SECTION 3 • ENVIRONMENTAL BASELINE STUDIES

3.1 ENVIRONMENTAL BASELINE STUDIES

Environmental baseline studies have been conducted in the project region since 1996 when exploration began. Scientific and traditional knowledge has been collected on all aspects of the environment, as shown by area in Table 3.1. For more details on the work completed to date, see Table 3.2 on the following page.

Table 3.1: Meadowbank Baseline Environmental Programs

Environmental Studies	1996	1997	1998	1999	2000	2001	2002	2003	2004
Wildlife	√	√	√	√	√	√	√	√	√
Aquatic	√	√	√	√			√	√	√
Water quality	√	√	√	√			√	√	√
Fisheries	√	√	√	√			√	√	√
Archaeology	√	√	√	√			√	√	√
Vegetation			√	√			√	√	√
Water balance		√	√	√	√	√	√	√	√
Acid base accounting		√	√	√	√	√	√	√	√
Traditional knowledge	√	√	√	√	√	√	√	√	
Socioeconomic		√						√	√
Public consultation	√	√	√	√	√	√	√	√	√

3.2 VALUED ECOSYSTEM COMPONENTS

VECs (valued ecosystem components) are defined as: "those environmental attributes or components identified as a result of an ecological and social scoping exercise, which were determined on the basis of perceived public concerns related to social, cultural, economic and aesthetic values. They also reflect scientific concerns of the professional community as expressed through social scoping procedures (i.e., hearings, questionnaires, interviews, workshops, media reports, etc.), and through technical studies." For the Meadowbank project, VECs (see list below) were primarily in identified in consultation with regulatory and governmental authorities, as well as through discussions with members of the local community. Each VEC is of ecological importance, and is intimately connected with one or more of the other components:

- ungulates (caribou and muskoxen)
- fish habitat
- fish populations
- air quality
- water quality
- surface water quantity and distribution
- small mammals
- predatory mammals (wolf, wolverine, fox, grizzly bear)
- raptors
- waterfowl
- other birds
- marine mammals
- permafrost
- vegetation cover: sedge communities, heath tundra, ridge complexes (including eskers), riparian birch and willow groves, boulder fields and rocky outcrops (including cliffs)

Table 3.2: Summary of Work Carried Out to Date

Year	Summary
1996	- Preliminary aquatic baseline study - Wildlife logs - Public consultation/traditional knowledge study
1997	- Aquatic baseline studies for water and sediment quality, lower trophic level populations, and fisheries - Wildlife logs - Public consultation - Traditional knowledge study - Installation of meteorological monitoring station
1998	- Reconnaissance survey for hydrology studies - Aquatic baseline studies for water and sediment quality, lower trophic level populations and fish populations - Identification of fisheries reference lakes - Review of existing wildlife literature - Reconnaissance survey for waste characterization studies - Wildlife logs - Public consultation - Traditional knowledge study - Meteorological monitoring station
1999	- Aquatic studies for lower trophic level populations and fisheries including population and distribution studies. - Vegetation baseline study for identification of flora and plant communities - Wildlife baseline studies to inventory species and wildlife habitat - Continuing water quality assessment and baseline climate descriptions - Geochemical studies to assess acid rock drainage and metal leaching - Baseline archaeological investigations to identify traditional use areas and sites - Wildlife logs - Public consultation/traditional knowledge - Meteorological monitoring station - Snow survey
2000	- Wildlife logs - Public consultation/traditional knowledge - Meteorological monitoring station
2001	- Wildlife logs - Public consultation/traditional knowledge - Meteorological monitoring station
2002	- Aquatic studies for lower trophic level populations and fisheries including population and distribution studies. - Vegetation baseline study to identify flora, plant communities and soil types - Wildlife baseline studies to inventory species and wildlife habitat - Participation in the grizzly bear traditional knowledge study for the HTO of Baker Lake - Ongoing baseline water quality assessment and baseline climate descriptions - Hydrologic monitoring - Lake bathymetry - Geochemical studies to assess acid rock drainage and metal leaching potential, and solubility - Wildlife logs - Public consultation/traditional knowledge - Meteorological monitoring station

3.3 DESCRIPTION OF THE ENVIRONMENT

The Meadowbank project is located in the tundra region of the central sub-Arctic (the Barrenlands) at the lower end of the Northern Arctic Ecozone, and within the Wager Bay Plateau Ecoregion. The project is on the watershed divide between streams flowing into the Arctic Ocean (Chantry Inlet) and those flowing to Hudson Bay via Chesterfield Inlet.

The general site area consists of low, rolling hills with numerous lakes, some of which are quite large (e.g., Tehek Lake and Third Portage Lake). The topography in the immediate vicinity of the project area is generally flat, with relief on the order of 10 to 12 m near the main deposit areas, and as high as 60 m locally. Elevations vary from approximately 133 meters above sea level (masl) along the lake shorelines to about 200 masl. Much of the limited topographic relief in the area can be attributed to typical land features of glaciated and permafrost terrain. Eskers are also present on the landscape, although none of significance occurs within approximately 15 km of the project area.

3.3.1 Geology & Geomorphology

3.3.1.1 Regional & Local Geology

The Meadowbank project is located within rocks of the Archean aged Woodburn Lake Group of the western Churchill Province, which is subdivided into the Rae and Hearne subprovinces.

The Woodburn Lake Group comprises a deformed sequence of Archean supracrustal rocks in the Rae Subprovince. Rocks of the Woodburn Lake Group have been correlated with units of the Prince Albert Group to the northeast due (Committee Bay area) to similarities in lithologies and ages. In the south, the Snowbird Tectonic Zone divides the Archean Rae and Hearne subprovinces, but the relationship of the Woodburn Lake Group to the Snowbird tectonic zone and the greenstone belts of the Hearne subprovince is uncertain. Units of the Woodburn Lake Group are unconformably overlain by rocks of the Paleoproterozoic Baker Lake Basin.

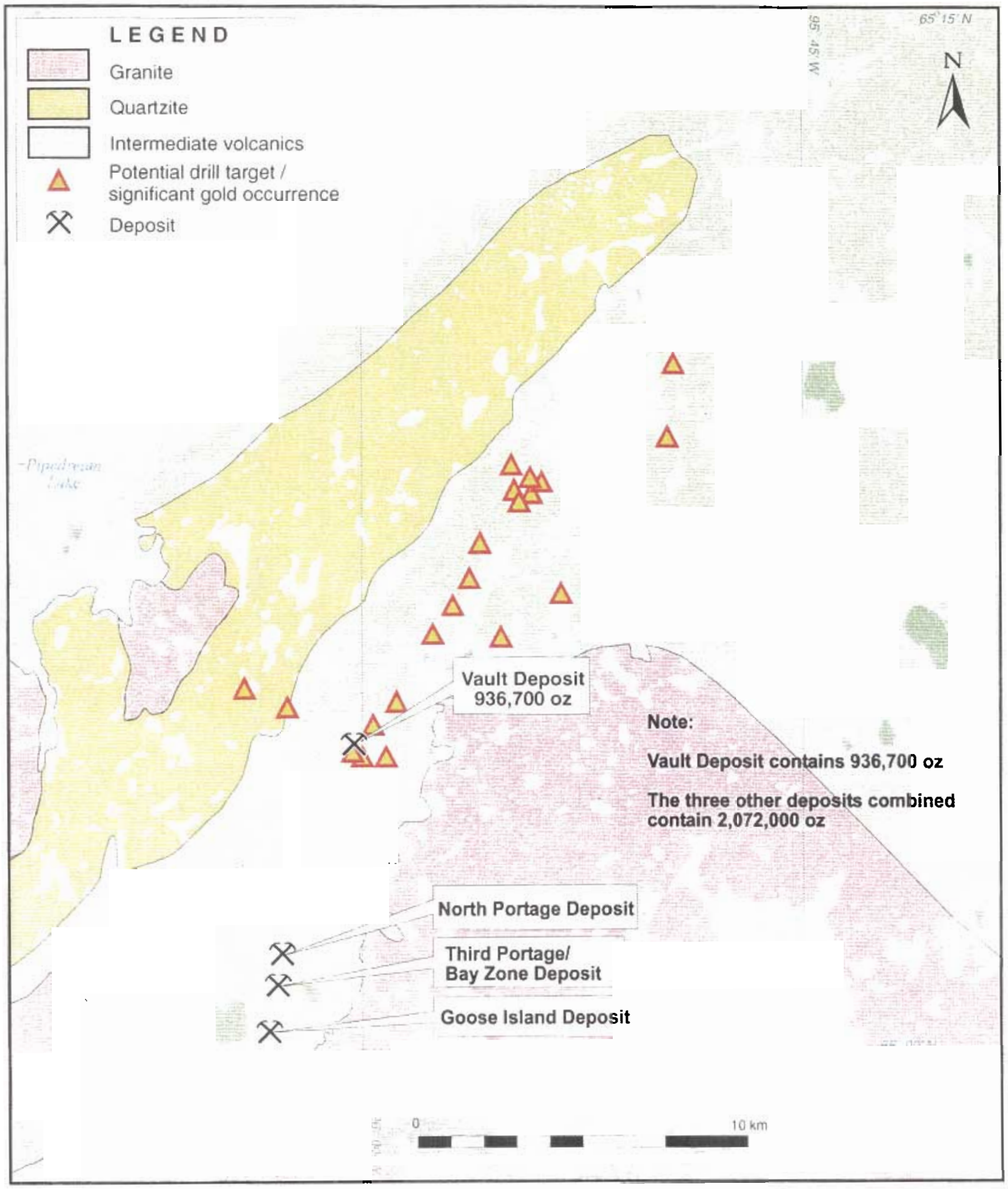
The regional geology of the Meadowbank project area is shown in Figure 3.1.

3.3.1.2 Mineralization

Gold mineralization in the deposits is intimately associated with low levels of sulphide mineralization, dominantly pyrrhotite and pyrite. In the main deposit area, near Third Portage Lake, which hosts the Bay Zone, Third Portage, North Portage, and Goose Island deposits, these sulphides dominantly occur as a replacement of magnetite in the oxide iron formations. They also occur as fracture fill ±silica and disseminations in both the iron formation and surrounding volcaniclastic units. The bulk of the gold mineralization in these deposits is contained within the iron formations, with mineralization occurring in the clastic units representing remobilization and secondary enrichment by gold-bearing fluids. The gold tends to be concentrated along the lower limb and in the hinge areas of a recumbant fold, and shows excellent continuity both along strike and down dip through the deposits.

In the Vault deposit, pyrite is the dominant sulphide mineral, and gold mineralization tends to be concentrated in the volcaniclastic unit. The gold mineralization in the Vault deposit shows excellent continuity both down dip and along strike, and remains open at depth and along strike for further expansion. The Meadowbank deposits are typified by trace levels to absence an of arsenopyrite or base metal sulphides.

Figure 3.1: Regional Geology of the Meadowbank Project Area



3.3.1.3 Surface Geology

Laterally extensive deposits of glacial till, a product of the Laurentide ice sheet, cover the central project area. Trenching, diamond drilling, and overburden drill data suggest an average thickness of 2.75 m with local deposits in excess of 10 m. Regionally, Meadowbank lies approximately 20 to 70 km northwest of the Keewatin ice divide as defined by Geological Survey of Canada (GSC) quaternary mapping. Although proximity to the ice divide might suggest complex glacial history, ice direction indicators recorded by the GSC are consistent, in the 300° to 330° range. Glacial striations measured by Cumberland geologists at Meadowbank are uniformly 345°.

The Meadowbank project is located in the transition zone between hummocky moraine and ribbed moraine, which is related to the Keewatin ice divide. Elevated moraines contain concentrations of boulders with intervening boulder-free terrain. Till is generally unsorted, medium-brown silty, sandy, and stoney, with 20% to 40% clasts of volcanics, sediments, and lesser granite. Clasts range from granule to bolder size with a high proportion in the granule to pebble range.

