2000-2005 (data provided by Yukon Government 2006).[1]

Wind comes most frequently from west, southwest and the east.

1.2 Site History

Little Salmon Carmacks has strong ties to the Mt. Nansen area.

The Little Salmon Carmacks First Nation has strong ties to the Mt. Nansen area with numerous accounts of significant use of the area dating back prior to mining or mining exploration. The harvesting of animals and plants in the area was and continues to be an important part of the lifestyle of many members of the Little Salmon Carmacks First Nation.

A detailed site history is presented in this section.

Early reports of placer gold on the Mt. Nansen property date back to the Klondike gold rush, over 100 years ago. Placer mining for gold at the site has continued since that era. The first hardrock gold discovery was made in 1943 by Brown and McDade. To the west of this deposit (on the other side of the hill), the Webber and Huestis hardrock deposits were subsequently identified.

An extensive exploration and sampling program was conducted at Mt. Nansen between 1963 and 1967, including underground development and the construction of a small

[1] Summer data is from May 1 to September 31. Monitoring station is located near the NE edge of the tailings pond.

flotation mill. The small mill treated 10,000 tonnes of material from the Webber and Huestis deposits in 1968 and 1969. However, gold recoveries from this operation proved uneconomical for production. During 1975 and 1976 an additional 5,000 tonnes of ore from the Huestis zone was processed in a sulphide flotation circuit, however the operation ceased again due to poor levels of gold recovery. It was noted at that time, as in the previous decade, that a cyanide leaching process was required for free gold recovery.

From 1985-1987, a substantial exploration program was conducted by Chevron Minerals in a partnership with BYG Natural Resources Inc. (BYG). This involved surface trenching and diamond drilling. This exploration continued in 1988, but concentrated exclusively on the Brown-McDade deposit. The upper portions of the deposit where the mineralization was oxidized became the focus, as this material can be treated in a cyanide leaching circuit, leading to better gold recoveries than the sulphide flotation process. BYG under new management recommenced exploration in 1994, which led to a feasibility study being initiated later that year. Environmental reviews for the mine were completed and water licensing was granted in early 1996.

Mining of the Brown McDade Pit occurred from 1996 to early 1999.

The BYG mining operation at Mt. Nansen was based on producing ore at a rate of 500 tonnes per day (DIAND, 2000) from the Brown-McDade open pit and processing it through a cyanide leaching circuit for a minimum of 4 years. However, unexpected setbacks prevented planned production targets from being achieved, and capital expenditures were considerably higher than planned. The unexpectedly high clay content in the ore, which limited production through the crushing plant, required a significant additional capital investment in the grinding circuit. A further problem then developed. Once the oxide material in the upper levels of the Brown-McDade Pit had been mined, gold recovery decreased as the ore in the lower levels of the pit was increasingly composed of sulphide materials. The cyanide leaching process is only effective for extracting the free gold available in oxide materials. Fine-grained inclusions of gold in pyrite, arsenopyrite, and peripheral infiltrations in sulfide materials found deeper in the pit are not easily recovered, and the processes required a much larger capital expenditure. Therefore extracting gold from sulphide materials is only feasible where the amount of available ore is large enough to justify such expenditure. In this case it appears that the composition of the ore in the Brown-McDade deposit was not well understood by BYG prior to mining. Therefore, once they removed the upper layers of oxide ore and its composition changed to a mix of oxide material and an increasing amount of sulphide material, gold recoveries fell below expected levels. The entire operation subsequently ceased on February 17, 1999 on an order from the Department of Indian and Northern Affairs (DIAND) due to non-compliance with the mine's water license. Cyanide and arsenic levels in the tailings pond had become elevated and proper treatment facilities were not in place. The stability of the tailings pond dam was also in question, and BYG was not able to meet requirements for an environmental liability bond.

Other than possible placer activity in nearby areas, no mining or mineral exploration has taken place since early 1999. DIAND, and subsequently the Yukon Government's Department of Energy, Mines, and Resources (YG-EMR) have assumed responsibility for management of the site.

The history of environmental impacts at the site may go back to the effects of historic placer operations in the area, and therefore the effects of the BYG operation cannot effectively be isolated from other past works at or near the site.

When BYG ceased operations in early 1999, several environmental issues required attention. For example, the tailings containment system of the BYG mine was not functioning properly, resulting in significant volumes of ongoing contaminated seepage flowing through the tailings pond dam. Symptoms were noticed early on in BYG's operations, including documentation of a fish kill due to high levels of ammonium in Victoria Creek at the mouth of Dome Creek (BYG, 1994). Ammonia is produced as a result of the photochemical breakdown of certain cyanide compounds. Elevated levels of metals and cyanide in Dome Creek were also found at that time.

Action was subsequently taken by DIAND (and subsequently YG-EMR) managers to address the short-term environmental issues. The tailings pond dam was determined to be stable if water levels in the pond were kept lower (Denholm 2000). A water containment and treatment program was undertaken from 1999 to 2004, to collect and treat tailings water in order to meet water quality standards mandated in the previous water license (BYG)[1]. Containment involved pumping the seepage water from a seepage containment pond (located immediately below the tailings pond dam) back to the tailings pond, from where it was run through the mill and chemically treated to precipitate out metals and cyanide. By 2005, levels of cyanide, bio-available (dissolved) arsenic, ammonia, and heavy metals had decreased to levels where the water could be released to the environment without treatment.

Current management of the tailings water ensures that water is only released into Dome Creek when it meets water license standards.

Further decommissioning of the site is currently being planned. The major outstanding environmental issues include accumulation of metal-contaminated water in the Brown-McDade open pit, as well as the fate of the tailings stored in the tailings pond. Beginning in 2004, studies have been undertaken to evaluate the water balance and potential for existing contamination in the pit to contaminate local ground and surface waters. Levels of metals above CCME water quality guidelines were found in Pony Creek downstream of the Brown-McDade pit; however, these elevated levels are thought to be attributable to an area of waste rock fill where the flow from Pony Creek temporary disappears to groundwater through the waste rock (Gartner Lee, 2005). Ongoing water balance research is currently underway to develop a more comprehensive understanding of the geochemistry and hydrology of this site.

There are a number of different options being considered to address the tailings pond area. Several of these options were identified by Denholm et al (2000); however, final decisions on closure will depend first upon the outcome of the water balance and contaminants assessment currently underway for the Brown-McDade pit. Once a clear understanding of the terrestrial and aquatic effects of the minesite have been developed,

[1] During the fall of 1999, untreated water was released until December 1999, due to a short term exemption from toxicity testing requirements.

reclamation activities can be properly planned. Feedback from the community will be instrumental in planning for final reclamation of the site.

1.3 Background Geology

The Mt Nansen property is situated within the southern part of the Dawson Range, a part of the Yukon Plateau Physiographic Province in the central Yukon. The area is located within the western boundary of the Yukon Crystalline Terrain, a fault-bounded tectonic terrain package that is dominated by schists and gneisses.

The area is dominated by gently rolling upland that transitions to high standing outcrops at irregular intervals. The area escaped the last major glaciation (Pleistocene) and appears to have avoided significant erosion, since at least Cretaceous time. Because of the apparent lack of glaciation and erosion, felsenmeer or broken rock on surface is generally mapped as representative of the underlying bedrock. Surficial weathering (oxidation) has been noted to be deep; measuring up to tens of meters as observed in drill cores (Carlson, 1987).

Local geology affects the soils and the plants.

Soil development is generally poor across the property; typically represented by several centimeters of organics overlying layer of volcanic tephra, which itself overlies decomposed bedrock. Unconsolidated alluvium has been mapped on the property, principally occurring in the Victoria and Nansen Creek Valley bottoms. Loess and volcanic ash have been observed in scattered patches throughout the property. The loess occurs as fine sand mantling some of the lower slopes. White ash appears as a few centimeters of soil exposed in road cuts, and is postulated to be from a recent eruption (1,230 years ago) in the Wrangell Mountains to the northwest. North facing slopes are typically permafrost-bound, as evidenced by thick moss cover and stunted conifers. The south facing slopes are well drained and can be grassy to barren of vegetation.

The geology can be simply divided into three main categories: basement metamorphic schists and gneisses, intruded by early Jurassic foliated plutonic rocks, followed by early Cretaceous to Paleocene plutonic and related volcanic rocks. There are no younger sediments mapped in the area, signifying considerable erosion of the landscape at some point in the Cretaceous time.

1.3.1 Property Geology

Specifics of the geology may help explain some of the results from this study.

The oldest rocks mapped on the property are found to the east of Victoria Creek and throughout the southern one-third of the property and belong to the Upper Paleozoic or older metamorphic assemblage known as the Basement Metamorphic Complex (Figure 1.3). These rocks regionally are comprised of metamorphosed and deformed sedimentary, volcanic and plutonic rocks. Locally, the unit is represented by quartz-feldspar-mica schists of meta-sedimentary affinity that outcrop in the southeast part of the property and are characterized by micaceous quartzite in bands of interlayered coarse mica. Another unit of the basement complex has been identified in an outcrop on the south and western part of the property. These rocks are biotite-quartz-feldspar schists for which the protolith is unknown but are postulated to be meta-volcanics. These rocks are comprised of a layered succession of quartzofeldspathic schists and plagioclase gneisses that exhibit a strongly developed foliation parallel to metamorphic banding.

The basement rocks are themselves intruded by Early Jurassic meta-plutonic rocks of the Mount Freegold Suite. The suite is dominated in the northeast quadrant of the property by plagioclase-hornblende monzonite and is generally strongly foliated. The emplacement of the suite likely caused the latest metamorphism of the basement crystalline schists.

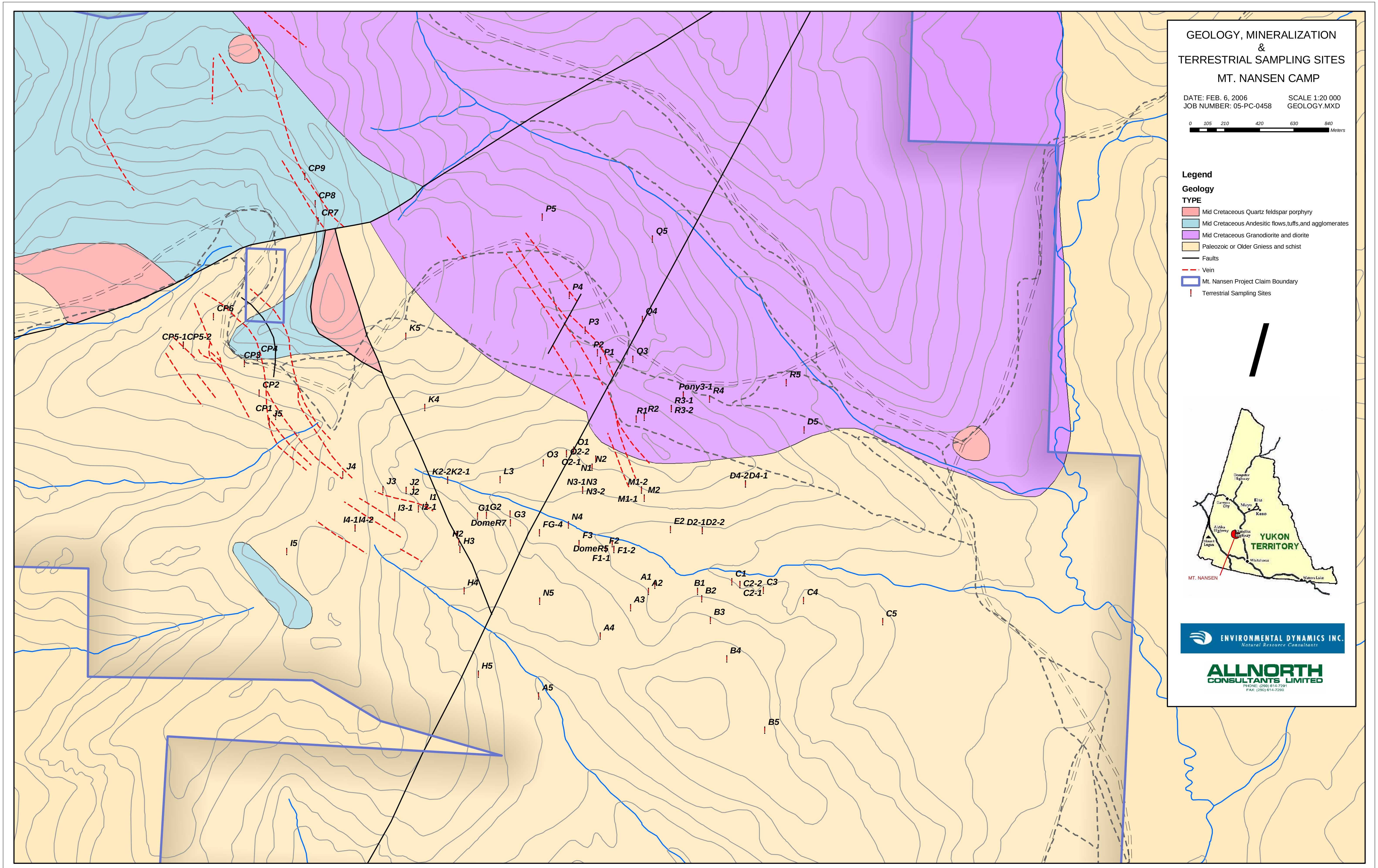
Early Cretaceous time saw the advent of regionally significant and extensive plutonism marked by the intrusion of the Dawson Range Batholith. In the Mt. Nansen area, the batholith is represented by the Casino granodiorite which is mapped mainly in the central and north central portion of the property. The rocks are comprised of biotite-hornblende granodiorite, are recessive in nature and are generally visible as irregular outcrops.

The northwestern most portion of the property is underlain by the Mount Nansen Volcanics, a suite of mainly andesite to latite flows and feeders. These rocks are Cretaceous or younger in age and have been postulated to be cogenetic with the Casino Granodiorite. The suite at Mt. Nansen is dominated by dark green to black fine-grained andesites with visible feldspar laths up to 2-3 mm in size. The rocks exhibit vertical, possibly columnar jointing in outcrop. Near the western edge of the property a sub-unit of volcanic breccia has been mapped. The origin of this sub-unit could be either intrusive or extrusive.

Cretaceous age porphyry dykes and stocks of the Mt. Nansen Site are found in the center of the property and bordering the northwestern edge of the property. The rocks are mainly porphyritic and show a wide range in composition, from intermediate to felsic. They are typically extensively altered and have a relatively high content of pyrite.

A variety of mineral deposits have been documented on the property, including porphyries, veins and placers. The dominant mineralization found to-date is gold- and silver-bearing quartz veins within the Brown-McDade and Heustis-Webber zones. These zones appear to be structurally associated with localized, northwesterly trending faults and shear zones where the favorable Casino Granodiorites or Mount Nansen volcanics are in contact with the basement rocks. There is also a strong spatial association with the porphyry dykes, suggesting the mineralization may therefore be late Cretaceous in age. At least one age date from the Heustis vein reveals an early Cretaceous date, so the actual timing is uncertain (Carlson, 1987). The porphyry system seems to be the locus for mineralization, and farther from the porphyries, the mesothermal precious metal veins and breccias developed. The mineralizing fluids were low in base metals. The mineralization at Brown-McDade is characterized by pyrite and arsenopyrite with minor chalcopyrite, galena, tetrahedrite, sphalerite and stibnite, in a northwest trending shear zone that cuts the Casino granodiorite. The Webber-Huestis veins occupy northwest trending shear zones which cut schistose rocks of the basement metasedimentary suite.

Economic minerals of interest at the Huestis-Webber zone include pyrite and arsenopyrite, with minor galena, chalcopyrite, sphalerite and some sulphosalts.


GEOLOGY, MINERALIZATION
&
TERRESTRIAL SAMPLING SITES
MT. NANSEN CAMP
DATE: FEB. 6, 2006
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JOB NUMBER: 05-PC-0458
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Legend
Geology
TYPE
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Mid Cretaceous Andesitic flows,tuffs,and agglomerates
Mid Cretaceous Granodiorite and diorite
Paleozoic or Older Gniess and schist
Faults
Vein
Mt. Nansen Project Claim Boundary
Terrestrial Sampling Sites
Dempster Highway
Dawson City
Mayo
Elsa
Keno
Alaska Highway
Klondike Highway
Mount Logan
YUKON TERRITORY
Whitehorse
Watson Lake
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2.0 METHODS

2

The methods presented in this report were developed by the project team with the assistance of many study advisors (see acknowledgements).

2.1 Community Survey

Community members were surveyed to determine what types of plants and animals are harvested in the vicinity of the minesite so that these could be collected and tested.

In late August 2005, a community survey was conducted in association with the Little Salmon Carmacks First Nation (LSCFN). A researcher from the First Nation (Leta Blackjack) assisted *Environmental Dynamics* staff in identifying, locating and interviewing local people. A total of 15 surveys were completed, targeting community members who used the resources within the study area. Survey participants were questioned in relation to the use of renewable resources within a 15 km radius of the Mt. Nansen minesite to determine the species of plants, animals, and fish that are harvested, or have been traditionally harvested, within this area. The survey also investigated the extent of use, general location, timing, and food parts consumed. In addition, individual's concerns regarding the minesite and perceived effects were also discussed. The information gathered by the survey was used to determine what species would be collected and analyzed. A summary of survey results is presented in Appendix A.

2.2 Study Design

Three potential sources of contamination were identified: the Tailings Pond, the Mill Site, and the Brown McDade Pit.

The findings of the Community Survey were further built upon through a two day visit to the mine site with LSCFN elder Clive Blackjack. Mr. Blackjack's Traditional Knowledge current and past use of the area by LSCFN members aided the project team in understanding and fine-tuning the study design. This was of particular relevance in terms of the final selection of species for collection/analysis.

The minesite has three potential sources of contamination; the tailings facility (including tailings pond and seepage pond), the Brown-McDade pit (with associated waste dumps), and the mill site including stockpiles of low-grade ore material adjacent to the site (photos 2.1 to 2.4). The tailings contain high concentrations of silver, arsenic, barium, copper, iron, manganese, lead, antimony and zinc; however, of these only arsenic and antimony appear readily leached (Conor Pacific 2000). While no analytical results for the waste rock dumps could be located, the Brown-McDade pit walls have high concentrations of silver, arsenic, barium, cadmium, chromium, copper, iron, manganese, lead, antimony and zinc (Conor Pacific 2000). Nicholson (2002) found some elevated arsenic levels in lichens and plants directly adjacent to the potential sources of contamination.

Metals were selected for analysis as they can accumulate in ecosystems.

Pathways for movement of contaminants from the three sources include aerial (from wind) or aquatic (water). Dome Creek and to a lesser extent, Pony Creek,[2] are potential receivers and transport pathways of contamination. The objective of this study was to determine whether or not elevated levels of metals currently exist in the terrestrial and

[2] Pony Creek is a potential receiver because of connection via the open adit which connects to the flooded surface workings in the Brown McDade pit.

aquatic ecosystems within the vicinity of these sources/pathways of contamination and also whether or not ongoing contamination is continuing. This has, in-turn, allowed the spatial extent of such contamination as well as any relationship to the mine and/or past mine operations to be evaluated.

Tailings Pond

Photo 2.1. Northwest view of main tailings pond during low to moderate water levels (late Aug 2005). Waste dumps around the Brown-McDade Pit in background.

Brown-McDade Pit

Photo 2.2. Southeast view of the Brown-McDade Pit and the surrounding area.

Mill site

Photo 2.3. West view of mill site from tailings pond.

Photo 2.4. Low-grade ore stockpile adjacent to mill site (west view; tailings pond in background).

Waste Rock Pile

Another area that was investigated was a prominent area of blackened (dead) vegetation that is present on the banks of Dome Creek. On the right bank (south), this area extends from the seepage pond downstream for approximately 500 m. The area of blackened vegetation on the left bank of Dome Creek begins approximately 75 to 100 m downstream from the seepage pond dam and continues for approximately 150 m to 200 m where it is patchy and inconsistent. The width of the blackened vegetation is approximately 4-5 m.

Blackened vegetation adjacent to Dome Creek was investigated.

Photo 2.5. Downstream view of Dome Creek below seepage pond. Note the blackened vegetation on the right bank.

Photo 2.6. Up-close view of blackened vegetation on right bank of Dome Creek.

2.3 Sampling

The study included both terrestrial and aquatic components. Each component required the collection of samples that would be later analyzed for metal concentrations. Members of the LSCFN worked with Project Team members to collect the samples during the fall of 2005. First Nation workers were trained in proper sampling protocols, and while in the field provided additional insight into the dynamics of plants, animals, and human use relating to the area. The rationale and specifics of each sampling component of the study is presented in the following sections. Figure 2.1 summarizes the sampling components.

Members of the Little Salmon Carmacks First Nation worked with the Project team to collect the samples.

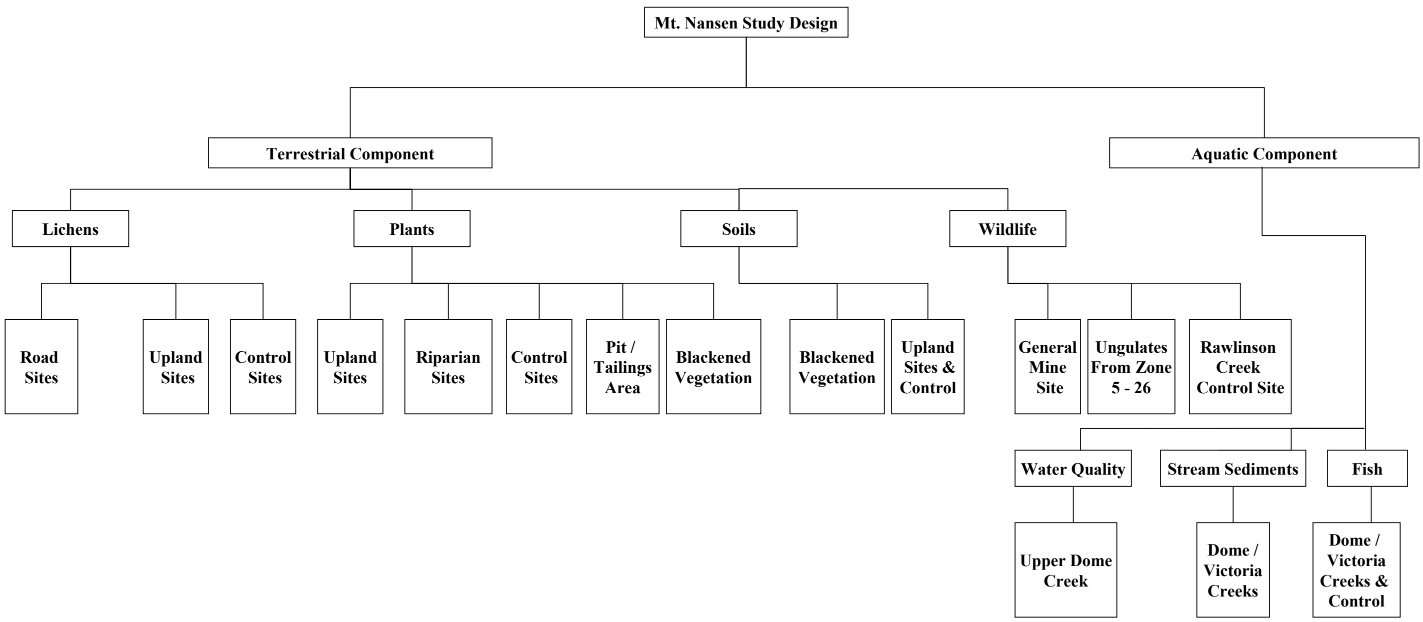


Figure 2.1. Summary of the structure of the Terrestrial and Aquatic Effects study.

2.3.1 Terrestrial Effects

Plants, animals, and soils were sampled to determine terrestrial effects.

The terrestrial ecosystem within the vicinity of Mt. Nansen could potentially be impacted through both aerial and aquatic pathways. Accordingly, both upland sites (subject to aerial contamination) and riparian sites (subject to aquatic contamination[1]) were sampled. In addition, metal uptake could occur as a result of vegetation growing directly on waste materials; therefore, plants growing directly on tailings and waste rock were sampled.

Lichens, vascular plants, soils and animals were investigated to evaluate metal contamination within the terrestrial component. At upland sites, lichens, vascular plants and soils were sampled to assist in the determination of airborne contamination. At riparian sites, vegetation was sampled to determine the presence/absence of contaminants from the aquatic environment (Note: the Aquatic Effects component also evaluated aquatic pathways.) Various small and large animal tissues were collected near the mine site. Animal samples were also collected from a control area situated outside the influence of the mine site (Rowlinson Creek; Figure 1.1).

Transects for sampling lichens, plants and soils were set-up radiating in several directions from each of the potential sources of contamination.

Eighty upland sample plots were established along 18 transects (Figure 2.2). Six transects radiated outwards from each of the three main "point" sources of potential contamination (labeled as A-R). Point sources were the tailings pond, the mill site, and the open pit/waste rock dumps. The first plot (labeled 1) on each transect was located in natural vegetation immediately adjacent to the disturbances. From here, additional plots were established at distances of 50, 200, 450 and 950 meters from the first plot (labeled as 2-5, respectively), and their exact location was recorded by GPS. Some adjustments were

[1] It should be noted that riparian sites could also be subjected to aerial contamination; however, they were sampled due to the possible effects of aquatic contamination.

made where transects radiating from point sources intersected one-another. This pattern allowed for inspection of the contamination immediately adjacent to the disturbances and for spatial analysis in all directions. The outermost plots on many transects were located outside of the Dome and Pony Creek watersheds and thus should provide a certain degree of control information (assuming that the contamination has not reached these points). All sampling was conducted within a 10 m radius of each plot site.

Vegetation samples were taken from a variety of other plots (see Figure 2.3). An additional nine upland control plots were sampled, three in each of the following documented areas of mineralization: the Spud, Webber and Flex zones. These sites provided reference samples for comparison within known areas of mineralization that are similar in structural and mineralogical style to the Brown-McDade zone. It should be noted that although these control areas have not been mined, there has been some surface disturbance resulting from exploration in the area.

Control plots were established in areas of mineralization.

In order to evaluate potential road dust impacts, three further upland sample sites were established immediately adjacent to the main access road between the Dome Creek crossing and the mill site.

Four plots sampling riparian vegetation were located on Dome Creek at a 300 m spacing between the tailings seepage impoundment and the Mt. Nansen road (DOME 1 – 4). A further three plots (DOME 5-7) were located on Dome Creek between the tailings pond and the mill site. Three plots were located along Pony Creek (PONY 1-3), downstream of the minesite. Three plots were established to sample the blackened vegetation and soils located along Dome Creek below the seepage impoundment where it occurs alongside each riparian site (BVEG 1-3). Sampling of vegetation (willow, wheatgrass, & foxtail) growing directly on the tailings, the Brown-McDade pit (and associated waste rock piles) was also conducted. This included random sampling along the "beach" or pond side of the tailings pond dam, as well as sampling from five plots within the pit itself and from three plots in the overburden surrounding the pit.

Several riparian plots were located along Dome and Pony creeks.

2.3.1.1 Lichens

The potential for airborne dispersal of metals was investigated in detail through sampling of lichens. As lichens mainly receive nutrients from air and rainfall, they are excellent indicators of airborne contamination. A total of 102 lichen samples were collected. Caribou moss (*Cladina mitis)* was collected from each upland sample site location (see Figure 2.2). This lichen species not only provides an indication of airborne contamination, it is also used by the LSCFN for medicinal purposes and by caribou as a food source. Lichens were collected using unpowdered gloves, which were replaced with new uncontaminated gloves for each sample site. Several lichens at each location were combined into one sample for composite analysis. Non-lichen material was removed from the samples to ensure that only lichen material was analyzed. Replicate and duplicate samples (submitted in a blind manner to the lab) were collected for quality assurance /quality control (QA/QC). Samples were placed in new zip-lock plastic bags, frozen and shipped to the lab for analysis.

"As lichens mainly receive nutrients from air and rainfall, they are excellent indicators of airborne contamination."

