Mount Nansen

Existing Environmental Conditions

Ver. 1.0, April 2010

Executive Summary

The Mt. Nansen Mine is an abandoned gold and silver mine located in south central Yukon, approximately 60 km west of Carmacks. The mine operated from 1997 to 1999, went into voluntary receivership, and Canada formally declared the property abandoned and took over under Section 39 of the Yukon Waters Act. In April 2003 the management of the site devolved to the Government of Yukon. The Yukon government Assessment and Abandoned Mines (AAM) Branch is preparing to proceed with the environmental and socio-economic assessment for abandonment and remediation of the site. EDI Environmental Dynamics Inc. was retained by AAM to summarize existing environmental conditions at the Mt. Nansen mine site and surrounding region.

The area is characterized by low rounded mountains, rolling hills, and broad valleys of the Yukon Plateau-Central Ecoregion. Geologically, the Project Area (PA) is located in the eastern portion of the Yukon Crystalline Terrane, and the common form of mineralization is found within planar structurally controlled vein systems consisting of quartz, carbonate and varying amounts of sulphide. The valley bottoms of Victoria and Nansen Creeks in the PA are covered by unconsolidated alluvium, while the Dome Creek valley is mainly of colluvial, residual and granular glacial outwash origin overlying bedrock. Soils vary from sandy gravel to fine sandy silt, and material is generally medium dense with some pockets of loose material made up usually of angular pieces of highly weathered rock. Soil thickness is greatest in the valley bottoms with thinner soils covering the steeper valley sides. The PA is within a discontinuous permafrost area that is 30–60 m thick, most of it below a thick active layer up to 1.5 m deep that varies based on overburden and topographic position. Permafrost has not been characterized within the PA.

Climate information is available regionally for several decades, but only since 2000 and intermittently from on-site monitoring stations. Two meteorological stations were installed at the mine site and have collected data intermittently since 2000, and one snow survey station is located east of the PA. While climate data from the site has been intermittent, longer-term climate data for the regional area is available from three meteorological stations near Carmacks. The driest months are generally January through April and most precipitation is received from June through August. Snow pack peak in April and typically melts in early May on south-facing slopes and in late May on north-facing slopes. The prevailing wind direction in both winter and summer is from the NNW. Climate data continues to be collected from the on-site meteorological station.

Vegetation and wildlife in the PA and surrounding Regional Study Area (RSA) are typical of that found in the Yukon Plateau-Central Ecoregion. The valley bottoms contain open stands of black and white spruce, and some of the lower elevation areas contain black spruce and trembling aspen. Birch and willow are the predominant cover at high elevation valley bottoms. Wildlife in the area include moose, grizzly and black bear, and caribou. The PA is at the eastern extent of the Klaza Caribou herd range. There is limited information on wildlife and habitat use specific to the PA, but information on

wildlife at the regional scale is relatively well understood. Several studies were initiated with the re-introduction of wood bison, and as baseline studies for other regional mines. There are also several species of plants and animals that are of conservation concern that may be found in the PA and RSA. A PA-specific survey to determine presence of species of conservation concern, a general distribution of animals and habitats is required.

Hydrological characterization of the PA is ongoing as surface water discharge data for these streams is limited to that collected in 2009. The site is drained by three small streams: Pony, Dome and Back creeks, which all flow into Victoria Creek, a tributary of the Nisling River. Hydrogeology studies on site are ongoing. Water quality monitoring began on site in 1999, and continues at the current time. The watercourses within the Mt. Nansen Project Area are clear water, low nutrient systems. In general, water quality in the watercourses flowing through the site is good, however, elevated concentrations (exceeding CCME protection of aquatic life guidelines) of some metals were detected in all of the sampling sites (including reference locations) at in some samples. Elevated concentrations in the watercourses were associated with sharp increases in TSS, as experienced during spring melt. The main metals of concern in the tailings pond and associated seepage pond include arsenic, cadmium, copper, iron, lead and silver. The metals of concern in the Brown-McDade pit are arsenic, cadmium, copper and zinc.

Fish and fish habitat is generally well understood within the PA. Fish species present in the area include Arctic grayling, burbot, northern pike, round whitefish, and slimy sculpin, none of which are of conservation concern. The site is not currently important for fisheries resources for the Little Salmon Carmacks First Nation (LSCFN). Within the last five years, fish sampling has occurred in Victoria, Back, Pony, Dome, and Rowlinson Creeks. Fish and fish habitat assessment confirmed that both Dome and Pony Creeks are non-fish bearing due to the presence of impassable natural barriers at the mouths of the streams and generally poor quality upstream habitat.

Stream sediment samples have been collected from Dome, Pony, Back and Victoria Creeks within the past five years. Concentrations of most metallic elements for which there are guidelines fell below CCME's Interim freshwater Sediment Quality Guidelines (ISQG). However, arsenic and cadmium levels exceeded ISQG in all sampled watercourses. Copper, lead and zinc also exceeded ISQG's in some sites in Victoria, Dome and Pony Creek and mercury exceeded ISQG in a single site in Dome Creek. Samples collected from the two creeks closest to the former tailings pond and mill site, Back and Dome Creek, indicate that these creeks contain the highest stream sediment metal concentrations.

Over the last three years, benthic invertebrate sampling has been conducted in Victoria, Nansen, Pony and Dome Creeks. The highest taxa richness was found in areas of Victoria Creek above minesite receiving watercourses, while taxa richness was considerably lower in downstream areas and in smaller watercourses such as Dome and Back Creeks. Trichoptera is not abundant in any PA watercourse and all other sampled invertebrate orders were moderately abundant only in upstream areas of Pony Creek.

Authorship

EDI Environmental Dynamics Inc. was retained by AAM in January 2010 to summarize existing environmental conditions at the Mt. Nansen mine site and surrounding region. Technical review was provided by Patricia Randell and Frank Patch of the Yukon government Assessment and Abandoned Mines Branch.

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1 Introduction

The Mt. Nansen Mine site is an abandoned gold and silver mine located in south central Yukon, approximately 60 km west of Carmacks (62.048˚N, 137.127˚W). The site is on the Mt. Nansen Road within the traditional territory of the Little Salmon Carmacks First Nation (LSCFN). The Mt. Nansen region has been an area of gold and placer mining since the late 1800s. The first recorded hard rock gold discovery was made by Brown and McDade in 1943. Subsequently, the Webber and Huestis hardrock deposits were identified nearby (Assessment and Abandoned Mines Branch [AAM] 2008).

An extensive exploration and sampling program was conducted at Mt. Nansen between 1963 and 1967, including underground development and the construction of a small flotation mill. The mill treated 10,000 tonnes of material from the Webber and Huestis deposits in 1968 and 1969; however, a full production operation was determined to be uneconomical. During 1975 and 1976 an additional 5,000 tonnes of ore from the Huestis zone was processed in a sulphide flotation circuit, but the operation ceased again due to poor gold recovery. It was determined at that time a cyanide leaching process was required to economically recover gold (AAM 2008).

From 1985 to 1987 a surface trenching and diamond drilling exploration program was conducted by Chevron Minerals in a partnership with BYG Natural Resources Inc. (BYG). Exploration continued through 1988, but concentrated exclusively on the upper portion of the Brown-McDade deposit. This part of the deposit is more oxidized, so it could be treated using a cyanide leaching circuit which allowed increased recovery of gold.

The BYG mining operation at Mt. Nansen was based on producing ore at a rate of 500 tonnes per day (Denholm et al. 2000) from the Brown-McDade open pit and processing the ore through a cyanide leaching circuit for a minimum of four years. Setbacks prevented production targets from being achieved, and capital expenditures were considerably higher than planned. A combination of unexpectedly high clay content in the ore that limited production through the crushing plant, and increasing sulphide material content in the pit's lower level ores, meant that significant additional capital investment was required. 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 sulphide materials found deeper in the pit were not easily recovered, and the processes required a much larger capital expenditure. Extracting gold from sulphide materials is only feasible where the amount of available ore is large enough to justify such expenditure. In the Mt. Nansen case it appears that the composition of the ore in the Brown-McDade deposit was not well understood by BYG prior to mining. Once the upper layers of oxide ore were removed the composition of the deposit changed to a mix of oxide material with an increasing amount of sulphide material, gold recoveries fell below expected levels.

Through the life of the mine, serious environmental concerns included problems with the tailings dam construction and operation, and discharges from the water treatment plant repeatedly failing toxicity tests. There were four requests for Water Licence amendments to suspend non-toxicity requirements. In February 1999, the Water Inspector issued a directive for BYG to comply with the Water Licence or cease operations. BYG ceased operations and declared voluntary receivership, appointing a receiver for the physical assets. However, in July of 1999 the voluntary receiver resigned and left the property. By August of 1999 Canada formally declared the property abandoned and took over under Section 39 of the Yukon Waters Act. In April 2003 the management of the site devolved to the Government of Yukon.

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. Contamination of Victoria Creek associated with a fish kill at the mouth of Dome Creek (drains into Victoria Creek) was documented in 1998 (Environment Protection 1999). DIAND (and subsequently YG-EMR) managers took action 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 et al. 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 licence. Containment involved pumping the seepage water from a seepage containment pond, located immediately below the tailings pond dam, back to the tailings pond, where it was then pumped to the mill and chemically treated to precipitate out metals and destroy cyanide, after which the water was discharged to the Dome Creek diversion. By 2005, levels of cyanide, biologically available (dissolved) arsenic, ammonia, and heavy metals had decreased to levels where the water could be released to the environment without treatment.

Care and maintenance activities that are currently on-going at the site under Yukon government's management include:

- Controlling access to the site to protect human health and safety;
- Managing operation of care and maintenance systems, including site security, water management, water treatment, sludge management, etc.;
- Monitoring and maintenance of tailings pond water and seepage pumping systems;
- Monitoring and maintenance of water diversion ditches through excavation of ice, soil or other materials if flows become restricted or ditch freeboard is minimized;
- Maintaining on-site access roads in a safe and useable state through summer repairs and winter snow removal;
- Overseeing the delivery of support systems and administrative elements (*i.e.*, purchasing of supplies for site manager and maintaining communication links);

- Ensuring all used buildings are maintained and operated in accordance with Yukon Occupational Health and Safety requirements;
- Regular monitoring through professional/qualified services of physical site features such as the dam, waste rock pile, surface water quality and flow, and groundwater flow and quality; and,
- Conducting miscellaneous site maintenance such as steaming of culverts.

The Yukon government Assessment and Abandoned Mines (AAM) Branch is preparing to proceed with the environmental and socio-economic assessment for abandonment and remediation of the Mt. Nansen Mine site. The assessment of this project has been identified to require an Executive Committee-level Screening by the Yukon Environmental and Socio-economic Assessment Board (YESAB).

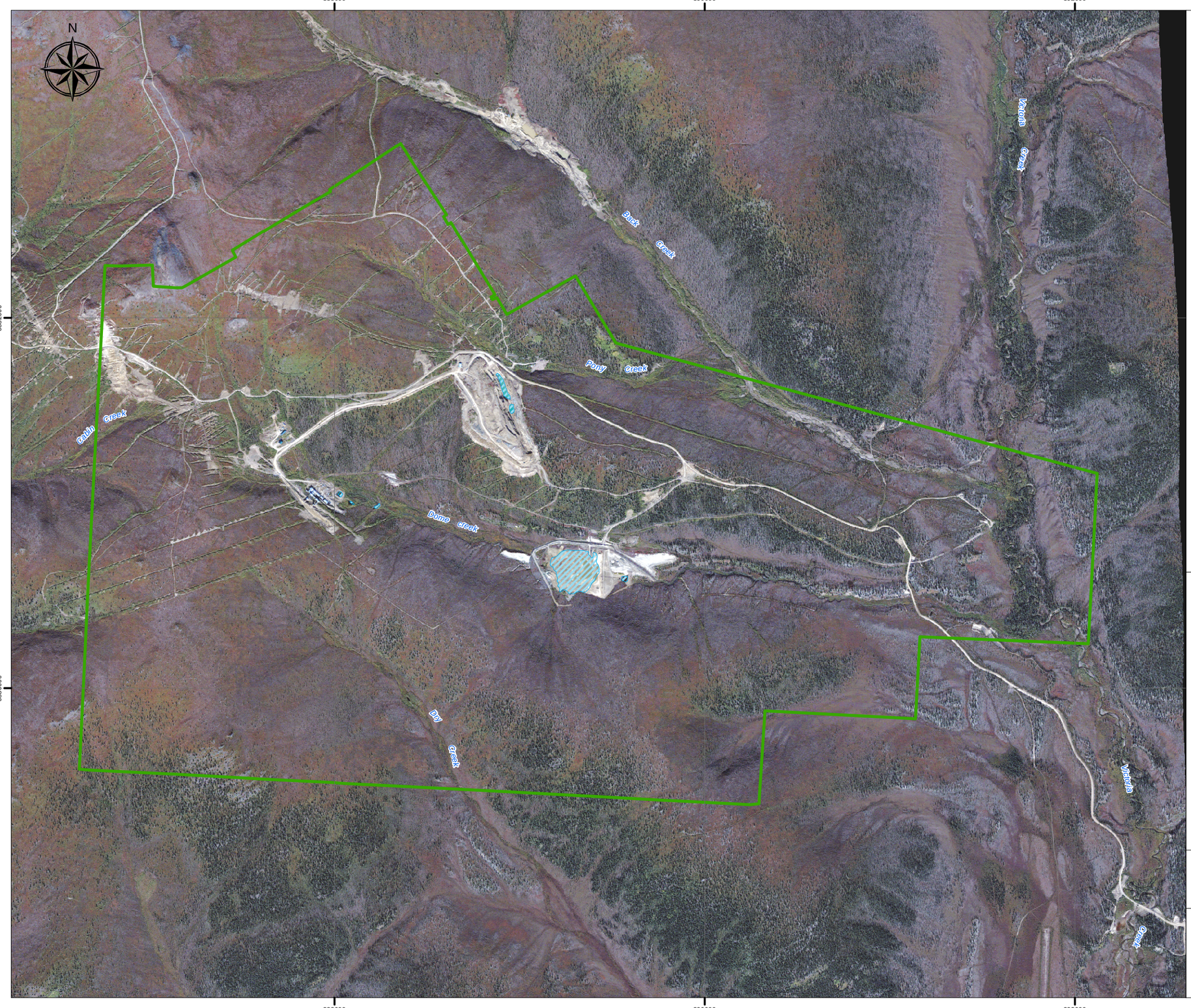
This document summarises the available environmental and historical information including published and unpublished data and reports related to the Mt. Nansen mine site and surrounding region.

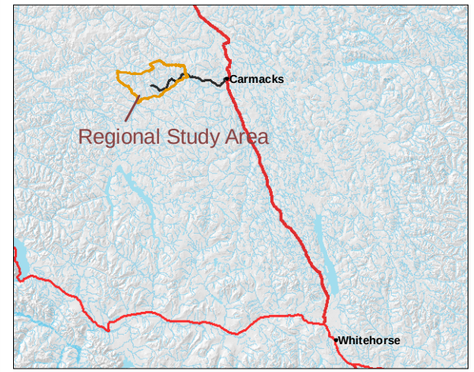
2 Study Area

For the purposes of understanding the existing conditions of the project and its relationship with local wildlife, fish, vegetation and human habitats, a Project Area (PA) has been defined. This area is encompassed by the Land Reservation 2850-25-115I03/082581 (Figure 2.1). A Regional Study Area (RSA) was delineated for comparative purposes to determine regional ecological characteristics and relative habitat availability. The RSA encompasses the proposed reclamation works, and includes Mt. Nansen (to the northwest), Victoria Mountain (to the north) and Mt. McDade (to the northeast), Rowlinson Creek along the eastern and northeaster edge. The northern border extends from the headwaters of Rowlinson Creek, west-south-west across the height of land to the head waters of Lonely Creek. The western boundary follows Lonely Creek, and the southern boundary is the Nisling River (Figure 2.2).

The RSA was established based on the following considerations:

- Major topographic features surrounding the site;
- Boundaries of previous assessments for this project (*e.g.*, terrestrial effects, water sampling, etc.); and
- An area large enough to encompass project disturbances and comparable, undisturbed areas within similar ecosystems.





Project Study Areas

- Project Area-OIC Reserve
- Regional Study Area

Topographic Features

- Tailings/Containment Pond

Drawn By: M. Power
Checked By: M. Setterington
Date: 26 March 2010

Projection: NAD 1983 UTM Zone 8
EDI Project #: 10-YC-0003

1:50,000 Topographic Spatial Data: Canvec and National Topographic Database (NTDB). Used under license courtesy of Her Majesty the Queen in Right of Canada, Department of Natural Resources. All Rights Reserved.

Study/drainage areas were digitized by EDI using specific parameters such as, height of land and relevant drainage courses (1:50,000 Canvec).

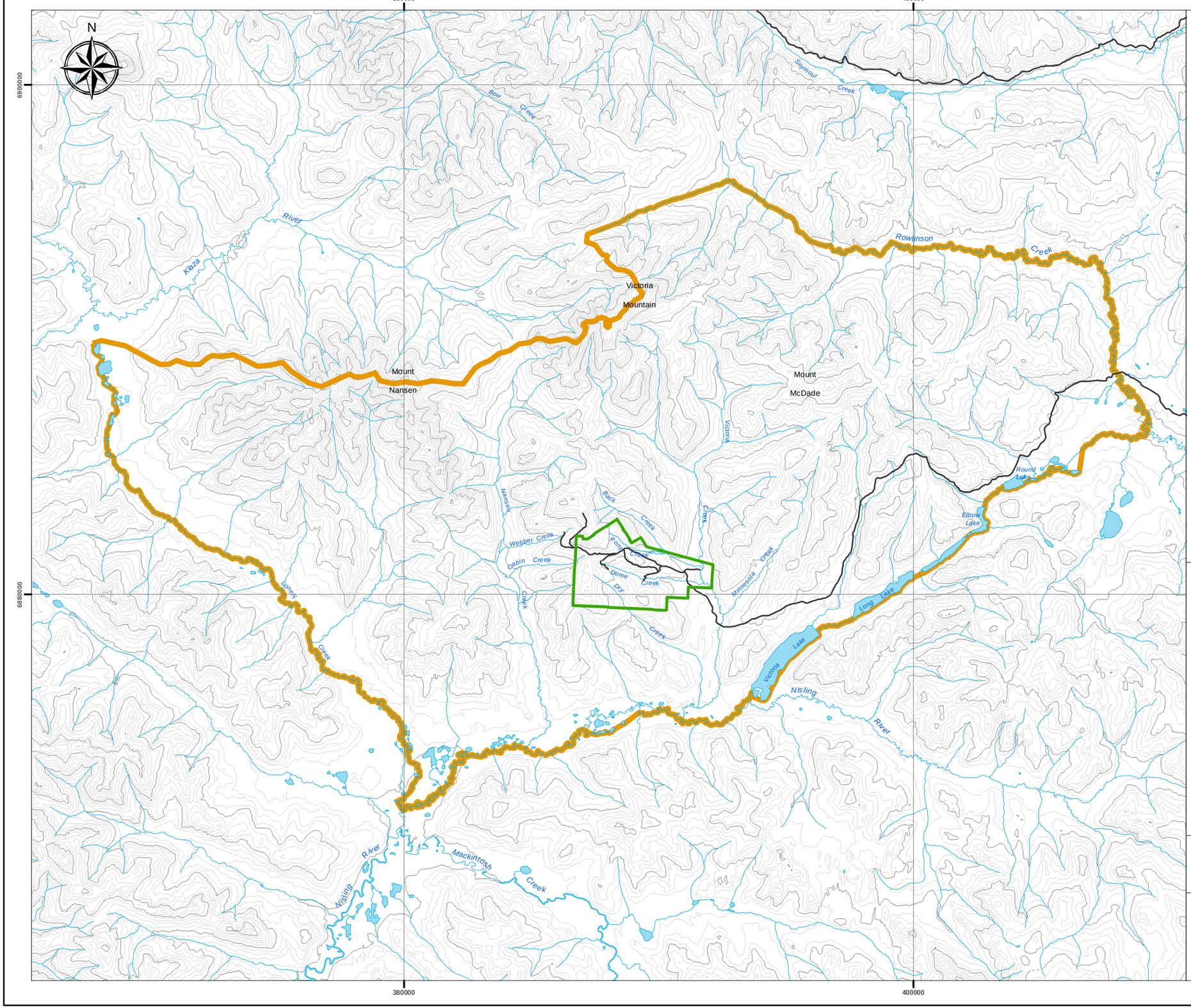
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0 250 500 750 1,000
Metres

Figure 2.1: The Project Area for the Mt. Nansen reclamation project environmental overview.

Prepared for: Yukon Energy, Mines and Resouces

Prepared by: EDI Environmental Dynamics Inc.



Project Study Areas

- Project Area-OIC Reserve
- Regional Study Area

Topographic Features

- Road
- Major Contour
- Minor Contour
- Watercourse
- Waterbody

Drawn By: M. Power
Checked By: M. Setterington
Date: 26 March 2010

Projection: NAD 1983 UTM Zone 8
EDI Project #: 10-YC-0003

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Study/drainage areas were digitized by EDI using specific parameters such as, height of land and relevant drainage courses (1:50,000 Canvec).

This document is not an official land survey and the spatial data presented on the map is subject to change without any notice.

0 2 4 6 8 10
Kilometres

Figure 2.2: The Regional Study Area for the Mt. Nansen reclamation project environmental overview.

Prepared for:
Yukon
Energy, Mines and Resouces

Prepared by:
EDI
ENVIRONMENTAL DYNAMICS INC.

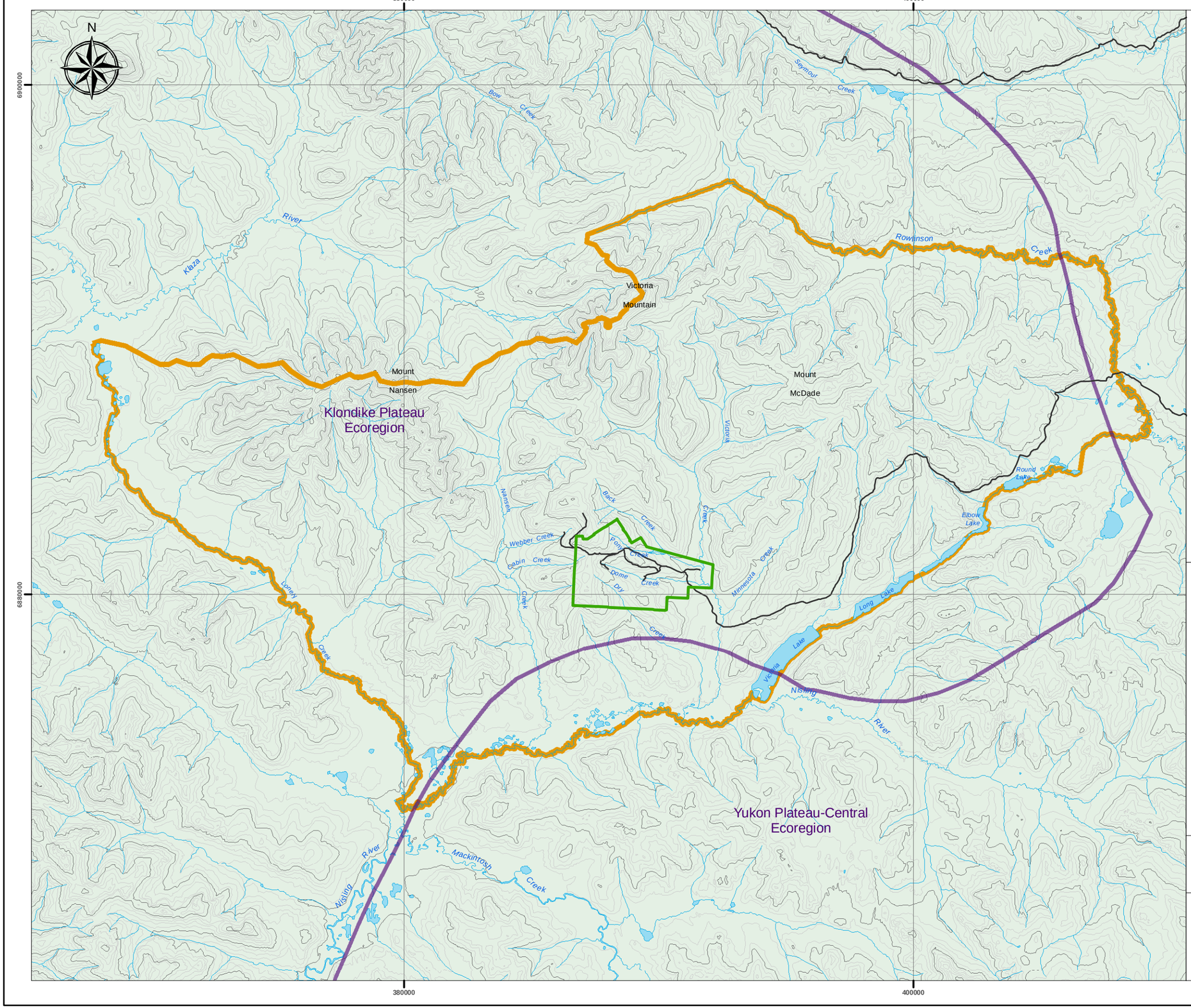
3 General Physiography

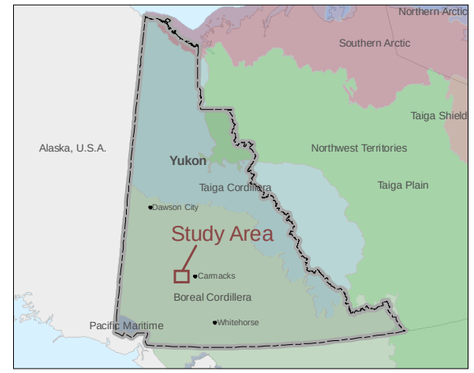
The project falls within the Boreal Cordillera Ecozone, which covers sections of northern British Columbia and the southern Yukon. At a regional level, the area lies within the southeastern portion of the Klondike Plateau Ecoregion, and is very close to the boundary with the Yukon Plateau-Central Ecoregion (Smith et al. 2004). Both of these ecoregions are described below.

The Klondike Plateau Ecoregion is characterized by smooth topped ridges dissected by deep, narrow, V-shaped valleys characteristic of an area left untouched by the most recent glaciation (Yukon Ecoregions Working Group 2004a). Most ridges are 1,200 to 1,700 m above sea level (asl) and local relief ranges from 450 to 700 m. Some high elevation ridges have rocky spines and towers which are bedrock remnants left after long periods of weathering. The Dawson Range is the most distinct feature of the Klondike Plateau, occupying the area between the Yukon River in the north and the Nisling River in the south. The major rivers of the region include the Yukon, White and Donjek Rivers. Wellesley Lake is the only major lake in the region. The climate of the region is continental with warm summers and very cold winters. Yearly precipitation is around 300 mm in the southeast and increases to 500 mm in the northwest with the wettest period from June through August (Yukon Ecoregions Working Group 2004a). Boreal forest occupies the valleys and lower slopes and alpine tundra covers the ridge crests. Most of Yukon's major boreal wildlife species occur within the region at moderate to high densities.

The Yukon Plateau-Central Ecoregion is characterized by low rounded mountains, rolling hills, and broad valleys (Yukon Ecoregions Working Group 2004b). The Yukon River bisects the ecoregion from south to north, from Lake Laberge and the mouth of the Teslin River to the confluence of the Pelly and Yukon Rivers. The Pleistocence glacial limit (most recent glaciation) forms the western and northwestern boundaries of the region. The Tatchun Hills and several peaks within the eastern portion of the Dawson Range are between 1,750 and 1,850 m asl (Yukon Ecoregions Working Group 2004b). The area lies within the rain shadow of the St. Elias/Coast Mountains and annual precipitation ranges from 250 to 300 mm. May through September have average daily temperatures above freezing. Temperature inversions are common with a mean January temp of -30 °C in the lowest valleys and to -20 °C in higher terrain (Yukon Ecoregions Working Group 2004b). South facing slopes support extensive grassland communities. Forest fires are frequent, thus maintaining vast areas of relatively young aspen and lodgepole pine stands, while spruce remains the main forest type. Tatlmain Lake is the largest lake in the region, but the region contains numerous small lakes including Tatchun, Frenchman, Diamain and von Wilczek. There are also various wetland complexes in the broad valleys providing habitat for waterfowl and semi-aquatic mammals.

There are no known, uncommon or unique physiographic features in or adjacent to the Project Area.





Project Study Areas

- Project Area-OIC Reserve
- Regional Study Area
- Ecoregion Boundary
- Boreal Cordillera Ecozone

Topographic Features

- Road
- Major Contour
- Minor Contour
- Watercourse
- Waterbody

Drawn By: M. Power
Checked By: M. Setterington
Date: 26 March 2010

Projection: NAD 1983 UTM Zone 8
EDI Project #: 10-YC-0003

1:50,000 Topographic Spatial Data: Canvec and National Topographic Database (NTDB). Used under license courtesy of Her Majesty the Queen in Right of Canada, Department of Natural Resources. All Rights Reserved.

Study/drainage areas were digitized by EDI using specific parameters such as, height of land and relevant drainage courses (1:50,000 Canvec).

Ecological Units Ver. 3.0, CanSIS, Agriculture and Agrifoods Canada [http://sis.agr.gc.ca/cansis/nsdb/ecostrat/gis_data.html]
February 20, 2003

This document is not an official land survey and the spatial data presented on the map is subject to change without any notice.

0 2 4 6 8 10
Kilometres

Figure 3.1: Ecozones and Ecoregions in the Mt. Nansen Regional Study Area.

Prepared for:
Yukon
Energy, Mines and Resouces

Prepared by:
EDI
ENVIRONMENTAL DYNAMICS INC.

4 Geology and Soils

4.1 Bedrock Geology

The geology of the property has been extensively described and documented in previous reports. The following is a basic summary of material obtained from Norecol Environmental Consultants Ltd. (1989a), T.W. Higgs Associates Ltd. (1994) and Denholm et al. (2000).

The Project Area is located in the eastern portion of the Yukon Crystalline Terrane (Yukon Tanana Terrane) found between the Coast Plutonic Complex to the southwest and the Yukon Cataclastic Terrane to the northeast (Denholm et al. 2000). The Yukon Crystalline Terrane's oldest rocks consist of Upper Paleozoic or older metamorphic sedimentary rocks (gneisses and schists). This assemblage was then intruded by Upper Triassic and Jurassic granodiorite and syenite batholiths, both intrusive igneous rocks similar to granite. These were in turn intruded or overlain by Mid- to Late Cretaceous mafic to felsic volcanic, pyroclastic, hypabyssal and plutonic rocks related to the Coast Plutonic Complex (Denholm et al. 2000, Norecol 1989a, T.W. Higgs Associates Ltd. 1994).

On the Mt. Nansen property, the lower third of the mineral claim group is covered by older Paleozoic rocks dominated by quartz feldspar-chlorite gneiss, quartzite, amphibole, and augen gneiss (Denholm et al. 2000). These rocks host three of the main mineralized zones, the Webber, Huestis and Flex. The Brown-McDade deposit in the northeast is hosted by mid-Cretaceous granodiorite, quartz-diorite, and quartz-monzonite. In the north of the mineral claim group there is large quartz-feldspar porphyry intrusive complex which has local associated gold values, as well as a copper, molybdenum and bismuth geochemical signature.

Faulting is the main structural feature with two main fault sets occurring on the property (Denholm et al. 2000). A north-northwest trending set dips from 50 to 70 degrees to the southwest and parallels the main vein direction. A second southeast trending set is sub-vertical and locally cuts some of the mineralized zones. These faults form part of the larger regional Mt. Nansen Trend.

The common form of mineralization is found within planar structurally controlled vein systems consisting of quartz, carbonate and varying amounts of sulphide (Denholm et al. 2000). The vein systems can occur as simple quartz veins (Huestis and Webber zones) or as a complex anastomosing series of veins and veinlets (Brown-McDade Zone). Gold occurs in three forms: 1) as fine-grained inclusions in pyrite and arsenopyrite; 2) as peripheral infiltrations in a number of sulphide minerals; and 3) as 'free gold' forming an intergrowth with galena, freibergite and sulphosalts. The 'free gold' is relatively easy to recover either by gravity or cyanide leaching, but the other forms present a greater processing challenge.

4.2 Surficial Geology and Soils

Four glacial advances have been identified across the central Yukon Territory. These are, from youngest to oldest, the Nansen, Klaza, Reid, and McConnell advances (Bostock 1966, O. Hughes et al. 1968). The Nansen and Klaza advances, referred to collectively as the Pre-Reid glaciations, covered the project area leaving only the high peaks of Mt. Nansen and Victoria Mountain free of ice (*i.e.*, elevations greater than 1,370 m asl). During the Reid and McConnell glaciations, the Mt. Nansen area was ice free with the limit of the Reid advance located a few kilometres east of Victoria Creek. Proglacial deposits related to advancing and retreating glaciers are found at lower elevations in the major valley floors (EBA, Mougeot GeoAnalysis, and SRK 1994).

Due to the unglaciated nature of the area, the dominant parent materials are stony residual materials along ridge tops and summits, coarse colluviums on upper slopes, and silty colluviums and loess, rich in organic matter on lower slopes (Yukon Ecoregions Working Group 2004b). The valley bottoms of Victoria and Nansen creeks are covered by unconsolidated alluvium (EDI 2007), while the Dome Creek valley is mainly of colluvial, residual and granular glacial outwash origin overlying bedrock (T.W. Higgs Associates Ltd. 1994). There are also extensive deposits of grey-brown sand in the valley bottoms and in the benchland near Dome Creek (Norecol 1989a).

Soil development is generally poor across the property, typically with several centimetres of organics overlying a layer of volcanic tephra and weathered bedrock (EDI 2007). Soils vary from sandy gravel to fine sandy silt, and material is generally medium dense with some pockets of loose material made up usually of angular pieces of highly weathered rock (T.W. Higgs Associates Ltd. 1994). Soil thickness is greatest in the valley bottoms with thinner soils covering the steeper valley sides (EDI 2007). Loess and volcanic ash have been observed in scattered patches throughout the property. Loess occurs as fine sand mantling some of the lower slopes. A thin layer of white ash (a few centimetres) is apparent in some areas below organic soils, and is postulated to be from a recent eruption (1,230 yrs ago) in the Wrangell Mountains to the northwest. Residual soils tend to be well graded and at times quite variable with respect to geotechnical characteristics such as moisture content, relative density, and permeability (EBA, Mougeot GeoAnalysis, and SRK 1994).

Cryosols are generally associated with areas of discontinuous permafrost which occur on lower slopes and valley bottoms (Yukon Ecoregions Working Group 2004a). Eutric Brunisols are more common on loamy colluvial materials which dominate well-drained ridge crests and south-facing slopes. On more upland positions active cryoturbation may develop Orthic Turbic Cryosols. Upland soils are dominated by residual soils that reflect the mineralogy of the underlying bedrock. These soils are well-drained and may thaw to a depth of 2 m in the summer season, while those overlayed with thick moss and forest floor material may only thaw to a depth of 50 cm each year.

