SUMMARY REPORT

ANVIL RANGE MINE
TIER 2 RISK ASSESSMENT OF REMEDIATION SCENARIOS

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INTRODUCTION

The Interim Receiver for the Anvil Range Mine Complex commissioned SENES Consultants Limited to carry out an assessment of the potential for metals present at the site in groundwater, surface water, soils and waste materials to harm fish and animals on and close to the site as well as people who use the site for hunting, trapping and gathering. The assessment was undertaken to assist the closure planning team in the development of remediation options for the site. The Anvil Range Mine Complex includes facilities at two locations, the Faro mine site and the Grum and Vangorda mine site. The Faro mine site is located within the Rose Creek watershed, a tributary of the Anvil Creek watershed, while the Grum and Vangorda mine site is located within the Vangorda Creek watershed. The Anvil Creek and Vangorda Creek watersheds both empty into the Pelly River.

A selection process was used to identify metals that may have the potential to cause harm at the Anvil Range Mine Complex. The process involved determining whether the concentrations of metals in water and soils were different from areas which were considered not to be affected by mining operations (these areas are termed background). If the concentrations were higher than background, they were then compared to guideline values established by the federal government. Metals with concentrations above these values were then considered in the risk assessment. Based on this screening procedure: arsenic; cadmium; copper; lead; manganese; nickel; silver; tin; thallium; and zinc were selected.

In order to compare the effects of potential remedial options at the Anvil Range Mine Complex, an assessment was carried out for existing metal concentrations at the site. The assessment of "Existing" conditions was based largely on data collected during the 2002 to 2004 period on the Rose Creek and Vangorda Creek watersheds as well as on the land at the Anvil Range Mine Complex.

RANGE OF REMEDIATION ALTERNATIVES

Remediation alternatives have not yet been fully developed for the complex, therefore the risk assessment considered a range of possible alternatives. The range of remedial alternatives was selected on the basis of controlling the amount of each metal that is released to Rose Creek, Vangorda Creek and Anvil Creek. It should be noted that some of the alternatives would also reduce dust emissions from waste materials (tailings or waste rock) as a result of using clean cover material over the waste. However, this factor was not considered in the risk assessment. Also, none of the alternatives that were evaluated involve remediation of the land at the Anvil Range Mine Complex. As a simplifying assumption, it was considered that concentrations of metals in soil and vegetation in the future are the same as those that are currently measured at the site. Risks associated with direct exposure to waste materials (tailings and/or waste rock) were not assessed.

The alternatives investigated ranged from:

- a "No Intervention" scenario, which means doing nothing at the site;
- a "Remediation" scenario, which would involve ways of reducing the amount of the metals released into the environment as well as collecting a large amount of the runoff and groundwater from the site and treating this water before releasing it back into the environment;
- a "Treat All Flows" scenario, which would in theory involve the collection of all contaminated water for treatment as well as reducing the amount of metals released into the environment. This is not a practical alternative; however, it was evaluated to determine if there were still risks remaining at the site after implementation of an extreme remediation scenario.

For the "No Intervention" and "Remediation" scenarios, different conditions were evaluated based on estimates made by the engineering team of a range of possible metal releases into the environment from the waste materials and pits present at the mine sites. A Future 1 condition was defined for the "No Intervention" scenario which assumed that none of the metal releases (contaminated surface runoff and groundwater) is collected for treatment. For the "Remediation" scenario, a Future 2 condition was defined which assumed partial collection of the metal releases (contaminated surface runoff and groundwater) for treatment. A Future 3 condition was defined for all scenarios based on maximum possible metal releases with no collection ("No Intervention" scenario), partial collection and treatment ("Remediation" scenario) and full collection for treatment ("Treat All Flows" scenario). Based on the calculations by the engineering team, it is believed that release of the maximum amount of metals is unlikely to occur at the Anvil Range Mine Complex.

