

Mount Nansen Care and Maintenance Project

Project Proposal

April 3, 2018

**Government of Yukon
Energy, Mines and Resources
Assessment and Abandoned Mines**

Executive Summary

The Government of Yukon is seeking assessment and authorization for care and maintenance of the Mount Nansen Site (the Site). This site is a former gold and silver mine located approximately 45 kilometers (km) west of the Village of Carmacks, Yukon. The Government of Yukon, Assessment and Abandoned Mines Branch has managed the care and maintenance of the Site since 2003. Ongoing care and maintenance of the Site is required until the remediation plans are prepared and presented in a separate YESAA project proposal, and all required authorizations to proceed are received.

The eventual remediation plan for the Site is for the Government of Canada to pay for remediation of the Site, but for this to be completed by a third-party bidder/purchaser. The current assessment is required in order for the Government of Yukon to obtain a Water Licence to operate care and maintenance activities at the Mount Nansen Site, allowing for the bidder/purchaser to continue such activities until further authorizations are obtained for remediation.

The proposed Mount Nansen Care and Maintenance Project (the Project) is primarily to allow the Government of Yukon to obtain a Water Licence for Care and Maintenance activities for a five-year term. The project includes the continuation of Site care and water management activities that have been ongoing since 2003, including the discharge of water from site and inspection and maintenance of various water conveyance structures. The Project also includes the construction and operation of a new water treatment plant that will act to lower the concentration of total suspended solids and total iron in discharge water from the tailings seepage pond through precipitation and clarification. A conceptual design supported by bench scale testing and solids characterization are presented within the project proposal and its appendices.

Various existing environment studies and socio-economic engagement processes have taken place in relation to the Site and its operations, and therefore a large body of information exists to support the project proposal. Existing environmental conditions are presented for general physiography, air quality, noise, surficial geology and soils, terrain hazards, seismicity, hydrogeology, groundwater quality, hydrology, surface water quality, aquatic environment, wildlife, and vegetation, with supporting appendices where relevant. Socio-economic existing conditions are presented for population, education and training, employment and economic stability, governance, services and infrastructure, community health and wellbeing, land and resource use, LSCFN cultural and social values, and sustainability and legacy.

The project proposal presents an environmental effects assessment that considered seven valued components (VCs) but focused on a detailed assessment of those VCs for which there were major interactions with the proposed project activities; these included surface water quality, fish and aquatic environment, and wildlife and wildlife habitat. The surface water quality and fish and aquatic environment VCs were assessed together (aquatics VCs) as the primary pathway for related effects was through water quality and is supported by a predictive model and water quality objectives. The model predicts an improvement of several key water quality parameters in Dome Creek, with less pronounced effects in Victoria Creek (both of which form the project receiving environment). Overall effects on the aquatics VCs

were found to be not significant moderate. The wildlife and wildlife habitat VC include several effects considerations but focuses on potential metals uptake and accumulation. The overall effects on wildlife were found to be not significant.

The project proposal also presents a socio-economic effects assessment that considered three VCs: employment and economic stability, community health and well-being, and sustainability and legacy. Through consideration of potential effects on subcomponents of these VCs, the assessment anticipated generally neutral or neutral to positive effects, with no negative effects. The primary neutral to positive predicted effects were related to training, human health, and the sustainability and legacy of the Site.

The project proposal presents numerous monitoring and inspection plans that accompany care and maintenance activities, and also presents a revised adaptive management plan (AMP) which provides the framework for Site water management and decision making. Aquatic effects and terrestrial effects monitoring programs are also presented as appendices.

List of Acronyms

<i>AAM</i>	Assessment and Abandoned Mines	<i>LSA</i>	Local Study Area
<i>AANDC</i>	Aboriginal Affairs and Northern Development Canada	<i>LSCFN</i>	Little Salmon/Carmacks First Nation
<i>ACH</i>	Aishihik Caribou Herd	<i>m</i>	Metres
<i>AEMP</i>	Aquatic Effects Monitoring Program	<i>m²</i>	Square Metres
<i>AMP</i>	Adaptive Management Plan	<i>m³</i>	Cubic Metres
<i>AQ</i>	Air Quality	<i>MAML</i>	Mobile Air Minorng Laboratory
<i>ASL</i>	Above Sea Level	<i>masl</i>	Meters above sea level
<i>BC</i>	British Columbia	<i>MCE</i>	Maximum Considered Event
<i>BCWQG</i>	British Columbia Water Quality Guidelines	<i>mg</i>	Milligram
<i>BMP</i>	Best Management Practices	<i>min</i>	Minute
<i>BYG</i>	BYG Natural Resources Inc.	<i>mm</i>	Millimetre
<i>°C</i>	Degrees Celsius	<i>MMER</i>	Metal Mining Effluent Regulations
<i>CABIN</i>	Canadian Aquatic Biomonitoring Network	<i>MNCMP</i>	Mount Nansen Care and Maintenance Project
<i>CAFN</i>	Champagne and Aishihik First Nations	<i>MNRP</i>	Mount Nansen Remediation Project
<i>CCME</i>	Canadian Council of Ministers of the Environment	<i>MOE</i>	Ministry of Environment
<i>CDA</i>	Canadian Dam Association	<i>MOECC</i>	Ministry of Environment and Climate Change
<i>CESCC</i>	Canadian Endangered Species Conservation Council	<i>MTL</i>	Maximum Tolerable Levels
<i>cm</i>	Centimetre	<i>NAD</i>	North American Datum
<i>cm²</i>	Square centimeters	<i>NAPS</i>	National Air Pollution Surveillance Program
<i>CN-WAD</i>	Weak Acid Dissociable Cyanide	<i>NWT</i>	Northwest Territories
<i>CO</i>	Carbon Monoxide	<i>OCP</i>	Official Community Plan
<i>COPC</i>	Contaminant of Potential Concern	<i>OIC</i>	Order-in-Council
<i>COSEWIC</i>	Committee on the Status of Endangered Wildlife in Canada	<i>PAL</i>	Protection of Aquatic Life
<i>CSPI</i>	Community Spatial Price Index	<i>PEL</i>	Probable Effects Levels
<i>CSQG</i>	Canadian Sediment Quality Guidelines for the Protection of Aquatic Life	<i>PM</i>	Particulate Matter
<i>CWB</i>	Common Well Being	<i>POPC</i>	Parameter of Potential Concern
<i>d</i>	day	<i>PSA</i>	Project Study Area
<i>dBA</i>	decibels	<i>PVC</i>	Polyvinyl Chloride
<i>DCDC</i>	Dome Creek Diversion Channel	<i>PwC</i>	PricewaterhouseCoopers
<i>DFO</i>	Fisheries and Oceans Canada	<i>RIC</i>	Resource Inventory Committee
<i>DTA</i>	Devolution Transfer Agreement	<i>RSA</i>	Regional Study Area
<i>ELC</i>	Ecological Landscape Classification	<i>RTC</i>	Registered Trap Concession
<i>EMP</i>	Environmental Management Plan	<i>s</i>	second
<i>EPT</i>	Ephemeroptera, Plecoptera and Trichoptera	<i>SAR</i>	Species at Risk
<i>ERPP</i>	Emergency Response Preparedness Plan	<i>SARA</i>	<i>Species at Risk Act</i>
<i>FAL</i>	Freshwater Aquatic Life	<i>SFN</i>	Selkirk First Nation
<i>FISS</i>	Fisheries Information Summary System	<i>Sp.</i>	Species

<i>g</i>	Gravity	<i>SQG</i>	Soil Quality Guidelines
<i>GGML</i>	Greenhouse Gas Measurement Laboratory	<i>SWE</i>	Snow Water Equivalent
<i>GHG</i>	Greenhouse Gas	<i>SWPC</i>	Surface Water Parameter of Potential Concern
<i>GMS</i>	Game Management Subzone	<i>SWQ</i>	Surface Water Quality
<i>GWQ</i>	Groundwater Quality	<i>t</i>	Tonne
<i>GWSG</i>	Groundwater Screening Guidelines	<i>TSF</i>	Tailings Storage Facility
<i>GY</i>	Government of Yukon	<i>TSS</i>	Total Suspended Solids
<i>ha</i>	Hectares	<i>uS</i>	Micro siemens
<i>Hp</i>	Horsepower	<i>VC</i>	Valued Component
<i>HPW</i>	Highways and Public Works	<i>VoC</i>	Village of Carmacks
<i>hr</i>	hour	<i>WKA</i>	Wildlife Key Area
<i>IDF</i>	Inflow Design Flood	<i>WQG</i>	Water Quality Guidelines
<i>ISQG</i>	Interim Sediment Quality Guidelines	<i>WQO</i>	Water Quality Objectives
<i>K</i>	Kelvin	<i>WRFN</i>	White River First Nation
<i>KCH</i>	Klaza Caribou Herd	<i>WTP</i>	Water Treatment Plant
<i>KFN</i>	Kluane First Nation	<i>YCDC</i>	Yukon Conservation Data Centre
<i>kg</i>	Kilograms	<i>YESAA</i>	<i>Yukon Environmental and Socio-economic Assessment Act</i>
<i>Km</i>	Kilometres	<i>YESAB</i>	Yukon Environmental and Socio-economic Assessment Board
<i>km²</i>	Square Kilometres	<i>YEWG</i>	Yukon Ecoregions Working Group
<i>kW</i>	Kilowatts	<i>YOIC</i>	Yukon Order in Council
<i>L</i>	Litre	<i>yr</i>	year

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Appendix 9A – LSCFN Valued Components and Community Based Information

1 Introduction and Proponent Information

1.1 Introduction

The Government of Yukon (GY) is seeking assessment and authorization for care and maintenance of the Mount Nansen Site (the Site). This site is a former gold and silver mine located approximately 45 kilometers (km) west of the Village of Carmacks (Carmacks), Yukon. GY has managed the care and maintenance of the Site since 2003. Care and maintenance activities include the ongoing operation and maintenance of various water management and mine-related facilities as well as the construction and operation of a water treatment plant.

The information contained in this document generally follows the order of the information required in the Designated Office Form 1 available from the Yukon Environmental and Socio-economic Assessment Board (YESAB).

1.2 Site History

Exploration in the Mount Nansen project area commenced in the 1940s, with mining operations occurring over three discrete periods beginning in the late 1960's. Between 1968 and 1969, approximately 10,000 tonnes of flotation tailings were generated from ore mined from the Huestis and Webber underground developments. The operation closed down due to poor gold and silver recoveries. At this time, the Brown-McDade deposit was explored underground from an adit collared adjacent to Pony Creek.

During the second period of mining between 1975 and 1976, approximately 5,000 tonnes of ore from the Huestis deposit were processed through the existing mill. Again, poor recoveries forced the premature closing of this operation.

The last stage of active mining occurred between 1996 and 1999, during which time BYG Natural Resources Inc. (BYG) accessed ore from the Brown-McDade zone. This open pit operation processed approximately 269,000 tonnes of ore through the existing mill at a production rate of approximately 500 tonnes per day, producing approximately 35,700 ounces of gold. BYG ceased operations in February 1999 due to difficulties meeting their water licence requirements, lower than expected gold and silver recoveries, and an inability to meet required financial security payments. The BYG operation was compounded by environmental concerns relating to the geotechnical and operational aspects of managing the tailings facility (i.e., tailings dam), as well as a failure to meet effluent toxicity requirements.

Operations ceased in early February 1999, and in August 1999, the then federal Department of Indian Affairs and Northern Development (DIAND) formally declared the property abandoned and took over under Section 39 of the Waters Act (Yukon). In April 2003, the Devolution Transfer Agreement (DTA) between Canada and the Yukon came into effect and management of the Site was transferred to the Government of Yukon who continues to oversee the care and maintenance for the Site. In April 2004, the Government of Yukon and DIAND successfully petitioned the Supreme Court of the Yukon Territory to

put BYG Natural Resources Inc. into receivership. PricewaterhouseCoopers (PwC) was appointed as Interim Receiver and was responsible for the assets left on the site and for resolving any outstanding creditor claims.

Since the DTA came into effect, the Government of Yukon was charged with the administrative and care and maintenance operations of Type II mine sites, including the Mount Nansen mine site, while the financial responsibility for Type II mine sites continues to reside with the federal government. Since 2003, the Government of Yukon and Government of Canada along with LSCFN have completed a number of scientific investigations at the Site (e.g., wildlife, surface water, groundwater, contaminants, fish and fish habitat) that informed the development of potential remediation options for the Site. Following remediation plan discussions, including public input, a final remediation option was chosen in 2012. Ongoing care and maintenance of the Site is required until the remediation plans are prepared, are presented in a separate YESAA project proposal and receive all the required authorizations to proceed.

1.3 Proponent Information

The proponent for this Mount Nansen Care and Maintenance Project is the Assessment and Abandoned Mines Branch (AAM), Department of Energy, Mines and Resources, Government of Yukon.

1.3.1 Proponent Contact Information

Proponent Representative and Primary Contact

Contact and mailing information:

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A/Manager, Type II
Assessment and Abandoned Mines
Department of Energy, Mines & Resources
Government of Yukon
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Whitehorse, YT, Y1A 2C6
Phone: 867.667-3208
Email: heather.mills@gov.yk.ca

Street Address:

Assessment and Abandoned Mines
Royal Bank Building
4114 Fourth Avenue, Unit 2C
Whitehorse, YT, Y1A 4N7

The preferred method of correspondence is through email.

1.3.2 Project Title

The title of this project is the Mount Nansen Care and Maintenance Project.

1.3.3 Other Proponent Related Information

The Government of Yukon maintains care and control of the Mount Nansen Site. Financial responsibility for the Mount Nansen Site resides with the Government of Canada (represented by INAC). Specifically, the Government of Canada provides funding for site care and maintenance operations as well as for the development of long-term remediation plans. This funding is provided through the Federal Contaminated Sites Action Plan. Little Salmon Carmacks First Nations is identified as affected under the DTA.

In 2016, the Government of Canada initiated the sale of the Mount Nansen site through the Interim Receiver PricewaterhouseCoopers. The sale includes the transfer of the abandoned mine site's claims to a third party private sector company, with a requirement for the purchaser to complete remediation work at the site.

The Government of Yukon will continue care and maintenance activities until the sale is complete, at which time the activities will be taken over by the Purchaser through assignment of regulatory instruments.

2 Requirement for an Evaluation under YESAA

The Mount Nansen Care and Maintenance Project (MNCMP; the Project) triggers assessment under the *Yukon Environmental and Socio-economic Assessment Act* (YESAA; 2003) because it includes several activities that are listed as assessable in the *Assessable Activities, Exceptions, and Executive Committee Projects Regulations*; the Government of Yukon is the proponent (YESAA Paragraph 47(2)(b)); and the Project that will also be subject to a number of authorizations and approvals in accordance with federal and territorial legislation (YESAA Paragraph 47(2)(c)).

2.1 Location

The project is located in the Yukon. For additional details about the Project location see Section 3.

2.2 Activities

The Project involves the following activities listed in Schedule 1 of *Assessable Activities, Exceptions, and Executive Committee Projects Regulations* (MOJ 2005) under YESAA.

Table 2.2-1 presents a list of potential activities at the Mount Nansen Site that are assessable under YESAA regulations. This list will be clarified and finalized with regulatory agencies as the Project proceeds through the various authorization processes.

Table 2.2-1: Assessable Activities for the Mount Nansen Care and Maintenance Project

Part	Item	Activity
1	3	On other than an Indian reserve, construction, operation, modification, decommissioning or abandonment of, or other activity in relation to, a mine — other than a coal or placer mine — but not including exploration for the purpose of quartz mining or other activity in relation to exploration for the purpose of quartz mining.
9	12	Other than for an electrical power undertaking, the deposit of waste into water or in any other place under conditions in which the waste, or any other waste that results from the deposit, may enter water.
13	12	On Crown Land or settlement land, moving earth or clearing land using a self-propelled power-driven machine.
13	13	On Crown Land or settlement land, leveling, grading, clearing, cutting or snow ploughing of a trail, the right of way of a road, or a route that provides access to land for the purposes of a geophysical, geological or engineering survey.

The Project will not include any activities related to mineral exploration, or any additional activities other than those for the purpose of planning the eventual remediation of the site.

2.3 Assessment Triggers and Decision Bodies

The Government of Yukon is the proponent of this project, and as such, triggers the requirement for assessment under Paragraph 47(2)(b) of YESAA (2015): “*a territorial agency, municipal government, territorial independent regulatory agency or first nation is the proponent and an authorization or the grant of an interest in land would be required for the activity to be undertaken by a private individual*”.

The project will also be subject to a number of authorisations and approvals, as identified in Table 2.3-1 below, in accordance with federal and territorial legislation, and therefore triggers the requirement for assessment under Paragraph 47(2)(c)) of YESAA (2015): “*an authorization or the grant of an interest in land by a government agency, independent regulatory agency, municipal government or first nation is required for the activity to be undertaken*”.

Table 2.3-1 presents permits/authorizations that are required and potentially applicable to the Project. This list will be refined and finalized with regulatory agencies as the project proceeds through the various authorization processes.

Table 2.3-1: Applicable Authorization

Applicable Legislation/Regulations	Permit or Authorization	Responsible Agency
Required Permits or Authorizations		
<i>Waters Act</i> Waters Regulation	Type B Water License	Yukon Water Board
Potentially Applicable Permits or Authorizations		
<i>Territorial Lands Act</i> (Yukon)	Land Use Permit	Energy, Mines and Resources, Government of Yukon
<i>Boiler and Pressure Vessel Act</i>	Pressure Vessel Boiler Permit	Community Services, Government of Yukon
<i>Building Standards Act</i>	Building Permit	Community Services, Government of Yukon
<i>Electrical Protection Act</i>	Plumbing Permit	
Storage Tank Regulations	Storage Tank Systems Permit	Community Services, Government of Yukon
<i>Gas Burning Devices Act</i>	Gas Installation Permit Gas Burning Devices Permit	Community Services, Government of Yukon

Given that funding will be provided through INAC, AAM is identifying the department as a federal Decision Body for the project as per Paragraph 2 (1)(c)(ii) of YESAA (2015): “any federal agency that (ii) in the case of a project to be located wholly or partly on non-settlement land, is a proponent of the project, has the power to grant an interest in land that is required for the project to be undertaken or has received an application for financial assistance for the project”.

3 Project Location

3.1 Assessment District

The project is anticipated to be assessed by YESAB's Mayo Designated Office given that the project is located within Central Assessment District Boundary.

3.2 Physical Location

The Mount Nansen Site is located approximately 180 km north of Whitehorse and 45 km west of Carmacks, Yukon (70 km by road; Figure 3.2-1). Elevation at the Site is approximately 1,200 m above sea level (a.s.l.). The Site is accessible year-round by a publicly maintained all-weather road from Carmacks. The project does not occur within a Yukon community.

The Government of Yukon has enacted an Order-In-Council (OIC) placing a prohibition from staking (quartz and placer) over approximately 1,200 hectares of land covering the mine site footprint (i.e., the project area is defined by the OIC boundary).

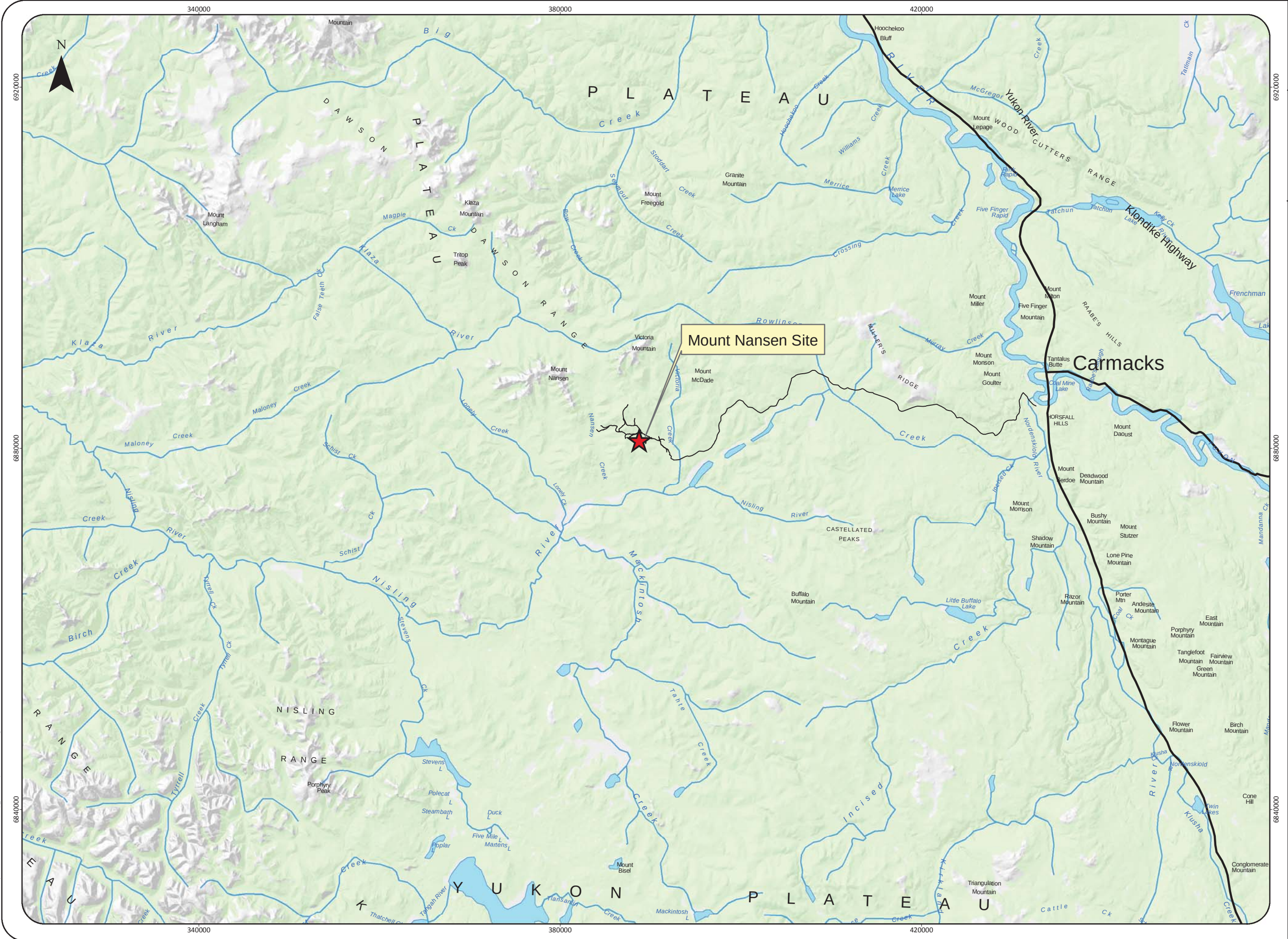
The UTM boundary coordinates (NAD 83) of the Mount Nansen Site on NTS map sheet 115 I03 are provided below and correspond with the extent set out by the Yukon Order in Council 2006/2005 (YOIC, 2006) for the Site (Figure 3.2-2). There is currently no Regional Land Use Plan in effect for the Project area.

NW: Zone 08N 386579 6882920

NE: Zone 08N 392152 6882960

SW: Zone 08N 386595 6879340

SE: Zone 08N 392144 6879348



Mount Nansen Care and Maintenance
Project Proposal
Figure 3.2-1
Location Overview Map



- Legend**
- Project Location
 - Roads
 - Watercourse
 - Waterbody
 - Vegetation



Data Source:

1.Roads digitized using imagery or spatial data provided by YG - Assessment and Abandoned Mines Branch.

2.National Topographic Data Base (NTDB) compiled by Natural Resources Canada at a scale of 1:250,000. Reproduced under license from © Her Majesty the Queen in Right of Canada, Department of Natural Resources Canada. All rights reserved.

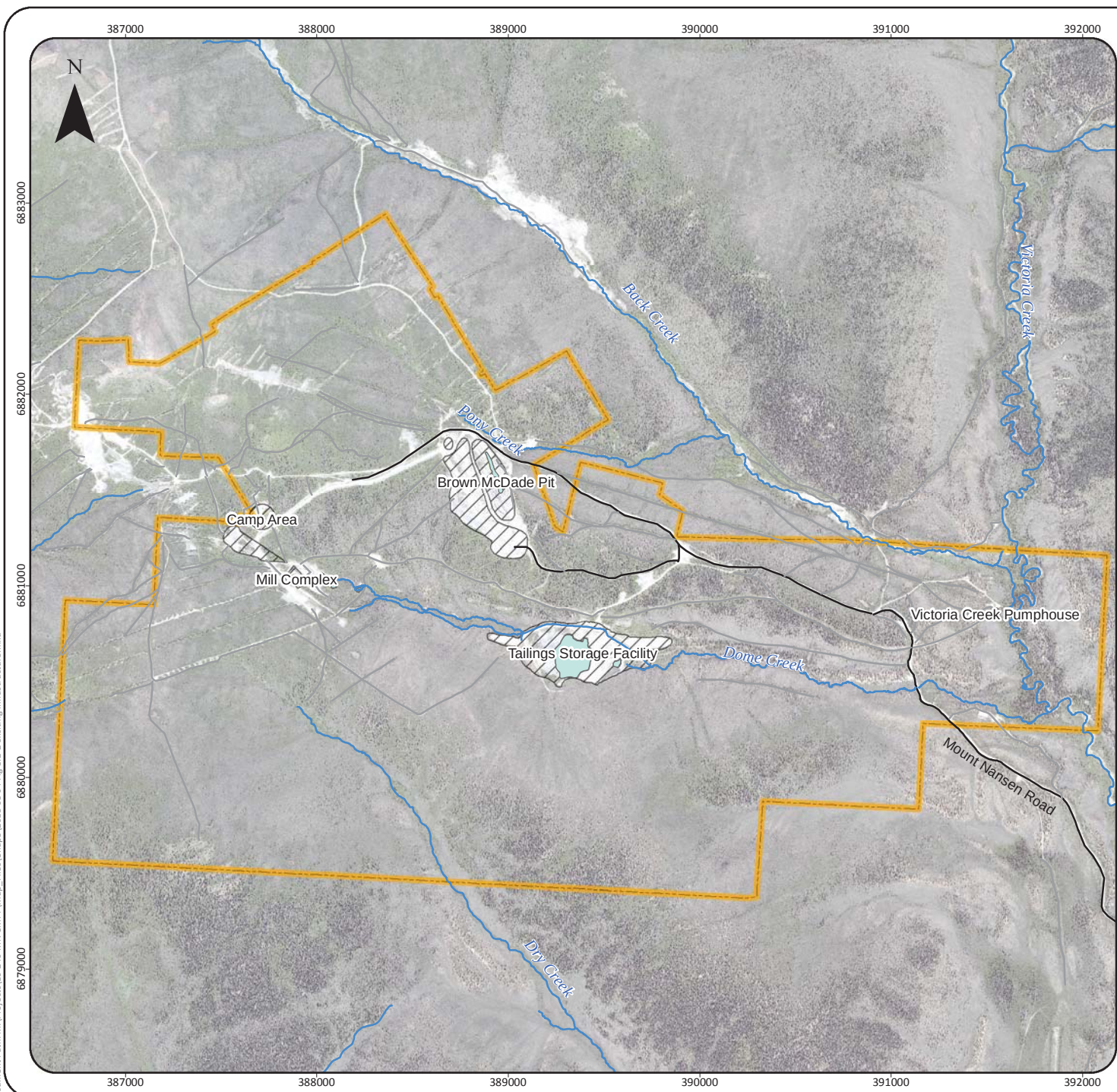
Datum: NAD 1983 CSRS UTM Zone 8N

Scale 1:400,000

Kilometers

0 8 16

March 4, 2018



Mount Nansen Care and Maintenance Project Proposal

Figure 3.2-2
Project Location Detail



Legend

~ Watercourses

~ Trails

~ Roads

Waterbodies

Site Infrastructure Areas

Local Boundaries

Order In Council Area (2006/2005)



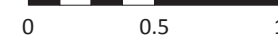
Data Source:

1. Site features (e.g., roads, trails, waterbodies, watercourses and infrastructure areas) digitized from imagery.
2. 2008 Quickbird imagery and spatial data provided by Yukon government.

Datum: NAD 1983 CSRS UTM Zone 8N

Scale 1:30,000

Kilometers



March 4, 2018

3.3 Watershed and Drainage

The Project is located within the White River watershed. Dome Creek and Pony Creek drain from within the Site (Figure 3.2-2). Dome Creek flows into Victoria Creek which then flows south into the Nisling River, which in turn empties to the Donjek River and White River (Figure 3.2-1). Pony Creek flows into Back Creek and then into Victoria Creek. All site facilities fall entirely within these two drainages (i.e., Dome Creek and Pony Creek drainages).

3.4 First Nation Traditional Territory and Lands

The Mount Nansen Site is located within the Little Salmon Carmacks First Nation (LSCFN) Traditional Territory. The Mount Nansen Site is also located in an area with asserted rights by the White River First Nation (WRFN). The boundary of the Champagne and Aishihik First Nations (CAFN) Traditional Territory is located approximately 8 km south of the Site. Water from the Site (to the point that the Nisling River enters the Donjek River) flows through or directly adjacent to the Traditional Territory of the CAFN, the Selkirk First Nation (SFN), and the WRFN (Figure 3.4-1).

The Project does not occur on First Nation settlement lands or interim protected lands, but such lands do occur within the vicinity and downstream of the Site. Table 3.4-1 provides a summary of lands within 15 km of the Site or adjacent to Victoria Creek or the Nisling River, as shown on Figure 3.4-2.

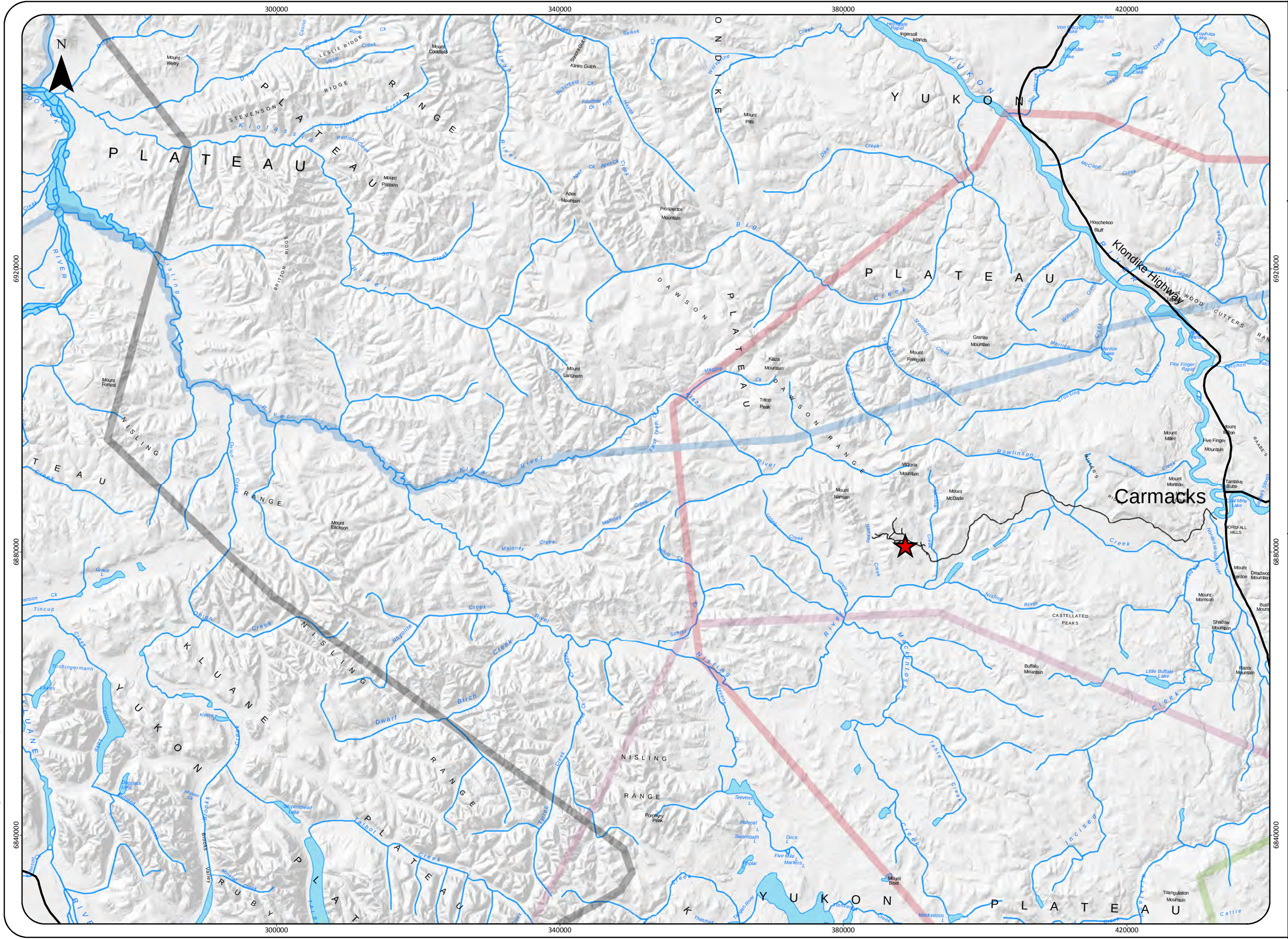
Table 3.4-1: First Nation Lands in the Vicinity or Downstream of the MNCMP

First Nation ¹	Land Parcel	Land Parcel Type	Distance and Direction ²
LSCFN	LSC R-21B	Settlement Land	0.5 km Southwest; at and upstream of the confluence of Victoria Creek and the Nisling River
LSCFN	LSC R-66A	Settlement Land	0.8 km South
LSCFN	LSC R-31A	Settlement Land	1.1 km Northwest on a tributary of Nansen Creek
LSCFN	LSC S-147B1	Settlement Land	4.9 km Southeast; adjacent to the Nisling River
LSCFN	LSC R-30A	Settlement Land	6.5 km Southwest; 9.9 km down the Nisling River
LSCFN	LSC R-8A	Settlement Land	8.8 km North
LSCFN	LSC R-65B	Settlement Land	10.1 km South west; 12.7 km down the Nisling River
CAFN	CAFN S-66B1	Settlement Land	10.2 km Southwest
LSCFN	LSC R-37B	Settlement Land	10.8 km Northeast
LSCFN	LSC S-164B1	Settlement Land	12.2 km East
LSCFN	LSC S-2B1	Settlement Land	13.8 km Northeast
CAFN	CAFN R-35B	Settlement Land	34.2 km down the Nisling River
CAFN	CAFN R-30B	Settlement Land	132.5 km down the Nisling River
KFN	KFN R-25B	Settlement Land	140 km down the Nisling River
WRFN	WRFN R-23B	Interim Protected Land	149.9 km down the Nisling River
WRFN	WRFN R-11B	Interim Protected Land	168 km down the Nisling River

Notes:

¹ LSCFN – Little Salmon Carmacks First Nation; CAFN – Champagne and Aishihik First Nations; KFN – Kluane First Nation; WRFN – White River First Nation

² Cardinal direction and distance measured from the nearest point on the boundary of the OIC. Watercourse distances represent the approximate distance downstream from the confluence of Victoria Creek and the Nisling River.



Mount Nansen Care and Maintenance Project Proposal

Figure 3.4-1
First Nations Traditional Territories

Yukon
Energy, Mines and Resources
Assessment and Abandoned Mines

Legend

- Project Location
- FN Traditional Territory**
 - Champagne and Aishihik First Nations
 - Kluane First Nation
 - Kwanlin Dün First Nation
 - Little Salmon/Carmacks First Nation
 - Selkirk First Nation
 - White River First Nation
- Base Layers**
 - Roads
 - Watercourse
 - Waterbody

Mount Nansen Site

Data Source:

- National Topographic Data Base (NTDB) compiled by Natural Resources Canada at a scale of 1:250,000. Reproduced under license from © Her Majesty the Queen in Right of Canada, Department of Natural Resources Canada. All rights reserved.
- First Nations Traditional Territory boundaries (courtesy of Yukon Geomatics) provided by Yukon government.

Datum: NAD 1983 CSRS UTM Zone 8N

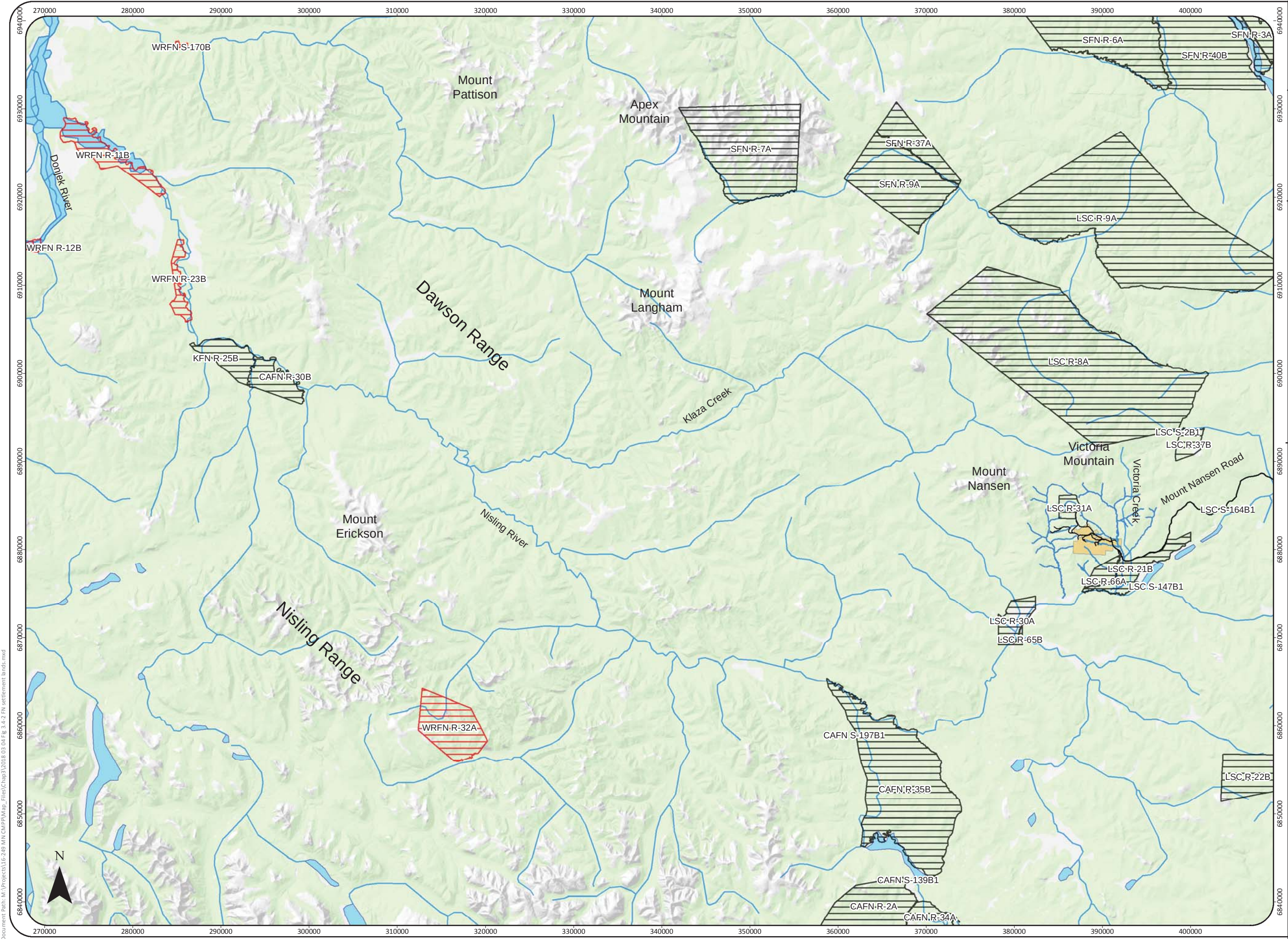
Scale 1:510,000

Kilometers

0 7.5 15

March 4, 2018

Document Path: M:\Projects\16-249 M/N CMP\Map_Files\Chap3\2018 03 04 Fig 3.4-2 FN settlement lands.mxd



**Mount Nansen Care and Maintenance
Project Proposal**
Figure 3.4-2
First Nation Lands



Legend

- Interim Protected Lands
- Yukon First Nation Settlement Lands
- Local Boundaries
 - Order In Council Area (2006/2005)
 - Watercourses
- Base Layers
 - Roads

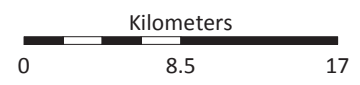


Data Source:

1. Site features (e.g., roads, trails, waterbodies, and watercourses) digitized using imagery.
2. 2008 Quickbird imagery (courtesy of Yukon Geomatics) and spatial data provided by Yukon government.
3. Land Disposition (courtesy of Yukon Geomatics) and spatial data provided by Yukon government.

Datum: NAD 1983 CSRS UTM Zone 8N

Scale 1:410,000



March 4, 2018

3.5 LSCFN and Village of Carmacks Engagement Activities

The DTA acknowledges the effects of the historical mine on LSCFN and as such mandates opportunities for LSCFN participation in project planning. The LSCFN has a critical role with respect to the decisions made on the Project, as well as its overall advancement through design, regulatory processes and implementation. The Government of Yukon has been working collaboratively with LSCFN to ensure that their views are provided full and fair consideration in advance of decisions. Further, the Government of Yukon has strived to provide LSCFN with the level of information required to provide effective and meaningful feedback on decisions that may affect them or their Traditional Territory. Funding has been provided to LSCFN since 2006 in an effort to ensure that LSCFN is able to effectively and meaningfully participate on the Project.

Funding provided to LSCFN has covered costs such as:

- Technical consultants;
- Community meetings;
- Studies and effects assessments in reference to the site and its influence; and
- A project-specific resource.

The Government of Yukon continues to maintain a dialogue and collaborative working relationship with LSCFN through various engagement activities, including but not limited to:

- Participating in monthly working group meetings;
- Participating in project decision-making and planning workshops/meetings;
- Participating in site-wide monitoring activities; and
- Participating in remediation planning, including:
 - Development and finalization of Project Objectives for the remediation of the site;
 - Selection of a remediation option; and
 - Remediation plan design development.

Table 3.5-1 below generally presents engagement activities completed in developing and selecting a remediation option for the site.

Table 3.5-1: Remediation Planning Engagement Activities

Date	Event Title or Subject	Parties Involved	Discussion Items / Outcome
2006 – 2010	Remediation Objectives	YG, LSCFN, Village of Carmacks, INAC	A series of public information sessions and workshops were held with the LSCFN and the Village of Carmacks to gather information on local priorities and concerns regarding the remediation of the abandoned Mount Nansen mine Site. These meetings determined and defined the remediation objectives for the project.
2011 – 2012	Remediation Option Selection	YG, LSCFN, INAC	A number of potential remediation options were identified and presented to the Project Parties. The Government of Yukon, the Government of Canada and LSCFN conducted an extensive evaluation process to determine which remediation option best met their objectives. In June 2012, the three parties identified and agreed on a preferred option (i.e., Option 4), and the three parties formally signed a letter of understanding confirming their selection of the option.
2013 – 2016	Option 4 Remediation Planning	YG, LSCFN, INAC	Following the selection of the preferred remediation option by the Project Parties, LSCFN was engaged on a number of occasions to provide an update on remediation planning and to seek feedback (i.e., during regularly scheduled Working Group Meetings or during design specific update workshops/meetings).

Table 3.5-2: Specific Engagement Activities

Date	Event Title or Subject	Parties Involved	Discussion Items / Outcome
17-Dec-15	2015/2016 Annual Engagement	YG, LSCFN	In 2015/2016, the Government of Yukon enabled LSCFN to participate in the Mount Nansen project; specifically, with: • Hiring of a Lands Technician and technical support to provide feedback and input on care and maintenance and remediation planning; • Participation in working group meetings; • Coordination of an Elders site visit; • Training; and • Environmental monitoring..
12-Jan-16	2015/2016 Water Quality Assessment	YG, LSCFN	In 2015/2016, the Government of Yukon enabled LSCFN to retain a consultant to complete a water quality assessment for the site, which included: • A review and analysis of water quality conditions and spatial and temporal changes; • An evaluation of the effects of current and potential future water quality conditions on aquatic ecosystems in Dome and Victoria Creeks; • Development of a conceptual response plan that includes water treatment; and • A review of the site AMP.
11-May-16	Water Quality Assessment Workshop #1	YG, LSCFN, INAC	The purpose of the Water Quality Assessment Workshop was to provide an opportunity to the LSCFN consultant to present a progress update and the results of their work to-date. Topics discussed/ presented included: • Review of the site AMP; • Summary of site water quality and preliminary effects assessment; • Summary of options for water quality management and mitigation; • The review of regulatory requirements/expectations; • Future monitoring approaches; and • Schedule/ next-steps.

Date	Event Title or Subject	Parties Involved	Discussion Items / Outcome
24-May-16	Water Quality Project Parties Planning Meeting	YG, LSCFN, INAC	The purpose of the Water Quality Project Parties Planning Meeting was to follow-up and discuss a path forward as a result of discussion held during the Water Quality Assessment Workshop.
8-Jul-16	Water Quality Assessment Workshop #2	YG, LSCFN, INAC	The purpose of the Water Quality Assessment Workshop was to provide an opportunity to the LSCFN consultant to present a progress update and the results of their work to-date. Topics discussed/ presented included: • Water Quality Objectives; • Existing Conditions; • Receiving Environment and Compliance; • Effluent Quality Standards; • Mitigation Options; • AMP and Triggers; and • Schedule/ next-steps.
24-Nov-16	YESAA Project Proposal – Project Parties Meeting	YG, LSCFN, INAC	The purpose of this meeting was to have YG’s consultant present the approach to preparing the Mount Nansen Care & Maintenance YESAA Project Proposal. Topics discussed/ presented included: • Project description; • Schedule overview; • Key project assumptions; • Proposed environmental assessment methods; • Proposed valued components; • The Project Parties review process; and • Next steps.
21-Dec-16	2016/2017 Annual Engagement	YG, LSCFN	In 2016/2017, the Government of Yukon enabled LSCFN to participate in the Mount Nansen project; specifically, with: • Administrative support; • Hiring of a Mount Nansen Coordinator/Monitoring Technician; • Training and capacity building; • Technical support; • Participation at a community meeting; • Site visit; and • A Cumulative Effects Study for Victoria Creek.
27-Feb-17	Socio-economic Update Meeting to LSCFN	YG, LSCFN	The purpose of this meeting was to have YG’s consultant provide an overview of the qualitative socio-economic data received from community interviews as part of preparing the LSCFN socio-economic existing conditions report.

Table 3.5-3: Ongoing Engagement Activities

Date	Event Title or Subject	Parties Involved	Discussion Items / Outcome
12-Dec-16 – 1-Mar-18	Distribution of YESAA Project Proposal Sections and Appendices	YG, LSCFN	YG has provided the YESAA Project Proposal sections and appendices to LSCFN for their review and feedback prior to finalization and submission to YESAB.
Ongoing	Distribution of Care and Maintenance and Monitoring Reports	YG, LSCFN	YG has been providing the following types of reports to LSCFN for their review and feedback: • Monthly Water Quality a Hydrology monitoring reports; • Monthly AMP Assessment reports; • Geotechnical Inspection reports; and • Groundwater Monitoring reports.
Monthly	Working Group Meetings	YG, LSCFN, INAC	YG holds monthly Working Group Meetings to present updates on work it's completing and receive updates from the Project Parties. Topics discussed/ presented over the last two years include, although is not limited to: • Care and maintenance activities; • Monitoring activities and results; • Monthly AMP Assessment results; • Annual work planning; • Updates on all recent and upcoming activities; • Issues or concerns from any of the Project Parties. • Feedback from Project Parties on deliverables; • Scheduling of meetings and workshops; • Updates on YESAA Project Proposal work; • LSCFN Funding Agreements; • LSCFN Water Quality Assessment updates; • LSCFN Victoria Creek Cumulative Effects Assessment updates; and • INAC Value Engineering updates.

Notes:

The intent of Table 3.5-1 and Table 3.5-2 is to present the most recent engagement activities completed with LSCFN, although it should be noted that YG's engagement with LSCFN has a longer record than that presented in the table.

The Village of Carmacks has also been engaged on the project. The most recent engagement completed was when Government of Yukon held a meeting with the mayor and council of the Village of Carmacks on April 17, 2017 in order to provide an update and seek feedback on the Project. Table 3.5-4 below presents previous community or mayor and council meetings held with the Village of Carmacks.

Table 3.5-4: Village of Carmacks Community or Mayor and Council Meeting

Date	Event Title or Subject	Parties Involved	Discussion Items / Outcome
17-May-06	Community Meeting	YG, LSCFN, Village of Carmacks, EDI	An open house community discussion regarding the Terrestrial and Aquatic Effects Study.
5-Dec-06	Community Meeting and Village of Carmacks Mayor and Council Meeting	YG, LSCFN, Village of Carmacks	Discussion of community objectives, site overview and options, Terrestrial and Aquatic Effects Study results, and plans for 2006/2007.
11-Dec-07	Meeting with Village of Carmacks s Mayor and Council	YG, Village of Carmacks	Site activities update, Terrestrial and Aquatic Effects Study results, preliminary options discussion, closure planning update.
15-Jan-08	Village of Carmacks Public Meeting	YG, LSCFN, Village of Carmacks	Final Community Objectives, Mount Nansen closure options, site update, potential 2008/2009 activities, LSCFN Coordinator office report.
Sep-13	Meeting	YG, Village of Carmacks	Project update; seek Mayor and Council's input into the design of consultation for the Mount Nansen Remediation Project (MNRP).

4 Project Purpose and Alternatives

4.1 Project Purpose

The purpose of the Mount Nansen Care and Maintenance Project is:

- To ensure the protection of human health and safety and the environment through ongoing care and maintenance activities and adaptive management (e.g., water management and treatment, site access management, health and safety assessments, ongoing structure monitoring and maintenance, and environmental monitoring).

The Water Licence for the operation of the Mount Nansen mine expired on December 31, 2001. AAM currently executes care and maintenance activities at the Site under Section 37(1) of the *Yukon Waters Act* that provides Government of Yukon with authority to “...take any reasonable measures to prevent, counteract, mitigate, or remedy any resulting adverse effect on persons, property, or the environment...” (*Waters Act*; Yukon, 2003).

In 2016, the Supreme Court of Yukon approved the remediation approach for the Mount Nansen abandoned mine site. The plan calls for the Government of Canada to pay for the remediation of the Site, but for the court-appointed receiver, PricewaterhouseCoopers, to find qualified bidders to purchase the property and implement the Mount Nansen Remediation Project (MNRP). At the time that the successful bidder/purchaser takes ownership of the site, the site would no longer be considered abandoned, and as such will require that a new Water Licence be in place. AAM is therefore submitting this Project Proposal with the objective of receiving regulatory approval (i.e., a Water Licence) authorizing care and maintenance activities at the site, ensuring that it is in place ahead of the Purchaser taking ownership of the site (note: the receipt of regulatory authorization is also a term of the sale of the site). AAM will be transferring its proponent status, including permits and licences, to the purchaser at the time that they take ownership of the site.

The purchaser will be required to submit a YESAA Project Proposal and Water Licence application for the remediation of the site prior to initiating any remedial works (i.e., for any works not described in this Project Proposal). Until such time that the purchaser of the site is ready to submit a YESAA Project Proposal and Water Licence application for remedial works, the care and maintenance of the site will be executed as described in this Project Proposal. Project Alternatives.

Several alternatives to the proposed care and maintenance Project were considered and reviewed. The selection of the preferred option was completed through a qualitative approach based on four criteria: (1) Protection of Health & Safety; (2) Protection of Environment; (3) Cost Effectiveness; and (3) Project Readiness. A description of these criteria is presented in Table 4.1-1.

Table 4.1-1: Description of Project Alternatives Selection Criteria

Protection of Health & Safety	Protection of Environment	Cost Effectiveness	Project Readiness
This criterion will be used to evaluate the ability of the project alternatives to ensure the protection of workers on-site and protect the public from site hazards. This criterion considers the ability to provide on-site protection from both physical and chemical risks.	This criterion will be used to evaluate the ability of the project alternatives to ensure the protection of both the aquatic and terrestrial environment.	This criterion will be used to evaluate cost-effectiveness of the project alternatives over time by reviewing cost over a 15-year period given that it is assumed that all alternatives include the eventual full remediation of the Site.	This criterion will be used to evaluate whether the Proponent is ready to implement the alternative from the perspective of the completion of design and/or supporting plans that are necessary to implement the alternatives.

The approach taken was to first evaluate how well each alternative to the proposed Project would meet the criteria (i.e., a rating of ‘Does-not-meet, Low, Moderate, or High’ was determined for how well each alternative met each criterion); see Table 4.1-2 for a description of how the rating for each criteria was evaluated. Thereafter, a screening step was completed given that not all criteria have the same importance; the screening of each criteria is described in the bullets below:

- The ‘Protection of Health & Safety’ and the ‘Protection of Environment’ are considered to be of the utmost importance, and therefore any rating below ‘Moderate’ was considered unacceptable for both these Criteria (i.e., if an alternative had a rating below ‘Moderate’ for either the ‘Protection of Health & Safety’ and/or the ‘Protection of Environment’ it was eliminated from being further considered).
- The ‘Cost Effectiveness’ is considered important but not critical to project success.
- The ‘Project Readiness’ was considered to be important for project success and therefore any rating below ‘Moderate’ was considered unacceptable for this criteria.

Table 4.1-2: Rating Guide for Selection Criteria

Rating Category	Protection of Health & Safety	Protection of Environment	Cost Effectiveness	Project Readiness
L (Low)	Provides low or no protection.	Provides low or no protection.	Provides low or no cost effectiveness.	Proponent is not ready or otherwise in a position to implement the alternative.
M (Moderate)	Provides a moderate level of protection.	Provides a moderate level of protection.	Provides moderate cost effectiveness.	Proponent could be ready or otherwise in a position to implement the alternative.
H (High)	Provides a high level of protection.	Provides a high level of protection.	Provides high cost effectiveness.	Proponent is ready to implement the alternative.

The rating results and rationale are presented in Table 4.1-3. The ‘Discontinue care and maintenance’ alternative was eliminated given that it did not meet the ‘Protection of Health & Safety’ and the ‘Protection of Environment’ criterion. The ‘Full Remediation’ alternative was eliminated given that it did not meet the ‘Project Readiness’ criterion. Between the ‘Basic care and maintenance based on current conditions’ and ‘Care and maintenance with water treatment, including adaptive management approach’, the latter was rated higher in its ability to provide ‘Protection of Environment’ and therefore was selected as the preferred alternative.

Table 4.1-3: Evaluation of Alternatives against the Selection Criteria

Project Option Considered	Objective of Option	Alternatives Selection Criteria							
		Protection of Health & Safety (Short-term [next 5 years])		Protection of Environment (Short-term [next 5 years])		Cost Effectiveness (Long-term [next 15 years]; assumes other alternatives include remediation after 5 years)		Project Readiness	
		Rating	Rationale	Rating	Rationale	Rating	Rationale	Rating	Rationale
Basic care and maintenance based on current conditions	Maintain current site conditions, including monitoring the tailings facility, discharge of seepage water into Dome Creek, and maintenance of the Dome Creek diversion channel.	M	The site operator would continue to provide: • 24/7 site security; • First aid services; • Monitoring of site infrastructure to identify issues; • Maintenance of site infrastructure (e.g., roads, pumps, diversion channel); and • Implementation of emergency response measures.	L	Without water treatment (or remediation) the site may continue to have an effect on the downstream environment. However, having a site operator (and bi-annual geotechnical inspections) ensures that issues with infrastructure will be monitored.	L	Not very cost-effective given that you are completing several more years of care and maintenance ahead of actually remediating the site (i.e., instead of just remediating the site now), although this alternative does not have the added cost of water treatment.	H	Currently ready to execute this alternative given that it is a continuation of the same activities occurring at present.
Care and maintenance with water treatment, including adaptive management approach	Maintain current site conditions, treat tailings seepage water being discharged to Dome Creek, and monitor water quality in Dome and Victoria Creeks to determine if further actions may be required to mitigate environmental effects.	M	The site operator would continue to provide: • 24/7 site security; • First aid services. • Monitoring of site infrastructure to identify issues; • Maintenance of site infrastructure (e.g., roads, pumps, diversion channel); and • Implementation of emergency response measures.	H	As water quality and the aquatic environment are valued components that are impacted by discharge of tailings pond seepage water, the treatment plant would provide a mitigation of potential effects. The potential effects from seepage water is further mitigated through the proposed monitoring program and adaptive management approach to changing water quality conditions.	L	Not very cost-effective given that you are completing several more years of care and maintenance ahead of actually remediating the site (i.e., instead of just remediating the site now). However, it should be noted that the water treatment facility at the site would likely be of use during remediation activities.	H	Planning for this alternative is underway and will be ready for execution upon licensing.
Discontinue care and maintenance	Reduce short-term costs by stopping current care and maintenance of the Site.	L	There would be no site operator to provide services, such as: • 24/7 site security the public could enter the site and suffer injury or death (i.e., given that they would not be aware of existing or new site risks); • First aid services, if a member of the public there would be no first aid or emergency evacuation that could be completed; • Monitoring and maintenance of site infrastructure (e.g., roads, pumps, diversion channel) there could a failure resulting in death or injury (e.g., tailings dam failure); and • Implementation of emergency response measures there would be no one to coordinate emergency response actions, including communication, which could lead to death or injury.	L	Without water treatment (or remediation) the site may have an effect on the downstream environment. Further, without a site operator, issues with infrastructure may go unnoticed and unaddressed, potentially resulting in a failure (e.g., tailings facility) causing acute and chronic downstream effects.	N/A	This alternative is arguably more cost effective than alternatives #1 and #2 in the short term, however the costs associated with potential risks is not quantifiable (e.g., without care and maintenance, infrastructure might fail resulting in greater remediation costs).	M	Could be ready to discontinue care and maintenance as all this would require is some minor additional works at the site (e.g., more gates and signage; securing or removing some equipment, material, and infrastructure).
Full Remediation	Placing tailings and contaminated materials in the pit and capping with a low infiltration cover, as well as removal of mine site infrastructure and the stabilization of the Dome Creek Valley.	H	This would provide the highest level of protection to health and safety given that there would continue to be a site operator and risks would be eliminated or reduced as remediation progressed.	H	The ‘Full Remediation’ alternative would require that a water treatment facility be in-place as well as the monitoring program and adaptive management approach to changing water quality conditions. Therefore, this alternative provides roughly the same level of protection as ‘Care and maintenance with water treatment, including adaptive management approach’.	H	The other alternatives all include eventual remediation, however this alternative is the most cost effective given that it entails completing remediation works at an early stage. This alternative therefore presents a reduced number of years that a site operator is required on-site for care and maintenance (including water treatment) and that monitoring is required.	L	The remediation design is currently at a 30% level of design. Would require another 1-2 years to complete the design as well as time for assessment and permitting.

5 Project Description

This section contains a project background summary and describes the activities that form the Mount Nansen Care and Maintenance Project. Additional details on care and maintenance activities are presented in the Mount Nansen Site Operations and Maintenance Manual (Appendix 5A) and the Tailings Facility and Associated Structure Operation Maintenance and Surveillance Manual (Appendix 5B). In general, the intention of the Project is to continue with current care and maintenance activities for a five-year term, until such time that the Site remediation plans have been fully developed and are ready for implementation. One new activity related to care and maintenance is being proposed, which is the construction and operation of a water treatment plant (WTP) for water discharged from the seepage pond to Dome Creek. Details about the proposed WTP are included below.

5.1 Principle Activities

5.1.1 Tailings Storage Facility (TSF) Components

The TSF, constructed between May and October 1996, is a collective term that refers to four key components:

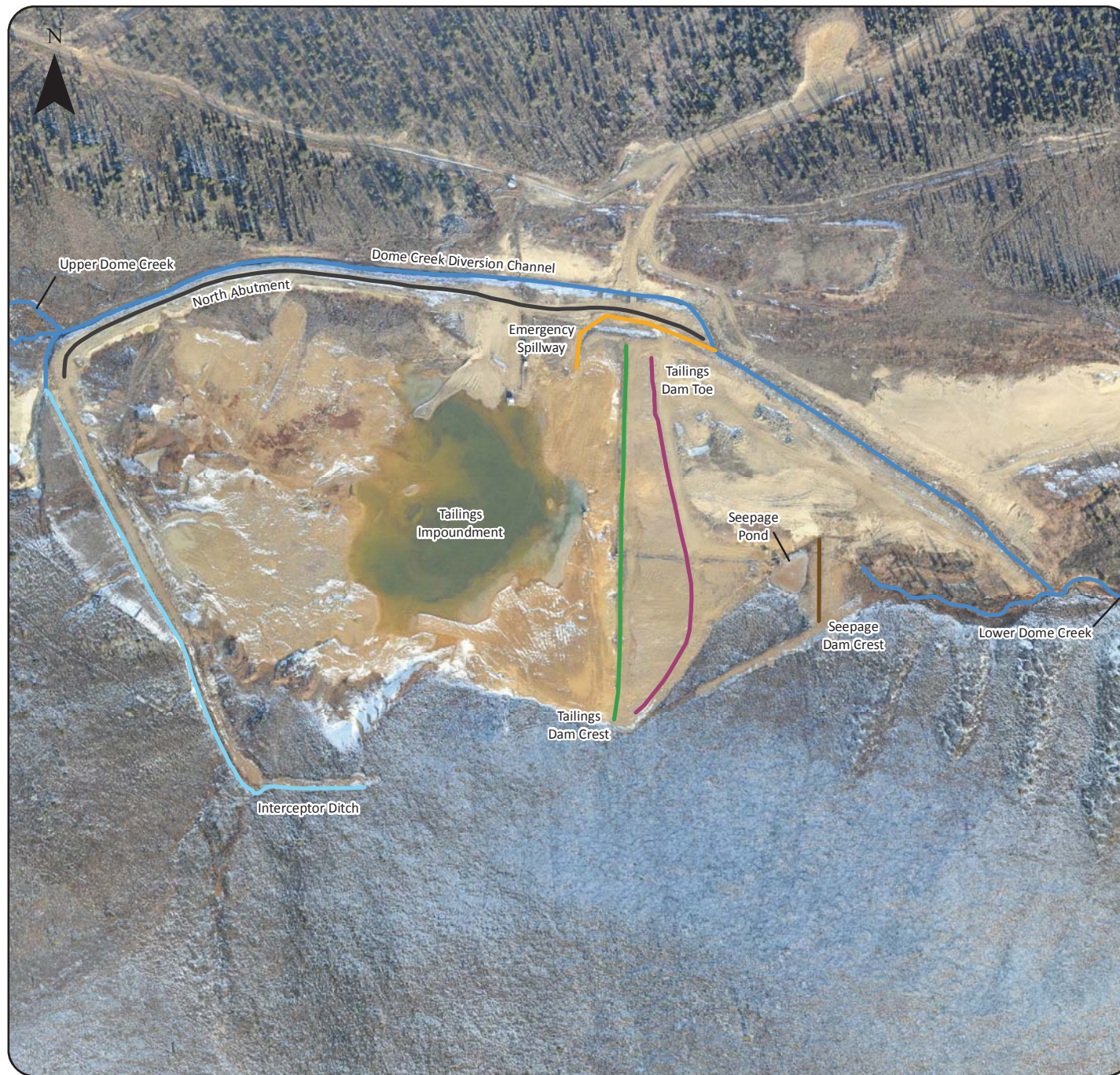
1. The tailings impoundment and dam.
2. The seepage pond and dam.
3. The Dome Creek diversion channel (DCDC) including the Emergency Spillway.
4. The interceptor ditch.

5.1.1.1 Tailings Pond and Dam

The impoundment behind the tailings dam (often referred to as a tailings pond) was where process water and mill effluent were discharged during the operation of the mine. Current inflows to the tailings impoundment include precipitation, subsurface flow from the surrounding terrain and leakage from the diversion. Some key information about the TSF is provided in Table 5.1-1.

5.1.1.2 Seepage Pond and Dam

The purpose of the seepage pond is to intercept water that flows from the tailings facility under or through the tailings dam. The seepage pond dam is approximately 50 m long; the crest elevation is 1,079.1 m ASL and has a width of 7 m. The maximum safe water elevation for this dam is 1 m below the crest at 1,078.1 m ASL. The seepage collection dam was reconstructed in 2000 and contains a geomembrane that is keyed in to a frozen key trench. The frozen conditions are maintained by two horizontal thermosiphon loops that were installed parallel to the dam centreline.



MOUNT NANSEN CARE AND MAINTENANCE PROJECT

Figure 5.1-1

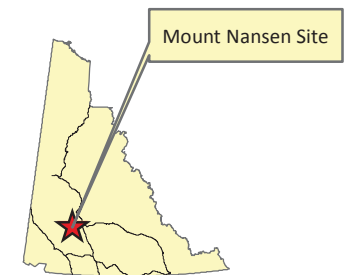
General Layout of Tailings Storage Facility



- Emergency
- Interceptor
- North Abutment
- Dome

Seepage/Tailings Dam Features

- Tailings Dam
- Tailings Dam
- Seepage Dam



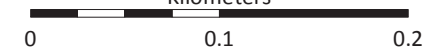
Data Source:

1. Site features (e.g., roads, trails, waterbodies, watercourses and infrastructure areas) digitized by ELR.
2. 2008 Quickbird imagery (courtesy of Yukon Geomatics) and spatial data provided by Yukon government.

Datum: NAD 1983 CSRS UTM Zone 8N

Scale 1:4,000

Kilometers



March 5, 2018

Table 5.1-1: Tailings Storage Facility (TSF) Key Information

Tailings Storage Facility Component	Key Information	Additional Information
Tailings Impoundment Design Volume	240,000 m ³	Klohn-Crippen, 1996
Tailings Dam Crest Width	6 m	
Tailings Dam Length	Approximately 240 m	
Maximum Dam Height	18.5 m	
Maximum Dam Crest Elevation	1,099.6 m above sea level (ASL)	
Dam Construction Materials	Compacted soil	With geosynthetic clay liner on the upstream side
Emergency Spillway	-	Northeast of impoundment area
Emergency Spillway Intake Elevation	1097.8 m	Elevation at which impounded water will start to flow through the spillway.
Emergency Spillway Exit Elevation	1,067.1 m	
Inflow Design Flood	1-in-200 year	Upgrades have been completed to address recommendations for the last Dam Safety Review (2014). The Emergency Spillway and DCDC are now capable to safely pass a 1-in-200 flow.
Earthquake Design Ground Motion	1-in-1000 year	During the last Dam Safety Review (2014), the facility was not considered susceptible to a 1-in-1000-year Earthquake Design Ground Motion.

The seepage pond pumping system consists of a small pump-house located over the top of a vertical culvert-type sump within the pond. The pump-house contains a 15 HP pump equipped with a flow meter and the water in the seepage pond will be pumped from the pump-house through a 50 mm diameter polyvinyl chloride (PVC) pipe to the new WTP. After the water has been treated by the WTP, it will be released into the lower portion of the DCDC/Emergency Spillway where it will then flow into Dome Creek. More information about the new WTP is provided in Section 5.2.6.

5.1.1.3 Dome Creek Diversion Channel and Emergency Spillway

The diversion channel (i.e., excavated channel) intercepts Dome Creek upstream of the tailings pond at the north-western edge, follows the northern embankment of the dam, and reconnects to Dome Creek downstream of the seepage control dam. The diversion channel and the emergency spillway share a channel for the last 290 m. An interceptor ditch is also located on the south-western edge of the tailings impoundment which intercepts water and directs it to the diversion channel.

5.1.1.4 Interceptor Ditch

The interceptor ditch is an excavated channel which intercepts water from the slopes to the south of the facility and directs the water to DCDC.

5.1.2 Tailings Storage Facility Operation, Maintenance and Surveillance

Three sources of water are managed at the Mount Nansen TSF: Dome Creek, which is diverted around the TSF via the diversion channel; the seepage pond; and any water that is impounded by the tailings dam. Management of these waters is important because the TSF components are susceptible to erosion (e.g., through excessive rainfall). Water management and monitoring measures therefore need to be in place to reduce the likelihood of a functional failure of facility components (e.g., north abutment, dam crest, and dam toe). Operations of the TSF are described below and divided into four different operation scenarios: Normal conditions; flood conditions; unusual conditions; and emergency conditions.

5.1.2.1 Normal Operating Conditions

Normal operating conditions occur when water flow rates and levels are within the seasonal average (as described in Appendix 5B). A staff gauge has been installed in the tailings impoundment and is read daily. Site operations personnel complete inspections twice daily, which includes measuring and recording flow and water level data. Site operations personnel also collect data monthly from 8 piezometer locations and 19 thermistor locations. The data are provided to a geotechnical engineer for review and analysis as part of the geotechnical assessments (twice per year) and monthly instrumentation reviews (see 5.2.5 ‘Formal Inspections’ section below).

Flow in the DCDC fluctuates seasonally and with precipitation events. These normal and anticipated fluctuations in the DCDC will not be actively managed other than the removal of any blockages in the channel (e.g., ice and sediment). The DCDC will be monitored daily by site operations personnel who will look for any changes to the flow of water, embankment stability, or accumulation of materials within the channel that may impact the flow of water. The diversion channel requires monitoring of, and response to, sediment deposition (i.e., through physical on-site monitoring) during the summer and ice buildup during winter, particularly along the section from the start of the DCDC to the intersection with the spillway (see Appendix 5B; Tailing Facility Operations Maintenance and Surveillance Manual).

The pump at the seepage pond is an electric powered unit located on the floor of the seepage pond pump-house. The water pump is capable of pumping up to 350 L/min and the flow meter allows the Site operations personnel to monitor the flow rate and adjust it accordingly to maintain the desired water elevation in the seepage pond. Water is drawn from the surface of the seepage pond, pumped through a series of valves and the flow meter, and then to the WTP for treatment. A staff gauge is installed on the outside of the pump-house support culvert and the water level is recorded daily (and can be compared to the water level recorded in the tailings impoundment). In order to maintain the desired water elevation in the seepage pond, the pumping system will operate continuously. In the event that pumping stops, the seepage pond dam may overtop which may compromise its integrity (see ‘Flood Operating Conditions’ and ‘Unusual Operating Conditions’ sections below for a description of the pumping back-up systems). Anomalies in flow volumes such as spikes or gradual increases or decreases will be assessed, and measures will be implemented if deemed necessary (e.g., additional pumps added, temporarily pumping water back to the tailings

impoundment). The rate of flow from the seepage pond is regulated through a series of valves within the pumping system. The valves are adjusted when needed to maintain the desired level of water. To reduce the flow from the pond, a bypass valve is opened which releases some water back into the seepage pond and the flow-through valve opening is reduced. The procedure is reversed if the water level is observed to be rising.

The treated water discharged to Dome Creek will be tested in accordance with the monitoring program to confirm if effluent levels are within acceptable limits for discharge (as detailed in Appendices 7C and 7D). If testing determines that the water does not meet established standards, then discharge will be discontinued immediately. In this event, water from the WTP will be recirculated back into the seepage pond such time that the water reaches acceptable discharge specifications.

5.1.2.2 Flood Operations

Flood operating conditions occur when recorded flow rates lie outside the normal range indicated by the data previously recorded on-site (e.g., by the meteorological station, seepage pond flow meter). In the event of a flood situation, flow volumes, water levels and observed abnormal events (e.g., prolonged periods of precipitation) will be recorded and evaluated every three hours.

The seepage pond dam is not equipped with an overflow structure (e.g., an Emergency Spillway). Therefore, it is important that water is pumped down, particularly during abnormally high flow conditions. Untreated water is not to be released into Dome Creek unless in the case of an absolute emergency and overtopping of the seepage dam must be avoided as this likely would erode the dam and could cause degradation of its frozen core and/or damage to the thermosyphon system. In the event of an unexpected rise in the water elevation at the seepage pond, the following steps will be taken (as detailed in Appendix 7C):

1. The WTP rate will be increased to its maximum capacity to discharge treated water.
2. The seepage water pump flow will be increased to full flow volume of water.
3. If the seepage pond has or is anticipated to rise beyond its operating capacity, backup pumping systems will be set-up and started to pump water back to the Tailings Pond (gas and electrical powered pumps).
4. If it is not possible to pump water back to the Tailings Pond at a rate required to keep the seepage pond from overtopping, controlled discharge from the seepage pond to Dome Creek will be made through pumps (gasoline or electric) or siphons.
5. In the event that the backup pumping or discharge systems are not able to maintain the water level in the seepage pond and an overtopping event is imminent, a controlled release will be initiated with the assistance of heavy equipment to cut a top notch in the dam and under the direction of the geotechnical engineer.
6. If a release occurs, the on-site personnel will monitor the length of time the release occurs, take photographs, and attempt to estimate the velocity and volume of the water. Water samples will be collected, if it is safe to do so.

5.1.2.3 Unusual Operating Conditions

Unusual operations are those activities that fall outside what is normally anticipated, other than a flood (e.g., power outage, ground movement or infrastructure failure that causes changes to normal flow or affects normal access to monitoring points and water management equipment such as pumps and instrumentation). Identification of an unusual condition will be performed by site operations personnel who are knowledgeable about site and normal operating conditions.

In the event of an unusual operating condition, the normal operating equipment may require the use of alternate systems to ensure continued operation and to reduce the risk of potentially negative effects on the environment or site personnel. The seepage pond pumping system has backup systems in place to ensure that the pond is maintained at the appropriate level. The backup systems for this facility component include:

- Gas powered pump that is available for quick connection to the pumping system;
- Mobile generator to power the primary or alternate pump;
- Backup electrical powered pump;
- Syphon system (can be used without a source of power to syphon water from the seepage pond to Dome Creek);
- Power failure alarm at the bunkhouse; and
- Heavy equipment and site operations personnel available 24 hours per day.

5.1.2.4 Emergency Operations

Conditions which may lead to a failure of systems and structures and/or which could constitute an emergency include, but is not limited to:

- A failure of a major structure, such as the diversion channel dike, tailings or seepage dam;
- A slope failure having the potential to cause dam or diversion channel failure;
- A blockage of the diversion channel which may cause the diversion dike to fail;
- A sudden increase in seep volume occurrences which could lead to a tailings dam failure;
- A rapid increase or unexplained turbidity of seepage water;
- Natural disasters such as earthquakes or extreme precipitation events; and
- Potential environmental contamination such as contaminated water at discharge, contaminated water seeps or tailings entering water courses (e.g., if the seepage pond water suddenly becomes contaminated and exceeds the discharge threshold).

In the event of an emergency the site operations personnel must immediately follow the instructions in the Tailings Facility and Associated Structures Emergency Response and Preparedness Plan (ERPP; Appendix 5C). The ERPP is available in designated locations on-site and is easily available to all site personnel (e.g., at the bunkhouse and the mill).

5.1.3 Tailings Storage Facility Maintenance Activities

Maintenance of Site facilities is critical for the safe and continuous operation of the Site as well as to ensure the integrity of the Site components. The objectives of the on-going maintenance program are to review and identify maintenance requirements, execute corrective measures, and repair all facility components as required and recommended by the advising geotechnical engineer, as appointed by AAM (see Section 5.1.4.2; Formal Inspections).

5.1.3.1 Tailings Dam and Seepage Pond Dam

Erosion and settlement of the embankments of the tailings dam or the seepage pond Dam may occur and will be repaired, as required. Rain, thaw, prolonged dry periods and wear can all contribute to erosion, and thaw of underlying permafrost can result in ground settlement. Ground settlement at the surface causes rain water to pool and water can infiltrate the dam structure. Any new or previously unnoticed depressions on the surface of the dams will be recorded, photographed and measured so they can be provided to a geotechnical engineer for review. This procedure is especially critical at the project site because of the underlying permafrost. Infiltration of water at the dams can lead to additional thawing of permafrost and potentially lead to catastrophic failure of the dams. Depressions in the surface of any structure will be investigated to determine the cause and then repaired. If the depression turns out to be caused by a subsurface failure it will require further investigation to determine the cause and the repairs required. In the event that depressions are identified, an engineering consultant will be contacted to inspect them and review Site documentation so that a plan of action can be developed and implemented.

Burrowing animals can present a problem to a dam's integrity if they create holes and tunnels within the structure. A plan for discouraging or removing burrowing animals (e.g., Arctic Ground Squirrels) from the dam will be developed as soon as the problem is noted and/or recommended by the advising geotechnical engineer.

Vegetation growth will be controlled on the surface of the dams. Plants need to be removed before the root systems have an opportunity to penetrate into the dam structure. This task will be completed every year before the plants go to seed.

5.1.3.2 DCDC and Emergency Spillway

The berm along the DCDC is subject to settlement and as such is susceptible to low spots where overtopping of the berm could occur resulting in water entering the tailings impoundment. An overtopping event could result in erosion of critical portions of the TSF and potentially release contaminated water and tailings through the Emergency Spillway. In the event that settlement along the DCDC berm is noted, repairs will be completed, with design and oversight provided by an engineer.

Sediment buildup interrupts flow by reducing the grade of the channel. Sediment will be removed in the spring and fall, and at any other times if the volume of deposition has a noticeable effect on the flow or capacity of the diversion channel. The removed material will be placed into the tailings impoundment.

Freezing temperatures may cause the build-up of ice in the DCDC (i.e., aufeis - a sheet-like mass of layered ice that forms from successive flows of groundwater to the surface during freezing temperatures). If the aufeis builds to the level of the berm along the DCDC it is likely to result in water overtopping and eroding the berm. The berm is constructed of sandy material and is subject to rapid erosion. Erosion of the berm could result in failure of the berm causing water to be directed towards the tailings impoundment. If this issue remains unchecked it is possible for the tailings dam (pond) to fill with water and release tailings and potentially contaminated water to the environment through the Emergency Spillway. If the capacity of the Emergency Spillway is exceeded, this situation may also cause erosion to the tailings dam and result in dam failure. This scenario, although possible, is unlikely to occur because the capacity available in the tailings impoundment to retain water would provide sufficient time (days to weeks) to mobilize equipment and manage the tailings impoundment water level before it reaches the maximum safe water level (1,097.8 m ASL). The amount of time available is dependent on the rate of water flowing into the impoundment and the amount of water that is in the impoundment at the time. It is unlikely the dam could overtop given current conditions, unless the Emergency Spillway was blocked, and a large amount of water were to enter the facility.

The frequency of silt and ice removal within the DCDC will be dependent on the conditions. The Emergency Spillway will also be kept clear of ice to maintain its function and capacity. Materials removed from this area will be stockpiled east of the Emergency Spillway.

5.1.3.3 New Erosion Channels

If fresh erosion channels on any surface of the TSF infrastructure (e.g., the dam face) is observed, a plan for the required repairs will be developed and implemented quickly to prevent further erosion. The source of water creating the erosion will also be investigated and corrective action will be taken, as required.

5.1.3.4 Seepage Pond Sediment Removal

Drawdown of the seepage pond will occur on a yearly basis to assess the buildup of sediment on the bottom of the pond and identify and monitor the seeps of water flowing into the pond. This activity will be coordinated with the geotechnical engineer during the annual spring inspection.

5.1.3.5 Flow Measurement Equipment

Flows are to be monitored in the WTP as described in Section 3.2 of Appendix 5D. Inflows and outflows are to be within the WTP through automated instrumentation, with manual instrumentation kept on Site for backup measurements or redundancy.

5.1.3.6 Pumping and Piping System

The piping at the seepage pond is subject to precipitate buildup and therefore sections must be replaced with clean sections on a regular basis. Cleaning is achieved by steaming the pipes and/or by shaking the removed dry pipes by hand in order to dislodge the buildup. In the event that adequate cleaning is not achievable, it may be necessary replace pipe sections with new sections. Spare pipe sections will be

available at the seepage pond for quick replacement, thereby decreasing the down time of the pumping system.

5.1.4 Monitoring the Tailings Storage Facility

The primary objective of the TSF surveillance program is to identify any conditions of concern that could compromise the integrity of the facility. The program focuses on three key areas:

1. Stability and deformation of the embankments.
2. Thermal conditions within the seepage and tailings dams.
3. The quantity and quality of the seepage from the tailings and seepage dams.

Visual inspections will be completed on both the structures and the surrounding landforms. Inspections are broken into two categories: operational and formal.

5.1.4.1 Operational Inspections

Site operations personnel will be trained in the identification of hazardous conditions and will provide details of any changes in Site conditions upon observation. Operational inspections are performed twice daily by Site operations personnel. The purpose of the inspection is to identify any changes in the condition of the structures that may have an effect on its performance or may signal its deterioration (e.g., settlement or seeps). Observations made during the inspection will be recorded, photographed and measured. If a condition is deemed to be serious or of immediate concern (e.g., large ground settlement, sinkhole on tailings dam crest or changes in the alignment of power poles), a qualified geotechnical engineer will be notified so the issue can be reviewed, and a repair can be planned and implemented. Any previously identified conditions will be recorded, photographed and measured on a weekly basis to identify changes in the condition and the information will be forwarded to a qualified geotechnical engineer for analysis.

A variety of control systems and information sources have been put in place to allow Site operations personnel to monitor conditions. These include:

- Staff gauges in ponds including high water level marking;
- Monthly calibrations of the seepage flow meter;
- Weather station data recording;
- Flow monitor readings;
- Site activity records;
- Site security (24 hours a day, 365 days a year);
- Health and safety records;
- Water sampling activities;
- Fuel usage;
- System maintenance records; and
- Records of inspections.

5.1.4.2 Formal Inspections

There are two different formal inspections completed, the first is a dam safety review and the second is the bi-annual inspection. The most recent formal dam safety review was completed in 2013. The dam safety review was completed by a qualified and experienced geotechnical engineer and in accordance with the Canadian Dam Association Dam Safety Guidelines. The purpose of the dam safety review was to evaluate the stability, functionality, safety, and risks of the tailings facility based on a review of the facility's configuration and dimensions; recent data (i.e., hydrological, climate, piezometer, thermistor); operations, maintenance and surveillance procedures; and emergency response procedures. The recommendations for repairs, management and maintenance of the facility found in the report have been addressed (e.g., emergency spillway upgrades to ensure functionality and sufficient freeboard). A summary of the conclusions of the dam safety review were as follows:

1. The dam is stable.
2. The dam failure consequence rating is determined as “Significant”. As per the Canadian Dam Association (CDA), consequence classification is based on an evaluation of the effects of a dam failure on ‘Loss of Life’, ‘Environment and Cultural Values’, and ‘Infrastructure and Economics’. The consequence class for the Mount Nansen dam was deemed to be “Significant” given the possibility of impairment to wetlands and aquatic life downstream of the facility in the event of a dam breach and loss of tailings containment; this class is the second-lowest rating out of five classes identified in the CDA Dam Safety Guidelines.
3. The seepage pond dam downstream of the tailings facility is considered to be stable.
4. The diversion channel, tailings pond emergency spillway and combined spillway, have sufficient cross section areas (i.e., volume capacity) and slope to convey the Inflow Design Flood (IDF) flows; however, the emergency spillway crest elevation provided insufficient freeboard within the tailings pond (see item 6 below).
5. The Operations and Maintenance manual is satisfactory.
6. The Emergency Preparedness Plan is satisfactory (Worley Parsons 2013).

As a result of recommendations identified in a 2013 Dam Safety Review, upgrades were completed to the Tailings Facility in 2014 to increase the available tailings impoundment freeboard and improve the performance of the Emergency Spillway. The upgrade work included:

- Raising of the dam crest to an elevation of 1,099.6 m ASL;
- Installation of four survey monuments;
- Lowering of the existing Emergency Spillway to provide sufficient freeboard;
- Reconstruction of the Emergency Spillway to improve hydraulic performance;
- Reconstruction of the Emergency Spillway tie-in to the DCDC; and
- Placement of riprap armouring to protect the DCDC from scouring and erosion.

Bi-annual assessment of the tailings facility will continue to be completed by a qualified geotechnical engineer familiar with the site (i.e., around freshet and prior to winter). As part of this assessment, a site

visit is completed where structures are visually inspected, and data collected on-site is provided for review. Reports continue to be issued detailing the observations made and actions required when applicable. The following data is made available to the engineer for the bi-annual assessments:

1. **Thermal Data:** Data from 20 thermistors from around the facility are collected monthly by site operations personnel.
2. **Piezometric Data:** Data from nine piezometers from around the facility will be collected monthly by site operations personnel.
3. **Flow Data:** Flow data from the seepage pond flow meter will be collected daily by site operations personnel.
4. **Water Elevation Data:** Reading on staff gauges in both the tailings pond and seepage pond are collected daily.
5. **Water Quality Data:** Water quality samples will be collected monthly by a consultant.
6. **Observations:** Notable observations will be recorded daily by site operations personnel.

