2.7 Terrestrial Environment

2.7.1 Vegetation

A 1974 baseline environmental study completed by BC Research Inc. (BC Research, 1975a) describes the terrestrial environment in the mine area. This included (among other topics) vegetation/ground cover mapping. Approximately 96% of the mine area was classified as "dry ridge" characterized by low productivity, sparse cover and low wildlife utilization. The generally sparse and rocky ground cover was found to be interspersed with small areas of denser vegetation coverage typically in small isolated areas where moisture was retained in surface soils.

The 1974 study of vegetation in the mine area included study sites selected to be representative of the range of plant communities in the area. Quadrats measuring 0.5 x 2.0 metres were studied for elevation, aspect, percentage and types of ground cover and identification of vegetation species. The plant community in the mine area was found to be predominantly made up of the following species:

- *Salix arctica* (Arctic willow);
- *Dryas integrifolia* (Arctic or mountain avens);
- *Carex rupestris* (sedge);
- *Ploygonum viviparum* (alpine bistort);
- *Saxifraga oppositifolia* (purple saxifrage);
- *Eriphorum* (cottongrass); as well as
- mosses (several species), lichens (several species), bryophytes and other vascular plant species.

The ground surveys resulted in the definition of five classes of land areas based on vegetation density and species (Table 2.2).

Table 2.2 Ground Cover Classifications

Land Classification	Percentage of Study Area
Dry Ridge	96.5%
Alluvial	1.9%
Meadow	0.9%
Mid Slope	0.4%
Moss-Lichen	0.3%

The dry ridge ground cover dominates the mine area (96.5%). This type of ground cover was characterized by sparse vegetation consisting of only a few species such as Arctic willow, avens and purple saxifrage. The ground surface commonly showed evidence of frost heaving and rock polygons. The areas mapped as dry ridge can contain small isolated pockets of denser and more varied vegetation where finer soils or other factors are present, which allow surface moisture retention.

The alluvial ground cover was found on sloping topography and was characterized as containing approximately 34% ground cover comprised primarily of Arctic willow and avens. These areas were observed to appear "streaked" on air photos due to the linear distribution of vegetation.

The meadow ground cover was found in flat areas or surface depressions where finer soils could accumulate and retain moisture. These areas were characterized as containing the densest vegetation cover observed (average 65%) comprised primarily of vascular species but no lichens.

The mid slope ground cover was identified as drier than alluvial but not as barren as dry ridge. The mid slope areas were characterized by low density of ground cover (average 10%) with the vegetation occurring in clumps separated by bare ground. Four species of vascular plants and moss were identified in these areas.

The moss-lichen ground cover was identified only on the north slope of Mt. Fuji, west of the townsite. This area was characterized by dense coverage comprised primarily of moss. Five species of lichen and five species of vascular plants were also identified in this area.

Observations collected by JWEL during 2003 (JWEL 2003a) indicate that the terrestrial habitat present at the site is essentially unchanged since it was described by BC Research (1975a).

2.7.2 Wildlife

A quantitative evaluation of mammals in the mine area was attempted by BC Research (1975a) as part of the baseline environmental studies that were conducted in 1974. However, the mammal density was determined to be too low to allow an evaluation. Small mammal traps were set near the (future) townsite and near the airport in late July 1974 but no animals were caught. Nonetheless, signs of four mammal species were observed: lemming, Arctic fox, Arctic hare and caribou.

Lemming signs consisted of small mammal runways, straw piles (winter shelters) and droppings. These were observed in the Meadow, Moss-Lichen and Dry Ridge areas. Two Arctic fox scats were observed. Arctic hare pellets were observed in one location. Caribou were not seen in the study area but past presence was indicated by "very old" antlers located near the airport. One resident of Arctic Bay (Isaac Attagutsiak) was reported to have indicated that he had not seen caribou in the area since 1948.

Anecdotal evidence collected during mine operations indicates that Polar Bears have occasionally passed through the mine area en-route to feeding locations (in the order of once per 5-6 years). The bears did not stop in the mine area or make attempts to hunt or feed in the mine area.

Observations of bird life were also made by BC Research (1975a). Eight species of birds were observed in the mine area, including Snow Bunting, Ptarmigan, Baird's Sandpiper, Snow Goose, Eider Duck, Semipalmated Plover, Jaeger and Raven. The Borden Peninsula was reported as having been previously identified as an important breeding area for some migratory species including Ptarmigan, Baird's Sandpiper and Snow Goose.

The Snow Bunting was the most common species observed with 22 birds seen. The mine area was observed to include most of the typical types of habitat used by Snow Bunting including coastal areas, rough stony terrain and mossy areas.

Snow Geese were observed in 1973 (by mine personnel) and in 1974 (BC Research) using Kuhulu Lake and some Meadow areas. Droppings were generally observed in the Meadow areas. Seven eider ducks were observed in July 1974 on the Twin Lakes and a total of 60 were seen during aerial census flights of seabird colonies. Ptarmigan droppings were observed in two locations in the study area. One pair of Semipalmated Plovers was observed in July 1974 on an alluvial fan west of the Twin Lakes. One pair and one individual Baird's Sandpiper were observed in Meadow and Dry Ridge areas. One observation of Long-tailed Jaeger flying over Strathcona Sound was recorded in July 1974. Four ravens were seen during the 1974 terrestrial studies. Raven was the only species observed in the mine area that was classified by BC Research (1975a) as non-migratory.

