Indigenous and
Northern Affairs Canada

Affaires autochtones
et du Nord Canada

Appendix O-2

Report: Contact Lake Mine Remedial Action Plan with Project Update

Indian and Northern Affairs Canada
Affaires indiennes et du Nord Canada

CONTACT LAKE MINE REMEDIAL ACTION PLAN

Prepared By:

Contaminants and Remediation Directorate
Indian and Northern Affairs Canada
In Association With:
SENES Consultants Limited

Canada

March 2008

FINAL

CONTACT LAKE MINE REMEDIAL ACTION PLAN

Prepared By:

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Indian and Northern Affairs Canada

In Association with

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March 2008

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EXECUTIVE SUMMARY

SENES Consultants Limited (SENES) was retained by Indian and Northern Affairs Canada (INAC) under Standing Offer Agreement No. 00-05-6007-1 to develop a remediation plan for the abandoned Contact Lake Mine site, which is located along the north-eastern shore of Great Bear Lake in the Northwest Territories. The Contact Lake Mine was operated intermittently from 1930 until 1980 and predominantly for silver and to a limited extent for uranium. New exploration activities have been initiated in the Contact Lake area since 2005.

Community concerns

The community of Délı̨nę has expressed significant concerns with abandoned mine sites in the Sahtu Region. Although the Contact Lake Site is a small site (less than 5 ha) in comparison to other nearby sites such as Port Radium and the Silver Bear Mines, there is still community concern associated with respect to historical and future potential impacts on the local environment. The water quality of Contact Lake and Great Bear Lake was the major concern expressed by the people of Délı̨nę along with the health of the vegetation and wildlife. The debris and the openings at the site were expressed as a concern with regard to human and wildlife health.

Remediation planning process

The proposed Remedial Action Plan is based on the results of environmental site investigations, human health and ecological risk assessment studies, best practices in mine closure, traditional knowledge, current use of the area, and community values. The plan takes the environmental status of the site, precedent practice, regulatory requirements, and site goals into consideration. Long term monitoring and reporting will be carried out at the site to provide ongoing assurance that the remediation works continue to perform as intended.

Principles relevant to the Contact Lake Mine from Federal policy and guidance documents were combined with the principles of the Sahtu Dene Comprehensive Land Claim Agreement to provide the site-specific approach for the development of the Remedial Action Plan. The final remediation plan has been developed under the management of the INAC’s Contaminants and Remediation Directorate (CARD), which has the mandate for management of all northern contaminated sites. The overall responsibility of the CARD is to minimize health and safety and environmental risks associated with the site and implement a remediation plan that meets the needs and concerns of INAC, its First Nation partners and all Northerners. In addition, a community involvement and consultation process was undertaken to ensure that the community of Délı̨nę is aware of the site issues and an active participant in the selection of the preferred closure options for the final remediation of the Contact Lake Mine site.

Proponents and regulators

INAC is the project proponent for the Remedial Action Plan and is responsible for securing appropriate approvals and resources, and implementation of the plan. The proposed works will require land and water licenses from the Sahtu Land and Water Board before they can be implemented.

Proposed remediation works

A summary of the remediation plan is presented in Table ES.1. The main elements of the remediation plan include activities associated with remedial actions to secure the mine openings; eliminate hazards and risks associated buildings, the fuel storage tank, the waste disposal areas, and miscellaneous debris; and mitigate existing or potential environmental issues associated with waste rock, tailings and hydrocarbon impacted soils. Within this context, the components considered within the Remedial Action Plan include the following:

TABLE ES-1
SUMMARY OF PREFERRED REMEDIAL ACTION PLAN

Site Component	Preferred Remediation Method
Mine Openings	• Seal mine shaft and vent raise with a cap • Seal adit entrance with rock fill (to limited height) • Open stope – blast sides to backfill and fence
Buildings and Infrastructure	• Remove designated substances for disposal • Demolish buildings • Dispose of debris in local landfill
Waste Rock	• Cover grid areas where gamma radiation exceeds 250 μR/h • Re-grade toe of waste rock area and remove miscellaneous waste rock from toe and fan area
Tailings Area	• Consolidate exposed surface tailings and cover • Leave tailings pond as is
Waste Disposal Areas	• Consolidate waste disposal areas into one area
Fuel Storage Tanks	• Clean out, demolish and dispose of East Arm tank
Hydrocarbon Impacted Soils	• Cover in place, or relocate for onsite/offsite disposal depending on level of concentrations
Miscellaneous Debris	• Clean up and dispose in onsite landfill
Roadways	• Upon remediation completion remove culvert(s) and leave as is for natural re-vegetation

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GLOSSARY OF TERMS

Aboriginal land claim: A claim to a specific area of land based on legal concepts of land title and the traditional use and occupancy of that land by aboriginal peoples who did not sign treaties, nor were displaced due to war or other means.

Acid generating: Material capable of or actually producing acidic drainage.

Acid Producing Potential (APP): The potential of a material to produce acid, generally stated as kg $CaCO_3$ equivalent per tonne of rock.