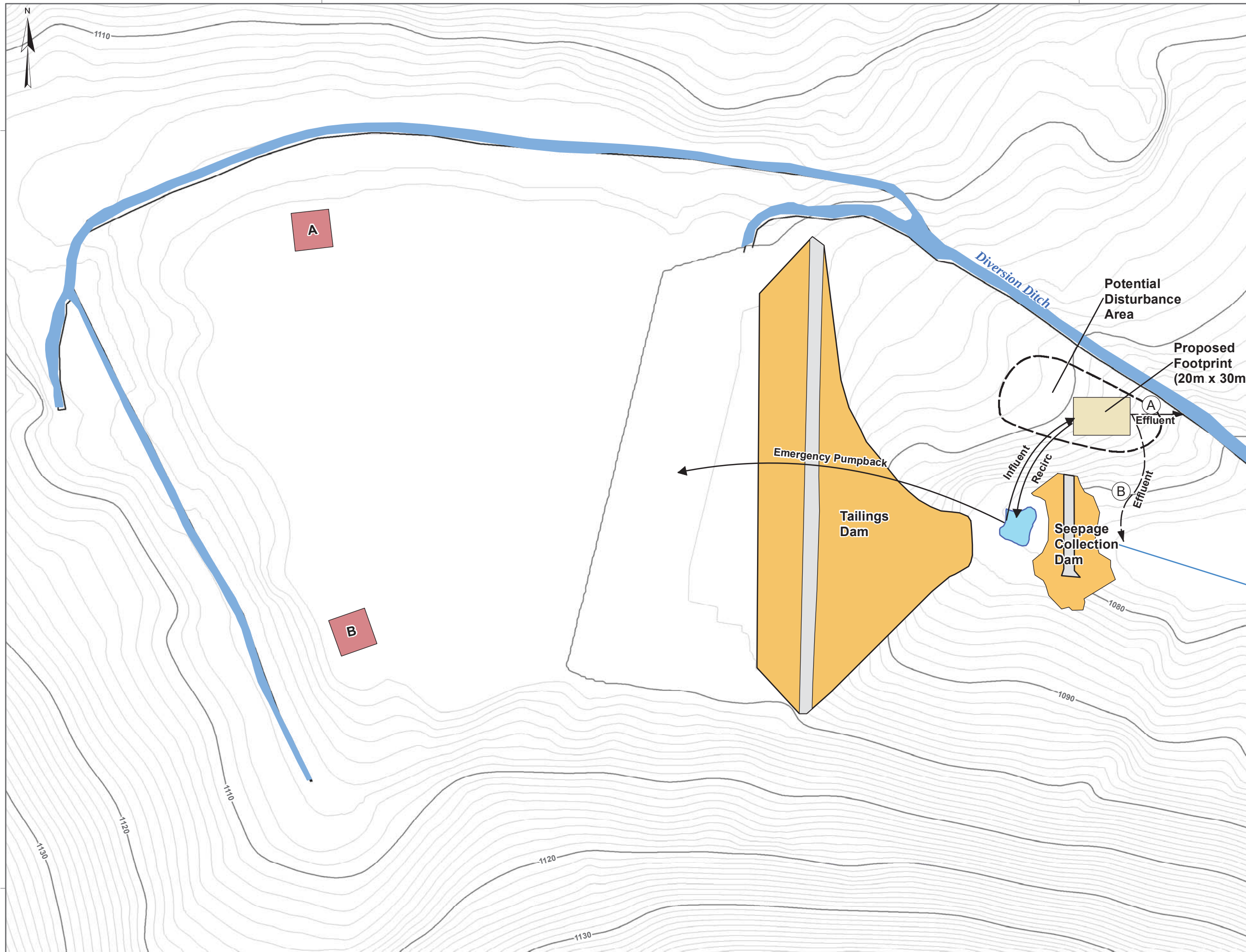
Monthly reviews of thermistor and piezometer data will also be completed by a geotechnical engineer to ensure that there are no changes in conditions that may be of concern and require further attention.

5.1.5 New Water Treatment Plant (WTP)

A WTP will be installed near the seepage pond to treat seepage pond water before it is discharged downstream to Dome Creek. The water requires treatment because concentrations of total suspended solids (TSS), total iron (T-Fe) and total arsenic (T-As) are considered to be high when compared to effluent quality standards in the historic Water Licence, and regulations and guidelines such as the Metal Mining Effluent Regulations (MMER 2002). Please note that the MMER standards do not apply to the Mount Nansen Care and Maintenance Project because the Site is no longer an operating mine. However, the MMER standards provide useful comparative concentrations on which to assess Site water quality. Treating seepage pond water before it is discharged will improve the water quality and overall aquatic environment downstream in both Dome Creek and Victoria Creek. More information about the WTP is provided in the following sections.

5.1.5.1 WTP Location and Construction

The WTP will be located on the sandy bench between the seepage pond and the DCDC, within proximity of the seepage pond and a suitable discharge location. This location is close to the existing electrical power infrastructure, relatively flat, and well-suited to convey influent from the seepage pond and effluent to Dome Creek via the DCDC. A conceptual layout for the proposed WTP is provided in Figure 5.1-2.



LEGEND

- Dam
- Dam Crest
- Seepage Collection Pond
- Water Treatment Plant Footprint
- Potential Disturbance Area
- Potential Sludge Management Area (20m x 20m)
- 10m Contour
- 1m Contour

Coordinate System: NAD 1983 UTM Zone 8N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter

1:2,000

0 50 100 Meters

DATE SAVED:	Mar 29, 2017
DRAWN BY:	GM
REVIEWED:	JM
VERSION:	1

CLIENT:



PROJECT:

**Mount Nansen
Care & Maintenance
Project Proposal**

TITLE:

Proposed Location and Operational
Layout of the Water Treatment Plant

PROJECT #:	A422-2	FIGURE:	5.1-2
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The WTP will be housed within modular, insulated containers that will be placed on a well-drained, level, gravel base. Two, connected 40-foot long containers are proposed for housing the water treatment process tanks, ancillary equipment, and polymer make-up systems. An insulated, heated, and ventilated galvanized shelter is proposed for the management of geotube bags containing sludge, as has been successfully used at the Brucejack Mine and Bralorne Mines in British Columbia. The sludge management shelter will be located downgradient of the WTP container to allow for gravity flow between the water treatment process and sludge dewatering chain. A covered walkway will be constructed between the WTP containers and sludge management shelter. All water pipelines will be above ground, insulated, and heat-traced (if necessary) for year-round operations as per current operations at Site. Three phase electrical power will be provided from the existing transmission line with above ground service to the WTP.

5.1.5.2 Seepage Pond Target Water Quality Concentrations

WTP effluent target concentrations and flows were developed based on recent Site water quality data (2000 to 2016) and guideline concentrations outlined in the MMER and CCME, as well as the Mount Nansen Mine historic Water Licence and other current Yukon mine Water Licences (Table 5.1-2).

Table 5.1-2: WTP Key Design Parameters - Historic and Target Concentrations and Flow Rates

Parameter	Units	Seepage Pond Discharge Minimum (2014 -2016)	Seepage Pond Discharge Maximum (2014 -2016)	Target Concentration After Treatment	Comparative Discharge Concentration Standard
Total Suspended Solids (TSS)	mg/L	21	47	< 15	15 ^A 50 ^B
Total Iron	mg/L	6.6	20	< 0.5	1.0 ^B
Total Arsenic	mg/L	0.04	0.13	0.05	0.500 ^A 0.15 (dissolved) ^B
Daily Flow	L/s	2	5.4	-	-

Notes:

^A MMER maximum authorized monthly mean concentration standards (Schedule 4) are used as a guide only and do not legally apply to the Site

^B Historic Mount Nansen Mine Operating Water Licence (QZ94-004). Expired December 31, 2001

Figure 5.1-3 presents the historic average daily seepage pond discharge between 2014 and 2016. Flows are stable and typically range from 2 to 3 L/s. Periodic spikes have been shown to be the result of scheduled maintenance and dam inspection and are not considered to be representative of natural variability (Tetra Tech EBA 2015).

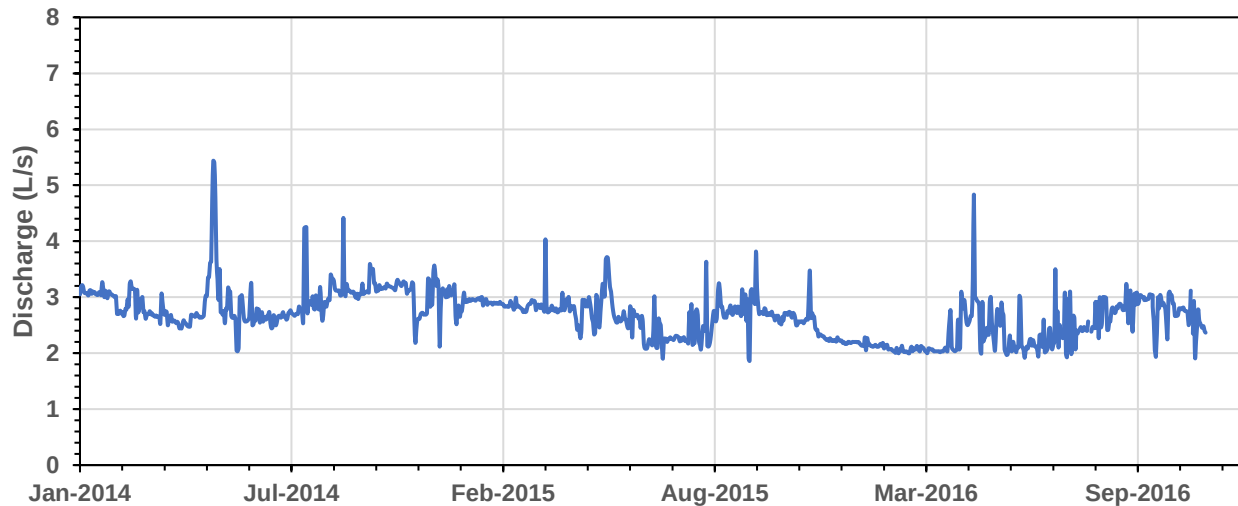


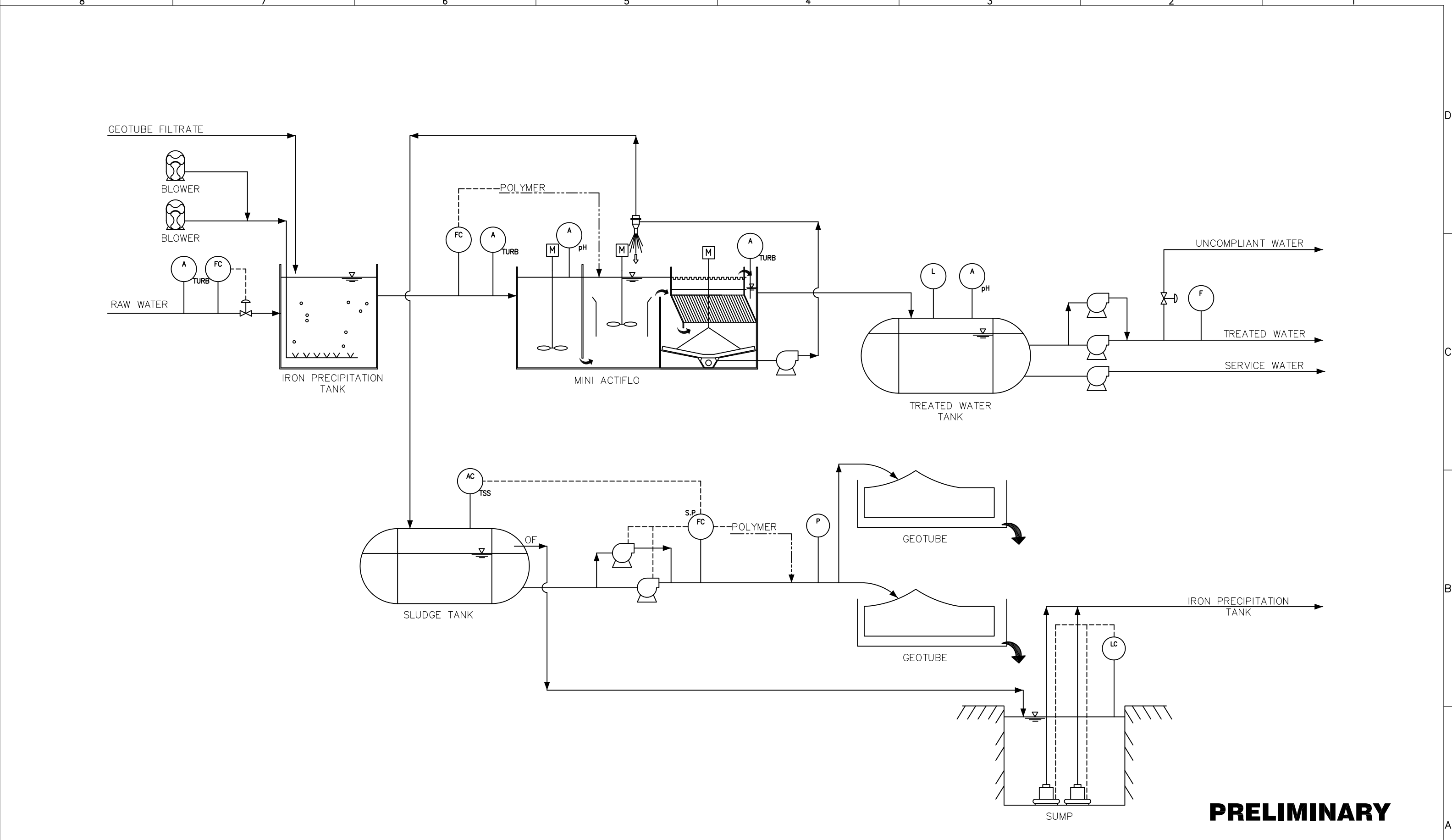
Figure 5.1-3: Seepage Pond Average Daily Discharge 2014-2016

5.1.5.3 Water Treatment Process

For the purposes of managing T-Fe and TSS in water discharged from the seepage pond, a modular, flow-through, engineered treatment system is proposed. The WTP has a maximum capacity of 360 m³/d, with the normal flow rate expected to be in the range of 173 m³/d to 260 m³/d.

The treatment process oxidizes the ferrous iron (Fe²⁺) naturally present in the influent water to form ferric oxyhydroxide precipitate for dissolved metal removal. Ferric oxyhydroxide precipitation is a common method for TSS and dissolved metal removal. This process occurs naturally in the seepage pond and Dome Creek. The reaction will be conducted at the influent pH (pH 7 to 8), and therefore, pH adjustment is not required for T-Fe removal. The only proposed reagents that will be added to the process include polymer and microsand. These reagents will aid with particle formation (flocculation) and are necessary for efficient TSS removal (clarification). An additional polymer will be used to aid sludge dewatering (J. Dallaire, personal communication, March 15, 2017).

The proposed treatment system consists of two main treatment chains: 1) water treatment (composing iron precipitation, decantation, and clarification); and 2) sludge dewatering (involving thickening and dewatering of sludge). Both treatment chains are illustrated in the process flow diagram (Figure 5.1-4) and described in the following sections.



PRELIMINARY

Figure 5.1-4																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
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5.1.5.4 Metal Precipitation and Clarification

This first treatment step is designed to precipitate ferrous iron present in influent water. Influent water is pumped into an Iron Precipitation Tank where the formation of ferric hydroxide is induced by aeration (using blowers). A recycle slurry stream is also mixed in this tank (J. Dallaire, personal communication, March 15, 2017).

Water from the iron precipitation tank flows by gravity into the water treatment unit that is designed to remove suspended solids present in the influent as well as those produced in the precipitation step. The water treatment process employs sand-ballasted settling, which is a high-rate flocculation/sedimentation process that utilizes microsand as a seed for floc formation. The microsand provides surface area that enhances flocculation and acts as a ballast or weight. The resulting floc settles rapidly, allowing for compact clarifier designs with high overflow rates and short retention times. The high TSS concentration maintained in the water treatment process due to the use of microsand also permits the unit to perform well under rapidly changing flow rates without impacting final effluent quality (J. Dallaire, personal communication, March 15, 2017).

The water treatment process unit consists of a coagulation chamber, maturation chamber, and settling chamber. The coagulation chamber provides retention time and mixing to complete the chemical reactions initiated in the iron precipitation tank. The water then flows into the maturation chamber where anionic polymeric flocculant and microsand are added to initiate floc formation. A mixer provides ideal conditions for bridging between the microsand and the destabilized suspended solids. A ferric hydroxide floc forms, which acts as both a bridge to tie colloidal particles together and as an active surface that can form surface complexes with many metals, providing further metal removal. The fully-formed ballasted floc then enters the settling chamber. The settling chamber is used for solid-liquid separation and is equipped with lamella plate settlers to provide rapid and effective removal of the sand/slurry floc. Scrapers force the slurry collected at the bottom of the clarifier into a center cone, from which it is continuously withdrawn and pumped to a hydrocyclone, where sand and slurry are separated by centrifugal force. After the hydrocyclone separation, the higher density microsand is discharged from the bottom of the cyclone and re-injected into the process for re-use. The hydrocyclone overflow is directed to a sludge tank. Part of the slurry in the sludge tank will be recycled to the iron precipitation tank, while another portion will report to the sludge dewatering chain. The recirculation of sludge reduces the potential of scaling, increases the reagent efficiency, and promotes solids growth (J. Dallaire, personal communication, March 15, 2017).

Clarified water exits the water treatment process via a series of collection troughs or weirs and reports to the treated water tank prior to final discharge. Part of the treated water is used as service water for polymer production (J. Dallaire, personal communication, March 15, 2017).

5.1.5.5 Sludge Dewatering

Slurry generated from the sedimentation and clarification process will be thickened with cationic polymer and dewatered using Geotube® technology. Geotubes® are a simple, low maintenance and cost effective dewatering solution that reduce the volume of resulting sludge that must be stored and managed.

A Geotube[®] is a geotextile container (approximately 3m³) made from specially designed, dual filament, polypropylene fabric. As the slurry is pumped into the Geotube[®], it is mixed with polymer to help the solids separate from the liquid. Filtered effluent flows through the special material of the Geotube[®] container, while the fabric liner keeps the solids trapped inside. The filtrate will collect in a sump and be recirculated as WTP influent, while the remaining solids inside the Geotube[®] retain up to 100% of chemicals and metals (Bishop 2017). The Geotube[®] along with its contents are to be then disposed of (they are single use vessels). The concurrent use of two Geotubes[®] will be necessary for the continuous withdrawal of sludge. One Geotube[®] will be used as described above (in “filling” mode) while the other will be in “drying” mode to optimize the dryness of the sludge (J. Dallaire, personal communication, March 21, 2017).

5.1.5.6 Operational Requirements

The WTP operational specifications are outlined in Table 5.1-3.

Table 5.1-3: Summary of Water Treatment Plant (WTP) Operational Specifications

Treatment Process	Coagulation-Flocculation
Maximum Flow	15 m ³ /hr (4.2 L/s) ¹
Retention Time in WTP	30 min
Reagents Used	Polymer and microsand
Solids Production (maximum)	160 L/day ²

Notes:

¹ The historic annual influent flows range from 2 to 4.2 L/s 95% of the time

² This volume represents total solids volume before dewatering the solids in the geotextile bags

WTP influent will be pumped from the seepage pond to the WTP. Treated effluent will be discharged to Dome Creek either through the DCDC (Option A) or to the historic Dome Creek channel (Option B), as per current operations. Both options result in the effluent discharging to Dome Creek. In the event malfunctions occur within the plant, untreated or partially treated effluent would be recirculated to the seepage pond by gravity. Effluent discharge via Option A is advantageous due to aeration and mixing along the relatively turbulent DCDC prior to reaching Dome Creek below the TSF. If freezing of effluent becomes an issue within the DCDC, discharge to Option B will be utilized. In the event that water cannot be discharged to Dome Creek for any reason (WTP failure, down time, or water quality that does not meet discharge requirements) water will be recirculated to the seepage pond as necessary until the water level in Seepage Pond near its functional maximum capacity. Should this occur, pump-back of seepage pond water to the tailings pond will be implemented to avoid the discharge of untreated water directly into Dome Creek (as described earlier in Section 5.1.2).

During normal operations, the water level of the seepage pond should be maintained at or below elevation 1077.1 m (Tetra Tech EBA 2015). Available storage capacity for the seepage pond at water levels of 1076.8 m and 1077.1 m are 1020 m³ and 860 m³, respectively (Table 5.1-4). In the event of upset conditions or maintenance requirements that require temporary shutdown of the WTP, the seepage pond water level and influent flow rate will determine the amount of storage time available before water treatment will continue or must be pumped back to the TSF if necessary.

Table 5.1-4: Seepage Pond Available Storage Volumes and Rates at 3 L/s Influent.

Water Level	Inflow Rate	Volume in Seepage Pond	Available Storage Capacity (Volume and Time)		
			m ³	hours	days
1078.1 ¹	3	1380	0	0	0
1077.1	3	520	860	79.6	3.3
1076.8	3	360	1020	94.4	3.9

Notes:

¹ – this is the maximum operating level (0.6 m below the dam crest).

A heated water supply is required for process control operations. The water heater will use propane or three-phase electricity connected from the existing electricity supply lines to the seepage pond.

Staff requirements will vary between the commissioning/optimization phase and the operational phase. During commissioning, two field technicians/engineers and one control engineer will be required on site 7-days a week. During plant operations, one water treatment technician will be required 24-hours a day, 7 days a week to monitor and operate the treatment process (J. Dallaire, personal communication, March 15, 2017).

5.1.5.7 Solids Management

Solids dewatering via Geotubes[®] will occur in a temporary metal structure that will be ventilated, heated, and constructed of galvanized metal. Inside this structure, Geotubes[®] will be contained within waste disposal hoppers (Figure 5.1-5). Two hoppers will be required, one during Geotube[®] solids filling, and one during Geotube[®] solids drying. The proposed hoppers are relatively small with a capacity of four cubic yards.

Approximately 22 Geotube[®] bags will be filled with WTP solids per year (approximately 1 each 17 days). Following solids dewatering and drying, filled Geotube[®] bags will be transported (either with or without the hopper) to the TSF using a forklift, and deposited within the dedicated management area located within the TSF. Based on the estimated solids production rate, Geotube[®] bag filling and exchange will take place approximately once every two weeks. Over four years of sludge production, an estimated Geotube[®] management area of 400 m² will be required, unless Geotubes[®] are to be stacked for the optimization of space.



Figure 5.1-5: Waste Disposal Hoppers for Geotube® solids (from J. Dallaire, personal communication, March 20, 2017)

5.1.5.8 Comparison with other Northern Water Treatment Plants

A process similar to the proposed treatment for the Site has been implemented at several northern environments including the Brucejack Mine (BC), CanTung Mine (NWT), Faro Mine Complex (YT), and Minto Mine (YT). Additionally, the Geotube® process of sludge dewatering has been used successfully at the Brucejack and Bralome mines (BC).

The Faro Mine Complex WTP increases pH and removes TSS and total metals, including iron. The process is based on ferric iron oxyhydroxide precipitation. Performance data collected in July and August 2016 from the Faro Mine Complex demonstrate high removal efficiencies for TSS and iron (Figure 5.1-5).

Table 5.1-5: Faro Mine Water Treatment Plant Performance¹

	Influent (average value; mg/L)	Effluent (average value; mg/L)	Removal (%)
TSS	19.8	1.21	94
Fe-T	18.8	0.008	>99
Fe-D	13.8	0.020	>99

Notes:

¹ D. Rainey, personal communication, February 8, 2017.

The Minto WTP uses Actiflo® technology in conjunction with sulfide precipitation, filtration, reverse osmosis, and pH adjustment. Performance data collected in 2015 also show a substantial reduction in TSS and T-Fe concentrations (Table 5.1-6).

Table 5.1-6: Minto Mine Water Treatment Plant Performance¹

Parameter	Influent (average value; mg/L)	Effluent (average value; mg/L)	Removal (%)
TSS	8.3	1.8	78
Fe-T	0.2	0.1	50

Note:

¹ Capstone (2016).

5.1.5.9 Monitoring Discharged Water Quality

Effluent from the WTP will be monitored at the discharge point and in Dome Creek to confirm WTP performance as per the Aquatic Effects Monitoring Program (Appendix 7C). Effluent monitoring will include daily measures of T-Fe and TSS for on-site analysis and weekly measures of complete water quality for external analysis.

5.2 Accessory Activities

5.2.1 Site Security and General Inspections

The site operations personnel will provide security services by patrolling the site regularly and administering health and safety and security processes. Site access will be restricted to authorized personnel only.

Upon entering the Site, all authorized personnel are provided with a site familiarization document and are required to attend the Site operator's orientation and safety training. Site operations personnel will inspect the entire Site a minimum of twice daily to help ensure the protection of human health and safety and the environment. Any observations of concern will be recorded, investigated, monitored and mitigated if necessary. Inspections will include the following:

5.2.1.1 Mill Area

- Generators to be checked (e.g., fluid levels) and hour meter readings recorded; and
- Diesel tanks to be dipped daily and levels recorded. Inspection of the diesel distribution pipes to be completed to check for any leaks or damage.

5.2.1.2 Brown McDade Pit Area

- The Brown McDade pit will be checked for any stability issues, increases or decreases in water level, and evidence of unauthorized entry;
- The Pony Creek adit will be checked for any stability issues, changes in flow, and evidence of unauthorized entry; and
- The waste rock piles around the pit will be checked for any stability issues and evidence of unauthorized entry.

5.2.1.3 Tailings Storage Facility

- The TSF will be inspected for stability and/or increased/decreased water levels. A checklist of items for the TSF will be referred to daily. Staff gauge readings at the tailings pond and seepage pond will be recorded daily;
- The DCDC will be visually inspected from top-to-bottom to look for any signs of instability, blockages or accumulation of sediment that may impact performance;
- Site operations personnel will collect monthly data from the 20 thermistors and 9 piezometers and submit it to a geotechnical engineer for review; and
- The flow rate of treated discharge water from the WTP will be monitored on an ongoing basis. The pipeline and discharge point to the DCDC will be checked daily to ensure it is functioning properly.

5.2.1.4 Victoria Creek Well House

- The Victoria Creek Well house is located approximately 2 km east of the Site on an access road that joins the Mount Nansen public road. The Victoria Creek Well House supplies potable water to the Site bunkhouse (water is trucked to the Site from this well). The well House is locked at all times when not in use and will be inspected a minimum of twice daily to ensure no un-authorized access to the building has occurred. Water quality sampling and analysis is completed routinely every month to ensure the water is potable (3rd party analytical laboratory drinking water package and bacteriology with Government of Yukon Environmental Health Services).

5.2.1.5 Bunkhouse

- The three propane tanks that provide fuel for the boilers and hot water tank at the bunkhouse will be inspected checked for leaks and will have their levels recorded daily;
- The gasoline storage tank for truck fuel is located outside of the bunkhouse and gasoline levels are recorded daily;
- The water level in the water storage shed (located northeast of the bunkhouse) are checked daily; and,
- The bunkhouse walkways and stairways are checked for icy/slippery conditions daily and appropriate action will be taken, as necessary.

5.2.2 Delivery and Storage of Fuel and Handling of Waste Fluids

5.2.2.1 Diesel and Gasoline

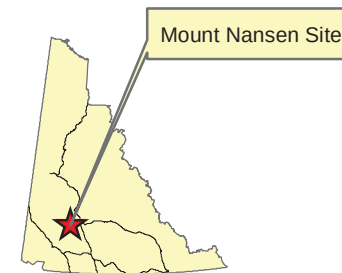
Diesel is used to power the generators on-site, as well as fuel the heavy equipment used to complete daily Site operations tasks. There are two aboveground single-walled steel 49,000 L storage tanks located beside the workshop (Figure 5.2-1) and the tanks are situated within a secondary concrete containment area. The storage tanks supply diesel directly to the generators as well as to a heater in the workshop. The storage tanks are also connected to a diesel pump that is used for fueling equipment.



**MOUNT NANSEN CARE AND MAINTENANCE
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Figure 5.2-1

Mill Area Layout



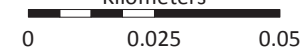
Data Source:

1. Site features (e.g., roads, trails, waterbodies, watercourses and infrastructure areas) digitized by ELR.
2. 2008 Quickbird imagery (courtesy of Yukon Geomatics) and spatial data provided by Yukon government.

Datum: NAD 1983 CSRS UTM Zone 8N

Scale 1:1,500

Kilometers



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Gasoline is used to power some of the light vehicles/equipment necessary to carry out Site operations. The gasoline storage tank is located adjacent to the bunkhouse and is an aboveground double-walled steel storage tank with a capacity of 4,500 L (Figure 5.2-2).

Annually, approximately 245,000 L of diesel and 8,000 L of gasoline will be consumed through site operation activities. Gasoline deliveries to Site are typically less frequent than the diesel deliveries. Generally, gasoline deliveries will be scheduled to occur at the same time as diesel deliveries and when public road and site conditions are suitable for the delivery trucks. It is estimated that 9 to 11 deliveries of fuel will be required annually to provide adequate diesel and gasoline for Site operations.

5.2.2.2 Propane

Propane is used to fuel the two boilers at the Site, which provide heating, via radiators, and hot water for the bunkhouse. There are three 1,000 L tanks located outside the bunkhouse that are connected in series to provide fuel to the boilers. Annually, approximately 17,000 L of propane will be consumed at the Site. It is estimated that two to three deliveries of propane will be required annually.

5.2.2.3 Waste Oil and Other Fluids

Waste oil and other fluids (e.g., hydraulic fluid, antifreeze) from the generators and equipment are stored on-site within a dedicated containment area adjacent to the generator sea-cans (Figure 5.2-1). Waste fluids (e.g., engine oil) are transported to Whitehorse for disposal at a permitted facility when volumes on-site are between approximately 140 L to 180 L.

5.2.2.4 Domestic Waste

Domestic waste includes food waste and garbage associated with routine operations. The domestic type waste (i.e., putrescible) is stored on-site either inside the bunkhouse or in bear-proof waste containers outside. Domestic waste is either burned on-site or are transported to, and disposed of in, the Carmacks Solid Waste Facility (i.e., approximately once every two weeks). Efforts are made to separate recyclable materials prior to disposal.

5.2.3 Road Maintenance

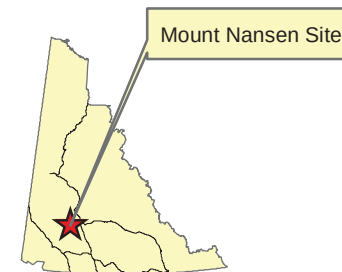
The Mount Nansen public road (sometimes referred to as the access road) is maintained by the Government of Yukon, Department of Highways & Public Works (HPW). There are times when access to the Site is difficult due to heavy snow fall or poor road conditions (e.g., during the spring freshet). The site operator maintains a two-week supply of food at the site as a precaution in the event that road access is lost (e.g., road wash out). Should there be an emergency, and road access is lost, helicopter services from Carmacks will be employed (see the Site Operations Emergency Response Plan; Appendix 5E).



**MOUNT NANSEN CARE AND MAINTENANCE
PROJECT**

Figure 5.2-2

Bunkhouse Area Layout



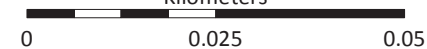
Data Source:

1. Site features (e.g., roads, trails, waterbodies, watercourses and infrastructure areas) digitized by ELR.
2. 2008 Quickbird imagery (courtesy of Yukon Geomatics) and spatial data provided by Yukon government.

Datum: NAD 1983 CSRS UTM Zone 8N

Scale 1:1,000

Kilometers



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All of the non-public roads within the Mount Nansen Site (Figure 5.2-3) are maintained by Site operations personnel. Maintenance activities include grading roadways, repairing pot holes or uneven surfaces, ploughing snow, and spreading sand over slippery sections. Ploughing of roadways will occur regularly throughout the winter months to enable access by light duty vehicles to all areas of the Site.

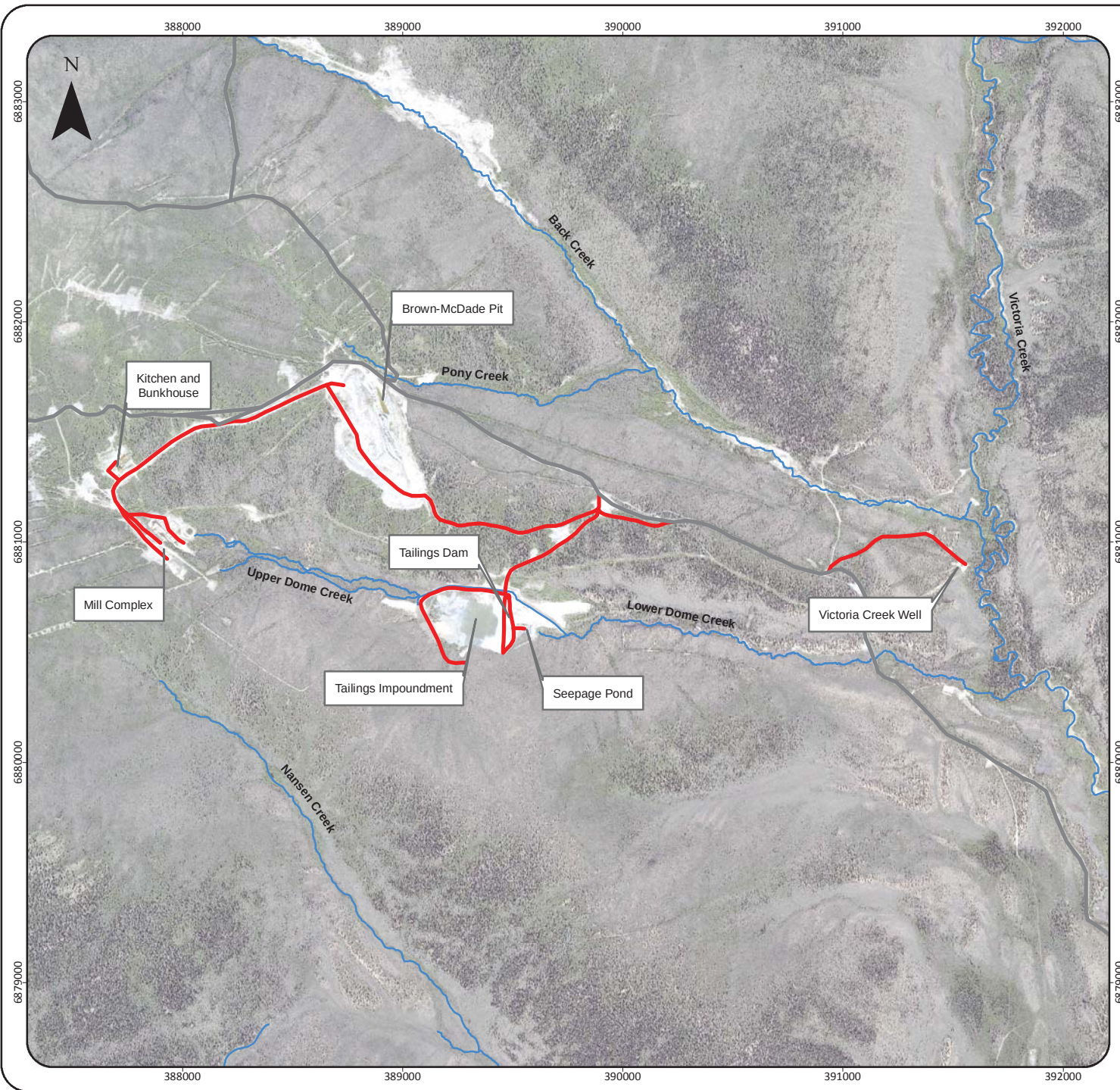
A single-lane bridge spans the DCDC and provides all-season access to the main components of the TSF. Ice will be removed from under the bridge using a rubber-tired backhoe or excavator to prevent any ice covering the bridge road surface. Other methods of ice removal include excavating ice by hand with picks and shovels, cutting the ice with a steamer or heating the area under the bridge with a space heater.

5.2.4 Maintenance of Power System

The Site is equipped with two 175 kW primary generators that are run separately to provide power to all areas of the Site. The generators are located in sea can containers adjacent to the workshop (Figure 5.2-1). The electrical distribution system consists of several kilometres of overhead power line as well as a variety of transformers, breakers and switching systems. Electricity is generated at 480 volts and transformed up to 4,160 volts for distribution around the Site. The generators will be inspected at least twice daily (e.g., for appropriate fluid levels). Once a generator has run its determined cycle (i.e., approximately 500 hours), it will be powered down and the other generator will be put on-line to provide power to the Site. All regular maintenance (e.g., oil changes, oil filter changes, belt changes, replacement of batteries, etc.) will be completed by Site operations personnel. All maintenance recommendations and schedules supplied by the manufacturer will be followed to ensure reliable service from the generators. An additional 175kW back-up generator is also located in a sea can and is available for use if and when both primary generators are not working. A power failure alarm is installed to notify Site operations personnel of any power failures, including a module located on the second floor of the bunkhouse to notify Site operations personnel of a power failure should it occur at night. Emergency response and contingency procedures to be implemented in the event of a power outage are detailed in the Mount Nansen Site Operations Emergency Response Plan (see Appendix 5E).

Routine inspections of the power lines are completed at Site and additional inspections will be completed following high winds and snow events to ensure that none of the power lines have been compromised or damaged.

A fourth 60 Kw mobile generator is available on-site as an emergency back-up generator. Connections for the mobile generator are available at the seepage pond and at the bunkhouse to ensure that electrical power is always available at these locations should there be a disruption in the main electrical system at the Site (e.g., failure of power poles or the main transformer).

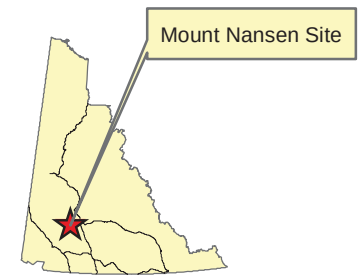


**MOUNT NANSEN CARE AND MAINTENANCE
PROJECT**
Figure 5.2-3
Mount Nansen Public Access
and Site Roads



Legend

- Public Access/Main Road
- Site Roads
- Watercourses



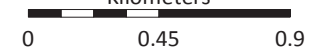
Data Source:

1. Site features (e.g., roads, trails, waterbodies, watercourses and infrastructure areas) digitized by ELR.
2. 2008 Quickbird imagery (courtesy of Yukon Geomatics) and spatial data provided by Yukon government.

Datum: NAD 1983 CSRS UTM Zone 8N

Scale 1:26,000

Kilometers



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5.2.5 Maintenance of Bunkhouse

Maintenance of the bunkhouse is completed by Site operations personnel. Maintenance may include minor repairs to the interior and exterior of the bunkhouse buildings (e.g., minor electrical and plumbing work). The bunkhouse is outfitted with a propane hot water heating system comprising boilers, piping and radiators (Figure 5.2-2). The boilers in the bunkhouse will be serviced annually by qualified contractors. The bunkhouse is equipped with a fire alarm system with smoke detectors, carbon monoxide detectors and pull stations to manually activate an alarm. Alarm systems will be inspected annually, at a minimum. Site operations personnel will also perform cleaning duties of the bunkhouse on a daily basis.

Site operations personnel perform their own cooking at the bunkhouse using on Site facilities.

Potable water for the Site comes from the Victoria Creek Well House. This is an artesian well located away from the public road. The well is housed within a small, insulated building. The water from the well is tested on a monthly basis for quality (analytical laboratory drinking water package). Potable water samples from the well and from the bunkhouse are also tested monthly for coliform and E. coli by the Government of Yukon Environmental Health Services laboratory in Whitehorse. Water in the storage tank is treated with approximately 15 ml of chlorine per tank-load delivered.

Two 1,500-gallon (approximately 6,820 L) tanks are housed in a small insulated shelter to supply water to the bunkhouse. Water is then distributed from the tanks to the boilers and to each cold-water tap. The water supply line to the bunkhouse has heat tracing to prevent it from freezing during the winter. Water is trucked from the Victoria Creek Well House every two weeks, or as required, to the water storage tanks when the water level in the tanks reaches the 600-gallon marker on the volume scale on the side of the tanks. Water is transported to the holding tanks from the Victoria Creek Well House using a 700-gallon, portable water tank stored in the workshop and mounted on a truck whenever water needs to be hauled to the bunkhouse. Both the water tank shelter and the Victoria Creek Well House have heaters that are turned on at the on-set of freezing temperatures.

5.2.6 Maintenance of Workshop

A workshop is located between the old mill and the generator sea-cans. It is a heated shop with large garage doors for equipment and is outfitted with a ceiling crane. Servicing of all Site vehicles and equipment takes place in the workshop, except for the stationary generators, and the excavator, which is too large to fit in the shop. The excavator is serviced in front of the shop doors. The workshop also contains fire extinguishers, an eye wash station, a first aid kit and a large spill kit. The oil furnace will be serviced as necessary by a qualified technician, and the crane will be inspected annually by a contractor licensed to certify cranes in the Yukon.

5.3 Scheduling of Project Components

In general, the timing and duration of the project activities described in previous sections is on an ongoing basis and the schedules for particular project components are indicated in the relevant sections above (e.g., daily Site checks, bi-annual formal inspections). The care and maintenance activities will continue for five years, or until a Site remediation plan has been prepared, approved and implemented (whichever is sooner). A Water Licence application will be submitted, based on a project duration of 5 years, although it is anticipated that the Site remediation plans will be implemented within this time frame.

The WTP installation is planned for the summer of 2018. Installation will be during snow-free conditions and will take approximately four months to complete. A period of operational testing and refinement of the WTP is expected to take approximately three months following installation. WTP Operators will be trained during the testing period. It is expected that the WTP will be fully operational in the late fall/early winter 2018.

5.4 Project Equipment

Based on the equipment that is currently used at the Site, the following list of equipment is anticipated for the project:

- A tracked excavator fitted with hydraulic thumb (Currently Case 210)
- 1 wheeled backhoe (currently CAT 420)
- 1 Tracked Bulldozer
- 1 Portable Crane
- 1 Heavy Duty pickup (e.g., 550 series)
- 3-4 Pickup trucks (1/2 – 1 ton)
- 1 water pump (10 hp)
- 1 motor grader (200-300 hp)
- 1 rubber tire loader (3-10 m³)
- Space heaters
- Miscellaneous tools as required (e.g., chain saws, tamper compactors, shovels, rakes, cutting torches, axes, hand tools)

6 Description of Existing Environmental Conditions

6.1 General Physiography and Climate

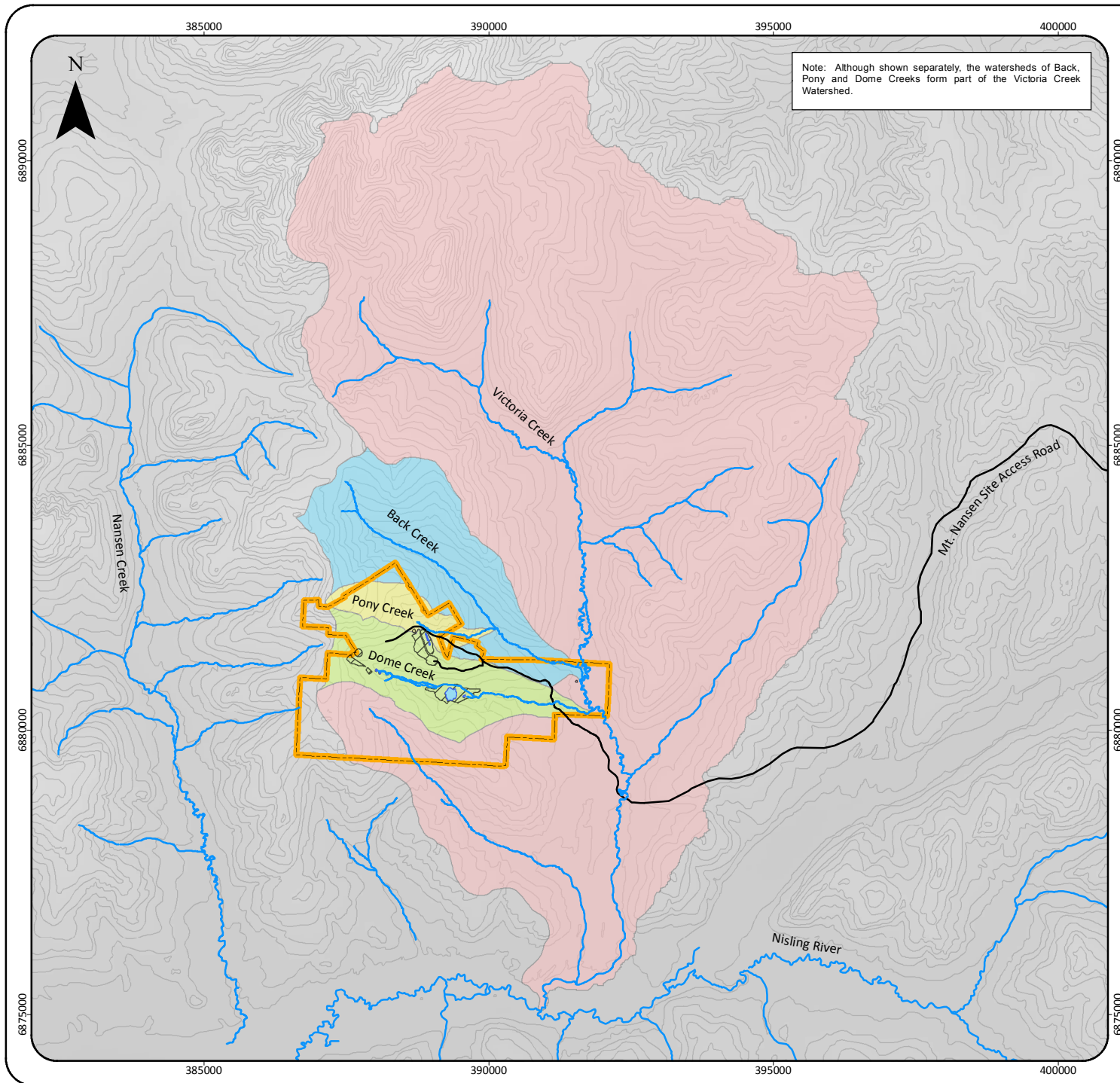
6.1.1 Physiography

The Site falls within the Boreal Cordillera Ecoregion, Klondike Plateau Ecozone (Yukon Ecoregions Working Group [YEWG] 2004). The elevation of the terrain in the ecoregion ranges from approximately 450 meters (m) in the river valleys to 1,700 m above sea level (asl) at the mountain peaks. Deep and narrow v-shaped valleys and prominent rocky ridges of the ecoregion are indicative of a lack of recent glaciations. Major features in the area include the Dawson Range, several rivers including the Nisling, Donjek, White and Yukon rivers, and several lakes in the Wellesley Depression. The Dawson Range is the most distinct feature in the region and trends northwest to southeast between the Yukon River to the north, and the Nisling River to the south. The Nisling River drains the southern part of the Dawson Range, flowing west along the southern boundary of the ecoregion before joining the Donjek and White rivers.

The regional climate and largely unglaciated state of the Plateau result in a mosaic of permafrost-free soils on well-drained uplands and slopes, with extensive discontinuous permafrost on lower slope and valley bottoms. Upper slopes generally are comprised of coarse colluviums with silty colluviums and loess (muck deposits) common on lower slopes that typically are capped with peat and underlain by permafrost. Regular freezing and thawing in permafrost soils resulting in the mixing of soil horizons (cryoturbation) is common throughout the area.

The Klondike Plateau around the Site consists of vegetation typical of boreal high, subalpine and alpine ecosystems (YEWG 2004). In the upper elevations, the subalpine treeline is close to 1,000 m asl and consists largely of shrub associations dominated by scrub birch (*Betula glandulosa*), various willow species (*Salix sp.*) and the occasional white spruce (*Picea glauca*). Alpine (between 1,000 m and 1,700 m asl) vegetation is dominated by shrub associations of scrub birch and willow. In the boreal high zones (between 450 m and 1,100 m asl), forest associations are more common with white spruce dominating the overstory. In low-lying areas, spruce and sphagnum moss bogs are common, particularly in the seepage areas associated with areas of cryoturbation and permafrost. Mixed forests of trembling aspen (*Populus tremuloides*), balsam poplar (*Populus balsamifera*) and spruce are common on warm, unfrozen aspects.

The Site is located within the Victoria Creek Watershed, a tributary to the Nisling River (Figure 6.1-1). Several sub-watersheds contribute to the Victoria Creek watershed, including Back Creek, Dome Creek, Pony Creek, and Dry Creek. Fish species documented in the watershed include Burbot (*Lota lota*), Arctic Grayling (*Thymallus arcticus*), Slimy Sculpin (*Cottus cognatus*) and Round Whitefish (*Prosopium cylindraceum*).



MOUNT NANSEN CARE AND MAINTENANCE PROJECT

Figure 6.1-1

Project Area Watersheds



Legend

Base Layers

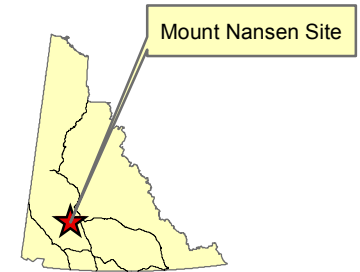
- Roads
- Watercourses
- Waterbodies
- Contour Lines
- Site Infrastructure Areas

Local Boundaries

- Order in Council Area

Watershed Name

- Back Creek Watershed
- Dome Creek Watershed
- Pony Creek Watershed
- Victoria Creek Watershed



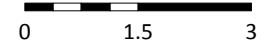
Data Source:

1. Site features (e.g., roads, trails, waterbodies, watercourses and infrastructure areas) digitized by ELR.
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Datum: NAD 1983 CSRS UTM Zone 8N

Scale 1:100,000

Kilometers



March 5, 2018

Historically one of the most biologically productive ecoregions and ecozones, the diversity of habitats found throughout the Klondike Plateau provides habitat for a wide variety of wildlife species (YEWG 2004). The Site is within the ranges of both the Klaza and Aishihik woodland caribou (*Rangifer tarandus caribou*) herds. The abundance of low-lying shrub, bog, and seepage areas provide habitat for moose (*Alces alces*) throughout the area. The densely-vegetated shrub associations act as refugia for snowshoe hare (*Lepus americanus*), which in turn are critical areas for hare specialist predators such as the Canada lynx (*Lynx canadensis*). Other commonly-observed carnivores in the area include marten (*Martes americana*) and wolverine (*Gulo gulo*). Both grizzly bear (*Ursus arctos horribilis*) and black bear (*Ursus americanus*) are present, with black bear reaching their highest densities in this ecoregion (YEWG 2004).

6.1.2 Climate

The climate of the Boreal Cordillera Ecozone, Klondike Plateau Ecoregion ecoregion (where the Site occurs) is strongly continental, with warm summers and very cold winters (YWEG 2004). Climate data has been recorded at the Site since the year 2000 at an on-site weather station (with a gap in 2006), and a new station was installed in 2011. The active station (ATM-Road) measures air and ground temperature, relative humidity, rainfall, snow depth, net shortwave and longwave radiation, atmospheric pressure, wind speed and wind direction (detailed in Appendix 6C). Ongoing regional climate data also has been collected by Environment Canada at Dawson, Carmacks and Pelly Ranch (on the Yukon River, west of Pelly Crossing), with Carmacks and Pelly Ranch being the closest to the Site. The period of record for these stations is long and extends for more than 50 years.

For the purpose of the Care and Maintenance Project, climate data for the Site was summarized for the last five years, which is the period of reporting from the new weather station (October 2011 to October 2016; Appendix 6C). This reporting period was chosen due to the quality of the data available, and because this period provides the best data from which to assess the care and maintenance project.

6.1.2.1 Temperature

Mean annual temperatures for the Klondike Plateau Ecoregion are near -5 degrees Celsius (°C), though regional temperatures do show significant seasonal variation around this mean value. January is typically the coldest month with mean temperatures ranging from -23 to -32°C. In July, mean temperatures are typically between 10 and 15°C. Frosts can occur at any time of the year, though it is relatively infrequent in July.

From the Site climate data, the mean annual temperature ranged from -3.5 to -0.8 °C, with the five-year mean being -1.4 °C. The warmest mean monthly air temperatures at the Site occurred in July (11.2 °C), and the coldest mean monthly air temperature occurred in November (-12.8 °C), although December and January were nearly as cold. The highest and lowest daily air temperature measurements at the Site during the recording period were 26.8 °C (June 23, 2013) and -36.6 °C (January 29, 2013), respectively. A summary of temperature data for the period of 2011-2016 is provided in Table 6.1-1, along with comparable data from the Carmacks and Pelly Ranch stations.

Table 6.1-1: Site and Regional Temperature Data for the Period of 2011-2016

Mount Nansen Site Weather Station													
Year, Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2011	---	---	---	---	---	---	---	---	---	-4.4	-15.9	-8.9	---
2012	-17.7	-8	-9.8	0.1	2.8	8.8	10	9.3	4.2	-6.2	-16.6	-18.4	-3.5
2013	-13.3	-8.4	-10.9	-7.7	4.4	12.1	11.9	11.6	4.6	0	-13.7	-15.9	-2.1
2014	---	---	---	1.9	6.6	8.5	11.3	9.4	4	-3.1	-7.5	-8	---
2015	-11.8	-10.4	-7	-1.1	9.8	10.1	11	8.1	3	-0.5	-10.2	-11.8	-0.8
2016	-7.5	-7.5	-3.6	1.8	6.8	10.4	11.8	10.7	4.8	-4.5	---	---	---
Average (2011-2016)	-12.5	-8.6	-7.8	-1	6.1	10	11.2	9.8	4.1	-3.1	-12.8	-12.6	-1.4
Regional Climate Stations													
Year, Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Carmacks (1963 to 2008)	-25.4	-17.9	-10.1	0.5	7.6	13.5	15.3	12.9	6.8	-1.8	-13.9	-22	-2.9
Carmacks CS (2011 to 2016)	-20.5	-12.9	-7.8	1.3	9.1	13.8	15.4	13.3	7.6	-1.5	-15.1	-21	-1.5
Pelly Ranch (1951 to 2015)	-26.5	-20.4	-11.7	0.2	8	13.6	15.4	12.7	6.6	-2.5	-16	-24.3	-3.8
Pelly Ranch (2011 to 2015)	-20.8	-18.3	-11.5	-0.1	9.2	14.7	16	13.8	7.9	-1.4	-16.4	-20.7	-2.3

Both regional stations have shown clear warming trends of about 2.5°C since the 1960s. It is likely that the Site may have also experienced a similar temperature increase over time.

The Site experiences winter altitudinal temperature inversions (warmer temperatures) due to its location at elevation, and this effect on temperature can be clearly observed when comparing Site winter temperature data with the regional stations which are at lower elevations. The Site also experiences slightly cooler summer temperatures compared to the regional stations (Table 6.1-1). The process and effect of temperature inversions is detailed further in Appendix 6C.

6.1.2.2 Precipitation

Generally, within the Klondike Plateau Ecoregion, annual precipitation ranges from 300 to 500 millimeters (mm). Drier periods occur from February through April, with monthly precipitation means of 10 to 20 mm typically. The wettest period is from June through August when monthly precipitation means increase to 50 to 90 mm (YEWG 2004).

Regional data from Brabets et al. (2000) suggests roughly 250 to 375 mm of precipitation should be expected in the Project area, which is similar to long-term data from both the Carmacks and Pelly Ranch regional stations (296 mm and 320 mm, respectively). On average, this precipitation has been realized at these regional stations at a ratio of 64-66% rain and 34-36% snow. Data from regional climate stations also show that least precipitation is received in March and April (3-4% of annual total), while the most is received between June and September (50-55% of annual total). Snow Water Equivalent (SWE) and Snow depth measurements

Adjacent to the Site, snow course surveys (snow depth and SWE) are conducted at Mount Nansen (09CA-SC01), and these data were compared to four other regional snow sampling sites within the Yukon. Regional data show snow depth and SWE tends to peak around April 1 with mean snow depth and SWE measurements at the Mount Nansen snow course station of 43 cm and 69 mm, respectively for March, and 45 cm and 80 mm respectively for April. These data are on average lower in comparison to the four regional stations for the same period of record, where SWE data ranges from 81-97 mm for March 1 and 100-102 mm for April 1. A summary of March 1 and April 1 snow depth measurements for the Mount Nansen snow course are provided in Table 6.1-2.

Table 6.1-2: Summary Statistics for Snow Depth and SWE for the Mount Nansen Snow Course (09CA-SC01), 1976 – 2016

Metric	March 1 Snow Depth (cm)	March 1 SWE (mm)	April 1 Snow Depth (cm)	April 1 SWE (mm)
Average	43	69	45	80
Max	61	112	63	158
Min	20	28	26	49
St Dev	9.1	18.1	10.1	24.3

Period of record snow depth and SWE relative to long-term averages are shown for Mount Nansen (09CA-SC01) in Figure 6.1-2, below. Recent years are highlighted grey in this figure show 2011-2013 SWE and 2011-2014 snow depths near the Site as being above average values, whereas 2014-2016 SWE and 2015-2016 snow depths have been below average.

In addition to the regional snow course data described above, snow course data were collected for one winter at Site and snow depth measurements were also measured continuously at ATM-ROAD from October 2011 to October 2016. A summary of Site snow depth trends and SWE data, measurements are presented in Appendix 6C.

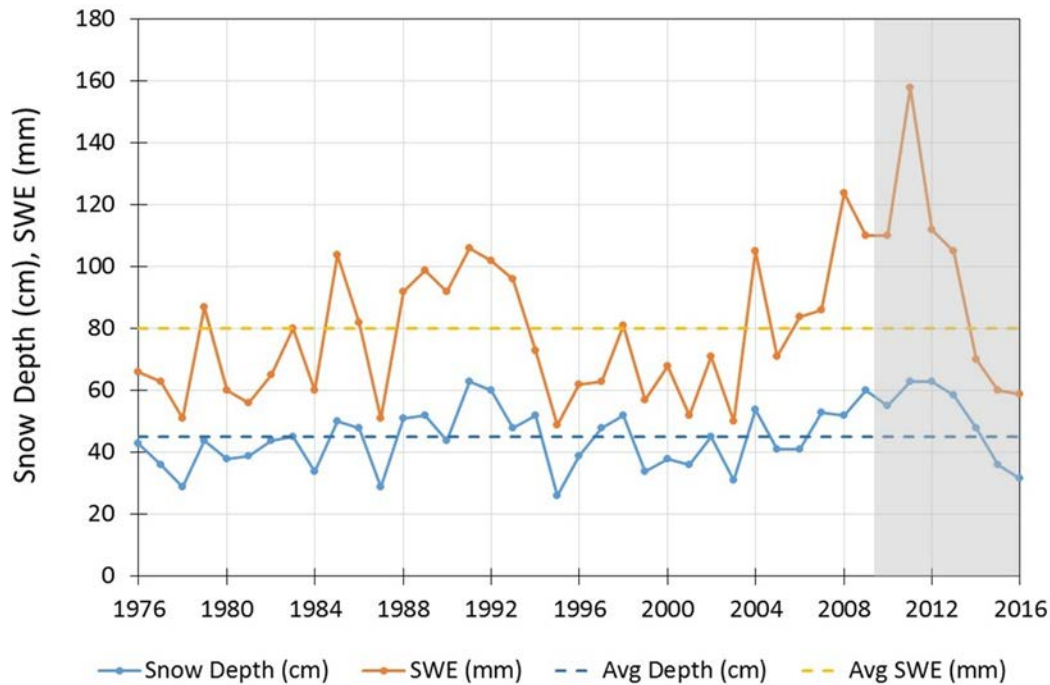


Figure 6.1-2: Time Series Plot Showing Patterns of SWE and Snow Depth in Comparison to Means for the Period of 1976-2016

In order to calibrate between data sources for Site Water Balance and modelling purposes, a relationship between ATM-ROAD and 09CA-SC01 Stations was developed for the April 1 snow depths and SWE. This was accomplished using October 2011-2016 Site climate data and available data for station 09CA-SC01. This comparison found that snow depths at the ATM-ROAD station consistently higher by approximately 20% for the 2012-2016 period. A good relationship was determined between SWE and snow depth for station 09CA-SC01, and from this and the comparison with ATM-ROAD it was determined that SWE at the Site is on average 20% higher than that which has been measured at station 09CA-SC01. These higher values were carried forward into the recurrence interval estimate for water balance and modelling purposes. Recurrence interval estimates for SWE are summarized in, with the methods supporting the analysis detailed in Appendix 6C.

Table 6.1-3: Recurrence Interval Estimates of SWE for the Site (elevation 1,255 m asl)

Probability	Event	April 1 SWE (mm)*
0.01	1:100 dry	49
0.02	1:50 dry	53
0.05	1:20 dry	59
0.1	1:10 dry	65
0.2	1:5 dry	74
0.5	1:2 median	94
0.8	1:5 wet	122
0.9	1:10 wet	140
0.95	1:20 wet	158
0.98	1:50 wet	180
0.99	1:100 wet	197

6.1.2.3 Rainfall

Rainfall data collected at the Site climate station between 2012 and 2016 show an average of 256 mm of rain during the year, occurring between April and October. The wettest months are July or August, with June and September having moderate rainfall. Rainfall data from the Site show that more precipitation occurs at the Site compared to the regional stations (Table 6.1-4). For example, for the period of 2012-2014, Site rainfall was approximately 20% higher than that at the Pelly Ranch station. Over the period of record available, rainfall is approximately 15 and 19% higher than at the Site compared to the Pelly Ranch and Carmacks regional stations, respectively. Figure 6.1-3 shows the relative consistency of rainfall at the two regional stations, as well as consistently greater rainfall at the Site. A recurrence interval estimate for Site rainfall was calculated based on the period of record rainfall data for the three sites, based on the relationships between rainfall data for the Site and each regional station. These data are provided in Table 6.1-5 and are further detailed in Appendix 6C.

Table 6.1-4: Summary of Annual Rainfall Data (mm) for the Site and Regional Stations, 2012-2016

Year	Site Weather Station								Pelly Ranch	Carmacks CS
	Apr	May	Jun	Jul	Aug	Sep	Oct	(Apr-Oct)	(Apr - Oct)	(Apr- Oct)
2012	3	21	61	63	79	21	10	256	196	-
2013	11	18	39	77	36	52	22	256	232	-
2014	5	24	26	71	41	57	13	236	193	160
2015	6	8	25	57	98	26	17	238	-	198
2016	23	50	42	107	41	29	2	294	-	198
Average	10	24	39	75	59	37	13	256	-	-

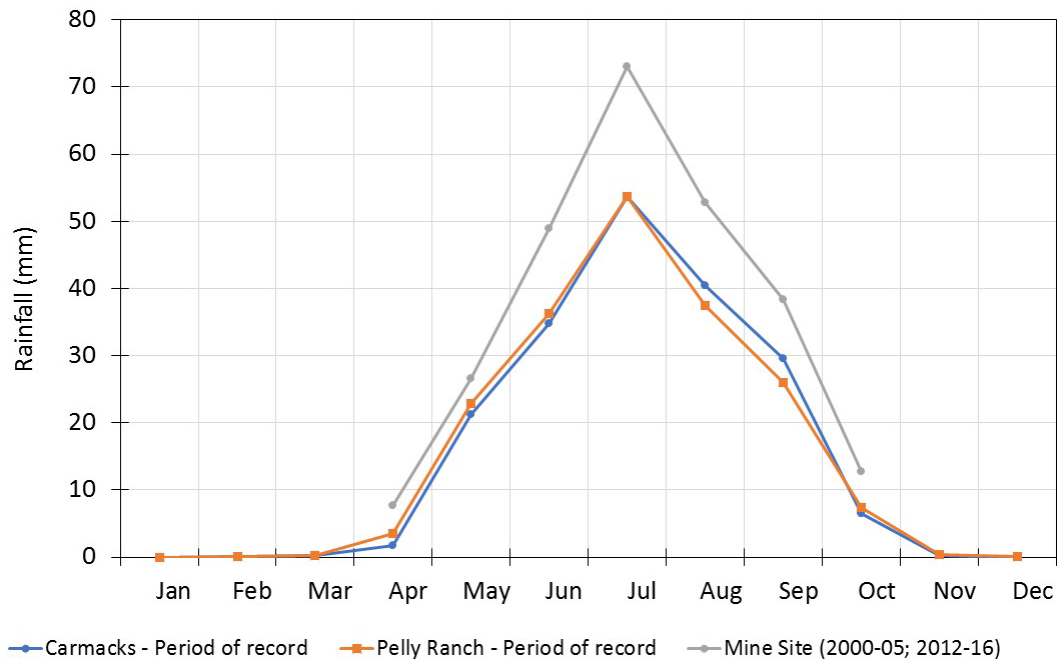


Figure 6.1-3: Comparison of Average Monthly Rainfall Data between the Site, Carmacks, and Pelly Ranch Stations for the Available Period of Record.

Table 6.1-5: Recurrence Interval Estimates for Site Rainfall (April to October)

Probability	Event	Seasonal Rainfall (mm; Pelly Ranch Predictor)	Seasonal Rainfall (mm; Carmacks Predictor)
0.01	1:100 dry	114	123
0.02	1:50 dry	124	131
0.05	1:20 dry	140	145
0.1	1:10 dry	155	158
0.2	1:5 dry	174	175
0.5	1:2 median	217	216
0.8	1:5 wet	266	271
0.9	1:10 wet	294	306
0.95	1:20 wet	318	340
0.98	1:50 wet	347	383
0.99	1:100 wet	365	414

Notes:

Adapted from Figure 3-7 of Appendix 6C. Based on an assessment of corresponding rainfall data available for Mount Nansen (Appendix 6C) and nearest regional stations, monthly rainfall data for Pelly Ranch and Carmacks were adjusted upward by factors of 1.15 and 1.19 to represent the Site. The adjusted time series (Pelly Ranch, n = 56 years; Carmacks, n = 40 years) were then analyzed using Mathwave-EasyFit.

6.1.2.4 Wind

At the Site, daily average wind speeds were between 1 and 3 m/s for the period of 2011-2016. Daily wind speed data showed considerable variability with time, and daily average wind speeds on the order of 4 to 6 m/s were not uncommon at the Site. Only 3% of the measurements during that time period exceeded 6 m/s, and the maximum hourly wind measurement for the period was 15 m/s.

The dominant wind directions during the summer period (April to September) are south, southwest and southeast. Wind direction in the winter is more variable (Appendix 6C).

6.1.2.5 Evapotranspiration

Details on regional and Site evapotranspiration and potential evaporation are presented in Appendix 6C. Months showing highest rates of potential evaporation include May to August, whereas rates for April and October are roughly one half those in warmest months. During warmest months daily rates of potential evaporation may range from 2-6 mm/day at the Site, with annual estimates in the range 430 to 490 mm/yr. These rates of potential evaporation are similar to those reported for regional stations.

6.2 Air Quality

6.2.1 Ambient Air Quality

Ambient air quality at the Mount Nansen site has not been monitored to date. Potential sources of airborne pollutants include:

- Fugitive dust from tailings materials and waste rock area;
- Fugitive dust from vehicle travel on unpaved roads (onsite and public road);
- Combustion emissions from stationary devices such as generators; and
- Combustion and particulate matter emissions from vehicles (onsite and public) and other nearby industrial activities.

The following pollutants are potentially of concern:

- Sulphur dioxide (SO₂);
- Nitrogen dioxide (NO₂);
- Carbon monoxide (CO); and
- Particulate matter (PM).

These pollutants are all emitted by combustions sources, both mobile and stationary, except for fugitive PM that originates from exposed soil and rock surfaces. Fine particulate matter (PM_{2.5}¹) is of most concern as it can cause significant health issues. Coarse particulate matter (PM₁₀²) is also considered a potential health concern. The Yukon has ambient standards for each substance listed above (Environment Yukon 2014a).

¹ PM_{2.5} refers to particles with a diameter of 2.5 µm or less.

² PM₁₀ refers to particles with a diameter of 10 µm or less.

As air quality monitoring data are not available for the Site, data collected from five sources (NAPS 2008, BC MOE 2013a, NAtChem 2013, Casino Project 2014, WCAS 2014) with similar emissions and surroundings have been used to estimate the existing air quality at the Site (Table 6.2-1).

Table 6.2-1: Representative Baseline Ambient Air Quality

Data Source	Station Location	PM _{2.5}	PM ₁₀	Nitrogen Dioxide (NO ₂)	Sulfur Dioxide (SO ₂)	Carbon Monoxide (CO)
National Air Pollution Surveillance Program (NAPS) 2005-2006	Whitehorse, Yukon	5	13	13	3	-
BC Ministry of Environment (BC MOE) 2010-2011	MAML	5	7	4	1	100
Alberta West Central Airshed (WCAS) 2000-2011	High Tower, Alberta (about 310 km west of Edmonton)	2	6	-	-	-
Environment Canada's Greenhouse Gas Measurement Laboratory (GGML) 2009-2010	Estevan Point, BC	-	-	-	-	141
Casino project Onsite Monitoring	Central West Yukon	4*	6*	-	-	-
Average	-	4	8	9	2	120

Notes: -: Not monitored

* This is the detection limit for the passive monitoring used at Casino

All values rounded to nearest 1.

All values are annual averages measured in µg/m³.

PM = particulate matter

MAML = Mobile air monitoring laboratory. 2010-2011 survey of five communities free of major emissions sources: Toms Lake, Ground Birch, Rolla, Farmington, and Kelly Lake.

6.2.2 Greenhouse Gas Emissions

Greenhouse gas (GHG) is emitted by all combustion processes, which would include mobile equipment and stationary generators at the Site. Fuel use was determined based on fuel deliveries to the Site from 2012 to 2014, with Table 6.2-2 showing fuel use and estimated GHG emissions for this period. The Carbonzero emissions calculator (Carbonzero 2018) was used to estimate greenhouse gas emissions at the Site. Site emissions are compared to Yukon emissions (Taggart 2013) and Canadian emissions (Environment Canada 2013). Mount Nansen greenhouse emissions are estimated to constitute approximately 0.1% of Yukon emissions, which are about 0.1% of the Canadian emissions.

Table 6.2-2: Greenhouse Gas (GHG) Emissions-Mount Nansen Site, Yukon and Canada (2012-2014)

	Year					
	2012		2013		2014	
Fuel Type	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel
Amount (L) Mount Nansen	12,376	254,370	10,925	251,574	8,042	266,685
GHG Emissions (t) Mount Nansen	29	685	26	677	19	718
Total GHG Emissions Mount Nansen (t)	714		703		737	
Yukon GHG Inventory ¹ (t)	718,000					
Canada GHG Inventory ² (t)	699,000,000					

Notes: Mt. Nansen emissions are rounded to nearest tonne

¹ Estimated 2011 inventory

² 2012 inventory

6.2.3 Metal Transport and Deposition

The transport and deposition of metals through wind activity has been considered as it relates to existing key mine infrastructure (i.e., TSF, Brown McDade Pit, and mill). Data collected from the Site suggests that some metals present in ore, waste rock, and tailings, and also potentially from process chemicals used during operations, have and may continue to be deposited in the vicinity of the Site. However, because the deposition of any fugitive dust may affect soil and plant tissue chemistry and the plants may be eaten by or come into contact with local wildlife, fugitive dust has been discussed in the vegetation existing environmental conditions section.

6.3 Noise

Ambient noise levels, representative of natural environmental noise and other sources of noise not associated with the existing Site activities have not been measured within or around the Project area. Background noise levels, representative of both the ambient noise and all other sources of noise that currently exist, including those associated with existing Site activities, also have not been measured within or around the Project area.

Ambient noise levels based on AER (2007) and MOECC (2008) were estimated to be 35 decibels (dBA) (Leq-9hr³) for night-time and 45 dBA (Leq-15hr⁴) for day-time. The existing background noise levels are expected to vary with time and spatial location. Based on the equipment and activities, background noise level is expected to fade to the ambient noise level at distances from 1 to 12 kilometres from the existing site activities. The upper limit of 12 kilometres is a worst-case situation based on a summertime scenario where two to three activities occur at the same time and within close proximity to each other (e.g., the generator is running with the shed doors open for cooling while an excavator grades the road in the mill area).

³ Leq-9hr refers to the energy equivalent sound level over a 9-hour time period

⁴ Leq-15hr refers to the energy equivalent sound level over a 15-hour time period

6.4 Surficial Geology and Soils

6.4.1 Glacial History and Deposits

The study area lies within the Yukon Plateau-Central Ecoregion and is characterized by rolling hills, low rounded mountains and broad valleys (YEWG 2004). As the glacial history of the Yukon is complex, it is common to simplify the many periods of ice advance and retreat into three main episodes (EBA 2009):

- Pre-Reid (Pliocene-Early Pleistocene; older than 3 million years);
- Reid (Middle Pleistocene; about 200 thousand years ago); and
- McConnell (Late Pleistocene; about 22 thousand year ago).

Glacial deposits in the Project area belong to the pre-Reid episode and are most commonly found in valley bottoms. It is possible that the highest peaks in the area (e.g., Mount Nansen) escaped glaciation. Glacial till was likely deposited across the study area, although given the long period of time since deposition (greater than 3 million years) till is not easily recognized in upland areas as it may have been modified by slope processes (e.g., colluviation). In upland areas, the surficial geology is dominated by thin (less than 5 m) colluvial deposits and patches of bedrock subcrop. Typically, the ridge tops and upper to mid-valley slopes consist of a thin veneer of colluvium overlying bedrock with limited outcrops of fractured rock. Lower valley slopes are generally comprised of thicker colluvial deposits as well as colluvial fans, glaciofluvial terraces, and low escarpments (EBA 2009).

Valley bottoms have significant thicknesses of fluvial and glaciofluvial outwash deposits. In the lower regions of Dome Creek and other valleys, these deposits were subsequently eroded creating terrace deposits. In localized areas at depth in the Dome Creek valley (and likely in other valleys as well), silt to silty clay and till has been encountered. Localized Aeolian deposits also occur, including in the vicinity of the TSF which is underlain by a thin veneer of native sediments consisting of organics, silty Aeolian sand and alluvial/colluvial sediments of the Dome Creek drainage.

Topsoil and organic material at the Site generally is limited and typically is less than 0.5 m thick, although it can be several metres thick in wide flat valley bottoms.

6.4.2 Permafrost

The study area lies near the northern boundary of the discontinuous permafrost region. Permafrost is expected in most areas onsite, typically within several metres of the ground surface. The active (seasonally thawed) layer is expected to be up to 2.5 m thick. The coarse nature of overburden in the Project area suggests most slopes will contain negligible ground ice (i.e., all types of ice contained in freezing and frozen ground). In the valley bottoms where finer grained sediments have accumulated, there is potential for local ice-rich deposits. In disturbed areas, permafrost may be deeper and/or absent, particularly near existing infrastructure areas. For example, there exists a thawed zone beneath the Brown McDade Pit and on the north side of the TSF where there has been a substantial amount of permafrost thaw. Permafrost conditions have been encountered below the base of the tailings but above the unfrozen conditions within and above the native sediments.

The historical (1967) and current (2013) expected distributions of permafrost at the Site are shown in Figure 6.5-1 and Figure 6.5-2. Because previous subsurface investigations and deep ground temperature measurements have been limited to disturbed areas within the Yukon Order in Council (OIC) 2006/205 (YOIC 2006) boundary, these figures were developed based on model predictions that consider soil type, slope aspect, vegetation, and snow cover. Ground temperatures shown on the maps are for steady state conditions with air temperatures consistent with the years shown (refer to discussion in the following paragraphs). As steady state conditions can take many years to develop, the warmer ground conditions predicted on the 2010-2013 map may not yet be present. This is reflected by the potential for relict permafrost.

With a mean annual air temperature of -1.4°C at the Site, permafrost conditions are expected in most areas of the Mount Nansen site except those with steep south-facing slopes. Under these conditions, permafrost would also re-establish in disturbed areas that have an expected ground temperature just below 0°C .

6.5 Terrain Hazards

The Project area is dominated by gentle to moderate slopes. Ridge tops and floodplains in the major valley bottoms (e.g., Victoria Creek) and the lower reaches of smaller creeks are flat to gently sloping. There are a few moderately steep slopes near the ridge tops in the northwestern part of the study area. Steep slopes are generally confined to disturbed cut and fill slopes. Only localized landslides and avalanches appear to be potential terrain hazards in the study area. Based on existing terrain, slope and site-specific conditions, other possible terrain hazards are of low risk.

There are no indications of previous large-scale, deep-seated landslides at the Site, although some slopes are affected by solifluction and by small-scale, localized landslides. Surface erosion and rilling is also evident where previous exploration trenching has disrupted the natural pattern of surface water flow. None of these features are expected to generate a large volume of debris or to pose significant risk to the Project area.

Areas of marginally stable permafrost at the Site are susceptible to ground disturbance, which could trigger surface erosion. The north-facing slopes of the Dome Creek valley in the vicinity of the tailings dam are amongst sensitive areas. In such areas, compression or removal of surface vegetation could result in terrain instability where soils have a high ice content. This process has occurred previously along the interceptor ditch south and west of the tailings facility, as well as along the toe of the tailings dam.

Generally, the slopes within the project area are not high or steep enough to generate avalanche hazards.

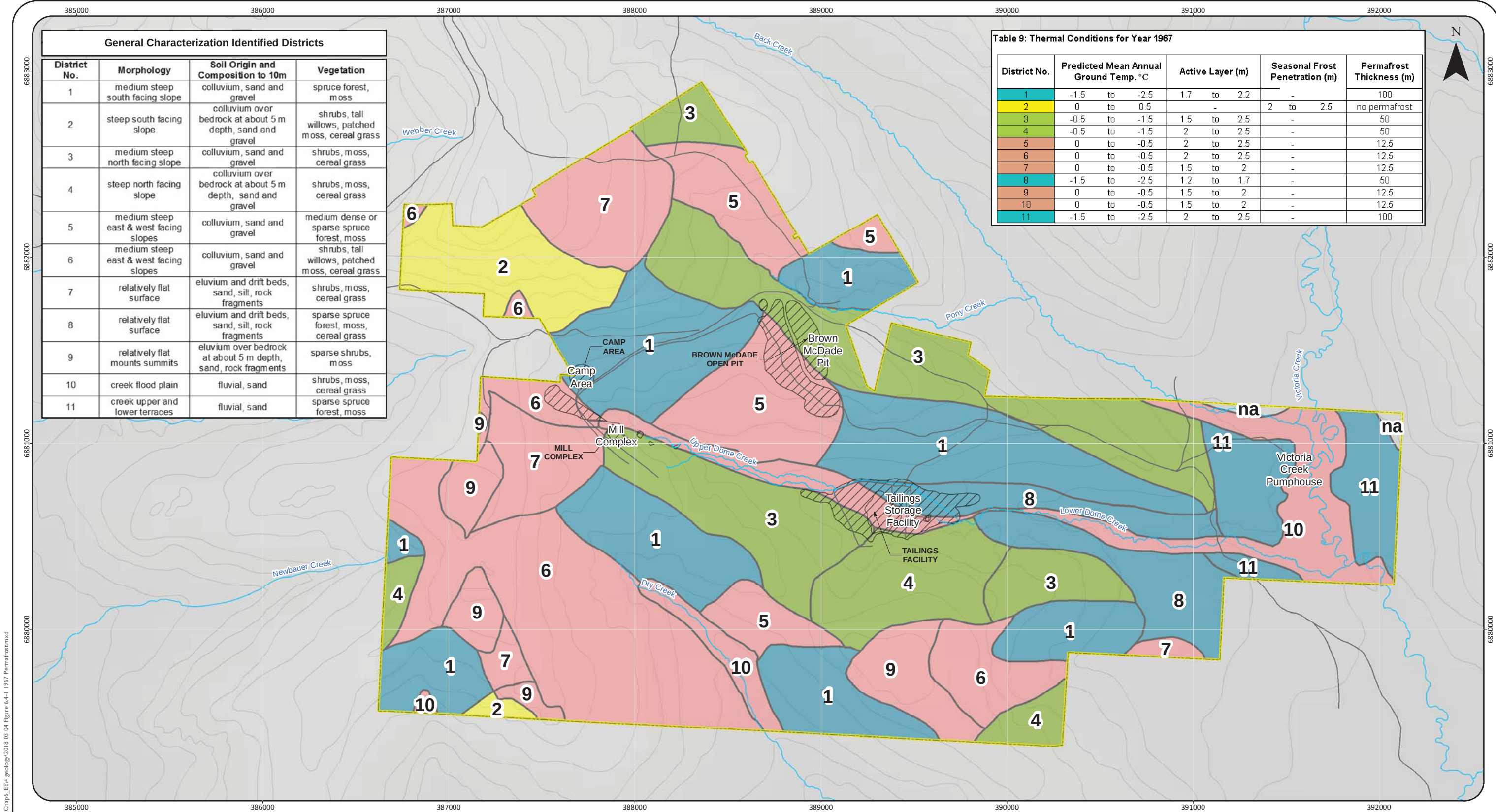


Table 9: Thermal Conditions for Year 1967							
District No.	Predicted Mean Annual Ground Temp. °C		Active Layer (m)		Seasonal Frost Penetration (m)		Permafrost Thickness (m)
1	-1.5	to -2.5	1.7	to 2.2	-	-	100
2	0	to 0.5	-	-	2	to 2.5	no permafrost
3	-0.5	to -1.5	1.5	to 2.5	-	-	50
4	-0.5	to -1.5	2	to 2.5	-	-	50
5	0	to -0.5	2	to 2.5	-	-	12.5
6	0	to -0.5	2	to 2.5	-	-	12.5
7	0	to -0.5	1.5	to 2	-	-	12.5
8	-1.5	to -2.5	1.2	to 1.7	-	-	50
9	0	to -0.5	1.5	to 2	-	-	12.5
10	0	to -0.5	1.5	to 2	-	-	12.5
11	-1.5	to -2.5	2	to 2.5	-	-	100

Data Source:
Roads, trails, streams, waterbodies, watercourses and infrastructure areas digitized using 2008 Quickbird imagery (courtesy of Yukon Geomatics) and spatial data provided by Yukon government.

Heli LIDAR Data Survey and Imagery, 2012

Datum: NAD 1983 CSRS UTM Zone 8N

- Legend**
- Order In Council Area
 - Existing Site Infrastructure
 - Topographic Contour (30 m Interval)
 - Roads
 - Watercourses

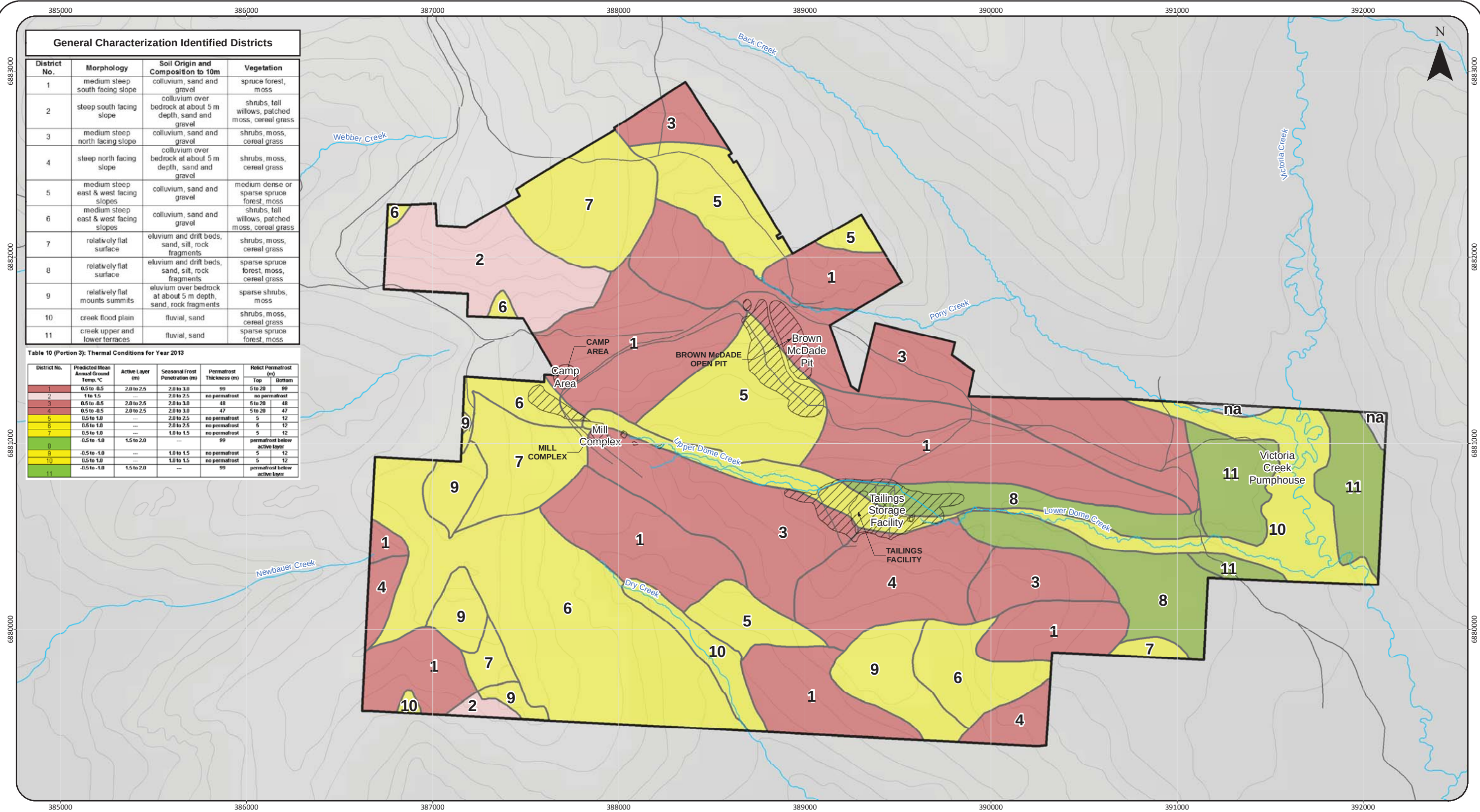


MOUNT NANSEN CARE AND MAINTENANCE PROJECT

Figure 6.5-1
Permafrost Map
Thermal Conditions for Year 1967
Scale 1:20,000
Metres

March 5, 2018

Document Path: M:\Projects\6-249 MN CMP\Map_Files\Chap6_EE4 geology\2018 03 04 Figure 6.4-2 2010-2013 Permafrost.mxd



Data Source:
Roads, trails, streams, waterbodies, watercourses and infrastructure areas digitized using 2008 Quickbird imagery (courtesy of Yukon Geomatics) and spatial data provided by Yukon government.