AQUATIC ENVIRONMENT ASSESSMENT

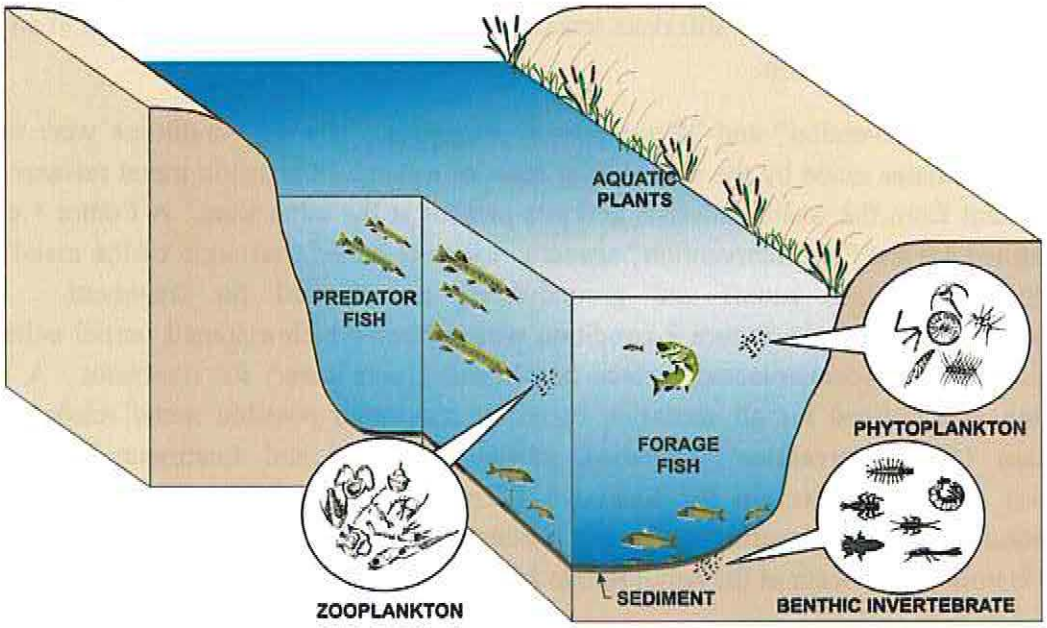
The aquatic environment assessment considered aquatic plants (plants that live along the edge of the water), phytoplankton (small plants that live in the water), zooplankton (small animals that live in the water), benthic organisms (small animals that live in the sediments) and fish (predatory and forage) that would come in contact (exposed) with metals in the water as seen in Figure 1. Both the upstream and downstream areas of Rose Creek and Vangorda Creek as well as Anvil Creek and the Pelly River were considered in the assessment. Effects on the health of aquatic species were determined by comparing the measured and predicted concentrations of metals in water to concentrations that are considered to protect these species. If the metal concentrations are below the protective levels then it can be concluded that the aquatic species are protected.

TERRESTRIAL ENVIRONMENT ASSESSMENT

The selection of terrestrial animals to carry through the risk assessment was based on information provided by First Nations people who use the site. The species selected included

bear, caribou, waterfowl (mallard, merganser and scaup), small furbearers (beaver and mink), fox, grouse, hare, hoary marmot, moose, Fannin sheep and wolf. From a risk assessment point of view, the ways (pathways) that the animals identified above come in contact with the metals present at the Anvil Range Mine Complex cover all possible pathways of exposure for any other animals that may be present on the Anvil Range Mine Complex. Exposure pathways for all animals are identified on Figures 2a to 2d, which also show the amount of food, water and soil or sediment that each animal consumes.

FIGURE 1
AQUATIC RECEPTORS CONSIDERED IN THE ASSESSMENT



The site was divided into different areas depending on the distance that the animal moves. Small terrestrial mammals such as hare, grouse and marmot, do not move over large distances and therefore were considered at several different locations across the site as seen in Figure 3. Fox and bear which travel larger distances were considered in larger areas on the site (see Figure 3) and animals such as caribou, moose and wolf that travel long distances were considered to move across the whole site (see Figure 3). Sheep were evaluated in the Mount Mye area and part of the Vangorda mine site. Terrestrial animals that have a large aquatic based diet such as waterfowl and small furbearers were evaluated on Rose Creek, Vangorda Creek, Anvil Creek and the Pelly River. Potential health effects in terrestrial animals were determined by calculating the intake for each animal (i.e. the amount of metal consumed) and comparing it to a level that results in minor health effects in laboratory species (generally rats). Test species such as rats are used because there is very little data available on wildlife. If the metal concentrations are below these minor health effects levels then it can be concluded that the populations of these animals are not at risk of health effects.