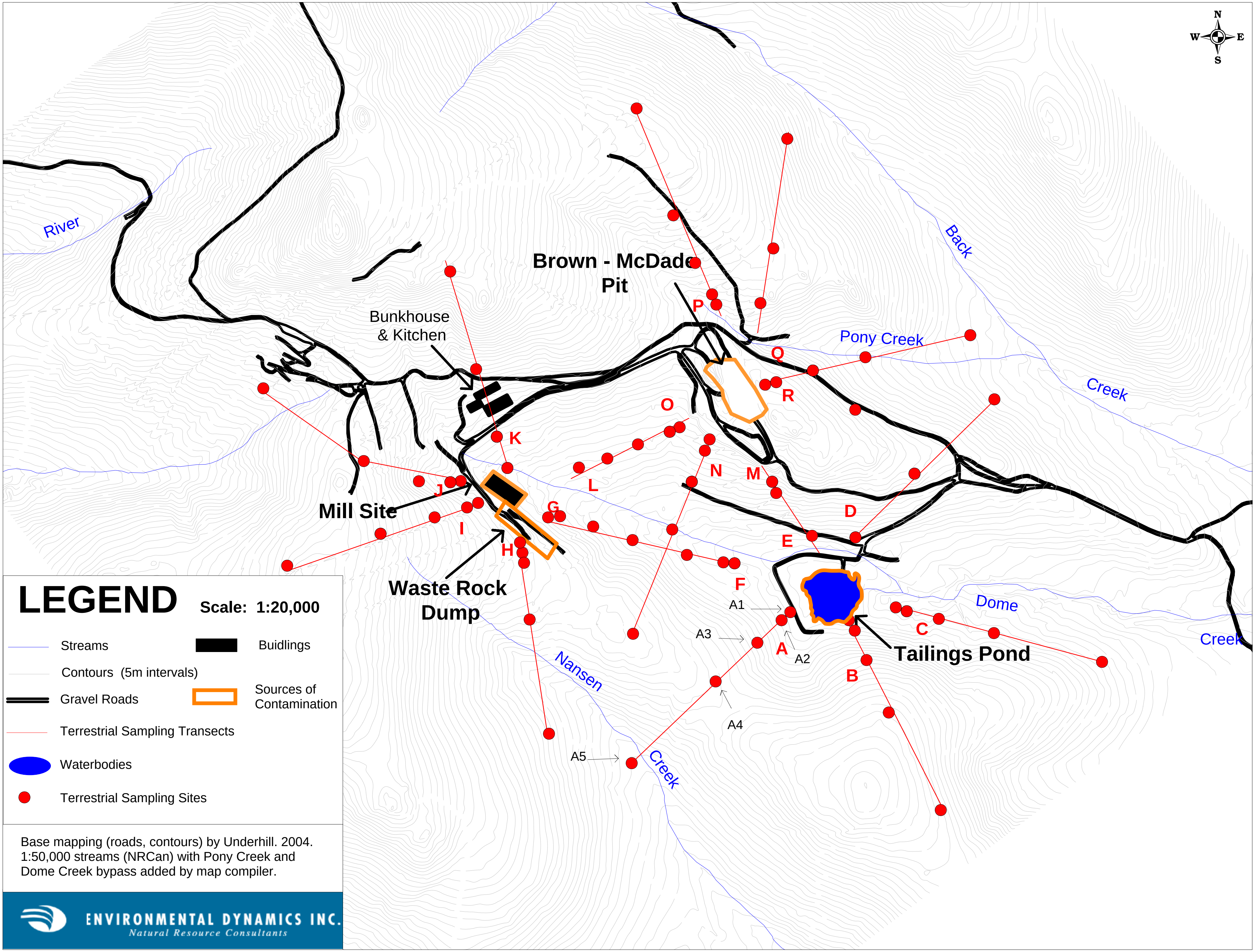


Figure 2.2. Map of transect vegetation and soil sampling locations.

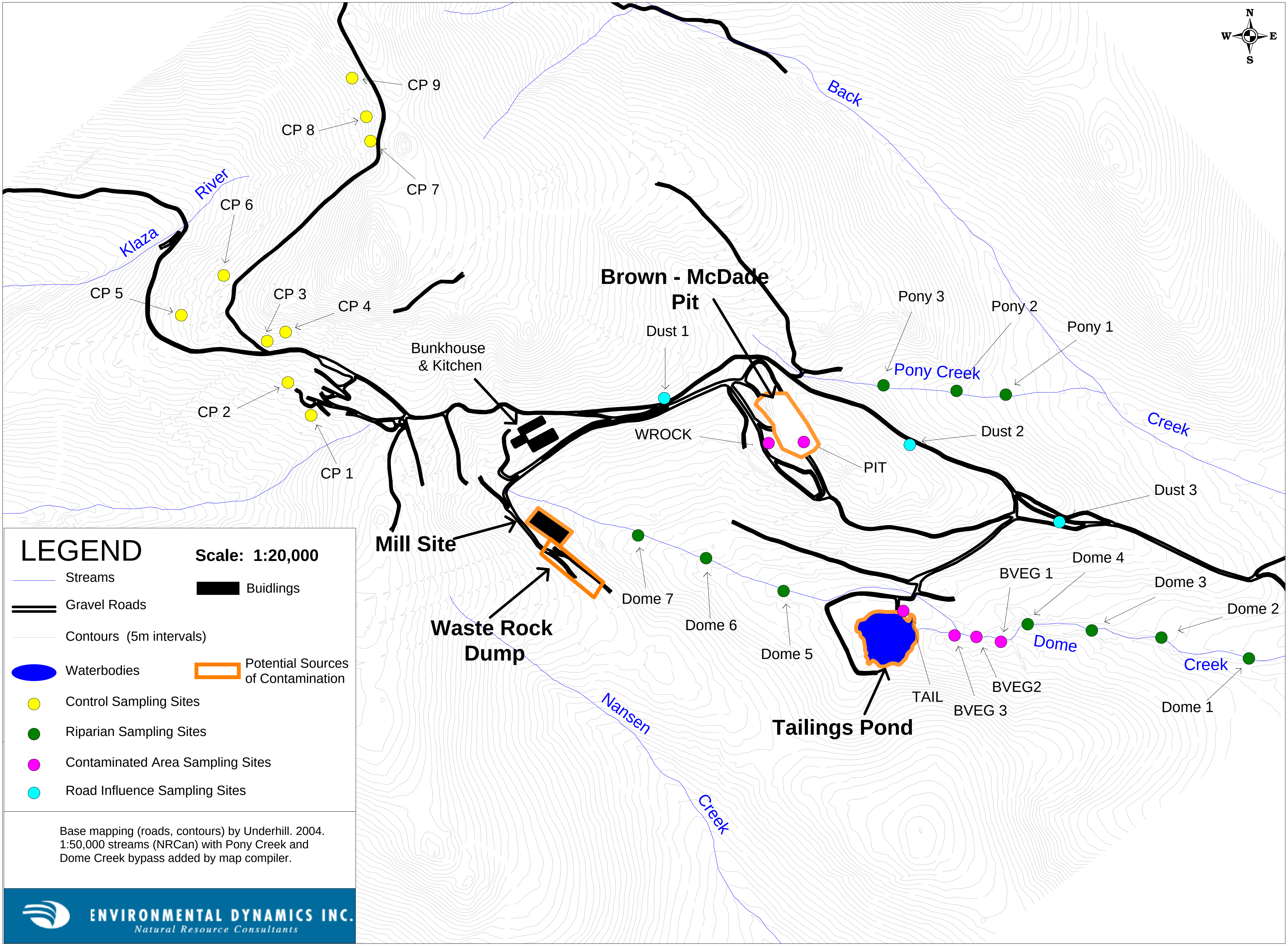


Figure 2.3. Map of supplementary vegetation and soil sampling locations.

2.3.1.2 Berries/Plants

At each upland site, significant occurrences of the species listed in Table 2.1 were also collected. These plant species were chosen based upon a review of existing information and as species of importance to the LSCFN. Samples were collected on an opportunistic basis at the riparian sites. Composite samples taken from a number of plants within the general vicinity of the sample site were collected (using the same protocol as for the lichens). Replicate samples were taken for 5-10% of the sites. In addition, some duplicate samples (split of the same sample) were submitted in a blind manner to the laboratory. Plant samples collected were frozen and stored prior to laboratory analysis. Samples were selected for analysis following the receipt of initial results from the lichen component of this project. At least one sample was sent from each plot with additional samples being sent from areas with high metal levels in lichen data.

Table 2.1. Species of vegetation sampled.

Species (Code)	Scientific Name	Portion of Plant/Lichen Utilized by Humans
Blueberries (VAUL)	*Vaccinium spp.*	Berry (leaf for medicinal)
Labrador Tea (LELA)	*Ledum groenlandicum and/or L. decumbens*	Shoot (used for tea)
Crowberry (EMNI)	*Empetrum nigrum*	Berry
Lowbush Cranberry (VAVI)	*Vaccinium vitis-idaea*	Berry
Bolete mushroom (BOSP)	*Leccinum spp.*	Stem
Rose (ROAC)	*Rosa spp.*	Fruit
Caribou Horn Lichen (MARI and MAHA)[1]	*Masonhalea richardsonii*	Whole plant (used for tea) also food source for caribou.
Willow (SASP)	*Salix spp.*	Leaf, bark, branch (food source for moose.
Spruce, Black /White (PIGL)	*Picea spp.*	Fresh pitch/sap
Trembling Aspen (POTR)	*Populus tremuloides*	Leaf
Wheatgrass (WHGR)	*Agropyron sp.*	Not used; however, abundant within pit and tailing facility.
Foxtail Barley (HOJO)	*Hordeum jubatum*	Not used; however, abundant within pit and tailing facility.

Plants parts used by community members were collected from the area.

A number of other species were identified as important to LSCFN members for subsistence use (as listed in Appendix A); however, these species were not found in the Mt. Nansen area and therefore were not sampled.

2.3.1.3 Soils

[1] The two codes used for caribou horn lichen reflect those used in the field and subsequently in laboratory analysis. They reflect no differences in the samples collected.

To support the lichen and plant analysis data, soil sampling was also conducted at all upland sites. Samples were taken from various soil layers, as available at each site. At each upland plot, 125 ml samples were collected from each of the top three horizons (as available). As ash (volcanic) was present at most sample sites (80-90%), it was sampled as one of the respective horizons, usually the second or third. In each case, a sample was taken from the soil layer below the ash. Sampling soil stratification by depth allows for further evaluation of the significance of airborne contamination as well as providing a thorough understanding of natural levels of metals. Soil samples were collected using stainless steel shovels and trowels. The samples were then placed in glass jars provided by the laboratory. Replicate samples were taken for 5-10% of the sites for QA/QC purposes.

Soils may provide a better understanding of natural and mine related metal levels.

Laboratory analysis was completed on a selected portion of the soils, based on the lichen results. Soils were analyzed from plots with high metal (lead and arsenic) levels in lichens and from plots located within the blackened vegetation.

2.3.1.4 Wildlife

Tissue from wildlife may indicate if certain contaminants are being transferred to primary and secondary consumers or bio-magnifying in the food chain. While most of the animals hunted by people in the area are big game species, there was significant value in sampling small mammals that spend most, if not their entire, lives within close proximity to the minesite (Figure 1.1). These animals can provide an important indicator of contamination that can clearly be attributed to the minesite itself. Various small mammal species were targeted due to their importance in the food chain (see Table 2.2).

Table 2.2. Targeted wildlife.

Type of Wildlife	Rationale for analysis
Small Mammals (voles, shrews, squirrels)	An important food source of many other animals, and are likely to spend most of their lives in a small area (i.e.: close to the minesite).
Small Game Species (grouse / ptarmigan and porcupine)	An important food source for larger wildlife as well as people.
Large Game Species	Food source for people.

It is important to test animal tissue as contaminants can build up in the food chain (bio-magnification).

2.3.1.4.1 Trapping Program

Small mammals were trapped within 500 m of the three main potential sources of aerial contamination (the tailings pond, the mill area, and the pit). Small mammals were also trapped in a control area near Rowlinson Creek, approximately 20 km from the minesite (see Figure 1.1). Generally speaking, small mammals have restricted home ranges, making them good indicators of contamination accumulation. As small mammals must be sacrificed for analysis of contaminants, two lethal sampling approaches were used. Snap traps and pit fall (drowning traps) traps were set at each sampling site.

Small mammals were trapped from the minesite and from a control area (Rowlinson Creek).

The snap traps were of various sizes (i.e. normal mouse trap and rat trap size) and were baited with various baits to target a variety of species. The traps were set on the ground and in trees within a variety of habitats. These traps caught 27 voles, a red squirrel, a ground squirrel, and 8 gray jays (*Perisoreus canadensis*; as a by-catch). It was hoped that weasels would also be obtained (as per recommendations by Jung, 2005), as they would represent a sample from higher on the food chain (carnivores) and therefore provide an indicator of any possible biomagnification of metals. However, no weasels or other predatory animals were captured. While gray jays were not targeted species, they may also provide some insight into site contaminants. Gray jays are not migratory and Alexander et al. (2003), documented a 23.2 ha breeding territory in a study conducted in the Kluane Lake area. They are omnivores (eat both plants and animals) and thus may also function as accumulators of contaminants.

Pitfall traps, consisting of a bucket dug into a hole on a natural pathway, were filled with distilled water to target shrews. Five shrews were captured in this effort. Shrews, due to their feeding habitats (insectivores with a very high metabolism), are classified as good indicators of monitoring contaminants in terrestrial environments (Hirvi, Henttonen and Suortti 2005).

2.3.1.4.2 Collection of Samples from Hunters

Efforts were made to collect samples from hunters.

While it was expected that small mammals would provide the most insight into contamination uptake, significant efforts were expended to obtain small game species (grouse/ptarmigan), porcupines and larger mammals that are consumed by humans to address possible concerns about potential contamination. Animal parts were obtained from species that were harvested in the area for analysis of metals contamination.

Samples were obtained from five caribou and two moose.

Attempts were made to obtain any samples available through the Northern Contaminants Program from organs (kidneys and liver) and tissue that was turned in to Yukon Environment under the current voluntary programs to collect and analyze ungulate parts (as outlined in the hunting regulations). However, no samples were submitted to the program from the study area in 2005. It should be noted that the contaminants program was able to provide the study team with data from some animals collected in the past and did allow access to additional samples that they have in stock. To inform hunters of the Northern Contaminants Program as well as the Terrestrial Effects study, the study team posted a sign on the Mt. Nansen Road. This information was also distributed to the community of Carmacks as well as in the town newsletter (The Hooter). The study team obtained samples from two caribou (2 samples) and one moose (3 samples) through the local community. In addition, one moose (2 samples) and three caribou (7 samples) that were in storage were provided by the Northern Contaminants Program.

2.3.1.5 Aerial Contamination

Moss bags were deployed to determine the extent of on-going aerial contamination.

Moss bags are a standard low-technology method for assessing both dry and wet (i.e., airborne and precipitation-based) deposition of airborne contaminants (Temple *et al.*, 1981). Moss bags were assembled following the protocol outlined by Temple *et al.* (1981). Golden fuzzy fen moss (*Tomenthypnum nitens*) was collected from the Rowlinson Creek area. The moss was sent to Cantest's Soilcon Laboratories for rinsing, drying, homogenization and analysis of pre-exposure metal concentrations. Soilcon constructed the moss bags from polypropylene mesh about 2 mm in size secured with nylon zip ties. Each bag contained approximately 3 g dry weight of moss. Moss bags were hung between tree branches with nylon zip ties on October 13, 2005 around the sources of contamination and at the Rowlinson Creek control site. The Rowlinson Creek site was chosen as a control in this case due to the convenience of its location as well as its certain isolation from any possible contamination from the Mt. Nansen Site. As this timing coincided with freeze-up, an expected time of little or no aerial contamination, the moss bags were not recovered. Rather, the intention is to recover these prior to spring melt and replace them with new ones.

2.3.2 Aquatic Effects

The aquatic effects component focused on determining levels of contamination in water, sediments and fish. Generally, efforts were focused on fish and sediment, as they provide the most insight to longer-term effects (i.e., compared to water quality sampling).

The aquatic component focused on sediments and fish and to a lesser extent, water quality.

2.3.2.1 Water Quality

The Yukon Government has conducted comprehensive water quality sampling programs since 1999, when BYG ceased operations at the site. Due to the extensive volume of existing water quality data, additional water quality sampling sites were positioned only in areas where past and present sampling information does not exist. The water sampling component of this study focused on 3 sites on Dome Creek upstream of the tailings pond (D1, D2 and D3; Figure 2.4). Water samples were collected using bottles provided by the laboratory (ALS Environmental), including separate bottles for total metals, dissolved metals, ammonium N, and other parameters. The samples for total metals were preserved using nitric acid, and ammonium N was preserved with a sulphuric acid solution, both provided by the lab. Laboratory methods are described in Appendix J.

Yukon Government has/are completing regular water sampling events around the minesite.

Additional samples were collected from three sites.

2.3.2.2 Sediments

Sediment sampling was completed in many of the same locations as the Conor Pacific (2000) study, similar to previous water license sampling requirements. Temporal comparisons to past sediment sampling results were thought to provide a good indication of the recent effects of the mine. Samples were collected (with stainless steel trowels) from depositional areas, dried and screened though a 100-mesh sieve (as outlined in the water license protocol). The sites sampled are presented on Figure 2.4. Samples were analyzed for metal concentrations using a strong acid leachable test (see Appendix K for more details). In addition, for some samples, a partial digestion analysis was completed to determine the metals that were weakly bound to the sediments (see Appendix K for additional details on laboratory methods).

Sediment samples were collected from Dome and Victoria creeks.

2.3.2.3 Fish

Slimy sculpin (*Cottus cognatus*) was chosen as the primary species used to monitor metal concentrations within the aquatic environment in the vicinity of the Mt. Nansen Mine because it is less mobile and less migratory than other fish in the region. Small-bodied fish, such as the slimy sculpin, are generally recommended for use as an indicator species, primarily due to the increased probability of longer exposure times as a result of reduced mobility and their non-migratory nature. Sculpin were collected via electrofishing from a number of sites within and outside the influence of the minesite (Figure 2.4). Other species known to occur in the Victoria Creek watershed (Arctic grayling and burbot) are either highly mobile or migratory or are found in lower densities, all of which makes them poor choices for monitoring metal contamination. As the LSCFN and other local community members do harvest Arctic grayling and burbot, some samples in the areas of greatest concern (Victoria Creek near mouth of Dome Creek) were collected. Due to their small size whole slimy sculpin were analyzed, while for Arctic grayling and burbot, liver, kidney and flesh were analyzed as available. It should be noted that the lower portion of Dome Creek was sampled for fish; however, none were captured[1].

Slimy sculpin do not migrate long distances and as such are good indicators of point-source contamination.

Grayling were analyzed to determine the safety of eating these species.

[1] There was a small waterfall at the lower end of Dome Creek that would pose a barrier to fish migration, especially during low flows.

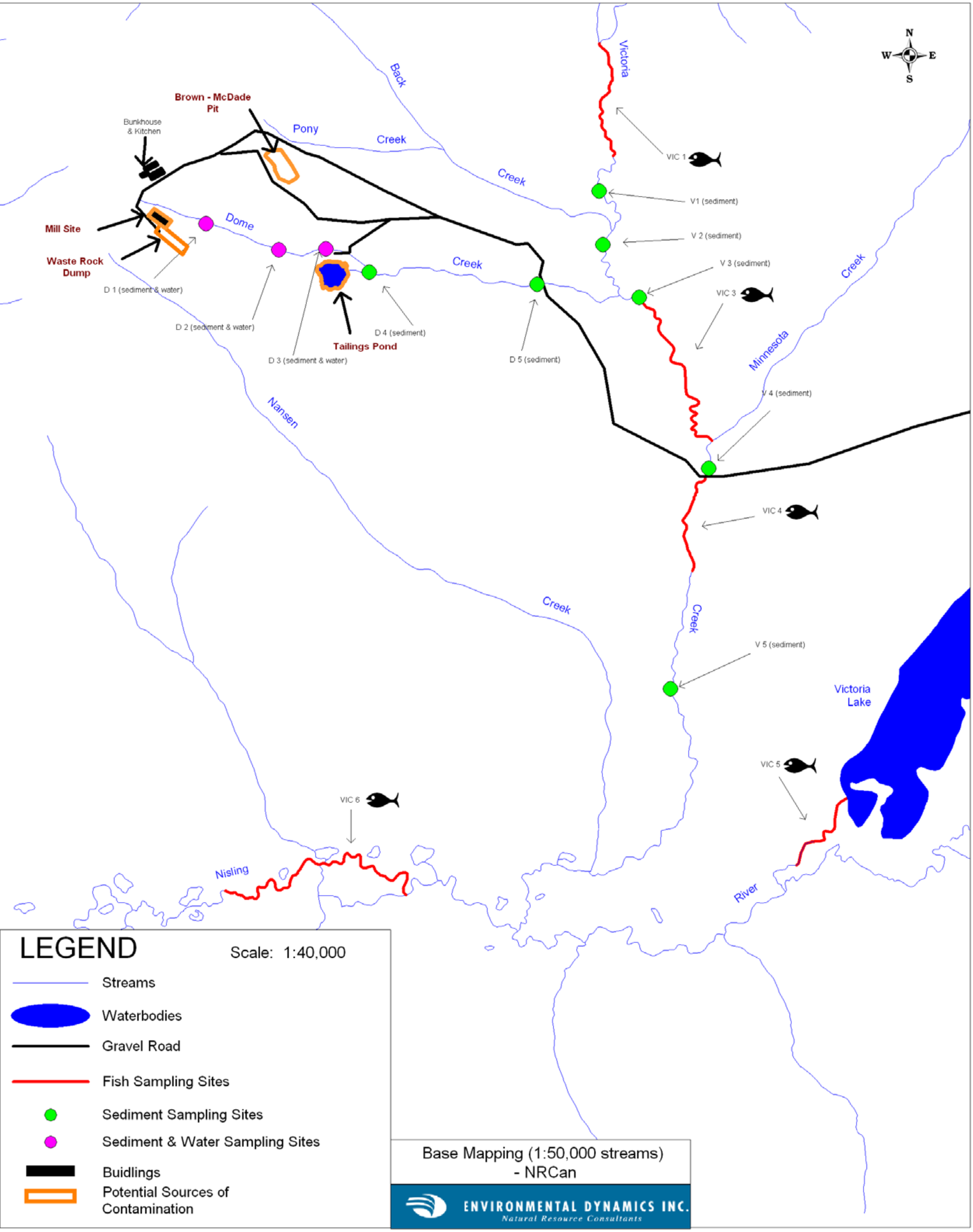


Figure 2.4. Aquatic sampling locations.

2.3 Analysis Summary

Table 2.3 shows the number of samples collected and analyzed. Adaptive management was required in some cases to decide which samples to analyze in order to address specific questions as they arose.

Rationale, types and numbers of analyzed samples.

Table 2.3. Category, objective and number of samples collected and analyzed.

Category	Objective	Laboratory Analysis Parameters	Number of Samples Collected	Number of Samples Analyzed
Lichens	To determine the presence and extent of airborne contamination.	Metals ICP-MS[1]	102	102
Soils	Assist with determining the presence and extent of airborne contamination. Confirm lichen results and determine natural non-mine related sources.	Metals ICP pH	262	72
Berries/Plants	Determine if plants and berries are safe to eat.	Metals ICP-MS	407	221
Blackened Vegetation	Determine what impacted the blackened vegetation on bank of Dome Creek.	Metals ICP-MS Cyanides & Nutrients	3	3
Soils at Blackened Vegetation site	Determine if whatever impacted the blackened vegetation has also impacted the soils.	Metals ICP-MS & Nutrients	10	10
Small Mammals	Investigate extent of metal accumulations in the food chain.	Metals ICP-MS	44	29 (many combined)
Ungulates	Investigate extent of metal accumulations in the food chain. Determine if they are safe to eat.	Metals ICP-MS	6 plus 8 from Northern Contaminants	14
Fish	Determine impacts on fish and fish consumption.	Metals ICP-MS	35	32 (some combined)
Sediment	Determine if metals are accumulating in sediments.	Metals ICP	21	40[a]
Water	Answer specific questions pertaining to point sources.	Metals ICP-MS Cyanides Nutrients Conductivity / pH / temperature	3	3
Moss Bags	Determine if airborne contamination is on-going	Metals ICP-MS	16 moss bags deployed	3 analyzed to date

[a] 21 samples were analyzed for strong-acid extractable by Cantest, 10 by Norwest and 9 for weak acid extractable by Norwest.

As outlined in the previous sections, all samples were collected using appropriate field sampling protocols to prevent contamination. Laboratory analysis for most samples was completed by Cantest Ltd. in Burnaby, BC. To allow for consistency of the current water quality-monitoring program, ALS Environmental, in Vancouver, BC completed the water

[1] ICP-MS (Inductively Coupled Plasma Metals Scan) was completed for 33 metals.

sample analysis. Norwest Labs, in Surrey, BC completed some of the sediment analysis. NLET laboratories, from Burlington, ON completed the ungulate analyses. Refer to Appendix H and J for detailed laboratory methods.

Replicate samples for QA/QC were taken at approximately 5 to 10% of the total number of sample sites. Duplicate splits (split of one sample; submitted blind to the lab) samples were submitted for most components. In addition, the three accredited laboratories completed the appropriate internal QA/QC requirements. QA / QC can be defined as Quality Assurance and Quality Control and is a conducted by collecting duplicate samples at a number of sampling location. Essentially, QA / QC confirms the accuracy of sampling and laboratory analysis.

3.0 RESULTS

3

Data were compared to Yukon background data and control sites.

Some variability was found between samples which is likely reflective of natural variation.

Analytical results are presented in the following sections. Data were compared to previous metal analyses conducted in the Yukon to provide a spatial context to the results. Further comparison to control site data was concentrated on metals that were above Yukon background levels to provide greater site specific context. Regression analyses were also applied to the results from this study to determine their statistical significance. The results section is divided into the terrestrial and aquatic ecosystem components.

Quality control included collection of replicate samples and duplicate splits as well as standardized laboratory QA / QC procedures. The data from the replicate samples (two field samples collected from the same site; Appendix B shows some variability; however, most metals exhibit relative percent difference (RPD) less than 20%. For lichens, there were some results between 20% and 71% (RPD), which was attributed to natural variability between plants. For plants, RPD was generally lower than lichens and generally lower than 50% with the exception of samples collected from the tailings pond. This is likely attributable to the low density of plants within the tailings pond requiring the replicate plant samples to be collected over a spread-out area. Replicates of soils had up to 65% RPD while sediments were below 20% for all metals where the results were greater than 5 times the detection limits.

Data from the duplicates in the lichen appear to be quite close, only two occurrences of metals were above a 20% RPD, and these had RPD of 24%. Difference for duplicate samples of plants were mainly within acceptable standards (Appendix C); with a few samples ranging up to 64% RPD. The exception was the samples of tree sap (PIGL-P1) which had commonly high RPD. It should be noted that the duplicates for plants were not homogenized (i.e. blended) as would be completed in a lab setting.

The duplicate fish data shows some variability for specific elements, specifically aluminum, barium and chromium, iron, manganese and strontium.

Two different labs analyzed duplicate sediment data. The results indicate that there was some variability especially for certain elements. These include potassium, sodium, strontium and nickel which had common RPD ranging from 20-50%. The results from other elements appear to be more consistent.

Laboratory QA/QC included duplicate splits, the analysis of blanks and duplicate blanks, as well as the analysis of unrelated tissues. The variability between replicate samples can be attributed to natural variability at the sampling sites. In all cases the duplicate split samples, and the duplicate blanks were within limits of 20% RPD and unrelated tissues were within acceptable limits. All laboratory QA/QC results are also presented in Appendices F to J.

3.1 Terrestrial Component

Results from the analysis of lichens, plants, soils and small mammals are described separately in the following sections.

3.1.1 Lichens

The lichen species, caribou moss, was present and thus collected from almost all transect sites, control plots and a few riparian sites. The complete laboratory results from the lichen analysis are presented in Appendix F (including lab QA/QC reports).

Comparing the data from the transect sites to known Yukon ranges (Gamberg 2006) and control sites (from this study) suggests that there are several metal levels that may be elevated within lichen tissues (Table 3.1). Of these arsenic, lead, silver, boron, antimony and uranium were present at levels that were more than 5 times above the highest level recorded in the Yukon (Gamberg 2006). Uranium concentrations, while higher than the Yukon background data, were still quite low compared to the levels of other elements (0.11 ppm[1] maximum). Some lichen samples exceeded the maximum Yukon averages for cadmium, manganese, copper and zinc concentrations. Of these cadmium and zinc were highest from the control sites and manganese was only slightly higher that in the transect sites than the controls (Table 3.1). Of note, all copper samples above Yukon background were located near the tailing facilities.

[1] Results are presented both in parts per million (ppm) and micrograms per gram (ug/g) which are equivalent.

Table 3.1. Lichen metal concentrations (ranges) from Mt. Nansen and other sites within the Yukon (only lists metals that were higher at Mt. Nansen than Yukon background data or control data where no Yukon background data existed).

Metal	Known Yukon Range (Gamberg 2006) (ppm)	2005 Mt. Nansen Control Site Ranges (ppm; n=10)	2005 Mt. Nansen Transect Ranges (ppm)	Comments
Arsenic (As)	0.0818 - 2.5539	0.3 – 9.9	0.3 – 36.9	Highest level 14 times higher than highest Yukon data.
Lead (Pb)	0.398 – 6.839	0.3 – 5.1	0.3 – 39.4	Highest level 5.76 times higher than highest Yukon data.
Silver (Ag)	0.0275 - 0.1781	0.08 – 0.33	0.07 - 3.1	Highest level 17.4 times higher than highest Yukon data.
Boron (B)	1.1 - 1.8	< 2.0	<0.2 – 18	Highest level 10 times higher than highest Yukon data.
Antimony	0.02 - 0.039 (n=6)	<0.1 – 1.0	0.1-3.5	Highest level 89 times higher than highest Yukon data; however, Yukon data limited to 6 sites.
Uranium (U)	0.0039 - 0.0109 (n=12)	<0.04	<0.04 - 0.11	Highest level 10 times higher than highest Yukon data; however, Yukon data limited to 12 sites.
Cadmium (Cd)	0.03 – 0.343	0.2 – 1.66	0.07 – 1.49	Highest level is from a control site.
Manganese (Mn)	19 - 382.5	233 – 512	33.7-605	Transect range slightly higher than control and Yukon data.
Copper (Cu)	0.71 - 7.17	1.2 – 4.3	1.0 - 14.6	4 samples above Yukon background data, all by pond
Zinc (Zn)	8.6 - 94	21.8 – 105	18.2 – 99.1	Highest [ppm] is from a control site.
Magnesium (Mg)	106 – 1,434	387 – 1640	274-1,880	Transect range slightly higher than control and Yukon data.
Nickel (Ni)	0.187 - 4.37	0.3 – 1.1	0.2-6.5	Only 1 above Yukon background data.
Mercury (Hg)	NA	<0.01 – 0.017	<0.01 – 0.064	Highest transect site 3.7 times maximum control [ppm].
Tin (Sn)	NA	<0.1 – 0.6	<0.1 – 4.0	Only 4 transect values higher than control sites.
Titanium (Ti)	NA	5.0 – 35.7	4.5 – 97.3	Highest transect 2.7 times maximum control [ppm].