Heli LIDAR Data Survey and Imagery, 2012

Datum: NAD 1983 CSRS UTM Zone 8N

- Legend**
- Order In Council Area
 - Existing Site Infrastructure
 - Topographic Contour (30 m Interval)
 - Roads
 - Watercourses



MOUNT NANSEN CARE AND MAINTENANCE PROJECT

Figure 6.5-2
Permafrost Map

Thermal Conditions for Year 2010-2013
Scale 1:20,000
Metres

0 500 1,000

March 5, 2018

6.6 Seismicity

The major faults that could pose seismic threats to Site are the Fairweather, Denali and Tintina faults, located 254 km southwest, 125 km southwest and 132 km northeast of the site, respectively. A deterministic analysis for a maximum considered event (MCE) predicted a maximum peak ground acceleration of 0.13 g associated with a magnitude 8.7 earthquake on the Fairweather fault (EBA 2002). A probabilistic seismic hazard analysis predicted a peak ground acceleration of 0.27 g associated local magnitude 7.5 seismic event with a return period of 1:10,000 years. The basis for the local earthquake magnitude value is considered to be conservative.

6.7 Hydrogeology

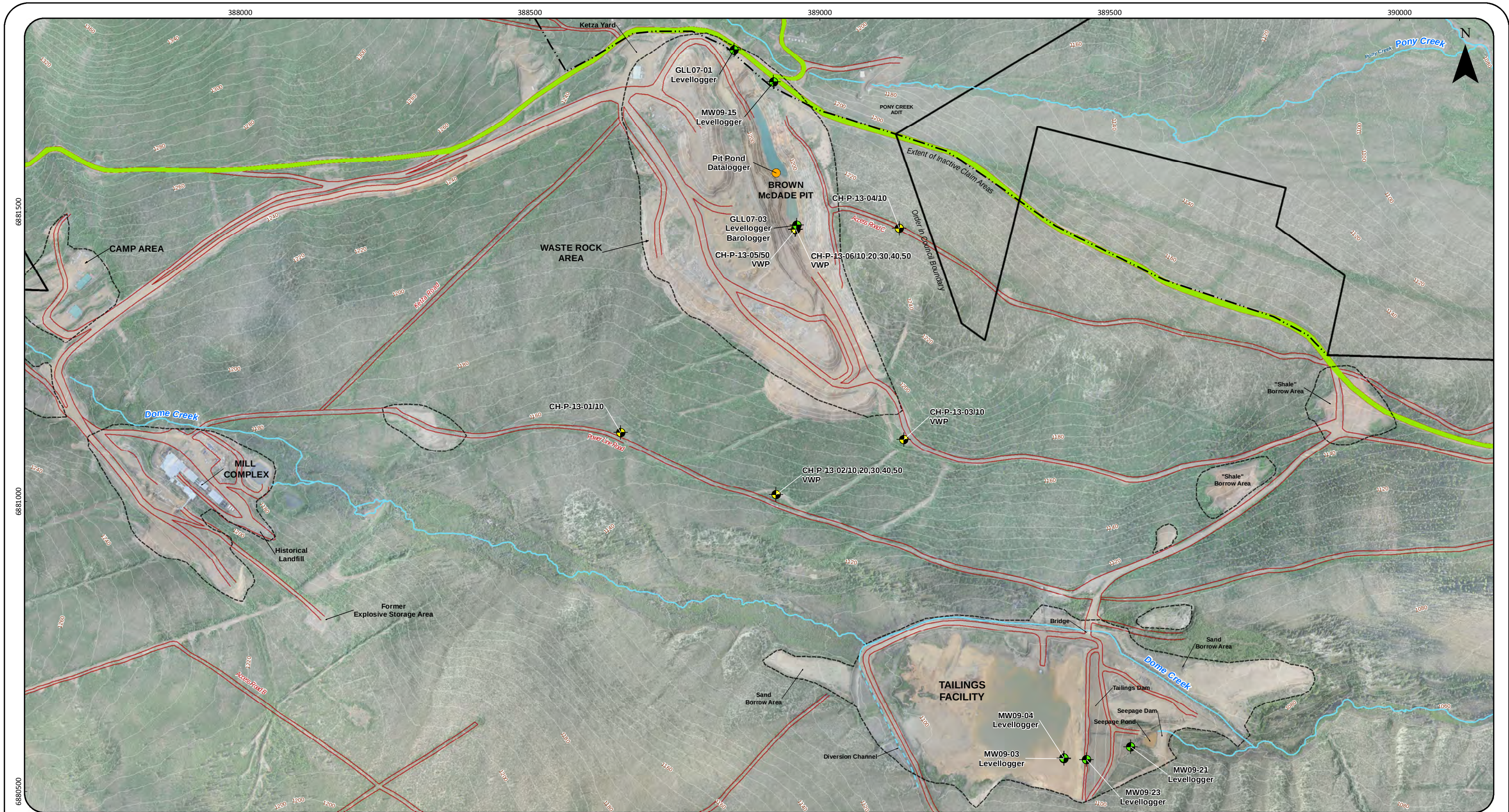
6.7.1 Introduction

Hydrogeological investigations were conducted at the Site between 2004 and 2014. The most recent study, a 2013-2014 field investigation with the objective of obtaining information for site remediation, was designed based on the findings of five earlier hydrogeological summary reports from investigations conducted between 2004 and 2009 (AMEC 2014a). Groundwater monitoring that occurred from October 2013 to July 2014 is summarized in the 2014 Site Investigation Report and Site Characterization Update (AMEC Foster Wheeler 2015).

The following sections summarize key hydrogeological information contained in Appendix 6A which provides a detailed description of the existing groundwater conditions at Site.

6.7.2 Groundwater Monitoring Network

The Site monitoring network consists of existing monitoring wells from previous hydrogeological investigations and from instrumentation installed prior to and during a 2013 field investigation. Pre-2013, water level and temperature instrumentation was installed inside the Brown McDade Pit to record the pit pond level and groundwater level within the fractured bedrock Pit floor, adjacent to the pond. Other pre-2013 instrumentation records groundwater levels in two monitoring wells constructed north of the Pit, adjacent to the public road. Of these monitoring wells, one experienced intermittent freezing conditions and the other experiences permanently frozen conditions. In 2013, a series of additional loggers, thermistors, and vibrating wire piezometers (to measure groundwater level) were installed in newly developed boreholes, primarily in relation to the Brown McDade Pit. Figure 6.7-1 shows the locations of groundwater monitoring wells and instrumentation.



Data Source: Roads, trails, streams, waterbodies, watercourses and infrastructure areas digitized using 2008 Quickbird imagery (courtesy of Yukon Geomatics) and spatial data provided by Yukon government. Heli LIDAR Data Survey and Imagery, 2012 Datum: NAD 1983 CSRS UTM Zone 8N	Legend - Order in Council Boundary - Extent of Inactive Claim Areas - Public Road - Road - Stream - Diversion Channel - Contour (20 m) - Contour (5 m) - Groundwater Monitoring Installations - Historic Monitoring Wells - Dataloggers - Disturbed Area			MOUNT NANSEN SITE FIGURE 6.7-1 CARE AND MAINTENANCE PROJECT PROPOSAL SITE DISTRIBUTION OF EXISTING GROUNDWATER MONITORING LOCATIONS Scale 1:6,500 Metres 0 130 260 February 22, 2017
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6.7.3 General Hydrogeological Characterizations

Hydrogeological characterizations were completed as part of the 2004 to 2014 assessment programs. These characterizations focused on the Brown McDade Pit, the TSF, the mill area, and Dome and Pony creeks.

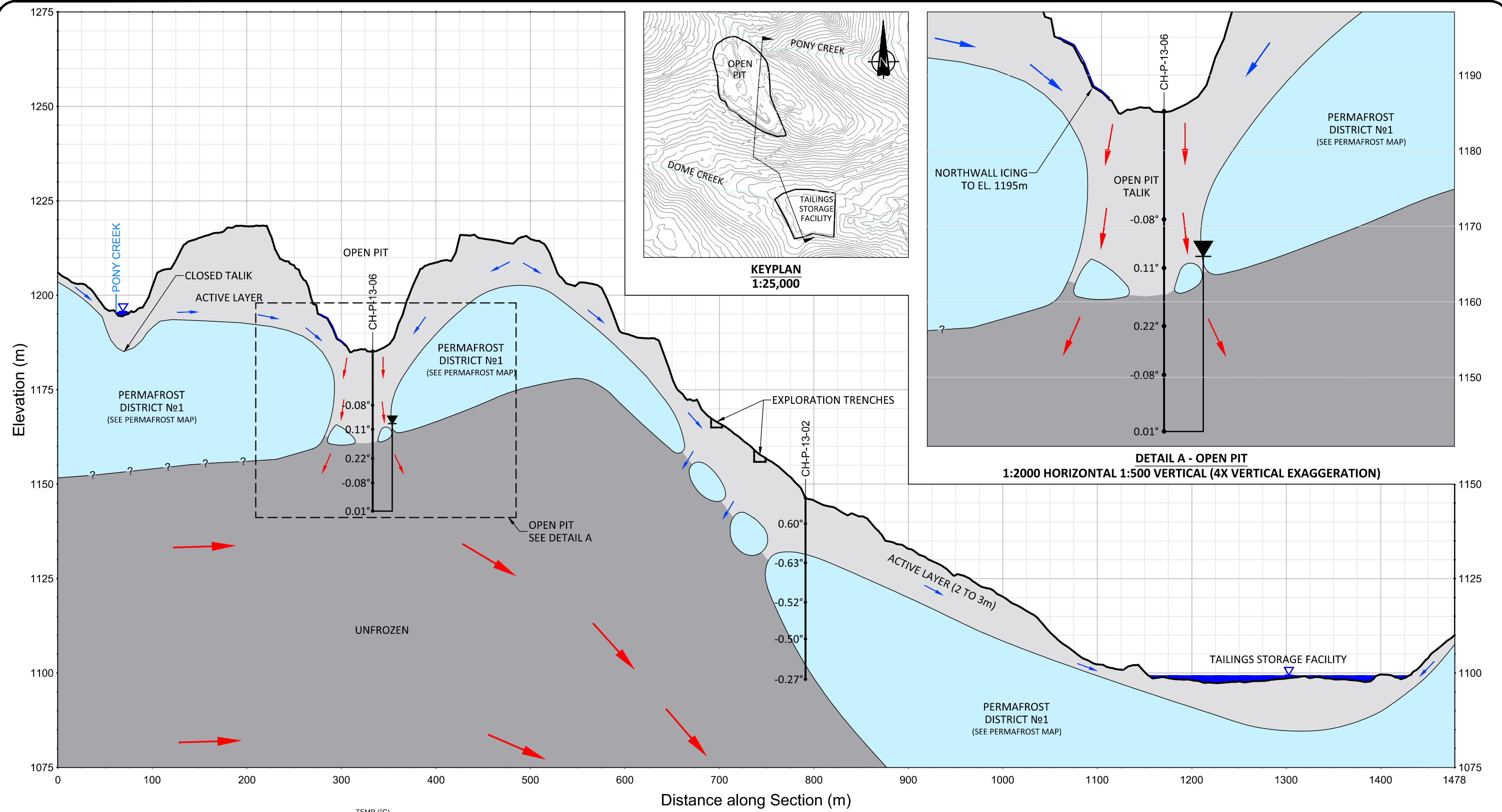
Highly conductive conduits for groundwater movement were not detected during the 2013 packer testing program, although outlier values were recorded. The most conductive result was 10-6 m/s (5.89 log₁₀ (K)) recorded at a monitoring well (CH-P-13-03/10) located south of the Brown McDade Pit, adjacent to a Site access road (Figure 6.7-1). Overall, groundwater levels rose in response to freshet and rain in the spring and were generally at their lowest levels around the end of winter. During freshet, the groundwater piezometric surface across the Site grades from north to south with an elevation of approximately 1,187 m in north to 1,167 m at the southern end. Additional information about the key areas are summarized in the sections below, with details provided in Appendix 6A.

6.7.4 Brown McDade Pit

Between the pit pond and the adjacent monitoring well located in the pit floor, a downward vertical gradient was consistently found to be present without any significant seasonal change or reversal gradient. This result indicates the Brown McDade Pit pond drains to the underlying groundwater system year-round (Figure 6.7-2). The two monitoring wells in and near the north high wall of the Brown McDade Pit appeared to be influenced by freezing ground that induces pressure build-up and thawing ground that induces pressure dissipation. An upper bound bedrock piezometric elevation on the order of 1,198 m appeared to be applicable to these two wells that are screened at elevations 1,191.6 m and 1,170.4 m. The latter well appeared to show some synchronicity and partially mimicked the pit pond suggesting a degree of hydraulic connectivity exists within the bedrock. If valid, bedrock groundwater movement would occur from the north towards the pit pond. The groundwater component of the Brown McDade Pit pond had a net loss over time (i.e., water predominantly leaving as groundwater). The rate of water loss from the Brown McDade Pit pond was quantified as being 0.2 L/s (17.3 m³/d).

There was a general increase in temperature with depth that may reflect a natural thermal gradient. The relatively slow four-month time-lag between pit pond temperature and groundwater temperature 10 m below ground surface provided an indication of groundwater travel time. The lack of seasonal temperature change at deeper depths indicated a lesser degree of hydraulic connection between deep groundwater and the Brown McDade Pit. Temperature data from the well located in the pit floor (elevation 1,135.6 m) confirmed the presence of a talik (i.e., unfrozen ground surrounded by permafrost) below the pit pond. This talik had consistently positive temperatures (+0.4°C).

Springtime snow melt caused rather sharp, yet short-lived increases in pit pond and groundwater levels to a depth of 60 m below ground surface. The onset of precipitation in the fall also led to dramatic increases in shallow groundwater levels and small increases in the pit pond level. However, the effect of fall precipitation was more long lived and had a more pronounced effect on groundwater levels than the spring freshet. Slower travel times reflected lower values of hydraulic conductivity. During the winter months the pit pond level and groundwater levels dropped, with minimum levels occurring during the month of April.



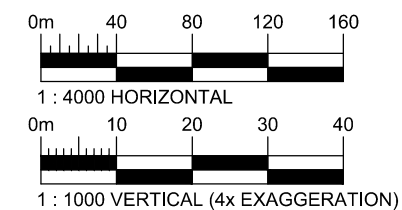
Data Source:
Datum: NAD 1983 CSRS UTM Zone 8N

LEGEND

- ACTIVE LAYER FLOW
- DEEP GROUNDWATER FLOW

Note: Groundwater and Ground Temperature data will be updated in 2014.

- NOTES:**
- FIGURE IS CONCEPTUAL. ALL ELEVATIONS ARE APPROXIMATE.
 - THE PIT FLOOR ELEVATION VARIES, MINIMUM ELEVATION IS 1176m.
 - GROUND SURFACE AT CH-P-13-06 IS 1184m, THE CROSS SECTION ON THE FIGURE INTERSECTS THE PIT AT THE CH-P-13-06 LOCATION, AND NOT AT THE MINIMUM PIT FLOOR ELEVATION.



Yukon
Energy, Mines and Resources
Assessment and Abandoned Mines

MOUNT NANSEN SITE
Figure 6.7-2
CARE AND MAINTENANCE
PROJECT PROPOSAL
CONCEPTUAL HYDROGEOLOGICAL
MODEL GROUNDWATER FLOW AND
PERMAFROST

FEBRUARY 2017

Baseflow regional groundwater levels, as experienced during winter low-recharge conditions, occurred near elevation 1,156 m which was approximately 20 m below the Brown McDade pit floor.

The spring groundwater level was found to traverse the Brown McDade Pit floor, ranging in elevation from 1,176 m to 1,179 m. Winter baseflow groundwater levels were substantially lower, with groundwater recorded beneath the Brown McDade pit at an elevation of approximately 1,156 m. The pit pond was documented as a possible perched water feature from 2010 to 2013, meaning that the pond was a surface water retention feature with saturated hydraulic connection to the deep groundwater system (i.e., a leaky retention feature). The average winter seepage rate out of the Brown McDade Pit to surrounding groundwater was calculated to vary between 0.2 to 0.6 L/s with an average 0.4 L/s. This average winter seepage rate was slightly lower than the average annual seepage rate of 0.46 L/s. Therefore, it was concluded that the pond behaves as a leaky surface water retention feature, with a seasonally intermittent saturated hydraulic connection to deep groundwater.

6.7.5 Tailings Storage Facility (TSF)

Groundwater levels in the tailings decreased throughout the fall and winter, indicating drainage of the tailings, which was followed by freshet when groundwater levels increased in the tailings. Groundwater in the shallow and deep tailings was found to behave in the same manner. A similar fall and winter groundwater level decrease was also observed at the dam crest monitoring well, and an increase in groundwater levels at the dam downstream monitoring well was also observed. Data from the other paired monitoring wells appeared to show the same seasonal increases and decreases.

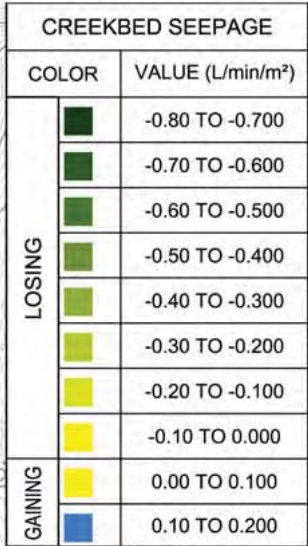
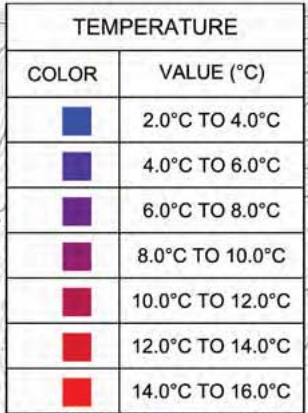
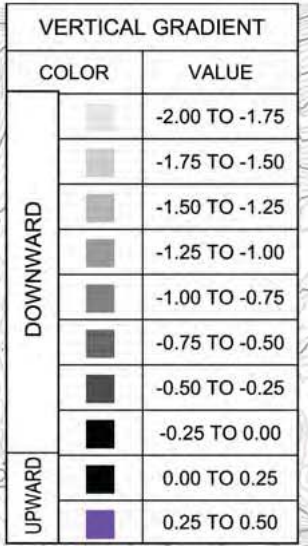
6.7.6 Dome Creek (including the mill area) and Pony Creek

The northwest portion of the mill area is in close proximity to Huestis Adit. This outlet could potentially release subsurface water to surface, in proximity to Dome Creek. Observed groundwater levels along Dome Creek in the vicinity of the mill and Huestis Adit indicated shallow groundwater that converged and formed a groundwater discharge zone at Dome Creek.

Dome Creek and Pony Creek were characterized as streams that both lose water to groundwater and receive (gain) water from groundwater along different reaches (segments) of the streams. To quantify these rates of losses and gains of water exchange, groundwater data were collected from fifteen creek stations (i.e., ten drive-point piezometers on Dome Creek and five on Pony Creek) and by conducting water temperature surveys and seepage meter tests.

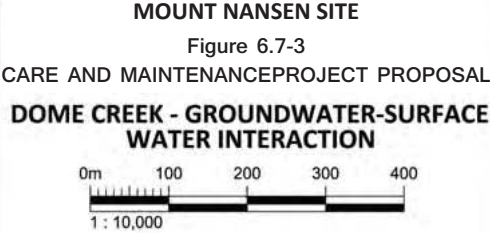
The temperature surveys indicated that reaches of Dome Creek upstream of the TSF and reaches of Pony Creek upstream and adjacent to the Brown McDade Pit had relatively warm creek bed porewater (shallow groundwater). Downstream of the TSF, Dome Creek porewater became cooler. Downstream of the Brown McDade Pit, Pony Creek porewater also became cooler.

Both Dome and Pony creeks demonstrated a pattern of low, positive gains from groundwater. One notable exception was a reach of Dome Creek near the Huestis Adit, which had the most negative seepage rate (loss) from Dome Creek (Figure 6.7-3 and Figure 6.7-4).

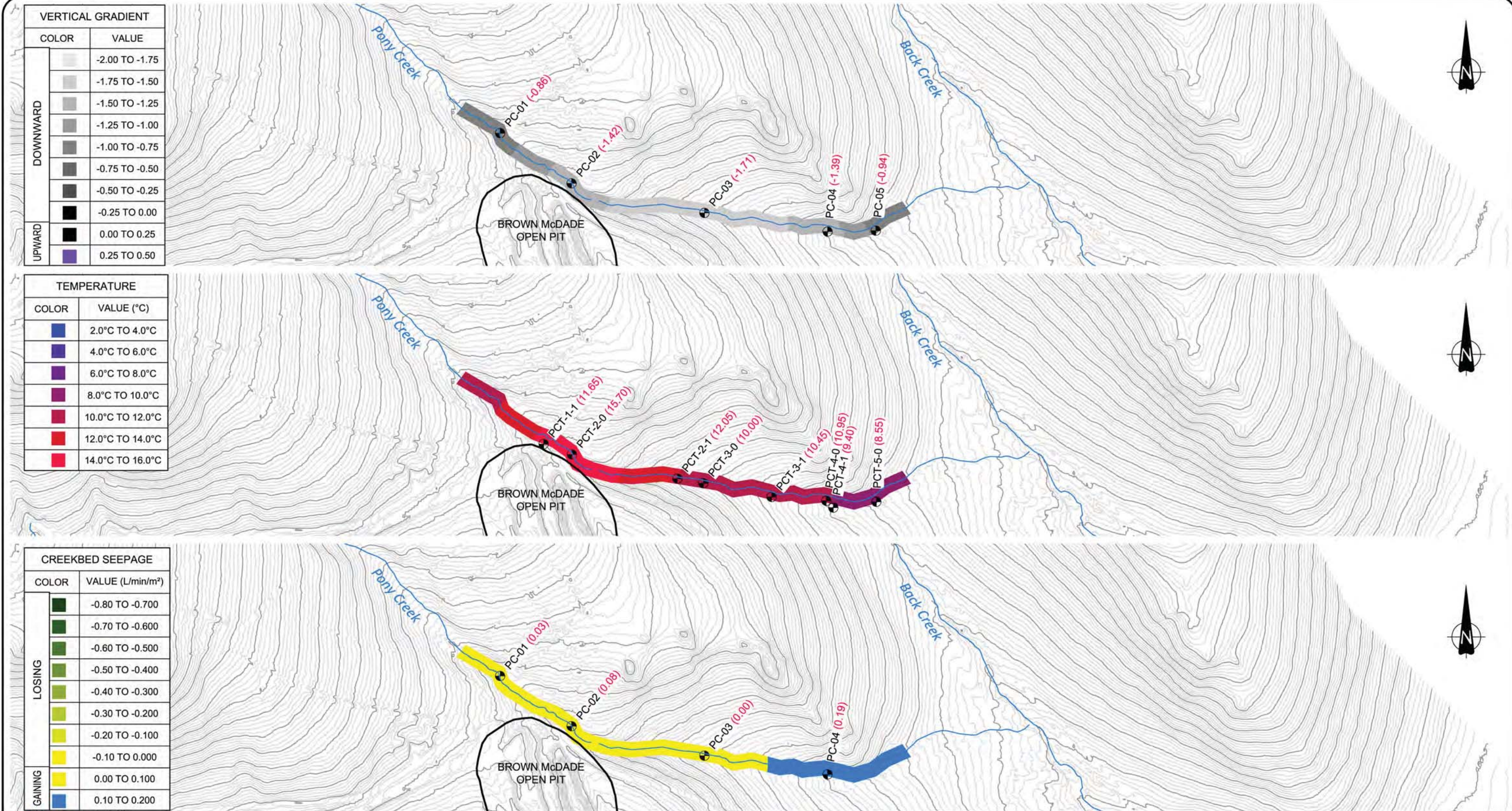


Data Source:
Datum: NAD 1983 CSRS UTM Zone 8N

Comments:
Vertical gradient - positive indicates upwards flow at the creek bed; and
- negative indicates downwards flow at the creek bed.
Seepage flow - positive indicates groundwater entering creek; and
- negative indicates groundwater leaving creek



March 2017



Data Source:
Datum: NAD 1983 CSRS UTM Zone 8N

Comments:

Vertical gradient - positive indicates upwards flow at the creek bed; and
 - negative indicates downwards flow at the creek bed.

Seepage flow - positive indicates groundwater entering creek; and
 - negative indicates groundwater leaving creek

MOUNT NANSEN SITE
Figure 6.7-4
CARE AND MAINTENANCE PROJECT PROPOSAL
**PONY CREEK - GROUNDWATER-SURFACE
WATER INTERACTION**

0m 100 200 300 400
1 : 10,000

Yukon
Energy, Mines and Resources
Assessment and Abandoned Mines

March 2017

Vertical groundwater gradients in both Pony and Dome Creeks, derived from the dual drive-point piezometers, were somewhat consistent with the seepage meter results. Creek stations produced both positive (i.e., upward) and negative (i.e., downward) groundwater directions, with a slight net loss indicating the creeks were losing water. This result did not agree with the temperature survey and seepage meter findings. The vertical gradients, therefore, may have been skewed by the onset of freezing conditions that influenced drive-point water levels. Groundwater originating from Pony Creek was found to move via shallow bedrock into the Brown McDade Pit. This process was first documented in 2004, observed as wintertime icing on the north pit wall above the water in the pit. A closed talik was found to currently limit groundwater-surface water exchange when the active shallow groundwater layer is absent. Water gains to Pony Creek upstream of the Brown McDade Pit were found to be limited by permafrost. The surface water contribution to the Brown McDade Pit may increase in the long-term as the closed talik degrades (because the surrounding permafrost melts), allowing Pony Creek water to recharge the overburden and deep groundwater in the vicinity of the Brown McDade Pit.

6.8 Groundwater Quality

6.8.1 Introduction

Groundwater quality data collection has been primarily focused around major infrastructure areas (e.g., the mill, TSF, and Brown McDade Pit). Additional investigations were completed around Dome Creek and Pony Creek to understand groundwater-surface water interactions. The highest number of groundwater quality samples exists for the mill area and the TSF, with monitoring events occurring fairly consistently from 2009 to 2014.

Previous groundwater monitoring efforts and existing groundwater quality data for the Site are described in a groundwater characterization report (Appendix 6B). This characterization report used a screening process whereby a series of groundwater parameters of potential interest were identified based on the site history and geochemistry, and data for these parameters were screened against groundwater screening guidelines (GWSG) that were based on generic water quality guidelines (GWQGs; CCME-FAL and BCWQG). Those exceeding GWSG were identified as parameters of potential concern (POPC).

6.8.2 General Groundwater Quality Conditions

Groundwater characterizations focused on the Brown McDade Pit, the TSF, the mill area, and Dome and Pony Creeks. The majority of groundwater at the Mount Nansen site was a calcium-magnesium-sulphate type water. Chloride concentrations across the Site were generally low (Appendix 6B - Water Quality Data Summary Tables). Groundwater pH across the Site was generally circum-neutral to slightly alkaline, ranging from 6.5 to approximately 9. Measured dissolved oxygen levels varied from non-detect to as high as approximately 8 mg/L and nitrate levels were generally quite low in concentration (< 1.5 mg/L) with the exception of notable locations within the TSF. Concentrations of dissolved iron across the Site varied from non-detect to as high as 80 mg/L. The presence of dissolved iron in groundwater indicated suboxic conditions likely prevail throughout the year in some locations.

6.8.3 Mill Area

Groundwater data collected from seven monitoring wells screened in bedrock or overburden was used to characterize groundwater quality in the mill area (Appendix 6B). Groundwater quality POPC in the mill area included aluminum, antimony, cadmium, chromium, cobalt, copper, iron, manganese, lead, selenium, and zinc.

Groundwater pH in the mill area was consistently circumneutral, but fluid conductivity increased from approximately 750 $\mu\text{S}/\text{cm}$ to approximately 2,500 $\mu\text{S}/\text{cm}$. Median sulphate concentrations increased with distance downstream along Dome Creek from medians of approximately 204-350 mg/L to median concentrations of 984-1,540 mg/L, exceeding the GWSG for sulphate of 128-429 mg/L, depending on hardness (BC MOE 2013b). The increase in fluid conductivity appeared to reflect the increase in sulphate concentrations as dissolved metals did not increase in concentration along the same flow path. The exception to this was for iron which was high within overburden groundwater and low within bedrock groundwater. The apparent loss of iron from groundwater in the mill area along the groundwater flow was attributed to oxidation and subsequent precipitation as oxidation-reduction potential levels for the deep wells was high, with dissolved oxygen concentrations at less than 1 mg/L. The increase in sulphate and the apparently oxic redox conditions would preclude losses of iron due to iron sulphide precipitation.

Arsenic concentrations generally exceeded the GWSG and were elevated relative to background, with the highest observed concentration being in the mill area. Manganese concentrations in groundwater exceeded the GWSG at all monitoring wells except the background and a down gradient bedrock well. Concentrations of antimony, copper, cadmium and zinc were generally consistent across all monitoring wells except one in which concentrations were consistently higher. Although selenium concentrations were below the GWSG, a statistical increase in concentrations was observed in down gradient areas.

Generally, metals concentrations were higher in overburden groundwater than bedrock groundwater, and much of the variability appeared to be associated with intra-annual variability, likely resulting from seasonal fluctuations in water levels and groundwater flows related to freshet and winter low flow or permafrost conditions.

6.8.4 Dome Creek

Groundwater collected from ten monitoring wells was used to characterize groundwater quality along Dome Creek, upgradient of the mill area, from the mill area to the TSF, and down gradient of the TSF (Appendix 6B). All Dome Creek wells are shallow installations screened in overburden or fluvial sediments of the streambed, and representative of the shallow groundwater system. Groundwater flow generally was towards Dome Creek as it is considered a groundwater discharge zone (AMEC 2014b). Dome Creek groundwater POPC along Dome Creek included sulphate, aluminum, arsenic, cadmium, cobalt, chromium, iron, and manganese.

Groundwater quality at two wells downstream of the TSF was fresh in composition (i.e., calcium-magnesium-bicarbonate type water), whereas elsewhere along Dome Creek sulphate was the dominant

anion. Groundwater pH along Dome Creek generally was circumneutral with conductivity that increased from 1,000 $\mu\text{S}/\text{cm}$ up to 1,500 $\mu\text{S}/\text{cm}$ downgradient of the mill, but then appeared to decrease down gradient of the TSF. There appeared to be a strong visual correlation between conductivity and sulphate concentrations.

Dissolved iron concentrations increased from a median value of 0.042 mg/L at the upgradient extent to 129.5 mg/L downgradient of the TSF, showing an apparent increase in concentration along the flowpath of Dome Creek, indicating contributions from both the mill area and the TSF. Arsenic concentrations were observed to generally also increase along the flowpath, getting distinctly higher at several wells down gradient of the TSF.

Concentrations of copper in groundwater demonstrated a decreasing trend with distance along Dome Creek. Cadmium and zinc concentrations in groundwater generally were consistent along Dome Creek and generally below GWSG, with several minor exceptions. Concentrations of aluminum in groundwater downgradient of the TSF exceeded the GWSG and appeared to originate from the TSF. Manganese concentrations in shallow groundwater exceeded the GWSG along the entire Dome Creek drainage downgradient of the mill area

Similarly, to groundwater in the mill area, much of the variability in parameter variation along Dome Creek was attributed to intra-annual variability resulting from seasonal fluctuations in water levels and groundwater flows related to freshet and winter low flow or permafrost conditions.

6.8.5 Tailings Storage Facility

Groundwater was characterized from twenty-three monitoring wells located within the TSF (Appendix 6B). These monitoring wells are distributed amongst the main components of the TSF: upgradient of tailings impoundment; at the tailings impoundment; at the tailings dam; and downgradient of the seepage dam. Groundwater POPC for the TSF area included sulphate, antimony, arsenic, cadmium, cobalt, copper, iron, manganese, zinc, weak acid dissociable cyanide and free cyanide.

Median pH of groundwater in the TSF area ranged from 6.7 to 8.7. Groundwater pH was highly variable beneath the tailings pond, reflecting source material, depositional history of tailings material, and subsequent geochemical reactions. Fluid conductivity within the native sediments averaged 1,000 $\mu\text{S}/\text{cm}$, whereas that within the tailings material averaged in the order of 2,500 $\mu\text{S}/\text{cm}$. Sulphate concentrations in groundwater within the native sediments had median values ranging from 8.8 to 136 mg/L, whereas that within the tailings ranged from 893 to 1,780 mg/L. The highest concentrations of free and weak acid-dissociable cyanide were observed within native sediments underlying the tailings, correlating with the higher pH values observed. This result suggested that higher pH values are helping to preserve the cyanide concentrations. Median free and weak acid dissociable cyanide concentrations at two locations were above GWSG.

The redox chemistry of the TSF is a significant geochemical process with implications for redox-sensitive metal species such as arsenic, chromium, and iron. The presence of dissolved iron, ammonia, and sulphate

indicate suboxic conditions. The redox chemistry of the TSF is complex and is believed to influence the availability of iron, arsenic, ammonia, nitrate, and sulphate; this is detailed in Appendices 6B and 6D.

Concentrations of arsenic, antimony, cadmium and cobalt were generally above GSWG in the tailings area. Similarly, concentrations of dissolved iron, chromium, and zinc were above GSWG, however the chromium exceedances appeared to be related to background sources.

Decreasing trends in concentrations of nitrate, free and total cyanide were observed over time. Among the trace elements cobalt and cadmium also appear to have declined in concentration over time, particularly within groundwater at the toe of the dam.

6.8.6 Brown McDade Pit

Groundwater collected from seven monitoring wells was used to characterize groundwater quality in the Brown McDade Pit area (Appendix 6B). Brown McDade Pit groundwater quality POPC included sulphate, arsenic, cadmium, cobalt, copper, iron, manganese, and zinc.

Groundwater quality at monitoring wells situated to the north-northwest of the pit have a calcium-magnesium-sulphate signature. At the downgradient end of the pit, groundwater quality grades between calcium-magnesium-sulphate and calcium-magnesium-bicarbonate. Groundwater pH around the pit generally was circumneutral, with no apparent trend associated with location. One exception to this was one well within the pit pond itself (CH-P-13-5/50) where pH appears to be decreasing with time (ranging from 7.98 to 5.98). Fluid conductivity at two wells (CH-P-13-5/50 located in the middle of the pit and CH-P-13-3/50 at the south extent) was distinctly elevated relative to surrounding groundwater indicating variable seepage rates within the pit, possibly due to fractures. Spatially there appeared to be an inverse correlation between pH and both conductivity and sulphate concentrations in the Brown McDade Pit area. The lowest pH observed in the pit area occurred along with the highest fluid conductivity and sulphate concentrations. There was no clear definitive correlation with metals species, except for copper and iron. However, concentrations of cadmium, copper, cobalt and zinc exceeded the GSWG primarily at two wells at the pit pond and east of the Brown McDade Pit. Dissolved manganese concentrations generally exceeded GSWG, as did concentrations of iron, arsenic, and selenium.

6.8.7 Pony Creek Area

Groundwater collected from six monitoring wells screened within bedrock, within overburden, or stream sediments were used to characterize groundwater quality along Pony Creek, up gradient of the Brown McDade Pit (Appendix 6B). Considering the elevation and position of the pit to Pony Creek and groundwater flow paths, it is unlikely the pit affects groundwater quality further downstream along the creek. Pony Creek groundwater POPC included sulphate, arsenic, cadmium, cobalt, chromium, copper, iron, manganese, selenium, and zinc.

Groundwater quality along Pony Creek generally was consistent in composition with a calcium-magnesium-bicarbonate-sulphate type signature. Groundwater pH along Pony Creek was circumneutral and

consistent along the creek over time. Conductivity along Pony Creek generally was also consistent, generally ranging from 500 to 1,000 $\mu\text{S}/\text{cm}$, with the exception of one well (GIS-PC-03B) approximately 200 m downstream of the Brown McDade Pit where conductivity was in the range of 3,500 $\mu\text{S}/\text{cm}$, alongside statistically higher sulphate values.

There is high distribution of arsenic and iron concentrations at one well near to the Brown McDade Pit (GIS-PC-03B), and with iron at another further downstream (GIS-PC-04B); however, the distribution is likely related to intra-annual variation as a result of seasonal changes in stream flow and groundwater levels (see Appendix 6B). Concentrations of arsenic, cadmium, chromium, cobalt, and selenium were consistently above GWSG in the Pony Creek area. Concentrations of manganese were generally at or below GWSG.

6.9 Hydrology

6.9.1 Introduction

The Project is located in the Victoria Creek Watershed, a tributary of the Nisling River, which is itself a medium sized basin located in the larger Donjek/White Rivers basin. The White River flows north into the Yukon River, which flows northwest through Alaska and into the Bering Sea.

The Site is drained primarily by Dome Creek and Pony Creek, with most of the Site footprint located in the Dome Creek Watershed. Regional streams include Back Creek, Minnesota Creek, and Victoria Creek itself.

The headwaters of Dome Creek are located above the mill site where the stream flows eastward past the TSF via the Dome Creek Diversion Channel (on the northern side of the TSF) and continues eastward and then southeastward to its confluence with Victoria Creek. The lower portion of Dome Creek currently receives flow from the diversion channel, as well as from the TSF seepage pond, which is pumped into the creek upstream of the confluence with the diversion channel.

Pony Creek is a small ephemeral stream that has been modified by historical mining activity, including ongoing placer mining (EDI 2014), trenching, exploration roads, waste rock piles, earth berms, gravel quarries, and old adit and core shacks (EDI 2012a).

The streamflow regime at the Site is dominated by spring snowmelt-driven freshet, followed by a rapid recession to summer low-flows maintained by groundwater and interflow discharging to the local stream channels. Low-flows are punctuated by intermittent rainfall-driven peak-flow events that generally last for several days and are followed by a rapid recession. Icing begins in the smaller stream channels in October, and Dome Creek freezes to the stream bed in several locations. One exception is discharge from the seepage collection pond (herein referred to by its station identifier SEEP), which is relatively constant year-round. In the winter, seepage discharge subsequently freezes and glaciates a portion of Dome Creek downstream of SEEP. The channel icing (shelf ice, as well as sporadic aufeis) melts during freshet, and contributes to streamflows into May and into June in some years. At the Mount Nansen public road crossing of the creek, this accumulation of aufeis often leads to ice blockage in the culvert and build-up on the road. The melt of

this aufeis, including the accumulated ice formed from the seepage pond outflows, typically leads to high flows in May and, at times, in June.

Streamflow data have been collected at the Mount Nansen site from 2009 up to and including 2016 (see list of studies in Appendix 6C). The hydrometric network at the site has been in continuous operation since 2009, with several modifications throughout this period in response to optimization of monitoring objectives. The full list of hydrometric stations that have been monitored at site is shown in Figure 6.9-1. Note that several of these stations are no longer monitored but are presented here for reference. A full description of the monitoring network in its current state is presented in Appendix 6C.

Hydrometric monitoring at the Site was conducted through two types of stations, continuous hydrometric stations and periodic instantaneous (manual) measurement stations. Continuous hydrometric stations consisted of a metric staff gauge, continuous water level meter (pressure transducer) housed within a well-anchored stilling well, and multiple benchmarks. Periodic instantaneous stations were standard locations suitable for stream gauging that are visited each month.

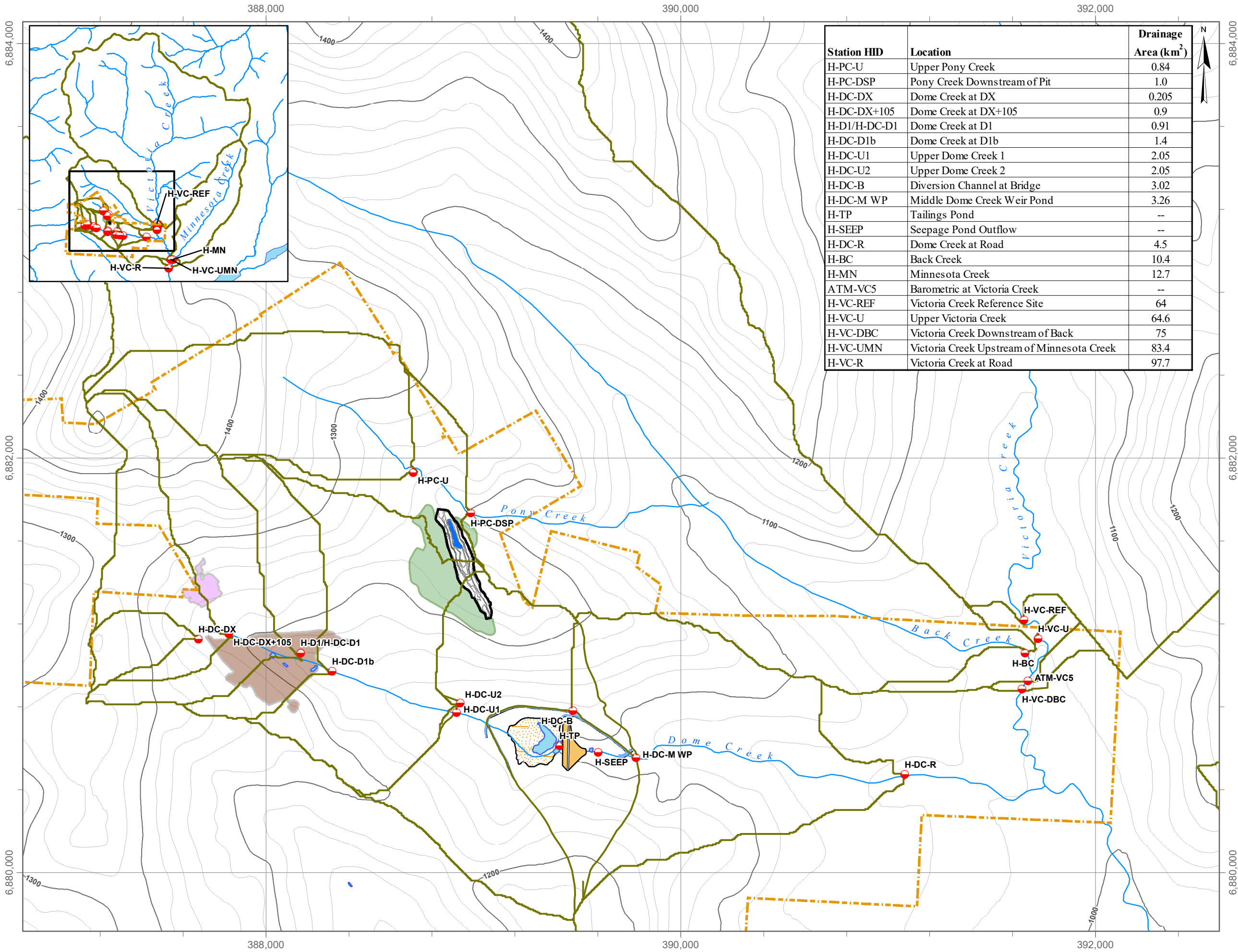
Hydrometric monitoring was conducted on a monthly basis, but with two manual measurements taken during freshet. Water levels were recorded at continuous stations on an ongoing basis, and this data was used alongside manual measurements to construct a continuous discharge record (except during winter due to the known influence of channel ice on the hydraulic relationship). Monthly data from periodic instantaneous measurement stations was used to augment the site water balance data.

6.9.2 General Hydrological Conditions

6.9.2.1 Site Streamflow

Manual streamflow measurements have been taken at the Site since 2011, at stations in Dome Creek (3), Back Creek (1), Victoria Creek (5), and the seepage pond outfall (1) and are presented in Appendix 6C. While discharge magnitude varies with watershed area (i.e., larger basin areas result in higher discharge values), it is more often instructive to compare runoff and/or unit yields to remove the influence of watershed area. A summary of the monthly average discharge, unit yield, and runoff for the Site is presented in Table 6.9-1. The variation in runoff and yields across the gauged basins at the Site is relatively low, with unit yields averaging 5.9 ± 1.5 L/s/km² and an average runoff of 104 ± 37 mm for the open water season. The Site sub-watersheds, and Dome Creek in particular, exhibited relatively lower average runoff (62 ± 6 mm) in 2015 and 2016 than the stations located on Victoria Creek (133 ± 15 mm).

A period of record yield plot (Figure 6.9-2) is presented for nine of the continuously recorded hydrometric stations in this section. The H-SEEP station gauges the outflows from the TSF seepage pond and does not have a specific drainage area. Therefore, unit yield and runoff values are not calculated for this station.



Station HID	Location	Drainage Area (km ²)
H-PC-U	Upper Pony Creek	0.84
H-PC-DSP	Pony Creek Downstream of Pit	1.0
H-DC-DX	Dome Creek at DX	0.205
H-DC-DX+105	Dome Creek at DX+105	0.9
H-D1/H-DC-D1	Dome Creek at D1	0.91
H-DC-D1b	Dome Creek at D1b	1.4
H-DC-U1	Upper Dome Creek 1	2.05
H-DC-U2	Upper Dome Creek 2	2.05
H-DC-B	Diversion Channel at Bridge	3.02
H-DC-M WP	Middle Dome Creek Weir Pond	3.26
H-TP	Tailings Pond	--
H-SEEP	Seepage Pond Outflow	--
H-DC-R	Dome Creek at Road	4.5
H-BC	Back Creek	10.4
H-MN	Minnesota Creek	12.7
ATM-VC5	Barometric at Victoria Creek	--
H-VC-REF	Victoria Creek Reference Site	64
H-VC-U	Upper Victoria Creek	64.6
H-VC-DBC	Victoria Creek Downstream of Back	75
H-VC-UMN	Victoria Creek Upstream of Minnesota Creek	83.4
H-VC-R	Victoria Creek at Road	97.7

LEGEND

- Hydrometric Station
- Mount Nansen OIC Boundary
- Catchment Boundary
- Mill Area
- Mine Camp Area
- Tailings Dam
- Tailings
- Pond
- Pit Outline
- Waste Rock Area
- 100m Contour
- 20m Contour

Coordinate System: NAD 1983 UTM Zone 8N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter

1:17,500

0 200 400 Meters

DATE SAVED: Mar 10, 2017

DRAWN BY: GM

REVIEWED: SJ

VERSION: 1

CLIENT:

Yukon

PROJECT:

Mount Nansen Project Proposal

TITLE:

Hydrology Monitoring Catchments and Hydrometric Station Network

PROJECT #: A422-1

FIGURE: 6.9-1

Table 6.9-1: MNCMP Summary of monthly average discharge, unit yield and runoff for hydrometric stations on Dome Creek (DC) and Victoria Creek (VC)

Station	Drainage Area (km ²)	Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average/Total
H-DC-B	3.0	Average Discharge (m ³ /s)	--	--	--	--	0.03	0.01	0.01	0.02	0.01	0.01	--	--	0.014
		Average Yield (L/s/km ²)	--	--	--	--	9.71	3.59	3.67	5.26	2.78	2.01	--	--	4.50
		Runoff (mm)	--	--	--	--	20	9	10	14	7	2	--	--	62
H-SEEP ¹	NA	Average Discharge (m ³ /s)	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.002	0.002
		Average Yield (L/s/km ²)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Runoff (mm)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
H-DC-M WP	3.3	Average Discharge (m ³ /s)	--	--	--	--	0.04	0.01	0.01	0.03	0.02	0.01	--	--	0.018
		Average Yield (L/s/km ²)	--	--	--	--	12.92	2.90	1.79	7.81	4.62	2.46	--	--	5.42
		Runoff (mm)	--	--	--	--	20	8	5	21	12	3	--	--	68
H-DC-R	4.5	Average Discharge (m ³ /s)	--	--	--	--	0.030	0.012	0.016	0.021	0.019	0.004	--	--	0.017
		Average Yield (L/s/km ²)	--	--	--	--	6.60	2.73	3.57	4.62	4.30	0.99	--	--	3.80
		Runoff (mm)	--	--	--	--	14	7	10	12	11	1	--	--	55
H-BC	10.4	Average Discharge (m ³ /s)	--	--	--	0.125	0.085	0.026	0.029	0.065	0.083	--	--	--	0.069
		Average Yield (L/s/km ²)	--	--	--	12.03	8.20	2.51	2.84	6.30	7.95	--	--	--	6.64
		Runoff (mm)	--	--	--	12	22	6	8	17	17	--	--	--	81
H-VC-U	64.6	Average Discharge (m ³ /s)	--	--	--	0.860	0.695	0.309	0.342	0.593	0.550	0.369	0.202	0.146	0.452
		Average Yield (L/s/km ²)	--	--	--	13.31	10.76	4.79	5.30	9.18	8.51	5.71	3.12	2.26	6.99
		Runoff (mm)	--	--	--	13	23	11	12	23	22	7	8	1	121
H-VC-DBC	75.0	Average Discharge (m ³ /s)	0.174	--	0.225	0.449	1.102	0.225	0.311	0.519	0.843	0.497	0.329	0.195	0.443
		Average Yield (L/s/km ²)	2.32	--	3.00	5.99	14.69	3.00	4.14	6.91	11.24	6.63	4.39	2.60	5.90
		Runoff (mm)	2	--	5	13	38	8	11	19	29	10	11	7	154
H-VC-UMN	83.4	Average Discharge (m ³ /s)	0.137	--	0.066	0.819	1.025	0.267	0.351	0.527	0.604	0.363	0.192	0.084	0.403
		Average Yield (L/s/km ²)	1.64	--	0.79	9.83	12.29	3.20	4.21	6.32	7.25	4.35	2.30	1.01	4.84
		Runoff (mm)	2	--	2	21	30	8	11	17	19	4	6	3	123
H-VC-R	97.7	Average Discharge (m ³ /s)	--	--	--	0.28	1.32	0.437	0.736	1.14	0.772	0.394	0.168	0.073	0.591
		Average Yield (L/s/km ²)	--	--	--	2.86	13.51	4.47	7.53	11.67	7.90	4.04	1.72	0.75	6.05
		Runoff (mm)	--	--	--	5	32	12	13	29	20	6	4	2	124
H-VC-R+290	97.7	Average Discharge (m ³ /s)	--	--	--	0.876	1.449	0.493	0.621	1.005	0.998	0.654	--	--	0.871
		Average Yield (L/s/km ²)	--	--	--	8.97	14.83	5.04	6.35	10.29	10.22	6.70	--	--	8.91
		Runoff (mm)	--	--	--	23	32	13	17	28	26	4	--	--	143

Notes:

1. The H-SEEP station gauges the TSF seepage pond outflows via a flow meter. There is no drainage area associated with this monitoring station, therefore unit yields and runoff are not calculated.

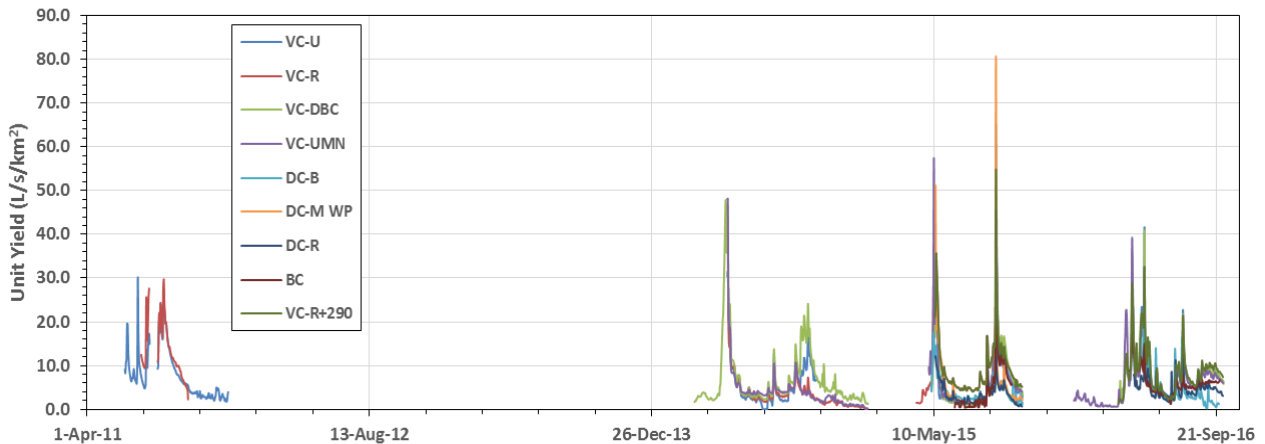


Figure 6.9-2: Average daily unit yield time-series for select stations (2011-2016)

Patterns of surface flow in Back, Dome, and Victoria creeks loosely match local melt signature and precipitation in the Site area (Table 6.9-1 and Figure 6.9-2), with significantly increased flows during spring freshet (i.e., April/May snowpack melt) and the fall rainy season (i.e., August/September). The highest monthly average discharge rates in Victoria Creek (at station H-VC-DBC) in spring ($1.10 \text{ m}^3/\text{s}$) and fall ($0.84 \text{ m}^3/\text{s}$) are one to two orders of magnitude (18 to 111 times) higher than those for Back and Dome creeks. Maximum discharge rates in Back Creek (at station H-BC) in spring ($0.13 \text{ m}^3/\text{s}$) and fall ($0.08 \text{ m}^3/\text{s}$) are 3 to 4 times higher than those for Dome Creek (H-DC-R) (spring ($0.03 \text{ m}^3/\text{s}$) and fall ($0.02 \text{ m}^3/\text{s}$)). As stated previously, these differences in discharge are driven primarily by differences in the contributing watershed areas.

6.10 Surface Water Quality

6.10.1 Introduction

Surface water quality data collection from 2012 to 2016 primarily focused on the two first order tributary streams of Victoria Creek that flow through the Site (i.e., Dome Creek and Pony Creek). These streams have the greatest potential to be affected by Site infrastructure, which includes the mill area, TSF, and Brown McDade Pit. Sampling also occurred in Back Creek and Victoria Creek. Each surface water quality sampling station that has been monitored is shown in Cyanide was below WQGs and often below method detection limits at both stations in Pony Creek. Trace levels of ammonia, nitrate, and nitrite have been measured in Pony Creek and were associated with blasting residue from historic open pit mining. Monthly mean concentrations for ammonia ranged from 0.003 mg/L (November) to 0.923 mg/L (June). Ammonia concentrations were significantly higher in 2016 compared to previous years, following the same pattern as TSS. However, concentrations were mostly below the pH and temperature-dependent WQG (Exceedances in 1 of 36 collected samples). No exceedances were found for nitrate in Pony Creek stations, with values well below WQGs. Concentrations for nitrite remained relatively constant since 2012 with a few exceedances to applicable WQGs in upstream stations. Similar to ammonia and TSS, an increase in nitrite

concentrations followed by a sharp decrease in subsequent months was observed in 2016 for upstream and downstream stations of Pony Creek.

All records of surface water monitoring events and data summaries at the Site are presented in Appendix 6D.

A two-step screening process was applied to identify surface water parameters of concern (SWPC). First, surface water quality data were screened against short and long-term CCME *Canadian Water Quality Guidelines for the Protection of Aquatic Life* (FAL) (Table 6.10-1). Where CCME-FAL guidelines did not exist, *British Columbia Approved Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture* (BCWQG) were used for the screening process.

Table 6.10-1: Screening Criteria Applied to Surface Water Quality Data for the Mount Nansen Site

Parameter	Short Term	Long Term
Total Metals		
Aluminium	Varies with pH < 6.5 pH 0.1 for pH ≥ 6.5	Varies with pH < 6.5 pH 0.05 for pH ≥ 6.5
Alkalinity	<10 mg/L, waterbody is highly sensitive to acid input; mg/L, waterbody is moderately sensitive to acid input; and 20 mg/L, waterbody has low sensitivity to acid input.	
Arsenic	5	
Barium	-	1,000
Beryllium	-	0.13
Boron	29,000	1,500
Cadmium	1	0.09
Calcium	4 mg/L is highly sensitive to acid inputs; 4 to 8 mg/L is moderately sensitive; and > 8 mg/L is low sensitivity	
Chromium, hexavalent (Cr(VI))	-	1
Chromium, trivalent (Cr(III))	-	8.9
Cobalt	110	4
Copper	WQG 2 ug/L when hardness 0 to < 82 mg/L $WQG = 0.2 * e^{\{0.8545[\ln(hardness)] - 1.465\}}$ when hardness ≥ 82 to ≤ 180 mg/L WQG = 4 ug/L when hardness > 180 mg/L	
Cyanide (WAD)	5	
Iron Dissolved	350	-
Iron Total	1,000	300
Lead	WQG = 1 ug/L when hardness 0 to ≤ 60 mg/L $WQG = e^{\{1.273[\ln(hardness)] - 4.705\}}$ when hardness > 60 to ≤ 180 mg/L WQG = 7ug/L when hardness > 180 mg/L	
Manganese	WQG ≤ 0.01102 hardness + 0.54 When hardness is 37 – 450 mg/L	WQG ≤ 0.0044 hardness + 0.605 When hardness is 25 – 259 mg/L
Mercury	-	0.026
Molybdenum	2,000	73

Parameter	Short Term	Long Term
Nickel	WQG = 25 ug/L when 0 to 60 mg/L hardness $WQG = e^{\{0.76[\ln(hardness)]+1.06\}} > 60$ to ≤ 180 mg/L hardness WQG = 150 ug/L when > 180 mg/L hardness	
Selenium	-	1
Silver	-	0.25
Thallium	-	0.8
Uranium	33	15
Zinc	-	30
General Chemistry		
Total Organic Carbon	30 day median $\pm$ 20% of the median background	
Dissolved Organic Carbon	30 day median $\pm$ 20% of the median background	
pH (pH units)	6.5 to 9	
Nutrients		
Ammonia-N	Varies with temperature and pH	
Nitrate-N	550,000	13,000
Nitrite-N	-	60
Phosphorous	-	ultra-oligotrophic <4 oligotrophic 4-10 mesotrophic 10-20 meso-eutrophic 20-35 eutrophic 35-100 hyper-eutrophic >100
Sulphate (mg/L)	-	128 (hardness 0-30 mg/L) 218 (hardness 31-75 mg/L) 309 (hardness 76-180 mg/L) 429 (hardness 181-250 mg/L)

Notes: All values in $\mu\text{g/L}$ unless otherwise noted. Bolded values indicate BCWQG (BC MOE 2017); CCME-FAL guidelines are shaded (CCME 2017); - = not available; WQG = water quality guideline.

Parameters for which there was more than one exceedance of WQGs at a given station were considered to be parameters of interest for that station. These parameters of interest were reviewed more closely to determine which were SWPC. Parameters of interest were not considered to be SWPC if they met the following criteria:

1. Parameter is consistently observed to be less than applicable guideline (LG).
2. Parameter exceedances are attributable to naturally elevated background (BG).
3. Parameter exceedances are attributable to placer mining activity that is not associated with Site activity (PL).
4. Parameter exceedances are local and do not extend beyond the Project Study Area (PSA).

In summary, parameters of interest that were attributable to Site activity, were not associated with elevated background or placer activity, and for which effects extended beyond the PSA into the LSA or RSA are identified as parameters SWPC.

6.10.2 Surface Water Quality Conditions

The description of water quality at the Site is presented in the following order of locations: Pony Creek; Brown McDade Pit; Back Creek; mill area of Dome Creek; TSF; Dome Creek downstream of the TSF, and Victoria Creek. Water quality parameters are organized and discussed as follows:

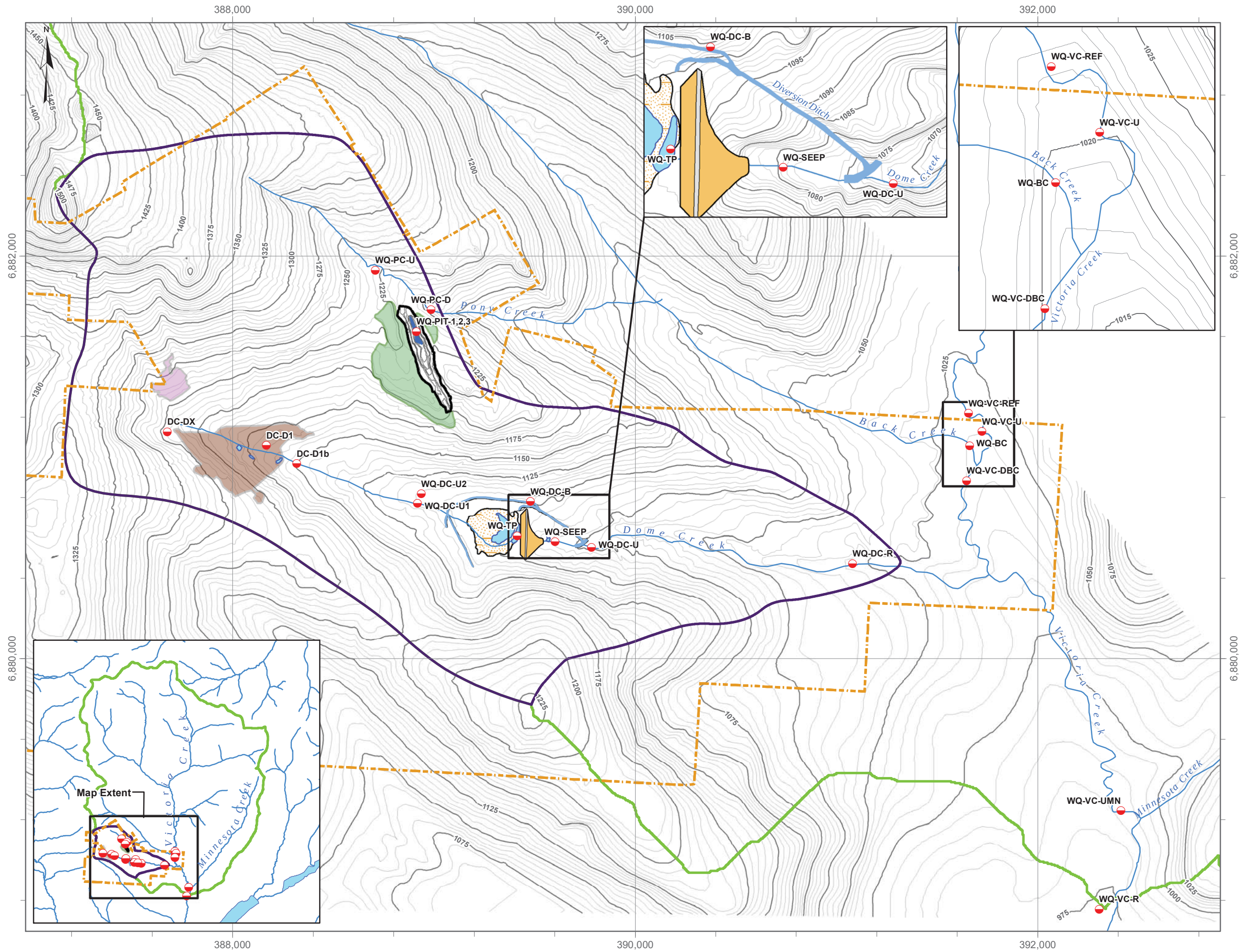
- General parameters, including hardness, conductivity, pH and total suspended solids (TSS);
- Cyanide and cyanide degradation products, including ammonia, nitrate, and nitrite;
- Sulphate; and
- Total and dissolved metals.

6.10.2.1 Pony Creek

A summary of parameters of interest for Pony Creek is presented in Table 6.10-2, which includes a total count of measured values in comparison to number of values above the guideline ($\# > \text{GL}$). Time series for each parameter are available in Appendix 6D.

Monthly mean water hardness (i.e., mineral content) in Pony Creek ranged from 76 mg/L CaCO_3 (May) to 344 mg/L CaCO_3 (June). Water in the creek generally was hard except during peak snowmelt months. Conductivity monthly mean concentrations ranged from 169 $\mu\text{S}/\text{cm}$ (PC-U May) to 641 $\mu\text{S}/\text{cm}$ (June). A seasonal trend was not evident for TSS in Pony Creek, ranging from 5.3 mg/L (September) to 311.5 mg/L (June). The highest TSS values were recorded in July-August 2016 followed by a sharp decrease in subsequent months. This increase may have related to an intensification in upstream placer mining activities at the time. The monthly mean pH was neutral and within CCME-FAL with values ranging from 7.2 (PC-D June) to 7.6 (several months) (CCME 2017).

Cyanide was below WQGs and often below method detection limits at both stations in Pony Creek. Trace levels of ammonia, nitrate, and nitrite have been measured in Pony Creek and were associated with blasting residue from historic open pit mining. Monthly mean concentrations for ammonia ranged from 0.003 mg/L (November) to 0.923 mg/L (June). Ammonia concentrations were significantly higher in 2016 compared to previous years, following the same pattern as TSS. However, concentrations were mostly below the pH and temperature-dependent WQG (Exceedances in 1 of 36 collected samples). No exceedances were found for nitrate in Pony Creek stations, with values well below WQGs. Concentrations for nitrite remained relatively constant since 2012 with a few exceedances to applicable WQGs in upstream stations. Similar to ammonia and TSS, an increase in nitrite concentrations followed by a sharp decrease in subsequent months was observed in 2016 for upstream and downstream stations of Pony Creek.



LEGEND

- Water Quality Monitoring Station
- LSA
- RSA
- Mount Nansen OIC Boundary
- Mill Area
- Mine Camp Area
- Tailings Dam
- Tailings
- Pond
- Pit Outline
- Waste Rock Area
- 25m Contour
- 5m Contour

Coordinate System: NAD 1983 UTM Zone 8N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter

1:18,000

0 200 400 Meters

DATE SAVED: Mar 28, 2017

DRAWN BY: GM

REVIEWED: JM

VERSION: 1

CLIENT:

Yukon

PROJECT:

**Mount Nansen
Care & Maintenance
Project Proposal**

TITLE: Study Area and
SWQ Monitoring Locations

PROJECT #: A422-1

FIGURE: 6.10-1

Table 6.10-2: Summary of Parameters of Concern for Pony Creek and Brown McDade Pit

Station		Sulphate	Ammonia-N	Nitrite-N	CN-WAD	T-As	T-Cr	T-Co	T-Cu	T-Fe	T-Pb	T-Mn	T-Hg	T-Ag	T-Zn	D-Al	D-Cd
PC-U	Count	29	27	20	29	29	29	29	29	29	29	29	28	29	29	29	29
	# > GL	1	3	3	0	8	6	2	5	9	5	3	5	4	5	6	0
Pit1	Count	26	22	20	0	26	26	26	26	26	26	26	22	26	26	26	26
	# > GL	25	0	2	0	24	1	0	0	0	0	0	1	0	26	0	26
PC-D	Count	23	19	15	23	23	23	23	23	23	23	23	22	23	23	23	23
	# > GL	1	2	1	1	14	5	1	15	5	4	1	4	4	20	1	20
Effect Summary		PSA	PL	LG	LG	PSA	PL	PL	PSA	PL	PL	PL	PL	PL	PSA	PL	PSA

Notes:

	Shaded = Values above guideline
PSA	Project effect above guideline but extent restricted to within project study area (parameter of interest)
LSA or RSA	Project effect above guideline extending beyond PSA to LSA or RSA, therefore is parameter of potential concern
LG	Less than guideline: not a parameter of concern
BG	Background: not a parameter of concern
PL	Placer: measured effect is due to placer mining activity.

A seasonal trend was not evident for sulphate. Upstream and downstream stations showed similar concentrations of sulphate with monthly mean values ranging from 42 mg/L (May) to 245 mg/L (July). Similar to TSS and ammonia, the highest sulphate concentrations, which included a few WQGs exceedances, were measured in July-August 2016. Concentrations decreased in the subsequent months but appeared to remain slightly above background levels.

Exceedances of WQGs were recorded for dissolved aluminum and total arsenic, chromium, cobalt, iron, mercury, manganese, and silver with little variation between upstream and downstream stations. Exceedances to WQGs in Pony Creek stations appear to have occurred in recent years associated with the increase in TSS levels. Concentrations of dissolved cadmium, copper, and zinc increased with distance downstream. Pony Creek may be a relevant source of copper, cadmium and zinc to Back Creek.

Based on the data screening, no SWPC were identified for Pony Creek.

6.10.2.2 Brown McDade Pit

A summary of parameters of interest for the Brown McDade Pit is presented in Table 6.10-2, which includes a total count of measured values in comparison to number of values above the guideline (# > GL).

Water hardness in Brown McDade Pit was characterized as very hard with monthly mean values ranging from 667 mg/L CaCO_3 (June) to 1,535 mg/L CaCO_3 (March) (Appendix 6D). Conductivity ranged from 921 $\mu\text{S}/\text{cm}$ (June) to 2,065 $\mu\text{S}/\text{cm}$ (April). A seasonal trend for TSS was not evident for the open pit station. Monthly mean values ranged from 1.0 mg/L (October) to 4.3 mg/L (July). The pH values have remained stable and were within WQGs with values ranging from 7.5 (October) to 8.1 (July).

Monthly mean concentrations for ammonia ranged from 0.003 mg/L (several months) to 0.04 mg/L (October) and were below the pH and temperature dependent WQG. Seasonal trends for ammonia were not evident for the open pit. Nitrate concentrations were well below WQGs, however, an increase in nitrate concentrations was observed mostly between 2012-2013 and 2015. Similarly, nitrite concentrations increased in 2012-2013 with values exceeding WQGs, followed by a decrease in subsequent years. This sharp transition in nitrite values was associated with the change in analytical laboratory in 2013 and is likely due to a change in analytical procedure. Cyanide was not used during mining of the open pit and, therefore, was not measured.

Seasonal trends were evident for sulphate with lower concentrations occurring in June. Measured concentrations typically exceeded the sulphate WQGs (86 of 87 collected samples). Monthly mean concentrations ranged from 575 mg/L (June) to 1,175 mg/L (April). Increases in sulphate concentrations in the pit are not reflected in downstream stations of Pony Creek.

The most WQG exceedances for metals occurred for total arsenic and zinc, and dissolved cadmium. Concentrations of dissolved manganese, cadmium, chromium, and zinc significantly decreased in recent years. Conversely, arsenic demonstrated a gradual increase over time. Observed increases in dissolved concentrations of arsenic, cadmium, and zinc in downstream stations of Pony Creek, relative to upstream stations, may be related to inputs from the pit.

Based on the data screening, no SWPC were identified for the Brown McDade Pit.

6.10.2.3 Back Creek

A summary of parameters of interest for Back Creek is presented in Table 6.10-3. Time series for each parameter are available in Appendix 6D.

Water hardness in Back Creek was characterized as hard, with some exceptions during freshet. Monthly mean values for hardness and conductivity ranged from 65 mg/L CaCO₃ (May) to 162 mg/L CaCO₃ (October) and from 126 µs/cm (May) to 301 µs/cm (October), respectively. A seasonal trend was evident for TSS in Back Creek with higher values typically occurring during freshet. Monthly mean TSS levels ranged from 1.5 mg/L to 543.9 mg/L (May). pH was relatively neutral and was within WQGs with values ranging from 7.5 (May) to 8.1 (July).

Monthly mean concentrations for ammonia ranged from 0.003 mg/L (March) to 0.63 mg/L (September) and were below the pH and temperature dependent WQG. Seasonal trends for ammonia concentrations were not evident, however, some higher values occurred during the summer months (July-August). Elevated ammonia was particularly evident during 2016. Nitrate and nitrite concentrations were below WQGs at all sites. Monthly mean concentrations ranged from 0.039 to 0.075 mg/L and from 0.001 to 0.044 mg/L for nitrate and nitrite, respectively. Nitrate concentrations have remained relatively constant since 2012, however, nitrite profiles showed evidence of decreasing values since 2013. This sharp transition in nitrite values is most likely due to a change in analytical protocols in 2013 and is assumed to not be related to changes in the natural environment. A change in analytical laboratory at this time resulted in improved method detection limits and associated procedures. All parameters measured after this change have remained stable or have shown a decreasing trend.

Concentrations of sulphate have remained relatively constant since 2012 and were below WQG. Seasonal trends were evident for sulphate with lower concentrations occurring during freshet. Monthly mean concentrations ranged from 22 mg/L (March) to 68 mg/L (August).

Exceedances to WQGs occurred for total metals (arsenic, chromium, copper, cobalt, iron, manganese, silver, and zinc) and dissolved metals (aluminum and cadmium). WQG exceedances for dissolved aluminum and cadmium generally occurred during freshet and, therefore, are associated with TSS and particulates. Similar to Pony Creek, increases in the concentrations of these metals may relate to increased values for TSS indicating a placer-mining related source. Placer mining is extensive within the Back Creek drainage. Metal input from Pony Creek also may occur, particularly for copper, cadmium and zinc. Except for aluminum, a decrease in the concentrations is evident for all the dissolved metal forms of these elements compared to Pony Creek and suggest that measurable effects from the Project are not evident in Back Creek.

Based on the data screening, no SWPC were identified for Back Creek.

Table 6.10-3: Summary of Parameters of Concern for Back Creek

Station		Sulphate	Ammonia-N	Nitrite-N	CN-WAD	T-As	T-Cr	T-Co	T-Cu	T-Fe	T-Pb	T-Mn	T-Hg	T-Ag	T-Zn	D-Al	D-Cd
BC	Count	28	25	21	28	28	28	28	28	28	28	28	27	28	28	28	28
	# > GL	0	0	3	0	20	17	8	15	17	14	5	4	10	13	5	5
Effect Summary		LG	LG	LG	LG	PL	PL	PL	PL	PL	PL	PL	PL	PL	PL	PL	PL

Notes:

	<i>Shaded = Values above guideline</i>
PSA	<i>Project effect above guideline but extent restricted to within project study area (parameter of interest)</i>
LSA or RSA	<i>Project effect above guideline extending beyond PSA to LSA or RSA, therefore is parameter of potential concern</i>
LG	<i>Less than guideline: not a parameter of concern</i>
BG	<i>Background: not a parameter of concern</i>
PL	<i>Placer: measured effect is due to placer mining activity.</i>

6.10.2.4 Mill Area - Upper Dome Creek

A summary of parameters of interest for the mill area and upper Dome Creek is presented in Table 6.10-4. Time series for each parameter are available in Appendix 6D.

Surface water in Dome Creek near the mill generally is hard, although some samples showed moderately soft values. Monitoring stations below the mill area generally showed increasing water hardness and conductivity. Monthly mean values for hardness in upper Dome Creek ranged from 59 mg/L CaCO₃ (May) to 1,385 mg/L (November). Monthly mean conductivity ranged from 131 µS/cm (April) to 2,095 µS/cm (November). Total suspended solids have decreased since 2012. Seasonal levels ranged from 1.0 mg/L (multiple months) to 264.7 mg/L (May) during freshet. The pH ranged from 7.4 to 8.1 and was similar among sampling locations.

Monthly mean ammonia concentrations in upper Dome Creek ranged from 0.005 mg/L (multiple months) to 0.49 mg/L (November) with values generally below the WQG. Nitrate concentrations were below WQG at all sites and ranged from 0.003 mg/L (April) to 0.17 mg/L (October). Concentrations of nitrite were lower in the upstream station than in the remaining sites indicating the mill area is a potential source for nitrite to Dome Creek. Nitrite concentrations ranged from 0.001 mg/L (DC-1b and DC-B, multiple months) to 0.22 mg/L (DC-D1, June). An increase in nitrite concentrations was evident in downstream and upstream stations of Dome Creek during 2012-2013 with a sharp decrease in concentrations in subsequent years. This sharp transition in nitrite values is most likely due to a change in analytical protocols in 2013. A change in analytical laboratory at this time resulted in improved method detection limits and associated procedures. All parameters measured after this change have remained stable or have shown a decreasing trend.

Concentrations of sulphate have remained relatively constant since 2012. A seasonal trend was evident, with highest values occurring during summer and winter low flows. Monthly mean concentrations for sulphate in upper Dome Creek ranged from 22 mg/L (April) to 1,120 mg/L (February). Observations indicate mine-related sources of sulphate generally increase with distance downstream in upper Dome Creek

Dissolved iron and manganese show the highest values downstream of the mill and are presumed to be associated with the interception of groundwater and associated oxidation artifacts. Given the circum-neutral pH conditions, the elevated levels of iron are presumed to remain local following rapid oxidation and precipitation along the surface water flow path. Seasonal trends were evident for some parameters, with higher values occurring during freshet (e.g., cadmium) and/or winter low flows (e.g., arsenic, cobalt, iron and zinc). Upstream exceedances generally were associated with elevated TSS values for aluminum, arsenic, copper, and chromium, suggesting the presence of background-related sources for these elements. Dissolved aluminum WQGs exceedances were mostly associated with TSS increases during freshet, with highest values occurring at stations immediately upstream of the TSF. The data from 2012 to 2016 indicated that contaminant levels cannot be linked to values in mill area groundwater wells. Rather, loadings may be associated with localized, point-source inputs to surface waters from mine wastes proximal to the historic

settling ponds or the Heustis Adit (Appendix 6D). Concentrations of arsenic, cadmium and zinc showed an inter-annual decrease that is particularly evident in downstream stations.

The highest concentrations of zinc were recorded in stations immediately downstream of the mill area, but zinc concentrations decreased progressively further down Dome Creek. Values in lower Dome Creek were generally similar to those measured upstream of the mill.

Based on the data screening, the SWPC identified for Dome Creek in the mill area were sulphate, total arsenic, total iron, total zinc, and dissolved aluminum (Table 6.10-4).

Table 6.10-4: Summary of Parameters of Concern for the Mill Area and Upper Dome Creek

Station		Sulphate	Ammonia-N	Nitrite-N	CN-WAD	T-As	T-Cr	T-Co	T-Cu	T-Fe	T-Pb	T-Mn	T-Hg	T-Ag	T-Zn	D-Al	D-Cd
DC-DX	Count	32	31	23	32	32	32	32	32	32	32	32	31	32	32	32	31
	# > GL	0	0	1	0	27	13	2	4	19	1	1	2	1	2	1	1
DC-D1	Count	15	12	8	15	15	15	15	15	15	15	15	13	15	15	15	15
	# > GL	1	0	6	0	15	2	1	1	3	0	0	1	1	15	0	15
DC-D1b	Count	32	31	25	32	32	32	32	32	32	32	32	30	32	32	32	32
	# > GL	27	0	1	0	32	9	0	1	17	2	0	3	2	32	0	18
DC-U1	Count	18	16	9	18	18	18	18	18	18	18	18	17	18	18	18	18
	# > GL	9	0	3	0	18	6	1	0	5	0	0	1	0	2	3	0
DC-U2	Count	16	14	10	16	16	16	16	16	16	16	16	14	16	16	16	16
	# > GL	5	0	3	0	15	14	0	1	15	0	0	2	1	16	0	0
DC-B	Count	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
	# > GL	12	0	0	0	16	8	0	1	18	0	0	1	2	6	5	0
Effect Summary		<u>LSA</u>	LG	LG	LG	<u>RSA</u>	BG	LG	LG	<u>RSA</u>	LG	LG	LG	LG	<u>LSA</u>	<u>LSA</u>	<u>PSA</u>

Notes:

	Shaded = Values above guideline
PSA	Project effect above guideline but extent restricted to within project study area (parameter of interest)
<u>LSA or RSA</u>	Project effect above guideline extending beyond PSA to LSA or RSA, therefore is parameter of potential concern
LG	Less than guideline: not a parameter of concern
BG	Background: not a parameter of concern
PL	Placer: measured effect is due to placer mining activity.

6.10.2.5 Tailings Storage Facility (TSF)

A summary of parameters of interest for the TSF is presented in Table 6.10-5. Time series for the parameters are available in Appendix 6D.

Surface water in the TSF was characterized as very hard, with higher values occurring for the water in the tailings impoundment (tailings pond). Monthly mean hardness values ranged from 709 mg/L CaCO₃ (May) to 934 mg/L CaCO₃ (January) and from 327 mg/L CaCO₃ (May) to 1,535 mg/L CaCO₃ (March) for the seepage and tailings ponds, respectively. Conductivity was higher in the tailings pond than in the seepage pond and ranged from 712 µS/cm (May) to 2,254 µS/cm. Conductivity is relatively constant over time in the seepage pond with values ranging from 1,331 µS/cm (May) to 1,680 µS/cm (January). Tailings pond TSS values showed a clear increase in 2012 and remained relatively constant after a sharp decrease in 2013. The TSS profiles in the seepage pond showed a clear increase in 2015. Monthly mean values ranged from 23.5 mg/L (August) to 48 mg/L (April) and from 2 (January) to 187 mg/L (March) for the seepage and tailings ponds, respectively. The pH was neutral in both locations, and within WQGs with values ranging from 7.2 to 8.1.

No seasonal trends were observed for cyanide in the TSF stations. Most of the cyanide exceedances occurred in the seepage pond. This result may have contributed to the cyanide WQGs exceedances observed in downstream stations of Dome Creek. Monthly mean concentrations for ammonia ranged from 3.8 mg/L (May) to 4.7 mg/L (June) and from 0.009 mg/L (July) to 2.23 mg/L (March) for the seepage and tailings ponds, respectively. Exceedances to the WQG for ammonia occurred mostly in the seepage pond outflow. Seasonal trends were only evident for the tailing ponds with higher concentrations occurring in April. Nitrate concentrations ranged from 1.11 mg/L (November) to 1.67 mg/L and from 0.03 mg/L (August) to 0.36 mg/L for the seepage and tailings ponds, respectively. Nitrate exceedances were measured only for the seepage pond station; however, an inter-annual trend shows a progressive decline over time for this element. Nitrite values ranged from 0.026 mg/L to 0.18 (multiple months) and from 0.001 mg/L (April) to 0.15 mg/L (August) for the seepage and tailing ponds, respectively. Most nitrite exceedances to WQGs in both seepage and tailings ponds occurred before 2013, followed by a decrease in concentrations to values well below WQGs in subsequent years. This sharp transition in nitrite values is most likely due to a change in analytical protocols in 2013.

Table 6.10-5: Summary of Parameters of Concern for Tailings Pond, Seepage Ponds and Middle Dome Creek

Station		Sulphate	Ammonia-N	Nitrite-N	CN-WAD	T-As	T-Cr	T-Co	T-Cu	T-Fe	T-Pb	T-Mn	T-Hg	T-Ag	T-Zn	D-Al	D-Cd
TP	Count	39	36	29	39	40	40	40	40	40	40	40	35	40	40	40	40
	# > GL	36	3	6	2	40	3	1	12	9	8	2	2	12	40	0	39
Seep	Count	57	53	51	57	58	58	58	58	58	58	58	53	58	58	57	57
	# > GL	57	52	19	53	58	5	58	0	58	0	57	2	1	11	2	38
DC-U	Count	49	45	38	49	49	49	49	49	49	49	49	45	49	49	49	49
	# > GL	30	17	8	15	49	21	15	1	49	0	12	2	0	16	7	3
Effect Summary		<u>LSA</u>	PSA	PSA	PSA	<u>RSA</u>	PSA	PSA	LG	<u>RSA</u>	LG	PSA	BG	LG	<u>LSA</u>	<u>LSA</u>	PSA

Notes:

	Shaded = Values above guideline
PSA	Project effect above guideline but extent restricted to within project study area (parameter of interest)
<u>LSA or RSA</u>	Project effect above guideline extending beyond PSA to LSA or RSA, therefore is parameter of potential concern
LG	Less than guideline: not a parameter of concern
BG	Background: not a parameter of concern
PL	Placer: measured effect is due to placer mining activity.

Seasonal trends were evident for sulphate in the tailings pond with higher concentrations occurring during freshet (April-May). Sulphate concentrations in the seepage pond station increased between 2012 and 2014, followed by a decrease in the subsequent years. This trend coincided with sulphate increases in lower Dome Creek. Several exceedances to the sulphate WQGs occurred at both seepage and tailing ponds stations. Monthly mean concentrations ranged from 591 mg/L (May) to 777 mg/L (January) and from ranged 305 mg/L (May) to 1,372 mg/L (March) for the seepage and tailings ponds, respectively.

6.10.2.6 Tailings Pond Metals

Concentrations of arsenic, cadmium, cobalt, copper, iron, manganese and zinc exceeded WQGs in the tailings pond. Concentrations of both cobalt and copper declined slightly after 2012. In contrast, concentrations for other parameters of concern (e.g., manganese) have not shown any definitive inter-annual trends in recent years. A pronounced decline in the concentration of chromium was observed in 2013, likely due a change in analytical laboratory. A decrease in the concentrations for dissolved forms compared to total values was evident for aluminum, arsenic, cadmium, and copper. Zinc concentrations were noted to increase in March 2012 followed by a sharp decrease in concentrations, most likely related to increased TSS values at the time.