2.8 Aquatic Environment

The primary surface drainage in the mine area is Twin Lakes Creek, and its tributaries, which drain the East and West Twin Lakes, Townsite and West Adit areas into Strathcona Sound. The other significant drainage pathway on the mining property is Chris Creek.

2.8.1 Twin Lakes Creek

Twin Lakes Creek originates at East Twin Lake (having been diverted to separate it from West Twin Lake), and flows a distance of approximately 7.3 km from its origin to the marine waters of Strathcona Sound. East Twin Lake is one of two lakes (the other being West Twin Lake) that contribute to the flow of water in the creek. West Twin Lake has been used for the disposal of tailings from the Nanisivik mine since operations began in 1976. The mine is presently undergoing decommissioning. Water from the tailings area, which meets federal mine effluent quality regulations, passes through a final settling pond and discharge weir before entering Twin Lakes Creek. There is no active effluent treatment system (such as precipitation with lime) at this location.

Twin Lakes Creek was described by BC Research (1975a) as being the largest watercourse in the region of the mine development. Twin Lakes Creek is naturally fishless, as are East Twin and West Twin lakes. The creek has an average gradient of 5% (BC Research 1975a), and there are several significant cascades and waterfalls along its length, which prevent access by fish.

The stream flowing out of East Twin Lake (see Photographs 1 and 2) was diverted when the mine started operations, so that flows from the tailings area and West Twin Lake could be regulated, measured and monitored at a discharge weir. The substrate and habitat in this area are generally similar to those in lower portions of the creek (i.e., the mixing zone within 600 m downstream from the point of effluent discharge). Stream substrate is dominated by small boulder and cobble-sided rocks, grading down to pebbles. Almost no fines are present, and there is no aquatic vegetation present. In steeper areas, there is much exposed bedrock and several significant waterfalls occur along the length of the creek (see Photographs 3, 4 and 5). Stream bank habitat is primarily bedrock and rubble. In low-lying areas near the head of the stream there is some grassy meadow habitat, but this is the exception, not the rule. There is no tree or shrub cover at Nanisivik, so the stream is not shaded in any way, except in areas where the stream banks are steep enough to partially shade the stream at some times of the day.

Photo 1 Stream bed substrate at site ETL, upstream from the point of mine effluent discharge.

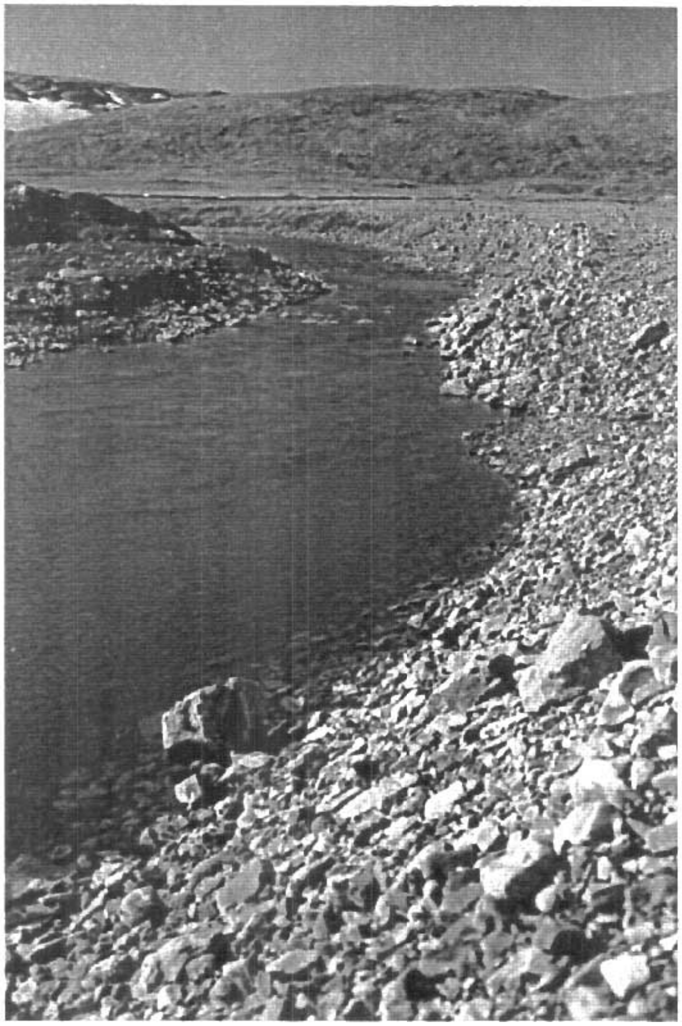

Photo 2 View upstream from site ETL, towards East Twin Lake.

Photo 3 View of a typical riffle section of Twin Lakes Creek, several hundred metres downstream from the effluent discharge weir.

Photo 4 View of a small cascade (about 1.5 m drop) about 400 m downstream from the effluent discharge weir.