Acid Rock Drainage (ARD): Drainage of low pH water from mineral areas as a result of the oxidation of sulphur-bearing materials which may release metals into the environment and result in significant environmental impacts.

Adit: A nearly horizontal passage from the surface by which a mine is entered and dewatered. A blind horizontal opening into a mountain, with only one entrance.

Aerial photography: Photographs taken from an aircraft either obliquely or vertically.

Aggregate: Sand, gravel, or crushed rock.

As low as reasonably achievable (ALARA): A concept in radiation protection according to which radiation exposures are kept as far below the regulatory limits as possible, taking into account the state of technology achievable and the cost of improvement in relation to: (1) benefit or risk to the environment and to public health and safety; (2) other societal and socioeconomic considerations, and (3) the use of radioactive materials in the public interest in medical diagnosis and therapy, research, the manufacturer of consumer products, and the production of electricity by nuclear power reactors.

Algae: Photosynthetic plants which live and reproduce entirely immersed in water. They range in size from simple, single-celled organisms to huge kelps several metres long.

Alkalinity: The aggregate measure of the concentration of hydroxyl, carbonate and bicarbonate ions, and dissolved CO_2. Therefore, it is a general indicator of the acid-buffering capacity of the water body.

Alpha radiation: The least penetrating, but most strongly ionizing, of the three principal forms of radiation from radioactive materials, alpha radiation will be halted by the outer layer of dead skin cells in human skin, or by a single sheet of paper. However, alpha radiation can damage live body cells if ingested or inhaled through food, water, air, etc.

Ambient: The natural surrounding (background) conditions in a given area.

Analyte: A compound or element being analyzed.

Analytic detection limit: The limit of measurement of a given parameter, below which variations in concentration are indistinguishable from one another.

Asbestos: A naturally occurring soft fibrous mineral commonly used in fireproofing materials and considered to be highly carcinogenic.

Assessment endpoint: A quantitative or quantifiable expression of the environmental value considered to be at risk in a risk assessment.

Back: The ceiling or roof in an underground mine.

Background radiation: The radiation in the natural environment, including cosmic rays and radiation from naturally radioactive elements. It is also called natural radiation.

Baseline: See "Environmental baseline".

Basement: The undifferentiated rocks (commonly igneous and metamorphic) which underlie the rocks of interest (commonly sedimentary) in a given area. In many regions the basement is of Precambrian age.

Becquerel or Bq: A standard international unit of radioactivity, equal to one radioactive disintegration per second. The obsolete unit curie or Ci, based upon the amount of radioactivity in a gram of radium, equals 3.7×10^{10} Bq.

Bedrock: The solid rock that underlies gravel, soil or other surficial material.

Benthic: Refers to the bottom of a lake or river and/or the organisms that inhabit it.

Benign: Not dangerous to human health or the environment.

Benthos: The whole assemblage of plants or animals living on the lake or river bottom; distinguished from *plankton*.

Best Management Practice (BMP): Methods that have been determined to be the most effective, practical means of preventing or reducing pollution from non-point sources.

Bioaccumulation: The net accumulation of a chemical by an organism as a result of uptake from all routes of exposure.

Bioavailability: Degree of ability to be absorbed and ready to interact in organism metabolism.

Biological diversity (biodiversity): The variety of different species, the genetic variability of each species, and the variety of different ecosystems that they form.

Biomagnification: The tendency of some chemicals to accumulate to higher concentrations at higher levels in the food web through dietary accumulation.

Biota: The animal and plant life of a region.

Bog: An acidic, poorly drained, rainwater fed peatland characterized by hummocks or sphagnum spp. Mosses with Labrador tea usually being the dominant shrub. Bogs may be treed with stunted black spruce and tamarack (muskeg) or may be open (open bogs).

Boreal Forest: The predominantly coniferous forest of northern Canada.

Borehole: Hole made with drilling equipment typically to obtain samples.

Buffering capacity: The degree to which a given volume of water or soil is able to neutralize acids.

Carbonate: Any mineral containing carbonate (CO_3^{-2}) ions.

C**arcinogen:** An agent that has the potential to cause cancer.

Carnivore: An animal that eats the flesh of other animals.

Chlorite: A group of widely distributed usually greenish, metamorphic minerals that are usually associated with micas, which they resemble.

Clay: Soil particles that are smaller than silt (less than 0.002 mm in diameter).

Climatology: The study of weather conditions or long periods of time.

Collar: The mount or upper end of a mine shaft or drill hole.

Conductivity: A measurement of the electrical conductivity of a water body or sample in order to determine the amount of dissolved material present.

Conservative: As used in the term conservative estimates, this is considered a pessimistic or an overestimate of the level, effect or hazard, as the case may be.

Contaminant migration: The movement of contaminants from one location to another.

Contamination: Elements both radioactive and non-radioactive that are present at levels above those normally found (i.e. above background).

Contingency plan: A prearranged plan to be implemented in the event of some unforeseen happening of serious concern.

Crown or surface pillar: A body of rock of variable geometry, which may or may not contain minerals. Located above the underground operations, it supports the surface above stopes.