FIGURE 2a
POTENTIAL PATHWAYS OF EXPOSURE FOR CARIBOU, GROUSE, HARE, MARMOT AND SHEEP

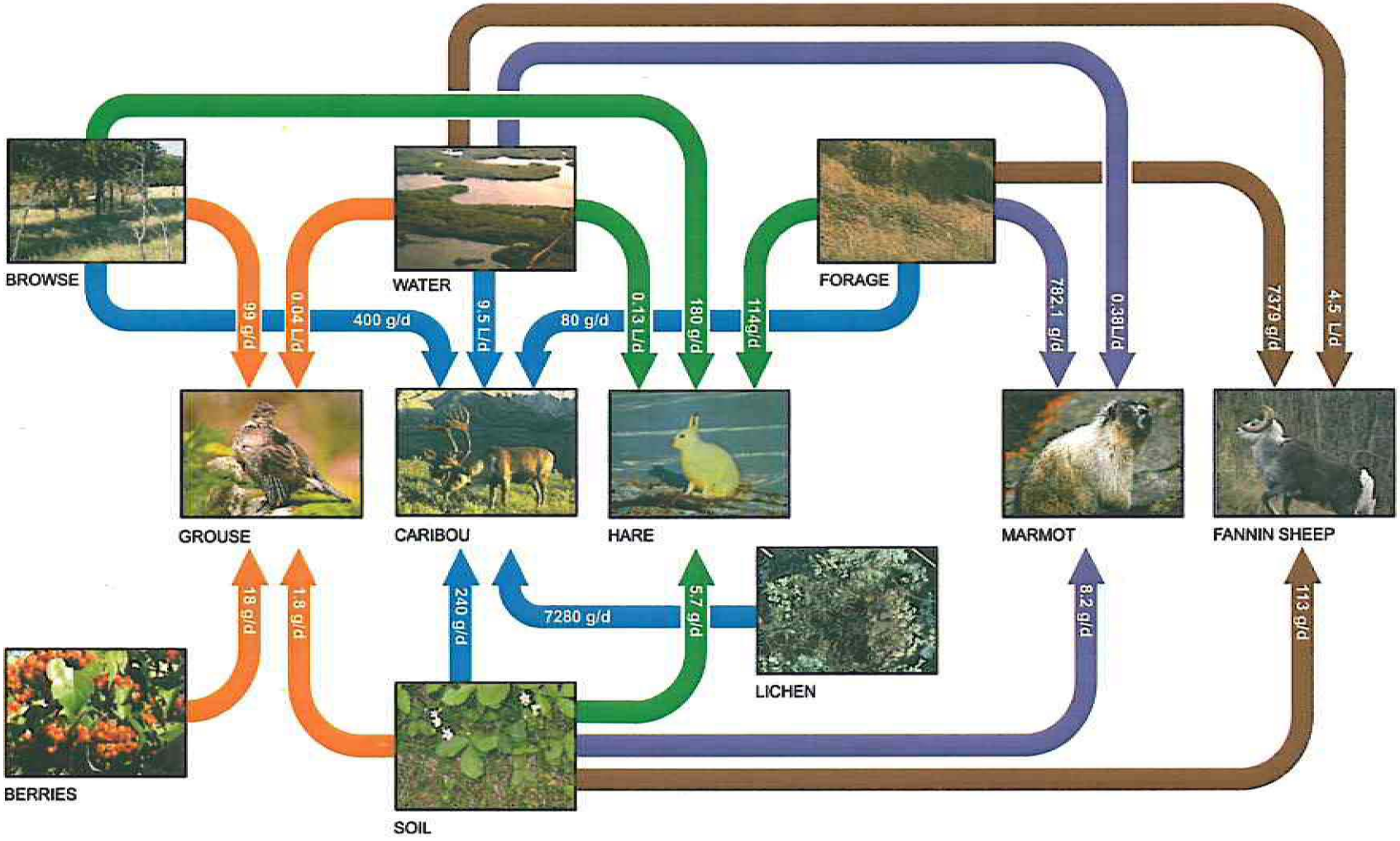