NA: Not Available

Metal levels in lichens were compared to existing Yukon data and control sites to determine which metals required further investigation.

Spatial and statistical analyses were used in combination to test if individual metal levels were elevated adjacent to the three potential sources of contamination. Various statistical tests were attempted; however, non-linear regressions were found to be the most useful. Kriging analysis using Vertical Mapper combined with MapInfo (GIS software) was conducted to map noticeable patterns in the data. Kriging is a geostatistical interpolation technique that considers both the distance and the degrees of variation between known

Statistics were used to determine if there was a pattern of higher metal levels around the potential sources of contamination.

data points to estimate values in unknown areas. It provides a means for understanding directional trends in data.

Using non-linear regressions combined with Kriging analysis, clear relationships were found between distance from the sources of contamination and arsenic, lead, copper, silver and antimony. The strongest relationships (with significant P values) were generally associated with the mill site followed by the Brown McDade Pit and the tailings pond respectively. Note that a P value can be defined as a "probability value". For example, a P value of 0.90 would indicate a 90% probability. Figures 3.1 – 3.10 show the patterns for the metals showing a significant relationship. Statistical analysis was used to predict metal concentrations from each of the 3 sources of contamination. These predicted values are shown by the red values in figures 3.2 – 3.10. Table 3.2 outlines the strength of each of the regressions. Levels of zinc, boron, uranium, manganese, magnesium, cadmium and nickel did not show relevant spatial patterns around the potential sources of contamination. Note that an R^2 value can be defined as a number from 0 to 1 which shows how closely the estimated (i.e.-predicted) values are to the actual values. The predicted values are likely closest to the actual values when the R^2 is at or near 1.

Table. 3.2. R^2 values[1] for the metals that did show a directional pattern.

Metal	Mill	Brown McDade Pit	Tailings Pond	All three	Mill and Pit
Lead (Pb)	0.83	0.78	0.29	0.82	0.65
Arsenic (As)	0.82	0.75	0.34	0.66	0.8
Copper (Cu)	0.94	0.88	0.54	0.69	0.91
Silver (Ag)	0.78	0.88	0.6	0.62	0.7
Antimony (Sn)	0.84	0.75	0.43	0.71	0.8

Mapping of the data shows the significant patterns found in the statistics.

[1] An R^2 value can be defined as a number from 0 to 1 which shows how closely the estimated (i.e.-predicted) values are to the actual values. The predicted values are likely closest to the actual values when the R^2 is at or near 1.

LEAD

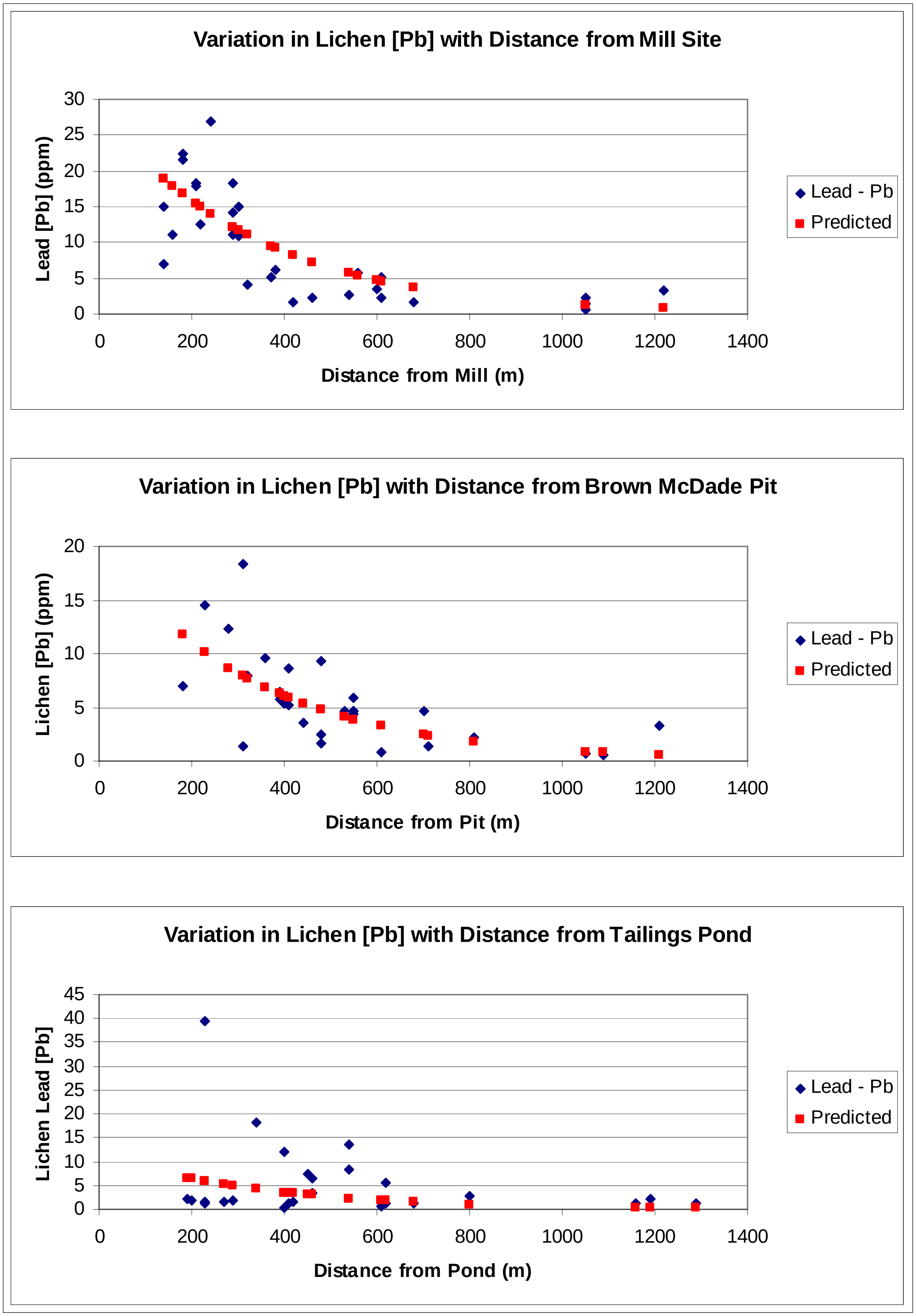


Figure 3.1. Non-linear regressions of lead (Pb) and distance from contamination sources.

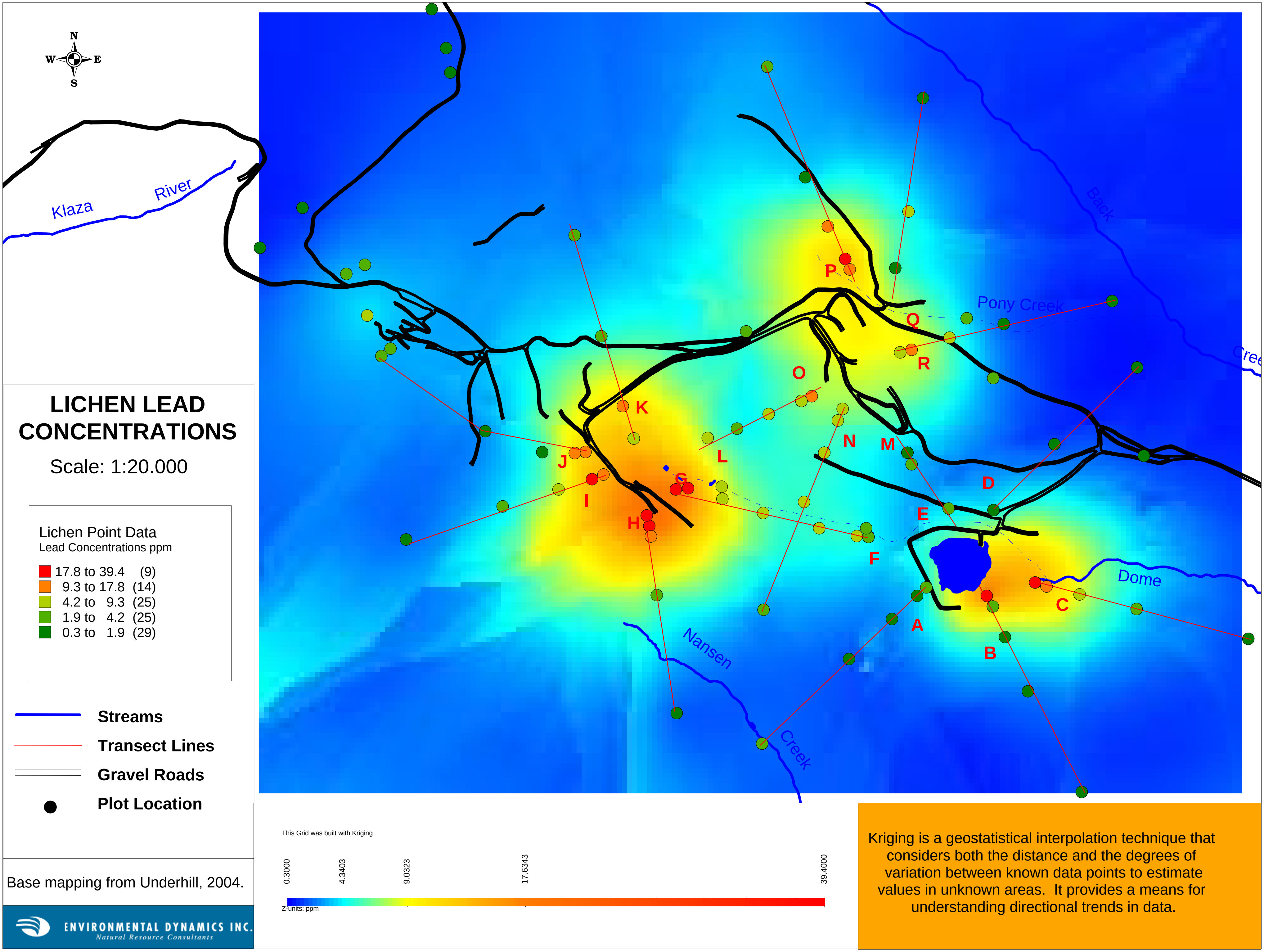


Figure 3.2. Map of lead (Pb) concentrations in lichens using the Kriging Analysis.

ARSENIC

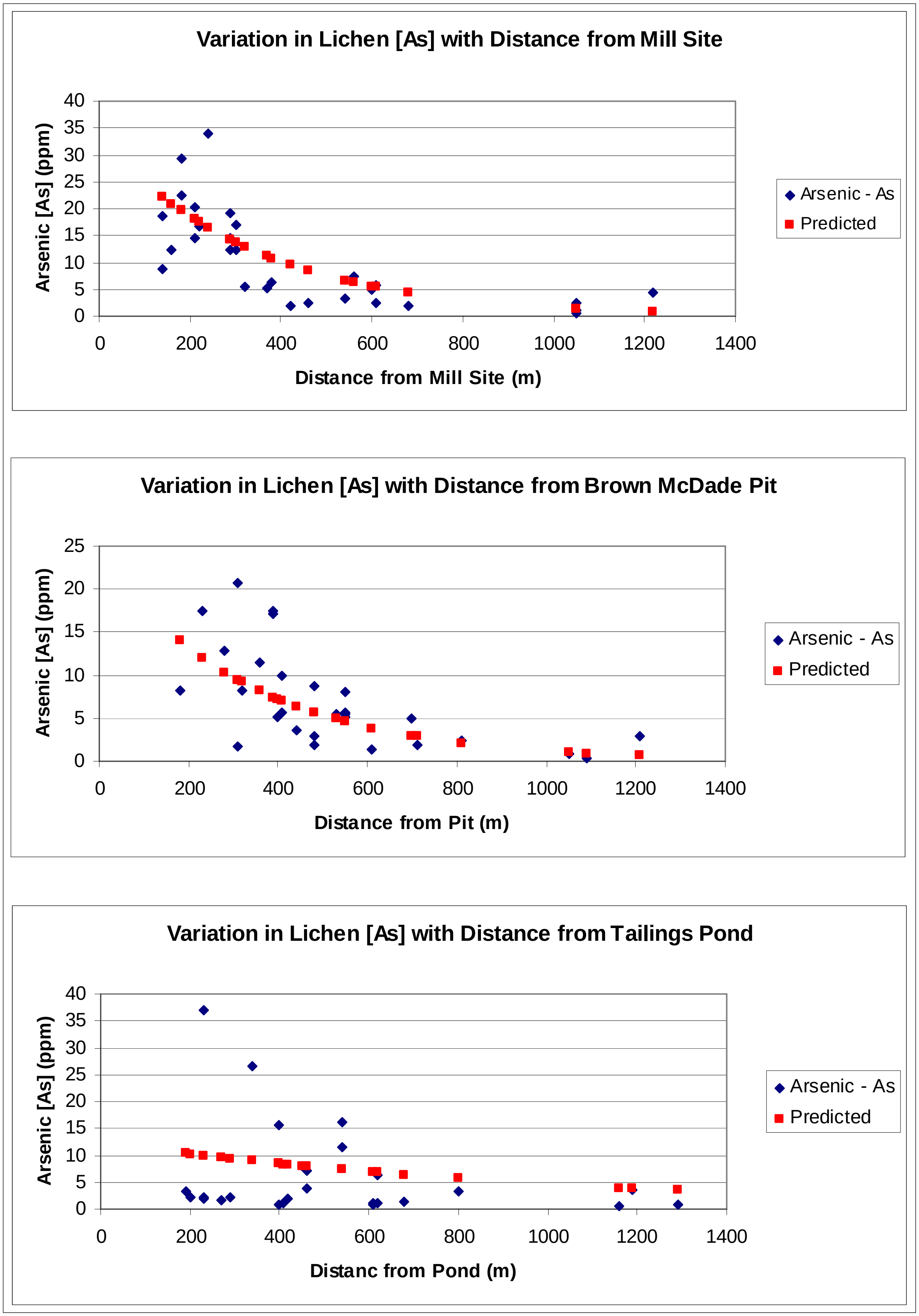


Figure 3.3. Non-linear regressions of arsenic (As) and distance from contamination sources.

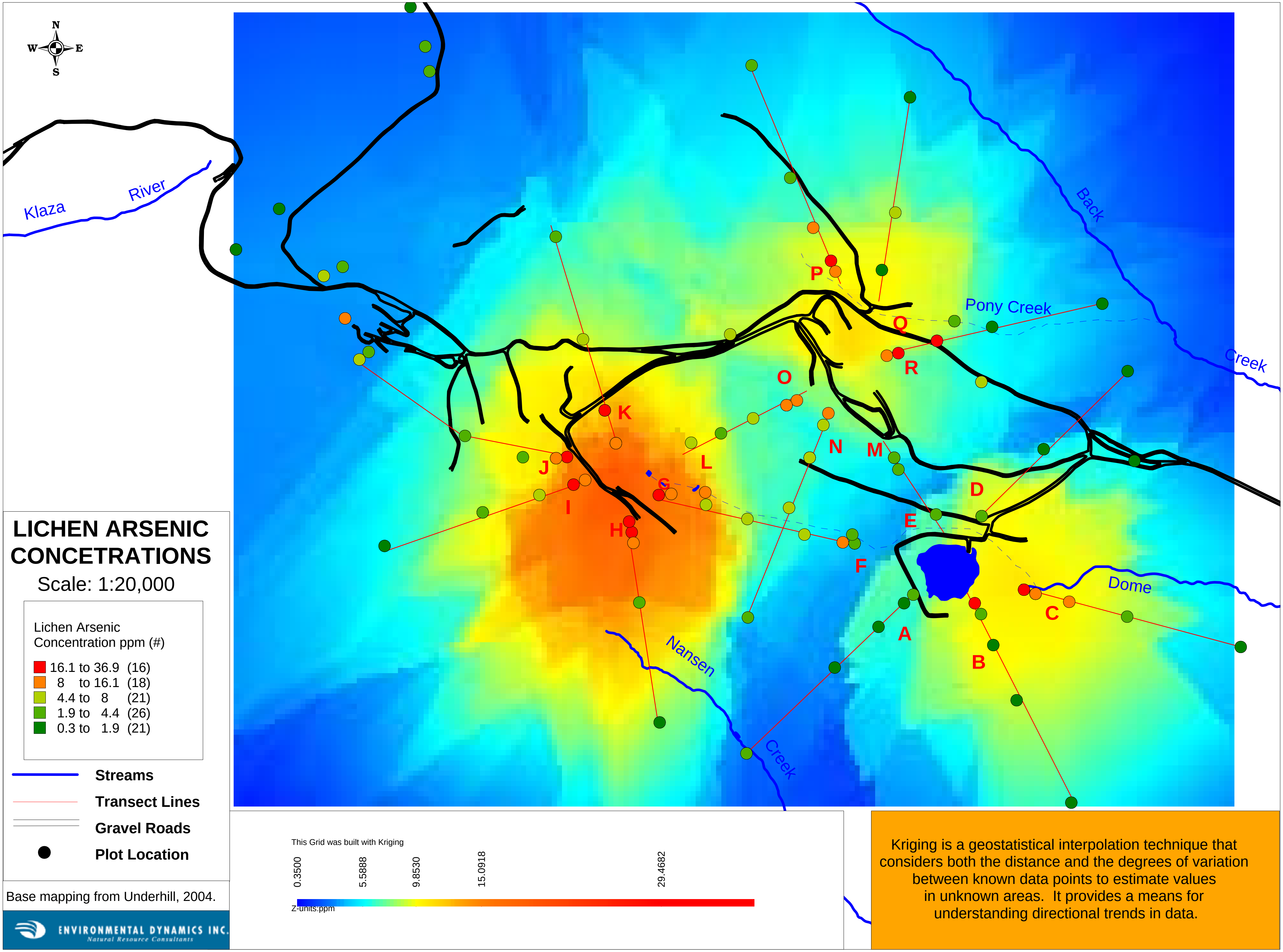
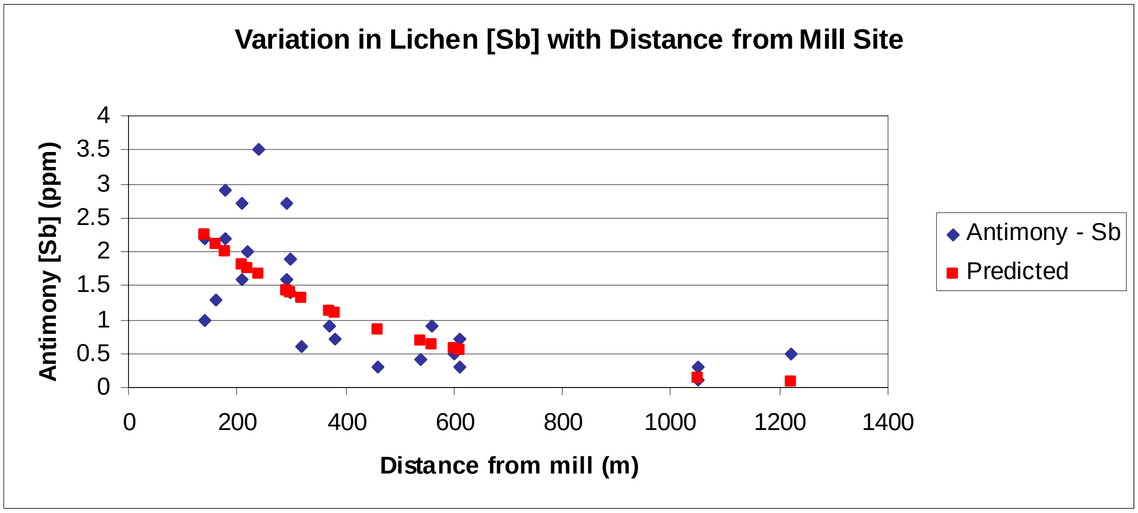
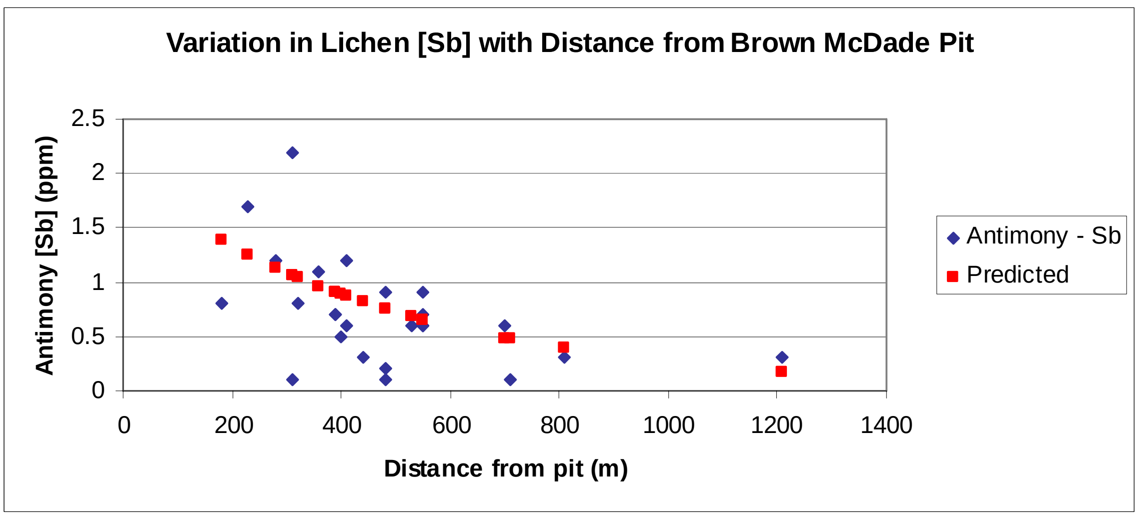


Figure 3.4. Map of arsenic (As) concentrations in lichens using the Kriging Analysis.

ANTIMONY





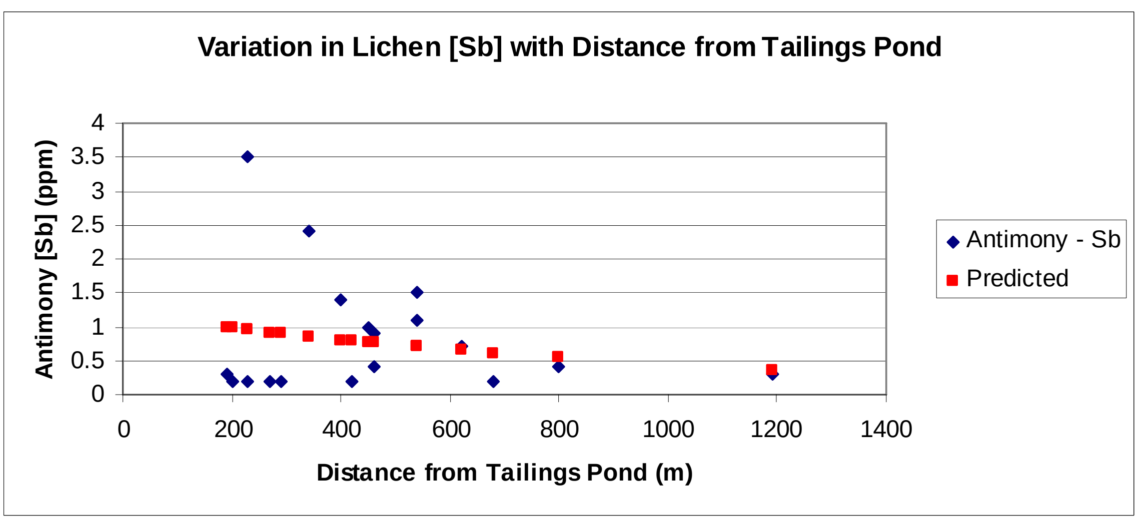


Figure 3.5. Non-linear regressions of antimony (Sb) and distance from contamination sources.

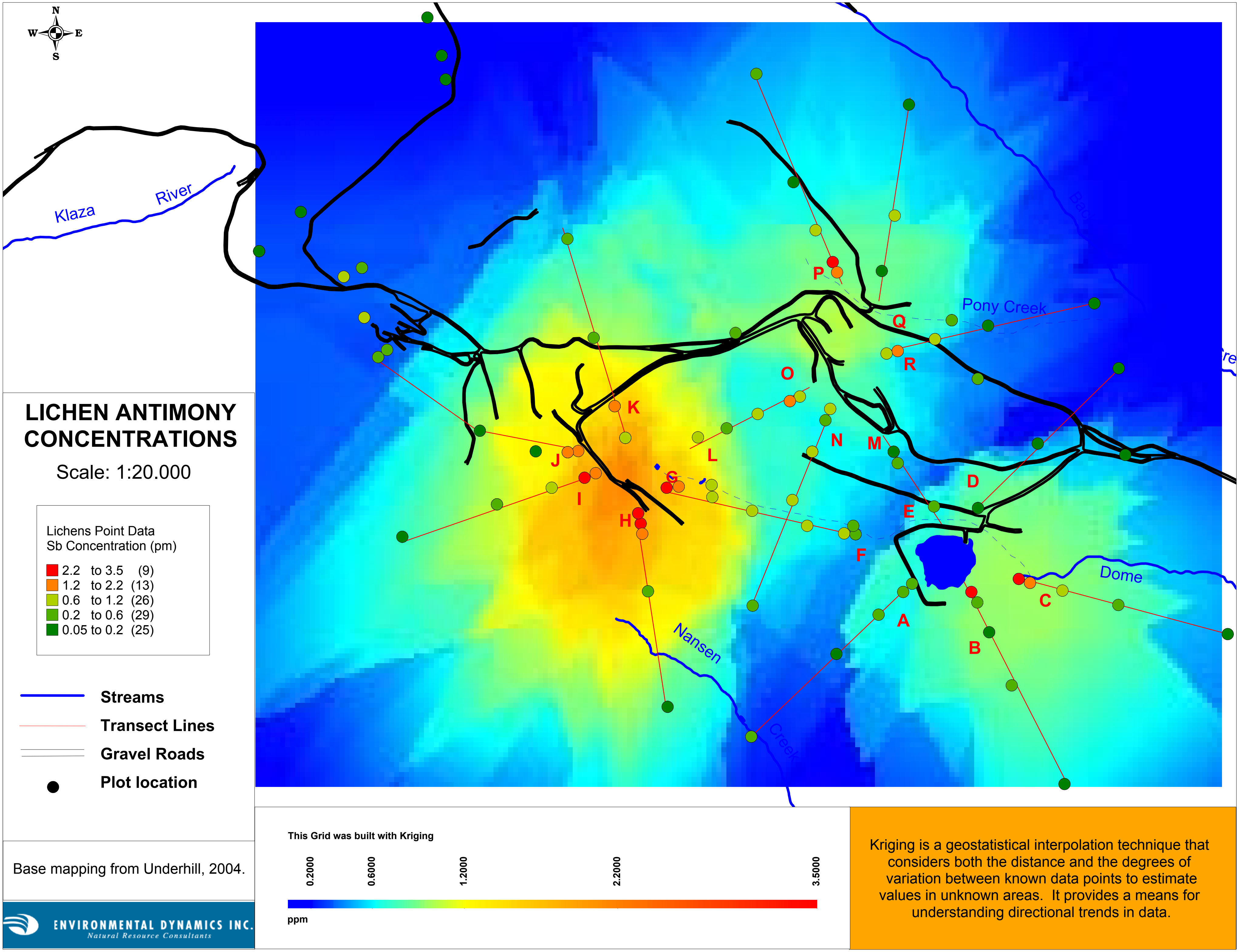


Figure 3.6. Map of antimony (Sb) concentrations in lichens using the Kriging Analysis.

COPPER

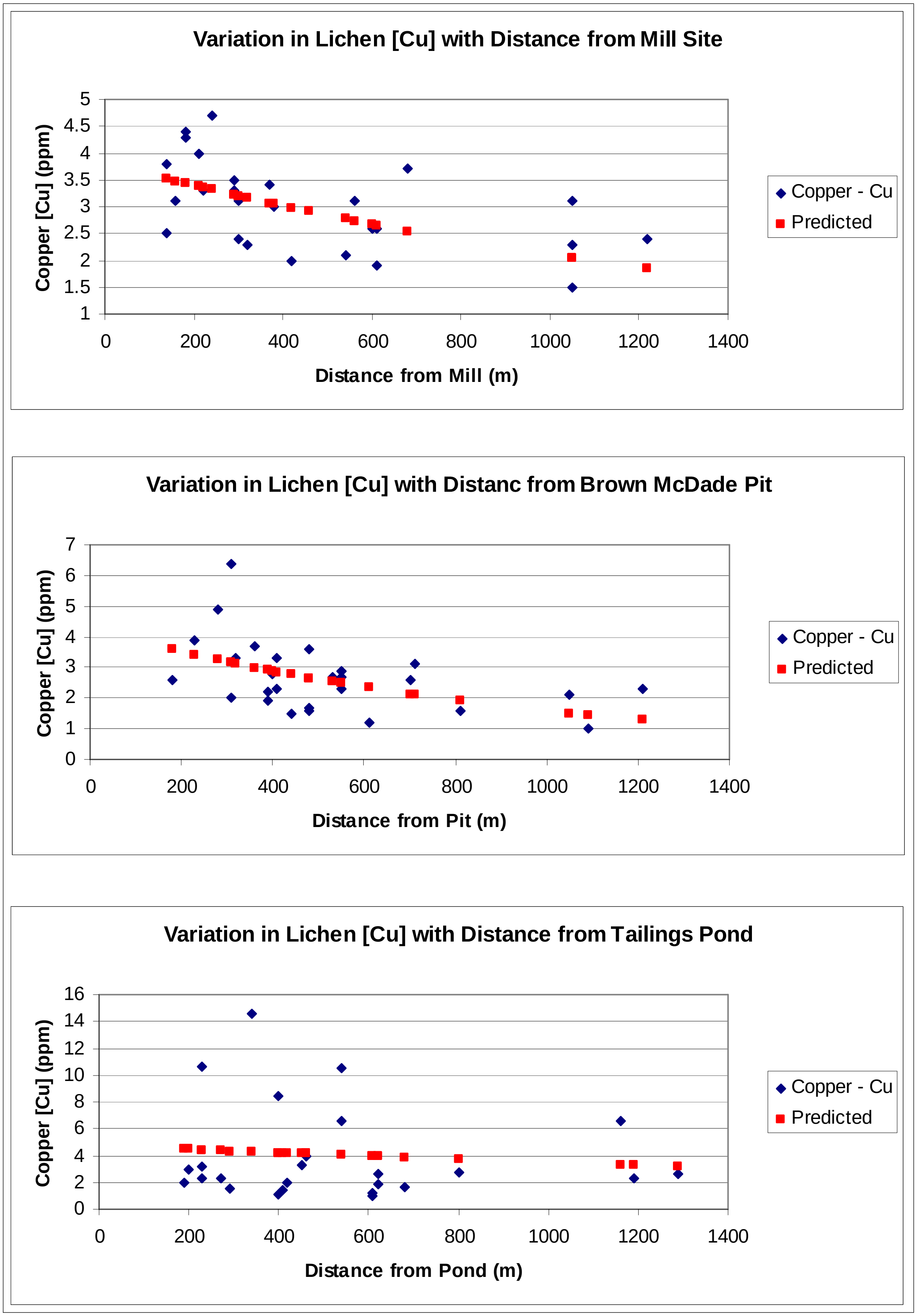


Figure 3.7. Non-linear regressions of copper (Cu) and distance from contamination sources.