Marine deposits such as raised beaches and sand plain veneers are not recognized locally. Glaciofluvial sand and gravel were observed in three areas: on the north shore of Second Portage Lake, the north shore of the eastern arm of Tern Lake, and immediately south of the Vault deposit. The nearest large eskers are more than 20 km to the north of the project site.

3.3.1.4 Soils

Soil development is extremely poor due the short growing season, cold temperatures, and duration of snow cover. Generally, dominant soils in the region include urbic and static cryosols that have developed on discontinuous, thin, sandy moraine and alluvial deposits. Further soil characterization and terrain analyses will be carried out in the 2003 field program, the results of which will be included in the EIS.

3.3.1.5 Permafrost

The project is located within the permafrost zone, and approximately 90% to100% of the land area is expected to be underlain by continuous permafrost. The ground ice content is expected to be low, between 0% and 10%, based on regional scale compilation data.

Locally the land surface is underlain by continuous permafrost, except under bodies of water that are too deep to freeze entirely. Thermal studies at site have included installing 11 thermistors to characterize and monitor thermal conditions and permafrost. The thermistors have been located to characterize the thermal regime inland (away from the influence of deep lakes), as well as adjacent to lakes. Based on the thermal studies carried out to date, the depth of permafrost is estimated to be 400 to 500 m. This is based on data collected from the two thermistors installed on the Third Portage peninsula. The depth of the active zone is estimated to be between 2 and 4 m, although this will vary based on proximity to lakes, overburden thickness, vegetation, snow cover, climate conditions, and slope direction.

Taliks occur beneath lakes in the region at an estimated depth of one-quarter to one-half the width of the lake. Because of low ambient air and ground temperatures, this ratio may be closer to one-quarter. For example, a lake in the project area that is 1 km wide may have a talik that is 250 m deep.

3.3.1.6 Further Studies

Information from ongoing soil and terrain characterization will assist in final mine planning and design, and provide a base for developing the Ecological Land Classification (ELC) for the study area. Results will be provided in the EIS.

Additional studies related to permafrost will include regional thermal and groundwater modeling, evaluation of frost susceptibility and thaw stability of soil types, the development of slope gradient plans, and the evaluation of soil ice content based on reverse circulation drilling. Additional thermistors will be installed, including one that will be installed in a borehole located more than 500 m from shore of the nearest large lake in the project area. This thermistor will provide additional information relating to the thermal conditions of the permafrost and the influence of deep lake bodies.

3.3.2 Climate

Climatic data have been collected at the Meadowbank project site since 1997. The nearest meteorological station is in Baker Lake, located approximately 70 km to the south of the Meadowbank area. Data at Baker Lake have been collected since 1949.

3.3.2.1 Precipitation

The total annual observed precipitation for Baker Lake and the Meadowbank project is shown on Table 3.3. Most of the regional annual precipitation falls in the form of rain between June and September, although snow may occur in any month of the year. Precipitation between October and May falls as snow. Snow surveys were completed in 1999 and will be carried out again in 2003.

Table 3.3: Meadowbank vs. Baker Lake Rainfall Amounts (June to September)

Year	Baker Lake Rainfall (mm)	Meadowbank Site Rainfall (mm)
1998	218.7	177.1
1999	217.8	190.2
2000	121.9	100.5
2001	130.9	84.1
2002	195.6	146.7

3.3.2.2 Temperature

Long, cold winters characterize the climate of the region, with temperatures ranging from 5°C to -40°C from October through May. Light to moderate snowfall is accompanied by variable winds up to 70 km/h, which create large, deep drifts and occasional whiteout conditions. Summers are short and cool, with temperatures ranging from -5°C to 25°C, and isolated rainfall increasing through

September. Monthly mean values for air temperature, soil temperature, net radiation, relative humidity and wind speed for the 1997-2002 period at Meadowbank project site are summarized in Table 3.4. The coldest temperatures typically occur in January and February; the warmest temperatures in July and August. Daily mean air and soil temperatures for the same period are presented in Figure 3.2.

Mean wind speed is consistent throughout the year, although the highest wind speeds generally occur in the fall. Prevailing winds are out of the northwest (~37%), from where the strongest winds also originate. A daily wind rose for the Meadowbank station is presented in Figure 3.3.

Table 3.4: Mean Monthly Climate Data Summary (1997-2002)

	Air Temperature								Wind Speed	
	Extreme Day		Average							
Month	Max (°C)	Min (°C)	Min (°C)	Max (°C)	Mean (°C)	Mean Soil Temp. (°C)	Mean Net Radiation (kW/m²/day)	Mean Humidity (%)	Mean (km/h)	Monthly Max (km/h)
January	-4.9	-43.0	-28.9	-35.6	-32.3	-25.4	-19.6	71.1	15.6	54.5
February	-9.1	-43.4	-26.9	-34.4	-30.8	-27.6	-21.9	72.1	15.4	45.2
March	-3.1	-40.1	-21.0	-29.1	-24.9	-23.6	-11.2	76.5	16.8	51.8
April	2.1	-35.4	-12.5	-22.1	-17.1	-17.5	-4.3	81.3	16.9	40.1
May	8.0	-22.3	-2.5	-9.4	-5.7	-8.0	21.6	87.9	18.9	56.6
June	22.7	-12.9	8.1	0.2	4.1	1.6	95.8	81.3	16.2	37.6
July	26.9	1.3	17.0	7.6	12.4	11.0	98.4	70.8	14.9	44.2
August	27.4	-0.4	13.4	6.6	9.9	9.5	50.8	80.6	18.2	46.7
September	20.5	-7.9	6.1	1.4	3.6	4.0	16.5	86.4	18.2	81.9
October	5.3	-24.1	-4.9	-10.4	-7.5	-3.2	-9.5	90.0	21.6	62.5
November	-1.3	-32.3	-14.3	-20.9	-17.5	-12.1	-17.8	86.3	16.9	46.1
December	-6.3	-39.6	-22.6	-29.0	-25.9	-19.4	-18.5	78.0	18.4	47.3

Figure 3.2: Daily Mean Air & Soil Temperature (1997 - 2002)

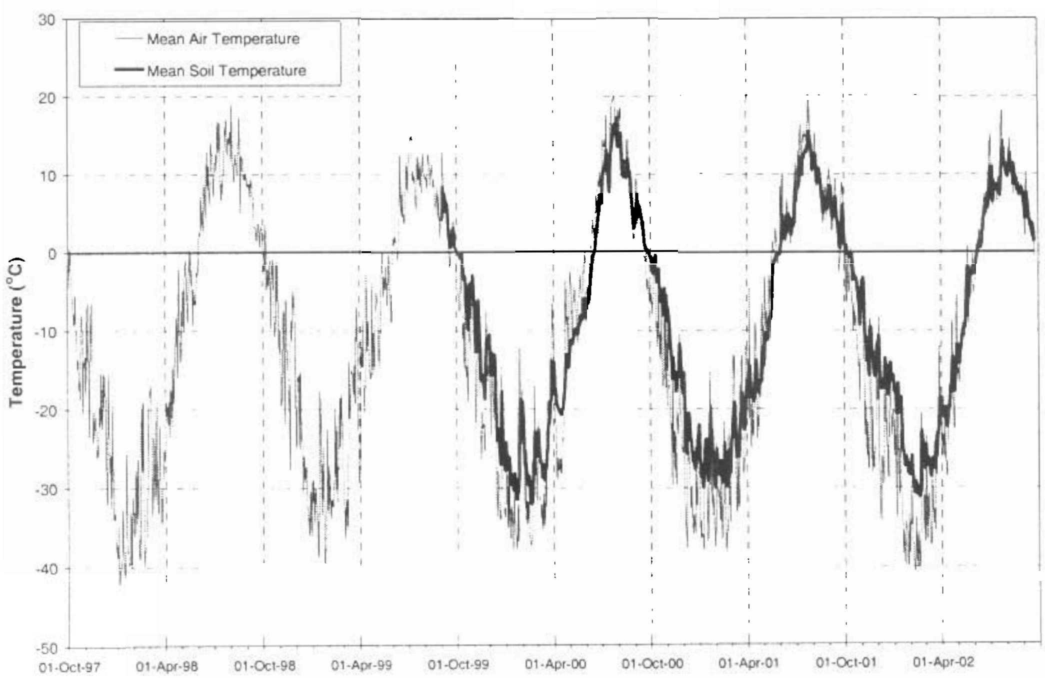
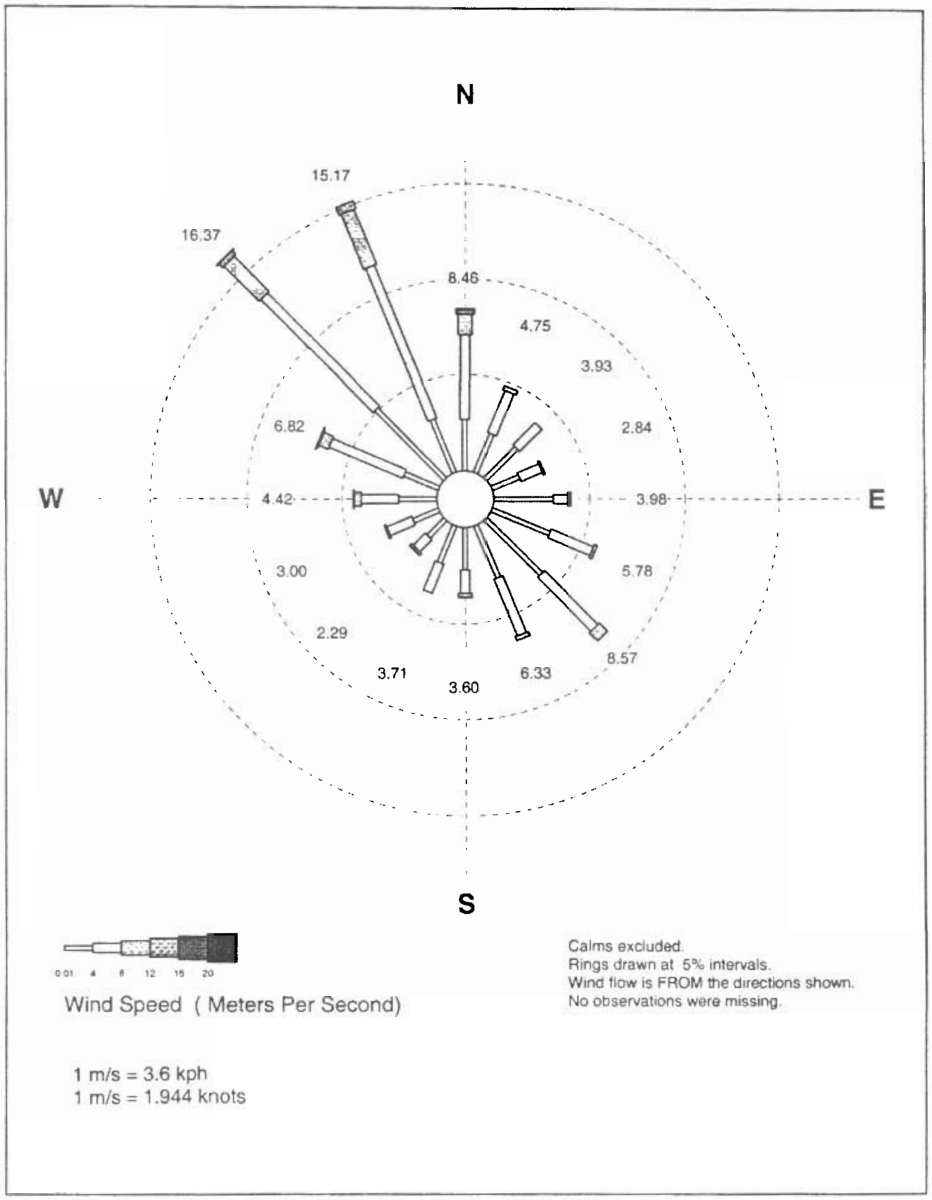


Figure 3.3: Daily Wind Rose – Meadowbank Camp Station (1997 – 2002)



3.3.2.3 Evaporation

Due to ice cover in other months, evaporation occurs during the four-month period from June to September (14 June to 22 September in 2002). Total pan evaporation for the 2002 season was 283.2 mm with the largest monthly evaporation occurring in July, when 123.4 mm or 44% of the annual total occurred.