FIGURE 2b
POTENTIAL PATHWAYS OF EXPOSURE FOR BLACK BEAR, FOX AND WOLF

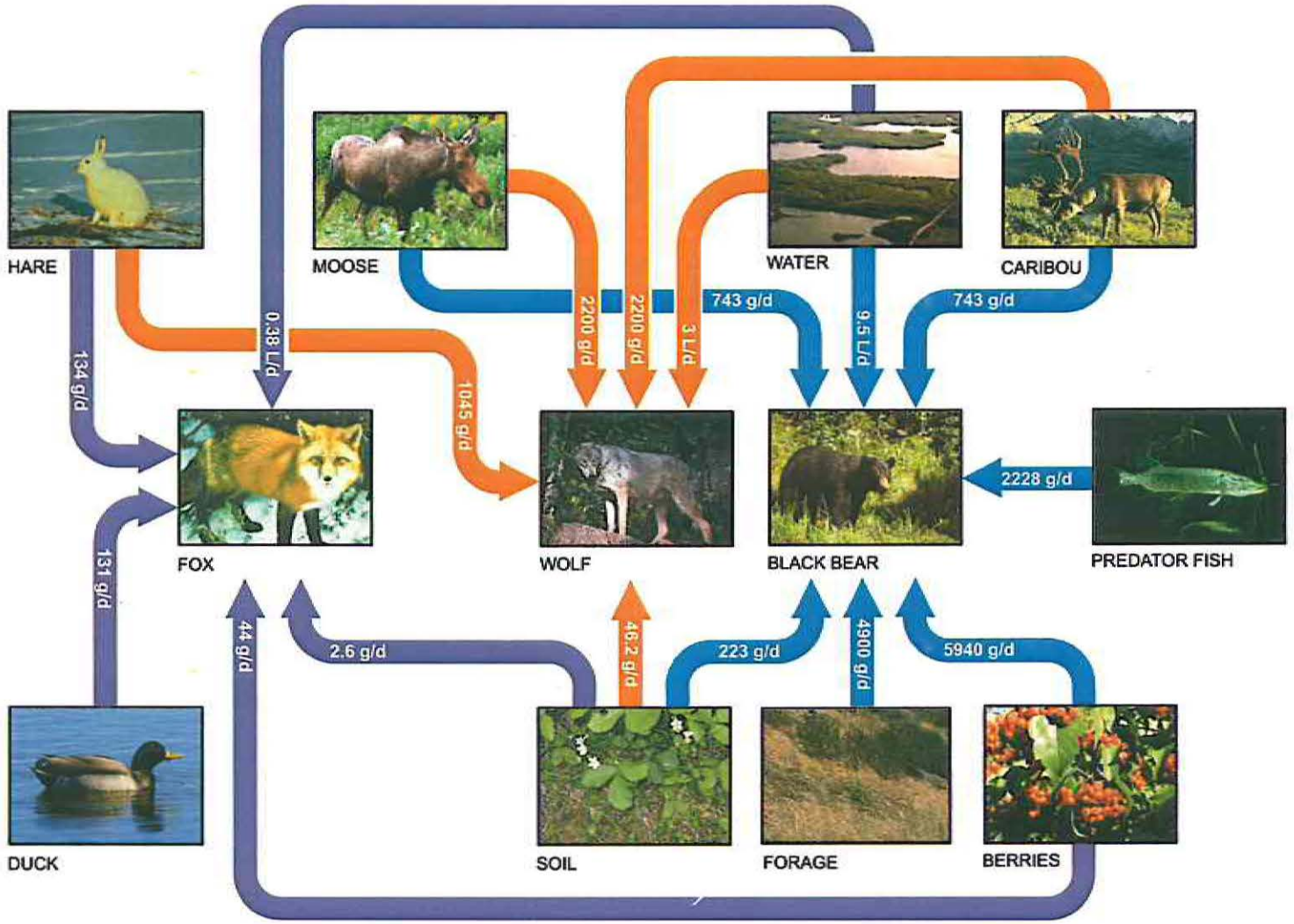


FIGURE 2c