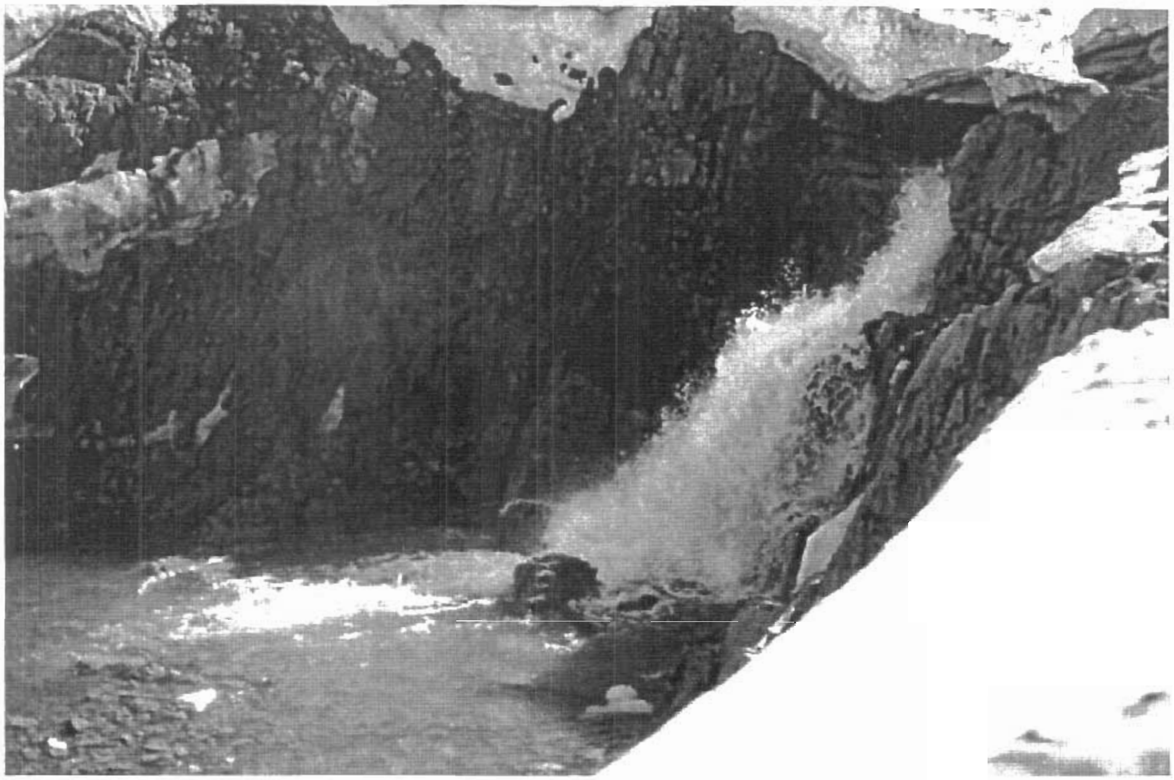

Photo 5 A 10 m waterfall located approximately 600 m downstream from the point of effluent discharge in Twin Lakes Creek.

The release of decant water (mine effluent) from West Twin Lake is manually controlled at a weir (see Photographs 6 and 7) according to the mine operating plan for maintaining water cover over tailings in the Reservoir. Discharge from East Twin Lake is natural, except to the extent that a relatively small volume of water is extracted from the lake for freshwater use in the town and the mill (prior to mine closure).

Twin Lakes Creek flows directly below the West Adit area, which includes three portals, two waste rock piles (the 02 South and 09 South waste rock dumps), the West Open Pit, exposed natural highly mineralized outcrops northeast of the Townsite (see Photograph 8), and the industrial complex (mill) site. Twin Lakes Creek enters Strathcona Sound west of the dock.

Photo 6 The effluent discharge weir from the West Twin Lakes tailings area.