6.10.2.7 Seepage Pond Metals

Concentrations of arsenic, cadmium, cobalt, iron, manganese, and zinc exceeded WQGs in the seepage pond. Concentrations of dissolved iron increased after 2012. Concentrations of dissolved manganese also showed evidence of modest increases. Given the neutral pH conditions of seepage waters, such increases are interpreted to represent the enhanced reductive dissolution of manganese (Mn)(IV)- and iron (Fe)(III)-oxide phases within the tailings mass. The onset to more vigorous Mn(IV) and Fe(III) reduction may result from decreased availability of nitrate. Dissolved zinc concentrations increased in the seepage pond in 2015 and 2016, with peaks occurring in the winter low-flow period when inputs to the seepage pond will be minimally diluted with surface runoff. This result implies zinc increases can be attributed to processes occurring within the tailings facility, and input to the pond via seepage pathways. The increase in zinc concentrations noted in 2015 does not correlate with iron and arsenic concentrations, nor with concentration trends in the tailing pond, suggesting other processes contributed to the observed increases. The concentrations of other elements such as cadmium, cobalt and copper decreased trend over time.

Based on the data screening, the SWPC identified for the TSF were sulphate, total arsenic, total iron, total zinc, and dissolved aluminum (Table 6.10-5).

6.10.2.8 Dome Creek – Middle and Lower Reaches

A summary of parameters of interest for the middle and lower reaches of Dome Creek is presented in Table 6.10-5 and Table 6.10-6. Time series for parameters are available in Appendix 6D.

Dome Creek surface water was generally hard, with lower monthly mean values in lower Dome Creek ranging from 352 mg/L CaCO₃ (May) to 941 mg/L CaCO₃ (January). Monthly mean conductivity ranged from 641 µs/cm (May) to 1,590 µs/cm (December). TSS levels ranged from 9.9 mg/L (January) to 189 mg/L (May), with elevated concentrations in middle Dome Creek compared to the lower reach. Seasonally, TSS followed a trend indicative of freshet conditions, with higher concentrations from April to July. The pH ranged from 7.5 to 8 and was similar among sampling locations.

Cyanide concentrations exceeded WQGs during winter low flows (24 of 72 collected samples) in middle Dome Creek. Concentrations ranged from 0.006 mg/L (September and November 2012) to 0.040 mg/L (March 2013) and generally coincided with seepage pond discharge observations. Seasonal trends for ammonia concentrations were apparent in middle Dome Creek, with higher values during freshet and winter months. Monthly mean ammonia concentrations in middle Dome Creek ranged from 0.23 mg/L (May) to 4.1 mg/L (February) with exceedances to the WQGs indicating mine-related contribution of ammonia likely due to cyanide decomposition. Only a few ammonia exceedances were observed further downstream, suggesting a pronounced attenuation effect most likely due to dilution. Nitrate and nitrite concentrations ranged from 0.16 mg/L (May) to 1.51 mg/L (March) and from 0.007 mg/L (September) to 0.12 mg/L (March), respectively. Nitrate concentration was below WQG, with concentrations progressively decreasing since 2012. Nitrite profiles showed WQGs exceedances at both middle and lower reach stations with evidence of decreasing values since 2013. This sharp transition in nitrite values is most likely due to a change in analytical protocols in 2013. Monthly mean sulphate concentrations ranged from 245 mg/L (May) to 739 mg/L (January). An increase in sulphate concentrations in lower Dome Creek was observed between 2012 and 2014 and coincided with increases in the seepage pond.

Sporadic exceedances for total mercury and silver were found in middle and lower Dome Creek, mostly associated with elevated TSS values. Concentrations of iron in the seepage pond were not evident in downstream stations of Dome Creek, likely due to attenuation of dissolved iron in close proximity to the mine facility. A peak in concentrations of dissolved manganese in the seepage pond was observed in 2014 and was congruent with peak values in middle Dome Creek, but not further downstream. Elevated concentrations of cadmium and zinc observed in the seepage pond in recent years were not also observed in the middle and lower Dome Creek stations, illustrating their likely co-attenuation with iron/manganese-oxides (Appendix 6D). Observed increases in arsenic in middle Dome Creek were similar to those observed at the seepage pond. Total cobalt and dissolved aluminum concentrations above WQGs in Dome Creek were correlated with increases in TSS. Only a few exceedances occurred in lower Dome Creek, suggesting attenuation processes may be occurring between the two reaches. Total chromium exceedances occurred in both reaches but displayed a decreasing inter-annual trend.

Based on the data screening, the SWPC identified for middle and lower Dome Creek were sulphate, total arsenic, total iron, total zinc, and dissolved aluminum (Table 6.10-5 and Table 6.10-6).

Table 6.10-6: Summary of Parameters of Concern for Lower Dome Creek

Station		Sulphate	Ammonia-N	Nitrite-N	CN-WAD	T-As	T-Cr	T-Co	T-Cu	T-Fe	T-Pb	T-Mn	T-Hg	T-Ag	T-Zn	D-Al	D-Cd
DC-R	Count	32	30	25	32	32	32	32	32	32	32	32	31	32	32	32	32
	# > GL	9	1	3	0	32	8	0	1	31	0	0	1	0	5	3	0
Effect Summary		<u>LSA</u>	LG	LG	LG	<u>RSA</u>	BG	LG	LG	<u>RSA</u>	LG	LG	LG	LG	<u>LSA</u>	<u>LSA</u>	LG

Notes:

	<i>Shaded = Values above guideline</i>
PSA	<i>Project effect above guideline but extent restricted to within project study area (parameter of interest)</i>
<u>LSA or RSA</u>	<i>Project effect above guideline extending beyond PSA to LSA or RSA, therefore is parameter of potential concern</i>
LG	<i>Less than guideline: not a parameter of concern</i>
BG	<i>Background: not a parameter of concern</i>
PL	<i>Placer: measured effect is due to placer mining activity.</i>

6.10.2.9 Victoria Creek

A summary of parameters of concern for Victoria Creek is presented in Table 6.10-7. Time series for parameters are available in Appendix 6D.

Surface water in Victoria Creek was generally hard, with dilution occurring during freshet. Monthly mean hardness values ranged from 56 mg/L (May) to 214 mg/L (April). Monthly mean conductivity ranged from 104 $\mu\text{S}/\text{cm}$ (May) to 404 $\mu\text{S}/\text{cm}$ (April). Seasonal trends for TSS were evident with higher values occurring during freshet. Mean TSS concentrations ranged from 1.0 mg/L (multiple months) to 121.2 mg/L (April). Concentrations of TSS appeared to increase downstream of the confluences with Back Creek and Dome Creek. Mean pH values ranged from 7.2 (April) to 8.0 (multiple months).

No seasonal trends were apparent for ammonia, with concentrations below the pH- and temperature-dependent WQG in Victoria Creek. Monthly mean concentrations ranged from 0.003 mg/L (multiple months) to 0.332 mg/L (January). No exceedances of the nitrate WQG occurred in Victoria Creek. Contrarily, nitrite exceedances occurred for most of the stations, mostly in 2013 and decreasing to below the WQG in subsequent years. These exceedances were most likely due to a change in analytical protocols in 2013.

No exceedances of sulphate WQGs occurred in Victoria Creek. Monthly mean concentrations ranged from 8 mg/L (May) to 119 mg/L (April) in upper Victoria Creek. Downstream of the Dome Creek confluence, mine-related signatures are evident for sulphate. Increases in inter-annual sulphate concentrations were consistent with the higher values observed over the same time period in the seepage pond and lower Dome Creek, suggesting a tailings-related source.

Exceedances of dissolved aluminum and total arsenic, chromium, manganese and zinc WQGs occurred in upstream and downstream stations of Victoria Creek. Water quality effects were evident downstream of the confluence with Back Creek, including elevated total arsenic, chromium, copper, iron, lead, and zinc and dissolved aluminum. These elevated concentrations coincided with elevated TSS and are associated with placer activity in Back Creek and upper Pony Creek. Increased arsenic concentrations were consistent with higher values observed in the seepage pond and lower Dome Creek over the same time period, indicating a seepage collection pond discharge source. No discernible inter-annual trends were evident for metals of concern (e.g., arsenic, zinc) in Victoria Creek after 2012. Observed mine signatures generally were not discernible further downstream in Victoria Creek.

Based on the data screening, the SWPC identified for Victoria Creek were total arsenic and total iron (Table 6.10-7).

Table 6.10-7: Summary of Parameters of Interest and Parameters of Concern for Victoria Creek

Station		Sulphate	Ammonia-N	Nitrite-N	CN-WAD	T-As	T-Cr	T-Co	T-Cu	T-Fe	T-Pb	T-Mn	T-Hg	T-Ag	T-Zn	D-Al	D-Cd
VC-REF	Count	26	21	20	27	27	27	27	27	27	27	27	24	27	27	27	25
	# > GL	1	0	3	0	2	4	0	6	5	2	0	1	0	2	1	2
VC-U	Count	49	43	41	49	49	49	49	49	49	49	49	45	49	49	49	49
	# > GL	0	0	4	0	3	5	1	7	6	3	1	2	0	2	6	0
VC-DBC	Count	52	47	44	52	52	52	52	52	52	52	52	51	52	52	52	52
	# > GL	0	0	4	0	10	14	1	12	12	9	1	3	0	5	6	2
Effect Summary		LG	LG	LG	LG	PL	PL	LG	PL	PL	PL	LG	PL	LG	PL	BG	BG
VC-UMN	Count	47	40	41	47	47	47	47	47	47	47	47	46	47	47	47	47
	# > GL	0	0	3	0	8	7	0	9	6	3	0	2	0	1	6	0
VC-R	Count	37	34	28	37	37	37	37	37	37	37	37	34	37	37	37	37
	# > GL	0	0	2	0	5	4	0	10	7	4	0	1	0	1	9	0
Effect Summary		LG	LG	LG	LG	<u>RSA</u>	BG	LG	PL	<u>RSA</u>	PL	LG	LG	LG	LG	BG	LG

Notes:

	Shaded = Values above guideline
PSA	Project effect above guideline but extent restricted to within project study area (parameter of interest)
<u>LSA or RSA</u>	Project effect above guideline extending beyond PSA to LSA or RSA, therefore is parameter of potential concern
LG	Less than guideline: not a parameter of concern
BG	Background: not a parameter of concern
PL	Placer: measured effect is due to placer mining activity.

6.11 Aquatic Environment

6.11.1 Introduction

Aquatic resources have been studied at the Site since prior to the development and operation of the current infrastructure, with more detailed surveys performed in recent years. This section presents a summary of the studies and information sources that contribute to the understanding of current aquatic resources at the Site, with a focus on the most recent studies and data. Aquatics information presented includes results of stream sediment, benthic macroinvertebrates, and periphyton surveys.

Fish and fish habitat in relation to the Site have been studied since prior to the development and operation of the site, but the most detailed data have been developed through more recent site studies. This section presents a summary of existing fish and fish habitat data for the Site.

Investigations of fish and fish habitat have focused primarily on watercourses under the direct influence of Site activities (i.e., care and maintenance) and appropriate reference areas. Accordingly, local and regional study areas were defined within which the characteristics of fish and fish habitat are described.

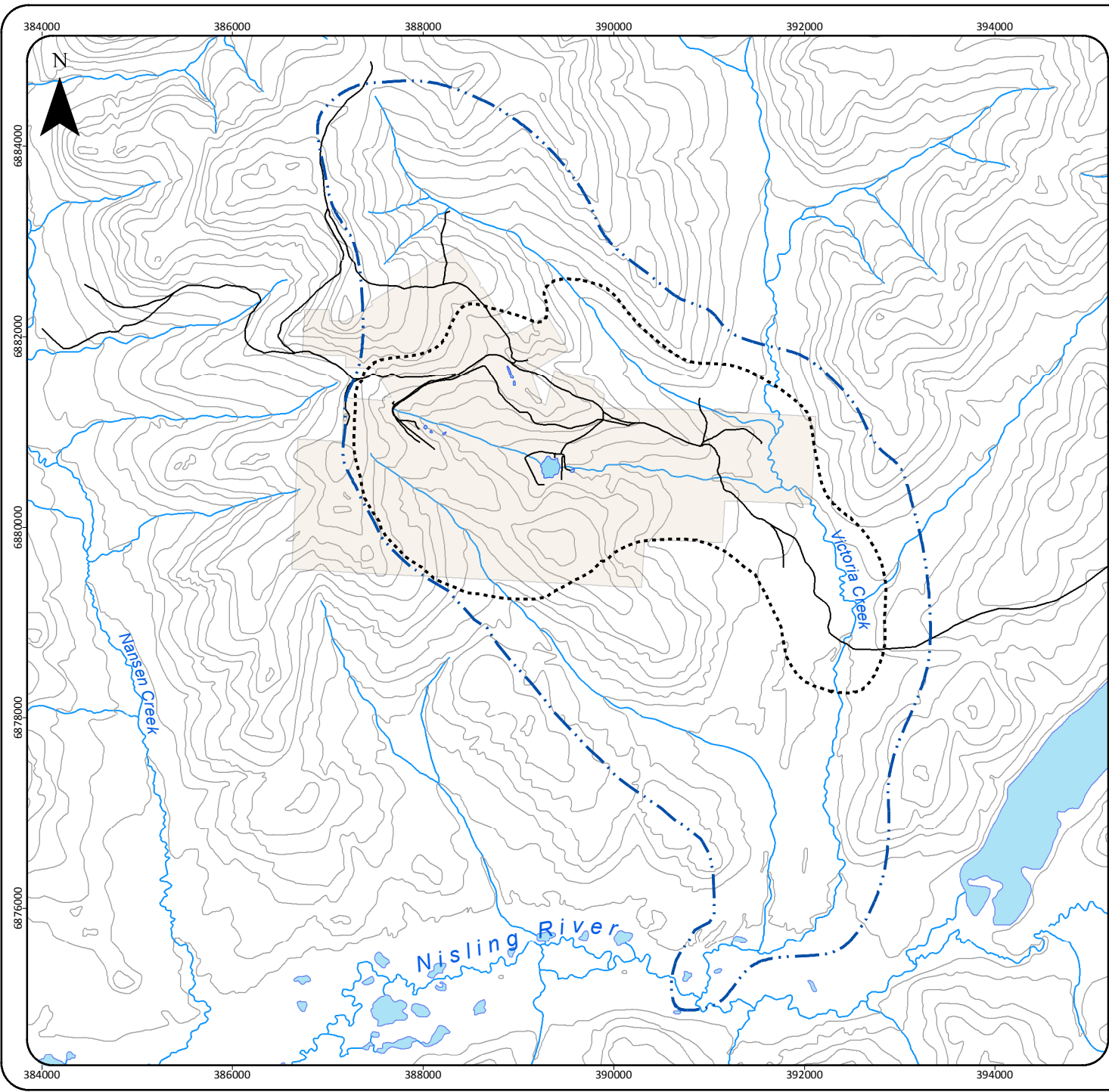
6.11.2 Fish and Aquatic Resources Local and Regional Study Areas

6.11.2.1 Local Study Area (LSA)

A local study area (LSA) was delineated to include those watercourses or watersheds where direct local effects on fish and aquatic resources could occur, with the inclusion of additional reference watercourses or watercourse areas outside of the spatial extent of direct local effects. The LSA includes the entirety of Dome and Pony Creeks, a section of Back Creek extending 1.6 km upstream from its confluence with Victoria Creek, a section of Victoria Creek extending 6.6 km from upstream of its confluence with Back Creek to downstream of its confluence with Dome Creek, and the portion of Dry Creek that falls within the OIC area. A 500 m segment of Minnesota Creek, leading upstream from its outflow into Victoria Creek, was also included as a reference to potential influence of that watercourse on the receiving areas of Victoria Creek. Figure 6.11-1 provides a detailed overview of the LSA and RSA boundaries used for the fish and aquatic sampling program.

6.11.2.2 Regional Study Area (RSA)

A regional study area (RSA) was delineated to include a larger reference area of the watercourses under direct influence of the proposed activities. The RSA allows for the description of any existing influences in the area on aquatic resources at a larger scale. The RSA includes the entirety of Dome, Pony, Back and Dry creeks, a 1,033 m segment of Minnesota Creek (leading upstream from its outflow into Victoria Creek), and Victoria Creek from 1,104 m upstream of the confluence of Back Creek to its outflow into the Nisling River (Figure 6.11-1).



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Figure 6.11-1

LSA and RSA Boundaries for the
Fish and Aquatic Sampling Program



Legend

Local Boundaries

- Order In Council Area
- Local Study Area
- Regional Study Area

Base Layers

- Roads
- Watercourse
- Topographic Contours (30 m Interval)
- Waterbody

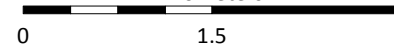
Data Source:

1. Mount Nansen Access Road and Study Area boundaries digitized by ELR.
2. Order in Council Boundary provided by YG, Assessment and Abandoned Mines Branch.
3. National Topographic Data Base compiled by Natural Resources Canada at a scale of 1:50,000. Reproduced under license from © Her Majesty the Queen in Right of Canada, Department of Natural Resources Canada. All rights reserved.

Datum: NAD 1983 CSRS UTM Zone 8N

Scale 1:60,000

Kilometers



March 5, 2018

6.11.3 Scope and Extent of Aquatic Resources Baseline Studies

Numerous studies on aquatic resources have been conducted on watercourses in the LSA and RSA through the pre-operational, operations, and post-operations (current) phase at the Site. A summary of previous studies from which data has been reviewed is presented in Table 6.11-1. A more detailed summary of existing studies and current conditions is provided for aquatic resources (i.e., sediments, benthic macroinvertebrates, and periphyton) in the following sections.

Table 6.11-1: Field Studies and Data Sources Used to Describe Aquatic Resources at the Mount Nansen Site.

Site Phase	Year	Lead Company/Group	Stream Sediment	Benthic Macroinvertebrates	Periphyton
Pre-operational	1976	Environmental Protection Service (Conor Pacific 2000)		•	
	1977	Environmental Protection Service (Conor Pacific 2000)		•	
	1986	Norecol Environmental Consultants (Norecol 1989)	•		
	1988	Environmental Protection Service (Davidge and Ballantyne 1995)	•	•	
Operations	1997	Environment Canada – referenced in (Conor Pacific 2000)		•	
Post-operations and current Care & Maintenance	1999	Conor Pacific (Conor Pacific 2000)	•		
	2005	EDI (EDI 2007)	•		
	2006	EDI (EDI 2007)	•		
	2007	EDI (EDI 2008)		•	
	2008	EDI (EDI 2009a)		•	
	2012-2014	ELR (Appendix 6E)	•	•	•

6.11.4 Stream Sediments

Pre-development baseline stream sediment samples were collected at the Site as early as 1986 by Chevron Minerals Ltd. (Norecol 1989), and in 1988 by the Environmental Protection Service (Davidge and Ballantyne 1995). Additional sampling was also completed in 1999 by Conor Pacific (2000) and in 2005 and 2006 by Environmental Dynamics Inc. (EDI 2007). More recent stream sediment characteristics were sampled in 2013 as part of a fisheries and aquatics baseline studies program (Appendix 6E).

Stream sediment sampling in the LSA area has focused on Victoria, Back, Pony, and Dome creeks, and to a lesser extent Minnesota, Weber, Cabin, and Nansen creeks. Each sediment sampling program has used its own unique sample site identification, with a total of 58 sample sites surveyed from 1986 to 2013. A summary of sample sites organized according to stream reach is provided in Table 6.11-2, with locations shown in Figure 6.11-2.

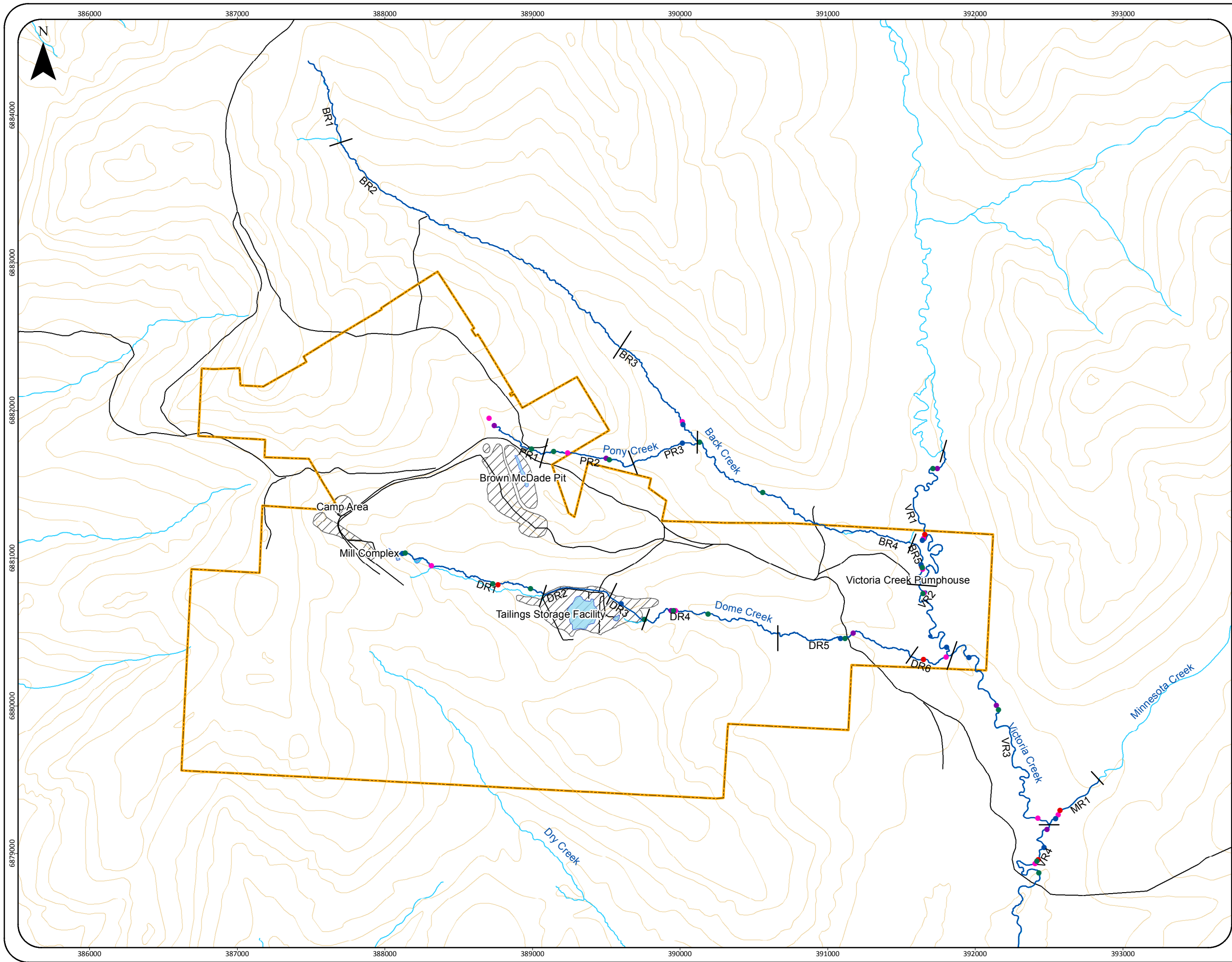
Stream sediment metal concentrations from the most recent sampling event in 2013 are considered to reflect current conditions at the Site. Recent results for all sampled sites are compared to CCME *Canadian Sediment Quality Guidelines for the Protection of Aquatic Life* (CSQG), including the Interim Sediment

Quality Guidelines (ISQG) and Probable Effect Levels (PEL; CCME 2002). These guidelines provide concentration limits for arsenic, cadmium, chromium, copper, mercury, lead and zinc.

Table 6.11-2: Stream Sediment Sampling Summary and Locations

Stream	Reach Description	Organization	Sample Site ID	Year Sampled
Victoria Creek	VR1 Victoria Creek Reference- Upstream of Back Creek	Norecol	V1	1986
		Davidge and Ballantyne	ST-8	1988
		Conor Pacific	V1	1999
		EDI	V1	2005/06
		ELR	V1	2013
	VR2 Victoria Creek - Downstream of Back Upstream of Dome Creek	Davidge and Ballantyne	ST-9	1988
		EDI	V2	2005/06
		ELR	V2	2013
	VR3 - Downstream of Dome Upstream of Minnesota Creek	Davidge and Ballantyne	ST-10	1988
		Conor Pacific	V4	1999
		EDI	V3	2005/06
		ELR	V3	2013
	VR4 - Downstream of Minnesota Creek	Norecol	V2	1986
		Davidge and Ballantyne	ST-12	1988
		Conor Pacific	V5 & V6	1999
		EDI	V4 & V5	2005/06
		ELR	V4	2013
Back Creek	BR1 - Upstream of Pony Creek	Davidge and Ballantyne	ST-5	1988
		EDI	B1	2005/06
		ELR	B1	2013
	BR2 - Downstream of Pony Creek	Norecol	B1	1986
		Davidge and Ballantyne	ST-7	1988
		EDI	B2 & B3	2005/06
		ELR	B2	2013
	BR3 - Riparian area of Victoria Creek	-	-	-
Pony Creek	PR1 - Upstream of adit outlet from Brown McDade Pit,	Conor Pacific	P2	1999
		ELR	P1	2013
	PR2 - Below adit outlet from Brown McDade Pit,	Norecol	P1	1986
		Conor Pacific	P1	1999
		EDI	P1, P2, & P3	2006
		ELR	P2	2013
	PR3 - Stream reaches Back/Victoria Creek floodplain	Davidge and Ballantyne	ST-6	1988
Dome Creek	DR1 - Uppermost reach of Dome Creek extending from the mill to tailings area	Norecol	D1	1986
		Davidge and Ballantyne	ST-1 & ST-2	1988
		EDI	D1, D2, & D3	2005/06
		ELR	D1	2013
	DR2 - Excavated diversion ditch	-	-	-
	DR3 - Dome Creek Diversion Channel	-	-	-
	DR4 - Uppermost channel segment downstream of tailings facility.	Davidge and Ballantyne	ST-3 & ST-4	1988
		Conor Pacific	D3 & D2	1999
		EDI	D4, D5, & D6	2005/06
		ELR	D2	2013
	DR5 - Wide grass/sedge wetland, includes road crossing	Norecol	D2	1986
		EDI	D7	2005/06
		ELR	D3	2013
	DR6 - Riparian area of Victoria Creek	-	-	-
Minnesota Creek	MR1 - Upstream from Victoria Creek Confluence	Norecol	M1	1986
		Davidge and Ballantyne	ST-11	1988
		ELR	MC	2013

Document Path: M:\Projects\16-249 MN CHPP\Map_Files\Chap6_EEA\aquatics\2018 03 04 Figure 6.11-2 Stream Sediment Sampling Locations.mxd



MOUNT NANSEN CARE AND MAINTENANCE PROJECT

Figure 6.11-2
Recent and Historical Stream Sediment
Sampling Locations Within the RSA and LSA



Legend

Sample Locations

- 1986
- 1988
- 1999
- 2006
- 2013

Local Boundaries

- Order In Council Area

Base Layers

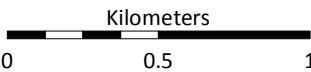
- Roads
- Watercourses
- Topographic Contour (30 m Interval)
- Waterbodies
- Existing Site Infrastructure

Data Source:

- 1.Mount Nansen site features digitized by ELR using spatial data provided YG, Assessment and Abandoned Mines Branch.
- 2.Sediment sample locations compiled from studies conducted at the Mount Nansen Site; refer to Table X.2 in Aquatic Existing Environment for summary.
- 2.Order in Council Boundary provided by YG, Assessment and Abandoned Mines Branch.
- 3.National Topographic Data Base compiled by Natural Resources Canada at a scale of 1:50,000. Reproduced under license from © Her Majesty the Queen in Right of Canada, Department of Natural Resources Canada. All rights reserved.

Datum: NAD 1983 CSRS UTM Zone 8N

Scale 1:25,000



March 5, 2018

6.11.4.1 Stream Sediment Metals

6.11.4.1.1 Victoria Creek

In 2013, stream sediment arsenic concentrations in Victoria Creek exceeded ISQG at all sample sites, and the PEL in one sample downstream of Dome Creek (Appendix 6E). The concentration of arsenic was relatively consistent among all Victoria Creek sample sites, ranging from 8.92 to 17.7 mg/kg (Table 6.11-3). No other metal exceedances of the ISQG were recorded in Victoria Creek.

Stream sediment from Victoria Creek had previously been found to exceed CSQG for arsenic, cadmium, lead, copper and zinc (Table 6.11-3). Arsenic has been the only metal to consistently exceed the ISQG in all areas of Victoria Creek sampled.

6.11.4.1.2 Dome Creek

Sediment samples taken from Dome Creek in 2013 were found to exceed CSQG for arsenic, cadmium, copper, lead, and zinc (Table 6.11-4; Appendix 6E). Metals exceeding the ISQG in Dome Creek demonstrated a pattern of decreased concentration in middle Dome Creek, but elevated levels at both the upper and lower Dome Creek sample sites. Arsenic concentrations in sediment from middle Dome Creek range from 20.6 and 56.5 mg/kg and were found to be significantly higher at upper and lower Dome Creek sample sites (values ranging from 598 and 893 mg/kg and 497 and 768 mg/kg, respectively). Zinc concentrations in sediment from Dome Creek demonstrated a similar pattern, with values ranging from 720 to 1,090 mg/kg at upper Dome Creek, 45.3 to 107 mg/kg at middle Dome Creek, and 200 to 256 mg/kg at lower Dome Creek. The highest metal concentrations on Dome Creek typically were found in sediments from the upper Dome Creek site.

In historical studies, ISQG exceedances occurred for arsenic, cadmium, copper, mercury, chromium, lead, and zinc in stream sediment from Dome Creek (Table 6.11-4). These early studies occurred after the development of the Heustis adit and possibly other developments and may not reflect natural pre-development conditions. Stream sediment metal concentrations in Dome Creek have likely changed since sediment sampling was first conducted in 1988 (Davidge and Ballantyne 1995). Sediments collected from middle Dome Creek in 2013, show arsenic concentrations have significantly decreased when compared to historical baseline levels (Table 6.11-4). Dome Creek has undergone substantial changes associated with the development and operation of the mine, and so historical datasets are not likely reflective of current stream sediment metal concentration.

Table 6.11-3: Summary of CCME Canadian Sediment Quality Guideline Exceedances for Victoria Creek

Metal	Reach Location	Year Sampled	Concentration (mg/kg)	CCME CSQG ^A	
				ISQG ^B	PEL ^C
Arsenic	VR1 - Upstream of Back Creek	1986	9.60	5.9	17
		1988	21^F		
		2013	13.6 ^F		
	VR2 - Downstream of Back Upstream of Dome Creek	1988	40.6^F		
		2006	6.8		
		2013	12.64 ^F		
	VR3 - Downstream of Dome Upstream of Minnesota Creek	1988	31.6 ^F		
		1999	89		
		2006	8		
		2013	16.9^F		
	VR4 - Downstream of Minnesota Creek	1986	50.4		
		1988	47 ^F		
		2006	12.8		
		2006	7.9		
		2013	15.7 ^F		
Cadmium	VR1 - Upstream of Back Creek	1986	<1.17	0.6	3.5
	VR3 - Downstream of Dome Upstream of Minnesota Creek	1999	2.3		
	VR4- Downstream of Minnesota Creek	1986	<1.22		
		1988	0.72		
Lead	VR2 - Downstream of Back, Upstream of Dome Creek	1988	43 ^E	35	91.3
	VR3 - Downstream of Dome Upstream of Minnesota Creek	1999	92.6		
Copper	VR3 - Downstream of Dome Upstream of Minnesota Creek	1999	76	35.7	197
Zinc	VR3 - Downstream of Dome Upstream of Minnesota Creek	1999	228	123	315

Notes: **BOLD** type indicates parameter exceeds CCME Probable Effect Level

^A CCME Canadian Sediment Quality Guidelines for the Protection of Freshwater Aquatic Life, 2001.

^B ISQG = Interim Sediment Quality Guidelines

^C PEL = Probable Effect Level

^E Indicates ICP SCAN analysis replaces graphite-furnace result due to GF sample loss.

^F Value represents the mean of two or more replicate samples.

Table 6.11-4: Summary of CCME Canadian Sediment Quality Guideline Exceedances for Dome Creek

Metal	Reach Location	Year Sampled	Concentration (mg/kg)	CCME CSQG ^A	
				ISQG ^B	PEL ^C
Arsenic	DR1 - Uppermost reach of Dome Creek	1988	101.3 ^F	5.9	17
			355.3 ^F		
		2006	2500		
			506 ^F		
	DR4 - downstream of tailings facility	1988	719.3 ^F		
			1551.3 ^F		
		1999	2090 ^F		
			189		
		2006	128		
			101 ^D		
			63.35 ^F		
		2013	34 ^F		
	DR5 - Wide grass/sedge wetland	1986	25.2 ^D		
		2013	645.3 ^F		
Cadmium	DR1 - Uppermost reach of Dome Creek	1988	0.72 ^F	0.6	3.5
			17.37 ^{E,F}		
		2006	48		
			13.7 ^D		
	DR4 - downstream of tailings facility	2013	8.6 ^F		
			16.9 ^{E,F}		
		1988	11.1 ^{E,F}		
			1.5		
		2013	0.807		
	DR5 - Wide grass/sedge wetland	1986	<1.23		
		2013	2.14 ^F		
Copper	DR1 - Uppermost reach of Dome Creek	2006	157	35.7	197
			123 ^D		
	DR4 - downstream of tailings facility	1988	61		
			69		
			50		
			162		
Mercury	DR1 - Uppermost reach of Dome Creek	2006	38.2 ^F	0.17	0.486
			0.207		
Lead	DR1 - Uppermost reach of Dome Creek	1988	35.8 ^F	35	91.3
		2006	507		
			447		
	DR4 - downstream of tailings facility	1988	303.7 ^F		
			530 ^E		
			386 ^E		
			215 ^E		
			470 ^E		
			887 ^E		
			1030 ^E		
	DR5 - Wide grass/sedge wetland	2013	78.3 ^F		
Zinc	DR1 - Uppermost reach of Dome Creek	1988	2375.3 ^F	123	315
		2006	2,030		
			1700 ^D		
	DR4 - downstream of tailings facility	1988	864 ^F		
			2620 ^F		
			813.7 ^F		
	DR5 - Wide grass/sedge wetland	2013	233.7 ^F		

Notes:**BOLD** type indicates parameter exceeds CCME Probable Effect Level^A CCME Canadian Sediment Quality Guidelines for the Protection of Freshwater Aquatic Life, 2002^B ISQG = Interim Sediment Quality Guidelines^C PEL = Probable Effect Level^D Indicates samples are partial digestions - 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.^E Indicates ICP SCAN analysis replaces graphite-furnace result due to GF sample loss.^F Value represents the mean of two or more replicate samples.**6.11.4.1.3 Back Creek**

Sediment samples taken from Back Creek in 2013 were found to exceed the ISQG for arsenic and the PEL for zinc (Table 6.11-5; Appendix 6E). Zinc concentrations in sediment from Back Creek were significantly elevated and exceeded the PEL by more than an order of magnitude, with values ranging from 5,060 to 5,710 mg/kg at upper Back Creek and 5,150 to 5,530 mg/kg at lower Back Creek, respectively. Arsenic concentrations in sediments from Back Creek exceeded the ISQG, with values ranging from 10.8 to 15.1 mg/kg at upper Back Creek and 8.28 to 8.8 mg/kg at lower Back Creek.

In previous studies, stream sediment from Back Creek exceeded CCME guidelines for arsenic and cadmium (Table 6.11-5). Exceedances of zinc in sediment from Back Creek had not previously been observed prior to the 2013 sampling program (Appendix 6E). Cadmium was found to be elevated above the ISQG in 1986, 1988, and 2006.

Table 6.11-5: Summary of CCME Canadian Sediment Quality Guideline Exceedances for Back Creek

Metal	Reach Location	Year Sampled	Concentration (mg/kg)	CCME GSQG ^A	
				ISQG ^B	PEL ^C
Arsenic	BR1 - Upstream of Pony Creek	1988	42.7^F	5.9	17
		2006	25.7^F		
		2013	12.4 ^F		
	BR2 - Downstream of Pony Creek	1986	22.1		
		1988	25.3^F		
		2013	8.6 ^F		
Cadmium	BR1 - Upstream of Pony Creek	1988	0.82 ^F	0.6	3.5
		2006	0.84 ^F		
	BR2 - Downstream of Pony Creek	1986	<1.25		
		1988	0.77 ^F		
Zinc	BR1 - Upstream of Pony Creek	2013	5,403^F	123	315
	Lower Back Creek	2013	5,317^F		

Notes:**BOLD** type indicates parameter exceeds CCME Probable Effect Level^A CCME Canadian Sediment Quality Guidelines for the Protection of Freshwater Aquatic Life, 2002.^B ISQG = Interim Sediment Quality Guidelines^C PEL = Probable Effect Level^F Value represents the mean of two or more replicate samples.

6.11.4.1.4 Pony Creek

Sediment samples taken from Pony Creek in 2013 exceeded the ISQG or PEL for arsenic, cadmium, copper, lead, and zinc (Table 6.11-6). In nearly all instances, the metal concentrations in the middle reach (downstream from the adit outlet of the Brown McDade Pit) were higher than the upper reaches beyond the outlet.

Stream sediment from Pony Creek also exceeded ISQG guidelines for arsenic, cadmium, copper, lead, and zinc in historical studies (Table 6.11-6) and were elevated in middle Pony Creek compared to upper Pony Creek. Sites nearer to the mouth of Pony Creek also had considerably higher stream sediment metal concentrations than site P1 in historical studies (EDI 2007). These early studies occurred after the development of the Pony Creek adit and may not reflect natural pre-development conditions.

Table 6.11-6: Summary of CCME Canadian Sediment Quality Guideline Exceedances for Pony Creek

Metal	Reach Location	Year	Concentration (mg/kg)	CCME CSQG ^A	
				ISQG ^B	PEL ^C
Arsenic	PR1 - Upstream of adit outlet	2013	49.7^F	5.9	17
	PR2 - Below adit outlet	1986	2093		
		2006	945		
			350^D		
			21.5		
			11.1^D		
			1020		
			454^D		
		2013	751.7^F		
Cadmium	PR1 - Upstream of adit outlet	2013	1.49 ^F	0.6	3.5
	PR2 - Below adit outlet	1986	11.8		
		2006	5.2		
			4.4^D		
			22.8		
			16.2^D		
			11.17^F		
		2013	11.17^F		
Copper	PR2 - Below adit outlet	1986	456	35.7	197
		2006	95		
			50.9^D		
			214		
			139^D		
		2013	123.3^F		
Lead	PR1 - Upstream of adit outlet	2013	64.1 ^F	35	91.3
	PR2 - Below adit outlet	1986	1268		
		2006	345		
			182^D		
			409		
			182^D		
		2013	281^F		
Zinc	PR1 - Upstream of adit outlet	2013	137	123	315
	PR2 - Below adit outlet	1986	702		
		2006	582		
			352^D		
			948		
			756^D		
			690^F		
		2013	690^F		

Notes:**BOLD** type indicates parameter exceeds CCME Probable Effect Level^A CCME Canadian Sediment Quality Guidelines for the Protection of Freshwater Aquatic Life, 2002.^B ISQG = Interim Sediment Quality Guidelines^C PEL = Probable Effect Level^D Indicates samples are partial digestions - 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.^F Value represents the mean of two or more replicate samples.

6.11.4.1.5 Minnesota Creek

Sediment samples from Minnesota Creek in 2013 exceeded the ISQG for arsenic (Table 6.11-7). All other metal concentrations were below the ISQG. Historical samples collected in 1988 from Minnesota Creek also were found to exceed ISQG guidelines for arsenic (Table 6.11-7), and at higher levels.

Table 6.11-7: Summary of CCME Canadian Sediment Quality Guideline Exceedances for Minnesota Creek

Stream	Metals	Year	Concentration (mg/kg)	CCME CSQG ^A	
				ISQG ^B	PEL ^C
Arsenic	Minnesota Creek	1988	15.7 ^F	5.9	17
		2013	6.80		

Notes:

BOLD type indicates parameter exceeds CCME Probable Effect Level

^A CCME Canadian Sediment Quality Guidelines for the Protection of Freshwater Aquatic Life, 2002.

^B ISQG = Interim Sediment Quality Guidelines

^C PEL = Probable Effect Level

^F Value represents the mean of two or more replicate samples.

6.11.4.2 Stream Sediment Grain Size

Stream sediment grain size distribution was measured during 2013 sampling at the Site (Appendix 6E). The majority of stream sediment found within the LSA was classified as sand, with the highest proportion of coarser materials found in Pony Creek, and the highest proportion of fines found in Dome Creek. Stream sediment compositions are presented in Figure 6.11-3.

Sediments in Victoria Creek had a higher relative composition of coarse and medium sand at the upstream reference site (V1) and the furthest downstream site (V4) than sediment collected downstream from Back Creek (V2) or Dome Creek (V3). The latter two sites consisted of higher relative silt and fine sand.

Back Creek sediments were dominated by very fine sand, with a higher relative component of silt at the upstream sample site (B1) than the downstream site which had a higher proportion of medium to coarse sand.

Sediment collected from Pony Creek was dominated by very coarse grain sediments. Silts also formed a major component of sediments at both Pony Creek sites

Dome Creek sediments were comprised of a higher relative composition of fine sediments compared with other LSA streams. This creek is subject to known metals precipitation. The upper and lower Dome Creek sampling stations (D1 and D3) were dominated by fine grain sand to silt, whereas middle Dome Creek (D2) had a much lower percentage of silt.

Sediments in Minnesota Creek (M1) were dominated by medium to fine grain sand.

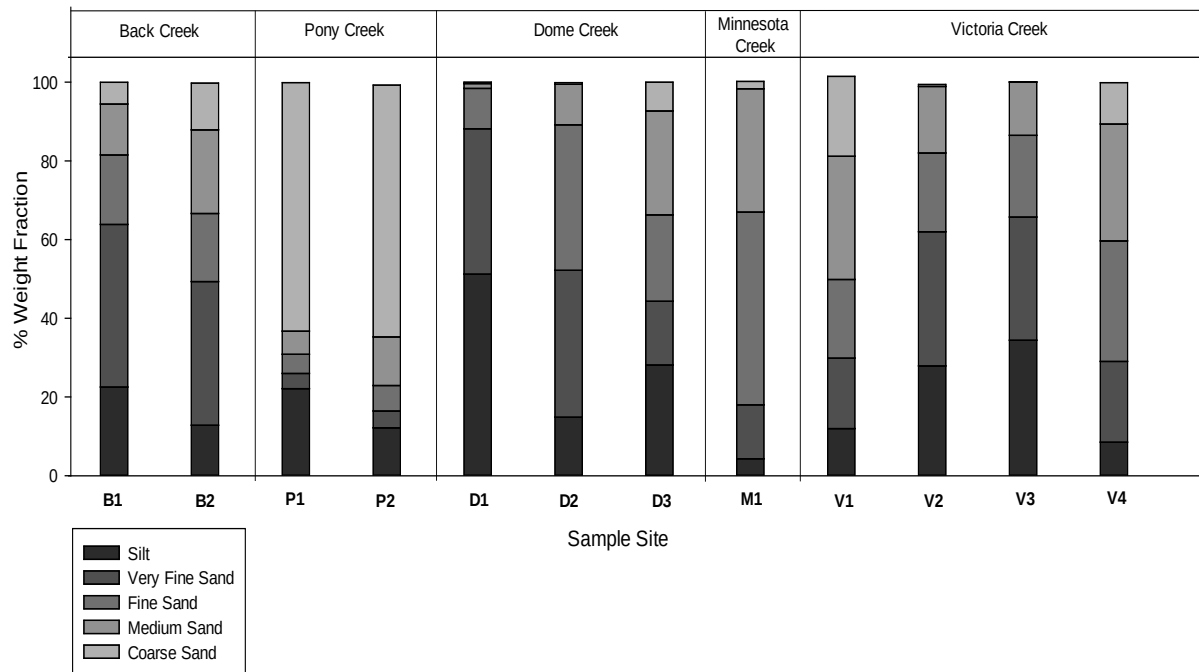


Figure 6.11-3: Summary of Sediment Grain Size Distribution (Site Mean Percentages) Mount Nansen Area Streams

6.11.4.3 Stream Sediment Organic Content

Organic content of stream sediment was measured by heating samples until their weights no longer changed (i.e., loss of ignition). Organic content varied between each stream at the Site, ranging from 1.2 to 10.0% of the total sample weight (Figure 6.11-4; Appendix 6E). The highest organic content was found in lower Dome Creek sediment, whereas the lowest values were found in the Back Creek system.

Organic content of stream sediments in Victoria (V1-V3) and Back (B1 and B2) creeks were relatively consistent throughout each system. The organic content of sediment from Pony Creek had a higher relative proportion of organics at the upstream site (P1) compared to downstream site (P2). The organic content of sediment from Dome Creek was highest at the downstream sample site (D3), with much lower organic content found in samples from upper and middle Dome Creek. The organic content of sediment from Minnesota Creek (M1) was relatively consistent among replicate samples.

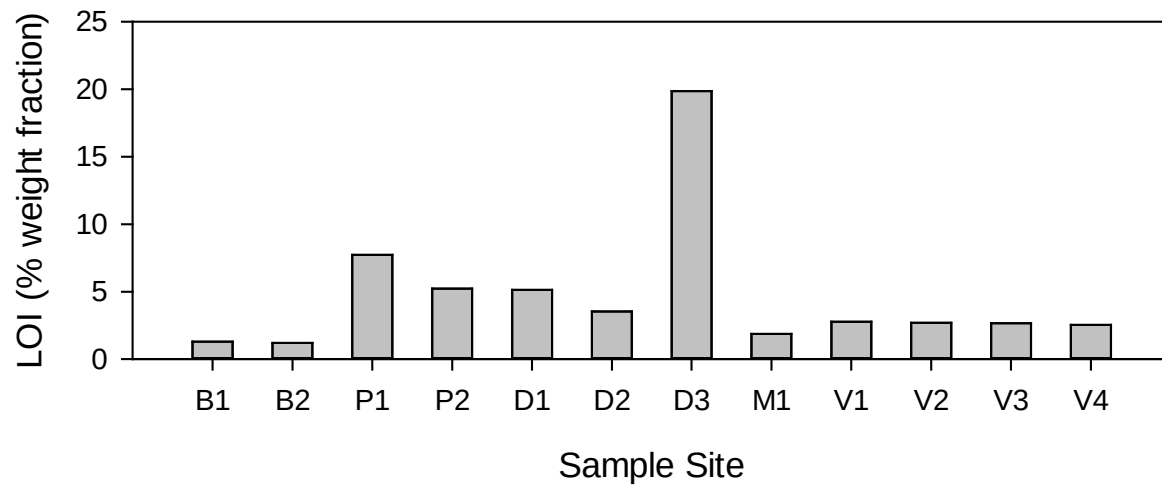


Figure 6.11-4: Summary of Sediment Organic Content (measured by Loss of Ignition) Site Mean Values for Mount Nansen Care and Maintenance Project Area Streams

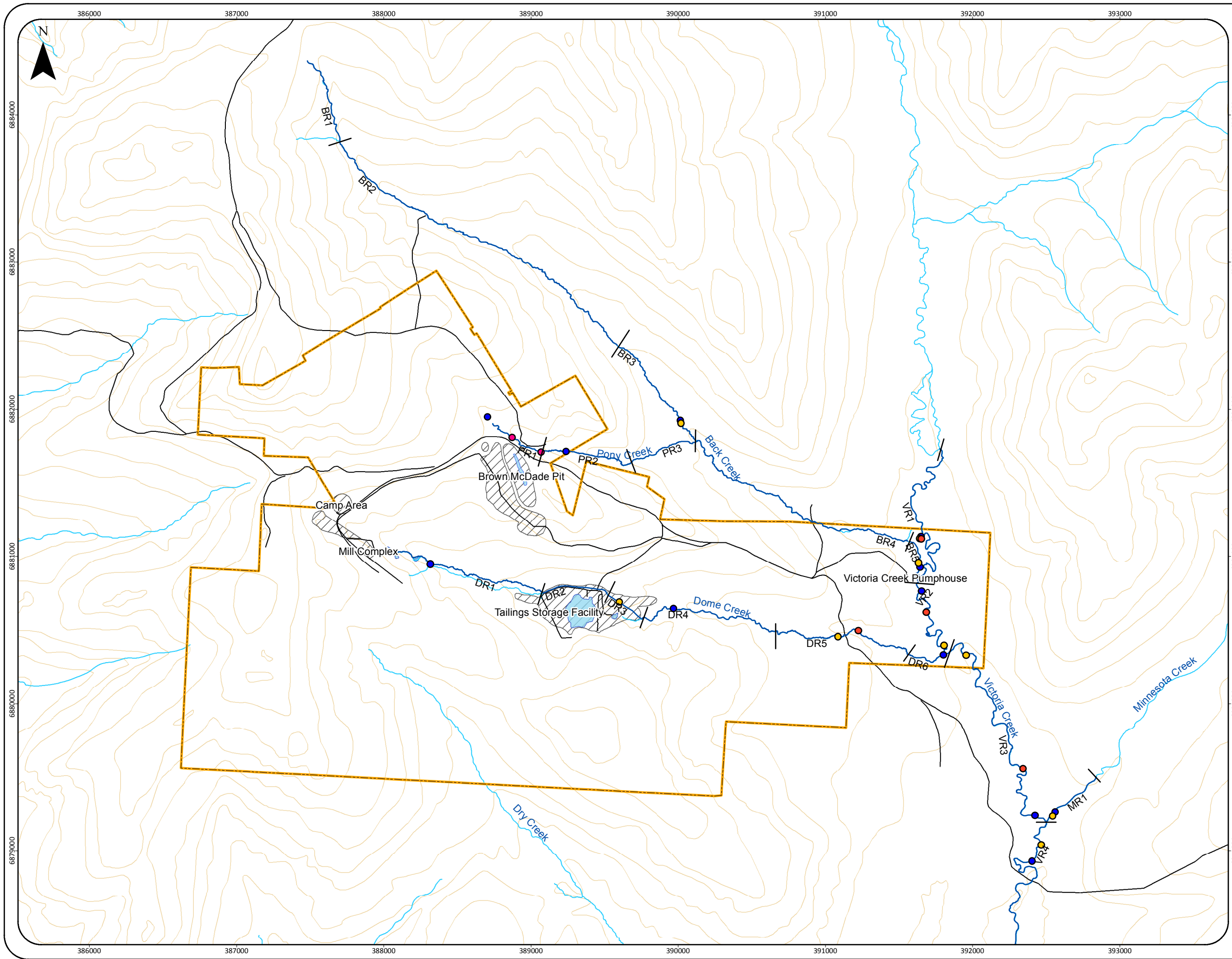
6.11.5 Benthic Macroinvertebrates

Benthic macroinvertebrate sampling was first conducted in the LSA by the Environmental Protection Service, between 1976 and 1977 (Conor Pacific 2000). Additional pre-development baseline studies were completed in 1988 using an artificial substrate sampling methodology (Davigde and Ballantyne 1995). Post development studies were completed in 2007 and 2008 by EDI (EDI 2008, EDI 2009a) using the Canadian Aquatic Biomonitoring Network (CABIN) methods (Reynoldson *et al.* 2003). The most recent benthic macroinvertebrate sampling was completed by ELR in 2013 and 2014 (Appendix 6E) using the Resource Inventory Committee (RIC) Freshwater Biological Sampling Methods (RIC 1997). Among these studies, a total of 25 benthic macroinvertebrate sample sites have been established in the LSA area between 1988 and 2013 (Table 6.11-8 and Figure 6.11-5). Although taxonomic identification of samples has been completed to the species level in nearly all studies, the methods used have varied considerably in terms of study design, sample collection techniques, and analytical measures (Table 6.11-9). The 2013 and 2014 benthic sampling results (Appendix 6E) best represent current conditions at the Site, with a summary provided in the following sections in the context of historical site data.

Table 6.11-8: Summary of Benthic Macroinvertebrate Sampling Locations in the Mount Nansen Area 1988-2013.

Stream	Reach Number and Description	Organization	Sample Site ID	Year Sampled	# of Replicates
Victoria Creek	VR1 - Reference- Upstream of Back Creek	Davidge and Ballantyne	ST-8	1988	3
		EDI	V1	2007	1
		ELR	V1	2013	3
		ELR	V1	2014	1
	VR2 - Downstream of Back Upstream of Dome Creek	Davidge and Ballantyne	ST-9	1988	2
		EDI	V2	2007	1
		ELR	V2	2013	3
		ELR	V2	2014	1
	VR3 - Downstream of Dome Upstream of Minnesota Creek	Davidge and Ballantyne	ST-10	1988	3
		EDI	VC-DDC	2007	1
		ELR	V3	2013	3
		ELR	V3	2014	1
	VR4 - Downstream of Minnesota Creek	Davidge and Ballantyne	ST-12	1988	3
		ELR	V4	2013	3
		ELR	V4	2014	1
Back Creek	BR1 – Upper high gradient reach	-	-	-	-
	BR2 – Mid, moderate gradient reach	-	-	-	-
	BR3 - Upstream of Pony Creek	Davidge and Ballantyne	ST-5	1988	1
		ELR	B1	2013	3
	BR4 - Downstream of Pony Creek	Davidge and Ballantyne	ST-7	1988	1
		ELR	B2	2013	3
	BR3 - Riparian area of Victoria Creek	-	-	-	-
Pony Creek	PR1 - Upstream of adit outlet from Brown McDade Pit	EDI	PC-US	2008	1
		ELR	P1	2013	3
	PR2 - Below adit outlet from Brown McDade Pit	EDI	PC-DS	2008	1
		ELR	P2	2013	3
	PR3 - Stream reaches Back/Victoria Creek floodplain	-	-	-	-
Dome Creek	DR1 - Uppermost reach of Dome Creek extending from the mill to tailings area	ELR	D1	2014	1
	DR2 - Excavated diversion ditch	-	-	-	-
	DR3 - Dome Creek Diversion Channel	Davidge and Ballantyne	ST-2	1988	3
	DR4 - Uppermost channel segment downstream of tailings facility	Davidge and Ballantyne	ST-4	1988	3
		ELR	D2	2013	3
		ELR	D2	2014	1
	DR5 - Wide grass/sedge wetland, includes road crossing	EDI	LDC	2007	1
	DR6 - Riparian area of Victoria Creek	ELR	D3	2014	1
Minnesota Creek	Upstream from Victoria Creek Confluence	Davidge and Ballantyne	ST-11	1988	3
		ELR	M1	2013	3

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MOUNT NANSEN CARE AND MAINTENANCE PROJECT

Figure 6.11-5
Recent and Historical Benthic
Macroinvertebrate Sampling Locations



Benthic Sample Locations

- 1988
- 2007
- 2008
- 2013/2014

Local Boundaries

- Order In Council Area

Base Layers

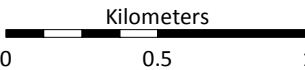
- Roads
- Watercourses
- Topographic Contour (30 m Interval)
- Waterbodies
- Existing Site Infrastructure

Data Source:

- 1.Mount Nansen site features digitized by ELR using spatial data provided YG, Assessment and Abandoned Mines Branch.
- 2.Benthic sample locations compiled from studies conducted at the Mount Nansen Site; refer to Table X.2 in Aquatic Existing Environment for summary.
- 2.Order in Council Boundary provided by YG, Assessment and Abandoned Mines Branch.
- 3.National Topographic Data Base compiled by Natural Resources Canada at a scale of 1:50,000. Reproduced under license from © Her Majesty the Queen in Right of Canada, Department of Natural Resources Canada. All rights reserved.

Datum: NAD 1983 CSRS UTM Zone 8N

Scale 1:25,000



March 5, 2018

Table 6.11-9: Summary of Benthic Macroinvertebrate Sampling Event Methods within the Mount Nansen Care and Maintenance Project LSA

Year Sampled	Organization (Reference)	# of Sample Sites	# of Replicate Samples per Site	Sampling Methods	Metrics ^A
1976	Environmental Protection Service (Conor Pacific 2000)	N/A	N/A	N/A	N/A
1977	Environmental Protection Service (Conor Pacific 2000)	N/A	N/A	N/A	N/A
1988	Environmental Protection Service (Davidge and Ballantyne 1995)	9	3, 2, or 1	Artificial Substrate Sampling Details: Triplicate Samples collected during a 41-day exposure time. 3 baskets established at each sampling location.	Density, order level relative abundance, species diversity, evenness. Analyses focused on the four major orders; Ephemeroptera, Plecoptera, Trichoptera and Diptera.
2007	EDI (EDI 2008)	4	1	Canadian Aquatic Biomonitoring Network (Reynoldson <i>et al.</i> 2003). Details: Sampling area was equal to six bank full widths of the stream. Sampling conducted using a kick-net (363 micron).	Taxa richness, relative abundance, community composition, functional feeding group composition.
2008	EDI (EDI 2009a)	2	1	Canadian Aquatic Biomonitoring Network (Reynoldson <i>et al.</i> 2003). Details: same as above.	Taxa richness, relative abundance, community composition, functional feeding group composition.
2013	ELR (Appendix 6E)	10	3	RIC Freshwater Biological Sampling Methods (RIC 1997) Details: Hess substrate invertebrate sampler. Three replicate samples were collected from riffle areas in each sampling site.	Density, relative abundance, richness, EPT index, diversity, evenness, community composition, and functional feeding group composition.
2014	ELR (Appendix 6E)	7	1	Canadian Aquatic Biomonitoring Network (Reynoldson <i>et al.</i> 2003). Details: Sampling area was equal to six bank full widths of the stream. Sampling conducted using a kick-net (363 micron).	Density, relative abundance, richness, EPT index, diversity, evenness, community composition, and functional feeding group composition.

Notes: ^AAll taxonomic identification was completed to the species level

6.11.5.1 Victoria Creek

Benthic macroinvertebrate sampling was completed at four sample sites in Victoria Creek in both 2013 and 2014 (V1, V2, V3, and V4; Appendix 6E) (Figure 6.11-5). Prior sampling of Victoria Creek had been conducted in 1988 (Davidge and Ballantyne 1995), and in 2007 (EDI 2008) (Table 6.11-8).

Benthic macroinvertebrate densities (2013) in Victoria Creek were highest at the upstream reference site (mean density of 2,097 organisms/m²) and downstream of Minnesota Creek (mean density of 2,287 organisms/m²). Lower densities were observed at sample sites downstream of Dome Creek (mean of 643 organisms/m²) and downstream of Back Creek (mean of 1,461 organisms/m²) (Table 6.11-10). 2014 kick sample results followed a similar trend, except that the highest abundance was observed downstream of Back Creek, where the lowest density had been observed the year prior (Table 6.11-10).

Ephemeroptera, Plecoptera, and Trichoptera (EPT) indices were generally found to be higher between 2013 and 2014 samples, but similar between Victoria Creek sites within each year. Species richness in samples collected in Victoria Creek were amongst the highest in the LSA (Table 6.11-10), with the lowest amongst Victoria Creek sites downstream of Back Creek (Site V3) in both years. Species evenness was lowest at the upstream reference site (V1) and downstream of Minnesota Creek (V4) and higher at sample sites V3 and V2.

The earliest benthic studies completed in 1988 identified Plecopterans, specifically *Podmosta* sp., as the dominant order at each sample site. 1995 baseline studies also showed that Victoria Creek samples were sub-dominated by species from the order Ephemeroptera, representing approximately 20% of each Victoria Creek sample (Higgs 1994). By 2006, Diptera (primarily the family Chironomidae) had replaced Ephemeroptera and/or Plecoptera as the dominant order in all Victoria Creek sampling locations. This finding is consistent with the 2013 studies in which Ephemeroptera, Plectotera and Diptera currently represent a mean of 10.93%, 17.45% and 48.10% of the benthic community composition across all Victoria Creek sites.

Table 6.11-10: Summary of Benthic Macroinvertebrate Indices for Samples Collected from the Mount Nansen LSA in 2013.

Sample Site ID	Sample Location	Year	Invertebrate Abundance	Invertebrate Density (#/m ²)	Mean Invertebrate Indices			
					Species Richness (#spp.)	EPT Index (#spp.)	Simpson's Diversity	Simpson's Evenness
V1	Victoria Creek – Reference Site	2013		2,097	20	8	0.82	0.34
		2014	3,871		32	15	0.84	0.20
V2	Victoria Creek Downstream Back Creek	2013		1,461	22	10	0.89	0.45
		2014	2,151		33	17	.82	0.17
V3	Victoria Creek Upstream Minnesota Creek	2013		643	17	9	0.91	0.71
		2014	5,586		29	15	0.79	0.16
V4	Victoria Creek Downstream Minnesota Creek	2013		2,287	21	9	0.80	0.26
		2014	4,030		32	17	0.87	0.24
D1	Upper Dome Creek	2014	654		30	6	0.88	0.28
D2	Middle Dome Creek	2013		1,760	18	1	0.75	0.23
		2014	1,561		38	8	0.88	0.22
D3	Lower Dome Creek	2014	13,940		14	5	0.17	0.09
B1	Upper Back Creek	2013		4,461	16	5	0.63	0.18
B2	Lower Back Creek	2013		1,969	15	5	0.68	0.21
P1	Upper Pony Creek	2013		14,826	22	3	0.85	0.34
P2	Lower Pony Creek	2013		3,267	20	4	0.68	0.16
M1	Minnesota Creek	2013		872	15	2	0.85	0.44

Note: 2013 sampling was conducted in triplicate using Hess sampler. 2014 sampling was conducted using CABIN kick protocol.
Mean indices are calculated from three replicate samples at each site.
Densities are provided for Hess samples (2013), whereas total abundance is provided for kick net samples (2014)

6.11.5.2 Dome Creek

Benthic invertebrate sampling was completed at one site in 2013 (D2, middle Dome Creek), and at three sites in 2014 (upper, middle, and lower Dome Creek; Appendix 6E). Prior benthic sampling of upper and middle Dome Creek had been conducted in 1988 (Davidge and Ballantyne 1995), and lower Dome Creek was sampled in 2007 (EDI 2008), respectively (Table 6.11-8).

The density of benthic invertebrates at middle Dome Creek in 2013 was 1,760 organisms/m², and 2014 abundances ranged from 654 (upper Dome Creek) to 13,940 (lower Dome Creek). Although middle Dome Creek abundances/densities were similar to those of Victoria Creek, abundances for upper and lower were the highest observed in the Study. Species richness in middle Dome Creek were found to be higher than in Back and Pony Creeks. The lowest EPT index value recorded in the study was at middle Dome Creek in 2013, with only one species of EPT found in each of the three replicate samples. Lower Dome Creek had lowest recorded species richness, Simpson's diversity, and Simpson's Evenness of all samples collected.

Baseline benthic invertebrate sampling (1988) found that Dome Creek invertebrate communities were heavily dominated by Plecoptera, comprising 92.7% of the community composition (Davidge and Ballantyne 1995). Results from sampling in 1997 and 2000 showed that Diptera became the dominant order, comprising 71% and 87%, respectively (Environment Canada 2008). By 2007, Plecoptera was again the dominant invertebrate order (64%) and Diptera the subdominant order (27%) in Dome Creek (EDI 2008). The most recent study shows the abundance of Dipterans was highly elevated on middle Dome Creek (91.6%), with Plecopterans representing only a small percentage of the community (1.54%) (Appendix 6E). These characteristics suggest simpler, impaired stream environments where pollution tolerant taxa (e.g., Diptera) can dominate, with reduced proportions of heavy-metal sensitive feeding groups (scrapers and predators).

6.11.5.3 Back Creek

Benthic invertebrate sampling was completed at two sample sites in Back Creek; B1 and B2 (Appendix 6E). Prior sampling of Back Creek had been conducted in 1988 (Davidge and Ballantyne 1995) (Table 6.11-8).

Benthic macroinvertebrate densities were highest at upstream Back Creek (mean density of 4,461 organisms/m²), and lower at downstream Back Creek (mean of 1,969 organisms/m²; Table 6.11-10). No major differences were evident in species richness between Back Creek sites, but both species diversity and evenness values in Back Creek were higher at the downstream location (B2) compared to the upstream sample site (B1; Table 6.11-10).

The earliest benthic study completed on Back Creek identified Plecoptera and Diptera as the two most abundant orders present at both upstream and downstream sample sites (Davidge and Ballantyne 1995). The 1988 results show slightly elevated proportions of Plecoptera at the upstream location (ST-5; 38.4%, ST-7; 25%) and reduced proportions of Dipterans at the downstream site (ST-5; 30.7%, ST-7; 43.7%). The most recent benthic invertebrate results show significant changes in the dominant taxa in Back Creek; particularly at the upper Back Creek sample site (B1; Appendix 6E). Significantly lower proportions of Plecopterans were observed at the upper Back Creek sample site (B1; mean of 1.88%), compared to those found at the downstream location (B2; mean value of 71.13%). Differences were also observed in the abundance of Diptera in Back Creek samples, with notably lower values observed at the downstream sample site (B1; 87.91%, B2; 15.94%).

6.11.5.4 Pony Creek

Benthic invertebrate sampling was completed in upper and middle Pony Creek sample sites in 2013 (Appendix 6E). Prior sampling of Pony Creek was conducted in 2008 in the same areas (EDI 2009a; Table 6.11-8).

The density of benthic macroinvertebrates in Pony Creek was significantly higher upstream (Site P1; mean density of 14,826 organisms/m²) compared to middle Pony Creek (Site P2; mean of 3,267 organisms/m²) (Appendix 6E). Species diversity and species evenness in Pony Creek were also higher at the upstream site compared to those observed at the midstream site (Table 6.11-10). Both species richness and EPT index values were similar between both sites.

Diptera were the dominant Order in all Pony Creek samples, comprising 94.8% of the community in upper Pony Creek, and 78.11% in middle Pony Creek (Appendix 6E). The subdominant Order was Plecoptera, which made up 13.81 and 1.78 % of the community at the upper and midstream sites. Diptera were also the dominant Order in the 2008 studies at both upper and middle Pony Creek sample sites, comprising 63.9% and 50% of the community, respectively (EDI 2009a). Plecoptera were the next most abundant Order in 2008, comprising 36.1 and 43.4% of the upstream and midstream sites, respectively. Ephemeroptera were absent from all samples taken at both upstream and downstream locations, and Trichoptera were present in low numbers at only the downstream location (6.6%). These characteristics suggest simpler, impaired stream environments where pollution tolerant taxa (e.g., Diptera) can dominate, with reduced proportions of heavy-metal sensitive feeding groups (scrapers and predators).

6.11.5.5 Minnesota Creek

Benthic invertebrate sampling was completed at a single sample site in Minnesota Creek; M1 (Appendix 6E). Prior sampling of Minnesota Creek had been conducted in 1988 (Davidge and Ballantyne 1995; Table 6.11-8).

The mean density of benthic invertebrates from Minnesota Creek was 872 organisms/m² (Appendix 6E). Benthic densities found in Minnesota Creek were relatively low compared to the other sites sampled. Species richness in Minnesota Creek is relatively low compared to the other sites (mean value of 15 species; Table 6.11-10). Mean EPT index values were also low on Minnesota Creek, with a mean value of only 2 species. Species diversity and evenness from samples collected in Minnesota Creek were higher in relation to those found in the other smaller streams, and more consistent with values found on the Victoria Creek system.

Early studies of Minnesota Creek show Plecoptera as the dominant order, comprising 48.3% of the community composition (Davidge and Ballantyne 1995). The 1988 results (Davidge and Ballantyne 1995) also show Ephemeroptera comprising a significant proportion of Minnesota Creek samples (20.4%).

More recent sampling of Minnesota Creek suggests a shift in community composition with invertebrates from the order Ephemeroptera absent from all replicate samples, and Plecopterans comprising a mean value of only 28.08% of the total community composition (Appendix 6E). Proportions of Diptera also have

increased in comparison to previous results. Dipteran comprised 25.2% of samples collected in 1988 (Davidge and Ballantyne 1995), which has increased to a mean value of 53.2% of samples collected in 2013 (Appendix 6E).

6.11.6 Periphyton

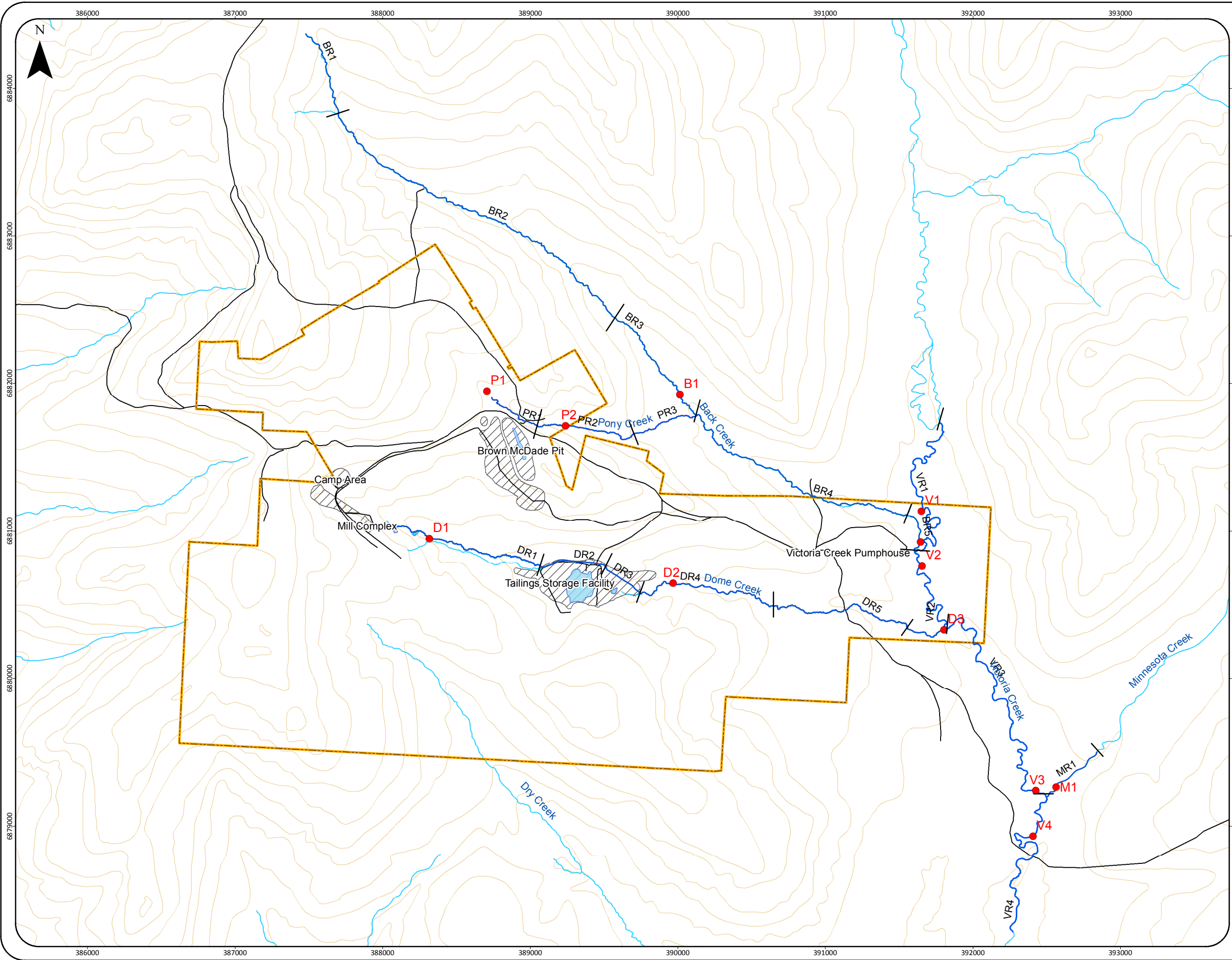
Periphyton communities were characterized through samples collected from 10 sample sites within the LSA, in Back, Dome, Pony, Victoria, and Minnesota Creeks (Table 6.11-11; Figure 6.11-6; Appendix 6E). All periphyton samples were analysed for both biomass (chlorophyll-*a*, chlorophyll-*b*, and phaeophytin-*a*) and taxonomic assemblage. Identification of periphyton species was completed to the lowest possible taxonomic level.

Samples were compared using various community measures, including: cell density, Simpson's Diversity Index, Simpson's Evenness, taxonomic richness, and taxonomic composition.

Table 6.11-11: Summary of Locations Sampled for Periphyton in 2013 and 2014

Stream	Sampling Location	Year Sampled	Sample Site ID	Type of Composite Sample
Victoria Creek	Victoria Creek Reference- Upstream of Back Creek	2013	V1	In-situ rocks
		2014		Artificial substrate
	Downstream of Back, Upstream of Dome Creek	2013	V2	In-situ rocks
		2014		Artificial substrate
	Downstream of Dome Upstream of Minnesota Creek	2013	V3	In-situ rocks
		2014		Artificial substrate
	Downstream of Minnesota Creek	2013	V4	In-situ rocks
		2014		Artificial substrate
Back Creek	Upper Back Creek (Upstream of Pony Creek)	2013	B1	In-situ rocks
	Lower Back Creek (Downstream of Pony Creek)	2013	B2	In-situ rocks
Pony Creek	Upper Pony Creek (Upstream of Brown McDade)	2013	P1	In-situ rocks
	Middle Pony Creek (Downstream of Brown McDade, Upstream Pony Fork)	2013	P2	In-situ rocks
Dome Creek	Upper Dome Creek (Upstream of Tailings Pond Confluence)	2014	D1	Artificial substrate
	Middle Dome Creek (Upstream of roadway crossing, Downstream of Tailings pond confluence)	2013	D2	In-situ rocks
		2014		Artificial substrate
	Lower Dome Creek (Downstream of roadway crossing)	2014	D3	Artificial substrate
Minnesota Creek	Upstream from Victoria Creek Confluence	2013	M1	In-situ rocks

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MOUNT NANSEN CARE AND MAINTENANCE PROJECT

Figure 6.11-6
Location of Recent and Historical
Periphyton Sampling Locations



● Periphyton Sample Locations

Local Boundaries

Order In Council

Base Layers

Roads

Watercourses

Waterbodies

Existing Site Infrastructure

Topographic Contour (30 m Interval)

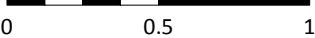
Data Source:

1. Mount Nansen site features digitized by ELR using spatial data provided YG, Assessment and Abandoned Mines Branch.
2. Periphyton data collected and digitized by ELR.
2. Order in Council Boundary provided by YG, Assessment and Abandoned Mines Branch.
3. National Topographic Data Base compiled by Natural Resources Canada at a scale of 1:50,000. Reproduced under license from © Her Majesty the Queen in Right of Canada, Department of Natural Resources Canada. All rights reserved.

Datum: NAD 1983 CSRS UTM Zone 8N

Scale 1:25,000

Kilometers



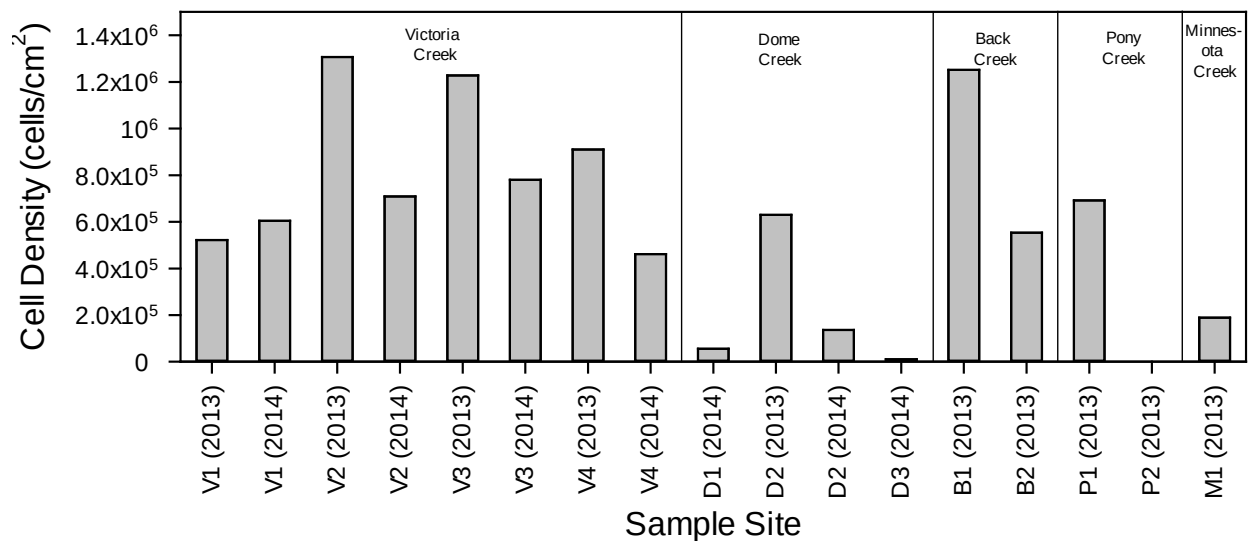
March 5, 2018

6.11.6.1 Productivity and Density

6.11.6.1.1 Victoria Creek

Periphyton cell densities in Victoria Creek were lowest at the upstream reference site in 2013 (V1; 522,183 cells/cm²) and at the furthest downstream site in 2014 (V4; 461,923 cells/cm²). The remaining two Victoria Creek sites (V2 and V3) yielded some of the highest cell densities in the study (1,306,636 and 1,227,788 cells/cm² in 2013, respectively).

Chlorophyll-*a* concentrations on Victoria Creek ranged from 0.94 mg/m² (site V3 in 2013) to 9.40 mg/m² (site V2 in 2014) (Figure 6.11-7). No apparent patterns were observed between upstream and downstream sample sites. Chlorophyll-*b* and phaeophytin-*a* concentrations were below detection limits in all 2013 samples collected from Victoria Creek, and in all 2014 samples with the exception of Site V1.



Note: The cell density value of P2 is too low to be shown graphically.

Figure 6.11-7: Comparison of Periphyton Cell Density Across all Stream Sites in the Mount Nansen Care and Maintenance Project Area.

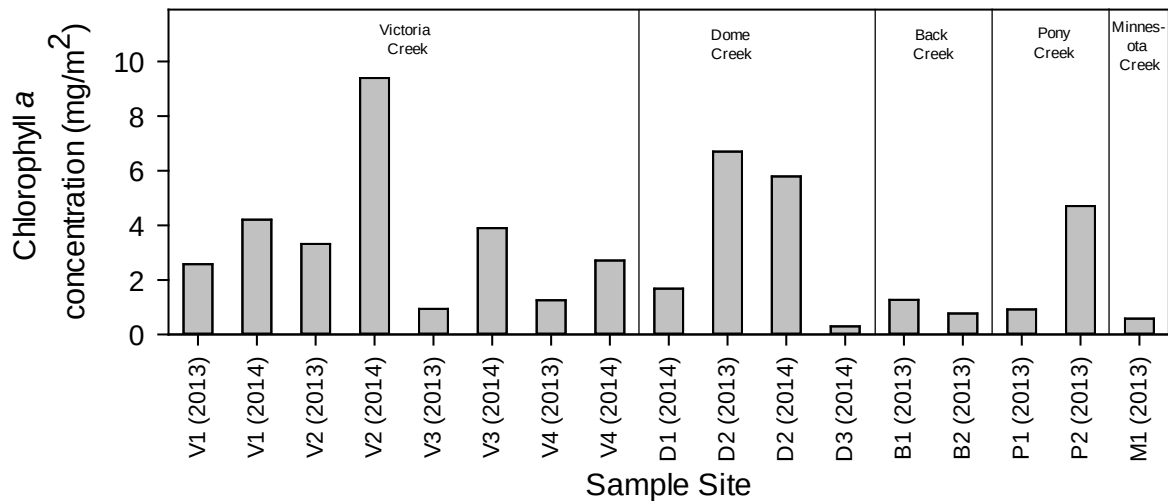


Figure 6.11-8: Comparison of Chlorophyll Levels Across all Stream Sites in the Mount Nansen Care and Maintenance Project Area.

6.11.6.1.2 Dome Creek

Periphyton cell densities in upper and lower Dome Creek were relatively low in comparison to the other sites sampled, but consistently high in middle Dome Creek. Accordingly, samples from middle Dome Creek also had relatively high measures of productivity (concentrations of chlorophyll-*a*; 6.7 and 5.79 mg/m² in 2013 and 2014, respectively). Chlorophyll-*b* was detected only at middle Dome Creek, and only in 2013. The sample from lower Dome Creek had the second lowest cell density (11,026 cells/cm²) and lowest productivity (<0.30 mg/m² of chlorophyll-*a*) recorded of any stream at the Site.

6.11.6.1.3 Back Creek

Periphyton cell densities in Back Creek were notably higher at the upstream sample site (B1; 1,251,538 cells/cm²) when compared to the downstream location (B2; 553,148 cells/cm²).

A slight decrease in chlorophyll-*a* concentrations was also observed from upstream to downstream Back Creek (1.27 mg/m² at B1 compared to 0.77 mg/m² at B2). Chlorophyll-*b* and phaeophytin-*a* concentrations were below detection limits in all samples collected from Back Creek.

6.11.6.1.4 Pony Creek

Periphyton cell densities in middle Pony Creek were the lowest of any site sampled (P2; 3,074 cells/m²), while densities in the upstream location were greater (P1; 692,092 cells/cm²).

Middle Pony Creek also had the third highest concentration of chlorophyll-*a* in comparison to all other sites (4.71 mg/m² at P2), in contrast to the upstream sample locations (0.92 mg/m² at P1). Chlorophyll-*b* and phaeophytin-*a* concentrations were detected in relatively low levels at both upstream and downstream Pony Creek sample site.

6.11.6.1.5 Minnesota Creek

Periphyton cell densities in Minnesota Creek were relatively low in comparison to the other sites sampled, with observed counts of 188,792 cells/cm²). Chlorophyll-*a* levels in Minnesota Creek were the second lowest of all samples, with observed concentrations of only 0.58 mg/m²). Chlorophyll-*b* and phaeophytin-*a* concentrations were below detectable limits in all samples collected from Minnesota Creek.

6.11.6.2 Community Composition

6.11.6.2.1 Victoria Creek

Periphyton taxonomic composition in Victoria Creek was consistent throughout samples sites. Victoria Creek sediments were dominated by species from the phylum cyanophyta (blue-green algae), primarily *Chamaesiphon* spp. and *Homoeothrix janthina* (Appendix 6E). Higher proportions of diatoms were identified in samples from the upstream sites.

6.11.6.2.2 Dome Creek

Periphyton taxonomic composition in Dome Creek is notably different compared to the other Site area streams. Although Dome Creek samples were similarly dominated by blue-green algae, proportions were significantly reduced, while diatoms were more common. The relative abundance of *A. minutissima* (heavy metal tolerant diatom species) was highest in lower Dome Creek but also present in the other Dome Creek sites.

6.11.6.2.3 Back Creek

Back Creek samples were heavily dominated by blue-green algae, primarily *Chamaesiphon* spp. (94% at both sites) (Appendix 6E). All other taxa groups were identified in relatively low abundance, with diatoms identified as the sub-dominant group at both Back Creek sample sites. No major differences were observed between upstream and downstream locations.

6.11.6.2.4 Pony Creek

The periphyton taxonomic compositions of upper and middle Pony Creek were notably different from each other, with samples from upper Pony Creek being heavily dominated by blue-green algae and those from middle Pony Creek with both blue-green algae and diatoms. All other taxa groups were identified in relatively low abundance, with no other major differences between upstream and downstream locations. *A. minutissima* (heavy metal tolerant diatom species) was only detected at the middle Pony Creek site.

6.11.6.2.5 Minnesota Creek

Minnesota Creek periphyton was dominated by blue-green algae, with red algae (Rhodophyta) as the sub-dominant phylum (Appendix 6E). All other taxa groups were identified in relatively low abundance.

6.11.7 Scope and Extent of Fish Baseline Studies

The most recent characterization of fish and fish habitat within the LSA was conducted in 2013 (Appendix 6E). This program included the inventory of stream habitat characteristics at 12 sites on Victoria, Dome, Back, Pony, and Minnesota Creeks. The results of several earlier assessment of fish and fish habitat within the LSA and RSA are also summarized, most notably assessments of Dome, Back, and Pony Creeks completed by EDI in 2008 and 2009 (EDI 2009b and EDI 2009c, respectively). Table 6.11-12 provides a summary of existing data sources. These studies have relied primarily on assessing stream habitat characteristics according to the Reconnaissance (1:20,000) Fish and Fish Habitat Assessment Inventory: Standards and Procedures (RIC 2001).

Table 6.11-12: Information and data sources used to describe fish and fish habitat in the Mount Nansen Site.