Decommissioning: The act of removing a regulated facility from operation and operational regulation. This usually entails a certain amount of cleanup (decontamination).

Decontamination: The process of removing contaminants from equipment, personnel, buildings or water.

Delineate: To determine the outer limits and size of something (i.e., an ore body).

Dip: A vertical angle measured downward from the horizontal plane to the level of an inclined plane such as a tilted sedimentary rock unit (see strike).

Discharge: The volume of water passing a given point per unit time, usually expressed as m^3/s.

Dose: A general term used to describe the amount of radiation or chemical absorbed by a person or in some cases a particular organ. The term dose can be used to describe two concepts. The first concept is a physical quantity; for radiation, it is the amount of energy absorbed per unit mass of tissue (see absorbed dose) and for chemicals, it is the concentration in tissue.

Drainage basin: The area of land and water bodies therein, draining to a given point, usually a lake or river.

Ecological Risk Assessment: The application of a formal framework, analytical process, or model to estimate the effects of human actions(s) on a natural resource and to interpret the significance of those effects in light of the uncertainties identified in each component of the assessment process. Such analysis includes initial hazard identification, exposure and dose response assessments, and risk characterization.

Ecosystem: Any natural system in which there is an interdependence upon and interaction between living organisms and their physical environment. This interdependence is characterized by the transfer of energy between the organisms themselves and their physical environment in a complex series of cycles.

Element: A substance that is comprised of one and only one distinct kind of atom.

Environment: The sum of all external conditions, influences and forces affecting the development and life of organisms.

Environmental baseline: The data collection characterizing the "natural" environment in its pre-development or pre-impact state. This data is used as a base for determining potential and actual impacts in the defined impact area.

Environmental Assessment: An environmental analysis to determine whether a site/facility would significantly affect the environment and thus require a more detailed environmental impact statement.

Environmental Impact: A change in environmental conditions resulting from an action or development, which may be negative, positive, or neutral.

Erosion: The wearing down (weathering) and removal of soil, rock fragments and bedrock through the action of rivers, glaciers, sea and wind.

Evapotranspiration: The total return of water from the land to the atmosphere, including the process of evaporation from the soil surface and transpiration from plants.

Exposure: The amount of radiation or pollutant present in a given environment that represents a potential health threat to living organisms.

Exposure Assessment: Identifying the pathways by which toxicants may reach individuals, estimating how much of a chemical an individual is likely to be exposed to, and estimating the number likely to be exposed.

Exposure Concentration: The concentration of a chemical or other pollutant representing a health threat in a given environment.

Exposure Pathway: The path from sources of pollutants via, soil, water, or food to man and other species or settings.

Fan: A mechanical device used as a means of forcing air into underground workings.

Fault: A fracture in bedrock along which movement has taken place.

Foot wall: The underlying surface of an inclined fault plane.

Fracture (geological): A crack, joint, fault or other break in rocks.

Rock fracture: The general term given to any non-sedimentary medicinal discontinuity thought to represent a surface or zone of mechanical failure.

Gamma radiation: The greatest penetrating power, but least ionizing, of the three principal forms of radiation from radioactive materials. Gamma radiation can completely penetrate and damage all body organs. Gamma radiation can be shielded effectively by several inches of lead, steel, or concrete, depending upon the shielding material and the energy and intensity of the gamma radiation.

Geochemistry: Refers to the chemical analysis of surface and subsurface water, rock alluvium, soil and plants.

Grade: The relative quantity or percentage of ore mineral content in an ore body (i.e. g/t Au or % U_3O_8).

Grading: The process of making a surface level or evenly sloped.

Groundwater: Water beneath the earth's surface, accumulating as a result of infiltration and seepage, and serving as a source of springs and wells.

Habitat: The natural home of a plant or animal.

Hanging wall: The overlying surface of an inclined fault plane.

Hazard: Potential for radiation, a chemical or other pollutant to cause human illness or injury. Hazard identification of a given substance is an informed judgment based on verifiable toxicity data from animal models or human studies.

Hazard Assessment: Evaluating the effects of a contaminant or determining a margin of safety for an organism by comparing the concentration that causes toxic effects with an estimate of exposure to the organism.

Headframe: The structure surmounting the shaft that supports the hoist rope pulley, and often the hoist itself.

Heavy metals: Any metal with a high atomic weight (usually greater than 100). They are poisonous and tend to persist in living tissue once ingested, e.g. mercury, lead, cadmium and chromium.

Human Health Risk Assessment: The process of quantifying risks and determining the acceptability of those risks to humans.

Hydraulic head: A combined measure of the elevation and the water pressure at a point in an aquifer that represents the total energy of the water; since ground water moves in the direction of lower hydraulic head (i.e. toward lower energy), and hydraulic head is a measure of water pressure, groundwater can and often does flow 'uphill'.

Hydrogeology: The study of subsurface waters and related geologic aspects of surface water.

Hydrology: The study of the characteristics, occurrence, movement and utilization of water on or below the earth’s surface and within its atmosphere.

