2002 Phase II Environmental Site Assessment
Nanisivik Mine, Nunavut

Prepared for:
CanZinco Ltd.

Gartner Lee

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GLL 21957

January 2003

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Executive Summary

A Phase II Environmental Site Assessment ("ESA") of the Nanisivik mine site and associated mine-owned facilities (owned by CanZinco Ltd.) was conducted in July 2002 according to protocols published in Federal guidelines and according to a scope of work that incorporated regulatory and community comments.

The scope of work for the field investigation included: review of existing information: sampling of soil on surface and at depth in test pits that were typically excavated to hard frozen ground; installation of seepage sampling wells in test pits that accumulated water; visual mapping and sampling of rock types in road beds; visual mapping and sampling of sediments and waste rock in Twin Lakes Creek; chemical analyses for various metals, hydrocarbons and other relevant parameters; data analysis; and reporting.

The existing information that was reviewed and that is summarized in this report includes:

- Widespread geochemical analyses of surface soils;
- Dust monitoring data;
- Acid rock drainage analyses;
- Metals in marine sediments;
- Metal loading studies in Twin Lakes Creek; and
- A survey of metal concentrations in surficial soils in the town conducted by others for the Government of Nunavut, which was incorporated with the permission of the Government of Nunavut.

The 2002 ESA field investigation program resulted in:

- The excavation of 147 test pits and the installation of seepage sampling wells in 8 of the test pits;
- The collection of 59 surficial soil samples;
- The collection of 9 sediment samples;
- Sampling of 2 surface seeps and the 8 seepage sampling wells;
- Measuring the organic vapour concentrations in soil; and
- The submission of soil, sediment and water samples for petroleum hydrocarbon (PHC) and metals analysis.

All of the known or suspected areas of potential environmental concern were investigated, which included: the landfill, the industrial complex area, the dock area, the roads to Oceanview, Area14 and the dock, wind blown tailings, the town, the East Adit treatment facility, the tailings pipeline route, Twin Lakes Creek and current or former fuel dispensing locations.

An Ecological and Human Health Risk Assessment was initiated in September 2002 by CanZinco Ltd. that will identify the most sensitive contaminants and receptors and recommend appropriate "Tier 3" site specific soil quality remediation objectives. The information provided in this ESA report will be directly relevant to that study. However, in the absence of those specific soil quality remediation objectives at this time, this report compares analytical results to generic “Tier 1” Federal guidelines for parkland and commercial land use as a means of providing some context for reviewing the data and assessing contaminants and areas of environmental concern.

Based on observations and results obtained during the Phase II ESA, the contaminants listed in the table below are considered to be of environmental concern. The Phase II ESA did not identify Ethylene glycol (antifreeze) and arsenic as contaminants of environmental concern.

Contaminants of Environmental Concern

Contaminant	Comment
Volatile Petroleum Hydrocarbons	Constituents of gasoline (<C10); identified by elevated concentrations of Canada Wide Standards for Petroleum Hydrocarbons (“PHC CWS”) fraction F1 and benzene, ethylbenzene, tolulene and xylene (“BETX”) compounds.
Extractable Petroleum Hydrocarbons	Constituents of diesel, oils and greases (>C10); identified by elevated concentrations of PHC CWS fractions 2, 3 and 4.
Napthalene	Constituent of diesel.
Chlorinated Ethenes – Volatile Organic Compounds	Constituents of Xanthate.
Cadmium, Copper, Lead, Zinc	Constituents of ore, concentrate and tailings.

Areas of Environmental Concern that were identified or verified by this Phase II ESA are illustrated on the following summary figure and listed in the two tables below for hydrocarbons and metals. These tables also present summary comments regarding the extent or nature of the environmental concern for each area.

Areas of Environmental Concern - Hydrocarbons

Area	Comment
a. Oceanview	Localized near surface contamination at an existing, small above ground storage tank ("AST"). Localized contamination to permafrost at a former, larger AST.
b. K-Baseline	Contamination to permafrost at one former AST and at former maintenance shop that extends downgradient.
c. East Adit Area	Localized near surface contamination at a small AST. Contamination to permafrost at one current AST at 39N dump.
d. 17N Refuge Station	Localized near surface contamination at an existing small AST.
e. Area14	Localized near surface contamination at a former AST.
f. West Adit Area	Localized near surface contamination at AST's at the ANFO building and 01 portal. Contamination adjacent a former underground storage tank ("UST').
g. Town	Hydrocarbon contamination at ASTs adjacent the homes is confined to shallow areas (less than 0.05 m) indicated by visual surface staining. Hydrocarbon impacted soil at larger ASTs is not readily detectable by visual observations due to resurfacing of the ground surrounding the tanks with shale fill and the vertical extent of contamination can extend to permafrost and could extend laterally.
h. Carpenter Shop	Contamination to permafrost downgradient of area remediated after 2000 diesel spill.
i. Land Farm	No soil or water contamination downgradient of landfill area. Soil in landfarm continues to require remediation.
j. STOL Airstrip	Localized contamination at former AST.
k. Industrial Complex Area	Contamination to permafrost in maintenance and parking areas. Contamination to permafrost downgradient of fuel storage area. Localized near surface contamination at waste oil tank and warehouse yard.
l. Dock Area	Localized near surface contamination at a current AST. Limited contaminant migration at the permafrost horizon downgradient of the fuel pump building does not extend to within 50 m of the ocean shore.

Areas of Environmental Concern - Metals

Area	Comment
1. Oceanview	Small quantities of mineralized rock along road side.
2. K-Baseline	Limited exposed mineralized rock in yard at portal.
3. East Adit Area	Waste rock dumps, open pits and exposed mineralized wall rock.
4. East Adit Treatment Facility	Residual treatment sediments in Treatment and Retention ponds. Localized surficial contamination in drainage paths.
5. Area14	Limited exposed mineralized rock in yard at portal.
6. Area14 Road	Small quantities of mineralized rock along roadside.
7. Tailings Pipeline/Dump Ponds	Residual tailings at former pipeline breaks.
8. West Adit Area	Waste rock dumps, open pits, exposed mineralized wall rock and natural outcrops in Twin Lakes Creek.
9. Twin Lakes Creek	Waste rock dumps and natural outcrops in contact with creek.
10. Wind Dispersed Tailings	Tailings are present as a very thin surficial coating on rocks and soil in a northwesterly direction and along the base of the hill on the south side of the town.
11. Town	Elevated metal concentrations in surficial soil.
12. Industrial Complex Area	General contamination of area. Concentrations decrease at depths greater than approx. 0.5 m.
13. Concentrate Haul Road	General contamination of roadfill. Surficial contamination of upper soil horizon along roadside.
14. Dock Area	General surficial contamination of area.

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1. Introduction

1.1 Project Objectives

The purpose of the 2002 Phase II Environmental Site Assessment (“ESA”) was to complete the data collection and interpretation that was initiated by CanZinco Ltd. in order to identify and delineate areas of environmental contamination related to mine activities. The areas considered encompassed all mine related facilities, including the town, all mining areas, the tailings disposal area, the industrial complex, the dock site, the landfill and the Short Take Off and Landing (“STOL”) air strip.

The 2002 ESA program attempted to take full advantage of previous work conducted by CanZinco Ltd. and others in order to avoid duplication of time and effort. The data collection was also intended to be appropriate for an ecological and human health risk assessment that would be conducted subsequent to the ESA. This risk based approach will be used to develop remediation objectives for the mine site.

1.2 Background on Closure and Reclamation Plan

Mining activities at the Nanisivik Mine were undertaken without interruption from 1976 to mine closure in September 2002. The mine operating plan projected mining rates and available ore reserves into the future and the mine operating plans developed prior to September 2001 projected that economic ore reserves would be depleted in late 2004. This is reflected in the terms and conditions the Water License, which is based in this closure timeframe.

A mine operating plan is a dynamic plan that is evaluated and assessed on an ongoing basis based on available ore reserves, economic conditions and operating costs. An evaluation of Nanisivik’s mine operating in late 2001 indicated that the mine was no longer economic due to depressed metal prices, which were not anticipated to improve significantly to 2004. Nanisivik’s mine operating plan identified, however, that the retreat mining of pillars would maintain an economically viable operation for one year. As a result of this evaluation, in September 2001 closure of the lead-zinc mine was announced for September 2002.

The Water License issued by the Northwest Territories Water Board took into consideration the possibility of an earlier than scheduled closure and included the requirement for submission of a Final Closure and Reclamation Plan shortly after announcement of mine closure. A Closure and Reclamation Plan (“C&R Plan”) was submitted to the Nunavut Water Board (“NWB”) in February 2002. The C&R Plan included a description of several technical studies that were required to complete the closure planning process and described a plan for their execution.

One of these technical studies was a Phase II Environmental Site Assessment ("ESA") for the purpose of identifying and delineating areas of environmental concern as a prerequisite to finalization of environmental remediation measures. An ESA is typically conducted prior to preparation of a Final Closure and Reclamation Plan and this was intended for the Nanisivik Mine. An ESA program was being discussed and designed prior to the September 2001 announcement of mine closure. The work was planned, at that time, to be conducted in 2002 prior to the preparation of a Final Closure and Reclamation Plan.

The 2002 ESA program described herein, follows the initial intent for an environmental characterization of the site. In addition, the 2002 ESA has also benefited from the communications initiated by submission of the February 2002 C&R Plan. Comments and suggestions that were provided, via the NWB, from various agencies and the community of Arctic Bay through written interventions and through verbal comments provided at the Water Board Hearing that was held in Arctic Bay in July 2002 (at the time when the ESA work was underway) were considered and incorporated into the ESA program to the intended benefit of the closure planning process.

1.3 Overview of Nanisivik Mine, Town and Related Facilities

1.3.1 Location

The Nanisivik Mine is located on the Borden Peninsula on northern Baffin Island in the Canadian Arctic at a latitude of approximately 73 degrees north (Figure 1). The mine site is on the south side of Strathcona Sound approximately 30 km from the inlet to the Sound. The community of Arctic Bay is located approximately 25 km to the west of Nanisivik. The two communities are linked by a 33 km all-weather road.

A jet airport that is owned and operated by the Government of Nunavut is located approximately 10 km south of the town of Nanisivik. Commercial flight service is currently provided via Ottawa, Iqaluit and Resolute.

1.3.2 Overview of Mine Development and Operation

Mineral exploration activities were carried out primarily from 1958 to 1968. Construction of the mine commenced in 1974 and operation/processing commenced in 1976, making it the first operating metal mine in the Canadian Arctic. Mine employees predominately lived in the town of Nanisivik, built approximately 1 km from the mine/mill area specifically to house mine workers. The town includes a church, recreation centre, school, housing, post office, store, diesel electric power plant and other amenities to provide comfortable living for employees and their families. Construction of the town was partially funded by the Government of the Northwest Territories and the Government of Nunavut currently owns some of the town facilities. A few employees commuted from the community of Arctic Bay.

The mill and mine are located approximately 3 km from Strathcona Sound, the town is located approximately 4 km from the Sound and the tailings disposal facility is located approximately 7 km from the Sound as illustrated on Figure 2. Photographs 1 to 4 in Appendix A are a panorama of pictures looking south towards Strathcona Sound and the mill, looking east towards the mine workings, and looking south towards the town.

A concentrate storage shed, ship loading facility, dock, fuel tank farm and reagent storage area are located at the Sound. The Canadian Coast Guard uses the dock as a storage facility for marine environmental emergency response equipment and also as a fueling station.

The mine was primarily an underground operation (primary workings plus 3 satellite areas) with smaller contributions of ore from four open pits. Underground mining has been primarily room and pillar method and focused on pillar recovery from the primary workings during the last months of operation in 2002.

The primary underground workings extend in an approximate east-west alignment (approximately 3 km long X 100 metres wide X 10 metres thick) and daylight on either side of a topographic ridge as indicated on Figure 3. Vehicle access into the underground mine is via several adits that allow passage of both heavy and light equipment. The underground mine is very “dry” due to the permafrost conditions to the extent where specialized dust collection apparatus is installed on drilling equipment. Ground temperatures in the underground mine are constantly below freezing (typically –13°C) and permafrost conditions are known to extend to at least 600 metres below surface.

Ore processing at the mill involves dense media separation (installed in 2001) and conventional grinding, flotation and dewatering circuits. Zinc and lead mineral concentrates were produced and hauled in gravel trucks from the mill to the concentrate storage shed, which is located at the dock. Mineral concentrates were loaded onto ocean going ships during the ice free season. The ship loading conveyor system was enclosed in the early 1980’s. On average, 790,000 tonnes of ore containing 8 to 14% zinc were processed per year to produce 110,000 tonnes of mineral concentrates per year.

Process tailings were pumped approximately 4 km from the mill to the tailings disposal facility, West Twin disposal area (WTDA), formerly West Twin Lake. The WTDA storage capacity was increased in 1990 with construction of an internal dyke across the lake that created upper and lower storage areas. The upper portion of the lake became a surface tailings deposition area and has been the primary storage area since 1990. With the exception of a raised area that was developed for testing of covers for reclamation of the surface tailings, the lower portion of the lake has remained a subaqueous tailings disposal cell and reservoir for water decanted from the upper area. A large portion of the water in the WTDA was returned to the mill via an overland pump/piping system for reuse in the concentrator. Surplus water was released seasonally through a polishing/retention system.

The two WTDA internal dykes were constructed using frozen tailings core construction. The upper storage area dyke has been raised on an incremental basis since 1990 using upstream construction with tailings and shale.

1.3.3 Related Government Owned Facilities

The construction of some facilities and infrastructure related to the Town of Nanisivik were funded by the Government of the Northwest Territories during construction of the mine and town. Ownership of these facilities was subsequently passed to the Government of Nunavut.

These facilities include:

- Sewage treatment system;
- Town centre (including: school, RCMP office, fire hall, daycare, store, post office);
- Town fresh water supply and distribution system;
- Road from town to East Twin Lake freshwater supply;
- Jet airport (1951 m X 46 m gravel runway);
- Road to airport;
- Road to Arctic Bay; and
- Some housing in the town of Nanisivik.

Construction of the dock was partially funded by the Government of Canada and is used routinely by the Canadian Coast Guard as a storage facility for marine environmental response equipment and for refueling.

1.3.4 Mine Ownership

The property was optioned by Mineral Resources International Limited in 1972 who subsequently hired Strathcona Mineral Services Limited to manage the property. Development of the mine facilities took place from 1974 to 1976. Mining and milling commenced in 1976 and continued to September 2002, when the mine was closed permanently. The property was sold to CanZinco Ltd., a division of Breakwater Resources Ltd., in July of 1996.

The Nanisivik Mine and related facilities are wholly owned by CanZinco Ltd., which is a division of Breakwater Resources Ltd. CanZinco Ltd. is the sole operator of the Nanisivik Mine.

1.4 Regulatory Setting/Framework

1.4.1 Operating Permits and Licenses

Operations at the Nanisivik Mine are governed by a water license. The Northwest Territories Water Board under the Northwest Territories Waters Act granted the original water license. The Nunavut Water Board assumed the responsibility for current water licenses in 1996 under the mandate of the Nunavut Land Claims Agreement Act.

The final “operating” water license (Water License NWB1NAN9702) came into effect July 1, 1997 and had an initial expiry date of June 30, 2002. The expiry date was extended to September 30, 2002 following CanZinco’s announcement that mine closure was scheduled for September 2002. The extension of the term of the License also stipulated that a Closure and Reclamation Plan be filed with the Nunavut Water Board by February 28, 2002.

The current water license (Water License NWB1NAN0208) came into effect October 1, 2002 and has an expiry date of May 1, 2008. This water license is focussed on mine closure and does not allow any commercial production from the mine.

The Nanisivik Mine occupies land leased from the Government of Canada under the Territorial Lands Act and the Territorial Lands Regulations.

Mineral title to the Nanisivik Mine is held under mineral leases. Mineral leases were issued for 21-year periods, with rights of renewal. The leases have historically been renewed as required, with the next renewal date being 2009.

In addition to the mineral title requirements, surface title is also required for certain operations. The Federal Government controls all of the surface title in the Nanisivik Mine area. However, at mine start-up, the surface rights to one block, called the Block Transfer, were transferred to the Government of the Northwest Territories (and subsequently to the Government of Nunavut).

Mine operating and other activities at the Nanisivik Mine are governed by an agreement signed June 18, 1974 (the "Master Agreement") between Nanisivik Mines Ltd. (as assignee of Mineral Resources International Limited) and the Department of Indian Affairs and Northern Development ("DIAND"), which provided for the development and operation of the Nanisivik Mine. Based upon the original mineral reserves and initial design capacity of the mine and mill, a mine life of 12 years was contemplated.

A portion of the dock area occupies a surface lease administered by the Department of Fisheries and Oceans (“DFO”).

1.4.2 Remedial Guidelines

Soil, sediment and water quality for the environmental site investigation has been assessed based on a framework of federal guidelines for the target potential contaminants of concern. Nunavut Territory refers to the Northwest Territory Remediation Guidelines and the required degree of remediation cited in the NWT guidelines is determined by the Canadian Council of Ministers of the Environment (CCME) guidelines. The Canadian Council of Ministers of the Environment (CCME) has established federal guidelines to address the protection of atmospheric, aquatic, and terrestrial resources. These guidelines were developed by using risk-based procedures to provide equal protection to human health and ecological receptors.

A three-tiered approach for the assessment and remediation of contaminated sites has been established by the CCME. Generic guidelines represent the first tier, while a second tier allows limited modification of the guidelines to establish site-specific remedial objectives[1,2]. The third tier uses risk assessment procedures to establish remediation objectives at contaminated sites on a site-specific basis. The first tier guidelines represent generic recommendations that are based on a conservative application of the most current scientific information without consideration of possible site-specific, special considerations.

The Nanisivik Mine intends to conduct an Ecological and Human Health Risk Assessment to recommend site-specific objectives for remediation of soils given that the designated generic CCME land uses, described in the following subsections, are not considered appropriate and because the background (natural) concentrations of a variety of metals are elevated above the generic guidelines. The CCME framework provides for the use of site-specific remediation objectives, which “allows the proponent to ensure that the assumptions used in the [soil] protocol apply to the site-specific conditions”.

Soil quality

Pending the development of site specific remediation objectives, the soil analytical results were compared to the generic commercial (CL) and parkland (PL) land use standards and guidelines in the following documents:

- *Canadian Environmental Quality Guidelines* (CEQG), Canadian Council of Ministers of the Environment (CCME), Winnipeg MB, 1999.
- *Canada Wide Standards for Petroleum Hydrocarbons (PHC) in Soil (PHC CWS)*, Canadian Council of Ministers of the Environment (CCME), Winnipeg, MB, 2001 05 01.

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[1] CCME. 1996a. Guidance Manual for Developing Site-Specific Soil Quality Remediation Objectives for Contaminated Sites in Canada. The National Contaminated Sites Remediation Program. En 108-4/9-1996e.

[2] *Canada-Wide Standards for Petroleum Hydrocarbons (PHC) in Soil - User Guidance*" submitted to CCME by O'Connor Associates Environmental Inc. and Meridian Environmental Inc., dated April 2001.

CCME Canadian Environmental Quality Guidelines for Soil

The Canadian Environmental Quality Guidelines (CEQG) provide criteria for soil based on land use activities (agriculture [AL], residential/parkland [RL/PL], commercial [CL] and industrial [IL]). Pending sufficient and adequate data for specific parameters, CEQG soil quality guidelines (SQG) are also derived using different receptors and exposure scenarios (environmental health [SQG_E] and human health [SQG_{HH}]) for each land use.

The mine area is currently being used for residential, commercial and industrial purposes. The residential land use criteria for the parameters of concern are equivalent to or more stringent than the commercial, which are equivalent to or more stringent than the industrial land use criteria. Negotiations are currently underway for transfer of ownership of some mine facilities for continued use. However, pending the resolution of these negotiations, the remediation objective for the mine site is to restore the land to as close as possible to natural conditions, which were arctic wild lands. The closest generic criteria for arctic wild lands are parkland land use objectives, even though these criteria were developed for urban areas in southern Canada.

Both the parkland and commercial land use guidelines have been used as a reference for assessing the quality of soil for this site characterization, pending the resolution of negotiations and the development of site specific remediation objectives. In cases where the recommended CEQG soil quality guideline (SQG) for specific parameters is presented for both "guidelines for environmental health" (SQG_E) and "guidelines for human health" (SQG_{HH}), the lower (i.e. more stringent) of the two has been used as the reference criteria.