Valued Component	Survey or Data
Field studies and investigations	- Recent baseline studies (2012-2013); Appendix 6E; - Victoria Creek fish overwintering study (EDI 2012b); - Fish and fish habitat assessment of in Back and Pony Creeks near the Mt. Nansen Mine Site (EDI 2009a); - Dome Creek fish and fish habitat assessment (EDI 2009b); - EDI terrestrial and aquatics effects study (EDI 2007); - Norecol environmental update report for the Mount Nansen Gold Project (Norecol 1989); and - Fish distribution survey of Victoria, Dome, and Nansen Creeks, Yukon Territory (Osbourne 1995).
Databases and Desktop Resources	- Yukon Placer Atlas; and - DFO FISS Database.

6.11.8 Distribution and Characteristics of Fish Habitats

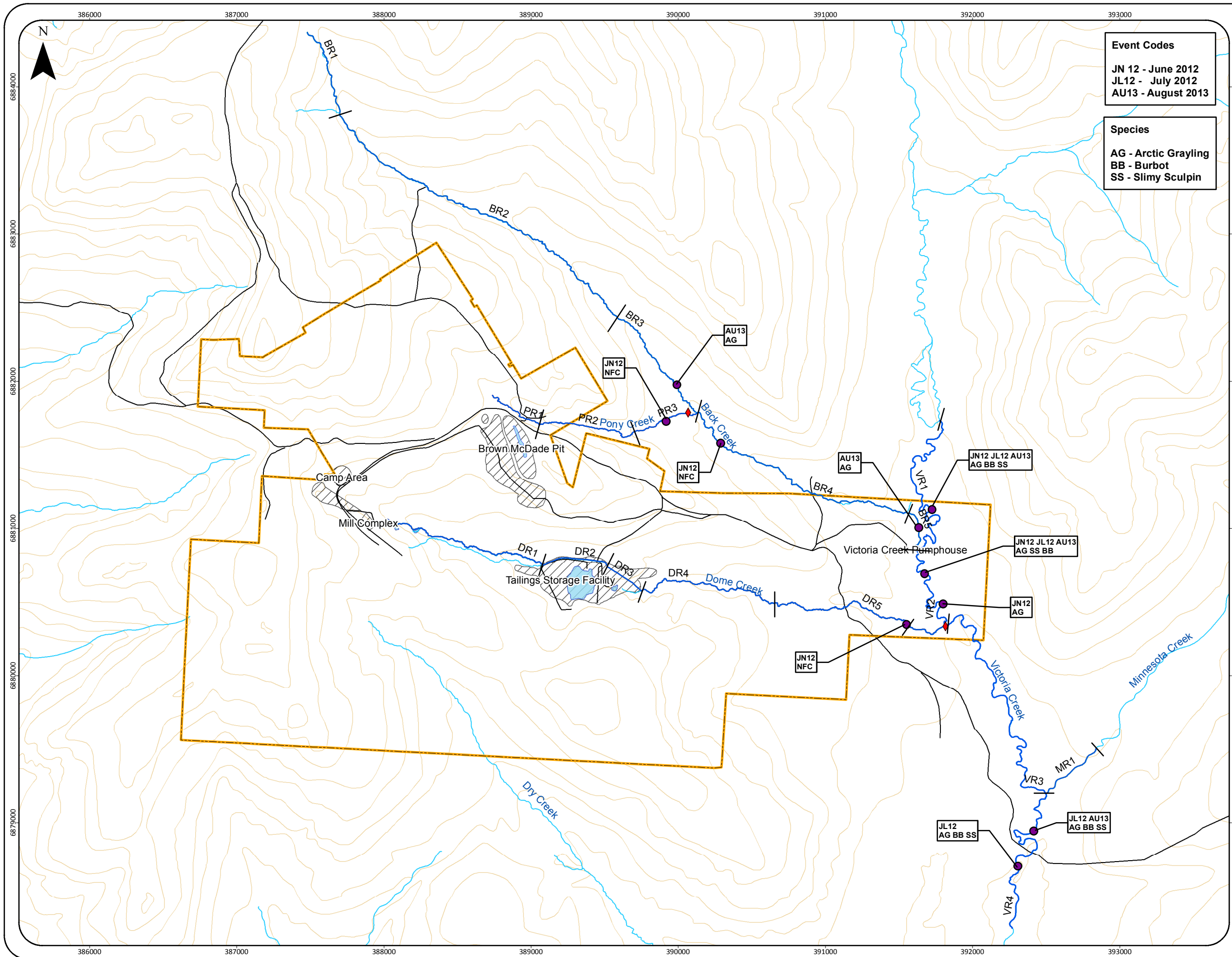
For the purpose of describing stream habitat characteristics across several different studies, the watercourses within the LSA and RSA were subdivided into a series of reaches based on stream confluences and distinct changes in stream morphology and gradient (Figure 6.11-9). A summary of stream habitat characteristics according to stream is provided in Table 6.11-13, and descriptions of the habitat characteristics of each watercourse are provided in the following sections.

Table 6.11-13: Summary of Reach Information for Streams within the Mount Nanson Remediation Project LSA

Stream	Reach	Reach Length (m)	Morphology ^A	Mean Channel Width (m)	Mean Wetted Width (m)	Residual Pool Depth (m)	Mean Bankfull Depth (m)	Gradient (%)	Dominant/Subdominant Substrate	Instream Cover %	Dominant Cover Types ^B	Fish ^C Present	Characteristics
Victoria Creek	VR1	1860	RP _c	4.95	3.6	0.64	0.64	0.5-3.5	Cobble/Gravel	7	OV, SWD, LWD	AG, BB, SS	Upstream reference area, not under influence from the Site. Irregularly meandering channel with large pools. Mature conifer and tall shrub riparian vegetation.
	VR2	1050		6.5	4.04	0.49	0.89	2.5	Cobble/Gravel	15	OV, UC, DP, LWD		Channel segment downstream of Back Creek. Channel similar to reach VR1 with deep pools, and sporadic functional large woody debris from mature conifer forest.
	VR3	2100		6.45	5.02	0.73	0.63	1.5 - 2	Cobble/Gravel	6	OV, LWD, DP		Channel segment downstream of Dome Creek. Channel similar to reach VR2, but slightly less frequently meandering. Canopy cover reduced due to a shift from mature conifer to mature tall shrub. Pools become slightly larger and deeper compared to reaches further upstream.
	VR4	1600		6.5	4.65	0.85	0.71	0.5 - 2	Cobbles/Gravel	8	DP, OV, UC, LWD		Channel segment downstream of Minnesota Creek, extending downstream of the public road crossing to the southern extent of the LSA. Water slightly more turbid in this reach (influence from Minnesota Creek. Large, deep pools, and comparatively more mature conifer riparian vegetation.
Dome Creek	DR1	1210	RP-Run	1.4	0.5	0.28	0.39	-	Fines	90	OV	Not Fish-Bearing	Uppermost reach of Dome Creek extending from the mill to tailings area. Shallow channel based in shrub vegetation, becoming undefined or split in numerous areas.
	DR2	470	Run	-	-	-	-	-	Sand		-		Excavated diversion ditch around tailings facility with sand substrate.
	DR3	280	RC _B	-	-	-	-	-	Boulder, Cobble	0	-		Constructed diversion channel with steeper gradient to rejoin Dome Creek with original channel alignment.
	DR4	1120	RP _c	1.2	0.725	0.21	0.36	1.5 - 6	Sand	50	OV		Uppermost channel segment downstream of tailings facility. Cobble dominated channel meanders irregularly through shrub riparian vegetation. Banks initially sloped but becoming steeper towards the downstream extent of the reach.
	DR5	1140	Riffle/Run	0.475 ^D	0.475 ^D	0.13 ^D	0.57 ^D	1 – 2 ^D	Fines	-	-		Channel gradient is reduced into a wide grass/sedge wetland. Substrate dominated by fines, with a narrow, sometimes undefined channel through wetland vegetation. Public road crossing within reach.
	DR6	290	Riffle/Run	1.3	0.83	0.33	0.41	3.5	Boulder/Cobbles	47	OV		Channel gradient increased slightly as stream re-enters riparian area of Victoria Creek. Riparian area transitions to tall shrub and conifer. Channel remains narrow with substrate dominated by fines. Cascade present at outlet into Victoria Creek.
Pony Creek	PR1	920	RP _G	0.78	0.42	0.19	0.31	4-5	Gravel/Fines	65	OV, LWD, SWD	Not Fish-Bearing	Uppermost reach of Pony Creek. Channel very narrow and at times undefined. Heavy riparian shrub cover. Gradient and pool depth/frequency variable as the stream follows local topography. Road crossing at this reach.
	PR2	1850	RP _c	2.01	0.74	0.2	0.24	6 - 6.5	Cobbles/Gravel	75	OV, UC		Channel gradient increased in this reach, below adit outlet from Brown McDade Pit. Cobble and gravel-based channel with riparian vegetation. Irregularly meandering channel has small, infrequent pools.
	PR3	310	RP _F	-	-	-	-	-	Fines/Cobble	-	-		Gradient is reduced in this reach as stream reaches the Back/Victoria Creek floodplain. Riparian vegetation consists of short to tall shrubs, and the channel is dominated by fines and sand. Channel braids and becomes undefined at times. Cascade present at the outlet into Back Creek.
Back Creek	BR1	450	RP _c	2.75	1.44	0.09	0.43	2.25 - 6	Cobbles/Gravel	3	OV, UC	AG, SS	Reach of Back Creek extending from lower extent of active placer activity to inlet of Back Creek. Reach is in an area of past placer mining activity. Low cover, and channel shows signs of high activity (bed load movement and channel bed level drops). Many eroding banks due to lack of riparian vegetation.
	BR2	720	RP _c	-	-	-	-	-	Gravel/Sand	-	-		Similar to reach BR1 upstream, but downstream of Pony Creek. Extends through an area of past placer mining operation, then through a riparian wetland closer to Victoria Creek. Extensive bed load movement and deposition throughout, particularly at downstream wetland area. Riparian vegetation mostly limited to shrubs.
	BR3	500	RP _c	1.6	1.1	0.16	0.43	2.25 - 3	Gravel/Sand	41	OV, UC, SWD, LWD		Short reach where Back Creek enters riparian area of Victoria Creek. Riparian vegetation transitions to tall shrub and conifer, with abundant small woody debris and organic input (leaves). Heavy cover through this area in the form of small woody debris and undercut banks.
Minnesota Creek	MR1	490	RP _c	3.13	2.28	0.22	0.34	2.5 - 3	Cobble	27	OV, SWD, LWD	None Captured	Lowermost reach of Minnesota Creek, upstream from Victoria Creek. Moderate gradient with coarse cobble substrate and irregularly spaced pools. Riparian vegetation primarily limited to tall shrub.

Notes: ^A General Morph. Characteristics are described using RIC 2001, acronyms are as follows; RP=Riffle-Pool, C=Cascade, CP=Cascade Pool, SP=Step Pool, and LC=Large Channel
^B Dominate cover types are as follows: DP=deep pools; OV=overstream vegetation; IN=instream vegetation; UC=Undercut; LWD=large woody debris; SWD=small woody debris; B=boulder
^C Fish species include: AG=Arctic Grayling; BB=Burbot; SS=Slimy Sculpin
^D Data was obtained from EDI Fish and Fish Habitat Assessment5 (EDI 2009)
“-“ indicates no assessment was completed or no data available

Document Path: M:\Projects\16-249 JN CHPP\Map_Files\Chap6_EEA\aquatic\2018 03 04 Figure 6.11-9 reach boundaries and fish catch summaries.mxd



Event Codes
JN 12 - June 2012
JL12 - July 2012
AU13 - August 2013

Species
AG - Arctic Grayling
BB - Burbot
SS - Slimy Sculpin

MOUNT NANSEN CARE AND MAINTENANCE PROJECT
Figure 6.11-9
Fish Catch Summaries

Barrier to Fish Passage

Fisheries Sample Sites

Local Boundaries
 Order In Council

Base Layers
 Roads
 Watercourses
 Topographic Contour (30 m Interval)
 Waterbodies
 Existing Site Infrastructure

Data Source:
1.Mount Nansen site features digitized by ELR using spatial data provided YG, Assessment and Abandoned Mines Branch.
2.Fisheries study reaches and data collected and digitized by ELR.
2.Order in Council Boundary provided by YG, Assessment and Abandoned Mines Branch.
3.National Topographic Data Base compiled by Natural Resources Canada at a scale of 1:50,000. Reproduced under license from © Her Majesty the Queen in Right of Canada, Department of Natural Resources Canada. All rights reserved.

Datum: NAD 1983 CSRS UTM Zone 8N
Scale 1:25,000

March 5, 2018

6.11.8.1 Victoria Creek

Victoria Creek is a tributary stream to the Nisling River, a medium-sized river in the Donjek/White Rivers drainage basin. Victoria Creek is the largest stream located in the LSA, and receives inputs from Back, Dome, Pony, and Minnesota Creeks within the LSA. Victoria Creek flows 6.6 km through the LSA, with the Site occurring within the lower reaches of the watercourse. Within the LSA, Victoria Creek is a third order stream. The broad level habitat characteristics of Victoria Creek are relatively consistent throughout the LSA despite its confluence with three lower order tributaries within this area. In the LSA (across all reaches studied), Victoria Creek meanders irregularly within a broader floodplain, and has a riffle-pool morphology with cobble and sand substrates that have resulted in the formation of frequent, large, deep pools. The watercourse has variable mature conifer and tall shrub riparian vegetation along its banks and has a moderate amount of cover in the form of deep pools, large woody debris, and undercut banks.

The furthest upstream reach delineated on Victoria Creek was an upstream section, VR1 (Table 6.11-13), occurring upstream of the Back Creek confluence and, therefore, under influence from the Site. In this reach, Victoria Creek has channel widths and wetted widths ranging from 3.9 to 5.7 m and 2.8 to 4.3 m, respectively. Pools occur frequently within this reach, with residual pool depth ranging from 0.3 to 1.0 m. The measured gradient upstream from the Back Creek confluence was as high as 3.5 %, with channel substrate sizes slightly larger than downstream sites.

Downstream of the Back Creek confluence, reach VR2 (Table 6.11-13) extends approximately 1 km downstream to the confluence with Dome Creek. Victoria Creek in this reach remains generally consistent in habitat, but with a higher occurrence of functional large woody debris from a more dense mature conifer riparian forest. Victoria Creek is also slightly wider in this reach than at VR1, with channel and wetted widths ranging from 4.6 to 9.3 m and 2.5 to 6.2 m, respectively. Although large pools remain frequent in this reach, residual pool depth was reduced slightly from VR1, ranging from 0.2 to 1.0 m. The gradient in this reach was slightly reduced, having a measured maximum of 2.5 %.

Downstream of Dome Creek, reach VR3 (Table 6.11-13) extends 2.1 km downstream to the confluence of Minnesota Creek. In this reach, Victoria Creek was also quite similar in morphology and habitat to the upstream sites, although stream meandering is slightly less frequent. A shift from mature conifer to mature tall shrub riparian vegetation also occurs, resulting in a reduction of canopy cover. Channel widths and wetted widths remained consistent, with values ranging from 5.2 to 9.1 m and from 3.6 to 6.6 m, respectively. Pools remain frequent and become slightly deeper than upstream sites, with residual pool depth ranging from 0.5 m to 1.1 m, respectively. The gradient in this reach continued the lowering trend from upstream, with a measured maximum of 2.0 %.

Downstream of Minnesota Creek, reach VR4 (Table 6.11-13) extends 1.6 km downstream, crossing the Mount Nansen Public Road to the southern extent of the LSA. In this reach, Victoria Creek becomes slightly more turbid, resulting from the influence from Minnesota Creek. In this reach, riparian cover also shifts back to comparatively more mature conifer vegetation. Stream habitat and morphology remain generally consistent with VR3, with pools of a similar size and frequency (residual pool depth ranging from 0.5 m to 1.3 m, respectively). Channel widths and wetted widths also remained consistent to VR3, with values

ranging from 4.8 to 9.7 m and from 3.8 to 5.2 m, respectively. The gradient in this reach was similar to VR3, having a measured maximum of 2.0 %.

6.11.8.2 Dome Creek

Dome Creek originates within the LSA, northwest of the mill complex, and flows southeast for approximately 4.5 km before entering the Victoria Creek system. Dome Creek is a first order stream and has experienced significant alterations from mining development of the Mount Nansen site. Approximately 1.2 km from the headwaters, Dome Creek enters an excavated diversion ditch that re-directs the stream to a constructed diversion (Dome Creek Diversion Channel) and around the tailings-pond facility. After re-connecting to its original channel, Dome Creek continues to flow southeast before crossing the Mount Nansen Public Road and cascading into Victoria Creek.

Stream habitat was characterized in upper Dome Creek along reach DR1 (Table 6.11-13), extending approximately 1.2 km from the headwaters of Dome Creek to where the channel enters the excavated diversion ditch. Dome Creek originates northwest of the mill complex to form a shallow channel based in shrub vegetation. Further downstream the channel becomes undefined or braided in numerous areas. Throughout the reach, the substrate is comprised entirely of fines and a significant amount (90%) of vegetation cover is present. The Dome Creek channel remains relatively narrow throughout the reach, with channel widths and wetted widths ranging from 0.9 to 2.5 m and from 0.2 to 0.7 m, respectively. Pools were infrequent and extremely shallow, with residual pool depth ranging from 0.1 to 0.7 m, respectively.

Dome Creek enters an excavated diversion ditch approximately 1.2 km from its headwaters and undergoes a dramatic shift in stream morphology and habitat. Although no habitat inventory was completed within this reach section, a notable shift in morphology occurs and, therefore, the stream section was delineated as a distinct reach (DR2; Table 6.11-13). In this reach, natural stream features are absent, and the channel becomes dominated by a sandy substrate. The excavated diversion ditch re-directs Dome Creek for 500 m into the Dome Creek Diversion Channel.

The Dome Creek Diversion Channel re-directs Dome Creek around the tailings pond facilities. No habitat inventory was completed within this reach (DR3; Table 6.11-13), but the channel again exhibits a distinct change in stream morphology. The Dome Creek Diversion Channel is a constructed channel with a slightly steeper gradient. The channel straightens out and continues for 280 m past the Seepage Dam, before re-joining with its original channel alignment.

Downstream of the Seepage Dam, reach DR4 (Table 6.11-13) extends 1.1 km downstream until the stream gradient is reduced and the channel enters a grass/sedge wetland. Cobble is the dominant substrate throughout this reach, and the channel meanders irregularly through shrub riparian vegetation. The channel banks are initially sloped in the upper portion of this reach but become steeper towards the downstream extent. The channel remains relatively narrow, with channel widths and wetted widths ranging from 0.8 to 1.9 m and from 0.5 to 1.1 m, respectively. Pools are still infrequent and shallow, with residual pool depth ranging from 0.1 to 0.4 m, respectively. This reach was measured as having a maximum gradient of 6.0 %.

Further downstream, the Dome Creek channel enters a wide grass/sedge wetland. Reach DR5 (Table 6.11-13) extends 1.1 km downstream from where the creek enters the wetland, crossing the Mount Nansen Public Road, and continues until it flows into Victoria Creek's riparian area. In this reach, the stream gradient is significantly reduced, and the channel becomes narrow with undefined sections as it moves through wetland vegetation. Stream substrate along this reach is comprised entirely of fines.

The furthest downstream reach of Dome Creek is DR6 (Table 6.11-13), which extends 290 m downstream and includes the riparian transition of Victoria Creek. In this reach, stream gradient increases to a maximum of 3.5 %. The channel remains narrow, with channel widths and wetted widths ranging from 0.8 to 2.1 m and from 0.4 to 1.7 m, respectively. Pools are quite shallow, with residual pool depth ranging from 0.2 to 0.6 m. Stream substrate was dominated by fines throughout the extent of the reach, and riparian vegetation consisted of primarily shrub and mature conifer forest. Finally, Dome Creek cascades into Victoria Creek with a slightly perched outfall 0.45 m (Appendix 6E) in height and a relatively shallow plunge pool of 0.1 m depth (EDI 2009b). This cascade was determined to be a temporary barrier that may change with streambed erosion over time.

6.11.8.3 Back Creek

Back Creek is a second order stream that originates within the RSA, with the majority of its southern extent included in the LSA. At the time of the study, there was an active placer mining operation present on Back Creek, upstream from its confluence with Pony Creek, as well as past placer mining activities throughout its channel length. Four stream reaches were delineated on Back Creek, extending from the lower extent of active placer operations to where Back Creek enters the Victoria Creek system.

The uppermost reach on Back Creek (BR1) extends 450 m, starting just below active placer operations, until the Pony Creek/Back Creek confluence (Table 6.11-13). This reach is an area of past placer mining activity, with a low percentage of stream cover (3 %) and channel morphology indicative of a high degree of placer activity. Bed load movement and channel bed gradients are reduced, and stream banks are heavily eroded due to lack of riparian vegetation. The channel is relatively narrow throughout the reach, with channel widths and wetted widths ranging from 2.0 to 3.4 m and from 0.9 to 2.3 m, respectively. Pools are infrequent and shallow, with residual pool depth ranging from 0.04 to 0.18 m. The gradient in this reach was measured to have a maximum of 6.0 %.

Downstream of Pony Creek, reach BR2 extends 720 m downstream until the channel enters a riparian wetland close to Victoria Creek. This reach is also an area of past placer mining activity and exhibits similar characteristics as reach BR1 (extensive bed load movement and deposition throughout). Extensive deposition is particularly apparent in the downstream wetland area. Riparian vegetation within this reach is limited to primarily shrubs. The channel is relatively narrow throughout the reach, with channel widths and wetted widths ranging from 0.8 to 2.6 m and from 0.7 to 1.8 m, respectively. Pools are infrequent but slightly deeper on average compared to the above reach, with residual pool depth ranging from 0.1 to 0.2 m. Stream gradient is slightly lower than BR1, with a maximum of 3.0 %.

The furthest downstream reach on Back Creek is BR3 (Table 6.11-13), which extends 500 m to its confluence with Victoria Creek. Riparian vegetation transitions to a tall shrub and conifer forest, with

abundant small woody debris and increased organic inputs (leaves). Heavy stream cover throughout this reach allow for increased habitat availability, including small woody debris and undercut banks.

6.11.8.4 Pony Creek

Pony Creek is a first order stream that originates within the LSA, draining a small portion of the Site north of the Brown McDade Pit. Pony Creek is a first order stream and extends for approximately 3 km before flowing into Back Creek and eventually entering the Victoria Creek system.

The furthest upstream reach delineated on Pony Creek was reach PR1 (Table 6.11-13), extending 920 m from the Pony Creek headwaters to the Mount Nansen Public Road crossing. In this reach, the Pony Creek channel is very narrow, with channel widths and wetted widths ranging from 0.4 to 1.8 m and from 0.2 to 0.9 m, respectively. Pool depth and frequency was variable, with residual pool depth ranging from 0.1 to 0.3 m. Stream gradient was also variable as the stream flows through local topography. The channel in this area is dominated by heavy riparian shrub cover, and substrate is comprised primarily of gravel and fines.

Downstream of the Mount Nansen Public Road crossing, reach PR2 (Table 6.11-13) extends 1.8 km downstream until the channel undergoes a dramatic reduction in stream gradient. In this reach, stream gradient increases (max. of 6.5 %) as the channel flows near the adit outlet from the Brown McDade Pit. In this reach, the channel continues to meander irregularly, with the channel dominated by cobbles and gravel and heavy riparian vegetation. Pools are infrequent, with residual pool depth ranging from 0.1 to 0.3 m. The channel remains relatively narrow, with channel widths and wetted widths ranging from 1.2 to 3.1 m and from 0.4 to 1.3 m, respectively.

Further downstream, stream gradient is significantly reduced as the Pony Creek channel reaches the Back/Victoria Creek floodplain. This shift in morphology represents the furthest downstream reach of Pony Creek (PR3; Table 6.11-13), extending for 310 m until Pony Creek flows into Back Creek. Riparian vegetation along this reach consists of short to tall shrubs, and channel substrate is dominated by fines and sand. The Pony Creek channel becomes braided in this area and is undefined in some locations. A series of cascades, with four sequential drops measuring 28 cm, 51 cm, 58 cm, and 68 cm (a total of 205 cm) are present at its outlet into Back Creek.

6.11.8.5 Minnesota Creek

Minnesota Creek is a second order stream that originates from outside of the study area boundaries, with only its most southern extent falling within the LSA. A single stream reach was inventoried in 2013 (Appendix 6E). This lowermost reach of Minnesota Creek (MR1; Table 6.11-13), extends approximately 500 m upstream from its confluence with Victoria Creek. Minnesota Creek was noticeably more turbid in relation to Victoria Creek, with visible precipitate on the substrate. The stream showed signs of being a heavily mineralized system due to the presence of fine sediment, likely caused by metal precipitate. In this reach, channel substrate was dominated by coarse cobble substrate, and riparian vegetation was limited to primarily tall shrubs. Pools were irregularly spaced, with residual pool depth ranging from 0.2 to 0.3 m. The channel varied throughout its length, with channel widths and wetted widths ranging from 1.8 to 5.4 m and from 1.4 to 3.1 m, respectively.

6.11.9 Fish Distribution and Habitat Use

6.11.9.1 Summary of Studies Completed

Several studies contribute to the understanding of fish and fish habitat within the Site LSA and RSA, dating as far back as the late 1970s and early 1980s (Environment Canada 1979; Norecol 1989). A limited study of fish presence in Victoria Creek was also performed by Osborne in 1995. EDI collected fisheries data in Victoria, Dome, Pony, and Back creeks from 2005 through 2009 through a terrestrial effects study and several targeted field investigations (EDI 2007, 2009a, and 2009b). The most recent studies include an overwintering survey on Victoria Creek (EDI 2012b) and fish and fish habitat investigations in Victoria, Back, Dome, Pony, and Minnesota creeks in 2013 (Appendix 6E). Table 6.11-14 provides a summary of fisheries investigation efforts organized according to watercourse.

Table 6.11-14: Summary of Fisheries Investigations Conducted within the Mount Nanson Project LSA

Stream	Study References	Techniques Used
Victoria Creek	Appendix 6E EDI 2007; EDI 2012b Osborne 1995 Norecol 1989	Backpack electrofishing, seine netting, visual (snorkel) surveys
Dome Creek	Appendix 6E EDI 2009c Norecol 1989	Backpack electrofishing, minnow trapping
Back Creek	Appendix 6E EDI 2009b	Backpack electrofishing
Pony Creek	Appendix 6E EDI 2009b	Backpack electrofishing, minnow trapping
Minnesota Creek	Appendix 6E	Backpack electrofishing

6.11.9.2 Fish Species

Three fish species have been confirmed to occur in the LSA and RSA streams: Arctic Grayling, Burbot and Slimy Sculpin). Round Whitefish are assumed to occur in the Nisling River and potentially in Victoria Creek, although their presence has never been confirmed in the Victoria Creek system. Chinook Salmon (*Oncorhynchus tshawytscha*) are known to spawn in the lower and middle reaches of the Nisling River (Norecol 1989), but neither adults nor juveniles have been captured in Victoria Creek or the other RSA watercourses. Table 6.11-15 provides a summary of fish species occurrences within the LSA. Descriptions of existing data on fish occurrences and habitat use are provided in the subsequent sections according to watercourse.

Table 6.11-15: Summary of Fish Presence in Mount Nansen LSA/RSA Watercourses

Watercourse	Arctic Grayling	Slimy Sculpin	Burbot
Victoria Creek	A, J, YY	A, J	A
Dome Creek	NFC	NFC	NFC
Back Creek	J, YY	A, J	NFC
Pony Creek	NFC	NFC	NFC
Dry Creek	Not assessed because only small portion within IOC boundary		

Notes: Fish presence is described using the following acronyms; A=adult, J=juvenile, YY=young of year, and NFC=no fish caught.

6.11.9.3 Watercourse Descriptions

6.11.9.3.1 Victoria Creek

Arctic Grayling, Burbot, and Slimy Sculpin have all been confirmed to occur in Victoria Creek across multiple sampling events (Norecol 1989, EDI 2007, EDI 2012b; Appendix 6E). Habitats in Victoria Creek are used by a variety of Arctic Grayling life stages throughout the year.

Arctic Grayling of a wide size range (58 to 350 mm; Appendix 6E) have been found in Victoria Creek throughout the LSA during the ice-free season, suggesting this watercourse provides habitat suited to several life stages of this species. Grayling as large as 350 mm fork length have been captured, most frequently in the numerous deep pools that occur in the creek, as well as in cover areas around large woody debris and undercut banks.

Osborne (1995) reported observing Arctic Grayling fry near the outflow of Victoria Creek, and small numbers of young of year Arctic Grayling (fork lengths of 58-80 mm) were observed in both 2012 and 2013 (Appendix 6E). These observations suggest spawning of Arctic Grayling may occur within the Victoria Creek watershed. However, the hundreds of young of year Arctic Grayling observed in lower Back Creek (Appendix 6E) suggests preferential usage of this watercourse for rearing. No probable Arctic Grayling spawning habitats have been observed in the LSA.

Victoria Creek appears to provide important late summer / early fall feeding habitat for subadult and adult Arctic Grayling that have been observed to congregate in high densities in pools across all reaches studied in Victoria Creek (Appendix 6E). Numerous deep pools also provide overwintering habitat for Arctic Grayling (EDI 2012b). These pools provide small but sustained flows and likely groundwater inflows that maintain suitable conditions beneath the ice. Arctic Grayling in central to lower Victoria Creek may use these pools as overwintering habitat or migrate seasonally downstream to the larger Nisling River to overwinter.

Slimy Sculpin have been captured consistently during fisheries studies in Victoria Creek, although in relatively low number (Appendix 6E). Juvenile and adult Slimy Sculpin have been captured in recent studies (total lengths of 76-133 mm), but no young of year were observed or captured. The low occurrence of Slimy Sculpin in catch records for Victoria Creek is considered to indicate low density within the watercourse.

Burbot have been captured consistently during electrofishing studies in Victoria Creek, although at low density (Appendix 6E). Victoria Creek provides good rearing and feeding habitat for this species. Burbot in Victoria Creek typically are captured in areas of suitable cover such as large woody debris (e.g., stumps or root wads), and deeply undercut banks or in deep back channels. The range of size of Burbot captured in Victoria Creek is 217-372 mm (total length). No young of year or small juveniles have been captured in the watercourse.

6.11.9.3.2 Back Creek

Only Arctic Grayling have been observed or captured in Back Creek (EDI 2009b; Appendix 6E). Back Creek generally provides poor habitat opportunities for fish, which may be the result of both historic and current placer mining activities on the stream. The upper reaches of this stream have little to no cover, infrequent and shallow pools, and a quickly migrating channel that appears to result in a large degree of substrate movement. Although no barriers are present, these poor-quality habitats are believed to limit fish presence. Only three juvenile Arctic Grayling (178-186 mm fork length) have been captured in the upper reaches of Back Creek during extensive survey efforts.

In contrast, high densities of young of year Arctic Grayling were captured and observed in the lowest reach of Back Creek during one sampling event in August of 2013 (Appendix 6E). Forty-one Arctic Grayling ranging in length from 51-68 mm were captured, and hundreds of others were observed. This level of habitat use is likely due to a combination of good cover and food availability; therefore, this stream section is likely seasonally important rearing habitat for young of year Arctic Grayling.

6.11.9.3.3 Dome Creek

Dome Creek has been assessed as being non-fish-bearing on at least three occasions (1989; EDI 2009c; Appendix 6E), and currently is not considered to support fish. A 45 cm potential barrier to upstream fish movement has formed at the outflow of Dome Creek at Victoria Creek. This barrier appears to have formed through a combination of an overly stable channel (i.e., non-degrading substrate) supported by vegetation in Dome Creek, and a gradually migrating channel in Victoria Creek. While this potential barrier is not permanent (i.e., not based in bedrock), it is considered to be seasonally stable.

Considerable efforts have been expended to assess Dome Creek upstream from the outlet, in early and late summer. Methods have included electrofishing and minnow trapping in 2008 (EDI 2009c), and electrofishing the entire length of the stream from its outlet to the public road crossing (845 m) in 2012 (Appendix 6E).

In addition to the presence of a temporary potential barrier, the high level of total metals loading (primarily iron) due to the presence of the TSF would limit available rearing, summer feeding, and spawning habitats due to lack of pools and gravels. Other effects of reduced water quality could include reduced oxygen content and an impairment of benthic macroinvertebrate and periphyton communities, which could lead to reduced resource availability for fish. This combination of factors currently excludes fish from Dome Creek.

6.11.9.3.4 Pony Creek

Pony Creek has been assessed as being non-fish bearing during two studies (EDI 2009b; Appendix 6E), and currently is not considered to support fish. Several series of barriers are present in Pony Creek, most prominently a stepped cascade at the outflow of Pony Creek into Back Creek consisting of four sequential drops measuring 28 cm, 51 cm, 58 cm, and 68 cm (a total of 205 cm). This potential barrier appears to have formed through a combination of a stable (i.e., non-degrading) channel in Pony Creek, and a rapidly degrading channel in Back Creek due to historical placer mining. Two additional potential barriers were observed further upstream: a cascade with two adjacent drops measuring 18 and 28 cm; and a cascade with a drop of 46 cm (Appendix 6E). As with Dome Creek, these barriers are not permanent, but are currently considered to be stable.

Despite the presence of potential barriers, considerable effort has been expended to assess Pony Creek upstream from the outlet barrier, including electrofishing and minnow trapping the lower 250 m of the stream in late summer (EDI 2009b) and electrofishing the entire length of stream in early summer to a point where the channel became undefined (440 m) (Appendix 6E). No fish were captured during these surveys.

The narrow and undefined channel widths of Pony Creek suggest even if the barriers were removed, this stream would not provide valuable fish habitat. No suitable overwintering areas such as deep pools with continuous water flow were observed, therefore habitat characteristics would be limited to seasonal rearing.

6.11.9.3.5 Minnesota Creek

Minnesota Creek was electrofished in 2013 and currently is not considered to support fish (Appendix 6E). The overall fish habitat value of Minnesota Creek was considered to be poor due to low visibility, presence of large amounts of iron precipitate, and poor habitat availability.

6.11.10 Fish Habitat Summary

Fish habitat within the LSA ranges from poor to excellent, varying widely by watercourse. Both Dome Creek and Pony Creek are currently non-fish-bearing, the result of potential barriers to upstream fish passage, poor water quality, sedimentation, and generally poor habitat quality (Table 6.11-16).

Victoria Creek provides good overall fish habitat within the LSA area. Observations of Arctic Grayling fry and young of year in this watercourse suggest spawning occurs, however, it is not known whether suitable habitats occur directly within in the LSA area. High quality rearing habitat is not abundant, but Victoria Creek does provide important feeding habitat for subadult and adult Arctic Grayling. Good quality overwintering habitat does exist in the form of deep pools.

Table 6.11-16: Summary of Fish Habitat Quality of LSA Streams

Watercourse	Spawning Habitat	Rearing Habitat	Over-Wintering Habitat
Victoria Creek	Poor-Moderate. Not anticipated due to high spring velocities but could occur. If not within LSA, spawning is likely to occur nearby.	Poor-Moderate. Large stream has some margin, riffle, and pool habitats suitable, but young of year/juveniles have not been frequently observed.	Good. Deep pools provide proven over-wintering habitat for Arctic Grayling, sculpin, and potentially Burbot.
Dome Creek	Poor. Lack of connectivity with Victoria Creek and lack of suitable habitat. High total metals load due to TSF influence.	Poor. High metals load due to TSF influence.	None. No deep pools with continuous water flow. Stream freezes down to stream bed.
Back Creek	Poor. Lack of suitable habitats and substrates due to prior and ongoing placer mining operations. Suitable glide features have not been observed.	Poor-Good. The lowest reach of the stream appears to provide good, preferred young of year rearing habitat for Arctic Grayling. Habitat poor in upper reaches.	None-Poor. Overwintering not anticipated due to lack of suitable pool habitats and reduced flows.
Pony Creek	Poor. Lack of appropriate habitat and connectivity with Back Creek.	Poor. Lack of appropriate habitat and connectivity with Back Creek.	None. No deep pools with continuous water flow. Stream freezes down to stream bed.
Minnesota Creek	Poor. Low visibility, presence of iron precipitate, and poor habitat availability.	Poor. Low visibility, presence of iron precipitate, and poor habitat availability.	None-Poor. Overwintering not anticipated due to lack of suitable pool habitats.

Fish habitat was found to be poor in Back Creek, with the exception of good quality rearing habitat immediately upstream from Victoria Creek. The remaining length of this watercourse appears to have been heavily affected by placer mining activities and is minimally used by fish. Overwintering and spawning are not known to occur in this stream.

Fish habitat in Minnesota Creek was rated as poor due to low visibility, the presence of large amounts of iron precipitate, and poor habitat availability including lack of pools.

6.12 Wildlife

6.12.1 Introduction

A large body of information has been reviewed and compiled to characterize wildlife resources at the Site. Baseline studies and the resulting body of data form the basis for describing wildlife resources in the area (Table 6.12-1). Additional information was compiled from recent regional studies and wildlife information datasets (e.g., Government of Yukon Wildlife Key Area (WKA) database and Government of Yukon harvest records). Several resources describing species of conservation concern were also reviewed, including the Yukon Conservation Data Centre (YCDC), *Wildlife Act* (Yukon; 2002), the federal *Species at Risk Act* (SARA 2002), the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and NatureServe Canada (2013).

Wildlife baseline studies were designed to characterize wildlife species of ecological, cultural, and economic importance. Accordingly, the information in this section describes the presence, distribution and relative abundance of major wildlife species occurring on or near the Site, including birds, ungulates (hoofed mammals), bears, and furbearers (species whose fur or pelt is commercially valued such as mink and martin). Information describing the importance and occurrence of small mammal and amphibian species is also presented.

Table 6.12-1: Field Studies Used to Describe Wildlife Resources at the Mount Nansen Site

Wildlife Resource	Field Study	Source
Caribou	Faecal pellet survey (2012) Post-calving aerial survey (2013) Late-winter aerial survey for moose (2013) Wildlife remote camera study (2012-2014)	Appendix 6F
	Aishihik and Kluane caribou herd census (2009) Nordenskiöld River late-winter moose survey and data (2009) Carmacks West-Casino Trail late-winter moose and caribou survey report and data (2011) Baseline monitoring of the Klaza caribou herd (2012) Klaza caribou herd collar data (2013)	Hegel and Russel 2009 O'Donoghue and Bellmore 2009 O'Donoghue and Bellmore 2011 Hegel and Russel 2013 Environment Yukon 2017
Moose	Faecal Pellet survey (2012) Mount Nansen late-winter aerial survey for moose (2013) Wildlife remote camera study (2012-2014)	Appendix 6F
	Nordenskiöld River late-winter moose survey and data (2009) Carmacks West-Casino Trail late-winter moose and caribou survey report and data (2011)	O'Donoghue and Bellmore 2009 O'Donoghue and Bellmore 2011

Wildlife Resource	Field Study	Source
Carnivores	Winter wildlife track study (2012) Faecal pellet surveys (2012) Wildlife remote camera study (2012) Incidental observations from aerial ungulate surveys (2009 - 2013)	ELR 2012 Appendix 6F
Small Mammals	Faecal Pellet survey (2012)	Appendix 6F
	Small mammal trapping program as part of a terrestrial effects study (2005)	EDI 2007 Appendix 6F
	Incidental observations from Site baseline studies (2011 - 2013)	
Birds	Point count surveys (2011-2012) Focal surveys (2012) Faecal Pellet surveys (2012) Waterfowl surveys at Site pit and ponds (2013)	EDI 2012c Appendix 6F

6.12.2 Wildlife Local and Regional Study Areas

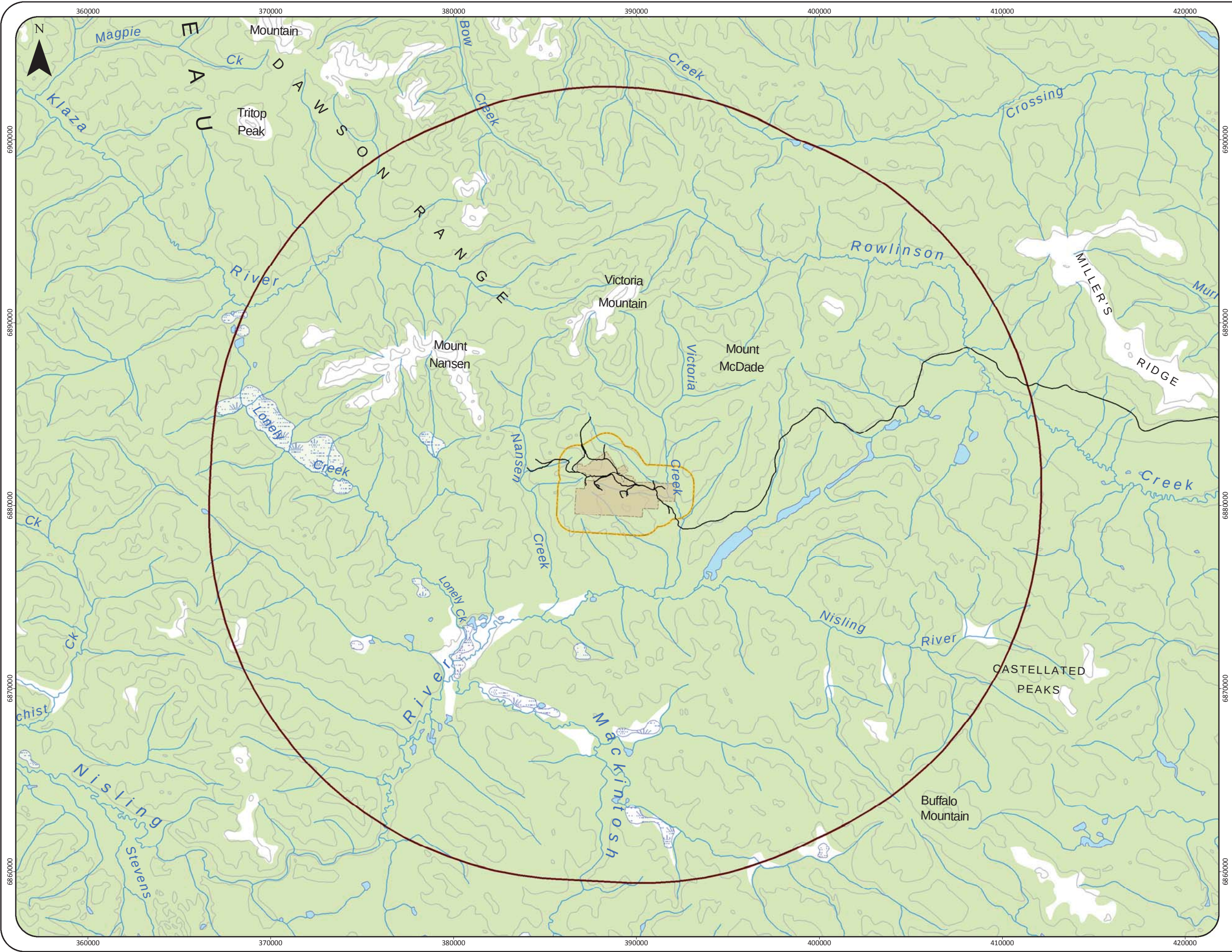
6.12.2.1 Local Study Area

A wildlife local study area (LSA) was delineated to collect information to describe wildlife abundance and distribution and assess potential local-scale Project effects on wildlife (Figure 6.12-1). Such effects may be realized slightly beyond the proposed remediation footprint, therefore, the LSA was defined using a 1 km buffer beyond the boundary of the OIC area, creating a total area of 31 km². The LSA encompasses the Project footprint and is characterized by roads, mine infrastructure, water bodies (e.g., tailings and seepage ponds, Brown McDade pit) and areas of regenerating vegetation communities. The LSA also encompasses surrounding undisturbed areas that include portions of Dome, Pony, Back and Victoria creek valleys, upland spruce forests and low subalpine ridges above the Site.

6.12.2.2 Regional Study Area

A wildlife regional study area (RSA) was delineated to describe more wide-ranging wildlife populations and assess potential effects at a broader geographical scale. The RSA was defined as an area extending 20 km beyond the OIC area (Figure 6.12-1), resulting in a total area of 1,574 km². The RSA encompasses physiographic features that include the Nisling River valley in the south and in the north the Klaza River headwaters, Victoria Mountain, Mount Nansen and Mount McDade.

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Figure 6.12-1
Wildlife Study Areas



Local Boundaries

- Order in Council
- Wildlife Local Study
- Wildlife Regional Study
- Road
- Topographic Contour (150 m Interval)
- Watercourse
- Wetland
- Waterbody
- Vegetation

Data Source:

National Topographic Data Base (NTDB) compiled by Natural Resources Canada at a scale of 1:250,000. Cadastral data compiled by Natural Resources Canada. Reproduced under license from © Her Majesty the Queen in Right of Canada, Department of Natural Resources Canada. All rights reserved.

Datum: NAD 1983 CSRS UTM Zone 8N

Scale 1:200,000

Kilometers

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6.12.3 Species of Conservation Concern

Several species of conservation concern occur or have the potential to occur in the LSA or RSA (Table 6.12-2). These species have been identified or protected under SARA (2002) or the Yukon *Wildlife Act*. (2002), or designated by either NatureServe Canada (2013), or by COSEWIC. SARA is a key federal government commitment to prevent wildlife species from becoming extinct and secure the necessary actions for their recovery. This act provides for the legal protection of wildlife species and the conservation of their biological diversity. The Yukon *Wildlife Act* regulates the hunting and trapping of wildlife in addition to protecting those listed in Schedule A (i.e., specially protected species). Some species and their populations may be considered as at-risk but are not currently afforded legal protection. Both NatureServe Canada and COSEWIC are committees that provide conservation ratings for species across Canada, recommending them for consideration under SARA or other regulations.

Four potentially occurring species in the RSA are identified as Threatened, and 10 species are identified as Special Concern by COSEWIC or SARA. An additional 14 species are identified by NatureServe Canada as Vulnerable, one of which is specially protected under the Yukon *Wildlife Act* (Table 6.12-2). Six of these species that occur in the LSA are discussed in the following sections.

Table 6.12-2: Species at Risk Confirmed or Potentially Occurring in the Local and Regional Study Areas of the Mount Nansen Care and Maintenance Project

Common Name	Scientific Name	Confirmed or Potentially Occurring in LSA	Confirmed or Potentially Occurring in RSA	Conservation Status ^{A,B}	SARA Status ^C	COSEWIC Status ^D
Mammals						
Woodland caribou	<i>Rangifer tarandus caribou</i>	Confirmed	Confirmed		Special Concern	Special Concern
Wood bison	<i>Bison bison athabasca</i>	Potential	Confirmed	Imperiled/Vulnerable ^A	Threatened	Special Concern
Grizzly bear	<i>Ursus arctos horribilis</i>	Confirmed	Confirmed			Special Concern
Wolverine	<i>Gulo gulo</i>	Confirmed	Confirmed	Vulnerable ^A		Special Concern
Collared pika	<i>Ochotona collaris</i>	Potential	Potential	Vulnerable ^A		Special Concern
Birds						
Bank swallow	<i>Riparia riparia</i>	Potential	Potential			Threatened
Harlequin duck	<i>Histrionicus histrionicus</i>	Potential	Potential		Special Concern	Special Concern
Horned grebe	<i>Podiceps auritus</i>	Potential	Potential			Special Concern
Lesser scaup	<i>Aythya affinis</i>	Potential	Potential	Vulnerable ^A		
Osprey	<i>Pandion haliaetus</i>	Potential	Potential	Vulnerable ^A		
White-winged scoter	<i>Melanitta fusca</i>	Potential	Potential	Vulnerable ^A		
Surf scoter	<i>Melanitta perspicillata</i>	Potential	Potential	Vulnerable ^A		

Common Name	Scientific Name	Confirmed or Potentially Occurring in LSA	Confirmed or Potentially Occurring in RSA	Conservation Status ^{A,B}	SARA Status ^C	COSEWIC Status ^D
Trumpeter swan	<i>Cygnus buccinator</i>	Potential	Potential	Vulnerable ^A / Apparently Secure. Specially Protected ^B		
Olive-sided flycatcher	<i>Contopus cooperi</i>	Confirmed	Confirmed	Imperiled/ Vulnerable ^A	Threatened	Threatened
Canada warbler	<i>Wilsonia canadensis</i>	Potential	Potential		Threatened	Threatened
Common nighthawk	<i>Chordeiles minor</i>	Confirmed	Confirmed		Threatened	Threatened
Rusty blackbird	<i>Euphagus carolinus</i>	Potential	Potential		Threatened	Special Concern
Peregrine falcon	<i>Falco peregrinus</i>	Potential	Potential	Vulnerable ^A , Specially Protected ^B	Special Concern	Special Concern
Gyrfalcon	<i>Falco rusticolus</i>	Potential	Potential	Specially Protected ^B		
Sharp-tailed grouse	<i>Tympanuchus phasianellus</i>	Potential	Potential	Vulnerable ^A		
American golden plover	<i>Pluvialis dominica</i>	Potential	Potential	Vulnerable ^A		
Lesser yellowlegs	<i>Tringa flavipes</i>	Potential	Potential	Vulnerable ^A		
Whimbrel	<i>Numenius phaeopus</i>	Potential	Potential	Vulnerable ^A		
Red-necked phalarope	<i>Phalaropus lobatus</i>	Potential	Potential	Vulnerable ^A		Special Concern
Short-eared owl	<i>Asio flammeus</i>	Potential	Potential	Vulnerable ^A	Special Concern	Special Concern
Northern shrike	<i>Lanius excubitor</i>	Potential	Potential	Vulnerable ^A		
Smith's longspur	<i>Calcarius pictus</i>	Potential	Potential	Vulnerable ^A		
Golden eagle	<i>Aquila chrysaetos</i>	Confirmed	Confirmed	Vulnerable ^A		

Notes:^A NatureServe Conservation Subnational Status Rating (NatureServe Canada 2013)^B Specially Protected under Section 5 of the Yukon Wildlife Act (Environment Yukon 2015)^C Species at Risk Public Registry (Government of Canada 2017a) under the Species At Risk^D COSEWIC status (COSEWIC 2017)

6.12.4 Distribution and Characteristics of Local Wildlife

Woodland caribou and moose are commonly occurring ungulates in the LSA and RSA, while bison are rare visitors to the LSA and more commonly occurring in the southern RSA. Thinhorn sheep and mule deer have not been detected in the area. Bears (black and grizzly) occur in the RSA and LSA, as well as furbearers including Canada lynx, grey wolf, red fox, American marten and wolverine. Many species of birds occur in the LSA and RSA, including passerine, shorebird, raptor and waterfowl species.

6.12.4.1 Woodland Caribou

Woodland caribou of the Northern Mountain population are identified by COSEWIC and listed under Schedule 1 of SARA as a species of special concern (Table 6.12-2). Caribou are traditionally hunted for food and have a high local value. The annual ranges of two woodland caribou herds overlap the LSA, the Klaza and Aishihik herds (Table 6.12-2; Environment Yukon 2012). The Klaza Caribou Herd (KCH) range extends from the Dawson Range Mountains, overlaps the LSA and extends south to the Nisling River. The Aishihik Caribou Herd (ACH) range extends from Kluane and Aishihik Lakes north to the Nisling River and overlaps the southern portion of the RSA. The Nisling River (approximately 5 km south of the LSA) marks the approximate boundary between these two herds (T. Hegel, personal communication, February 5, 2013).

Yukon hunting regulations restrict the caribou harvest in Game Management Zone 5 with closures for both cow and bull caribou hunts in some Game Management Subzones (GMS). All GMS that overlap the RSA are limited to a permit hunt for bull caribou only (Environment Yukon 2014b). Portions of GMS 5-23, 5-24, 5-25, 5-26, 5-42 and 5-43 occur within the RSA (Figure 6.12-2). Only GMS 5-26 overlaps the LSA, so this GMS will be discussed in more detail below.

Caribou harvest data provided by Environment Yukon (2014b) indicates a total of 86 caribou were harvested in the past decade (2004 to 2013) from the GMS surrounding the Mount Nansen Site (Table 6.12-3; Figure 6.12-2). GMS 5-26 had the highest number of caribou harvested ($n = 38$) over the ten-year period, providing some evidence for the hunting pressures occurring in that area, while GMS 5-24 and 5-25 had the lowest number of caribou harvest ($n = 1$ and 3, respectively). GMS 5-26 is accessible from the south along the Mount Nansen Public Road and from the north along Freegold Road. Across all years, total caribou harvested ranged from three to twelve animals with an average 8.6 caribou/year.

Table 6.12-3: Total Caribou Harvest in Game Management Subzones (GMS) Near the Local Study Area (LSA)

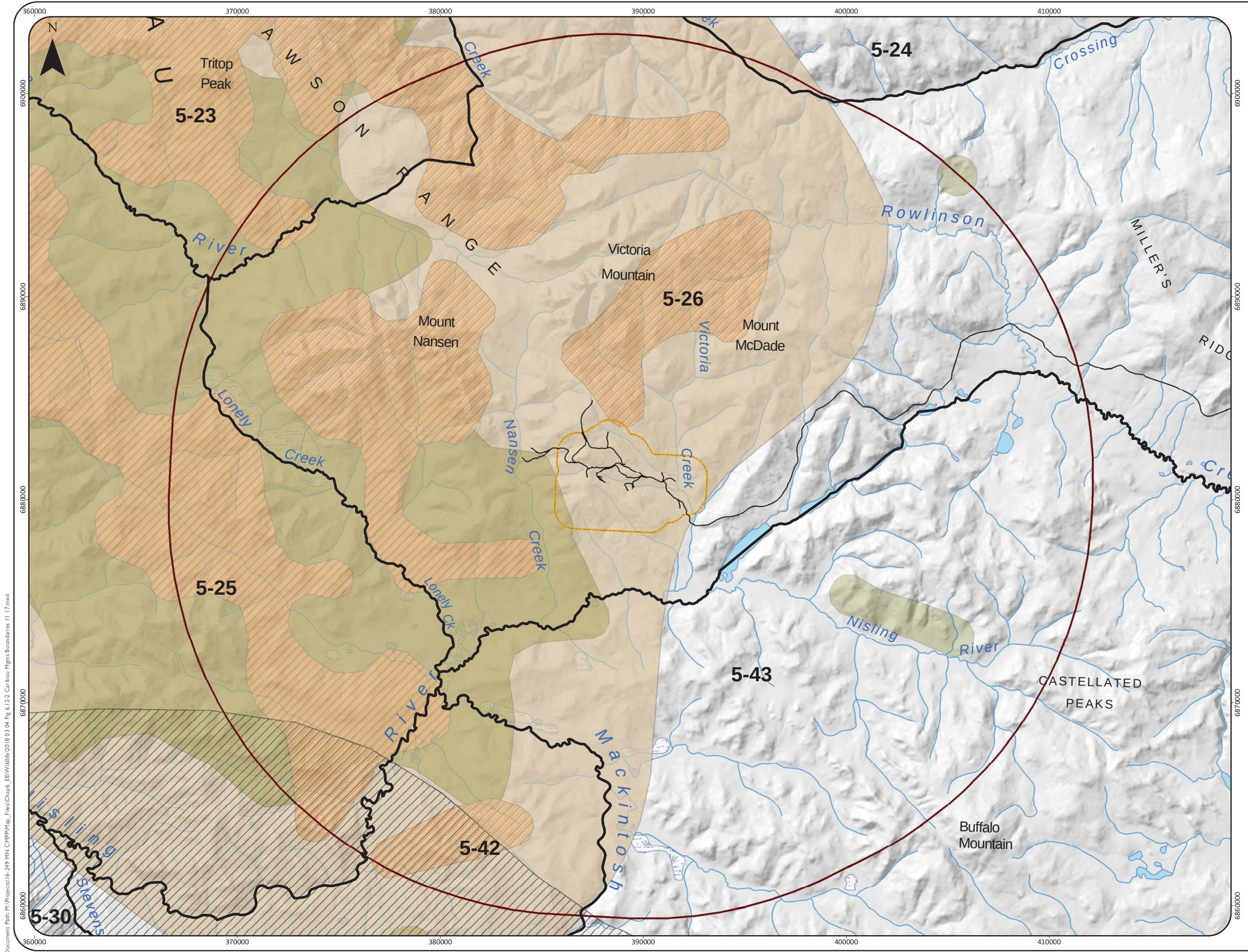
GMS Code	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	GMS Total
5-23	1	1	3	2	3	4	4	5	4		27
5-24									1		1
5-25					2		1				3
5-26	1	1	7	2	6	5	3	4	6	3	38
5-42	1	3	2	2	1	2	2		3	1	17
5-43											
Yearly Total	3	5	12	6	12	11	10	9	14	4	86

Notes: Environment Yukon, 2014b unpublished data.

Woodland caribou move throughout their core range to access seasonal habitats. The KCH and ACH are alpine-wintering caribou (Kuzyk *et al.* 1999), but in severe winters will migrate to lower elevations (e.g., forested or subalpine shrub areas) where shallower snowpack provides easier access to snow covered terrestrial lichens (Johnson *et al.* 2004). Summer and fall habitat requirements for calving/post-calving and rutting are in alpine habitats, and therefore woodland caribou spend most of their time at subalpine and alpine elevations with foraging movements to mid-elevations in late-winter or during seasonal migration periods. There can be moderate to wide variation in the actual portion of the overall range of a caribou herd in any given year.

Wildlife Key Areas (WKA) are geographical locations in Yukon that are used by wildlife for critical life functions and are defined by Environment Yukon, based on survey and harvest data, local knowledge and available literature (Environment Yukon 2014c). Fall rut and winter habitat WKAs for woodland caribou overlap the western portion of the RSA, and the latter overlaps the southwestern boundary of the LSA (Figure 6.12-2; Environment Yukon 2013). Fall rut WKAs are traditional caribou rutting areas in higher elevation subalpine and alpine zones.

Wildlife baseline studies show that caribou use the LSA. A remote camera study conducted in the LSA from 2012-2014 (Appendix 6F) indicated caribou are most common in the LSA during the mid-winter (January/February) and summer (July/August). Caribou were the most frequently detected species during the remote camera study. All winter detections occurred in or adjacent to the Dome Creek Valley, while caribou detections during the remainder of the year occurred in the Dome and Victoria creek valleys, on the subalpine ridges south and west of the mill area, and along the road that crosses Pony Creek near the adit. Feeding craters and faecal pellets were observed in subalpine shrub and conifer habitats in the northwest portion of the LSA during a winter track study (ELR 2012). Caribou pellets were also observed once during the pellet surveys along middle Dome Creek.



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Figure 6.12-2

Woodland Caribou Occurrence in RSA

Legend

Wildlike Key Areas - Klaza Herd

- Fall Breeding Area
- Winter Range Area

Caribou Herd Range

- Klaza Herd
- Aishihik Herd

Area Boundaries

- Wildlife Local Study Area
- Wildlife Regional Study Area
- Game Management Subzones

Base Layers

- Roads
- Watercourse
- Wetland
- Waterbody

Data Source:

- Klaza Caribou Herd Wildlife Key Areas and Caribou Herd Ranges provided by Environment Yukon, March 2014.
- Game Management Subzones downloaded from Geomatics Yukon. (<http://www.geomaticsyukon.ca/data/datasets>).
- Roads digitized by ELR using imagery or spatial data provided by YG - Assessment and Abandoned Mines Branch.
- National Topographic Data Base (NTDB) compiled by Natural Resources Canada at a scale of 1:250,000. Reproduced under license from © Her Majesty the Queen in Right of Canada, Department of Natural Resources Canada. All rights reserved.

Datum: NAD 1983 CSRS UTM Zone 8N

Scale 1:180,000

Kilometers

0 5 10

March 5, 2018

Environment Yukon has documented caribou abundance in the RSA and surrounding region. The ACH was last estimated at 2,044 individuals (95% confidence interval [CI]: 1,724 – 2,507) in 2009 and was considered to be stable and increasing in size by 5% per year (Hegel and Russell 2009). The KCH herd was estimated at 1,180 individuals using mark-resight methods in 2012. The current population trend for this herd is unknown (Hegel and Russell 2013).

Additional caribou observations within the RSA include a group of individuals observed south of the Nisling River during late-winter surveys (Hegel and Russell 2009, O'Donoghue and Bellmore 2009). Additionally, a cow and calf pair were observed near an alpine snow patch on Victoria Mountain, and two caribou along the Nisling River during an aerial post-calving caribou survey in late-July of 2012 (Appendix 6F).

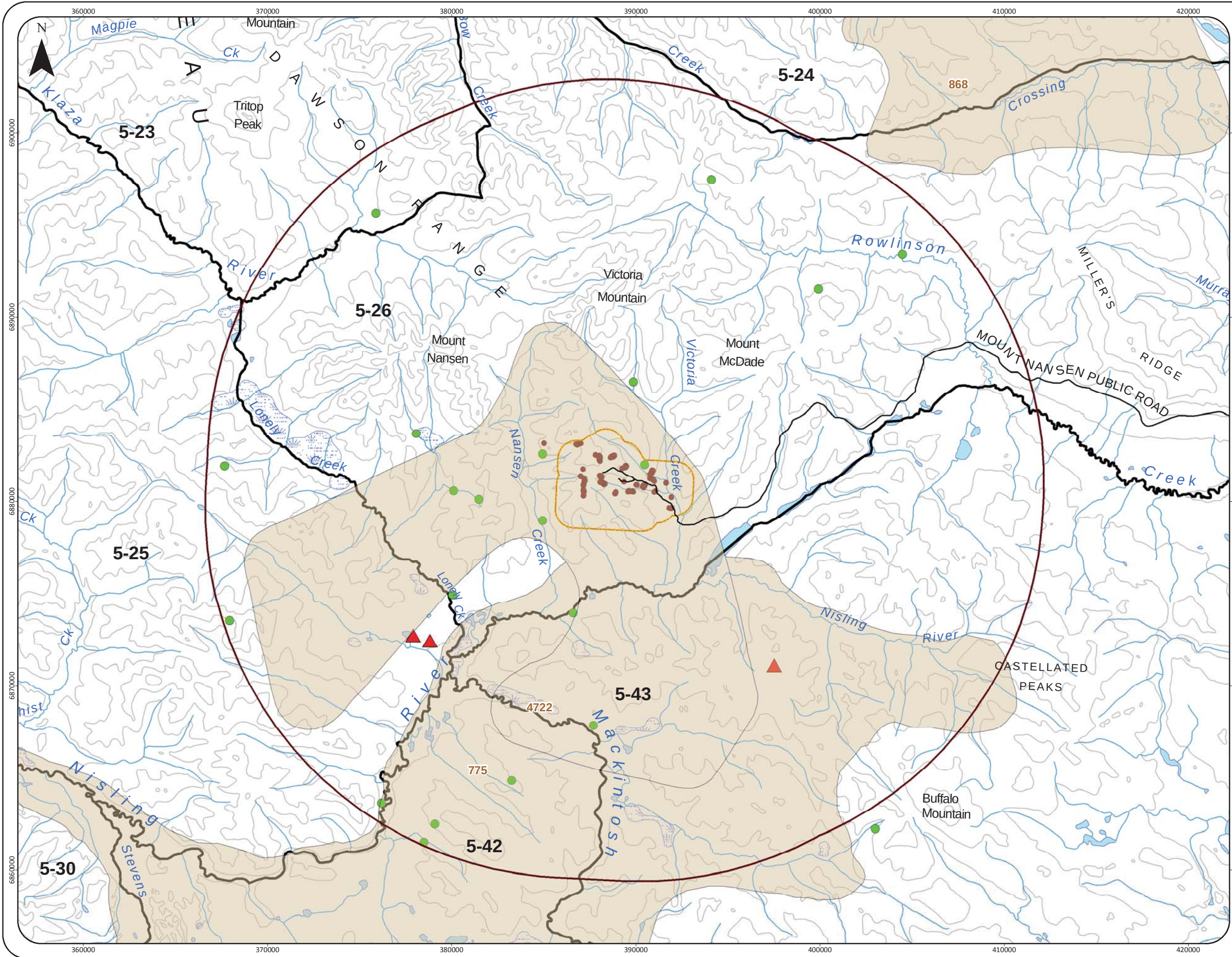
6.12.4.2 Moose

Moose are an important species in Yukon. Yukon First Nations and licensed hunters value moose as a big game species, many of whom rely on moose for subsistence. Moose are ranked as secure in the Yukon by the Canadian Endangered Species Conservation Council (CESCC 2011).

Important habitats for moose include riparian areas, marshes, ponds, and meandering streams; burned or logged areas; and treeline and subalpine areas with abundant shrub forage species (Wall *et al.* 2011). The late winter months are important to moose survival because forage availability is scarce, and a deep winter snowpack can hamper moose movements and ability to access browse buried beneath the snow. In severe winters, moose move to lower elevations to where browse (e.g., willow) is more abundant. A moose late winter range WKA occurs south of the Mount Nansen Site, extending from the Nisling River and Mackintosh Creek area, where forest fires burned in 2009 and 1996, respectively, encompassing the entire LSA (Environment Yukon 2013; Figure 6.12-3).

Baseline studies showed moose use a range of habitats in the LSA and RSA ranging from riparian valleys to subalpine areas, with preference for the former. Moose were the second most frequently detected species during an 18-month remote camera study conducted at the Mount Nansen Site (Appendix 6F). Moose detections from a remote wildlife camera study were distributed throughout the year, occurring most frequently in February and July, and least frequently in April to May, August, and November. The majority of moose detections occurred in the Dome Creek, Victoria Creek and Pony Creek valleys, while few or no moose were detected at higher (and more exposed) elevations. Among these detections, the majority occurred at the riparian areas of these creeks while some occurred along the terraced ridge game trails running parallel to Victoria Creek and the power line trail running parallel to Dome Creek. Although few ($n = 12$) fresh moose pellet groups were observed during the faecal pellet study, 31 old pellet groups were observed and provide further evidence of moose site use throughout the LSA (Appendix 6F).

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MOUNT NANSEN CARE AND MAINTENANCE PROJECT

Figure 6.12-3

Moose Locations in the Project Area



Late-Winter Moose Aerial Survey

- Moose Locations

Faecal Pellet Surveys

- Incidental Moose Pellet Locations

Post-Calving Caribou Survey

- ▲ Moose Locations

Local Boundaries

- ▭ Wildlife Local Study
- ▭ Wildlife Regional Study
- ▭ Game Management Subzones
- Moose Late-Winter Wildlife Key Area

Base Layers

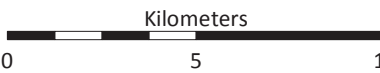
- ~ Mount Nansen Access
- ~ Watercourse
- ~ Topographic Contour (150 m Interval)
- Waterbody

Data Source:

- 1.Moose data collected and compiled by ELR.
- 2.Wildlife Key Areas accessed from Yukon Government - Geomatics Yukon, Corporate Spatial Warehouse: www.geomaticsyukon.com.
- 3.Mount Nansen Access Road digitized by ELR.
- 4.National Topographic Data Base (NTDB) compiled by Natural Resources Canada at a scale of 1:250,000. Reproduced under license from © Her Majesty the Queen in Right of Canada, Department of Natural Resources Canada. All rights reserved.

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Scale 1:200,000



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Several late-winter regional surveys were conducted to estimate winter distribution and relative abundance of the observed population and were conducted in the RSA (Appendix 6F), Carmacks West Moose Management Unit (O'Donoghue and Bellmore 2011) and the Nordenskiöld Moose Management Unit (O'Donoghue and Bellmore 2009). Poor sightability and challenging animal classification in late-winter results in biased population data and limits the application of data to a relative population measure instead of a total count. The survey areas were divided into 4 km² x 4 km² survey blocks, each of which are classified into high or low strata based on the expected density of moose within them. Despite using similar methods, direct comparisons between studies should take into consideration that the surveys were conducted in different years (i.e., 2009, 2011 and 2013). However, observed moose density can be used as an indicator of distribution in late-winter within the region. Observed moose density within the Mount Nansen RSA was 19 moose/1,000 km² overall and 23 and 18 moose/1,000 km² for high and low strata blocks, respectively (Appendix 6F). Observed moose density was 27 and 20 moose/1,000 km² in the Carmacks West and Nordenskiöld surveys, respectively. A comparison amongst the three studies suggests moose distribution (rather than density) in the RSA may be comparable to the other study regions. The observed calf composition index in the Mount Nansen RSA was 14%, above the Yukon average of 11% reported for 2013 (O'Donoghue *et al.* 2013). The observed calf composition index was lower in the Carmacks West (5%) and Nordenskiöld (4%) surveys. These results suggest moose survival to 10 months old was high in the Mount Nansen RSA for 2013.

In spring months, moose are expected to range in low elevation riparian zones where snow melt and green-up occurs first, and cows can find safety cover near water bodies during calving season (i.e., May and June). There was a lower rate of detections for moose in spring in the LSA during the camera study, potentially due to the elevation of the Site which would provide less abundant post-wintering and calving habitats (which moose would find in riparian areas of lower elevations river corridors such as the Nisling River valley). Abundant vegetation growth in summer months allows moose to disperse to a range of habitats. Camera detection rates in summer months suggest moose visit the LSA to browse on available forage species. Few moose were detected in the LSA during fall months.

Yukon hunting regulations restrict moose harvest in GMS 5-25 and 5-43 to one bull per year per licensed hunter (Environment Yukon 2014b; Figure 6.12-4). Moose hunting in GMS 5-42 is also restricted to one bull per year and limited to a permit hunt only. The remaining GMS that overlap the RSA (5-23, 5-24 and 5-26) are closed to moose hunting. Moose harvest data provided by Environment Yukon (2014b) indicates a total of 61 moose were harvested in the past decade (2004 to 2013) from the GMS surrounding the Mount Nansen Site (Table 6.12-4; Figure 6.12-3). Across all years and subzones, the total number of harvested moose ranged from four to nine and average 6.1 moose/year. GMS 5-43 had the highest number of moose harvested ($n = 38$) over the ten-year period, followed by 5-42 ($n = 19$), while GMS 5-23, 5-24 and 5-26 had the lowest number of moose harvested ($n = 1, 2$ and 1 , respectively).

Table 6.12-4: Total Moose Harvest in Game Management Subzones Near the Local Study Area

GMS Code	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	GMS Total
5-23					1						1
5-24	1							1			2
5-25	4	2	2	1		2	1	1	1	1	15
5-26									1		1
5-42	2	1	2	1	3	3	1	2	2	2	19
5-43	2	3	3	2	4	2	3		2	2	23
Yearly Total	9	6	7	4	8	7	5	4	6	5	61

Notes: Environment Yukon 2014; unpublished data.

6.12.4.3 Bison

A wood bison (*Bison bison athabasca*) reintroduction program started in the late 1980's in Yukon as part of a national bison recovery plan, at which time approximately 170 individuals were released in the Nisling River area (Government of Yukon 2012). In 2014, the Aishihik wood bison herd was estimated to have grown to be between 1,306 and 1,684 individuals (Jung and Egli 2014). Although natural predation by wolves on bison is increasing in the Yukon, hunter harvest remains the primary method of population control, with hunters encouraged to harvest both cow and bull bison. Licensed hunters are limited to harvesting a single bison per year and require a permit to do so in each of the GMS that occur in the Mount Nansen area (Environment Yukon 2014b). The species is currently ranked by COSEWIC as special concern and is protected under Schedule 1 of SARA as a threatened species but is currently awaiting down-listing (Environment Yukon 2015).

The Aishihik wood bison herd home range extends east to the Klondike Highway, south to the Alaska Highway, north to the Nisling River and west toward Haines Junction. Annual range and key winter range wood bison WKAs have been identified south and west of and overlapping with the RSA (Figure 6.12-4). The LSA occurs at the northeastern extent of the herd's range and bison occurrence in the LSA is infrequent based on recent studies. Only four bison detections occurred in the LSA (faecal clumps in open shrub areas above Back Creek, adjacent to Dome Creek and west of the Mount Nansen public road above Victoria Creek; and bison tracks along an old road on the subalpine ridge dividing Dome Creek and Nansen Creeks) (Appendix 6F). A group of five bison were observed in the Nisling River burn located outside of the LSA, but within the RSA, during an ungulate survey in July 2012 (Figure 6.12-4).

6.12.4.4 Mule Deer

Mule deer (*Odocoileus hemionus*) occur in Yukon at the northernmost extent of their range and the population density is accordingly low. Mule deer are poorly adapted to deep snow conditions and are often found on south-aspect slopes at low elevations in river valleys or in recently burned areas. Mule deer are not known to occur in the Mount Nansen area and were not detected during baseline studies in the LSA or RSA. Accordingly, mule deer occurrence within the LSA is considered unlikely or rare.

6.12.4.5 Thinhorn Sheep

Thinhorn sheep (*Ovis dalli*) occur in mountain regions of the Yukon and use traditional areas to fulfill seasonal life history requirements, including winter range, spring lambing, early winter rut and migration corridors (Environment Yukon 2014c). There are no thinhorn sheep WKAs in the RSA that identify traditional sheep areas. No evidence of sheep was encountered during any studies performed in the Project area, and sheep occurrence within the LSA is considered unlikely or rare.

6.12.4.6 Grizzly and Black Bear

Grizzly bears are important ecologically and culturally and are considered ecological indicators because they are critical to ecosystem diversity and integrity. The western population of grizzly bear is listed by COSEWIC as a species of special concern but have no protection status under SARA. Grizzly bear range across the entire Yukon, with the exception of the southwestern territory that is characterized by the largely uninhabitable Icefield Ranges of the St. Elias Mountain Range.

Black bears were designated not at risk in Canada in 1999 by COSEWIC and defined as stable in Yukon (CESCC 2011). Black bear are distributed in Yukon from the southern portion of the territory, where they are most abundant, to treeline areas near Old Crow (Environment Yukon 2014d).

Grizzly bears and black bears in Yukon become reproductively mature at between seven and nine years old. Both bear species have a low reproductive rate, reproducing every three to four years (Environment Yukon 2014e).

Both bear species require large home ranges to fulfill dietary and life history requirements. The most limiting seasons for bears are the pre- and post-hibernation periods, during which they are recovering from, or preparing for, hibernation fast. Accordingly, key habitats are those with ample food availability at these times. Dry south-facing slopes, shrubby subalpine hillsides and creek valleys in the LSA may provide some forage plants (e.g., berry-producing shrubs, *Hedysarum spp.*, *Equisetum spp.*). Bears also will feed opportunistically on caribou or moose calves, but baseline data indicate the latter do not occur frequently in the LSA.

Nine grizzly bears and three black bears were detected in the LSA during baseline studies. Grizzly bears were only observed within the Victoria Creek valley, while black bears were observed along subalpine ridges above Dome Creek and along the powerline trail that runs parallel to Dome Creek (Appendix 6F). Bear signs (e.g., tracks, scat, and claw-marked trees) were observed in other areas of the LSA including

areas in the Dome and Pony creek valleys. Incidental observations of bear scat have occurred throughout the LSA, including at the Site. The low detection rate found for bears is likely due to their large home range requirements that results in a low population density as well as the variable forage vegetation (e.g. riparian forbs, berry-producing shrubs) across the area.

Spring and fall hunts occur for grizzly and black bear in Game Management Zone 5, Hunting regulations restrict hunters in Zone 5 to two black bears harvested per licence year and one grizzly bear harvest per three license years (Environment Yukon 2014b). Grizzly bear and black bear harvest data for GMS-26 in the Mount Nansen Site area for the ten-year period from 2004 to 2013 is presented in Table 6.12-5 (Environment Yukon 2014f). During this time period, a total of 10 grizzly bears and 11 black bears were harvested across all nearby GMSs in Zone 5, ranging from 0 to 3 bears in any one year. Grizzly bear harvest was reported in each of the Mount Nansen Site area GMS during the ten-year period and ranged from 0 to 2 bears per year across all subzones. Black bear harvest was reported in three of six GMS (5-24, 5-26 and 5-43) and ranged from 0 to 3 bears per year across all subzones. When considering all 10 years, GMS 5-23 had the highest number of harvested grizzly bears ($n = 3$) and GMS 5-24 had the highest number of black bear harvests ($n = 6$) among the data provided.

Table 6.12-5: Total Bear Harvest in Game Management Subzones Near the Local Study Area

GMS	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	GMS Total
5-23					1		1		1		3
5-24	1		2					1	1	1*	7
5-25		1							1		2
5-26	1		1		1		1			1	5
5-42	1						1				2
5-43			1	1							2
Yearly Total	3	1	4	1	2	0	3	1	3	3	21

Notes: Environment Yukon 2014b; unpublished data.

White boxes denote grizzly bear harvest; grey shade denotes black bear harvest; grey shade with asterisk denotes grizzly and black bear harvest.

6.12.4.7 Furbearers

Furbearing species occurring in the Site area include American marten, ermine (short-tailed weasel; *Mustela erminea*), fisher (*Pekania pennanti*), Canada lynx, wolverine, red squirrel (*Tamiasciurus hudsonicus*), grey wolf (*Canis lupus*), coyote (*Canis latrans*), and red fox (*Vulpes vulpes*) (Environment Yukon 2014g). Among these species, COSEWIC has indicated Canada lynx is not at risk and wolverine is listed as special concern (Table 6.12-2). Wolverine is not currently listed under SARA and is considered stable within Yukon (YCDC 2011). The remaining species listed here have not been assessed by COSEWIC.

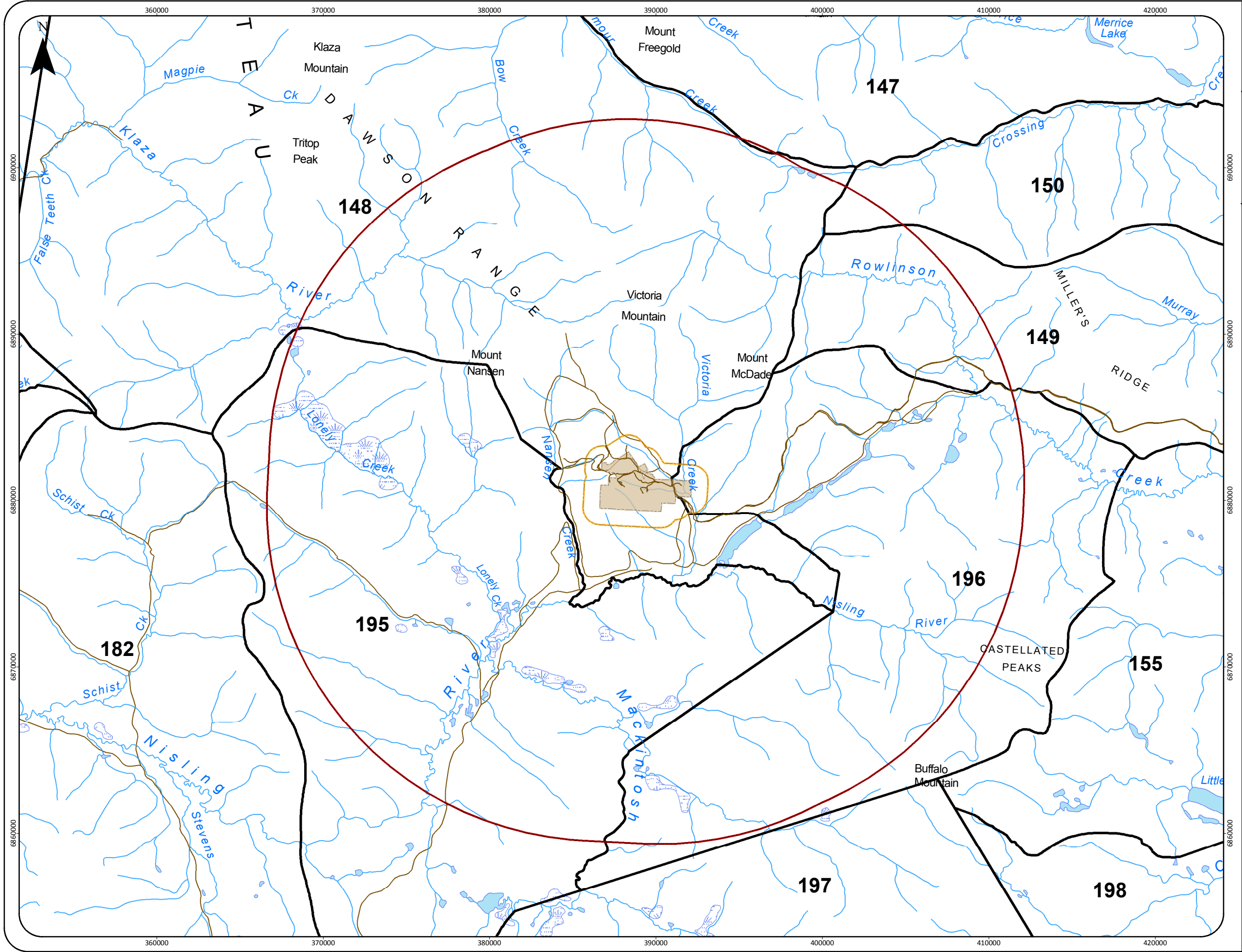
Trapping of furbearers is an important economic activity in much of Yukon. Furbearer harvest is generally permitted over the winter months, extending variably from October or November to February or March depending on the species (Environment Yukon 2014g). The RSA overlaps with seven Registered Trapping Concessions while the LSA overlaps only two, RTC 148 and 196 (Table 6.12-6; Figure 6.12-5).

Table 6.12-6: Fur Harvest in Registered Trapping Concessions Near the Site (2003 – 2012)

Species	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Species Total
Marten		2		2		4	2	4	82	34	130
Grey wolf									2	6	8
Wolverine		1			2	5	5		4	2	19
Red squirrel		17			14				1	2	34
Otter				1							1
Lynx		14	4	7	6	4	4		9	1	49
Beaver	3		2	20	37			3	2		67
Coyote							1		1		2
Arctic fox										2	2
Red fox							2		2		4
Yearly Total	3	34	6	30	59	13	14	7	103	47	316

Notes: Environment Yukon, 2014b, unpublished data.

Document Path: M:\Projects\16-249 MN CHPP\Map_Files\Chap6_EE\W\idle\2018 03 04 Figure 6.12-5 Trapping Concessions 1117.mxd



MOUNT NANSEN CARE AND MAINTENANCE PROJECT
Figure 6.12-5
Trapping Concession in Relation to the Mount Nansen Site

Road

Local Boundaries

- Order in Council Area
- Wildlife Local Study Area
- Wildlife Regional Study Area
- Registered Trapping Concessions
- Watercourse
- Wetland
- Waterbody

Data Source:
National Topographic Data Base (NTDB) compiled by Natural Resources Canada at a scale of 1:250,000. Cadastral data compiled by Natural Resources Canada. Reproduced under license from © Her Majesty the Queen in Right of Canada, Department of Natural Resources Canada. All rights reserved.

Datum: NAD 1983 CSRS UTM Zone 8N

Scale 1:220,000
Kilometers
0 6 12
March 5, 2018

6.12.4.8 Mustelids

Four mustelid (i.e., weasel family) species (i.e., wolverine, American marten, fisher and ermine) were detected in the LSA during winter months (Figure 6.12-5). A winter wildlife tracking study detected marten tracks most frequently among the mustelids. Most tracks were observed in dense conifer, with others observed in riparian shrub habitats (ELR 2012). Marten were also detected at lower densities and incidentally (i.e., not while conducting tracking surveys) in sparse conifer, shrub, wetland and disturbed habitats in the LSA. While marten are reliant on complex habitats, mature forest cover, and a suitable prey base, they sometimes are generalist in nature. LSA observations across a range of habitats are likely the product of complex habitat, thermal and snow cover, and an abundance of prey items such as red squirrel, snowshoe hare, and grouse.

Wolverine were detected four times during a remote camera study, representing at least two unique individuals (Appendix 6F). All detections occurred in late October 2012, along the low open ridge to the north of Dome Creek. Wolverine can travel long distances in search of food, and prey on small mammals (including porcupine), young or weak ungulate species, as well as scavenging on carrion. Wolverine have very large home ranges from 100 to 500 km² in size. The low detection rate of wolverine indicates they are a rare visitor to the LSA.

Fisher and ermine were detected in the LSA at low density. Ermine tracks were observed in several drainages in the LSA and occurred in dense conifer and mixed shrub/conifer habitats (ELR 2012). Fisher tracks were observed in riparian shrub habitats near Dome and Back Creek and in upland spruce stands above these creeks (ELR 2012). Fisher generally occur in mature forests with dense canopies and a high level of habitat complexity. Their detection in the LSA could suggest the presence of foraging habitat and a suitable abundance of prey items. Fishers prey on grouse, snowshoe hare, and are specialist predators on porcupine. All of these prey species were detected in several habitats within the LSA. While abundant prey may be available, reproductive denning habitat is limited within LSA and in surrounding areas. The identification of fisher tracks at the Site is of interest, as this location is outside of the current known range of fisher in Yukon (Jung and Slough 2011).

6.12.4.9 Canids

Three canid species (i.e., grey wolf, coyote and red fox) were detected at low density in the LSA. Grey wolf tracks were observed incidentally on unused road corridors during the winter tracking survey (ELR 2012), and individuals were observed in summer and fall months by remote wildlife cameras along Victoria and Dome Creek and on a subalpine ridge dividing Dome and Nansen creeks (Appendix 6F). Fox and coyote tracks were observed in the vicinity of roads and mine infrastructure (ELR 2012). These species are generalist feeders, and likely take advantage of prey species such as ptarmigan, hare, and red squirrel that may be concentrated around areas of disturbance (ELR 2012). Fox were also observed in fall months in the Dome and Victoria Creek valleys (Appendix 6F).