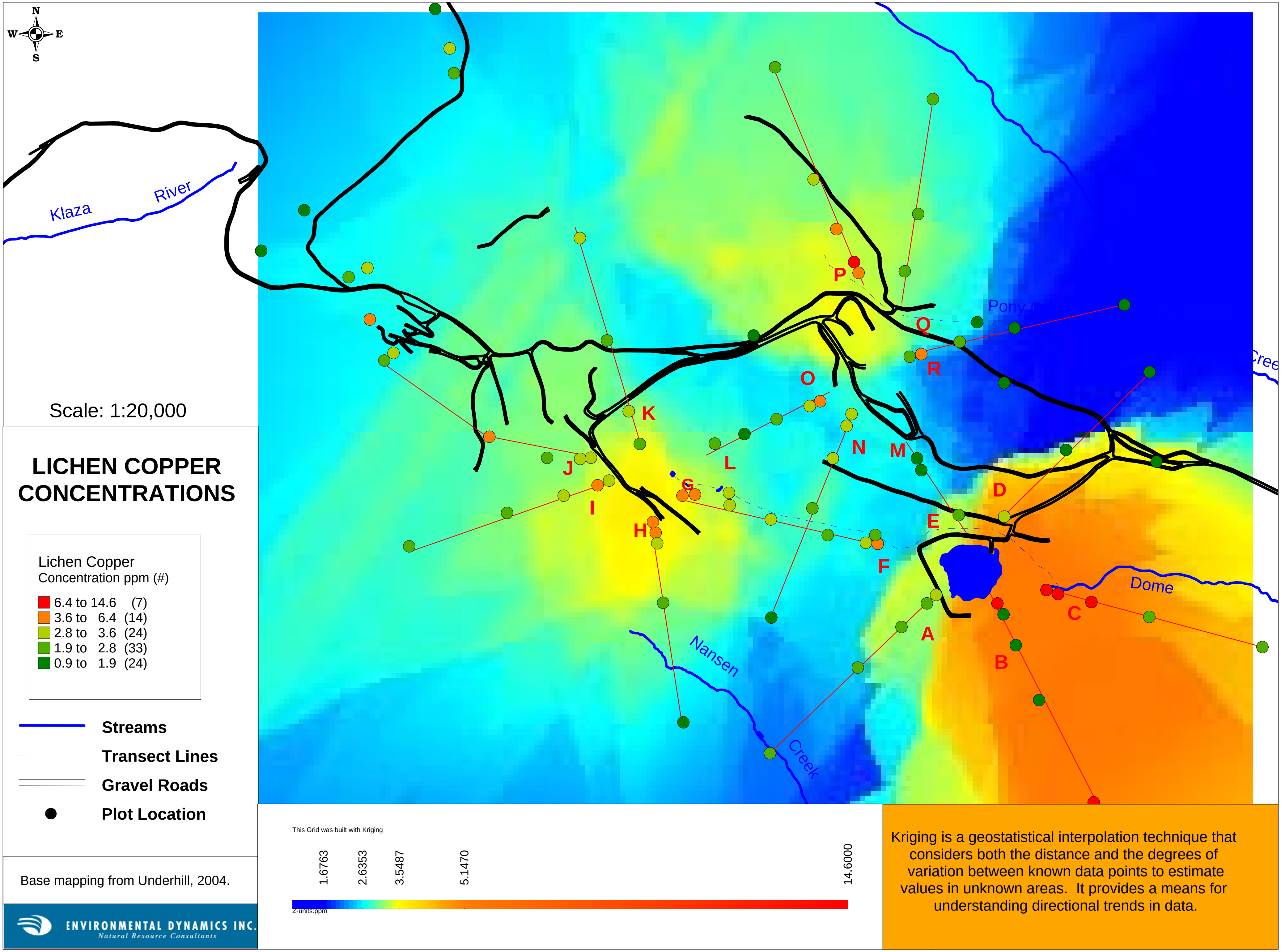


Figure 3.8. Map of copper (Cu) concentrations in lichens using the Kriging Analysis.

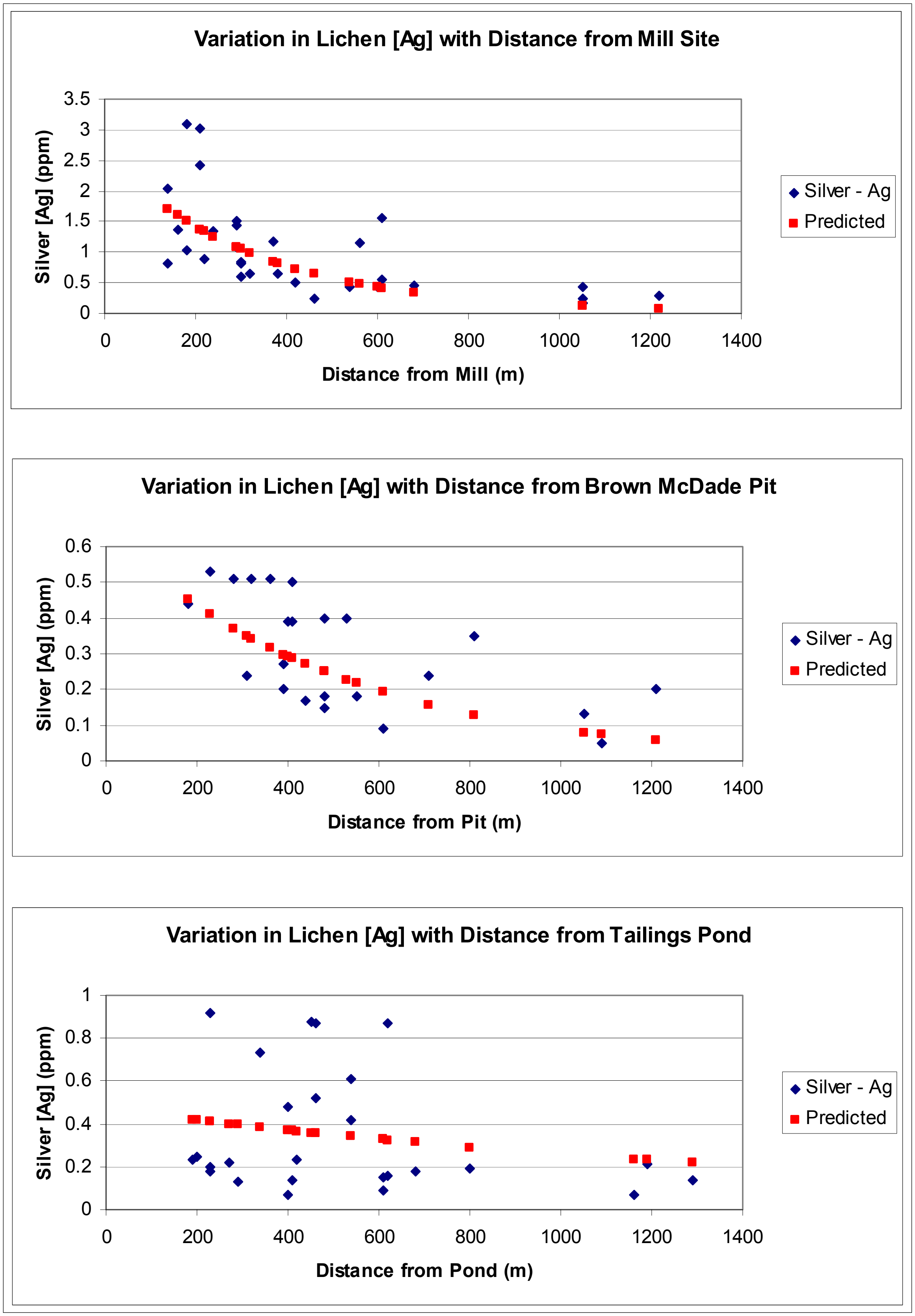


Figure 3.9. Non-linear regressions of silver (Ag) and distance from contamination sources.

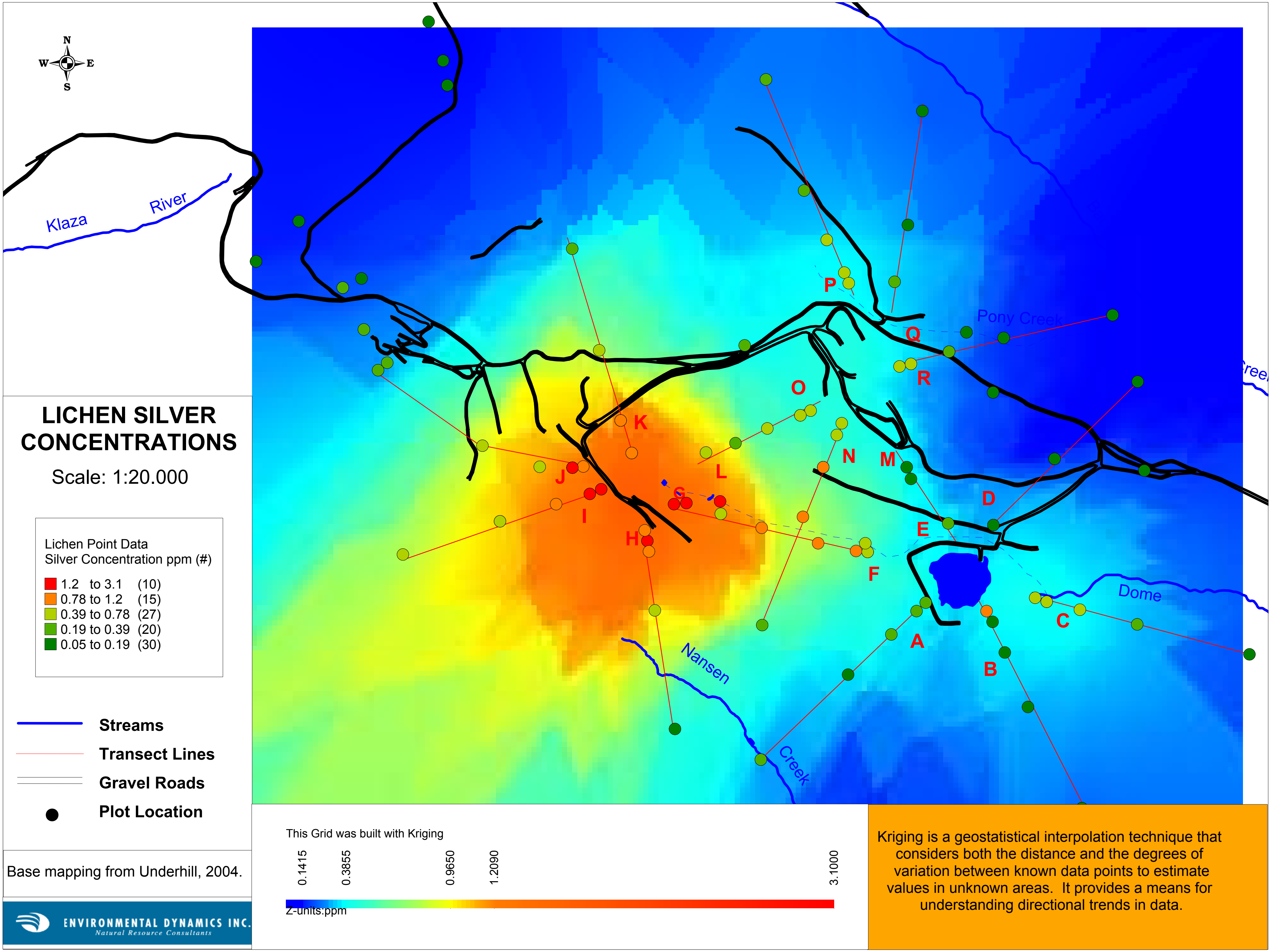


Figure 3.10. Map of silver (Ag) concentrations in lichens using the Kriging Analysis.

Further statistical analyses using pairwise t-tests (assuming unequal variances) provided some insight to the dynamics of the data. A comparison of the metal levels of lichens within 600 m of each source demonstrated some interesting patterns (verified by t-test). For example, lead levels near the mill were nearly double those near the pit and the pond sites. Arsenic and antimony levels were also highest around the mill compared to the other two sites (Table 3.3).

Additional statistics show that most elevated metal levels are highest around the mill site.

Table 3.3. Means and significance of metal levels within 600 m of each of the potential sources of contamination.

Metal	Mean Value			Significant Difference[1]		
	Around Mill (ppm)	Around Pit (ppm)	Around Mill (ppm)	Mill Versus Pit	Mill Versus Pond	Pit versus Pond
Lead (Pb)	12.01	6.8	7.15	✓	✓	
Arsenic (As)	13.72	8.72	8.42	✓	✓	
Copper (Cu)	3.17	2.91	4.75			✓
Silver (Ag)	1.23	0.44	0.42	✓	✓	
Antimony	1.63	0.79	0.96	✓	✓	

[1]p-level <0.05

Interestingly, nickel, titanium, and chromium were significantly higher around the pond than the other two sites (using the t-test; complete results in Appendix D). Cobalt was slightly higher around the pond and the pit than at the mill. Aluminum was higher around the pond than the mill site. Differences in aluminum, cobalt and chromium are likely influenced by natural variation, especially given that all results fell within typical ranges measured in other areas of the Yukon (Gamberg 2006).

3.1.2 Plants

Trace metal concentrations in the plants analyzed as part of this study were compared to background data for plants across the Yukon as well as the control sites. Particular emphasis was placed on arsenic, antimony, copper, lead and silver given the patterns of elevated levels for these metals in lichens around the potential sources of contamination. It should be noted that the background data utilized (Gamberg 2006) has a limited sample size for many of the plant parts analyzed. Some spatial comparison was made between the areas surrounding the points of contamination (mill site, pit and tailings pond) and the remainder of the terrestrial sampling sites as well as the control plots. All laboratory results for plants are presented in Appendix G.

3.1.2.1 Berries

Crowberries

Fruit bearing crowberries (*Empetrum nigrum*) were encountered in moderate densities within the study site. A representative number (n=11) of berry samples collected from the terrestrial sites transects were chosen for analysis. In addition to these samples, control (n=2), riparian (n=1), replicate (n=1) and duplicate (n=1) samples were chosen for analysis.

The major trace metals of concern (antimony, arsenic, copper, lead and silver) as determined in lichen sampling in this study were not elevated in crowberries when compared to the existing Yukon background data (Gamberg 2006). The results obtained by this study were either below the detection limit or within the range of the background data for the five major elements of concern. Levels of boron, calcium, and manganese were slightly elevated compared to Yukon data; however, this was deemed to be the result of natural conditions (geology and soils) given that many of the higher levels were in areas a significant distance from the minesite (i.e. control sites and at end of transects). Perhaps the most notable result was found at a riparian site (Pony 3) where tin levels were 1.7 ppm, which is substantially higher than the maximum of 0.14 ppm found by Gamberg (2006) and 0.1 ppm found at the control sites (refer to Figure 2.3 for location of Pony 3). The low level of variability in metal concentrations across the landscape did not warrant spatial analysis for this data.

Metal levels in crowberries appeared to be similar to existing Yukon data.

Prickly Rose

Fruit bearing prickly rose (*Rosa acicularis*) stems were encountered in very low densities within the study site. Two samples made up of several fruits each were collected and analyzed from the terrestrial site transects. In addition, replicate (n=1) and duplicate (n=1) samples were also selected for analysis. Due to the low sample size, no statistical analysis of trace metals was carried out for this species. The results obtained by this study were either below the detection limit or within the range of the background data for the five major elements of concern. However, the concentrations of a number of other metals were elevated when compared to Yukon background data (Table 3.4). No samples were found at control sites.

Metal levels in rosehips were compared to background Yukon data.

Table 3.4. Metal levels in prickly rose fruit for those metals exceeding maximum Yukon background levels (highlighted).

Sample ID[1]	Metal Concentration (ppm)			
	Ca	Fe	Mn	Ni
ROAC-M2-1	14000	63	128	1.5
ROAC-EM3-1B	12000	48	403	0.9
ROAC-EM3-1A	10200	37	365	0.7
ROAC-EM3-2	9940	37	266	0.9
Gamberg (2006) Mean	6501.27	23.36	32.82	0.68
Gamberg (2006) Maximum	9300.00	41.00	64.70	0.98
Gamberg (2006) sample size	11	11	11	8

[1]Sample ID = species code-plot#-sample#.

Blueberry

Fruit bearing blueberries (*Vaccinium uliginosum*) were encountered in low numbers within the study site. A representative number (n=6) of berry samples collected from the terrestrial site transects were chosen for analysis. In addition to these samples, control (n=3) and riparian (n=1) samples were also chosen for analysis. Due to the low number of fruit bearing blueberries at the time of sampling, samples of blueberry leaves as well as leaf / berry composite samples were collected. A low number of composite (n=4) samples were obtained from the transect sites in addition to leaf samples from transect sites (n=5), riparian sites (n=4), control sites (n=1) and a replicate (n=1) sample.

The major trace metals of concern (antimony, arsenic, copper, lead and silver) in this study were not elevated in comparison to the background data. Due to restrictions with the existing Yukon background data for arsenic, it is not possible to compare the arsenic levels found in blueberries. Most samples of berries were below the detection limit (0.1 ppm) or slightly above (0.2 ppm). The composite samples were slightly higher, up to 0.6 ppm and the leaf samples even higher, up to 1.0 ppm. This result is expected, as the leaves would have more opportunity to accumulate metals than would the berries.

Metal levels in blueberries were compared to background Yukon data.

Boron, cadmium and nickel were elevated in comparison to Yukon background data, and of these only boron and nickel were higher than control sites (Table 3.5). While no spatial analysis was completed, it is apparent that these elevated levels were present throughout the area including control plots and at the end of a terrestrial transect (A5). It should be noted that an insufficient sample size (in Yukon background data) did not allow a comparison for the following list of metals; however, control site samples were used to compare concentrations of these metals. Any elements not contained within Table 3.5 were within the normal range for this species when compared to Yukon background data and/or control site concentrations.

Table 3.5. Metal levels in blueberries for sites where at least one metal was above maximum Yukon background levels and control site levels (highlighted).

Sample ID	Plant Part	Metal Concentration (ppm)					
		B	Ni	As	K	Si	Na
VAUL-A5-3	berry	17	0.7	< 0.1	9910	118	6
VAUL-DOMER5-1	berry	25	0.7	< 0.1	7080	97	25
VAUL-F3-1	berry	15	0.7	< 0.1	6140	69	12
VAUL-FG4-1	berry	13	1.2	< 0.1	7950	75	3
VAUL-K3-1	berry	25	0.3	0.2	11500	95	1
VAUL-O1-1	berry	21	0.3	< 0.1	12300	147	3
VAUL-O3-1	berry	17	0.5	< 0.1	8120	63	< 1
Gamberg (2006) Mean	berry	5.4	0.49	NA	NA	NA	NA
Gamberg (2006) Maximum	berry	10.7	0.56	NA	NA	NA	NA
Gamberg (2006) sample size (n)	berry	3	5	0	0	0	0
Control Site Maximum	berry	14	0.7	<0.1	9960	92	9
Control Site Mean (n=3)	berry	10.7	0.53	<0.1	9417	88	4

[1]Sample ID = species code-plot#-sample#.

Lowbush Cranberry

Fruit bearing lowbush cranberry (*Vaccinium vitis-idaea*) was found throughout the study area and was the most common berry sampled. A representative number (n=28) of berry samples collected from the terrestrial sites transects were chosen for analysis. In addition to these samples, control (n=4), riparian (n=4), replicate (n=1) and duplicate (n=1) samples were also chosen for analysis.

Of the major trace metals of concern (antimony, arsenic, copper, lead and silver) in this study, arsenic was the only element that was above the detection limit (0.1 ppm). This indicates that very low concentrations of most metals were found in lowbush cranberry fruit. Three of the terrestrial transect sites and one of the riparian sites had arsenic concentrations of 0.2 ppm and 0.3 ppm, respectively. A number of other elements were commonly higher than Yukon background data and control data (Table 3.6). Again the distribution of these higher levels appears to be random, given that many of the plots that are located a considerable distance from the sources of contamination (I4, D3) showed similar numbers. It should be noted that an insufficient sample size in the background data did not allow a comparison for a number of metals; however, data obtained from the control sites were used as a comparison for these metals. Any elements not presented within Table 3.6 are within the normal range for this species according to Yukon background and/or control plot data.

Table 3.6. Metals in lowbush cranberries above maximum Yukon background and control plot values (highlighted).

Sample ID[1]	Metal Concentration (ppm)													
	Al	As	B	Ca	Co	Fe	K	Mg	Mn	Na	Si	Sn	Sr	Ti	V
VAVI-C1-1	43.5	0.2	9	1750	<0.1	66	8290	641	647	2	123	<0.1	1.5	1.9	0.6
VAVI-C2-1	19.5	<0.1	9	1580	<0.1	18	7580	614	251	2	112	0.2	1.93	0.7	<0.5
VAVI-D2-1	19.5	<0.1	15	1390	<0.1	18	7940	621	361	3	126	<0.1	2.12	0.7	< 0.5
VAVI-D3-1	7.6	<0.1	16	3000	<0.1	19	8230	793	166	1	120	<0.1	7.09	0.8	< 0.5
VAVI-D3-2	6.5	<0.1	18	3270	<0.1	23	9930	968	170	3	130	<0.1	8.45	0.9	< 0.5
VAVI-DOME3-1	18.4	0.3	16	1620	0.2	42	7730	619	92.7	58	128	<0.1	4.84	1.2	< 0.5
VAVI-DOME5-1	11.4	<0.1	12	1420	<0.1	22	8260	730	246	44	113	<0.1	2.14	0.8	< 0.5
VAVI-F1-1	44.8	<0.1	5	896	<0.1	22	6660	492	444	1	106	<0.1	1.78	1	< 0.5
VAVI-F2-1	31.4	<0.1	5	1110	<0.1	13	5530	577	193	3	100	<0.1	2.22	0.5	< 0.5
VAVI-G1-1	15.4	0.2	37	1950	<0.1	19	7100	618	431	11	97	<0.1	2.24	0.8	< 0.5
VAVI-H1-1	14.3	0.2	8	1310	<0.1	17	6210	510	385	2	87	<0.1	1.54	0.7	< 0.5
VAVI-H2-1	14.3	<0.1	8	1880	<0.1	25	8280	633	646	2	113	<0.1	1.32	1	< 0.5
VAVI-H3-1	19.8	<0.1	11	1060	<0.1	11	5980	567	402	6	100	<0.1	0.91	0.4	< 0.5
VAVI-I1-1	16.5	0.1	10	2130	<0.1	25	7840	571	611	7	112	<0.1	2.21	0.9	< 0.5
VAVI-I4-1	20.9	<0.1	10	1690	<0.1	19	7510	565	478	<1	97	<0.1	1.64	0.9	< 0.5
VAVI-K4-1	18	0.2	9	1710	<0.1	25	7890	590	124	1	129	<0.1	2.39	0.8	< 0.5
VAVI-M1-1	13.1	0.2	8	987	<0.1	17	6440	542	193	1	69	<0.1	1.5	0.6	< 0.5
VAVI-N1-1	14.3	<0.1	19	1810	<0.1	15	7660	705	250	3	108	<0.1	2.32	0.6	< 0.5
VAVI-N4-1	15.8	<0.1	14	1840	<0.1	21	8360	606	534	<1	99	<0.1	1.88	0.8	< 0.5
VAVI-O1-1	7.5	<0.1	16	1760	<0.1	21	8990	646	405	1	98	<0.1	2.26	0.8	< 0.5
VAVI-O2-1	4.3	<0.1	20	2340	<0.1	21	7880	657	259	<1	110	<0.1	3.65	0.8	< 0.5
VAVI-PONY3-1	16.8	<0.1	11	1720	<0.1	16	8000	692	475	2	96	<0.1	2.52	0.6	< 0.5
VAVI-R1-1	21.3	0.1	7	1140	<0.1	12	5990	546	270	4	121	<0.1	1.67	0.5	< 0.5
Gamberg (2006) Mean	15.09	NA	5.4	1065	0.03	22.6	NA	553	180	NA	NA	0.02	2.6	NA	0.16
Gamberg (2006) Maximum	30.8	NA	9.1	2341	0.03	39	NA	862	359	NA	NA	0.03	5.7	NA	0.25
Gamberg - Sample size	10	0	5	10	1	8	0	10	10	0	0	2	10	0	4
Control Plot Maximum	24.2	<0.1	12	2160	<0.1	23	9390	815	457	5	127	<0.1	4.35	1.1	< 0.5
Control Plot Mean (n=4)	19.6	<0.1	9	1772	<0.1	19	8445	729	303	3	115	<0.1	3.35	0.9	< 0.5

[1]Sample ID = species code-plot#-sample#.

Given the low level of variability (levels mainly below detection limits) in concentrations of the five elements of concern across the landscape no spatial analysis was conducted.

3.1.2.2 Shrubs

Due to the large number of shrubs (Labrador tea and willow) collected across the landscape it was possible to use this data to determine the levels of metals in plants within the study site. In order to assess whether or not the concentration of the five major elements (antimony, arsenic, copper, lead and silver) varied across the landscape, a statistical analysis was carried out. This analysis was based upon the lichen results obtained for each of the five metals. Sample sites were grouped into categories for each contamination source (mill site, pit and pond). The results from each site were compared

As there were many samples of shrubs analyzed, some spatial analysis could be completed.

to the control sites as well as the remainder of the transect sites deemed to be outside of major zone of contamination as determined by the lichen results. The sites determined to be within the zone around each contamination source were those which had the following minimum concentrations in the lichen samples; antimony – 1.2 ppm, arsenic – 8.0 ppm, copper – 3.6 ppm, lead – 9.3 ppm and silver – 0.78 ppm (this grouping was conducted separately for each metal). In the case of the mill site, two sites which did not have lichens sampled (L1 and L2) were also added to the "mill" category. Results from the riparian sampling sites and the contaminated areas (tailings pond, waste rock dump and pit area) were also grouped separately and statistically compared to the control sites and the transect sites. Refer to Appendix D for the full statistical output of the t-tests (two-sample assuming unequal variances, $\alpha = 0.05$) performed on the shrub data.

Labrador Tea

Labrador tea (*Ledum groenlandicum / L. palustre*) was a very common plant within the study area where it was encountered at nearly all samples plots with the exception of some of the riparian sites. A representative number (n=34) of leaf samples collected from the terrestrial site transects were chosen for analysis. In addition to these samples, control (n=4), riparian (n=6), road influence (dust; n=2) duplicate (n=2) and replicates (n=1) samples were also chosen for analysis.

Pre-existing Yukon background data for Labrador tea was for stems and flowers, while this study focused on leaves only. As such, values obtained in this study were compared solely to control plot values. Table 3.7 presents the data for all elements that appeared elevated when compared to control site data, any elements not presented were within the normal range for this species. Several elements were commonly higher at transect/riparian sites than control values including arsenic and lead. The site PONY 3 had sixteen metals that were above levels found at the control plots. This site was located in close proximity to the Pony Creek adit waste dump.

Table 3.7. Metals in Labrador tea leaves above maximum control plot values (highlighted).