CCME Canada-Wide Standard for Petroleum Hydrocarbons in Soil

The CCME Canada-wide standard for petroleum hydrocarbons in soil (the PHC CWS) has been used to assess soil quality at the Nanisivik Mine. The PHC CWS is a CCME remedial guideline for petroleum-hydrocarbons impacted soil. In this guideline petroleum hydrocarbons are subdivided according to specified ranges of equivalent carbon number as follows:

- PHC CWS fraction F1 encompasses the range of equivalent carbon number from C_6 to C_{10}. Constituents of fraction F1 include the volatile fraction of most hydrocarbons mixtures (including gasoline) such as benzene, ethylbenzene, toluene and xylene (BETX).
- PHC CWS fraction F2 encompasses the range of equivalent carbon number from C_{11} through C_{16}. Constituents of fraction F2 are semi-volatile petroleum hydrocarbons and include constituents of gasoline and diesel fuels.
- PHC CWS fraction F3 encompasses the range of equivalent carbon number from C_{17} through C_{34}. Constituents of fraction F3 include typical lubricating oils and greases, heavy fuel oils, road oils and asphalts.
- PHC CWS fraction F4 encompasses ranges of equivalent carbon number from C_{35} through C_{50+}. PHC within this fraction often make up a significant proportion of crude oils.

Consistent with the CCME Canadian Environmental Quality Guidelines (CEQG) for soil, the PHC CWS was developed for four generic land uses: agricultural, residential/parkland, commercial and industrial.

Sediment Quality

CCME Canadian Environmental Quality Guidelines for Sediment

The CEQG provides sediment quality guidelines that provide reference points for evaluating the potential for observing adverse biological effects in freshwater and marine aquatic systems. Sediment guidelines referenced in this report include the interim sediment quality guidelines (ISQGs) and the probable effect level (PEL) for freshwater sediment.

ISQGs are established if insufficient information exists to establish "full" sediment quality guidelines and are recommended for concentrations in surficial sediments (i.e. top 5 cm). The probable effect level (PEL) is a concentration at which adverse biological effects frequently occur.

Water Quality

CCME Canadian Environmental Quality Guidelines for Water

The CEQG also provides drinking water and surface water quality guidelines. Criteria for surface water quality are based on usage (community water supplies, recreational use and aesthetics, aquatic life [freshwater {FWAL} and marine] and agricultural water uses).

In order to provide a reference for the water quality data gathered at the Nanisivik Mine site, the CEQG generic water quality guidelines established for the protection of fresh water aquatic life are included with the results. The CEQG freshwater aquatic life (“FWAL”) guidelines apply to total concentrations in surface water bodies that host aquatic life and are provided for comparative purposes only.

The CEQG FWAL guidelines are not, however, applicable to the evaluation of groundwater quality. Modifying factors for chemical limits in groundwater due to factors such as natural attenuation and dilution are not considered in the CEQG FWAL guidelines. Groundwater quality standards for the protection of freshwater aquatic life have been developed for other jurisdictions generally apply a 10-fold dilution factor to regulated chemical parameters. These standards have also been presented with the analytical data for discussion purposes only to provide a comparison for the site groundwater quality and seepage water data.

1.5 Scope of Work

1.5.1 Field Program

A preliminary scope of work for the ESA field program was initially proposed in the Gartner Lee Limited report, *Nanisivik Mine 2001 Environmental Site Assessment and Proposal for Phase 2 ESA*, which was included in the February 2002 C&R Plan as Appendix A.

In response to written comments provided from the NWB, the scope of work for the field program was refined according to a Gartner Lee Limited memo dated July 3, 2002. This memo was submitted to the NWB as part of a written response provided by CanZinco Ltd. to written interventions regarding the February 2002 C&R Plan.

The ESA field program was underway at the time of the Public Hearing in Arctic Bay in July 2002. The scope of work was further refined at that time in response to comments made at the hearing.

The scope of work was also refined in the field based on professional judgement, field observations and the practicalities of completing the work.

The scope of work for the field program, as completed in July 2002, included the following components:

1. Soil sampling in the vicinity of the concentrate storage shed and the ship loader;
2. Soil sampling of the storage yard near the dock and tank farm;
3. Soil sampling along the road from the concentrate storage shed to the industrial complex;
4. Soil sampling along a transect perpendicular to either side of the road from the concentrate storage shed to the industrial complex;
5. Soil and water sampling in the industrial complex area, including the outdoor warehousing yards;
6. Soil sampling along a transect across the area between the town and the industrial complex;
7. Soil sampling in the town;
8. Soil and water sampling along the right of way from the town to the freshwater supply tank;
9. Soil sampling downgradient of the south tailings dump pond and locations of historical tailings pipeline breaks;
10. Soil sampling in the “saddle” area to the north (i.e. downwind) of the WTDA;
11. Visual inspection and sampling of road fill along the Oceanview and Area14 roads;
12. Soil sampling and visual inspection of current and historical fuel day tank areas;
13. Soil and water sampling at the landfill; and
14. Sediment sampling and visual inspection of Twin Lakes Creek.

1.5.2 2002 Work by Others

A report was made available by the NWB in September 2002 that describes a June 2002 sampling program that focussed on the metal content of surficial soils around the Town of Nanisivik (EBA

Engineering Consultants Inc. ["EBA"], 2002). That work has been incorporated into the ESA program and has been used to complement the soil sampling and observations made during the July 2002 ESA.

The comprehensive survey of metal concentrations in surficial soils around the town site was completed in June 2002 by EBA on behalf of the Government of Nunavut. The methodology and results of this survey are presented in the report referenced as EBA, 2002 and excerpts are included in Appendix D for ease of reference.

2. Pre-Mining Environmental Setting

2.1 Climate

Nanisivik is located in a climatic zone classified as "polar desert", which is characterized by cold temperatures and relatively low precipitation. Meteorological data has been collected by Atmospheric Environmental Services (AES) of Environment Canada since 1976 at the Nanisivik Airport (located approximately 10 km south of the mine site).

Over the period of record, the maximum daily temperature recorded was 23.0 ^{0}C, the minimum daily temperature recorded was -53.0 ^{0}C and the mean daily temperature recorded was –14.8 ^{0}C.

Mean annual precipitation has been recorded at 231 mm, of which approximately 50 mm was in the form of rain. The greatest daily recording of snowfall was 68.4 cm and the greatest daily recording of rainfall was 36 mm.

Annual evaporation data at the WTDA has been measured at an average of 187 mm during the period 1993 to 2001 (DIAND meteorological station).

The daily rainfall probable maximum precipitation ("PMP") event is estimated to be approximately 140 mm and the daily snowmelt PMP event is estimated to be 155 mm. The magnitude of these extreme events is low relative to southern Canada (for example, a daily PMP event in Northern Ontario is approximately 500 mm to 700 mm) which reflects the characterization of the site as a "Polar Desert".

2.2 Permafrost

Nanisivik is located in the permafrost region of the Canadian Arctic Archipelago where permafrost is characterized as "continuous" (i.e. existing over the landscape as a continuous layer).

The local permafrost conditions have been described as follows:

1. Permafrost at the northern end of Baffin Island has a potential for high amounts (>20%) of ground ice;
2. Permafrost at Nanisivik has been found to be deeper than 430 metres in a borehole drilled from the underground workings;
3. The subsurface rock temperature was noted to range from –11.7 ^{0}C to –9.4 ^{0}C in the project feasibility study;
4. Baseline environmental studies noted that permafrost was encountered in two shallow test pits: at a depth of 25 cm on the north-facing slope of Mt. Fuji and at 60 cm on an exposed dry ridge and

that permafrost was not encountered to 85 cm depth in another shallow test pit on an exposed dry ridge; and

5. Studies related to the reclamation testing covers indicated that on-land deposition of mine wastes leads to rapid permafrost aggradation into the waste material within a one to two winter timeframe.

2.3 Geology

A description of the geology of the mine site is provided in the February 2002 Closure and Reclamation Plan that is repeated here for reference and context.

The Nanisivik sulphide deposits are hosted in carbonate rocks within a Proterozoic sedimentary sequence. This sequence developed as a Neohelikian intracratonic basin, the Borden Basin, on a peneplaned gneiss complex of Archean-Aphebian age.

The present Borden Basin sequence consists of generally shallow water clastic and carbonate sediments up to 6,100 metres thick, called the Bylot Supergroup. The Supergroup is divided into three Groups, a lower clastic group (the Eqalulik Group), a middle carbonate group (the Uluksan Group) and an upper clastic group (the Nunatsiaq Group).

The Uluksan Group is made up of the lower Society Cliffs Formation and the upper Victor Bay Formation. The Society Cliffs Formation varies in thickness from 260 metres at Arctic Bay to 856 metres at Tremblay Sound. West of Tremblay Sound, it was deposited in a subtidal to intertidal environment. The Society Cliffs Formation is conformably overlain by the Victor Bay Formation, which consists of shales, siltstones, dolostones and coarse carbonate clastics and varies in thickness from 156 metres to 735 metres. The Victor Bay Formation is considered to have acted as a cap rock to mineralization in part of the mine area. All of the economic mineralization at the Nanisivik mine lies within the upper member of the Society Cliffs Formation.

The Nanisivik mine property is up to 7 km wide and up to 15 km long. Rocks cropping out on the property include small exposures of quartzite of the Adams Sound Formation on the southern edge of the lease area. The unit immediately below the Society Cliffs Formation, the Arctic Bay Formation, crops out in the area but is not exposed on the property. The main units exposed are the Society Cliffs Formation and the overlying Victor Bay Formation, together with Paleozoic sandstones of the Gallery Formation.

In the mine area, dips are usually quite shallow and the main structure is faulting. Major structures that are recognized in the mine include the South Boundary Fault, which marks the southern margin of sulphide mineralization, and the Keystone Graben Fault, which defines the southern margin of the Main Ore Zone horst.

The various massive sulphide deposits contain more than 50 million tonnes of which barren massive pyrite (iron sulphide mineral) bodies occupy most of the area and contain the largest sulphide tonnages. Zones containing sphalerite (zinc sulphide mineral) are present within the massive pyrite bodies, but are confined to a restricted vertical interval. All of the known significant sphalerite deposits are in horsts adjacent to the Keystone Graben. Galena (lead sulphide mineral) mineralization increases in the eastern ore zones.

The South Boundary Zone is wedge-shaped and consists of massive pyrite. The zone is controlled by the South Boundary Fault. The Main Ore Zone is an elongated, sinuous, lenticular body, hosted in carbonate, with a nearly horizontal upper contact. A number of bodies are irregular subvertical veins, while some other bodies underlie gently dipping shale contacts. These variations in structural style occur both in the massive pyrite and in the sphalerite zones.

Each of the sphalerite-rich ore bodies is confined to a restricted vertical interval that varies in thickness and elevation from zone to zone. Flat sulphide contacts cut at low angles across dolostone bedding and sulphides rarely follow the beds.

The Main Zone deposit is about 3 km long. It is oriented east-west, although it is sinuous in plan. The deposit is broadly 'T' shaped, with a flat-topped upper section that is typically about 100 metres wide and 20 metres high. A remarkable feature of this deposit is the constant elevation of the top of the deposit over its entire length. The keel section of the deposit extends to about 80 metres below the upper section. While it is subvertical, no obvious controlling structures have been recognized to date. In places, flat-lying “wings” of sulphides extend out laterally from the keel zone.

Internal structures in the ore zones tend to be complex, and range from massive and banded to chaotic or brecciated. Banding tends to be subhorizontal in both the upper section of the Main Zone and the keel section of the deposit, but it may be parallel to dipping dolostone contacts in some areas. As well, the ore is porous in places and large irregular zones of ice are present in some faces underground.

The accepted geological model is that the Nanisivik deposits are Mississippi-Valley Type. By definition, these are post-depositional, carbonate hosted deposits. Typically, they are coarse-grained and mineralogically simple. They tend to be sphalerite-rich, may be very large and may contain high base metal grades. However, Mississippi-Valley Type deposits include quite diverse deposits, different in shape, grade and mineralogy. This diversity appears to result from source fluid chemistry, rocks through which the fluids pass prior to deposition, source fluid temperature and the nature of the depositional environment.

2.4 Topography

The mine area consists of a few intermittent planar areas predominately surrounded by relatively steep high-relief hills rising out of Strathcona Sound.

The surface topography is moderately steep rising from sea level to a local high of 650 metres immediately west of the mine area ("Mount Fuji"). The approximate elevations of several areas around the minesite (Figures 2 and 3) are listed in Table A.

Table A: Approximate Elevations of Mine Facilities

Location	Approximate Elevation (m asl)
Industrial Complex	260
Town site	325
Freshwater storage tank	375
lower portion of West Twin disposal area (West Twin Lake)	370
Freshwater supply (East Twin lake)	372
01 Portal (main entrance to underground mine)	300
Oceanview Open Pit	260
Area14 mining area	450
Landfill/STOL air strip	360

asl = above sea level

2.5 Hydrology

The primary surface drainage in the mine area is Twin Lakes Creek, which drains the East and West Twin Lakes, town area and west adit area watersheds into Strathcona Sound as illustrated on Figure 2.

The release of decant water from West Twin Lake is manually controlled according to the mine operating plan for maintaining water cover over tailings in the Reservoir. Water flow exiting East Twin Lake is not artificially controlled 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 and the industrial complex site, as shown on Figure 3. Twin Lakes Creek enters Strathcona Sound west of the dock area.

Water quality in Twin Lakes Creek is significantly affected by runoff from the areas listed above and contains seasonally variable loadings of heavy metals. The potential sources of metals in Twin Lakes Creek have been extensively investigated by Nanisivik Mine and others and are considered to include both naturally occurring exposures of sulphides and mine activities.

Chris Creek is a smaller creek that drains surface water into Strathcona Sound from the watershed on the north side of the mine area. Specifically, surface run off from the East Adit area, waste rock piles, K-Baseline area and discharge from the east adit water treatment system enters Strathcona Sound via Chris Creek where water quality is also monitored.

Baseline studies indicated that neither Twin Lakes Creek nor Chris Creek supported fish populations prior to mine development due to steep gradients, waterfalls and generally unsuitable habitat. Baseline studies also indicated that neither East nor West Twin Lakes supported fish populations prior to mine development.

2.6 Vegetation

A 1974 baseline environmental study completed by B.C. Research Inc. 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 contain of the following species:

1. *Salix arctic*a (Arctic Willow);
2. *Dryas integrif*olia (Arctic or Mountain Avens);
3. *Carex rupestris* (Sedge);
4. *Ploygonum viviparum* (Alpine Bistort);
5. *Saxifraga oppositifolia* (Purple Saxifrage);
6. *Eriphorum* (Cottongrass);
7. Moss (several species);
8. Lichen (several species); and
9. Other vascular, bryophyte, lichen and moss species were also identified during the ground surveys.

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

Table B: 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 dryer 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 Mount Fuji, west of the (future) 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.

2.7 Soil

Soil studies were conducted by B. C. Research Inc. in conjunction with the 1974 vegetation mapping and reported that virtually no soil formation has occurred in the mine area. The little soil that has developed was found to be located primarily in alluvial plains where eroded and wind blown material have settled.

Soil moisture varied widely between the various types of ground cover. Soil in the Meadow area was wet with a water table near surface. Soil in the Mid Slope and Moss-Lichen areas was moist but no free water was observed. Soil in the Dry Ridge area was generally dry at surface although some isolated moist areas were also observed.

Soil texture was observed to vary widely based, primarily, on the underlying bedrock. Dolomitic rock was observed to produce a relatively small amount of fine material whereas shale was observed to produce abundant fine material. Sample sites were also noted as often having an unweathered surface "capping" overlying finer material.

Soil Geochemistry

Naturally occurring sulphide mineralization at surface is well documented throughout the mine area. Surficial soils in the area can be stained red due to oxidation. An extensive survey of metal concentrations in surficial soils throughout the mine area was conducted as part of mineral exploration activities in 1985. Samples were analysed for zinc, lead and copper at the on-site laboratory using a detection limit of 20 ppm. This data documents the range of metal concentrations that were present in surface soils in areas peripheral to mining actives as well as across some of the mineralized zones. Prior to this 1985 survey, tailings were deposited underwater in West Twin Lake such that the dispersion of wind blown tailings (that commenced around 1991) did not affect the results. In addition, the East Open Pit, K-Baseline and Oceanview mining areas were undeveloped at the time of the 1985 soil survey mining.

Results of the 1985 soil survey for total lead, zinc and copper concentrations are shown on Figure 4 along with results of geological mapping from the same time period showing the locations of natural exposures of gossan, highly mineralized and weathered bedrock occurrences.

The natural soils at Nanisivik generally displayed elevated metal concentrations when compared to generic CEQG CL and/or PL guidelines. The generic CEQG CL guidelines are 260 µg/g lead, 360 µg/g zinc and 91 µg/g copper and the PL soil quality objectives are 140 µg/g lead, 200 µg/g zinc and 63 µg/g copper.

Fully 63% of the soil metal concentrations shown on Figure 4 are greater than the PL guidelines for lead, zinc or copper. Lead concentrations, as shown on Figure 4 ranged from <20 ppm to 12154 ppm, with an average concentration of 227 ppm. Zinc concentrations ranged from <20 ppm to 3383 ppm, with an average concentration of 314 ppm and copper concentrations ranged from <20 ppm to 453 ppm with an average concentration of 64 ppm.

The area immediately northeast of the town of Nanisivik, from the fresh water supply tank to Twin Lakes Creek, is of particular relevance to the determination of natural metal concentrations in surface soils because it is an area containing a surficial trend of naturally occurring mineralized soil. Eleven soil samples were collected in this area, which contained metal concentrations that were, on average, greater than the CEQG CL and PL guidelines and that correlate with the mapping of natural exposures of a weathered and highly mineralized (gossan) zone on surface, as illustrated on Figure 4. Lead concentrations in these samples ranged from 48 ppm to 2296 ppm, with an average concentration of 662 ppm. Zinc concentrations ranged from 93 ppm to 1404 ppm, with an average concentration of 825 ppm.

2.8 Mammals

A quantitative evaluation of mammals in the mine area was attempted by B.C. Research Inc. 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.

2.9 Birds

Observations made by B.C. Research Inc. as part of the 1974 environmental baseline studies reported eight species of birds in the mine area: 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 three of the species observed in the mine area: 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 (mine personnel) and 1974 using Kuhulu Lake and some Meadow areas (Table B). 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 B.C. Research Inc as non-migratory.

3. Environmental Site Assessment Setting

3.1 Marine Sediments

3.1.1 1974 to 1992 Studies

The following summary of surface water quality is excerpted from the report "*Nanisivik Mine, 2001 Environmental Site Assessment and Proposal for Phase 2 ESA*", Gartner Lee Limited, February 28, 2002, which was submitted to the Nunavut Water Board in February 2002 as Appendix A to the CanZinco Ltd. report "*Nanisivik Mine, Closure and Reclamation Plan*", February 2002.

The concentrations of heavy metals in marine sediments in Strathcona Sound have been recorded in:

1. August 1974;
2. September 1975;
3. August 1979, August 1980 and August 1981;
4. June 1982;
5. June 1985; and
6. August 1992.

The studies of marine sediments confirmed that heavy metals are concentrated in the fine fraction of the sediment. Concentrations of zinc, lead and cadmium have been elevated in the near-field area as compared to areas more distant from Twin Lakes Creek in all of the studies (i.e. including the pre-operational studies). The reference areas are illustrated on Figure B.1 in Appendix B.

Metal concentrations have increased in the near-field area from the pre-operational studies to 1992.

The areas of interest (near-field to far-far-field) are illustrated on Figure B.1 in Appendix B.

August 1974 Study

Sediment samples were collected at 14 locations in Strathcona Sound in August 1974 by B.C. Research Inc. representing near-field (2 samples), mid-field (4 samples), far-field (2 samples), far-far-field (3 samples) and reference (3 samples) areas. Samples were collected using a dredge designed to collect sediment to a depth of 10 cm. Pebbles and visible organic fragments were removed from the samples prior to analysis.