The infrequent detections of grey wolf, red fox, lynx and wolverine suggests these individuals move through the LSA rather than occurring as residents. These species tend to occur in low density relative to prey species, and their distribution is dependent on the availability and distribution of prey. In Yukon, wolves

prey predominantly on moose and occur in areas where moose are present. Red fox prey on small mammal species such as voles and mice and have been detected in areas (e.g., riparian zone of Dome Creek valley) that provide an abundant source of rodent prey species.

6.12.4.10 Felids

Baseline studies indicate one felid (i.e., cat family) species, Canada lynx, occurs in the LSA at low densities. One set of tracks was detected during the winter tracking survey (ELR 2012) and remote cameras captured lynx images on 10 occasions between June and September 2013 (Appendix 6F). Detections occurred primarily in the Victoria Creek valley, but two camera detections occurred along the power line that parallels lower Dome Creek. Lynx prey mainly on snowshoe hare, and winter tracking and summer pellet surveys suggest hare occur in abundance within the LSA. Lynx presence in the LSA is likely linked to the presence of snowshoe hare as a primary prey species, although they are not limited to feeding on hare.

6.12.4.11 Bird Species

Three bird studies conducted in the LSA from 2011 to 2013 have contributed to the overall understanding and knowledge of species presence, abundance and bird density in the area (Appendix 6F; EDI 2012c; Appendix 6F).

6.12.4.11.1 Breeding Bird Point Count Survey Summary

The breeding bird point count survey data from both 2011 and 2012 (Appendix 6F) provides quantitative data with good coverage of both the disturbed footprint and surrounding natural habitats. An analysis of the pooled point count data (78 100-m-radius plots, 10-minute survey period) indicated that a total of 582 individual birds, and 26 species and one unidentified species were detected (observed and/or heard).

The total number of individual birds in each plot ranged from 1 to 39 individuals and the mean number of individuals per plot was 7.46 (median = 7). The mean number of species per plot was 4.24 (median = 4). This equates to a mean of 2.38 individual birds per hectare (ha) and 0.11 species per ha when observations are pooled across all points (244.9 ha.). Species evenness across all plots was 0.046, indicating there were typically many individuals representing a relatively low number of species.

The species most commonly detected during point counts was white-crowned sparrow (*Zonotrichia leucophrys*; n = 118), followed by dark-eyed junco (*Junco hyemalis*; n = 102), Wilson's warbler (*Cardellina pusilla*; n = 89), yellow-rumped warbler (*Setophaga coronata*; n = 44), and orange-crowned warbler (*Oreothlypis celata*; n = 41).

Point count data were summarized according to six broad habitat classes at the site (Appendix 6F). The highest number of distinct species (n = 23) were detected in the spruce dominant habitat, which accounts for approximately 36% of the LSA. The second highest number of distinct species (n = 19) were detected in non-riparian shrub habitat that accounts for approximately 45% of the LSA. The third highest number of distinct species (n = 14) were detected in the riparian shrub / sedge habitat which accounts for approximately 5% of the LSA. The lowest number of distinct species (n = 4) were detected in both the mine footprint areas

(little or no vegetation) and alpine scrub areas, which account for approximately 2 % and 1.3 % of the LSA, respectively (Table 6.12-7).

Table 6.12-7: Broad Habitat Class Ranked by Number of Detected Species (All Survey Plots), 2011 – 2012

Broad Habitat Class	Approximate Proportion of LSA (%)	Number of Point Count Plots	Total Number of Detected Species	Total Number of Detected Birds
Spruce Dominant	35.8	28	23	208
Non-Riparian Shrub	45.5	29	19	234
Riparian Shrub / Sedge	4.9	8	14	56
Wetland / Fen	8.7	10	11	68
Alpine Scrub	1.3	1	4	5
Footprint (little / no vegetation)	2.0	2	4	11
Totals	98.3 ^A	78	26 ^B	582 ^C

Notes: ^A Approximately 1.7 % of the LSA includes habitats not surveyed (e.g., road surfaces, and talus slope).

^B Total number of detected species in LSA, not the sum of the column for all habitats separately.

^C A total of 582 birds were detected, of which 35 were identified only as redpoll sp. or pine siskin.

6.12.4.12 Other Bird Information and Data

Data from all bird surveys, including incidental detections, indicates a total of 42 bird species are confirmed in the LSA (Table 6.12-8), which is considerably higher than the total of 26 observed during the 2011 – 2012 surveys (Table 6.12-7).

There are no bird WKAs within the LSA, and only one WKA for gyrfalcon (*Falco rusticolus*) occurs within the RSA. This WKA indicates gyrfalcon habitat exists in the vicinity of Victoria Mountain, northeast of the LSA (Environment Yukon 2013; Figure 6.12-6). Gyrfalcons were not detected during the bird surveys. The species prefers tundra, and rock escarpments, which are limited in the LSA.

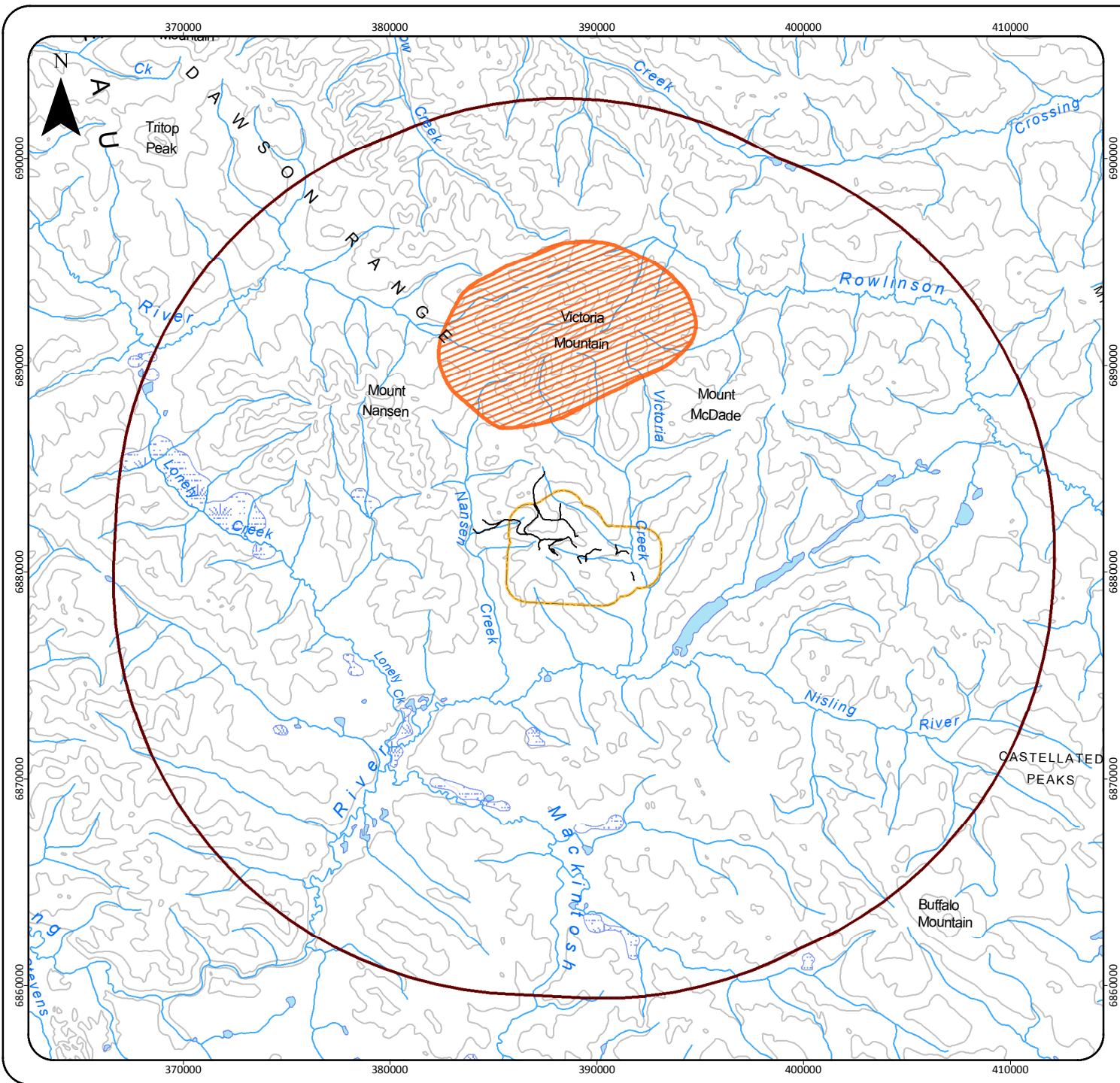
Table 6.12-8: Bird Species Confirmed to Occur in the Local Study Area

Common Name	Scientific Name	Number of Observations from 2011 – 2013 ^C
White-crowned sparrow	<i>Zonotrichia leucophrys</i>	151
Dark-eyed junco	<i>Junco hyemalis</i>	118
Wilson’s warbler	<i>Cardellina pusilla</i>	78
Orange-crowned warbler	<i>Oreothlypis celata</i>	55
Yellow-rumped warbler	<i>Setophaga coronata</i>	45
Cliff swallow	<i>Petrochelidon pyrrhonota</i>	40
American kestrel	<i>Falco sparverius</i>	39
Gray jay	<i>Perisoreus canadensis</i>	42
American tree sparrow	<i>Spizella arborea</i>	34
American robin	<i>Turdus migratorius</i>	25
Common redpoll	<i>Carduelis flammea</i>	20
Boreal chickadee	<i>Poecile hudsonicus</i>	13
Swainson’s thrush	<i>Catharus ustulatus</i>	12
Alder flycatcher	<i>Empidonax alnorum</i>	11
Lincoln sparrow	<i>Melospiza lincolnii</i>	10
Spruce grouse	<i>Falcapennis canadensis</i>	10
Spotted sandpiper	<i>Actitis macularius</i>	10
Olive-sided flycatcher ^A	<i>Contopus cooperi</i>	9
Townsend’s solitaire	<i>Myadestes townsendi</i>	8
Pine siskin	<i>Carduelis pinus</i>	7
Blackpoll warbler	<i>Setophaga striata</i>	5
Willow ptarmigan	<i>Lagopus lagopus</i>	5
White-winged crossbill	<i>Loxia leucoptera</i>	5
Golden eagle ^B	<i>Aquila chrysaetos</i>	4
Say’s phoebe	<i>Sayornis saya</i>	4
Common yellowthroat	<i>Geothlypis trichas</i>	3
Northern flicker	<i>Colaptes auratus</i>	3
Ruby-crowned kinglet	<i>Regulus calendula</i>	2
Western wood peewee	<i>Contopus sordidulus</i>	2
Common raven	<i>Corvus corax</i>	1
Horned lark	<i>Eremophila alpestris</i>	1
Northern harrier	<i>Circus cyaneus</i>	1
Rock ptarmigan	<i>Lagopus muta</i>	1
Red-tailed hawk	<i>Buteo jamaicensis</i>	1
Savannah sparrow	<i>Passerculus sandwichensis</i>	1
Tennessee warbler	<i>Oreothlypis peregrina</i>	1
Upland sandpiper	<i>Bartramia longicauda</i>	1
Violet-green swallow	<i>Tachycineta thalassina</i>	1
Yellow warbler	<i>Setophaga petechia</i>	1
Tundra swan	<i>Cygnus columbianus</i>	1
Common nighthawk ^A	<i>Chordeiles minor</i>	1

Notes: ^A Identified as Threatened by both SARA (Government of Canada, 2012) and COSEWIC (COSEWIC, 2007a,b)

^B Identified as Vulnerable by NatureServe Canada (2013)

^C Total number of observations are the sum of point-count and encounter surveys, and incidental observations.



MOUNT NANSEN CARE AND MAINTENANCE PROJECT

Figure 6.12-6

Bird Wildlife Key Areas in the RSA



Local Boundaries

- Wildlife Local Study
- Wildlife Regional Study
- Gyrfalcon Reproductive/Nesting Wildlife Key Area

Base Layers

- Road
- Watercourse
- Topographic Contour (150 m Interval)
- Waterbody

Data Source:

1. Wildlife Key Areas accessed from Yukon Government - Geomatics Yukon, Corporate Spatial Warehouse: www.geomaticsyukon.com.
2. Mount Nansen Access Road digitized by ELR.
3. National Topographic Data Base (NTDB) compiled by Natural Resources Canada at a scale of 1:250,000. Reproduced under license from © Her Majesty the Queen in Right of Canada, Department of Natural Resources Canada. All rights reserved.

Datum: NAD 1983 CSRS UTM Zone 8N

Scale 1:275,000

Kilometers



March 5, 2018

Based on the bird surveys conducted in 2011 and 2012, including incidental observations, three species of conservation concern are confirmed to occur within the LSA, including the olive-sided flycatcher (*Contopus cooperi*), common nighthawk (*Chordeiles minor*) and golden eagle (*Aquila chrysaetos*) (Table 6.12-8). Olive-sided flycatchers inhabit sparse spruce forests associated with rivers, bogs and swamps (COSEWIC 2007a) that exists within the LSA. Common nighthawks inhabit open areas and even disturbed habitats (COSEWIC 2007b). These habitats include boreal high bogs and alpine short-shrub and dry shrub habitats that can be found in the LSA. Golden eagle is a bird of prey with a home range of upwards of 200 km², relying on high cliffs and rock outcrops for both nesting and hunting (Alexander *et al.* 2003), habitats that are scarce in the LSA.

Three additional raptor species are known to occur in the LSA besides golden eagles (Table 6.12-8): American kestrels (*Falco sparverius*), northern harrier (*Circus cyaneus*) and red-tailed hawk (*Buteo jamaicensis*). American kestrels are a common migratory species in open spruce and mixed wood forests in subalpine and boreal habitats, as well as bogs and grasslands in alpine habitats such as those in the LSA. Northern harriers typically occur in open bogs, grasslands and dry alpine habitats. Red-tailed hawks prefer the open and semi-open coniferous forests that provide both nesting and hunting habitats where their preferred prey of Arctic ground squirrel (*Spermophilus parryii*) and other small rodents are present (Alexander *et al.* 2003).

6.12.4.13 Small Mammals

Small mammals are an integral component of the ecosystem food web as many are prey species for land-based carnivores and raptors. The following small mammal species have been observed in the LSA (EDI 2006; Appendix 6F):

- Red squirrel (*Tamiasciurus hudsonicus*);
- Snowshoe hare;
- Northern red-backed vole (*Clethrionomys rutilus*);
- Porcupine (*Erethizon dorsatum*);
- Masked shrew (*Sorex cinereus*); and
- Arctic ground squirrel (*Spermophilus parryii*).

Red squirrel were commonly observed in the LSA in a wide variety of habitats. Red squirrel was the most frequently detected species during a 2012 winter tracking study (ELR 2012; Appendix 6F). Track densities were highest in broadleaf forest, coniferous riparian forests and coniferous forest habitats. Red squirrel generally has a preference for mature conifer forests (spruce, pine) as these habitats provide a more consistent supply of cones for food, and thermal and visual cover, as well as a thick canopy for movement above ground.

Snowshoe hare signs were observed in the LSA in low densities in deciduous and mixed wood forest during the summer pellet surveys. During winter tracking surveys, tracks occurred in coniferous riparian forests and along old roads. Snowshoe hare signs were also recorded in open coniferous forests above Dome and Victoria creeks by remote wildlife cameras.

Porcupine were observed in the LSA solely within in dense, dry coniferous forests. Porcupine likely spend a large proportion of time feeding in trees or in dens and may not move large distances in deep snow conditions on a regular basis. Porcupine tracks and evidence of feeding were noted incidentally in dense coniferous forest between the pit and tailings areas during the winter track survey (Appendix 6F). Remote wildlife cameras recorded porcupine on dry open coniferous forest ridge above Dome Creek and lower Victoria Creek, along a power line, near Back Creek in mixed wood forests and in an old exploration trench south of the Site (Appendix 6F).

The northern red-backed vole, masked shrew, and Arctic ground squirrel were also observed within the LSA. These species were observed during a contaminant-related study in 2005 (EDI 2006), and pellet and snow tracking surveys completed in 2012 (ELR 2012; Appendix 6F). A low density of mice and vole tracks were observed in sparse coniferous forest habitats during snow tracking surveys (Appendix 6F). Arctic ground squirrel were observed incidentally during a faecal pellet survey in 2012 (Appendix 6F).

The collared pika (*Ochotona collaris*) lives in talus slopes or patches in alpine areas (Kukka *et al.* 2014). This habitat within the LSA is limited to the rounded summit of Dome Mountain. Collared pika are not known to occur in the Mount Nansen LSA and were not detected while conducting baseline studies. For these reasons, pika occurrence within the LSA is considered unlikely.

6.12.4.14 Amphibians and Reptiles

Although wood frog (*Rana sylvatica*) is the only likely amphibian species known to occur in the LSA (Environment Yukon 2005), this species was not observed during any surveys or incidentally. Wood frog is secure both territorially and federally, and if present, is not anticipated to be abundant in the LSA. There are no known reptile species in Yukon (Canadian Amphibian and Reptile Conservation Network 2012).

6.13 Vegetation

6.13.1 Introduction

Vegetation at the Site was classified within a defined Local Study Area (LSA) using broad and localised classification of different land cover types. Vegetation was also assessed for contaminant loading to determine baseline tissue concentrations of metals. The LSA includes the OIC area, plus a 1 km buffer, for a total area of 3,109 hectares (ha). This area was considered suitable for describing local existing vegetation conditions, and for establishing potential effects within and beyond the Project footprint.

The Ecological Landscape Classification (ELC) program completed between 2012 and 2014 identified three bioclimate zones in the LSA: 1) boreal high; 2) subalpine; and 3) alpine (ELR 2016; Figure 6.13-1). The boreal high is the largest bioclimate zone in the LSA, occurring in mountain valleys and plateaus from approximately 450 meters above sea level (masl) to 1,100 masl. This zone consists largely of coniferous and mixed wood forest associations influenced by frequent fires. The subalpine zone occurs at elevations above the boreal high, occurring between 1,100 masl and 1,500 masl. Trees are more sparse in these areas, with shrub associations becoming more common. The alpine zone consists of non-forested landscapes found in the highest elevations of the LSA, above 1,500 masl. The three bioclimate zones identified in the ELC program were further delineated into major landscape types made up of ecosites. Ecosites are determined by a number of factors, including the dominant tree, shrub, herb and non-vascular plant species that occur within the LSA and also include non-vegetated land cover types (e.g., anthropogenic land cover such as mining related terrain and roads). Figure 6.13-1: Ecological Landscape Classification Map and Table 6.13-1 presents a summary of the ecosites within the LSA.

The Scrub birch - Labrador tea - Feathermoss was the most common ecosite mapped within the LSA, making up approximately 30% (915 ha) of the total area and occurring primarily within the Subalpine bioclimate zone. The next most common ecosite was the White spruce - Labrador tea - Feathermoss upland forest type, which made up almost 18% (552 ha) of the LSA, split almost evenly between the Subalpine and Boreal High bioclimate zones. Wetland types were also quite common within the LSA, making up almost 13% (390 ha) of the total area, and Scrub birch - Labrador tea - Sphagnum ecosite making up almost 10% of the LSA (308 ha).

Anthropogenic ecosites are a relatively high proportion of the LSA, making up over 14% (444 ha) of the area. The most extensive anthropogenic type was the Exploration Trenching ecosite, comprising almost 9% (273 ha) of the Mount Nansen LSA.



Mount Nansen Care and Maintenance Project

Figure 6.13-1
Ecological Landscape Classification Map

Bioclimate

ALP

BOH

SUB

roads

trails

Streams_50K

Legend

N

100 50 0 100 200 300 400 500 m

NAD83 Datum UTM8N Projection
Map Scale 1:10,000

March 9, 2018

Map Source/Notes:

Natural features from Yukon Government, Ortho Imagery and map features provided by Mount Nansen Mine. Original ecovite data provided by Beckingham Environmental Ltd. Ecovite and bioterrain data adjustments and mapping by Ardea Biological Consulting Ltd. Smithers BC, May 2016.

This project provides detailed ecosystem mapping of the Mount Nansen Mine Site located in west central Yukon. Mapping was completed following the methods outlined in Standard for Terrestrial Ecosystem Mapping in British Columbia (RIC 1998) and the Yukon Ecological and Landscape Classification (ELC) Program: Five Year Strategic Plan (ELCSC 2013).																	
Ecovite Unit Label																	
Ecovite Code Component 1 Component 2 Ecovite Modifier Structural Stage 1 Structural Modifier Stand Type Structural Stage 2																	
Ecovite					Bio-Climatic Units												
kp: Klondike Plateau					BOH kp: Boreal High Klondike Plateau SUB kp: Subalpine Klondike Plateau ALP kp: Alpine Klondike Plateau												
Ecovite Modifiers																	
Code		Description															
a		Active floodplain															
d		Deep soils (>100 cm)															
e		Cryoturbation occurs within the site															
g		Gullied Terrain															
i		Permafrost occurs within the site															
j		Gentle slope (< 25%)															
k		Cool aspect (285° to 135°) on 25% to 100% slope															
o		Seepage found in site															
p		Peat material / organic soils															
s		Shallow soils (20 - 100 cm)															
t		Glacioluvial terrace															
v		Very shallow soils (< 20 cm)															
w		Warm aspect (135° to 285°) on 25% to 100% slope															
Structural Stage																	
Code		Structural Stage															
1		Sparsely/Bryoid		1a		Sparse		1b		Bryoid							
2		Herb		2a		Forb-dominated		2b		Graminoid-dominated							
2c		Aquatic		2d		Dwarf Shrubs											
3		Shrub/Herb		3a		Low Shrub (<2m tall)		3b		Tall Shrub (2-10m tall)							
4		Pole/Sapling		>10m tall, usually greater than 10-15 yrs old													
5		Young Forest (generally 40-80 yrs but may begin as early as age 30)															
6		Mature Forest (80-250 yrs old)															
7		Old Forest (>250 yrs old)															
ALP kp Alpine - Klondike plateau subzone																	
Map Code		Ecovite Name						Site Description		SMR		SNR					
BL		Scrub birch - Labrador tea - Feathermoss						Scrub birch - Labrador tea - Feathermoss shrublands are common throughout LSA on cold, moderately-well drained less-rich colluvial veneers over weathered bedrock. Soils are typically Turbic Cryosols with resultant hummocky micro-topography. The shrub, herb and moss layers are extensive.						3-4		A-B	
BT		Scrub birch - Two-tone sedge - Lichen						Scrub birch - Two-tone sedge - Lichen Alpine Tundra occurs on weathered bedrock and colluvium primarily in the Alpine but extends into the Subalpine subzone. Soils are typically well-drained Turbic Cryosols with hummocky micro-topography. The shrub, herb and moss layers are extensive with diverse and well-developed lichen cover where the ground surface has been recently disturbed by frost boils.						3-5		A-B	
MA		Mountain avenes						Mountain avenes Alpine Tundra occurs in crest positions in the rolling Alpine and into the Subalpine over weathered bedrock where soils development is limited. Broken bedrock may make up 50% of ground cover. Mountain avenes (Dryas integrifolia) is the dominant herb.						1-2		A-B	
SUB kp Subalpine - Klondike plateau subzone																	
Map Code		Ecovite Name						Site Description		SMR		SNR					
AK		Al - Kinnikinnick						Trembling aspen - Kinnikinnick are uncommon and restricted to steep warm-aspects on thin rocky colluvial veneers over bedrock. Soils are typically rapidly-drained Eutric Brunisols and are permafrost-free. Trembling aspen, stunted by drought, is dominant in the overstory with a well developed and diverse shrub and herb layer. Moss and lichen cover is scant.						1-2		B-C	
BL		Scrub birch - Labrador tea - Feathermoss						See Description in Alpine						3-4		A-B	
BT		Scrub birch - Two-tone sedge - Lichen						See Description in Alpine						3-5		A-B	
KB		Kinnikinnick - Arctic bramble - Alta fescue						Kinnikinnick - Arctic bramble - Alta fescue dwarf shrub - grassland communities are very uncommon, small and localized, on south-facing, weathered bedrock outcrops with shallow colluvial veneers, and on eolian deposits. Rapidly-drained Brunisols soils are typical. This ecovite occurs in association with Al - Kinnikinnick and Sw - Kinnikinnick ecovites						1-2		A-B (C)	
SF		Sw / AI - Feathermoss						White spruce (Trembling aspen) - Feathermoss Upland Forests are restricted to warm aspects, on well-drained coarse-textured colluvium and on glacioluvial terraces that are not affected by cold-air drainage. Soils are Brunisols and are permafrost-free. Stands are dominated by robust white spruce and a lesser component of trembling aspen. The shrub, herb and moss layers are not well developed.						3-4		C	
SH		Sw - Horsetail						White spruce - Horsetail - Feathermoss forests are restricted to moderately to imperfectly-drained, silty/sandy fluvial materials subject to sub-surface seasonal flooding. Soils are Regosols and Cryosols with permafrost present within 1 m of soil surface. Relatively large white spruce grow on elevated microsites. A limited shrub layer, but moderate herb and moss layer are present.						5		C-D	
SK		Sw - Kinnikinnick						White spruce - Kinnikinnick forests are very uncommon, small and localized on rapidly-drained, warm, upper slope positions underlain by weathered bedrock with shallow colluvium, and on eolian deposits. Well to rapidly-drained Brunisols soils are typical, with permafrost absent or deep. These stands are open canopied with This ecovite occurs in association with Kinnikinnick - Arctic bramble - Alta fescue and Al - Kinnikinnick ecovites.						2		B-C	
SL		Sw - Labrador tea - Feathermoss						White spruce - Labrador tea - Feathermoss Upland Forests are widespread in the LSA, occurring on moderate to imperfectly-drained colluvium, and occasionally on glacioluvial terraces. The ecovite is always affected by cryoturbation and cold-air drainage, with permafrost present at variable depths. The open canopy is dominated by white spruce and has moderate shrub, herb and moss layers.						4-5		A-B	
SS		Scrub birch - Labrador tea - Sphagnum						Scrub birch - Labrador tea - Sphagnum Poor Fens are widespread on gradual seepage slopes and frost prone basins of the BOH (and lower SUB) on poorly-drained less-rich colluvial aprons (internal "muck") and blankets. These sites often have a thin veneer of organics (< 40 cm). These sites are strongly cryoturbated, with the resulting micro-topography consists of frost hummocks with moist depressions. Seepage was evident within 30 cm of the soil surface. Permafrost is relatively shallow. The shrub and herb layer are moderate, with an extensive, thick moss and lichen layer.						7		A-B	
SW		Sw - Willow - Feathermoss						White spruce - Willow - Feathermoss forests occur on warm aspects on moderately to well drained colluvium transported down slope by soil creep and sheet wash. Soils are coarse textured Eutric Brunisols and Cryosols. This ecovite is characterized by open-grown white spruce and extensive shrub and moss - lichen layer.						4-5		B-C	
WF		Willow - Labrador tea - Feathermoss						Willow - Scrub birch - Labrador tea - Feathermoss shrublands are common throughout the Subalpine, generally on warm, moderately-well drained less-rich colluvial veneers over weathered bedrock. Soils are typically Turbic Cryosols with resultant hummocky micro-topography. Willows dominate the shrub layer and the moss layer contains various feathermoss and lichen species.						4		B-C	
WS		Willow - Water sedge Swamp / Fen						The Grey-leaved willow - Sedge Swamp/Fen ecovite occurs along small to large creeks in the study area where groundwater flow occurs. A peaty veneer accumulates and the soil is cold, with permafrost within 50 cm of the surface. Soils are Regosols and Cryosols. The shrub layer typically consists of Grey-leaved willow (Salix glauca) and tea-leaved willow (Salix planifolia). The herb and moss layers are diverse and extensive.						6		C-D	
Non-vegetated, sparsely vegetated, and anthropogenic sites																	
Map Code		Ecovite Name						Description									
EP		Exploration Pit						Area cleared for exploration to find mineral ore and other materials.									
ET		Exploration Trench						Trench cleared for exploration to find mineral ore and other materials.									
OP		Open Pit						Area cleared for open pit mining of mineral ore and other materials.									
PM		Placer Mining						Area cleared for placer mining operations of mineral ore and other materials.									
RI		River						A watercourse formed when water flows between continuous, definable banks.									
RO		Rock Outcrop						A gentle to steep, bedrock escarpment or outcropping, with little soil development and sparse vegetative cover.									
RS		Road Surface						An area cleared and compacted for the purpose of transporting goods and services by vehicles.									
TA		Talus						Angular rock fragments of any size accumulated at the foot of steep rock slopes as a result of successive rock falls. It is a type of colluvium.									
TP		Tailings Pond						Primarily within the Subalpine.									

BOH kp Boreal High - Klondike plateau subzone				
Map Code	Ecovite Name	Site Description	SMR	SNR
BL	Scrub birch - Labrador tea - Feathermoss	See Description in Alpine	3-4	A-B
KB	Kinnikinnick - Arctic bramble - Alta fescue	See Description in Subalpine	1-2	A-B
SE	Sedge Fen/Marsh	Sedge fen/marshes are uncommon in the study area and were not well-sampled. This ecovite commonly occurs in association with Willow - Sedge ecovites, on peaty veneers in the cold valley bottom of the Dome Creek drainage. Permafrost is within 50 cm of the soil surface. Water sedge (Carex aquatilis), sphagnum mosses and brown mosses are prominent.	7	C-D
SF	Sw / AI - Feathermoss	See Description in Subalpine	3-4	C
SH	Sw - Horsetail	See Description in Subalpine	5	C-D
SK	Sw - Kinnikinnick	See Description in Subalpine	2	B-C
SL	Sw - Labrador tea - Feathermoss	See Description in Subalpine	4-5	A-B
SS	Scrub birch - Labrador tea - Sphagnum	See Description in Subalpine	7	A-B
SW	Sw - Willow - Feathermoss	See Description in Subalpine	4-5	B-C
WS	Willow - Water sedge Swamp / Fen	See Description in Subalpine	6	C-D

Table 6.13-1: Summary of Ecosite Areas within the Mount Nansen LSA

Broad Type	Map Code	Ecosite Name	Area in Alpine (ha)	Area in Subalpine (ha)	Area in Boreal High (ha)	Total Area in LSA (ha)	% of Total Area
Upland	AK	Trembling aspen - Kinnikinnick		20.4		20.4	0.66
	BL	Scrub birch - Labrador tea - Feathermoss	1.2	0.4	11.8	11.8	0.38
			3.2	735.0	163.7	901.9	29.02
	BT	Scrub birch - Two-tone sedge - Lichen	24.0	4.1		28.1	0.90
			12.9			12.9	0.42
	KB	Kinnikinnick - Arctic brome - Altai fescue		11.7	0.3	12	0.39
				6.9		6.9	0.22
	MA	Mountain avens	6.2	0.4		6.6	0.21
	RO	Rock Outcrop	3.0	0.7		3.7	0.12
	SF	White spruce / Trembling Aspen - Feathermoss			3.3	3.3	0.11
				64.8	6.8	71.6	2.30
				43.9	22.6	66.5	2.14
	SH	White spruce - Horsetail		6.6	0.8	7.4	0.24
					0.3	0.3	0.01
					6.0	6	0.19
					24.8	24.8	0.80
	SK	White spruce - Kinnikinnick			0.8	0.8	0.03
				20.4	7.2	27.5	0.88
					19.3	19.3	0.62
	SL	White spruce - Labrador tea - Feathermoss		7.6	4.0	11.6	0.37
				53.2	82.5	135.7	4.37
				62.5	2.2	64.7	2.08
				54.5	35.6	90.1	2.90
	SW	White spruce - Willow - Feathermoss		120.6	129.4	250	8.05
				84.7		84.7	2.73
	TA	Talus		111.2	6.7	117.9	3.79
			4.1	0.5		4.6	0.15
	WF	Willow - Labrador tea - Feathermoss		249.5		249.5	8.03
				21.3		21.3	0.69
Wetland	SE	Sedge Fen			25.4	25.4	0.82
	SS	Scrub birch - Labrador tea - Sphagnum		141.3	158.4	299.7	9.64
				5.7	3.3	9.0	0.29
	WS	Willow - Water sedge Swamp / Fen		18.2	9.9	9.9	0.32
Water	RI	River			28.5	46.7	1.50
					9.2	9.2	0.30
Anthropogenic	EP	Exploration Pit	1.3	19.0	0.9	21.2	0.68
				15.4		15.4	0.50
	ET	Exploration Trench	2.7	4.2	3.9	10.8	0.35
			0.7	71.2	10.8	82.7	2.66
				174.4	4.7	179.1	5.76
	OP	Open Pit Mining		30.7		30.7	0.99
				1.2		1.2	0.04
	PM	Placer Mining		20.7	6.8	27.5	0.88
					8.0	8.0	0.26
				20.9	7.1	28.0	0.90
	RS	Road		15.3	5.1	20.4	0.66
					0.7	0.7	0.02
	TP	Tailings Pond		16.2	2.2	18.4	0.59
Total			59.20	2,235.50	812.8	3,107.5	100.00

6.13.2 Rare Plants and Plant Species of Conservation Concern

The LSA provides suitable habitat for 21 rare or at-risk plant species identified by Nature Serve Canada and through consultation with Government of Yukon botanist, Bruce Bennett (Table 6.13-2; YCDC 2012).

Rare plant surveys completed in 2012 and 2013 (Appendix 6F) focused on areas anticipated to be disturbed during future remediation activities, specifically around existing infrastructure within the OIC. Surveys included systematically working through identified areas in both meandering and patterned searches (ANPC 2000). Specimens requiring positive identification were confirmed with the aid of a Yukon floristic key (Cody 1996) or submitted to Bruce Bennett for identification.

Table 6.13-2: Plant Species of Conservation Concern Potentially Occurring within the LSA

Common Name	Scientific Name	Habitat Requirements	Yukon Conservation Data Centre Ranking*	Federal Species at Risk Status
Aleutian cress	<i>Aphragmus eschscholtzianus</i>	Alpine tundra, heath and solifluction areas by rivulets.	S2S3	
Arctic thrift; Sea-pink	<i>Armeria maritime ssp. sibirica</i>	Wet areas on tundra (and coastal sand dunes).	S2	
Alaska moonwort	<i>Botrychium alaskense</i>	Gravel.	S2S3	
Alpine springbeauty	<i>Claytonia megarhiza</i>	Alpine tundra, base of scree slope near streams.	S1	
Ogilvie Mountain springbeauty	<i>Claytonia ogilviensis</i>	Alpine slopes and talus.	S2S3	Candidate
Scamman's springbeauty	<i>Claytonia scammaniana</i>	Alpine tundra, talus and scree slopes on serpentine rivers.	S3	
Arctic larkspur	<i>Delphinium brachycentrum</i>	Alpine meadows and valleys.	S1S3	
Star-flowered draba	<i>Draba stenopetala</i>	Alpine scree and turf slopes.	S2	Candidate
Umbrella plant; Yellow buckwheat	<i>Eriogonum flavum var. aquilinum</i>	Sandy and gravelly slopes.	S1S2	Candidate
Bristle-like quillwort	<i>Isoetes echinospora</i>	Silty lake or pond margins; often submerged.	S1	
Spiked saxifrage	<i>Micranthes spicata</i>	Shady cool creek sides usually under birch and alder. Often associated with late season overflow ice.	S1S2	Candidate
Merten's locoweed	<i>Oxytropis mertensiana</i>	Moist alpine slopes and gravel bars.	S1S2	Candidate
MacBrides' phacelia	<i>Phacelia mollis</i>	Dry sandy or rocky slopes and turf tundra.	S2S3	
Macoun's podistera	<i>Podistera macounii</i>	Dry alpine heath and stony slopes.	S2S3	
Yukon woodroot	<i>Podistera yukonensis</i>	Talus slopes and cliff crevices.	S2	Under Review
Arctic primrose	<i>Primula eximia</i>	Wet meadows and stream banks.	S2S3	
Arctic glasswort	<i>Salicornia borealis</i>	Alkaline flats.	SNR	Candidate

Common Name	Scientific Name	Habitat Requirements	Yukon Conservation Data Centre Ranking*	Federal Species at Risk Status
Porsild's smelowskia	<i>Smelowskia porsildii</i>	Alpine ridges and scree slopes.	S1S2	
Matted starwort	<i>Stellaria dicranoides</i>	Calcareous scree slopes at high altitudes.	S1S2	Candidate
Twin-flowered violet	<i>Viola biflora</i> ssp. <i>biflora</i>	Alpine meadows.	S3	
Horned pondweed	<i>Zannichellia palustris</i>	Shallow water along edge of pond.	S1S3	

Notes: *S1 – Critically Imperiled S2 – Imperiled S3 – Vulnerable SNR – Unranked (not yet assessed)

Three rare plant species associated with mountainous terrain that potentially occur within the Mount Nansen area were identified by the Canadian Wildlife Service (Syd Cannings, personal communication, July 23, 2012):

1. Yukon podistera (*Podistera yukonensis*).
2. Ogilvie Mountain spring beauty (*Claytonia ogilviensis*).
3. Porsild's smelowskia (*Smelowskia porsildii*).

None of the three species listed above or any of the species identified as rare plants or species of conservation concern by the Yukon Conservation Data Centre (YCDC) were located during any of the vegetation surveys. Very few areas within the LSA were characterized as habitats suitable for the three rare plant species listed above (i.e., alpine areas, rocky outcrops or talus slopes), although considerable time was spent searching these small areas.

6.13.3 Metal Transport and Deposition

The transport and deposition of metals through wind activity has been considered as it relates to existing key mine infrastructure (i.e., TSF, Brown McDade Pit, and mill). Data collected from the Site suggests that some metals present in ore, waste rock, and tailings, and also potentially from process chemicals used during operations, have and may continue to be deposited in the vicinity of the Site.

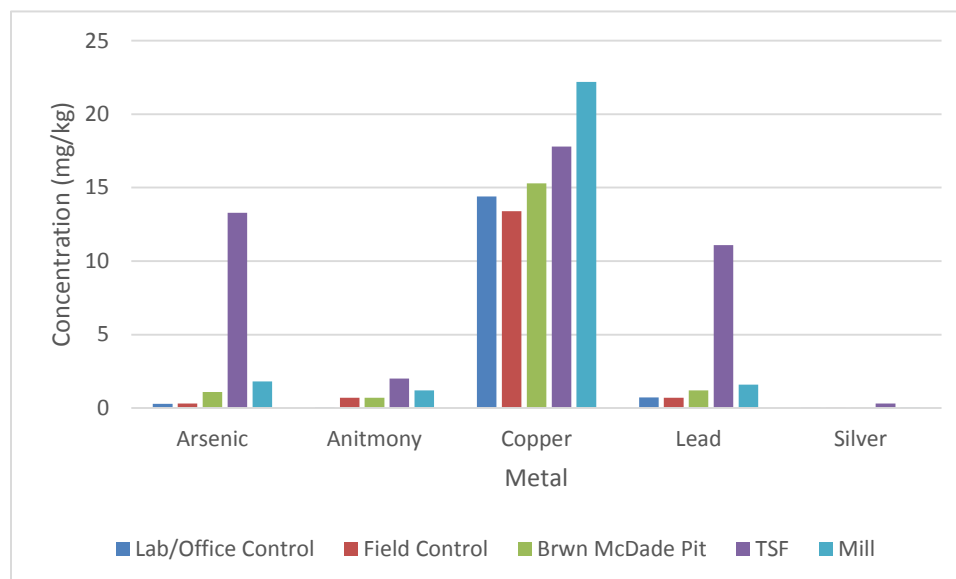
Three previous studies have provided information to describe metals transport and deposition:

- A study of metals deposition in moss bags in 2005 and 2006 (EDI 2007);
- A study of metals in vegetation tissue in 2005 and 2006 based on transects oriented around existing Site infrastructure and related controls (EDI 2006); and
- A study of metals in vegetation tissue and soils in 2013 based on a grid of points across the Project area and related controls (APPENDIX 6F).

Evidence of both existing and historical metals deposition in relation to mine infrastructure was provided in the studies, and instances of elevated metals were also observed in areas where there was no clear

relationship with past mining activities or infrastructure (such as control/reference sites established in studies).

The most relevant Site data related to aerial metals deposition from fugitive dust is from moss bag studies conducted from 2005 to 2006 (EDI 2007). These studies demonstrated that in 2005 and 2006 that there was some dispersion and deposition of metals occurring from existing mine infrastructure sites, but only for certain metals. The study looked at three time periods – winter, spring to early summer, and late summer to fall. Observed results were greatest for the spring to early summer period, with arsenic and lead being the metals detected at highest concentrations; around the TSF, but to a lesser extent around the mill and Brown McDade Pit. Cases of elevated antimony, silver, and cadmium were also observed. During the summer to early fall period, the mean metal concentrations for each area followed a similar trend to the spring to early summer results, with lead, antimony, arsenic and silver levels being highest around the tailings pond, but not as highly elevated as the spring to early summer results. In most cases where specific site data were available, deposition levels were found to be highest east or southeast of the TSF. Despite metals being deposited, only levels of lead from the spring to early summer survey (from the TSF) were found to have exceeded maximum tolerable levels (MTL) for rodents; by roughly 10% (11.1 mg/kg mean value compared to the MTL of 10 mg/kg; National Research Council 2005). Figure 6.13-2 provides the spring to early summer moss bag results for arsenic, antimony, copper, lead, and silver (EDI 2006).



Note: Figure produced from data in EDI (2006).

Figure 6.13-2: Results of Spring to Early Summer 2006 Moss Bag Metals Deposition Study Results

Lichen tissue sampling was conducted in 2005/2006 and in 2013 and suggested that levels of several metals were in some cases elevated around mine infrastructure, including antimony, arsenic, cadmium, copper, lead, and silver. Clear positive relationships between proximity to infrastructure and concentration were shown for silver (mill only), lead (mill and TSF), arsenic (mill, TSF, and Brown McDade Pit), antimony (mill, TSF, and Brown McDade Pit), and copper (TSF). Concentrations in a number of cases were elevated

relative to reference or control sites, but without a clear indication of whether they could cause effects. The 2013 analysis of lichen tissues found that only a select number of samples had elevated tissue concentrations that exceeded the MTL for rodents and cattle. Of 43 test sites, there were exceedances at two sites for aluminum for rodents and cattle, an exceedance at one site for arsenic for rodents and cattle, an exceedance of at one site for lead for rodents only, and exceedances at 11 sites for iron for rodents and cattle. These results demonstrate that while some metals are elevated in lichen tissues in some areas compared to background concentrations, the actual values in lichen tissue rarely exceed accepted feed levels for rodents or cattle (i.e., the MTLs). Furthermore, the collection of lichen tissue represents an accumulation of metals over time because lichens are slow growing and long-lived plants, and so the metals concentrations likely represent both the recent past and the period when the mine was operating, and it is not possible to separate the results into mining and post-mining periods.

Berry and willow tissue were both sampled in the 2005/2006 and 2013 studies. Both studies found that certain metals were elevated in relation to background concentrations. The results of the 2013 study found the only MTL exceedances were for cadmium and iron in willow tissue (one sample site each). No MTL exceedances were detected for berry tissue (Table 6.13-3).

Table 6.13-3: Number of Sites Exceeding the MTL Limit for Rodents and/or Cattle (2013) in Plant Tissue*

Metal	Aluminum		Iron		Copper		Lead		Arsenic		Zinc	Cadmium		
MTL Category	Rodents	Cattle	Rodents	Cattle	Rodents	Cattle	Rodents	Cattle	Rodents	Cattle	Rodents	Cattle	Rodents	Cattle
Lichen	2 ^A	2 ^A	11 ^B	11 ^B	0	0	1	0	1	1	0	0	0	0
Willow	0	0	1	1	0	0	0	0	0	0	0	0	1	1
Berry	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Notes: *Numbers exclude the control sites.

^A Exceedances of MTL concentrations for rodents were also detected at three of the four control sites.

^B Exceedances of MTL concentrations for rodents and cattle were also detected at three of the four control sites.

In general, the results of the studies indicate that although the concentrations of many metals in soil and plant tissue on Site are higher than background levels, most metals concentrations do not exceed the MTL for rodents. In some cases, the background control concentrations of some metals are comparable to the plant tissue concentrations at the Site (e.g., iron, aluminum).

7 Environmental Effects Assessment

7.1 Introduction and Scope

This section describes the environmental effects assessment conducted for the Project. Section 7.1 provides an introduction to the approach and scope of the environmental effects assessment, while the methods used are described in Section 7.2. The assessment of the Project's potential environmental effects and its results are detailed in Section 7.3.

7.1.1 Valued Environmental Components

The environmental effects assessment employs a valued component-based approach that is consistent with guidance provided in YESAB's Proponent's Guide to Project Proposal Submission to a Designated Office (YESAB 2010). This approach focuses the assessment on key interactions between the Project components and elements of the environment that are valued for environmental, scientific, social, aesthetic, or cultural reasons (valued components or VCs). The screening method used to select VCs is outlined in Section 7.2.1.

7.1.2 Geographic Scope

The geographic scope of the assessment defines the area in which project activities may interact with each of the VCs. The area of influence varies for each VC; therefore, the geographic scopes are defined separately within the assessment of each VC, and for some specific indicators within them.

To promote consistent approaches for establishing the spatial boundaries to assess effects on different VCs, the assessment team considered the criteria described in Table 7.1-1.

Table 7.1-1: Criteria for Defining Spatial Scope

Study Area	Definition
Site or Project (PSA)	Existing disturbed area and immediate zone of direct project effects
Local (LSA)	Area with reasonable potential for effect interactions (direct or indirect) between the Project and the relevant VC
Regional (RSA)	Wider area with potential for socio-economic or cumulative effects.

7.1.3 Existing Conditions Definition

This assessment compares potential Project-related effects with current conditions at the Site. This approach is appropriate for a Project that involves interim measures to maintain and care for existing effects from an abandoned mine. The objective of the Project is to maintain the ongoing care and maintenance activities at the Site while improving water quality in Dome Creek through the treatment of seepage water downstream of the tailings facility.

Specific timeframes used to characterize existing conditions vary for different environmental elements, depending on data availability, quality, and applicability. Please refer to Section 6 for specific timelines used to define existing conditions.

7.1.4 Temporal Scope

The temporal scope of the environmental assessment defines the timeframe associated with the potential project effects. Effects are considered within the 5-year scope of the Project. Potential effects from the Site that may continue beyond the duration of the Project are not addressed in this assessment.

7.1.5 Effects of Extreme Environmental Events

The potential effects of extreme environmental events on the Project was taken into consideration in the assessment. Extreme environmental events are external factors that have the potential to interact with project activities, potentially resulting in potential environmental effects. The Project assessment considers effects that may result from extreme precipitation events, seismic events, and forest fires.

Global climate change could affect the long-term performance of various Site components (e.g., diversion capacity). However, climate change was not considered for the Project because of its short (5 year) duration. Within that timeframe, the effects of global climate change are not likely to be measurable. Using recent data to define the existing conditions assures any past effects of climate change are incorporated into the assessment.

7.1.6 Accidents and Malfunctions

The potential for accidents and malfunctions to result in environmental effects was taken into consideration in the assessment. Such unforeseen events during all phases of the project could result to damages to Site infrastructure, with the potential to result in effects to the environment. This assessment considers the effects that could arise from a variety of potential failure modes and events, including:

- Engineering or equipment failures (e.g., loss of electrical power);
- Human error (e.g., accidents, operator error, inspector error, mischief, or vandalism); and
- Equipment malfunctions (e.g., breakdown of water treatment facility).

7.2 Environmental Effects Assessment Method

7.2.1 Identification and Screening of Valued Environmental Components

VCs were selected by considering the type and scale of activities proposed for the Project in the context of the existing environmental setting. An initial screening of environmental components of value that had the potential to interact with the project was completed (according to the definition outlined in Section 7.1.1), which resulted in a number of potential VCs. These were further assessed against the detailed components of the project description and several removed from direct consideration because the potential for

measurable effects resulting from the project were considered to be too remote, or because potential effects pathways were better assessed through another VC.

Taken together, the selected VCs are intended to be comprehensive, providing a framework for the assessment to identify and consider the effects of the Project within its proposed spatial and temporal bounds.

7.2.2 Identification and Classification of Interactions

To inform the environmental assessment, potential interactions between project activities and the selected VCs were assessed to identify the magnitude of effects that could result. To accomplish this, a matrix was developed to intersect a detailed list of project activities with the list of VCs. This systematic approach allowed thorough consideration and identification of all potential interactions, regardless of scale, magnitude, or direction. Within the matrix, each intersection between a Project activity and VC was classified according to the following numerical criteria:

“0” = No Interaction: no measurable interaction that could cause an effect.

“1” = Minor Interaction: potential interaction where measurable effects are possible but minimal.

“2” = Major Interaction: potential interaction where measurable effects are likely.

7.2.3 Evaluation of the Effects of Interactions

Minor interactions between Project activities and environmental components (classified as “1”) were addressed by identifying best management practices or existing management plans that eliminate or suitably mitigate any potential effects. Section 7.3 describes the results of the assessment for these Project interactions.

Major interactions between Project activities and environmental components (classified as “2”) were carried forward to a detailed assessment of potential effects. For each VC, a similar general method was followed to evaluate each major interaction with Project activities:

1. Identify and describe specific pathways of potential effects for identified interactions between Project activities and VCs.
2. Identify indicators to characterize the interactions between the project and a specific VC, as well as the metrics of those indicators.
3. Develop and describe ecological objectives for VC indicators that define acceptable conditions and levels of changes from the existing conditions.
4. Conduct effects assessment on VCs using qualitative or quantitative methods appropriate to each VC and interaction type. The assessment goals are to: 1) predict the potential environmental conditions arising as a result of the Project; and 2) compare the predicted conditions with the existing condition for the VC. In some cases, rigorous scientific modelling approaches were applied to predict effects (e.g., water balance models, water quality predictive modelling). In other

cases, project outcomes were predicted based on experience with other projects, case studies, experiments, and professional judgement.

5. Develop mitigation measures to address adverse environmental effects. Adaptive management is an important component of the Project and proposed mitigation plans. Where the effects analysis identified uncertainty about potential effects from changing site conditions, adaptive management plans were developed to identify: (1) events that may lead to adverse effects; (2) appropriate performance indicators; (3) detailed monitoring programs to understand status and trends of indicators; (4) triggers for actions; and (5) specific actions to be undertaken.
6. Evaluate the significance of residual effects (i.e., Project effects remaining after mitigation measures are applied). This method is further described below.
7. Develop effects monitoring programs to confirm assessment predictions and the performance of mitigation measures (effects monitoring).

7.2.4 Evaluation of Significance

The following list of criteria was considered when evaluating the significance of Project activity adverse residual effects on VCs (following the application of mitigation measures):

- **Direction** – Identifying if the overall direction of an effect is considered to be negative or positive.
- **Magnitude/Likelihood** - Magnitude is the amount of change in an indicator, relative to the existing or baseline condition, or change above an established objective. Likelihood refers to the probability that an effect will occur.
- **Duration** - Duration addresses how long an effect may continue once it has started. For example, the period of time required until indicator or metric returns to its pre-project condition, or until the effect can no longer be measured. The overall duration of the Project is 5 years, so the significance of effects is assessed within this period of time.
- **Geographic Extent** - The geographic extent of an effect due to Project activity. The geographic extent of a Project effect can vary from site-specific (i.e., localized or PSA) to larger geographically (e.g., regional), and the significance associated with such effects depends on the characteristics and existing condition of that VC.
- **Reversibility** – The ability of an adverse effect to return to pre-project or pre-activity conditions. It considers the timeframe within which, and probability that, an adverse effect could be reversed.
- **Ecological Context** – Refers to the value (e.g., fish spawning habitats) and/or fragility of the environment. This also includes the consideration of previous activities in the area, for example if the environment was adversely affected by previous human activities and/or other project developments.

Significance of all criteria but direction was classified into one of three categories: not significant (NS), not significant moderate (NSM), or significant (S); with the understanding that criteria and significance are defined according to the specific VC or indicator being considered. The criteria of direction was classified

as being negative or positive. The rating of overall significance for each VC is based on the balance of ratings for the criteria. If an activity had an overall classification of significant, that activity was deemed to potentially have an unacceptable adverse effect and additional mitigation measures were proposed.

7.3 Environmental Effects Assessment Results

7.3.1 Environmental Valued Components

The selected VCs for the environmental assessment are provided in Table 7.3-1, accompanied by rationales for their selection. Similarly, a list of additional components that were considered but not included as VCs is provided in Table 7.3-2, accompanied by rationale for their exclusion.

Table 7.3-1: Valued Components (VCs) Considered in the Assessment

Valued Component	Rationale for Inclusion
Air Quality	Air quality is valued for environmental reasons and can have a direct effect on the health of humans, wildlife, and vegetation. Dust mobilization from the tailings storage facility (TSF), mill, and from access road activities have the potential to affect air quality through the mobilization of dust, as does the construction and maintenance of the water treatment facility. A potential effects pathway has been identified through which contaminants from the TSF, Mill, and other potentially contaminated sites could be deposited into neighbouring vegetated areas, resulting in uptake of metals by vegetation and in turn by wildlife. However, these potential effects have been addressed through the assessment of effects on wildlife. Additionally, the potential effects of airborne dust contamination on surface water quality have been addressed in the surface water quality assessment.
Hydrology	Hydrology (surface water flows and discharge) is valued for environmental and cultural reasons, and surface water flows are closely related to surface water quality and integral to the health of aquatic ecosystems through water availability. Surface water flows have been disrupted for many years in Dome Creek, and care and maintenance activities will continue to alter surface water flows through impoundment, diversion, treatment, and discharge of water in Dome Creek.
Surface Water Quality	Surface water quality is highly valued for environmental and cultural reasons, and can have a direct influence on human health, the aquatic environment, and secondary effects on terrestrial ecosystems. Aqueous transmission is the primary pathway for contaminants to be released from the tailings storage facility (TSF) and other Project components, and through which potential effects on the environment could manifest themselves. This pathway was established during original mining activities and will continue through the care and maintenance period.
Fish and Aquatic Environment	Fish and the aquatic environment are valued for environmental and cultural reasons. Dome and Pony Creeks do not currently support fish but they are contributing streams to Victoria and Back Creeks, both of which do provide fish habitat for various species. Care and maintenance activities could potentially result in effects on the health of the aquatic environment (e.g., benthic aquatic organisms, primary productivity) in Dome and Pony Creeks, as well as on fish and fish habitat in Victoria and Back Creeks.
Wildlife and Wildlife Habitat	Wildlife and wildlife habitat are valued for cultural, social, and environmental reasons. The Project area provides habitat for a range of wildlife species. Care and maintenance activities may affect wildlife and wildlife habitat directly (e.g., sensory disturbance, traffic-related mortality, uptake of metals) and indirectly (e.g., vegetation disturbance).
Vegetation	Vegetation is valued for environmental, social, and cultural reasons. The Project effects on vegetation are anticipated to be generally minor. No significant disturbances to vegetation are planned during the project and care and maintenance activities will be focused in areas of existing disturbance. The contamination of vegetation through deposition of metals contaminated dust and subsequent metals uptake can in turn affect wildlife and wildlife habitat, and these potential effects will be addressed through the assessment of effects on that VC.

Valued Component	Rationale for Inclusion
Groundwater Quality	Groundwater quality is valued for environmental and cultural reasons, and the linkage of potential effects pathways from groundwater to surface water is important when considering effects. Within the Site, groundwater quality and flows have already been altered by mining-related site disturbance and contaminant loading, and geochemical processes occurring within the TSF have reached a state that is not expected to significantly change during the timeframe of the Project. For contaminated groundwater currently at the Site, one of the fundamental goals of the Project is to prevent onsite groundwater from significantly affecting local ecosystems through groundwater collection (i.e., seepage pond) and treatment. The diversion of water around the TSF also acts to reduce the production of additional contaminated groundwater. Other sources of groundwater contamination include the pit and waste rock pile. Groundwater will continue to be part of the pathway for effects on the Surface Water Quality and Fish and Aquatic Environment VCs. Changes in the quantity and quality of groundwater could affect these VCs, and effects pathways related to groundwater are addressed through their effects on the Surface Water Quality and Fish and Aquatic Environment VCs. As a critical pathway of effects, groundwater may also be an important early indicator of conditions for these VCs and will be a critical component of monitoring programs and adaptive management. The nearest direct groundwater use is at the Victoria Creek pumphouse (which provides the water supply for the Site bunkhouse). This well is located near Victoria Creek upstream of its confluence with Dome Creek, and hydrogeological investigations in this area have concluded this well is situated solely within the Victoria Creek Watershed, with no direct groundwater linkage to the Site.

Table 7.3-2: Components Excluded from Direct Incorporation as Valued Components

Component	Rationale for Exclusion
Hydrogeology	Hydrogeology (groundwater flow and quantity) has been affected by prior activities and infrastructure at the Site, most notably the establishment of the TSF (e.g., seepage interception pond and dam, DCDC) and Brown McDade Pit. Alterations to groundwater flow and quantity as a result of the project are believed to be relatively stable and not expected to change significantly during the timeframe of the project. Additionally, the key effects pathway for hydrogeology at the Site is through its effect on surface water flows (hydrology) since there are no direct groundwater users within the groundwater influence of the Site. Accordingly, potential project effects related to hydrogeology have been addressed under the hydrology VC.
Surficial Geology and Soils	Surficial geology and soils have been affected directly by past mining and Site activities via ground disturbance. Dust has been the principal product of ground disturbance and it has been transported by wind mainly from the TSF, mill and McDade Pit areas to the soils and vegetation surrounding those infrastructure components. While dust from the tailings impoundment will continue to affect surficial geology and soils, direct changes to surficial geology and soils arising from care and maintenance activities are expected to be minimal as no major ground disturbances are planned as part of the Project, including in areas of known permafrost. The evaluation of the effects of the Project on surficial geology and soils have been addressed under the wildlife and wildlife habitat VC (i.e., dust deposition).
Climatic Conditions	The assessment did not consider potential effects of the Project on climatic conditions because of the short-term nature and small scale of the proposed care and maintenance activities. Project effects on climatic conditions are not likely to be measurable but may be more relevant during future assessment of remediation activities. Similarly, the Project contributions to regional and territorial greenhouse gas production are expected to be negligible.
Noise	While some activities proposed for care and maintenance will generate noise at the Site, the levels of activity and noise are not substantially different from those that have been generated during similar activities since Mining operations ceased. The Site is remote, and project related noise is sufficiently isolated from other land users. Wildlife in the Project area could be affected by potential excessive noise from project activities, but these potential effects have been addressed through the assessment of effects on the wildlife and wildlife habitat VC.

7.3.2 Identification and Classification of Interactions

Potential interactions between project activities and environmental VCs are presented and ranked in Table 7.3-3. Where minor measurable effects are possible (interaction of “1”), effects will be avoided or suitably mitigated by complying with regulatory requirements and/or applying standard best management practices. For these potential effects, the application of effective appropriate mitigation measures is required, which for this project have been organized into environmental management plans (Appendices 9A-9E). These plans describe the best management practices and a framework for the administrative structure that will be established to assure the plans are carried out and applied during the Project. As a result of this approach, the minor interactions have not been considered further.

Major interactions for individual VCs (interactions of “2”) are assessed and detailed in the forthcoming sections.

Table 7.3-3: Project/Valued Component (VC) Interactions

Project Activity or Physical Work	Valued Component						
	Air Quality	Groundwater Quality	Hydrology	Surface Water Quality	Fish and Aquatic Environment	Wildlife and Wildlife Habitat	Vegetation
Construction							
Water treatment plant construction	1	1	0	1	0	1	1
Waste and Water Management							
Storage of tailings and water in TSF	1	1	1	2	2	2	1
Storage of Waste Rock near Brown McDade Pit	0	1	1	1	1	0	1
Storage of potentially contaminated water in Brown McDade Pit	0	1	0	0	0	1	0
Treatment and discharge of seepage pond water into Dome Creek	0	1	1	2	2	0	1
Diversion of upper Dome Creek flow around TSF	0	1	1	1	0	0	0
Continued presence of mill area including potentially contaminated soils	1	1	0	2	2	1	1
Transportation and disposal of sludge from WTP into TSF	0	1	0	1	1	1	0
Facilities Management							
Maintenance of Dome Creek Diversion (Ice and sediment removal as needed).	0	0	1	2	1	0	1
Inspection and maintenance of the embankments of the tailings dam, seepage pond, and diversion.	1	1	1	1	0	0	1
Flood control of seepage dam water	0	1	1	1	1	0	0
Maintenance of Power System	0	0	0	0	0	0	0
Structural Maintenance of Camp and Workshop	1	0	0	0	0	0	1
Site Investigations							
Potential new monitoring equipment installation (e.g., wells, thermistors, flow measurement facilities).	0	0	0	0	0	1	1
Accessory Activities							
Transport of potentially hazardous materials (fuel, reagents, solvents and their waste products) to and from the Site	1	1	0	1	1	1	1
Transport of personnel, food, and supplies.	1	0	0	0	0	1	1

Project Activity or Physical Work	Valued Component						
	Air Quality	Groundwater Quality	Hydrology	Surface Water Quality	Fish and Aquatic Environment	Wildlife and Wildlife Habitat	Vegetation
On-site storage of hazardous materials (reagents, fuel, and solvents).	1	1	0	1	1	0	0
Camp waste management	0	0	0	0	0	1	1
Site road maintenance (grading, snow plowing, minor repairs)	1	1	0	1	1	1	1
Access control	0	0	0	0	0	0	0

Notes: 0 - No Interaction: no measurable interaction that could cause an effect

1 - Minor Interaction: minimal interaction where minor measurable effects are possible, but the effects will be avoided or suitably mitigated through compliance with regulatory requirements and the application of standard best management practices.

2 - Major Interaction: potential interaction where measurable effects are likely even with application of best management practices, or where understanding the scale or magnitude of effects requires detailed analysis.

7.3.3 Surface Water Quality and Aquatic Environmental Effects Assessment

This section describes the detailed analysis and results for the potential effects of the Project on the valued components of surface water quality and fish and aquatic environment (herein referred to as the aquatics VCs). This assessment details a series of interactions between project activities and the VCs of surface water quality and the aquatic environment as identified in Table 7.3-3. These are largely associated with the storage of tailings in the TSF, the treatment and discharge of seepage pond water, and the continued presence of the mill area. Table 7.3-3 also identifies a series of minor interactions between project activities and the aquatics VCs. As described in the effects assessment methods, these minor interactions are addressed through Site management plans and associated mitigations and are not fully detailed within this assessment.

The scope of this assessment has been defined by the regulatory context, spatial and temporal boundaries, and potential for project interactions with the aquatic VCs (as described in Section 7.1).

7.3.3.1 Context

The effects of the project on the aquatic VCs have been assessed in the context of the history and current operation of the Site. The Site is a historical mining property that was not developed or operated by the current proponent. These historical activities resulted in environmental liabilities at the site that include exposed tailings and waste rock, diversions to watercourses, and a tailings storage facility, all of which have resulted in degraded water quality and an impaired aquatic environment, in particular in Dome Creek.

This project proposal involves temporary care and maintenance while the site remediation can be planned, assessed, permitted, and completed. This remediation project is anticipated to have an overall positive effect.

The current care and maintenance activities being performed at the Site are designed to protect the public, worker health and safety, and the environment, and will simply be continued under the Project. The addition of water treatment is a new measure that directly addresses one of largest ongoing concerns related to the ongoing care and maintenance of the Site (degraded water quality) and will further protect aquatic life in Dome Creek.

In summary, this project presents largely a term of status quo site care with some improvement to water quality. While this application does not present water quality outcomes that may be acceptable for a long term project, these works are intended to provide interim management guidelines while the remediation project is assessed and finalized.

7.3.3.2 Pathways of Effects

The potential project interactions and related effects pathways for the aquatics VCs are presented in Table 7.3-4. The potential effects pathways identified are associated with physical or chemical changes in surface water quality. Physical water quality has the potential to be altered through:

- The input of terrestrial sources of sediment that can be mobilized and transported to the stream through maintenance or construction activities (i.e., activities that generate TSS through erosion and sediment deposition from terrestrial activities, or from dredging of the Dome Creek Diversion Channel); or,
- The precipitation of metals in surface waters (e.g., the oxidation and precipitation of iron associated with groundwater discharge including seepage reporting to the Seepage Collection Pond).

Chemical water quality has the potential to be altered through:

- Chemical inputs originating from mine infrastructure and weathering of stored tailings (e.g., total and dissolved metals, sulphate, and cyanide degradation products including ammonia and nitrate).

In addition to the direct changes in surface water quality, these physical and chemical changes can in turn contribute to indirect effects pathways on aquatic biota through toxicity, bioaccumulation, and eutrophication. These can include:

- Physical effects such as physical impairment or habitat impairment due to TSS effects on fish and biota respiration or feeding, or accumulation within substrates; and
- Toxicity (chronic or acute) resulting from direct contact with total or dissolved metals in surface waters, or from contact or ingestion of metals contaminated sediments within the streams. This can include bioaccumulation or magnification through the trophic system.

No direct (physical) effects pathways on fish or fish habitat were identified as part of the Project, as Project activities will not result in any direct physical changes to habitat (e.g., habitat losses, alterations, or direct fish mortality).

Table 7.3-4: Detailed Project Interactions and Effects Pathways for Surface Water Quality and Fish and Aquatics Environment VCs

Project Activity or Physical Work	Surface Water Quality	Fish and Aquatic Environment	Description of Interaction / Effect Pathway
Construction			
Water treatment plant construction	1	0	Potential for release and transport of sediment or deleterious substances to Dome Creek
Waste and Water Management			
Storage of tailings and water in TSF	2	2	Potential for mobilization of metals from tailings material, and seepage of metals contaminated water through to the Seepage Pond / Dome Creek
Storage of Waste Rock near Brown McDade Pit	1	1	Potential for metals from waste rock to be mobilized into precipitation / runoff water, eventually reporting to surface waters
Treatment and discharge of seepage pond water into Dome Creek	2	2	Release of metals contaminated seepage water into Dome Creek which can in turn affect aquatic biota
Diversion of upper Dome Creek flow around TSF	1	0	Potential for release and transport of sediment or deleterious substances to Dome Creek
Continued presence of mill area including potentially contaminated soils	2	2	Release of metals contaminated seepage water into Dome Creek which can in turn affect aquatic biota
Transportation and disposal of sludge from WTP into TSF	1	1	Re-suspension of captured metals from sludge in the tailings area.
Facilities Management			
Maintenance of Dome Creek Diversion (ice and sediment removal as needed).	2	1	Potential for release and transport of sediment or deleterious substances to Dome Creek
Inspection and maintenance of the embankments of the tailings dam, seepage pond, and diversion.	1	0	Potential for release and transport of sediment or deleterious substances to Dome Creek
Flood control of seepage dam water	1	1	Potential for release and transport of sediment or deleterious substances to Dome Creek
Accessory Activities			
Transport of potentially hazardous materials (fuel, reagents, solvents and their waste products) to and from the Site	1	1	Potential for release and transport of deleterious substances to local area Watercourses
On-site storage of hazardous materials (reagents, fuel, and solvents).	1	1	Potential for release and transport of deleterious substances to local area Watercourses
Site road maintenance (grading, snow plowing, minor repairs)	1	1	Potential for release and transport of sediment or deleterious substances to Dome Creek

Notes: 0 - No Interaction: no measurable interaction that could cause an effect

1 - Minor Interaction: minimal interaction where minor measurable effects are possible, but the effects will be avoided or suitably mitigated through compliance with regulatory requirements and the application of standard best management practices.

2 - Major Interaction: potential interaction where measurable effects are likely even with application of best management practices, or where understanding the scale or magnitude of effects requires

7.3.3.3 Ecological Indicators to Characterize Project Interactions

The assessment of effects on the aquatics VCs is intended to focus on major interactions with the project. Based on the analysis of potential project effects pathways (Section 7.3.3.2), it was found that the relevant effects pathways originated with physical and chemical surface water quality, and therefore the assessment was focused on this component (both direct effects on water quality, and indirect effects resulting in effects on aquatic biota). The next step in the assessment process was to identify ecological indicators through which the assessment could be characterized. For surface water quality, this refers to those specific parameters on which the assessment could be performed to appropriately assess potential effects on the aquatics VCs.

The selection of ecological indicator parameters for the aquatics VCs began with those surface water quality parameters of potential concern that had been identified during a project screening process as described in Section 2.4 of the surface water quality existing conditions assessment (Appendix 6D). The anticipated interaction between these individual parameters and project activities were then screened similar to the interactions described in Section 7.3.2, and those determined to have potentially major interactions (“2”) with the project being chosen as indicators for the detailed assessment (Table 7.3-5). In most cases these were parameters for which the interaction of project activities with water quality extended beyond the PSA. The resulting ecological indicators of the aquatics VCs on which the project effects were assessed included sulphate, total arsenic, total cadmium, total and dissolved iron, total manganese and total zinc.

Table 7.3-5: Project Interactions with SWQ and Aquatic Environment Parameters of Concern

Project Activity or Physical Work	Terrestrial Source Total Suspended Solids (TSS)	Aluminum	Arsenic	Cadmium	Iron including precipitate	Manganese	Zinc	Sulphate
Water treatment plant construction	1	0	0	0	0	0	0	0
Storage of tailings and water in TSF	1	1	2	1	2	2	2	2
Storage of Waste Rock near Brown McDade Pit	0	1	1	1	1	1	1	1
Treatment and discharge of seepage pond water into Dome Creek	1	1	2	1	2	2	2	2
Diversion of upper Dome Creek flow around TSF	1	1	1	1	1	1	1	1
Continued presence of mill area including potentially contaminated soils	1	1	1	1	1	1	2	1
Transportation and disposal of sludge from WTP into TSF	1	1	1	1	1	1	1	1
Maintenance of Dome Creek Diversion (Ice and sediment removal as needed).	1	2	1	0	1	1	1	0
Inspection and maintenance of the embankments of the tailings dam, seepage pond, and diversion.	1	0	0	0	0	0	0	0
Flood control of seepage dam water	1	1	1	1	1	1	1	1
Transport of potentially hazardous materials (fuel, reagents, solvents and their waste products) to and from the Site	0	0	0	0	0	0	0	0
On-site storage of hazardous materials (reagents, fuel, and solvents).	0	0	0	0	0	0	0	0
Site road maintenance (grading, snow plowing, minor repairs)	1	0	0	0	0	0	0	0

Notes: 0 - No Interaction: no measurable interaction that could cause an effect

1 - Minor Interaction: minimal interaction where measureable effects are possible, but the effects will be avoided or suitably mitigated through compliance with regulatory requirements and application of standard best management practices

2 - Major Interaction: potential interaction where measurable effects are likely even with application of best management practices, or where understanding the scale or magnitude of effects requires detailed analysis

7.3.3.4 Ecological Objectives of Valued Components

A series of ecological water quality objectives (WQOs) were developed for this assessment, against which predicted project water quality values were then compared to quantify potential project-related effects. The WQO were developed as thresholds for various parameters against which the probability and magnitude of project related effects could be quantified. WQOs were developed for Dome Creek and Victoria Creek. Specific WQOs were not derived for Pony and Back Creeks because while measurable effects on water quality were observed, they could not be discerned from placer induced effects (Appendix 6D). Further, Pony Creek does not support fish habitat and therefore any potential effects realized from Pony Creek were captured within the effects assessment for Victoria Creek, which includes all effects from placer mining upstream of the project.

Table 7.3-6 presents the ecological WQOs developed for the six ecological indicators identified in Section 7.3.3.2: sulphate, aluminum, arsenic, iron, manganese and zinc. Some of the WQOs are based on generic water quality guidelines, while others are site specific. Each is described further in the following text, while a detailed description of methods used to derive WQOs that differ from generic water quality guidelines is provided in Appendix 7A.

Table 7.3-6: Ecological Water Quality Objectives (WQOs) for Water Quality Indicators

Parameter	Watercourse	
	Victoria Creek	Dome Creek
Sulphate	309	857
Dissolved Aluminium	0.05	
Total Arsenic	0.005	0.025
Total Iron	1	
Dissolved Iron	0.35	
Total Manganese	0.9 to 1.3	2.3 to 6.1
Total Zinc	0.03	

Notes: All values are presented in mg/L. Highlighted WQOs are equivalent to generic water quality guidelines (WQGs). WQOs that are not highlighted have been derived specifically for the Project and apply to lower Dome Creek only. Further detail is provided in the text following this table.

7.3.3.4.1 Aluminum

As with the Canadian Council of Ministers of Environment Water Quality Guidelines for the Protection of Aquatic Life (CCME-PAL; CCME 2017) and the British Columbia Approved Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture (BCWQG; BC MOE 2017; pH-dependent when pH > 6.5; aluminum WQO applies to dissolved aluminum only). The project WQO is equivalent to the generic, long-term (chronic) BCWQG which is 0.05 mg/L. Note that the short-term BCWQG (0.10 mg/L) is equivalent to the CCME-PAL, however the long-term BCWQG was used as the WQO as it is more conservative (lower).

7.3.3.4.2 Arsenic

The CCME-PAL and BCWQG for arsenic are both 0.005 mg/L. The CCME-PAL is based on the sensitivity of a species of planktonic algae (*Scenedesmus obliquus*) which has been shown to exhibit reduced growth at an arsenic concentration of 0.05 mg/L (CCME 2001). This guideline concentration was chosen as the WQO for arsenic in Victoria Creek.

Golder (2013) updated the aquatic toxicity dataset used to generate the CCME-PAL guideline for arsenic using data from more recent studies in order to identify the species that are most sensitive to arsenic. This study included chronic toxicity end points for stream systems. The result agreed with the CCME-PAL dataset in showing that algae are more sensitive to arsenic than invertebrates or fish. A WQO of 0.025 mg/L for Dome Creek was derived from the species sensitivity distribution curve in that study. This WQO is mostly based on the most sensitive organisms in the system (benthic algae) and is therefore inherently protective of less sensitive taxa (benthic invertebrates, fish and amphibians; Appendix 7A).

7.3.3.4.3 Iron

A CCME-PAL guideline for iron was derived in 1987 (CCME 1987). The BCWQG was most recently updated in 2008 using more up-to-date toxicity information and is proposed as the WQO for iron. Dissolved iron is a more accurate indicator of toxicity given its greater bioavailability. Therefore, water quality guidelines for dissolved iron are more relevant to managing potential effects to aquatic organisms and water quality guidelines for total iron should be followed only if dissolved iron data are not available (BC MOE 2008). For this assessment, the BCWQG for dissolved iron and total iron are applied as the proposed WQOs (0.35 mg/L and 1 mg/L, respectively) for both Dome and Victoria Creeks.

7.3.3.4.4 Manganese

No CCME-PAL has been derived for manganese and therefore, the BCWQG was applied directly as the manganese WQO for Victoria Creek and modified to a site-specific WQO for Dome Creek. Similar to many other metals, hardness is known to ameliorate the toxicity of manganese (Stubblefield *et al.* 1997, Lasier *et al.* 2000). Thus, the derived BCWQG for manganese is hardness dependent and based on the lowest manganese toxicity values, then decreased by a factor of 4 to make it more conservative (4:1 safety factor). This safety factor is incorporated in the BCWQG equation below, which is therefore also used to calculate the WQO:

$$\text{Manganese WQO} = 0.0044 \times \text{hardness (mg/L CaCO}_3\text{)} + 0.605$$

The BCWQG specifies that the hardness-based guideline be applied for hardness values up to 300 mg/L (as CaCO₃) which are deemed representative of natural, “unaffected” freshwater in British Columbia. Based the equation, a hardness of 300 mg/L results in a BCWQG for manganese of 3.9 mg/L.

Victoria Creek waters are well below 300 mg/L hardness (monthly averages range from 76 to 119 mg/L CaCO₃), and therefore the calculation can be directly applied (WQO values range from 0.9 to 1.3 mg/L). The hardness of water in Dome Creek is much higher, where monthly averages range from 500 to 727 mg/L

CaCO₃ on an annual basis. For the effects assessment in Dome Creek, the hardness-based equation was extrapolated according to the actual range of hardness values observed to form a site-specific WQO, resulting in a maximum manganese value for Dome Creek of 6.1 mg/L.

7.3.3.4.5 Sulphate

British Columbia is one of the few jurisdictions to have a generic water quality guideline for sulphate (BC MOE 2013b), and a CCME-PAL has not yet been derived for sulphate. The BCWQG for sulphate is hardness dependent, based on studies showing decreasing toxicity with increasing hardness. No BCWQG sulphate is recommended for hardness values greater than 250 mg/L due to a lack of toxicological data at these higher hardness levels. To develop an objective for sulphate concentrations against which to determine potential Project-related toxicological effects from sulphate, an assumption was made that the modifying effect of hardness on sulphate toxicity plateaus at 250 mg/L CaCO₃. The BCWQG for sulphate is based on toxicity to early life stage rainbow trout, which was assumed to be relevant to the salmonid present to Victoria Creek (Arctic Grayling). Other organisms (e.g., the water flea *Ceriodaphnia dubia*) are less sensitive to sulphate, and therefore the project WQO may be quite conservative for Dome Creek since it is currently considered to be not fish bearing (Appendix 6E). Based on this, two sulphate WQOs were derived for the assessment: 429 mg/L for Victoria Creek to protect salmonids and 857 mg/L for Dome Creek based on the lowest toxicity value observed for the water flea *Ceriodaphnia dubia* (Appendix 7A).

7.3.3.4.6 Zinc

The WQO for total zinc was taken directly from the CCME-PAL for total zinc (CCME 2017).

7.3.3.5 Significance Criteria

The characterization, description, and quantification of residual environmental effects provide the structure for determining significance on the aquatics VCs. The effect characterization and associated significance ranking criteria for residual effects are provided in Table 7.3-7 and include magnitude relative to the WQOs, duration, geographic extent, reversibility, and ecological context.

Table 7.3-7: Characterization of Residual Environmental Effects for Surface Water Quality and Aquatic Environment

Effect Characterization	Effect Measurement	Significance Ranking	Description of Qualitative Categories
Magnitude	The type and amount of change in a measurable parameter	NS	Below WQO, no measurable change from background or changes within the variability of current (baseline) conditions
		NSM	Measurable change beyond variability of baseline (current) conditions, above generic WQG but below WQO (or marginally above [< 2 times] seasonally) but with a low risk of adverse effects on aquatic biota due to: - Low availability of dissolved (i.e., more toxic) forms; - The conservatism of benchmarks (WQG or WQO) derivation; and - The consideration of other toxicological (e.g., ameliorative factors such as hardness) and ecological factors (e.g., presence of species of concern).
		S	Measurable change from baseline conditions, resulting in significant exceedances (> 2 times) of WQOs for most of the year with high risk of adverse effects to aquatic biota when other toxicological (e.g., ameliorative factors such as hardness) and ecological factors (e.g., presence of species of concern) are considered.
Duration	The period of time required until the value component returns to its baseline (current) condition, or measured effect is no longer apparent	NS	Infrequent/sporadic within the year and occurs at irregular intervals (e.g., one-month of the year)
		NSM	Seasonally continuous for parts of the year returning to baseline conditions within the year, effect occurs on a regular basis and at regular intervals (e.g., during freshet or winter low-flow periods)
		S	Effect occurs continuously and extend to more than a year
Geographic Extent	The geographic area in which an environmental, effect of a defined magnitude occurs	NS	Project effects limited to Project Study Area (PSA)
		NSM	Project effects limited to PSA and Local Study Area (LSA)
		S	Project effects extend to Regional Study Area (RSA)
Reversibility	Probability of recovery from an effect	NS	Not applicable as there is no measurable change from background
		NSM	System will recover after reclamation/maintenance
		S	Effects are permanent
Ecological context	Ecological fragility and degree of disturbance of area in which the Project is located.	NS	Component adversely affected by previous human activities and/or other project developments
		NSM	Component has been adversely affected by previous human activities, but the level of disturbance is considered relatively low
		S	Component is pristine or has high ecological value (for example, fish spawning grounds) and has not been subject to any previous disturbance by human activities

Notes: WQGs = Water Quality Guidelines; WQOs = Water Quality Objectives (Table 7.3.3-3).
NS=not significant; NSM= not significant moderate; S=significant

7.3.3.6 Effects Description and Proposed Mitigation Measures

The primary existing infrastructure components at the Site include the Brown McDade Pit, waste rock storage, the mill complex, and the TSF. Seepage from the tailing facility is collected within a seepage collection pond and is currently pumped to Dome Creek, which flows to Victoria Creek. The TSF seepage collection pond represents the point of discharge for the Site and affects surface water chemistry in Dome Creek downstream of the seepage collection pond (location DC-U) and in lower Dome Creek (location DC-R).

Discharges into Dome Creek occur year-round, however most of those discharges freeze during winter (December to March) within the reach of Dome Creek immediately below the seepage collection pond (DC-U) with minor inputs continuing to report to Victoria Creek via shallow groundwater. During this time of year, lower Dome Creek (DC-R) is frozen to ground. As a result, there is no continuous surface water flow path for discharges from the seepage collection pond to reach Lower Dome Creek and Victoria Creek. Further, lower Dome Creek does not have the potential to provide overwintering habitat for fish, which may be a contributing factor to why fish have not been observed in Dome Creek.

The effects assessment on the aquatics VCs focuses on Dome Creek and Victoria Creek (Table 7.3-8). The habitat in Dome Creek has low ecological value, is not fish bearing and the presence of unusual or uncommon benthic invertebrate or algae species has not been documented (Appendix 6E). Victoria Creek in contrast has high ecological value and provides good quality fish habitat, including for overwintering. Arctic Grayling, Burbot, and Slimy Sculpin reside in Victoria Creek, however no unusual invertebrate and/or algae species have been observed (Appendix 6E).

Lower Dome Creek is the pathway via which the indicator parameters from the TSF can reach fish bearing habitat in Victoria Creek. Since surface water discharges from the Site do not report to lower Dome Creek in the winter and since lower Dome Creek is frozen, Project effects on water quality and aquatic biota in lower Dome Creek are limited to the open water season from April to November. Year-round project effects to Victoria Creek are considered as this watercourse provides overwintering habitat for fish.

Table 7.3-8: Selected Water Quality Nodes and Rationale

Watercourse	Node / Point Code	Description
Dome Creek	DC-R	Lower Dome Creek captures all project effects within Dome Creek including surface water discharges from the Site. Lower Dome Creek habitat does not support fish and is of low ecological value, but it is an important pathway between Site discharges and fish and fish habitat located in Victoria Creek during the open flow season (April to November) when the creek is not frozen to ground.
Victoria Creek	VC-UMN	Victoria Creek upstream of Minnesota Creek captures all effects from the Site as well as regional placer mining. Victoria Creek provides good quality, year-round fish habitat.

Water quality in the tailings seepage collection pond is elevated in TSS, sulphate, metals, cyanide and cyanide degradation products (e.g., ammonia and nitrate). Concentrations of these compounds and metals have generally been declining over time or have remained stable with the exception of TSS, iron and

arsenic, which have more recently increased following denitrification and a change in redox within the impoundment (Appendices 6D and 7A). Early in the project design it was recognized that TSS, iron, and arsenic would result in effects that were potentially unacceptable to project stakeholders, and therefore the design, construction and operation of a water treatment plant (WTP) was integrated into the project description as an integral mitigation measure to reduce concentrations of these parameters to acceptable levels during controlled discharges from the seepage pond to Dome Creek.

The proposed WTP is a modular, flow-through, engineered treatment system with a maximum capacity of 360 m³/d. The treatment process oxidizes the ferrous iron (Fe²⁺) naturally present in the influent water via aeration to form ferric oxyhydroxide precipitates. The ferric oxyhydroxide formation is a common method for TSS and dissolved metal removal. Enhanced coagulation and settling technology will be employed for solid/liquid separation of precipitates and TSS. Solids generated from the WTP sedimentation and clarification process will be thickened with polymer and dewatered using Geotube[®] technology. Geotubes[®] are a simple, low maintenance and cost-effective dewatering solution which reduce the volume of resulting solids that must be stored and managed. Treatment solids will be contained within the Geotubes and will be deposited in a dedicated management area within the footprint of the TSF. Solids will be kept physically stable and will be stored above the water table so that effects to existing water quality remain negligible. A detailed description of the proposed WTP can be found in Section 5 and in Appendix 5D.

Project effects on surface water quality were characterized with the help of data from a water balance and water quality model (Appendix 7B). The model was used to predict water quality related to the Project both based on existing conditions and following the implementation of water treatment. The water balance and water quality model was developed using GoldSim software as a non-reactive⁵ (e.g., conservative), mass balance model. Model estimates were derived to inform the design of water treatment, evaluate its benefits on water quality, and to support the surface water quality effects assessment. Model estimates were calibrated to observations of flow and water chemistry over the period from 2012 to 2016.