Sample ID[1]	Metal Concentration (ppm)																					
	Al	Sb	As	Ba	B	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	Si	Ag	Na	Sr	Ti	V	Zn
LELA-A1-1	47.6	< 0.1	< 0.1	65.5	12	0.06	5640	< 0.1	< 0.1	2.4	45	0.1	1060	921	0.3	0.3	89	< 0.01	8	7.76	1.3	< 0.5	15.3
LELA-C3-1	40	< 0.1	0.1	53.2	12	0.05	6120	< 0.1	< 0.1	3.1	51	0.1	949	1400	< 0.1	0.4	110	< 0.01	4	5.11	1.5	< 0.5	15.8
LELA-A2-1	35.6	< 0.1	< 0.1	60	7	< 0.02	5360	0.4	< 0.1	3.2	84	< 0.1	946	1550	0.2	0.3	95	< 0.01	4	5.04	1	< 0.5	18.4
LELA-J2-1	25.4	0.1	0.7	53.7	24	< 0.02	5970	< 0.1	< 0.1	3.3	59	0.6	1190	603	< 0.1	0.3	98	0.01	1	9.22	1.4	< 0.5	20.8
LELA-C1-1	52.2	< 0.1	0.8	69.8	14	0.05	7540	< 0.1	< 0.1	3.9	68	0.7	1060	2540	< 0.1	0.4	101	0.01	3	4.62	1.4	< 0.5	21.9
LELA-C2-1	29.1	< 0.1	0.4	76.7	8	0.05	4920	0.1	< 0.1	3.7	44	0.4	847	1170	< 0.1	0.4	101	< 0.01	4	7.04	0.9	< 0.5	23.4
LELA-O1-1	10.9	< 0.1	0.1	54.6	21	0.04	6740	< 0.1	< 0.1	3.1	105	< 0.1	1210	618	< 0.1	0.1	120	< 0.01	1	10.5	1.6	< 0.5	23.6
LELA-H1-1	24.6	< 0.1	0.5	54.9	16	0.04	6400	< 0.1	< 0.1	4.5	55	0.2	1180	1200	< 0.1	0.4	123	< 0.01	3	6.1	1.4	< 0.5	24.4
LELA-I2-1	16.6	< 0.1	0.2	46.2	21	0.03	6370	< 0.1	< 0.1	3.4	55	< 0.1	1080	1330	< 0.1	0.2	117	< 0.01	2	6.35	1.3	< 0.5	24.5
LELA-C4-1	30.4	< 0.1	< 0.1	74.6	15	0.05	5680	< 0.1	< 0.1	3.5	40	< 0.1	1010	1310	< 0.1	0.2	101	< 0.01	< 1	5.78	0.9	< 0.5	24.8
LELA-H4-1	44.1	< 0.1	0.1	42.7	12	0.03	4640	< 0.1	< 0.1	2.5	42	< 0.1	875	1070	< 0.1	0.2	100	< 0.01	6	5.96	0.9	< 0.5	25.4
LELA-J3-1	10.5	< 0.1	0.7	47.8	20	< 0.02	8640	< 0.1	< 0.1	3	61	0.4	1630	741	< 0.1	0.1	111	0.01	2	9.27	1.4	< 0.5	25.4
LELA-P2-1	24.9	< 0.1	0.3	38.2	19	0.07	5920	< 0.1	< 0.1	3.2	69	0.2	1370	572	< 0.1	0.3	148	< 0.01	2	9.5	1.8	< 0.5	26.1
LELA-H5-1	7.9	< 0.1	< 0.1	56.6	19	0.05	6000	< 0.1	< 0.1	3.6	42	< 0.1	942	733	0.2	0.2	68	< 0.01	3	8.76	1.1	< 0.5	26.4
LELA-DOMER5-1	34.2	< 0.1	0.9	24.1	33	0.09	6710	< 0.1	< 0.1	3.1	175	0.3	2330	73	< 0.1	0.2	89	< 0.01	30	8.74	1.6	< 0.5	26.7
LELA-P1-1	14.6	< 0.1	0.4	46.8	18	0.06	7280	< 0.1	< 0.1	3	64	0.2	1180	985	< 0.1	0.1	122	0.01	4	12	1.4	< 0.5	27
LELA-O2-1	11.5	< 0.1	0.1	86.2	25	0.05	8340	< 0.1	< 0.1	3.2	58	< 0.1	1280	942	< 0.1	0.1	123	< 0.01	1	8.59	1.4	< 0.5	28.2
LELA-G2-1	12	< 0.1	0.3	80.7	25	0.02	6170	< 0.1	< 0.1	2.6	38	0.2	1380	688	< 0.1	0.3	84	< 0.01	15	11.3	0.8	< 0.5	28.7
LELA-I1-1	17.4	< 0.1	0.6	47.1	24	0.02	6950	< 0.1	< 0.1	3.9	64	0.3	1060	1200	< 0.1	0.1	115	0.01	5	7.07	1.7	< 0.5	29.3
LELA-K4-1	14.3	< 0.1	0.2	68.2	16	< 0.02	6070	< 0.1	< 0.1	4.1	54	< 0.1	1240	276	< 0.1	0.7	101	< 0.01	2	7.21	1.2	< 0.5	29.4
LELA-J1-1	19.9	0.1	1.1	50.5	9	0.19	7900	< 0.1	< 0.1	3.8	83	0.9	1240	862	< 0.1	0.2	110	0.02	30	9.19	1.8	< 0.5	29.6
LELA-DOMER6-1	40.4	< 0.1	0.7	54.8	39	0.07	9280	< 0.1	< 0.1	2.3	115	0.5	2340	604	< 0.1	0.2	140	< 0.01	5	14.6	1.3	< 0.5	29.8
LELA-DOMER7-1A	16.7	0.1	1.7	37.8	40	0.05	8970	< 0.1	< 0.1	3.3	122	0.7	2360	107	< 0.1	0.3	82	0.02	6	13	1.8	< 0.5	30.2
LELA-K2-1	14.2	< 0.1	0.6	74	31	< 0.02	5760	< 0.1	< 0.1	3.6	55	0.5	981	481	< 0.1	0.3	125	0.01	10	8.01	1.1	< 0.5	30.5
LELA-DUST1-1	66.7	< 0.1	0.7	86.2	24	0.07	6460	< 0.1	< 0.1	3	144	0.3	1200	781	0.1	0.4	99	0.01	2	12.7	5.8	< 0.5	30.6
LELA-P3-1	27.6	< 0.1	0.2	77.6	20	0.05	8070	< 0.1	< 0.1	3.2	79	0.1	1100	1740	< 0.1	0.1	138	0.01	5	11.5	2.2	< 0.5	31
LELA-H3-1	24.4	< 0.1	0.2	59.8	11	0.02	5240	0.3	< 0.1	4.1	42	0.1	1020	2080	< 0.1	0.3	113	< 0.01	9	4.51	0.8	< 0.5	31.3
LELA-G1-1	15.8	< 0.1	0.6	56.3	49	0.05	8390	< 0.1	< 0.1	3.4	67	0.3	1340	1310	< 0.1	0.2	138	0.02	4	7.46	1.6	< 0.5	32.6
LELA-N1-1	23.6	< 0.1	0.4	45.2	30	< 0.02	6050	0.1	< 0.1	2.7	55	0.3	991	558	< 0.1	0.2	116	0.01	5	8.25	1.2	< 0.5	33.1
LELA-Q4-1	20.3	< 0.1	< 0.1	65.9	11	< 0.02	5300	< 0.1	< 0.1	3.6	38	< 0.1	1030	775	< 0.1	0.2	114	< 0.01	< 1	13.7	0.8	< 0.5	34
LELA-DOMER7-1B	16.1	0.1	1.7	33.6	34	< 0.02	7290	0.1	< 0.1	3.2	106	0.9	2040	83.1	< 0.1	0.2	77	0.01	7	12.6	1.4	< 0.5	35.1
LELA-I3-1	14.3	< 0.1	0.5	47.1	23	< 0.02	5230	< 0.1	< 0.1	4.1	51	0.3	899	1360	< 0.1	0.2	82	< 0.01	5	7.79	0.8	< 0.5	35.3
LELA-R3-1	43	< 0.1	1.4	75.1	15	< 0.02	5880	< 0.1	< 0.1	2.5	87	0.5	1330	1660	< 0.1	0.3	122	< 0.01	4	8.11	1.2	< 0.5	36.2
LELA-DUST3-1	91.6	< 0.1	0.8	104	34	0.05	8520	0.4	< 0.1	3	228	0.3	1670	1240	< 0.1	0.4	120	< 0.01	2	10.3	3.7	0.6	37.6
LELA-PONY2-1	11.9	< 0.1	0.3	34	25	0.07	5850	< 0.1	< 0.1	3.8	49	< 0.1	1240	48.4	< 0.1	0.1	119	0.01	14	12.8	1.2	< 0.5	39.5
LELA-PONY2-2	10.2	< 0.1	0.3	36.9	18	0.11	6140	< 0.1	< 0.1	3.9	48	0.1	1350	39.6	< 0.1	0.1	119	0.01	< 1	14	1.1	< 0.5	41.6
LELA-H2-1	18	< 0.1	0.5	87.3	18	0.07	5510	0.2	< 0.1	4.5	53	0.2	1320	1760	0.1	0.2	96	< 0.01	4	5.99	1	< 0.5	44.3
LELA-PONY3-1	72.4	1.4	12.5	41.4	25	0.27	8670	< 0.1	< 0.1	5.1	509	5.2	1850	318	< 0.1	0.3	125	0.15	13	22.7	2.7	< 0.5	71.5
LELA-DOMER7-1	20.8	< 0.1	0.5	3.6	15	1.4	10900	< 0.1	0.9	4.7	101	0.3	3660	606	< 0.1	0.6	100	0.01	23	18.9	1.7	< 0.5	202
Control Plot Maximum	37.8	< 0.1	0.1	73.4	19.0	0.06	7580	< 0.1	< 0.1	3.8	71.0	< 0.1	1490	2070	0.1	0.3	114	0.01	2.0	11.0	2.0	< 0.5	34.4
Control Plot Mean (n=4)	31.7	< 0.1	< 0.1	63.1	14.8	0.05	6422	< 0.1	< 0.1	3.2	52.4	< 0.1	1296	1289	< 0.1	0.2	101	< 0.01	1.6	8.2	1.5	< 0.5	28.7

[1]Sample ID = species code-plot#-sample#.

In order to determine the spatial distribution of elevated levels of the five elements of concern, a series of t-tests (two tailed, assuming unequal variance) were conducted and are summarized in Table 3.8. The detailed results of the t-tests performed can be found in Appendix D.

Table 3.8. Summary of t-tests performed on Labrador tea for the five major elements.

		Antimony	Arsenic	Copper	Lead	Silver
Mean Value	Mill	0.061	0.522	3.68	0.375	0.009
	Pit	0.05	0.414	3.1	0.125	NA
	Pond	0.133	1.35	3.53	1.05	NA
	Riparian	0.231	2.33	3.675	1.06	0.0275
	Control	0.05	0.06	3.2	0.05	0.006
	Transects	0.05	0.182	3.37	0.135	0.0084
Mill vs Control			✓		✓	
Mill vs Transects			✓		✓	
Pit vs Control						
Pit vs Transects						
Pond vs Control						
Pond vs Transects						
Riparian vs Control						
Riparian vs Transects						

Transects = plots where lichen levels were not elevated for each particular metal.

Labrador tea leaves had higher arsenic and lead levels near the mill site compared to controls.

It is evident that the most significant relationship in this species is in the area surrounding the mill site where arsenic and lead concentrations were elevated in comparison to control areas. Despite somewhat elevated concentrations in the riparian and pond sites, a small sample size and high degree of variability in these areas lead to an insignificant difference in metal concentration.

Willow

Willow (*Salix spp.*) was a very common plant within the study area and was encountered at nearly every sample plot. A representative number (n=31) of stem samples collected from the terrestrial sites transects were chosen for analysis. The samples collected were a mixture of new growth and leaves as these were the parts deemed to be eaten by both humans and animals. In addition to these samples, control (n=5), riparian (n=9), contaminated area (n=4), duplicate (n=1) and replicate (n=1) samples were also chosen for analysis.

A number of metals including antimony, arsenic and lead were elevated in comparison to Yukon background and control plot data for this species. Refer to Table 3.9 to see all elements that were elevated. It should also be noted that a number of metals had an insufficient sample size in Yukon background data and were thus compared to control site values only.

Table 3.9. Metals in willow shoots above maximum control plot levels (highlighted).

Sample ID	Metal Concentration (ppm)																			
	Al	As	Be	B	Ca	Cr	Co	Cu	Fe	Pb	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	Ti
SASP-J1-1	8.7	0.5	< 0.02	29	9010	< 0.1	0.1	2.6	78	0.2	0.2	0.2	969	5230	< 0.2	91	< 0.01	130	13.6	1.1
SASP-DOME1-1	45.7	0.3	< 0.02	6	9180	0.1	1.4	3.8	87	0.2	0.1	1.2	1110	7030	< 0.2	116	< 0.01	10	49.2	1.1
SASP-Q1-1	32.2	< 0.1	< 0.02	7	9200	< 0.1	2.3	2.4	82	< 0.1	0.2	0.8	2040	7510	< 0.2	95	< 0.01	78	81.7	1.5
SASP-H1-1A	38.5	0.5	< 0.02	7	14100	< 0.1	1.1	4.8	104	0.4	0.2	3.2	1550	8260	< 0.2	107	< 0.01	40	99.1	1.1
SASP-K2-1	12.4	0.4	< 0.02	46	13100	< 0.1	0.8	3.6	96	< 0.1	0.6	0.6	1860	6320	0.2	72	< 0.01	155	29.6	1.7
SASP-H1-1B	13.8	0.5	< 0.02	37	11300	< 0.1	0.7	3.6	90	0.1	0.6	0.9	1520	7110	< 0.2	86	< 0.01	66	36	1.6
SASP-R2-1	22.4	0.2	< 0.02	8	21500	< 0.1	0.9	3.3	124	0.2	< 0.1	1.3	1340	8340	< 0.2	106	0.01	5	84.2	2.1
SASP-PONY2-1	81.7	1.4	0.02	10	17700	< 0.1	1.5	4.3	190	1	0.6	1.4	1730	11400	< 0.2	97	0.02	5	90.5	2.7
SASP-L2-1	10.5	0.3	< 0.02	23	15700	< 0.1	0.2	3.4	80	0.2	0.2	0.5	1480	8730	< 0.2	102	< 0.01	5	44	1.2
SASP-C1-1	18.7	< 0.1	< 0.02	14	16300	< 0.1	0.6	3.1	86	< 0.1	0.9	1.3	1480	11100	< 0.2	50	< 0.01	2	49.4	1.6
SASP-DOMER6-1	14.9	0.4	< 0.02	12	13400	0.1	0.3	4.7	85	0.4	< 0.1	1.4	830	6560	< 0.2	97	0.01	17	51.4	1.3
SASP-H3-1	10.4	0.1	< 0.02	33	11000	< 0.1	0.2	4.7	71	< 0.1	0.3	0.7	1110	11600	< 0.2	116	< 0.01	260	22.6	1.1
SASP-L1-1	60.4	2.2	< 0.02	5	9500	0.4	0.9	3.5	215	1.3	0.1	1.1	936	7430	< 0.2	75	0.02	40	47.9	2.9
SASP-PIT1-1	34.2	1.6	< 0.02	11	20300	< 0.1	0.8	3.6	155	1.3	< 0.1	1.6	1270	7850	< 0.2	98	0.07	4	71.4	2.7
SASP-WROCK2-1	21.1	1.8	< 0.02	7	22700	< 0.1	0.8	3.4	117	0.6	< 0.1	1.4	973	7670	< 0.2	106	0.01	3	79.7	1.3
SASP-J2-1	51	3.5	< 0.02	4	14700	0.3	0.4	3.2	251	1.2	0.4	0.9	1050	7210	< 0.2	85	0.01	41	64	3.7
SASP-G1-1	18.9	0.3	< 0.02	13	16500	< 0.1	0.9	3.6	117	0.2	< 0.1	1.4	1500	9600	< 0.2	110	0.01	14	69.3	2
SASP-PONY3-1	17.5	1.4	< 0.02	4	18100	< 0.1	0.4	3.6	140	1	0.2	0.3	1650	9270	< 0.2	86	0.03	49	56	2.1
SASP-P1-1	43.1	0.3	< 0.02	8	22400	< 0.1	1.2	2.3	137	0.2	< 0.1	1.5	1840	8330	< 0.2	90	0.02	5	124	2.8
SASP-P2-1	109	0.1	0.03	10	14200	0.1	1.6	3.6	77	0.2	0.1	3.6	3210	7750	< 0.2	90	< 0.01	13	130	2.1
SASP-P3-1	24.1	0.6	< 0.02	11	16600	< 0.1	0.8	3.7	138	0.4	0.2	0.6	1050	6050	< 0.2	112	0.01	93	82.7	2.2
SASP-R3-1	49.4	0.1	0.02	8	21400	< 0.1	0.9	3.4	108	0.2	< 0.1	2.9	3050	10600	< 0.2	56	< 0.01	8	142	2.6
SASP-PONY1-1	16.8	0.6	< 0.02	227	17900	< 0.1	0.2	5	114	0.4	0.3	0.8	1150	7250	< 0.2	110	0.02	12	40.1	2
SASP-K1-1	66.2	2.3	< 0.02	11	14100	0.2	1.4	4.9	206	1.4	0.2	0.9	2000	7160	< 0.2	108	0.02	7	93.3	2.6
SASP-I1-1	10.2	< 0.1	< 0.02	15	9860	< 0.1	0.2	4.1	73	< 0.1	< 0.1	0.8	1180	6770	< 0.2	104	< 0.01	6	30.4	1.4
SASP-D1-1	10.5	0.2	< 0.02	15	11300	0.2	0.2	5.2	76	< 0.1	0.3	0.4	1150	6080	< 0.2	87	0.02	82	60.4	1.1
SASP-DOME3-1	13	0.6	< 0.02	10	11300	< 0.1	0.7	4.3	138	0.3	< 0.1	0.2	851	3570	< 0.2	68	0.03	286	57.2	1.1
SASP-DOME4-1	48.5	4.5	< 0.02	11	18700	< 0.1	1.2	4.5	153	6	0.5	2.6	1060	7410	< 0.2	74	0.09	4	101	1
SASP-TAIL-2	17.5	0.2	< 0.02	39	15200	< 0.1	0.5	5.2	92	< 0.1	0.5	2.3	3130	10600	< 0.2	67	< 0.01	2	47.5	2.8
SASP-G2-1	113	< 0.1	0.03	5	22800	< 0.1	1.6	3.4	96	0.1	< 0.1	3.3	2260	7630	< 0.2	69	< 0.01	5	145	2.3
SASP-I4-1	18.8	0.9	< 0.02	9	11200	< 0.1	0.4	4.4	139	0.5	< 0.1	0.2	861	3690	< 0.2	59	0.03	180	54.5	1.4
SASP-O1-1	21.2	0.2	< 0.02	11	11600	0.2	0.2	2.5	72	0.2	< 0.1	1.3	1070	7940	< 0.2	107	0.04	16	56.4	1.3
SASP-C3-1	26.3	0.8	< 0.02	31	19400	0.1	0.3	4.5	178	0.4	0.3	0.5	1400	10800	< 0.2	110	0.03	15	100	1.8
SASP-DOMER5-1	18.2	0.5	< 0.02	33	19100	< 0.1	0.8	6	111	0.3	0.8	2.6	3140	10200	< 0.2	108	0.01	8	88.7	2.2
SASP-TAIL-1	19.9	8.3	< 0.02	79	23200	< 0.1	2	11.2	223	6.3	0.9	2.2	2190	11600	< 0.2	97	0.08	5	62.9	2.3
SASP-J5-1	39.3	0.1	< 0.02	8	19300	< 0.1	1.2	4.7	96	0.2	0.1	2.3	1570	8710	< 0.2	65	0.01	6	146	1.6
SASP-C2-1	25.4	2.1	< 0.02	21	14700	0.2	0.8	6.3	147	1.5	0.3	1.1	2770	12100	< 0.2	96	0.02	7	30.2	1.9
Gamberg (2006) Mean	15.5	0.16	0.014	14.5	7098	0.64	0.1	5.08	47	0.09	0.29	1.3	NA	NA	0.34	NA	0.034	NA	22.1	NA
Gamberg (2006) Maximum	94.5	1.02	0.02	20	18100	1.89	0.3	11.4	173	0.29	0.82	3.3	NA	NA	0.7	NA	0.203	NA	58.6	NA
Gamberg - Sample size	14	8	6	10	15	10	10	15	15	8	10	12	0	0	6	0	9	0	15	0
Control Plot Maximum	81.3	3	0.02	92	22700	0.1	1.4	6.6	203	1.5	0.5	3.3	3320	9190	< 0.2	95	0.05	94	135	2.3
Control Plot Mean (n=5)	32.2	0.94	< 0.02	37.8	15560	< 0.1	1	4.18	107	0.55	0.3	16	1784	6248	< 0.2	80	0.023	42	61	1.7

[1]Sample ID = species code-plot#-sample#.

In order to determine the spatial distribution of elevated levels of the five elements of concern, a series of t test were conducted and are summarized in Table 3.10. The detailed results of the t-tests performed can be found in Appendix D.

Table 3.10. Summary of t-tests performed on willow for the five major elements.

		Antimony	Arsenic	Copper	Lead	Silver
Mean Value	Mill	0.95	1.135	4.12	0.693	0.023
	Pit	0.067	1.256	3.80	0.643	NA
	Pond	0.25	2.20	4.86	2.43	NA
	Riparian	0.055	0.435	3.97	0.14	0.012
	Control	0.05	0.09	3.70	0.16	0.007
	Transects[1]	0.134	0.15	3.62	0.157	0.021
	Contam[2]	0.325	3.85	7.00	3.53	0.05
Mill vs Control			✓		✓	✓
Mill vs Transects			✓		✓	
Pit vs Control			✓		✓	
Pit vs Transects			✓		✓	
Pond vs Control						
Pond vs Transects				✓		
Riparian vs Control			✓			
Riparian vs Transects			✓			
Contam[1] vs Control						
Contam[1] vs Transects						

[1] Transects includes transect sites where metal levels were not elevated in the lichen data for each particular metal.
[2] Contam includes samples taken directly from the pit, the waste rock and the tailing pond.

As shown by the t-tests, arsenic and lead in willow plants have significantly higher concentrations than the controls at both the mill and the pit sites. The significant difference in the arsenic concentrations between riparian and control areas suggest that there may be transportation of this metal by Dome and Pony creeks. The only significant difference in silver concentrations was found between the mill site and the control sites. There were no significant differences found in levels of antimony. The only significant relationship found for copper was between the pond sites and the transect sites.

Willow showed some elevated metal levels near the mill, pit, pond and in riparian sites.

The elevated level of arsenic in a sample collected from the tailings pond (on dried portion of tailings) had the highest concentration of arsenic at 8.3 ppm. The results indicate that Dome Creek and/or the tailings pond may be a source of arsenic as the nearby points Dome Riparian 4 and C2 also had elevated concentrations of 4.5 and 2.1 ppm, respectively. A similar pattern is seen with lead, since these values were somewhat elevated in and around the tailings pond area. Results from the area surrounding the mill site also suggest this may be a point source of contamination for arsenic and lead as shown by points K1, J2, L1 and H2. These points were all in close proximity to the mill site (Figure 2.2).

3.1.2.3 Mushrooms

Bolete mushroom

A single sample (n=1) of a bolete mushroom (*Bolete spp.*) was collected within the study site and plot I2. The low sample size of this species collected within the study site as well as in the background data makes any comparisons difficult. However, the sample collected within the study site did show relatively moderate levels of both arsenic and lead (Table 3.11).

Table 3.11. Arsenic and lead concentrations in a sample of *Bolete* mushroom.

	Arsenic	Lead
Mt Nansen (2006)	3.6	2.3
Gamberg (2006)	0.07	0.53

3.1.2.4 Spruce Sap

White Spruce

White spruce (*Picea glauca*) was very common in portions the study area; however, significant amounts of sap to warrant sample collection was limited to a few trees. Four (n=4) samples were collected as well as a single (n=1) duplicate sample. The samples collected were of fresh sap and Yukon background data was analyzed for twigs and cones rather than sap. Furthermore, no control samples were obtained for white spruce sap. Due to this discrepancy it is difficult to make comparisons for this species. It is for this reason that the five metals of concern (as identified by lichen contamination) are shown below in Table 3.12. There are a few trace metals which appear to be elevated in the Pony Creek riparian plot (see site P1 in Table 3.12).

Table 3.12. Metal concentrations in samples of white spruce sap that were higher than Yukon background data for white spruce twigs and cones.

Sample ID[1]	Metal Concentration (ppm)				
	Antimony	Arsenic	Copper	Lead	Silver
PIGL-E2-1	<0.1	<0.1	0.1	<0.1	<0.01
PIGL-L3-1	<0.1	0.3	0.4	0.2	0.01
PIGL-M2-1	<0.1	0.5	0.2	0.4	<0.01
PIGL-P1-1A	0.3	3.7	1	4	0.06
PIGL-P1-1B	0.2	1.8	0.8	2.1	0.03

[1]Sample ID = species code-plot#-sample#.

Trembling Aspen

Trembling aspen (*Populus tremuloides*) was encountered infrequently within the study site. A single sample was collected in the Pony Creek area (site Q3) and was compared to the Yukon background data for this species. There were no elevated trace metal concentrations found through this comparison.

3.1.2.5 Lichens (other than caribou lichen)

Tumble Lichen / Caribou Horn Lichen

Tumble lichen, also locally known as caribou horn lichen (Masonhalea richardsonii) was encountered in moderate amounts within the study site, primarily at the sites at higher elevations. A small number of samples were analyzed (n=3) along with control (n=2) and road influenced (n=1) sites. The small samples size (n=2) of control samples makes a meaningful comparison difficult. However, the levels of metals that appeared elevated when compared to control samples are presented below in Table 3.13.

Table 3.13. Concentrations of the five metals of concern in caribou horn lichen (levels above maximum control value are highlighted).

Sample ID	Metal Concentration (ppm)													
	Al	Sb	As	Ba	Ca	Co	Cu	Fe	Pb	Si	Ag	Na	Sr	Ti	V
MARI-A4-1	41.2	< 0.1	0.3	5.7	878	< 0.1	0.8	75	1.1	56	0.05	72	2.45	3	< 0.5
MARI-DUST2-1	132	< 0.1	1.8	9.1	4030	0.2	1	280	3.2	80	0.06	64	2.94	5.8	0.6
MARI-F1-1	69.6	< 0.1	0.9	5.7	3110	0.2	0.8	108	3.4	73	0.12	29	6.21	4.8	< 0.5
MARI-R2-1	60.1	0.2	1.8	9.1	2190	0.2	1	141	6	72	0.1	80	4.86	2.3	< 0.5
Control Plot Maximum	51.2	< 0.1	0.5	6.2	3590	0.1	0.8	89	0.9	65	0.03	60	5.86	3.6	< 0.5
Control Plot Average	45.3	< 0.1	0.45	5.7	2905	0.1	0.75	77	0.75	60	0.025	51.5	4.525	3	< 0.5

[1]Sample ID = species code-plot#-sample#.

3.1.2.6 Grasses

Slender Wheat Grass

Slender wheat grass (*Agropyron trachycaulum*) was collected at the study area only from possible sources of contamination (tailings pond and pit). There was no pre-existing background data for this species; however, the levels of arsenic and lead found in this species growing on the tailings pond were among the highest found (for plants) in the study (Table 3.14).

Grasses collected from potential sources of contamination revealed some high metal levels compared to other plants.

Table 3.14. Notable metal concentrations (ppm) in slender wheat grass.

Sample ID[1]	Antimony	Arsenic	Copper	Iron	Lead	Silver	Strontium	Titanium
WHGR-PIT1-1	0.6	16	2.8	737	13.1	0.08	11.1	2.8
WHGR-TAIL-1	1.3	11.4	7.5	207	9.4	0.12	20.6	0.7
WHGR-TAIL-2	0.7	3.5	2.7	64	1.3	0.06	16.9	1.1

[1]Sample ID = species code-plot#-sample#.

Foxtail Barley

As with slender wheat grass, foxtail barley (*Hordeum jubatum*) was collected at the study area only from the possible point sources of contamination (tailings pond, pit and waste rock dump). There is no existing background data for this species; however, it appears that some levels are quite high (Table 3.15). In particular, a sample collected from the tailings pond (highlighted in table) had the highest levels of antimony, arsenic, copper, iron, and lead, compared to all other plants collected in this study. Many other metals were high as well.

Table 3.15. Notable metal concentrations (ppm) in foxtail barley.

Sample ID[1]	Aluminium	Antimony	Arsenic	Cadmium	Copper	Iron	Lead	Silver	Strontium	Titanium
HOJU-PIT3-1	19.8	0.1	1.3	0.22	8.8	99	3.1	0.04	7.32	0.7
HOJU-PIT5-1	51.3	0.6	5.6	0.24	8.3	240	3.1	0.1	8.24	1
HOJU-TAIL-1	135	4.8	50.5	1.76	54.2	930	50.1	0.42	17	1.6
HOJU-WROCK2-1	24.5	< 0.1	0.2	0.08	3.9	57	0.2	0.03	6.03	1

[1]Sample ID = species code-plot#-sample#.

3.1.2.7 Blackened Vegetation

Sphagnum Moss

Three samples of sphagnum moss (*Sphagnum spp.*) were analyzed from the area of blackened vegetation along Dome Creek downstream of the seepage collection area. While there is no background data for sphagnum moss, metals were extremely high compared to the other plants. In fact, 16 metals were higher in these three sites compared to any other plants analyzed in this study. Table 3.16 lists the levels for each site compared to the mean for the other plants analyzed. To give the results some perspective, the iron at site BVEG1 is 534 times that of the average of all other plants. In addition to the elements listed in the table, calcium, manganese, magnesium, selenium, thallium, silicon, sodium and strontium all had higher averages than the averages of the other plant samples (Appendix D).

Blackened Vegetation along Dome Creek had extremely high metal levels.

Table 3.16. Results from metals that were highest in all three blackened vegetation sites than any other vegetation.

Sample ID	Al	As	Ba	Be	Co	Cu	Cr	Fe
BVEG1-1	5000	219	179	0.25	7.3	195	9.7	42,000
BVEG2-1	1000	141	252	0.06	5.7	613	2.1	26,400
BVEG3-1	976	64.4	171	0.04	3.4	332	1.2	32,400
Mean for other plants[1]	**28.75**	**1.6**	**33.1**	**0.02***	**0.71***	**3.99**	**0.26***	**78.89**
Sample ID	**Hg**	**Mo**	**Ni**	**Pb**	**Sb**	**Ti**	**U**	**V**
BVEG1-1	0.076	1.5	12.8	48.3	1.6	195	2.54	22.4
BVEG2-1	0.561	0.9	21.8	62.6	1.7	39.1	1.99	9.3
BVEG3-1	0.151	1.8	4.5	15.2	1.3	37.3	1.87	2.9
Mean for other plants[1]	**0.04***	**0.27***	**0.61**	**1.69**	**0.52**	**1.37**	**0.6***	**0.72***

[1] not including caribou moss or green samples within BVEG area * for samples above the detection limit.