Concentrations of zinc and lead were greatest in the near-field area at 171 and 19.3 mg/kg, respectively. Concentrations of arsenic, copper, iron and nickel were greatest, however, in various other areas (mid, far, far-far, reference) at 7.9, 27.9, 34,000 and 25.7 mg/kg, respectively. Concentrations of cadmium were all less than the method detection limit of 0.4 mg/kg. Metal concentrations were uniformly least at one far-

far-field location near the south shore of the Sound. The bottom sediments at this location were described to be sandy, which may relate to the lower metal concentrations as compared to clayey (i.e. finer grained) soils described for most other areas.

September 1975 Study

Sediment samples were collected at seven locations using an Ekman dredge covering near-field (1 sample), mid-field (1 sample), far-field (1 sample), far-far-field (2 samples) and reference (2 samples) areas. The depth of sediment collected is unknown with this methodology but is representative of the upper sediment layer at the water/soil interface. The samples were collected by the Geological Survey of Canada (GSC). The size fraction analysed was alternately <2µm, <180µm or whole sample.

The results confirmed the general expectation that heavy metals are concentrated in the fine fraction of the sediment. The results did not indicate any clear spatial trend with respect to near-field, mid-field and far-field areas. All results were generally within or close to the range in the reference area. The concentrations of zinc for all of the samples ranged from 50 µg/g (mid-field, whole sample) to 175 µg/g (near-field, <180µm).

August 1979, August 1980 and August 1981 Studies

Sediment samples were collected over three years by the Department of Fisheries and Oceans at a variety of locations. The sample locations covered near field (1 sample), mid-field (3 samples), far-field (1 sample), far-far-field (2 samples) and reference (4 samples) areas. Samples were collected using a corer but the reported methodology does not specify whether the cores were extruded and cut at discreet intervals or whether the same depth of sediment was analysed at each location. The size fraction analysed was <1.00 mm.

The results indicated that concentrations of zinc were elevated in the near-field area at 379 to 750 µg/g. The remainder of the zinc concentrations (including the mid-field area) ranged from 20 µg/g (far-far-field) to 135 µg/g (reference area). A similar spatial trend was also observed for lead and cadmium. No apparent consistent temporal trends from 1979 to 1981 were apparent.

June 1982 Study

The June 1982 study included sampling at 26 locations that covered near-field (6 samples), mid-field (16 samples), far-field (1 sample), far-far-field (1 sample) and reference (2 samples) areas. Samples were collected using a corer and the samples were extruded and cut (in the field) into discreet intervals for analysis. Analysis was performed on the size fraction less than 75 µm (#200 mesh sieve). The samples were collected by sampling through a continuous ice cover.

The sample results identified spatial and depth trends with greater concentrations of zinc, lead and cadmium observed near surface and proximal to Twin Lakes Creek. The interface (0-1 cm) concentrations of zinc in the near-field, mid-field, far-field and far-far-field areas were 1.81 to 25.09

mmol/kg, 1.30-3.93 mmol/kg, 1.52 mmol/kg and 1.34 mmol/kg, respectively. Two reference area samples contained 1.00 and 1.56 mmol/kg zinc in the 0-1 cm interval. Zinc concentrations were all less than 2.5 mmol/kg below 5 cm depth except at some of the near field locations. Nonetheless, the same spatial distribution was also observed for the 5-10 cm sample interval, although at lower concentrations than for the surface interval.

The 1992 study estimated sedimentation rates using three methods: Pb-210 dating, sedimentation trap data and hydrometric analysis. The estimates suggested that the annual sedimentation rate in Strathcona Sound would be expected to range from <1 mm to 6 mm. This range of sedimentation rates suggests that the spatial trend in metals observed in the 5-10 cm interval is indicative of the deposition of heavy metals prior to the commencement of mine activities (i.e. related to natural sources).

Electron microscopy of sediment particles indicated that sulphide particles were present but the methodology was unable to distinguish whether the particles originated as ore concentrates or as sulphide minerals eroded from surface exposures and transported into the Sound.

June 1985 Study

Sediment traps were set out at five locations in Strathcona Sound from December 1984 to June 1985. The locations covered near-field (2 samples) and mid-field (2 samples) areas. Two sediment traps were hung at two depths (approximately 20 m below surface and approximately 20 m above bottom) at each location.

Sedimentation rates were measured to average 8.3 $\mu g/cm^2/day$ with no significant variance between stations or with depth. The amount of sediment collected over the period of the study was suggested to represent approximately 2% of the minimal annual sedimentation load (0.5 mm/yr) that was estimated by a previous (1982) study. However, sedimentation rates vary seasonally and annually due to a wide variety of factors and the single set of measurements from 1985 are representative only of the controlling factors present at that time.

Particles were analysed for concentrations of zinc, lead and cadmium. Concentrations of zinc were greater in the upper trap than in the lower trap at all locations but concentrations of lead and cadmium did not display a consistent trend with depth. Concentrations of lead and zinc were slightly elevated in the near-field area, when taking into account the suggestion that the upper sample from one of the mid-field locations was suspected to be contaminated. Concentrations of cadmium did not display a clear spatial trend.

Microscopic examination of particulate matter indicated that there was there was “very little, if any” presence of particulates of lead and zinc concentrates in the sediment traps.

August 1992 Study

Sediment core samples were collected from 19 locations in August 1992 covering near-field, mid-field, far-field, far-far-field and reference areas. Sample cores were extruded and cut into discreet intervals in the field. Chemical analysis was conducted on the size fraction less than 75 µm. The complete report including data tables and appendices was not available but the synopsis text was used for this summary.

Average concentrations of zinc, lead and cadmium were elevated in the near-field and mid-field areas at 2,911 µg/g and 141-214 µg/g, respectively. Concentrations of zinc in other samples in Strathcona Sound ranged from 58-111 µg/g. The concentration of lead in the near-field area was 695 µg/g and was 36 µg/g at one mid-field locations. Other lead concentrations were generally below the detection limit of 3.0 µg/g.

Concentrations of zinc, lead and cadmium were relatively consistent with depth in the near-field area, indicating that sedimentation with metal rich particles had been occurring over the period represented by the sediment core. Concentrations of zinc and lead decreased with depth in the mid-field area. The report suggested that these trends may be related to a greater rate of sedimentation in the near-field area combined with increased contaminant load in the near-field area.

Sediment toxicity for select sample sites was tested using three standard tests described by Environment Canada:

1. 10-day acute lethality test using the amphipod Rheopoxinius abronius.
2. acute/chronic toxicity test using the bacterium *Photobacterium phosphoreum* (luminescence).
3. fertilization inhibition using the white sea urchin *Lytechinus pictus*.

Test results were compared to an artificial control sample and to a regional reference sample that was collected from the head of Strathcona Sound. Amphipod toxicity was the same for the reference sample and the test samples although toxicity was greater than in the artificial control sample. Some effects on bacterium bioluminescence were observed but these effects did not follow a clear spatial trend and were not greatest in the near-field or mid-field areas but the effects did not result in a “fail” of the test per Environment Canada requirements. Some variations in sea urchin fertilization rates were observed but confidence in the test was low because the results for the control sample were below the minimum recommended by Environment Canada for a useful test.

3.1.2 2000 Study

Six locations in Strathcona Sound were sampled for sediment metal concentrations in September and October 2000 by Dr. Bo Elberling of the University of Copenhagen with in-kind support from CanZinco Ltd. The sample locations included 2 samples in each of the near-field, mid-field and far-field areas. Sediment was collected in intervals of 0.5 cm or 1.0 cm to depths ranging from 20.5 cm to 37.5 cm. The depth of water at the sample locations ranged from 42.8 m to 177 m. The sampling locations are illustrated on Figure B.1 and summarized on Tables B.1 to B.6 in Appendix B.

Sedimentation Rate

Lead isotope dating of sediment cores was used to estimate the depth at which sediments representative of the year 1970 were located (i.e. as an approximation of the pre-mining/post-development timeframes).

The results indicate that the depth of sediment representative of post-1970 deposition for station 1.3, located 82 m from the mouth of Twin Lakes Creek was 7.5 cm or 0.25 cm per year. The depth of sediments representative of post-1970 deposition for the remaining five stations, located further from Twin Lakes Creek in deeper water, ranged from 1.75 to 3.75 cm or an average of 0.1 cm per year.

The indications of the 2000 lead isotope dating are consistent with the suggestion of the June 1992 study that the rate of sedimentation in Strathcona Sound would be expected to range from 0.1 to 0.6 cm per year.

The indications of the 2000 lead isotope dating are also consistent with the observed concentrations of metals at some locations, as described below.

Metal Concentrations

The concentrations of some metals (especially lead and zinc) are elevated in the upper, post-1970 deposition sediment as compared to the lower, pre-1970 sediment at most stations. This trend is most pronounced for locations 1.3 and 10.2, located closest to Twin Lakes Creek, and the clarity of the trend diminishes with distance from Twin Lakes Creek. This trend is most pronounced for lead and zinc but is also apparent for iron, manganese and calcium. This trend is not apparent, even at stations 1.3 and 10.2, for copper, nickel and potassium.

Within the upper, pre-1970 deposition sediment, there is not a consistent trend with depth for the various stations. For example, at station 1.3 closest to Twin Lakes Creek, the maximum concentrations of lead and zinc occur at approximately ¾ depth within the upper sediment. At location 10.2, however, concentrations of lead and zinc generally decrease with depth within the upper sediment.

The concentrations of some metals within the upper, post-1970 deposition sediment decreased with distance away from Twin Lakes Creek. The average concentration of zinc, for example, in the upper sediment decreases from 1,478 mg/kg at station 1.3 closest to Twin Lakes Creek to 75 mg/kg at station 51.1 furthest form Twin Lakes Creek.

The concentrations of some metals also decreased in the lower, pre-1970 sediment with distance from Twin Lakes Creek. For example, the concentration of zinc ranged from 174 mg/kg to 345 mg/kg at station 1.3 closest to Twin Lakes Creek and from 50 mg/kg to 71 mg/kg at location 51.1 furthest removed from Twin Lakes Creek.

3.2 Air Quality/Dust Monitoring

3.2.1 Sampling Installations

CanZinco Ltd. operated and monitored three air samplers on the mine property (Figure 2) as summarized in Table C.

Table C: Dust Monitoring Installations

Sampler	Location	Type	Period of Record	Data Available
AS1	Intersection of town and dock access roads	HiVol PM10; 24 hr/6 days	May 1997 to May 2001	TRP, heavy metals
AS2	near potable water tank	HiVol; 24 hr/6 days	November 1997 to May 2001	TSP, heavy metals
AS3	south side of West Twin Disposal Area	HiVol; 24 hr/6 days	May 1998 to May 2001	TSP, heavy metals

"TRP": total respirable particulates

"TSP": total suspended particulates

The monitoring devices collected a 24 hour composite sample on a six day cycle basis, by vacuuming air through a filter such that particulate matter was retained on the filter. The six day cycle collection protocol was established by CanZinco Ltd. in consultation with Environment Canada and was intended to remove any bias from weekly schedules (i.e. specific days of the week could have routine activities scheduled that would bias the results according to that activity).

Sampler AS1 is a "PM10" sampler and retains particulate up to 10 microns in size, which is commonly referred to as total respirable particulate ("TRP"), whereas samplers AS2 and AS3 retain all air borne particulates. Therefore, the results of analyses are not directly comparable between AS1 and AS2/AS3 because of the differing sample collection methods.

The quantity of retained particulates was routinely determined. Analysis of heavy metals was also conducted on a sample by sample basis based, in part, on the quantity of particulate present. The measured quantities of particulates are listed in Tables C.1, C.2 and C.3 and illustrated on Figures C.1, C.2 and C.3 (located in Appendix C) for samplers AS1, AS2 and AS3, respectively. The measured concentrations of metals in particulates are listed in Tables C.4, C.5 and C.6 for samplers AS1, AS2 and AS 3, respectively, and illustrated on Figures C.4 and C.5 for samplers AS1 and AS2, respectively. An illustration of metal concentrations for sampler AS3 is not provided since the number of metals analyses conducted at AS3 is fewer than for the other samplers.

3.2.2 Summary of Particulate Concentrations

The concentrations of TRP measured at AS1 from May 1997 to May 2001 ranged from zero to 105 $\mu g/m^3$ (24 hour period). The reference level for PM10 particulate concentrations published in Federal guidelines is 25 $\mu g/m^3$ (24 hour period). The published reference level is stated to be the scientifically determined level above which adverse effects to human or environmental receptors may be expected but does not take into account any risk assessment. A total of 17 of 200 samples (8%) exceeded the guideline. No temporal trends are apparent for TRP at AS1 (Figure C.1).

The concentrations of TSP measured at AS2 from November 1997 to May 2001 ranged from zero to 51.9 $\mu g/m^3$ (24 hour period). The federal air quality objective for TSP is presented in two forms: the "acceptable level" is 120 $\mu g/m^3$ and the tolerable level is 400 $\mu g/m^3$. These are expressed as National goals for outdoor air quality that incorporate risk assessment. None of the concentrations of TSP measured at AS2 exceeded the objectives. No temporal trends are apparent for TRP at AS2 (Figure C.2).

The concentrations of TSP measured at AS3 from May 1998 to May 2001 ranged from zero to 33.9 $\mu g/m^3$ (24 hour period). The federal air quality objective for TSP is presented in two forms: the "acceptable level" is 120 $\mu g/m^3$ and the tolerable level is 400 $\mu g/m^3$. These are expressed as National goals for outdoor air quality that incorporate risk assessment. None of the concentrations of TSP measured at AS2 exceeded the objectives. A trend of decreasing TSP concentration with time is apparent at AS3 (Figure C.3).

3.2.3 Summary of Metal Concentrations

Metal concentrations at AS1 display no clear temporal trends, although the concentrations of lead and zinc were greatest in 2001. Iron is typically greater than zinc, lead or cadmium, with lead and cadmium typically at very low levels (Figure C.4). Correlations between iron, lead and zinc are good (linear correlations > 0.9) while correlations with cadmium are slightly weaker (linear correlations from 0.79 to 0.83). The correlation between TRP and metals is generally good (from 0.80 to 0.89) with cadmium being the weakest (0.80).

Metal concentrations at AS2 display no clear temporal trends. Iron is typically greater than zinc, lead or cadmium by at least two orders of magnitude (Figure C.5). Concentrations of zinc were uniformly reported at the detection limit. Correlations between metals is generally poor with only the iron/lead correlation showing a weak correlation (linear correlation of 0.63). The correlation between TSP and metals is poor with a maximum linear correlation of only 0.44 for lead.

Few metal analyses were conducted for location AS3 to assess temporal trends. Iron is typically greater than zinc, lead or cadmium by at least one order of magnitude (Table C.3). Concentrations of zinc were uniformly reported at the detection limit. Correlations between metals is generally poor except for the iron/lead correlation which was excellent (linear correlation of 0.98). The correlation between TSP and metals is poor with a maximum linear correlations of only 0.61 for lead and 0.53 for iron.

3.2.4 Summary of Observations

The following summary observations can be drawn from a review of the information presented above:

- Direct comparison of results can not be made between locations AS1 and AS2/AS3 due to differing sample collection methods;
- Particulate levels (TRP) at location AS1 occasionally exceeded the Federal guideline;
- Particulate levels (TSP) at locations AS2 and AS3 were below Federal objectives;
- Particulate levels at location AS3 generally decreased with time (over the period of record);
- Iron was present in the highest concentrations at all three locations;
- The linear correlation for iron/lead was stronger than for other metals at all three locations;
- Location AS1 also showed a strong linear correlation for lead/zinc and iron/zinc which was not present at locations AS2 and AS3;
- The correlation between TRP and metals was good for all metals (zinc, iron, lead and cadmium) at location AS1; and
- The correlation between TSP and metals was poor at locations AS2 and AS3 although the correlation for TSP/lead was stronger than for the other metals at both locations.

3.3 Surface Water Quality

The following summary of surface water quality is excerpted directly from the report "*Nanisivik Mine, 2001 Environmental Site Assessment and Proposal for Phase 2 ESA*", Gartner Lee Limited, February 28, 2002, which was submitted to the Nunavut Water Board in February 2002 as Appendix A to the CanZinco Ltd. report "*Nanisivik Mine, Closure and Reclamation Plan*", February 2002.

3.3.1 Summary

A great deal of surface water quality data is available. B.C. Research Inc. (BCRI) conducted initial baseline studies 1974. Nanisivik Mine conducted sampling per the terms of the Water License throughout the mine life. Additionally, discreet comprehensive studies have also been undertaken at times that collected detailed information in one area or over one time period.

The most important of the studies carried out in excess of the Water License Surveillance Network Program are a series of metal loading studies in Twin Lakes Creek. The first of these studies was conducted by Indian and Northern Affairs Canada (INAC) in 1987 and 1988. Nanisivik Mine has conducted an annual metal loading study since 1995 and has reported these to the Nunavut Water Board. The most recent of these studies (for the year 2000) provides observations and conclusions of recent years and is a recommended accompaniment to this summary document.

The general observations provided by the water quality studies is that metal loadings entering Strathcona Sound from Twin Lakes Creek increased as a result of mine activities, even in light of the elevated concentrations of metals that pre-existed the mine. The studies show that the dominant source of the metals is run off in the west adit area, which includes both naturally occurring and anthropogenic sulphide exposures. Concentrations of zinc and cadmium generally follow similar trends with maximum concentrations typically observed in the west adit/mill area that are greater than the concentrations at the mouth of the creek. The record of compliance with the Water License maximum allowable discharge limits at the decant from West Twin Lake has been excellent over the life of the mine.

The most recent (year 2000) metal loading study in Twin Lakes Creek indicates that there are typically two peaks in metal loadings in Twin Lakes Creek. An early summer peak may be related to early season thawing and release of stored water from rock dumps comprised of coarse materials. A late summer peak may be related to the release of stored water from natural soils and natural exposures of sulphides. The late summer peak includes peak iron loadings and is typically accompanied by orange staining in many local creeks (including Twin Lakes Creek and Strathcona Creek) due to the release of iron stored in surface soils.

3.3.2 Individual Water Quality Studies

July 1974 Study

A suite of surface water samples was collected by BCRI in late July 1974 from 12 locations that included Twin Lakes Creek, Chris Creek and other streams in the area on both the north and south shores of Strathcona Sound. Samples were also collected at 2 depths (surface and bottom) in Kuhulu Lake and at 3 depths (surface, middle and bottom) in East Twin Lake and West Twin Lake (2 locations). The samples were analysed for dissolved concentrations of zinc, lead, arsenic, cadmium and iron.

The metal concentration data generally indicates that metal concentrations in Twin Lakes Creek and Chris Creek were elevated above reference locations and that the metal concentrations in Chris Creek were generally greater than in Twin Lakes Creek. The greatest concentrations of zinc, arsenic and cadmium were alternately measured in a tributary to Twin Lakes Creek north of the (future) townsite and a tributary to Chris Creek near the (future) east adit area. The metal concentrations in Kuhulu Lake, East Twin Lake and West Twin Lake were similar to the reference locations.

Zinc concentrations at all reference locations (i.e. excluding Twin Lakes Creek and Chris Creek and their tributaries) ranged from 9.0 to 40 µg/L. This includes all of the samples from Kuhulu Lake, East Twin Lake and West Twin Lake. Strathcona Creek located on the north side of Strathcona Sound approximately opposite the mine area contained 90 µg/L zinc. One tributary to West Twin Lake on the northwest side contained 80 µg/L zinc.

The water samples from Twin Lakes Creek and Chris Creek and their tributaries contained greater concentrations of zinc than other locations. The highest concentration was measured in a tributary to Twin Lakes Creek north of the (future) town site and was 54,000 µg/L. The second greatest concentration of zinc measured was a tributary to Chris Creek near the (future) east adit area and was 15,000 µg/L. The concentrations of zinc at the mouths of Chris and Twin Lakes Creeks were 700 µg/L and 150 µg/L, respectively.

The spatial variability of lead concentrations was generally similar to that for zinc. The exception was that the concentration of lead at the mouth of Twin Lakes Creek was the same as observed at the reference locations (range from 0.7 µg/L to 1.0 µg/L). The greatest concentration of lead measured was in the northwest tributary to West Twin Lake at 110 µg/L. Lead in Strathcona Creek was slightly elevated at 2.0 µg/L. The concentration of lead at the mouth if Chris Creek was slightly elevated at 1.6 µg/L.