Lake evaporation is estimated from the evaporation pan data using the method adopted by Environment Canada (Kohler et al, 1955), which takes into account pan water temperature, air temperature, daily wind run (i.e., wind speed x duration), and pan evaporation. Based on an average pan coefficient of 0.82 for the 2002 period, total lake evaporation was estimated at 232.2 mm.

3.3.3 Air Quality & Noise

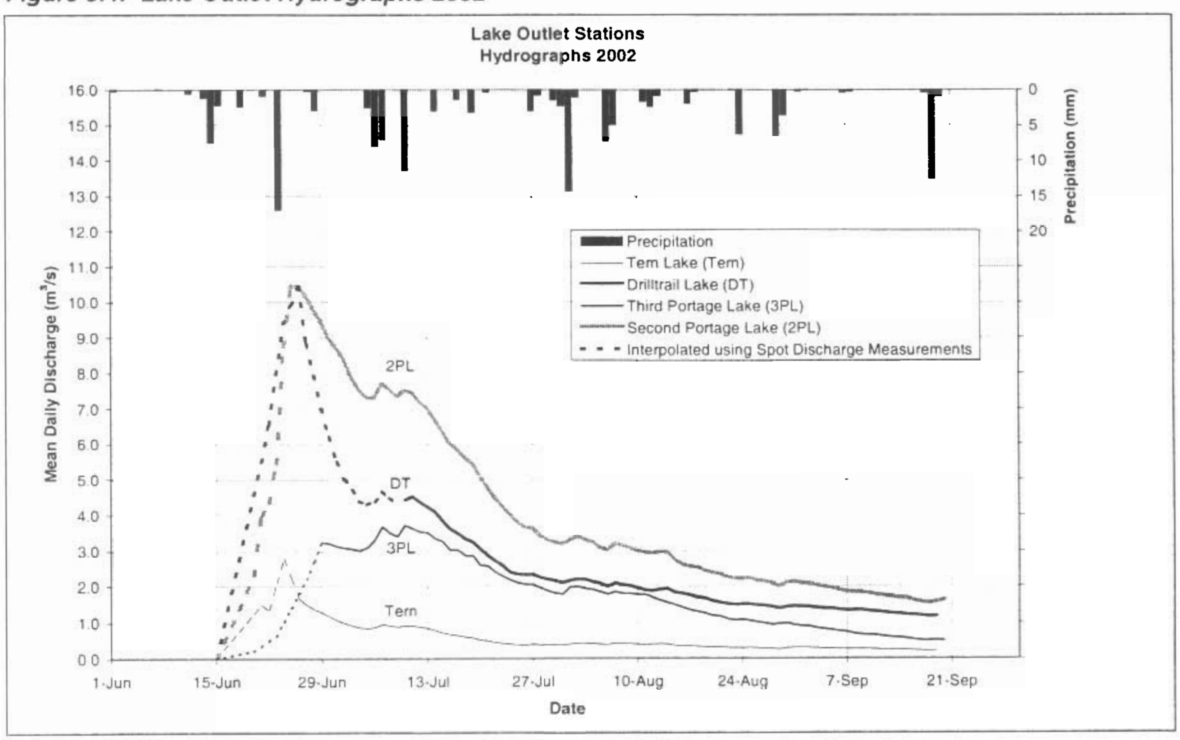
Studies to monitor air quality and noise conditions at the Meadowbank project are scheduled as part of the air and noise monitoring program for mine construction and operation. Baseline data will be collected from the existing database on air and noise quality in the Arctic.

3.3.4 Hydrology

Site hydrometric data were gathered from the meteorological weather station (operational since 1997) as well as through monitoring of lake levels and lake outlet discharges at four locations: Third Portage Lake outlet (one station, three outlet channels), Tern Lake outlet, Drilltrail Lake outlet, Second Portage Lake outlet.

Tern Lake drains southeast into Drilltrail Lake, which drains into Second Portage Lake. Third Portage Lake drains north into Second Portage Lake across a narrow strip of land dividing the two lakes via three distinct outflow channels: a western channel, a centre channel, and an eastern channel (see Figure 3.4). Water level and discharge monitoring were carried out using automated hydrometric monitoring equipment selected, procured, and installed by the Water Survey of Canada, Yellowknife.

Figure 3.4: Lake Outlet Hydrographs 2002



3.3.4.1 Water Quality

Water quality and limnology studies began in 1996 and continue to 2003. All of the lakes in the Meadowbank project area are ultra-oligotrophic (i.e., clear and nutrient-poor) with the following characteristics:

- soft water
- isothermal
- well-mixed throughout the open water season with high oxygen concentration
- neutral pH
- very low turbidity or suspended solids concentrations.

Vertical temperature and oxygen profiles measured from each station in each lake during both seasons showed very little difference between surface and bottom water, with ephemeral or non-existent stratification. Oxygen concentrations ranged between 10.3 and 13.7 mg/ℓ, depending on water temperature, and were nearly always completely saturated.

Water temperature was lowest in July (4.3°C) in the large basins of Third Portage Lake shortly after ice break up. Water temperature increased throughout July, reaching 8°C. By mid- to late-August, the maximum water temperature observed was 12°C. Some minor stratification (2°C to 3°C) was observed after two or three calm, windless days, although this was quickly dispersed during the first wind event.

Conventional Parameters

Conventional water quality parameters in each of the study lakes and reference areas—for example, Third Portage Lake south basin (internal reference) and Inuggugayualik Lake (external reference)—were very similar among lakes typical of oligotrophic Arctic lakes. There were no meaningful differences in any parameter related to season.

Results from 2002 also closely resembled results from 1997 and 1998 (see Table 2 in Appendix B). Total and dissolved solids in surface waters were very low, typically below laboratory detection (<1 and <10 mg/ℓ, respectively), as was turbidity (<1.1 NTU). Hardness (6.6 to 12 mg/ℓ) and dissolved anions were also very low and near detection limits. The pH of surface waters was circum-neutral (6.6 to 7.7). Conductivity was lowest in Third Portage Lake (8 to 9 μS/cm) and Inuggugayualik Lake (5.3 μS/cm) and was higher elsewhere in the study lakes: Second Portage (38 μS/cm), Tehek (43 μS/cm), Tern (33 μS/cm), and Vault (53 to 77 μS/cm).

Nutrient concentrations (nitrogen, carbon, phosphorus) in the study lakes were very low (Appendix B) and did not differ appreciably within or between lakes. Most were below laboratory detection limits and did not differ between seasons. Nearly all of the nitrogen nutrients (nitrate, nitrite, ammonia, dissolved phosphate) were very low, seldom exceeding 0.001 mg/ℓ. Dissolved phosphate ranged from <0.001 to 0.003 mg/ℓ, and dissolved organic carbon ranged from 1.9 to 2.2 mg/ℓ over all lakes and seasons in 2002.

Metals

Total and dissolved metals concentrations measured from surface waters from multiple stations in all lakes in spring/summer and summer/fall showed remarkable similarity. Values for 2002 were also very similar to 1997 and 1998 monitoring results (Golder, 1998/1999). Concentrations of virtually all metals from all stations were below laboratory detection limits and well below CCME (2001) water quality guidelines for the protection of aquatic life. At only three stations, two in Vault Lake and one in Tehek Lake, did lead marginally exceed the guideline concentration of 0.001 mg/ℓ. Cadmium also exceeded the guideline value (0.0023 mg/ℓ) at two stations in Vault 1 and Vault 3 lakes.

Dissolved metals concentrations comprised the vast majority of total concentrations where results exceeded detection limits, suggesting that nearly all metals are dissolved and not associated with particulates. This trend is supported by the empirical data on total suspended solids and turbidity.

Water was also measured for cyanide speciation (total cyanide, cyanate, thiocyanate, and WAD cyanide) in spring and summer. All cyanide species concentrations were below laboratory detection limits, which is in keeping with 1997 test results (Golder, 1998). For this reason, no further sampling for cyanide speciation was conducted.

All of the conventional water quality parameters, metals concentrations, and limnological data indicate that water quality of the study and reference lakes is very high, as would be expected given the remote location and absence of anthropogenic activities. In addition, because the study lakes are situated in the uppermost reaches of the Quioch River system, they do not receive inputs from upstream lakes or streams that might carry suspended and dissolved solids and/or nutrients into the study lakes. Therefore, all inputs are restricted to the immediate vicinity of the lakes within very small watersheds. This helps to explain why the lakes are so oligotrophic, nutrient-poor, and relatively unproductive.

Regional Hydrometric Data

Hydrographs for the four drainages show some response to summer rainfall events, but the rise is typically very limited compared to the snowmelt peak in June and July. The hydrograph for Third Portage Lake is an exception, as it shows a significant rise in response to early July rainfalls; the general shape of the hydrograph also differs from that of the other three stations, likely due to the high proportion of lake area in the Third Portage watershed, from which there is no outflow or discharge. The initial days of the runoff hydrographs were interpolated using spot observations of water levels and discharge measurements.

The annual discharge volume for each station was obtained by computing the area under the hydrograph and adding estimates for discharges prior to and after the monitoring period of record. The runoff volumes and yields of the four basins ranged from 168 mm for Third Portage Lake to 263 mm for Drilltrail Lake. The magnitude of runoff is generally correlative with the relative percentage of lake surface area in the basins. This is consistent with the fact that a greater proportion of lake area will result in a relatively higher evaporation loss, leaving less water for runoff. Recorded runoff volumes and the estimated volumes for the post-monitoring and winter runoff periods are summarized in Table 3.5.

Table 3.5: Runoff & Basin Yield Summary (2002)

Station Name	Catchment Area (km²)	Period of Record (2002)	Est. Pre-Record Volume (dam³)	Measured Volume (dam³)	Est. Post-Record Volume (dam³)	Total Volume (dam³)	Total Volume (mm)
Third Portage Lake Outlet	88.9	25 Jun - 20 Sep	975	13,140	847	14,962	168
Tern Lake Outlet	21.4	26 Jun - 19 Sep	1,185	3,727	367	5,279	247
Drilltrail LakeOutlet	107.0	9 Jul -19 Sep	11,688	12,830	3,610	28,128	263
Second Portage Lake Outlet	210.5	25 Jun - 20 Sep	2,558	31,077	4,957	38,592	183

Note: The total volume is reported both in cubic decametres (dam^3) and in mm of depth over the catchment area. One dam^3 of runoff volume is equivalent to a yield of 1 mm of runoff depth from a catchment area of 1 km^2.

Hydrometric and climate monitoring will continue at the Meadowbank project in 2003. To allow a determination of the total precipitation input to the seasonal water balance for the study basins, snow surveys will be performed in early- to mid-May 2003 to determine the spring snowpack/snowwater equivalent. In addition, the top of ice and water levels will be surveyed for all monitored lakes prior to the start of runoff, to establish pre-season lake levels and lake storage values.

3.3.4.2 Lake Depth & Ice Cover

The Third Portage and Second Portage Lake systems are variable in depth based on the results of ground penetrating radar (GPR) bathymetric surveys. Within the area of GPR coverage, many areas of the lakes were found to be shallow enough to allow ice grounding. Deeper basins within Third Portage Lake reached depths of up to 20 to 24 m, and up to 36 m within Second Portage Lake. The Vault Lake basin is relatively shallow, with depths of only 9 m. More detailed lake depth and ice cover studies will be investigated in spring 2003 and reported in the EIS.