Live Labrador Tea and Willow Growing in Area of Blackened Vegetation.

A small number of living shrubs were present within the area of blackened vegetation. Samples of live Labrador tea (n=2) and willow (n=3) were collected from this location. Table 3.17 outlines the comparison made between live samples collected from the blackened vegetation area to control samples. Several samples had metal levels that were higher than the highest levels at the control sites; however, in most cases the difference was not more than an order of magnitude. Interestingly the metal levels found in Labrador tea in the area of blackened vegetation were often higher than all control samples. It should be noted that the blackened vegetation area is adjacent to Dome Creek and somewhat near the tailings ponds and as such may be influenced by many factors compared to the control samples.

Table 3.17. Metal levels that were higher than the control samples for live vegetation collected within the area of blackened vegetation (BVEG). Yellow highlighted values have at least one sample above the range of control sites while orange highlighted values were all above control samples.

	Labrador Tea		Willow	
Metal	Green Samples from BVEG area	Control Samples	Green Samples from BVEG area	Control Samples
Al	20.2 - 22.4	24.6 - 37.8	18 -142	26.6 - 113
As	0.5 - 3.2	<0.1 - 0.1	0.4 - 1.4	<0.1 - 0.1
Ba	98.6 - 110	54.2 - 73.4	21.3 - 55.7	52.7 - 130
B	27 - 81	12.0 - 19.0	25 - 29	5.0 - 10.0
Ca	8000 - 10000	5090 - 7580	13000 - 15300	13100 - 22800
Cr	<0.1	<0.1	<0.1 - 0.3	<0.1 - 0.1
Co	<0.1 - 0.1	<0.1	0.2 - 1.8	0.9 - 1.6
Cu	3.2 - 5.8	2.8 - 3.8	4.3 - 5.1	3.4 - 4.7
Fe	68 - 753	40 - 71	104 - 141	77 - 108
Pb	0.5 - 0.5	<0.1	0.4 - 1.3	0.1 - 0.2
Mg	1440 - 2150	1200 - 1490	3350 - 4210	1890 - 6360
Mo	<0.1	<0.1 - 0.1	<0.1 - 0.2	<0.1 - 0.1
Ni	0.5 - 0.7	0.2 - 0.3	0.8 - 6.2	2.3 - 3.6
Si	180 - 182	83 - 114	145 - 179	56 - 90
Ag	0.01 - 0.09	<0.01 - 0.01	<0.01 - 0.03	<0.01 - 0.01
Na	8 - 160	1.0 - 2.0	13 - 38	5.0 - 32
Sr	24.6 - 27.1	6.7 - 11.0	49.8 - 54.6	66.3 - 146
Tl	0.11 - 0.28	0.03 - 0.11	<0.02	<0.02
Sn	0.1 - 0.3	<0.1	<0.1 - 0.2	<0.1

3.1.3 Soils

The soils component of the project was undertaken with the view that soils are one of the environmental components that in context with other parameters, may provide insight into the natural and human induced geochemical processes occurring in this area.

Soil samples were analyzed from sites located within areas found to contain elevated levels for metals (arsenic and lead) in lichen samples. As well, soil samples from three sites located within the zone of dead/blackened vegetation located along the bank of Dome Creek were analyzed. In addition, for reference purposes 5 samples from the mineralized control area (Spud, Webber and Flex zones) located approximately 1-2 km northwest from the minesite were analyzed. These samples should provide insight into the background levels of metals present in the Mt. Nansen area which are believed to be not directly impacted by mining activities (please note there was some surface exploration activity in this area). In all cases, these included samples from the A and B soil horizons. It also included samples from the C soil horizon where sampling was not restricted by permafrost conditions. Refer to Appendix H for the results of all soil samples analyzed.

Laboratory analyses of the control site samples showed noticeable patterns between the sampled horizons (Table 3.18). Mean metal levels in the C-horizon are often higher compared to the other horizons perhaps a result of the underlying geology (mineralized zone). The B-horizon, which mostly consisted of a volcanic ash layer appeared to be relatively depleted of several elements (As, Ba, Cu, Fe, Mg, Mn), indicating that vertical transport between the existing horizons in this area may be limited. The A-horizon was relatively acidic (pH ~ 4.5) most likely due to the well-developed organic layer, which typically contains humic and fluvic acids. The slightly elevated levels of As, Cd, Hg are likely the result of higher organic matter content of this horizon. These metals are known to be readily adsorbed by organic substances.

Table 3.18. Mean levels of metals in soils at the control sites.

Soil Horizon	Mean Metal Levels (ppm)[1]														
	Sb	**As**	**Ba**	**Be**	**Cd**	**Cr**	**Co**	**Cu**	**Pb**	**Hg**	**Mo**	**Ni**	**Se**	**Ag**	**Sn**
A	<DL	29.2	133	<DL	2.22	8.2	2.8	14	11	0.142	<DL	5.4	<DL	1.4	<DL
B	<DL	11.2	46	<DL	0.30	8	3.2	12	8.9	0.021	<DL	7.5	0.14	<DL	<DL
C	<DL	85.2	125	<DL	1.34	21	8.2	30	28	0.042	<DL	12	0.11	<DL	<DL
	V	**Zn**	**Al**	**B**	**Ca**	**Fe**	**Mg**	**Mn**	**P**	**K**	**Na**	**Sr**	**Ti**	**Zr**	
A	15	62	5882	0.9	2984	7932	1223	121	981	664	83	30	108	.6	
B	24	31	4200	<DL	997	8890	1225	134	245	344	132	8	254	.6	
C	43	111	17120	<DL	2156	19980	3956	356	450	691	92	18	347	1.8	

[1] To calculate average levels, detection limits estimated at ½ of detection limit. DL = below detection limit.

Table 3.19 details the mean levels of metals found in the soil samples from each horizon taken at transect plots with high levels or lead and arsenic (in the lichens). Of interest, unlike the control plots the mean levels for many metals were highest in the A-horizon. Of the five metals of primary concern (determined by the lichen sampling) arsenic, lead, antimony and copper all show this pattern (this pattern was not evident in silver where all values were below the detection limit).

Table 3.19. Mean levels of metals in soil samples from transect sites with high lead and arsenic levels in lichens.[a]

Soil Horizon	Mean Metal Levels (ppm)[1]													
	Sb	**As**	**Ba**	**Be**	**Cd**	**Cr**	**Co**	**Cu**	**Pb**	**Hg**	**Mo**	**Ni**	**Se**	**Ag**	**Sn**
A	6	59	239	DL	2	6.3	6	27	10	0.09	DL	7	0.3	DL	DL
B	DL	35	118	DL	1	6.5	6	8.1	9	0.03	DL	4	0.2	DL	DL
C	DL	30	130	DL	1	13	7	20	7	0.03	DL	7	0.1	DL	DL
	V	**Zn**	**Al**	**B**	**Ca**	**Fe**	**Mg**	**Mn**	**P**	**K**	**Na**	**Sr**	**Ti**	**Zr**	
A	19	56	6098.5	1	9272	11017	1510	1079	977	478	101	58	140	1	
B	31	40	4653.4	DL	2566	11864	1418	1253	514	324	158	16	367	1	
C	43	44.4	10089	DL	3210	16650	3450	290.3	624	814	112	19	483	1	

[1] To calculate average levels, detection limits estimated at ½ of detection limit. DL = below detection limit.
[a] Plots where lichen lead levels were 9.3 ppm and/or arsenic levels over 11.5 ppm

Table 3.20 details the mean levels of metals found in the soil samples from each horizon taken from the beneath the zone of dead/blackened vegetation along Dome Creek. The samples from the zone along Dome Creek generally exhibited levels of metals higher than those found in other soil samples (both control and transect sites). This was most prominent in the A and B-horizons. In some cases, such as copper (Cu), iron (Fe) and manganese (Mn) the mean levels were dramatically higher in the dead/blackened vegetation area (A horizon) soil samples than those from the other A horizon samples. Conversely, the vast majority of the C-horizon soil samples from the dead/blackened vegetation sites often had much lower levels of metals than the other C-horizon samples.

Table 3.20. Mean levels of metals in soils under blackened vegetation along Dome Creek.

Soil Horizon	Mean Metal Levels (ppm)[1]													
	Sb	**As**	**Ba**	**Be**	**Cd**	**Cr**	**Co**	**Cu**	**Pb**	**Hg**	**Mo**	**Ni**	**Se**	**Ag**	**Sn**
A	DL	104	162	DL	2.5	6	12.3	160.7	7.3	0.1	DL	9.3	0.4	2.7	4.5
B	6.7	320	342.6	DL	4.2	4.2	28.6	92.7	27.3	0.1	3.7	17.3	0.9	DL	5.9
C	DL	9	44.3	DL	DL	7.3	3.5	7	DL	0.01	DL	5.3	DL	DL	DL
	V	**Zn**	**Al**	**B**	**Ca**	**Fe**	**Mg**	**Mn**	**P**	**K**	**Na**	**Sr**	**Ti**	**Zr**	
A	16.3	90	4846.7	6	8776.7	24966.7	1747.3	3921	746.3	388.3	81.7	38.3	102.3	1	
B	82.7	130.7	27766.7	DL	4650	86933.3	2673.3	6103.3	973.7	510.7	114.7	39.7	251	5.3	
C	19.5	27	4737.5	DL	1945	6660	1806	71.8	423.8	433	163	11.8	291.5	1	

[1] To calculate average levels, detection limits estimated at ½ of detection limit. DL = below detection limit.

Soil sampling results by major element types are presented below.

Antimony

The levels of antimony were found to be at very low levels (below the detection limit of 10 ug/g) at all sites except J-1 in the upper horizon where concentration was 25 ug/g. All levels were within CCME (2002) guidelines and Yukon Contaminated Sites Regulations (2002) for industrial sites (40 ug/g). Antimony levels were below or at detection limits for all other sites (including control sites and blackened vegetation sites).

Arsenic

Arsenic appears to be the most noteworthy metal found in the soils in this study. High levels of arsenic were found at several sampling sites, mostly within the upper horizon.

Many sites including controls have levels that exceed the CCME (2002) guideline for industrial sites (12 ug/g) for arsenic as such this guideline has limited applicability to this study. The Yukon Contaminated Sites Regulations (2002) limit for industrial sites (toxicity to soil invertebrates and plants) is 100 ug/g. Only 2 control samples, both in the C-horizon (CP8 and CP5) had levels over the 100 ug/g (141 and 106 ug/g respectively).

The area of highest arsenic concentrations was around the mill site (J1, J2, K2) where the highest levels (209-485 ug/g) were detected within the upper soil horizon. In this area, horizon B (ash layer) and even the C horizon showed relatively high levels of arsenic (70 – 247 ug/g). The levels of arsenic in the mill area exceeded the Yukon Contaminated Sites Regulations (2002) for industrial sites (100 ug/g) in the A horizon at site J2 and in both the A and B horizons at J1 and K2. Levels were also high in the B-horizon beneath the blackened vegetation (212-400 ug/g) and in the A-horizon at one site (201 ug/g). Archer, Cathro & Associates Limited (1987) completed extensive soil sampling around the Mt. Nansen area (in the B and C-horizons) prior to mine development and found many areas with levels of arsenic (up to 4,010 ug/g).

Cadmium

For all sites cadmium levels were variable and ranged from less than the detection limit (0.5 ug/g) to 7 ug/g. All samples fell below the CCME limits for industrial sites (22 ug/g) and Yukon Contaminated Sites Regulations (2002; 500 ug/g).

Copper

For transect and control sites the concentration of copper was below the CCME guidelines (2002) and Yukon Contaminated Sites Regulations (2002) for industrial sites at all sampling sites (91 ug/g and 250 ug/g respectively). The levels were generally highest in A and C-horizon.

The highest copper levels were found within the blackened vegetation plots, with levels up to 340 ug/g in the A-horizon and 94 ug/g in the B-horizon. Conversely, the lowest copper concentrations were found in the C-horizon (2-11 ug/g).

Lead

Although there is an increase in lead levels in the A-horizon at several sites near the Mill site (129 ug/g at J1/ 13 ug/g at J2 / 28 ug/g at K2) the numbers were still within the CCME (2002) guidelines (600 ug/g) and Yukon Contaminated Sites Regulations (2,000 ug/g) for industrial sites. There were relatively low lead levels detected within B and C-horizons (up to 35 ug/g). Lead levels were relatively low in the soil samples under the blackened vegetation (highest level recorded was 31 ug/g in the B-horizon). Levels at the control sites were generally low with the highest levels found in the C-horizon (maximum of 32 ug/g).

Mercury

Concentrations of mercury were detected at very low levels at all sampling sites (well below all CCME guidelines (50 ug/g; 2002)[1]. The highest mercury levels were found in the A-horizon.

Silver

Concentrations of silver were below the detection limit (2 ug/g) at all sites, with the exception of a levels of 6 ug/g and 3 ug/g found in the A-horizon at one site under the blackened vegetation and one control site, respectively. These levels are well below CCME (2002) guidelines and Yukon Contaminated Sites Regulations for soils (industrial sites; 40 ug/g).

Zinc

The highest concentration of zinc was detected at J1 near the Mill site (253 ug/g for A horizon and 222 ug/g for B horizon) and was likely due to a natural anomally. The samples from other sites showed relatively uniform concentrations and all were below CCME (2002) guidelines and Yukon Contaminated Sites Regulations for industrial sites (360 ug/g and 600 ug/g respectively).

3.1.4 Wildlife

3.1.4.1 Small Mammals/Birds

The species collected and subsequently analyzed for levels of metals were red-backed vole (*Clethrionomys glareolus*), gray jay (*Perisoreus canadensis*), masked shrew (*Sorex cinareus*), a red squirrel (*Tamiasciurus hudsonicus*), and an arctic ground squirrel

[1] No Yukon Contaminated Sites Regulations limits for Mercury were found.

(*Spermophilus parryii*). These were collected from within the mine site as well as within a control area near Rowlinson Creek. No control samples were obtained for shrews, red squirrel, or ground squirrel. The complete laboratory results from this analysis are presented in Appendix I.

Shrews were analyzed as whole animals due to their small size, and the individual kidneys and livers of the red squirrel and the ground squirrel were also analyzed. However, these results have no corresponding control samples with which to compare, and further, the sample sizes were too small to make any definitive statements about the impact of the mine. It should be noted that the levels in shrews were generally quite low (at or near detection limits) for arsenic, silver, lead and antimony. It is also worth noting that levels of arsenic (As), were slightly higher in the liver samples of the ground squirrel (5.4 ppm dry weight or 1.63 ppm wet weight; taken very close to the mill) than maximum levels from samples collected throughout northern Alaska (wet weight – 1.02 ppm; Allen-Gill, 1997).

Metal levels within small mammals and gray jays were generally slightly higher near the minesite compared to the control site.

Comparing the data from each species taken within the mine site to that taken from within the control area shows some elevated levels of metals within animals collected near the mine site. All applicable samples showed differences in some metal concentrations in the tissues tested between the control and mine sites. However, due to the sample sizes, only those for certain metals from red-backed vole livers could be determined to have differences in metal levels between the control and sample sites with statistical significance (95% confidence—using a 2 variable t-test). Tables 3.21, 3.22, 3.23, and 3.24 illustrate results compared with those of the control site, as per species and tissue type analyzed. Results are detailed for only those metals showing higher levels than at the control site. It should be noted that while some results lack the sample size to obtain statistical significance, they do illustrate higher levels of metals than the control site. A larger sample sizes would be required to confirm that such higher levels represent an identifiable trend. Appendix D presents the statistical data.

Table 3.21. Results of elevated metals at the mine site for gray jay kidneys (not statistically significant—one sample at mine and control sites).

Metal	Mine Site (ppm)	Control Site (ppm)	Comments
Chromium (Cr)	0.6	0.5	Levels similar between sites.
Manganese (Mn)	12.4	10.9	Level only slightly above control level.
Cadmium (Cd)	13.7	7.35	Level almost 2 times control level.
Magnesium (Mg)	734	686	Level only slightly above control level.

* It should be noted that levels of copper (Cu), mercury (Hg), and zinc (Zn) in gray jay kidneys were higher from control samples than from the mine site samples.

Table 3.22. Results of elevated metals at the mine site for gray jay livers (note sample size is 2 for each site).

Metal	Mine Site Ranges (ppm)	Control Site Ranges (ppm)	Significant Difference[1]	Comments
Arsenic (As)	0.7-0.8	<0.1	✓	Highest level 8 times higher than control data.
Lead (Pb)	0.2-0.3	<0.1		Highest level 3 times higher than control data.
Silver (Ag)	0.04-0.11	<0.01		Highest level 11 times higher than control data.
Manganese (Mn)	8.8-10.3	4.6-5.5	✓	Highest level 2 times higher than control data.

[1] P value < 0.05, note small sample size.

Statistics only showed significant differences in vole livers for three metals (Cd, Ag, & Cr) and gray jay livers (As and Mn).

Table 3.23. Results of elevated metals at the mine site for red-backed vole kidneys (not statistically significant—only 1 sample from control site).

Metal	Mine Site Ranges (ppm)	Control Site (ppm)	Comments
Cadmium (Cd)	14.1-24.3	5.12	Highest level over 4 times higher than control data.
Lead (Pb)	0.5-1	0.15	Highest level over 6 times higher than control data.
Manganese (Mn)	10.9-12.7	8.5	Highest level slightly higher than control data.
Zinc (Zn)	85.5-86.3	80.3	Highest level slightly higher than control data.

* It should be noted that levels of chromium (Cr), nickel (Ni), and mercury (Hg) in red-backed vole kidneys were higher from the control samples than from the mine site samples.

Table 3.24. Results of elevated metals at the mine site for red-backed vole livers with significantly significant (95% confidence) differences when compared with control samples.

Metal	Mine Site Ranges (ppm)	Control Site (ppm)	Significant Difference[1]	Comments
Cadmium (Cd)	6.0-36.6	0.7-2.15	✓	Highest level 17 times higher than control data.
Chromium (Cr)	0.05*-0.5	0.05*-0.1*	✓	Highest level 5 times higher than control data.
Silver (Ag)	0.005*-0.04	0.005*-0.01*	✓	Highest level 4 times higher than control data.

* For statistical purposes, levels below detection limits were estimated at ½ of detection limits.

A comparison of the results was conducted using data sources for background levels of metals in the Yukon as well as for other wildlife and domestic livestock. Table 3.25 details these observations in this regard.

Table 3.25. Comments on levels of metals found in gray jays and red-backed voles collected from the Mt. Nansen Mine and control sites (Gamberg, 2006, pers. comm.).

Metal	Observations
Arsenic (As)	Appears to be slightly elevated at the mine site. However, levels of 0.4 ppm have been found in red-backed voles from other control areas, so this may not be due to mining activity. Generally, animal tissues have <0.3 ppm wet weight (which translates to about 1 ppm dry). The highest values obtained in this study fall under this level, it appears that arsenic may not be an issue for voles or gray jays.
Cadmium (Cd)	Appears that elevated levels are present at the mine site. There is one anomaly within the gray jays, but this could easily be an age effect. Cadmium levels increase with age of the animal, and since the age is unknown for gray jays, this could have an effect. Levels of cadmium are comparable to levels found in voles from other control sites. Concentrations are not at a level that would affect the survival of the animal, but they are definitely elevated around the mine site.
Chromium (Cr)	Appears to be slightly higher at the mine site, however, the concentrations are similar to those found in other voles and mice in the Yukon. Only the highest value (1.4 ppm) from a vole kidney sample is higher than the normal range, however it still falls within the range considered normal for domestic rabbits. There are often problems with laboratory accuracy in chromium measurements; therefore, limited emphasis can be placed on these small differences.
Copper (Cu)	Does not appear to be elevated at the mine site. Concentrations are similar to those found in voles from other control areas and are not of toxicological concern.
Manganese (Mn)	Levels appear slightly higher at the mine site, however all measured levels are similar to levels found in voles from other control sites and should not be of toxicological concern.
Magnesium (Mg)	Does not appear that concentrations are elevated at the mine site. Measured levels are somewhat lower than levels seen in voles from other control sites, and they still fall within the adequate range cited for domestic goats and pigs. These concentrations should not be a concern either toxicologically or in terms of deficiencies.
Nickel (Ni)	Does not appear that concentrations are elevated at the mine site. Measured levels are similar to those found in voles from other control sites and should not be of toxicological concern.
Lead (Pb)	Levels appear to be higher at the mine site. Mine site concentrations are higher than concentrations in voles from other control sites, but not as high as concentrations in voles at another mine site. More pronounced differences in kidneys as opposed to liver are expected because kidney concentrations tend to be higher than liver in lead exposed animals. Measured levels are not of toxicological concern for the voles.
Mercury (Hg)	Does not appear that concentrations are elevated at the mine site. Measured levels are somewhat lower than levels found in voles from other control sites. Mercury concentrations in these voles are not of toxicological concern.
Silver (Ag)	Although it appears that silver is somewhat higher in gray jays from the mine site than the control area, the same is not seen in the vole data. Concentrations in voles were similar to those measured in voles from other control sites, while the gray jays from the mine site were higher. However, these levels are similar to concentrations measured in moose throughout the territory and probably should not be considered to be of concern.
Uranium (U)	Does not appear that concentrations are elevated at mine site. Measured levels are similar to levels in voles from other control sites and should not be of toxicological concern.
Zinc (Zn)	Does not appear that concentrations are elevated at mine site. Measured levels are similar to levels in voles from other control sites and should not be of toxicological concern.

3.1.4.2 Ungulates

Element concentrations in moose and caribou tissues from the Mt. Nansen mine site were compared to concentrations in moose and caribou from other parts of the Yukon. Data from the Yukon Contaminants Database was utilized for comparisons, and all data from Game Management Zone 5 (near the Mt. Nansen mine site) were removed before comparisons were made. Caribou were compared only to other woodland caribou from the territory, and not to barren-ground caribou (*Rangifer tarandus granti*; Porcupine herd) because of the differences in diet that could contribute to differential body burdens of some elements.

Some elements can vary with age in moose and caribou (Gamberg 2000), and should be considered as a factor when comparing element concentrations among sites or herds. Because the data were not normally distributed, the effect of age was investigated for each element in each tissue in each species using Spearman's Rank Correlation. When age was a significant factor (α=0.05), the element concentration was normalized for age (age/year) before proceeding further with the analysis.

Element concentrations were compared between the Mt. Nansen site and the rest of the Yukon for each moose tissue (kidney, liver, muscle) using a t-test where the data were normally distributed, and a Mann-Whitney Rank Sum test when the data were not normally distributed, and using age-normalized data where appropriate. The effect of herd on element concentration was tested for woodland caribou tissue (kidney, liver, muscle) was tested using an ANOVA and Tukey's test for multiple comparisons when the data were normally distributed, and using a One-Way ANOVA on Ranks and Dunn's test for multiple comparisons when the data were not normally distributed. In all cases α=0.05. In the multiple comparison tests, all other herds were compared against the Klaza herd (from the Mt. Nansen site). It should be noted that sample numbers from the Mt. Nansen site were very low, and caution should be taken when drawing conclusions from the analyses of so few data.

Mean concentrations of elements are compared in tissues from Mt. Nansen and other areas of the Yukon for woodland caribou in Table 3.36, and for moose in Table 3.27. Each element of concern will be discussed individually. Note that boron and magnesium were not measured by the analytical laboratory.

Concentrations of some elements, such as zinc, were fairly consistent for each organ, even between species, with the exception of one individual moose, that had anomalous levels of several elements. This individual moose was shot near the Mt. Nansen tailings pond and was sampled because there was a concern about contamination from a human consumption standpoint. This individual (ID# 99-774) had relatively high concentrations of liver aluminium, copper, iron and tin, and very low concentrations of renal zinc (kidney).

Antimony

Antimony is not an essential element for animals and although it can be toxic, mobility in food chains is low (Ainsworth et al., 1990). Little antimony occurs free in nature, most being found as the ore stibnite. Industrial uses of antimony include the manufacture of dyes, rubber, paint and enamel vessels. Antimony-tin alloys have also been used in battery grids, lead shot, cable coverings, printer type, foil and solder (Puls, 1994).

Age did not significantly affect antimony concentrations in any tissues measured in moose or caribou measured in this study. In this study, most samples were near or below the detection limit for antimony (Tables 3.26 and 3.27) and no significant differences were observed between the Mt. Nansen mine site and other areas of the Yukon for any tissue in moose or caribou.

Antimony levels in ungulates harvested near the mine site were similar to ungulates from other areas.

Table 3.26. Mean concentrations (mg/kg dry weight) of elements in woodland caribou tissues from the Mt. Nansen mine site (Klaza herd) and from other areas of the Yukon, and a statistical comparison of element concentrations between the two areas.

	Kidney			Liver			Muscle		
	Mt. Nansen	Yukon	Difference	Mt. Nansen	Yukon	Difference	Mt. Nansen	Yukon	Difference
N	3	169		5	107	-	2	50	-
Antimony	0.003	0.023	-	0.003	0.003	-	0.004	0.004	-
Arsenic	0.04	0.22	-	0.01	0.05	-	0.03	0.25	-
Cadmium	33.3	95.7	-	5.5	8.4	-	0.1	0.1	-
Copper	28.3	24.3	-	95.5	73.0	-	13.6	10.4	p=0.007
Chromium	0.014	0.692	-	0.090	0.583	-	0.451	0.502	-
Lead	0.172	0.566	p<0.001	0.059	0.709	p=0.001	0.008	0.054	-
Manganese	7.9	8.3	-	11.2	10.4	-	1.6	1.1	-
Mercury	0.88	2.51	p<0.001	0.18	0.54	p=0.006	0.02	0.02	N/A
Nickel	0.008	0.247	-	0.058	0.065	p=0.001	0.253	0.095	-
Selenium	2.11	5.53	p<0.001	0.64	1.38	p<0.001	0.21	1.72	-
Silver	0.0002	0.0227	-	0.8860	1.9960	-	<0.0001	0.0068	-
Zinc	126.2	124.5	-	80.4	81.0	-	100.8	164.1	p=0.002

- indicates no significant difference at α=0.05; N/A indicates too few data to compare.

Table 3.27. Mean concentrations (mg/kg dry weight) of elements in moose tissues from the Mt. Nansen mine site and other areas of the Yukon, and a statistical comparison of element concentrations between the two areas.

	Kidney			Liver			Muscle		
	Mt. Nansen	**Yukon**	**Difference**	**Mt. Nansen**	**Yukon**	**Difference**	**Mt. Nansen**	**Yukon**	**Difference**
N	4	365		4	55		3	36	-
Antimony	0.001	0.016	-	0.003	0.010	-	0.003	0.061	-
Arsenic	0.07	0.33	p=0.008	0.04	0.08	-	0.06	0.09	-
Cadmium	125.5	144.3	-	16.9	15.6	-	0.1	0.1	-
Copper	17.5	17.0	-	351.0	107.7	p=0.029	4.8	5.8	-
Chromium	0.233	1.068	p=0.007	0.190	1.526	p=0.006	0.290	0.997	p=0.008
Lead	0.060	0.451	-	0.028	0.300	-	0.013	5.068	-
Manganese	15.2	8.7	-	11.2	7.3	-	0.7	0.8	-
Mercury	0.06	0.08	-	0.03	0.03	-	<0.002	0.07	-
Nickel	0.325	0.470	-	0.179	0.093	-	0.125	0.092	-
Selenium	2.87	4.99	p=0.017	1.21	4.89	p=0.045	0.41	0.93	-
Silver	<0.0001	0.0151	-	0.3683	0.3514	-	<0.0001	0.0911	-
Zinc	128.4	143.9	-	65.5	100.7	-	178.4	208.9	-

- indicates no significant difference at α=0.05.

These data show no evidence of elevated antimony concentrations in moose or caribou from the Mt. Nansen area.

Arsenic

Although arsenic is a generally considered a non-essential element, it has recently been identified as an essential trace element for domestic goats (Puls, 1994). It can be absorbed by ingestion, inhalation and permeation of skin or mucous membranes and accumulates in the liver, kidney, spleen, muscle, skin and hair. Toxic effects include respiratory cancer, peripheral nervous system disorders and dermatitis (Jaworski, 1980). Toxicity depends on the concentration and form, trivalent arsenic (arsenite) being 5 to 10 times more toxic than pentavalent (arsenate). Elemental arsenic is non-toxic. Since the use of arsenic in herbicides, insecticides, fungicides and rodenticides has been largely discontinued, the main sources of arsenic to the environment are mine tailings, smelter waste and natural mineralizations (Jaworski 1980).

Arsenic levels in ungulates harvested near the mine site were lower than ungulates from other areas.

Age did not significantly affect arsenic concentrations in any tissues measured moose or caribou from this study. Arsenic levels in caribou and moose from this study were consistently low (Tables 3.26 and 3.27) and were significantly lower in moose kidneys from the Mt. Nansen mine site than from other areas of the Yukon. No significant differences were seen between the two areas in any other tissues for moose or caribou. As such, these data show no evidence of elevated arsenic concentrations in moose or caribou from the Mt. Nansen area.