The spatial variability of cadmium was generally similar to that for zinc and lead. The exception was that the concentration of cadmium in the northwest tributary to West Twin Lake was the same as at the reference locations (range from 0.1 to 0.3 µg/L). The greatest concentration of cadmium measured was in the tributary to Twin Lakes Creek north of the (future) townsite at 140 µg/L. The concentrations of cadmium at the mouths of Chris and Twin Lake Creeks were slightly elevated at 2.2 and 0.4 µg/L, respectively.

The spatial variability of iron was different than that for zinc, lead and cadmium in that all of the sample locations save two were within the range from 3.4 to 49.0 µg/L including all of the lake samples. The highest concentration was measured in the tributary to Twin Lakes Creek north of the (future) townsite at 3,350 µg/L. Strathcona Creek was also slightly elevated at 100 µg/L.

Samples were also collected at the mouth of Twin Lakes Creek by FMS in 1974, 1975 and 1976 (one sample per year reported that are assumed to have been collected in summer in conjunction with other environmental studies). These samples contained dissolved zinc concentrations of 223, 236 and 47 µg/L in 1974, 1975 and 1976, respectively. These concentrations are in general agreement with the sampling by BCRI as described above wherein the concentration of dissolved zinc at the mouth of Twin Lakes Creek was measured to be 150 µg/L in July 1974.

1982 Study

Surface water samples in East Twin Lake, West Twin Lake and Twin Lakes Creek were collected on 4 occasions in June, July and August 1982. The samples included Twin Lakes Creek at the outflow from the West Twin Disposal Area, on Twin Lakes Creek upstream of the west adit area, approximate mid-point on Twin Lakes Creek downstream of the mill and at the mouth of Twin Lakes Creek. It is assumed that the samples were filtered and preserved in the laboratory and subsequently analysed within 4 months, although this is not explicitly stated. In this case, the metal concentrations reported are dissolved concentrations although the timeframes between sampling and filtering/preservation and subsequent analysis introduces some uncertainty into the evaluation of results.

The sample results illustrated that the dominant source of metals entering Twin Lakes Creek was from the west adit area. However, sampling was not detailed to the degree of differentiating between individual sources (rock dumps, outcrops, etc.) in the west adit area. The greatest concentrations of metals were commonly observed at the sample location located immediately downstream of the mill. The concentrations of zinc at the mouth of Twin Lakes Creek ranged from 3.63 mmol/m^3 to 135 mmol/m^3.

June 1985 Study

One sample was collected at the mouth of Twin Lakes Creek in June 1985 as part of a seawater quality assessment. This sample returned a zinc concentration of 12 mmol/m^3 zinc and 0.012 mmol/m^3 lead.

INAC Studies, 1977 to 1988

This report summarized the water quality information that had been gathered from 1977 to 1988. The available data was primarily gathered as part of the Surveillance Network Program but also included special detailed sampling that was conducted from 1981 to 1984 in the west adit area.

The data indicated that decant (outflow) from West Twin Lake represented a minor percentage of zinc (<1% in 1982) and cadmium (14% in 1982) entering Strathcona Sound. The majority of the loadings of zinc and cadmium entered Twin Lakes Creek in the mid-creek/west adit area where maximum concentrations were observed. The concentration of lead in Twin Lakes Creek water progressively decreases with distance downstream, which suggests that lead may be bound to suspended particles that settle out along the length of the creek.

Specific detailed investigations of sources of metal were undertaken in 1982. A naturally occurring outcrop of massive sulphides in the west adit area resulted in a small flow of extremely poor quality drainage with pH around 2 and zinc around 15,000 mg/L. A gossan zone near the townsite on the south side of Twin Lakes Creek resulted in a small flow of drainage with pH around 5 and "high" metal values (not reported). Flow through the west open pit that entered Twin Lakes Creek until 1982 (then diverted to the mill) was measured to have pH around 2 and zinc as high as 1,000 mg/L. A reduction in zinc and cadmium concentrations in Twin Lakes Creek from 1982 to 1984 was attributed to this diversion. The report recognizes that this flow would include seepage and runoff passing over both naturally mineralized areas and mining disturbed areas. Waste rock piles, vehicle wash area and drainage from the lower west portal were also investigated and concluded to have a negligible effect in Twin Lakes Creek.

2000 Twin Lakes Creek Metal Loading Study (Nanisivik Mine)

An annual study of metal loadings in Twin Lakes Creek has been undertaken since 1995. The studies have involved detailed sampling along the length of Twin Lakes Creek and flow monitoring at the mouth. The 2000 metal loading study as prepared by Nanisivik Mine was submitted to the Nunavut Water Board in early 2001 and contained the following observations:

1. Zinc concentrations and loadings exiting the West Twin Lake tailings containment area are a very minor contributor to metal loadings in Twin Lakes Creek.
2. Zinc concentrations and loadings generally increase from the East/West Twin Lakes area to Strathcona Sound with the greatest concentrations observed at various times in proximity to certain rock dumps and natural outcrops of massive sulphides.
3. An early season (spring) spike in zinc concentrations occurs in proximity to rock dumps, which is considered to be related to the melting of snow and ice and subsequent flushing of rock dumps.

4. A second spike in zinc concentrations occurs in proximity to a natural sulphide outcrop, which is considered to be related to slower (as compared to rock dumps containing very coarse material) melting of snow and ice and subsequent runoff from natural soils.
5. The late season spike in zinc concentrations is accompanied by high iron concentration, which is also considered to be related to natural runoff and the thawing of surface soils.
6. The high late season iron concentrations result in a visible orange discolouration of the creek water and staining of creek sediments in Twin Lakes Creek and other local creeks.

3.4 Acid Rock Drainage Testing

3.4.1 Summary

The following summary of acid rock drainage testing is excerpted from the report "*Nanisivik Mine, 2001 Environmental Site Assessment and Proposal for Phase 2 ESA*", Gartner Lee Limited, February 28, 2002, which was submitted to the Nunavut Water Board in February 2002 as Appendix A to the CanZinco Ltd. report "*Nanisivik Mine, Closure and Reclamation Plan*", February 2002.

An investigation of the potential for acid rock drainage from tailings and from the proposed shale rock cover material was conducted by Lorax Environmental and reported on in "Acid Generation Potential of Tailings and Shale Cover Material" dated September 1999. This study confirmed that the tailings are potentially acid generating and that zinc is the metal of primary concern. The study indicated that the shale rock that was used for construction of the dyke and that is proposed for the tailings cover is geochemically benign or acid consuming.

A follow up study by Lorax Environmental investigated the potential for acid rock drainage from soil, waste rock, roads, pit walls and tailings and was reported in "Acid Generation Potential of Soil, Waste Rock and Shale" dated April 2001. This study conducted static tests on approximately 88 samples collected in 1997. The test results indicated that all samples, including tailings and waste rock, contained a relatively high neutralization potential due to the calcareous nature of the local country rock. The tailings, 00 rock dump and K-Baseline rock dump were indicated to be potentially acid generating. Most other rock dumps and pit walls were indicated to be possibly acid generating although acid generation from these locations was suggested to be unlikely given the relatively high neutralization potential and cold climate. All of the shale quarries, the shale rock used in construction of the tailings containment dyke and soil in the West Twin Lake area were indicated to have a positive net neutralization potential (i.e. acid consuming).

3.4.2 Tailings and Shale

The following summary of acid rock drainage testing of tailings and shale is excerpted from the report "*Nanisivik Mine, Reclamation Cover Design for Nanisivik Mine West Twin Disposal Area Surface Cell*", Gartner Lee Limited, March 8, 2002, which was submitted to the Nunavut Water Board as Appendix B to the CanZinco Ltd. report "*Nanisivik Mine, Closure and Reclamation Plan*", February 2002.

Acid generation and acid consumption potentials for tailings and shale have been investigated by Lorax Environmental. A report titled "Acid Generation Potential of Tailings and Shale Cover Material" dated September 1999 describes metals analysis, acid base accounting, mineralogical examination, grain size analysis and humidity cell testing. The samples investigated were tailings collected from the WTDA Surface Cell and shale collected from the West Twin Dyke. A second report titled "Acid Generation Potential of Soil, Waste Rock and Shale" dated April 2001 presents acid base accounting of additional samples of tailings from the WTDA Surface Cell (3 samples), shale from the West Twin Dyke (7 samples), shale from the East Twin Lakes borrow area (10 samples), shale from the Mt. Fuji borrow area (10 samples) and shale from the Area14 borrow area (11 samples).

The determinations of total metals in tailings were: iron (25.2%), zinc (2,610 ppm), lead (406 ppm), cadmium (4.5 ppm) and silver (6 ppm), which were greater than metals in shale and typical concentrations in the earth's crust.

The acid base accounting analyses confirmed that the tailings are potentially acid generating. The tailings samples contained high concentrations of total sulphur (39.5 to 48.0%) of which most was in the form of sulphides (39.3 to 45.5%). The tailings samples contained some neutralizing potential (79 to 237 kg$CaCO_3$/t) that was primarily in the form of carbonates (72 to 232 kg$CaCO_3$/t). The resulting net neutralization potential for tailings was negative (–997 to –1419 kg$CaCO_3$/t) and the resulting NP/AP ratio was much less than one for all samples (0.05 to 0.19), which demonstrates that their classification as potentially acid generating.

The acid base accounting analyses confirmed that the shale is acid consuming. The shale samples contained low concentrations of total sulphur (0.11 to 2.34%) of which most was in the form of sulphides (0.09 to 2.10%). The shale samples contained large neutralizing potential (315 to 600 kg$CaCO_3$/t) that was primarily in the form of carbonates (224 to 593 kg$CaCO_3$/t). The resulting net neutralization potential for tailings was large and positive (+373 kg$CaCO_3$/t) and the resulting NP/AP ratio was much generally greater than one (4.7 to 49.2), which demonstrates their classification as acid consuming.

The mineralogical analysis indicated that sulphides in the tailings sample consisted primarily of pyrite (80%) with trace amounts of marcasite and sphalerite. Calcite (crystallized carbonate) comprised the majority of the remainder of the sample with minor quartz grains. The shale sample consisted primarily (>90%) of carbonate rock that was considered to probably be dolomite. The remainder of the shale sample consisted of bituminous material (2.5%), quartz (2%), microdiorite (1%) and sulphides (0.5%).

Grain size analyses demonstrated that the shale was generally within the size ranges for sand and gravel with approximately 45% finer than 2 mm (i.e. coarse sand and finer) and approximately 90% finer than 6mm (i.e. pebble and finer). The sample of tailings was generally within the size ranges for silt and sand with approximately 81% finer than 0.2 mm (i.e. fine sand and silt) and 100% finer than 2mm (i.e. coarse sand and finer).

Humidity cell tests were conducted for 35/37 weeks for one sample each of tailings/shale. The tests were run at 20°C for 26/28 weeks and then at 2°C for the remainder of the test to determine the effect of colder temperatures. The primary observations of the tests are as follows:

1. Leachate remained neutral (pH>7.5) throughout the test for both samples;
2. Sulphate production rates from the tailings sample were generally steady throughout the test but became reduced by approximately 50% at the time of switching to the colder temperature; the calculated rate of carbonate depletion did not vary with temperature;
3. Sulphate production rates from the shale generally decreased throughout the test and were not clearly affected by the decrease in temperature; the calculated rate of carbonate depletion increased slightly throughout the test and was not clearly affected by the reduction in temperature;
4. Calcium and magnesium were released at rates of at least two orders of magnitude greater than other metals in both the tailings and the shale sample; and
5. Zinc was released at the greatest rate from tailings sample, which was approximately 2 orders of magnitude greater than other heavy metals.

The general conclusions of the humidity cell tests were:

1. The tailings sample was confirmed to be potentially acid generating (neutralization depletion rate faster than acidity);
2. The shale sample was confirmed to be acid consuming (sulphate depletion faster than neutralization);
3. Zinc is the most mobile metal in the tailings; and
4. Both samples were confirmed to have neutralizing potential present primarily in the form of carbonates.

3.5 Possible Contaminants and Potential Areas of Concern

3.5.1 2001 Environmental Site Assessment

The report, *Nanisivik Mine 2001 Environmental Site Assessment and Proposal for Phase 2 ESA (*Gartner Lee Limited, 2002) (the "2001 Environmental Site Assessment") provides a listing and summary of previous environmental studies related to the Nanisivik Mine. This report was included in the 2002 Closure and Reclamation Plan as Appendix A.

The summary of information in 2001 Environmental Site Assessment was used as a reference for the determination of possible contaminants of concern ("PCOC's") and areas of potential environmental concern ("APEC's").

3.5.2 Possible Contaminants of Concern

On the basis of the information provided in the 2001 Environmental Site Assessment concerning industrial activities and storage, use, and disposal of chemicals as well as contaminant observations during the field investigations, the potential chemicals of concern at the mine site would include: metals, predominantly lead and zinc, resulting from the mining, milling and concentration of ore; and, petroleum hydrocarbons from fuel storage, dispensing and disposal. Other chemicals of potential concern include: arsenic, cadmium, copper, ethylene and propylene glycol; calcium chloride; ammonium nitrate; and process chemicals including: potassium amyl xanthate, methyl isobutyl carbinol and copper sulfate.

3.5.3 Areas of Potential Environmental Concern

On the basis of the review of site information presented in the 2001 Environmental Site Assessment and a detailed inspection of current site conditions at the Nanisivik Mine site, several areas of potential environmental concern (APECs) have been identified.

Surface soils around the mine site may be contaminated with metals and hydrocarbons that originated from mine activities. Some mining related sources of metals in surface soils may be: tracking of concentrates in vehicles tires, air dispersion of concentrates, air dispersion of tailings dust, spillage of concentrates at the ship loading dock, or tailings pipeline breaks or drainage. Some mining related sources of hydrocarbons in surface soils may be: spillage during offloading of ships, pipeline breaks, spillage during filling small mobile tanks or spillage from stationary tanks.

The primary areas where metal contamination related to mining activities might be expected to be identified are:

- Mill yard;
- Warehouse yard;
- Road from mill to concentrate storage shed;
- Dock/ship loading area;
- Downwind of the WTDA;
- Tailings pipeline route, including “dump ponds”; and
- Town site.

The primary areas where hydrocarbon contamination related to mining activities might be expected to be identified are:

- Tank farm at dock;
- Fuel supply pipeline route; and
- Various fuel storage tanks, including the carpenter’s shop.

4. Site Development and Operations

4.1 Description of Facilities and Mining Activities

4.1.1 Town and Related Facilities

The town, as shown on Figure 3, consists of approximately 50 small houses, several apartment/bunkhouse buildings, a recreation centre complete with swimming pool, a cook/mess building, a church, a school, an arena, a fire hall, a library, a post office and various garages and shops for maintenance equipment.

CanZinco Ltd. owns much of the town facilities and infrastructure. The Government of Nunavut owns several houses and some public infrastructure buildings such as the school and various maintenance garages and maintenance equipment. The Government of Nunavut also owns the freshwater and sewage systems.

The buildings are heated by oil fired furnaces with each building served by an individual supply tank. The typical arrangement is one 100 gallon above ground tank per house. Buildings are typically wood frame construction and are generally in the order of 25 years old, Photograph 5. Maintenance garages are sheet metal construction or quonset hut construction.

4.1.2 Industrial Complex and Related Facilities

General Description

The Industrial Complex includes the mill, warehouse, administration offices, maintenance shops, power house, dense media separation ("DMS") plant, loadout building, compressor building, mine rescue building, outdoor warehousing yards, warm storage, cold storage and related laydown and parking areas, as shown on Figure 3 and in Photograph 6. A dry/shower facility, lunch room, first aid facility and assay laboratory are also included in the industrial complex building.

The outdoor storage and laydown yards include miscellaneous small buildings/sheds, waste oil tank and the diesel fuel delivery system for the diesel electric power plant and other ancillary uses.

Mill Process

The concentrator plant is a conventional grind/flotation plant that produces two mineral concentrates from sulphide ore. The DMS plant, constructed in 2000/2001, is a pre-concentration process step that removes gangue material from the ore before it enters the mill circuit. Other major mill equipment includes: flotation cells, pumps, piping, cyclones, grinding mills, thickeners, dewatering filters, air compressors, blowers, vacuum pumps, controllers/instrumentation and electrical wiring.

The mill had a proven capability of processing 780,000 tonnes per year using conventional crushing, rod and ball mill grinding, differential lead and zinc flotation, and concentrate drying. Waste heat from the diesel power generators heated the buildings and dries the concentrates. Run-of-mine ore was crushed in an underground jaw and cone crusher circuit. The crushed ore was stored underground to prevent thawing. From the underground bin the ore was conveyed to the mill where it was pre-concentrated in the DMS circuit to remove waste rock from the ore. The up-grade ore passed through a rod and ball mill circuit to liberate the contained minerals, prior to reagent addition and selective flotation for lead and zinc. Lead and zinc flotation concentrates were thickened, filtered and dried in rotary dryers to about 5% moisture, using waste heat from the power plant. The concentrates were trucked approximately three kilometres to the 125,000 tonne capacity storage shed at the dock site.

Flotation tailings were pumped through a four kilometre pipeline to the West Twin disposal area (WTDA). Process water for the mill was recycled from the Reservoir portion of the tailings disposal area.

Chemicals used in the mill as process reagents were as follows:

- Lime (2300 g/t) was used to modify the ground ore so pyrite (iron sulphide) particles were not recovered in the marketable concentrates;
- Xanthate (100 g/t) was used in the flotation circuits to coat the selected particles (lead and zinc bearing) so that they were recovered in the flotation process;
- Methyl Isobutyl Carbinol (MIBC) (3 g/t) was used to stabilize the air bubbles (froth) in the flotation circuit so that the recoverable mineral will float; and
- Copper Sulphate (500 g/t) was used to activate the surface of a sphalerite particle so that it could be floated and recovered in the zinc circuit.

The reagents were shipped to the site by ocean freighter and transferred to land for outdoor storage. The mill reagents were stored outside in a designated area adjacent to the concentrate storage shed. Reagents were transported to the mill in weekly allotments and mixed/dispensed from a specific area in the mill where all spills were collected in a designated sump for subsequent reuse in the milling operation.

4.1.3 Dock and Related Facilities

The dock facilities that are owned by Nanisivik Mine include: the concentrate storage shed, the ship loading conveyor, the fuel tank farm and the reagent storage/laydown yard. The concentrate storage shed is approximately 225 metres X 35 metres. The tank farm consists of 15 tanks varying in capacity from 100,000 litres to 10,000,000 litres, as shown on Figure 3 and Photograph 7.

The concentrate handling system consists of truck haulage of concentrates from the mill to the storage shed. Front end loaders may rehandle and repile concentrates within the shed and, ultimately, load the concentrates onto the ship loading conveyors. The ship loading conveyor was enclosed in 1982 to minimize concentrate losses to the environment. There is a possibility of surficial contamination of road material by tracking or spillage of concentrates in haulage areas.

The tank farm was used to store diesel fuel for use in mine activities and home heating, jet fuel and gasoline. Jet fuel was stored and delivered to the jet airport by mine personnel on a contract basis for the Government of Nunavut. Diesel fuel was stored and provided to the Canadian Coast Guard for refueling of ships. A diesel fuel supply pipeline runs from the tank farm at the dock to the mill yard day tanks and dispensing facilities. Gasoline was dispensed from a fuel pump at the tank farm and was also trucked to a dispensing tank located in the mill yard.

The Government of Canada owns the dock itself. The dock and dock area are used by the Canadian Coast Guard as a storage depot for marine environmental emergency response equipment.

4.1.4 Tailings Disposal and Fresh Water Supply Facilities

Fresh Water Supply System (East Twin Lake)

Water is pumped from East Twin Lake to a freshwater supply tank located on a hill above the town and subsequently distributed to the town and the mill. A relatively small quantity of fresh water was required for the processing system in the mill (less than 10% of the water usage).

Outflow from the lake is not manually controlled but is passed through a short diversion channel (the East Twin Diversion Channel) prior to mixing with water from the WTDA. The diversion channel ensures that mixing of water from East Twin Lake with water from the WTDA reservoir takes place below the WTDA decant control structure.

A hydrogeological assessment that was completed in 2000 confirmed that there is no subsurface hydraulic connection that would allow subsurface water flow from the WTDA tailings disposal facility (formerly West Twin Lake) into East Twin Lake. The study also verified that the permafrost is intact between the two lakes. The water elevation in West Twin Lake is manually maintained below that in East Twin Lake to provide increased environmental protection.