4.3 Permafrost

Mt. Nansen is within the discontinuous permafrost area of Yukon where permafrost is 30–60 m thick. Its presence is controlled by vegetation, slope aspect, and elevation (EBA, Mougeot GeoAnalysis, and SRK 1994). Most of the area contains permafrost below a thick active layer up to 1.5 m; however, the residual nature of the overburden (weathered bedrock) and the associated well-drained conditions infer that ground ice contents will be negligible on the mountain tops and valley sides. South facing slopes which are well drained with barren or grassy vegetation are also typically free of permafrost (EDI 2007).

North slopes are normally permafrost bound as evidenced by thick moss cover and stunted conifers. In these areas, permafrost can be evident at shallow depths of about 0.4 m (T.W. Higgs Associates Ltd. 1994). Where thick moss cover has been removed permafrost layer can occur at greater depths of about 5.0 m.

There is currently no map of permafrost characteristics within the RSA and PA. Permafrost presence needs to be understood for the PA, specifically where earth works are likely to occur (*i.e.*, containment dam).

5 Terrain Hazards

Terrain hazards in the area are mainly associated with permafrost and colluvial processes. Disruption of organic cover reduces the insulation that preserves frozen soil and will initiate or enhance soil creep, solifluction and slope failure (EBA, Mougeot GeoAnalysis, and SRK 1994). This issue is more of a concern on north facing slopes and valley bottoms where excess ground ice is high. These concerns are negligible for mountain tops and valley sides which are better drained due to the weathered nature of their surficial material.

Rock fall is a common terrain hazard in the Brown-McDade Pit where pieces of rock frequently break off from the pit walls. There is potential for rock fall and other colluvial processes wherever highly weathered bedrock is exposed on a slope. Where exploration trenches dissect the hillsides, there are areas with erosion, gullying, side wall collapse and sediment deposition (EBA, Mougeot GeoAnalysis, and SRK 1994).

Flooding is common on Victoria and Dome creeks during ice breakup as significant overflow ice occurs in these valleys. In some instances flooding will breach culverts and obstruct the main access road. There are also other creek crossings to the east of Victoria and Dome creek which experience similar conditions. Culvert and road work is done on an annual basis. Summer rainstorms are less of a concern, aside from causing some moderate erosion around the site.

The terrain does not provide for avalanche risks, therefore they are not a concern. Timber blow down is not a large risk in the sub-alpine ecosystem. There are no other known terrain hazards in the Project Area.

5.1 Seismic Activity

The area lies within a seismically active area of the Canadian north known as the Northern British Columbia source zone found between the McKenzie zone and Denali Shakwak zone (T.W. Higgs Associates Ltd. 1994). To determine the seismic risk for the area the 2005 National Building Code Seismic Hazard Calculation website was used (Natural Resources Canada 2010). The maximum ground accelerations associated with 1/100, 1/475 and 1/1,000 year return earthquakes was 0.076 g 0.142 g and 0.185 g, respectively (Table 5.1). These values are not a measure of the total size of potential earthquake, but rather how hard the earth shakes in a given geographic area. Extensive deposits of loose soils are susceptible to liquefaction under earthquake loading (T.W. Higgs Associates Ltd. 1994), particularly where windblown silt and sand have accumulated.

Table 5.1: Earthquake return prediction (1:100, 1:475 and 1:1,000 year return) for the Mt. Nansen Area (Natural Resources Canada 2010).

Site	Location		Peak ground acceleration [a]		
	Latitude	Longitude	1/100 year	1/475 year	1/1000 year
Mount Nansen	61.98 N	132.45 W	0.076 g	0.142 g	0.185 g

Notes: [a] peak ground acceleration (g); 1g = 9.8m/s^2

6 Climate

Climate of the area is strongly continental in nature and the mine site aspect is south, southeast. Data from selected regional meteorological stations is available for use in describing the general climatic conditions for the PA, RSA and other areas nearby.

Two meteorological stations have been installed at the mine site and data were collected and managed by AAM, in addition to one snow survey station located east of the PA that is managed by EMR and the Water Resources Branch (Figure 6.1). Longer-term climate data for the regional area is available for three different Meteorological Service of Canada meteorological stations near the community of Carmacks. Monthly climatic records for these stations are available from Environment Canada's National Climate Data and Information Archive (Environment Canada 2010a). See Table 6.1 for information on the meteorological stations within and adjacent to the RSA.

For the purposes of this baseline study, data from the two Mt. Nansen meteorological stations will be summarized for air temperature, precipitation, and wind, while data from the Mt. Nansen Snow Survey station will be summarized for snow depth. One of the Mt. Nansen meteorological stations, referred to as the old station, operated from 2000 to 2006, and collected data on precipitation, temperature, snow depth, relative humidity, solar radiation, wind direction, and wind speed at every one hour interval. When the old station was damaged in 2006, a new station was installed in 2007 at a different location. This station collects data on rain, temperature, relative humidity, wind speed, wind direction and gust speed.

6.1 Air Temperature

The climate of the area is characterized by long cold winters and short warm summers, like most of the south-central Yukon (EBA, Mougeot GeoAnalysis, and SRK 1994). Temperature inversions frequently develop in valley bottoms during winter with the milder temperatures found at higher elevations. In the summer, the warmer temperatures develop in the valley bottoms.

For most areas within Yukon, January is typically the coldest month and July is the warmest. Within the RSA, January was the coldest month at the new Mt. Nansen station from 2007 to 2009 with a mean temperature of -22.5 °C. From 2000 to 2003, December was the coldest month at the old Mt. Nansen station with a mean temperature of -14.6 °C. July remains the warmest month on record, with a mean temperature of 11.8 °C (old station) and 12.4 °C (new station). The most extreme temperatures recorded during these periods were -47.7 °C (February 2008) and 27.1 °C (July 2009). See Table 6.2 for mean monthly air temperatures and extreme maximum and minimum monthly temperatures.

6.2 Precipitation

The study area receives most of its precipitation from June to August due to convective rain showers and summer thunderstorms (Yukon Ecoregions Working Group 2004a). Precipitation values at this time of year have ranged from an average of 38.7 mm to 75.0 mm per month (AAM 2010) (Figure 6.2, Table 6.3). The greatest monthly precipitation recorded was 119.8 mm (July 2008) and the greatest daily precipitation recorded was 31.2 mm (July 8, 2007). Note, monthly means were only calculated for those months with complete data.

The driest months within the RSA are generally January through April with an average monthly precipitation ranging from 4.3 mm to 7.8 mm per month (Table 6.3; Figure 6.2). In general, 60% of the annual precipitation falls as rain and the remainder as snow (EBA, Mougeot GeoAnalysis, and SRK 1994). To measure precipitation the new station uses a tipping bucket, which does not measure snow and thus monthly precipitation during winter could not be calculated and is displayed as 'N/A' (not available) in Table 6.3. The old station used a pressure transducer in the anti-freeze tank to measure precipitation in the winter, and thus estimates of precipitation are available from the old station.

Annually the area receives on average 257 mm of precipitation per year. This average is based on two years of data, 2002 and 2003, as these years have complete precipitation records. Annual precipitation values ranged from 226 mm (2002) to 288 mm (2003). These values are relatively low for what is typically described for the larger Klondike Plateau ecoregion (300 to 500 mm), as the RSA lies in the southeast corner of the ecoregion, and the general trend is for annual precipitation to gradually increase from southeast to northwest (Yukon Ecoregions Working Group 2004a).

6.3 Snow

The Mt. Nansen snow survey station has been in operation for the past 33 years. It is located downstream of the confluence of Victoria and Minnesota Creek and is under the jurisdiction of the Department of Energy, Mines and Resources, Yukon government. Every year the data is prepared for March, April and May in a survey bulletin issued by the Water Resources Section - Environmental Programs Branch of Environment Yukon. The bulletins from 2006 to 2009 are accessible on the Water Resources Branch website (Water Resources Section 2009a).

Snow pack peaks sometime in April and typically melts in early May on south-facing slopes and in late May on north-facing slopes (EBA, Mougeot GeoAnalysis, and SRK 1994). From 2006 to 2009 the average snow depth was 46 cm in March, 52 cm in April and 13 cm in May (Table 6.4). The water equivalent of these values was on average 70 mm in March, 101 mm in April and 30 mm in May. There is typically no snow in May and this is reflected in Table 6.4 with the '0' values.

6.4 Wind

Wind data has been collected within the Study Area from 2000 to the present. The old Mt. Nansen meteorological station was located near the northeast edge of the tailings pond in a semi-treed location. This station measured wind direction and speed but was primarily installed to measure precipitation data as it was placed in a sheltered location to avoid wind. During this period, prominent winds were from the west, southwest, and east (EDI 2007); however wind data from this station is not representative of wind conditions for the site. From 2007 to present, wind data was collected from the new Mt. Nansen meteorological station installed at the camp kitchen. Data from this station is summarized for the purposes of this report as it represents the most recent conditions. This station is used to record wind direction, wind speed and gust wind speeds.

Wind data from 2007 to the present was divided into winter and summer data; 'winter' was defined as October to April and 'summer' was defined as May to September. Prominent wind direction patterns were similar for the winter and summer, with the winds most frequently originating from the north (Figure 6.3). Overall, 44% and 38% of winds in the winter and summer, respectively, were from the north (*i.e.*, N, NE, NW, NNE, and NNW); while 26% and 32% of the winds in the winter and summer, respectively, were from the south (*i.e.*, S, SE, SW, SSE, and SSW).

An analysis of wind speeds found that wind speeds were greatest for the summer, likely associated with summer rain and thunder storms. The average wind speeds for the winter and summer were 3.7 km/hr and 6.1 km/hr, respectively (Figure 6.4). The maximum gust speeds were 66.8 km/hr in the summer and 58.8 km/hr in the winter.

6.5 Climate Change

Average winter temperatures in Alaska and north-western Canada have increased by as much as 3–4^{o}C between 1950 and 2000 (ACIA 2004). Climate change predictions for Yukon are for winters to warm more than summers, with summer warming occurring mostly in the south and central Yukon. More precipitation is expected to occur in the winter with the change being greater farther north, and there will be more extreme winter and summer weather events, particularly heavy summer rainfalls and thunderstorms (ACIA 2004).

Table 6.1: Location of meteorological stations with current and historical data within and adjacent to the Mt. Nansen Regional Study Area (Source: AAM 2010a; Environment Canada 2010a; Water Resources Section 2009a).

Station name	Agency	Station number	Location		Elevation (m)	Data years
			Latitude	Longitude		
Carmacks	EC	2100300	62.10 N	136.30 W	524.9	1963–2007
Carmacks CS	EC	2100301	62.12 N	136.19 W	542.9	2000–present
Carmacks Tower	EC	2100302	63.18 N	136.48 W	1,234.4	1976
Mt. Nansen — New	AAM	n/a	62.05 N	137.15 W	1,250.0	2007–present
Mt. Nansen — Old	AAM	n/a	62.04 N	137.11 W	1,125.0	2000–2006
Mt. Nansen Snow Survey	EMR	09CA-SC01	62.03 N	137.05 W	1,021.0	1977–present

Notes: Environment Canada (EC);
Assessment and Abandoned Mines Branch, Yukon Government (AAM);
Department of Energy, Mines, and Resources, Yukon Government (EMR).

Table 6.2: Mean monthly air temperatures (ºC) and extreme temperature recordings for Mt. Nansen Old (2000–2003) and Mt. Nansen New (2007–2009) meteorological stations (AAM 2010).

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mt. Nansen — Old 2000–2003												
mean temp	-11.2	-10.3	-9.9	-3.2	3.6	10.2	11.8	9.5	3.9	-1.15	-7.6	-14.6
extreme high	3.0	2.6	4.3	17.3	21.8	23.2	25.0	25.4	18.5	20.1	6.3	2.2
extreme low	-41.5	-26.4	-32.5	-23.5	-14.5	0.5	1.5	-2.5	-10.1	-17.9	-29.0	-31.8
Mt. Nansen — New 2007–2009												
mean temp	-22.5	-18.0	-13.5	-1.8	6.2	10.7	12.4	9.3	4.5	5.0	-11.2	-16.7
extreme high	4.4	4.2	6.2	13.6	23.6	25.6	27.1	22.5	18.7	7.2	-1.1	0.8
extreme low	-45.4	-47.7	-36.5	-18.8	-5.2	-2.7	0.10	-3.4	-9.8	-23.43	-24.4	-41.3

Table 6.3: Mean monthly precipitation (mm) and extreme monthly precipitation (mm) values for Mt. Nansen Old (2000–2003) and Mt. Nansen New (2008–2009) meteorological stations (AAM 2010).

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mt. Nansen – Old 2000 & 2003												
mean precipitation	7.0	4.3	7.8	7.0	30.7	48.0	67.0	75.0	38.6	15.7	11.9	12.4
ext monthly high	7.1	7.0	16.0	10.0	48.0	68.0	88.0	117.0	85.0	25.8	13.0	15.0
ext monthly low	7.0	1.0	4.0	7.0	20.0	29.0	52.0	38.0	5.0	4.0	10.0	8.6
Mt. Nansen – New 2008–2009												
mean precipitation	N/A	N/A	N/A	N/A	N/A	53.8	66.6	38.7	28.4	N/A	N/A	N/A
ext monthly high	N/A	N/A	N/A	N/A	N/A	53.8	119.8	45.6	31.4	N/A	N/A	N/A
ext monthly low	N/A	N/A	N/A	N/A	N/A	53.8	13.4	31.8	25.4	N/A	N/A	N/A

Table 6.4: Monthly snow depths and water equivalent recorded at the Mt. Nansen snow survey meteorological station, 2006 to 2009 (Water Resources Section 2009).

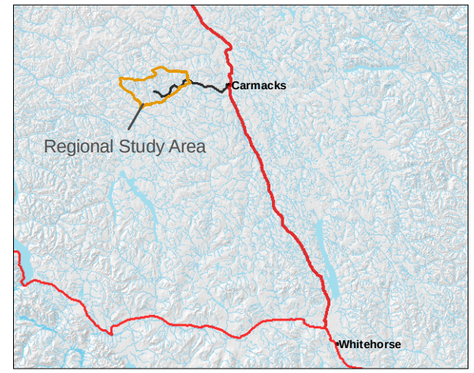
	2006	2007	2008	2009	
Month of Survey	**Snow Depth (cm)**				**Average (cm)**
March	38	41	55	51	46
April	41	53	52	60	52
May	0	0	0	53	13
	Water Content (mm)				**Average (mm)**
March	56	58	89	76	70
April	84	86	124	110	101
May	0	0	0	120	30

386000
388000
390000
392000
6882000
6880000
6878000

N

New Station
Old Station
Dome Creek
Diversion Channel

Back Creek
Victoria Creek
Pony Creek
Cabin Creek
Dome Creek
DNY Creek
Victoria Creek



Project Specific Features

Project Area-OIC Reserve

Monitoring Stations

Climate Monitoring Station

Snow Survey Station

Topographic Features

Road
Major Contour
Minor Contour
Watercourse
Waterbody
Tailings/Containment Pond

Drawn By: M. Power
Checked By: M. Setterington
Date: 26 March 2010

Projection: NAD 1983 UTM Zone 8
EDI Project #: 10-YC-0003

1:50,000 Topographic Spatial Data: Canvec and National Topographic Database (NTDB). Used under license courtesy of Her Majesty the Queen in Right of Canada, Department of Natural Resources. All Rights Reserved.

Study/drainage areas were digitized by EDI using specific parameters such as, height of land and relevant drainage courses (1:50,000 Canvec).

This document is not an official land survey and the spatial data presented on the map is subject to change without any notice.

0 500 1,000 1,500
Metres

Figure 6.1: Climate monitoring & snow survey stations within the vicinity of Mt. Nansen Project Area.

Prepared for:
Yukon
Energy, Mines and Resouces

Prepared by:
EDI
ENVIRONMENTAL DYNAMICS INC.

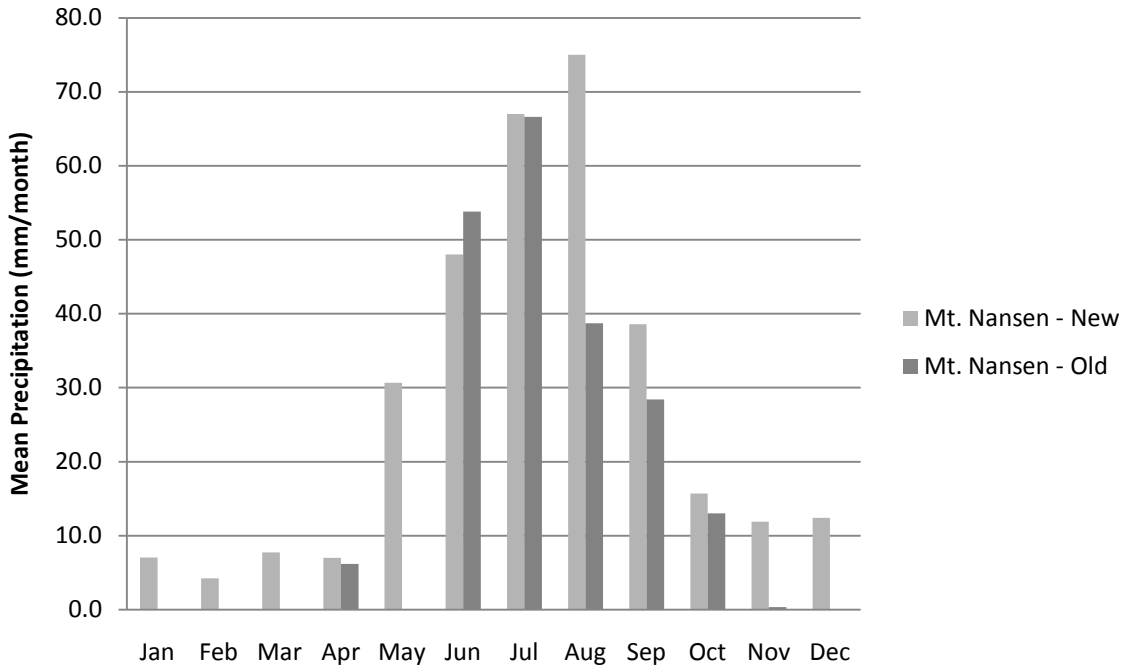


Figure 6.2: Mean monthly precipitation for Mt. Nansen Old (2000–2003) and Mt. Nansen New (2008–2009) meteorological stations (AAM 2010).

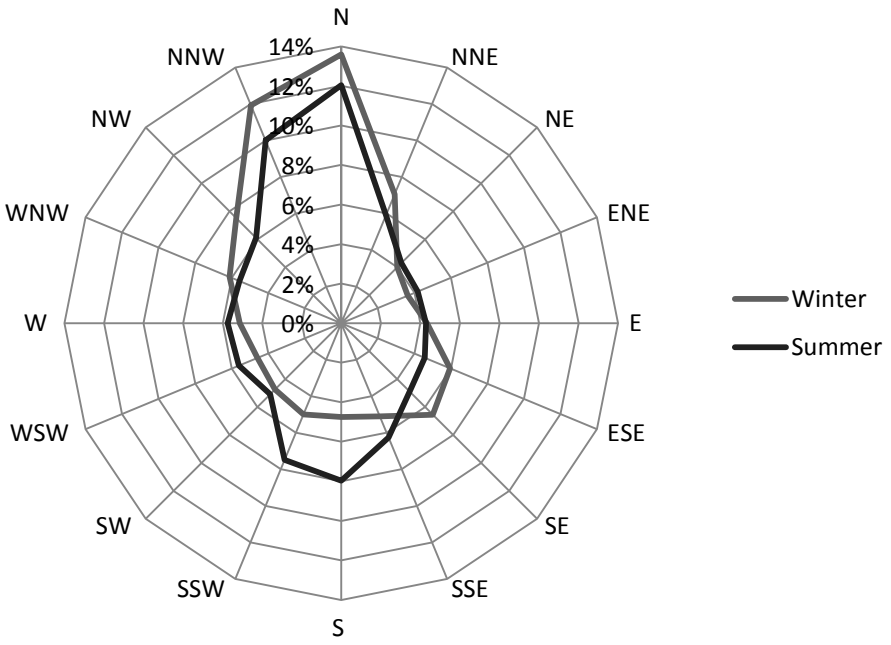


Figure 6.3: Wind direction for summer and winter 2007–2010 (AAM 2010).

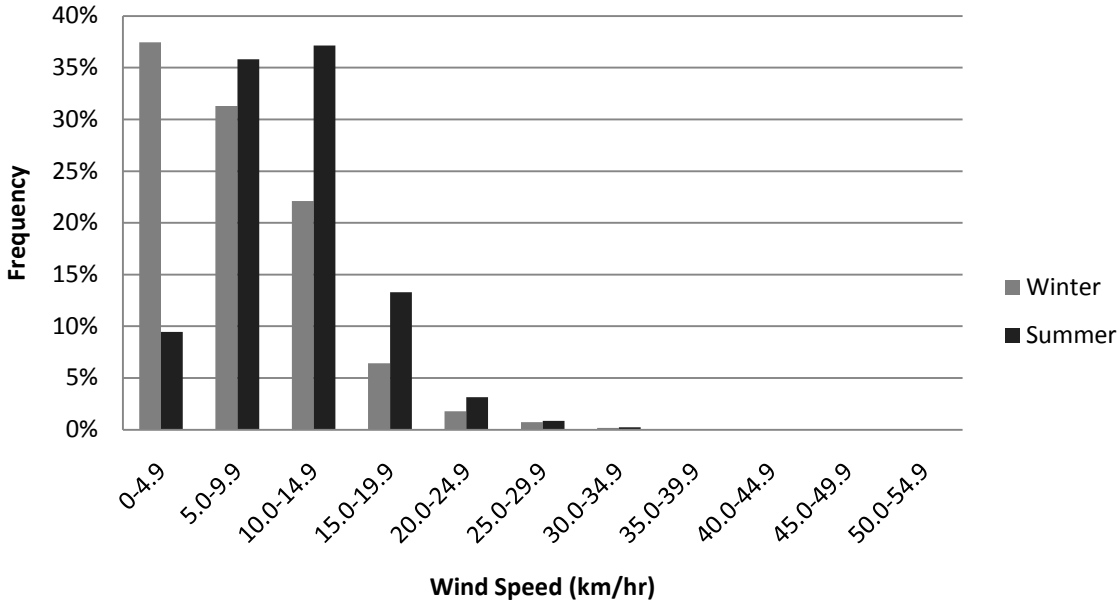


Figure 6.4: Average Wind speed during summer and winter, 2007–2010.

7 Air Quality and Noise

7.1 Air Quality

Poor air quality can affect human health as well as the environment. Air quality is often considered in terms of the amount of gaseous pollutants and/or particulate matter in the air. Further causes associated with poor air quality may be attributed to human activities and/or natural processes. Yukon has one air quality monitoring station located in Whitehorse, which is part of the National Air Quality Surveillance Network. Pollutants monitored at the station include carbon monoxide, nitrogen dioxide, ground level ozone and fine particular matter. Sources of air pollution in this area can include vehicle emissions, wood smoke (including forest fires) and dust from various sources.

The project area lies in a remote area, 60 km west of Carmacks. The regional air quality is affected by rural activities (*i.e.*, home heating and transportation), industrial activities (*i.e.*, mining, exploration, and transportation), and natural causes (*i.e.*, wildfires). Within the PA, air quality may be influenced by airborne contamination from the tailings pond, mill site, and open pit/waste rock dumps, and can include localized emissions from diesel generators, or more extensively by dust raised by traffic on gravel roads. Studies on airborne contamination were undertaken by EDI in 2005 and 2006 during a terrestrial and aquatic effects study (EDI 2007). This included the collection of lichen and other plant samples which provide information on past aerial contamination as well as the deployment of moss bags across the mine site to provide information on current aerial dispersion and contamination. The Rowlinson Creek area was used as a control site.

Lichen samples from around the mine site were found to contain elevated levels of arsenic, lead, antimony, silver, and copper. Contamination was most apparent around the mill site, followed by the pit, and to a lesser extent, the tailings pond. The zone of influence where metal concentrations were highest extended to between 200 to 500 m from the mill, pit and tailings pond. Outside of this zone, metal concentrations were significantly lower, except for concentrations of copper and silver which remained relatively constant between the mine and control sites.

Metal levels in other plants were much lower compared to lichens, however willow (*Salix* ssp.) and Labrador tea (*Ledum groenlandicum*) appeared to show higher levels of arsenic (and antimony in willow only) near sources of contamination compared to the Rowlinson control sites.

Moss bags were deployed over three periods: winter (October–May), spring/early summer (May–July), and summer/early fall (July–October). Moss bags around the tailing pond tended to contain the highest levels of arsenic, lead, sliver, and antimony, especially in the spring and summer months, indicating a current source of aerial dispersion of dust from the tailings pond. Levels of arsenic and lead also tended to be higher near the pit and mill than at control locations.

The only wind direction data for the area over the course of the 2005–2006 study was from the old meteorological station which indicated that winds were most prominent from the west, southwest, and east for both winter and summer (EDI 2007). However, due to the placement of this station in a sheltered, treed location, the wind data is not representative of overall conditions at the site. Regardless, this pattern combined with the swirling of winds due to local topography was likely responsible for the ongoing contamination and dispersion around the tailings pond area.

The extent of ongoing airborne contaminants is limited to the area surrounding the contaminant sources. The lichen study found that the zone of elevated contaminant concentrations was within 200 to 500 m from contaminant sources (*i.e.*, the mill, pit and tailings pond), and beyond that zone metal levels were significantly lower. The moss bag study also suggested that elevated metal concentrations did not extend to the Rowlinson control sites, which lie approximately 30 km to the east of the project area. As such contamination or impacts on air quality does not likely influence air quality in the community of Carmacks, located approximately 60 km to the east. The risk to human health from contaminated dust is considered generally insignificant relative to direct ingestion of soil and water, and to dermal absorption (Health Canada 2004).

7.2 Noise

The Project Area is situated in a remote area where ambient noise consists of natural and human-induced sounds. Some of these noises may be short-term sounds (soft or loud) while others may be more constant and long-term. Natural sounds include wind, rockfall, water, and wildlife (*i.e.*, birds and arctic ground squirrels). Human-induced sounds include generators, water pumps, gunshot, all terrain vehicles, heavy machinery (*i.e.*, loader), and other vehicular traffic associated with placer mining, recreation, or monitoring work.

Generators operate year round and vehicular traffic is predominantly in the summer. Most vehicular noise is associated with maintenance and monitoring work at the abandoned mine site, while other noise comes from other land users (*i.e.*, hunters and placer miners). Major road maintenance work, such as culvert repair and grading, often takes place at least twice a year, typically following snowmelt and prior to snow fall to prepare road surfaces for the coming winter.

In general, noise levels are affected by distance, air density, wind, and obstructions (vegetation, buildings, and topography). The mine site is located in the subalpine where trees are relatively sparse but still offer some sound protection in conjunction with the mountainous topography. Also, distance to the nearest community of Carmacks is 60 km and the ambient noises described above are not likely to carry at that distance given the terrain and vegetation cover. The effects of noise generated at the mine site, as described above, would be limited to the PA.

There are no quantitative data on noise levels within the Project Area.

8 Vegetation

The Klondike Plateau Ecoregion is an area that includes a diversity of vegetation communities. Boreal forest is common in lower elevations and alpine tundra is common at higher elevations. White and black spruce are the dominant tree species in the region. Other tree species include balsam poplar, paper birch and trembling aspen. Black spruce dominates wet poorly drained areas, while drier areas contain spruce forest with lichen understory (an important late-winter habitat type for caribou). Stable riparian areas contain white spruce communities, while more unstable riparian areas contain dense shrub and herd communities. Forest fires in the area are common, so the region contains many successional forest stages (Yukon Ecoregions Working Group 2004a).

Vegetation data for the Project Area was generally described in the terrestrial effects study (EDI 2007). Common species observed included:

- White spruce (*Picea glauca*);
- Black spruce (*P. mariana*);
- Willow, birch (*Betula glandulosa*);
- Labrador tea (*Ledum groenlandicum*);
- Blueberry (*Vaccinium uliginosum*);
- Cranberry (*V. vitis-idaea* ssp.);
- Sedges (*Carex* sp.);
- Mosses and lichens.

The forest vegetation in the RSA contains open stands of black spruce and white spruce in valley bottoms (Norecol 1989a). Some of the lower elevation areas contain black spruce and trembling aspen (*Populus tremuloides*). Above treeline, birch and willow are the predominant species in high elevation valley bottoms. The PA generally represents vegetation typical of that found in the RSA; however, the RSA contains more alpine tundra vegetation communities.

8.1 Rare and Conservation Concern Plants

Environment Yukon in collaboration with Nature Serve Canada (http://www.natureserve-canada.ca) is developing a list of rare and conservation concern plant species in Yukon. Environment Yukon has provided a list of plant species that may occur within the RSA and that are of conservation concern within Yukon (Mulder 2010).

Table 8.1: Summary of plant species that are of conservation concern in Yukon and that may occur within the RSA (Mulder 2010)[a].

Scientific name	Common name	G-Rank	N-Rank	S-Rank
Artemisia laciniata	Siberian Wormwood	G4 [b]	N1	S1
Artemisia rupestris	Rock Wormwood	G3 [b]	N2	S2
Aster yukonensis	Yukon Aster	G3	N1	S1S2
Botrychium alaskense	Alaska Moonwort	G2G3	NNR	S1S3
Botrychium lineare	Narrow-leaf Grape-fern	G2 [b]	N1	S1
Botrychium multifidum	Leathery Grape-fern	G5	NNR	S1
Botrychium spathulatum	Spoon-leaf Moonwort	G3	N2N3	S1S2
Botrychium tunux	Tunux' Moonwort	G2G3	NNR	S1
Botrychium yaaxudakeit	Yaa Xu da Keit's Moonworts	G2	NNR	S1
Carex laxa	Weak Sedge	G5 [b]	N1	S1
Claytonia scammaniana	Scamman's Springbeauty	G3G4	N3	S3
Comandra umbellata	Umbellate Bastard Toad-flax	G5	NNR	S1S2
Corispermum ochotense	Russian Bugseed	G3G4	N1N3	S2
Cypripedium guttatum	Spotted Lady's-slipper	G5	N2	S2
Delphinium brachycentrum	Northern Larkspur	G4G5	N1	S1
Draba densifolia	Dense-leaf Whitlow-grass	G5	N2	SNR
Draba murrayi	Murray's Whitlow-grass	G2	N1	S1
Draba stenopetala	Star-flowered Draba	G3G4	N2	S2
Eriogonum flavum	Umbrella Plant	G5	N5	S1
Erysimum angustatum	Dawson Wallflower	G2	N2	S2
Koeleria asiatica	Oriental Junegrass	G4	N2	S2
Krascheninnikovia lanata	Winter-fat	G5	NNR	S1
Minuartia yukonensis	Yukon Stitchwort	G3	N2N3	S2S3
Oxytropis mertensiana	Mertens' Crazy-weed	G4	NNR	S1
Oxytropis scammaniana	Scamman's Crazy-weed	G3G4	N2N4	S3S4
Phacelia mollis	Coffee Creek Scorpion-weed	G2G3	N2	S2S3
Podistera macounii	Macoun's Podistera	G4	N2	S2S3
Podistera yukonensis	Yukon Podistera	G2	N1	S1
Polystichum lonchitis	Northern Holly-fern	G5	NNR	S1
Potamogeton subsibiricus	Yenisei River Pondweed	G3G4	N3	S1
Primula eximia	Arctic Primrose	G5	N2N3	S2S3
Saxifraga spicata	Spiked Saxifrage	G3G4	N1	S1
Silene williamsii	Williams' Campion	G5T4	N1	S1S2
Stellaria dicranoides	Matted Starwort	G3	N1	S1
Stenotus macleanii	Northern Mock Golden-weed	G2	N2	S2
Trisetum sibiricum	Siberian False-oats	G5	N1	S1
Viola biflora	Northern Violet	G5	NNR	S1
Alyssum obovatum	American Alyssum	G5	NNR	S2S3
Antennaria microphylla	Small-leaf Cat's-foot	G4G5	NNR	S2
Aster borealis	Boreal Aster	G5	N5	S2S3

Scientific name	Common name	G-Rank	N-Rank	S-Rank
Carex eleusinoides	Goosegrass Sedge	G4G5	N3	S3
Carex lapponica	Lapland Sedge	G4G5Q	NNR	S2
Carex sychnocephala	Many-headed Sedge	G4	NNR	S2
Ceratophyllum demersum	Common Hornwort	G5	NNR	S2
Cryptogramma stelleri	Fragile Rockbrake	G5	NNR	S2
Draba ogilviensis	Ogilvie Range Whitlow-grass	G3	N3	S3
Draba porsildii	Porsild's Whitlow-grass	G3G4	N3N4	S2
Draba stenoloba	Alaska Whitlow-grass	G5	NNR	S3
Erigeron grandiflorus ssp. arcticus	Large-flower Fleabane	G4T3T4	NNR	S2S3
Erigeron hyperboreus	Boreal Fleabane	G3G4	N1	S1
Erigeron purpuratus	Purple Fleabane	G5	NNR	SNR
Erigeron yukonensis	Yukon Fleabane	G2G4	NNR	S2
Luzula rufescens	Hairy Woodrush	G5	NNR	SNR
Minuartia stricta	Rock Sandwort	G5	NNR	SNR
Montia bostockii	Bostock's Miner's-lettuce	G3	N3	S3
Phlox richardsonii	Richardson's Phlox	GNR	NNR	S3
Poa porsildii	Porsild's Bluegrass	G3	N3	S3
Polypodium sibiricum	Siberian Polypody	G5*	N4*	S1
Potentilla furcata	Hooker's Cinquefoil	G4TNR	NNR	S2S3
Rumex acetosa	Green Sorrel	G5	N4N5	S1
Sagina saginoides	Arctic Pearlwort	G5	NNR	S2S3
Saussurea nuda		G3G4	NNR	S2S3
Saxifraga eschscholtzii	Cushion Saxifrage	G4	N2	S2
Silene macrosperma	Large-fruit Catchfly	G4	NNA	SNR
Synthyris borealis	Alaska Kitten-tail	G3G4	NNR	S2S3
Thlaspi arcticum	Arctic Pennycress	G3	N2	S1S2
Townsendia hookeri	Hooker Townsend	G5	NNR	S2S3
Woodsia ilvensis	Rusty Woodsia	G5	NNR	S1

Notes: [a] The vegetation species conservation status is ranked on a scale from 1 (critically imperiled) to 5 (secure) at the Global (G), National (N), and Sub-national (S) scales. For example, G5 is globally secure and S1 is sub-nationally critically imperiled.
[b] Indicates uncertainty in the ranking because of limited data.
T indicates intraspecific taxons (*i.e.* sub-species or varieties).
NR indicates an unranked status.
Q indicates questionable taxonomy.
For more information on ranking go to: http://www.natureserve.org/explorer/ranking.htm.

9 Wildlife

Terrestrial animals are important nutritionally, culturally, economically and ecologically to the people that use the Mt. Nansen area. Mitigating any effects from industrial activities first requires an understanding of the state of animals and, consequently, the entire ecosystem. The following text is a summary of baseline information that is available on the occurrence, abundance, distribution, and human use of wildlife in the region. A section on the species at risk in the RSA is included as well as a description of the local extent of the species that are known, or are likely, to be present in the area.