Impervious liner: A layer of clay or manmade material such as High-Density Polyethylene (HDPE), used to seal the bottom of containment structures in order to prevent percolation and migration of potential contaminants.

Incremental: Small increase.

Lay-down area: An open area for storing equipment or materials at a mine site prior to their use.

Leachate: The water that percolates through a porous medium such as soil and transports any salts or other dissolvable materials, which may be found in the soil.

Leaching: Washing out of soluble substances by water passing down through rock or soil. In a milling sense, indicates the dissolving of ore minerals from the ground ore.

Limnological: Referring to the scientific study of lakes and their physical, chemical and biological components.

Loadings: Total mass of contaminants to a water body or to the land surface over a specified time.

Lower limit of detection: This is the lowest concentration of radioactive material in a sample that can be detected at the 95% confidence level with a given analytical system.

Macrophytes: Rooted aquatic vascular plants.

Maintenance Activities: activities undertaken to ensure that conditions remain in the desired state

Manway: Vertical opening that can be used by miners to exit the underground workings. A shaft compartment used to accommodate ladders, pipes and electric cables. Underground usually a small passage used as a travelway for miners, an airway and supply route.

Mean: The average value of the data.

Measurement endpoint: A quantitative summary of the results of a toxicity test, a biological monitoring study, or other activity intended to reveal the effects of a substance.

Mine drift: A horizontal (or near horizontal) passageway in a mine through or parallel to a vein, or a secondary passageway between shafts or tunnels.

Mineral: A naturally occurring inorganic, crystalline solid that has a definite chemical composition and characteristic physical properties.

Mineralization: The process by which a valuable mineral or minerals are introduced into a rock, resulting in a potential or actual ore deposit.

Mitigation: An action or design intended to reduce the severity or extent of an environmental impact.

Modeling: Using mathematical principles, information is arranged in a computer program to model conditions in the environment and to predict the outcome of certain operations.

Monitoring: sampling, measurement, and/or inspection.

Neutralizing potential (NP): The potential of material to neutralize an acid or a base.

Ore: Naturally occurring rock material from which a mineral or minerals of economic value can be profitably mined.

Ore body: A continuous well-defined mass of material containing enough ore to make extraction economically feasible.

Outcrop: The part of a rock formation that appears at the surface of the earth, uncovered by water or overburden.

Overburden: Unconsolidated soil and rock material overlying bedrock.

Oxidation: The process of combining with oxygen, especially at the atomic level.

Particulate: Consisting of particles.

Pathway: The physical course a chemical or pollutant takes from its source to the exposed organism.

Pathways analysis: A method of estimating the transfer of contaminants (e.g. radionuclides released in water) and subsequently accumulating up the food chain to fish, vegetation, mammals and humans and the resulting radiological dose to humans.

PCB's: A group of manufactured chemicals including 209 different, but closely related, compounds made up of carbon, hydrogen, and chlorine. If released to the environment, they persist for long periods of time and can biomagnify in the food web. They are an organic toxicant suspected of causing cancer, endocrine disruption, and other adverse impacts on organisms.

Permafrost: Thermal conditions remaining below 0 ºC continuously for more than one year.

Permeability: Describes the ability of subsurface features to transport water.

pH: A number expressing the degree of alkalinity or acidity of a substance according to the hydrogen ion concentration. A substance is said to be "neutral" if its pH is 7, acidic if less than 7 and alkaline if greater than 7.

Phytoplankton: Any microscopic or near microscopic, free-floating autotrophic aquatic plant.

Pitchblende: The most common form of uranium. A mineral consisting of uranium oxide and two amounts of iodine, thorium, polonium and lead. Uraninite in massive form is called pitchblende.

Population: A group within a single species, the individuals of which can and do freely interbreed.

Porosity: The relative volume of open spaces within a rock or soil. (Usually expressed as a percentage of the total volume of the material occupied by the open spaces, or interstices.)

Porewater: Water contaminated and trapped within void spaces in soils or rocks.

Precipitation: The deposition of atmospheric moisture as rain, sleet, snow, hail, frost or dew.

Prospector: An individual engaged in the search for economic mineral deposits, identifying minerals or mineral properties visually or with the use of portable instruments.

Pyrite: A common yellow mineral with a brilliant metallic lustre often crystallizing into cubes. It is an important sulphur ore and is often associated with gold and copper.

Radiation: The emission and propagation of energy through space or matter in the form of electromagnetic waves (e.g. gamma rays) or fast-moving particles such as alpha and beta particles.

Radioactive: The condition of a material exhibiting the spontaneous decay of an unstable atomic nucleus into a stable or unstable nucleus (e.g. uranium-238 decays into thorium-234 (unstable) and polonium-210 decays into lead-208 (stable)).

Radionuclide: An element or isotope which is radioactive as a result of the instability of the nucleus of its atom (e.g. radium or uranium).

Radon: A radioactive element in the uranium-238 decay chain produced by the radioactive decay of radium-226. Radon occurs as an inert gas. The half-life of radon-222 is 3.8 days.