The water balance and water quality model was run on a monthly time step using data from 2012 to 2016. Model results are presented as average monthly values for this time period. Separate model routines were conducted for existing conditions (pre-treatment) and for a post-water treatment case. Model results for the effects assessment are presented as monthly average concentrations for lower Dome Creek (DC-R) and Victoria Creek (VC-UMN). By operating the model in this manner, the water balance for both scenarios are identical and the average monthly water quality data for the two cases are directly comparable. This allows for direct comparison to evaluate the benefit of treating discharge from the seepage collection pond.

7.3.3.6.1 Dome Creek (DC-R)

The lower Dome Creek station DC-R is located at the Mount Nansen Road culvert and represents the pathway for contaminants between controlled surface water discharges from the Site and fish bearing habitat in Victoria Creek. Lower Dome Creek is below the TSF and the proposed WTP discharge and

⁵ The terms conservative or non-reactive refer to how water quality parameters are assumed to behave in the water for the purpose of the model. Conservative refers to a state where conservation of mass is maintained as parameters do not precipitate as solids and are not otherwise removed from the water column.

captures all Project-related effects on Dome Creek. Project-related values for the aquatics VC indicator parameters in lower Dome Creek are presented for current conditions (Table 7.3-9) and for the post-implementation of water treatment scenario (Table 7.3-10; representing the residual Project effect). The result is that the Project is expected to have an overall positive effect on surface water quality in lower Dome Creek a result of water treatment, which will be exclusive to the open water season (April to November) as no flowing water occurs during winter months. The results of the assessment for each indicator parameter is presented below.

7.3.3.6.2 Dissolved Aluminum

Predicted dissolved aluminum concentrations were marginally above applicable WQOs during freshet. Elevated dissolved aluminum typically coincides with elevated TSS during freshet and is assumed to be associated with particulate aluminum that passes through filtration during sampling. It is not uncommon to see elevated dissolved aluminum during freshet and the predicted concentrations are not expected to generate any adverse effects for aquatic biota in Dome Creek due to the small magnitude of exceedances, in addition to the conservative assumptions included into the water quality model and the short-term of exceedance period.

7.3.3.6.3 Total Arsenic

Total arsenic concentrations are predicted to be slightly above the proposed WQO in April and June due to elevated total arsenic upstream in Dome Creek upstream of the tailings facility at DC-B. This elevated background signature is typically associated with elevated TSS and is not managed by the water treatment facility. Overall, water quality is expected to improve following treatment and total arsenic concentrations are estimated to remain below the WQO for the remaining six open water months. Model estimates for total arsenic generally over-estimate observations and are conservative. Due to the conservatism included in the water quality model and WQO derivation, adverse effects on aquatic biota in Dome Creek are not expected to occur as a result of total arsenic exposure.

7.3.3.6.4 Total and Dissolved Iron

Iron concentrations were predicted to exceed WQOs during some months for the post-treatment scenario. Overall, water quality is expected to improve following treatment and total and dissolved iron concentrations are significantly lowered from current conditions (pre-treatment). Iron concentrations in downstream Dome Creek that are estimated to exceed the WQO are due to elevated total iron upstream of the TSF as measured at DC-B. Some exceedances to the WQO (1.3 to 4.4 times the WQO) were predicted to occur for seven of eight months of the open water season (May to November) for total iron, whereas exceedances of the dissolved iron WQO were marginal and limited to a single month (October).

In addition to the small magnitude of exceedances of the dissolved iron WQO (which is the form of most concern for aquatic biota), the model is also believed to be over-conservative as it did not take into account the attenuation of contaminants of concern along the discharge path. Redox changes that occur in the oxic, neutral pH waters of Dome Creek are expected to readily attenuate and therefore reduce remnant dissolved

iron, as has already been observed within close proximity of the seepage pond. As a result, aquatic toxicity from iron is not expected to occur in Dome Creek.

7.3.3.6.5 Total Manganese

Predicted total manganese exceeded the WQO during one freshet month (April), with predicted values slightly above the objective value. These manganese concentrations are not expected to generate adverse effects to aquatic biota in Dome Creek due to the small magnitude and short term of exceedances, the presence of conditions that are expected to ameliorate manganese toxicity such as, hardness, in addition to the conservatism of the water quality model.

7.3.3.6.6 Sulphate

Predicted concentrations of sulphate did not exceed the WQO during open water periods (April to November), and are therefore not expected to cause adverse effects on aquatic biota. Rainbow trout (*Oncorhynchus mykiss*) is identified as the most sensitive species to sulphate exposure, however, there are no fish expected to be present in Dome Creek. Thus, applicable toxicity benchmarks for this element should be based on invertebrates and algae species that currently inhabit the creek (Appendix 7A). Sulphate has shown no toxicity to widely distributed aquatic invertebrates and algae species at concentrations higher than 429 mg/L and with an associated hardness of 80-250 mg/L CaCO₃. For example, *C. dubia* showed mortality (LC10) and reproductive (IC10) effects due to sulphate exposure at 857 mg/L and 1,184, respectively (BC MOE 2013b). For algae including *Pseudokirchneriella subcapitata* and *Lemna minor*, sulphate concentrations up to 2,300 mg/L showed no adverse effects in cell growth and proliferation (BC MOE 2013b). Predicted concentrations of sulphate for Dome Creek are well below the expected toxicity values for invertebrates and algae, therefore adverse effects due to sulphate exposure are not expected to occur for aquatic biota in Dome Creek.

7.3.3.6.7 Total Zinc

Total zinc concentrations were predicted to be only marginally above the WQO, and only during the month of May. Accordingly, total zinc is not expected to generate adverse effects to aquatic biota in Dome Creek due to the small magnitude of exceedances, in addition to the conservative assumptions included into the water quality model and the short-term of the exceedance period.

Table 7.3-9: Project Effect on Surface Water Quality Indicators Screened Against Ecological Objectives for Dome Creek, Pre-Mitigation

Indicator	WQO	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
SO4	857	No flow	No flow	No flow	670	260	420	550	510	490	550	750	No flow
T-As	0.025	No flow	No flow	No flow	0.048	0.021	0.029	0.018	0.022	0.026	0.021	0.033	No flow
D-Al	0.05	No flow	No flow	No flow	0.021	0.076	0.036	0.019	0.020	0.029	0.015	0.0088	No flow
T-Fe	1	No flow	No flow	No flow	12	5.8	5.5	3.9	4.4	5.3	5.4	8.3	No flow
D-Fe	0.35	No flow	No flow	No flow	9.4	1.4	1.2	1.7	1.5	1.9	2.8	5.6	No flow
T-Mn	2.3 to 4.8	No flow	No flow	No flow	5.5 (4.4)	1.1	1.3	1.8	1.8	2.2	2.3	4.3	No flow
T-Zn	0.03	No flow	No flow	No flow	0.032	0.034	0.027	0.0094	0.013	0.020	0.022	0.029	No flow

Notes: values in mg/L; values above ecological objective are presented in bold and italicized text; a range is provided for the T-Mn objective, which is a function of hardness; where T-Mn is above the WQO and highlighted, the associated objective is provided in parenthesis.

Table 7.3-10: Residual Project Effect on Surface Water Quality Indicators Screened Against Ecological Objectives for Dome Creek, Post-Mitigation

Indicator	WQO	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
SO4	857	No flow	No flow	No flow	670	260	420	550	510	490	550	750	No flow
T-As	0.025	No flow	No flow	No flow	0.032	0.018	0.026	0.015	0.017	0.021	0.017	0.024	No flow
D-Al	0.05	No flow	No flow	No flow	0.021	0.076	0.036	0.019	0.020	0.029	0.015	0.0088	No flow
T-Fe	1	No flow	No flow	No flow	1.0	4.4	3.8	1.9	2.3	2.6	2.2	1.3	No flow
D-Fe	0.35	No flow	No flow	No flow	0.18	0.19	0.057	0.078	0.099	0.13	0.38	0.30	No flow
T-Mn	2.3 to 4.8	No flow	No flow	No flow	5.4 (4.4)	1.1	1.3	1.8	1.8	2.2	2.3	4.3	No flow
T-Zn	0.03	No flow	No flow	No flow	0.024	0.034	0.027	0.0090	0.012	0.020	0.021	0.024	No flow

Notes: values in mg/L; values above ecological objective are presented in bold and italicized text; a range is provided for the T-Mn objective, which is a function of hardness; where T-Mn is highlighted, the associated objective is provided in parenthesis.

7.3.3.6.8 Victoria Creek (VC-UMN)

The Victoria Creek node is located upstream of Minnesota Creek (VC-UMN) and is a proxy for cumulative potential Project effects on Victoria Creek, including regional effects associated with placer mining that occur upstream of the Site. Upstream effects from placer mining are captured at the Victoria Creek downstream of Back Creek station (VC-DBC). The comparative data for this upstream input to the system is presented in Table 7.3-11 in order to assist with the assessment of effects from the Project on the aquatics VCs (by isolating them from upstream inputs). Potential Project effects in Victoria Creek are assessed for the entire year as Victoria Creek contains overwintering fish habitat, however Project effects are most evident during the open water season (April to November) as contributions from Dome Creek are relatively low during the winter due to freezing and observed aufeis effects.

Project effects on Victoria Creek water quality are presented for current conditions (Table 7.3-12) and following the implementation of water treatment (Table 7.3-13), which represents the residual Project effect. Generally, the project was predicted to result in a marginal improvement in surface water quality at VC-UMN as a result of water treatment. This predicted positive effect on water quality resulting from water treatment is less pronounced than that predicted for Dome Creek due to the dilution afforded by Victoria Creek and the overprinting of effects from regional placer mining activity. This is most pronounced during freshet when TSS and total metals are particularly elevated. One of the key project effects that is predicted to be mitigated through the implementation of water treatment is dissolved iron, the more bioavailable and potentially toxic form of iron.

The assessment relies on a comparison of predicted water quality at VC-UMN compared to the WQO, which for Victoria Creek are all based on generic WQGs (Table 7.3-6). Following mitigation, exceedances of the WQO are limited to:

- Total arsenic for the months of May and June at less than twice the WQO;
- Dissolved aluminum for the months of May and June at 1 to 1.5 times the WQO; and
- Total iron for the months of May, June, and September at less than 3.5 times the WQO (dissolved iron is predicted to be consistently below its WQO).

A comparison of post treatment data (Table 7.3-13) with upstream reference data (Table 7.3-11) suggests that the vast majority of these exceedances are the result of upstream inputs to the system (not Project-related).

Given the conservatism included in the water quality model, the short-term of the exceedance period (generally 2 months during freshet), and the particulate nature of contaminants associated with TSS and placer activity (Table 7.3-11), adverse effects to aquatic biota in Victoria Creek due to Project effects on aluminum, arsenic and/or iron are not expected to occur.

Table 7.3-11: Surface Water Quality Indicators Screened Against Ecological Objectives for Victoria Creek Upstream of Dome Creek and Downstream of Placer Activity on Back and Victoria Creeks (VC-DBC)

Indicator	WQO	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
SO ₄	309	17	17	18	19	12	14	18	18	18	19	19	19
T-As	0.005	0.0003	0.0002	0.0003	0.0012	<i>0.0074</i>	<i>0.0051</i>	0.0020	0.0018	0.0025	0.0013	0.0006	0.0004
D-Al	0.05	0.006	0.006	0.005	0.015	<i>0.072</i>	<i>0.052</i>	0.017	0.019	0.026	0.021	0.011	0.007
T-Fe	1	0.03	0.03	0.02	0.78	<i>3.5</i>	<i>2.5</i>	0.52	0.38	<i>1.2</i>	0.37	0.15	0.06
D-Fe	0.35	0.009	0.009	0.009	0.025	0.15	0.11	0.040	0.052	0.071	0.067	0.034	0.016
T-Mn	0.9 to 1.1	0.05	0.07	0.10	0.12	0.20	0.51	0.08	0.07	0.08	0.07	0.06	0.05
T-Zn	0.03	0.0021	0.0020	0.0021	0.0055	0.020	0.012	0.0053	0.0051	0.0083	0.0044	0.0031	0.0027

Notes: values in mg/L; values above ecological objective are presented in bold and italicized text; a range is provided for the T-Mn objective, which is a function of hardness.

Table 7.3-12: Project Effect on Surface Water Quality Indicators Screened Against Ecological Objectives for Victoria Creek, Pre-Mitigation

Indicator	WQO	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
SO ₄	309	24	31	47	70	25	43	46	33	27	44	35	26
T-As	0.005	0.00077	0.0013	0.0026	0.0048	<i>0.0081</i>	<i>0.0067</i>	0.0029	0.0025	0.0029	0.0022	0.0013	0.00078
D-Al	0.05	0.006	0.006	0.005	0.015	<i>0.072</i>	<i>0.051</i>	0.017	0.019	0.026	0.021	0.011	0.007
T-Fe	1	0.16	0.28	0.60	<i>1.6</i>	<i>3.6</i>	<i>2.7</i>	0.70	0.50	<i>1.2</i>	0.60	0.34	0.16
D-Fe	0.35	0.11	0.21	<i>0.51</i>	<i>0.75</i>	0.22	0.18	0.13	0.095	0.10	0.19	0.16	0.090
T-Mn	1.0 to 1.3	0.13	0.20	0.37	0.54	0.26	0.55	0.17	0.12	0.12	0.17	0.15	0.10
T-Zn	0.03	0.0024	0.0029	0.0039	0.0079	0.021	0.013	0.0055	0.0054	0.0085	0.0052	0.0037	0.0029

Notes: values in mg/L; values above ecological objective are presented in bold and italicized text; a range is provided for the T-Mn objective, which is a function of hardness.

Table 7.3-13: Residual Project Effect on Surface Water Quality Indicators Screened Against Ecological Objectives for Victoria Creek, Post-Mitigation

Indicator	WQO	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
SO ₄	309	24	31	47	70	25	43	46	33	27	44	35	26
T-As	0.005	0.00062	0.00093	0.0018	0.0036	<i>0.0080</i>	<i>0.0065</i>	0.0027	0.0023	0.0028	0.0021	0.0011	0.00064
D-Al	0.05	0.006	0.006	0.005	0.015	<i>0.072</i>	<i>0.051</i>	0.017	0.019	0.026	0.021	0.011	0.007
T-Fe	1	0.035	0.035	0.040	0.82	<i>3.5</i>	<i>2.6</i>	0.59	0.44	<i>1.2</i>	0.46	0.18	0.069
D-Fe	0.35	0.010	0.011	0.013	0.036	0.15	0.11	0.042	0.053	0.073	0.081	0.040	0.018
T-Mn	1.0 to 1.2	0.12	0.20	0.37	0.54	0.26	0.55	0.17	0.12	0.12	0.17	0.15	0.10
T-Zn	0.03	0.0023	0.0025	0.0032	0.0071	0.021	0.013	0.0055	0.0053	0.0085	0.0052	0.0036	0.0029

Notes: values in mg/L; values above ecological objective are presented in bold and italicized text; a range is provided for the T-Mn objective, which is a function of hardness.

7.3.3.7 Characterization of Residual Environmental Effects

The characterization of residual environmental effects for the aquatics VCs provide the context for evaluating their significance. This includes the characterization and associated ranking of effects based on the criteria provided in Table 7.3-7.

Following the implementation of mitigation (water treatment of seepage pond discharge) and other minor project mitigations or best practices, the residual Projects effects on the aquatics VCs in Dome Creek and Victoria Creek are expected to represent an improvement to existing conditions. A summary of the residual effects is described below for both nodes, with significance for each indicator provided in Table 7.3-14.

7.3.3.7.1 Dome Creek

The habitat in Dome Creek has low ecological value, does not support fish, and the presence of unusual or uncommon benthic invertebrate or algae species are not documented (Appendix 6E). Applied mitigations (water treatment) are predicted to result in positive not significant effects on surface water quality for some elements (e.g., TSS, total arsenic and total and dissolved iron) as shown through comparison of the post-treatment and pre-treatment scenario predictions. Positive not significant effects are also expected for other indicators as a result of water treatment (e.g., dissolved aluminum, dissolved cadmium), while not significant effects are expected for sulphate or manganese (Section 7.3.3.5). Ongoing monitoring will be used to assess the overall aquatic health of Dome Creek downstream of the Site, and to inform future decision-making regarding WQOs, including total manganese.

Predicted concentrations for parameters of concern after treatment are marginally above applicable WQOs and only for a limited period of time associated with higher-flow, TSS-related events (fresnet) which are typical of the region. Therefore, toxicity to aquatic biota in Dome Creek is not expected to result.

Potential residual effects in Dome Creek for the post-treatment scenario are not significant moderate as water quality is predicted to be beyond the variability of existing conditions but have low risk of adverse toxicological effects. The geographic extent and duration for these effects are also not significant moderate as they are limited to the LSA and expected to occur continuously but be limited to fresnet. Potential effects are expected to be reversible in nature as this aquatic system regularly experiences and recovers from natural disturbances, such as high flow events. The ecological context is considered to be not significant as the system is currently adversely affected by previous human activity. The overall significance of residual effects on Dome Creek are predicted to be not significant moderate.

7.3.3.7.2 Victoria Creek

Victoria Creek is considered to have moderate to high ecological value as it provides good fish habitat quality, including for overwintering, but does not provide critical or limiting habitats. The presence of fish such as Arctic Grayling, Burbot, and Slimy Sculpin has been documented in Victoria Creek, but no unusual invertebrate and/or algae species (Appendix 6E). Applied mitigations (water treatment) are predicted to have a much less pronounced effect on water quality in Victoria Creek due to the dilution factor of Victoria

Creek from Dome Creek, as well as upstream background influences on Victoria Creek. A positive not significant effects on surface water quality is predicted for some elements (e.g., total arsenic, total and dissolved iron, and total zinc) as shown through comparison of the post-treatment and pre-treatment scenario predictions. Not significant effects are expected for sulphate, dissolved aluminum, and total manganese (Section 7.3.3.5). Ongoing monitoring will be used to assess the overall aquatic health of Victoria Creek downstream of the Site, and to inform future decision-making regarding WQOs.

Predicted concentrations for total arsenic, dissolved aluminum, and total iron remain marginally above applicable WQOs for a limited period of time associated with higher-flow and are driven by upstream influences. The post-treatment scenario sees the predicted reversal of exceedances for total iron (month of April only) and for dissolved iron (Table 7.3-12 and Table 7.3-13). In the case of total arsenic and dissolved aluminum, TSS-related events (freshet) are typical of the region. Therefore, toxicity to aquatic biota in Dome Creek is not expected to result.

Potential residual effects in Victoria Creek for the post-treatment scenario are considered not significant moderate as water quality is predicted to be beyond the variability of existing conditions, but with a low risk of adverse toxicological effects. The anticipated Project effects related to dissolved iron (the more bioavailable and potentially toxic form of iron) are predicted to be mitigated through the implementation of water treatment.

The duration of predicted exceedances of the WQOs in Victoria Creek (which are based on generic WQGs) are considered not significant moderate as they are limited to a short timespan (up to 2 months), are associated with high flow and elevated TSS (freshet) and are largely the result of upstream activities unassociated with the current Project. The geographic extent and reversibility of the predicted effects are also not significant moderate as are limited to the LSA and the potential effects are expected to be reversible in nature. The ecological context is considered to be not significant moderate because although the system has been affected by previous human activity that level of disturbance is very low. The overall significance of residual effects on Victoria Creek are predicted to be not significant moderate.

Table 7.3-14: Summary and Significance of Residual Effects for Major Project Interactions for Water Quality

Indicator Parameter (Exceedances)	Summary of Effect on Aquatic Environments	Recommended Mitigation Measures or Best Management Practices	Residual Effect characteristics	Significance of Residual Effect
Sulphate	Effects above background with no exceedance of WQOs in Dome or Victoria Creeks.	None specified at this time.	NSM magnitude and duration; NSM geographic extent; NSM reversibility and NS ecological context.	Not Significant Moderate
Total Arsenic	Effects above background and equal to WQO in Dome Creek; above WQO in Victoria Creek.	Implementation of water treatment; sediment and erosion control.	NSM magnitude and duration (seasonal effects); S geographic extent; NSM reversibility and NSM ecological context.	Not Significant Moderate
Dissolved Aluminum	Effects above background and marginally above WQO in Dome Creek and Victoria Creek.	Implementation of water treatment; sediment and erosion control.	NSM magnitude and duration (seasonal effect); NSM geographic extent (local); NSM reversibility and ecological context.	Not Significant Moderate
Total Iron	Effects above background and above WQO in Dome Creek and Victoria Creek.	Implementation of water treatment; sediment and erosion control.	NSM magnitude and S duration (effects continuous); NSM geographic extent (local); NSM reversibility and ecological context.	Not Significant Moderate
Dissolved Iron	Effects above background with marginal WQO exceedance in Dome Creek only.	Implementation of water treatment; sediment and erosion control.	NSM magnitude and duration (effects are seasonal); NSM geographic extent (local); NSM reversibility and NS ecological context.	Not Significant Moderate
Total Manganese	Effects above background with a marginal WQO exceedance in Dome Creek only.	Implementation of water treatment; sediment and erosion control.	NSM magnitude and duration; NS geographic extent (PSA); NSM reversible and NS ecological context.	Not Significant Moderate
Total Zinc	Effects above background with no exceedance of WQOs in Dome or Victoria Creeks.	Implementation of water treatment; sediment and erosion control.	NSM magnitude and duration; NS geographic extent (PSA); NSM reversibility and ecological context.	Not Significant Moderate

7.3.3.8 Further Monitoring Program and Adaptive Management Plans

The aquatic environment will be monitored to confirm predicted environmental performance and to demonstrate compliance with regulatory requirements. Monitoring results will be presented in comprehensive reports that will assess conditions relative to predictions and provide recommendations for future actions and/or additional mitigation plans. The proposed surface water quality and aquatic effects monitoring program (AEMP; Appendix 7C) is a continuation and refinement of the existing, well-established programs. The AEMP will also include monitoring that will focus on detecting changes to the aquatic environments of Dome and Victoria Creeks, so that stakeholders will be able to monitor improvements to overall surface water quality and aquatic health of the receiving environment following WTP implementation.

In addition to ongoing surface water quality and aquatic monitoring, water treatment management and monitoring will be conducted as outlined in Appendix 5D. Observations from site monitoring program will inform the on-going adaptive management plan (Appendix 7D) to ensure best management practices and environmental compliance.

7.3.4 Wildlife Effects Assessment

This section describes the analysis of the Project on wildlife and wildlife habitat (herein referred to as WWH). As identified in Table 7.3-3, one major interaction (i.e., ranked as "2" in the interaction matrix) was identified between the Project activities and WWH. Several potential minor interactions (i.e., ranked as "1" in the interactions matrix) were also identified. These interactions occur through effects pathways of contaminant transport and uptake, wildlife physical safety risks, or disturbances. Each of these effects pathways were considered in the context of all project activities to develop the interactions noted previously.

In order to refine the interactions between the project and WWH, a series of WWH indicators were defined that allowed for pathways and potential effects to be described more precisely, and in relation to a specific component of WWH. Each of these indicators has a set of ecological objectives specifically related to Project activities. This Section provides an analysis of potential project effects and associated mitigation measures, as well as a description of effect significance as described in Section 7.2.3.

7.3.4.1 Effects Analysis

Pathways of effects are mechanisms through which project activities result in effects to a VC. Pathways can be of a physical, chemical, environmental, or other nature. Effects on WWH as a result of the Project are anticipated to occur via four main pathways (Table 7.3-15). Each identified pathway is subsequently described in terms of the linkages between the Project activities and potential effects.

Table 7.3-15: Wildlife and Wildlife Habitat Pathways of Effects

Pathway	Potential Effects
Waste food or deliberate feeding of animals regularly attracts them to areas of the Site (habituation).	Animals are euthanized because they become a nuisance or pose a serious hazard to site safety.
Metals uptake through feeding or exposure.	Direct or indirect sub-lethal health effects or mortality.
Vehicle or equipment collisions with wildlife.	Mortality or sub-lethal health effects.
Sensory disturbance (visual, olfactory, auditory).	Disturbance, disruption or avoidance (e.g., feeding, breeding) leading to lethal or sub-lethal effects.

7.3.4.1.1 Habituation of Wildlife

Poor food waste management and the deliberate feeding of animals can lead to individual animals or groups of animals becoming habituated to an area and their activities may become a nuisance (e.g., flocking gulls at a work site) or could pose a safety risk for site personnel (e.g., bears attracted to stored garbage, barbecues, or discarded food). Once habituation of an animal occurs it can be a very difficult situation to manage or reverse and often results in animals being euthanized.

7.3.4.1.2 Metals Uptake

Tailings and tailings water storage as well as other water management activities related to Site care and maintenance can result in pathways of metals uptake to wildlife. Tailings stored in the tailings impoundment

can remobilize to the surrounding environment by wind erosion, creating fugitive dust that settles on the surrounding ground and vegetation, potentially increasing the metal concentrations in vegetation and soils.

Metals contaminated water is present in the Brown McDade Pit, tailings impoundment, seepage pathways, and other wet environments at the Site, and can be taken up by vegetation in these areas. Once mobilized in the environment, the contaminant pathway is realized if wildlife ingest contaminated sediment, soil, vegetation, animal/invertebrate tissue, or water. In addition, direct contact (e.g., skin exposure) with vegetation, soil, water, and tailings sediment can be an alternate pathway of uptake. Depending on factors such as metals concentrations, exposure duration, and uptake rates, mortality or sub-lethal effects may result from the accumulation of heavy metals in body systems.

7.3.4.1.3 Vehicle and Equipment Collisions with Wildlife

Mortality through vehicle and equipment collisions with wildlife is a pathway that has the potential to occur, including from traffic associated with transporting fuel, materials, personnel and supplies, as well as snow management, pad clearing (for the water treatment plant) and general onsite traffic. Collisions could cause mortality or sub-lethal injury. In the case of sub-lethal injury, physical trauma from the collision may hinder or reduce the individual's ability to survive (e.g., reduced motility or ability to feed) and may therefore indirectly result in mortality by increasing an individual's vulnerability and potential risk of predation.

7.3.4.1.4 Sensory Disturbance

Sensory disturbance is a pathway that has the potential to occur as a result of Site activities and physical works including on-land construction, waste and water management, site monitoring activities, and water treatment plant site preparation and construction. Sensory disturbance can result from any activities that stimulate and disrupt the visual, olfactory, and auditory senses of wildlife. Personnel and equipment (e.g., work crews, trucks, excavators, and drill rigs) create temporary noise and vibrations (e.g., engine operation, hydraulics and verbal communication) and also odours (e.g., exhaust fumes, crew food and cigarette smoke). These disturbances can result in the direct avoidance of an area, or in a stress response in wildlife. Such responses can be minor, or if more serious could potentially lead to the disruption of a migration route or movement trajectory, or in the abandonment of activities and habitat related to breeding, nesting, resting, feeding, or sheltering that ultimately could lead to sub-lethal effects or mortality.

7.3.4.2 Indicator Species and Habitats

Effects on WWH can manifest themselves through a variety of pathways, and on a multitude of local species or species groups. Consequently, it is not feasible to assess the potential effects of the Project for all species occurring within the area of influence of the Site. To adequately describe potential effects applicable to a wide variety of species, seven indicators of WWH were chosen on which to conduct a detailed assessment of potential project effects. Indicator species were chosen based on their relative high local value or cultural significance, their effectiveness as key receptors for a particular project interaction, their specific habitat requirements and documented occurrence on site. These indicator species or species groups exemplify the potential interactions of many other species; for example, one indicator (avian nesting habitat) was chosen based on its importance to sustain a specific life function for a broad group of species (Table 7.3-16)

Together, these seven indicators are considered to represent the pathways of potential effects and the wildlife and wildlife habitats occurring in the vicinity of the MNCMP.

Table 7.3-16: Wildlife and Wildlife Habitat Indicators

Indicator	Rationale
Woodland Caribou	Woodland Caribou are an important species traditionally, ecologically, and socio-economically, and are harvested in the Project area.
Moose	Moose are an important species traditionally, ecologically, and socio-economically, and are harvested in the region of the Project. Moose densities range from low to high within the LSA and RSA.
Avian species and avian nesting habitat	Passerines (small terrestrial migratory or non-migratory birds) occur within the Project LSA, including Olive-Sided Flycatcher, and Common Nighthawk, both are Species at Risk (SAR). Passerines have relatively specialized nesting habitat requirements and are ubiquitous to nearly all habitats at the Site. Accordingly, avian nesting habitat (which would include foraging habitat) was chosen as an indicator for the effects of local disturbance caused by project activities and the potential for fugitive tailings dust to affect avian habitat. Shorebirds are known to occur in and around the tailings impoundment area seasonally (e.g., Spotted Sandpiper). They could potentially be exposed to contaminant pathways through drinking water and feeding (including ingesting grit, soil and tailings) and therefore are a representative indicator for wildlife that may occur at the Site either regularly or occasionally.
Grizzly Bear and Black Bear	Grizzly Bears are listed as a species of Special Concern under the federal <i>Species at Risk Act</i> (SARA), and both Grizzly Bears and Black Bears are of ecological, cultural and socio-economic importance. Bears use a variety of specific habitats seasonally, are wide ranging and omnivorous. These species are good indicators of ecosystem integrity, as well as indicators of local wildlife-human interactions (e.g., vehicle-wildlife interactions and attracted to human food waste) and are known to occur within the LSA. Both species are good indicators to represent effects on other large-ranging carnivores and omnivores.
Small Mammals (e.g., mice, voles)	Several species of small mammals are ubiquitous to the Project area and form a primary food source for other wildlife species (e.g., birds or canids). As small mammals generally have limited home ranges and forage on vegetative materials, they are good indicators of local conditions and form a potential pathway for environmental contaminants to enter the food chain and reach higher trophic levels.
Rodents (e.g., Red Squirrel, Porcupine, Arctic Ground Squirrel)	Several species of rodents occur in the Project area. These species are commonly prey sources for larger animals. Rodents also generally have limited home ranges and forage on vegetative materials, therefore they are good indicators of local conditions, either directly or as a potential pathway for environmental contaminants to enter the food chain and reach higher trophic levels.
Canids (e.g., Red Fox, Coyote, Wolf)	Several species of canids occur in the Project area, and feed on rodents, birds and small mammals as well as vegetation (e.g., berries). Canids generally range over moderately sized areas and their abundance is not considered to be high at the Site. They do however spend longer periods in localised areas when birthing and rearing young. This behaviour, coupled with their feeding preferences means they are good indicators of local conditions and form a potential pathway for metals to be ingested directly or through lower trophic levels. Canids are also indicators of local wildlife-human interactions (e.g., vehicle-wildlife interactions and are attracted to human food waste).

7.3.4.3 Consideration of Species at Risk (SAR) in Indicator Selection

SAR occurring in the LSA and RSA include caribou, Wolverine, Grizzly Bear, and Olive-Sided Flycatcher, (as identified in Appendix 6F). Not all SAR occurring or potentially occurring in the PSA were included as indicators; however, the habitat requirements and sensitivities of the selected indicators are considered to adequately represent potential impacts to these SAR.

Caribou are listed under Schedule 1 of *Species at Risk Act* (SARA) as a species of special concern and do occur in the project area, although not frequently within the project footprint (as described in Appendix 6F). Caribou observations have been recorded over a two-year period at the Site (2012-2014), and the LSA does overlap with a Wildlife Key Area (WKA) for a caribou winter range (Klaza Herd). Based on these data, effects on caribou are not predicted to result from the MNCMP and are believed to be adequately represented by moose (i.e., for caribou moving through the LSA area).

Wolverine are listed as a Species of Special Concern by the Committee on the Status of Endangered Species in Canada (COSEWIC) and are stable in the Yukon. While wolverine do occur in the LSA, their presence is rare, likely due to very large home ranges and nomadic behaviours. Wolverine are sensitive to anthropogenic disturbances on habitat; however, effects on this species are considered to be adequately represented by bears and wolves for the purposes of this assessment as the diet of bears, wolves and Wolverine overlap and all species will both hunt and scavenge food.

Several avian SAR have the potential to occur in the Project LSA area (e.g., rusty blackbird, SARA Schedule 1 - special concern; horned grebe, SARA Schedule 1 - special concern) or have been documented in the area (olive-sided flycatcher, SARA Schedule 1 – threatened; common nighthawk, SARA Schedule 1 - threatened). These species have not specifically been identified as project indicators as effects on these avian SAR were considered to be adequately represented through the assessment of effects on avian nesting habitat.

7.3.4.4 Ecological Objectives

The following series of ecological objectives were developed for the Project to define acceptable thresholds or limits associated with the identified pathways and project-related effects on wildlife and wildlife habitat. Ecological objectives will assist in determining the significance of potential effects and guide the development of project-specific mitigation measures in the PSA and LSA.

Ecological objectives considered for the MNCMP include those related to habitat use, habitat availability or acceptable loss and metals concentrations in tissue, as well as acceptable rates of project-related wildlife mortality. Ecological objectives for the project are described for the chosen indicator species and habitats in terms of these four broad categories and are summarized according to each indicator in Table 7.3-17.

Table 7.3-17: Ecological Objectives for Wildlife and Wildlife Habitat Indicators

Indicator	Category	Specific Ecological Objective
Moose	Habitat Loss	No project related habitat loss within the LSA.
	Mortality	No project related mortality of moose within the LSA.
	Local Site Use	No project related reduction in the frequency of LSA usage by moose.
	Metals Uptake	No objective defined.
Caribou	Habitat Loss	No project related habitat loss within the LSA.
	Mortality	No project related mortality of caribou within the LSA.
	Local Site Use	No project related reduction in the frequency of LSA usage by caribou.
	Metals Uptake	No objective defined.

Indicator	Category	Specific Ecological Objective
Grizzly and Black Bear	Habitat Loss	No project related habitat loss within the LSA.
	Mortality	Zero project related mortality within the LSA.
	Local Site Use	Zero project related human-bear incidents within the LSA. No project related reduction of frequency of LSA use by grizzly and black bear.
	Metals Uptake	No objective defined.
Avian Nesting Habitat	Habitat Loss	Minimize project related losses of avian nesting habitat within the LSA. No habitat loss during the active nesting window (May 1 to August 15) for migratory and non-migratory birds.
	Mortality	No mortality of nesting birds, eggs, or hatchlings caused by project activities within the LSA.
	Local Site Use	No objective defined.
	Metals Uptake	No objective defined.
Rodents	Habitat Loss	No project related loss of rodent habitat within the LSA.
	Mortality	No project related mortality except when infrastructure stability is threatened or there is a risk to human health.
	Local Site Use	No objective defined.
	Metals Uptake	No project related exceedance of the maximum tolerable limit of metals for rodents (NRC 2005) in food source (vegetation)
Small Mammals	Habitat Loss	Minimize project related losses of small mammal habitat within the LSA.
	Mortality	Minimize mortality of small mammals in the LSA.
	Local Site Use	No objective defined.
	Metals Uptake	No project related exceedance of the maximum tolerable limit of metals for rodents (NRC 2005) in food source (vegetation)

7.3.4.5 Potential Project Effects and Mitigation Measures

All potential effects on WWH and related mitigation measures are summarized in Table 7.3-18. A number of standard mitigation measures are included in the Site Environmental Management Plan (EMP; Appendix 5F) and will be applied to the Project, where relevant. Some additional mitigation measures have also been included in Table 7.3-18. The standard mitigation measures are anticipated to mitigate all minor interaction effects in Table 7.3-18 to an acceptable level. Major interactions will require additional site-specific mitigation measures to be applied in order to achieve the Project ecological objectives for WWH. The potential projects effects and their related mitigation measures are discussed below for each indicator.

7.3.4.5.1 Moose and Caribou

Moose and Caribou may be affected by the Project activities identified in Table 7.3-18. Most notably, mortality or sub-lethal effects could result from interactions between vehicles and Moose or Caribou. The pathway for this effect is via the transport of site personnel and goods around the Site and along the access road. Any mortality of Moose or Caribou would not meet the ecological objective of zero project related mortality of Moose within the LSA. However, the interaction between vehicles and Moose or Caribou is considered to be minor (ranked as a “1”) as neither Moose or Caribou are commonly observed in the LSA, and less frequently on Site. This interaction can be mitigated by applying standard mitigation measures or

BMPs to minimize the risk of interactions between vehicles and Moose or Caribou occurring (e.g., applying and enforcing strict speed limits to project related traffic; promoting wildlife awareness information in site safety orientations and, when possible, planning vehicular travel only in daylight hours).

7.3.4.5.2 Avian Species and Nesting Habitat

Several standard mitigations measures will be employed to limit effects on avian nesting habitat, including best management practices directed at preventing avian mortality during the bird nesting season, as regulated by the *Migratory Bird Convention Act* and the *Yukon Wildlife Act*. These standard mitigation measures will focus on scheduling any construction activities to fall outside of the migratory bird nesting window of May 1 to August 15 (Government of Canada 2017b), and pre-clearing vegetation from planned construction areas during the non-nesting season. In addition, avian nest searches by a qualified person will be conducted within areas scheduled to be cleared prior to commencing works if such works must be completed during the bird nesting window of May 1 to August 15.

The potential effects of metal concentrations found in soil and plant tissue on avian species and habitat are considered to be similar to the potential effects on small mammal and rodent species and have been discussed in the small mammals and rodent section below.

7.3.4.5.3 Bears and Canids

The effects of the Project on bears (Grizzly Bear and Black Bear) and canids are expected to be limited to minor interactions (ranked as "1") that involve potential mortality resulting from animals becoming a nuisance or posing a site safety hazard. Poor garbage and food management or Site personnel and contractors deliberately feeding the animals would be the main pathways by which these effects would occur. Bears and canids are not regularly observed on Site and following the implementation of standard mitigation measures and BMPs (e.g., use of bear-proof containers for garbage and other waste, and a strict no feeding policy), the effects on bears and canids are expected to be low.

Vehicle interactions with bears or canids leading to sub-lethal or lethal effects have the potential to occur. The pathway for this effect is via the transport of site personnel and goods around the Site and along the access road. However, these interactions are considered to be minor (ranked as a "1") as bears and canids are not commonly observed in the LSA, and less so on Site. This interaction can be mitigated by applying standard mitigation measures or BMPs to minimize the risk of vehicular/bear or canid interactions occurring (e.g., applying and enforcing strict speed limits to project related traffic, promoting wildlife awareness in site safety orientations and, when possible, planning vehicular travel only in daylight hours).

7.3.4.5.4 Small Mammals and Rodents

The deposition of fugitive dust generated from the tailings impoundment is identified as a potential contaminant pathway for small mammals and rodents (and also avian species and habitat). Previous studies at the Site have described metal concentrations in soil and plant tissue (willow leaves, lichen and berries) at a minimum of 47 locations (Appendix 6F) including four reference control sites, and through the deployment of moss bags in six areas to trap dust over different seasonal periods for laboratory analysis

(EDI 2006). The results of both studies indicate that the concentrations of some metals were in some cases higher than those at comparable reference/control sites. Soil samples were compared to CCME *Soil Quality Guidelines for the protection of Environmental and Human Health* for both parkland and industrial sites (SQG-PL and SQG-I, respectively). Antimony and thallium each exceeded the SQG-I value once (both close to the mill area), and arsenic concentrations exceeded the SQG-I concentration at 19 locations. No exceedances of SQG-I or SQG-PL concentrations were exceeded at any of the background control locations.

For plant tissue, most metals concentrations did not exceed the maximum tolerable limit (MTL) for rodents set by the National Research Council (NRC 2005). The metals concentrations in lichen tissue that did exceed the rodent MTL included aluminum (27 exceedances including at three reference control sites), arsenic (one exceedance), lead (one exceedance) and iron (11 exceedances including three exceedances at background control sites). It should be noted that lichen species are slow growing and long-lived, and therefore metals concentrations in lichens from those studies are likely a result of years of accumulation, dating to before mining activity at the Site. Conversely, metals concentrations in berries, young willow shoots and leaves would provide concentrations resulting from one or two years of deposition and/or uptake. Metals concentrations in willow tissue exceeded the MTL for rodents twice, once each for iron and cadmium, and there were no exceedances of the MTL for rodents of metal concentrations in berry tissue, including the four background control sites.

In general, the results of the studies indicate that although the concentrations of many metals in soil and plant tissue on Site are higher than background levels, most metals concentrations do not exceed the MTL for rodents. In some cases, the background control concentrations of some metals are comparable to the plant tissue concentrations at the Site (e.g., iron, aluminum).

Because the Site is no longer an operating mine it is anticipated that metals concentrations will not greatly increase over the life of the Project. However, the studies demonstrated that some metals are still being deposited seasonally around the TSF (e.g., arsenic, copper, lead) and the Brown McDade Pit (copper). As the water level in the tailings impoundment is generally lower than the historic levels, more of the tailings are exposed. This presents more potential for fugitive tailings dust to be generated over the life of the project, further increasing the concentrations of some metals on and in soils and plants. This fugitive dust deposition is the pathway by which small mammals, rodents, and avian species may be affected through direct contact with the dust or ingestion of dust or plant material. As the duration of the Project is only five years, a major increase in concentrations of metals is not anticipated, but this can effectively be monitored through the implementation of an annual moss bag study, where study thresholds can be established that would trigger specific mitigation measures. In years one to five of the project, moss bags are proposed to be deployed around the TSF and at control sites between early spring and mid-summer and analyzed for a full suite of metals. Moss bags are a simple and effective way of quantifying the rate of deposition of metals in dust within a specific time frame. If the laboratory analytical results indicate that metal concentrations exceed the relevant MTL for rodents in a specified number of moss bag locations, then an additional mitigation measure would be initiated (e.g., the application of tackifiers on the tailings to greatly reduce fugitive dust). Please see the Terrestrial Effects Monitoring Program (Appendix 7E) for more detail.

Vegetation is currently managed within the TSF as part of on-going maintenance at the Site and this activity also serves as a mitigation for deterring small mammals and rodents. The implementation of this mitigation measure will also serve to reduce the potential for dust-mammal contact or ingestion (a toxicological pathway). Without sufficient food resources and suitable habitat, the potential for a contaminant pathway will be reduced.

Any sensory disturbances (e.g., from construction work) are not expected to be of a high magnitude and would be temporary in nature.

Table 7.3-18: Wildlife and Wildlife Habitat Interactions Summary by Indicator

Activity Group	Project Activity	Wildlife Indicator							Description of Interaction / Effects	Mitigation Measures
		Caribou	Moose	Avian Species / Nesting Habitat	Bears (Black and Grizzly)	Small Mammals (e.g., mice, voles)	Rodents (e.g., Red Squirrel, Porcupine, Arctic Ground Squirrel)	Canids (e.g., Red Fox, Coyote, Wolf)		
Construction	Water treatment plant construction	0	0	0	1	1	0	1	- Habituation of the area by wildlife (because of food waste or deliberate feeding) may lead to nuisance or dangerous wildlife that are euthanized - Sensory disturbance from equipment or crews has the potential to cause changes in behaviour (breeding, nesting, resting, feeding, or sheltering) leading to mortality or sub-lethal effects.	Mitigation measures to be implemented from the EMP.
Waste and Water Management	Storage of tailings and water in the TSF	0	0	2	0	2	2	0	Wildlife feeding on surrounding vegetation or nesting, foraging around the tailings impoundment may lead to the potential uptake of contaminants that may also be passed up the food chain to higher trophic levels.	- Mitigation measures to be implemented from the EMP. - Monitor metals deposition through moss bag study. If threshold criterion is met, apply tackifiers to the tailings in the TSF (see Terrestrial Effects Monitoring Plan).
	Storage of Waste Rock near Brown McDade Pit	0	0	0	0	0	0	0	None anticipated	
	Storage of potentially contaminated water in Brown McDade Pit	0	0	1	0	0	0	0	Wildlife occurring in the water (shorebirds) may potentially uptake contaminants that may lead to mortality or sub-lethal effects and be passed up the food chain to higher trophic levels.	- Mitigation measures to be implemented from the EMP. <i>Additional Mitigation Measures:</i> - During regular Site monitoring events, discourage any birds from foraging in the water or at the shoreline. Air horns, bear bangers and clapping can be used to encourage the birds to move away from the water in the pit.
	Treatment and discharge of seepage pond water into Dome Creek	0	0	0	0	0	0	0	None anticipated.	
	Diversion of upper Dome Creek flow around the tailings impoundment	0	0	0	0	0	0	0	None anticipated.	
	Continued presence of mill area including potentially contaminated soils	0	0	1	0	0	1	0	Wildlife feeding on surrounding vegetation or nesting, foraging around the mill area may lead to the potential uptake of contaminants that may also be passed up the food chain to higher trophic levels.	No specific mitigation is required as the effect, although possible, is likely very minor and will not be fully mitigated until remediation of the site.
	Transportation and disposal of sludge from WTP into TSF	0	0	1	0	0	1	0	Sensory disturbance from equipment or crews has the potential to cause changes in behaviour (breeding, nesting, resting, feeding, or sheltering) leading to lethal or sub-lethal effects.	- Mitigation measures to be implemented from the EMP. <i>Additional Mitigation Measures:</i> - Plan the removal and the transportation of the sludge so that sensory disturbance of local wildlife is minimized (e.g., noise levels, route taken by trucks, minimal idling of trucks)
Facilities management	Maintenance of Dome Creek Diversion (Ice and sediment removal as needed).	0	0	0	0	0	0	0	None anticipated.	
	Inspection and maintenance of the embankments of the tailings dam, seepage pond, and diversion.	0	0	0	0	0	0	0	None anticipated.	
	Flood control of seepage dam water	0	0	0	0	0	0	0	None anticipated.	
	Maintenance of Power System	0	0	0	0	0	0	0	None anticipated.	
	Structural maintenance and management of bunkhouse and workshop.	0	0	0	0	0	0	0	None anticipated.	
Site Investigations	Potential new monitoring equipment installation (e.g., wells, thermistors, flow measurement facilities.	0	0	1	0	1	1	1	- Habituation of the area by wildlife (because of food waste or deliberate feeding) may lead to nuisance or dangerous wildlife that is euthanized - Sensory disturbance from equipment or crews has the potential to cause changes in (breeding, nesting, resting, feeding, or sheltering) leading to mortality or sub-lethal effects.	- Mitigation measures to be implemented from the EMP. <i>Additional Mitigation Measures:</i> - Plan the site investigations so that time on site is kept to a minimum and any sensory disturbance is minimized (e.g., noise levels).
Accessory Activities	Transport of potentially hazardous materials (fuel, reagents, solvents and their waste products) to and from the Site	1	1	0	1	1	1	1	Vehicular/wildlife interactions leading to potential lethal or sub-lethal effects	- Mitigation measures to be implemented from the EMP <i>Additional Mitigation Measures:</i> - As far as is practicable, deliveries to the Site should occur during daylight hours
	Transport of personnel, food, and supplies.	1	1	0	1	1	1	1	Vehicular/wildlife interactions leading to potential lethal or sublethal effects	- Mitigation measures to be implemented from the EMP. <i>Additional Mitigation Measures:</i> - As far as is practicable, deliveries to the Site should occur during daylight hours

Activity Group	Project Activity	Wildlife Indicator							Description of Interaction / Effects	Mitigation Measures
		Caribou	Moose	Avian Species / Nesting Habitat	Bears (Black and Grizzly)	Small Mammals (e.g., mice, voles)	Rodents (e.g., Red Squirrel, Porcupine, Arctic Ground Squirrel)	Canids (e.g., Red Fox, Coyote, Wolf)		
	On-site storage of hazardous materials (reagents, fuel, and solvents).	0	0	0	0	0	0	0	• None anticipated	
	Bunkhouse waste management	0	0	0	1	0	1	1	• Habituation of the area by wildlife (because of food waste or storage or deliberate feeding) may lead to nuisance or hazardous wildlife that may be euthanized	• Mitigation measures to be implemented from the EMP
	Site road maintenance (grading, snow plowing, minor repairs)	0	0	0	0	1	1	0	• Sensory disturbance from equipment or crews has the potential to cause changes in behaviour (breeding, nesting, resting, feeding, or sheltering) leading to lethal or sublethal effects.	• Mitigation measures to be implemented from the EMP <i>Additional Mitigation Measures:</i> • Plan the access route maintenance so that sensory disturbance to local wildlife is minimized (e.g., noise levels, efficient routing of equipment)
	Access control	0	0	0	0	0	0	0	• None anticipated	

7.3.4.6 Significance Criteria

Criteria were established on which to evaluate the significance of residual project effects on wildlife for the potential major interaction (storage of tailings and water in the TSF), based on the defined ecological objectives and the effects criteria listed earlier. A significance ranking is the level of significance of a residual effect after mitigation measures have been applied to the project activity, with the objective of having avoid significant project effects. The significance criteria are presented in Table 7.3-19, and the residual effects of storage of tailings and water in the TSF is described below for each affected indicator species or habitat. A significance statement and summary of residual effects is provided in Table 7.3-20.

Table 7.3-19: Characterization of Residual Environmental Effects on Wildlife and Wildlife Habitat

Effect Characterization	Effect Measurement	Significance Ranking	Description of Qualitative Categories
Magnitude and Likelihood	Concentrations of heavy metals in vegetation tissue and related health of local populations.	NS	No increase in heavy metal concentrations in vegetation tissues. No measurable decrease to small mammal or bird population density.
		NSM	Minor increase in heavy metal concentrations in vegetation tissues. Slight to moderate decrease in small mammal or bird population density.
		S	Significant increase in heavy metal concentrations in vegetation tissues. Significant decrease in small mammal or bird population density.
Duration	The period of during which the project-related effect can be observed.	NS	Short-term where the effect is not observed beyond the 5-year project period.
		NSM	Medium term where the effect may be observed for 5-25 years due to the retention of metals within soils and vegetation tissues.
		S	Long term where the effect continues to be observed for greater than 25 years.
Geographic extent	The geographic extent within which a project effect is observed.	NS	Effects limited to within the proximity of Site infrastructure only (i.e., project footprint area).
		NSM	Effects extent to the Project LSA area.
		S	Effects extend to the regional area.
Reversibility	The extent to which an effect will be reversed over time.	NS	Not applicable as there are no measurable changes from existing state.
		NSM	Effects are reversible over time once factors resulting in effect are removed.
		S	Effects are not reversible.
Ecological Context	Ecological value and fragility and of affected area.	NS	Habitats or populations affected by previous human activities and/or other project developments. No high value habitats or rare populations.
		NSM	Habitats or populations affected by previous human activities and/or other project developments, but the level of disturbance is low. Populations or species of moderate integral value.
		S	Habitats or populations not or minimally affected by previous activities. Habitats that are considered limiting, critical could be affected by project.

Notes: NS=not significant; NSM= not significant moderate; S=significant

7.3.4.7 Effects Description and Proposed Mitigation Measures

7.3.4.7.1 Avian Nesting Habitat

The storage of tailings and water at the Site was ranked as a major interaction for avian species and nesting habitat because fugitive dust from the tailings is deposited on surrounding vegetation and could come in contact with or be ingested by avian species, particularly during the nesting period. This interaction could lead to mortalities or sub-lethal effects on nesting adult birds, eggs or young. Following the implementation of project mitigations, effects on avian species and nesting habitat are expected to be not significant in magnitude as most bird species will only nest and forage at the Site during a limited nesting and rearing period. Effects may continue beyond the Project time frame (five years) because of accumulation and retention of metals in soil and some plants or lichen (not significant moderate effect). The reversibility of effects are expected to be not significant moderate as most existing metals concentrations at the Site are not greatly elevated above background levels. The geographic extent of the effect is highly localized around existing infrastructure (not significant effect), and the ecological context is not significant. Overall, project effects on avian species and nesting habitat are expected to be not significant. The potential application of tackifiers to the tailings, if triggered and implemented, will also further help reduce the exposure of avian species to fugitive tailings dust and harden the surface of the tailings, making it less attractive for foraging shorebirds.

7.3.4.7.2 Small Mammals and Rodents

The storage of tailings and water at the MNCMP was ranked as a major interaction for small mammal and rodent species because fugitive dust from the tailings is deposited on surrounding vegetation and can come in contact with or be ingested by these species. For some species, this could occur year-round (e.g., mice and voles) and so the magnitude of the effect would be greater. This interaction could lead to mortalities or sub-lethal effects on individuals at all life stages. Following the implementation of project mitigations, effects on small mammals and rodents are expected to be not significant in magnitude. Effects may continue beyond the time frame of the project (five years) because of historic metals accumulation in soil and some plants and lichens but are not anticipated to greatly increase over the term of the project (not significant moderate effect). Effects over the long term are expected to be reversible (not significant moderate), especially as existing metals concentrations at the Site are not greatly elevated above background levels and very few metals exceed the MTL for rodents. The geographic extent of the effect is localized around existing infrastructure (not significant geographic extent), and the ecological context is not significant. The potential application of tackifiers to the tailings, if triggered and implemented, will also further help reduce the exposure of small mammals and rodent species to tailings dust. Overall, the project effects on small mammals and rodents are expected to be not significant.

Table 7.3-20: Wildlife and Wildlife Habitat Effects Summary and Significance of Residual Effects for Major Project Interactions

Project Activities / Physical Works	Indicator Species / Habitat	Description of Interaction / Effect	Recommended Mitigation Measures or Best Management Practices	Residual Effect	Significance of Residual Effect
Storage of tailings and water in the TSF	Small mammals, rodents, avian species and avian nesting habitat	Potential uptake and transfer of metals resulting from contact and ingestion of plant material or water contaminated by fugitive tailings dust	- Remove vegetation within the TSF to limit the feeding opportunities and reduce the overall habitat value. - Apply tackifiers to the tailings if the moss bag study indicates that tackifiers should be applied (see Terrestrial Effects Monitoring Plan). This will minimize the generation and subsequent deposition of fugitive dust on vegetation within the LSA and make the tailings texture less attractive to any foraging shorebirds.	No increase in plant tissue heavy metal concentrations and no resulting increase in wildlife tissue heavy metal concentrations.	Not Significant

7.3.5 Effects of Extreme Environmental Events on the Project

The potential effects of extreme environmental events on the project were considered as part of the environmental effects assessment. For the purpose of this assessment, extreme environmental events refer to factors external to the project that are outside of the control of the proponent and operators, namely extreme precipitation and flooding events, seismic events (earthquakes), and forest fires.

The potential magnitude of and risk associated with these extreme environmental events has been characterized through existing environment studies, ongoing monitoring and management plans, and ongoing assessments associated with current care and maintenance activities. This information is summarized and described in the relevant sections below.

7.3.5.1 Extreme Precipitation and Flooding Events

The management of water and mine waste products (namely tailings) is a key component of the Project, and includes several water conveyance, storage, and treatment structures. These structures are primarily found in the Dome Creek drainage area. Water from upper Dome Creek is conveyed around the TSF via the DCDC and re-joins Dome Creek downstream of the seepage pond. Precipitation and runoff water is also captured by the tailings dam and held until either evaporation or downstream seepage occurs. Seepage water (from the seepage pond) will be treated prior to being released to Dome Creek.

Extreme precipitation and flooding events have the potential to exceed the capacity of the DCDC, potentially resulting in damage to the structure and uncontrolled water inputs to the tailings impoundment. Such uncontrolled inputs could exceed the storage capacity of the tailings impoundment, causing water and tailings to report to Dome Creek via the emergency spillway. Such an overflow could result in a temporary uncontrolled input of tailings material to Dome and Victoria creeks, with the potential to result in negative effects on water quality and aquatic life. There also exists the potential for flooding events to overtop and

compromise road crossings at Dome Creek and Victoria Creek, resulting in a temporary loss of access for personnel and supplies to the Site.

Dome Creek has a relatively small catchment area of 3.0 km² at Station DC-B (at the DCDC; Appendix 6C). Worley Parsons (2013) identified 1:200 year return period flood estimates as being suitable inflow design flood (IDF) values for the dam safety review (DSR). The IDF value used in the DSR was 3.0 m³/s (EBA 2002 in Worley Parsons 2013). For comparative purposes, a 2017 1:200 year return period flood estimate of 1.047 m³/s was calculated for the current project (Appendix 6C). The 2013 DSR concluded that the DCDC was capable of conveying the larger 1:200 year instantaneous flood event of 3.0 m³/s (Worley Parsons 2013).

Worley Parsons (2013) also determined that the emergency spillway leading from the tailings impoundment to the DCDC was capable of conveying an IDF (for that structure) of 1.3 m³/s based on a 1:200 year instantaneous peak flood event (Worley Parsons 2013). However, for this flow to be realized in the emergency spillway, a flood event would need to be of sufficient duration and magnitude to first fill the tailings impoundment to capacity. Similarly, Worley Parsons (2013) determined that 290 m of combined channel (that act as the emergency spillway and DCDC) was also capable of conveying a suitable IDF capacity. These capacities indicate that overtopping of the tailings impoundment dam (which could lead to its failure) would not occur at the IDF of a 1:200 year event.

In addition, and based on the most recent (2013) Dam Safety Review (DSR) for the TSF, a consequence classification rating of two (“significant”) was assigned for a dam failure (with one being least significant and five being most significant; Worley Parsons 2013). The rating characterization of “significant” is described in Table 7.3-21 below.

If a flood event were to overtop and cause a failure of the public road crossing at Dome Creek or Victoria Creek, on-site Staff would be temporarily cut off from receiving supplies and fuel by road. Water for staff is available on Site; however, staff would require fuel to keep Site generators running, as well as food and other miscellaneous supplies to keep the Site operational until the road could be repaired. While no alternate road access to Site exists, the fuel storage capacity on Site is sufficient to fuel generators and equipment for approximately 60-70 days. Crew changes or the transport of essential supplies to Site could be completed via helicopter, if required.

Table 7.3-21: Description of Class Two (“Significant”) Dam Consequence Classification

Category	Description
Loss of life	There is no identifiable population permanently living or working downstream of the dam at risk, so there is no possibility of loss of life other than through unforeseeable misadventure.
Environment	There is possible impairment to the wetlands and aquatic life downstream of the dam in the event of a dam breach and loss of tailings containment; however, this potential loss is not considered significant and restoration is highly possible. Further, if a breach were to result in the escape of contaminants from the tailings facility into the downstream watersheds, the dilution factor would reduce the human health risk to negligible levels. The exception to this is the groundwater wells on Victoria Creek which supply the Mt. Nansen site itself. These could be shut off in the event of a dam emergency.
Economy	Aside from the public access road, no infrastructure or services are present downstream of the facility within the anticipated zone of inundation in the event of a loss of containment.

Notes: From Worley Parsons (2013)

Based on available information, the likelihood of a failure of the DCDC or tailings impoundment is low, and the maintenance of these structures are supported by ongoing TSF inspections and ongoing maintenance as identified by these inspections.

7.3.5.2 Seismic Events

The potential for effects resulting from Seismic events were considered as part of the assessment, namely the risk of failure of the TSF impoundment. Approximately 243,000 m³ of tailings are stored behind the tailings dam, which has been in its current location since 1996 (AMEC 2014b). A failure of the tailings dam resulting from a seismic event has the potential to result in the release of tailings to Dome Creek, as well as the potential to cause flooding and failure of downstream watercourse crossings on the Site public road.

The most recent DSR assessed the potential risk of seismic events on the tailings dam, taking into account the dam construction, underlying material, as well as the potential for seismic activity at the Site (Worley Parsons 2013). The DSR found that the dam was capable of withstanding a 1:1,000 year earthquake design ground motion, and that the foundation soil and dam fill are not considered susceptible to liquefaction during such seismic events (Worley Parsons 2013).

Given the 5-year temporal cycle of the Project, the risk of seismic events of a greater magnitude than a 1:1,000 year event on the project is considered to be extremely low. Annual TSF inspections will continue according to the inspection schedule as outlined in the *Tailings Facility and Associated Structures Operation Maintenance and Surveillance Manual* (Appendix 5B).

7.3.5.3 Forest Fires

Forest fires along, adjacent to, or crossing the public access road have the potential to limit access to the site for a period of time, and therefore limit or prevent the transport of fuel and other supplies that are required for continued operation of the Site. Similar to the scenario of a compromised watercourse crossing, water for staff is available on Site, but staff would require fuel to keep on-site generators running and food and other miscellaneous supplies to keep the Site running until road access was reinstated. While no alternate access to Site exists, the fuel storage capacity on Site is sufficient to fuel generators and equipment for approximately 60-70 days. Crew changes or the transport of essential supplies to Site could be completed via helicopter.

Although the potential exists for a significant forest fire to damage at the Site itself, this potential is considered to be remote because the site lacks vegetation of a sufficient density or age to fuel a large forest fire, and many areas consist of shrub-based habitats. If it were to happen, a forest fire could cause damage to infrastructure including the staff quarters, generators, pumping infrastructure, or other equipment. Staff would be evacuated in the event of a forest fire, during which time pumping would be discontinued. Pumping would resume as soon as possible, and temporary pumping measures, as described in the project description, would be employed until any infrastructure could be repaired.

7.3.5.4 Significance of Extreme Environmental Effects

Based on the review of potential effects in the context of controls that will be in place during the term of the Project, Extreme Environmental Effects (i.e., flooding, seismic events, and forest fires) are not expected to result in significant environmental effects. The combination of design engineering controls, ongoing maintenance and inspections, as well as natural factors are considered to be sufficient to prevent significant effects.

7.3.6 Effects of Accidents and Malfunctions on the Project

The potential effect of accidents and malfunctions on the project were considered as part of the assessment. Unplanned engineering or mechanical failures, human error or negligence have the ability to result in environmental effects despite excellent project planning. The key potential accidents and malfunctions are described below.

7.3.6.1 Loss of Generator Power

The potential exists for power generation at the Site to fail due to mechanical breakdowns or a lack of fuel; however, this possibility is remote. Should generator power be lost, there is a potential for an uncontrolled release of untreated water resulting from a combination of shutdown of the WTP and loss of pumping capacity from the seepage collection pond. Despite these potential risks, numerous mitigations are in place through the *Site Operations Emergency Response Plan* (Appendix 5E), including the use of backup electrical generating capacity, and backup (gas-powered) pumping capacity for water from the seepage collection pond to Dome Creek or back to the tailings impoundment.

7.3.6.2 Physical Damage to Dams or Water Infrastructure

There exists the potential for the uncontrolled release of untreated water and tailings material resulting from an accidental failure of the tailings impoundment dam or the seepage collection pond dam. Such failures could result from human error (neglect of monitoring, pumping, or inspections; or professional error), or from unanticipated failures (unnoticed risks), or from intentional or unintentional physical damage (e.g., misuse of equipment).

These risks have been mitigated through the DSR (Worley Parsons 2013), and through measures outlined in the *Site Operations Environmental Management Plan* (Appendix 5F), *Tailings Facility Operation Maintenance Manual* (Appendix 5B), and *Tailings Facility Emergency Response Plan* (Appendix 5C).

7.3.6.3 Pumping Infrastructure Damage

Potential damage to pumping infrastructure has the potential to occur from accidents (e.g., being struck by equipment), accidental breakages (e.g., defects), or from errors in design (incorrect materials or sizing). Such damages could result in the temporary inability to pump water from the seepage collection pond, or in the temporary release of untreated water to Dome Creek.

These risks have been mitigated through the project design (WTP infrastructure design), and through redundancies in pumping infrastructure allowing for temporary storage within the seepage collection pond, alternate pumping capabilities (e.g., backup pumps), and the ability to temporarily store water in the tailings impoundment if needed. Backup pumping and water storage capabilities are described in the Project Description (Section 5).

7.3.6.4 Significance of Effects of Accidents and Malfunctions

Based on the review of potential effects in the context of controls that will be in place during the term of the Project, accidents and malfunctions are not expected to result in significant environmental effects. Sufficient design redundancy will be in place and the maintenance, monitoring, and inspections schedules are considered to be sufficient that large-scale accidents and malfunctions will not occur.

7.4 Summary of Environmental Mitigation Measures

Table 7.4-1 presents a summary of the environmental mitigation measures that are to be implemented as part of the project. This summary outlines both a summary of the mitigation measures that were defined in the detailed assessment major interactions (i.e., level “2”), as well as mitigation measures associated with minor interactions (i.e., level “1”) that were identified in the interactions table but for which a detailed effects assessment was not completed. These mitigations form part of Site operational and monitoring plans that form part of this proposal and are to be implemented during the Project. References to specific parts of the corresponding document has been provided wherever possible to guide the reader.

Table 7.4-1: Summary of Project Environmental Mitigation Measures

Project Activity or Physical Work	VC Interactions	Types of Mitigation Measures	Document	Location within Document	Comments / Specific Mitigations
Construction					
Water treatment plant construction	AQ, GWQ, SWQ, Wildlife, Vegetation	Erosion and sedimentation control measures	Sediment and Erosion Control Plan	p. 3, 4	In addition, during very dry and/or windy conditions water can be applied to the ground to help suppress fugitive dust when necessary
		Wildlife mitigation measures	Wildlife and Habitat Management Plan	p. 7	
		Water treatment plant construction location benefits	Water Treatment Plant Management Plan and Tech Report	Section 3.1.1	
		Handling and spill response for petroleum and contaminated water	Spill Contingency Plan	p. 3-5	
Waste and Water Management					
Storage of tailings and water in the TSF	AQ, GWQ, SWQ, Hydrology, Fish & Aquatic, Wildlife, Vegetation	Erosion and sedimentation control measures	Sediment and Erosion Control Plan	p. 3, 4	
		Wildlife mitigation measures	Wildlife and Habitat Management Plan	p. 7	
		Wildlife mitigation measures	Chapter 7: Environmental Effects Assessment	Table 7.3.4-4 Table 7.3.4-5	
		Actions to prevent structural failure	Tailings Facility and Associated Structures Emergency Response and Preparedness Plan	p. 9-11	
		Tailings pond seepage management	Tailings Facility and Associated Structures Operation Maintenance and Surveillance Manual	p. 10-11	
		Tailings pond seepage pump-back and treatment	Adaptive Management Plan	p. 13-18, p. 19-23, p. 24-27, p. 28-31, p. 62-65	
		Tailings pond seepage treatment	Water Treatment Plant Management Plan and Tech Report	Section 2.3, Table 2-5	
Storage of Waste Rock near Brown McDade Pit	GWQ, SWQ, Hydrology, Fish & Aquatic, Vegetation	Erosion and sedimentation control measures	Sediment and Erosion Control Plan	p. 3, 4	
		Water quality monitoring in Dome Creek and interception and diversion of contaminant sources including waste rock in Ponv Creek	Adaptive Management Plan	p. 32-38, p. 45-49	

Storage of potentially contaminated water in Brown McDade Pit	GWQ, Wildlife	Water quality monitoring in Dome Creek and interception and diversion of contaminant sources	Adaptive Management Plan	p. 32-38, p. 53-55	
Treatment and discharge of seepage pond water into Dome Creek	GWQ, SWQ, Hydrology, Fish & Aquatic, Vegetation	Erosion and sedimentation control measures	Sediment and Erosion Control Plan	p. 3, 4	
		Actions to prevent structural failure	Tailings Facility and Associated Structures Emergency Response and Preparedness Plan	p. 9-11	
		Tailings pond seepage treatment	Adaptive Management Plan	p. 13-18, p. 19-23	
		Tailings pond seepage treatment	Water Treatment Plant Management Plan and Tech Report	Section 2.3, Table 2-5	
		Tailings pond seepage pumping and discharge	Site Operations and Maintenance Manual	p. 21-22	
		Tailings pond seepage management	Tailings Facility and Associated Structures Operation Maintenance and Surveillance Manual	p. 10-12	
Diversion of upper Dome Creek flow around TSF	GWQ, SWQ, Hydrology	Erosion and sedimentation control measures	Sediment and Erosion Control Plan	p. 4	
		Actions to prevent structural failure	Tailings Facility and Associated Structures Emergency Response and Preparedness Plan	p. 9-11	
		Diversion channel maintenance	Tailings Facility and Associated Structures Operation Maintenance and Surveillance Manual	p. 9-10	
Continued presence of mill area including potentially contaminated soils	AQ, GWQ, SWQ, Fish & Aquatic, Wildlife, Vegetation	Erosion and sedimentation control measures	Sediment and Erosion Control Plan	p. 3, 4, 5	
		Wildlife mitigation measures	Wildlife and Habitat Management Plan	p. 7	
		Wildlife mitigation measures	Chapter 7: Environmental Effects Assessment	Table 7.3.4-4 Table 7.3.4-5	
		Water quality monitoring, interception and diversion, and potential remediation	Adaptive Management Plan	p. 8-12 p. 48-49	
		mill area pond maintenance and wildlife ladders	Site Operations and Maintenance Manual	p. 25	
Transportation and disposal of sludge from WTP into TSF	GWQ, SWQ, Fish & Aquatic, and wildlife	Erosion and sedimentation control measures	Sediment and Erosion Control Plan	p. 4	
		Wildlife mitigation measures	Wildlife and Habitat Management Plan	p. 7	
		Tailings pond seepage treatment	Adaptive Management Plan	p. 14-16, 26	
		Tailings pond seepage treatment	Water Treatment Plant Management Plan and Tech Report	Section 2.3, Table 2-5, Section 3.6	

Facilities Management					
Maintenance of Dome Creek Diversion (Ice and sediment removal as needed)	SWQ, Hydrology, Fish & Aquatic and Vegetation	Erosion and sedimentation control measures	Sediment and Erosion Control Plan	p. 3, 4	
		Wildlife mitigation measures	Wildlife and Habitat Management Plan	p. 7	
		Wildlife mitigation measures	Chapter 7: Environmental Effects Assessment	Table 7.3.4-4 Table 7.3.4-5	
		Actions to prevent structural failure	Tailings Facility and Associated Structures Emergency Response and Preparedness Plan	p. 9-11	
		Excavator winter ice removal	Site Operations and Maintenance Manual	p. 21	
		Diversion channel maintenance	Tailings Facility and Associated Structures Operation Maintenance and Surveillance Manual	p. 14-15	
Inspection and maintenance of the embankments of the tailings dam, seepage pond, and diversion	AQ, GWQ, SWQ, Hydrology and Vegetation	Erosion and sedimentation control measures	Sediment and Erosion Control Plan	p. 3, 4	
		Actions to prevent structural failure	Tailings Facility and Associated Structures Emergency Response and Preparedness Plan	p. 9-11	
		Maintenance of tailings dam, seepage pond, and diversion channel structures	Site Operations and Maintenance Manual	p. 22, 24	
		Maintenance of tailings dam, seepage pond, and diversion channel structures	Tailings Facility and Associated Structures Operation Maintenance and Surveillance Manual	p. 14-15, 17-19	
Flood control of seepage dam water	GWQ, SWQ, Hydrology, Fish & Aquatic	Erosion and sedimentation control measures	Sediment and Erosion Control Plan	p. 4	
		Actions to prevent structural failure	Tailings Facility and Associated Structures Emergency Response and Preparedness Plan	p. 9-11	
		Seepage pond pump power and back-up	Site Operations and Maintenance Manual	p. 20, 22-23	

Structural maintenance of Camp and Workshop	AQ, Vegetation	Erosion and sedimentation control measures	Sediment and Erosion Control Plan	p. 3, 4	In addition, during very dry and/or windy conditions water can be applied to the ground to help suppress fugitive dust when necessary
		Maintenance of boiler, furnace, generators, electrical cabling and pipes,	Site Operations and Maintenance Manual	p. 7, 9, 16	
Site Investigations					
Potential new monitoring equipment installation (e.g., wells, thermistors, flow measurement facilities)	Wildlife, Vegetation	Erosion and sedimentation control measures	Sediment and Erosion Control Plan	p. 3, 4	
		Wildlife mitigation measures	Wildlife and Habitat Management Plan	p. 7	
		Wildlife mitigation measures	Chapter 7: Environmental Effects Assessment	Table 7.3.4-4 Table 7.3.4-5	
		Seepage flow measurement Tailings dam instrumentation	Tailings Facility and Associated Structures Operation Maintenance and Surveillance Manual	p. 15, 18	
Accessory Activities					
Transport of potentially hazardous materials (fuel, reagents, solvents and their waste products) to and from the Site	AQ, GWQ, SWQ, Fish & Aquatic, Wildlife, Vegetation	Erosion and sedimentation control measures	Sediment and Erosion Control Plan	p. 3, 4	
		Waste management measures	Waste Management Control Plan	p. 2, 3	
		Wildlife mitigation measures	Wildlife and Habitat Management Plan	p. 7	Includes a measure to minimize dust by posting speed limits for vehicles. In addition, during very dry and/or windy conditions water can be applied to the ground to help suppress fugitive dust when necessary
		Wildlife mitigation measures	Chapter 7: Environmental Effects Assessment	Table 7.3.4-4 Table 7.3.4-5	
		Handling and spill response for petroleum and contaminated water	Spill Contingency Plan	p. 3-5	
		Fuel transport	Site Operations and Maintenance Manual	p. 15	
		Controlling fugitive dust	Wildlife and Habitat Management Plan	p. 7	Includes a measure to minimize dust by posting speed limits for vehicles. In addition, during very dry and/or windy conditions water can be applied to the ground to help suppress fugitive dust when necessary
Transport of personnel, food, and supplies	AQ, Wildlife, Vegetation	Erosion and sedimentation control measures	Sediment and Erosion Control Plan	p. 3, 4	
		Wildlife mitigation measures	Wildlife and Habitat Management Plan	p. 7	
		Wildlife mitigation measures	Chapter 7: Environmental Effects Assessment	Table 7.3.4-4 Table 7.3.4-5	

		Water transport	Site Operations and Maintenance Manual	p. 11	
		Erosion and sedimentation control measures	Sediment and Erosion Control Plan	p. 4	
On-site storage of hazardous materials (e.g., reagents, fuel, and solvents)	AQ, GWQ, SWQ, Fish & Aquatic	Waste management measures	Waste Management Control Plan	p. 2, 3	
		Handling and spill response for petroleum and contaminated water	Spill Contingency Plan	p. 3-5	
		Propane storage Fuel and oil storage Vehicle refuelling	Site Operations and Maintenance Manual	p. 10, 15, 21	Hazardous materials will be stored in sealable containers (e.g., pails with lids, metal containers with screw caps) to minimize fugitive and potentially hazardous vapours
		Waste management measures	Waste Management Control Plan	p. 1-3	
Camp waste management	Wildlife, Vegetation	Wildlife mitigation measures	Wildlife and Habitat Management Plan	p. 7	
		Wildlife mitigation measures	Chapter 7: Environmental Effects Assessment	Table 7.3.4-4 Table 7.3.4-5	
		Trash disposal	Site Operations and Maintenance Manual	p. 24	
		Erosion and sedimentation control measures	Sediment and Erosion Control Plan	p. 3, 4, 5	
Site road maintenance (grading, snow plowing, minor repairs)	AQ, GWQ, SWQ, Fish & Aquatic, Wildlife, Vegetation	Wildlife mitigation measures	Wildlife and Habitat Management Plan	p. 7	Includes a measure to minimize dust by posting speed limits for vehicles. In addition, during very dry and/or windy conditions water can be applied to the ground to help suppress fugitive dust when necessary
		Wildlife mitigation measures	Chapter 7: Environmental Effects Assessment	Table 7.3.4-4 Table 7.3.4-5	
		Road maintenance	Site Operations and Maintenance Manual	p. 14-15	
		Roads and bridge maintenance	Tailings Facility and Associated Structures Operation Maintenance and Surveillance Manual	p. 16	

Notes: AQ=Air Quality, GWQ = Groundwater Quality, SWQ = Surface Water Quality

8 Socio-Economic Existing Conditions

8.1 Existing Conditions

A description of the current socio-economic conditions in the Village of Carmacks (VoC) and the Little Salmon Carmacks First Nation (LSCFN) was developed based on data collected from various sources, including input from LSCFN. Existing conditions were characterized for all VCs and related subcomponents, including employment and economic stability, community health and well-being, and sustainability and legacy. Demographic data and other socio-economic information provide further insight on the community and individuals potentially affected by the Project.

Socio-economic conditions were characterized using the most recent data available. Sources of information include:

- Census data from Statistics Canada (2001, 2006, 2011, 2016) where available;
- Yukon Bureau of Statistics information from Yukon Socio-Economic Web Portal;
- Websites (LSCFN, VoC);
- Village of Carmacks Official Community Plan (2013); and
- Integrated Community Stability Plan (2006).

The data available for the Carmacks region are limited. In addition, census tabulations are subject to rounding to protect individual information, and due to small population size, rounding has a greater effect on the data, which can be further pronounced during statistical analysis.

Primary socio-economic information gathered through engagement with LSCFN by AAM in conjunction with North/West Consulting for the purpose of the Project is compiled in the report titled *Little Salmon Carmacks First Nation Socio-economic Valued Components and Supporting Community-Based Information for the Assessment of the Mount Nansen Care and Maintenance Program* (Pinard and Staples 2017; Appendix 9A). Since the preparation of the Pinard and Staples (2017) report, Census 2016 data has been released. Where possible, the most recent census data has been incorporated.

Notwithstanding the information outlined above, it should be recognized that there is an overall lack of socio-economic data specific to LSCFN. Limited First Nation and community-level data is not unique to this assessment, but rather represents a common challenge to many impact assessments throughout the territory. Despite the limitations of the data, this report provides the closest estimation to the existing socio-economic conditions in Carmacks and LSCFN. Furthermore, given the scope and scale of the proposed project (i.e., to continue to conduct care and maintenance activities at the site over a five-year period), Government of Yukon considers the information available to be sufficient for the purpose of the assessment.

8.2 Population

Population trends within Carmacks were reviewed based on information obtained from the Government of Yukon Socio-Economic Web Portal, Statistics Canada and the Department of Indigenous and Northern Affairs Canada (INAC). The time period selected for review dates back to 1986 to include periods when the mine was operational, through the closure in 1999, and the last 18 years of care and maintenance. Overall Yukon population trends were also assessed for comparative purposes.

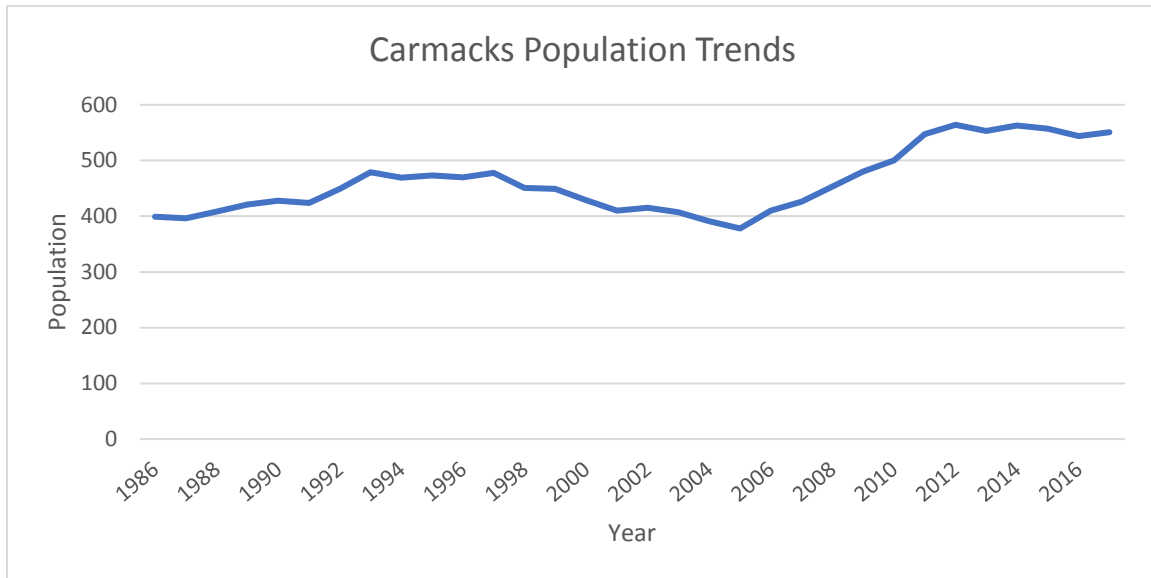


Figure 8.2-1: Population Trends (Carmacks) 1986-2017

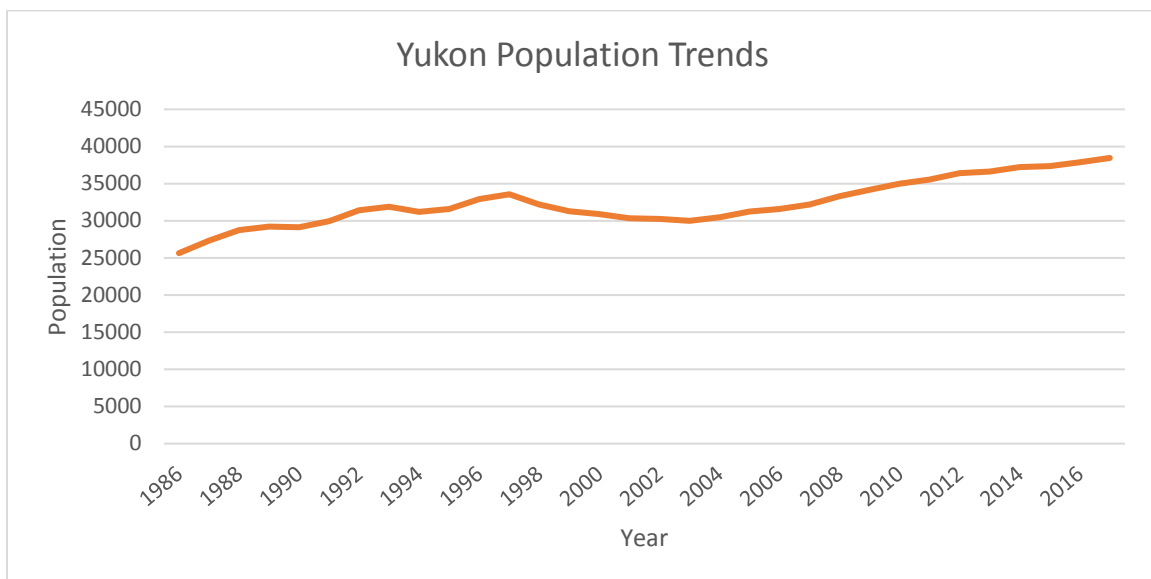


Figure 8.2-2: Population Trends (Yukon) 1986-2017

In general, according to the Yukon Bureau of Statistics (GY 2017a, GY 2017b), the estimated Carmacks population trends mirror the trends in Yukon (Figure 8.2-1 and Figure 8.2-2). The population in Yukon generally decreased beginning in the late 1990s and continued to decrease until the early 2000s. In comparison, the population decline in Carmacks was more pronounced during the same time period and continued to decrease until 2005. The onset of the downward trend prior to the mine closure in 1999, combined with the overall decline in population throughout the territory during the same time period, suggests that the decline in population in Carmacks cannot be solely attributed to closure of the mine. The population of Carmacks began to rebound in 2005, eventually increasing at a greater rate compared to the rest of the Yukon. Between 2005 and 2014, the population in Carmacks increased by 4.2% each year on average, compared to the territorial average of 1.9% during the same period. However, after 2014, the Carmacks population appeared to decline by 1-2% each year until 2017 (GY 2017a).

The Official Community Plan (OCP; VoC 2013) predicted three 2016 population scenarios: 555 (low growth), 612 (moderate growth), and/or 705 (high growth). The estimated 2016 population in June was 544, (Stats Canada Census 2016 population 493) indicating that the village is nearing the low growth scenario set out in the community plan.

The registered LSCFN population, per Indigenous and Northern Affairs Canada, as of November 2017, is 666 citizens; it is estimated that approximately half of these citizens live in the Carmacks area (INAC 2017). According to the 2016 Census Profile, there are 153 people who live in Carmacks Landing Settlement on the north bank of the Yukon River (Statistics Canada 2017b). The INAC data indicate there are 277 people living on LSCFN land (INAC 2017). The 2016 census indicated that 73% of Carmacks residents identified as North American Indian (Statistics Canada 2017a).

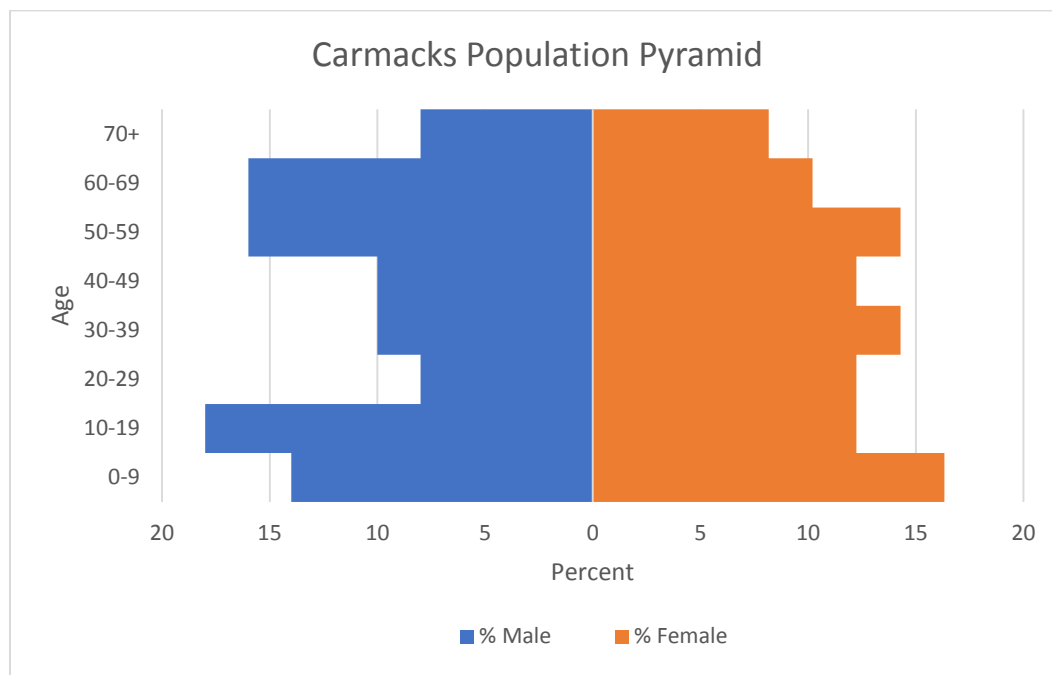


Figure 8.2-3: Carmacks 2016 Population Pyramid

Overall, the population pyramid for Carmacks (Figure 8.2-3) is interpreted as stationary, illustrating a population that has slow growth. This is congruent with the other population data reviewed. The largest age cohort of females in Carmacks is the 0-9 age range; there are also a higher base of younger cohorts compared to the older cohorts. Comparably, there is a low percentage of males aged 20-29, and a high percentage of males aged 10-19 and 50-69 (Statistics Canada 2017a). It is possible that men of working age (i.e., aged 20-29) leave the community to seek work opportunities not available in Carmacks.