The Klondike Plateau Ecoregion, which the Project Area is located within, tends to have a greater abundance of wildlife and is described as one of the most biologically productive areas in Yukon (Yukon Ecoregions Working Group 2004a). Large game (*e.g.*, caribou and moose) have been documented at relatively high densities within the region. Large carnivores, furbearing mammals (*e.g.*, lynx and marten) and other mammals are also relatively abundant. Two migratory bird corridors are found within this ecoregion: the Tintina Trench in the north and the Shakwak Trench in the south (Yukon Ecoregions Working Group 2004a). In contrast, the Yukon Plateau-Central Ecoregion, which is south and east of the Project Area, tends to have a lower abundance of animals than the Klondike Plateau, but still supports moderate densities of most of Yukon's animals (Yukon Ecoregions Working Group 2004b). Part of the Tintina Trench bird migration corridor is within this ecoregion.

There is limited information on most wildlife specific to the PA, but information on wildlife at the regional scale is relatively well understood. Several studies were initiated with the re-introduction of wood bison, and as baseline studies for other regional mines.

9.1 Birds

Although there have been no specific studies of birds within the RSA, there are a variety of birds that have been documented in the Mt. Nansen region. These species represent a typical assemblage of northern boreal and alpine-related species (Table 9.1). A number of the species are of conservation concern based on assessments by the Committee of the Status of Endangered Wildlife in Canada (COSEWIC) and the Canadian Endangered Species Conservation Council (CESCC). The birds in the Mt. Nansen region that were assessed by COSEWIC include two species with a status of "Threatened" and four species with a status of "Special Concern." Several species have a General Status rank of "Sensitive" indicating that those species are not believed to be at risk of immediate extirpation or extinction but may require special attention (CESCC 2006). Species that have a General Status rank of "May be at Risk" indicates that they may be at risk of extirpation or extinction and are therefore candidates for a detailed risk assessment by COSEWIC (CESCC 2006).

Documented bird records within the Mt. Nansen RSA are limited to incidental and casual observations contained within the Birds of the Yukon Database (CWS 1998). A dedicated inventory of birds within the RSA has not been completed; however, an inventory of breeding birds completed in the vicinity of Klaza Mountain (Frisch 1983) to the north of the RSA provides records for a region with similar habitats to the Project Area. For species of conservation concern listed by COSEWIC or CESCC, additional information is provided on the breeding habitat requirements and likely areas of occurrence within the RSA (Table 9.2). For CESCC species listed as "Sensitive" are only included if the breeding status within the RSA was "confirmed" or "likely."

Table 9.1: Bird species occurring or potentially occurring within the Mt. Nansen RSA and associated conservation status.

Species	Status within the RSA		Conservation status	
	Presence [a]	Breeding [b]	COSEWIC [c]	Yukon General Status
Common Loon	Suspected	Likely	Not At Risk	Sensitive
Horned Grebe	Documented	Confirmed (CWS 2009)	Special Concern	Secure
Red-necked Grebe	Suspected	Likely	Not At Risk	Secure
Canada Goose	Suspected	Likely		Secure
Trumpeter Swan	Suspected	Likely	Not At Risk	Sensitive
American Wigeon	Documented	Confirmed (CWS 2009)		Sensitive
Mallard	Documented	Confirmed (CWS 2009)		Secure
Blue-winged Teal	Suspected	Unlikely		Secure
Northern Shoveler	Documented	Confirmed (CWS 2009)		Secure
Northern Pintail	Suspected	Likely		Sensitive
Green-winged Teal	Suspected	Likely		Secure
Canvasback	Suspected	Unlikely		Secure
Ring-necked Duck	Suspected	Likely		Secure
Lesser Scaup	Documented	Confirmed (CWS 2009)		Sensitive
Surf Scoter	Suspected	Likely		Sensitive
White-winged Scoter	Suspected	Likely		Sensitive
Bufflehead	Documented	Likely		Secure
Common Goldeneye	Suspected	Likely		Secure
Barrow's Goldeneye	Documented	Confirmed (CWS 2009)		Secure
Common Merganser	Suspected	Likely		Secure
Red-breasted Merganser	Suspected	Unlikely		Secure
Osprey	Suspected	Likely		Sensitive

Species	Status within the RSA		Conservation status	
	Presence [a]	Breeding [b]	COSEWIC [c]	Yukon General Status
Bald Eagle	Documented	Likely	Not At Risk	Secure
Northern Harrier	Documented*	Likely	Not At Risk	Secure
Sharp-shinned Hawk	Suspected	Likely	Not At Risk	Secure
Northern Goshawk	Suspected	Likely	Not At Risk	Secure
Red-tailed Hawk	Suspected	Likely	Not At Risk	Secure
Golden Eagle	Documented	Likely	Not At Risk	Sensitive
American Kestrel	Documented*	Likely		May Be At Risk
Merlin	Documented	Likely	Not At Risk	Secure
Peregrine Falcon	Suspected	Unlikely	Special Concern	Sensitive
Gyrfalcon	Documented	Confirmed (CWS 2009)	Not At Risk	Secure
Ruffed Grouse	Suspected	Likely		Secure
Spruce Grouse	Suspected	Likely		Secure
Willow Ptarmigan	Documented*	Likely		Secure
Rock Ptarmigan	Documented	Likely		Secure
White-tailed Ptarmigan	Documented*	Unlikely		Secure
Dusky Grouse	Suspected	Likely		Secure
Sharp-tailed Grouse	Suspected	Likely		Sensitive
American Golden-Plover	Documented	Likely		Sensitive
Semi-palmated Plover	Documented	Unlikely		Secure
Killdeer	Suspected	Likely		Secure
Lesser Yellowlegs	Documented	Confirmed (CWS 2009)		Sensitive
Solitary Sandpiper	Suspected	Likely		Secure
Spotted Sandpiper	Documented	Likely		Secure
Upland Sandpiper	Documented	Likely		Secure
Whimbrel	Documented*	Unlikely		Sensitive
Surfbird	Documented*	Likely		Sensitive
Least Sandpiper	Suspected	Likely		Secure
Pectoral Sandpiper	Documented	Likely		Secure
Wilson's Snipe	Documented	Likely		Secure
Red-necked Phalarope	Documented	Unlikely		Sensitive
Long-tailed Jaeger	Documented	Unlikely		Secure
Bonaparte's Gull	Documented	Confirmed (CWS 2009)		Secure
Mew Gull	Suspected	Likely		Secure
Arctic Tern	Suspected	Unlikely		Secure
Great-Horned Owl	Suspected	Likely		Secure
Northern Hawk Owl	Suspected	Unlikely	Not At Risk	Secure

Species	Status within the RSA		Conservation status	
	Presence [a]	Breeding [b]	COSEWIC [c]	Yukon General Status
Great Gray Owl	Suspected	Unlikely	Not At Risk	Sensitive
Short-eared Owl	Documented*	Unlikely	Special Concern	Sensitive
Boreal Owl	Suspected	Likely	Not At Risk	Secure
Common Nighthawk	Documented		Threatened	Secure
Belted Kingfisher	Documented*	Likely		Secure
Hairy Woodpecker	Documented	Unlikely		Secure
American Three-toed Woodpecker	Suspected	Likely		Secure
Northern Flicker	Documented	Likely		Secure
Olive-sided Flycatcher	Documented	Likely	Threatened	Sensitive
Western Wood-Pewee	Documented	Unlikely		Secure
Yellow-bellied Flycatcher	Suspected	Unlikely		Secure
Alder Flycatcher	Documented	Likely		Secure
Hammond's Flycatcher	Suspected	Likely		Secure
Say's Phoebe	Documented*	Likely		Secure
Northern Shrike	Suspected	Likely		Sensitive
Gray Jay	Documented	Likely		Secure
Common Raven	Documented	Likely		Secure
Horned Lark	Documented	Unlikely		Secure
Tree Swallow	Suspected	Likely		Secure
Violet-green Swallow	Suspected	Likely		Secure
Bank Swallow	Documented	Confirmed (CWS 2009)		Secure
Cliff Swallow	Documented*	Likely		Secure
Black-capped Chickadee	Documented	Likely		Secure
Boreal Chickadee	Documented	Likely		Secure
Ruby-crowned Kinglet	Documented*	Likely		Secure
Townsend's Solitaire	Documented	Confirmed (CWS 2009)		Secure
Gray-cheeked Thrush	Documented*	Unlikely		Secure
Swainson's Thrush	Documented	Likely		Secure
Hermit Thrush	Suspected	Likely		Secure
American Robin	Documented	Likely		Secure
Varied Thrush	Documented	Likely		Secure
American Pipit	Documented	Likely		Secure
Bohemian Waxwing	Documented	Likely		Secure
Orange-crowned Warbler	Documented	Likely		Secure
Yellow Warbler	Suspected	Likely		Secure
Yellow-rumped Warbler	Documented	Likely		Secure

Species	Status within the RSA		Conservation status	
	Presence [a]	Breeding [b]	COSEWIC [c]	Yukon General Status
Blackpoll Warbler	Documented	Likely		Secure
Northern Waterthrush	Documented	Likely		Secure
Common Yellowthroat	Documented	Likely		Secure
Wilson's Warbler	Documented	Likely		Secure
American Tree Sparrow	Documented	Likely		Secure
Chipping Sparrow	Documented	Likely		Secure
Savannah Sparrow	Documented	Likely		Secure
Fox Sparrow	Suspected	Likely		Secure
Lincoln's Sparrow	Documented	Likely		Secure
White-crowned Sparrow	Documented	Likely		Secure
Golden-crowned Sparrow	Suspected	Unlikely		Secure
Dark-eyed Junco	Documented	Likely		Secure
Lapland Longspur	Documented*	Unlikely		Secure
Smith's Longspur	Documented*	Likely		Sensitive
Red-winged Blackbird	Documented	Unlikely		Secure
Rusty Blackbird	Suspected	Likely	Special Concern	Sensitive
Gray-crowned Rosy Finch	Documented*	Unlikely		Secure
Pine Grosbeak	Documented*	Likely		Secure
White-winged Crossbill	Documented	Likely		Secure
Common Redpoll	Documented*	Likely		Secure
Pine Siskin	Documented	Likely		Secure

Notes: [a] Species denoted with a * documented only by Frisch (1983)and not within the RSA itself. Species classified as “suspected” not documented in the RSA or by Frisch (1983); however, there is a high likelihood of occurrence.

[b] Designation of “likely” or “unlikely” made based on geographic occurrence (Sinclair et al. 2003), professional knowledge of Yukon birds and suitability of habitats within the RSA.

[c] Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

Table 9.2: Habitat associations and probable breeding habitat within the Mt. Nansen RSA for bird species of conservation concern.

Common name	Yukon specific habitat characteristics[a]	Probable breeding areas within the Mt. Nansen RSA[b]
Common Loon	Large and small lakes in forested areas, usually with fish.	Victoria Lake and unnamed lakes along the southeast border of the RSA.
Horned Grebe	Small lakes and ponds with marshy margins.	Victoria Lake and unnamed lakes along the southeast border of the RSA; ponds throughout the Nisling River and Lonely Creek valleys.
Trumpeter Swan	Small lakes, marshes and slow moving rivers with abundant emergent vegetation.	
American Wigeon	Various sized lakes, ponds, sloughs and slow moving rivers.	
Northern Pintail	Small lakes and ponds, often substantial distance from water.	
Lesser Scaup	Small lakes and ponds and marshy areas near open water.	
Surf Scoter	Variety of lakes and ponds in forested habitats.	
White-winged Scoter		
Osprey	Small to medium sized, productive fish bearing lakes.	Victoria Lake and unnamed lakes along the southeast border of the RSA.
Golden Eagle	Tundra and river outwash plains with rock outcrops for nesting.	High elevation areas, including Mt. Nansen, Mt. McDade and Victoria Mountain.
American Kestrel	Open forests, burns, meadows, subalpine and alpine areas with tree cavities for nesting.	Throughout much of the RSA wherever suitable nesting sites are present.
Sharp-tailed Grouse	Open parkland areas including river outwash meadows and subalpine areas.	Open meadows in the Nisling River and Lonely Creek valleys.
American Golden-Plover	Dry and moist tussock tundra.	High elevation areas, including Mt. Nansen, Mt. McDade and Victoria Mountain.
Lesser Yellowlegs	Ponds or wetlands and open boggy spruce forest.	Margins of Victoria Lake and unnamed lakes along the southeast border of the RSA; ponds throughout the Nisling River and Lonely Creek valleys.
Surfbird	High elevation stony heath.	High elevation areas, including Mt. Nansen, Mt. McDade and Victoria Mountain.
Short-eared Owl	Open alpine, wetland and meadow areas.	High elevation areas, including Mt. Nansen, Mt. McDade and Victoria Mountain; open areas in the Nisling River and Lonely Creek valleys.
Common Nighthawk	Open forests, burns and wetlands.	Open forests in the Nisling River and Lonely Creek valleys.
Olive-sided Flycatcher	Variety of forests from lowlands to subalpine; wetland margins, areas with snags for signing/foraging perches.	Forested areas throughout the RSA.

Common name	Yukon specific habitat characteristics[a]	Probable breeding areas within the Mt. Nansen RSA[b]
Northern Shrike	Shrubby subalpine areas, often near creeks.	High elevation areas, including Mt. Nansen, Mt. McDade and Victoria Mountain.
Smith's Longspur	Sparsely shrubby tundra habitats.	
Rusty Blackbird	Wetlands along the edges of ponds or lakes with dense marsh vegetation/shrubs and scattered standing dead trees.	Victoria Lake and unnamed lakes along the southeast border of the RSA; ponds throughout the Nisling River and Lonely Creek valleys.

Notes: [a] As described in (Sinclair et al. 2003).
[b] Based on available bird distribution data and appropriate breeding habitat within the RSA.

9.2 Mammals

Wildlife in the RSA is important for the local people and is relatively abundant. Some trappers are active in the area, and the road provides important access to licensed and subsistence hunters. The RSA is known to contain important habitat for moose and caribou, and many other large and small mammals. In the following text we summarize and discuss the available distribution and abundance data, when available, that exists for the wildlife species within the PA, RSA or at a larger regional scale.

No distribution or abundance data exists for some species of mammals that occur within or near the RSA. However, the following general information is known:

- Elk (*Cervus canadensis*) range east of the RSA and currently elk are not known to occur within the RSA;
- Mule deer (*Odocoileus hemionus*) and white-tailed deer (*Odocoileus virginianus*) have been observed within the RSA and near the PA, but observations are rare (B. Wheeler 2010 pers. comm.);
- Thinhorn sheep (*Ovis dalli*) have been observed within the RSA (O'Donoghue 2010 pers. comm., Wheeler 2010a pers. comm.);
- Goats (*Oreamnos americanus*) are not known to occur within or near the RSA;
- Coyotes (*Canis latrans*) have been trapped in the region (Table 9.4), so they likely occur within the RSA;
- Foxes (*Vulpes vulpes*) are frequently observed at the mine site (B. Wheeler 2010 pers. comm.);
- Wolverines (*Gulo gulo*) have been trapped within the region (Table 9.4) and are infrequently observed within the PA (B. Wheeler 2010 pers. comm.).

Terrestrial wildlife information review is limited to those species expected to commonly occur within the RSA.

Moose (*Alces alces*)

Moose were identified as the wildlife species of greatest importance to the LSCFN members during a community-based survey (EDI 2007 appendix B). Moose are the most hunted wildlife species in the area. The Mt. Nansen area was identified by the Carmacks community members to be an area where moose numbers are low, and consequently, moose harvest is a concern (Little Salmon Carmacks Fish and Wildlife Planning Team 2004). As a result of the concerns identified, Environment Yukon conducted an aerial moose survey of the area northwest of Carmacks in the fall of 2007. The survey included the southern portion of the Dawson Range — a survey area known as "Carmacks West." The survey was completed using a Stratified Random Block (SRB) technique with a Sightability Correction Factor (SCF) applied to account for moose missed during the survey. The results of the survey suggest that there are 520 (± 21%) moose within the survey area, and the population density in the area is 127 moose per 1000 km^2 of suitable moose habitat (O'Donoghue et al. 2008). Compared to previous moose density estimates from similar surveys conducted in 1987 and 2003 (45 moose per 1000 km^2 and 53 moose per 1000 km^2, respectively), the 2007 results suggest that the population has likely increased. Survival of calves born in 2006 and 2007 was low, but insufficient data exist to make any conclusion about the state of moose recruitment in the area (O'Donoghue et al. 2008).

Moose are relatively evenly distributed throughout suitable habitat in the Dawson Range (O'Donoghue et al. 2008 fig. 4 and 5). The Wildlife Key Area (WKA) dataset identifies the area directly south of the Mt. Nansen mine site as late-winter range (Environment Yukon 2009b). The area identified falls within the southern part of the RSA and is very close to the Project Area (described below). Late winter habitat is the most limiting season for moose because of increased energy demands needed to move and access food through snow. As snow depth increases moose populations are more limited by available habitat, and late-winter habitat becomes more important. Typical late-winter habitat includes river valley bottoms that contain abundant shrub and poplar browse (Environment Yukon 2009b).

Moose is the most harvested species in south and central Yukon. In the Mt. Nansen area, licenced moose harvest is limited to the GMS south of the Mt. Nansen Road (Environment Yukon 2009a). The four GMSs north of the Mt. Nansen Road are closed to licenced moose harvest (Environment Yukon 2009a). Between 1999 and 2008 only two moose were harvested by licenced First Nation harvesters within the RSA. Because of the greater abundance of moose observed during the last survey compared to previous surveys, a closely managed licensed harvest is thought to be sustainable (O'Donoghue et al. 2008). As part of the 2004 Community-based fish and wildlife management plan, the LSCFN is currently trying to manage LSCFN moose harvest through disbursement of information within the community about the state of the moose population in the Mt. Nansen area, and by collecting their members' moose harvest information.

Caribou (*Rangifer tarandus*)

Caribou are an important harvest species for local people (EDI 2007), and are the most harvested animal by licensed harvesters in the GMS that is within the RSA (Table 9.5). The amount of food caribou provide for the local community is unknown, but it is likely a significant portion of the total amount of meat harvested.

The caribou herd that currently uses the range within the RSA is the Klaza Caribou Herd (KCH). The RSA comes close to Aishihik Caribou Herd (ACH) range, but only for the most northern extent of the herd (Figure 9.2). Both of these herds are part of the Northern Mountain caribou population which is listed by the Species at Risk Act (SARA) as a species of Special Concern in Canada — see Section 9.3 for further discussion. The most recent status assessment of woodland caribou in Canada was done in 2002 (COSEWIC 2002a). A management plan is currently being completed for the Northern Mountain caribou population and should be available sometime in 2010. The Fortymile Herd, a migratory caribou herd, also used this area before they were overharvested in Alaska and Yukon. There is currently a joint management plan between the governments of Alaska and Yukon with a goal of increasing the size of this herd. The herd was estimated to include more than 500,000 caribou in the 1920s (Environment Yukon 1989). Today the herd is composed of approximately 31,000 caribou which winter in Yukon sporadically (Yukon Fish and Wildlife Management Board 2000).

As mentioned above, the Mt. Nansen Project Area is outside the range of the ACH. This herd was intensively managed and monitored during the 1990s (see R.D. Hayes et al. 2003). For the KCH, which ranges within the RSA, there is moderate to abundant baseline information in the form of reports and unpublished data. The herd was studied intensively from 1987 to 1991 as part of a baseline data acquisition study by the Government of Yukon. Since this period, the herd has been surveyed 11 times — the most recent in 2003.

The objective of the intensive study, conducted from February 1987 to March 1990, was to collect baseline information on distribution, movement, demography, and habitat use in order to assess the potential impact on the herd from the proposed Casino mine access road. The study design included collaring 17 cow caribou with VHF collars. Relocations were collected during early winter (December), mid winter (February), late winter (March), calving (June), post-calving (July) and the rut (September – October). A total of 19 surveys were completed and a total of 236 relocations were collected.

From this study, two relatively distinct winter ranges were identified for the KCH: the Hayes Creek drainage and upper Klaza River (Figure 9.3). By late winter the range of the caribou was reduced to only the Hayes Creek drainage, which is recognized as the KCH's principal winter range (Farnell et al. 1991). However, the March 1989 survey noted an abundance of caribou tracks in upper Klaza River indicating that the upper Klaza River is also important caribou winter range. No migration corridors were identified for the KCH.

The KCH have three identified rutting grounds: the upper Klaza River, Prospector and Apex mountains, and Mount Cockfield (Farnell et al. 1991). The upper Klaza River rutting area was used by more than half of the collared caribou and it is partly within the RSA. Farnell et al. (1991) did not record Klaza caribou within the mine site area or south of the Mt. Nansen Road; however, they are commonly observed at the mine site (B. Wheeler 2010 pers. comm.). The importance of this habitat is unclear.

The KCH is currently estimated to contain approximately 650 animals (Hegel 2010 pers. comm.). The most recent series of consecutive surveys, between 1993 and 2003, indicated a calf:cow ratio of about 0.30 (30 calves/100 cows) which may suggest a stable population. The bull:cow ratio of the KCH herd was about 0.44 (44 bulls/100 cows) which is thought to be above the minimum number of bulls needed for a caribou population to achieve full reproductive potential (Table 9.3) (Environment Yukon 1996).

Table 9.3: Klaza Caribou Herd fall rut composition surveys results. Data provided by Environment Yukon.

Year	Bull:Cow	Mature Bull:Cow	Immature Bull:Cow	Calf:Cow
1987	0.47	0.20	0.27	0.28
1993	0.42	0.23	0.19	0.24
1994	0.37	0.22	0.14	0.30
1995	0.42	0.24	0.19	0.33
1996	0.48	0.18	0.29	0.45
1997	0.48	0.24	0.24	0.48
1999	0.50	0.15	0.35	0.26
2000	0.48	0.18	0.30	0.22
2001	0.37	0.17	0.20	0.18
2002	0.43	0.21	0.21	0.20
2003	0.42	0.19	0.23	0.30

Wood Bison (*Bison bison athabascae*)

Yukon's wood bison population is the result of a reintroduction of 170 animals in the late 1980s in the Nisling River area west of Carmacks. The release was part of a national bison recovery plan. Wood bison are listed under SARA as "Threatened". The most recent wood bison status assessment was in 2000. A Yukon-based wood bison management plan is currently being completed.

Following the reintroduction of the bison in the 1980s, the bison quickly expanded their range south to the Aishihik Lake area. The most recent bison survey, conducted in July 2009, estimates that the population had grown to approximately 1,150 bison (Jung 2010 pers. comm.). The target size of the

bison population is 500 animals. The fact that there is limited mortality of bison from predators has led the Government of Yukon to encourage bison harvest. The current annual allowable harvest is 300 bison/year. A consequence of the bison harvest has been an increase in hunter traffic within bison range.

The Project Area is near the north-eastern extent of the current wood bison range. Bison range expansion is thought to be density dependent, so if the population stops growing the range will cease to expand. However, there remains a concern that the bison are degrading local habitat and that they might start out-competing other large ungulates (*e.g.*, moose, sheep, and caribou) for habitat in the Mt. Nansen area (Little Salmon Carmacks Fish and Wildlife Planning Team 2004). Three bison were harvested from GMS 526 within the RSA by licensed harvesters between 1999 and 2009. The low bison harvest likely reflects the limited availability of bison in the area as the Project Area is outside the bison's core range.

Thinhorn sheep (*Ovis dalli*)

Thinhorn sheep have been observed within the RSA (B. Wheeler 2010 pers. comm.). Thinhorn sheep use very specific habitats. They use traditional winter range, lambing areas and seasonal migration corridors. None of the habitats that meet requirements of thinhorn sheep within the RSA are known support populations of sheep.

Mule Deer (*Odocoileus hemionus*)

Mule deer occur in Yukon. Yukon is the northern part of their range, so the number and density of deer in Yukon tends to be low. Deer generally prefer open dry sites such as south facing slopes along rivers and recent burns. As Yukon is the northern part of mule deer range, habitat selection and seasonal habitat use are likely unique compared to southern areas were deer have been extensively studied. The RSA may contain some suitable habitat, but the amount and quality of suitable habitat within the RSA is unknown. No mule deer studies have been completed in Yukon.

Grizzly Bear (*Ursus arctos horribilis*)

Baseline information on grizzly bear abundance and distribution within the RSA is sparse. Grizzly bear density estimates within the Klondike Plateau and Yukon Plateau-Central ecoregions is 11.0 bears per 1000 km^2 and 14.6 bears per 1000 km^2, respectively (Marshall 2010 pers. comm.). Grizzly bears are often observed within the PA and RSA (B. Wheeler 2010 pers. comm.). The species is likely to be widely distributed throughout areas that contain suitable habitat and prey densities in the

region. Five grizzly bears have been harvested from the GMS 526 within the RSA between 1999 and 2008. The north-western population of grizzly bears is not yet listed under SARA, but its status was assessed to be "Special Concern" (COSEWIC 2002b). Based on the general habitat characteristics of this site, it could provide low to moderate suitability forage habitat grizzly bears. Grizzly bears could potential use habitat within the RSA as foraging and/or denning habitat. The quality of the habitat relative to other regions is unknown.

Black Bear (*Ursus americanus*)

There is no baseline information on the abundance and distribution of black bears within the RSA. Black bears are common within the PA and RSA (B. Wheeler 2010 pers. comm.). The species is likely to be widely distributed throughout areas that contain suitable habitat and prey densities in the RSA. Nine black bears were harvested from the GMS (526) that overlaps with the RSA between 1999 to 2008. Based on the general habitat characteristics of this site, it could provide low to moderate suitability forage habitat black bears. Black bears could potential use habitat within the RSA as foraging and/or denning habitat. The quality of the habitat relative to other regions is unknown.

Wolves (*Canus lupus*)

The Government of Yukon conducted a wolf survey of the Nisling River area in March 1986. The survey area included almost all of the RSA, with the Mt. Nansen Mine Site at the centre of the survey area. Another larger survey was conducted in 1988, but since then no wolf surveys have been conducted. Both surveys were conducted using fixed wing aircraft at a coverage rate of about 250 km/hr. Direct and indirect (trails) observations of wolves were used to estimate the number of wolf packs in the study area and the size of each pack.

Wolves were infrequently observed during the 1980s' surveys. The density of wolves was low relative to other Yukon wolf densities. For example, the 1986 survey estimated wolf density for the survey area to be 3.2 wolves/1000km^2, which is very low relative to wolf densities in other areas of Yukon that have densities closer to 10 wolves/1000km^2 (Baer and R D. Hayes 1987).

The low number of wolves in the area was thought to be a result of the limited availability of prey, which was low in the mid 1980s (Baer 2010 pers. comm.). Today, with the increased abundance of moose, wolf numbers are expected to have increased in the area (Baer 2010 pers. comm.). Also, the 2004 LSCFN community-based plan noted that wolf numbers have increased in recent years, therefore YG, LSCFN, and the Carmacks Renewable Resource Council (CRRC) committed to providing wolf-trapping workshops to train local people to snare wolves. The Project Area was suggested as an area to snare wolfs. No individuals contacted during the writing of this report were

able to provide information that this commitment was addressed; however, the fact that no wolves have been trapped in the area during the last 10 years (Table 9.4) suggests that the commitment was not followed through.

Red Fox (*Vulpes vulpes*)

Red foxes use diverse habitats. They are common in forested and alpine ecosystems. Their occurrence in an area is often limited more by interspecific competition, as they are unable to compete for habitat with coyotes, and by availability of food (*i.e.*, small mammals). Foxes easily habituate to human activity and in some cases may thrive in disturbed areas because other larger carnivores are less likely to be present.

Wolverine (*Gulo gulo*)

Wolverines are known to occur in alpine and sub-alpine habitats through the RSA and occasionally occur in the PA. Wolverine abundance is limited by availability of carrion left by wolves. Trapping records indicate that wolverines are present in the area.

Lynx (*Lynx canadensis*)

Lynx abundance is directly dependent on snowshoe hare abundance. When the density of hares increases, then number of lynx in an area increases at a one to two year time-lag. They occupy forest habitats that offer cover, camouflage and prey. Trapping records indicate that lynx occur in the area. Their abundance in the RSA and PA will increase and decrease with snowshoe hare abundance.

Snowshoe Hare (*Lepus americanus*)

Snowshoe hare abundance and distribution is directly related to intraspecific competition (*i.e.*, density of snowshoe hares) and predator abundance. Hare select boreal forest habitat that provide suitable forage. They will be abundant in the PA and RSA during peaks in their population cycle, but will be almost absent during population lows.

Rodents

Porcupines (*Erethizon dorsatum*) were identified as one of the most important harvested species by the LSCFN members, behind moose and caribou (EDI 2007 appendix B). Porcupines are observed frequently within the PA and RSA, most often on or near roads within the RSA (B. Wheeler 2010 pers. comm.). However, distribution and relative abundance of porcupine is unknown in the area.

Arctic ground squirrels (*Spermophilus parryii*) occur throughout Yukon and are likely common in the RSA. Hoary marmots (*Marmota caligata*), sometimes referred to as "whistlers," occur in open sub-alpine and alpine areas throughout Yukon. Both species emerge from their dens in early summer to mate, give birth and gain weight. They spend most of the summer feeding and gaining weight so that they are able to survive the following hibernation. Ground squirrels are common throughout open habitats in Yukon. Ground squirrels have been observed and captured in the Project Area (EDI 2007). Some squirrels are harvested for food, but hunting pressure is very low to negligible (EDI 2007 appendix B). Marmots have also been harvested within the Mt. Nansen RSA (EDI 2007 appendix B), but the extent of the harvest is also very limited.

Small Mammals

Small mammals captured directly at the mine site include the red-backed vole (*Clethrionomys glareolus*) and masked shrew (*Sorex cinareus*) (EDI 2007). Based on the broad scale distribution of other small mammals, there are probably other species present within the RSA; for example, other species of shrews and voles, lemmings, collared pika and mice (CESCC 2006).

Amphibians

The wood frog (*Lithobates sylvaticus*) is the only amphibian whose range likely extends into the RSA. All other amphibians only occur in the most southern parts of Yukon. Wood frogs are abundant across much of North America. The closest record of a wood frog is near Carmacks (Slough 2009).

9.2.1 Trapping

Trapping has provided a source of revenue for some Yukon residents during the last century. Trapping data provides a good indication of the occurrence of animal species in an area; however, it will not provide an indication of abundance or even current occurrence because of the recent decrease in trapping effort. Trapping effort has decreased because the demand for fur has dropped

and trapping has become a less lucrative industry. For example, wolves have not been trapped in the area since 1999 (Table 9.4), but the local people have noted an increase in wolf numbers during the same period (Little Salmon Carmacks Fish and Wildlife Planning Team 2004). Environment Yukon provided grouped trapping data for Registered Trapping Concessions (RTCs) 147, 148, 149, 150, 154, 155, 195, 196, 197, and 198 (Kuhn 2010 unpublished data) — Environment Yukon does not release fur harvest data by trapping concession.

Table 9.4: Summary of trapping data from RTCs 147, 148, 149, 150, 154, 155, 195, 196, 197, and 198, 1999 to 2008. We also included the sum of all trapping records from 1980 to 2008.

	Year										Total	29 Year Total
	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999		
Beaver		37	22	2		3	10	20	1	15	110	358
Coyote											0	29
Red Fox						1					1	180
Lynx	4	6	4		9	1	2		7	1	34	686
Marten	4		2		8	1		5	17	1	38	169
Mink									2		2	40
Muskrat											0	272
Otter			1								1	3
Red Squirrel		14			17				18		49	5,480
Weasel											0	93
Wolf											0	40
Wolverine	5	2			2	8			10	1	28	109

9.2.2 Harvest

The Project Area is within an important hunting area for licenced and First Nation harvesters. The area is easily accessible because of the access road and abundance of trails throughout the area. The major targets of harvesters in the area are moose, caribou and bison. The RSA is solely within the Game Management Subzone (GMS) 526 (Figure 9.1); however, the Mt. Nansen Road provides harvesters easier access to other nearby GMSs increasing harvest in those subzones.

Table 9.5: Summary of large game harvest for Yukon GMSs 524, 525, 526, 542 and 543 — 1999–2008 for moose, wolf, grizzly bear, and black bear, and 1999–2009 for caribou and bison. Grey column indicates the GMS within the RSA.

	GMS 524	GMS 525	GMS 526	GMS 542	GMS 543
Moose	1	22	2	10	36
Caribou	1	4	33	15	0
Bison	0	15	3	193	31
Wolf	1	1	1	2	3
Black Bear	6	0	9	2	2
Grizzly Bear	1	4	5	3	3
Total	12	46	55	229	75

9.3 At Risk and Conservation Concern Wildlife

As discussed earlier, COSEWIC is tasked with assessing the conservation status of species that may be at risk of extirpation in Canada. Currently, one ‘Endangered’ species, six ‘Threatened’ species and ten species of ‘Special Concern’ occur either permanently or seasonally within Yukon. The presence, absence or likelihood of these species occurring within the RSA is summarized in Table 9.6.

The SARA listed species within the RSA, as described in the above sections, are woodland caribou, wood bison, wolverine, and grizzly bear. Species that seasonally use habitat within the RSA may include the Olive-sided Flycatcher, Common Nighthawk, Horned Grebe, Rusty Blackbird and Short-eared Owl.

Table 9.6: Summary of the conservation status of wildlife within Yukon. The conservation status was determined by COSEWIC and CESCC assessments.