POTENTIAL PATHWAYS OF EXPOSURE FOR MALLARD, MERGANSER AND SCAUP

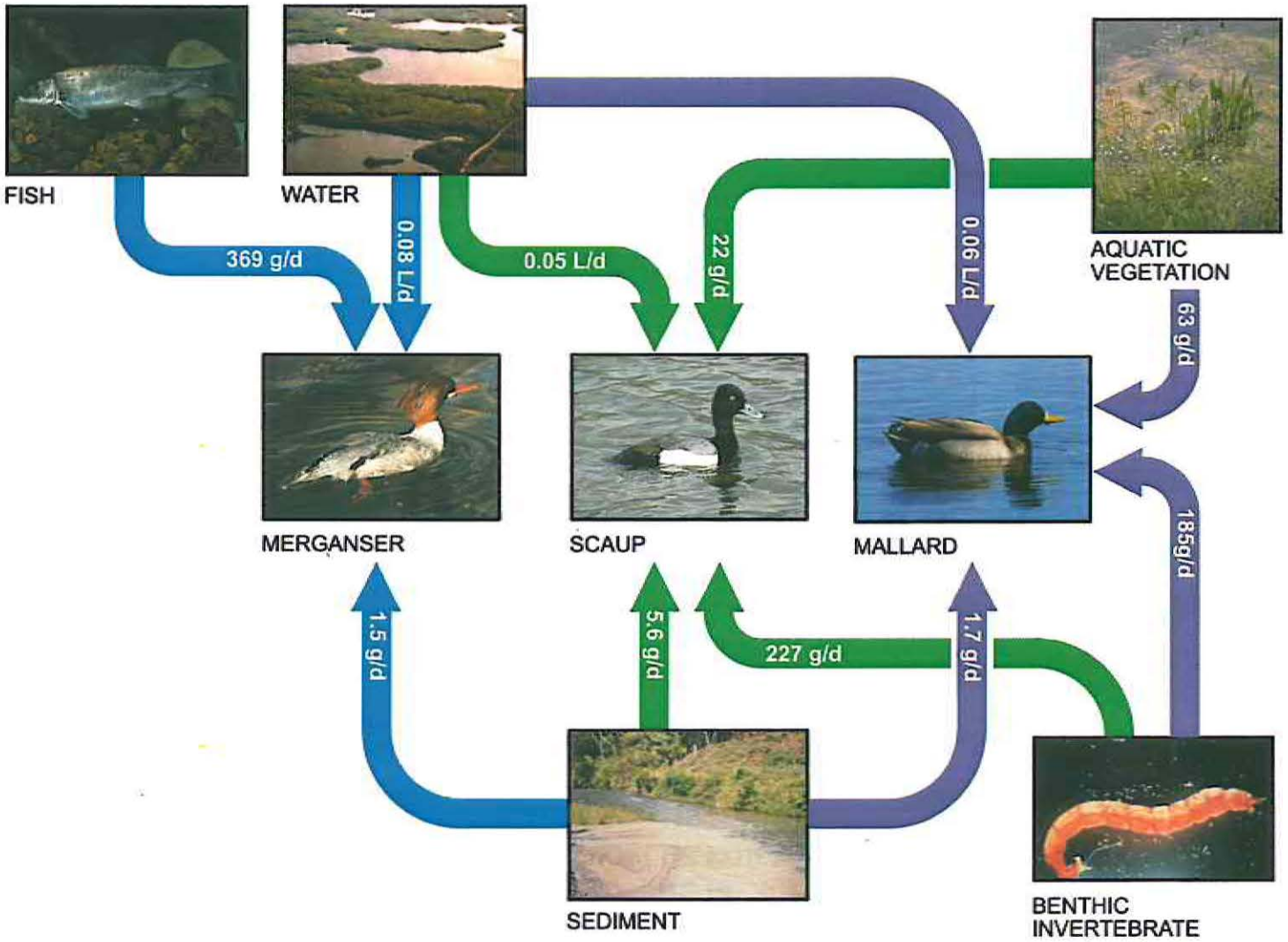


FIGURE 2d