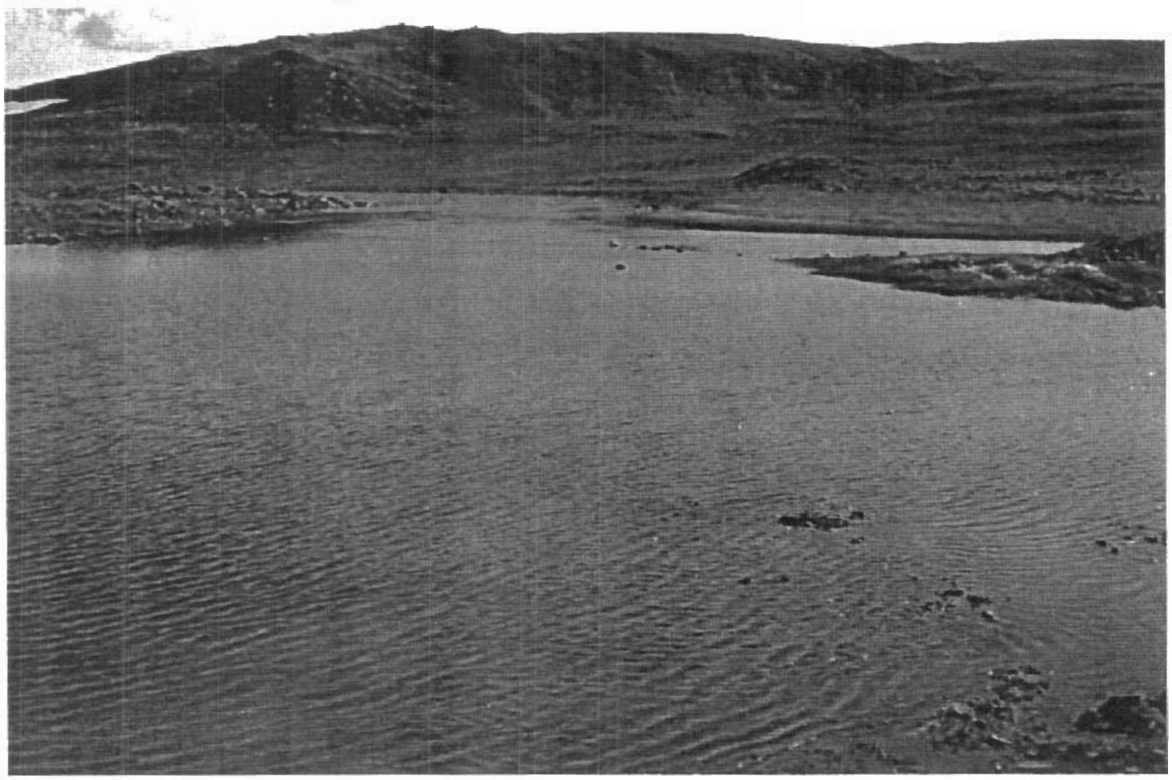

Photo 7 View downstream from the effluent discharge weir. The flow from East Twin Lake enters at the far right, and the combined flows leave directly away from the viewer, turning to the left in the distance.

Photo 8 View of Twin Lakes Creek as it passes by the natural sulfide mineral zone near the mine, about 3 km downstream from the point of effluent discharge.

Water quality in Twin Lakes Creek is modified by runoff from the areas listed above and receives a seasonally-varying load of heavy metals. The potential sources of metals in Twin Lakes Creek have been extensively investigated by Nanisivik Mine (Nanisivik Mine Limited, 1995, 1999, 2000) and are considered to include both naturally occurring exposures of sulphides and mine activities. Trends in metal concentrations in Twin Lakes Creek that have been identified from the metal loading studies are as follows (Nanisivik Mine Limited, 2000).

- In June during the initial thawing and initial runoff, most of the zinc loading occurs from the two waste rock dumps located near the mine entrance, which are being actively reclaimed.
- Zinc concentrations decline in July, once flow in the creek has stabilized. Some zinc is still contributed from the area of industrial operations, but contributions from the waste rock piles decrease greatly.
- During the later part of August and the early part of September, when ground thaw is at its maximum depth, the bulk of zinc loading originates from the natural sulfide outcrop located within the creek.
- Lead and cadmium concentrations can show similar trends to the zinc results, but the concentrations are much lower.
- Zinc loadings are correlated with, but lag a few days behind, periods of heavy precipitation.

2.8.2 East Adit Treatment Facility

The East Adit Treatment facility consists of a lime treatment pond, and a polishing pond. Effluent from the polishing pond was formerly discharged into an unnamed watercourse, which drains into Strathcona Sound. This unnamed watercourse is an intermittent stream which flows in a rocky gully. Seepage from the surrounding hillsides and other gullies join this flow on the way to the Sound. There is no fish habitat present, although standing water appears to be present in several pools within a few hundred metres of the effluent discharge point.

As was noted above, there was no discharge from the East Adit treatment system in 2002 or 2003. Due to mine reclamation activities, it is unlikely that there will be any discharge from this potential effluent discharge point in future. During periods of discharge, the flow from the East Adit area is visible at the ground surface only part of the time. Over much of the discharge flow path, the flow is subterranean, in the coarse rocky substrate. As flow moves downgradient, it is joined by flow from other areas, and eventually enters Strathcona Sound.

2.8.3 Effluent Plume Delineation in Twin Lakes Creek

The mine effluent plume in Twin Lakes Creek was delineated using thermal and conductivity techniques in July, 2003 (JWEL, 2003b). Information regarding the plume delineation is provided below.

Effluent discharged into Twin Lakes Creek forms a plume that initially hugs the left bank, and gradually mixes across the full width of the stream. A plume delineation study carried out on the evening of July 11, 2003, found that the effluent discharge was both warmer (13.7°C) and had higher specific conductance (740 μs/cm) than the water in Twin Lakes Creek (temperature 6.3°C, specific conductance 30.1 μS/cm). It was determined that both of these parameters were potentially useful tracers of the mixing of the effluent in the stream channel.

Based on conductivity measurements obtained from the plume delineation study (JWEL, 2003b and Figure 2.2), at a distance of 100 m downstream, the effluent concentration ranged from 76.5% at a distance of 1 m from the left bank, to 0% effluent at a distance of 1 m from the right bank. At 255 m downstream, the effluent concentration ranged from 25.6% effluent near the left bank, to 1% effluent near the right bank. By 400 m downstream, the effluent concentration ranged from 15.2% near the left bank, to 11.5% near the right bank. Finally, after plunging over a 10 m waterfall (see Photo 5) approximately 600 m downstream of the effluent discharge point, the effluent concentration stabilized at 13.8% effluent across the full width of the creek.