Cadmium

Cadmium is a toxic element that accumulates in animals over time (and therefore with age), primarily in the kidneys and liver. Chronic exposure may lead to anemia, enteropathy, renal damage, osteoporosis and osteomalacia. Long-range transport distributes cadmium widely over the environment, and natural mineralization may serve as point sources. Lichens absorb cadmium directly from the air, eventually passing it on to caribou who feed on the lichen. Plants differ in their ability to absorb cadmium from soil and water, some species, such as willow (*Salix* spp.), accumulating relatively high concentrations if they grow in cadmium-rich soil. Cadmium accumulates in long-lived herbivores, generally not in high enough levels to impair their health. Industrial uses of cadmium include production of cadmium-plated metal, nickel-cadmium batteries, pigments and plastic stabilizers, mining and refining of copper, lead and zinc (Jaworski, 1980).

Cadmium levels in ungulates harvested near the minesite were normal.

Age significantly affected cadmium concentrations in moose and caribou kidneys, but not in liver and muscle. Age-normalized data for cadmium in moose and caribou kidneys were used to test for differences between the Mt. Nansen area and other areas of the Yukon. No significant differences were found in kidney, liver or muscle in moose or caribou (Tables 3.26 and 3.27). Renal tubule dysfunction has been shown to occur at kidney cadmium levels of 400-800 ppm dry wt for most birds and mammals studied (Elliot et al., 1992; Kjellstrom, 1986). Concentrations measured in this study do not approach these concentrations, and should not be cause for concern in terms of the health of the animals. These data show no evidence of elevated cadmium concentrations in moose or caribou from the Mt. Nansen area.

Chromium

Chromium is an essential trace element in animals, and is closely associated with the functioning of insulin. Toxicity may cause scouring, dehydration, dermatitis and skin allergies. Chromate is used in oil fields as a drilling aid, production of pigments for ink, paint, etc., as a wood preservative and in the tanning industry (Puls, 1994).

Age significantly affected chromium concentrations in moose kidneys, but not in liver or muscle, or in any of the tissues measured in caribou. Age-normalized data for chromium in moose kidneys were used to test for differences between the Mt. Nansen area and other areas of the Yukon. Chromium concentrations in caribou kidney, liver and muscle and in moose liver and kidney were significantly lower in animals collected from the Mt. Nansen area as compared with other areas of the Yukon (Tables 3.26 and 3.27). Chromium concentrations in moose muscle were also lower from the Mt. Nansen area, but the difference was not statistically significant. All concentrations of chromium measured in this study fall within the range considered normal for domestic cattle (Puls, 1994) and should not be a toxicological concern for the animals.

Chromium levels in ungulates harvested near the minesite were lower than in other areas.

These data show no evidence of elevated chromium concentrations in moose or caribou from the Mt. Nansen area.

Copper

Copper is an essential element. Since it is homeostatically controlled, excess Cu is excreted in the urine, and toxicity is rare under normal conditions. Toxic effects may occur, however, and can include dermatitis, anemia, gastric ulcers, renal damage and hemolysis (Aaseth and Norseth, 1986). Copper deficiency has been noted in Alaskan moose with faulty hoof keratinization and reduced reproductive rates (Flynn et al., 1977). Industrial uses include production of electrical equipment and alloys, plating, plumbing, heating, and uses in mining and smelting.

Age significantly affected copper concentrations in moose kidneys and caribou liver, but not in other tissues measured. Age-normalized data for copper in moose kidneys and caribou liver were used to test for differences between the Mt. Nansen area and other areas of the Yukon. Significantly higher concentrations of copper were found in moose liver and caribou muscle from Mt. Nansen when compared with the same species collected from other areas of the Yukon (Tables 3.26 and 3.27). Copper concentrations were also higher in moose kidney and caribou liver and kidney from the Mt. Nansen area, but the differences were not statistically significant. Although most of the copper concentrations measured in this study fall within the range considered normal for domestic cattle, one individual moose (sampled from near the tailings pond) had a high concentration of copper in the liver (564 mg/kg dry weight) which would fall into the category of 'high' for domestic cattle (however below 'toxic'; Puls, 1994). It should be further noted that liver copper appears to be the most informative regarding copper status of the animal.

Lead

Lead is a toxic element that is stored for the long term in bone tissue, and in the short-term, in liver and kidney. Toxic signs include anemia, anorexia, fatigue and blindness. Common sources of lead include mining, smelting and refining of lead and other ores, burning petroleum fuels containing lead additives, burning coal and oil and use in shotgun pellets. Lead may also be found in paint (even 'lead-free paint may contain up to 1% lead), waste engine oil, lead batteries, putty, roofing tiles, linoleum, solder and golf balls. Some pipe joint or thread compounds (used on drilling sites) can contain up to 40% lead powder (Puls, 1994).

Age significantly affects lead concentrations in caribou muscle, but not in other tissues measured. Age-normalized data for lead in caribou muscle were used to test for differences between the Mt. Nansen area and other areas of the Yukon. Lead concentrations in all tissues measured in moose and caribou were lower in animals from the Mt. Nansen mine area when compared with other areas of the Yukon, but only differences seen in caribou kidney and liver were significantly lower (Tables 3.26 and 3.27). All lead concentrations measured in the study were low, and did not approach the threshold value of 20 ppm wet weight (≅ 80 ppm dry weight) indicative of lead poisoning (Scheuhammer, 1991). These data show no evidence of elevated lead concentrations in moose or caribou from the Mt. Nansen area.

Lead levels in ungulates harvested near the minesite were lower than in other areas.

Manganese

Manganese is an essential element for normal thyroid function, cartilage and bone formation, lipid and carbohydrate metabolism, maintaining normal central nervous system function and for reproductive processes. Calcium, cadmium, cobalt, iron, phosphorus and zinc are antagonistic to manganese. Deficiency of manganese is rare, but may lead to reduced reproductive success and skeletal deformities in newborns. Toxic signs include reduced appetite and growth rate, anemia and abdominal discomfort. Manganese is used in gasoline in Canada to raise the octane level (Puls, 1994).

Age significantly affects manganese concentrations in moose kidney and liver, but not in moose muscle or caribou kidney, liver or muscle. Age-normalized data for manganese in moose liver and kidney were used to test for differences between the Mt. Nansen area and other areas of the Yukon. No significant differences were found between manganese concentrations in kidney, liver or muscle from moose or caribou between the two areas (Tables 3.26 and 3.27). However, manganese concentrations in moose liver and kidney appear somewhat higher in moose from the Mt. Nansen area.

Manganese appears somewhat higher from moose in the Mt. Nansen area; however, this could not be proven given the small sample size.

Mercury

Mercury is a toxic element that accumulates in brain and kidney tissue, affects neurological functions and may cause gastrointestinal disturbance, reduction of food intake, poor growth, renal damage or death. Prenatal exposure may lead to cerebral palsy (Berlin, 1986). Inorganic mercury may be transformed to methylmercury (a more toxic form of mercury) by natural microbial action in lakes. This process may be promoted by excess sulphides from atmospheric deposition or nutrification of lakes. Aquatic life is generally more sensitive to methylmercury than terrestrial species. Environmental sources of mercury include mining, milling and smelting of mercury-containing ores, chlor-alkali plants, coal-burning plants, municipal wastewater treatment plants, pulp and paper mills and fungicides. Natural mercury occurs as volcanic gases, natural mineralization and evaporation from oceans (World Health Organization, 1989).

Age did not have a significant effect on mercury concentrations of kidney, liver or muscle from moose or caribou from this study. Mercury concentrations in all tissues measured in moose and caribou were lower in animals from the Mt. Nansen area as compared to other areas of the Yukon, but the only differences that were statistically significant were for caribou kidney and liver (Tables 3.26 and 3.27). There were too few samples to statistically analyze the difference in mercury concentrations between areas in caribou muscle. Mercury concentrations found in this study were uniformly low and should not pose a health hazard to the animals.

Mercury levels in ungulates harvested near the minesite were similar or less than in other areas of the Yukon.

These data show no evidence of elevated mercury concentrations in moose or caribou from the Mt. Nansen area.

Nickel

Nickel is an essential micronutrient accumulating mainly in the kidney, and appears to be under homeostatic control in mammals but not birds. Deficiency may cause decreased weight gain and increased mortality, while toxic effects include decreased immune system function, growth, insulin function, bone density, organ weights and reproductive performance. Acute poisoning affects the central nervous system and may be lethal. Nickel is not biomagnified in mammalian or avian food chains. The groups most at risk are those depending on freshwater plants, fish or invertebrates as food. Terrestrial plant herbivores are least susceptible (Outridge, 1991).

Age significantly affects nickel concentrations in moose kidney and muscle, but not in moose liver or caribou kidney, liver or muscle. Age-normalized data for nickel in moose kidney and muscle were used to test for differences between the Mt. Nansen area and other areas of the Yukon. Although nickel concentrations in caribou liver were significantly lower in caribou from the Mt. Nansen area when compared to other areas of the Yukon (Tables 3.26 and 3.27), the absolute difference between means was low, and there was no similar trend in the other tissues measured. Nickel concentrations measured in moose and caribou in this study were uniformly low and should not pose a toxicological threat to the animals.

These data show no evidence of elevated nickel concentrations in moose or caribou from the Mt. Nansen area.

There was no evidence of elevated nickel in ungulates harvested near the minesite.

Selenium

Selenium is an essential element which interacts with vitamin E to ensure optimum functioning of the immune and reproductive systems. Because some geographical areas are naturally low in selenium, deficiencies can occur, causing white muscle disease, reduced growth and reproductive rates, and reduced immune response. Signs of toxicity may include emaciation, lameness, cracked or deformed hooves and loss of hair. It has been thought that excess selenium also causes 'blind staggers', but this may be due to other compounds in the selenium-accumulating plants (*Astralagus* sp.) responsible for this disease (Puls, 1994). Industrial uses of selenium include electronics, photography, glass production, fungicides, insecticides and pigments in plastics, paints, enamels, inks and rubber.

Age significantly affects selenium concentrations in moose kidney, but not in moose liver or muscle or caribou kidney, liver or muscle. Age-normalized data for moose kidney were used to test for differences between the Mt. Nansen area and other areas of the Yukon. Selenium concentrations in moose and caribou kidney and liver were significantly lower in animals collected from the Mt. Nansen area when compared to other areas of the Yukon (Tables 3.26 and 3.27). The same trend was seen in selenium concentrations in moose and caribou muscle, but the differences were not statistically significant. Although some moose and caribou from the Yukon have concentrations of selenium that fall into the high to toxic range for domestic cattle (Puls, 1994), this is not the case for those animals from the Mt. Nansen mine which were measured in this study; those moose and caribou fall into the marginal to adequate range.

The data from this study show no evidence of elevated selenium in ungulates harvested near the minesite.

These data show no evidence of elevated selenium concentrations in moose or caribou from the Mt. Nansen area.

Silver

No essential function of silver has been demonstrated in animals, and most ingested silver is eliminated in the feces. Toxic signs include those of induced selenium/vitamin E or copper deficiency, reduced weight gain and increased mortality (Puls, 1994).

This study found no evidence of elevated silver in ungulates harvested near the minesite.

Age did not significantly affect silver concentrations in kidney, liver or muscle from moose or caribou measured in this study. No significant differences were seen in silver concentrations between the Mt. Nansen area and other areas of the Yukon for moose or caribou kidney, liver or muscle tissue. Silver concentrations measured in this study were low in tissues of both moose and caribou and should not be of toxicological concern.

These data show no evidence of elevated silver concentrations in moose or caribou from the Mt. Nansen area.

Zinc

Zinc is an essential, homeostatically controlled element, and is an important component of many proteins and enzymes. Zinc deficiency may result in reduced conception rate, reduced feed intake and growth rate, and thickening and shortening of bones. Toxic effects include anemia, poor bone mineralization, arthritis, general osteochondrosis and lameness (Sileo and Beyer, 1985). Zinc is released into the environment through mining, smelting and residential and industrial effluents and is used industrially in electroplating, the combustion of fossil fuels, petroleum by-products and solid wastes.

Zinc levels in ungulates harvested near the minesite did not appear elevated.

Age did not significantly affect zinc concentrations in moose or caribou kidney, liver or muscle tissue from this study. Zinc concentrations in caribou muscle were significantly lower in caribou collected from the Mt. Nansen area when compared with other areas of the Yukon. The same trend was seen in moose kidney, liver and muscle, whereas concentrations of zinc were very similar between both areas in caribou kidney and liver. Zinc concentrations found in moose and caribou in this study ranged from marginal (liver) to adequate to high (kidney) as compared with domestic cattle (Puls, 1994).

These data show no evidence of elevated zinc concentrations in moose or caribou from the Mt. Nansen area.

3.2 Aquatic Component

The results for water, sediment and fish are presented in the following sections.

3.2.1 Water Quality

Water sampling was conducted in the upper part of Dome Creek above the tailings pond in order to gain a better understanding of the water chemistry and processes occurring in this area which was not part of the routine water quality sampling program. Sampling was conducted on the 29th of September 2005, simultaneously with water samples taken for the weekly monitoring program[1]. The water was analyzed for physical parameters (conductivity, pH), alkalinity, nutrients, cyanides and total and dissolved metals. These results were compared with existing data from the regular weekly monitoring program.

Complete water sampling results are presented in Appendix J. Table 3.24 lists the parameters of most interest. It should be noted that the sites located downstream of the tailings pond (Upper Dome / Dome at Road / Victoria at Road) were influenced by the active discharging of water from the seepage pond into Dome Creek.

Table 3.24. Selected results from the water quality sampling program.

Parameter	Dome 1	Dome 2	Dome 3	Upper Dome – (D4)	Dome at Road - (D5)	Victoria at Road -(V4)
Total Zinc (mg/L)	0.496	<0.010	0.024	0.0114	0.0103	<0.0050
Dissolved Zinc (mg/L)	0.343	<0.010	<0.010	0.0054	0.0058	<0.0050
Dissolved Arsenic (mg/L)	0.00420	0.00530	0.00212	0.00269	0.00624	0.00102
Thiocyanate (mg/L)	1.24	1.16	1.07	1.99	1.83	<0.50
Alkalinity-Total CaCO3 (mg/L)	259	190	153	153	140	65.8
Sulphate SO4 (mg/L)	561	460	378	461	376	24.1

Flow direction →

Water quality data indicates that some parameters are highest directly downstream of the mill site.

In general, the results revealed elevated levels for metals and dissolved anions upstream from the tailings pond but downstream from the mill site (DOME 1 and DOME 2). The most significant elevated metal was zinc. Levels of zinc at the upper site were above the CCME (2002) Guidelines for Protection of Aquatic Life (0.03 mg/L); however, 600 m downstream (at Dome 2) concentrations dropped below the detection limit (Table 3.24).

Alkalinity was the only parameter that showed the highest levels at the upstream most site and decreased consistently with distance downstream. Sulphate and thiocyanate showed a similar pattern; however, were higher downstream of the seepage discharge than levels at the upstream most site.

[1] The YG Abandoned Mine Branch had been testing water quality at a number of sites within the Dome and Victoria Creek watersheds on a regular basis.

3.2.2 Sediments

Results from the sediment analysis are presented below for the most notable metals, while complete results are presented in Appendices H (Cantest), K (Norwest) and E (which includes comparisons to previous studies). Initial results from the laboratory (Cantest) were drastically lower for most metals at all sample sites (including controls) than previous studies using the same sites and procedure (Conor Pacific 2000; Yukon Geological Survey 2003; Environment Canada 1988 and 1997). Accordingly, the same samples were sent to a second lab (Norwest), which produced similar results to those of Cantest. Norwest also completed a partial digestion procedure to determine weakly bounded metals. Figure 2.4 shows the stream sediment sampling sites.

Sediments were analyzed in various methods and compared to past data.

Antimony (Sb)

Antimony concentrations were below detections limits (10 ug/g) at all but one sampling site (D1) where levels were slightly higher (49 ug/g, 57 ug/g[1]). Results from the partial digestion show a very small amount of antimony easily bound or releasable in to the aquatic environment (4.6 ug/g at D1).

Arsenic

Highest concentrations were found in the Dome Creek drainage. The concentrations of arsenic in Victoria Creek were generally very low, at or slightly above the detection limit (10 ug/g). The highest levels of arsenic were found at D1 (1,180 ug/g, 1,080 ug/g). There was a considerable drop in arsenic levels downstream from this site with arsenic concentrations at D2 and D3 in the range of 11-25 ug/g. A remarkably low concentration of arsenic (38 ug/g, 34 ug/g) was found at D4 located just below the tailings facilities (seepage pond). The lower part of Dome Creek (D5) also contained elevated (206 ug/g, 186 ug/g) levels of arsenic.

Partial digestion analysis (182 ug/g) confirmed that the high amount of arsenic present in D1 was relatively strongly bound and its bioavailability is likely limited. Quite the opposite was evident downstream at site D5 where the total concentration of arsenic was much lower (206 ug/g, 186 ug/g) than that from D1 but most of the arsenic seems to be weakly bound thus bioavailable at levels similar to D5 (partial digestion at D5; 163 ug/g). Partial digestion shows that bioavailable arsenic is low, in Victoria Creek, but lowest upstream of the minesite (V1; 1.7 ug/g; compared to 3.4 to 7.2 ug/g in other Victoria sites).

Arsenic levels were highest near the mill site; however, little appeared to be bio-available.

Barium

Barium concentrations were generally very uniform (mostly falling between 40-70 ug/g) throughout the whole study area. The highest concentration was found at D1 (88 ug/g, 94 ug/g) which was only slightly higher than the upstream control areas on Victoria Creek

[1] When referring to specific results for strong acid extraction, those provided by CanTest are provided first followed by those provided by NorWest Labs.

(V1; 67-72 ug/g). In addition, the results from the partial digestion indicate similar levels of barium bioavailability in Dome Creek (29-54 ug/g) and Victoria Creek (36-52.9 ug/g).

Cadmium

Except for sites D1 and D5, cadmium concentrations in sediment were at or below the detection limit (0.5 ug/g). The Dome Creek site furthest downstream, D5, had slightly higher levels (1.7 ug/g, 1.7 ug/g; partial digestion of <0.05 ug/g) possibly due to a higher organic content in the sediment and also possible impact from the blackened vegetation strip along the lower part of Dome Creek drainage. The high cadmium levels at D1 (13.1 ug/g, 14.8 ug/g; partial digestion 2.6 ug/g) were likely related to the mill site. Questionable results came from site D2 where Norwest Labs detected levels at 13.2 ug/g compared to data from Cantest showing levels below the detection limit (0.5 ug/g). Data from partial digestion revealed relatively small amounts of cadmium weakly bound in all other sites (0.5-0.2 ug/g).

Cadmium levels were slightly higher in Dome Creek than other sites.

Chromium

The levels of chromium are very uniform throughout the study area and it is very likely that they represent the natural background levels of this element. The obtained results were in the narrow range from 8-18 ug/g. There seems to be a similar pattern of narrow range concentration in cobalt and nickel as well. These two elements have a similar geochemical behaviour to that of chromium, and from the low and uniform numbers it appears that these metals are within natural background levels.

Copper

The Dome Creek site closest to the mill, D1, had the highest concentration of copper (40 ug/g, 43.3ug/g). In comparison to copper levels found at the upstream (control) Victoria Creek station, V1 (5 to 19 ug/g), these levels appear relatively low. Victoria Creek sites downstream of Dome Creek had similar levels than the control site. Conor Pacific (2000) found that elevated concentrations of copper were recorded at both reference and exposure stations in 1999 suggesting that the increases are not related to point source discharges. Partial digestion revealed a relatively high proportion of the copper in most sites to be weakly bound.

Lead

Concentrations in the sediments samples have a similar pattern to arsenic. Highest levels were recorded at site D1 (295 ug/g, 324 ug/g; partial digestion 283 ug/g), in the vicinity of the mill site. A moderate concentration was present at D5 (25 ug/g, 22.4 ug/g). Generally lower levels of lead were found in stream sediments in this study in comparison to assessments studies done in the past. Levels within Victoria Creek are consistently below 10 ug/g which is considerably lower than the CCME (2002) interim sediment quality guideline of 30 ug/g. Bioavailable lead in Victoria Creek downstream of Dome

Lead levels were highest in sediments near the mill site; however, all levels found in this study were within guidelines.

Creek ranges from 2.7 ug/g at V4 to 5.94 ug/g at V5 compared to 3.5 ug/g upstream of Dome and Back Creeks.

Mercury

Concentrations of mercury were recorded around or below the detection limit (0.01 ug/g) at all sampling sites; therefore, should not pose any threat in the local environment.

Silver

There was a moderate and questionable level (7 ug/g in the ALS results, not in the Norwest <0.15 ug/g) in silver concentration at site D1). All other sampling sites showed low levels of silver usually below the detection limit (2 ug/g). Silver's bioavailability was very limited (partial digestion <0.15 ug/g) and it likely that almost all of the silver is bound within very solid crystalline structures.

Zinc

The highest concentration of zinc was found near the mill site (D1; 662ug/g-744 ug/g). The samples from other sites show very uniform concentrations and even those from the Dome Creek drainage were not typically higher in zinc concentration compared to Victoria Creek. A high potential for bioavailability was found at the mill site (D1 partial digestion of 400 ug/g).

3.2.3 Fish

Three species of fish were sampled from Victoria Creek and the Nisling River and analyzed for metals. Slimy sculpin were the focal point of sampling and were sampled from five sites, three of which were within the possible zone of impact from past / present activities at the Mt Nansen Minesite (downstream of Back and Dome Creek; VIC 3, VIC 4 and VIC 6; Figure 2.4). Of these, VIC 3 and 4 are within 2.5 km of Dome Creek, while VIC 6 is on the Nisling River approximately 7.5 km downstream from Dome Creek.

Slimy sculpin, Arctic grayling and burbot were sampled within the study area.

Due to their small size, slimy sculpin were analyzed whole, while Arctic grayling and burbot were dissected to test specific parts (Table 3.25). In cases where the sample size did not meet the minimum sample weight required for analysis, samples were pooled together to form a composite sample (Table 3.25).

Table 3.25. Details regarding fish collected during this study.

Location	Sample ID	Species	Body Part	Weight (g) [1]	Length (mm)
Victoria Ck, ~500m above Back Ck	VIC1-CCG-1	Slimy Sculpin	whole	12.9	110
	VIC1-CCG-2	Slimy Sculpin	whole	13.4	105
	VIC1-CCG-3	Slimy Sculpin	whole	11.4	100
	VIC1-CCG-4	Slimy Sculpin	whole	6.3	82
	VIC1-CCG-5	Slimy Sculpin	whole	3.1	64
Victoria Ck, between Dome Ck & road crossing	VIC3-CCG-1A & 1B	Slimy Sculpin	whole	3.1, 3	70, 70
	VIC3-CCG-2	Slimy Sculpin	whole	12.7	100
	VIC3-CCG-3	Slimy Sculpin	whole	20.5	110
	VIC3-GR-K-1	Arctic Grayling	kidney	2.2	170, 160, 155, 160, 175, 170, 150
	VIC3-GR-L-1	Arctic Grayling	liver	3.9	
	VIC3-GR-T-1	Arctic Grayling	muscle	8.8	170, 150
	VIC3-GR-T-2	Arctic Grayling	muscle	18.0	160, 175
	VIC3-GR-T-3A	Arctic Grayling	muscle	18.3	155, 160, 170
	VIC3-GR-T-3B	Arctic Grayling	muscle	15.9	155, 160, 170
	VIC3-BB-L-1	Burbot	liver	3.6	174, 180, 193
	VIC3-BB-T-1	Burbot	muscle	8.3	
Victoria Ck, ~400m downstream of road crossing	VIC4-CCG-1	Slimy Sculpin	whole	16.6	115
	VIC4-CCG-2	Slimy Sculpin	whole	7.3	90
	VIC4-CCG-3	Slimy Sculpin	whole	15.1	110
	VIC4-CCG-4	Slimy Sculpin	whole	28.2	30
	VIC4-CCG-5	Slimy Sculpin	whole	2.2, 1.5	60, 55
	VIC4-GR-K-1	Arctic Grayling	kidney	3.1	190, 190, 220
	VIC4-GR-L-1	Arctic Grayling	liver	2.6	
	VIC4-GR-T-1	Arctic Grayling	muscle	34.2	
Victoria Lake outlet stream	VIC5-CCG-1	Slimy Sculpin	whole	6.2	83
	VIC5-CCG-2	Slimy Sculpin	whole	7.2	89
	VIC5-CCG-3A & 3B	Slimy Sculpin	whole	3.2, 3.2	70, 70
	VIC5-CCG-4	Slimy Sculpin	whole	0.9	40
	VIC5-BB-L-1	Burbot	liver	2.0	250
	ViIC5-BB-T-1	Burbot	muscle	11.4	250
Nisling River, below Victoria Ck	VIC6-CCG-1	Slimy Sculpin	whole	14.5	95
	VIC6-CCG-2	Slimy Sculpin	whole	0.8	42

[1] Weight refers to weight of sample submitted. Only slimy sculpin were submitted whole.

Statistics were used to compare metal levels of fish from different areas.

In order to determine if trace metals were elevated in sculpin from the zone of influence, a series of significance tests were carried out. Sites VIC 3 and VIC 4 were thus compared to samples from control site VIC 1 (upstream of Dome and Back Creeks) and VIC5 (the outlet of Victoria Lake) to see if there was a significant difference in the concentration of trace metals. Samples from these sites were compared using a t-test (assuming unequal variance) to determine if trace metal levels were significantly higher in the area influence by the mine (Table 3.26, Appendix I).

Table 3.26. Results of significance tests for slimy sculpin in zone of influence and control sites.

Trace Metal	Mean value (ppm)			Significant Difference[1]	
	Influence (VIC 3, VIC 4)	Control A (VIC 1)	Control B (VIC 5)	Influence vs Control A (VIC1)	Influence vs Control B (VIC5)
Arsenic (As)	1.49	0.84	0.30	✓	✓
Silver (Ag)	0.02	0.01	0.01	✓	
Cadmium (Cd)	0.19	0.25	0.03		✓
Cobalt (Co)	0.35	0.30	0.09		✓
Lead (Pb)	0.26	0.10	0.08		✓
Selenium (Se)	4.03	4.70	0.86		✓
Titanium (Ti)	17.36	14.00	11.82		✓

[1] $p < 0.05$

The significance tests show that a select number of trace elements were elevated in Victoria Creek within 2.5 km of the outlet of Dome Creek as compared to the control areas. Although slight, the difference between elemental concentrations is greatest when comparing the zone of influence to the Victoria Lake outlet. This may be due to the greater distance between the two locations and the decreased probability of a slimy sculpin migrating such a distance. In order to provide insight into the magnitude of trace metal concentrations, comparisons to a study done on contaminants in slimy sculpin which took place near Cook Inlet, Alaska were completed. This study (Frenzel 2000) found similar metal concentrations as the means found in VIC3 and VIC4 for arsenic (1.5 ppm) and lead (0.3 ppm) in an undeveloped watershed (Deshka River) and similar or higher metal levels for selenium (8.5 ppm), cadmium (0.4 ppm) and copper (4.6 ppm) levels in a creek within Denali National Park (Costello Creek).

Some metal levels in sculpin were somewhat elevated in areas close the mine site.

Aside from location, another variable that appeared to affect arsenic concentration was size of the sculpin captured. Figure 3.11 shows the relationship between arsenic concentration and total length for sculpin from all sites. This figure shows that larger sculpins do have a higher arsenic concentration in comparison to smaller individuals. This pattern was seen in all sampling sites, including the control areas. This comparison was also made for the other metals elevated in the zone of influence; however, there was not a significant relationship between total length and concentration of the other metals.

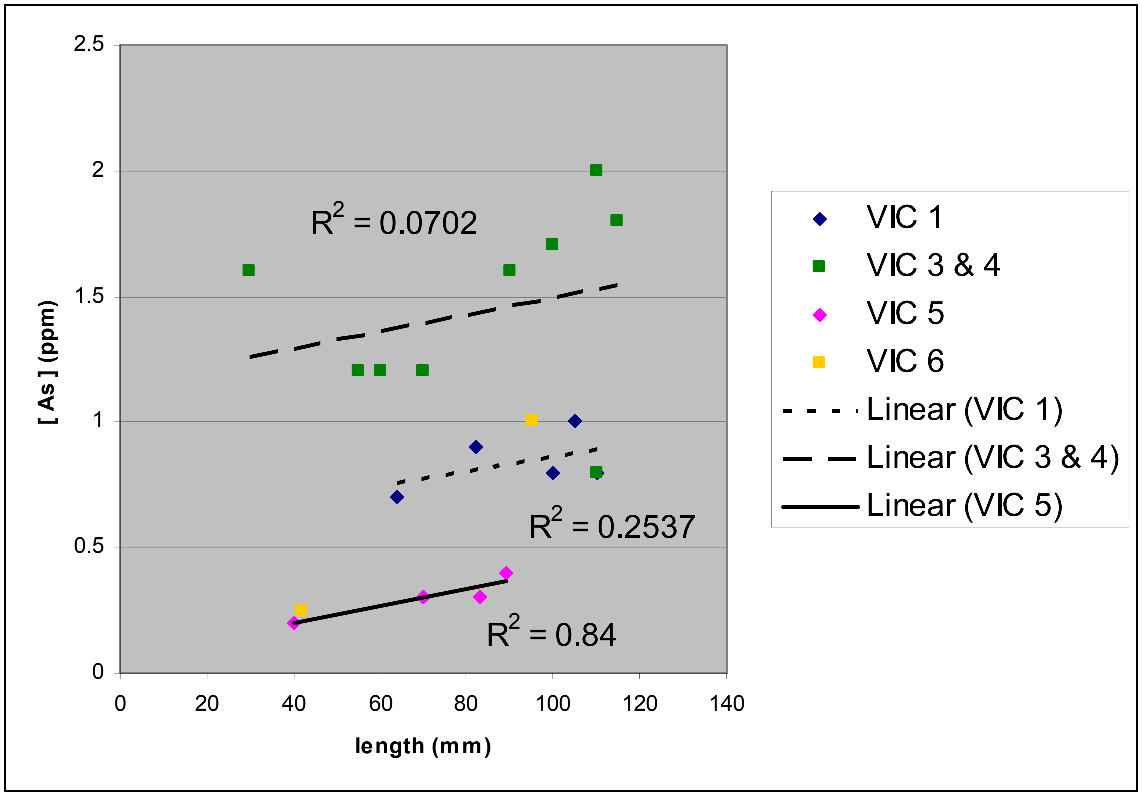


Figure 3.11. Relationship between arsenic concentration and total length for all slimy sculpin.