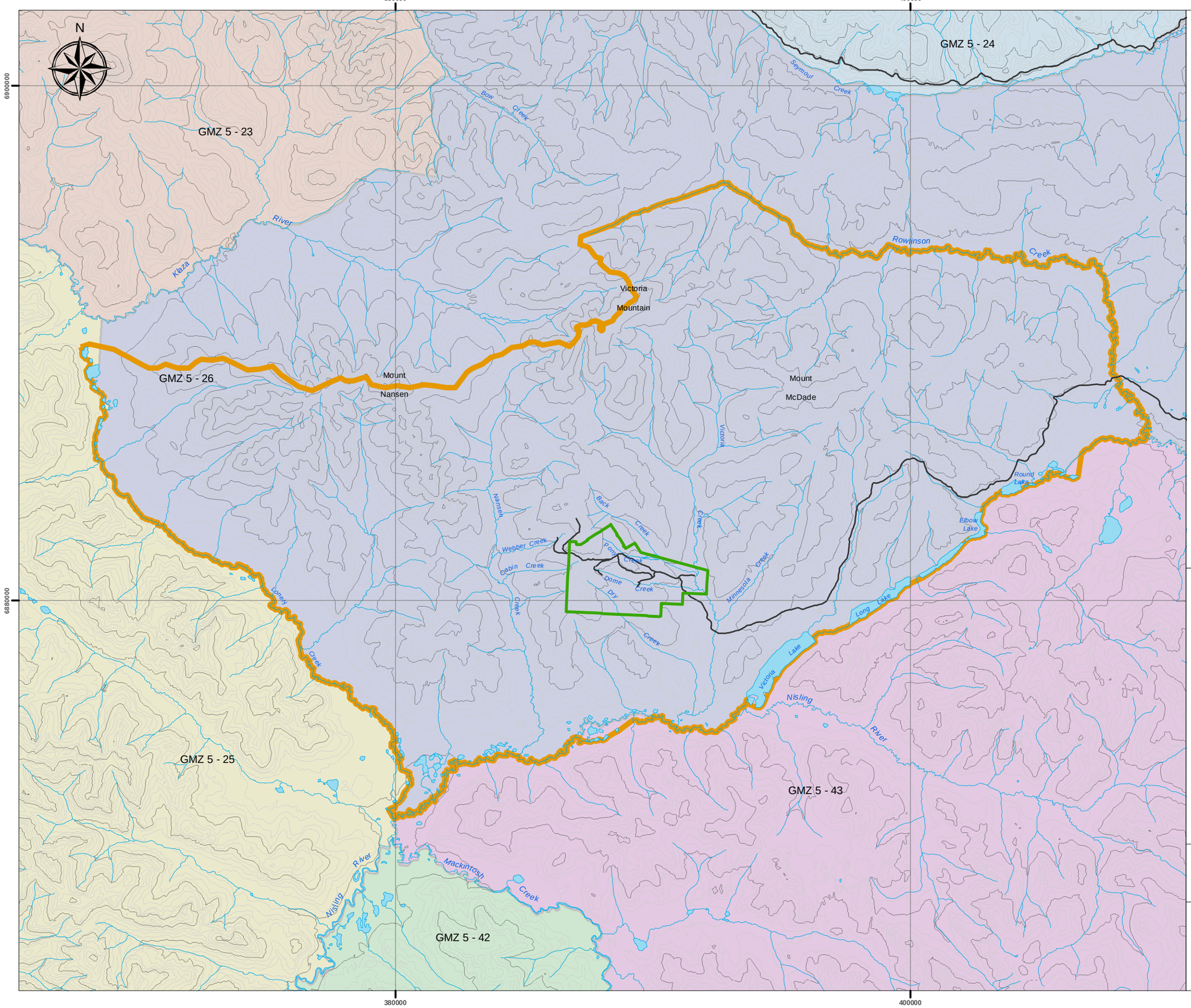
Species	Presence within RSA	COSEWIC	General Status
Birds			
Eskimo Curlew	No	Endangered (2009)	Not Present (2005)
Olive-sided flycatcher	Documented	Threatened (2007)	Sensitive (2005)
Red Knot roselaari type	No	Threatened (2007)	Accidental (2005)
Common Nighthawk	Documented	Threatened (2007)	Secure (2005)
Canada Warbler	No	Threatened (2008)	At risk (2005)
Horned Grebe	Observed	Special Concern (2009)	Secure (2005)
Rusty Blackbird	Possible	Special Concern (2006)	Sensitive (2005)
Peregrine Falcon	Possible	Special Concern (2007)	Sensitive (2005)
Short-eared Owl	Observed	Special Concern (2008)	Sensitive (2005)
Mammals			
Northern mountain woodland caribou	Observed	Special Concern (2002)	Sensitive (2005)
Wood bison	Observed	Threatened (2000)	At risk (2005)
Mountain Goat	No	NA	Sensitive (2005)
Muskox	No	NA	May be at risk (2005)
Mule Deer	Observed	NA	Sensitive (2005)
White-tailed Deer	Observed	NA	May be at risk (2005)
Grizzly bear	Observed	Special Concern (2002)	Sensitive (2005)
Polar Bear	No	Special Concern (2008)	May be at risk (2005)
Wolverine	Observed	Special Concern (2003)	Sensitive (2005)
Arctic Fox	No	NA	Sensitive (2005)
Fisher	Possible	NA	May be at risk (2005)
Woodchuck	Possible	NA	May be at risk (2005)
Long-eared myotis (bat)	No	NA	May be at risk (2005)
Barrenground Shrew	No	NA	Sensitive (2005)
Southern Red Backed Vole	No	NA	May be at risk (2005)
Northern Collared Lemming	No	NA	Sensitive (2005)
Western Jumping Mouse	Possible	NA	May be at risk (2005)
Amphibians			
Western Toad	No	Special Concern (2002)	Secure (2005)
Fishes			
Bering Cisco	No	Special Concern (2004)	Undetermined (2005)
Squanga Whitefish	No	Special Concern (1987)	N/A

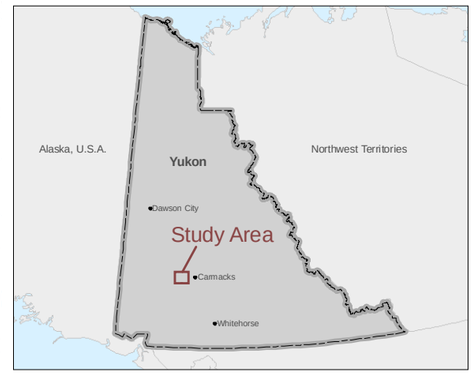
9.4 Regional Wildlife Management Plans

The Project Area falls within the Traditional Territory of the LSCFN. Within the LSCFN Traditional Territory the CRRC provides the Carmacks community a consolidated voice that gives input into fish, wildlife and forest management. The CRRC is made up of six council members, three members nominated by the LSCFN and three nominated by the Government of Yukon. The council's mandate is to provide input into management decisions related to fish, wildlife and their habitat as outlined in Chapter 16 of the Little Salmon/Carmacks First Nation Final Agreement. The Council also provides local input in the management of forest resources as outlined in Chapter 17 of the Final Agreement.

A five year community-based fish and wildlife management plan (2004–2009) was developed through cooperation between the LSCFN, the CRRC, and the Government of Yukon. The Plan addresses community concerns about various fish and wildlife (bears, bison, caribou, elk, fish, moose and sheep) in addition to other issues such as habitat, recreation, trapping, access, enforcement and public information. Solutions for each concern were discussed, and commitments and timelines were set by each partner.

The key issues identified in the Plan for the Mt. Nansen area were bison herd management, disturbance to caribou and moose, moose harvest, and winter road access (Little Salmon Carmacks Fish and Wildlife Planning Team 2004). Moose harvest in the area has been closed to licensed hunters since 1988 and populations were considered low at the time of community consultations, while the KCH which uses the area year round was perceived to be increasing. Year-round access provided by the Mt. Nansen Road has been associated with increased traffic and disturbance to wildlife populations. Much of the increased traffic has been attributed to the winter bison harvest. A wood bison management plan is still in the development stages by Yukon Wood Bison Technical Team.





Project Study Areas

- Project Area-OIC Reserve
- Regional Study Area

Topographic Features

- Road
- Major Contour
- Minor Contour
- Watercourse
- Waterbody

Game Management Zones

- 5-23
- 5-24
- 5-25
- 5-26
- 5-42
- 5-43

Drawn By: M. Power
Checked By: M. Setterington
Date: 26 March 2010

Projection: NAD 1983 UTM Zone 8
EDI Project #: 10-YC-0003

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Game Management Zones provided courtesy of Yukon Government Geomatics Yukon – Information and Communication Technologies Division, Dept. of Highways and Public Works.

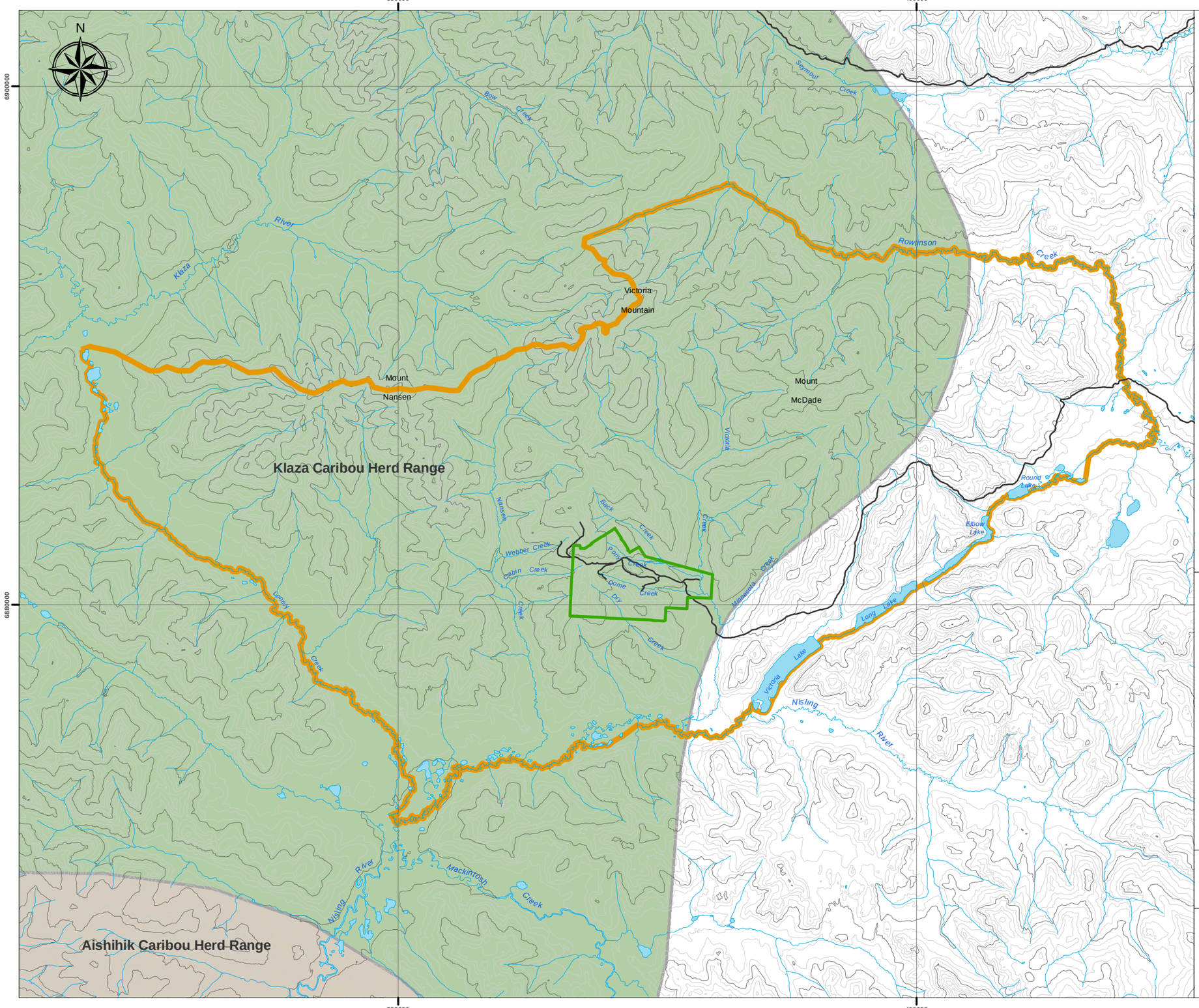
This document is not an official land survey and the spatial data presented on the map is subject to change without any notice.

0 2 4 6 8 10
Kilometres

Figure 9.1: Game Management Sub-zones (GMZs) in the Mt. Nansen Regional Study Area.

Prepared for:
Yukon
Energy, Mines and Resouces

Prepared by:
EDI
ENVIRONMENTAL DYNAMICS INC.





Project Study Areas

- Project Area-OIC Reserve
- Regional Study Area

Caribou Herd Ranges

- Aishihik Caribou Herd
- Klaza Caribou Herd

Topographic Features

- Road
- Major Contour
- Minor Contour
- Watercourse
- Waterbody

Drawn By: M. Power
Checked By: M. Setterington
Date: 26 March 2010

Projection: NAD 1983 UTM Zone 8
EDI Project #: 10-YC-0003

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0 2 4 6 8 10
Kilometres

Figure 9.2: Known Caribou Herd Ranges in the vicinity of the Mt. Nansen RSA.

Prepared for: Yukon Energy, Mines and Resouces

Prepared by: EDI Environmental Dynamics Inc.

380000

400000

6900000

6880000

N

WKA #868
Moose
late winter (Feb-Apr)range

WKA #1340
Gyrfalcon
summer (Jun-Aug)reproduction (birth, nest)

WKA #366
Woodland Caribou
fall (Aug-Oct)breed (court, rut)
Klaza Caribou Herd

WKA #1556
Woodland Caribou
winter (Oct-Apr)range
Klaza Caribou Herd

WKA #2528
Woodland Caribou
winter (Oct-Apr)range
Aishihik Caribou Herd

WKA #2529
Woodland Caribou
winter (Oct-Apr)range
Aishihik Caribou Herd

WKA #2880
Bison
year roundall functions

WKA #2530
Woodland Caribou
winter (Oct-Apr)range
Aishihik Caribou Herd

WKA #2527
Woodland Caribou
winter (Oct-Apr)range
Aishihik Caribou Herd

WKA #2526
Woodland Caribou
winter (Oct-Apr)range
Aishihik Caribou Herd

WKA #2881
Bison
winter (Oct-Apr)range

WKA #775
Moose
late winter (Feb-Apr)range

WKA #2532
Woodland Caribou
winter (Oct-Apr)range
Aishihik Caribou Herd

WKA #2544
Woodland Caribou
winter (Oct-Apr)range
Aishihik Caribou Herd

WKA #2545
Woodland Caribou
winter (Oct-Apr)range
Aishihik Caribou Herd

Saprout Creek
Bow Creek
Klaza River
Rowinson Creek
Victoria Mountain
Mount Nansen
Mount McDade
Nansen River
Webber Creek
Cabin Creek
Dome Creek
Dry Creek
Minesota Creek
Long Lake
Victoria Lake
Nisling River
Mackintosh Creek
Round Lake
Elbow Lake



Project Study Areas
- Project Area-OIC Reserve
- Regional Study Area

Wildlife Key Areas
- Bison,
- Gyrfalcon,
- Moose,
- Woodland Caribou, Aishihik Caribou Herd
- Woodland Caribou, Klaza Caribou Herd

Topographic Features
- Road
- Major Contour
- Minor Contour
- Watercourse
- Waterbody

Drawn By: M. Power
Checked By: M. Setterington
Date: 26 March 2010

Projection: NAD 1983 UTM Zone 8
EDI Project #: 10-YC-0003

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Study/drainage areas were digitized by EDI using specific parameters such as, height of land and relevant drainage courses (1:50,000 Canvec).

Wildlife Key Areas provided by Yukon Department of Environment (May 31, 2007) Yukon Wildlife Key Area Inventory Digital database and software produced by Habitat and Regional Management Section, Fish and Wildlife Branch, Department of Environment Government of Yukon, Whitehorse., WKA.

This document is not an official land survey and the spatial data presented on the

0 2 4 6 8 10
Kilometres

Figure 9.3:
Key Wildlife Areas in the Mt. Nansen RSA.

Prepared for:
Yukon
Energy, Mines and Resouces

Prepared by:
EDI
ENVIRONMENTAL DYNAMICS INC.

10 Water Resources

10.1 Hydrology

The Mt. Nansen project area lies within the Nisling River drainage basin, approximately 60 km to the west of the village of Carmacks. The Nisling River drainage flows into the White River, which in turn empties into the Yukon River drainage basin and ultimately the Bering Sea. There are four main watercourses flowing through the Mt. Nansen mine site: Pony, Back, Dome, and Victoria creeks (Figure 10.1).

Hydrology and water quality data collected by government agencies at various sites within the general region have been used to aid in the interpretation of site specific data and to provide a foundation upon which to make comparisons.

Pony Creek

Pony Creek is a small, ephemeral stream that flows southeast past the north end of the mine pit. Its drainage basin encompasses an area of 167 ha. There are a number of locations along the length of the creek where surface flow infiltrates into the ground, only to discharge again to surface some distance downstream. Its original channel was affected by the construction of an access road with culvert, the deposition of waste rock piles onto the stream channel during active mining and the presence of earth berms in the upper reaches, which caused the watercourse channel to pool and meander in some places. It is suspected that the Pony Creek drainage is one source of seepage into the mine pit lake via the north wall. Pony Creek empties into Back Creek near the south east corner of the mine site.

Back Creek

Back Creek originates to the north of the Mt. Nansen mine site; the Back Creek drainage basin has an area of 952 ha. It flows southeast to the eastern edge of the mine site where it flows into Victoria Creek just upstream of the artesian well water source. Back Creek is heavily affected by past and ongoing placer mining operations located approximately 5 km upstream of the Mt. Nansen site. These operations release both sediment and water to Back Creek, drastically increasing the sediment load in the watercourse, which leads to changes in channel shape as the sediment settles to substrate. Discharge from the placer operation also sharply increases the flow in Back Creek for short periods of time.

Dome Creek and Diversion Channel

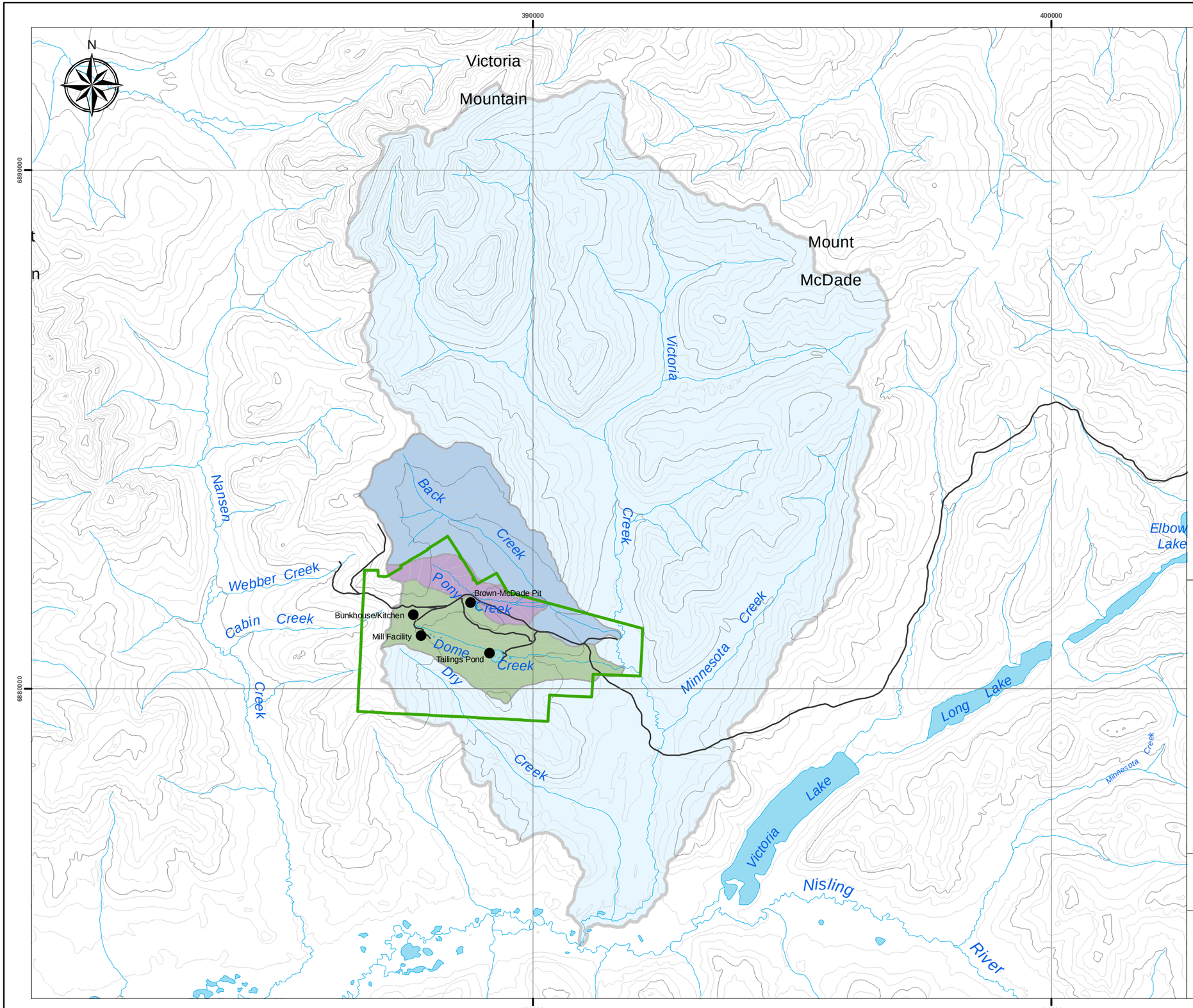
Dome Creek is a small watercourse that originates above the existing mill site and flows southeast past the mill; its total drainage area is 483 ha. Above the tailings pond Dome Creek was re-routed into a diversion channel constructed during mine operations to prevent upstream flow from entering the tailings pond. It is diverted east and south past the tailings facilities and re-enters the original Dome Creek channel approximately 200 m below the tailings dam. Dome Creek continues flowing southeast below the tailings dam, crosses the mine access road via a culvert and ultimately empties into Victoria Creek.

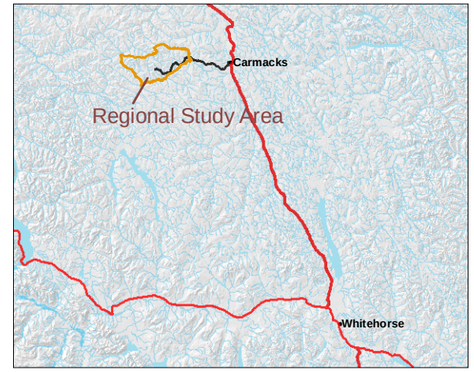
The diversion channel is a man-made construction that moves water from the upper Dome Creek drainage around the mine tailings and tailings pond and returning it to Dome Creek downstream of the tailings dam. This channel also conveys most of the runoff from both sides of the Dome Creek valley, in addition to water flowing in the creek itself.

Victoria Creek

Victoria Creek is the largest watercourse flowing through the Mt. Nansen site. It originates in a region with considerable relief north of the Mt. Nansen mine site and flows south along its eastern border. The Victoria Creek drainage basin has an area of 11,097 ha. All surface watercourses flowing through the Mt. Nansen site ultimately empty into Victoria Creek which flows into the Nisling River, approximately 5 km south of the Mt. Nansen footprint.

There is an area of considerable groundwater discharge beside Victoria Creek just east of the mine site; an artesian well located here provides water for all uses, including drinking, for the site. Near this well Victoria Creek remains open (ice-free) year-round, indicating considerable inputs to the stream from groundwater are likely. Winter flow may be composed largely of groundwater, with less flow attributed to surface water.





Project Study Areas

Project Area-OIC Reserve

Sub-basin Drainages

Victoria Creek Drainage
Back Creek
Dome Creek
Pony Creek

Topographic Features

Road
Major Contour
Minor Contour
Watercourse
Waterbody
Tailings/Containment Pond

Drawn By: M. Power
Checked By: M. Setterington
Date: 23 March 2010

Projection: NAD 1983 UTM Zone 8
EDI Project #: 10-YC-0003

1:50,000 Topographic Spatial Data: Canvec and National Topographic Database (NTDB). Used under license courtesy of Her Majesty the Queen in Right of Canada, Department of Natural Resources. All Rights Reserved.

Study/drainage areas were digitized by EDI using specific parameters such as, height of land and relevant drainage courses (1:50,000 Canvec).

Water quality sampling sites (EDI).

This document is not an official land survey and the spatial data presented on the map is subject to change without any notice.

0 1,000 2,000 3,000 4,000
Metres

Figure 10.1: Drainage Systems associated with the Mt. Nansen Mine Site.

Prepared for: Yukon

Prepared by: EDI Environmental Dynamics Inc.

10.1.1 Surface Water Discharge

Hydrology data for the Mt. Nansen site is limited to that collected during the open water season of 2009. Data collection included gauging of all on site watercourses a total of six times over the open water season. The following flow estimations are based on the draft hydrographs derived from the 2009 data (AECOM 2010). The flows measured to date may overestimate flows during spring freshet due to the higher than average snowpack seen in the winter of 2008 and underestimate flows throughout the rest of the season those because during June and July 2009 the Mt. Nansen site received below-average precipitation. The Mt. Nansen site receives considerable snowfall through the winter season; therefore, peak flows in all on site watercourses occur during snowmelt, generally in late April/early May of each year.

Pony Creek

Pony Creek is a small ephemeral stream. Discharge measured at the road culvert, shows that the stream experienced high flows during spring melt, as well as in late summer (*i.e.* September), when it responded very quickly to precipitation events (Table 10.1, and hydrographs presented in AECOM, in prep).

Back Creek

Back Creek is another small watercourse on site (Table 10.2). It is generally one of the first watercourses flowing through the Mt. Nansen site to freeze to substrate; in both 2008 and 2009 Back Creek just upstream of the confluence with Victoria Creek was frozen to substrate by middle to late October and remained frozen until early May. Therefore, open water flow is measurable only for six months of each year. The highest flows in Back Creek were noted in late May, and coincided with spring melt. Low precipitation through June and July lead to low flow; however, increased precipitation in August did little to increase the flows in Back Creek.

Dome Creek

Despite having a drainage basin approximately half that of Back Creek, Dome Creek has slightly greater surface discharge than both Pony and Back creeks (Table 10.3), and contains flowing water below ice for approximately one month longer than Pony and Back creeks. The accumulation of large amounts of overflow ice in the Dome Creek valley is an indication that while the watercourse freezes to substrate through the winter season, groundwater inputs continue. Also, at the road

crossing this accumulation of overflow ice often leads to ice blockage of the culvert and subsequent build up on the road. The highest flows in Dome Creek occurred at the end of May, which coincides to snow and ice melt in the lower Dome Creek valley. High flows also occur in mid to late June, corresponding to the melting of large amounts of overflow ice which accumulate in the Dome Creek valley below the tailings dam where the diversion channel re-enters the original Dome Creek channel. Dome Creek appeared to respond rapidly to rainfall events in early fall.

Victoria Creek

Victoria Creek is the largest watercourse on the Mt. Nansen site (Table 10.4). Pony, Back and Dome creeks all flow into Victoria Creek. Peak flows in Victoria Creek were seen in late May, corresponding with ice and snowmelt of the surrounding valley. Midsummer flows were lowest, and corresponded to a period with little to no precipitation. Increased precipitation in the fall had only a small effect on the flow in Victoria Creek, indicating that the majority of flow in the creek is composed of inflow from tributary streams combined with groundwater discharge. Some reaches of Victoria Creek freeze to substrate through the winter season, including the areas at the road crossing culvert. However, further upstream of the crossing site, near the location of the artesian well flowing water is present year-round, and is likely fed by groundwater inputs over the winter months.

Table 10.1: Estimated flow parameters in Pony Creek. Values estimated from hydrographs created from 2009 discharge data[a].

	Estimated surface discharges in Pony Creek (cms)			
Peak Flow	0.14			
Minimum Flow	0.00			
Seasonal Flow	Spring: 0.05	Summer: 0.02	Fall: 0.05	Winter: NA[b]
Mean Annual Flow	0.02			

Notes: [a] Preliminary estimates based on data from 2009.
[b] Flow was too low to be measured and/or stream was frozen to substrate.

Table 10.2: Estimated flow parameters in Back Creek. Values estimated from hydrographs created from 2009 discharge data[a].

	Estimated surface discharges in Back Creek (cms)			
Peak Flow	0.18			
Minimum Flow	0.01			
Seasonal Flow	Spring: 0.10	Summer: 0.02	Fall: 0.03	Winter: NA[b]
Mean Annual Flow	0.01			

Notes: [a] Preliminary estimates based on data from 2009. These numbers were only estimates based on the flow hydrographs developed by AECOM (2010) using one year's worth of data (and it was a very dry open water season). They should be re-visited next year.
[b] Flow was too low to be measured and/or stream was frozen to substrate.

Table 10.3: Estimated flow parameters in Dome Creek. Values estimated from hydrographs created from 2009 discharge data[a].

	Estimated surface discharges in Dome Creek (cms)			
Peak Flow	0.18			
Minimum Flow	0.01			
Seasonal Flow	Spring: 0.12	Summer: 0.02	Fall: 0.06	Winter: NA[b]
Mean Annual Flow	0.02			

Notes: [a] Preliminary estimates based on data from 2009.
[b] Flow was too low to be measured and/or stream was frozen to substrate.

Table 10.4: Estimated flow parameters in Victoria Creek. Values estimated from hydrographs created from 2009 discharge data [a].

	Estimated surface discharges in Victoria Creek (cms)			
Peak Flow	6.00			
Minimum Flow	0.05			
Seasonal Flow	Spring: 2.50	Summer: 0.10	Fall: 0.20	Winter: 0.10
Mean Annual Flow	0.40			

Notes: [a] Preliminary estimates based on data from 2009.

10.1.2 Surface/Groundwater Contributions and Associated Project Changes

There is significant interaction between surface and groundwater at the Mt. Nansen mine site. Pony Creek repeatedly infiltrates to ground and re-emerges at surface. Dome Creek is partially fed by groundwater in the upper reaches of the Dome Creek valley as it moves beneath the tailings pond and dam. Also, groundwater seeping below the pit lake flows mainly into the Dome Creek drainage. Finally, Victoria Creek is also partially fed by groundwater due to the presence of a groundwater discharge area near the confluence of Victoria and Back Creeks.

10.2 Water Quality

The Mt. Nansen site is drained by three small streams, Pony, Dome and Back creeks; water from all three streams ultimately flows into Victoria Creek, a tributary of the Nisling River. The Nisling River is a medium-sized stream within the Donjek/White Rivers drainage basin. The primary drainage is Dome Creek which flows from above the mill site, past the tailings facilities into Victoria Creek. Pony Creek drains a small portion of the mine site north of the Brown-McDade Pit and empties into Back Creek shortly before the confluence with Victoria Creek. In addition to the watercourses flowing through the site, there are other loading sources on site: the pit lake, the tailings pond and its associated seepage pond, which contains water that has seeped through the tailings dam. Also, surface runoff from both the waste rock stores and from the mill site can act as loading sources. There are a total of fourteen sampling locations at the Mt. Nansen site (Table 10.5, Figure 10.5).

10.2.1 Study Methods

An ongoing water quality sampling program began on site in 1999. A number of sites were added in intervening years to address gaps in the program (Table 10.5). Therefore, extensive water quality data is available for the Mt. Nansen site. More than one season of data is available for all sampling locations on site. Water samples were analyzed for a number of parameters including routines (*e.g.*, pH, conductivity, anions and cations, particulates), nutrients, cyanides, and total and dissolved metals.

For the purpose of interpretation the data were organized by season, and median values for each site and season were calculated (Appendix 1). A median was chosen rather than an arithmetic mean because water quality results tend to be non-normally distributed; therefore a median is a more accurate estimator of central tendency. For the organization of data into different seasons the winter is considered the under-ice season and includes November through April data. Most steams on site are small and freeze to substrate in early winter; therefore, winter data for watercourses generally does not include data from January through March or April. Spring is designed to capture melt water inputs into the watercourses and waterbodies on site, and includes May and June. Summer is generally characterized by low precipitation and higher evaporation, and includes July and August, and finally fall months generally have higher precipitation (both rain and snowfall), and includes September and October.

Data for the metals arsenic, cadmium, copper, lead and silver were analyzed from 2004 through 2007 with analytical detection limits that exceeded the Canadian Council of Ministers of the Environment (CCME) objectives. As the analytical method was not sensitive enough to detect the CCME

standard, the vast majority of this data was found to be below detection, and consequently above CCME guidelines. Therefore data for these metals from 2004 to 2007 was removed for the purposes of analysis. All other data were included in the interpretation, noting that not all sampling sites were included in the program at the same time, so some variation in data collection is present.

Once medians were calculated these values were compared to two sets of water quality guidelines and standards (Table 10.6). The first set of guidelines is the CCME water quality objectives for the protection of aquatic life (freshwater) (CCME 2007). The second set are the effluent quality standards associated with water licence QZ94-004, issued by Yukon Water Board to BYG Natural Resources Inc for the Mt. Nansen mine site (Yukon Territorial Water Board 1996).

Table 10.5: Water Quality Sampling Locations and Site Descriptions and Rationales in the Mt. Nansen Project Area.

Sampling Location and Identifier		Site Descriptions and Rationales	Sampling Schedule
Victoria and Back creeks			
Victoria Creek Reference	V1	Located on Victoria Creek ~500 m upstream of the upper Victoria site. The site was added when it was determined that some effects from Back Creek were seen in samples from the upper Victoria site.	2007 – 2008, spring, summer, fall. 2009 – current, bi-weekly
Upper Victoria Creek	V2	Located on Victoria Creek upstream of where Back Creek flows into Victoria Creek. It is intended to represent Victoria Creek before it receives inputs from Dome and Back creeks.	2005 – current, bi-weekly
Victoria Creek at Road	V3	Located on Victoria Creek where it crosses the mine access road. It is intended to document the water quality at a location downstream of the mine site.	1999 – 2005, minimum monthly, 2005 – current, bi-weekly
Back Creek	BC	Located on Back Creek above the confluence with Victoria Creek. Back Creek is often affected by placer mining activities and this sampling location is intended to identify any potential effects from these activities.	2008 - current, bi-weekly
Pony Creek			
Pony Creek Upstream	P1	Located upstream of all mining effects.	2008 - current, bi-weekly
Pony Creek Downstream	P2	Located on Pony Creek downstream of where the waste rock was historically piled.	2008 - current, bi-weekly

Sampling Location and Identifier		Site Descriptions and Rationales	Sampling Schedule
Dome Creek			
Dome Creek	DX	Located upstream of all mining activities, and represents background water quality in Dome Creek. Drainage is very small and consists of shallow flow over fines and organics.	2007 - current, bi-weekly
Dome Creek	D1	Located on Dome Creek downstream of the mill site. It is intended to quantify effects to water quality due to the mill.	2007 - current, bi-weekly
Upper Dome Creek	D2	Located on Dome Creek downstream of the seepage pond/discharge site ~ 25 m downstream of the tailings diversion. It aids in identification of any changes to water quality due to inputs from the tailings facilities, waste rock area, mill site, and potentially ground water from the pit.	2005 - current, bi-weekly
Dome Creek at Road	D3	Located on Dome Creek as it crosses the mine access road. This site defines water quality in Dome Creek as it flows into Victoria Creek. Data from this site aids in quantifying the dilution and potential attenuation between the Upper Dome Creek site and the waters discharging to Victoria Creek.	1999 – 2005, minimum monthly, 2005 – current, bi-weekly
Reference Site			
Dry Creek	DC	Located on the other side of the ridge from the mine site and was selected to act as a reference location.	2007 - current; spring, summer, fall
Mine Loading Sources			
Brown - McDade Pit	P	Sampled at the deepest part of the excavation. Samples are collected at surface, middle and bottom of the water column.	2005 - current, monthly
Tailings Pond	TP	Pond holds tailings and water affected by mining and milling activities.	1999 – 2005, minimum monthly, 2005 – current, bi-weekly
Seepage Pond	SP	Samples are collected from the end of discharge/pump pipe.	1999 – 2005, minimum monthly, 2005 – current, bi-weekly

Table 10.6: Water quality guidelines applied to data collected from Mt. Nansen site.

Sample Parameters	Units	CCME AL Guidelines [a]	Effluent Quality Standards [b]
pH	pH units	6.5 – 9.0	6.0 – 8.5
Total Dissolved Solids	mg/L	—	50
Ammonia-N	mg/L	0.832[a]	—
Nitrate-N	mg/L	2.9	—
Nitrite-N	mg/L	0.06	—
Total Aluminum	mg/L	0.1	—
Total Antimony	mg/L	—	0.15
Total Arsenic	mg/L	0.005	—
Total Barium	mg/L	—	1
Total Cadmium	mg/L	0.000017	0.02
Total Chromium	mg/L	0.0089	0.04
Total Cobalt	mg/L	—	—
Total Copper	mg/L	0.002 –0.004	0.2
Total Iron	mg/L	0.3	1
Total Lead	mg/L	0.001 – 0.007	0.1
Total Manganese	mg/L	—	0.5
Total Molybdenum	mg/L	0.073	—
Total Nickel	mg/L	0.025 – 0.15	0.3
Total Selenium	mg/L	0.001	—
Total Silver	mg/L	0.0001	0.1
Total Thallium	mg/L	0.0008	—
Total Zinc	mg/L	0.03	0.3
Arsenic, Dissolved	mg/L	—	0.15

Notes: [a] CCME guidelines for the protection of freshwater aquatic life (AL) (CCME 2007).
[b] Effluent quality standards associated with water licence QZ94-004, issued by Yukon Territory Water Board to BYG Natural Resources Inc. (Yukon Territorial Water Board 1996).