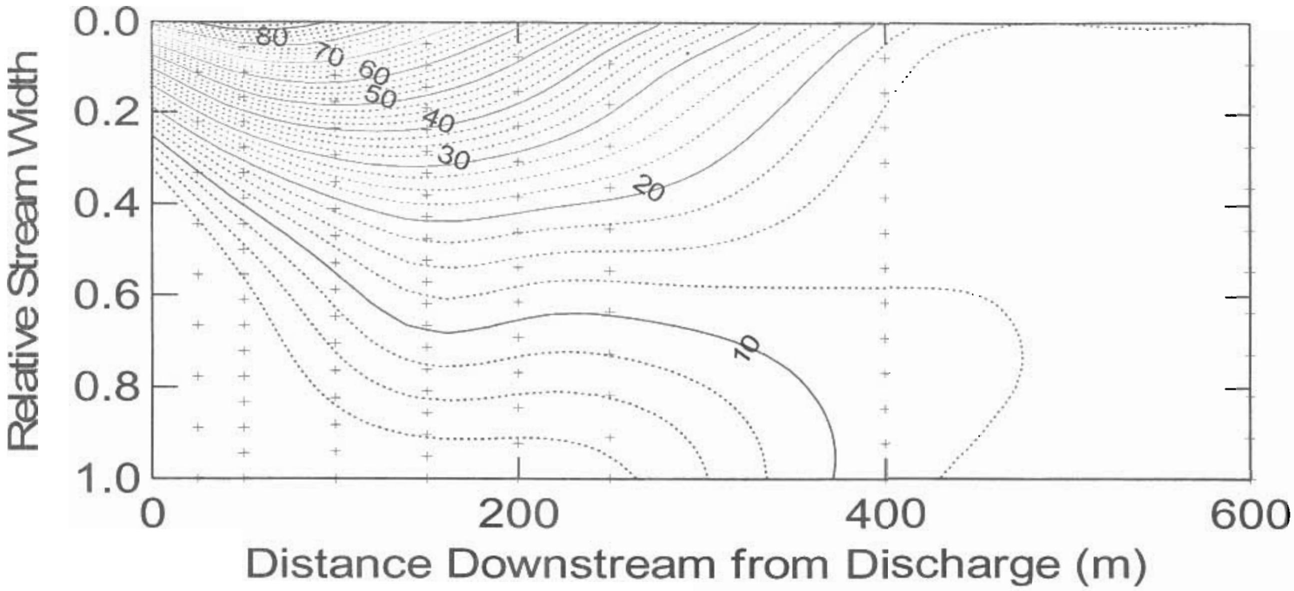

Figure 2.2 Effluent Dilution Measured by Conductivity

Based on the temperature measurements, at a distance of 100 m downstream (JWEL, 2003b and Figure 2.3), the effluent concentration ranged from 88% at a distance of 1 m from the left bank, to 0% effluent at a distance of 1 m from the right bank. At 255 m downstream, the effluent concentration ranged from 22.7% effluent near the left bank, to 1% effluent near the right bank. By 400 m downstream, the effluent concentration ranged from 13.3% near the left bank, to 10% near the right bank. Finally, after plunging over a 10 m waterfall approximately 600 m downstream of the effluent discharge point, the effluent concentration stabilized at 12% effluent across the full width of the creek.