POTENTIAL PATHWAYS OF EXPOSURE FOR MINK, MOOSE AND BEAVER

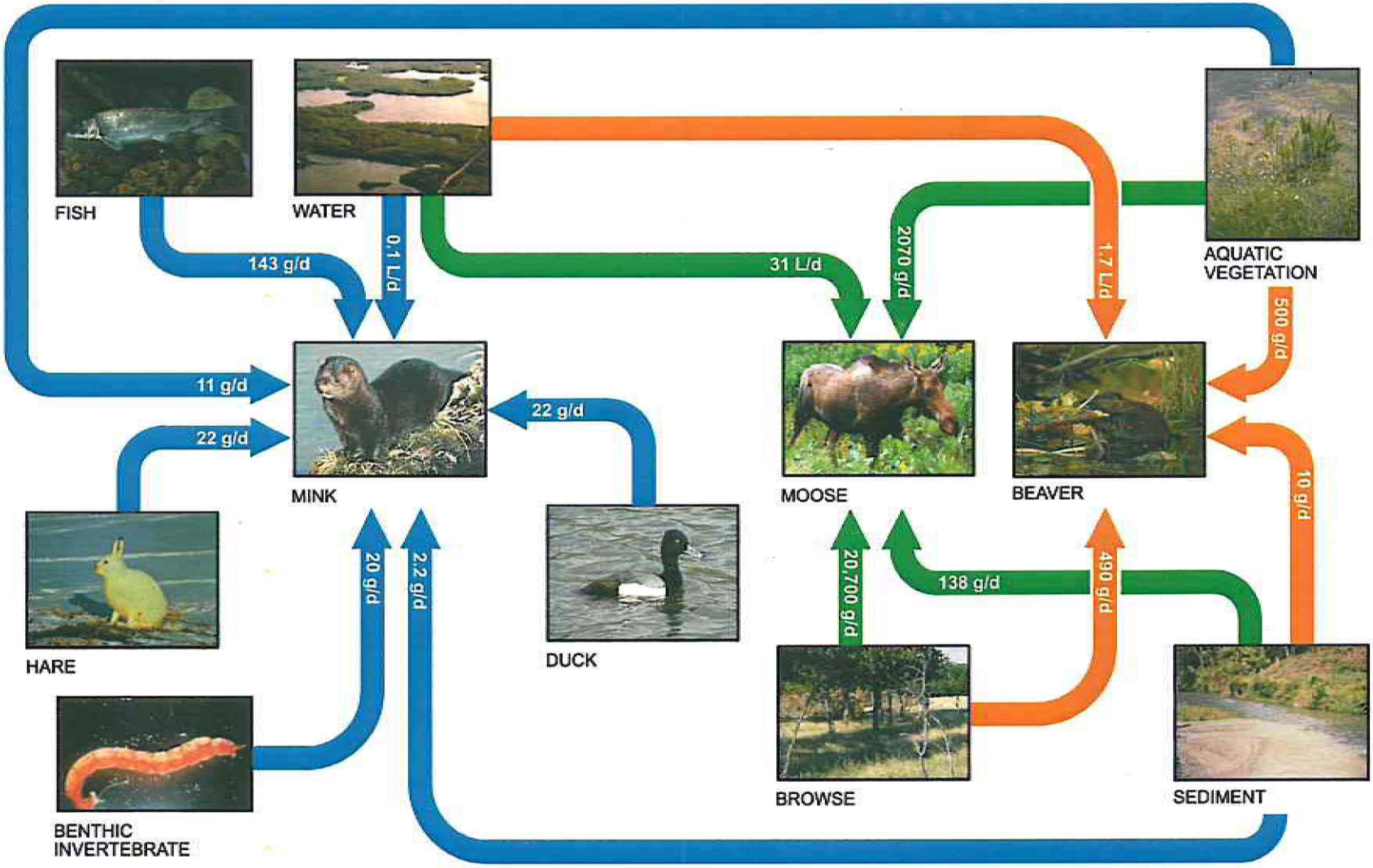
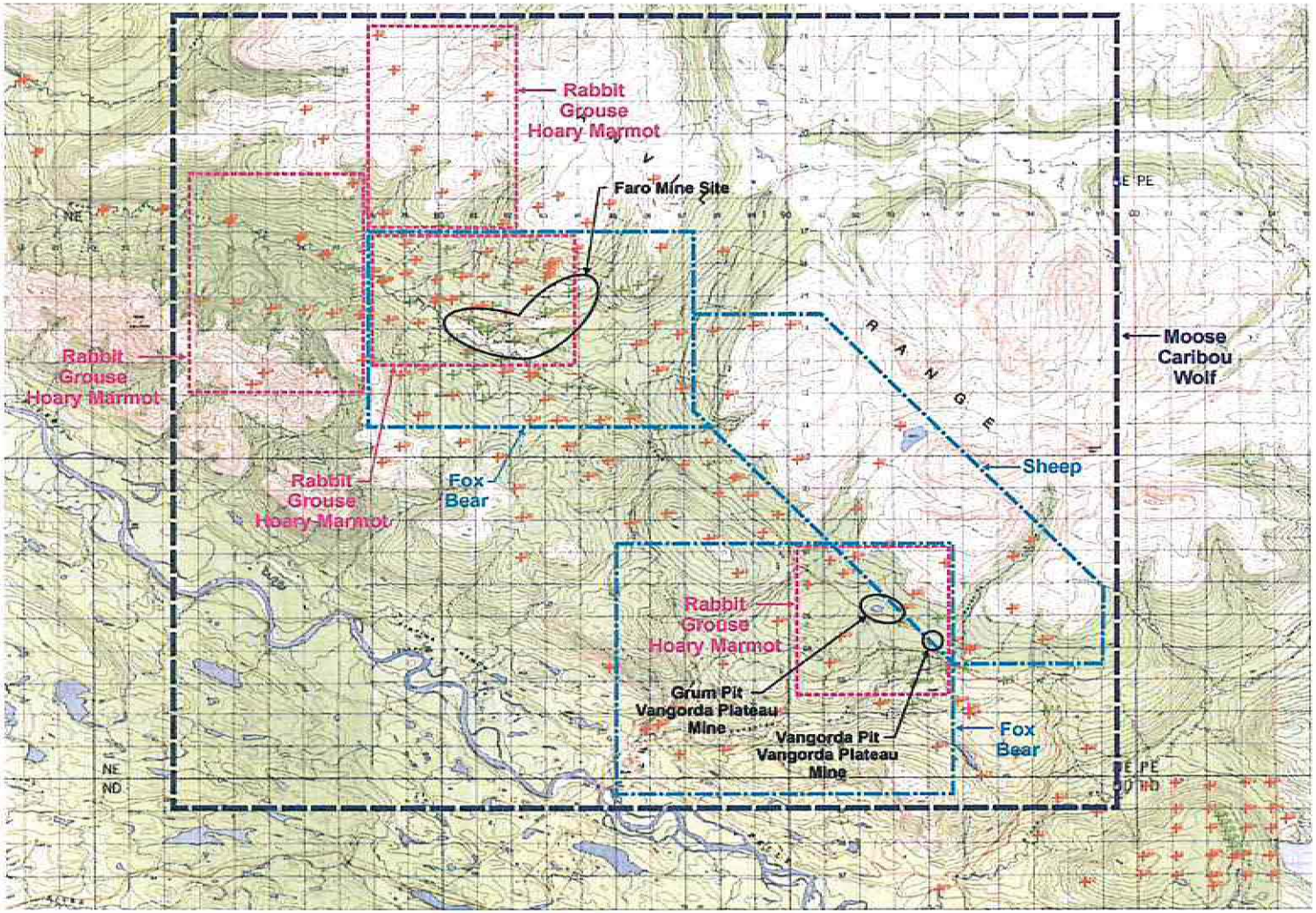