10.2.2 Current Site Conditions

Watercourses

Routine parameters among the watercourses share many characteristics. The pH was generally slightly alkaline, varying only slightly around 8.0. Pony Creek was an exception; both sampling locations had a more neutral pH which centered on 7.0. The majority of samples fell within CCME objectives (6.5–9.0; CCME 2007).

Water on site was generally moderately alkaline, and therefore well buffered against acidification. Alkalinity generally followed a distinct seasonal trend with the lowest values during high water in May and the highest values during midsummer when water levels are lower. The one exception was

Pony Creek where the alkalinity was lower than measured in other watercourses in the area. Median alkalinity concentrations were 47 and 44 mg/L in the upstream and downstream site, respectively. These values categorize the watercourse as having low alkalinity; low values are generally associated with sandy or highly-leached soils.

Electrical conductivity (EC) varied widely across the Mt. Nansen site. Conductivity was low in most sampling sites. Conductivity was higher in Back Creek than seen in nearby Victoria Creek, likely due to sediment and water releases from upstream placer mining activities. Electrical conductivity in Dome Creek was affected by the mill site, as EC at the DX site was approximately 450 µS/cm and doubled to 1050 µS/cm below the mill site at D1. Further downstream in Upper Dome Creek (D2), the EC varied seasonally from 500 to 1000 µS/cm in summer months, to greater than 1000 µS/cm in winter months when the creek was not frozen to substrate. Higher EC values in winter are common when the majority of water forms ice and ions are concentrated in a significantly lower quantity of water (ice freeze-out). It is also likely that in winter, water at the D2 site is made up largely of seepage discharge, with little dilution from upstream D1 and DX sites which are frozen.

In general, watercourses flowing through the Mt. Nansen site can be categorized as moderately hard; having a hardness concentration ranging from 50 to 150 mg/L (Boyd 2000). Hardness on site also followed seasonal patterns, increasing in the winter and decreasing in the spring and summer months when dilution becomes a factor. In Back Creek, hardness concentrations varied considerably, likely because it is heavily affected by placer mining, and hardness, generally increased with increasing Total Suspended Solids (TSS; during times of placer mine discharge). Dome Creek had the hardest water of the watercourses on site, and could generally be characterized as ‘hard’ > 300 mg/L (Boyd 2000). Above the mill (DX) the median hardness was 251 mg/L. This concentration sharply increased to 684 mg/L downstream of the mill (D1) and 578 mg/L downstream of the tailings facilities, and by the downstream road crossing (D3) it had again fallen to a median concentration of 457 mg/L.

Water in Victoria Creek is very clear with low concentrations of TSS and total dissolved solids (TDS). Concentrations increase when spring melt causes erosion into the watercourse, but quickly return to normal and remain clear for the remainder of the year. Pony Creek also follows this trend. Dome Creek is slightly more turbid — the TSS concentration is low but there are higher concentrations of TDS. Again, higher concentrations are seen in the spring due to snowmelt and subsequent runoff; however, at other times of the year it is visually more turbid than other watercourses on site. Back Creek is heavily influenced by upstream placer mining, and TSS increases dramatically for short periods when there are discharges from placer activities. The TDS effluent standard is 50 mg/L, and most TDS concentrations from all samplings sites exceed this value year round.

Most of the watercourses within the Mt. Nansen Project Area are clear water and are low nutrient systems. This holds true for Victoria, Back and Pony creeks where concentrations of ammonia, nitrate, nitrite and total phosphorus were all low to undetectable. Nutrient concentrations were also

low in Dome Creek at the D1 and DX sampling sites. However, nutrient concentrations were higher in Dome Creek downstream of the tailings facilities (D2 and D3). A number of samples at the D2 sampling site had ammonia concentrations that exceeded the CCME guideline for protection of freshwater aquatic life (0.832 mg/L at pH 8, and water temperature of 10°C). Most of the ammonia is a by-product of the decomposition of thiocyanate in the tailings. These high concentrations were generally seen in winter months, possibly because nitrification (ammonia breakdown to nitrites and ultimately nitrates) happens more slowly in cold water under ice. Some nitrite concentrations at the Upper Dome site were also elevated. Water samples from the D3 sampling site also had nutrient concentrations higher than D1 and DX, but lower than at D2.

All cyanide parameters (total, cyanate, thiocyanate, SAD and WAD cyanide) were present at low to undetectable concentrations in most watercourses on site. Though some historically higher concentrations were noted, these have decreased over time. Dome Creek remains the only watercourse on site with measurable cyanide concentrations. Some winter concentrations of cyanate at both the D2 and D3 sites have exceeded the CCME protection of aquatic life guideline (0.5 mg/L). However, guideline exceedances, even in Dome Creek, are now rare occurrences.

There are a number of metals that were present in most of the sampling sites (including reference locations and all sampling sites on Victoria Creek) in concentrations that exceed CCME protection of aquatic life guidelines. These metals include aluminum, cadmium, copper and iron. In addition, water samples from Back Creek had elevated concentrations of arsenic, lead and zinc which exceeded the CCME guidelines for protection of aquatic life. The presence of elevated concentrations of these metals was generally associated with episodes of high TSS concentrations associated with turbid water releases from upstream placer mining. In addition to the aforementioned metals found in all sampling sites, Pony Creek had concentrations of arsenic exceeding the CCME guideline at the upstream sampling site (P1), and arsenic, lead, silver and zinc at the downstream site (P2). Therefore, there is some indication that mining operations have affected the water quality in Pony Creek. Finally, Dome Creek had concentrations of aluminum, arsenic, cadmium, copper, iron, lead, and zinc that exceeded the CCME guidelines at the D1 through D3 sites. The presence of arsenic, lead, silver and zinc in elevated concentrations in the Dome Creek valley are likely associated with past mine operations and existing facilities including the mill, tailings and seepage ponds, while elevated concentrations of aluminum, cadmium, copper and iron are also seen in reference area (DX), and may be present naturally. In general, metals concentrations did not follow any seasonal trends; however, some short-lived increases are noted at all sites in the spring when snowmelt and increased runoff carries in higher concentrations of TSS and associated metals into surface watercourses.

Tailings and Seepage Pond

Water quality in the tailings pond and nearby seepage pond is closely related, and as such, will be discussed together. Most water in the seepage pond can be sourced to the tailings pond because there is a continual underground seepage of water through the tailings dam. This water is discharged into Dome Creek when the water quality is of an acceptable nature. Water has not been pumped back to the tailings for a number of years.

The pH of water in the tailings pond was slightly alkaline, with seasonal medians all just below 8; pH does not vary with season. The pH in the seepage pond was more neutral, with median values for all seasons below 7.5. These lower values are associated with water that has filtered through highly leached sandy soils. Alkalinity in the tailings pond was generally greater than 100 mg/L; therefore, the tailings pond was well buffered against acidification; the highest concentrations were noted in winter samples due to concentration of ions in the smaller fraction of non-frozen water (this is true of all water parameters that are measures of ion concentrations including EC, hardness, etc.). Alkalinity in the seepage pond was slightly higher, approaching 200 mg/L, likely due to minerals garnered from the sediments through which this water moved before it is collected in the seepage pond. Electrical conductivity had a median value approaching 2000 µS/cm, which is high for surface water, but not unexpected in tailings pond water due to high metals and particulate concentrations; EC values in the seepage pond were comparable. Water in both the tailings and seepage ponds was very hard; hardness concentrations were greater than 800 mg/L. Water hardness had a median value of 934 mg/L; therefore, the water is classified as very hard (Boyd 2000) with high concentrations of calcium and magnesium. TSSs in the tailings pond were low; however, TDS concentrations were very high, with median values between 1000 to 2000 mg/L. The highest TDS concentrations were seen in winter and are likely associated with ice freeze-out. Suspended solids concentrations in the seepage pond were higher than in the tailings pond; however, the TDS concentrations were comparable, but without the sharp increase in winter concentrations since the source of water in the seepage pond is mostly water from the tailings pond that has filtered through the tailings dam.

Ammonia concentrations are high in both the tailings pond and seepage pond. Medians from all seasons exceed the CCME guideline (0.832 mg/L, at pH 8, and temperature 10°C). Concentrations in the tailings pond are highest in winter, when less ammonia is broken down through nitrification and ice cover and cold temperatures decrease off- gassing of ammonia Nitrite concentrations are also high, exceeding CCME guidelines.

Total cyanide concentrations have been measured in the tailings pond since early 2004. All concentrations have been well below the water license standard of 0.3 mg/L. Cyanate concentrations are lower in the tailings pond than in the seepage pond indicating that some cyanate may be stored in the tailings pond pore water or the tailings themselves. Cyanate concentrations in the tailings pond periodically exceed the CCME guideline (0.5 mg/L), while median concentrations from all seasons for the entire body of data (2004 – 2010) in the seepage ponds exceed the guideline. Concentrations of all cyanide parameters in both the tailings and seepage ponds have decreased significantly over

time, and the majority of samples taken over the past year only (2009) show concentrations that are below laboratory detection.

Metals present in the tailings pond at concentrations that exceed the CCME protection of aquatic life guidelines include arsenic, cadmium, copper, iron, lead, silver and zinc. While concentrations of these metals have decreased since active mine operations, many still remain over guidelines. In the seepage pond the concentrations of metals are slightly lower, and those with seasonal median concentrations include arsenic, cadmium, copper and iron. Therefore lead, silver and zinc are likely attenuated in the organic layer under the tailings as the water moves through sediments and the resulting concentrations in the seepage pond are lower.

Brown–McDade Pit

There was a slight decreasing trend in the pH of water in the pit lake from the surface to the bottom, though values remained between 7 and 8. As expected, alkalinity concentrations had the opposite trend, and increased with depth. Alkalinity concentrations were highest under ice in winter, and concentrations over all seasons were greater than 100 mg/L, indicating that the water was well-buffered. Conductivity and hardness, like alkalinity, increase with depth. Median seasonal EC ranged from 713 to 1320 µS/cm at the top, 949 to 1405 µS/cm in the middle and 1550 to 2230 µS/cm at the bottom of the pit water. Water hardness concentrations indicate water in the pit is very hard (Boyd 2000) with high concentrations of calcium and magnesium.

Nutrient concentrations including ammonia, nitrate, nitrite and total phosphorus were all low in the pit water column and no trends were noted with depth. Ammonia concentrations were slightly higher over the winter months when compared to other seasons; however, seasonal median concentrations were all below CCME guidelines for the protection of aquatic life.

The main source of metal loading into the pit lake water column is the pit walls. Since the pit flooded following cessation of mine operations the majority of sulphites located in the lower wall have undergone reduced oxidation, thus leading to a slow decrease in metals concentrations in the pit lake over time. The concentration of many metals is slightly lower in spring samples, likely due to increased dilution associated with snowmelt. Zinc and cadmium are the two metals of greatest concern in the pit lake. Concentrations in samples from all depths exceed the CCME guidelines for protection of aquatic life (0.03 mg/L and 0.000017 mg/L, respectively). Other metals present in elevated concentrations include arsenic and copper, which also exceed guidelines in many samples.

10.2.3 Mine Effects to Surrounding Watershed

Dome Creek

Dome Creek is impacted from inputs originating in the mill site, the tailings and seepage ponds, and likely the Brown-McDade pit. The uppermost upstream site, DX, had lower concentrations of most total metals compared to concentrations recorded in samples from all downstream sites. Arsenic increases continuously moving downstream on Dome Creek. Cadmium and zinc concentrations increase dramatically downstream of the mill site, and are gradually diluted and/or attenuated before reaching the road crossing sampling site (Figure 10.2).

Pony Creek

There are changes in water quality between the upstream and downstream sites at Pony Creek. This indicates that inputs from mine loading sites (Brown–McDade pit and nearby and historical waste rock piles) are likely affecting the water quality in Pony Creek. This trend is most apparent with the metals cadmium and zinc (Figure 10.3). Pony Creek is a small ephemeral stream, in late summer there is little flow at the upstream site, a little farther downstream the flow infiltrates entirely to ground and then discharges to surface just above the downstream site. Therefore, in later summer the downstream sample is entirely composed of groundwater discharge, with less dilution from precipitation, ultimately leading to higher concentrations of many metals. There are not yet any decreasing trends in metals concentrations at the downstream sampling location since the removal of the waste rocks piles in 2008. However, there is only one year of data to investigate this trend, and there was very little precipitation in the 2009 year, which likely affected the metals concentrations.

Back Creek

Back Creek does not appear to be highly influenced by Pony Creek. Pony Creek does not maintain surface flow during the entire flow-path, but infiltrates the ground and flows subsurface before resurfacing just upstream of the confluence with Back Creek. While flowing subsurface many of the metals present in the water appear to be partially attenuated. Also, Pony Creek does not contribute significant discharge compared with the base flow in Back Creek. Back Creek water quality does appear to be heavily influenced by placer activities further upstream. Samples with high metals concentrations are commonly associated with high TSS concentrations; particularly zinc and cadmium (Figure 10.4).

Victoria Creek

Victoria Creek receives inputs from Pony Creek (via Back Creek), Back Creek and Dome Creek. From all these inputs, the water quality in Victoria Creek is undoubtedly affected by the Mt. Nansen mine site. Concentrations of many metals are slightly elevated in Victoria Creek at the road crossing sampling site when compared with sites further upstream; however, total metal concentrations, as described by seasonal median values, generally meet CCME guidelines. The exceptions to this are aluminum, copper and iron concentrations during the spring season, when the water quality is likely affected from snowmelt/runoff, and the TSS concentration is higher in the water column. Also, elevated iron was found during the summer season; however, this was also been noted at reference sites and is likely not attributable to inputs from the Mt. Nansen mine site.

In addition to metal concentrations it appears that the high sulphate concentrations in Dome Creek have affected concentrations in Victoria Creek at the road crossing site; sulphate is commonly used to identify mine impacts. The concentrations increase in Dome Creek downstream of the mill site, and increase in Victoria Creek downstream of the Dome Creek confluence.

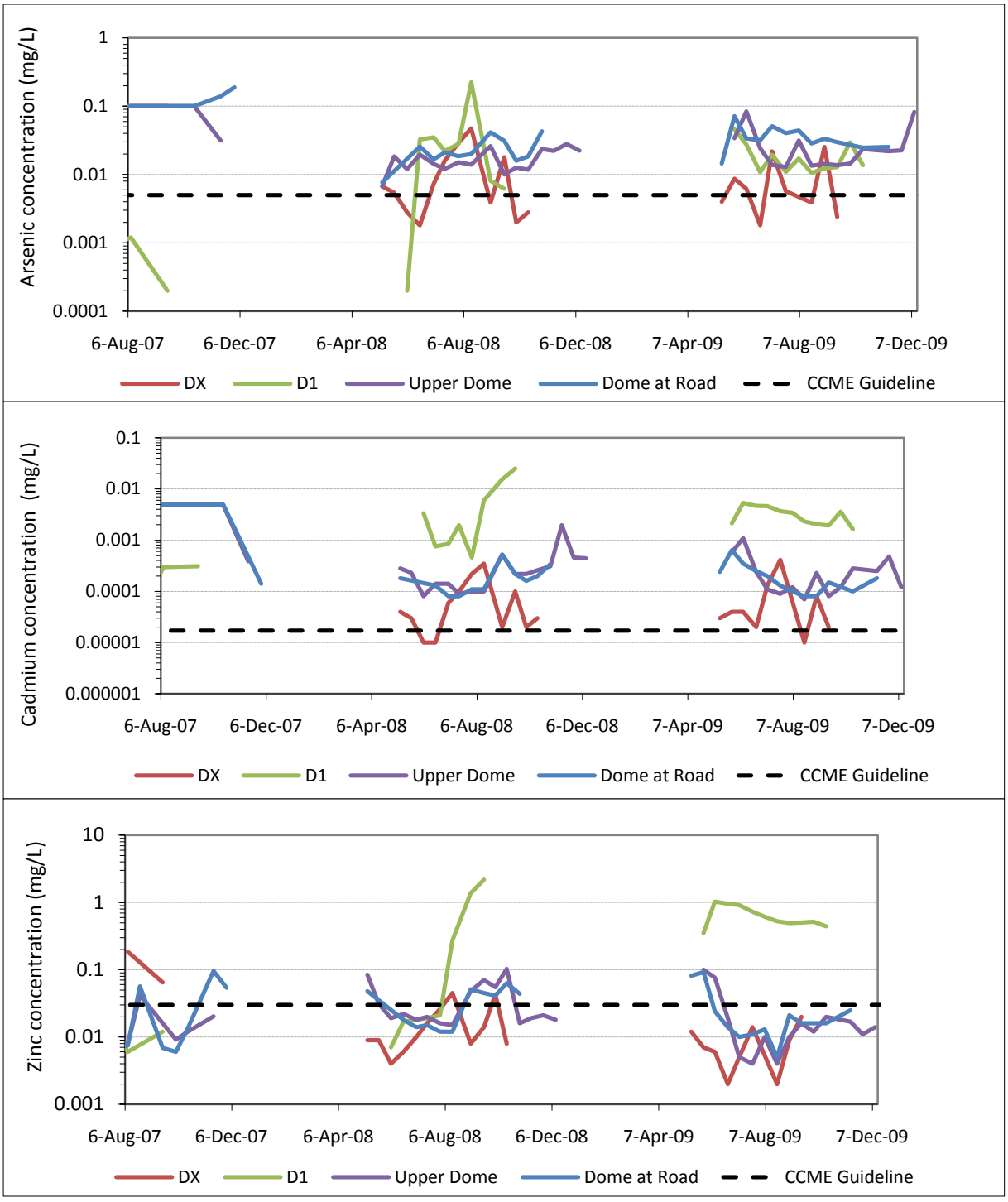


Figure 10.2: Arsenic, cadmium and zinc concentrations at all sampling locations in Dome Creek from August 2007 through December 2009.

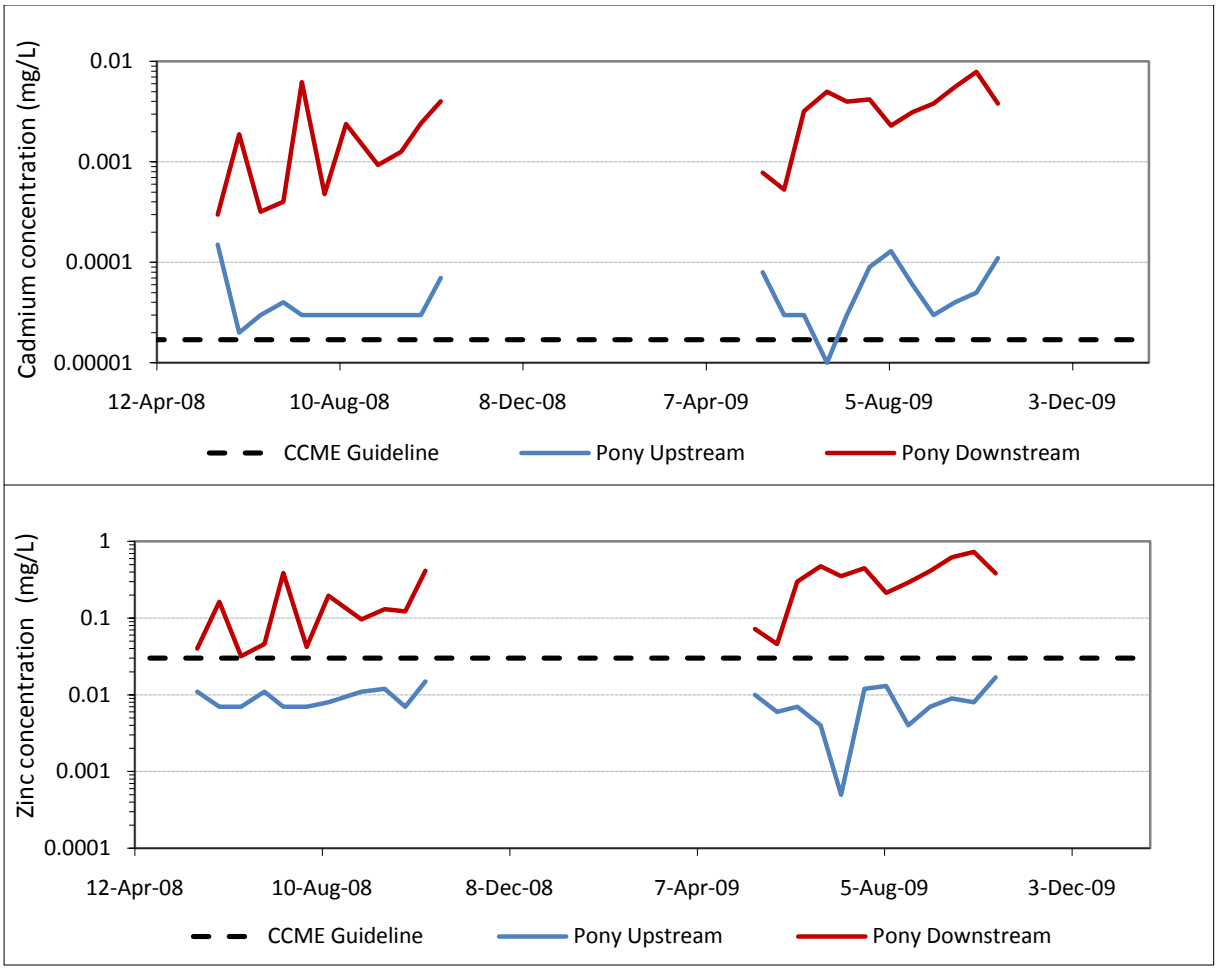


Figure 10.3: Cadmium and zinc concentrations at upstream and downstream sampling sites on Pony Creek, April 2008 through December 2009.

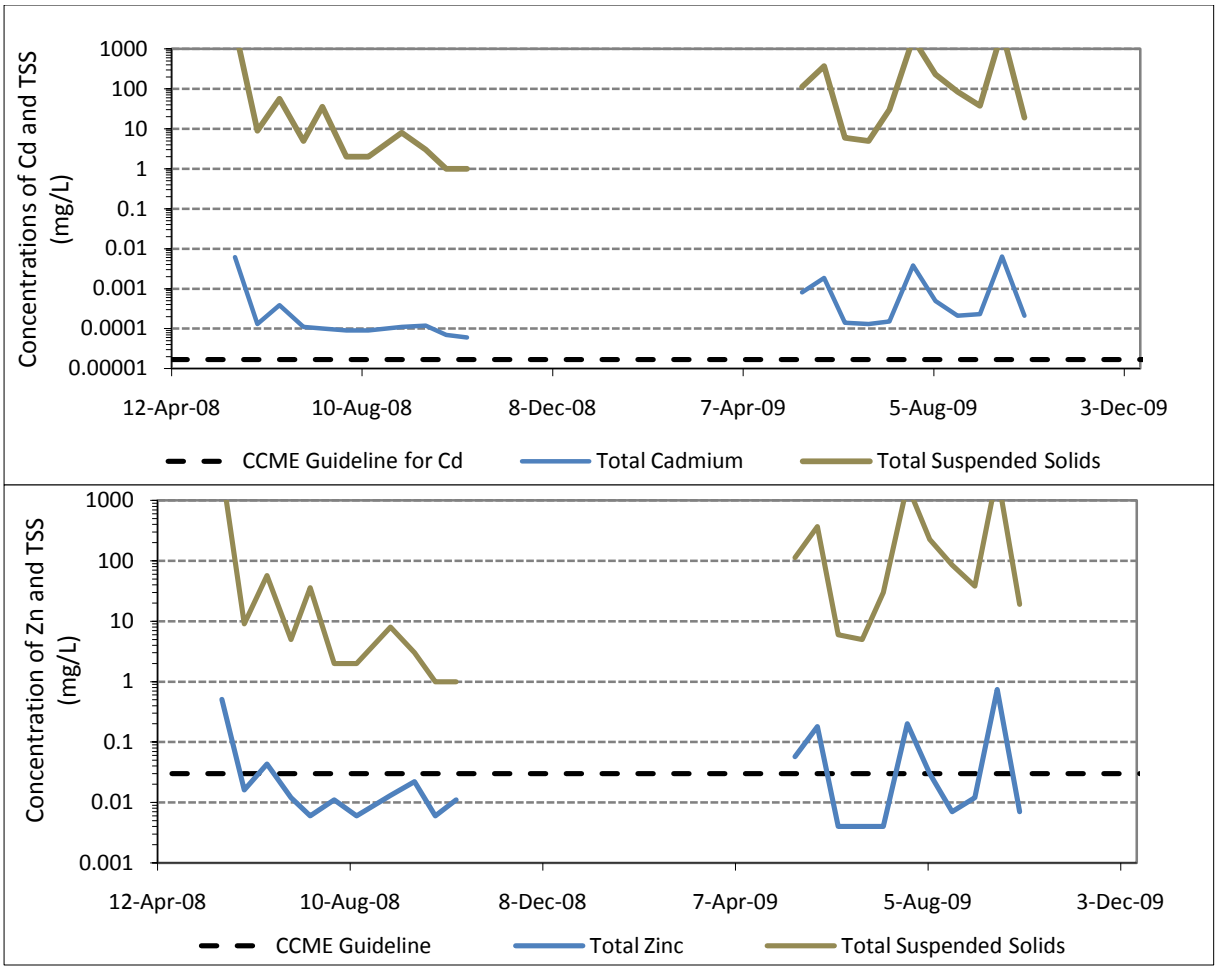


Figure 10.4: Cadmium and zinc concentrations in relation to TSS concentrations in Back Creek, April 2008 through December 2009.

10.3 Hydrogeology

The hydrogeology of the Mt. Nansen mine site and surrounding area has been investigated in a number of reports since the Government of Yukon assumed control over the site. The construction of the tailings facility and the mine pit lake altered the hydrogeology of the site, and therefore require particular consideration. The following information is divided into three sections to aid in the interpretation of the findings: the pit lake, the tailings pond facilities and the receiving environment.

10.3.1 Stratigraphy

Overburden characteristics

The overburden on the project area ranges in thickness from less than 1 m on upland bedrock outcrops to greater than 20 m in the lower centre of the Dome Creek Valley (AECOM 2010). The overburden is largely composed of colluvial blanket sediments. At the headwaters of Dome and Pony Creeks the alluvial complex sediment is overlain by blanket big sediments. In the tailings area the surface sediment is a silty fine to medium aeolian sand up to 15 m thick.

Bedrock characteristics

The area surrounding the Mt. Nansen mine site was not glaciated during the Pleistocene glaciations. Therefore the shallow bedrock is heavily fractured due to freeze-thaw action, more so than is noted in previously glaciated areas. Underlying the shallow weathered bedrock is a more competent layer, which forms the deepest hydrostratigraphic unit (T.W. Higgs Associates Ltd. 1994). Within upland areas this competent bedrock unit hosts the groundwater table, whereas in the creek valley bottoms the groundwater table is near surface in the overburden layer. The bedrock geology consists of highly deformed Upper Paleozoic or older gneiss and schists that are intruded by Upper Triassic/Jurassic granodiorite and syenite batholiths (BYG Natural Resources Inc. 1994). Also, mid to late Cretaceous mafic to felsic stocks, dykes, volcanic flows and pyroclastic rocks intruded into the other rock types. Finally, a series of sub parallel anastomosing veins occur in a 2.5 km wide belt that hold precious metals and extend the length of the Mt. Nansen project area (BYG Natural Resources Inc. 1994). The complex geological structure results in numerous fault sets that cross each other at varying angles. Joint sets and geologic contacts, together with the fault sets, form the dominant pathways for groundwater flow through the competent bedrock.

Multiple fault and shear zones occur near the open pit mining area. These zones are generally coarse granular host rock, or sand with clay content. These zones are also heavily weathered and range in thickness from less than one to five metres. The major hanging wall and footwall faults form a graben structure that trends northwest. These major faults are crosscut by a second series of faults that trend north to northeast and are generally steeply dipping to the east or west.

Permafrost Characteristics

The Mt. Nansen site is located in an area characterized by discontinuous permafrost. Frozen areas were noted on north-facing slopes and within the north and south abutment of the main tailings dam. The presence of stunted vegetation in both the Pony and Dome Creek catchments indicates that permafrost is widespread through those areas. Permafrost can be a discontinuous barrier to

groundwater flow. In frozen areas an active, or thawed, layer forms overlying the permafrost during summer and fall months which acts as a pathway for shallow groundwater flow.

10.3.2 Groundwater Flow

The Pit Lake

During active mining operations at the Mt. Nansen site, no pooled water was present in the mine pit; however, following mine operations water began to collect. Groundwater discharge is believed to originate from a site above the resistant quartzite bedrock and from the easternmost exploration drift at the north end of the pit. Drainage appears to move from the Pony Creek catchment towards the pit lake based on the relative elevation of the Pony Creek catchment to the pit lake water surface (Gartner Lee Ltd. 2007). However, it is important to note that a deep regional groundwater divide exists between the Pony Creek catchment and the pit (AECOM 2010). The heavily weathered and fractured rock surrounding the pit is thought to provide the pathway for groundwater flow from Pony Creek toward the open pit. There is some water input to the Pit from Pony Creek via flow occurring within the shallow fractured bedrock (AECOM 2010). In winter months a large icing is observed at a groundwater discharge point midway up the north wall of the pit. This apparent seepage water flow path was also noted on numerous occasions during unfrozen periods where water flows into the pit in a similar location. The groundwater pathway appears to be active for two periods per year. The first, during May/June, appears to be a response to snowmelt and freshet in the Pony Creek valley. The second, during October through December, follows rainfall and before freezing of the active layer within the weathered bedrock. During all other times of the year the flow pathway is frozen (December through May) or unsaturated (June through October). The amount of water flowing through this underground pathway is estimated to be 1,051 m^3 per year, and the travel time from Pony Creek into the pit lake is estimated to be 105 days or 3.5 months (AECOM 2010).

Water eventually flows out of the pit from the south end and flows down gradient and toward the Dome Creek Valley. Groundwater travel time from the pit lake to the Dome Creek diversion channel area is estimated to be approximately 23 years; however, the amount of time could vary from 2.3 to 230 years (Gartner Lee Ltd. 2007).

It is believed that the pit water elevation may be a reflection of the regional water table. However, during the winter months this water table drops several metres causing it to detach from the pit lake. The water table drop in the winter results in steeper vertical groundwater gradients, causing water that is known to be poor quality to seep out of the pit at a constant rate of approximately 0.2 L/sec through the winter months.

Tailings Pond Facilities (including Diversion Channel and Seepage Pond)

The tailings area is underlain by silty aeolian sand and alluvial sediments associated with the Dome Creek valley, which lie just under a thin layer of organics. Also, a thin layer (5 to 10 m) of permafrost is present in much of the valley, particularly the bottom and north facing slopes. A deep groundwater system exists under the permafrost, but interacts little with water from the Mt. Nansen site. Also, there is a shallow groundwater system that moves through the Aeolian sand and alluvial sediments above the permafrost in the summer months. Water moves into this system from the valley bottom aquifer, upstream of the tailings in the Dome Creek valley, and from the south facing slopes of the catchment. Some of the groundwater flowing through the shallow system also discharges to the diversion channel and is carried downstream of the tailings before re-entering Dome Creek.

Below the tailings relatively permeable materials act as a conduit for groundwater movement below the tailings and horizontally down the Dome Creek valley through the shallow groundwater system. Water in the tailings pond and porewater within the tailings is thought to slowly infiltrate through the mine tailings into the underlying groundwater. Once it enters this aquifer water flows down gradient through the tailings dam fill and collects in the seepage pond.

Water collected in the seepage pond comes from two different sources: seepage through the tailings dam and groundwater flow from the diversion channel that moves horizontally through the Aeolian sand deposit and shallow groundwater from the slope to the south of the tailings impoundment. Extensive permafrost suspected along the north-facing slopes of the Dome Creek valley prevents any significant contribution of water from this direction. Combined inputs to the seepage pond are estimated to be approximately 5 L/s (AECOM 2010).

Receiving Environments

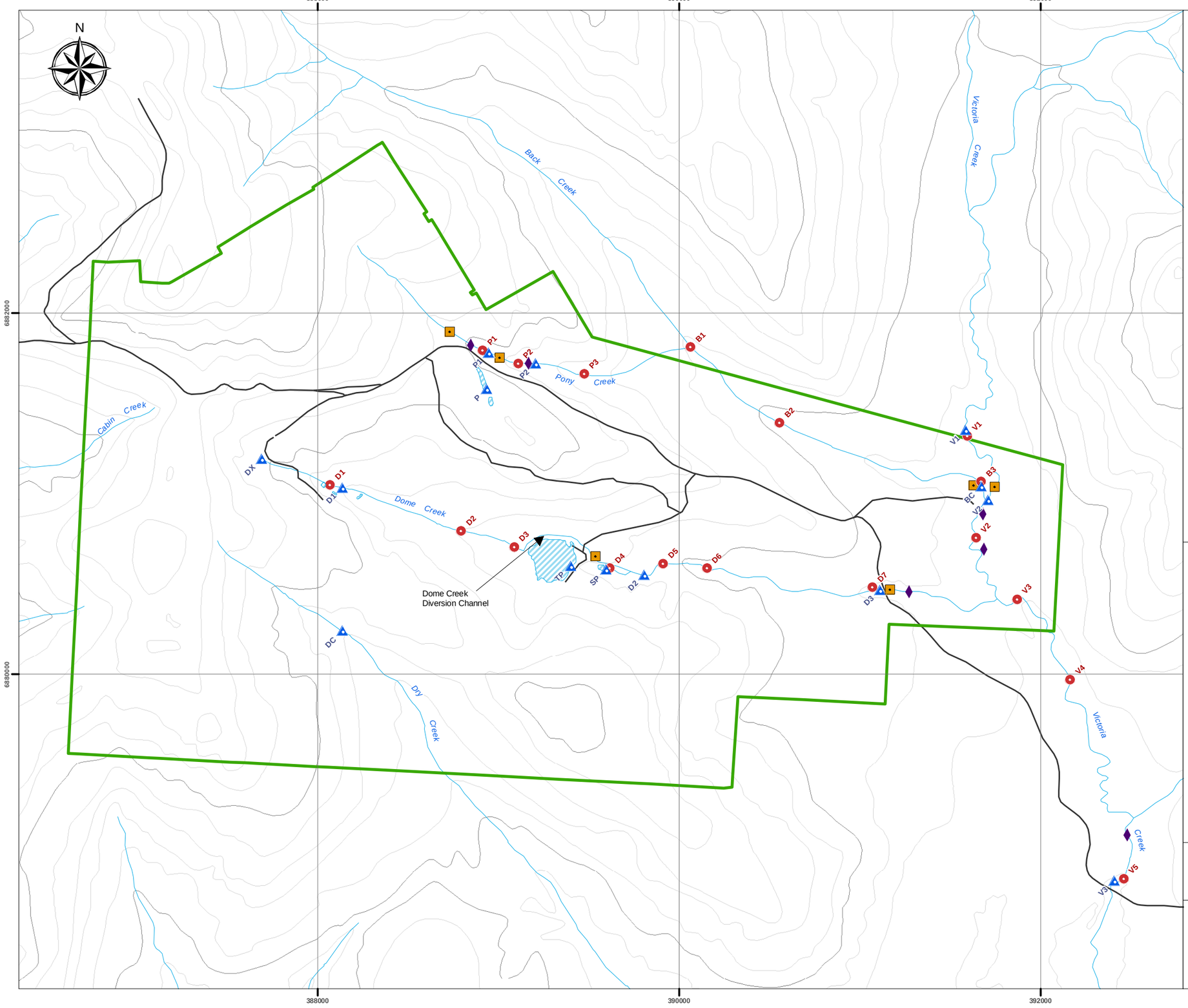
In both Dome and Pony Creek catchments, shallow groundwater generally flows through the active layer just below the surface during summer months. Once it reaches the valley bottoms, the water in each catchment generally discharges to Dome and Pony Creeks. In areas where no permafrost is present, some shallow groundwater will move vertically down to the deeper regional groundwater table.