Short-lived radon decay products or, daughters, are the principal radiation hazard in the underground mine. The decay of radon-222 and short-lived decay products produces lead-210.

Receptor: A human or ecological entity exposed to a contaminant released to the environment.

Reclamation: Restoration of a site to a beneficial use, which may be for purposes other than the original use.

Remediation: The improvement of a contaminated site to prevent, minimize or mitigate damage to human health or the environment. Remediation involves the development and application of a planned approach that removes, destroys, contains or otherwise reduces the availability of contaminants to receptors of concern.

Remediation Issue: Issues of concern for a specific aspect of the site.

Risk: A measure of the probability that damage to life, health, property, and/or the environment will occur as a result of a given hazard.

Risk Assessment: Qualitative and quantitative evaluation of the risk posed to human health and/or the environment by the actual or potential presence and/or use of specific pollutants.

Risk Characterization: The last phase of the risk assessment process that estimates the potential for adverse health or ecological effects to occur from exposure to a stressor and evaluates the uncertainty involved.

Roentgen (R): The roentgen is a historical unit used to measure radiation exposure, the number of ionizations in a mass of air. The roentgen can only be used to describe the amount of X or gamma radiation, and only in air. In metric units, one roentgen is equal to depositing in dry air enough energy to produce 2.58×10^{-4} coulombs per kg.

Run-off: The part of rainfall that is not absorbed directly by the soil but is drained off in rills or streams.

Screening: A preliminary stage of the assessment process for quick evaluation of relatively simple and routine activities, or for determining the level of effort required for evaluating more complex projects.

Sediment: Loose, solid particles resulting from the breakdown of rocks, chemical precipitation or from organisms.

Seismic: Pertaining to, characteristic of, or produced by earthquakes.

Sievert or Sv: A unit of equivalent or effective dose. In theory, the unit Sv should only be applied at low doses and low dose rates. Equivalent and effective doses are frequently expressed as millisievert (mSv), equal to one-thousandth of a sievert, or as microsievert (µSv), equal to one-millionth of a sievert.

Slumping: Sagging or physical subsidence of materials.

Spalling: Material breaking off from a surface, typically due to freeze/thaw processes.

Staff Gauge: A pole or 'staff" graduated in standard units of measurement for the purpose of measuring depth.

Stopes: Underground mine working from which ore has been extracted for processing and metal recovery.

Strike: Refers to the direction taken by a structural surface as it intersects the horizontal plane e.g. bedding or fault plane. The strike is at right angles to the direction of dip.

Structure (geological): Features produced by deformation or displacement of the rocks, such as a fold or fault.

Sulphides: Any mineral compound characterized by the chemical linkage of sulphur with a metal e.g. galena (PbS), pyrite (FeS_2).

Taiga: The northern forest of coniferous trees that lies just south of the arctic tundra.

Tailings: Finely ground rock particle material rejected from a mill after most of the recoverable ore minerals have been extracted.

Tailings: Residue of raw material separated out during the processing of mineral ores.

Tailings Containment Area or TCA: an area designated for the purpose of receiving and containing milling residues.

Tank farm: An area designed to contain various size tanks holding various types of liquids or gases, most commonly propane or petro-chemicals.

Till: An unsorted heterogeneous mixture of rock debris carried and deposited directly by a glacier, with very little subsequent reworking by melt water.

Topographic map: A map showing elevations by means of contour lines (i.e. lines joining points of equal elevation).

Total dissolved solids (TDS): The sum of all the concentrations of dissolved ions in a solution usually expressed as mg/L.

Total suspended solids (TSS): The total amount of suspended solid material in a sample, usually expressed as mg/L.

Traditional knowledge: Refers to the ancient understanding of philosophy, events and things passed on orally through generations by aboriginal people.

Traditional land use: Refers to land use by aboriginal people that reflect the historic activities of their people prior to European settlement (i.e. hunting, fishing, gathering).

Traditional lifestyle: Refers to the lifestyle of aboriginal people prior to European settlement.

Uncertainty: A quantitative expression of error.

Uraninite: Black uranium ore, mineral commonly called pitchblende (composition ranges from UO_2 to U_3O_8).

Uptake: The process/act by which a contaminant (e.g. a radionuclide) enters a biological organism (e.g. inhalation, ingestion by humans).

Vent: An (vertical) opening used for input of fresh air or exhausting used air from underground.

Ventraise: See **Vent**.

Waste rock: That rock or mineral that must be removed from a mine to keep the mining scheme practical, but which has no economic value.

Watershed: A drainage area or basin into which all surface water from a particular area collects and is transported.

Winter Road: A substandard, seasonal road passable only during the winter when the ground, muskegs and lakes it passes over are frozen.

Zooplankton: Any microscopic or nearly microscopic animals that move passively in aquatic ecosystems.