3.3.4.3 Potential for Acid Generation

A comprehensive program to assess PAG and non-PAG mine rock (mine rock includes overburden, ore and non-ore rocks) is ongoing. To date, static testing has been completed and kinetic tests are underway. A full discussion of the results will be included in the EIS. The overall approach is as follows:

- identify all potential short- and long-term water quality issues
- design and implement a geochemical test program to evaluate the issues; modify the program on an ongoing basis as issues are shown to be more or less of a concern
- evaluate and test alternative control measures
- combine geochemical test results with facility design and water balance to calculate contaminant loading and resultant water chemistry
- evaluate alternative designs or control measures where the predicted environmental impact is not acceptable
- design the facilities to prevent or control contaminant release.

Mine Tailings Geochemical Test Programs

To characterize the water chemistry associated with mine tailings, both the geochemical nature of the tailings and the selected metallurgical process is considered over short and long time periods. In the short term, the tailings solids and pond water are evaluated with respect to:

- recycle of water within the processing circuit and tailings pond
- expulsion of pore water (process water) from the tailings solids to the pond water
- residual reagents and degradation products of reagents (e.g., cyanide and the products of the cyanide destruction)
- metal leaching, both from tailings solids, and from the products of processing and cyanide destruction.

Much of this testing is addressed as part of the metallurgical test program.

In the longer term, environmental characterization work is designed to evaluate:

- geochemical conditions in the tailings solids and in the pond supernatant
- changes over time in water quality for each
- interaction with foundation soils and construction rock
- metal leaching and possibly net acid generation within the tailings solids if the tailings are drained.

To date, the testing of tailings samples (including flotation tailings and leach residue tailings) consists of: static testing including whole rock analysis of solids, elemental analyses, and acid base accounting; mineralogy; water chemistry on tailings supernatant or final tailings/each residue filtrate; and kinetic testing (in progress). This testing has shown that a cyanide destruction process can effectively remove cyanide and precipitate metals from solution.

Kinetic testing is in progress to assess tailings solids geochemistry on individual samples from each ore type and tailings stream. As metallurgical optimization proceeds, calculations based on the process flowsheet, milling rates, and ore schedule will be used to quantify overall acid generation potential. Flotation prior to leaching will concentrate the sulphide minerals into a small fraction of the ore, leaving the bulk of the tailings with a low potential to generate acidic drainage. The flotation concentrate is then leached with cyanide and treated by cyanide destruction, producing a “leach residue” fraction. The smaller leach residue fraction of some ores may have a net potential to generate acid.

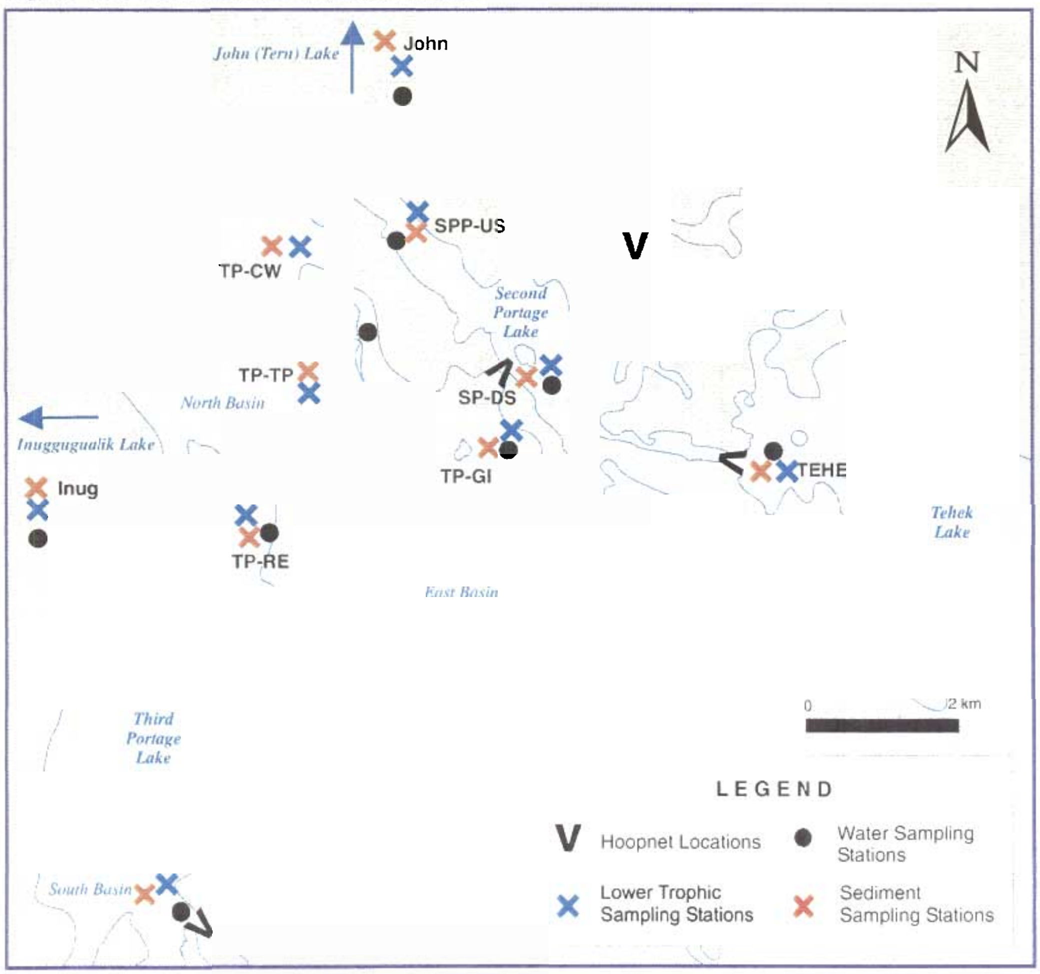
The tailings from each circuit will be recombined, either for further leaching or for disposal into the tailings impoundment. The overall potential for acid generation from the tailings will depend on the proportions of the leach residue fraction to the tailings fraction. Amenability work is in progress to evaluate alternatives and alternate disposal techniques to take advantage of the alkalinity contained within the bulk of the tailings mass and limit any potential for net acid generation. The existing plan for aqueous tailings storage prevents air from accessing the tailings and prevents the acid generating process with tailings.

3.3.5 Fisheries & Aquatic Resources

Traditionally, fish has been the secondary food source for Baker Lake residents after caribou meat. Key fish species in the Meadowbank project region include lake trout, Arctic char, lake whitefish, and lake cisco. Fishing or "jigging" is a year-round activity that is pursued more vigorously in spring and early winter. A study for DIAND completed in 1978 by Interdisciplinary Systems Ltd (ISL) found that lake trout accounted for approximately half of the domestic harvest, totalling 65,000 kg from the lakes around and north of Baker Lake. According to the Elders of Baker Lake, the area around the mine was not used for fishing, although some fishing did take place several kilometres to the south.

Second and Third Portage lakes, Tehek Lake, and Tern Lake have been the subject of limnological, biophysical, and fisheries studies since 1996 (see Figure 3.5). Studies have been conducted in each of these lakes to assess seasonal and inter-annual trends in water and sediment quality, lower trophic level (i.e., phytoplankton, zooplankton, benthos), community structure and abundance, and fisheries.

Figure 3.5: Location of Sampling Stations



In addition, regional studies were conducted to examine the physical, chemical, and biological features of several lakes on a broader geographic scale. The information presented below is a summary of more than six years of baseline work on the study lakes and the regional environment.

3.3.5.1 Limnology

The study lakes are situated in the headwaters of the Quioch River system, which flows to Hudson Bay. All of the lakes in the study area share common limnological features that are typical of Arctic lakes in this region. The open water season is relatively short with spring ice break up occurring in June. As air temperatures rise, surface water temperatures increase to create small, weak surface water layers (i.e., thermoclines). The thermoclines are frequently broken down by strong winds causing the warm, surface water to mix with cold, bottom water, resulting in uniform temperature and oxygen profiles from top to bottom that gradually warm throughout the summer, reaching a maximum temperature of about 16°C. As air temperatures cool, water temperatures in the lake decline in much the same way as they increased. By late September, ice begins to form around the margins of lakes, with complete freeze-up usually in October. During winter, water temperatures are uniformly cold from top to bottom with a maximum temperature of about 2°C near the bottom. Oxygen levels remain high throughout the winter, even beneath 2 m of ice.

Due to the low relief, there are no large streams flowing into or out of the study area lakes; instead, each has a very small watershed. Combined with the low precipitation in the area, this means that water replacement in each of the lakes occurs quite slowly.

Water quality in all of the lakes is excellent with very low dissolved metals and suspended solids concentrations. The water is exceptionally clear with low conductivity, hardness, and alkalinity. The study lakes are also very nutrient-poor and classified as ultra-oligotrophic, with low concentrations of the nutrients nitrogen, carbon, and phosphorus (see Section 3.3.4.1 and Appendix B for more water quality details). For this reason, fish productivity in all of the study lakes is correspondingly low and similar to other lakes in the region.

3.3.5.2 Fish

Six species of fish have been identified within the study lakes, as listed in Table 3.6 below.

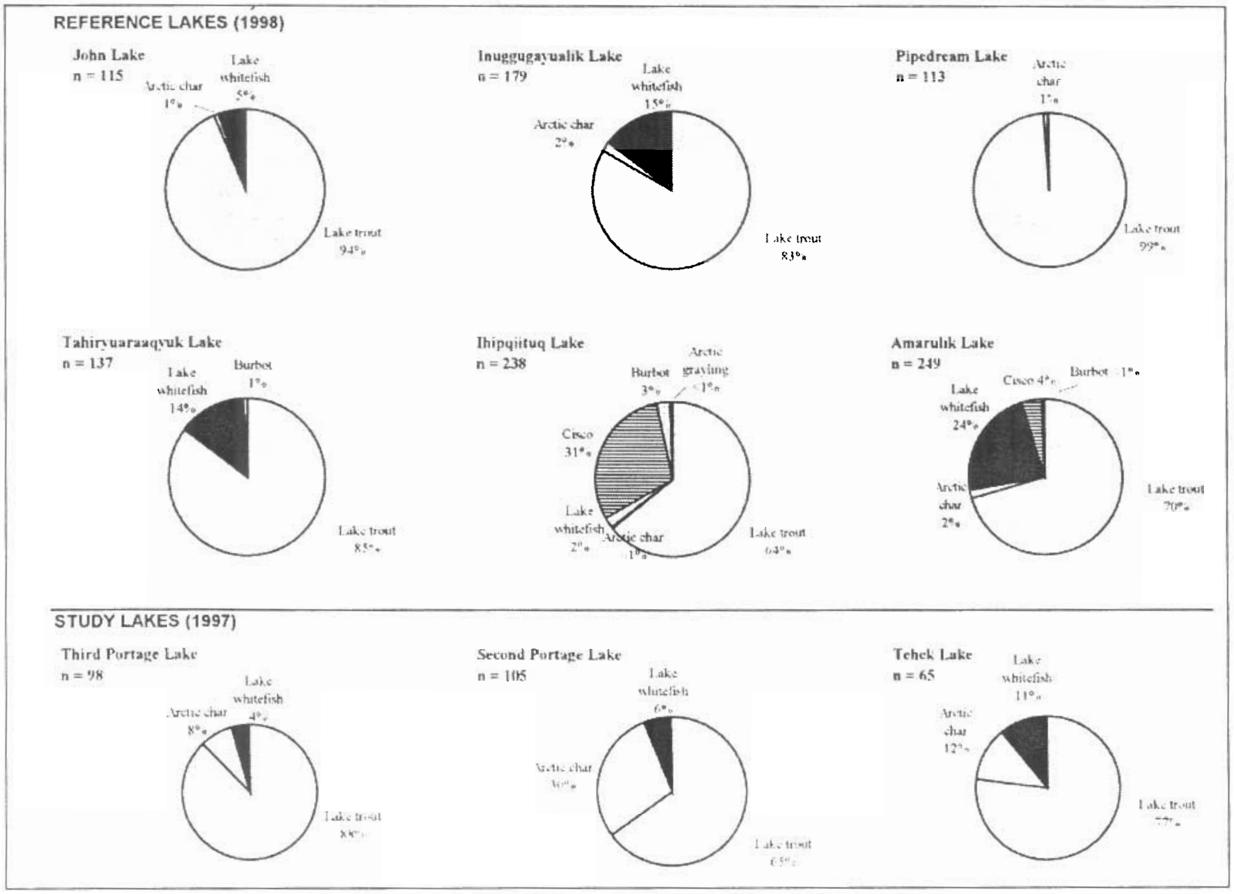
Table 3.6: Fish Species in the Project Area

Common Name	Scientific Name	Status	Conservation Status[1]
Arctic Char	*Salvelinus alpinus*	Anadromous/resident	Sensitive
Burbot	*Lota lota*	Uncommon resident	Secure
Lake Trout	*Salvelinus namaycush*	Common resident	Secure
Lake Whitefish	*Coregonus clupeaformis*	Uncommon resident	Secure
Ninespine Stickleback	*Pungitius pungitius*	Uncommon resident	Secure
Sculpin sp. (likely Slimy)	*Cottus sp* (ssp. *cognatus?*)	Uncommon resident	Undetermined

The conservation status is obtained from the CESCC (2001). "Secure" = species that are not at risk or sensitive; "sensitive" = species that are not at risk of extinction or extirpation but may require special attention or protection to prevent them from becoming at risk; undetermined = insufficient data, information, or knowledge is available with which to reliably evaluate the status of a species.