FIGURE 3
LOCATIONS CONSIDERED IN TERRESTRIAL ASSESSMENT



Note: + - soil and vegetation sampling locations

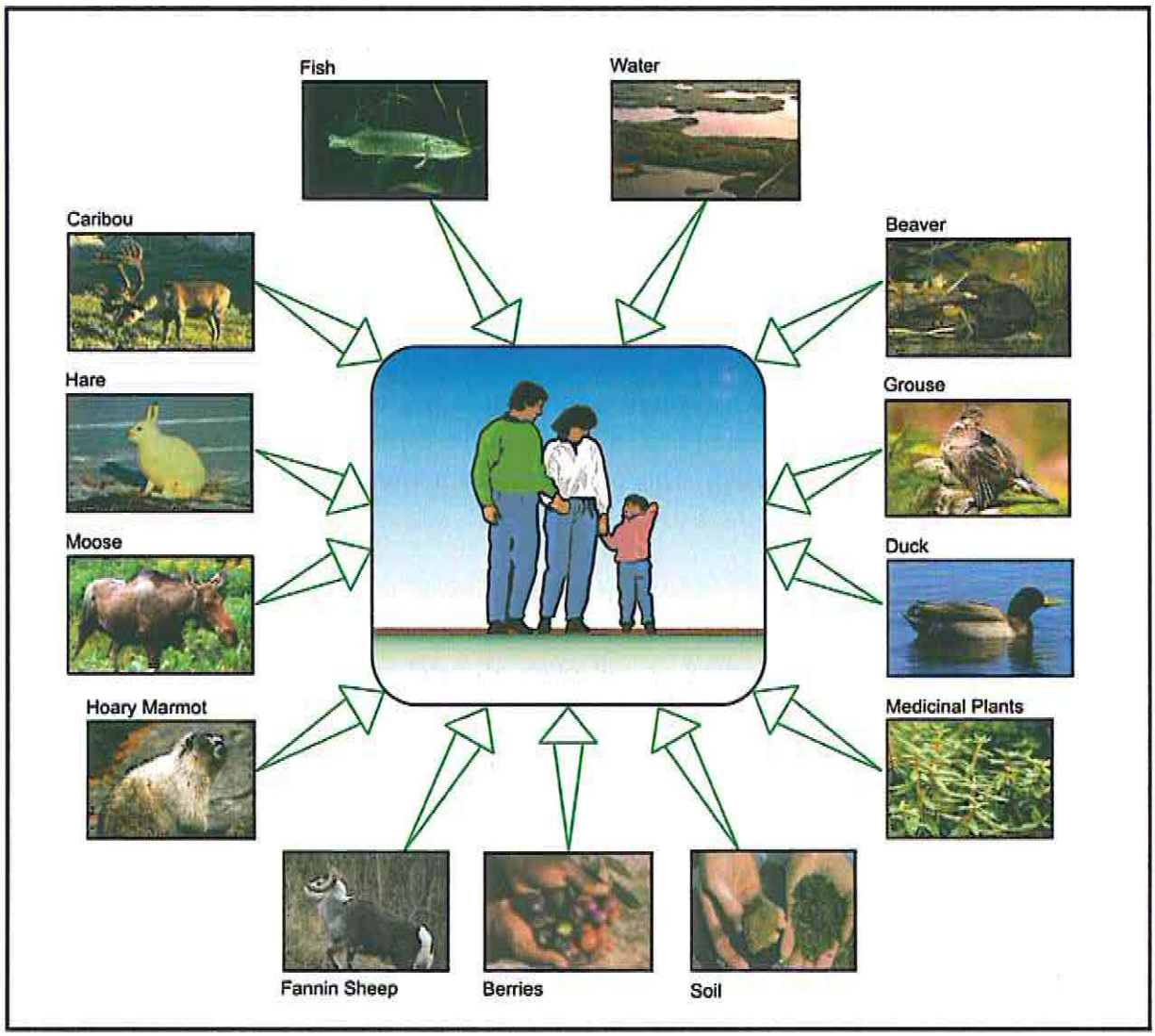
HUMAN HEALTH ASSESSMENT

The assessment of the potential health effects to people who use the site for hunting, gathering and trapping considered that individuals (toddler, child, adult) may camp at the site for 1.5 months at different locations with the time spent on-site depending on the scenario being considered. Currently, the site is only used for gathering of berries and trapping; therefore, in the "Existing" scenario it was considered that individuals would trap small mammals and gather berries from around the Faro mine site but will not camp on or near the Faro or Vangorda mine sites. For comparison, it was assumed that individuals would also be present in the Swim Lakes area for 1.5 months per year and would trap and gather berries from this baseline reference area but hunt large game on the Anvil Range mine site. Measured concentrations of caribou and moose captured at the site were used in the assessment. After remediation, it was assumed that conditions at the site were improved such that campers would actually camp on the Faro and Vangorda mine sites and would trap and gather berries near the sites, as well as from downstream on the Rose Creek and Vangorda Creek watersheds. All individuals who hunt or trap at the site were assumed to take game and fish back to their communities.

The different considerations or pathways of exposure that went into determining the amount of a metal that an individual may be exposed to while on-site is illustrated in Figure 4. These considerations were based on traditional knowledge, dietary information from a survey of First Nations people in the Yukon as well as professional judgement. As seen from the figure, it has been assumed that individuals would hunt, fish and trap animals in the study area. It was also assumed that gathering of berries and medicinal plants would occur at the Anvil Range Mine Complex. Other information required for the risk assessment such as the amount of water consumed by an individual, the amount of soil an individual may consume, the amount of skin available for contact and the body weight of an individual was obtained from data on the general Canadian population for various age ranges (i.e. 5 to 11 yr olds, 19 years and older).

The risk of health effects from exposure to metals that are known not to cause cancer was determined by a comparison of the calculated metal intakes by individuals to reference metal intakes that are considered to result in no health effects. Intakes for metals that do not result in health effects are provided by regulatory agencies such as Health Canada. For cancer causing metals such as arsenic, the calculated risks were compared to an "acceptable" risk level of one-in-one hundred thousand as provided by Health Canada.

FIGURE 4
POTENTIAL PATHWAYS OF EXPOSURE FOR HUMAN RECEPTORS



SUMMARY OF RESULTS

The risk assessment was undertaken using measured data where available from the site. There is a very good database for water, soils/sediments, and terrestrial vegetation that provides a good description of existing conditions at the mine site and in the surrounding environment. As the remediation scenarios carried through the risk assessment affect mainly metal levels in the surface waters of Rose Creek, Vangorda Creek and Anvil Creek, corresponding metal levels in sediments, aquatic plants and animals and fish were predicted using transfer factors determined

from measurements made on samples collected from the study area for each of these media. Measured metal levels in soils and vegetation were used directly in the risk assessment.