West Twin Disposal Area (WTDA)

Process tailings were pumped from the mill to the WTDA. Tailings were deposited under a water cover in West Twin Lake until 1990, at which time a frozen core dyke was constructed of tailings and shale that divided the lake into two approximately equal sections. The dyke was built in annual upstream lifts of approximately 2 metres each to ensure permafrost aggradation. The dyke is currently 18 metres high and 800 metres in length. Tailings deposition at the toe of the dyke provides increased physical stability for the structure. Tailings have been confirmed to possess the potential to produce acid rock drainage under certain environmental conditions.

Tailings were deposited subaerially (exposed) in the upper containment area (the "surface cell") according to a strategic plan that ensures the maximum utilization of the available storage capacity.

Water was decanted from the upper surface cell to the lower “reservoir” via syphon pipes and pumping. The water was largely clear due to rapid settlement of solids.

The lower containment area (the “reservoir”) contains subaqueous tailings that are covered with water and a relatively small amount of tailings that are exposed in a reclamation test cell area and around the littoral area of the reservoir. Water was pumped from the reservoir to the mill for reuse in the concentrator process. The water elevation in the reservoir is manually controlled at a valved discharge structure where water is released to Twin Lakes Creek. The water elevation is managed in such a way to maintain adequate water supply for the reclaim pumping system and to maintain at least one metre over the subaqueous tailings. The water level is also managed to remain below the water elevation in East Twin Lake as a means of reducing the possibility for subsurface flow from the WTDA to East Twin Lake.

The reclamation test area (the “test cell”) is located within the lower containment area separated from the wet reservoir by a small (approximately 4 metres high) dyke constructed of tailings and shale. The test cell area has been used to evaluate the efficiency of various materials and methods of placement as the reclamation soil cover on exposed tailings.

Wind dispersion of tailings particles has been an issue of environmental concern in recent years. Wind dispersion has typically been observed during the winter when the surface of the upper containment area might be windswept clear of snow cover exposing dry tailings particles. The wind direction is predominantly from the south-southeast and dispersion of particles has been observed to the lee side of the surface cell. Dust control methods have been implemented to mitigate wind dispersion including: induced ice cover (through flooding and water cannons), natural and induced snow cover (through fencing), shale cover, and water saturation during periods of thaw.

Tailings Pipeline Route

Pipelines run on surface between the mill and the East/West Twin Lakes area for transport of tailings, reclaim water and fresh water. Two small sediment ponds are located along the tailings pipeline route between the mill and the WTDA. These ponds provided for retention of solids and water in the event of a pipeline break or a planned draining. The ponds are lined with impermeable plastic liners and have been cleaned, as required to maintain storage capacity. The east dump pond located between a pond and Twin Lakes Creek is shown on Photograph 8.

4.1.5 Solid Waste Disposal Facility

Landfill

The landfill is located approximately 1 km west of the town near the STOL airstrip. The landfill has been used for disposal of waste materials from the Town of Nanisivik, the jet airport and the mine throughout the life of the mine. Paper/wood and foodstuff materials are routinely burned to reduce volume. Waste materials are routinely compacted and covered with local shale.

The primary environmental concern regarding the landfill is the potential for transport of contaminants (especially hydrocarbons) from the landfill. Hydrocarbons in the landfill originated from historical operating practices and the disposal of spill clean up materials. Environmental protection measures include a soil berm at the toe of the landfill that directs run off water to a hydrocarbon absorbent boom.

Nanisivik Mine completed an internal Phase1/2 site assessment for the landfill in 2000/01, which included water and soil sampling downslope from the toe of the landfill. The report indicates that an average annual volume of 1,150 m^3 of solid waste (post burning) was added to the landfill with the majority of this volume originating from “institutional sources” such as the mill kitchen, the “dome” kitchen and the jet airport.

Land Farm Cell

A land farming cell was constructed in the landfill area as a means of treating hydrocarbon contaminated soil that was recovered from small spills. The cell was constructed with a bentofix geotextile liner to prevent the transport of hydrocarbons into the soil.

4.1.6 Miscellaneous Access Facilities

STOL Air strip

The Short Take Off and Landing (STOL) air strip and satellite communication equipment is located approximately 1.5 km west of town as shown on Photograph 9. The strip is used occasionally by charter helicopter and small fixed wing aircraft.

4.1.7 Mine Workings

Open Pits

There are four small open pits on the property: Oceanview, East Open Pit, East Trench and West Open Pit.

- The Oceanview pit is located north and east of the East Adit area. Drainage from this pit was retained in a holding pond and trucked to the East Adit Treatment Facility during operations.
- The East Open Pit is located in the East Adit Area adjacent to the 39 portal that connects to the primary underground workings.
- The East Trench is located adjacent to and east of the 88 portal in the East Adit area as shown on Photographs 10 and 11. The East Trench is a relatively small mined-out trench with minor underground mining into the trench wall. This underground mining did not connect with the primary underground mine workings.
- The West Open Pit is located in the West Adit Area, between the 00/01 portals and Twin Lakes Creek (Photograph 12). During the later years of mine operations, the mined-out West Open Pit

served as a water collection pond for the adit area. Water that was collected in this pond was pumped to the mill for subsequent pumping to the WTDA tailings facility.

Underground Mines

Main Lens

The mining method was drill and blast in ore using standard trackless equipment (jumbo drills, remote scoop trams, and haulage trucks). Ore was hauled to an underground pass that controls ore flow to the primary and secondary crushers. All crushing takes place in the underground mine and the crushed ore was moved to surface via a conveyor system. Since the mine is located in permafrost, there is no water pumping requirement.

The primary underground mine workings are located immediately east of the mill. The workings extend in an approximate northeast-southwest direction. There are eight openings to surface:

1. 00 portal: West Adit area – ventilation;
2. 01 portal: West Adit area – primary vehicle access west side;
3. 09 portal: West Adit area – alternate (summer) vehicle access;
4. lower portal: West Adit area – ore conveyor to the mill;
5. 17N portal: currently unused vehicle access;
6. shale hill vent raise: East Adit area – ventilation;
7. 39 portal: East Adit area – no longer accessible (crown pillar mined); and
8. 88 portal: East Adit area – primary vehicle access.

The Main Lens mined at the Nanisivik Mine was flat lying and outcropped on surface at both ends of the zone. The geometry of the mineralized body and the presence of permafrost permitted large underground excavations and the use of large scale mining equipment. In the Main Lens, where the dimensions of the mineralized zone are up to 150 metres in width and 20 metres in height, the primary mining method was room and pillar. For the other zones adjacent to the Main Lens, the mining methods were drift and slash stoping with some cut and fill stoping. The same mining equipment was used in these zones as in the Main Lens. The extent of the undergound workings is shown on Figures 2 and 3.

Stope backfill consists of low grade material sourced from surface stockpiles, development waste or shale from surface. Water was applied to the surface of the backfill, which would freeze generally within two days to form a strong working surface.

Nanisivik was a unique mine in that dry drilling was used due to the permafrost (the rock temperature is minus 12°C). Dust collectors were required on drilling equipment in order to keep respirable dust within acceptable safety limits. Most blasting at Nanisivik was done using ANFO, non-electric delay detonators, and detonating cord, fired with an electric cap.

Other Underground Developments

Three small underground mines were developed at the K-Baseline, Oceanview and Area14 sites. There is one entrance to each of these workings and the Oceanview workings has one ventilation raise to surface.

Haulage Roads

There are approximately 30 km of roadways around the mine site and the town of Nanisivik. The majority of these roads were used for mine exploration, mine access and the hauling of ore.

Waste Rock Piles

Waste rock piles are located at each of the open pits and underground mine adits. The waste rock contains, in some areas, sulphide mineralization. The mining method employed waste rock underground as fill material necessary to facilitate pillar removal. This process resulted in the relocation of a large portion of waste rock from the East and West Adit areas into the underground mine during the last years of mine operations.

East Adit Water Treatment System

A lime treatment system is operated on an as-required basis in the East Adit area. The influent is runoff from the adit area that is collected in a constructed holding pond as shown on Photograph 13. Influent is mixed directly with dry lime in a conditioning tank and pumped to a settlement pond where treatment sediments are deposited as shown on Photograph 14. Two small dykes form the treatment pond and the settlement pond. The system is typically operated on an intermittent basis through the summer season during freshet or a rainfall event.

4.2 Development Sequence

Most of the mine facilities were constructed from 1974 to 1976 during the initial development of the mine. There were also some modifications and additions, however, to the facilities through the life of the mine. Table D provides an outline of the sequence of construction, major modifications, mining sequence and major closure milestones.

Table D: Sequence of Major Events

1974-1976	initial mine development including town housing, dome cafeteria, town centre, school, church, bunkhouse building, industrial complex, concentrate storage shed, tank farm, STOL air strip, freshwater supply system
1974	begin operations at landfill site
1975	begin flight operations at STOL air strip
1976	begin tailings deposition in West Twin Lake
1976	begin mine production underground
1976-1977	jet airstrip/airport constructed
1980 – 1995	West Open Pit mined
1982	ship loading conveyor enclosed
1983 – 1987	Area14 mined
1985	Soil geochemistry survey
1986 – 2001	East Open Pit and East Trench mined
1987 – 1990	K-Baseline mined
1989	East Adit water treatment facility constructed
1990	PAMO apartment building constructed
1990	Construction of West Twin Dyke and creation of the “Surface Cell”
1992-1997	tailings reclamation cover tests
2000-2002	Oceanview mined
2000/2001	Dense Media Separation (DMS) plant constructed
September 2001	mine closure announced for September 2002
February 2002	February 2002 Closure and Reclamation Plan submitted to Nunavut Water Board
July 2002	Water Board Hearing in Arctic Bay re. mine closure
Summer 2002	Phase II Environmental Site Assessment
August 2002	Meeting of Technical Consultants re. mine closure
September 2002	Cessation of mining and milling operations
September/ October 2002	Ecological and Human Health Risk Assessment
October 2002	Updated October 2002 Closure and Reclamation Plan submitted to Nunavut Water Board

5. Phase II Environmental Site Assessment

The Phase II Environmental Site Assessment (ESA) constituted field investigations and incorporation of other relevant environmental information to characterize the occurrence and extent of contamination in the areas of potential environmental concern. The scope of work for the Phase II ESA included: a field investigation to collect soil and water samples; laboratory analysis to determine the concentrations of chemicals of concern in soil and water samples; an assessment of the environmental setting, an evaluation of the chemical data in relation to federal regulatory guidelines for environmental quality; and a preliminary assessment of the area, depth and severity of contamination observed.

The overall objective of the Phase II ESA was to assess current environmental conditions to provide direction for future remedial planning. Specific objectives for the Phase II ESA conducted at the Nanisivik mine site were:

- To conduct a soil, sediment and groundwater sampling and analytical program to determine the nature, concentration and possible extent of contaminants identified in section 3.3, in the subsurface which are greater than the generic federal environmental quality guidelines for parkland and commercial land use, freshwater sediment or protection of freshwater aquatic life as described in section 1.4.2; and
- To generate a document suitable for review by government agencies and application to an Ecological and Human Health Risk Assessment.

5.1 Methodology

The majority of the Phase II field investigation program was conducted at the Nanisivik mine site from July 15 to July 29, 2002. The field investigations conducted included: a test pit excavation and soil sampling program; surficial soil, sediment and dust sampling using judgmental and systematic grid sampling techniques; and, installation of wells to sample the meltwater or seepage that collects within the active layer. The field investigation program resulted in:

- The excavation of 147 test pits and the installation of seepage sampling wells in 8 of the test pits;
- The collection of 59 surficial soil samples;
- The collection of 9 sediment samples;
- Sampling of 2 surface seeps and the 8 seepage sampling wells;
- Measuring the organic vapour concentrations in soil; and
- The submission of soil, sediment and water samples for petroleum hydrocarbon (PHC) and metals analysis.

Table E provides the areas investigated, how many sample locations were examined, the number of samples collected from these locations and an indication of the analyses completed:

Table E: Phase II ESA Methodology

Area	Sample Sites	Samples Collected	Sample Analysis to date
Town and Related Facilities	25	48 soil	16 for PHC, 10 for metals (external laboratory)
Industrial Complex and Related Facilities	20	52 soil, 3 water	25 for PHC, 3 for glycols, 24 for metals (external laboratory)
Dock and Related Facilities	93	190 soil	10 for PHC, 88 for metals (in house laboratory), 46 for metals (external laboratory)
Tailings Disposal Facility	35	51 soil, 1 water	6 for metals, (in house laboratory), 29 for metals (external laboratory)
Solid Waste Facility	13	22 soil, 6 water	17 for PHC, 11 for metals (external laboratory)
STOL air strip	3	7 soil	4 for PHC, 1 for glycols, 1 external laboratory for metals
Mine Workings	34	45 soil, 9 sediment	16 for PHC, 7 for metals (in house laboratory), 10 for metals (external laboratory)

In addition to the sampling program listed above the haulage roads were visually inspected to locate the used of mineralized waste rock used as road fill and the occurrence of waste rock and mineralized outcroppings in Twin Lakes Creek from the mill complex to the WTDA tailings facility was mapped.

Sampling locations for the field investigation were chosen to address the areas of potential environmental concern (APECs) identified in the 2001 Environmental Site Assessment.

5.1.1 Test Pit Excavation Program

Test pitting was conducted to observe of the subsurface soil conditions for the presence of fill zones, soil horizons, permafrost, discoloration, oil sheens, hydrocarbon or other unusual odours, and seepage zones. Test pitting also permitted the collection of subsurface soil samples and the installation of seepage monitors. A total of 147 test pits were excavated in areas of potential environmental concern using a tracked excavator. Consideration was also given to obtaining adequate sampling coverage over the site.

Soil samples were taken during excavation of the test pits based on stratigraphy, visual and olfactory observations. Up to three soil samples were obtained from each test pit. Soil samples were collected directly from the walls of the test pit to a depth of 1.2 m and from the excavator bucket at deeper depths. Test pits were generally excavated to expose frozen ground. The depths of the test pits ranged from 0.75

m (TP02-100 at the solid waste facility) to 2.2 m (TP02-86 at the industrial complex) measured by tape and accurate to an estimated =/-0.1 m.

Soil samples for hydrocarbon analyses were collected into clean, laboratory certified 250 mL glass jars, which were sealed with a Teflon®-lined lid. All soil for potential hydrocarbon analyses was kept cool until delivery to the analytical laboratory. As a field-screening method, concentrations of organic vapours in the soil at sampling location suspected of having the potential to be impacted by hydrocarbons were measured using a bag-headspace method. The bag headspace method involves placing soil in a sealable polyethylene bag, sealing the soil in the bag, dis-aggregating the soil in the bag, allowing organic vapours in the soil to accumulate in the bag's headspace, and then monitoring the concentration of organic vapour in the bag headspace. Th concentrations of organic vapours were measured using a portable photoionization detector (PID). The results of the PID measurements along with the visual appearance and olfactory indicators are used to determine which samples warrant laboratory testing.

Soil samples collected for metals analyses were collected in polyethylene bags. Duplicate soil samples were collected for metals analysis at the mine assay laboratory.

Standard chain-of-custody forms were completed for each sample and the form accompanied the samples to the external analytical laboratory.

5.1.2 Surficial Soil Sampling

Surficial soil sampling was conducted within the active mine site, in areas previously identified as representing potential environmental concern. Figure 3 shows the location of the surficial sampling locations.

Surficial soil sampling consisted of the collection soil from surface (less than 0.3 m depth) using a stainless steel trowel or shovel. Samples of surficial accumulation of tailings up to 0.01 m thick on boulders due to wind dispersion were collected using the stainless steel trowel.

Soil samples were inspected, logged and collected directly into a cleaned, laboratory certified 250 mL capacity jar or sample bags as appropriate for the analyses to be completed. Duplicate soil samples for metal analysis were also collected for analysis at the mine assay laboratory. All soil collected for possible petroleum hydrocarbon analysis was kept cool until delivery to the analytical laboratory. Standard chain-of-custody forms were completed for each sample and the form accompanied the samples to the laboratory.

5.1.3 Installation of Seepage Sampling Wells and Water Sampling

Sampling wells were installed within test pits where seepage water was observed and consisted of 50 mm diameter PVC screen pipe set to the base of the test pit. A solid PVC riser was used to complete each well that was greater than 1.5 metres deep. The annulus surrounding each screened section was backfilled with soil excavated from the test pit and the surface was compacted. Coarse rock from the excavation was placed around PVC pipe to support it upright within the pit.

Dedicated sampling equipment consisting of disposable polyethylene bailers used at each well for the purpose of developing, purging and sampling the seepage water. Developing involved the agitation and evacuation of a minimum of 95 L of water from the well to remove installation-induced disturbances. A large volume of water was removed because the method used to install the wells, in test pits and securing the pipe with backfill soils, involves the disturbance of a considerably larger volume of soil than if a drill hole were used to install the wells.

The wells were purged by removing an additional 15 L of water approximately 2 days after well development activities and one day before sampling to allow for the stabilization of subsurface conditions. Surface water samples were collected in areas that had not been disturbed during the site assessment program. The collection of water samples was timed to coincide with a "flight-day" in order to minimize the travel time to the analytical laboratory.

Water samples were placed into precleaned, laboratory certified containers, specific for the chemical parameters analyzed. A 1 litre capacity plastic bottle was used for conventional parameter analysis; samples collected for extractable petroleum hydrocarbons (EPH), polycyclic aromatic hydrocarbons (PAHs), nutrient samples were collected into 250 mL amber bottles and preserved with sulfuric acid; and, samples to be submitted for analysis of dissolved metal concentrations, were filtered in the field using and preserved with nitric acid.

Immediately after collection, each sample was placed in a cooler and stored at approximately 4^{o}C until delivered to the analytical laboratory. Standard chain-of-custody forms accompanied all samples submitted to the laboratory.

5.1.4 Sample Site Locations and Surveying

Mine site survey personnel conducted a location and elevation survey for test pit locations in the dock area, the industrial complex area and the landfill area. All test pit locations with a monitor installed were surveyed. Topographical maps were used to locate surface sampling stations and the remaining test pits. All survey data was transferred to the mine grid and plotted.

5.1.5 Analytical Program

Chemical analyses were carried out by Accutest Laboratories Ltd. (Accutest) of Ottawa, ON. Accutest is accredited by the Canadian Association For Environmental Analytical Laboratories (CAEAL). In addition soil samples were also analyzed at the on-site laboratory for zinc, lead and iron. Table D provides an indication of where samples were analyzed along with how many sample locations were examined at each area, the number of samples collected from these locations and the number analyzed.

Soil samples were collected from various depths in test pits to provide complete documentation of observations and to provide for possible follow up research. Not all samples collected were intended to undergo immediate chemical analyses but are stored for possible future use.

The soil analytical program was designed to complement the professional observations made in the field by providing chemical analyses focused on the areas of environmental concern. The analyses were performed on several series of select soil samples with each set of analytical results obtained used to select the next series of samples. Soil samples were analyzed for metals, hydrocarbons and ethylene glycol, a component of antifreeze.

Water samples were analyzed for a variety of parameters including metals, hydrocarbons and other organic constituents.

Surfical sediment samples were collected from areas previously identified as being of environmental concern and analyzed for metals, the parameters of concern.

There were no acid base accounting analyses performed for the ESA program. However, should the need arise in the future, these could be carried out at the CanZinco Ltd. Caribou Mine as initially proposed, with a QA/QC program conducted with an external laboratory.

5.2 Observations

5.2.1 Town and Related Facilities

Townsite

Test pit investigations within the townsite commenced July 23, 2002. Nanisivik maintenance personnel assisted GLL in locating the proposed test hole locations of buried electrical utilities and services. Test pits TP02-106 to TP02-119 (14 test pits) were excavated within the town and 4 surface soil samples were collected adjacent to above ground storage tanks ("ASTs") at homes. The locations of the test pits and surface soil sample sites are shown on Figure 3.

Test pits were excavated to depths that ranged from 1.0 m to 1.2 m below surface. Stratigraphy generally consisted of shale fill overlying till. Pyrite rich silt was observed in the upper 0.05 m in test pits TP02-113 and TP02-114 excavated at the south side of town. Test pit TP02-115 was excavated in weathered bedrock at the eastern edge of town and test pit TP02-116 was excavated in a creek bed between the town site and the tailings pipeline. Tailings from surface runoff were observed in the test pit.