Three species dominate the fish populations in each of the study lakes, namely lake trout (75%), Arctic char (15%) and lake whitefish (10%) (see Figure 3.6). Small numbers of burbot were also captured. Ninespine stickleback and sculpin have been found in the stomachs of fish. The species composition, relative abundance, size, and age distribution of fish in the study lakes are very similar to that of fish in other lakes in the region. In regional lakes south of the Meadowbank area, small numbers of lake cisco (*Coregonus artedii*; considered 'secure' by CESCC 2001) and Arctic grayling (*Thymallus arcticus*; considered 'sensitive') were also captured, although neither of these species is present in the study lakes.

Figure 3.6: Abundance of Fish Species Captured in Gill Nets



The lake trout in Second and Third Portage lakes are large and long-lived, with a mean size and age of nearly 2 kg and 16 years, respectively. The condition factor of each species is also quite high, indicating that the overall health of the fish is excellent. Metals concentrations in muscle tissue were relatively low and did not differ among lakes. Mean mercury concentration in lake trout muscle ranged from 0.32 ppm in Third Portage Lake to 0.55 ppm in Second Portage Lake.

Arctic char captured in Second and Third Portage lakes are anadromous, migrating from Chesterfield Inlet via the Quioch River. Abundance of char in Second Portage Lake was greater than in Third Portage Lake. The stream connection between Second and Third Portage lakes is small and ephemeral, with fish passage possible only during early spring. Access into Third Portage Lake for Artic char is therefore limited. Metals and mercury concentrations in Arctic char in both lakes were very low.

Domestic use of fish appears to be low in the Tehek Lake area (ISL, 1978). In the study, few people that were interviewed indicated the area around Tehek Lake was used for fishing. Some use of the area by hunters and trappers can be expected.

3.3.6 Zooplankton

Zooplankton are small, weakly swimming planktonic crustaceans that are an important part of the food chain and the main dietary component of juvenile lake trout, and juvenile and adult lake whitefish. They consist of Cladocera, such as *Daphnia* sp., and calanoid and cyclopoid copepods. A similar zooplankton species composition and relative abundance is found in lakes in the Meadowbank area and documented in lakes elsewhere in Nunavut and the Northwest Territories (e.g., in the Lac de Gras region and Ekati mine area). Species diversity is very low, consisting of only seven or eight species of copepods, which is typical for Arctic lakes.

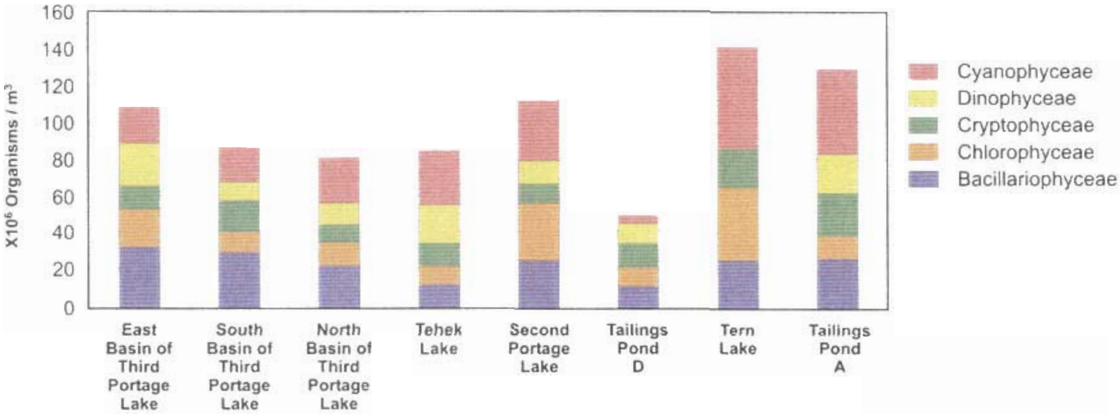
Zooplankton comprised the majority of food items in stomachs of lake whitefish in the study area. Another group of zooplankton called Nototstracaa or tadpole shrimp were common in zooplankton samples and stomachs of whitefish in regional lakes outside of the study area.

3.3.7 Phytoplankton & Chlorophyll a

Phytoplanktons are microscopic plants suspended in the water column of aquatic ecosystems, especially lakes that form the base of the food chain and ultimate nutrient source for all aquatic animals. Phytoplanktons are regarded as primary producers and are grazed by zooplankton. Changes in species composition and abundance of phytoplankton have been monitored at different times throughout the open water season in each of the study and reference lakes, as shown in Figure 3.7. Species diversity was very similar among lakes during spring/summer and during fall, ranging from 28 to 40 species. Biomass of phytoplankton was dominated by chrysophytes (golden brown algae), followed by diatoms. There were differences in seasonal biomass among lakes during spring/summer, but not during fall. Shallower, warmer lakes tended to have greater abundance of phytoplankton than colder, deeper lakes. However, there is typically great natural variability in phytoplankton abundance and biomass from lake to lake and between seasons, so generalizations are difficult to make.

Since *Chlorophyll a* is a pigment found in phytoplankton, the concentration of chlorophyll found in water has been used as a rough measure of plankton biomass in surface water. In the study lakes, chlorophyll a was low and ranged from 0.3 to 0.9 mg/m^3, suggesting that biomass of phytoplankton was relatively low, which is expected in these oligotrophic Arctic lakes.

Figure 3.7: Phytoplankton Species Community Composition of Water Samples Collected From Lakes in the Meadowbank Study Area (1997)



3.3.8 Benthic Invertebrates

Benthic invertebrates are small organisms that live in or on the surface of bottom sediments of lakes and streams and are very important components of the food web, providing food for juvenile lake trout and Arctic char, as well as for juvenile and adult lake whitefish. The majority of benthic invertebrates consist of the aquatic larval stage of insects, especially chironomids. Chironomid larvae typically comprise at least 50% of species diversity and biomass of all benthic invertebrate taxa. Other groups such as bivalve clams, oligochaete worms, leeches, mites, and other insects such as mayflies and caddisflies comprise a smaller portion of the benthic community. A thorough understanding of the health of the benthic community is important because many contaminants ultimately end up in sediments. Changes in the benthic community structure therefore provide an early warning system for potential changes in fish health.

Chironomids are the most important group of benthic invertebrate organisms in all of the study lakes in terms of species diversity and abundance. There are differences in terms of relative abundance and seasonal differences that help to explain differences in abundance of fish between lakes. There can be considerable heterogeneity in abundance of organisms in samples simply because of natural heterogeneity in community abundance within lakes. Benthic community data collected since 1997 provide several years of baseline information that is being used to assess the effects of mine development.

3.3.9 Lake Habitat

Habitat within the study lakes is very typical of lakes elsewhere in the region and in the Kivalliq region in general. Lake area as a percentage of the surrounding landscape is very high, and there is an abundance of available habitat for fish and waterfowl in the study region.

Lake shorelines are typically bedrock controlled, with very coarse substrate (rock, boulder, cobble) surrounding the lakes and extending for several metres in depth into the lakes. There are no exposed permafrost soils on any of the lakes. Numerous rocky shoals scattered throughout the lakes, and

Third Portage Lake in particular, provide spawning habitat for lake trout. Coarse shoreline substrate provides stability from ice scouring and also provides abundant spawning, rearing, and feeding habitat for juvenile lake trout, Arctic char, and lake whitefish. A large part of the surface area of the study lakes consists of deep water between 10 and 35 m in depth, which provides excellent overwintering habitat.

With all of the lakes having abundant spawning, rearing, and overwintering habitat, habitat availability is not considered limiting for fish in any way. Although the fish populations are healthy and reasonably abundant, they are slow growing and cannibalistic, and the productive capacity of the lakes is limited by the small amount of available nutrients for plankton in water and sediment.

3.3.10 Stream Habitat

There is a paucity of stream habitat in the study lakes and Meadowbank region in general. Because the study lakes are situated in the headwaters of the Quioch River system, they receive only local inflow from a relatively small area. The lakes are in close proximity to one another and are connected by small stream channels that are often no more than 10 or 20 m in length. Given the small drainage area of each lake relative to its size, the magnitude of stream flow tends to be highly seasonal, with the greatest flow occurring in spring (i.e., June), diminishing flows occurring throughout the summer, and little to no flow in winter.

The lack of stream flow indicates that stream habitat is quite limited in the area and does not provide habitat for fish, except as migratory corridors between lakes. The stream that connects Third Portage and Second Portage lakes is small and ephemeral, with fish passage possible only during spring. The lack of stream habitat explains the absence of Arctic grayling and the reduced population of Arctic char in the study area.

3.3.11 Further Studies

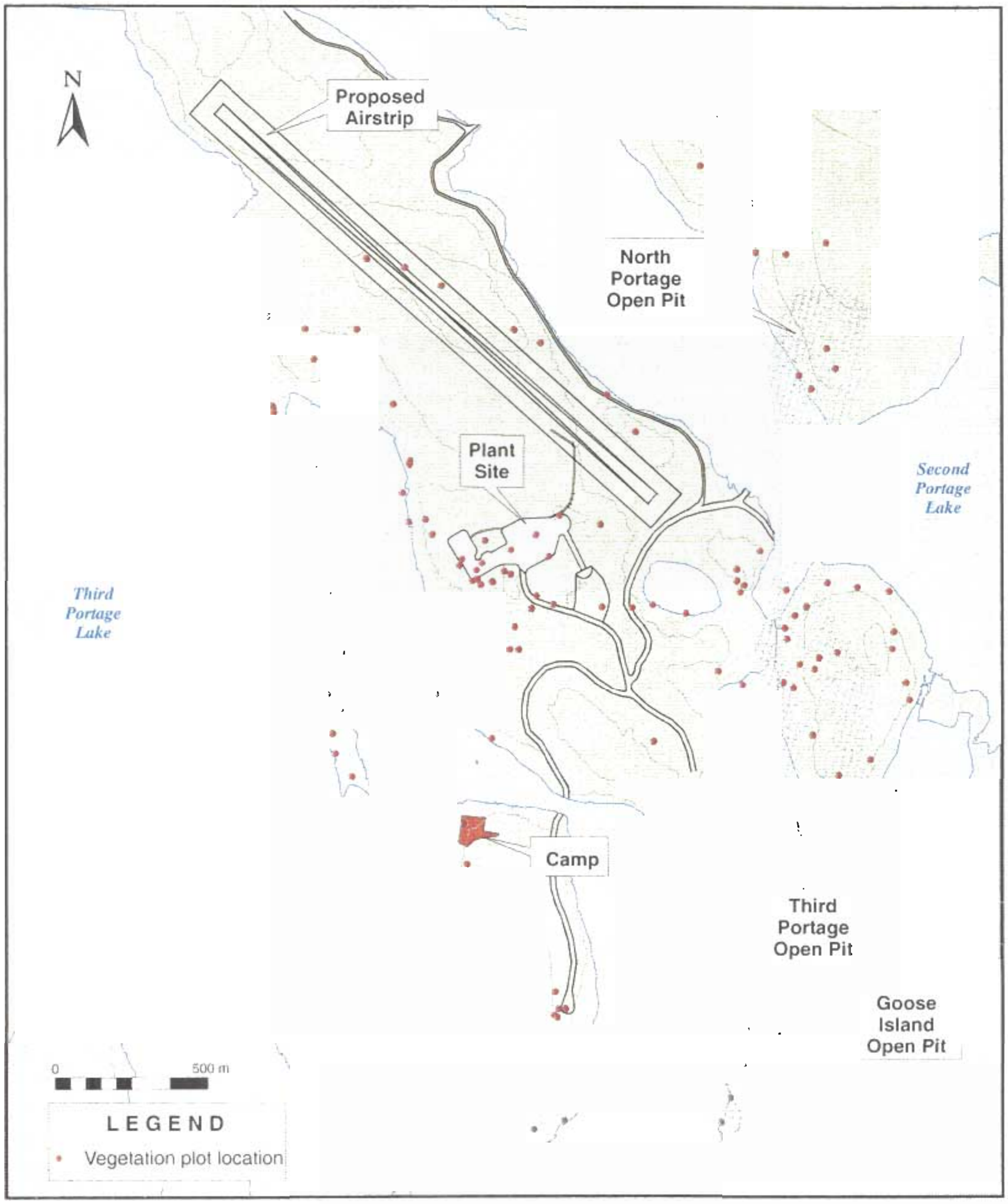
Proposed field studies for 2003 will address the remaining data gaps. Studies will include: winter water chemistry, fish habitat assessment and mapping, stream fish movement/migration, and lake sedimentation. The results will be included in the EIS.