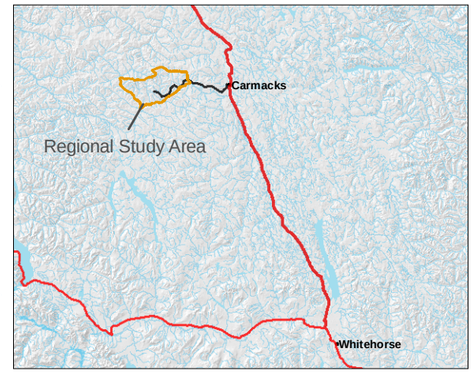
The regional groundwater is located deeper within the competent bedrock in the upland areas on site and within the organic overburden in the valley bottoms (joining with shallow groundwater). Permafrost is not thought to be continuous through either Pony or Dome creek valleys, as evidenced by variation in vegetation density. Shallow and deep groundwater receives recharge only through unfrozen windows. The shallow and deep groundwater systems join in the lower reaches of both valleys and in many places groundwater discharges to surface.

10.3.3 Contaminant Transport

At the Mt. Nansen site there are two main effects to groundwater quality; they include inputs to groundwater from the pit lake and inputs from the tailings area, including the mill and waste rock piles. Potentially these impacts migrate downstream through the Dome Creek valley and ultimately affect Victoria Creek.

Water from the seepage pond is discharged directly to the Dome Creek valley. Though this water meets the discharge requirements as outlined by the water license (Yukon Territorial Water Board 1996), concentrations of many metals and ammonia often exceed CCME guidelines set for the protection of freshwater aquatic life. Also pit lake water quality has concentrations of many metals that exceed the CCME guidelines including cadmium and zinc (see section 10.2.2).





Project Specific Features

- Water Quality Sample Site
- Benthic Sampling Site
- Sediment Sampling Site
- Hydrology Sites
- Project Area-OIC Reserve

Topographic Features

- Road
- Major Contour
- Minor Contour
- Watercourse
- Waterbody
- Tailings/Containment Pond

Drawn By: M. Power, M. Marjanovic
Checked By: M. Setterington
Date: 23 March 2010

Projection: NAD 1983 UTM Zone 8
EDI Project #: 10-YC-0003

1:50,000 Topographic Spatial Data: Canvec and National Topographic Database (NTDB). Used under license courtesy of Her Majesty the Queen in Right of Canada, Department of Natural Resources. All Rights Reserved.

Study/drainage areas were digitized by EDI using specific parameters such as, height of land and relevant drainage courses (1:50,000 Canvec).

Water quality sampling sites, benthic sites and sediment sample sites provided, in part, by EDI. Additional sites have been located from past literature research for the attached report; Mt. Nansen Existing Environmental Report (EDI, 2010).

This document is not an official land survey and the spatial data presented on the map is subject to change without any notice.

0 250 500 750 1,000
Metres

Figure 10.5: Water and Aquatic Resources Sampling and Monitoring Sites, Mt. Nansen reclamation project.

Prepared for:
Yukon
Energy, Mines and Resouces

Prepared by:
EDI
ENVIRONMENTAL DYNAMICS INC.

11 Aquatic Organisms and Habitat

The Mt. Nansen mine site is within the Nisling River watershed, itself a part of the White River watershed and the Upper Yukon River drainage. With the exceptions of Rowlinson Creek, all creeks within the Mt. Nansen RSA flow into the Nisling River (Table 11.1). Several small lakes are also present within the RSA (Table 11.2).

The site was historically important for fisheries resources for the LSCFN; however, recent interviews with local LSCFN members suggest that the area is not as heavily used at present (EDI 2005). In addition, interviewees indicated that fisheries resources were not a high concern in terms of mine site effects on local ecology (EDI 2005). There is currently limited sport fishing that is known to occur on any of the creeks or lakes within the mine site or on the access road (B. Wheeler 2010 pers. comm.).

Table 11.1: Summary of major Creeks within the Mt. Nansen RSA.

Creek name	Drainage direction
Back Creek	Victoria Creek to Nisling River
Cabin Creek	Nansen Creek to Nisling River
Dome Creek	Victoria Creek to Nisling River
Dry Creek	Victoria Creek to Nisling River
Lonely Creek	Nisling River
Minnesota Creek	Victoria Creek to Nisling River
Nansen Creek	Nisling River
Pony Creek	Dome Creek to Victoria Creek
Rowlinson Creek	Nordenskiold
Victoria Creek	Nisling River

Table 11.2: Summary of Lakes within the Mt. Nansen RSA (EDI 2007).

Lake name	Drainage direction	Watershed	Area (km²)
Victoria Lake	West	Nisling River	2.2
Long Lake	West	Nisling River	0.98
Elbow Lake	East	Nordenskiold River	0.62
Round Lake	East	Nordenskiold River	0.29

11.1 Fish

Fish and aquatic resources studies in the RSA include baseline summaries of the fisheries resources in Nansen and Victoria Creek in 1979 (Environment Canada 1979) and in the 1980s by Norecol Environmental Consultants Ltd. In 1995, Osborne sampled for fish on Victoria Creek and Nansen Creek. Fisheries data during the operational period of the Mt. Nansen mine is limited to a field observation in the summer of 1998 by Environmental Protection (Environment Protection 1999). Within the last five years EDI has completed fish sampling and in Victoria, Back, Pony, Dome, and Rowlinson Creeks. These recent events were associated with an aquatic effects study and studies to determine fish presence in Dome and Pony Creeks. Table 11.3 summarizes the fish sampling data within the PA.

Table 11.3: Summary of baseline fisheries studies and capture methods within the Mt. Nansen PA.

Stream name	Results [a]	Sampling method	Reference
Dome Creek	None	Electrofishing	(EDI 2009c; EDI 2007; Norecol 1989a; Osbourne 1995)
Pony Creek	None	Electrofishing	(EDI 2009a)
Back Creek	GR	Electrofishing	(EDI 2009a)
Victoria Creek	GR, CCG, BB	Electrofishing, gillnetting, minnow trapping	(EDI 2007; Osbourne 1995; Norecol 1989b)
Nansen Creek	GR, CCG	Electrofishing	(Jessup 2010; Osbourne 1995; Norecol 1989b)
Rowlinson Creek	CCG	Electrofishing	(EDI 2007)

Notes: [a] Description of species found including: slimy sculpin (CCG), Arctic grayling (GR), burbot (BB)

Fish species present within the Nisling River (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)* (EDI 2007). Chinook salmon (*Oncorhynchus tshawytscha*) are known to spawn in the lower and middle reaches of the Nisling River as well as in the Nordenskiold River; however, they are not known to be present in the vicinity of the mine site (EDI 2007).

Arctic grayling, burbot and slimy sculpin have been captured in the Victoria Creek drainage through electrofishing, minnow trapping and gillnetting (EDI 2007). Electrofishing in Nansen and Rowlinson Creeks yielded Arctic grayling (Norecol 1989b) and slimy sculpin in Rowlinson Creek (EDI 2007). Electrofishing in Back Creek in 2008 yielded a single juvenile Arctic grayling (EDI 2009a).

A fish habitat assessment and electrofishing by Norecol Environmental Consultants Ltd. in the 1980s suggested Dome Creek was non-fish bearing (Norecol 1989b). More recent fish habitat assessment

and electrofishing confirmed that both Dome and Pony Creeks are non-fish bearing (EDI 2009a; EDI 2009c). There are natural impediments at the mouths of these streams and habitat is generally of poor quality.

No formal studies have been conducted on the fisheries resources of the lakes in the Mt. Nansen study area; however, the mine caretaker has reported that northern pike, burbot, Arctic grayling, longnose sucker (*Catostomus catostomus)* and humpback (lake) whitefish *(Coregonus clupeaformis)* are found in Victoria and Long Lakes (B. Wheeler 2010 pers. comm.). Recreational angling by mine employees occurred during the operation of the Mt. Nansen mine (B. Wheeler 2010 pers. comm.); however, no catch data exists for those lakes.

None of the fish species present within the study area are rare, endangered or otherwise listed as a species of conservation concern.

Victoria Creek (Mainstem)

Arctic grayling, slimy sculpin and burbot have been found throughout Victoria creek during multiple open water season sampling events (EDI 2007; Norecol 1989b). Rearing habitat is of good quality for grayling; however, the watercourse has been subjected to high sediment discharge associated with upstream placer mining operations (Osbourne 1995; Norecol 1989b). The lower reaches of the creek have suitable burbot rearing habitat (Osbourne 1995). EDI staff have observed Arctic grayling during winter surface water sampling events and some areas of Victoria Creek remain ice free during the winter. EDI staff also noted that the area in the vicinity of the road bottom freezes completely. Overwintering habitat is likely limited to areas with notable groundwater input.

Is it likely that some portions of Victoria Creek support spawning of Arctic grayling. Osbourne (1995) captured grayling fry approximately 500 m upstream of the creek mouth. Grayling fry were also observed between the mine access road crossing and the mouth of Dome Creek by Environmental Protection personnel in 1998; fry were distributed throughout this section of Victoria Creek but were not abundant (Environment Protection 1999). Capture of fry is a good indication that grayling spawning occurs nearby.

Back Creek

Fish sampling in Back Creek is limited to a single sampling event in the summer of 2008 when a single juvenile Arctic grayling was captured (EDI 2009c). Fish habitat quality in Back Creek was of low quality overall; many small barriers were present at the time of sampling, bed materials were unsuitable for spawning grayling and rearing habitat was generally of low quality (EDI 2009c).

Observations by EDI during winter water sampling events suggest that Back Creek freezes to bottom during winter months, precluding the use of this creek as overwintering habitat.

Nansen Creek

Nansen Creek was sampled for fish prior to the operation of the Mt. Nansen mine in 1989 and again in 1995 (Osbourne 1995; Norecol 1989b). Both juvenile and adult Arctic grayling were captured at a sampling site approximately 8 km upstream of the creek mouth (Norecol 1989b). The 1989 study indicates Nansen Creek had good rearing habitat and had suitable spawning gravels for Arctic grayling. Despite the presence of suitable spawning habitat for grayling, no grayling fry were captured. Sampling near the creek mouth in 1995 failed to capture any fish (Osbourne 1995). The extent of overwintering habitat in this watercourse is unknown.

Rowlinson Creek

Fish sampling was conducted in the vicinity of the Rowlinson Creek Road crossing in conjunction with the Mt. Nansen terrestrial and aquatic effects study (EDI 2007). Fifteen slimy sculpin were captured during the summer sampling season; the sedentary nature of sculpin suggests that this area may provide some overwintering habitat. However, the true extent of overwintering habitat in this creek is unknown.

Arctic grayling, burbot and juvenile Chinook have been documented approximately 2.3 km from the mouth of Rowlinson Creek (Department of Fisheries and Oceans 2010). However, this sampling location is a considerable distance (approximately 30 km) downstream of the RSA. The distribution of these species in the watershed is unclear.

In addition to fish sampling work to establish the diversity and abundance of fisheries resources at the Mt. Nansen site, fish were collected from the Regional Study Area in 2005 and 2006 in order to conducted toxicology studies on local species (EDI 2007). Slimy sculpin were chosen as an indicator species due to their relatively sedentary behaviour. Samples were collected from a number of locations on Victoria Creek and the Nisling River (within the zone of influence of the mine) and Rowlinson Creek (outside the zone of influence of the mine). Grayling and burbot were also collected from a single location on Victoria Creek near the mouth of Dome Creek.

Analysis of whole body sculpin samples indicated that concentrations of arsenic, cadmium, lead, selenium, and silver were significantly higher in sculpin captured within the zone of influence of the mine than those captured outside the zone of influence (EDI 2007). Arctic grayling tissues (muscles, kidney and liver) showed normal levels of metal concentrations comparable to grayling captured in pristine streams (EDI 2007). Analysis of burbot muscle tissue showed that arsenic concentrations

were higher in fish captured nearer to the mine site; however, this difference was not statistically significant (EDI 2007). Burbot liver tissues showed higher levels of some metals nearer the mine site, while other metals were found in higher concentrations within samples collected further away from the mine site (EDI 2007).

11.2 Stream Sediment

Baseline stream sediment samples were collected in September 1986 (Norecol 1989a), by the Yukon Geological Survey in 1985 and by the Environmental Protection Service in 1988 (Davidge 2006 pers. comm.). Environment Canada conducted stream sediment sampling in 1997 (Davidge 2006 pers. comm.) that was followed by additional sampling in 1999 by Conor Pacific (2000). The most recent stream sediment sampling was conducted as a component of the Mt. Nansen terrestrial and aquatic affects survey in 2005 and 2006 (EDI 2007).

A total of 23 sites have been sampled for sediment within the RSA from 1986 to 2006 (Table 11.4). Those sites that were sampled within the PA are illustrated in Figure 10.5. Most stream sampling has focused on Back, Pony and Victoria Creeks. Stream sediment metal concentrations from the most recent sampling events (2005/2006) reflect current conditions at the project site. Recent results for all sampled sites are compared to CCME's Interim freshwater Sediment Quality Guidelines (ISQG; see Table 11.5) (CCME 2002). These guidelines provide data for arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), mercury (Hg), lead (Pb) and zinc (Zn). Metals for which no guidelines concentrations exist are listed in Appendix 2, but are not discussed further in this baseline report.

Back Creek

Recent sampling of Back Creek (2005/2006) was conducted at two sites approximately 1 km from the creek mouth and approximately 200 m upstream of the confluence of Pony Creek (B1 and B2; EDI 2007). Sampling was also conducted near the mouth of Back Creek in 1986 by Norecol (1989a). Concentrations of arsenic and cadmium at all three sites exceed ISQG (Table 11.6). Concentrations of all other metals for which there are guidelines fell below ISQG at the time of sampling. Current metal concentrations in stream sediments near the mouth of Back Creek (site B3) are unknown.

Cabin Creek

Stream sediment sampling at Cabin Creek was conducted in 1986 by Norecol (1989a). Concentration of arsenic (22.1 ug/g) and cadmium (<1.25 ug/g) exceed ISQG (as listed in Table 11.6).

Concentrations of all other metals for which there are guidelines fell below ISQG at the time of sampling. Current metal concentrations at this sampling location are unknown.

Dome Creek

Recent sampling of Dome Creek has been conducted at 3 sites (D1-D3; EDI 2007) above the tailings pond outlet and two sites below the outlet (D4 and D6; EDI 2007). Two additional sites, D5 and D7, were sampled in 1999 (Conor Pacific 2000) and 1986 (Norecol 1989a), respectively.

The results of the 2006 stream sediment sampling program (EDI 2007) indicate that arsenic concentrations at all sample sites exceeded ISQG (Table 11.7). Bio-available arsenic concentrations (partial digestion) were also above ISQG. At site D1 cadmium, copper, lead and zinc concentrations in stream sediment also exceeded ISQG; mercury concentrations exceed ISQG when exposed to a full digest, but not when exposed to a partial digest. At site D5 cadmium, chromium and copper concentrations in stream sediment also exceeded ISQG. Cadmium concentrations at site D7 exceeded ISQG. Concentrations of all other metals for which there are guidelines fell below ISQG at the time of sampling.

Stream sediment metal concentrations have likely changed at D5 since it was last sampled in 1999. Similarly, this area of the mine where site D7 is located underwent substantial changes following sampling in 1986 (associated with the development and operation of the mine) and data are likely not reflective of current stream sediment metal concentration.

Nansen Creek

Stream sediment sampling was conducted on Nansen Creek at two sites in 1986 (Norecol 1989a). Sample site N1 was located near the headwaters of Nansen Creek (upstream of the confluence of Webber Creek) while site N2 was located near the mouth of Nansen Creek (Norecol 1989a). Results from the sampling indicate that stream sediment concentrations of arsenic and cadmium at both sites were above ISQG (Table 11.8). Concentrations of all other metals for which there are guidelines fell below ISQG at the time of sampling. Current metal concentrations at this sampling location are unknown.

Pony Creek

The most recent stream sampling of Pony Creek was conducted in 2006. Sampling was conducted at 3 locations within Pony Creek (P1-P3). Results indicate that sites P2 and P3 (nearer to the mouth of

Pony Creek) have considerably higher stream sediment metal concentrations then site P1 (Table 11.9). Arsenic concentration exceed CCME stream sediment standards at P1; however, stream sediment metal concentrations at sites P2 and P3 exceed ISQG for arsenic, cadmium, copper, lead and zinc (including total concentrations as well as bio-available concentrations; Table 11.9). Concentrations of all other metals for which there are guidelines fell below ISQG at the time of sampling.

Victoria Creek

Stream sediment samples in Victoria Creek were collected at seven different locations (Figure 10.5). Sampling sites on Victoria Creek include:

- V1 (upstream of the mouth of Back Creek)
- V2 (downstream of the mouth of Back Creek)
- V3 (downstream of the mouth of Dome Creek)
- V4 (midway between road crossing and Dome Creek mouth)
- V5 (upstream of the Mt. Nansen access road crossing)
- V6 (downstream of the Mt. Nansen access road crossing)
- V7 (upstream of the mouth of Victoria Creek).

Sites V4 and V7 were sampled in 1999 (Conor Pacific 2000a); all other sites were sampled most recently by EDI in 2005 and 2006 (EDI 2007). At all sites except for V1, total stream sediment arsenic concentrations exceeded ISQG (bio-available stream sediment concentrations were below ISQG; Table 11.10). At sites V4 and V7, stream sediment concentrations of cadmium, copper, lead and zinc also exceeded ISQG. Concentrations of all other metals for which there are guidelines fell below ISQG at the time of sampling. Sites V4 and V7 were sampled while the mine was operational; stream sediment metal concentrations at these locations have likely changed since that time.

Webber Creek

Stream sediment sampling was conducted in Webber Creek at one location near the mouth in 1986 (Norecol 1989a). Concentrations of arsenic (14.2 ug/g) and cadmium (<1.21) exceeded ISQG (5.9 and 0.6 ug/g, respectively) at the time of sampling. Current metal concentrations at this sampling location are unknown.

Table 11.4: Stream sediment sampling locations in the Mt. Nansen Project Area.

Site Name	Location	Sample Date	Reference
B1	Back Creek	September 05/06	(EDI 2007)
B2	Back Creek	September 05/06	(EDI 2007)
B3	Back Creek	September 86	(Norecol 1989a)
C1	Cabin Creek	September 86	(Norecol 1989a)
D1	Dome Creek	August 88; September 05/06	(Davidge 2006; EDI 2007)
D2	Dome Creek	September 05/06	(EDI 2007)
D3	Dome Creek	September 05/06	(EDI 2007)
D4	Dome Creek	August 88; September 05/06	(Davidge 2006; EDI 2007)
D5	Dome Creek	September 99	(Conor Pacific 2000)
D6	Dome Creek	June 97; August 00; September 99/05/06	(Conor 2000; Davidge 2006; EDI 2007)
D7	Dome Creek	September 86	(Norecol 1989a)
N1	Nansen Creek	September 86	(Norecol 1989a)
P1	Pony Creek	September 99/06	(Conor Pacific 2000; EDI 2007)
P2	Pony Creek	September 06	(EDI 2007)
P3	Pony Creek	September 86/99/06	(Norecol 1989a; EDI 2007)
V1	Victoria Creek	June 97; August 88; September 86/ 99/05/06	(Conor Pacific 2000; Norecol 1989a; EDI 2007)
V2	Victoria Creek	August 88; September 99/05/06	(Conor Pacific 2000; Davidge 2006; EDI 2007)
V3	Victoria Creek	June 97; August 1988; September 2005/06	(Davidge 2006; EDI 2007)
V4	Victoria Creek	August 88; September 99	(Conor Pacific 2000)
V5	Victoria Creek	June 97, September 86/99/05/06	(Conor Pacific 2000; Davidge 2006; Norecol 1989a; EDI 2007)
V6	Victoria Creek	September 05/06	(EDI 2007)
V7	Victoria Creek	September 99	(Conor Pacific 2000)
W1	Webber Creek	September 86	(Norecol 1989a)

Table 11.5: ISQG (Updated 2002) for elements present in Mt. Nansen mine site stream sediments.

Element	CCME stream sediment standard (ug/g, dry weight)
As	5.9
Cd	0.6
Cr	37.7
Cu	35.7
Hg	0.17
Pb	35
Zn	123

Table 11.6: Summary of metals that exceed ISQG at Back Creek.

Site (Year)	Element	Digestion (Full/Partial)[a]	Measured concentration (ug/g, dry weight)	CCME Stream sediment standard (ug/g, dry weight)
B1 (2006)	As	Full	40.6	5.9
		Partial	10.8	5.9
	Cd	Full	0.85	0.6
		Partial	0.83	0.6
B2 (2006)	As	Full	34.4	5.9
		Partial	11	5.9
	Cd	Full	0.72	0.6
		Partial	0.66	0.6
B3 (1986)	As	Full	22.1	17
	Cd	Full	<1.25	0.6

Notes: [a] Digestion determines the concentration of weakly bound elements which are more likely to be released from sediment and are more likely to become bio-available. Full digestions use strong acids to mobilize all elements within the stream sediments; partial digestions use weak acids to mobilize weakly bound elements that are more likely to become bio-available.

Table 11.7: Summary of metals which exceed ISQG at Dome Creek.

Site (Year)	Element	Digestion (full/partial)[a]	Measured concentration (ug/g, dry weight)	CCME stream sediment standard (ug/g, dry weight)
D1 (2006)	As	Full	2500	5.9
		Partial	506	5.9
	Cd	Full	48	0.6
		Partial	13.7	0.6
	Cu	Full	157	35.7
		Partial	123	35.7
	Hg	Full	0.207	0.17
	Pb	Full	507	35
		Partial	447	35
	Zn	Full	2030	123
		Partial	1700	123
D2 (2006)	As	Full	153	5.9
		Partial	124	5.9
D3 (2006)	As	Full	61.7	5.9
		Partial	32.6	5.9
D4 (2006)	As	Full	128	5.9
		Partial	101	5.9
D5 (1999)	As	Full	189	5.9
	Cd	Full	1.5	0.6
	Cr	Full	38	37.7
	Cu	Full	162	35.7
D6 (2006)	As	Full	74.8	5.9
		Full	51.9	5.9
D7 (1986)	As	Partial	25.2	5.9
	Cd	Full	<1.23	0.6

Notes: [a] Digestion determines the concentration of weakly bound elements which are more likely to be released from sediment and are more likely to become bio-available. Full digestions use strong acids to mobilize all elements within the stream sediments; partial digestions use weak acids to mobilize weakly bound elements that are more likely to become bio-available.

Table 11.8: Summary of metals which exceed ISQG at Nansen Creek.

Site (Year)	Element	Digestion (full/partial)[a]	Measured concentration (ug/g, dry weight)	CCME stream sediment standard (ug/g, dry weight)
N1 (1986)	As	Full	22.1	5.9
	Cd	Full	<1.25	0.6
N2 (1986)	As	Full	10.7	5.9
	Cd	Full	<1.24	0.6

Notes: [a] Digestion determines the concentration of weakly bound elements which are more likely to be released from sediment and are more likely to become bio-available. Full digestions use strong acids to mobilize all elements within the stream sediments; partial digestions use weak acids to mobilize weakly bound elements that are more likely to become bio-available.

Table 11.9: Summary of metals which exceed ISQG at Pony Creek.

Site (Year)	Element	Digestion (full/partial) [a]	Measured concentration (ug/g, dry weight)	CCME stream sediment standard (ug/g, dry weight)
P1 (2006)	As	Full	21.5	5.9
		Partial	11.1	5.9
P2 (2006)	As	Full	945	5.9
		Partial	350	5.9
	Cd	Full	5.2	0.6
		Partial	4.4	0.6
	Cu	Full	95	35.7
		Partial	50.9	35.7
	Pb	Full	345	35
		Partial	182	35
	Zn	Full	582	123
		Partial	352	123
P3 (2006)	As	Full	1020	5.9
		Partial	454	5.9
	Cd	Full	22.8	0.6
		Partial	16.2	0.6
	Cu	Full	214	35.7
		Partial	139	35.7
	Pb	Full	409	35
		Partial	182	35
	Zn	Full	948	123
		Partial	756	123

Notes: [a] Digestion determines the concentration of weakly bound elements which are more likely to be released from sediment and are more likely to become bio-available. Full digestions use strong acids to mobilize all elements within the stream sediments; partial digestions use weak acids to mobilize weakly bound elements that are more likely to become bio-available.

Table 11.10: Summary of metals which exceed ISQG at Victoria Creek.

Site (Date)	Element	Digestion (Full/Partial)[a]	Measured concentration (ug/g, dry weight)	CCME stream sediment standard (ug/g, dry weight)
V2 (2006)	As	Full	6.8	5.9
V3 (2006)	As	Full	8	5.9
V4 (1999)	As	Full	89	5.9
	Cd	Full	2.3	0.6
	Cu	Full	92.6	35.7
	Pb	Full	76	35
	Zn	Full	228	123
V5 (2006)	As	Full	12.8	5.9
V6 (2006)	As	Full	7.9	5.9
V7 (1999)	As	Full	52	5.9
	Cd	Full	1.2	0.6
	Cu	Full	44	35.7
	Pb	Full	43	35
	Zn	Full	133	123

Notes: [a] Digestion determines the concentration of weakly bound elements which are more likely to be released from sediment and are more likely to become bio-available. Full digestions use strong acids to mobilize all elements within the stream sediments; partial digestions use weak acids to mobilize weakly bound elements that are more likely to become bio-available.

11.3 Benthic Invertebrates

Baseline benthic invertebrate sampling within the RSA was conducted by the Environmental Protection Service in 1979 and 1988. EDI conducted sampling on Victoria and Dome Creeks in 2007, and on Pony Creek in 2008 (EDI 2008; EDI 2009b). As a component of the Canadian Aquatic Biomonitoring Network (CABIN), the Yukon government, Department of Environment, and Environment Canada have also conducted benthic invertebrate sampling on Nansen and Victoria Creeks, as well as the Nisling River in 2008 (Environment Canada 2010b). Those sample sites that are within the PA are shown in Figure 10.5.

The benthic invertebrate sampling methodology on Victoria and Dome Creek in 2007 followed the field procedures outlined in the CABIN Invertebrate Biomonitoring Field and Laboratory Manual (Reynoldson et al. 2003). This method involved sampling a stream reach equal to six full widths of the stream bank at the sampling location, using a 363 micron kick-net (EDI 2008). The same sampling methods were used in Pony Creek in 2008 (EDI 2009b). CABIN sampling conducted by the Yukon government Department of the Environment employed a 500 micron mesh kick-net; kick netting was done for three minutes at each site.

Routine analyses were performed on benthic invertebrate samples collected by EDI in 2007 and 2008 (EDI 2008; EDI 2009b). These analyses include measurement of taxa richness and order level relative abundance of benthic invertebrates at each sample site. Analyses focused on the four major invertebrate orders: Ephemeroptera, Plecoptera, Trichoptera and Diptera.

11.3.1 Taxa Richness

Taxa richness is a measure of the number of distinct taxa counted at each site. Distinct taxa include those individuals identified only to family/order (Karr and Chu 1999, Resh and Jackson 1993). Order level taxa richness is presented for all collected benthic invertebrates (total taxa richness), and family level taxa richness is presented for the four major benthic invertebrate orders (Ephemeroptera, Plecoptera, Tricoptera and Diptera).

Total Taxa Richness

Total taxa richness of benthic invertebrates was highest in Victoria Creek (20 to 15 taxa) upstream of Back and Dome Creeks. Taxa richness decreased downstream of the mouth of Back Creek, and again downstream of the mouth of Dome Creek (Figure 11.1). Nansen and Dome Creeks had a slightly lower number of taxa than Victoria Creek. At Nansen Creek, the highest numbers of taxa were found near the mouth (the opposite of Victoria Creek). Pony Creek had low numbers of taxa at both sites (9 and 5; Figure 11.1). The morphology of Dome and Pony Creeks (small streams dominated by fine substrate) likely influences taxa richness in comparison to bigger stream such as Victoria.

Ephemeroptera — Overall, Ephemeropteran taxa richness was lower than other major benthic invertebrate orders (Plecoptera/Trichoptera/Diptera; Figure 11.2). No Ephmeroptera were found in Dome or Pony Creeks during recent (2007–2008) sampling events. In Victoria Creek, the largest number of Ephemeroptera families (4) was upstream of Back and Dome creek (Figure 11.2). Downstream of Dome and Back Creek, Emphemeroptera taxa richness was lower (2 and 1 families, respectively). The highest numbers of Emphemeropteran families in Nansen Creek were found in upstream areas.

Plecoptera — Plecoptera taxa richness was the highest of all major benthic invertebrate orders. Considerably more plecopteran families were found in Victoria Creek as compared to most areas of Nansen Creek (with the exception of the mouth of Victoria Creek; Figure 11.3). Relatively high numbers of plecopteran families were found in the upstream Nansen Creek sample site as well as Dome Creek. All other sites had low Plecoptera Taxa richness.

Trichoptera — Trichoptera taxa richness was the lowest of all major benthic invertebrate orders. No Trichoptera were found in Dome Creek or in upstream areas of Nansen Creek; a single Trichoptera family was found in Pony Creek and in the upper most Victoria Creek sampling site (Figure 11.4). The highest Trichoptera taxa richness (3 families) was in Victoria Creek downstream of the mouth of Back Creek.

Diptera — Diptera taxa richness was the highest overall of all major benthic invertebrate orders. In upstream area of Victoria Creek, as well as Dome and Pony Creeks, five benthic invertebrate families were found (Figure 11.5). Even sites with lower Diptera taxa richness had high numbers of families, relative to other major invertebrate orders.

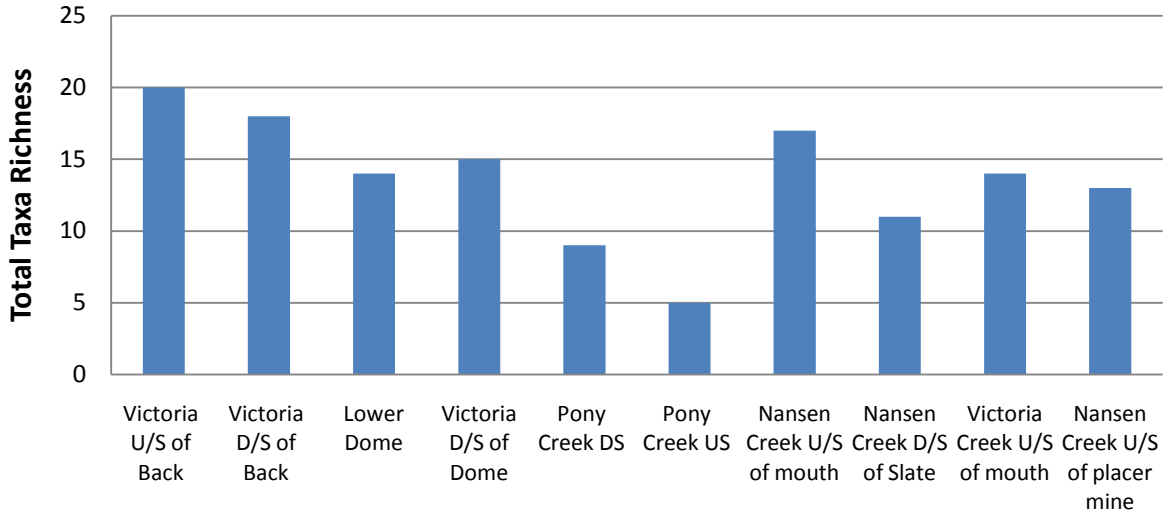


Figure 11.1: Total taxa richness of benthic invertebrates collected from watercourses within the Regional Study Area. (Note: U/S = upstream; D/S = downstream).

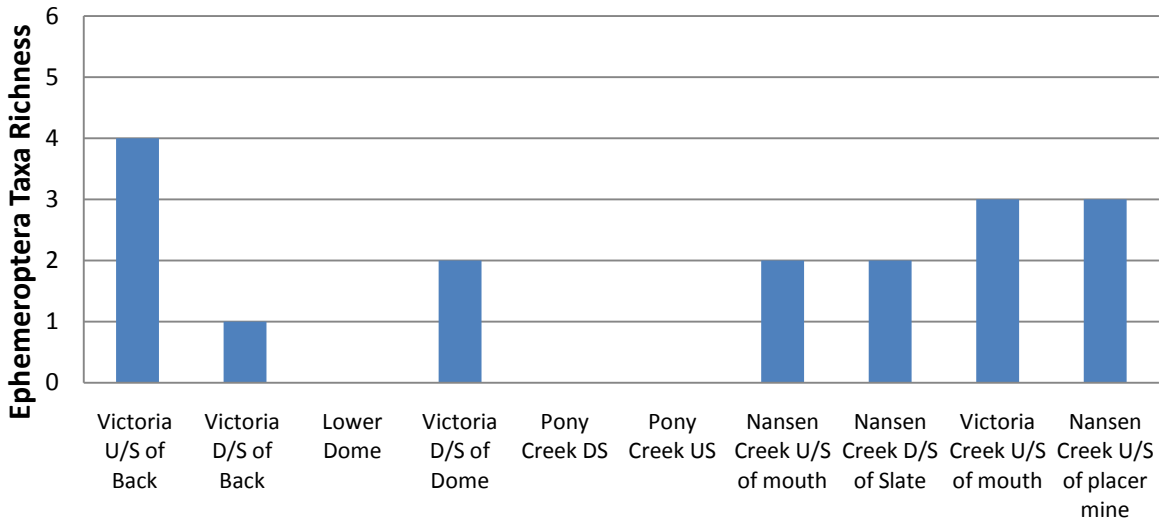


Figure 11.2: Ephemeroptera taxa richness of benthic invertebrates collected from watercourses within the Regional Study Area. (Note: U/S = upstream; D/S = downstream).