Trace metal levels in grayling appeared generally low.

Arctic grayling tissue, kidney and liver were sampled and analyzed only from sites downstream and close to the mouth of Dome Creek (VIC3 and VIC4). Trace metal concentrations were very low in grayling tissue collected from the zone of impact. The average mercury concentration in grayling tissue within the zone of influence was 0.136 ppm. This is well below the average found in grayling by Matz et al. (2005) in a pristine spring-fed stream in the Tetlin National Wildlife Refuge in Alaska. Results from this study were also comparable to mean mercury concentrations found in lake whitefish tissue from Kloo Lake (0.11 ppm wet weight; Northern Contaminants Program 1997).

Metal concentrations from kidneys and livers sampled from grayling in this location were higher than that in the muscle tissue, which is to be expected due to the role of these organs within the body. Within kidney samples, the following metal concentrations appeared to be slightly elevated; arsenic (0.8 ppm), cadmium (1.36 ppm) and silver (0.14 ppm). Within livers analyzed, levels of copper appeared to be slightly elevated (18 ppm at VIC 4) in comparison to Matz et al. (2005), who found a maximum copper concentration of 11.5 ppm for grayling livers. Mercury concentrations within the kidneys and livers averaged 0.242 ppm and 0.323 ppm respectively which are well within the range of values found by Matz et al. (2005).

Burbot were collected at one site within the zone of influence and one from a control site (Victoria Lake outlet). Liver and tissue samples were pooled together for 3 fish from VIC 3 (zone of influence) and compared to a single fish captured at site VIC 5 (outlet of

Victoria Lake; control). Arsenic was considerably higher in both liver and muscle tissue samples from the zone of influence than the control. The concentration in liver and tissue from the zone of influence was 14.1 and 2.8 ppm, respectively as compared to 2.1 and 0.7 ppm from the control area. Matz et al. (2005) found a maximum arsenic concentration in livers and tissue of 7.4 and 0.94 ppm respectively in tissue from burbot collected in the Tanana River in Alaska. Silver also appears to be slightly elevated in burbot livers within the zone of influence with a concentration of 0.08 ppm compared to <0.02 ppm at the control area. Levels of mercury in both the liver and tissue samples were lower in burbot than in Arctic grayling sampled at the same locations. The small sample size of burbot prevents confirmation of a pattern of elevated levels within the zone of influence.

4.0 DISCUSSION

4

4.1 Terrestrial Effects

The results from the lichens show a significant increase in certain metals around the three sources of contaminants. This effect has been most apparent around the mill site, followed by the Brown McDade pit and to a lesser extent, the tailings pond. The element copper is an exception to this, for which the increase was most pronounced in association with the tailings pond.

It must be noted that lichens are very long lived and therefore are not necessarily good indicators of current deposition. However, these results do indicate that past mining activities and possibly the current state of the mine has resulted in some aerial dispersion of metals. No results are available as of yet for the on-going aerial dispersion component (moss bags[1]). It is likely that most of any aerial dispersion was related to past mining activities at the site. Especially given that the area around the mill site has the most significant levels of lead, arsenic, antimony and silver compared to the other two potential sources of contamination. During the operation of the mill there are accounts of significant dust being generated in this area (Wheeler pers. comm. 2006). Not only was there a crusher that created significant dust as it broke down the ore, but also truck traffic and activity (i.e. dumping) was common in this area. The aerial dispersion analysis utilizing moss bags will provide the most relevant information in this regard.

Aerial dispersion of metals has been documented; however, it is not known if this is an on-going concern.

The apparent aerial dispersion around the mill appears in all directions but is most prominent in a southwest direction. Although wind comes frequently from the west and southwest, followed by the east (Figure 1.2) it is possible that the winds from the east have had the most impact given the mill's position in the landscape. The mill is located midway down a west facing slope (Photo 2.3) and as such is likely protected from the wind coming from the west. Also a low-grade ore stockpile (Photo 2.4) is located in the southwest portion of the mill site, which may partially explain this southwest trend.

Aerial dispersion of metals appeared most prominent around the mill site but also evident at the pit and tailings facilities.

Aerial dispersion around the Brown McDade pit appears most prominent in a north direction, likely a result of common winds from the southwest. The dispersion around the tailings pond in an east direction appears likely a result of the winds from the west that are most prominent in this location (the wind measuring device is located in this location).

While the results indicate that metal levels are elevated within proximity of the pit and the pond, they are generally not as drastic as the mill site, with the exception copper levels. It is possible that during the late stages of BYG's operation that the ore being accessed/processed contained a higher copper content. This could in-turn have been deposited in the upper layers of the tailings, which would most likely have been dispersed

[1] Moss bags were deployed October 13, 2005 which roughly coincided with freeze-up, and thus these were left in place. There are plans to collect, analyze and replace these prior to the spring melt. Deployment in non-frozen conditions will likely provide the best indication of current aerial dispersion.

through aerial pathways in association with the pond. Again, the results from moss bag work will provide some insight into the dynamics of these sites. The tailings within the pond facility are made up of primarily fine materials that have been known to mobilize during strong wind events combined with low water levels in the pond (Wheeler pers. comm. 2006).

The results from the plants (especially willow) indicate that this aerial contamination has started to show up in plants (at much lower levels than the lichens). As the plants were not washed it is possible that these higher levels could be a result of dust on the plant surface, rather than root uptake from the soils. Again the results of the moss bag work may provide some insight to on-going contamination and the likelihood of these elevated plant levels being from dust or from uptake from soils.

Some plants showed somewhat elevated metal levels.

It appears that some soils immediately adjacent to the sources of contamination (especially the mill) may have been influenced by aerial contamination. However, as soils are influenced by many variables including geology, weathering and plant uptake it is difficult to confirm this. The strongest evidence for this includes the high arsenic levels near the mill site in the A-horizon and the different horizon patterns between the control plots and transect plots taken within the apparent zone of aerial contamination. The highest levels of antimony, arsenic, copper and lead were found in the A-horizon for the transect plots and in the C-horizon for the control plots.

Although some soils immediately adjacent to the point sources had some higher metal levels, it is unclear if this is related to the mine site.

It is possible that the bedrock geology and local zones of higher mineralization is responsible for enriching the lowest C-horizon. This pattern is obvious from the sampling site I1 where the highest levels of arsenic were recorded at the bottom (100 ug/g) and low readings were obtained in B horizon (<10 ug/g) and A horizon (17 ug/g). Similar patterns were noticed at the control sites.

From the background information gained from the control sites and low levels under the blackened vegetation it appears that the C-horizon in the studied area is not likely impacted by aerial contamination. This can be demonstrated from the results under the blackened vegetation where the upper horizons (A and B) appeared impacted by contamination while the C-horizon was not. Rather, the concentrations of the metals in the C-horizon are predominately determined by the composition of the underlying rocks and proximity of the mineralized zones.

At some sites (BVEG / Transect) it appeared that the B-horizon may have been impacted by contaminants moving down from the A-horizon. This situation could occur when the buffering or adsorption capacity of the A-horizon was exhausted. The shallow nature of the upper A-horizon in the area likely limits its buffering capacity.

Uptake of arsenic by plants is generally low, depending on plant species, composition of the soil and form of the arsenic. It is not rare to see the soil contaminated at extreme levels and plants still containing levels of arsenic near background. When evaluating the potential phytotoxicity of the arsenic it is very important to evaluate the content of clay minerals, Fe, Al oxy-hydroxides and organic matter in the soil. The pH and Eh values are decisive factors for the arsenic form and the As^{3+} is considered a more mobile form and more phytotoxic as the As^{5+}. Three sites with highest As levels (J1, J2 and K2) are also those with highest pH levels (7.2-7.6) which is likely a beneficial factor limiting arsenic mobility and phytotoxicity. Arsenic levels in willow from J1 and J2 were only slightly higher than natural maximum Yukon background levels (1.4 ppm compared to 1.02 ppm) and levels in K2 were low (0.3 ppm).

Analysis of small mammals and birds indicate that slightly elevated levels of some metals may be present in the local wildlife. Elevated metals include arsenic, cadmium, chromium, manganese, lead, and silver; however, only the results for cadmium, chromium, and silver were statistically significant in red-backed vole livers, which is likely related to the limited sample sizes and the nature of the tissues analyzed. For example, lead concentrates more readily in kidneys rather than livers (Gamberg, 2006, pers. comm.), while only the number of liver samples was sufficient to achieve statistical significance. Of the metals found to have elevated levels in samples from the mine site, none posed a significant threat of toxicity to wildlife, and most were within levels found in other areas and/or in other wildlife or domestic livestock (Gamberg, 2006, pers. comm.). Due to the nature of the species sampled, no information was obtained regarding any possible biomagnification of metals in predatory species existing at higher trophic levels. Considering the indication of slightly elevated levels in the results obtained in this study, it is possible that such bioaccumulation is occurring.

It is not known if bio-magnification of metals in the food chain is occurring.

The metal levels within caribou and moose from within the Game Management Zone 5 (near the Mt. Nansen site) were generally similar to that of Yukon background data with some exceptions. Levels of lead, mercury, and selenium in caribou livers and kidneys were significantly lower within the Mt Nansen compared to Yukon data. In addition, nickel in caribou liver and zinc caribou muscle tissue were significantly lower than Yukon background.

Of all the elements tested, copper was the only element that was significantly higher at the Mt Nansen area (for moose liver and caribou muscle) compared to the Yukon background data. While copper is one of the metals of concern, specifically around the tailings pond (in lichens), there is limited evidence to suggest the minesite is responsible for this. While caribou eat lichen they are a migratory species that cover large ranges and would be unlikely to spend considerable amount of time in the area of the pond. The copper levels within willow (primary moose forage) were all below background Yukon levels. In addition, the copper levels in the tailings pond water have not been identified as a concern. For example, weekly water sampling of the tailings pond from April 13 to Oct 27, 2005 found a highest level of total copper was 0.09 mg/l. This level is well below the CCME (2002) guidelines for Aquatic life (2-4 mg/l) or for livestock (500-5000 mg/l).

4.1.1 Blackened Vegetation

Blackened vegetation area appears to be a physical barrier to plant growth.

The results of this study indicate that a significant source of metals contamination killed the vegetation along the banks of Dome Creek. According to a local source, a perforated drainpipe was laid out along the slope of the right bank during active mining, where it was used to discharge contaminated water from the mining operation. No knowledge of similar activities that may explain the dead vegetation on the left bank was found. However, any number of factors such as flow across the ice surface during the winter months may have influenced the left bank.

The levels of metals in the dead, blackened plant material were extremely high; however, metals only appeared to be somewhat elevated in the soils (relative to the plants) and only in the A and B-horizons. While there is minimal green vegetation growing in the area, it is likely the result of the physical barrier created by blackened vegetation. The blackened vegetation (moss-lichen base) is quite thick and likely prevents seed from reaching the soil surface. The live vegetation (Labrador tea and willow) growing in the area of blackened vegetation had some high metal levels compared to control sites. Of interest, Labrador tea was more commonly higher than controls compared to willow versus controls. It is speculated that this pattern was likely related to rooting depth. Generally speaking willow has a deeper root system than Labrador tea and as such likely penetrates into the less impacted C-horizon.

Removal or modification of this blackened vegetation would likely help promote plant growth in this area. Another option would be to plant through the area with live willow stakes (i.e. bioengineering). This method involves driving willow stakes into the ground approximately 1 m and as such would promote root growth in the C-horizon.

4.1.2 Vegetation in Sources of Contamination

Many of the vegetation samples collected within the potential contamination sources (Brown McDade pit and tailings pond) were among the highest for some metals including arsenic, lead and copper. This is consistent with past data indicating these areas had high levels of certain metals (Conor Pacific 2000). The two samples taken from the waste rock piles around the pit did not show elevated levels of metals. Reclamation plans should consider the higher levels found within the tailings and the pit.

Reclamation plans should consider the higher metal levels found in plants collected within the tailings and the pit.

4.2 Aquatic Effects

Generally, aquatic systems can be important indicators often showing pathways of contamination leading to point or even diffuse sources. In this case, the results indicate that present contamination of the affected aquatic systems may not be particularly significant, particularly in comparison with the results of studies conducted during or shortly after BYG's operation of the mine.

4.2.1 Water Quality

The results indicate that headwaters of Dome Creek are negatively impacted.

The results indicate that the headwaters of Dome Creek are negatively impacted by nearby sources of potential contamination, including the mill site, waste rock dump, former tailings facility (pre-BYG era), roads, and past exploration activity.

Surface water quality improves moving downstream.

Generally the surface water in the upper parts of the Dome Creek has a higher mineralization (sulfates, calcium, magnesium are most notable parameters). The water quality is predominantly affected by high amounts of zinc, which was found at a level approximately 16 times higher than CCME guidelines for aquatic life. Other than invertebrates, aquatic life is likely quite limited in this part of Dome Creek, especially given that no fish have been documented in Dome Creek. Generally the water quality improves moving downstream due to the processes of natural attenuation occurring within the stream and its riparian zone. In this regard, zinc is being effectively attenuated moving downstream from the ponds, and this is likely due to dilution, relatively high pH levels, and an abundance of organic matter in the riparian zone.

4.2.2 Sediments

Patterns for sediments were similar to surface water quality.

With a few exceptions, the levels of metals identified in sediments during this study are generally lower than those obtained in past studies (Conor Pacific 2000, Yukon Geological Survey 2003; Environment Canada 1988 and 1997). Almost every natural system has a tendency to attenuate contamination once it is introduced into the system. It appears that the natural attenuation process may be occurring in this area as well, which would correspond with the overall decrease in levels of several metals when compared to past data. The drop in levels of metals and semi-metals composing a significant part of the surrounding geological materials (i.e. Fe, Al, Ca, Mg) remains unexplained. Possible causes include highly variable composition of stream sediments within a small spatial scale, and/or subtle changes in laboratory digestion or analyzing processes, and/or variations of sampling procedures.

Nevertheless the analysis of metal levels in stream sediments in key areas within and around the mine site did confirm the presence of some above normal levels which may be attributable to past mining activities. The stream sediments with highest concentrations of contaminants were found at the sample site closest to the mill, as well as at the bottom part of Dome Creek. The results obtained in this study indicate that the mill site is a likely major source of contamination of the area. As well, the low-grade ore stockpile,

storage and frequent handling of chemicals in the past, and heavy use of the road may all be, or have been, factors contributing to contamination of the area.
The natural process of attenuation occurring within Dome Creek may be effective enough to significantly lower the levels of many contaminants when results are compared with those of previous work. The concentrations of metals are generally low at sites D-2 and D-3. Remarkably low levels of contaminants were found at site D-4, immediately below the seepage pond. This was an unexpected result, as it was expected that higher levels of metals would be found immediately below the seepage pond, presumably where contaminated water would be first discharging into the system. The analysis of the samples conducted by two different laboratories and two different methods indicates that errors in the analysis are not likely, and, if errors in sampling and handling are also ruled out, the lower levels of metals at site D-4 are currently unexplained. It can be speculated that the water seeping from below the seepage pond may be highly reactive and therefore could be causing the release of some existing metals from stream sediments. This would then create a zone of metal depletion not evident during the time of the past sampling events. Further to this, the enrichment of metal contaminants in the lower part of Dome Creek at site D-5 may then be considered to be in an area of a natural sink. Finer sediment composition, slower water flow, probable higher organic content would contribute to such a metals sink in the stream sediments at this site. There is also a possibility that the blackened vegetation strip (5 m wide and approximately 300m long) along the lower part of Dome Creek may play a role in additional contamination. The vegetation samples from the area of blackened vegetation contained extremely high concentrations of a wide group of metals that could easily be/have been mobilized into the aquatic environment of Dome Creek.

The high metal levels in Dome Creek sediments were not apparent in Victoria Creek.

While some metals in sediments are commonly high in Dome Creek, this has not translated into obvious elevated levels in Victoria Creek. In fact, most metal levels in Victoria Creek downstream of the minesite (Dome and Back Creeks) have similar metal levels as the upstream control site (V1). In addition, while there are problems with comparisons to past data as noted above, comparing arsenic levels in Victoria Creek with Conor Pacific's (2000) data indicate levels are declining in Victoria Creek. Conor Pacific found arsenic to be lowest (11 ug/g) in the control site (V1) compared to the other Victoria site (52-97 ug/g) in 1999. Conversely, the 2005 results show similar levels in all Victoria sites (<10 ug/g with exception of one replicate sample of 17 ug/g at V4).

There are significant limitations of using stream sediments as indicators of potential environmental impact. It is important to note that elevated levels of certain metals in stream sediments do not necessarily translate into a threat to the surrounding environment. The key factor in this regard is the form in which the metals are present in the aquatic environment. If they are primarily in a stable form, this limits their bioavailability and thus any potentially adverse environmental effect. Using the partial digestion method of analysis, further insight can be obtained regarding the chemical form and distribution of metals between various phases of stream sediments. Detecting metals that are weakly bound and thus easily released from these phases into the aquatic environment is an important component of quantifying the potential impact of contaminants. The lack of such information from the past studies represents a current disadvantage in terms of comparison and changes of metals levels over time. Such data provided by this study may serve as a starting point for comparison in future assessments of the Mt. Nansen area.

4.2.3 Fish

Slimy sculpin appear to have some slightly elevated levels of metals in Victoria Creek downstream of Dome Creek. Higher levels of arsenic and silver found in burbot from Victoria Creek near the mouth of Dome Creek may indicate that these metals are biomagnifying up the food chain, although the sample size for burbot was not sufficient to confirm this. Levels within grayling appeared to be within normal ranges for this species and are not a concern in terms of toxicity to the species. Provided that metal levels within the water remain within CCME standards for protection of aquatic life, metal levels for fish within the zone of influence is not expected to be a concern in the future (with the possible exception of burbot).

Levels of arsenic and silver in burbot were of note and may require more study.

4.3 Tolerable Intake Analysis

In order to put the results into perspective, it was deemed important to determine if the levels of metals found in the plants and animals were a concern in terms of human health. To accomplish this, the results were compared to the tolerable daily or weekly intakes as presented in Table 4.1. It should be noted that this is not a comprehensive human health risk assessment; rather, provides some insight to the daily intakes for several metals. For more comprehensive information on human health at the Mt. Nansen minesite refer to SENES Consultants Limited (2003).

Tolerable intake limits were calculated to put the results in perspective.

Table 4.1. Tolerable daily or weekly intakes as listed by Joint FAO/WHO Expert Committee on Food Additives (2006)[1].

Metal	Tolerable Intake mg/kg of body weight	Tolerable Intake for a 50 kg person (*ug*)
Antimony (Sb)[2]	0.003 daily	150 daily
Arsenic (As)	0.015 weekly	750 weekly
Cadmium (Cd)	0.007 weekly	350 weekly
Copper (Cu)	0.5 daily	25,000 daily
Iron	0.8 daily	40,000 daily
Lead	0.025 weekly	1,250 weekly
Mercury (Hg)	0.005 weekly	250 weekly
Silver (Ag)[2]	0.005 daily	250 daily
Zinc (Zn)	1 daily	50,000 daily

[1] Lists only metals that had a tolerable intake listed.
[2] TDI for antimony and silver as provided by Hilts, Pers. comm. (2006).

Using the above values, maximum amounts of tissue that could be consumed for each plant or animal were calculated based on the maximum metal concentrations found in this study (Appendix L). It should be noted that this approach tests the unlikely event that a person will collect a particular tissue only in the location of most concern. As many metals are present in each tissue, it was deemed important to identify the metal which limited consumption to the greatest degree for each tissue type (Tables 4.2). For example, if berries were consumed, a person could eat 2,351 grams (approximately 18.5 cups) per day before reaching the tolerable daily intake for arsenic; however, at 417 grams (approximately 3.3 cups) per day the limit for cadmium would be reached. Table 4.2 lists the metal that would limit daily in-take the most for each tissue type.

Table 4.2. Tolerable daily intakes for tissue from the mine site as determined by the metal that would limit consumption the most.

Tissue Type	Species	Limiting Factor			Amount (wet weight) that could be directly consumed by a 50 kg person (g / day)
		Metal	Site	Concentration (*ug*/g) (based on dry weight)	
Lichens	Caribou Moss	Arsenic (As)	B1	36.9	5.3
Shrubs	Labrador Tea	Arsenic (As)	PONY3	12.5	15.5
	Willow	Cadmium (Cd)	L1	55.0	1.85
Mushrooms	*Bolete* Mushroom	Arsenic (As)	I2	3.6 [a]	59[a]
Berries	Blueberry	Cadmium (Cd)	CP 1	0.79	417
Arctic Grayling Liver	Arctic grayling	Cadmium (Cd)	VIC 4	1.36	122
Arctic Grayling Flesh	Arctic grayling	Mercury (Hg)	VIC 3	0.155	1,047
Burbot Liver	Burbot	Arsenic (As)	VIC 3	14.1	22
Ground Squirrel Kidney	Ground squirrel	Cadmium (Cd)	MILL	44.8	6.4
Red Squirrel Kidney	Red Squirrel	Cadmium (Cd)	MINE	1.86	109
Caribou Liver	Caribou	Cadmium (Cd)	N/A	7.37	31
Caribou Kidney	Caribou	Cadmium (Cd)	N/A	7.91	26
Caribou Flesh/muscle	Caribou	Iron (Fe)	N/A	41.8	3,518
Moose Kidney	Moose	Cadmium (Cd)	N/A	23.9	10
Moose Liver	Moose	Cadmium (Cd)	N/A	5.87	29
Moose Flesh/muscle	Moose	Zinc	N/A	50.7	4,196

Please note there was no moisture content for some plant samples; however, this was estimated using data from other samples: Willow (50%), Labrador tea (45%) and mushrooms (50%).
[a] It should be noted that Nicholson 2002 found arsenic levels in bolete mushroom a considerable distance from the minesite to be 34.8 *ug*/g with a TDI of 1.6 g dry weight for a 57 kg person.

Tolerable intake limits for most restrictive metal for all tissue types.

Tolerable intake of the tissue types is limited mainly by elements that do not appear to have elevated patterns around the sources of contamination (cadmium, mercury). These elements likely occur at levels that are reflective of natural conditions at the site. In a few cases, arsenic, which is elevated around the sources of contamination, appears to be of most concern. Arsenic is also a carcinogen, and therefore is of further concern.

Of the plant tissue types, willow and caribou moss (reindeer lichen) collected near the mill and tailings pond, respectively, have the lowest tolerable daily intakes. Willow is used by the LSCFN members for medicinal purposes and is not likely not ingested fully. Caribou moss is also used for medicinal purposes in the form of tea. Unless the metals are on the lichen surface (i.e. dust) and/or a considerable amount of tea is consumed, it is unlikely that consumption of tea would result in consumption over the weekly intake.

In small mammals, not surprisingly kidneys and livers appear the most restrictive. Given the small size of these organs it is unlikely that someone would consume above the tolerable limits. Further, the only species analyzed that would possibly be consumed by humans was ground squirrel. The ground squirrel kidney collected was 1.7 grams; therefore, 3.7 kidneys of the similar concentration would have to be consumed to meet the daily limit for cadmium. It must be considered that a sample of ground squirrel flesh was not analyzed, and that only one ground squirrel was captured. Therefore, these results may not be representative regarding any implications for human health.

For moose and caribou organs the limiting element was cadmium. Cadmium levels were not significantly different in ungulate organs from the site than other areas in the Yukon. In fact the Tolerable Daily Intake, averaged out over a yearly basis appear less restrictive than Yukon Health standards that recommend yearly consumption levels for ungulate organs. In addition, cadmium is the element which restricts the Yukon Health consumption levels for organs (Gamberg pers comm. 2006) which is consistent with the finding of this project. It does not appear that moose and caribou flesh contain metals that would be concern from a human consumption point of view. It appears metal levels in moose and caribou are not a concern for human consumption beyond those already identified for the Yukon as a whole.

It appears metal levels in moose and caribou are not a concern for human consumption beyond those already identified for the Yukon as a whole.

In fish, the livers from Victoria Creek were also the most restrictive. However, considering the size of the fish captured in Victoria Creek, Arctic grayling are the only species likely to be consumed by humans. Grayling livers could be consumed up to 122 grams (approximately 1 cup) per week to meet the weekly limit for cadmium. However, over a kilogram of grayling flesh could be consumed per day before exceeding any of the tolerable daily intakes. Considering the size of the grayling in Victoria Creek, several could be consumed per day. It should be noted that SENES Consultants Limited (2003) found the risk level for arsenic exceeded the accepted risk level and the ingestion of fish was of most concern. It should be noted that this data was calculated via water transfer to fish calculations and was not based on sampling of fish.

It should be noted again that the levels above are for the most extreme cases found in this study. However, given the above results, perhaps some caution and some moderation should be used when consuming plants and animals at the site. Collection of plants/small animals should be limited at or immediately around the three sources of contamination (the mill site/pit/pond). In addition, rinsing plant parts prior to consumption or preparation is recommended. Avoiding collection of plants/small animals in the immediate vicinity of the mine site would likely eliminate any concern regarding the consumption of contaminants.

As a precautionary step, collection of plants/small animals should be limited at or immediately around the three sources of contamination (the mill site/pit/pond).

5.0 RECOMMENDATIONS

The on-going contamination into the aquatic pathway (Dome Creek) at the mill site should be investigated and addressed. The sediment and the water quality data indicate that contamination is on going and will likely continue without intervention. Possible contributors to contamination in the area include the low-grade ore stockpile, extensive waste in the stream channel (metal and debris from old vehicles and equipment), erosion around the mill site and the old tailings facilities in this area. Reclamation of the area to prevent further contamination would benefit not only the aquatic ecosystem, but also the terrestrial ecosystem (i.e. plants in the riparian as well higher levels of the food chain).

The area around the mill site should be investigated and addressed in reclamation works.

Other recommendations in terms of reclamation require additional information. Specifically, the metal levels in vegetation growing on the tailings, the pit, and the waste rock piles, indicate a need to prescribe some action; however, information regarding current aerial dispersion would provide more rationale and a better understanding of how these areas should be treated.

The following recommendations for further study are proposed.

This section outlines recommendations for further study.

1. **Completion and enhancement of the Moss Bag program to determine if aerial contamination is on-going.**

The extent of on-going aerial contamination is important for reclamation planning. Moss bag sampling should provide valuable information in this regard. Given the importance of this, it is recommended that the moss bag program be expanded so that there are samples in several directions surrounding the identified sources of contamination (i.e. 8 bags per source of contamination).

2. **Build Upon Wildlife Program.**

In order to obtain a more complete understanding of the levels of metals in small mammal and bird tissues at the Mt. Nansen mine site, further sampling is required. Further, sampling of predatory animals higher on the food chain would provide insight into the effects of possible contamination at higher trophic levels. In this regard, weasels and martins would be the most appropriate target species as they are carnivorous but maintain small ranges.

Efforts to collect small game species such as grouse were not successful. Further efforts focusing on these species may provide some insight to consumable levels.

It may be valuable to sample additional small mammals (shrews, voles) and gray jays to confirm patterns found in this study. Additional samples from the mine site and Rowlinson control area will help with the statistical comparisons.

3. Collect samples from low-grade ore stockpile near mill.

No samples were collected from the low-grade ore stockpile near the mill. Collection of grasses and willows growing in this area may provide direction in terms of future reclamation requirements at this location.

4. Sediments

Due to the inexplicable nature of the sediment results compared to previous sampling, it is suggested that further sampling and analysis be conducted in additional sites within Dome Creek and Victoria Creek. Additional sampling using the same methods should help promote a better understanding of the dynamics of sediments in this stream. Analysis should be completed for partial and strong acid digestion. In addition, sites should be sampled on Pony Creek.

5. Fish

Given the arsenic concerns listed in the Screening Level Human Health Risk Assessment (SENES Consultants Limited 2003) was based on predictions of concentrations in fish, the data collected in this study should be used to evaluate the human consumption concern.

Given the results from the small sample size of burbot, there may be a desire to determine if biomagnification is occurring in the fish population. Collection of additional samples of burbot in Victoria Creek and control locations would provide an indication of biomagnification. Additional samples of slimy scuplin would help with the statistical analyses made in this study.

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Project Biologists: Ben Schonewille, Isaac Anderton
Project Geochemist: Roman Krska
Project Technologist: Matt Power
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APPENDIX A:

SUMMARY OF COMMUNITY SURVEY

APPENDIX B:

REPLICATE ANALYSIS RESULTS

APPENDIX C:

DUPLICATE ANALYSIS RESULTS

APPENDIX D:

STATISTICAL ANALYSIS RESULTS

APPENDIX E:

CURRENT AND HISTORICAL STREAM SEDIMENT ANALYTICAL RESULTS

APPENDIX F:

LICHEN TISSUE ANALYSIS RESULTS

APPENDIX G:

PLANT TISSUE ANALYSIS RESULTS

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SOIL ANALYSIS RESULTS

APPENDIX I:

ANIMAL AND FISH TISSUE ANALYSIS RESULTS

APPENDIX J:

WATER QUALITY ANALYSIS RESULTS

APPENDIX K:

STREAM SEDIMENT ANALYSIS RESULTS

APPENDIX L:

TOLERABLE DAILY INTAKE CALCULATIONS