3.4 VEGETATION

The Meadowbank study area lies at the lower end of the Northern Arctic Ecozone and is characterized by a continuous vegetation cover interspersed with bedrock outcroppings and continuously aggrading surfaces. Vegetative cover is composed of lichens, various moss species, ericaceous shrub and heath species, and a variety of herbs, grasses, and sedges.

In the summers of 1999 and 2002, baseline vegetation studies were conducted to inventory the flora and plant communities in the project area (see Figure 3.8). The objectives were to investigate, document, and map the plant communities of the site, and to determine whether rare or endangered

Figure 3.8: Meadowbank Project Vegetation Baseline Studies, Plot Locations with Existing & Proposed Project Facilities



plant species were present. Several studies have been conducted in the Kivalliq Region (related to caribou research, academic plant studies, natural gas pipeline considerations, geological surveys, and mineral exploration) that have contributed to the general knowledge of plants in this region and provided a basis for vegetation descriptions and associations.

Two aerial surveys and approximately 175 vegetation plots were completed during the 1999 and 2002 field assessments. Field surveys were conducted within a 5 km radius area around the camp, at the Vault deposit, and along a proposed road corridor between the Vault and the main mine site. The areas selected for baseline studies included all main deposits, both camps, and the proposed plant site, road, airstrip, tailings ponds, and dike areas.

The aerial survey found few anomalous sites, one riparian area, and several small sandy deposits bearing plant communities typical of esker crest communities. Square vegetation plots, 5 x 5 m in size, established randomly in the highest impact areas of the deposit and potential mine site, facilitated the description of site flora and plant communities. In 2002, five phenology plots (for observing plant development both seasonally and annually) were established near north camp in the following communities: sedge, heath tundra, birch seep, lichen rock, and snowbank. Since work in both field seasons was done in August, no meaningful phenology data could be recorded.

The vegetation at the mine site is typical of upland tundra. No obvious sensitive or endangered plant species or communities are at risk.

3.4.1.1 Plant Communities

The eight natural plant communities identified on the Meadowbank property include the following: sedge, moss, heath tundra, birch seep, riparian birch shrub, snowbank, avens, and lichen rock. Several associations characteristic of disturbed sites also occur.

Sedge Communities

Dominant vegetation in sedge communities includes *Carex* sedges and Arctic cotton or cottongrass (*Eriophorum* sp.). Sedge communities are located in depressions or drainage basins, and sometimes in shallow lake edges or at the edges of ponds. Small willows (*Salix arctica*, *S. glauca* ssp. *callicarpaea*, and *S. tyrrellii*) are often found in the sedge communities, especially where the ground is not flooded.

The sedge community can be divided into three associations, each slightly different: the emergent association at the edges of lakes or ponds; the non-tussock association in the centre or deepest part of drainage basins; and the tussock association, which occupies the sides of a drainage basin. As the delineations between these associations are not clear, all sedge associations are mapped together.

Sedge communities are important to caribou, especially lactating cows, which feed selectively on the emerging leaves immediately after calving, seeking out even small sedge basins in the upland tundra. Sedge associations are also important to small mammals such as voles and lemmings, providing year-round nutrients in the form of green shoots at the bases of the sedge plants.

Moss Communities

Plant communities with a high percentage of sphagnum mosses occur sporadically within the study area. These tend to occupy shoreline areas where the ground is fairly level, where solifluction reaches local base levels and tends to pile up mounds of vegetation in wet areas. Moss communities are also found at the bases of cliffs, including those that face the northwestern prevailing winds, although these are uncommon due to the lack of cliffs.

Heath Tundra Communities

The heath tundra is the climax community on the uplands in the Meadowbank area. It consists of a complex web of vegetation, dominated by woody plants in the *Ericaceae* or heath family. As the moisture in the soil or exposure to wind varies, so does the vegetation. In addition, different substrates support different types of heath tundra associations. There are five "heath" species that are found throughout the area. In most communities these include: blueberry, lingonberry, white Arctic heather, Labrador tea, bearberry, and the closely related crowberry (family *Empetraceae, Empetrum nigrum*).

Heath tundra in all its variations covers thousands of hectares across the mainland Arctic. It covers most uplands and gentle slopes, drapes like a net over flat areas and low ridges covered with glacial erratic boulders, and forms mats on top of boulder fields and felsenmeer. It can be broken down into several relatively similar associations.

The heath associations provide important foraging and nesting habitat for small tundra birds like redpolls, lapland longspurs, horned larks, savannah sparrows, and in rocky areas, snow buntings. The abundant berries and buds provide forage for ptarmigan, gulls, foxes, ground squirrels, and even grizzlies.

Birch Seep Communities

In areas where seepage occurs through the active layer, with an outflow of water at the base of a slight slope, low "forests" of dwarf birch often develop. From the air, these appear as darker areas on the land. *Betula nana* is a water-loving species, and dense growths develop where the water source is more reliable than on the upland heath tundra, yet not so abundant as to support a sedge community (Thompson, 1980).

The type of plant species growing under the birches depends on the amount of water in the soil. Sometimes the understory is composed of heaths such as mountain cranberry, blueberry, and white Arctic heather, bearberry and crowberry, and occasionally large-flowered wintergreen (*Pyrola grandiflora*). Small willows also occur and lichens are usually sparse. In the larger birch seeps, where the birches form a dense canopy that excludes sunlight, there is often little or no understory or ground cover, just birch leaf litter on the ground.

Birch seeps are important as nesting habitat for some species of small passerine birds, especially those that prefer to nest above ground rather than in the tundra itself (e.g., hoary and common redpolls and white-crowned sparrow).

Riparian Birch Shrub Communities

The term "riparian" refers to stream habitat. In the Meadowbank area, there are few well-defined streams because the area is relatively level and located on the "divide" between a northward drainage via the Meadowbank River to the Back River system, and a southeastward drainage via the Quioch River to Chesterfield Inlet. The birch riparian association occurs in the drainages between lakes, invariably on a boulder substrate, although plants may be rooted in perched material on the boulders. True "soil" is at a minimum. These drainage systems usually have a relatively constant flow of water, and often occur between lakes, especially where there is a gradient of more than 1% to 2%.

In the Meadowbank study area, riparian communities are usually characterized by the presence of upright dwarf birches (*Betula nana*), as opposed to prostrate specimens. Vegetation is low with small birches to about 30 cm in height often forming an unbroken cover. Because of the boulder substrate, the ground may have little other vegetation except where there are old tundra mats bridging the boulders. These associations are often moist, and grasses and sedges sometimes grow profusely, especially at the edges where there is more sunlight. Like birch seeps, the riparian shrub habitat is important for small birds, providing nest sites for redpolls, and some of the sparrows.

Snowbank Communities

Snowbank communities occur on the leeward sides of hills, outcrops, eskers, or banks of stream valleys. They can develop in places where wind deposits deep drifts over many consecutive winters, and usually occur in areas where the snow lies on the ground until early to mid-July. Because the prevailing winds usually come from the northwest in the Meadowbank area, these communities usually (but not always) occur on east, southeast, or south-facing slopes.

In the Meadowbank area, these communities usually have a mixture of three "indicator" species: least willow (*Salix herbacea*), Labrador tea, and Arctic heather. Where the bank is steep and the drifts very large, mountain heather (*Phyllodoce coerulea*), few-flowered anemone (*Anemone parviflora*), some of the mustards (*Draba glabella, D. lactea*), *Carex scirpoidea*, mountain sorrel (*Oxyria digyna*), pygmy buttercup (*Ranunculus pygmaeus*), and fleabane *(Erigeron humilis),* occur. Snowbank communities are easily recognized in August, as their showier inhabitants are the only ones left blooming so late in the season.

Avens Communities

The avens community is similar to the heath tundra community, but occurs in drier areas, usually on ridgetops, and often in thin soil over bedrock. A high percentage of mountain avens (*Dryas integrifolia*; 20% to 85%) distinguishes it from heath tundra. The avens community is not common in the Meadowbank study area and covers only limited areas; it is more common to the west.

Mountain avens is the dominant species in this community, but is often accompanied by other species, such as the heaths (including lingonberry, blueberry, black bearberry, Labrador tea, and sometimes Lapland rosebay), and a mixture of other species including dwarf birch, several willows, grasses and sedges. Thrift (*Armeria maritima*) was found only in this community during this study.

Lichen Rock Communities

Crustose lichen associations occur on rocks throughout the barrenlands, and foliose and fruticose lichen associations occur between the rocks in boulder fields or felsenmeer (shattered bedrock). These associations vary according to the exposure of the rock to winds, the amount of moisture available, and the chemical composition of the rock. Lichen rock communities are best described based on the physical components of their rock substrates.

Disturbed Sites

Disturbed sites develop their own plant communities, which are often quite different from those on the surrounding undisturbed land. Disturbances have several causes, which can be simplified into two main categories: those resulting from the addition of nutrients, and those resulting from the wearing away of the vegetation or removal of plant cover and soil.

Types of disturbances include those resulting from animal activity (e.g., den sites, bear diggings, caribou trails) and human activity (e.g., camps, roads, mining sites, grey-water outflow from camps, etc.). Most of these are small and cannot be mapped, except as points.

3.4.1.2 Rare & Endangered Flora & Plant Associations

The potential occurrence of rare plants and rare plant associations was a primary focus of the field investigations. Three major publications are available on rare plants in the north: "Rare Vascular Plants in the Northwest Territories" (McJannet et al, 1995), "Rare Vascular Plants in the Canadian Arctic" (McJannet et al, 1993), and "Vascular Plants of Restricted Range in the Continental Northwest Territories, Canada" (Cody, 1979). These sources, as well as information posted on the COSEWIC web site, were used.

No plant species or associations identified as "rare" in the above resources were found in the Meadowbank study area. One species of willow, *Salix tyrrellii*, was previously listed on the COSEWIC list, but as a result of work on the Meliadine Gold project has now been delisted, as it is far more common than originally thought. *Salix tyrrellii* occurred commonly throughout the Meadowbank study area.