Olfactory indications of hydrocarbon were encountered in: TP02-106 from 0.3 to 0.85 m adjacent the Northern Telecom building at the northwest corner of town; in TP02-110 from 0.20.4 m located at the southeast corner of the baseball diamond; inTP02-117 from surface to 1.2 m (into frozen ground) located adjacent an AST at the dining Dome; and in TP02-119 from 0.3 m to 0.6 m located at the northwest corner of the fence around the main town AST.

Surface staining was observed at two of the four surface soil sample locations (SS02-025 and SS02-027) collected beneath ASTs at homes within the town.

Organic vapour concentration field screening results were measured based on a 'dry headspace' method using a combustible gas meter calibrated to a hexane standard at those sites suspected of being potentially contaminated with hydrocarbons. Field screening results within the townsite ranged from 1.6 ppm to 1127 ppm. Samples exhibiting the highest ppm concentration of organic vapour concentrations from a given test pit were selected for hydrocarbon laboratory analysis.

Carpenter Shop

On July 17, 2002 a soil test pit investigation was completed at the Carpenter Shop. The field investigation identified the general location of the area excavated following a diesel spill in June 2000. No indications of surficial staining were observed. Test pit locations are shown on the detail insert in Figure 3.

Test pit TP02-08, was excavated adjacent the northern wall of the previous excavation. Field screen results from soil obtained at the base of the test pit (1.3 m) was 149 ppm. Five additional test pits (TP02-09 to TP02-13) were excavated further north (downgradient) to test for contaminant migration.

Field screening results obtained from the floor of the test pits ranged from 6.6 ppm to 43.9 ppm. Test pits were excavated to depths that ranged from 1.0 m to 1.6 m. A surface soil sample, SS02-019, was collected from a damp area apparently downgradient of TP02-08. Organic vapour concentrations for the surface soil sample were 23.6 ppm.

Sewage Treatment Facility

The sewage pipeline was walked from the townsite to the facility and no signs of breakage observed. The facility was not active during the investigation and raw sewage was reportedly being discharged directly in to Twin Lakes Creek in the vicinity of the Warehouse Yard.

5.2.2 Industrial Complex and Related Facilities

Industrial Complex

Investigations during the Phase II ESA focused on evaluating soil conditions around the exterior of the industrial complex. Twenty (20) test pits were excavated on July 21, 2002 and July 22, 2002 to evaluate areas for hydrocarbon contamination and metals concentrations. Seepage sampling wells were installed into three of the test pits.

Visual and olfactory indications of hydrocarbons were detected in test pit TP02-76, Photograph 15. The test pit was excavated directly in front of the power house area of the industrial complex and down gradient of the maintenance shop's oil/water separator. Organic vapour concentrations were 599 ppm in the surface soils and 629 ppm from soil excavated at frozen ground encountered at 1.0 m. The soil was coarse-grained sand, cobbles and silt.

The test pit excavated in front of the wash-bay, TP02-83 encountered olfactory indications of hydrocarbons from surface to 1.4 m. Vapour concentrations ranged from 44.4 ppm on surface to 10.0 ppm at the floor of the excavation.

Test pit TP02-85 was excavated adjacent the south wall of the industrial complex. The upper 0.1 m of soil consisted of tailings/pyrite dust and trace gravel.

Auxiliary Buildings

Test pits TP02-73 to TP02-75 were excavated adjacent to the warm storage building at the industrial complex. Heavy equipment and light vehicles being repaired in the maintenance shop were parked in this area. The warm storage building contained trucks, lubricants and a paint shop area. The test pits were excavated to between 1.4 m and 2.1 m in the test pits. Organic vapour concentrations at surface ranged between 40.2 ppm to 491 ppm and from 245 ppm to 887 ppm at the base of the excavations.

Hydrocarbon staining was observed on surface on the east side of the compressor building. A confined work area and the presence of underground sevices in this area precluded the test pit investigation of the areas with the heaviest staining. Test pits TP02-80 to TP02-82 were excavated on the west side of the building. Seepage sampling wells were installed in test pits TP02-81, Photograph 16 and TP02-82.

Test pit TP02-84 was excavated between the recently constructed DMS plant and loadout building. Broken bed rock was encountered at 0.35 m depth. The upper 0.15 m was covered with reject from the DMS plant.

Waste Oil and Fuel Storage areas

The waste oil tank is located at the southeast corner of the industrial complex, in an area that has been used for mill reagent storage. Two test pits were excavated at the waste oil tank. TP02-86 was excavated below the discharge pipe and TP02-87 was excavated at the tank fill pipe. Olfactory indications of hydrocarbon impacts were detected in both test pits.

Field screening results ranged from 89.2 ppm at surface to 11 ppm at the floor of the test pit TP02-86. The test pit was excavated to 2.2 m depth. Tailings or concentrate dust was observed in the upper 0.15 m of the test pit. Test pit TP02-87 was excavated in an area of black surface staining below the tank fill pipe. The staining extended to a depth of 0.15 m. No visual or olfactory indications of hydrocarbon contamination was observed below 0.15 m. However, the soil was stained blue and green between 0.2 m and 0.25 m as shown in Photograph 17, and a pungent organic odour.

The fuel storage area at the industrial complex contains two 105,000 litre diesel tanks and one 47,000 litre gasoline tank, which are located in a bermed and lined enclosure upgradient of the cold storage building. A diesel fuel pipeline from the dock is used to fill the diesel tanks. Gasoline is delivered by truck from the Tank Farm at the dock to the industrial complex and pumped into the gasoline storage tank. From there, it is dispensed at the main fueling station.

Test pits TP02-78, TP02-79 and TP02-88 were excavated to test soil and seepage water conditions downgradient of the fuel storage area. Vapour concentrations ranged from 0.0 ppm to 0.7 ppm in test pits TP02-78 and TP02-79. Bedrock was encountered at 1.4 m in both test pits.

Test pit TP02-88 was excavated in wet area at the toe of a gravel bank behind the cold storage building. Organic vapour concentrations ranged from 132 ppm to 270 ppm.

Warehouse Yard

Four test pits (TP02-89 to TP02-92) were excavated to investigate subsoil conditions at the warehouse yard. Test pits TP02-89 and TP02-90 were excavated in areas suspected of being stained by hydrocarbons. TP02-89 was in an area used for oil storage (10W30) and encountered organic vapour concentrations of 148 ppm to 221 ppm. Weathered and highly fractured bedrock was encountered at 0.2 m depth. TP02-90 was excavated in an area currently used to store machine parts. Organic vapour concentrations ranged from 176 ppm in the upper 0.15 m to 202 ppm at the base of the pit (1.2 m).

Test pits TP02-91 and TP02-92 were excavated in areas that did not exhibit surface staining. No indications of hydrocarbon contamination or elevated metals were observed on surface or at depth in TP02-91. Test pit TP02-92 intercepted tailings in the upper 0.3 m and organic vapour concentrations ranged from 1857 ppm to 3442 ppm. It appeared that drums containing material spilt in the mill were being stored in this area.

Bone Yard

The bone yard was not being used for storage during the site investigation. It consisted of a relatively flat area of bedrock.

5.2.3 Dock and Related Facilities

The dock facilities were investigated July 18 and 20, 2002. At the time of the investigation concentrate was being hauled to the storage shed at the dock and maintenance work was ongoing at the conveyor in preparation for the arrival of a supply ship. A total of 124 samples were collected from 69 test pits, plus one surface sample (SS02-020) was collected beneath the day tank at the lunch room/refuge station.

Concentrate Shed and Loadout Conveyor and Dock

The soils in the area consisted of coarse sand and gravel fill overlying coarse beach sediments (cobbles) as seen in Photograph 18. Test pit locations are shown on Figure 3. Black silt (lead and zinc concentrate dust) was present on surface immediately adjacent to the concentrate shed. The thickness of concentrate dust was greatest adjacent the conveyor up to 0.1 m thick. Photograph 19 is of concentrate that had accumulated in a ditch adjacent the conveyor.

Chemical and Fuel Storage Area

The fuel tank storage area and fuel pump building are shown in Photograph 6 (photograph taken November 2001). Areas of surface staining were observed adjacent the waste oil storage tank and at the toe of the berm around the fuel pump building. The fuel tank storage berm was visually inspected and no seepage signs observed in July 2002.

Test pit TP02-50 was excavated in the northwest corner of the berm surrounding the fuel pump building as shown in Photograph 20. Hydrocarbon contaminated water was encountered. Test pits TP02-52, to TP02 –54 were excavated 20 m to 35 m downgradient of this test pit, did not encounter water, and the soil at the interface with frozen ground did not exhibit olfactory indications of hydrocarbon contamination (PID reading).

Test pit TP02-57 was excavated in an area of oil stained soil. The test pit was excavated to 2.0 m depth. The soil was damp below 0.9 m and olfactory indications of hydrocarbon contamination increased at this depth. A series of test pits were excavated cross gradient and down gradient of this site and no indication of hydrocarbon contamination observed.

Haulage Road

Six test pits (RD02-1 to RD02-6) were excavated at the shoulder of the road from the industrial complex to the concentrate shed on July 26, 2002. Test pit RD02-3 was excavated by hand and the other five test pits were excavated using the tracked excavator. Horizontal layering was observed in several of the test pits indicating various generations of road surfacing. Surface soil samples were collected from 0 to 0.10 m at each test pit.

Surface and subsurface soil was sampled along two northwest-southeast lines (or transects) that were established at oblique angles to the haulage road as illustrated on Figure 3. Surface samples were collected from the upper 0.03 m to 0.05 m and subsurface samples from between 0.05 m to 0.1 m or 0.25 m at each sample site. Trucks were hauling concentrate to the dock during the sampling program and heavy winds were present. While sampling the eastern end of the transect closest to the dock dust was observed/detected in the air when trucks drove past.

Fuel Pipeline Route

The diesel fuel line from the dock to the industrial complex was inspected. A bend in the line that had been spot welded (i.e. patched) was observed approximately 500 m north of the industrial complex and olfactory indications of hydrocarbons were detected at this location. Surface soil sample SS02-055 was collected at this location.

5.2.4 Tailings Disposal and Freshwater Supply Facilities

Freshwater Supply System

The freshwater supply pipeline was observed during the inspection of the tailings pipeline. No areas of potential environmental concern were identified.

WTDA Tailings Facility

During the site investigation the Surface Cell (upper) area of the WTDA tailings facility was being covered with shale and tailings deposition was ongoing. No samples were collected from the WTDA during the Phase II ESA.

Tailings Pipeline Route

The tailings pipeline was inspected and samples collected on July 16, 2002 and July 24, 2002. Surface samples SS02-006 to SS02-011 were collected along the route in areas where evidence of historical tailings spills was suspected (i.e. fresh shale under the tailings pipeline indicated possible repair sites [Photograph 21] and small areas of tailings like grey, silty clay as seen in Photograph 22, or areas showing evidence of surface run off staining beneath the pipeline as in Photograph 23).

Test pits TP02-127 and TP02-128 were excavated downgradient of the south tailings dump pond and no iron staining or other possible signs of tailings contamination were observed. The test pits were excavated into frozen ground at 1.2 m and 1.1 m respectively. Test pit TP020-129 was excavated in the vicinity of sample SS02-007. The evidence of a tailings spill was confined to the surface soils. Test pit TP02-130 was excavated at sample SS02-006. Tailings was observed in the upper 0.05 m.

Wind Dispersed Tailings

A series of test pit samples and surface soil samples were collected and a visual investigation was conducted to document the extent and nature of historical wind blown tailings.

The visual investigation supported anecdotal information that wind blown tailings were historically dispersed from the WTDA towards the north through a topographic “saddle” or pass in the hills to the north of the WTDA. Upon exiting the north end of the “saddle”, wind blown tailings appear to have then been dispersed to the west and northwest (towards the town).

The visual investigation identified visible pockets of tailings in the saddle area and along the base of the hill on the southeast side of the town that were accumulated in surface depressions and in rock crevices.

The ground surface in the saddle consists of coarse rock and boulders with little soil exposed and the primary accumulation of tailings was on the surfaces and crevices of the coarse rock and boulders. At the north end of the saddle, a surface depression contained accumulated tailings, which appeared to be the in a flow path of surface water from the saddle to the north and east into Twin Lakes Creek.

The base of the hill on the southeast side of the town consisted of coarse rock and boulders, which also contained accumulations of tailings on surfaces, and in crevices.

The south facing hillside below the freshwater supply tank was visually inspected and no visible tailings were noted.

“Saddle” Area and South of Town

Samples “DUST02-01” to “DUST02-04” were collected as surficial samples representative of the tailings that had been dispersed from the WTDA in the wind. The materials sampled were clearly visually identified as tailings.

Test Pits TP02-139 to TP02-144 were excavated and sampled on the south (approach) side of the saddle and within the saddle. The upper soil horizon was uniformly sampled over a surface interval of 0 to 0.1 m and was analyzed for metal concentrations. Test pit TP01-142 was excavated within the depression that was visually identified as containing an increased accumulation of tailings and the metal concentrations clearly confirm that, at this single location, tailings are present to a depth of at least 0.1 m.

A water sample was collected from a small stream, that originated at the north end of the saddle and flowed to the northeast towards the tailings dump pond. The stream was flowing at a rate of less than 1 L/min.

East of Town

Test pits TP02-120 to TP02-126 were excavated and sampled along the south side of the road from the town to the WTDA for the purpose of investigating the presence of wind blown tailings in the area on the “outlet” side of the saddle.

North of Town

Surface and subsurface soil was sampled along an east-west line (a transect) across the area north of the town (TP02-131 to TP02-139) as illustrated on Figure 3. Soil samples of the upper horizon were uniformly collected over the interval from 0 to 0.10 and samples of subsurface horizons were also collected.

5.2.5 Solid Waste Facility

Landfill

Landfill operations were underway at the time of the inspection. The operations included the placement of solid waste over the outer crests, the burning of putrescible wastes, the compaction of some materials (i.e. steel drums) prior to placement and the covering of waste with shale by advancing the outer crests.

Two berms were observed at the landfill, as shown on Figure 3. A berm, approximately 1 m high located along the southern and western edge of the landfill area was installed to divert surface runoff from upgradient of the site around it. A second berm, approximately 2 m high at the toe of the landfill was installed to control surface run-off from the landfill itself. The berm at the toe of the landfill is visible in Photograph 29.

Six (6) test pits (TP02-94 to TP02-99) were excavated at the toe of the second berm as shown on Figure 3. Two of the test pit TP02-93 and TP02-102 were excavated to evaluate background conditions. Test pit TP02-93 was excavated inside of southwest berm, in an area that appeared to be upgradient of drainage from the west side of the landfill area and test pit TP02-102 was excavated on the north side of the landfill, upgradient of the landfill in an undisturbed area. Seepage sampling wells were installed in 5 of the test pits (Photograph 30) that encountered water. A water sample was collected from water seeping out of the west side of the landfill area (LF-WSEEP).

The test pits were excavated in a meadow ground cover and intersected clayey, silty, sand and gravel (till) at depth. The test pits were excavated into frozen ground to depths of 0.8 m and 0.90 m. A white crystalline substance was observed on surface at test pits TP02-94 and TP02-97. Vegetation in and surrounding the precipitate did not appear to be impacted and the precipitate is therefore not considered an environmental concern.

Land Farm Cell

A petroleum hydrocarbon bioremediation cell that was constructed at the landfill site in 2000 contains approximately 1000 m^3 of diesel contaminated soil excavated from the Carpenter shop. The berm surrounding the cell is visible in Photograph 29 and the location of the land farm cell is shown on Figure 3.

Two test pits, LFC02-1 and LFC02-2 were excavated within the landfarm cell. A grab sample was collected at 0.3 m depth in LFC02-1 and organic vapour concentrations were 177 ppm. At LFC02-2 as sample was collected at 0.6 m depth and field screening results were 783 ppm. The sample locations are shown in Photograph 31

Two additional test pits were excavated downgradient on the east side of the landfarm and seepage sampling wells were installed in both test pits. The test pits intersected coarser soil conditions than downgradient of the landfill area (sand, gravel and cobbles). TP02-100 was excavated to 0.75 m and TP02-101 to 0.9 m.

5.2.6 Miscellaneous Access Facilities

STOL Air Strip

The air strip is covered with shale fill and remnants of a former lighting system run down the north side of the strip. Three test pits were excavated at the STOL air strip on July 23, 2002. The test pits were excavated into frozen ground to between 1.0 m and 1.3 m depth. Test pit TP02-103 was excavated in an area used to park airplanes, an apron. Shale fill (0.15 m) overlaid native silty, sand and gravel (till). Organic vapour concentrations ranged from 3.1 ppm to 4.9 ppm.

An area of possible hydrocarbon surface staining was observed at the southeast junction of the access road and the air strip. The area had historically been used for AST. Test pit TP02-104 was excavated in the stained area and test pit TP02-105 was excavated 30 m down slope to the southeast. Olfactory indications of hydrocarbons were present in TP02-104 from surface to 0.9 m depth. Below 0.9 m depth the clay content of the till increased and organic vapour concentrations were 13.8 ppm. Organic vapour concentrations were 43.2 ppm in the 0.15 m of fill at surface and 181 ppm in the till from 0.7 m to 0.9 m.

Organic vapour concentrations in TP02-105 ranged from 4.2 ppm at surface to 40.7 ppm at the floor of the test pit. No olfactory indications of hydrocarbons were detected. The till at TP02-105 was clayey sand and gravel.

5.2.7 Mine Workings

Open Pits

During the site investigation the four small open pits (Oceanview, East open pit, East trench, West open pit) had been or were in the process of being backfilled and the surface recountoured. The Oceanview open pit and the East open pit, were in the process of being backfilled. Partial backfilling and recontouring of the West open pit had completed prior to the site investigation. The east trench were not observed but was reported as not having been backfilled at that time.

Drainage from the Oceanview open pit was being retained in a sump area at the north end of the workings, pending removal by pump truck to the WTDA via the mill. In the past, water was taken to the East Adit treatment facility. A vent raise located to the southwest of the pit was filled with water and overflowing into earthen containment berms, which appeared to allow settling of suspended solids, promote percolation of the water into the ground and prevent surface runoff of the water.

The location of the former above ground storage tank (AST) at the Oceanview area, as seen in November 2001 in Photograph 32, was inspected and two test pits excavated: one at the fill pipe location (TP02-02) and one in the discharge area (TP02-01). Coarse-grained textured soil was intersected as shown in Photograph 33 of TP02-01. Organic vapour concentrations in TP02-02 ranged from 18.9 ppm from 0.5 m to 1.0 m to 1.8 ppm from the floor of the test pit (1.0 m depth). Vapour concentrations were 357 ppm from 0.0 m to 0.5 m in TP02-01, 151 ppm from 0.5 m to 0.8 m and 489 ppm at the floor of the test pit, 1.0 m. Black surface staining was observed at the discharge area. Surface soil sample SS02-012 was collected at the base of the refuge station AST in a small area (<1 m diameter) of stained soil.

Underground Mines

During the investigation access to the underground workings was via the Lower Portal, the 01 Portal and at the 88N Portal. Crown pillar recovery above the 39 portal entrance was ongoing. The K-Baseline, Oceanview and Area14 portals had been sealed with waste rock prior to the site investigation.

The present or known former locations of above ground storage tanks (“ASTs”) and underground storage tanks (“USTs”) at each of the mine openings were investigated and samples collected for hydrocarbon analysis. Test pits TP02-03 toTP02-07 investigated AST locations at K-Baseline and 39 portal. Surface soil samples SS02-013 to SS02-015 and SS02-024 investigated the soil conditions beneath existing ASTs at 39 portal, 17N portal, the ANFO Plant and 01 portal. No containment berms were present at these ASTs. SS02-017 and SS02-018 were collected at the floor of the excavation exposed during the removal of an UST adjacent the ANFO Plant.

Test pits TP02-05 and TP02-06 investigated an historical fuel spill area at an AST outside of the former K-Baseline shop. Organic vapour concentrations were between 215 ppm and 243 ppm from surface to the floor of test pit TP02-05 at 1.6 m. In test pit TP02-06 organic vapour concentrations were below 3.5 ppm to a depth of 1.0 m and 198 ppm at the floor of the test pit, 1.8 m depth.