UNITS AND ABBREVIATIONS

Bq	Becquerel (1 disintegration per second, or 27 pCi)
Bq/L	Becquerel per liter
g/m^3	grams per cubic metre
m	metre
m^2	square metre
m^3/y	cubic metres per year
µg/g	microgram per gram
µg/L	microgram per liter
µrem	microrem (1 x 10^{-6} rem, or 0.01 µSv)
µR/h	micro Roentgen per hour
µSv	microsievert (1 x 10^{-6} Sv, or 100 µrem)
µSv/y	microsievert per year
Sv	sievert (100 rem)

AMC	Asbestos Containing Material
DDT	Dicloro-diephenyl-trichloroethane
NaI	sodium iodide scintillation detector
PAH	Polyaromatic Hydrocarbon
Pb-210	lead-210
PCB	Polychlorinated Biphenyl Compound
PHC	Petroleum hydrocarbon
Po-210	polonium-210
Ra-226	radium-226
SI	International System of Units
TCA	Tailings Containment Area
Th-230	thorium-230
U	uranium

CHEMICAL SYMBOLS

Aluminum	Al
Ammonia	NH_3
Arsenic	As
Barium	Ba
Beryllium	Be
Cadmium	Cd
Calcium	Ca
Chloride	Cl
Chromium	Cr
Cobalt	Co
Copper	Cu
Iron	Fe
Lead	Pb
Lithium	Li
Magnesium	Mg
Manganese	Mn
Molybdenum	Mo
Nickel	Ni
Phosphorous	P
Potassium	K
Selenium	Se
Silver	Ag
Sodium	Na
Strontium	Sr
Sulphate	SO_4
Vanadium	V
Zinc	Zn

1.0 INTRODUCTION

1.1 OVERVIEW OF THE PROJECT

This Remedial Action Plan was developed to address human health, ecological, and environmental concerns associated with the Contact Lake abandoned mine site. It is intended to be a supporting document for assisting in regulatory decisions and funding decisions, and will provide the bases for development of tender documents and technical designs for the implementation of the remediation.

The proposed Remedial Action Plan is based on the results of environmental site investigations, human health and ecological risk assessment studies, best practices in mine closure, traditional knowledge, current use of the area, and community values. The plan takes the environmental status of the site, precedent practice, regulatory requirements, and site goals into consideration. Long term monitoring and reporting will be carried out at the site to provide ongoing assurance that the remediation works continue to perform as intended.

1.1.1 Location

The abandoned Contact Lake Mine site is located in the Northwest Territories, 425 km northwest of Yellowknife (65^0 59' N; 117^0 48' W), along the eastern shores of Great Bear Lake within the vicinity of Echo Bay. More specifically, the mine site is located approximately 500 m north of the northeast shore of Contact Lake, which flows to Moody Lake and drains to Conjuror Bay of Great Bear Lake. The site lies within the boundaries of the Sahtu Dene and Metis Comprehensive Land Claim Agreement. The nearest community in the Land Claim is Délı̨nę, approximately 263 km to the west.[1] The general location of the site is presented in Figure 1.1-1. Other abandoned sites in the vicinity of Contact Lake include the former Port Radium Mine located about 14 km to the northwest, and the former El Bonanza/Bonanza Mine located about 10 km to the west, as depicted in Figure 1.1-2. At present, access to the site is by air and can include, depending on the time of year and conditions, use of either fixed wing planes with floats or skis landing on Contact Lake, or by helicopter landing directly at the site. Access can either be directly to the site, or by staging from the airstrip at Glacier Lake near Port Radium.

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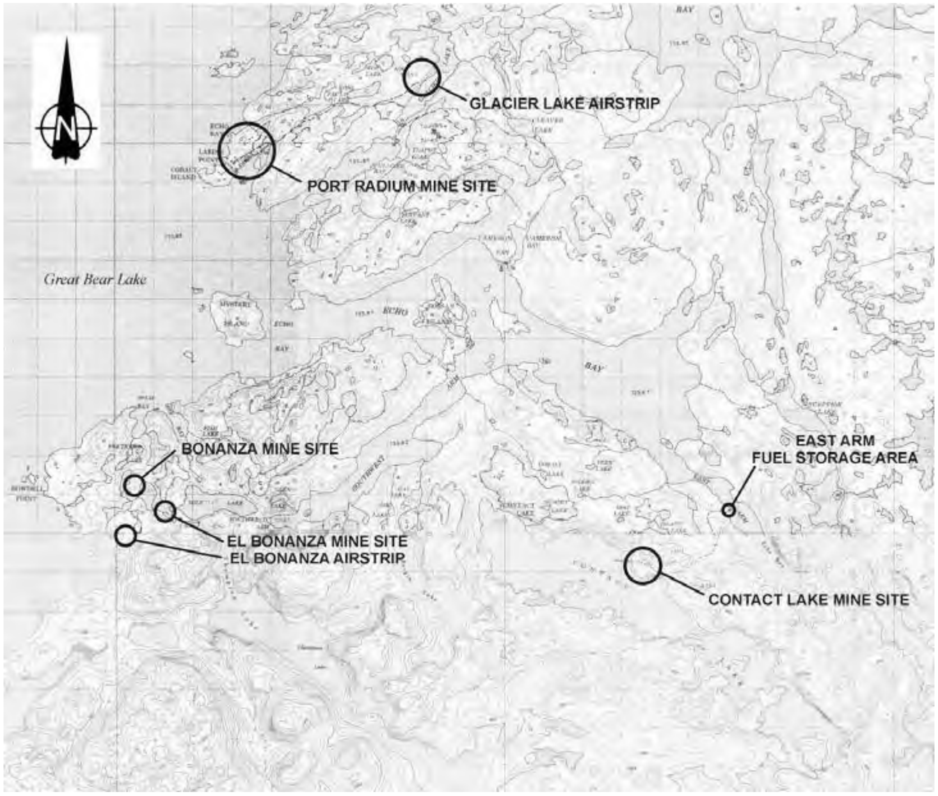
[1] The Tłîchô community of Gameti (Rae Lakes) is located roughly 210 km to the south. Although closer than Délı̨nę, the residents of Gameti have limited interactions with sites in the near vicinity of Great Bear Lake. Residents of Délı̨nę, on the other hand, travel, hunt and fish around the perimeter of Great Bear Lake. On this basis, Déline is considered to be the nearest potentially affected community to the site.