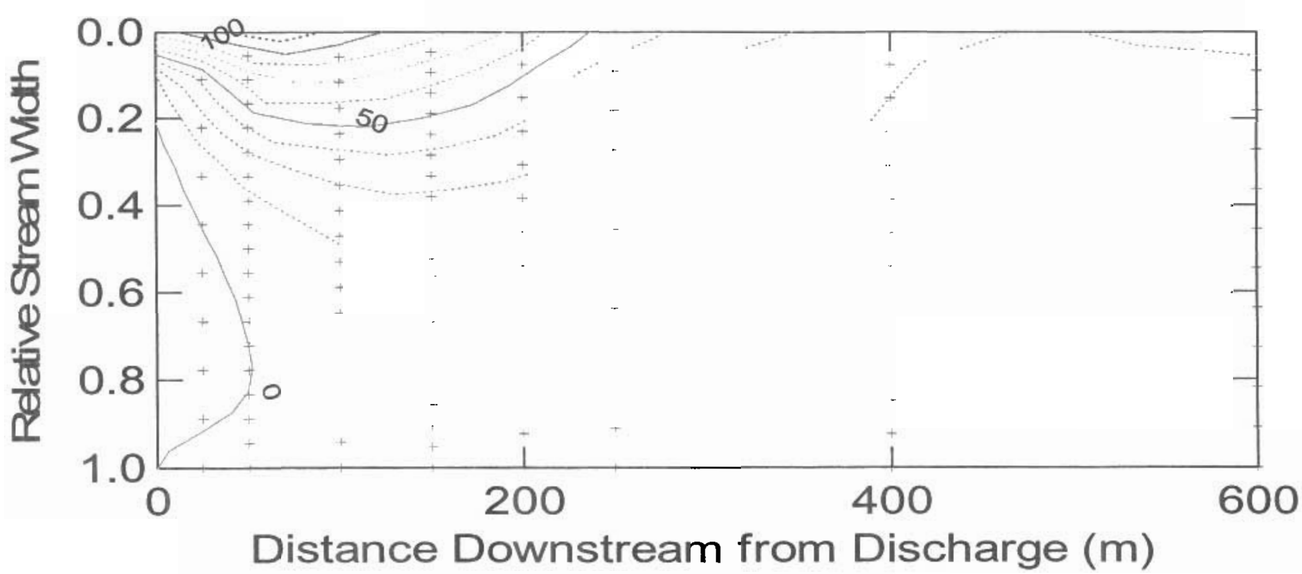

Figure 2.3 Effluent Dilution Measured by Temperature

The plume delineation dilution estimates were also directly corroborated (JWEL, 2003b) by flow measurements that were made in-stream, and at the effluent discharge weir, at the time of the study. Based upon the stream flow measurements, the effluent discharge stream was between 12.0 % and 13.2 % of the total stream flow.

At the time of the plume delineation study in July, 2003, Twin Lakes Creek was at a moderate flow stage (around 1.0 m^3/second). Higher flow rates are expected during spring runoff. Much lower flow rates are also expected later in the season (August), and at this time, the effluent stream will comprise a larger fraction of the overall stream flow. During low flow conditions, it is expected that the plume will disperse more gradually across the stream channel. However, it is still expected that the plume will be fully mixed with the stream flow as it passes over the waterfall located 600 m downstream from the effluent discharge weir.

It has thus been determined that a waterfall approximately 600 m downstream from the point of effluent discharge results in complete mixing during low stream flow scenarios, and it is likely that complete mixing will occur before the waterfall in high stream flow scenarios. In either scenario, samples taken after the waterfall can be regarded as representing a completely mixed condition, and the stream reach between the effluent discharge weir and the waterfall can be regarded as the mixing zone.

2.8.4 Biological Characteristics of Twin Lakes Creek

Twin Lakes Creek is a naturally fishless system from its headwaters at East Twin Lake until it reaches the marine waters of Strathcona Sound. The fishless condition is attributable to multiple factors, including naturally-occurring mineralized zones that cause elevated zinc concentrations in the creek water; the presence of waterfalls that are impassable to fish; and the general climatic conditions which cause the creek to completely freeze during the winter.

Despite the harsh environmental conditions, there is a sparse benthic invertebrate community present in the creek. As documented by BC Research (1975a), and as verified by JWEL (2003b) in a reconnaissance survey carried out in July, 2003, the community is dominated by Chironomidae (Orthocladiinae?), although a few Tipulidae and one other unidentified dipteran larva (Tabanidae?) were collected. Some Cladocerans (Daphnia?) were also collected, but these were presumably drifting down from the zooplankton population present in East Twin Lake, and do not represent true benthic fauna. These data can be found in Appendix B.

Three stations were sampled by JWEL during 2003, with five individual U-net samples (0.25 mm mesh size) being collected at each station. The first two stations were designated ETL (in the outflowing stream from East Twin Lake, upstream of the point where mine effluent enters the creek) and TLC (in Twin Lakes Creek downstream from the effluent discharge point, and exposed to the partially diluted mine effluent). The assemblages present at the ETL site were qualitatively and quantitatively similar to the assemblages present at the TLC site. However, no benthic invertebrates were recovered from a third site (WTL), located immediately below the effluent discharge weir, and exposed to undiluted mine effluent.

2.8.5 Special Features of Twin Lakes Creek

Twin Lakes Creek is a lake outflow system that drains East Twin Lake (which is undisturbed and serves as a potable water supply for the Nanisivik townsite) and West Twin Lake (the tailings area and polishing basin). The water quality of East Twin Lake is excellent. Chemical data collected from the outflow to East Twin Lake in July 2003 can be found in JWEL (2003b), included as Appendix B to this document. The two lakes are separate basins, and the channel of Twin Lakes Creek has been diverted over short area near the effluent discharge weir in order to further separate and regulate the flow from the tailings area.

Both East Twin Lake and West Twin Lake, as well as Twin Lakes Creek are naturally fishless. Chris Creek, another stream draining a portion of the mine lease area is also naturally fishless. The nearest freshwater fish habitat (supporting a landlocked population of Arctic char) is located in Kuhulu Lake, several kilometres east of the mine site, and unaffected by mining activities.

Scientific studies of mine effluent effects on fish and fish habitat in Twin Lakes Creek will be confounded by the following features:

- the creek is not fish habitat, being naturally fishless;
- the creek receives metal loadings (particularly zinc, but also lead and copper) from waste rock piles and a natural mineral outcrop located in the reach between the mill and the townsite, which substantially exceed the loadings from the West Twin Lake tailings area (mine effluent discharge);
- the creek receives an input of nutrients near the mill location, in the form of sewage from the townsite;
- the mine effluent is discharged only during the months of June, July, and August; and
- during the winter months, Twin Lakes Creek freezes completely.

2.8.6 Exposure and Reference Areas in Twin Lakes Creek

Exposure and reference areas in Twin Lakes Creek apply only to the benthic invertebrate survey, and water quality monitoring. Exposure and reference areas for the fish study will be discussed below, in the sections describing Strathcona Sound.