Haulage Roads

The presence of waste rock used for the construction of haulage roads was mapped and is summarized on Figure 5. Mineralized waste rock in the haulage roads was limited to small isolated areas.

Waste Rock Piles

Waste rock was being backfilled into the open pits at Oceanview and the east adit area during the investigation. Waste rock was also being relocated underground from the 09S and 39N rock dumps and from the rejects of the DMS plant.

Waste rock was observed along the shore and in Twin Lakes Creek along with a significant amount of weathered mineralized bedrock. The presence of waste rock in the creek was mapped and sediment samples collected both up stream, mid stream and downstream of the occurrences of waste rock in the creek. The geological map of natural exposures of mineralized rock (outcrops) along the creek in the vicinity of the West Adit Area was validated.

Mine Discharge Water and Treatment Facilities

Soil samples were collected downgradient of the East Adit Water Treatment Facility on July 15, 2002 and follow-up sampling was conducted July 21, 2002. The high water mark at the treatment pond was stained dark red. Five soil samples (SS02-001 to SS02-005) were collected from surface to 0.1 m depth downgradient of the facility on July 15, 2002 and submitted to the on-site laboratory for analysis of lead, zinc and copper. Three additional surficial soil samples (SS02-021 to SS02-023) were collected to evaluate the areal extent of metal concentrations in the area on July 21, 2002. Sample sites SS02-002 and SS02-003 were also replicated and samples collected below 0.1m to provide QA/QC samples for analysis at the external laboratory and to evaluate the horizontal extent of metal content.

During the initial inspection of the facility, surface drainage from the east end of the East Adit Area was being redirected towards the treatment pond by a lined berm on the up slope face of the access road. Soil sample SS02-005 was collected below the down slope side of the access road in this area and encountered oxidized silt and gravel that had been naturally cemented or welded within the upper 0.1 m.

5.3 Results

The results of analysis for the samples collected at the Nanisivik Mine during the Phase II field program are provided in Appendices E and F and summarized on Figure 5: *2002 Phase II ESA Results – Petroleum Hydrocarbons*, Figure 6: *2002 Phase II ESA Results – Metals.* Only the highest result obtained in a given test pit is illustrated on the figures, regardless of the depth at which the sample was collected. and A complete listing of all results obtained are provided in the following tables:

Table 1.	Key to Table of Test Pit Results
Table 2.	Town and Related Facilities, Summary of Analytical Results in Soil
Table 3.	Industrial Complex and Related Facilities, Summary of Analytical Results in Soil
Table 4.	Dock and Related Facilities, Summary of Analytical Results in Soil
Table 5.	Tailings Disposal Facility, Summary of Analytical Results for Metals in Soil
Table 6.	Solid Waste Disposal Facility, Summary of Analytical Results in Soil
Table 7.	Miscellaneous Access Facilities, Summary of Analytical Results in Soil
Table 8.	Mine Workings, Summary of Analytical Results for Hydrocarbons in Soil
Table 9.	Mine Workings, Summary of Analytical Results for Metals in Soil
Table 10.	Mine Workings, Summary of Analytical Results Metals in Sediment
Table 11.	Summary of Analytical Results in Groundwater and Surface Seeps
Table 12.	Summary of Analytical Results for Iron, Lead and Zinc in Soil and Sediment from On-Site Laboratory

5.3.1 Town and Related Facilities

Townsite

Hydrocarbons

Results of the surface soil sampling at ASTs adjacent homes in the townsite has indicated that hydrocarbon contamination is identifiable by obvious surface staining on the ground beneath the ASTs. Samples SS02-025 and SS02-027-1 were collected from areas with visible hydrocarbon staining on surface and the analytical results for these samples exceeded the CCME guidelines. Results for samples collected from beneath ASTs that did not exhibit visual indications of hydrocarbon staining were less than the CCME guidelines. Results from sample site SS02-027 indicate that the hydrocarbon contamination is restricted to the upper 0.05 m of soil in these areas.

Hydrocarbon contamination was not detected at the AST south of the Fire Hall. The soil at the AST adjacent the Dome was contaminated. Results from test pit TP02-117 indicated that hydrocarbon contamination had migrated vertically to within frozen ground (1.2 m). The lateral extent of contamination was not determined.

Metals

Data Sources

In addition to soil geochemistry data presented in section 2.7 and summarized on Figure 4 and the samples collected for the Phase II ESA and presented in Table 2 and on Figures 5 and 6, the results of a comprehensive survey of metal concentrations in surficial soils in the town that was conducted by EBA Engineering Consultants Ltd. ("EBA") on behalf of the government of Nunavut have been reviewed. Appendix B includes Figures and Tables from EBA's report *Soil Sampling Program, Nanisivik Town Site, Nanisivik, Nunavut*, dated August 2002, which are reproduced here with the permission of EBA and the Government of Nunavut.

Although the EBA information was not available at the time of the Phase II ESA investigation, it was known that a comprehensive professional survey of metal concentrations had been completed and would be published. As a result, the Phase II ESA in the town area focussed on potential hydrocarbon contamination and collection of additional samples at depth.

The methodology of the EBA survey included the collection of surface soil representative of the interval from 0.0 m to 0.05 m using a hand trowel based on a grid network of sampling locations throughout the townsite. At four locations, soil depth profiles were completed to 0.15 or 0.20 m depth using a hand auger for sample collection. The methodology used during the Phase II ESA involved the excavation of test pits to expose frozen ground and the collection of samples from the walls of the test pits.

Distribution of Metals on Surface

The distribution of the metals of primary concern (lead and zinc) on surface, as represented by the 0.0 m to 0.05 m sampling interval, are illustrated on EBA's Figures 6 and 7 in Appendix B. Lead concentrations ranged from 17 µg/g to 2720 µg/g, zinc ranged from 90 µg/g to 38,500 µg/g and cadmium from <0.5 to 50.2 µg/g in the EBA sample set, which included sampling to the northeast of town in the area of natural mineralization. Surface concentrations of lead, zinc and cadmium within the town area itself obtained for the Phase II ESA ranged from 58 µg/g to 751 µg/g for lead, 1030 µg/g to 3690 µg/g for zinc and 1.5 µg/g to 5.5 µg/g for cadmium.

The two highest concentrations of lead reported by EBA occur as isolated points within the town that are considered to be representative of highly localized effects of vehicle driveways. The extreme and localized nature of these two highest lead concentrations (2,720 µg/g and 1,380 µg/g) is illustrated by the difference with the next highest concentration of 678 µg/g. The highest concentrations of zinc obtained by EBA correspond directly with a zone of highly mineralized weathered bedrock on the northeast side of town as illustrated on Figure 4 (of this Phase II ESA report).

The contours of metal distribution on surface illustrate that the tracking of concentrates on vehicles has been a primary source of metals throughout the town. This is evidenced by the high concentrations of lead and zinc in the busiest vehicle areas, such as the dome and the main streets. This observation agrees with intuitive reasoning given that mine trucks routinely travel throughout the mine site (including the mill and concentrate loadout area where concentrate contamination is possible) as well as through the town. This source of metals to the town area will cease upon cessation of mining activities and remediation of areas of metal contamination.

Five surface soil samples from the Phase II ESA investigation at the townsite were analyzed from the upper 0.05 m to 0.25 m of soil. Three of these sample locations are located on the west side of the town area and contained concentrations of lead ranging from 159 µg/g to 342 µg/g and zinc ranging from 1,650 µg/g to 3,690 µg/g. These three test pits (TP02-106, TP02-107 and TP02-109) were excavated within fill material..

Distribution of Metals with Depth

The data for soil samples below surface indicate that metal concentrations in the town decrease rapidly with depth.

Of the four subsurface locations that were sampled by EBA at 3 intervals up to 0.15 or 0.20 m depth, all lead concentrations were low. Only one location (EBA #870-P3) did not display a clear decreasing trend with depth for zinc; however, the zinc concentrations at this location were relatively low for the database at less than 210 µg/g. At the remaining three locations, the concentrations of zinc uniformly decreased with depth as illustrated on EBA's Figures 10 and 11 in Appendix B.

Soil samples collected beneath the surface soil samples during the Phase II ESA investigation returned relatively low lead concentrations ranging from 9 µg/g to 79 µg/g and zinc concentrations ranging from 83 µg/g to 512 µg/g providing additional indication that the elevated metal concentrations are confined to the surface soils in the townsite.

Test pit TP02-115 was excavated into naturally mineralized weathered bedrock at the east side of town. Lead and zinc concentrations in the weathered bedrock at this location were 367 µg/g and 1300 µg/g, respectively. This sample was collected to provide an indication of the natural mineralization in the area using the sampling and analytical techniques consistent with the ESA program. The results confirm that the background, or natural, quality of the weathered bedrock does not meet the generic CEQG CL guidelines of 260 µg/g for lead and 360 µg/g for zinc.

Carpenter Shop

Hydrocarbons

The analytical results indicate that hydrocarbon concentrations in excess of the federal guidelines for soil are present 30 m north of the carpenter shop at the permafrost horizon in test pit TP02-11. Results from test pits TP02-8 and TP02-12, which were excavated cross gradient to the west and east, indicate that the contamination does not extend laterally more than 15 m.

Metals

Surface soil sample SS02-019 was analyzed for cadmium, lead and zinc concentrations. The sample was collected from the upper 0.1 m of soil adjacent the carpenter shop. As illustrated on Figure 6 and documented in Table 2, the analytical results were comparable with those obtained in the upper 0.25 of soil on the east side of the road to the jet airport and industrial complex.

5.3.2 Industrial Complex and Related Facilities

Industrial Complex

Hydrocarbons

Soil quality results from test pits excavated on the north side of the industrial complex (TP02-73 to TP02-76) indicated that hydrocarbon contamination is present beneath areas where heavy equipment is parked for mechanical maintenance and immediately adjacent to the oil/water separator. Contamination can extend from surface to the permafrost horizon. Results from the soil sample collected at 1.3 m depth in test pit TP02-77 was less than the CCME PHS CWS PL guidelines. Test pit TP02-77 was excavated approximately 55 m to 65 m down slope of test pits TP02-73 and TP02-74, to determine the lateral extent of hydrocarbon contaminated soil downgradient of the areas used for mechanical maintenance.

Test pit TP02-88 was excavated at a location inferred to be downgradient of the fuel storage area based on topography and the location of surface water seeps between the fuel storage area and the test pit. Hydrocarbon concentrations in the soil at the floor of the test pit (1.5 m) were greater than federal guidelines. Concentrations of hydrocarbons in the soil above this depth (0.6 m to 0.8 m) were less than federal guidelines indicating that the contamination may have migrated laterally to this location along the surface of the permafrost horizon. Results obtained from a sample of seepage water collected from the well installed in the test pit were less than the federal guidelines for volatile petroleum hydrocarbons in surface water. However, detectable total petroleum hydrocarbon concentrations (1.8 mg/L) for extractable petroleum hydrocarbons (C_{10}-C_{24}), which are associated with diesel fuel, were obtained indicating that soil upgradient of the test pit may have been impacted by diesel.

At the waste oil tank, located west of the industrial complex, hydrocarbon contamination was present in the upper 0.15 m of soil in test pit TP02-86. Hydrocarbon concentrations at the floor of the test pit (2.2 m) however, were less than the method detection limit, indicating that the contamination had not migrated vertically. Contamination in the vicinity of the waste oil tank appears to be confined to an area of shallow surface staining below the discharge pipe.

Seepage water samples were collected from two wells installed in test pits adjacent to the compressor station south of the industrial complex building. Results for the extractable petroleum hydrocarbons (C_{10}-C_{24}) were 0.4 mg/L in test pit TP02-81 that was installed at the entrance to the building indicating a possible petroleum hydrocarbon impact to seepage water in this area. A second well was installed in test pit TP02-82, down slope of TP02-81. The hydrocarbon concentration results from a water sample collected from the well in TP02-82 were all below the method detection limits for volatile and extractable petroleum hydrocarbons. This indicates that any petroleum hydrocarbon contamination in the seepage water at TP02-81 was very localized and had not migrated down slope 40 m to this well.

Metals

Concentrations for cadmium, lead and zinc were elevated in all of the samples analyzed from the upper 0.15 m to 0.4 m of the test pits excavated around the industrial complex. Lead concentrations ranged from 461 µg/g to 2750 µg/g, zinc concentrations ranged from 1220 µg/g to 131000 µg/g and cadmium from 10.3 µg/g to 230 µg/g, with the highest zinc and cadmium concentrations being obtained from test pit TP02-87. One sample from the surface of test pit TP02-73 was analyzed for a full suite of metals and in addition to having elevated cadmium, lead and zinc it was also had copper (88 µg/g) concentrations which exceeded the CEQG PL guideline of 63 µg/g, but were less than the CL guideline of 91 µg/g for copper.

Metal concentrations in soil samples collected below 0.5 m depth were considerable less than those at surface. Lead concentrations ranged from16 µg/g to 1170 µg/g, zinc from 130 µg/g to 9580 µg/g and cadmium from 0.5 µg/g to 24.7 µg/g. The highest concentrations were obtained from test pit TP02-86 at a depth of 0.6 m to 0.8 m below surface.

Dissolved zinc concentrations in seepage water collected from wells installed in test pits were 1.30 mg/L in TP02-81, 6.99 mg/L in TP02-82 and 0.438 mg/L in TP02-88. Lead concentrations were 0.003 mg/L in TP02-81 and TP02-88 and 0.009 mg/L in TP02-82.

Warehouse Yard

Hydrocarbons

Soil samples from each of the test pits excavated in the warehouse yard were submitted for analysis of petroleum hydrocarbons. Only the sample collected from test pit TP02-89 returned petroleum hydrocarbon concentrations greater than the federal guidelines. The concentration for PHC CWS fraction 3 (indicating lubricating oil) was 7200 µg/g. The test pit was excavated in an area used to store 10W30 oil.

Two soil samples were collected from test pit TP02-90, which was excavated in an area of surface staining, one from the upper 0.15 m and the other at the base of the test pit at 1.1 m. The sample from the base of the test pit exhibited a higher organic vapour concentration and was therefore analyzed for petroleum hydrocarbons. Petroleum hydrocarbon concentrations in the soil were below the federal guidelines, indicating no impact on the soil at depth by the oils or greases stored nearby.

The organic vapour concentrations detected using the PID as the field screening method in test pit TP02-92 were relatively high and the soil sample collected from the floor of the test pit (1.1 m) was therefore analyzed for volatile petroleum hydrocarbons. The results indicate that the vapour concentrations were not due to petroleum hydrocarbon contamination.

Metals

Elevated lead (490 µg/g) and zinc (4220 µg/g) concentrations were obtained in test pit TP02-92 from surface to 0.3 m depth. Concentrations of lead (126 µg/g) and zinc (928 µg/g) were considerably reduced in the sample collected from the floor of the test pit (1.1 m). Tailings were observed in the test pits walls to a depth of 0.3 m and the results correlate with this observation.

Zinc concentrations at test pit TP02-91 were 660 µg/g, which is greater than the generic CEQG CL guideline of 360 µg/g. This test pit was excavated in an area with no visible or olfactory indications of contamination (hydrocarbon or metals) and, therefore, the results may be representative of other areas in the warehouse yard that do not exhibit signs of contamination on surface.

5.3.3 Dock and Related Facilities

Concentrate Shed and Loadout Conveyor and Dock

Results for test pits TP02-14 to TP02-48 are referred on Table 4 as documenting conditions surrounding the concentrate shed, loadout conveyor and dock. Results for test pits TP02-49 to TP02- 72 are referenced under the chemical and fuel storage area at the dock. Results obtained from the on-site laboratory from this area are provided in Table 12.

Cadmium concentrations reported by Accutest ranged from 58.6 µg/g to 156 µg/g in the surface soil samples and from 1.4 µg/g to 50.6 µg/g at depth. The generic federal guideline for cadmium in soil is

22µg/g for commerical land use (CL), thus all of the samples analyzed from surface in the vacinity of the concentrate shed are greater than the CL guideline.

Lead concentrations reported by Accutest ranged from 1250 µg/g to 4330 µg/g at surface and from 24 µg/g to 1690 µg/g at deeper depths in the test pits. Lead concentrations reported by the on-site laboratory ranged from 400 µg/g to 10500 µg/g at surface and 100µg/g to 1100 µg/g at depths. The generic federal CL guideline for lead in soil is 260 µg/g, thus surficial soils adjacent the concentrate storage shed exceed this CL guideline.

Zinc concentrations reported by Accutest ranged from 9860 µg/g to 41000 µg/g at surface and 529 µg/g to 21200 µg/g at depth. The on-site laboratory soil laboratory results ranged from 400 µg/g to 155100 µg/g on surface to 100 µg/g to 6300 µg/g at depth. Most of the zinc results regardless of depth were greater than the generic federal PL guideline of 200 µg/g zinc and the CL guideline of 320 µg/g zinc.

Chemical and Fuel Storage Area

Hydrocarbons

Petroleum hydrocarbon concentrations greater than the federal guidelines for soil were detected downgradient of the fuel pump building, adjacent the tank farm in test pits TP02-50 and TP02-53. Additional test pits, TP02-69 and TP02-70, excavated 45 m to 50 m further downgradient did not encounter petroleum hydrocarbon concentrations in greater than the federal guidelines. These results indicate that petroleum hydrocarbon contaminated soil is 50 m or more from the high tide mark of the ocean. The high tide elevation referenced on Figures 4, 5 and 6 was marked out by site personnel during the highest tide period in August 2002.

Results of the surface soil sample collected beneath the AST outside the refuge/lunchroom at the concentrate storage shed were greater than the federal guideline from PHC CWS fraction 2 from surface to 0.15 m depth. The sample was collected below the air vent on the tank, from a patch of stained soil less than 1 m in diameter. It is not considered likely that the petroleum hydrocarbon contamination extends beyond the visually definable zone.

Metals

Results obtained from soil samples collected at the chemical and fuel storage area of the dock show that the distribution of metals are different in this area than those obtained adjacent to the concentrate storage shed. Copper concentrations are greater, while cadmium, lead and zinc concentrations are generally lower in the chemical and fuel storage area.

Copper concentrations in the upper 0.15 m to 0.2 m were 67 µg/g in test pit TP02-51 and 835 µg/g in test pit TP02-66, which are greater than the generic federal PL guideline (63 µg/g) . Test pit TP02-51 was excavated adjacent to the fuel storage area and TP02-66 was excavated in an area used predominately for chemical storage.

Soil samples collected from the upper 0.1 m to 0.2 m of soil in this area had cadmium concentrations that ranged from 5.1 µg/g to 42.0 µg/g. Lead concentrations reported by Accutest ranged from 67 µg/g to 2320 µg/g on surface and those reported by the on-site laboratory ranged from 100 µg/g to 900 µg/g. Zinc concentrations on surface ranged from 2020 µg/g to 12900 µg/g as reported by Accutest and 400 µg/g to 10200 µg/g as reported by the on-site laboratory.

Nine samples of soil collected from depths greater than 0.4 m were analyzed for iron, lead and zinc at the on-site laboratory. Iron concentrations ranged from 1.55% to 2.54% at depth, which is similar to surface concentrations of iron that ranged from 1.49% to 1.95%. Lead and zinc concentrations at depth were uniformly low for all samples. Lead concentrations were reported as 100 µg/g for all samples, which is the on-site laboratory's method detection limit for that parameter. Zinc concentrations were between 300 µg/g and 700 µg/g.

Accutest analyzed three soil samples collected within frozen ground for cadmium, lead and zinc. Soil sample TP02-65-2 was collected adjacent to the shore, which was excavated in a surface drainage path from the chemical storage area. Cadmium and lead results for this sample were both less than the generic federal PL guidelines and zinc concentrations were 251 µg/g which is less than the CL guideline of 320 µg/g but greater than the PL guideline of 200 µg/g. The results for soil samples TP02-70-2 and TP02-72-2, which were also collected within frozen ground, were similar. Cadmium and lead concentrations were less than the stringent PL guidelines for both of these samples and zinc concentration moderately elevated (325 µg/g and 488 µg/g respectively).

Haulage Road

Soil quality results from samples collected at the shoulder of the haulage road from the industrial complex to the dock returned elevated cadmium, lead and zinc results with respect to the generic federal guidelines. The greatest metal concentrations were observed at varying depths within these test pits.