3.4.1.3 Further Studies

Additional vegetation plots may be conducted as part of an ecosystem land classification (ELC) program. Ecosystem mapping is being conducted, which will allow project effects on vegetation communities and wildlife to be modelled.

Phenology plot studies will be conducted if they are deemed necessary for wildlife assessment. Studying the development of individual plants throughout the growing season over a period of years can assist in understanding the use of an area by wildlife, as the availability of leaves, seeds, and flowers may influence local foraging activity. Phenology plots would be surveyed using protocols adapted from the International Tundra Experiment (ITEX) manual.

3.4.2 Wildlife

Caribou has traditionally been the primary food source for Inuit in this region and continues to be a main food source for the people of Baker Lake. The caribou are one of the community's primary concerns. ISL found that the Meadowbank site is in a low usage area for caribou hunting due to low abundance and distance from Baker Lake; hunting usage increases with proximity to Baker Lake. In addition to caribou, foxes, wolves, bears, and wolverines are taken irregularly. Ptarmigan is sometimes hunted in the fall, but no other bird species is hunted with any regularity. This study found no large aggregations of waterfowl between Baker and Tehek Lakes. The study area is of low usage for fox trapping.

Results of regional and local studies based on traditional and scientific knowledge are shown on Figures 3.9, 3.10, 3.11, on which the main routes of the spring and fall migrations and calving grounds are outlined. In all cases, the Meadowbank project is a long distance from any vital caribou areas or protected wildlife area (ISL, 1978).

3.4.2.1 General Wildlife Habitats

Aerial and ground surveys for wildlife were conducted in the spring of 1999 and summer and fall of 2002. The purpose of the surveys was to establish baseline conditions, diversity, relative abundance, and distribution of wildlife species within two designated study areas: local study area (LSA; set at ~5 km radius around proposed development area for initial surveys), and regional study area (RSA; ~50 km radius). Data collected during both aerial and ground surveys included the number of individuals, sign type (e.g., visual, den, pellet, scat, wash), sex, age class, and behaviour (e.g., bedded, flying, feeding). Additional information was obtained from camp wildlife logs and from the Baker Lake Hunters' and Trappers' Organization (HTO) and various Elders.

The Meadowbank project is situated in the lower end of the Northern Arctic Ecozone within the Wager Bay Plateau Ecoregion. Heath tundra and boulder field complexes characterize this area. Climate, hydrology, landform, and vegetation are important environmental elements for wildlife. Due to the characteristics of the Arctic climate, most wildlife (e.g., caribou, waterfowl, songbirds) in this region display migratory behaviour. Grizzly bear and Arctic ground squirrel (aka SikSik) adapt by estivating or hibernating. Voles and lemmings take on subnivean behaviour while species such as wolves, wolverine, Arctic fox, and snowy owl remain above ground throughout the winter. Vegetation surveys and habitat classifications have been conducted in the Meadowbank area, and ecosystem mapping will be conducted in 2003. Natural plant community types identified within the Meadowbank area (see Section 3.4.1.1) include sedge, moss, heath tundra, birch seep, riparian birch shrub, snowbank, avens, and lichen rock.

3.4.2.2 Land Mammals

Ten mammal species were recorded in the Meadowbank study area during the 1999 and 2002 spring, summer, and fall field surveys (see Table 3.7). Five other mammal species that are expected to occur but not observed include barren-ground shrew (*Sorex ugyunak*), brown lemming (*Lemmus sibiricus*), collared lemming (*Dicrostonyx torquatus*), meadow vole (*Microtus pennsylvanicus*) and red fox (*Vulpes vulpes*).

Figure 3.9: Spring (top) and Autumn (bottom) Migration Routes of Caribou Herds

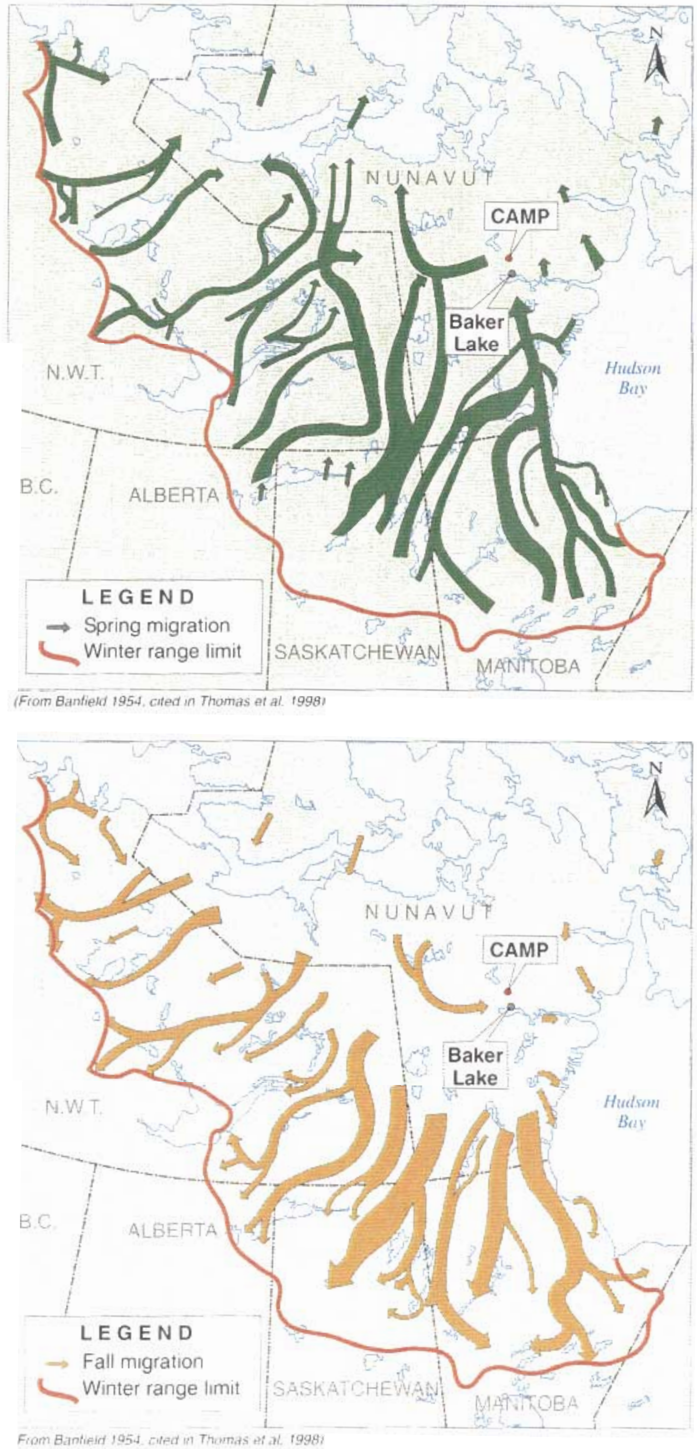
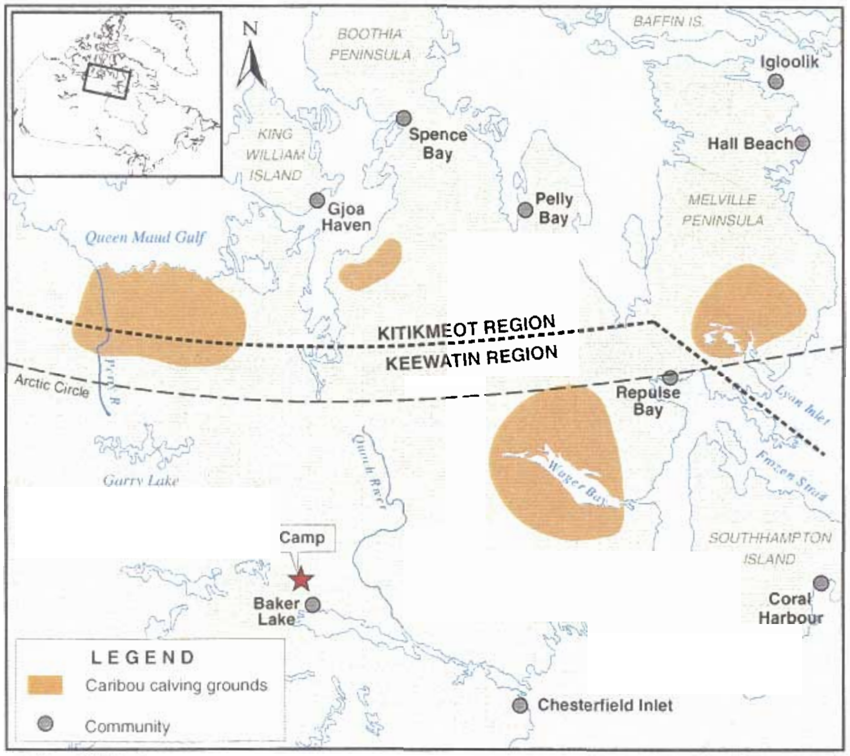


Figure 3.10: Caribou Calving Grounds on the Northeastern Mainland



(Draft from BQCMB n.d.)

Figure 3.11: Caribou Protection Areas in the Keewatin Region

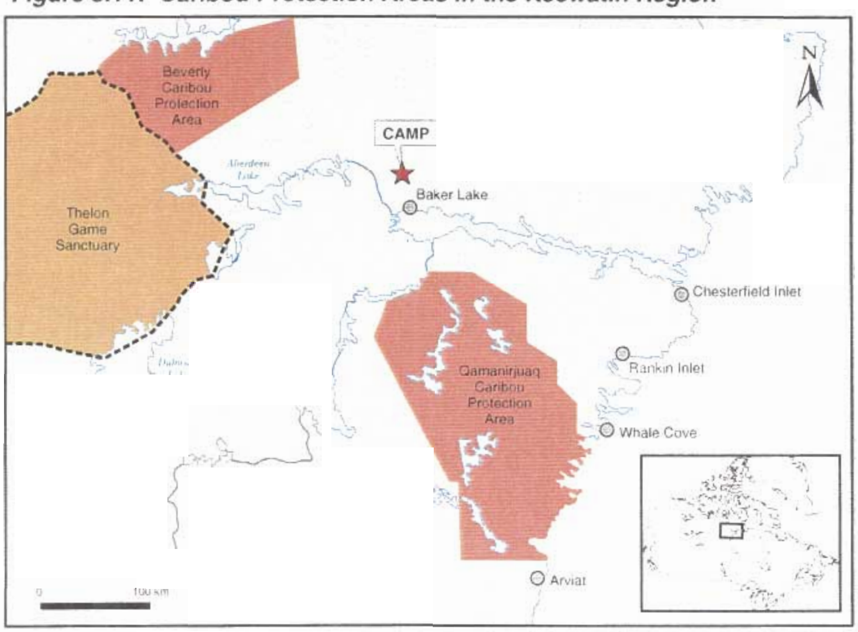


Table 3.7: Mammal Species Observed in the Project Area (1999 & 2002)

Common Name	Scientific Name	Status	Conservation Status
Arctic hare	*Lepus arcticus*	Common resident	Secure
Arctic hround squirrel	*Spermophilus parryi*	Common resident	Secure
Northern red-backed vole	*Clethrionomys rutilus*	Resident	Undetermined
Gray wolf	*Canis lupus*	Uncommon resident	Sensitive
Arctic fox	*Alopex lagopus*	Uncommon resident	Secure
Grizzly bear	*Ursus arctos*	Rare resident/visitor	Sensitive
Ermine	*Mustela erminea*	Uncommon resident	Secure
Wolverine	*Gulo gulo*	Rare resident/visitor	Sensitive
Caribou	*Rangifer tarandus*	Common visitor	Sensitive

Notes: The conservation status is derived from the CESCC (2001). "Secure" = species is not at risk or sensitive; "sensitive" = species is not at risk of extinction or extirpation but may require special attention or protection to prevent them from becoming at risk; undetermined = insufficient data, information, or knowledge is available with which to reliably evaluate the status of a species.