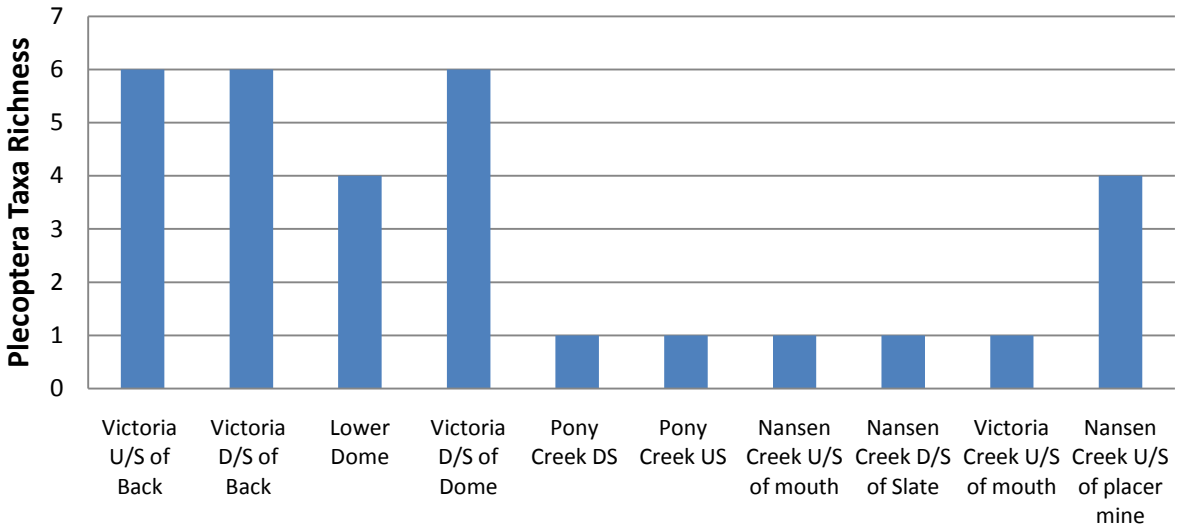


Figure 11.3: Plecoptera taxa richness of benthic invertebrates collected from watercourses within the Regional Study Area. (Note: U/S = upstream; D/S = downstream).

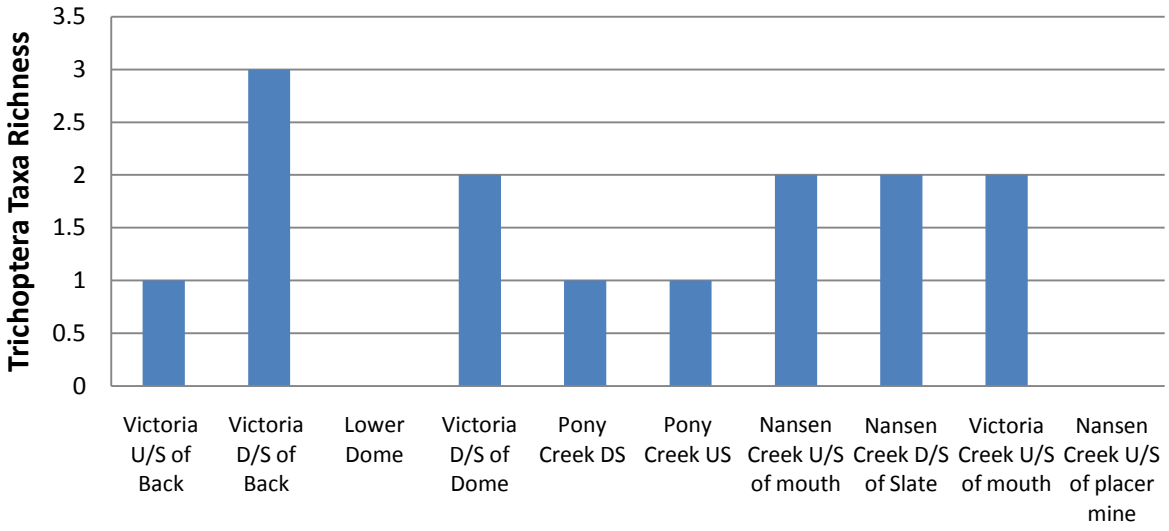


Figure 11.4: Trichoptera taxa richness of benthic invertebrates collected from watercourses within the Regional Study Area. (Note: U/S = upstream; D/S = downstream).

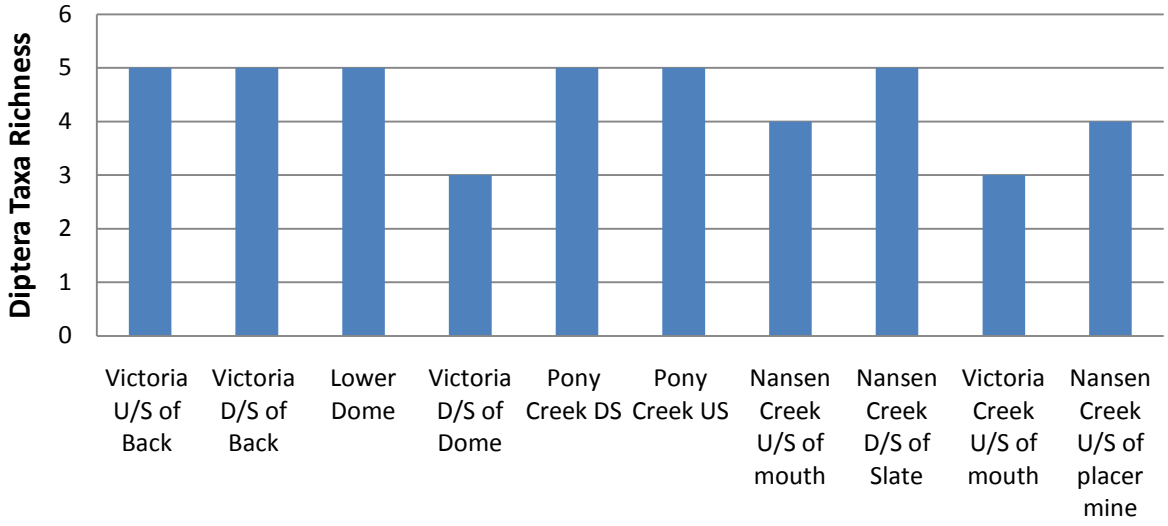


Figure 11.5: Diptera taxa richness of benthic invertebrates collected from watercourses within the Regional Study Area. (Note: U/S = upstream; D/S = downstream).

11.3.2 Order Level Relative Abundance

Relative abundance is a measure of the contribution of each of the major benthic invertebrate orders to the total number of individuals within the sample (expressed as a percentage). This analysis is conducted at the order level, and includes other benthic invertebrates outside of the four major orders. The relative abundance is presented for each sample site.

Victoria Creek

Sample sites within the upper reaches of Victoria Creek showed similar distributions of the four major benthic invertebrate orders (Figure 11.6, Figure 11.7 and Figure 11.8). At these sites, Diptera is the dominant order of benthic invertebrates (range of 68 to 81%); Plecoptera is the subdominant order followed by Ephemeroptera and Trichoptera. Other orders of invertebrates, if present, represent a small proportion of the diversity of the benthic invertebrate community.

In contrast to sites within the upstream reaches of Victoria Creek, Ephemeroptera were the dominant benthic invertebrate order (56%) at the samples site near the mouth of Victoria Creek (Figure 11.9). Diptera was subdominant (35%) at this site. Other orders of invertebrates (outside of the major four benthic invertebrate orders) were present at this site and represent 6% of the order level relative abundance at this site (Figure 11.9). Trichoptera and Plectoptera represented minimal percentage of the order level relative abundance at this site (2% and 1%, respectively).

Nansen Creek

At samples sites in Nansen Creek, Ephemeroptera is the dominant order of benthic invertebrates (Figure 11.10, Figure 11.11 and Figure 11.12). At the samples site upstream of the placer mining operation and the site near the mouth of Nansen Creek (Figure 11.10, Figure 11.11 and Figure 11.12), relative abundances of Diptera (37% and 43%, respectively) were close to relative abundances of Ephemeroptera (42% and 47%, respectively). Also, other orders constituted a notable portion of the relative abundance downstream of the placer mining operation (14%; Figure 11.10) and near the mouth of Nansen Creek (6%; Figure 11.12)

At the sample site downstream of Slate Creek relative abundance of the major orders were different; the relative abundance of Emphemeroptera (78%) was considerably higher than that of Diptera (13%; Figure 11.11). The relative abundance of Plecoptera was low; Trichoptera and other invertebrate orders were minimally represented.

Pony Creek

Upstream of the former waste rock piles, only two orders of benthic invertebrates were identified (Figure 11.13). Diptera represented 64% of the relative abundance of the benthic invertebrates at this site and Plecoptera represented the remaining 36%. Downstream of the former waste rock piles, similar relative abundances of Plecoptera, Diptera and other benthic invertebrate orders were identified (37%, 32% and 25%, respectively; Figure 11.14). Trichoptera were present in minimal amounts (5% of relative abundance) and Ephemeroptera were absent.

Dome Creek

Plecoptera were the dominant invertebrate order in lower Dome Creek (64%; Figure 11.15). Diptera were subdominant (27%) followed by other invertebrate orders (9%). No Ephemeroptera or Trichoptera were identified.

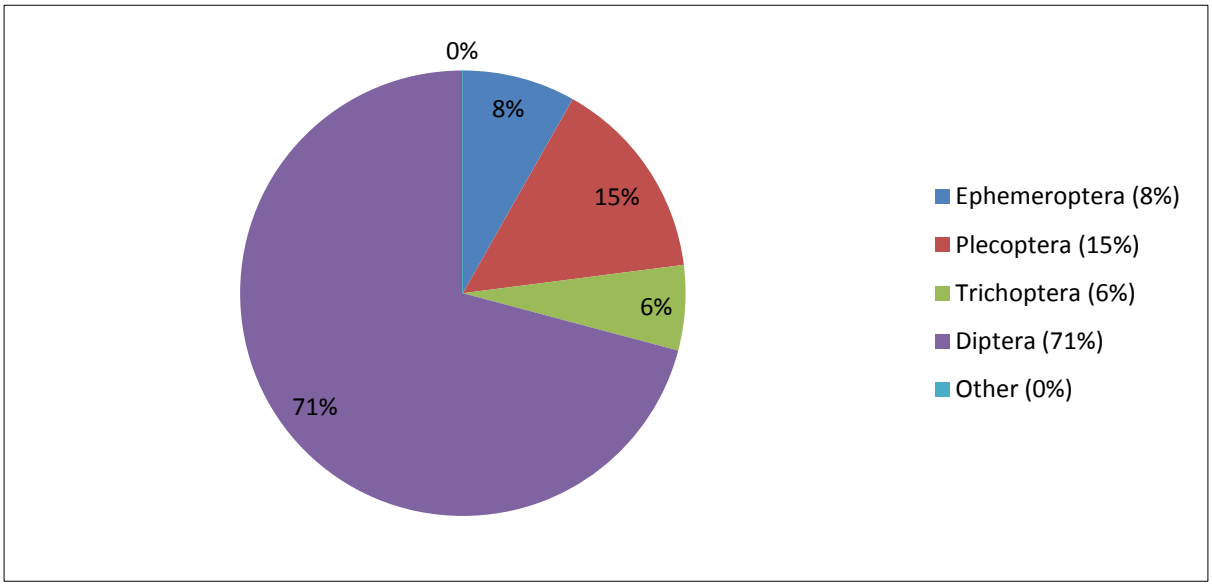


Figure 11.6: Relative abundance (%) of benthic invertebrate orders in Victoria Creek upstream of the mouth of Back Creek.

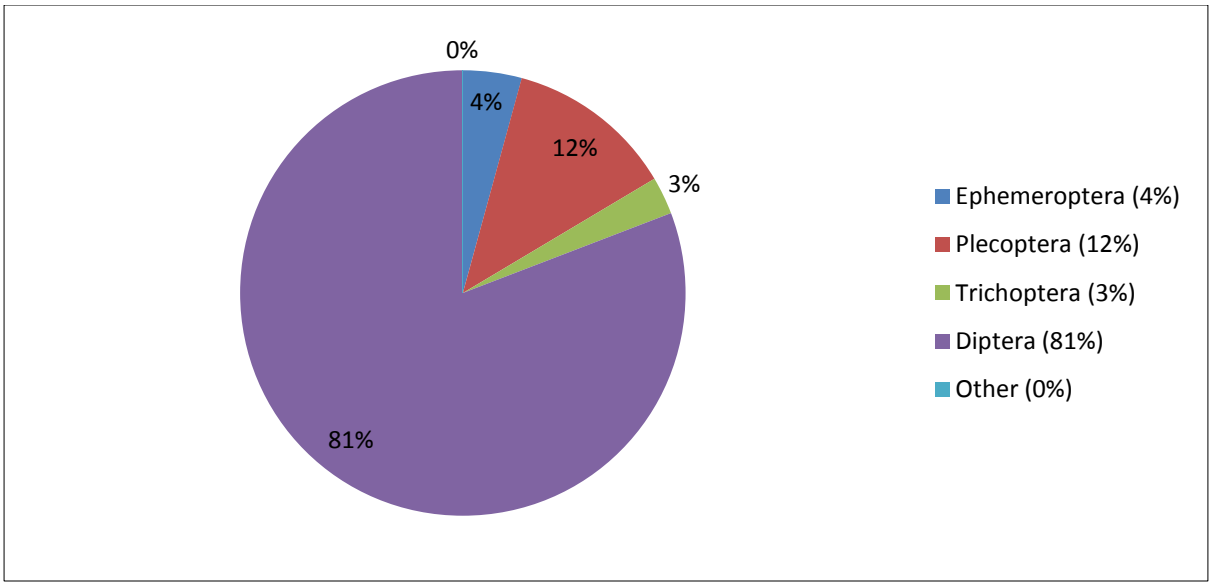


Figure 11.7: Relative abundance (%) of benthic invertebrate orders in Victoria Creek downstream of the mouth of Back Creek.

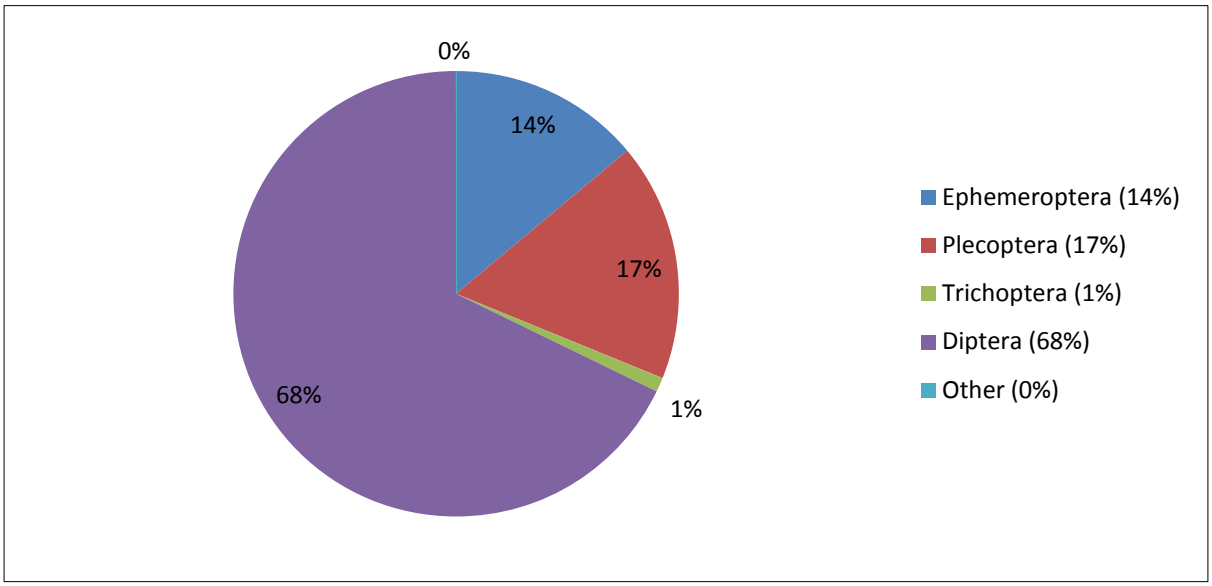


Figure 11.8: Relative abundance (%) of benthic invertebrate orders in Victoria Creek downstream of the mouth of Dome Creek.

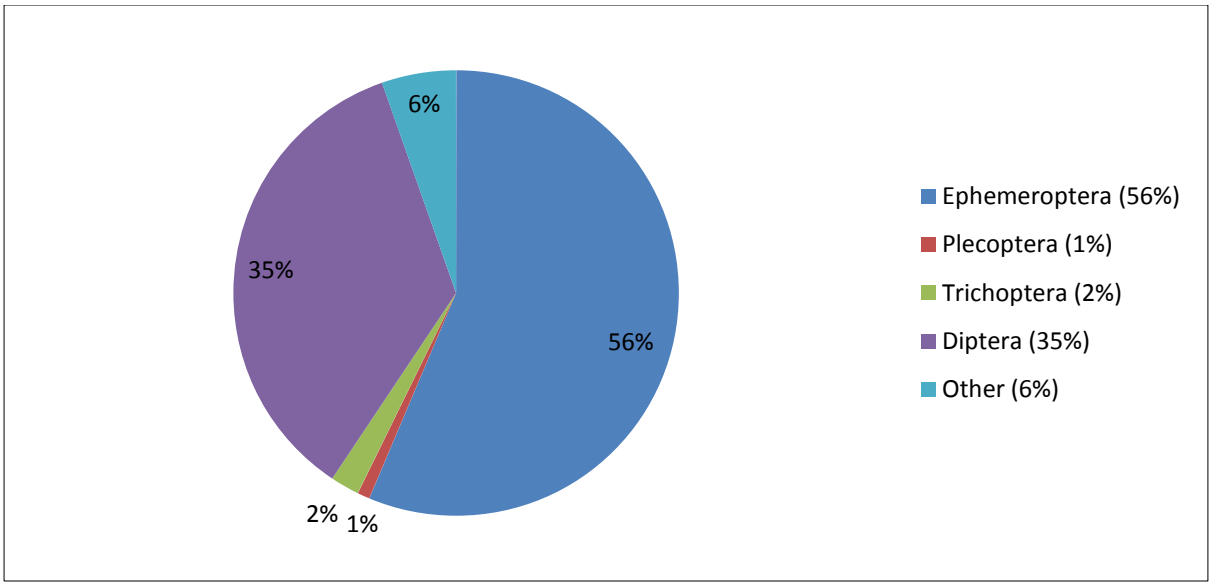


Figure 11.9: Relative abundance (%) of benthic invertebrate orders in Victoria Creek downstream of upstream of the creek mouth.

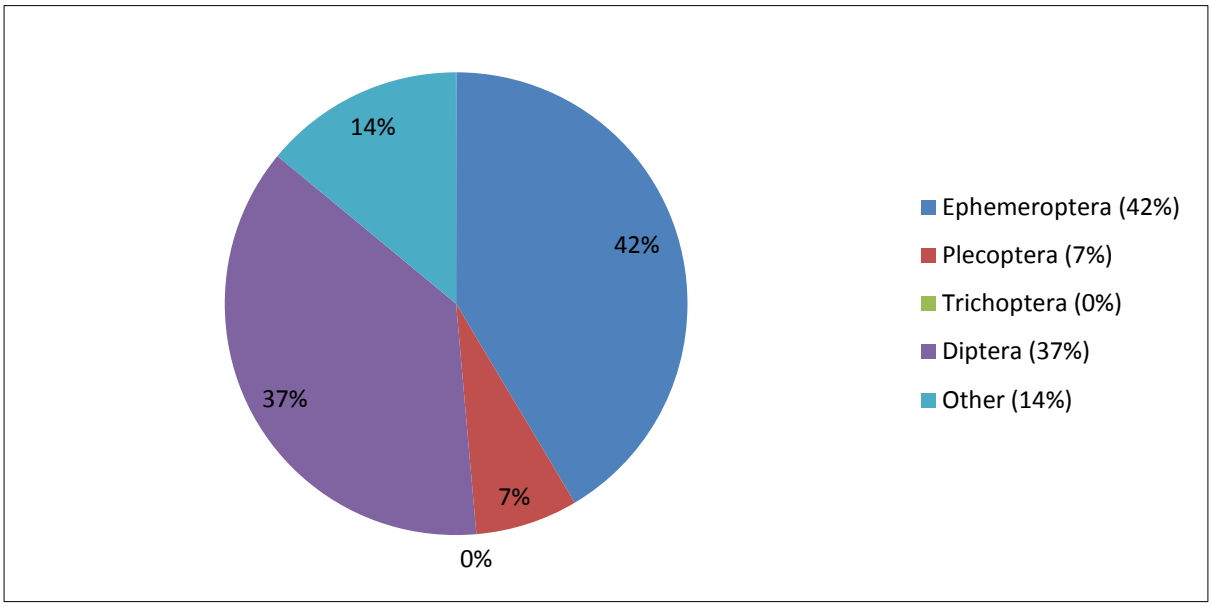


Figure 11.10: Relative abundance (%) of benthic invertebrate orders in Nansen Creek upstream of placer mining activity.

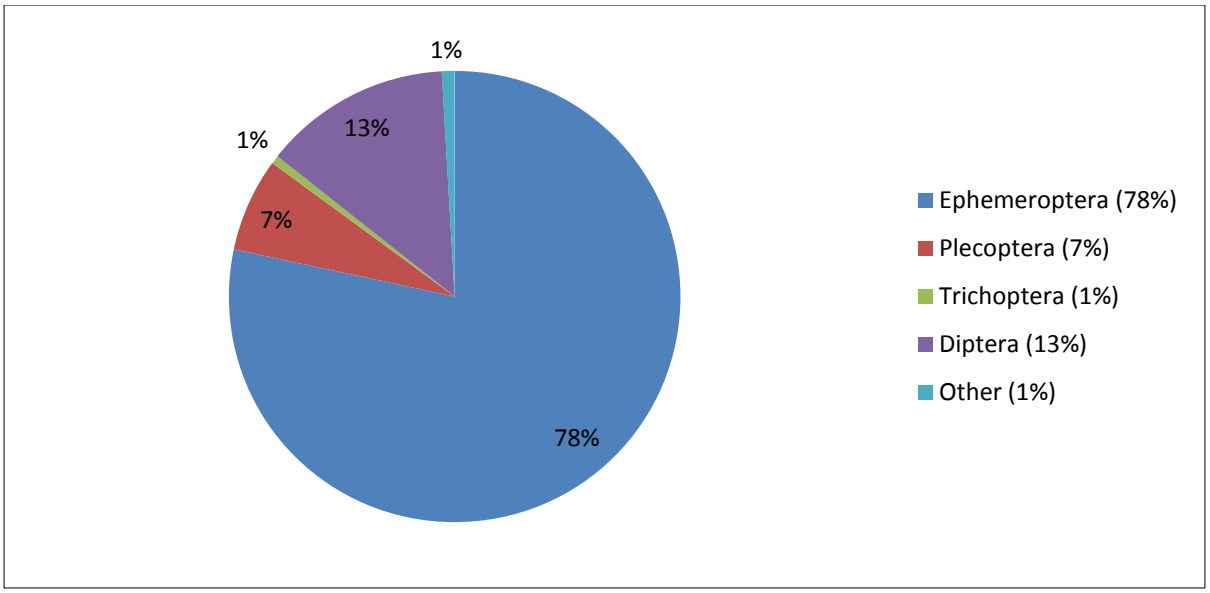


Figure 11.11: Relative abundance (%) of benthic invertebrate orders in Nansen Creek downstream of the mouth of Slate Creek.

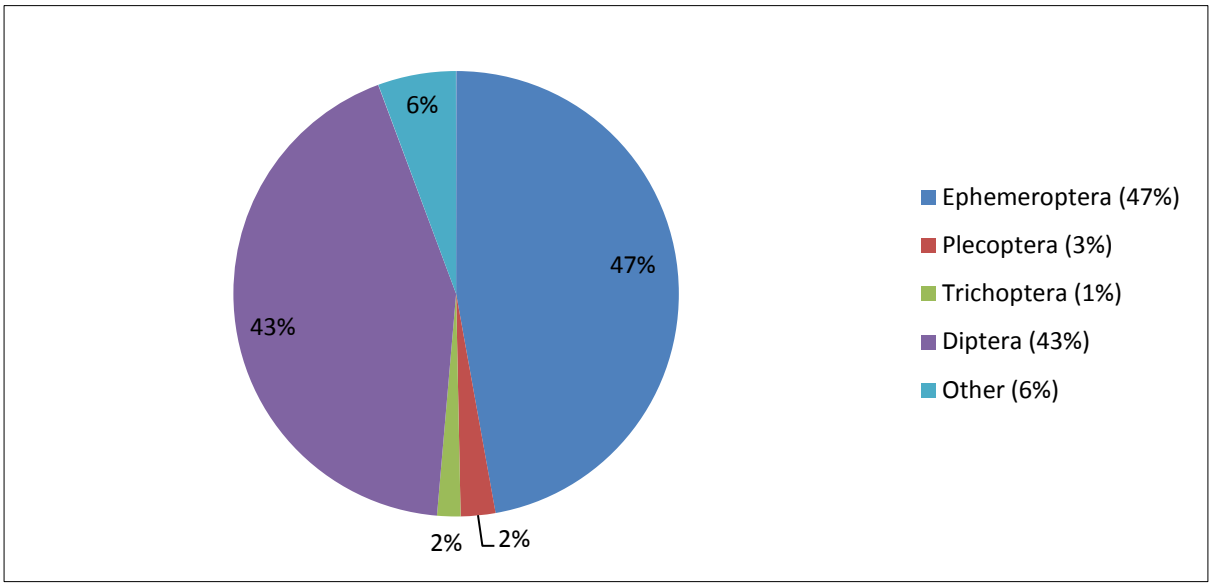


Figure 11.12: Relative abundance (%) of benthic invertebrate orders in Nansen Creek upstream of the creek mouth.

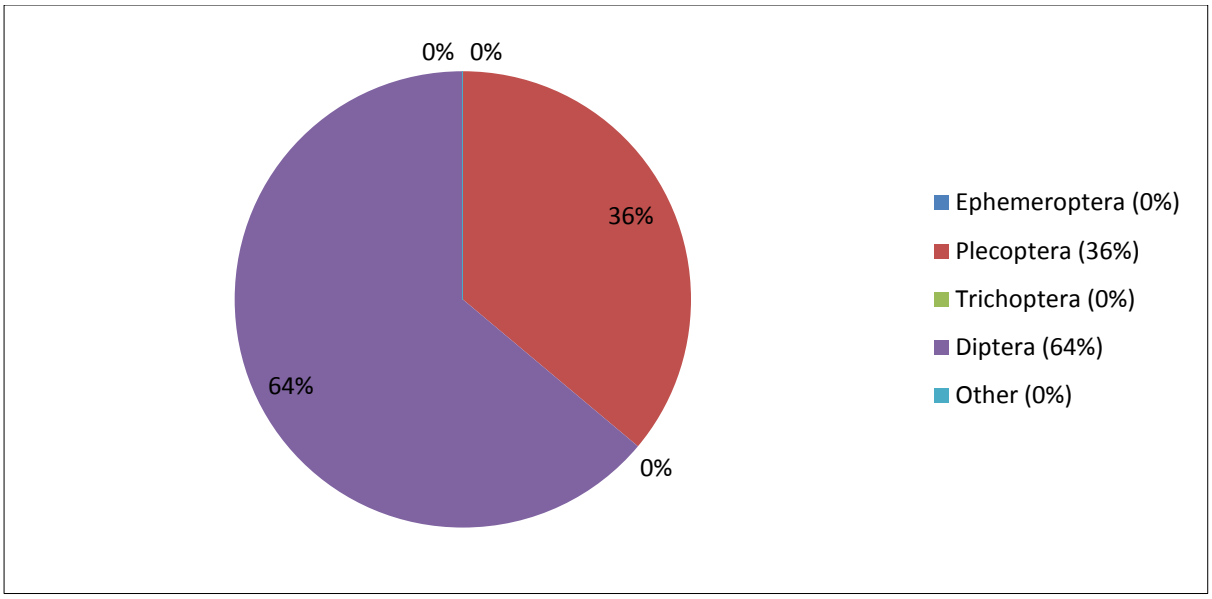


Figure 11.13: Relative abundance (%) of benthic invertebrate orders in Pony Creek upstream of former waste rock pile.

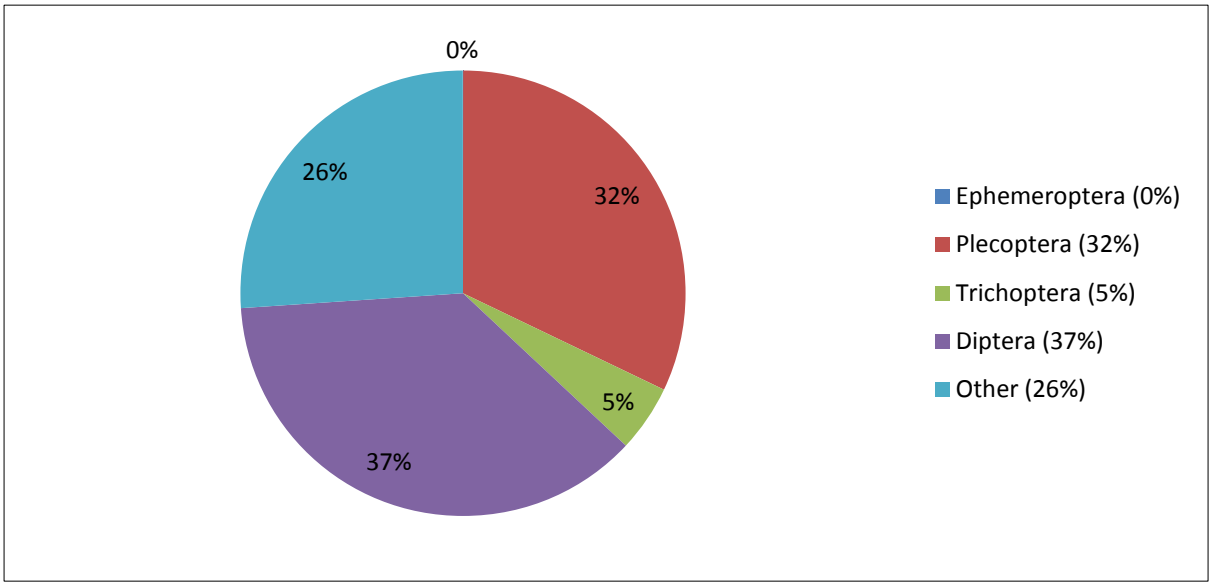


Figure 11.14: Relative abundance (%) of benthic invertebrate orders in Pony Creek downstream of former waste rock pile.

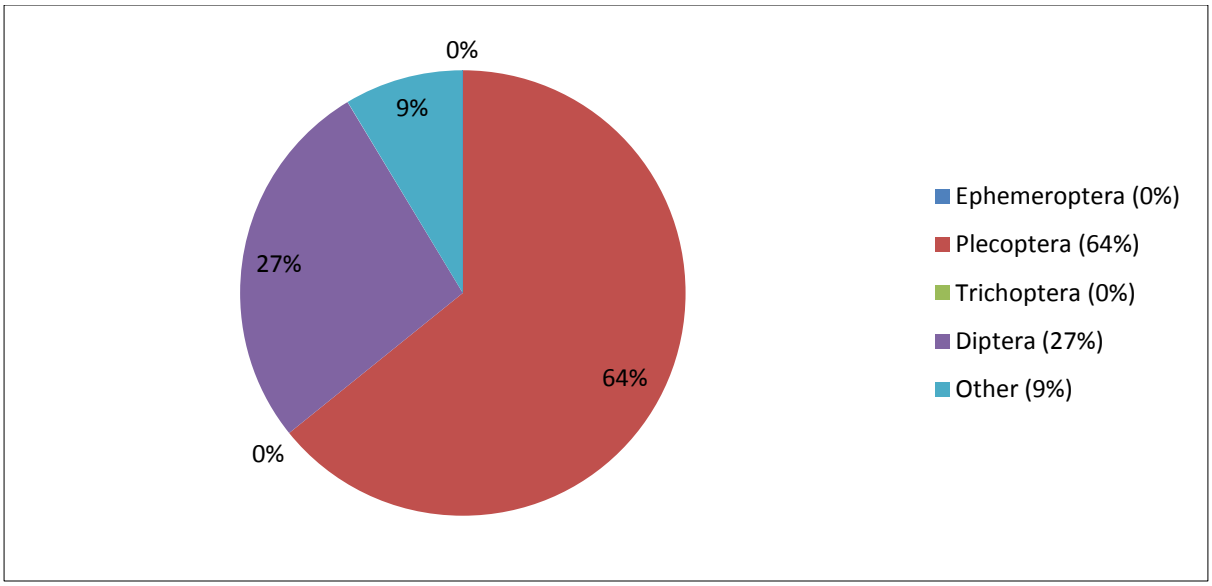


Figure 11.15: Relative abundance (%) of benthic invertebrate orders in lower Dome Creek.

12 References

12.1 Literature Cited

AECOM. 2010. Mt. Nansen Alternatives Characterization: January 2010 Draft. Page 37 + Append. Prepared for Assessment and Abandoned Mines, Yukon Government.

Arctic Climate Impact Assessment (ACIA). 2004. Impacts of a Warming Arctic - Arctic Climate Impact Assessment. Cambridge University Press, Cambridge, UK. 144 pp.

Assessment and Abandoned Mines Branch (AAM). 2008. Mount Nansen Mines Fast Facts. Page 2. Retrieved from http://www.emr.gov.yk.ca/aam/pdf/mn_fastfacts_march2008.pdf.

Assessment and Abandoned Mines Branch (AAM). 2010. Mount Nansen Climate Data. Provided by Patricia Randell, AAM, Department of Energy, Mines, and Resources, Yukon Government. Accessed 20 January, 2010.

Baer, A., and R. D. Hayes. 1987. Wolf Population Research and Management Studies in the Yukon Territory, Population Inventories — 1985–‘87. Part 3. Wolf Inventory, Nisling River Area. Yukon Department of Renewable Resources, Whitehorse, Yukon. 10 pp.

Bostock, H. 1966. Notes on Glaciation in Central Yukon Territory. Geological Survey of Canada, Paper No. 65-36.

Boyd, C. 2000. Water Quality: An Introduction. Kluwer Academic Publishers. 330 pp.

Canadian Endangered Species Conservation council (CESCC). 2006, August 28. Wild Species 2005, General Status Report. Retrieved January 29, 2010, from http://www.wildspecies.ca/wildspecies2005/.

Canadian Wildlife Service. 1998. Birds of the Yukon Database. Canadian Wildlife Service, Whitehorse, Yukon.

Canadian Council Ministers of the Environment (CCME). 2002. Canadian Sediment Quality Guidelines for the Protection of Aquatic Life. Updated in: Canadian environmental quality guidelines, 1999. Canadian Council of Ministers of the Environment, Winnipeg.

Canadian Council Ministers of the Environment (CCME). 2007. Canadian Environmental Quality Guidelines, Update 7.0., Winnipeg.

Conor Pacific Environmental Technologies Inc. 2000. Mount Nansen Mine site Historical Review, Site Assessment and Field Sampling Program. Prepared for Indian and Northern Affairs Canada. June 2000. 108 pp.

COSEWIC. 2002a. COSEWIC assessment and update status report on the woodland caribou *Rangifer tarandus* caribou in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa. Retrieved January 22, 2010, from http://www.cosewic.gc.ca/eng/sct5/index_e.cfm. 98 pp.

COSEWIC. 2002b. COSEWIC assessment and update status report on the Grizzly Bear *Ursus arctos* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa. Retrieved January 22, 2010, from http://www.cosewic.gc.ca/eng/sct5/index_e.cfm. 91 pp.