The general proposed reference area from which reference samples for the benthic invertebrate survey and water quality monitoring will be collected is located in the portion of Twin Lakes Creek upstream from the effluent discharge point to East Twin Lake where creek flow is originated. The general proposed exposure area begins at the effluent discharge weir from WTDA and extends downstream to the naturally occurring weathering mineralized zone, rich in zinc and lead sulphides.

2.8.7 Chris Creek

Chris Creek is a smaller creek that drains surface water into Strathcona Sound from the watershed on the east side of the mine area. Specifically, surface run off from the East Adit area, waste rock piles, and K-Baseline area enters Strathcona Sound via Chris Creek. Water quality in Chris Creek is also monitored under the Water License from the Nunavut Water Board.

2.9 Marine Environmental Conditions in Strathcona Sound

Baseline information on the marine environment of Strathcona Sound was documented by BC Research (1975b), and most of the following discussion is derived from that document. Additional observations were made by JWEL (2003c), and this source is identified where it is relevant.

2.9.1 Oceanography of Strathcona Sound

Strathcona Sound is a marine inlet approximately 55 km long that reaches east to southeast from Admiralty Inlet, in northern Baffin Island. The sound is cradled between steeply sloping hills with narrow beach zones. The steeply sloping ground contours along most of the Sound continue below sea level, gradually levelling out at bottom depths that vary from approximately 50 m to over 300 m. In the vicinity of the mine property and the mouth of Twin Lakes Creek, the sea floor drops rapidly and reaches a maximum depth of approximately 250 m. There is a deep sill located approximately 8 km into the sound from its mouth at Admiralty Inlet, and this sill confines a deep hole in the inner Sound.

The intertidal zone of Strathcona Sound, as is typical of intertidal zones elsewhere in the high Arctic, is virtually barren. Tidal ice scouring, possibly in combination with extremely low levels of nutrients and harsh winter conditions at low tide effectively prohibit the growth of the rockweed community that is common in more temperate areas. Below the intertidal zone, BC Research (1975b) observed sea urchins and shorthorn sculpins (*Myxocephalus scorpius*). The latter fish were readily caught by jigging with a baited hook. JWEL (2003c) were also able to catch shorthorn sculpin at the present wharf with similar gear.

Currents in the Sound were reported by BC Research (1975b) to be most pronounced in the surface 10 to 20 m, with minimal currents below that depth. The Sound is tidal, and currents of up to 30 cm/second were observed, with tidal action. The Sound is also highly exposed to westerly winds, and wave action could potentially be significant. The maximum tidal range recorded by BC Research (1975b) was 2.74 m.

Salinity in the Sound was reported to range from 15 ppt (parts per thousand) to 24 ppt in the surface layers during August, 1974. During July 2003, JWEL observed surface salinities as low as 2 ppt in association with melting sea ice and moderate stream flows from Twin Lakes Creek. In both cases, salinity increased below 2 m, to the 25 ppt range. BC Research reported a halocline around 10 m depth (presumably reflecting the depth of surface water warming and mixing during August), with salinity increasing to 31 to 33 ppt below 10 m depth.

Surface water temperatures ranged from 7°C to 10°C during August 1974. Colder waters were present below 10 m depth. Dissolved oxygen concentrations were typically highest at 10 m depth, and decreased significantly at greater depth, in most cases to less than 5 mg/L. These observations may suggest a semi-stagnant bottom water zone in Strathcona Sound (as confined by the sill near the mouth of the Sound), with full mixing occurring only at irregular intervals when severe wind stress on the surface of the Sound causes turnover.

Twin Lakes Creek has a high flow rate in the early summer, and at the same time, the sea ice on Strathcona Sound is melting. The ice left the Sound in mid July during 2003, but some variability in this date can be expected. The combined freshwater inputs from Twin Lakes Creek and the melting sea ice lead to the formation of a thin surface freshwater lens (1 to 2 parts per thousand total salinity) on top of more strongly marine influenced water (a halocline exists so that the salinity increases from about 4 ppt to 25 ppt at a depth of about 2 m. The halocline was strong enough to provide a reflecting surface for sonar, so that a hand-held sonar unit periodically gave depth readings of 2 m or less in waters that were substantially deeper.

As a result of the halocline, fresh water discharged from Twin Lakes Creek does not mix rapidly with the marine waters of Strathcona Sound. Instead, a fresh water lens may extend some distance (perhaps several kilometres) away from the mouth of Twin Lakes Creek, and will be advected east-west by tidal action. Only the heaviest sediment particles will be deposited near the mouth of Twin Lakes Creek. These can be expected to include coarse particles including gravels and sands, and the denser fine-grained particles in the silt size range. Silt-sized particles with less dense mineralogy, and clay-sized particles will have low-enough settling rates to be advected a considerable distance away from the mouth of Twin Lakes Creek before settling. Likewise, dissolved trace metals can also be expected to be transported a considerable distance from the mouth of Twin Lakes Creek before mixing with the full water column. Therefore, it is not likely that substantial accumulations of fine-grained sediments will occur at the mouth of Twin Lakes Creek. However, most of the input of coarse material transported by the creek will deposit near the mouth.

The behaviour of fresh water entering Strathcona Sound from Twin Lakes Creek is relevant because the most common local fish species (shorthorn sculpin) is a bottom dweller. Therefore, the degree of exposure of these fish to the freshwater plume from Twin Lakes Creek, and any associated metals regardless of origin, is uncertain.