A summary presentation of the results of the risk assessment is provided in Table 1. Only those metals which were found to pose some level of risk are identified in the table. Nickel, silver, thallium and tin were found to pose no risks of health effects on fish, animals or humans in any of the scenarios considered in the assessment. By contrast, cadmium, copper, lead, manganese and zinc levels at the Anvil Range Mine Complex have the potential to result in health effects, especially for fish, in some, but not all, of the scenarios evaluated.

Table 1 shows that the current conditions at the site as evaluated by the "Existing" scenario are not expected to result in health effects in fish, animals and humans that are currently present on the site. However, the human health risk assessment indicated that consumption of caribou and moose organs, which accumulate cadmium, could pose a risk of health effects. Therefore, it would be advisable to restrict consumption of kidneys from caribou and moose (i.e. they should not be consumed on a regular basis). This observation is not restricted to animals captured on site.

Not surprisingly, the "No Intervention" Future 3 scenario is the worst scenario that was evaluated. In the "No Intervention" scenario, it was assumed that the site is essentially abandoned and that there is no control or collection of metal releases at the site, therefore all surface water and groundwater contaminated with metals ends up in Rose Creek, Vangorda Creek and Anvil Creek. Similarly, the waste materials (tailings and waste rock areas) were assumed to be left uncovered.

A review of Table 1 indicates that the "No Intervention" Future 1 scenario while somewhat better than "No Intervention" Future 3 scenario could still result in a risk of potential health effects on fish, animals and humans that use the site. Zinc exposure levels are very high. Therefore, abandonment of the site is not an environmental acceptable option.

The "Remediation" scenarios examine the effects of a combination of measures to reduce the amount of metals reaching the environment. It should be noted that these scenarios do not represent a planned closure option. In these scenarios, it was assumed that the remedial activities at the site would result in improved conditions such that individuals would camp on or near the Faro and Vangorda mine sites for 1.5 months per year and take game and fish home from the site for consumption over the remainder of the year.

In the "Remediation" Future 2 scenario, copper and zinc exposures in Rose Creek and Anvil Creek may result in a low risk of health effects in fish. This scenario represents a good basis for development of an appropriate remedial option.

In the "Remediation" Future 3 scenario, when maximum metal releases from the site are assumed to occur, elevated copper and zinc levels in Rose Creek and Vangorda Creek are predicted to pose high risks of health effects to fish. As well, there is a high risk that the cadmium level in Rose Creek could affect fish health. Zinc exposures in this scenario also represent a low risk of health effects in waterfowl and small furbearers.

The "Treat All Flows" scenario illustrates the effects of collecting all contaminated water from the site and releasing it into the environment after it has been treated. While collection of 100% of the contaminated water is not practical, the scenario was considered to provide insight into the level of remedial activities that may be required to achieve acceptable metal levels in Rose Creek, Vangorda Creek and Anvil Creek. No surprisingly, this scenario represents the best of the remediation scenarios considered in the assessment.

In summary, the results of the risk assessment indicate that the "Remediation" Future 2 scenario is a good starting point for the development of the appropriate remedial option for reducing groundwater and surface water contamination at the Anvil Range Mine Complex.

As with all risk assessments, the collection of additional data always helps to improve the assessment. As the primary objective of the risk assessment was to compare the relative risks to fish, animals and humans for a range of remediation scenarios, the database for the site was considered to be sufficient. However, in the future, it would be helpful to collect additional information from the site to reduce some assumptions used in the assessment. For example, it would be most useful to survey the local community to determine the extent of current usage of the site, potential future usage of the site following remediation and the dietary characteristics of the First Nation people who hunt, gather and trap at the site.

TABLE 1
SUMMARY TABLE OF RISK ASSESSMENT FINDINGS

Scenario	Potential Effects on Fish Around the Anvil Mine Site				Potential Effects on Waterfowl and Small Furbearers at the Anvil Mine Complex		Potential Effects on Bear, Fox and Wolf		Potential Effects on Humans					
	Rose Creek	Vangorda Creek	Anvil Creek	Pelly River	Rose Creek	Vangorda Creek	Faro Mine Site	Vangorda Mine Site	Faro Mine Site			Vangorda Mine Site		
									Toddler	Child	Adult	Toddler	Child	Adult
Existing														
"No Intervention" - Future 1	cadmium copper zinc	cadmium copper manganese zinc	cadmium copper zinc	copper zinc	cadmium copper zinc	cadmium copper manganese zinc		zinc						
"No Intervention" -Future 3	cadmium copper manganese lead zinc	cadmium copper manganese lead zinc	cadmium copper manganese zinc	copper zinc	cadmium copper manganese zinc	cadmium copper manganese zinc	cadmium copper zinc	copper zinc	zinc	zinc				
Remediation - Future 2	copper zinc		copper zinc		zinc				lead					
Remediation - Future 3	cadmium copper zinc	copper zinc	copper zinc		zinc	zinc			copper lead zinc	zinc	zinc	zinc		
Treat All Flows		copper												

LEGEND

Green (light grey) – no risk of potential health effects.
Gold (medium grey) – low risk of potential health effects.
Orange (dark grey) – high risk of potential health effects.