In test pit RD02-6 samples were collected and analyzed at 0.1 m intervals to a depth of 0.4 m. The results show the highest concentrations of metals are present from 0.1 m to 0.2 m and that the concentrations decrease with depth below this interval. These results suggest that metal concentrations in the roadbed may be linked to various successions of road surfacing and concentrate handling methods during the life of the mine.

Results from the two surface soil sampling transects established to evaluate wind dispersed concentrate showed elevated cadmium, lead and zinc concentrations in the upper 0.03 m to 0.05 m of soil within 60 m of the haulage road. Cadmium concentrations on surface ranged from 8.6 µg/g to 52.4 µg/g. Lead concentrations ranged from 227 µg/g to 1270 µg/g and zinc from 5250 µg/g to 22700 µg/g on surface. Three samples of soil analysed for the depth interval from 0.05 m to 0.15 m or 0.2 m indicated that the elevated concentrations of metals is restricted to the upper 0.03 m to 0.05 m of soil adjacent to the road. The results for cadmium, lead and zinc from the deeper samples ranged from <0.5 µg/g to 3.3 µg/g for cadmium, 16 µg/g to 161 µg/g for lead and 114 µg/g to 1040 µg/g zinc..

Fuel Pipeline Route

Petroleum hydrocarbon results for the surface soil sample, SS02-055 collected from an isolated patch of stained soil at a bend in the fuel pipeline to the industrial complex were less than the federal guidelines. No other areas of surface staining were observed along the pipeline route.

5.3.4 Tailings Disposal Facilities

Tailings Pipeline Route

Six areas possibly impacted by historical tailings spills were observed during the investigation and sampled. Evidence of soil excavation from possible clean-up operations was observed in most of the areas and surficial soil samples were collected at the base of these excavations. The surfical soil samples (SS02-006 to SS02-011) were analyzed by the on-site laboratory and are documented in Table 12. Iron concentrations ranged from 2.51% to 7.83%. Lead concentrations ranged from <0.01% to 0.04 % and zinc concentrations ranged from 0.22% to 0.56%. These results were less than those obtained from soil contaminated with spilt tailings at the mill as obtained from test pit TP02-85 (0.189% (1890 μg/g) lead and 0.806% (8060 μg/g) zinc). The results obtained from sampling the areas of historical tailings spills indicates that the concentrations remaining are possibly associated with residual tailings in the soil or, in some aras, they may be associated with natural mineralization as documented on Figure 3.

Results of the soil samples collected downgradient of the south tailings dump pond in test pits TP02-127 and TP02-128 were less than the generic federal PL guidelines. Confirming the visual observation that no tailings were present on surface below this pond. The dump ponds are lined and no impact from their use to store tailings is considered likely downgradient of the ponds.

Two test pits were excavated to investigate the vertical extent of contamination associated with tailings spills. Results from test pit TP02-129 show that the elevated lead and zinc concentrations do not extend past 0.1 m depth. The results obtained from the upper 0.1 m and from 0.1 m to 0.3 m (bedrock) in test pit TP02-130 show that elevated zinc concentrations (651 μg/g and 516 μg/g respectively) extend from surface to bedrock at 0.3 m.

Wind Dispersed Tailings

"Saddle" Area

The metal concentrations in samples DUST02-1 to DUST02-4, which were collected from shallow depressions on rocks, are relatively high. Lead concentrations range from 822 μg/g to 934 μg/g and zinc concentrations range from 2310 μg/g to 6430 μg/g. These results indicate that the material sampled is tailings that have been dispersed by wind.

The results of samples analyzed from Test Pits TP02-139 to TP02-144 confirm the visual observations that tailings are not dispersed over the hillside south of the saddle and that tailings are restricted to a surficial accumulation that does not extend to 0.1 m depth.

East of Town

The results from TP02-125 generally confirmed the visual observations in that wind dispersed tailings were not present to the east of the saddle but were indicated to the northwest of the saddle (towards the town). The metal concentrations in the surficial soil horizon (0 m to 0.1 m in test pits TP02-120 to TP02-124) were less than those identified for the tailings specifically but zinc was elevated at 1690 µg/g or greater.

A sample of the surface water flowing from the north end of the saddle, sample S-SEEP (downgradient of TP02-142) was collected and analyzed. This small stream (estimated at 0.25 L/sec) was flowing towards the east where it entered a pond on the upgradient side of the access road to the WTDA tailings pond. The concentrations of total metals in this water were relatively low when compared to the CEQG FWAL guidelines, indicating that the surficial accumulation of tailings in the saddle area was not affecting surface water flowing out of the area.

South of Town

The June 2000 survey of metal concentrations in surficial soils that was conducted by EBA also provides some information in this regard. Sampling of surficial soils in the area on the south side of the town was included in the EBA survey.

Some of these samples are removed from roadways and elevated metals in these areas may be indicative of other sources of metals in surficial soils than tracking on vehicles, such as wind blown tailings. Specifically, EBA samples generally west to southeast of grid area 900X60 and samples generally southwest to east of grid area 400X70 (refer to EBA Figure 5 in Appendix B) may be considered representative. However, samples collected from stream beds in this grid areaare likely representative of water transport of metals rather than wind transport. The information also suggests that wind blown tailings may be a source of elevated metal concentrations in some areas in the vicinity of the town.

North of Town

Zinc concentrations in the surface soil horizon (0 m to 0.10 m) were moderately elevated (less than 655 µg/g) in select samples along the sample line but to a lesser degree than observed in soil samples considered representative of wind blown tailings (such as TP02-122-1). Lead and zinc concentrations are comparable to the 1985 soil geochemistry results for this area, Figure 4.

The soil geochemistry results from 1985 (Figure 4) confirm the field observation that some of these samples were collected in an area of natural sulphide mineralization (i.e. results of 1459 µg/g lead and 1404 µg/g zinc were obtained historically and TP02-136 returned a concentrations of 256 µg/g lead and

19,800 µg/g zinc). Therefore, these elevated metal concentrations are not considered to be related to wind blown tailings.

Similarly, two sample locations (TP02-137 and TP02-138) were located within the pipe line right of way and the elevated zinc concentration reported for location TP02-138 (2,120 µg/g) is considered to be related to pipeline right of way activities and not to wind blown tailings.

5.3.5 Solid Waste Disposal Facility

Landfill

Hydrocarbons

The analytical results for soil and seepage water samples indicate that no petroleum hydrocarbon contamination is present downgradient of the landfill area. Results for PHC CWS fractions 1 through 4 and benzene, ethylbenzene, toluene, and xylene (BETX) in soil were less than the method detection limit. Petroleum hydrocarbons in the seepage water samples collected from test pits TP02-95, TP02-97 and LF-WSEEP were less than the method detection limits also. Results from the seepage water sample from test pit TP02-102 are indicative of background conditions.

Metals

Metal concentrations in soil samples analyzed for cadmium, lead and zinc at the landfill area were less than the stringent generic federal PL guidelines. Concentrations of silver, cadmium, copper, selenium and zinc in the seepage water sample LF-WSEEP were greater than the federal surface water quality guidelines for the protection of freshwater aquatic life. None of the other seepage water samples collected in the area had metal concentrations greater than the federal guidelines, including in the sample collected in the downgradient test pit TP02-95. These seepage water quality results indicate that the metal concentrations drop out before reaching the toe of the outer berm surrounding the west side of the landfill area.

Landfarm

Hydrocarbons

The soil in the landfarm originated from remediation of the diesel spill at the Carpenter shop and would be anticipated to contain elevated concentrations of diesel related petroleum hydrocarbons. However, results from the two grab samples collected of soil within the landfarm cell indicate that some of the soil in the cell (sample LFC02-1) does not exceed the federal guidelines for PHC CWS fraction 2 (constituents of diesel fuel). Concentrations of volatile petroleum hydrocarbons (toluene, ethylbenzene, xylene), PHC CWS fraction 1 (indicative of gasoline) and PHC CWS fraction 2 in sample LFC02-2 exceed the recommended guidelines.

Two seepage water samples were collected from test pits downgradient of the east side of the landfarm cell. Petroleum hydrocarbon results were less than the method detection limit in samples from both wells.

5.3.6 Miscellaneous Access Facilities

STOL Air strip

Hydrocarbons

Petroleum hydrocarbon contamination was detected at test pit TP02-104, which was excavated in an area of a former diesel AST. The contamination extended from surface to 0.9 m. The clay content of the soil was observed to increase below 0.9 m. The contamination does not extend vertically through the clay rich soil to frozen ground at 1.3 m depth. Results from test pit TP02-105 indicate that the contamination does not extend 25 m downgradient.

Metals

A sample collected from surface to 0.15 m (TP02-103-1) from the apron adjacent to the air strip, used mainly for maintenance and parking of aircraft, returned elevated lead (9350 µg/g) and zinc (926 µg/g) concentrations. The lead:zinc ratio exhibited by this sample is not typical of contamination associated with tailings or concentrate. This is the only sample result obtained during the Phase II ESA in which the lead concentrations exceeded the zinc concentrations.

5.3.7 Mine Workings

Underground Mines

Hydrocarbons

Results of surface soil samples collected beneath existing small ASTs outside the refuge stations at Oceanview, 39N Portal and the 17N Portal, and at the ANFO plant building were greater than the federal guideline from PHC CWS fraction 2. The federal guideline for PHC CWS fraction 3 was also exceeded in all of these sites except Oceanview. The samples were collected in areas of obvious hydrocarbon stained patches that were generally less than 1.0 m in diameter. It is not considered likely that the petroleum hydrocarbon contamination extends beyond the visually definable zone. Nor is it considered likely that the contamination extends more than 0.15 m into the soil from these tanks.

Soils surrounding larger existing and former ASTs and USTs were also investigated during the Phase II ESA. Soil beneath the discharge pipe at the former Oceanview AST had concentrations of PHC CWS fraction 2 greater than the federal CL guideline at a depth of 1.0 m. Results from test pit TP02-02 excavated in the vicinity of the fill pipe of the former AST did not exceed the PHC CWS guidelines for fractions 2 or 3. These results indicate that hydrocarbon contamination at Oceanveiw is likely localized to a small area at the discharge side of the tanks.

Concentrations of PHC CWS fraction 2 exceeded the CL guideline at each of the test pits excavated at the former K-Baseline AST and at the former maintenance shop down slope of the tank platform. A sample from test pit TP02-05 was also analyzed for polycyclic aromatic hydrocarbons and the naphthalene result was greater than the CEQG CL guideline. Elevated concentrations of petroleum hydrocarbons extended from surface to frozen ground (1.6 m to 2.0 m) in this area. The lateral extent of petroleum hydrocarbon contamination in this area is unknown.

During the site investigation a diesel AST was being used to refuel heavy equipment at the 39N dump. Concentrations of PHC CWS fractions 1 and 2 exceeded the federal guideline in soil collected from the base of the test pit at 1.0 m. Downgradient of the test pit TP02-07 mineralized waste rock was being excavated and relocated to the mine workings.

A soil sample was collected and analyzed from the area recently excavated to remove the UST at the 01 Portal. This sample was analyzed and returned concentrations of PHC CWS fractions 2 and 3. The tank was utilized only during the latter years of mining and it is suspected that the contamination detected is localized. A soil sample (SS02-017) from the area recently excavated to remove the UST returned concentrations of PHC CWS fraction 2 (500 µg/g) that met the CEQG CL guideline (760 µg/g) but exceeded the CEQG PL guideline (450 µg/g) for coarse grained surface soil.

Haulage Roads

Metals

Small areas with mineralized fill were observed at the edges of the haulage roads as shown on Figure 6. The sources of the mineralized fill have been derived from adjacent bedrock exposures in most cases. Three samples were submitted for analysis of cadmium, lead and zinc from test pits excavated along the haulage road to Area14. Two test pits, TP02-145 and TP02-146 were excavated in the shoulder of the road to inspect metal concentrations at depth. Results for test pit TP02-145 were relatively high for cadmium (61.0 µg/g), lead (1120 µg/g) and zinc (25000 µg/g). The test pit excavated weathered bedrock and shale in an area with visible hematite altered bedrock, so it is considered possible that these results are indicative of the adjacent mineralized bedrock. Test pit TP02-147 was excavated into a stock pile of shale that appeared to have been used for road construction. Results for TP02-146 and TP02-147 were less than the generic federal PL guidelines.

Waste Rock Piles

Metals

The waste rock dumps from the West Adit area of the mine were historically in contact with Twin Lake Creek. Highly mineralized naturally occurring outcrops of ore grade material are also in contact with Twin Lakes Creek in this area as shown on Figure 4. Sediment samples were collected along the creek from East Twin Lake to the industrial complex. Results for SED02-3 indicate that the sediment downstream of the lake and upstream of the mineralized bedrock or waste rock contains relatively low metal concentrations. SED02-4 was collected upstream of mineralized waste rock dumps adjacent to the creek. Zinc concentrations were three to four times higher at this location than at SED02-3, which is thought to be the result of the creeks' interaction with mineralized outcrops in the area. Concentrations of metals in the sediment do not uniformly increase at the downstream toes of waste rock dumps. Metal concentrations in the sediments of the creek are related to the combination of weathered waste rock's proximity to the creek and the location and degree of mineralized bedrock and it's contribution to the sediments in the creek. Sediment quality results generally exceeded the interim federal guidelines for freshwater sediment for cadmium, lead and zinc as listed on Table 10 and shown on Figure 6.

During the site investigation, work was ongoing to remove mineralized waste rock between the haulage road and the creek at the West Adit area.

Mine Discharge Water and Treatment Facilities

Metals

Sediment results for samples collected within the lime treatment pond (SED02-2) and the retention pond (SED02-1) at the East Adit Area are reported on Table 12 along with additional results obtained from the on-site laboratory for iron lead and zinc. Iron, lead and zinc concentrations for the sample collected from the treatment pond are less then those obtained from the retention pond. The proximity of the lime treatment system to the sample location SED02-2 is thought to be the reason for the lower concentrations at this site.

Results for SS02-001 to SS02-004, as listed on Table 12 and under the heading Treatment and Retention ponds on Table 8, show elevated cadmium, lead and zinc concentrations downgradient of the ponds with respect to the generic federal PL guidelines. Metal concentrations are reduced below 0.1 m depth as shown by the results from SS02-002 and SS02-003 on Table 8. SS02-005 was collected from a surface drainage path cross gradient of the treatment pond and results for this sample were also elevated with respect to zinc and lead concentrations.

6. Contaminants and Areas of Environmental Concern

6.1 Contaminants of Environmental Concern

Based on observations and results obtained during the Phase II ESA, the contaminants listed in Table F are considered to be of environmental concern.

Table F: Contaminants of Environmental Concern

Contaminant	Comment
Volatile Petroleum Hydrocarbons	Constituents of gasoline (<C10); identified by elevated concentrations of Canada Wide Standards for Petroleum Hydrocarbons ("PHC CWS") fraction F1 and benzene, ethylbenzene, tolulene and xylene ("BETX") compounds.
Extractable Petroleum Hydrocarbons	Constituents of diesel, oils and greases (>C10); identified by elevated concentrations of PHC CWS fractions 2, 3 and 4.
Napthalene	Constituent of diesel.
Chlorinated Ethenes – Volatile Organic Compounds	Constituents of Xanthate.
Cadmium, Copper, Lead, Zinc	Constituents of ore, concentrate and tailings.

The Phase II ESA did not identify Ethylene glycol (antifreeze) and arsenic as contaminants of environmental concern.

6.2 Areas of Environmental Concern

Areas of Environmental Concern that were identified or verified by this Phase II ESA are illustrated on Figure 7 and are listed in Tables F (Hydrocarbons) and G (Metals). Tables G and H also present summary comments regarding the extent or nature of the environmental concern for each area.

Table G: Areas of Environmental Concern - Hydrocarbons

Area	Comment
a. Oceanview	Localized near surface contamination at an existing, small above ground storage tank ("AST"). Localized contamination to permafrost at a former, larger AST.
b. K-Baseline	Contamination to permafrost at one former AST and at former maintenance shop that extends downgradient.
c. East Adit Area	Localized near surface contamination at a small AST. Contamination to permafrost at one current AST at 39N dump.
d. 17N Refuge Station	Localized near surface contamination at an existing small AST.
e. Area14	Localized near surface contamination at a former AST.
f. West Adit Area	Localized near surface contamination at AST's at the ANFO building and 01 portal. Contamination adjacent a former underground storage tank ("UST').
g. Town	Hydrocarbon contamination at ASTs adjacent the homes is confined to shallow areas (less than 0.05 m) indicated by visual surface staining. Hydrocarbon impacted soil at larger ASTs is not readily detectable by visual observations due to resurfacing of the ground surrounding the tanks with shale fill and the vertical extent of contamination can extend to permafrost and could extend laterally.
h. Carpenter Shop	Contamination to permafrost downgradient of area remediated after 2000 diesel spill.
i. Land Farm	No soil or water contamination downgradient of landfill area. Soil in landfarm continues to require remediation.
j. STOL Airstrip	Localized contamination at former AST.
k. Industrial Complex Area	Contamination to permafrost in maintenance and parking areas. Contamination to permafrost downgradient of fuel storage area. Localized near surface contamination at waste oil tank and warehouse yard.
l. Dock Area	Localized near surface contamination at a current AST. Limited contaminant migration at the permafrost horizon downgradient of the fuel pump building does not extend to within 50 m of the ocean shore.

Table H: Areas of Environmental Concern - Metals

Area	Comment
1. Oceanview	Small quantities of mineralized rock along road side.
2. K-Baseline	Limited exposed mineralized rock in yard at portal.
3. East Adit Area	Waste rock dumps, open pits and exposed mineralized wall rock.
4. East Adit Treatment Facility	Residual treatment sediments in Treatment and Retention ponds. Localized surficial contamination in drainage paths.
5. Area14	Limited exposed mineralized rock in yard at portal.
6. Area14 Road	Small quantities of mineralized rock along roadside.
7. Tailings Pipeline/Dump Ponds	Residual tailings at former pipeline breaks.
8. West Adit Area	Waste rock dumps, open pits, exposed mineralized wall rock and natural outcrops in Twin Lakes Creek.
9. Twin Lakes Creek	Waste rock dumps and natural outcrops in contact with creek.
10. Wind Dispersed Tailings	Tailings are present as a very thin surficial coating on rocks and soil in a northwesterly direction and along the base of the hill on the south side of the town.
11. Town	Elevated metal concentrations in surficial soil.
12. Industrial Complex Area	General contamination of area. Concentrations decrease at depths greater than approx. 0.5 m.
13. Concentrate Haul Road	General contamination of roadfill. Surficial contamination of upper soil horizon along roadside.
14. Dock Area	General surficial contamination of area.

7. Limitations

This report was prepared for the exclusive use of Canzinco Ltd. The report is intended to provide the results of the 2002 environmental site characterization and other activities as documented in the report at the Nanisivik Mine site, Nunavut. The report, which specifically includes all tables and figures, is based on data and information collected during the investigations conducted by GLL, and is based solely on the conditions of the site at the time of the investigation, supplemented by historical information and data obtained by GLL, as described in this report.

The investigation programs described in this report, were conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and science professions currently practicing under similar conditions, subject to the time limits and financial and physical constraints applicable to the services.

Any use which a third party makes of this report, or any reliance on, or decisions to be made based on it, are the responsibility of such third parties. GLL accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on the information contained in this report.

The assessment of environmental conditions at this site have been made using the results of chemical analysis of soil, sediment and groundwater/surface seeps from a limited number of locations. The site conditions between sampling locations have been inferred based on conditions observed at sampling locations. Subsurface conditions may vary from those encountered at the sample locations. Additional study, including further subsurface investigation, can reduce the inherent uncertainties associated with this type of study. However, it is never possible, even with exhaustive sampling and testing, to dismiss the possibility that part of a site may be contaminated and remain undetected.

Figures

Tables

Appendices

Appendix A

Photographs

Appendix B

2000 Marine Sediment Data

Appendix C

Air Monitoring Data

Appendix D

Excerpts from:
Soil Sampling Program, Nanisivik Town Site,
Nanisivik, Nunavut
EBA Engineering Consultants Ltd., August 2002

Appendix E

Laboratory Reports, Accutest Laboratories Ltd.

Appendix F

Laboratory Reports, CanZinco Ltd. Nanisivik Mine Laboratory