Denholm, E., D. Dumka, and G. Farquharson. 2000. A Review of the Mt. Nansen Property Yukon Territory. Toronto, Ontario. Prepared for DIAND. 85 pp.

Department of Fisheries and Oceans. 2010. FISS Database Search Engine. Retrieved February 25, 2010, from http://habitat.rhq.pac.dfo-mpo.gc.ca/fiss/dcf01.cfm.

EBA Engineering Consultants Ltd., Mougeot GeoAnalysis, and SRK Inc. 1994. Reclamation for Hardrock Exploration Mount Nansen Area, Yukon Territory. Prepared for DIAND – Northern Affairs Program. March 1994. 39 pp + append.

EDI Environmental Dynamics Inc. 2005. Mt. Nansen Terrestrial and Aquatic Effects Community Survey Summary. Summary, EDI Environmental Dynamics Inc., Whitehorse, Yukon. Prepared for: Government of Yukon, Abandoned Mines Branch; Energy, Mines and Resources, Whitehorse, YT.

EDI Environmental Dynamics Inc. 2007. Mt. Nansen Terrestrial and Aquatic Effects Study 2005–2006: Volume 1 of 3. 120 pp. Prepared for: Government of Yukon, Abandoned Mines Branch; Energy, Mines and Resources, Whitehorse, YT.

EDI Environmental Dynamics Inc. 2008. Benthic Invertebrate Communities at the Mt. Nansen Mine Site. 31 pp. EDI Environmental Dynamics Inc., Whitehorse, Yukon. Prepared for: Government of Yukon, Abandoned Mines Branch; Energy, Mines and Resources, Whitehorse, YT.

EDI Environmental Dynamics Inc. 2009a. Fish and Fish Habitat Assessment of Back and Pony Creeks Near the Mt. Nansen Mine Site. EDI Environmental Dynamics Inc., Whitehorse, Yukon. Prepared for: Government of Yukon, Abandoned Mines Branch; Energy, Mines and Resources, Whitehorse, YT. 15 pp.

EDI Environmental Dynamics Inc. 2009b. Benthic Invertebrate Communities at the Mt. Nansen Mine Site, Pony Creek. EDI Environmental Dynamics Inc., Whitehorse, Yukon. Prepared for: Government of Yukon, Abandoned Mines Branch; Energy, Mines and Resources, Whitehorse, YT. 27 pp.

EDI Environmental Dynamics Inc. 2009c, September 22. Re: Dome Creek Fish and Fish Habitat Assessment. Prepared for: Government of Yukon, Abandoned Mines Branch; Energy, Mines and Resources, Whitehorse, YT.

Environment Canada. 1979. Water Chemistry and Biological Conditions in the Watershed Near Mount Nansen Mines Ltd., Yukon Territory. Yukon District Office, Environmental Protection Service, Environment Canada. 21 pp.

Environment Canada. 2010a. Canadian Climate Data On-line Customized Search, National Climate Data and Information (NCDI) Archive. Government of Canada. Retrieved February 2, 2010, from www.climate.weatheroffice.ec.gc.ca/climateData/canada_e.html.

Environment Canada. 2010b, January 28. CABIN — Current Activities. Retrieved January 28, 2010, from http://cabin.cciw.ca/Main/cabin_current_activities.asp.

Environment Protection. 1999. Data Report: Summer 1998 field program Victoria Creek/Nisling River. Environment Canada, Whitehorse, YT.

Environment Yukon. 1989. The Fortymile Herd: On the Comeback Trail to the Yukon. Yukon Government, Whitehorse, YT. 16 pp.

Environment Yukon. 1996, July. Woodland Caribou Management Guidelines. Retrieved January 20, 2010, from http://www.yfwcm.ca/species/caribou/guidelines.php.

Environment Yukon. 2009a. Hunting Regulations Summary 2009–‘10. Yukon Government, Whitehorse, Yukon.

Environment Yukon. 2009b. Yukon Wildlife Key Area Inventory User's Manual. Yukon Government. Retrieved January 21, 2010, from http://environmentyukon.gov.yk.ca/mapspublications/documents/wka_manual_2009.pdf.

Farnell, R., R. Sumanik, J. McDonald, and B. Gilroy. 1991. The distribution, movements, demography, and habitat characteristics of the Klaza Caribou Herd in relation to the Casino Trail development, Yukon Territory. Yukon Department of Renewable Resources, Whitehorse, Yukon. 75 pp.

Frisch, R. 1983. Notes on birds and their habitats, Klaza-Prospector Mountains area, Dawson Range, Yukon Territory June 2–10, 1982. Unpublished Report Prepared for Canadian Wildlife Service, Whitehorse, Yukon.

Gartner Lee Ltd. 2007. Mt. Nansen Mine Site, Brown - McDade Pit Desktop Hydrogeology Study. Prepared for Energy, Mines and Resources Abandoned Mines Project Office.

Hayes, R., R. Farnell, R. Ward, J. Carey, M. Dehn, G. Kuzyk, A. Baer, C. Gardner, and M. O'Donoghue. 2003. Experimental reduction of wolves in the Yukon: Ungulate responses and management implications. Wildlife Monographs 35 pp.

Health Canada. 2004. Federal Contaminated Site Risk Assessment in Canada. Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA). http://www.hc-sc.gc.ca/ewh-semt/pubs/contamsite/part-partie_i/index-eng.php. Accessed February 12, 2010.

Hughes, O., R. Campbell, J. Muller, and J. Wheeler. 1968. Glacial Limits and Flow Patterns, Yukon Territory, South of 65 degrees North Latitude. Page 9. Paper, Geological Survey of Canada.

Karr, J. and E. Chu. 1999. Restoring Life in Running Waters: Better Biological Monitoring. Island Press, Washington, D.C. 220 pp.

Little Salmon Carmacks Fish and Wildlife Planning Team. 2004. Community-Based Fish and Wildlife Management Plan, Little Salmon/Carmacks First Nation Traditional Territory, 2004–2009. 44 pp.

Natural Resources Canada. 2010. 2005 National Building Code Seismic Hazard Calculation. Retrieved February 1, 2010, from http://earthquakescanada.nrcan.gc.ca/hazard/interpolator/index_e.php.

Norecol Environmental Consultants Ltd. 1989a. Environmental Up-Date Report for the Mount Nansen Gold Project. Vancouver, BC.

Norecol Environmental Consultants Ltd. 1989b. BYG Mount Nansen Fisheries and Hydrology Trip Report. August 21–22, 1989. 5 pp.

O'Donoghue, M., R. Ward, S. Westover, A. Reyner, and J. Bellemore. 2008. Carmacks west moose management unit. Summary of early-winter 2007 moose survey. 30 November – 7 December 2007. Department of Environment, Whitehorse, Yukon. 18 pp.

Osbourne, C. 1995. Fish Distribution Survey of Victoria, Dome and Nansen Creeks, Yukon Territory, 1995. Whitehorse, Yukon. Prepared by Government Renewable Resources. 13 pp.

Resh, V., and J. Jackson. 1993. Rapid assessment approaches to biomonitoring using benthic macroinvertebrates. Pages 195–233 *in* Rosenberg, D.M. and V.H. Resh (eds). Freshwater biomonitoring and benthic macroinvertebrates. Chapman and Hall, New York. 504 pp.

Reynoldson, T., C. Logan, T. Pascoe, and S. Thompson. 2003. Canadian aquatic biomonitoring network (CABIN) Invertebrate Biomonitoring Field and Laboratory Manual. National Water Research Institute, Environment Canada.

Sinclair, P., W. Nixon, C. Eckert, and N. Hughes. 2003. Birds of the Yukon Territory. UBC Press, Vancouver, BC.

Slough, B. G. 2009. Status Report on Amphibians in the Yukon (Western toad *Anaxyrus boreas*, boreal chorus frog *Pseudacris maculata*, Columbia spotted frog *Rana luteiventris* and wood frog *Lithobates sylvaticus*). Status Report, Environment Yukon, Whitehorse, YT.

Smith, C., J. Meikle, and C. Roots (Eds.). 2004. Ecoregions of the Yukon Territory: Biophysical properties of Yukon landscapes. Agriculture and Agri-Food Canada, Summerland, British Columbia. PARC Technical Bulletin No. 04-01

T.W. Higgs Associates Ltd., 1994. Initial Environmental Evaluation. Mt. Nansen Development, Volume 1 and Volume 2 (Appendices). Prepared for B.Y.G. Natural Resources Inc. 159 pp. + append.

Water Resources Section, Environmental Programs Branch, Yukon Government. 2009. Yukon Snow Survey Bulletins & Water Supply Forecasts. Retrieved February 12, 2010, from http://environmentyukon.gov.yk.ca/monitoringenvironment/snow_survey.php.

Yukon Ecoregions Working Group. 2004a. Klondike Plateau. Pages 159–168 in C. A. S. Smith, J. C. Meikle, and C. F. Roots, editors. Ecoregions of the Yukon Territory: Biophysical properties of Yukon landscapes. Agriculture and Agri-Food Canada, PARC Technical Bulletin No. 04-01, Summerland, British Columbia.

Yukon Ecoregions Working Group. 2004b. Yukon Plateau-Central. Pages 187-196 in C. A. S. Smith, J. C. Meikle, and C. F. Roots, editors. Ecoregions of the Yukon Territory: Biophysical properties of Yukon landscapes. Agriculture and Agri-Food Canada, PARC Technical Bulletin No. 04-01, Summerland, British Columbia.

Yukon Fish and Wildlife Management Board. 2000, September 20. Woodland Caribou Management Guidelines: July 1996 — Yukon Co-operative Fish & Wildlife Management. Retrieved February 23, 2010, from http://www.yfwcm.ca/species/caribou/herds.php.

Yukon Territorial Water Board. 1996. Water Licence QZ94-004.

12.2 Personal Communications

Baer, A. 2010. Coordinator, Wolf Management Program, Government of Yukon Department of Environment. Summary of Mt. Nansen wolf surveys. Pers. comm. with EDI, January 27, 2010.

Davidge, D. 2006. Environmental Protection Officer, Environment Canada Whitehorse. Raw benthic invertebrate sampling data for Mt. Nansen site from 1988 and 1997. Sent via e-mail to EDI, January 2010.

Hegel, T. 2010. Caribou Biologist, Species Programs. Government of Yukon Department of Environment. Klaza caribou herd survey summary. Pers. com. with EDI, January 20, 2010.

Jessup, L. 2010. Fisheries Technician, Government of Yukon Department of Environment. January 26. Meeting regarding Mt. Nansen Aquatic resources.

Jung, T. 2010. Senior Wildlife Biologist (Biodiversity), Government of Yukon Department of Environment. Summary of Yukon bison population, and bison range use around Mt. Nansen. Pers. comm. with EDI, January 25, 2010.

Kuhn, T. 2010. Wildlife Harvest Technician, Government of Yukon Department of Environment. Harvest in Mt. Nansen area. Pers. com. with EDI, February 1, 2010.

Marshall, S. 2010. Wildlife Technician, Species Programs, Government of Yukon Department of Environment. Mt. Nansen carnivores. Pers. com. with EDI, January 9, 2010.

Mulder, R. 2010. Biodiversity Information Specialist, Government of Yukon, Department of Environment. Mt. Nansen reclamation baseline report conservation concern vegetation summary. Pers. com. with EDI, February 1, 2010.

O'Donoghue, M. 2010. Regional Biologist, Northern Tutchone Region. Government of Yukon, Department of Environment. Interview with EDI, January 18, 2010.

Wheeler, B. 2010. Site Caretaker, Mt. Nansen Mine Site. Mt. Nansen fish and wildlife. Discussion with EDI, January 29, 2010.

Appendices

Appendix 1: Mt. Nansen site water quality data organized by season, and median values for each site and season.

| Sample Parameters | Units | Dry Creek - Reference (2007 - 2009) | | | Victoria Creek - Reference (2007 - 2009) | | | | Upper Victoria Creek (2005 - 2009) | | | | Victoria Creek at Road (1999 - 2009) | | | | DX (Dome Creek) (2007 - 2009) | | | | D1 (Dome Creek) (2007 - 2009) | | | | Upper Dome Creek (2005 - 2009) | | | | Dome Creek at Road Crossing (1999 - 2009) | | | | Pony Creek - Upstream site (2008 - 2009) | | | | Pony Creek - Downstream Site (2008 - 2009) | | | | Back Creek (2008 - 2009) | | | | Tailings Pond (1999 - 2009) | | | | Seepage (1999 - 2009) | | | | CCME AL Guidelines[1] | Water License Standards[2] |
|---|---|---

Appendix 2: Mt. Nansen sediment quality data summary.

Sample Site	Sampled by	Digest (Full/Partial)	Sample Year	Ag	Al	As	B	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Li	Mg	Mn	Mo	Na	Ni	P	Pb	S	Sb	Se	Si	Sn	Sr	Ti	Tl	U	V	Zn	Zr
B1	EDI	Full	2006	0.2	6580	40.6		141	0.25	<0.5	3590	0.85	5.19	14.3	14	19800	0.013	611	5.5	2500	676	1	148	7.49	892	31.8		0.8	<0.3	353	0.5	22.2	256	<0.3		46	84.3	3.2
	EDI	Partial	2006	0.2	2110	10.8		102	0.11	<0.5	2770	0.83	3.2	3.22	6.34	3850		250	1.9	1170	604	0.2	44	3.5	822	23.5	22	<0.5	<0.25		<0.2	13.4	48.4	<0.25	7	8.93	42.1	<0.05
B2	EDI	Full	2006	0.2	6570	34.3		124	0.3	<0.5	4000	0.72	4.5	16.1	13.5	20700	0.012	527	5.5	2460	523	0.76	161	7.29	990	28		0.9	<0.3	314	0.7	23.7	284	<0.3		52	82.1	2.7
	EDI	Partial	2006	0.2	2050	11		78.5	0.1	<0.5	2860	0.66	2.5	3.23	7.29	3790		220	1.9	1060	428	0.2	45	3.2	887	19	28	<0.5	<0.25		<0.2	13.9	51.1	<0.25	7.3	7.94	44.5	<0.05
B3	Norecol	Full	1986	<1.25		22.1						<1.25			11.5	19223	<0.05									14.9										59.4	
C1	Norecol	Full	1986	<1.24		10.7						<1.24			5.46	33009	<0.05									<2.5										39	
D7	Norecol	Full	1986	<1.23		25.2						<1.23			5.93	12112	<0.05									8.9										47.4	
D6	EDI	Full	2006	0.3	6520	74.8		59.2	0.16		3950	0.3	3.3	12.2	8.84	14000	0.008	538		2890	192	0.2	190	8.29	576	15.9		2.9	0.2		0.4	20.7	291			28.7	69.5	2
	EDI	Partial	2006	0.2	2120	51.9		36.1	0.08	<0.5	2900	0.2	1.9	3.3	6.14	5210		260	1.8	1010	122	0.07	69.8	4	571	13.1	83.2	<0.5	<0.2		<0.2	11.2	62.1	<0.2	4	7.8	44.6	<0.05
	EDI	Full	2005	< 2	5060	206	< 1	43	< 1		4110	1.7	4	13	7	15200	< 0.01	396		2210	159	< 4	165	6	803	25		< 10	< 0.2		< 5	16	262			38	54	1
	EDI	Full	2005	< 2	5030	216	< 1	46	< 1		4150	1.7	4	14	7	15600	< 0.01	395		2220	165	< 4	163	6	789	24		< 10	< 0.2		< 5	16	266			39	55	1
	EDI	Full	2005	<0.15	6150	186		50.4	0.19		4600	<0.05	3.3	15.4	7.03	19900		593		2480	195	0.1	208	8	724	22.4		1.5	0.96		1	23.6	172			46.4	65.5	2
	EDI	Partial	2005	<0.15	2540	163		29.6	0.09		2700	<0.05	1.8	4.62	5.39	7040		290		1260	122	<0.05	80.5	4.6	721	20.4		<0.5	<0.2		3.2	12.3	64.9			8.86	38.4	<0.05
	Yukon Geological Survey	Full	1985	0.2		92.5						0.6	5		9		0.019				550	1		7		8					0.5					50	77	
	Environment Canada	Full	1997	2	31540	848		411	1		15800	3.4	29.9	54.4	73.5	88500		5465		7780	2069	5	470	34	1100	222		60	8		8	77.4	1424			140	459	
	Environment Canada	Full	1997	2	24470	937		294.8	0.8		12200	4	18.9	47.7	54.3	49510		4025		7580	950.6	2	480	26	910	199		55	8		9	69.3	1667			100	449	
	Environment Canada	Full	1997	2	25720	924		287.6	0.7		12300	2.7	17.2	47.8	43.7	50200		4224		7540	665.2	2	680	23	930	120		30	8		19	77	1776			99	380.5	
	Environment Canada	Full	1997	2	28090	1300		384	1		13500	7	20.6	60.4	83.5	61700		5538		9260	1587	4	430	35	920	371		80	8		10	69.6	1552			130	730.7	
D5	Conor Pacific	Full	1999	1.5	21800	189		264	0.5		11400	1.5	7.9	38	162	24000		4790		6590	571	1	2780	20.3	630	90		5	<2		3	77	1160			54	172	9.5
D4	EDI	Full	2006	<0.2	5920	128		74.2	0.18		3610	<0.05	3.8	16.4	12	22100	0.005	570		2560	182	0.4	195	9.66	792	5.8		<0.5	<0.3		0.3	18.6	252			47.2	37.7	2.1
	EDI	Partial	2006	<0.1	1760	101		45	0.08	<0.5	2210	<0.05	1.7	2.95	8.21	6430		270	1.5	771	90.4	0.05	70.3	4	700	4.1	152	<0.5	<0.2		<0.2	8.71	44.2	<0.2	3	6.09	18	<0.05
	EDI	Full	2005	< 2	6310	38	< 1	55	< 1		5630	0.5	5	13	16	12800	< 0.01	494		2770	228	< 4	201	7	715	5		< 10	< 0.2		< 5	21	306			30	46	1
	EDI	Full	2005	< 2	6180	35	< 1	47	< 1		5440	< 0.5	5	13	15	12400	< 0.01	487		2730	223	< 4	185	7	681	6		< 10	< 0.2		< 5	20	298			29	43	1
	EDI	Full	2005	< 2	4960	11	< 1	58	< 1		2520	< 0.5	3	10	18	8330	< 0.01	493		2170	133	< 4	148	6	420	6		< 10	< 0.2		< 5	13	236			16	27	1
	EDI	Full	2005	<0.15	7500	34.2		48.7	0.23		5670	0.7	3.6	14	16.6	16400	NA	786		2880	276	0.2	285	9.2	568	8.1		1.1	0.84		0.81	31.4	343			37.2	51.3	2.3
	EDI	Full	2005	<0.15	3100	27.3		35.6	0.11		4020	0.2	2.5	5.5	15.1	7040		360		1540	188	<0.05	99.2	6	646	5.64		<0.5	<0.2		0.4	17.2	87.9			10.4	34.8	<0.05
	Environment Canada	Full	1988	2	6690	1340		89.4	0.2		6640	6.3	20	15	17.5	22400				3170	930	5	200	8	700	470					8	28.6	490			45	555	
	Environment Canada	Full	1988	2	6290	2170		102	0.3		7610	13	20	16	30.5	22900				3100	1320	7	100	9	750	887					8	29.8	356			42	876	
	Environment Canada	Full	1988	2	6280	2760		106	0.3		8240	14	20	14	38.5	24700				3130	1310	5	100	7	800	1030					8	30.8	301			42	1010	
	Conor Pacific	Full	1999	15.7	22700	239		204	0.5		16300	0.8	9.5	59.7	683	34000	NA	4130		8520	589	1	1790	19.2	1070	24		<2	<2		2	74	2310			78	114	15.8
D3	EDI	Full	2006	<0.2	7080	61.7		69.5	0.2		4690	0.2	3.2	14.4	8.08	18000	0.012	535		2980	184	0.4	172	8.66	761	8.6		0.6	0.3		0.3	22.2	306			38.2	52.8	2
	EDI	Partial	2006	<0.1	2260	32.6		47.3	0.1	<0.5	3620	0.1	1.6	3.73	6.84	7120		220	1.7	995	101	0.09	53.7	4	750	6.94	118	<0.5	<0.2		<0.2	12.9	67.6	<0.2	5.1	11.9	25.8	<0.05
	EDI	Full	2005	< 2	5790	25	< 1	45	< 1		6600	< 0.5	4	12	6	11500	< 0.01	456		2770	302	< 4	170	7	641	6		< 10	< 0.2		< 5	22	295			28	44	1
	EDI	Full	2005	< 2	4680	14	< 1	42	< 1		2620	< 0.5	3	8	9	7380	< 0.01	324		1860	88	< 4	121	5	471	< 5		< 10	< 0.2		< 5	12	229			15	33	1
	EDI	Full	2005	<0.15	6990	12.7		48	0.2		6490	0.1	3.1	11.9	5.58	12200	NA	713		2960	354	0.2	268	8.2	491	5.02		0.62	0.67		0.5	31.9	296			27.9	41.9	2.2
D2	EDI	Full	2006	0.2	6240	153		53	0.14		3880	<0.05	2.6	9.88	5.43	14400	0.013	420		2360	140	0.2	163	6.05	740	7.2		1	<0.3		0.3	19.3	255			22.6	64.1	1.6
	EDI	Partial	2006	<0.1	1980	124		28.6	0.065	<0.5	2640	<0.05	1.6	2.75	4.2	7590		190	1.7	819	73.8	0.06	46	2.9	703	5.17	185	<0.5	<0.2		<0.2	10.2	66.6	<0.2	4	7.41	49.4	<0.05
	EDI	Full	2005	< 2	5450	13	< 1	47	< 1		3350	< 0.5	3	12	11	11200	< 0.01	412		2290	95	< 4	138	6	721	< 5		< 10	< 0.2		< 5	15	293			29	33	1
	EDI	Full	2005	<0.15	6680	11		50.1	0.19		3390	13.2	2.5	13.2	9.23	13400	NA	686		2570	107	0.2	223	7.4	504	4.5		<0.5	0.4		0.8	22.4	292			33.2	37.1	2.1
	EDI	Partial	2005	<0.15	2870	16.8		32.2	0.09		2210	0.1	1.5	4.88	8.32	4900		310		1390	53.8	0.06	64.5	4.6	717	13.7		<0.5	<0.2		0.59	11	85.3			8.86	39.6	<0.05
D1	EDI	Full	2006	8.6	6440	2500		97	0.21		6290	48	9.3	11.2	157	51900	0.207	855		2800	713	0.96	146	9.84	915	507		99.6	<0.3		1.3	34.2	243			35.1	2030	3
	EDI	Partial	2006	13.3	1980	506		63.9	0.12	<0.5	5520	13.7	6.08	2.96	123	34800		220	1.5	1220	2170	0.2	32	5.1	754	447	398	13.4	<0.25		0.2	25.3	42.9	<0.2	15	11.7	1700	0.3
	EDI	Full	2005	7	6370	1180	< 1	88	< 1		4450	13.1	4	11	40	14500	0.05	556		2740	305	< 4	127	6	683	295		49	0.2		< 5	18	273			21	662	1
	EDI	Full	2005	<0.15	7840	1080		94.1	0.2		4480	4.8	4	11.7	43.6	18200	NA	930		3210	385	0.3	205	7.7	556	324		57	0.61		1.4	26.5	248			26.4	744	1.9
	EDI	Full	2005	<0.15	3490	182		54.2	0.12		3360	2.6	2.6	5.95	27.7	9470		400		1940	297	0.06	57.5	4.9	629	283		4.6	0.3		0.94	15.6	138			13.4	400	0.3
N1	Norecol	Full	1986	<1.22		21.1						<1.22			26	14216	<0.05									18.1										51.5	
N2	Norecol	Full	1986	<1.20		13						<1.20			14.9	10333	<0.05									9.13										41.6	
P1	EDI	Full	2006	0.2	7600	21.5		85.4	0.19	<0.5	3560	0.3	3	10.8	7.44	14200	0.023	587	7.1	2740	153	0.1	134	5.97	774	12.7		1	<0.3	274	0.4	22.1	293	<0.3		28.1	69.3	1.4
	EDI	Partial	2006	0.2	2870	11.1		65.4	0.11	<0.5	2760	0.3	1.8	3.35	4.9	5730		300	2.7	1260	82.8	0.08	41	3	700	11.4	75.2	<0.5	<0.2		<0.2	14.9	112	<0.2	4	9.62	45.6	<0.05
	EDI	Full	1999	0.9	39400	125		406	0.7	<5	10600	2.2	11.3	26.7	114	35000	NA	4560	17.2	6420	1980	<1	1360	16.2	944	72	940	<2	<2	2990	<1	68	1140	<1	<5	61	243	13.2
P2	EDI	Full	2006	9.5	7800	945		137	0.3	5.1	4260	5.2	5.56	13	95	28700	0.079	986	6.6	2790	892	0.4	167	8.18	748	345		88.8	<0.3	513	0.6	41.9	239	<0.3		33	582	2.1
	EDI	Partial	2006	5.68	2650	350		85.4	0.16	1.9	3400	4.4	3.3	3.37	50.9	9450		270	1.8	1100	789	<0.05	50.1	3.8	593	182	319	3.4	<0.25		<0.2	25.8	47.4	<0.25	7.7	10.1	352	0.1
P3	EDI	Full	2006	12.7	7910	1020		150	0.3	13.5	5400	22.8	7.35	10.4	214	55600	0.136	698	7	2370	1800	<0.05	150	7.99	708	409		91.7	<0.3	356	0.8	60.2	176	2		29.1	948	2.9
	EDI	Partial	2006	8.92	2610	454		136	0.2	4.3	4700	16.2	4.6	2.66	139	33900		140	1.8	866	1710	<0.05	41	4.3	501	188	462	1.7	<0.25		0.4	48.6	21.6	2.1	25	12.8	756	1.1
	Conor Pacific	Full	1999	98.9	57900	4480		669	0.6	54	3780	31.5	9.6	17.2	1150	106000	NA	17300	23.6	2710	3360	3	882	8.9	694	4090	23000	310	<2	457	1	93	296	<1	<5	56	2070	8.4
V7	Conor Pacific	Full	1999	<0.5	33000	52		357	0.7		10300	1.2	11.2	29.4	44	32000	NA	7200		7910	1210	2	1560	13.1	834	43		<2	<2		2	78	1300			71	133	13.7
V6	EDI	Full	2006	<0.2	5630	7.9		75.5	0.15	<0.5	3560	0.1	2.8	11.9	5.62	14100	0.007	340	5.2	2120	185	0.4	143	5.7	828	6.7		<0.5	<0.3	280	0.3	20.6	271	<0.3		36.5	31.3	1.6
	EDI	Partial	2006	<0.1	1780	3.6		51.6	0.085	<0.5	2400	0.1	1.4	2.55	3.4	3180		160	1.7	712	112	0.1	44	2.5	842	4.5	21	<0.5	<0.2		<0.2	12.4	47.3	<0.2	5.8	6.55	17.2	<0.05
	EDI	Full	2005	< 2	4980	< 10	< 1	70	< 1		3030	< 0.5	3	9	11	9580	< 0.01	304		1900	139	< 4	121	4	734	< 5		< 10	< 0.2		< 5	15	238			23	30	< 1
	EDI	Full	2005	<0.15	6550	5		71.9	0.19		3400	0.1	2.6	10.3	10.6	11400	NA	546		2290	154	0.3	196	6	577	6.04		<0.5	0.53		0.61	25.6	253			26.1	35	1.9
	EDI	Partial	2005	<0.15	2740	3.5		52.9	0.1		2460	0.1	1.8	4.62	9.88	4980		190		1190	100	0.1	55.5	3.9	892	5.94		<0.5	<0.2		0.64	14.9	62.7			9.22	24.2	<0.05
	Yukon Geological Survey	Full	1985	0.1		7.1						0.4	14		14		0.052				1750	1		10		1					4					55	85	
V5	EDI	Full	2006	<0.2	6760	12.8		93.3	0.19	<0.5	3920	0.2	3.7	16.5	9.17	20200	0.014	440	6.3	2480	288	0.51	154	7.28	892	8.8		<0.5	0.3	249	0.4	24.2	310	<0.3		51.9	45.6	2
	EDI	Partial	2006	<0.1	2160	5.66		68	0.095	<0.5	2560	0.2	1.9	3.24	5.71	4190		200	1.9	860	189	0.1	46	3.1	770	6.65	36	<0.5	<0.2		<0.2	15.1	53.7	<0.2	5.6	8.6	24.8	<0.05
	EDI	Full	2005	< 2	4070	< 10	< 1	59	< 1		2650	< 0.5	3	8	4	10000	< 0.01	269		1620	172	< 4	107	4	614	< 5		< 10	< 0.2		< 5	13	233			25	26	< 1
	EDI	Full	2005	< 2	5690	17	< 1	77	< 1		3000	< 0.5	4	11	19	11100	< 0.01	378		2280	207	< 4	129	6	697	9		< 10	< 0.2		< 5	17	255			26	45	1
	EDI	Partial	2005	<0.15	1380	7.32		36.4	0.075		943	0.1	1.6	2.44	2.7	3720		120		610	199	0.1	39	2.4	257	5.05		<0.5	<0.2		0.5	8.16	32.3			6.42	16.4	<0.05
	EDI	Full	2005	<0.15	4090	7.69		57.5	0.15		2070	< 0.5	2.5	7.67	4.9	9960	NA	430		1490	233	0.3	122	4.7	334	5.17		<0.5	0.6		4.8	15.8	181			22.6	29.4	1.8
V4	Conor Pacific	Full	2000	0.6	34600	89		434	0.9		9530	2.3	14.1	68.7	92.6	36000	NA	6900		7420	2650	5	1400	20.3	927	76		<2	<2		4	79	1160			77	228	15.3
V3	EDI	Full	2006	<0.2	6130	8		85	0.18		3780	0.2	3.6	17.4	8.65	22600	0.012	370		2250	236	0.5	143	6.51	879	7.4		<0.5	0.4		0.4	22	314			61.6	38	1.9
	EDI	Partial	2006	<0.1	1890	3.2		55.9	0.085	<0.5	2460	0.2	1.6	2.7	5	3460		170	1.6	736	137	0.1	44	2.5	810	4.9	30	<0.5	<0.2		<0.2	13.3	52.8	<0.2	6.5	7.19	19.6	<0.05
	EDI	Full	2005	< 2	4880	< 10	< 1	69	< 1		2910	< 0.5	3	11	6	11500	0.012	320		1870	192	< 4	121	5	687	6		< 10	< 0.2		< 5	16	259			30	31	1
	EDI	Full	2005	< 2	5020	< 10	< 1	72	< 1		3060	< 0.5	4	11	6	12100	0.01	326		1900	196	< 4	122	5	717	6		< 10	< 0.2		< 5	16	279			33	32	1
	EDI	Full	2005	< 2	4270	< 10	< 1	66	< 1		3520	< 0.5	4	18	12	20100	< 0.01	261		1620	143	< 4	100	5	1010	7		< 10	< 0.2		< 5	14	322			67	30	1
	EDI	Full	2005	<0.15	6190	7.71		67.1	0.2		3900	0.2	3.1	19.7	8.51	18100	NA	538		2120	311	0.6	191	7.7	592	9.18		<0.5	0.96		5.15	25.5	297			46.5	78.9	2.3
	EDI	Partial	2005	<0.15	2030	3.4		46.4	0.09		1790	0.1	1.8	7	5.29	4530		180		875	197	0.2	50.8	3.7	433	6.79		<0.5	<0.2		3.6	12.1	55.5			8.58	46	<0.05
	Conor Pacific	Full	2000	<0.5	31600	97		409	0.8		9210	1.9	14	27.2	127	36000	NA	6000		7510	3560	5	1850	17.3	1020	76		<2	<2		4	79	1020			70	210	14.9
V2	EDI	Full	2006	<0.2	5500	6.8		75	0.16		3720	0.1	3.2	16.8	6.36	23400	0.009	320		2020	199	0.4	132	5.96	920	6.1		<0.5	0.4		0.5	20.2	295			64.4	33.2	1.7
	EDI	Partial	2006	<0.1	1710	2.7		51.8	0.07	<0.5	2520	0.1	1.4	2.5	3.8	2930		160	1.4	656	109	0.1	41	2.4	918	4.8	26	<0.5	<0.2		<0.2	12.3	51	<0.2	7	6.3	17.1	<0.05
	EDI	Full	2005	< 2	4310	< 10	< 1	63	< 1		2870	< 0.5	3	12	5	14000	< 0.01	280		1670	147	< 4	105	4	725	< 5		< 10	< 0.2		< 5	15	247			40	28	1
	EDI	Full	2005	< 2	4560	< 10	< 1	71	< 1		2880	< 0.5	3	12	17	13100	< 0.01	289		1750	127	< 4	112	5	721	8		< 10	< 0.2		< 5	15	275			37	31	1
	EDI	Full	2005	<0.15	4540	4.5		54.6	0.16		2370	0.1	2.8	10.3	5.39	16100	NA	420		1620	183	0.3	125	4.7	397	6.73		<0.5	0.76		0.8	21.5	243			39.9	28.8	1.9
V1	EDI	Full	2006	<0.2	5780	5		77.3	0.18		3320	0.1	3.2	14.7	9.16	19600	0.01	340		2130	168	0.5	135	6.16	778	5.4		<0.5	0.5		0.6	20.5	301			52	32.5	1.8
	EDI	Partial	2006	<0.1	1810	2		55.1	0.075	<0.5	2190	0.1	1.4	3.17	6.51	3170		180	1.5	671	77.1	0.1	44	2.4	739	4.4	35	<0.5	<0.2		0.3	12.7	57	<0.2	5	6.68	17	<0.05
	EDI	Full	2005	< 2	4670	< 10	< 1	67	< 1		2800	< 0.5	3	10	5	10500	< 0.01	297		1800	118	< 4	112	4	656	< 5		< 10	< 0.2		< 5	16	245			27	26	< 1
	EDI	Full	2005	< 2	4620	< 10	< 1	67	< 1		3020	< 0.5	3	12	18	12600	< 0.01	292		1760	113	< 4	115	4	774	< 5		< 10	< 0.2		< 5	15	287			36	28	1
	EDI	Full	2005	< 2	4750	< 10	< 1	72	< 1		3050	< 0.5	3	12	19	12000	0.012	296		1830	119	< 4	109	5	753	5		< 10	< 0.2		< 5	15	269			32	30	1
	EDI	Full	2005	<0.15	5870	2.5		71	0.17		3390	0.1	2.6	10.8	5.64	13400	NA	500		2040	141	0.3	174	5.6	600	4.9		<0.5	0.52		1	24.9	246			33	30.6	1.8
	EDI	Partial	2005	<0.15	1950	1.7		45	0.08		1310	0.07	1.5	3.11	3.5	4000		160		806	84.3	0.09	44	2.8	385	3.6		<0.5	<0.2		0.52	12.4	56.7			7.41	16.6	<0.05
	Conor Pacific	Full	1999	<0.5	35000	11		339	0.7		12800	0.5	11.5	30.5	87.6	35000	NA	5900		9170	440	5	1710	12.9	1020	35		<2	<2		2	79	1960			76	119	19.3
W1	Norecol	Full	1986	<1.21		14.2						<1.21			5.59	17015	<0.05									3.89										28.7	