FIGURE 1.1-1
GENERAL AND VICINITY SITE LOCATION

FIGURE 1.1-2
VICINITY SITE LOCATION MAP



1.1.2 Setting

The site, shown on Figure 1.1-3, is characterized by the barren and rugged relief typical of the area surrounding the eastern shores of Great Bear Lake. The setting features rock ridges, outcrops, and cliffs that rise rapidly from the shoreline. Peak elevations in the region around the site rise to more than 456 m a.s.l. (above sea level), approximately 300 m above Great Bear Lake, while peak elevations at the site proper rise to about 285 m a.s.l., or about 129 m above Great Bear Lake. Contact Lake is at a water level of 206 m a.s.l. and drains to the south to Moody Lake, and subsequently to Conjuror Bay in Great Bear Lake, which is at an elevation of 156 m a.s.l. Natural flat lying land is, for the most part, non-existent at the site and the surrounding areas. Soil cover in the area is generally sparse with rocky outcrops and, to the extent that it exists, is generally very shallow. Where layers of weathered sedimentary rock and deposits of glacial till exist, such areas are accompanied by denser vegetation growth than at areas with limited soils.

Extensive areas of bare rock outcrop exist at the Contact Lake Mine site, but sand and cobble deposits are also found in the areas adjacent to the site and along the access road. Only sparse vegetation consisting of lichen, grasses, bushes, and pine trees cover the undisturbed areas of the site.

FIGURE 1.1-3
CONTACT LAKE REGIONAL SETTING

1.1.3 Operation

The Contact Lake Mine was operated for various periods between 1930 and 1980 and presently exists as an abandoned or orphaned site that has not been officially decommissioned. The site was predominantly mined for its silver content and to a lesser extent for its uranium content during this period.

1.1.4 Community Concerns

The community of Délįnę has expressed significant concerns with abandoned mines sites in the Sahtu Region. Although the Contact Lake Site is a small site (less than 5 ha) in comparison to other nearby sites (i.e. Port Radium and Silver Bear Mines), there is still community concern around the mining that was done there (mostly silver with limited uranium mining) and the potential contamination to the local environment. The water quality of Contact Lake and Great Bear Lake was the major concern expressed by the people of Délįnę along with the health of the vegetation and wildlife. The debris and the openings at the site were expressed as a concern in regards to human and wildlife health.

1.2 INAC'S RESPONSIBILITIES

Indian and Northern Affairs Canada (INAC) is the project proponent for the remediation of the Contact Lake Mine. It is INAC's responsibility to develop the remediation plan, obtain appropriate approvals, secure resources, and implement the plan by a consistent approach to closure of all INAC contaminated sites in the Northwest Territories region. Following remediation, INAC is responsible for the implementation of a long-term monitoring plan that is suitable for the site.

1.2.1 Approach to Preparation of the Remediation Plan

1.2.1.1 Overview

Section 39 of the *Northwest Territories Waters Act* (1992) identifies INAC authority to manage environmental contamination and risk to human health and safety. Abandoned Contaminated sites are sites where historic endeavours cannot be identified or held responsible to address existing environmental contamination.

The Contact Lake Mine site is considered an abandoned site under the management of the Contaminants and Remediation Directorate (CARD) of INAC in Yellowknife. CARD works within a broader management system for all northern contaminated sites. This being the case, CARD must follow several guiding documents while developing the final remediation plan for the Contact Lake Mine. The following federal policies or guidance documents provide a broad context as to how CARD approaches remediation of contaminated sites in Northern Canada:

- A Federal Approach to Contaminated Sites (CSMWG 2000);
- Northern Affairs Program Contaminated Sites Management Policy (INAC 2002a); and,
- Treasury Board Federal Contaminated Sites Management Policy (Treasury Board 2002).

Although the INAC Mine Site Reclamation Policy for the Northwest Territories (INAC 2002b) and the Mine Site Reclamation Guidelines for the Northwest Territories (INAC 2006b) were not intended for abandoned properties such as the Contact Lake Mine, some parts of the policy are generally applicable and have also been considered.