8.3 Mobility

A review of census data indicates that the population in Carmacks was more stable between 2001 and 2006 when compared to data from 2011 to 2016 (2006 to 2011 National Household Survey data was suppressed for confidentiality reasons). In 2006, 75% of the population had not moved within the last five years, and 94% of the population had not moved within the last year (Statistics Canada 2007). In contrast, in 2016, 64% of people had not moved within the last five years, and 87% had not moved within the last year (Statistics Canada 2017a).

Between 2011 and 2016, of those individuals that had moved, 45% were migrants into the Carmacks area, and 55% of movers relocated to a different dwelling within the community. Between 2015 and 2016, only 25% of movers were migrants into the Carmacks area, and 75% of movers relocated to another dwelling within the community (Statistics Canada 2017a). Migrants may include internal migrants (moved to a different area within Canada) and external migrants (lived outside Canada prior to moving).

8.4 Education and Training

As of November 2017, 113 students were enrolled at the Tantalus Public School in Carmacks. Of these students, 78 were enrolled in kindergarten to grade 7, and 35 were enrolled in grades 8 to 12 (GY 2017c). A Yukon College campus in Carmacks also offers training and development opportunities (LSCFN 2007).

The education information presented is from Census 2016 (Figure 8.4-1). The data represent the highest level of education that a person has successfully completed. For example, the category “High School or Equivalent” includes only people who have this as their highest educational qualification, and would exclude those with a postsecondary certificate, diploma or degree.

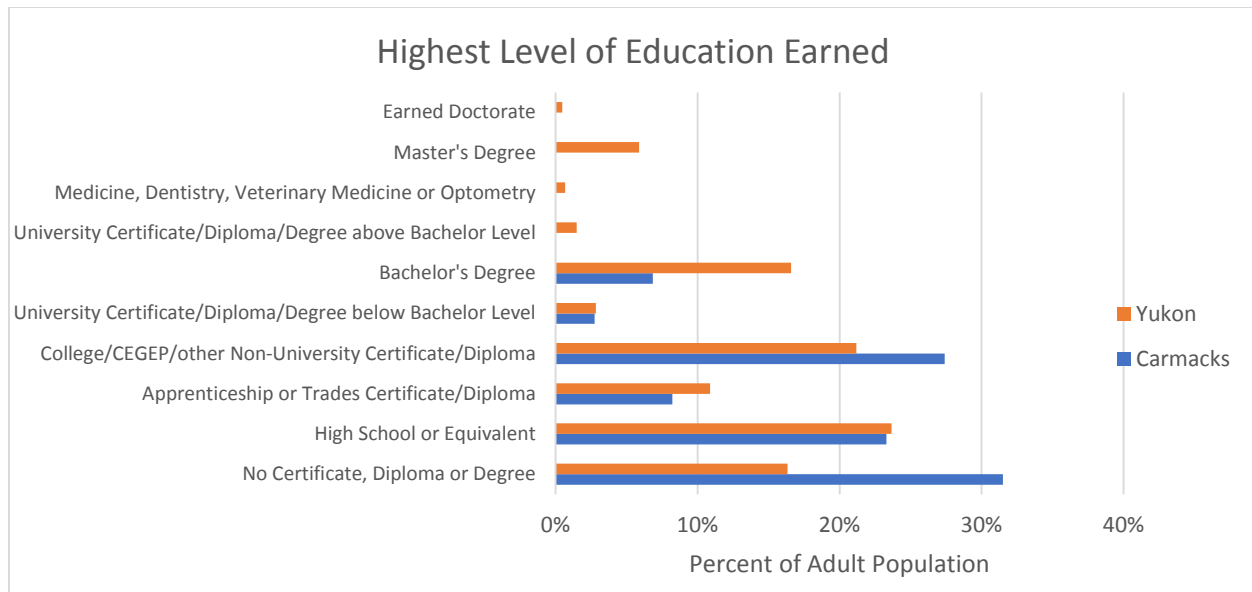


Figure 8.4-1: Highest Level of Education Earned Carmacks 2016

As presented in Figure 8.4-1, Carmacks has a greater percentage of individuals who have either not completed high school or who have not pursued higher education compared to Yukon as a whole. Carmacks and Yukon have a similar percentage of adults who have obtained a high school (or equivalent) diploma; a similar proportion of adults have also obtained a university certificate, diploma or degree below the Bachelor Degree level. Carmacks has a greater percentage of adults who have obtained a college or other non-university certificate or diploma. In contrast, Yukon has a much higher percentage of adults who have earned a Bachelor's Degree as the highest level of education, and Carmacks has 0% of adults with a degree in the field of medicine, have obtained a master's degree, or have earned a doctorate (Statistics Canada 2017a).

Between 2006 and 2016, the highest level of education earned has changed in Carmacks (Figure 8.4-2). In 2006, a higher percentage of individuals had no certificate, diploma or degree when compared to the data from 2016. In 2016, fewer adults reported having an apprenticeship or trades certificate or diploma, while the percentage of adults with a college or other non-university certificate or diploma almost doubled. A higher percentage of adults also obtained a Bachelor's Degree in 2016. The percentage of adults with a degree in the field of medicine, have obtained a master's degree, or have earned a doctorate remained low (Statistics Canada 2007, Statistics Canada 2017a).

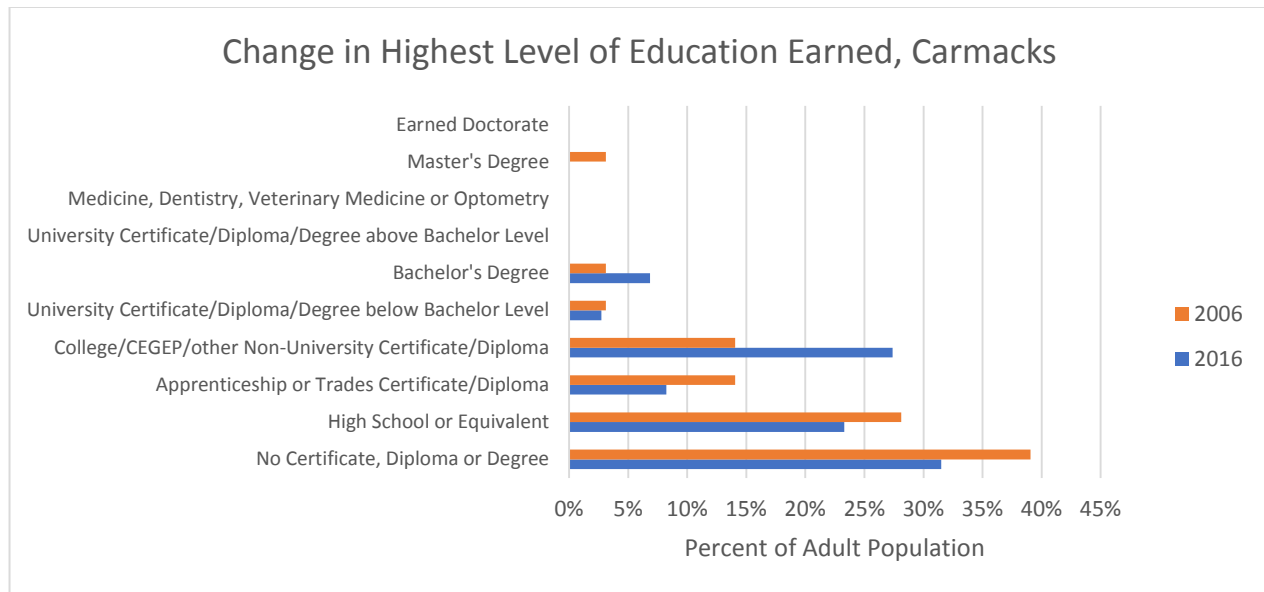


Figure 8.4-2: Change in Highest Level of Education Earned, Carmacks 2006 to 2016

Pinard and Staples (2017) indicate that LSCFN has a strong interest in training opportunities related to the care and maintenance program at the Mount Nansen site, particularly with respect to equipment operation and environmental monitoring. This interest is directly related to the employment and economic stability VC. One indicator for this VC is the capacity to participate in training. Pinard and Staples (2017) note that there are several residents in Carmacks that have the training required to operate heavy machinery and to perform environmental monitoring and suggest that more training opportunities, particularly for young people, would be beneficial to the LSCFN community. The capacity to participate in training offered in Carmacks would be subject to the equipment required and qualified local trainers. Further, the capacity for training would depend on local interest, availability and possible prerequisites for training courses. In 2010, the LSCFN developed a Capacity Development Plan that identified the employment and business opportunities that may arise from the remediation of the mine (Precision and Cambio 2010). Decommissioning/Construction Phase jobs were identified as primarily short-term positions, while Environmental Monitoring Phase jobs were anticipated to be longer-term but would require more specialized training. Precision and Cambio (2010) noted that if training were offered locally at a reasonable cost, skills gained could be used to secure jobs during remediation at the Mount Nansen site, but could also be transferrable to other projects in the area and throughout the Yukon. There has been no recent assessment of skills capacity or requirements within the community, although there is community interest to participate in training, particularly if it is offered locally (Pinard and Staples 2017). Pinard and Staples (2017) found that there are qualified and trained people available in Carmacks to provide a workforce as well as local training as needed.

8.5 Employment and Economic Stability

8.5.1 Employment

Figure 8.5-1 displays employment statistics related to labour force participation. Statistics Canada defines an employed person as one who, during the reference period, worked at a job or business. Unemployed persons are those who were without paid work, but who had either been actively looking for work or were subject to a temporary layoff. Those considered not in the labour force were neither employed nor unemployed. Census 2016 data indicate that there is a lower percentage of adults employed in Carmacks compared to Yukon as a whole, and there is a higher percentage of adults not in the labour force (Figure 8.5-1). The unemployment rate in Carmacks in 2016 was 15.9%, a higher percentage than the Yukon unemployment rate of 9.2% (Statistics Canada 2017a). Of note, the unemployment rate recorded in Census 2006 for Carmacks was 18.8%, while the unemployment rate in Yukon was mostly unchanged (9.4%) (Statistics Canada 2007).

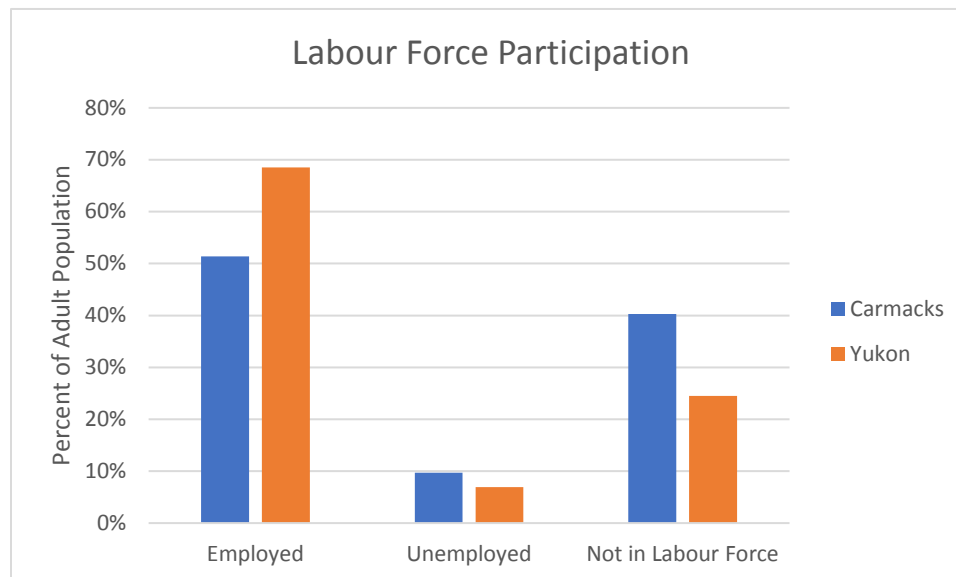


Figure 8.5-1: Labour Force Participation (2016)

Pinard and Staples (2017) found that there was a concern about lack of employment for youth in Carmacks. Unemployment is believed to cause some young workers, particularly between the ages of 20 to 24, to leave the community. In 2006, the unemployment rate for youth aged 15 to 24 was 36%, compared to 15.4% for the Yukon. This data was not available from Census 2016.

The 2016 Census data indicate that Carmacks residents were primarily employed in the education, law and social, community and government services sector (Figure 8.5-2). This sector employs a higher percentage of people in Carmacks when compared to Yukon. Other sectors in Carmacks with a significant labour force include trades, transport and equipment operators, and the sales and service industry. Similarly, Yukon residents are also primarily employed in those three sectors, and a high percentage of Yukoners also work in business, finance and administration relative to other employment sectors (Statistics Canada 2017a).

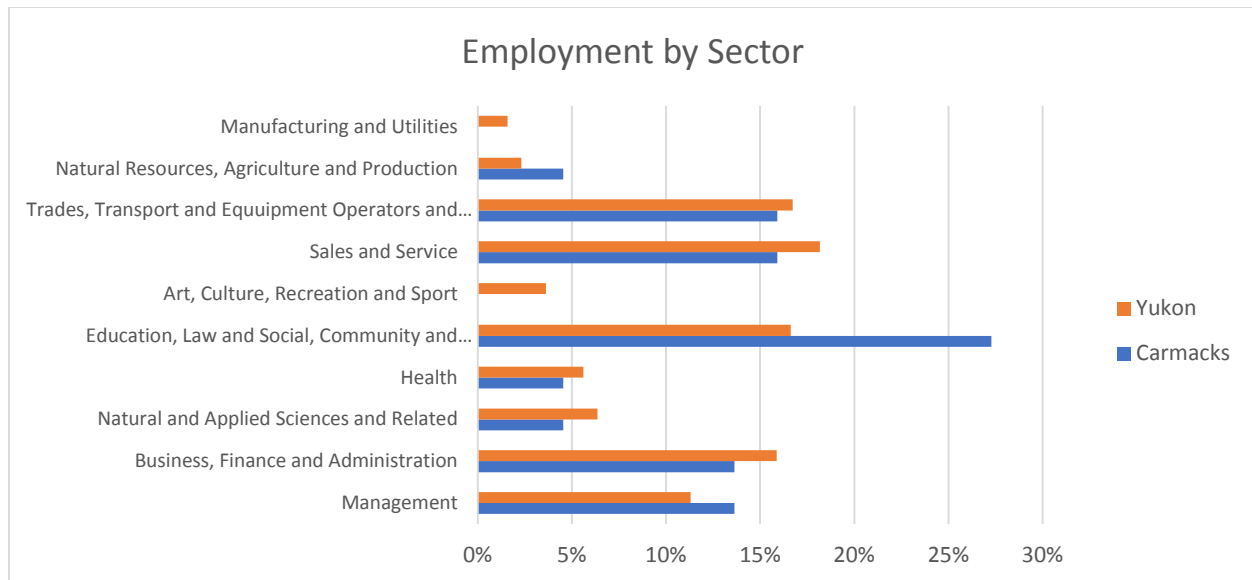


Figure 8.5-2: Carmacks Employment of Adult Population by Sector (2016)

When compared to Yukon, a higher percentage of Carmacks residents are employed in management and the natural resources, agriculture and production industry. No Carmacks residents indicated that they were employed in manufacturing and utilities or art, culture, recreation and sports occupations (Statistics Canada 2017a).

The number of businesses located within Carmacks has increased steadily since 2003, doubling in that time (Figure 8.5-3). The number of workers employed at those businesses has also almost doubled from 47 to 81 during the same period (GY 2016). This shows a trend towards business growth and development for small businesses in the area, offering more employment opportunities outside of the government sector.

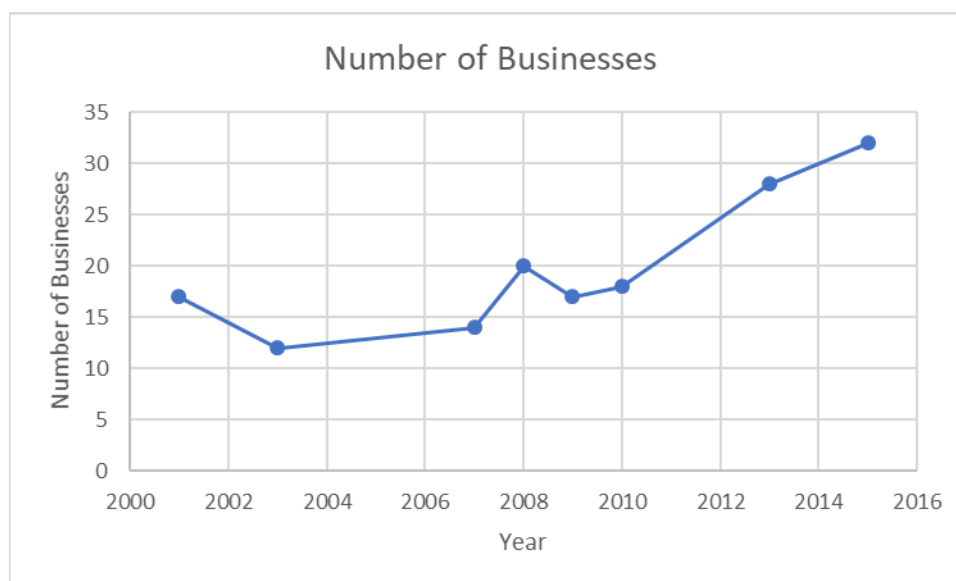


Figure 8.5-3: Businesses in Carmacks 2000-2016

At the Mount Nansen site, there are currently four caretakers employed who rotate through shifts (two weeks on and two weeks off rotation), all of which are residents of Yukon. Over the last several years, one LSCFN citizen has been employed as a caretaker (Pinard and Staples 2017). The small number of employees is representative of the limited scale of activities associated with care and maintenance of the site. Employment opportunities also arise through contractors conducting work at the site. For example, the current consultant responsible for water quality monitoring has trained at least one LSCFN citizen as a field technician and has retained this individual as a casual employee to assist with other work within the territory. Other consultants have also retained LSCFN citizens to participate in monitoring activities at the site.

8.5.2 Income

Total gross income increased between 2005 and 2015 in both Carmacks and Yukon. In Carmacks, average gross income was \$27,586 in 2005, and increased to \$41,648 in 2015. Median gross income also increased from \$22,912 in 2005 to \$32,604 in 2015 (Statistics Canada 2007, Statistics Canada 2017a). Gross income for Yukon is higher when compared to Carmacks, suggesting lack of year-round, high-earning job opportunities in the Carmacks area. Average gross income in Yukon was \$38,687 in 2005 and \$53,809 in 2015. Median gross income increased from \$31,352 in 2005 to \$45,804 in 2015 (Statistics Canada 2007, Statistics Canada 2017a).

The OCP (VoC 2013) identified a need to expand the economic base in Carmacks. The plan outlines efforts to renew Carmacks' role as a regional service centre, building on community culture and history to increase tourism potential, and encouraging training and employment in local projects to increase employment and income opportunities in the community.

8.5.3 Economy

The OCP identifies a heavy reliance on seasonal employment in Carmacks and states the proximity to Whitehorse as an impediment to supporting extensive full-time employment (VoC 2013). Government, resource development, and tourism provide the foundation of the economy in Carmacks. The OCP identified opportunities related to further enhancement of Carmacks' role as a regional supply and service centre (VoC 2013). Economic development strategies have identified the cyclical nature of a reliance on resource extraction and have explained the need for a diversified economic base to ensure economic success.

The LSCFN Final Agreement states the intention to enhance the ability of LSCFN people to participate fully in all aspects of the economy of the Yukon. LSCFN people, as most Yukon First Nations, participate in a mixed economy that includes a reliance on traditional foods as well as practices such as trapping and trade to supplement the currency-based economy. Moose, caribou, and fish are acquired near the site for food; and marten, lynx, foxes, wolverine and wolves are trapped in the area. A number of berries, mushrooms, and medicinal plants are also available in the area.

The Community Spatial Price Index (CSPI) measures the cost of a “basket” of items in comparison with Whitehorse, where the average price is represented by the number 100. The basket includes: meat, dairy

and eggs, fruit and vegetables, bread, other foods, household operations, health and personal care, gasoline, cigarettes, and home heating fuel (added in 2013). When reviewing the CSPI for Carmacks, it has fluctuated over the years; however, the average cost of goods is approximately 11% higher than in Whitehorse since 1998 (GY 2017d) (Figure 8.5-4).

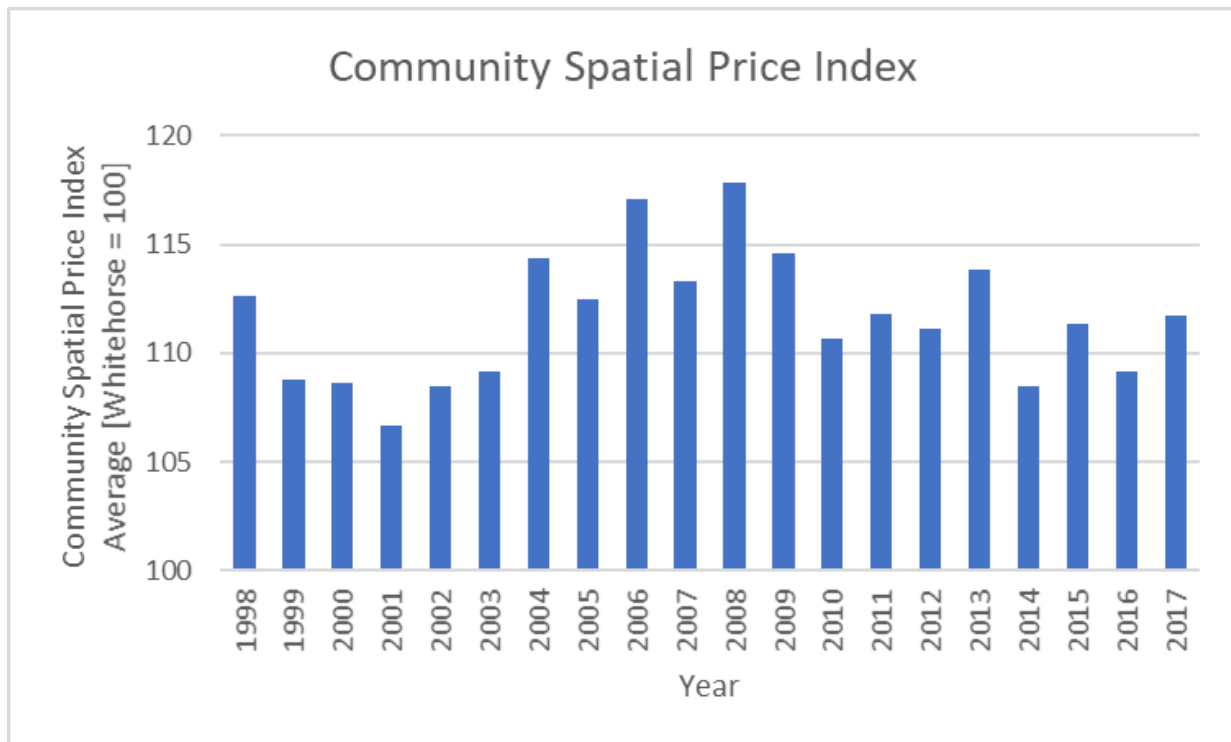


Figure 8.5-4: Community Spatial Index Carmacks 1999-2017

Typically, vegetables and fruit have the greatest price difference, costing an average of 24% more in Carmacks than in Whitehorse since 1998. Since 2000, LSCFN have successfully developed a greenhouse program that provides fresh vegetables to community members. The greenhouse and garden program grow potatoes, tomatoes, beans, corn, peppers, peas, lettuce, kale, cucumbers, and even melons.

8.5.4 Housing

The 2013 OCP (VoC 2013) identified a demand and need for homes within the central area of Carmacks. The housing shortage was identified as an impediment to economic stability, growth, and diversification.

The shortage of housing in the community has led to the funding and development of a six-unit rental accommodation in the village in 2015. There have been five bylaws passed since the approval of the OCP that have addressed changes in zoning to provide more residential spaces within the community.

8.6 Government, Services and Infrastructure

8.6.1 Government (Local Jurisdiction)

Local government in the area is municipal and First Nation. The VoC is an incorporated village and is governed by an elected Mayor and Council. The Little Salmon/Carmacks First Nation became a self-governing First Nation in 1997 and is governed through a combination of a traditional moiety system of wolf and crow clans, and an elected Chief and Council. Governance as it relates to the Mount Nansen site is discussed further in Section 8.10 Sustainability and Legacy.

LSCFN governance is mandated by the Final Agreement and Self-Government Agreement, and supported by the LSCFN Constitution, policies, and legislations. The current governing body, elected in November 2016, consists of:

Chief Russell Blackjack

Deputy Chief Ed Shultz

Elder Councillor Eddie Skookum

Crow Councillor Lennie Charlie

Crow Councillor Terry Billy

Wolf Councillor Zackery Cochrane

Wolf Councillor Veronica Burgess

Youth Councillor Christian Gull

The LSCFN Constitution (LSCFN 2015) is based on the values, beliefs, traditions, and responsibilities of the citizens and governing bodies. The values and beliefs are founded in the relationship with the Creator God and with fellow citizens, as well as fundamental respect, respect for the spirit, and all things living. The traditions of the LSCFN people indicate that they are the caretakers of the land, water, air and resources.

The VoC governance is mandated primarily through by-law development and enforcement. The current governing body, elected in October 2015, consists of:

Mayor Lee Bodie

Councillor Doris Hanson

Councillor Tara Wheeler

Councillor Pat McKenny

Councillor Kevin Unterschute

The most recent Official Community Plan (OCP) by-law was adopted in December of 2013. The purpose of the OCP is to provide guidance and reference for community development. The principles outlined in the plan include:

- Appropriate land use;
- Appropriate and adequate land allocation;
- Encouraging economic diversification and increase economic activity;
- Cooperation with LSCFN;
- Environmentally sensitive and appropriate development; and
- Affordable, sustainable, and consistent community infrastructure.

The 2006 Integrated Community Sustainability Plan also highlights the values and vision that guide the governance of the community. The values include maintaining the natural environment, developing a diverse and stable economy to support residents in the long-term, maintaining a physically and emotionally healthy population, community pride and unity, and maintaining the history, heritage and culture of the community (LSCFN 2007).

8.6.2 Services and Infrastructure

Two nurse practitioners are on call 24 hours per day at the nursing station in Carmacks, but there is no local doctor. Doctors from Whitehorse visit the village 3 to 4 times per month. A limited pharmacy is available for emergencies. A volunteer-based ambulance service is available 24 hours per day. Fire protection is provided by a volunteer force of 12 personnel with two tanker trucks. Carmacks search and rescue services are also provided by volunteers. Police services are provided by the RCMP; one corporal and two constables are stationed in Carmacks.

LSCFN provides health services to its citizens, such as a wellness program, youth liaison coordinator, prenatal care, outreach services, home care services and elder care. Daycare services are also provided by LSCFN. Dental services for children are provided through the Carmacks Tantalus school.

Communication services are available in the community and are provided by Northwestel (internet, phone). Cellular services are provided within the community by Bell Mobility and Latitude Wireless.

The Yukon Housing Corporation manages 14 staff units and 16 social housing units in Carmacks, and also run programs and services that enable home renovations, construction of rental suites, mortgages and financing. LSCFN provides housing services to its citizens and employs a housing manager.

The Village of Carmacks does not provide garbage pickup, although LSCFN and Yukon Housing collect from their residents. The municipality operates a landfill site, compacting and covering household solid wastes. Recycling is encouraged, and a recycling depot in Carmacks is open three days per week.

Government of Yukon Highways and Public Works is responsible for ensuring safe and efficient public highways, airstrips, buildings and information services. The LSCFN department of Capital Projects and

Infrastructure employs a housing manager, utilities manager, water technician, warehouse manager and capital projects manager. Power is provided throughout Carmacks by ATCO and includes a backup diesel generator. The airport, maintained by YG, has firefighting capabilities and landing for private aircraft.

An upgraded sewage facility was constructed in Carmacks in 2007, and services are provided by the Village of Carmacks. LSCFN residents use septic systems for liquid waste treatment. Water services for the Village of Carmacks are provided by private wells and water deliveries. LSCFN constructed and operates a water plant to provide drinking water to its citizens.

Recreational facilities include a flexi-hall complex, outdoor ice rink, a curling rink, a summer use swimming pool, a playground, a campground and several parks. Yukon College offers courses and development opportunities within the community.

8.7 Community Health and Well-Being

The well-being of a community is typically measured by a combination of socio-economic indicators including income, education, housing, and labour force activity. First Nations communities identify additional contributing factors to community health and well-being, such as strength of cultural values, social participation, physical and mental health, ability to participate in traditional land use activities, and a sense of local jurisdiction (Pinard and Staples 2017). For an understanding of community health and well-being in Carmacks, the existing conditions for these contributing factors are presented. Where possible, historical data is discussed for comparison. Information pertaining to harvesting and traditional food security is presented in Section 8.8, Land and Resource Use.

8.7.1 Community Well-Being Index

The Community Well-Being (CWB) Index is a measure of socio-economic well-being in communities across Canada and is based on a score derived from data concerning income, education, housing, and labour force activity. These scores are used to compare well-being across First Nation communities with well-being in non-Aboriginal communities over time. The score ranges from a low of zero to a high of 100 (AANDC 2015). The CWB Index was identified as an indicator for the human health VC. Due to low response rates in the community, the most recent CWB is from the 2006 census and Carmacks scored a 70, compared to the Yukon average for First Nation communities which was 78 (INAC 2016).

8.7.2 Health

LSCFN citizens feel that the health of the land, water, and wildlife are connected directly to the health of the people. Perceived state of the environment and legacy was identified as an indicator for the sustainability and legacy VC. Over the years, various data have been collected, measured, and monitored in the Mount Nansen area, including potential impacts to ecological receptors and human health. Table 8.7-1 summarizes information concerning the health of the land as it pertains primarily to resources gathered and used by LSCFN citizens and other persons accessing nearby areas. A more thorough summary of these reports is provided in Pinard and Staples (2017).

Table 8.7-1: Health of the Land

Year	Researcher	Findings	Conclusions
2003	DIAND, SENES	High levels of antimony, copper, molybdenum, thiocyanate, uranium, zinc, and petroleum hydrocarbons	Hazards exceeded reference values for risk assessment of human consumption (assumed 3 consecutive months on the land) of food and water from the site
2007	EDI	Arsenic, lead, antimony, silver, and copper in lichens	Plant uptake of arsenic is generally low
2007	EDI	Copper and chromium in moose and caribou found in higher levels near mine compared to other areas of Yukon	Metal levels in moose and caribou hunted near the site were not of concern for human consumption
2007	EDI	Elevated levels of zinc in surface water at Dome Creek	No evidence of biomagnification up the food chain (i.e., fish)
2007	EDI	Arsenic levels in consumable foods in the site	Traditional use of plant tissues is unlikely to cause users to consume over the daily intake Moose and caribou not a concern for human consumption, however recommend limiting collection of plants and animals in or immediately around the mine to avoid sources of contamination
2008	SENES	Elevated copper in tailings pond	No adverse effects for wildlife with terrestrial-based diet
2008	SENES	Copper and/or zinc in Dome Creek Tailing pond Brown-McDade pit Pony Creek	Adverse effect to individual waterfowl but not population
2009	SENES	Elevated levels of sulphate, unionized ammonia, antimony, iron, manganese, and selenium in Dome, Pony, and Victoria Creeks	Exceed water quality guidelines for protection of aquatic life and community water supply
2009	SENES	Cadmium concentrations in squirrel liver and kidney	No adverse effects on humans from exposure to arsenic or non-carcinogenic COPC at the site
2012-2014	ELR	Elevated arsenic, zinc, cadmium, lead, copper, and silver in Dome and Pony Creek sediments	No fish in Dome and Pony Creeks
2016	ELR	Metal concentrations in lichen, willow and berries at 44 sites near the mine site	Concentration exceeds maximum tolerance levels for animal intake at 2 sites

Pinard and Staples (2017) identify the importance of traditional harvesting activities to provide physical, cultural and spiritual connections to the land. The Mount Nansen area is an important harvesting area for LSCFN. Pinard and Staples (2017) found that more than half of the citizens interviewed use the area for harvesting activities, and “there is general concern among LSCFN citizens that contaminants coming from the mine site and from other exploration activities in the area are spreading and are affecting wildlife and

vegetation”. This concern extends to water and aquatic life. Traditional harvesting activities are discussed further in Section 8.8 Land and Resource Use.

8.7.3 Social Participation

Social participation relates to the availability and access to community-based activities and recreation as well as indicators of anti-social participation such as crime. Rates of participation in traditional land use activities, opportunities for Elders to be involved in community activities, intergenerational activities, and other data related to social participation, specifically within the context of LSCFN, is not readily available and has not been incorporated here.

Recreation in the area is advertised in various locations. According to Yukon Community Profiles, “Carmacks is surrounded by beautiful trails readily accessible and enjoyed by the community to walk, run, mountain bike, cross-country ski and snowmobile” (GY 2014). The Carmacks Hotel advertises activities in Carmacks, which are primarily centered on enjoying outdoor activities including walks along the river, historical walking tours, hiking, kayaking, canoeing, snowmobiling, wildlife and flora viewing, fishing, cross-country skiing, photography, and camping. LSCFN operates an interpretive centre and gift shop through the summer to attract cultural tourism to the area.

The 2006 Community Recreation Facility Inventory and Assessment (GY 2006) identified the community hall, recreation centre, swimming pool, outdoor ice rink, playground, boardwalk, and golf course as recreational facilities available in Carmacks. The recreation centre has a curling rink, gymnasium, weight room, and youth centre.

8.7.4 Crime

Criminal Code violations (including traffic violations) have fluctuated in Carmacks over time, with 2015 having the fewest incidents since 1998 (Figure 8.7-1) (Statistics Canada 2017c). In general, Carmacks has more criminal code violations per capita (Figure 8.7-2), with an average crime rate of 0.39 violations per capita, when compared to the Yukon average (0.25 violations per capita; 1998-2016) (Statistics Canada 2017c).

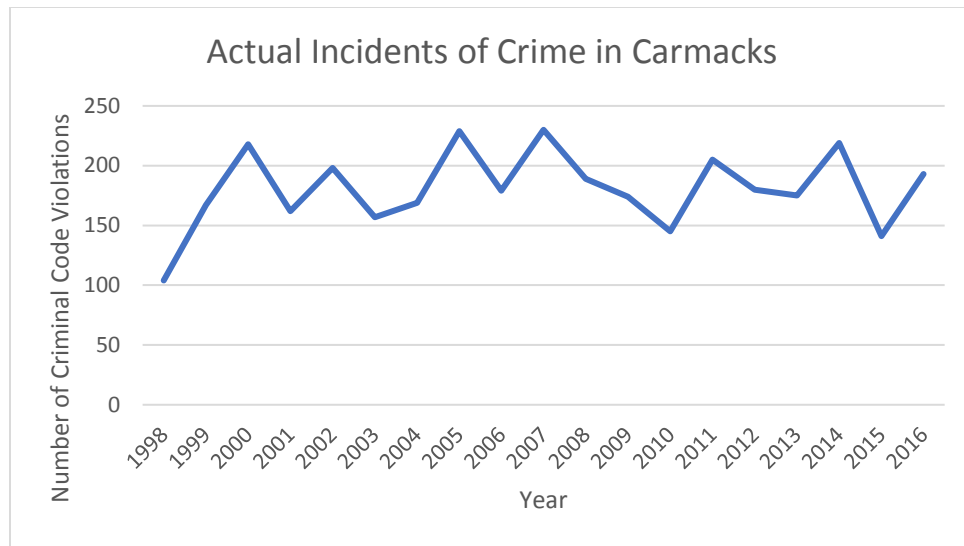


Figure 8.7-1: Criminal Code violations in Carmacks 1998-2016

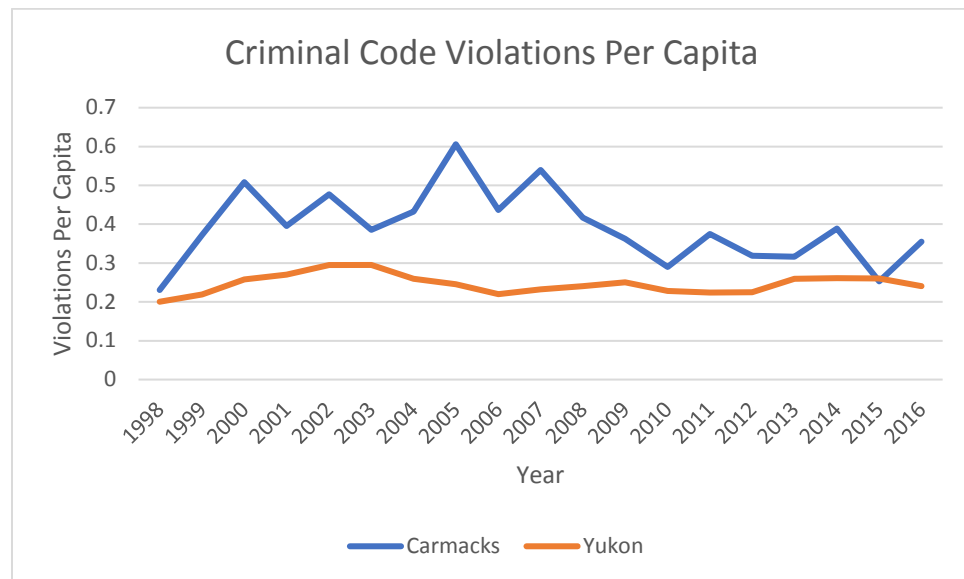


Figure 8.7-2: Criminal Code Violations Per Capita, Carmacks and Yukon, 1998-1996

8.8 Land and Resource Use

This section will review existing land use within the project area. Any governance concerning land use in the area is primarily focused on the land use designations within the VoC boundaries and does not specifically pertain to the project.

The governance and management of land use was a specific provision of the First Nation Final Agreements; specifically, Chapter 11 of the Umbrella Final Agreement. The chapter identifies the need for regional land use planning that will encourage development outside of community boundaries and recognize and promote

the cultural values of Yukon First Nations, by having plans that are founded in the knowledge and experience of Yukon First Nations. Pinard and Staples (2017) note that the LSCFN Integrated Community Sustainability Plan (2007) identified the concept of sustainability as “the ability of people to meet their needs now, without hindering the ability of others to do so in the future for seven generations”.

To date, no land use plan has been developed for the region. The footprint of the project is reserved as a mining claim. There is LSCFN settlement land located to the north (R-31A) and south (R-66A, R-21B) of the project footprint; these are Category A lands, where the First Nations own the surface and sub-surface of the lands and Category B lands where the First Nations owns the surface of the land but not what is below the surface. Settlement lands were selected to address any number of needs including: hunting, fishing, trapping, gathering, habitat protection, historic, archaeological, spiritual, residence, occupancy, access, agriculture, forestry, wilderness, and economic development.

R21-B is Category B land measuring 19.22 square kilometres; R31-A is category A land measuring 5.68 square kilometres; and R-66A is category A land measuring 7.52 square kilometers. The specific reasons for selection are not included in the Final Agreement, however, the association with traditional resources including the Nansen Creek Trail may be indicators.

8.8.1 Harvesting Activities

Harvesting of moose, caribou, small game, fish, waterfowl, berries and medicinal plants within the Mount Nansen area has been reported. Based on feedback received from LSCFN members, approximately half of LSCFN families use the Mount Nansen area for harvesting activities (Pinard and Staples 2017).

Wildlife in the Yukon is protected through First Nations traditional practices and legislated through the *Yukon Wildlife Act*. The study area is located in Game Management Subzone (GMS) 526 and surrounded by subzones 523, 524, 525, and 543. Low moose populations recorded in 1987 resulted in a closure to hunting in zones 523, 524, and 526 by any non-First Nation hunters. Caribou hunting is regulated under a permitting system. Based on harvest data, caribou are the most hunted species in the area by licensed hunters with an average of 3-4 being harvested annually. The Mount Nansen Road is also used by hunters to access nearby elk and bison hunting areas.

8.8.2 Traditional Food Security

Relative availability and quality of traditional foods was identified as an indicator for food security (a subcomponent of the Community Health and Wellbeing VC) by LSCFN. LSCFN noted a decrease in the availability of big game animals since 1999 (Pinard and Staples 2017). Research has indicated that the Klaza caribou may have altered their winter range as a result of the development and human activities in the Mount Nansen area (Francis and Nishi 2016). LSCFN citizens no longer fish in Victoria Creek due to concern about contaminants, and do not typically harvest berries and plants found below or near the mine site due to contamination concerns.

Notwithstanding the concerns noted above, LSCFN citizens feel that they have access to a sufficient amount of traditional food in the region.

Pinard and Staples (2017:18) found that, “the Mount Nansen area is one of the most important harvesting areas for LSCFN citizens. More than half the families use this area for harvesting activities, especially for moose, but also for caribou, small game, fish, waterfowl, berries and medicinal plants.”

8.8.3 Drinking Water Sources

There is an artesian well located at the site. This well has been used by LSCFN citizens and residents in the past and the water is sought after by locals (Pinard and Staples 2017). Access to this water is located within the mine site, and therefore, is currently restricted. Confidence in quality and supply of drinking water and availability of drinking water sources are identified as indicators for the human health, a subcomponent of the community health and well-being VC.

8.8.4 Site Access and Trails

The public road to the Mount Nansen site is maintained year-round, including regular snow clearing during winter months. LSCFN citizens and others use the road to access harvest areas and for recreational purposes such as ATV use. In addition to site care and maintenance staff, the road is also used by those with mineral claims in the area. Traffic along the public road is typically higher during summer months. Pinard and Staples (2017) reported that an increase in mineral exploration has resulted in more traffic and heavy equipment in the area.

There are several trails in the area and travel between the public road and the Casino road is connected by a trail, offering more opportunities for recreational and subsistence activity in the area. A community camp is located near Victoria Creek. LSCFN interview participants noted that there was activity happening everywhere in the area (Pinard and Staples 2017). Pinard and Staples (2017) also noted concern by LSCFN that summer traffic on the Mount Nansen Road can disturb wildlife and modify wildlife movement patterns and impact traditional activities.

8.8.5 Nearby Land Use

There are several active mineral claims northwest of, and overlapping, the site. Previous exploration activities in the region have impacted the environment. Other mining developments in the region, such as Casino Mine, have the potential to impact the region as they move forward. Potential impacts to the region include increased traffic and access on the Freegold Road located to the north of the Mount Nansen Road, fluctuations in employment rate, or additional strain on community services, including access to health care and housing.

8.9 LSCFN Cultural and Social Values

The archaeological record indicates that First Nation people have inhabited this area for around 13,000 years. The White River volcano eruption and subsequent ash deposits dating back 1,250 years mark the earliest identifiable Athapaskan influences (Ecofor 2014). This indicates a depth of cultural attachment to the area.

There are 14 recorded heritage sites within the mine site. Many of these sites were surface collections or identified in areas of disturbance. The sites are primarily small lithic scatters and fire-cracked rock reflecting short-term temporary use areas, likely associated with resource collection. Sites tend to be located on terrace edges, benches, and knolls associated with creeks and larger drainages (Ecofor 2014). The heritage resource investigations have all been stimulated by development, with specific areas targeted for investigation. Other nearby resources identified by LSCFN include campsites and cabins associated with Victoria Creek and Victoria Lake, as well as a burial site near Discovery Creek and a caribou fence near Victoria Lake (Pinard and Staples 2017).

The Mount Nansen Road follows the Nansen Creek Trail route, a traditional trade and transportation route. The trail was used as a trade route by Tlingit traders and then Hudson's Bay Company traders; likely the route provided access to the area for gold seekers as well.

The archaeological and heritage resources indicate long-term use of the area for transportation as well as hunting and resource collection. The cultural connection to the land has been continuous for the Little Salmon/Carmacks people. The Mount Nansen Road provides access to the area, which is used regularly by LSCFN citizens for traditional harvesting activities including primarily moose, but also caribou, small game, fish, waterfowl, berries, and medicinal plants (Pinard and Staples 2017).

The LSCFN Integrated Community Sustainability Plan (LSCFN 2007) describes the cultural values of the LSCFN people and how these values are reflected in the community of Carmacks. It states (LSCFN 2007:9), "In Northern Tutchone cultural terms, stewardship involves managing the land and resources with the future of seven generations in mind. This resource management principle governs all resource harvesting activity and provides the context for land use decision-making."

8.10 Sustainability and Legacy

Since the mine was abandoned 16 years ago, the federal government and territorial government have overseen management of the site, and various contractors have undertaken care and maintenance activities. Remediation options were developed, although implementation of a remediation plan has been delayed due to pending sale of the property. Throughout this period, a new mine (Casino) has been proposed in LSCFN's traditional territory. The legacy of mining and exploration in LSCFN traditional territory is complex, and exploration and placer activities have been on the rise. Projects such as Carmacks Copper and Casino Mine have resulted in a large effort by the First Nation to raise concerns related to the protection of land and water and proper consultation.

Given this history, it is understandable that community members and LSCFN citizens have expressed an interest in overall legacy and sustainability, cumulative effects of other projects, and greater participation and involvement during care and maintenance and remediation of the site. It is considered important to include these views as part of the description of existing conditions because they affect the relationships between the community, GY, the LSCFN Government, and the future owners of the mine who will take over responsibility for mitigation. Furthermore, LSCFN has identified sustainability and legacy as a VC. The following factors were raised by LSCFN in relation to the sustainability and legacy VC.

8.10.1 Mineral Development and Exploration

LSCFN has expressed overall concern related to increased exploration and mineral development projects (such as Casino mine) within their traditional territory. Active claims are located northwest of the mine site. LSCFN citizens have indicated that they would like to see increased monitoring of these activities. LSCFN indicated petroleum hydrocarbons and other types of waste have been released within these areas in the past, and they expressed concern related to potential injury to animals travelling through dredged areas.

8.10.2 Care and Maintenance Participation

LSCFN expressed a sense of disconnection to the care and maintenance program due to a change in contractors in recent years, as well as internal staffing and organization issues within LSCFN. Government of Yukon administrative requirements for contract award has compounded this frustration.

8.10.3 Site Governance

Confidence in site governance was identified by Pinard and Staples (2017) as an indicator to the Sustainability and Legacy VC and is related to LSCFN's concerns about care and maintenance decisions being made without LSCFN's support. LSCFN citizens are generally dissatisfied with the current management situation and care and maintenance program due to the slow progress achieving an active remediation program. Further adding to this distrust are concerns raised over water quality issues, not only during operation of the mine site, but also since operations have ceased (Pinard and Staples 2017). LSCFN has expressed interest in greater involvement and a shared role in management of the site.

8.10.4 Environmental and Socio-economic Legacy

Mining projects such as Mount Nansen are viewed as having significant impacts to land and traditional activities. It is understandable that LSCFN has concerns related to the environmental and socio-economic legacy of the site, given that it has been many years since the mine closed and remediation has not yet been implemented. However, LSCFN and community members do recognize the potential benefits to the local economy and the employment opportunities these types of projects create for their citizens. LSCFN has expressed the view that the care and maintenance project create an opportunity and foundation for a long-term outcome that can contribute to a more positive and sustainable legacy for the site (Pinard and Staples 2017).

9 Socio-Economic Effects Assessment

This section describes the socio-economic effects assessment conducted for the Mount Nansen Care and Maintenance Project (the Project), including an overview of the assessment approach and methodology applied. The effects assessment considered potential impacts to VCs and related subcomponents that may result from the five-year Care and Maintenance program.

9.1 Matters Considered in the Socio-economic Assessment

As per Section 50(2) of YESAA, the Project Proposal addresses the following matters that must be considered in a Project Proposal submitted to a Designated Office:

- 42(1)(b) – All stages of the project: The assessment considers all stages of care and maintenance throughout the 5 years of the Project.
- 42(1)(c) – The significance of any socio-economic effects of the project that have occurred or might occur in or outside Yukon: Section 9.6 describe the results of the socio-economic effects assessment and evaluate the significance of effects. Section 7.3.6 addresses effects that may arise from accidents and malfunctions.
- 42(1)(e) – Alternatives to the project, or alternative ways of undertaking or operating it, that would avoid or minimize any significant adverse environmental or socio-economic effects: Section 4 describes alternatives to care and maintenance and alternative ways of executing it.
- 42(1)(f) - Mitigative measures and measures to compensate for any significant adverse socio-economic effects: Sections 9.6.1.4, 9.6.2.4 and 9.6.3.2 describe the mitigative measures developed to address potential adverse socio-economic effects.

9.2 Valued Components

The Care and Maintenance effects assessment employs a VC, or VC-based, approach that is consistent with guidance provided in YESAB's *Proponent's Guide to Project Proposal Submission to a Designated Office* (YESAB 2010). This approach focuses the assessment on key interactions between the project and the environment or people. The VCs are relevant environmental, social, or economic elements that have scientific, social, cultural, economic, historical, archaeological, health, or aesthetic importance. When combined, the selected VCs are intended to be comprehensive, providing a framework for the assessment to efficiently identify and consider the effects of care and maintenance.

VCs were selected by considering the socio-economic context of the study area, previous assessments of similar projects, and through engagement with LSCFN. Further information on the VCs identified by LSCFN can be found in the report titled *Little Salmon Carmacks Socio-economic Values Components and Supporting Community-Based Information for the Assessment of the Mount Nansen Care and Maintenance Program* (Appendix 9A). The report is based on interviews with Little Salmon Carmacks First Nation members and information gathered during a workshop held within the community.

Subcomponents were established for some VCs to capture linkages between similar components and to ensure all elements were considered during the assessment process. Table 9.2-1 lists the VCs and related subcomponents for the care and maintenance assessment and provides the rationale for their inclusion.

Table 9.2-1: Socio-economic Valued Components Considered in the Assessment

Valued Component	Subcomponent	Rationale for Inclusion
Employment and Economic Stability	Employment	Employment, contracting and business opportunities associated with Care and Maintenance could have a meaningful effect on a small economy such as the Village of Carmacks and Little Salmon Carmacks First Nation communities. Qualitative research such as Pinard and Staples (2017), the Village of Carmacks Official Community Plan (2013), and Integrated Sustainability Plan (2006) identified the value of economic diversity and stability. Due to the small nature of these communities, any opportunities associated with Care and Maintenance over the 5-year Project may have an impact. Training opportunities and capacity building are also considered as they are closely linked to employability, income and overall economic stability.
	Training	
	Youth Employment	
	Business Opportunities	
Community Health and Well-being	Traditional Food Security	Pinard and Staples (2017) identified that the ability of Little Salmon Carmacks First Nation members to participate in a culturally appropriate lifestyle that enables them to harvest traditional foods in quantities and quality that they feel are necessary, while balancing the needs for contemporary goods and services significantly contributes to an overall sense of community well-being. LSCFN traditional land use is dependent on a sense of connection to the land and water and access to resources. Community well-being also encompasses perceived risks to human health from potential impacts from the mine site, including harvesting traditional foods in the area and a sense of connection to the land and water. Further, in both the Village of Carmacks Integrated Community Sustainability Plan and the Official Community Plan, there are overarching themes of community health, quality of life and well-being, which guides the documents.
	Connection to the Land and Water	
	Human Health	
	Community Well-being	
Sustainability and Legacy		Sustainability and legacy was identified as a VC through engagement with LSCFN. This VC is related to the prevalence of mining activity in the LSCFN Traditional Territory, the legacy of past poor mining practices, and site governance. This VC has been retained in recognition that the C&M program contributes to the ongoing legacy of the Site.

9.3 Geographic Assessment Scope

The geographic assessment scope defines the area where care and maintenance activities may overlap socially or economically with each of the VCs. The area of influence varies for VCs; therefore, the Care and Maintenance assessment defines geographic assessment scopes separately for each VC and for some specific indicators or key characteristics. Relevant portions of Section 9.6 describe the specific geographic scopes.

To promote consistent approaches for establishing the spatial boundaries to assess effects on different VCs, the assessment team considered the criteria described in Table 9.3-1.

Table 9.3-1: Geographic Assessment Boundaries

Study Area	Definition
Site	Existing disturbed area and immediate zone of direct project effects.
Local	The Little Salmon Carmacks First Nation Traditional Territory, an area with reasonable potential for effect interactions (direct or indirect) between Care and Maintenance and the socio-economic VCs.
Regional	The Yukon Territory, an area encompassing the largest area with potential for measurable effects.

9.4 Assessment Temporal Boundaries

The assessment temporal boundary defines the timeframe associated with the effects predictions. For care and maintenance, the assessment considers effects within its 5-year project scope. Potential effects from the Site that may continue beyond the duration of the Project are not addressed in this proposal and will be assessed in a separate application as part of the remediation planning process.

9.4.1 Existing Conditions Definition

This assessment compares potential Project-related effects with current conditions at the Site. This approach is appropriate for a Project that involves interim measures to maintain and care for existing effects from an abandoned mine. The objective of the Project is to maintain the status quo at the Site while improving water quality in Dome Creek via treatment of seepage water downstream of the tailings facility. During the 5-year scope of Project activities, other positive outcomes will include decreased risk to human health and safety and the environment and continued economic development.

Specific timeframes used to characterize existing conditions vary for different elements, depending on data availability, quality, and applicability. Please refer to Section 5 of the Project Proposal for specific timelines used to define existing conditions.

9.5 Assessment Methods

The proponent's assessment team applied a VC-based approach to the assessment, evaluating project effects on a range of VCs to identify and then characterize potentially significant effects. Table 9.2-1 describes the VCs and the rationale for their consideration in the assessment.

For the selected VCs, the environmental and socio-economic assessment teams used consistent methods comprising two main steps to identify and characterize effects. The first step identified potential interactions between care and maintenance activities and the VCs and their subcomponents, then potential interactions were classified to highlight those warranting detailed evaluation. The second step characterized the important interactions to define and describe the potential effects and evaluate their significance.

This section describes the methods used to assess the potential socio-economic effects of care and maintenance, and to determine their significance.

9.5.1 Step 1: Initial Identification and Classification of Project/VC Interaction

The first step in conducting the effects assessment involved a comprehensive identification of interactions between care and maintenance activities and VCs. It also classified the interactions to highlight those warranting detailed consideration in the effects assessment.

The potential for specific pathways of effects between each care and maintenance activity and each VC (and subcomponent) was considered. This systematic approach created a matrix of project activities and VCs, promoting thorough consideration and identification of all potential interactions, regardless of scale, magnitude, frequency, geographic extent or direction. Within the matrix, each project-activity/VC intersection was classified according to the following numerical criteria:

- “0” = No Interaction: no measurable interaction that could cause an effect;
- “1” = Weak Interaction: minimal interaction where measurable effects are possible, but the effects will be avoided or suitably mitigated through compliance with regulatory requirements and application of standard best management practices; and
- “2” = Strong Interaction: potential interaction where measurable effects are likely even with application of best management practices, or where understanding the scale, magnitude, duration or frequency of effects requires detailed analysis.

The assessment addressed interactions classified as “1” by identifying specific regulatory requirements and best management practices to eliminate or suitably mitigate potential effects. Tables 9.3, 9.5 and 9.7 describe the results of the assessment for these interactions.

The assessment addressed interactions classified as “2” by conducting more detailed analyses of potential effects (Step 2 of the assessment methodology).

9.5.2 Step 2: Evaluate Effects of Relevant Project/VC Interactions

Each interaction classified as “2” was carried forward for a more detailed assessment. Analytical processes were followed to understand the interaction pathways, predict the effects, identify appropriate mitigation measures, evaluate the significance, and design monitoring plans to confirm the validity of the assessment.

The assessment team applied the following general steps to evaluate project-activity interactions for socio-economic VCs:

- Identify indicators to characterize the interactions between the project and a specific VC;
- Identify and describe specific pathways that may lead to effects on VCs;
- Describe baseline conditions and acceptable levels of change for VCs;

- Analyze potential project effects on VCs. Analytical methods varied for each VC and for each type of interaction, with appropriate methods selected to achieve the overall assessment goals: to predict the potential socio-economic conditions arising from the project and compare the predicted conditions with baseline conditions. Secondary statistical data, at best available scales, were reviewed to predict potential socio-economic effects using quantitative and qualitative measures;
- Develop mitigation measures. Where necessary, the assessment team identified the need for mitigation or enhancements to existing best management practices and communication protocols, to address adverse socio-economic effects; and
- Evaluate the significance of residual effects.

9.5.3 Methodology for Evaluating Significance

The proponent's assessment team considered the following list of criteria when evaluating the significance of project activities' residual effects on VCs:

- Direction;
- Magnitude/Duration;
- Likelihood/Frequency;
- Geographic extent; and
- Reversibility.

9.5.3.1 Socio-economic VCs

The criteria for evaluating potential effects to socio-economic VCs are similar to the criteria for environmental VCs. However, they are defined more specifically to reflect the socio-economic conditions and indicators. The following criteria were established to evaluate the significance of socio-economic VCs:

- **Direction:** Socio-economic effects may differ in direction and are therefore considered when evaluating significance. Direction is defined as the ultimate long-term trend of the socio-economic effect (neutral, positive, or negative), relative to the baseline conditions;
- **Magnitude/Duration:** The amount or degree of change relative to baseline conditions. The period of time required until the VC or indicator returns to its baseline condition, or until the effect can no longer be measured or otherwise perceived. In this case, duration provides a measure of reversibility as well;
- **Geographic extent:** The geographic area within which a socio-economic effect occurs;
- **Probability/Frequency:** This is considered separately from magnitude/duration to reflect the probability that an effect will occur, and how often it could occur (i.e., once, daily, weekly, monthly, continuous). Probability and frequency addresses the likelihood of effects; and
- **Reversibility:** The ability of the VC or indicator to return to an acceptable condition if the activity stopped.

For each criterion except direction, significance is measured as High, Moderate/Medium, or Low. Specific criteria and significance definitions reflect the specific VC and indicator under consideration. Before significance was evaluated, the assessment team determined that if an activity had a rating of ‘High’ for overall significance, the activity was deemed to have significant effects and was not acceptable to proceed in accordance with YESAA requirements. As a result, mitigations were adjusted, and a significance rating was re-evaluated. If the direction criterion was considered neutral, it was assumed that there was no change to baseline conditions and therefore had no effect. In those circumstances, other criteria were considered not applicable (N/A) and therefore were not evaluated further.

9.6 Socio-economic Effects Assessment Results

9.6.1 VC – Employment and Economic Stability

Employment and economic stability were identified as VCs because the economic activity generated as a result of Care and Maintenance may influence how income and capital is distributed in the local and regional study areas. The employment and economic stability VC is comprised of four subcomponents: employment, youth employment, business opportunities and training. These subcomponents were informed through the consultation process, as well as standard practices typically applied for similar projects.

Table 9.6-1: Project/ Employment and Economic Stability Subcomponent Interactions

Project Activity or Physical Work	Employment and Economic Stability Subcomponent Interactions			
	Employment	Training	Youth Employment	Business Opportunities
Construction (water treatment plant construction)	2	1	0	2
Site Operations	2	2	1	2
Accessory Activities	0	0	0	0

9.6.1.1 Geographic Scope

The Little Salmon Carmacks First Nation Traditional Territory, which includes the communities of the Village of Carmacks and Little Salmon Carmacks First Nation, was identified as the Local Study Area. The Regional Study Area is the Yukon Territory.

9.6.1.2 Indicators

The assessment uses indicators, or key characteristics, to evaluate potential changes in the VCs due to the Project. The indicators identified for the employment and economic stability VC are:

- **Employment:** a change in the number and distribution of employment opportunities for skilled and unskilled labor;
- **Youth Employment:** a change in the number and distribution of employment opportunities for youth in skilled and unskilled labour;

- **Business Opportunities:** change in the number of businesses and associated employment in local economies; and
- **Training:** a change in training and skill development opportunities associated with project activities.

9.6.1.3 Analysis of Potential Effects

Care and Maintenance activities have been ongoing at the Mount Nansen site since 1999 and since that time have incrementally changed as site conditions evolved, and as YG's understanding of the Project needs developed. With the exception of the water treatment plant construction and operation, Care and Maintenance activities are expected to continue in a similar fashion to how they are currently conducted. The assessment explores the potential effects of Care and Maintenance activities on the employment and economic stability VC subcomponents by examining associated indicators.

9.6.1.3.1 Employment

Current Care and Maintenance activities require two staff on site, on a two week on, two-week off rotation schedule throughout the year for a total of four employees on site year-round. During the summer, a student is typically employed. The addition of the water treatment plant is not expected to alter the on-site staffing requirements for Care and Maintenance activities. The continued employment of four full-time employees who are all currently Yukon residents has a positive impact. The recently awarded Care and Maintenance contract will remain in place until such time that the Site is transferred to the purchaser. The current contractor has committed to hiring and training First Nations and local employees, and the competitive sale process (expected to be completed in June 2019) encourages First Nation and local hiring practices.

The construction of the water treatment plant will require specialized labour and equipment to implement. The majority of the specialized labour will be specified by the manufacturer of the water treatment plant, however where possible local specialized labour will be used, and where not possible it will be sourced regionally, before being sourced outside of the territory. The construction of the water treatment plant is therefore expected to have a positive impact to the local and regional study areas.

Ongoing site monitoring will continue to be undertaken throughout the care and maintenance program. Contractors undertaking these activities (such as water quality monitoring) also provide training and employment opportunities to First Nations and community members. One LSCFN employee was hired and trained to conduct water quality monitoring at the Site. As a casual employee, this individual has the opportunity to work on other projects in the territory.

9.6.1.3.2 Training

The expected five-year duration of Care and Maintenance activities offers a small window to train the local or regional workforce to meet the overall requirements of the Project. However, training for existing employees who will be required to operate the water treatment plant will be required. This training will likely be provided by the company the water treatment plant is procured from.

The Care and Maintenance operator has historically offered a summer student position as a training or job shadowing opportunity. The advertising of the opportunity has typically been focused on the local workforce. This opportunity has successfully resulted in the employment of one the summer students as a permanent on-site employee.

The current care and maintenance contractor has committed to working with Yukon First Nations and local community human resource coordinators to determine priority areas of experience and skills and to identify potential employees for future employment opportunities. Future opportunities could continue to be offered to encourage Little Salmon Carmacks First Nation, Carmacks and Yukon residents to seek opportunities in the Care and Maintenance and reclamation fields. Overall, it is not expected that the Project will have an effect on the uptake of training opportunities particular to Care and Maintenance due to the limited scale and scope of the project.

9.6.1.3.3 Youth Employment

As part of Care and Maintenance a small number of summer student positions have been made available, as described above in the training section. These opportunities have successfully resulted in the hiring of one student as a full time, on site employee, however these opportunities are limited due to the duration of the Project. It is expected that the Project will have a minor positive effect in youth employment (one summer student per summer) but will not largely affect the overall the overall youth employment opportunities in the local or regional study areas.

9.6.1.3.4 Business Opportunities

The communities of Carmacks and Little Salmon Carmacks First Nation are the closest to the Mount Nansen site, and may experience a small increase in demand for equipment or construction-related activities. The current Care and Maintenance contractor has committed to using Yukon First Nation and Yukon vendors for at least 90% of the good and services they procure throughout their care and maintenance contract. However, due to the duration of the Project and the limited scope it is not expected that Care and Maintenance will create the demand for additional or diversified businesses within the Traditional Territory of Little Salmon Carmacks First Nation or the Yukon.

Table 9.6-2: Employment and Economic Stability Effects Rating Table

VC Subcomponent	Rationale	Measure	Effects Attributes	Effects Rating
Employment	Employment opportunities associated with Care and Maintenance could have a meaningful effect on a small economy such as the Village of Carmacks and Little Salmon Carmacks First Nation communities.	Employment rates, unemployment rates	Direction	Positive
			Magnitude/Duration	Low
			Geographic Extent	Moderate
			Likelihood/Frequency	Moderate
			Reversibility	Low
Training	Project- and site-specific training opportunities	Available training opportunities, capacity to participate in training	Direction	Neutral/Positive
			Magnitude/Duration	Low
			Geographic Extent	Moderate
			Likelihood/Frequency	Moderate
			Reversibility	Low
Business Opportunities	Contracting opportunities and procurement of goods through local business could have a meaningful effect on the local economy.	Change in demand for goods and services.	Direction	Positive
			Magnitude/Duration	Low
			Geographic Extent	Low
			Likelihood/Frequency	Moderate
			Reversibility	Low

9.6.1.4 Mitigation and Enhancements

Care and Maintenance activities are expected to have a neutral to positive (beneficial) effect on employment, training, and business opportunities in the study areas. For the Employment and Economic Stability VC, mitigations are currently in place to ensure the effect remains neutral to positive, including:

- Using a competitive bid process to evaluate proponents on proposed First Nation Participation Plans;
- Maintaining the summer student position that is currently offered by the site operator;
- Prioritizing the use of First Nation and local vendors; and
- Continuing to encourage consultants to offer training and employment during ongoing site monitoring programs.

9.6.1.5 Significance of Residual Effects

Overall, Mount Nansen Care and Maintenance is neutral to positive. No adverse effects on the economy and employment values are predicted therefore no significance test is required.

9.6.2 VC – Community Health and Well-being

Community Health and Well-being was identified as a VC due to the importance of maintaining a lifestyle that was culturally appropriate to the Little Salmon Carmacks First Nation. Based on research conducted by Pinard and Staples (2017) a significant aspect of wellness of LSCFN citizens was the ability to harvest foods within their traditional territory. Further, the Village of Carmacks has also identified the overall importance of community well-being in documents such as the 2006 Integrated Community Sustainability Plan and 2013 Official Community Plan.

The “Community Health and Well-being” VC is comprised of four subcomponents: traditional food security, connection to the land and water, human health, and community well-being. These subcomponents were informed through the consultation process, as well as standard practices typically applied for similar projects.

Table 9.6-3: Project/Community Health and Well-being Subcomponent Interactions

Project Activity or Physical Work	Community Health and Well-being Subcomponent Interactions			
	Traditional Food Security	Connection to the Land and Water	Human Health	Community Well- being
Construction (water treatment plant construction)	2	2	2	1
Site Operations	2	2	2	2
Accessory Activities	0	0	0	0

9.6.2.1 Geographic Scope

The Little Salmon Carmacks First Nation Traditional Territory, which includes the communities of the Village of Carmacks and Little Salmon Carmacks First Nation, was identified as the Local Study Area. The Regional Study Area is the Yukon Territory.

9.6.2.2 Indicators

The assessment team has identified the following indicators for change in Community Well-being VC and associated subcomponents:

- **Traditional Food Security:** the ability to access the regional study area to harvest traditional foods in the quantities desired, and the real and perceived safety of foods harvested in the area which may reduce consumption;
- **Connection to the Land and Water:** the number of families that participate in traditional activities in the area;
- **Human Health:** real and perceived risks to human health from potential impacts from the Site; and

- **Community Well-being:** a change in the cost of the basket goods comprised in the Spatial Community Price Index and/or a change in the Community Well-being Index, availability of affordable housing.

9.6.2.3 Analysis of Potential Effects

The assessment explores the potential effects of Care and Maintenance activities on the Community Well-being VC.

9.6.2.3.1 Traditional Food Security

Pinard and Staples (2017) note that LSCFN citizens feel that big game animals have become more difficult to harvest since 1999 and the abandonment of the Site. Currently, only LSCFN citizens are able to hunt moose in the game management zone 526 which overlaps with the Site, and caribou hunting is based on a permit system. Despite the increased difficulties, LSCFN noted that it was still possible to obtain a sufficient amount of traditional foods in the area to meet their needs (Pinard and Staples 2017).

It should be noted LSCFN citizens indicated that they avoid harvesting fish and berries in certain areas near to the Site due to concerns of contamination from historic mining operations. It is expected that this perception may not change until such time remediation of the Site is completed. The Care and Maintenance program is not expected to significantly alter or change this perception, although the installation of a water treatment plant and resulting improvement in the quality of water discharged from the Site may have a positive impact.

There will be a temporary short-term influx of contractors associated with the assembly of the water treatment plant, including increased traffic on the public road. Due to the small nature of the project and the short duration a significant negative impact is not predicted. However, further mitigations are described in Section 9.6.2.4: Mitigations and Enhancements; Significance Testing has been conducted in order to minimize any negative effects.

Due to the small number of people on site associated with site operations at any one time, and the low number of contractors that visit site, it is not expected that Site Operations will have an effect on the ability to harvest traditional foods. However, mitigations have been put in place due to potential concerns with harvesting of traditional foods by site operations staff, and these mitigations are described in Section 9.6.2.4.

Many of the concerns regarding the harvesting of traditional foods described in Pinard and Staples (2017) surround the use of the public road to the Mount Nansen site. With the building of the road, and its continued maintenance, a larger portion of Little Salmon Carmacks First Nation Traditional Territory has been made accessible to a wider population due to the increased accessibility. Although Assessment and Abandoned Mines is not responsible for the road, it does advocate for the continued maintenance of the road to provide safe access to the Site by the operations staff and associated contractors. For this reason, the mitigations described in Section 9.6.2.4 largely pertain to how site operations staff and contractors are able to hunt in regard to the road.

9.6.2.3.2 Connection to the Land and Water

LSCFN's traditional land use is dependent on a sense of connection to the land and water and the traditional knowledge that is embedded in that relationship (Pinard and Staples, 2017). This connection is interrelated with other VC subcomponents, including traditional food security, the perception of risk of exposure of contaminants through harvesting activities and other land and water uses, and availability of safe drinking water sources. Although the Mt. Nansen Mine has affected LSCFN connection to the land and water the proposed Care and Maintenance project is not expected to cause a significant change to LSCFN's current connection to the land and water, although installation of the water treatment plant will improve water quality discharging from the Site and could potentially alter perceptions of risk in a positive way. The continuation of Care and Maintenance activities is not expected to significantly alter or effect the rate of participation of traditional land use in the area.

9.6.2.3.3 Human Health

Various studies and assessments conducted over the last several years indicate that although contaminant concentrations around the Site are elevated due to previous mining activity, the risk to human health through the consumption of traditional foods is relatively low. The Care and Maintenance program is not expected to change the level of exposure of contaminants to humans through direct pathways or the consumption of traditional foods. The installation of the water treatment plant will reduce contaminant concentrations in water discharged from the Site and therefore could have a positive impact on human health. Mitigations intended to reduce risks to human health are conducted on an ongoing basis as part of the Care and Maintenance program.

9.6.2.3.4 Community Well-being

Community Spatial Price Index

The Community Spatial Price Index measures the cost of goods in a Yukon community, such as Carmacks, that a typical household would require. The basket includes the following household goods: meat, dairy, eggs, fruit and vegetables, bread, other foods as well as household operations, health and personal care, and gasoline and home heating fuel. The index compares the cost of those goods in the community to the cost of goods in Whitehorse. The Community Spatial Price Index is therefore an important indication of the availability of affordable foods and household goods that may supplement a traditional lifestyle, or which may be the primary source of food and goods.

Since 1999 the average cost of goods has been 11 percent higher in the Village of Carmacks than in Whitehorse. As care and maintenance has not changed significantly since the Yukon Government has assumed management of the Site, and the Community Spatial Price Index has fluctuated, it is unlikely that there is a relationship between care and maintenance activities and the cost of household goods in Carmacks.

Site operations staff and contractors are encouraged to purchase goods and services locally where possible. However, due to the small size and short duration of the construction phase, and the small number of people

employed during regular care and maintenance activities, the Project is expected to have a neutral effect on the Community Spatial Price Index.

Community Well-Being Index

The Community Well-Being Index (CWB) is a socio-economic wellness tool developed by Indigenous and Northern Affairs Canada that takes into account income, education, housing and labour force to compare the well-being of those living in Aboriginal communities versus non-Aboriginal communities (INAC 2016). The index compiles the scores of the four indicators to create a score out of 100. The last CWB index compiled for Carmacks was in 2006 and the community had a score of 70. Yukon had an overall score of 78.

Scores for income, education and housing in Carmacks were typically eight to ten points below that of Yukon, whereas the labour force activity score had a two-point discrepancy. Although the majority of indicators for Carmacks remain stable between 1996 and 2006, the score for housing conditions has consistently gone down.

Site operations may make a positive contribution to the CWB indicators for income and labour force for Carmacks as it is a priority to hire from the local study area. Construction activities related to the water treatment plant are unlikely to affect the income and labour indicators for Carmacks as this labour will come from larger centers such as Whitehorse, located in the regional study area. Care and maintenance activities will not have an effect on the education or housing indicators. Housing for both the construction and site operations phases will be provided on site. The Project is predicted to have a neutral or positive effect on the CWB score for Carmacks.

Table 9.6-4: Community Health and Well-being Effects Rating Table

VC Subcomponent	Rationale	Measure	Effects Attributes	Effects Rating
Traditional Food Security	The ability to access the regional study area to harvest traditional foods in the quantities desired is an indicator of participation in a traditional lifestyle that is conducive to the well-being of the community.	Ability to secure traditional food sources of the community's desired quantity and quality, as well as the perception of safety of those foods near the mine site.	Direction	Neutral
			Magnitude/Duration	N/A
			Geographic Extent	N/A
			Likelihood/Frequency	N/A
			Reversibility	N/A
Connection to the Land and Water	Traditional land use is dependent on the strength of connection to the land and water.	Participation of families participating in traditional activities, areas of disturbance and displacement, access to resources.	Direction	Neutral
			Magnitude/Duration	N/A
			Geographic Extent	N/A
			Likelihood/Frequency	N/A
			Reversibility	N/A

VC Subcomponent	Rationale	Measure	Effects Attributes	Effects Rating
Human Health	Real and perceived risks to human health from the mine site affect land use.	Confidence in water quality, availability of drinking water sources, real and perceived risk of exposure of contamination from history mining operations	Direction	Neutral
			Magnitude/Duration	N/A
			Geographic Extent	N/A
			Likelihood/Frequency	N/A
			Reversibility	N/A
Community Well-being	The overall well-being of the citizens of Carmacks and LSFCN is tied to the ability to acquire goods, services and housing.	Community Spatial Price Index, Community Well-being Index, availability of affordable housing.	Direction	Neutral
			Magnitude/Duration	N/A
			Geographic Extent	N/A
			Likelihood/Frequency	N/A
			Reversibility	N/A

9.6.2.4 Mitigations and Enhancements

For the Community Health and Well-being VC, mitigations are currently in place, and will continue to be in place to mitigate negative effects of the construction of the water treatment plant and site operations on traditional food security. The installation of the water treatment plant will reduce concentration of contaminants in water discharged from the Site and released into receiving waters where traditional foods are harvested.

As part of regular site operations procedures, it is prohibited to bring firearms to the Site, or to participate in hunting from the Site when personnel are there as part of their site operations responsibilities. Further, should site operations personnel wish to hunt when they are off duty, they must first leave the site, and can commence hunting activities from Carmacks. With these policies, local hunters will not experience competition from site operations personnel or contractors who are on site and engaged in care and maintenance activities.

Site operations personnel are trained to follow all relevant rules and regulations in regard to site access, such as driving at posted speed limits, to avoid any unnecessary risk with oncoming traffic. Contractors accessing the site as part of the construction of the water treatment plant will be expected to follow the same site policies in regard to firearms and hunting as the site operations personnel, as well as adhering to relevant rules and regulations when driving the public road.

While on site, personnel, contractors and visitors are expected to follow health and safety procedures designed to reduce exposure to potential contaminants.

9.6.2.5 Significance of Residual Effects

Following the application of mitigations that are currently in place as part of the care and maintenance there are no significant effects expected to occur because of care and maintenance on the community well-being VC.

9.6.3 VC – Sustainability and Legacy

Sustainability and Legacy was identified as a VC by LSCFN. Although the Care and Maintenance program is small in scale and scope compared to historic mining activities and future remediation, LSCFN views the program as part of the overall legacy of the mine and for that reason these VCs have been retained for further assessment. LSCFN raised several factors that influence this VC, including potential cumulative impacts from other exploration and mining activity in the area, participation in the Care and Maintenance program, site governance and the overall environmental and socio-economic legacy of the mine.

Table 9.6-5: Project/Sustainability and Legacy Interactions

Project Activity or Physical Work	Sustainability and Legacy Interactions
Construction (water treatment plant construction)	2
Site Operations	2
Accessory Activities	1

9.6.3.1 Analysis of Potential Effects

Overall, no significant adverse effects from the Care and Maintenance project are anticipated in relation to the sustainability and legacy VC. The project is intended to ensure continued protection of the environment and human health and safety until such time remediation of the site is initiated.

The project is not expected to cause adverse cumulative impacts in relation to other projects in the area. No new areas of disturbance are proposed during care and maintenance, and the installation of a water treatment plant will reduce potential loading of contaminants to the receiving water bodies that could be influenced by other exploration and mining activity in the area.

LSCFN has expressed an interest in greater involvement with the site. LSCFN will continue to be engaged throughout the care and maintenance program. Government of Yukon will continue to facilitate regular meetings and other communication with LSCFN to foster information sharing and collaborative decision making. The transfer of the Site to the new purchaser provides an opportunity for involvement by LSCFN, as the new purchaser is not bound by YG contracting requirements (which are considered restrictive by LSCFN). The Care and Maintenance program may also be viewed as a capacity building opportunity by the purchaser in preparation for the larger-scale remediation project.

LSCFN is discouraged by the relatively slow progress towards remediation of the Site and the lack of water treatment. The installation of the water treatment plant will have a positive effect as it will fulfill LSCFN's previous request to implement water treatment. In addition, the purchaser will obtain regulatory authorizations during the Care and Maintenance program in preparation for remediation.

Table 9.6-6: Sustainability and Legacy Effects Rating Table

VC	Rationale	Measure	Effects Attributes	Effects Rating
Sustainability and Legacy	The prevalence of mining activity in the area, past mining practices, and opportunities to participate in decisions affecting the Site influence perceived sustainability and legacy.	Confidence in site governance and programs, perceived state of the environment and legacy, perceived socio-economic legacy.	Direction	Neutral/Positive
			Magnitude/Duration	Low
			Geographic Extent	Moderate
			Likelihood/Frequency	Moderate
			Reversibility	Low

9.6.3.2 Mitigations and Enhancements

Although some of the concerns raised by LSCFN in relation to the sustainability and legacy VC extend beyond the temporal scope of the care and maintenance program, the project provides a framework and foundation for LSCFN's continued (and enhanced) involvement as a project partner as the Site progresses toward remediation. LSCFN's involvement in the project could have a positive impact on LSCFN's confidence in site governance and programs, and the progression towards remediation is expected to have a positive effect on the overall environmental and socio-economic legacy of the site.

9.6.3.3 Significance of Residual Effects

No significant residual effects are anticipated from the Care and Maintenance activities in relation to the sustainability and legacy VC.

10 Significance Summary

10.1 Significance of Environmental and Socio-economic Effects

This section provides a summary of the major potential effects that were identified in the Environmental and socio-economic effects assessments and describes the significance of those effects.

For the aquatics VCs (surface water quality and fish and aquatic environment) the major potential effects are the result of water quality contaminants of concern (primarily metals) being released to the receiving environment via Dome and in turn Victoria creeks. While the concentrations of these contaminants of concern are elevated due to existing Site infrastructure and other existing conditions (e.g., upstream placer mining in Victoria Creek), the implementation of a WTP is predicted to result in slight improvements in water quality. The assessment evaluated the potential effects of Aluminum, arsenic, iron, manganese, zinc, and sulphate in relation to Project-specific WQO using before (existing conditions) and after (treatment scenario during the project) modelling.

For the wildlife VC the major potential effects relate to potential contamination arising from the storage of tailings and water in the TSF, where pathways of metals uptake and accumulation exist. The evaluation of potential effects used a comparison of expected effects with ecological objectives for avian nesting habitat and small mammals and rodents.

For the employment and economic stability VC no negative effects were identified, but several positive effects were identified in relation to the employment, training, and business opportunities indicators. The assessment found that the project would result in short-term increases to employment, training opportunities for First Nations and local communities, as well as business opportunities for local businesses.

For the community health and well-being VC no negative effects were identified. Neutral effects were identified for traditional food security, connection to the land and water and community well-being, while a neutral to positive effect was predicted for human health.

For the sustainability and legacy VC a neutral to positive effect was predicted through increased opportunity and for movement towards the overall goal of site remediation and improved water quality.

The environmental and socio-economic effects assessments also considered effects on other VCs for which minor or weak interactions were identified. Measurable but minimal effects are possible for these interactions and mitigations, where required, were described through general operations manuals and best management practices.

A summary of the significance of the environmental and socio-economic effects considered in the assessment is provided in Table 10.1-1 below. Following the implementation of project-specific mitigation measures, all effects are predicted to have positive, not significant, or not significant moderate effects, therefore the project is not predicted to cause significant environmental or socio-economic effects.

Table 10.1-1: Summary of Significance of Project Effects

Environmental Valued Component	Indicator	Direction	Magnitude and Likelihood	Duration	Geographic Extent	Reversibility	Ecological Context	Overall Significance
Aquatics VCs	Sulphate	-	NSM	NSM	NSM	NSM	NS	NSM
	Total Arsenic	-	NSM	NSM	NSM	NSM	NSM	NSM
	Dissolved Aluminum	-	NSM	NSM	NSM	NSM	NSM	NSM
	Total Iron	-	NSM	S	NSM	NSM	NSM	NSM
	Dissolved Iron	-	NSM	NSM	NSM	NSM	NS	NSM
	Total Manganese	-	NSM	NSM	NS	NSM	NS	NSM
	Total Zinc	-	NSM	NSM	NS	NSM	NSM	NSM
Wildlife	Avian Nesting Habitat	-	NS	NSM	NS	NSM	NS	NS
	Small Mammals and Rodents	-	NS	NSM	NS	NSM	NS	NS
Socio-Economic Valued Component	Indicator	Direction	Magnitude and Duration	Likelihood and Frequency	Geographic Extent	Reversibility	Ecological Context	Overall Significance
Employment and Economic Stability	Employment	Positive	Low	Moderate	Moderate	Low	-	Not applicable as effects are neutral to positive
	Training	Neutral/Positive	Low	Moderate	Moderate	Low	-	
	Business Opportunities	Positive	Low	Moderate	Low	Low	-	
Community Health and Well-Being	Traditional Food Security	Neutral	N/A	N/A	N/A	N/A	-	
	Connection to the Land and Water	Neutral	N/A	N/A	N/A	N/A	-	
	Human Health	Neutral/Positive	Low	Low	Moderate	Low	-	
	Community Well-Being	Neutral	N/A	N/A	N/A	N/A	-	
Sustainability and Legacy	-	Neutral/Positive	Low	Moderate	Moderate	Low	-	

Notes: NS = not significant, NSM = not significant moderate, S = significant

11 Acknowledgment and Certification

This document has been prepared to support the Project Proposal Submission Form 1 for the Mount Nansen Care and Maintenance Project on behalf of the Government of Yukon, Assessment and Abandoned Mines Branch, and is intended to accompany that document.

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14 Appendices

Appendix 5A – Site Operations Manual

Appendix 5B – Tailings Facility Operations, Maintenance and Surveillance Manual

Appendix 5C – Tailings Facility Emergency Response and Preparedness Plan

Appendix 5D – Water Treatment Plant Technical Data Report

Appendix 5E – Site Operations Emergency Response Plan

Appendix 5F – Site Operations Manual Environmental Management Plan

Appendix 6A – Hydrogeology Existing Environment Summary

Appendix 6B – Groundwater Quality Existing Environment Summary

Appendix 6C – Hydrology Existing Environment Summary

Appendix 6D – Surface Water Quality Existing Environment Summary

Appendix 6E – Aquatic Environment Existing Conditions

Appendix 6F – Terrestrial Environment Existing Conditions

Appendix 7A – Proposed Water Quality Objectives

Appendix 7B – Water Quality Model Technical Data Report

Appendix 7C – Aquatic Effects Monitoring Program Appendix

Appendix 7D – Adaptive Management Plan (AMP)

Appendix 7E – Terrestrial Effects Monitoring Program Appendix

Appendix 9A – LSCFN Valued Components and Community Based Information