Caribou

Caribou are a vital component of the subsistence economy in this region. During aerial and ground surveys, caribou were detected and were present during all seasons sampled, and were most abundant in the fall. This corresponds with seasonal migration activities as caribou move from post-calving areas to winter habitat. Based on the patterns of seasonal abundance observed to date, the Meadowbank area does not appear to represent critical habitat during spring migration, calving, summer post-calving, or fall migration (see Figures 3.9 to 3.11). This is supported by the traditional studies, which indicated low usage by the community, as well as previous studies by ISL (1978).

The Meadowbank site occurs on the northern edge of post-calving and late summer ranges for the Beverly and Qamanirjuaq caribou. Based on observations in the fall of 2002 and discussions with Elders, the Meadowbank area appears to provide habitat for caribou during fall and spring movements. Winter pellet data and incidental observations during early winter (October) suggest that large numbers of caribou may spend time in the Meadowbank area during the winter, an observance that is supported by local residents who have historically seen caribou in the area. Caribou tracking from the Lorillard and Wager herds suggests the Meadowbank area may be used for wintering habitat for these two herds (M. Campbell, pers. comm.). ISL noted in the 1970s that caribou from the Kaminuriah herd were wintering north to Tehek Lake. In addition, the area may provide wintering habitat for the Queen Maud caribou herd (M. Campbell, pers. comm.). Interestingly, in early winter 2002, some of the largest caribou herds seen for some time appeared along the outskirts of Baker Lake (P. Tapatai, pers. comm., 2002).

Proposed late winter surveys and additional monitoring data from the Department of Sustainable Development's collared caribou program should provide better information on the importance of the Meadowbank area to various caribou herds.

Muskoxen

Muskoxen were regularly detected during aerial and ground surveys. Based on seasonal sampling, a small but relatively stable population of muskoxen resides north of the project site. These herds have been observed in the same general area since the spring of 1999. Herd sizes ranged from single individuals to up to 40 to 50 animals. Smaller groups have also been observed west and south of the study area. Baker Lake residents suggest that the number of muskoxen has increased since the 1960s and may be originating from the Thelon Game Reserve.

Grizzly Bear & Wolverine

COSEWIC (2002) has identified both the grizzly bear and the wolverine as species of special concern nationally. Grizzly bears (i.e., a sow with two cubs) were only seen on one occasion on the spring 1999 aerial survey within the RSA. Little other evidence of grizzly bear was recorded during the surveys. These data suggest that a small population of grizzly bear occurs in the Meadowbank RSA, as would be expected for a wide-ranging species typically existing at low densities (e.g., three individuals/1,000 km^2). An increased number of bears observed and killed in the Baker Lake area has lead to concerns by local residents that the grizzly bear population is increasing rapidly and needs to be controlled. To determine the actual status of the grizzly bear, the HTO has initiated a traditional grizzly bear study that is being co-funded by Cumberland Resources, WWF, the HTO, and the Department of Sustainable Development.

Wolverine and their sign have been detected in the study area, including one wolverine that was observed just south of the Meadowbank site. The infrequent sightings are expected given the wide-ranging habits and low densities of this species. The wolverine is an important furbearing species for the Baker Lake community, partially because the anti-icing qualities of wolverine fur make it a highly sought after trim on parkas.

The presence of both grizzly bears and wolverine in the area is considered an important indicator of an intact wilderness ecosystem. Both species are sensitive to disturbance and require special management consideration.

Wolf, Fox & Weasel

Wolves are predators whose principal prey is caribou. Muskoxen serve as a secondary food source, and small mammals and birds are hunted as necessary. Wolves were observed throughout the RSA during all sample seasons. Two young pups were observed with two adults during the fall survey suggesting that denning sites may occur within the RSA. Baker Lake residents have indicated that an increasing number of wolves have been harvested in recent years.

Arctic fox were recorded in the vicinity of the Meadowbank field camp, and within the LSA and RSA. Arctic fox are opportunistic omnivores that rely on a variety of prey including small mammals and birds. Their populations seem to be closely tied to the collared lemming, which is their principle food item (Speller, 1972; Shank, 1997). Arctic fox are attracted to human infrastructures and can cause high mortality on local prey species such as ptarmigan. Arctic foxes are important to local trappers, but are subject to low trapping pressure in the Meadowbank area (ISL, 1978).

Ermine were observed in the Meadowbank RSA during spring surveys, but are expected to be uncommon year-round residents. Ermine rely on a variety of prey species, particularly small mammals. Maintaining small mammal populations will be important to maintaining ermine numbers. This small carnivore is also an important furbearing species for local trappers.

Small Mammals

Hare pellet densities and direct observations during ground surveys indicated that Arctic hares were abundant throughout the Meadowbank LSA. Hare pellet densities at observation stations were particularly high. Hares at these sites may seek shelter behind boulders, forage on wind-swept ridges, or gain increased views of potential predators. An apparent increase in Arctic hare abundance was observed between the summer and fall of 2002 in the LSA. This may be a result of an increased population following a productive summer season, or increased visibility of white hares against a generally dark background in the fall.

Arctic ground squirrels were observed throughout the Meadowbank RSA. Burrows were concentrated in areas with sandy substrates suitable for digging, such as eskers and grassy slopes. Lemmings were not observed during the field surveys, suggesting that this species is at the low phase of its population cycle. One northern red-backed vole and one shrew (unspecified) was observed within the LSA during the fall 2002 surveys.

Small mammals, such as Arctic hares, Arctic ground squirrels (SikSiks), lemmings, and voles are important prey species for many mammals (e.g., Arctic wolf, grizzly bear, Arctic fox, ermine) and raptors (e.g., rough-legged hawk, peregrine falcon, gyrfalcon, snowy owl) in the tundra ecosystem. To maintain a healthy ecosystem, maintaining small mammal populations will be essential.

3.4.2.3 Birds

Birds occurring in the RSA are typical to those occurring in other tundra habitats of Nunavut. Wildlife surveys in 1999 and 2002 incidentally recorded a total of 27 bird species (see Table 3.8). Several other bird species will likely be observed during dedicated songbird and waterbird surveys within the Meadowbank project area in June 2003.

Loons & Waterfowl

No critical migrating waterfowl habitat is known to occur within or immediately adjacent to the Meadowbank area (ISL, 1978). Previous aerial waterfowl surveys conducted as part of the Polar Gas development suggested that the Meadowbank region did not represent significant habitat for waterfowl (Allen and Hogg, 1978). In addition, no important bird area (IBA) has been identified for this region (M. Setterington, Department of Sustainable Development, pers. comm., 2002). However, important habitats do occur in the region: Mistake River and Franklin Lake to the north, Quioch River and the eastern bay of Tehek Lake to the east, and Pitz Lake and Baker Lake lowlands to the south. The Quioch Lake area is recognized as an important habitat for moulting Canada geese (CWS, 1991).

Table 3.8: Bird Species Observed in the Project Area (1999 - 2002)

Common Name	Scientific Name	Status	Conservation Status[1]
Common Loon	*Gavia immer*	Summer resident	Secure
Yellow-Billed Loon	*Gavia adamsii*	Summer resident	Secure
Tundra Swan	*Cygnus columbianus*	Migrant	Secure
Greater White-Fronted Goose	*Anser albifrons*	Migrant	Secure
Lesser Snow Goose	*Chen caerulescens*	Migrant	Secure
Ross Goose	*Chen rossii*	Migrant	Sensitive
Brant	*Branta bernicla*	Migrant	Secure
Canada Goose	*Branta canadensis*	Summer resident	Secure
Northern Pintail	*Anas acuta*	Summer resident	Secure
Long-Tailed Duck	*Clangula hyemalis*	Summer resident	Secure
Red-Breasted Merganser	*Mergus serrator*	Summer resident	Secure
Rough-Legged Hawk	*Buteo lagopus*	Summer resident	Secure
Peregrine Falcon	*Falco peregrinus*	Summer resident	May be at risk
Gyrfalcon	*Falco rusticolus*	Year-round resident	Secure
Rock Ptarmigan	*Lagopus mutus*	Year-round resident	Sensitive
Sandhill Crane	*Grus canadensis*	Migrant	Secure
American Golden Plover	*Pluvialis squatarola*	Summer resident	Sensitive
Long-Tailed Jaeger	*Stercorarius longicaudis*	Summer resident	Secure
Herring Gull	*Larus argentatus*	Summer resident	Secure
Snowy Owl	*Nyctea scandiaca*	Year-round resident	Secure
Horned Lark	*Eremophila alpestris*	Summer resident	Sensitive
Common Raven	*Corvus corax*	Year-round resident	Secure
American Pipit	*Anthus rubescens*	Summer resident	Sensitive
Savannah Sparrow	*Passerculus sandwichensis*	Summer resident	Secure
White-Crowned Sparrow	*Zonotrichia leucophrys*	Summer resident	Sensitive
Lapland Longspur	*Calcarius lapponicus*	Summer resident	Secure
Snow Bunting	*Plectrophenax nivalis*	Summer resident	Sensitive

Note: The conservation status is from derived CESCC (2001). "May be at risk" = species may be at risk of extinction or extirpation and is a candidate for detailed risk assessment by COSEWIC; "secure" = species is not at risk or sensitive; "sensitive" = species is not at risk of extinction or extirpation but may require special attention or protection to prevent them from becoming at risk.

Relatively small flocks of Canada geese were recorded during the summer, while flocks of snow geese were recorded during the fall as they moved south through the Meadowbank area. Tundra swans and other waterfowl (e.g., northern pintail, long-tailed duck, and loons) were also recorded in low numbers during spring, summer, or fall periods. Surveys in 2003 will provide a better understanding of waterbird use within the study area.

Shorebirds

The only shorebird detected during surveys in the Meadowbank region was the American golden plover. Although wetlands exist in the area, they are relatively unproductive and likely offer limited habitat for shorebirds. Other species are possible, particularly during the migratory period. Surveys in June 2003 will better determine the distribution, diversity, and abundance of shorebirds in the Meadowbank area.

Raptors

Four raptor species were detected during aerial and ground surveys within the RSA—peregrine falcon, gyrfalcon, rough-legged hawk, and snowy owl—all of whom likely breed in the area. An active peregrine falcon nest site was identified in 1999; 2.5 km north of the Meadowbank camp, but was inactive during 2002.

Some unoccupied nests (based on sticks, whitewash) or potential nesting habitat (based on south facing cliffs) for falcons were also observed. Generally, suitable cliff nesting habitats for falcons and hawks are not widespread within the Meadowbank RSA area.

Songbirds

Breeding bird surveys have not been conducted in the Meadowbank area to date. However, at least seven songbird species were detected during wildlife surveys, suggesting that a relatively simple passerine community exists (see Table 4.6). Bird surveys in the vicinity of the Doris Hinge project (Hope Bay Joint Venture, 2002) only encountered an additional two bird species: American tree sparrow (*Spizella arborea*) and redpoll (*Carduelis* spp.). Dedicated breeding bird surveys in the Meadowbank area in June 2003 will likely result in the identification of these and possibly other songbird species.

Other Birds

Sandhill cranes were observed in greatest abundance during the summer months but appear to be widely distributed throughout the RSA. Small migratory flocks were also observed during the spring and fall seasons. Rock ptarmigan and their sign (e.g., pellets) were commonly observed within the Meadowbank area. Willow ptarmigan are expected to occur in the area but no visual observation of this species was recorded during the survey period. Ptarmigan are an important food source for carnivores and raptors when other prey species are not available.

Rare & Endangered Species

Three mammal species and one bird species known or expected to occur in the study area have been identified as "Species at Risk" by COSEWIC (2002). COSEWIC has identified both the grizzly bear and the wolverine as "Special Concern." These two species have been confirmed in the study area. The peregrine falcon has been confirmed nesting in the study area and COSEWIC has identified this species as "Threatened."

3.4.2.4 Further Studies

Wildlife monitoring and habitat mapping programs will continue in 2003. The study area will be visited on several occasions to collect information on wildlife occurrence and habitat, caribou abundance and movement, migratory birds, nesting landbirds and waterbirds, and resident small mammals.