2.9.2 Metal Concentrations in Fish from Strathcona Sound

Relatively high concentrations of the metals zinc and lead were documented in marine biota both by BC Research (1975b), prior to the mine development, and by JWEL (2003c), after the mine had ceased operating.

Canadian guidelines for chemical contaminants in fish and fish products exist for the heavy metals mercury (0.5 mg/kg in all fish products except swordfish), arsenic (3.5 mg/kg in fish protein concentrate) and lead (0.5 mg/kg in fish protein concentrate). The mean arsenic concentration reported by JWEL (2003c) was 5.3 mg/kg (range 2.02 to 9.98 mg/kg). The mean lead concentration was 0.48 mg/kg (range 0.027 to 2.22 mg/kg). The mean mercury concentration in shorthorn sculpin tissues was 0.15 mg/kg (range 0.07 to 0.26 mg/kg). This is an important observation since the *MMER* considers the usability of fish tissues be impaired at a mercury concentration greater than 0.45 mg/kg.

Of the three elements for which there are guidelines, only the mean arsenic concentration exceeds the guideline. However, arsenic concentrations in sediments near the mouth of Twin Lakes Creek are not excessive. Arsenic concentrations in many marine biota, including shellfish, crustaceans and bottom-dwelling fish are commonly elevated, and of low significance to consumers. Many species of fish contain from 1 to 10 mg/kg total arsenic, and some bottom feeders and shellfish contain arsenic at or above 100 mg/kg (World Health Organization, 2001). Lobster tissues commonly contain from 10 mg/kg to 20 mg/kg total arsenic (U.S. Food and Drug Administration, 1993). Moreover, arsenic present in the tissues of marine organisms is predominantly present as a water-soluble organic form (arsenobetaine), which has low toxicity and does not biomagnify. There are no reported instances of toxicity in man or animals from the consumption of organic arsenic compounds in seafood. Therefore, the fact that shorthorn sculpin muscle tissues contain moderate concentrations of total arsenic (<10 mg/kg) should not be a source of concern.

Lead concentrations in fish tissues approached and in some cases exceeded the Canadian guideline for fish protein concentrate, and were relatively variable both from fish to fish, and within fish tissues analyzed as replicate subsamples. The source of this variability is not clear, and such variability was not observed for most other elements. Much less variability was observed for zinc, for example. However, zinc concentrations in fish tissue are subject to biological regulation, whereas lead may not be. The conclusion remains that most fish collected at the wharf have low lead concentrations, and that the average exposure to lead from consuming these fish would be low.

In addition to the above metals, cadmium, copper and zinc are worthy of mention. Cadmium concentrations in shorthorn sculpin tissues were low (averaging 0.029 mg/kg, and ranging from 0.01 to 0.057 mg/kg). Copper concentrations were also low, and lay within a very narrow range (averaging 0.56 mg/kg, and ranging from 0.45 to 0.72 mg/kg), consistent with active biological regulation. Zinc concentrations were slightly elevated, but also lay within a narrow range consistent with active biological regulation (averaging 18.1 mg/kg, and ranging from 10.2 to 26.7 mg/kg). None of these metal concentrations merit concern about possible human consumption.

The data reported above can be compared with data collected by BC Research (1975b). They reported arsenic concentrations in shorthorn sculpin fillet samples of 10.1 to 37.4 mg/kg dry weight. Assuming a water content of 80%, these results would translate into fresh tissue concentrations of 2.0 to 7.5 mg/kg, very similar to the results of the present survey. Lead concentrations were generally below the detection limit obtained by BC Research. However, their reported results range from <7 to <46 mg/kg dry weight, with one reported detection of 4.6 mg/kg dry weight. The highest concentration reported during the 2003 survey was 2.2 mg/kg wet weight, which would translate into a dry weight concentration of about 11 mg/kg. Copper concentrations reported by BC Research ranged from 5.3 mg/kg to 26.3 mg/kg dry weight. This range would translate to a range of 1.1 to 5.3 mg/kg wet weight (results for 2003 were less than 1 mg/kg wet weight). Zinc concentrations reported by BC Research range from 57.6 to 144 mg/kg dry weight, which would translate to a range of 11.5 to 28.8 mg/kg wet weight. The zinc concentration reported for 2003 averaged 18.1 mg/kg wet weight.

Taken overall, there appears to be a consistent weight of evidence to indicate that metal concentrations measured in the tissues of shorthorn sculpin in 2003 are very similar to those measured prior to the mine development, in 1974 (JWEL, 2003c).

2.9.3 Exposure and Reference Areas in Strathcona Sound

Following discussions with the Technical Advisory Panel for the Nanisivik Mine EEM study, it has been determined that the most appropriate area for a fish study is in Strathcona Sound, near the mouth of Twin Lakes Creek. Accordingly, this area will be designated the exposure area for the fish study, and a reference area will be located on the opposite side of Strathcona Sound, near the mouth of the Strathcona River.

2.10 Mine Production Process and Environmental Protection Practices

The following information was obtained from the Phase 2 ESA Report (GLL, 2002).

2.10.1 Mine Production Process