The overall responsibility of CARD is to minimize health and safety and environmental risks associated with the site by implementing a remediation plan that meets the needs and concerns of INAC, its First Nation partners and all Northerners.

1.2.1.2 Regulatory

Currently, INAC has no land use permits or water licences associated with the Contact Lake Mine site. The remediation of Contact Lake Mine will likely require a Type "A" Land Use Permit as the equipment and camp requirements may exceed one or more of the threshold limitations triggering a type A license such as the use of equipment with net weight exceeding 10 tonnes, use of a campsite for more than 400 person days, or use of a petroleum fuel storage container with a capacity equal to or exceeding 4,000 L (Appendix A, Sahtu Land and Water Board 2004). Once the remediation of the site is complete, long-term monitoring suitable for the site conditions and remediation options will occur as identified through the Federal Approach to Contaminated Sites (CSMWG 2000).

It is noted that Canadian Nuclear Safety Commission (CNSC), which administers the 1997 Nuclear Safety and Control Act, as approved in May of 2000, has listed Contact Lake as an exempted uranium mine and, as such, there is no requirement for a Waste Nuclear Substance License (CNSC 2005). The mine was exempted for the following reasons:

- There are no uranium tailings at the site (CNSC 2005);
- Although there are small amounts of waste rock at the site, the "gamma fields generated should not result in any member of the public receiving the public dose limit" (CNSC 2004);
- The physical size and isolated location of the mine (CNSC 2004); and,
- The conventional hazards have been reported to local authorities and can be dealt with under their existing regulations (CNSC 2004).

1.2.1.3 General Principles

Principles, relevant to the Contact Lake Mine, from Federal policy and guidance documents were combined with the principles of the Sahtu Dene Comprehensive Land Claim Agreement to provide the site-specific approach for the development of the Remedial Action Plan.

Federal and Sahtu guiding principles for the Contact Lake Mine Remedial Action Plan are listed below.

1.2.1.4 Federal Policies

The following principles were adopted for the Contact Lake Remedial Action Plan from federal policy and guidance documents referenced above. Specifically:

- Meet the overall INAC objective to contribute to a safer, healthier, sustainable environment for Aboriginal peoples and northern residents by striving to preserve and enhance the ecological integrity of the environment (INAC 2002a);
- Take immediate and reasonable action to protect the environment and the health and safety of persons (Treasury Board 2002);
- Meet federal and INAC policy requirements and legal obligations regarding the management of contaminated sites (INAC 2002a);
- Ensure sound environmental stewardship of federal real property by avoiding contamination and by managing contaminated sites in a consistent and systematic manner that recognizes the principle of risk management and results in the best value for the Canadian taxpayer (Treasury Board 2002);
- Provide a scientifically valid, risk management based framework for setting priorities, planning, implementing and reporting on the management of contaminated sites (INAC 2002a);
- Develop a Remediation Plan to be sufficiently flexible to allow adjustments as the remediation progresses, including the flexibility to adapt to new and improved technologies and methodologies (INAC 2002b);
- Adopt solutions tailored to the northern environment and peoples wherever possible (INAC 2006a – management framework); and,
- That the approach to the Remedial Action Plan should take into account the Department of Fisheries and Oceans Policy for the Management of Fish Habitat (1986) which has an overall objective for the net gain of habitat for Canada's fisheries resources, and fish habitat restoration.

1.2.1.5 Partnerships with First Nations

The following principles regarding partnerships with First Nations were adopted from the policy and guidance documents referenced above specifically for the Contact Lake Mine Remedial Action Plan:

- Promote Aboriginal and northern participation and partnership (INAC 2002a; INAC 2006b);
- Promote respect and sharing of knowledge, experience and resources in partnerships/teamwork with clients and partners;
- Promote the social and economic benefits that may accrue to First Nations and northern communities (INAC 2002a);
- Plan, where appropriate, the scale and pace of remediation/risk management in keeping with northern and Aboriginal capacity to be involved (INAC 2002a); and,
- Incorporate economic opportunities, to the extent possible, for northern and Aboriginal communities in the management and remediation of the site (INAC 2002a).

In keeping with the above policies, community representatives from the Sahtu and Tłicho regions actively participated in the review of remedial actions and selected their preferred options. Records of community participation, the options reviewed, and preferred options selected by the community are presented in Appendix A.

1.2.1.6 Sahtu Dene and Metis Comprehensive Land Claim Agreement

The Contact Lake Mine Site is within the Sahtu Dene and Metis Comprehensive Land Claim Agreement that was signed in 1993 (INAC 1993) (see Figure 1.2-1). The Land Claim Agreement was signed to, among other things, “recognize and encourage the way of life of the Sahtu Dene and Metis which is based on the cultural and economic relationship between them and the land”. The following principles were adopted from the Sahtu Dene and Metis Comprehensive Land Claims Agreement specifically for the Contact Lake Mine Remediation Plan:

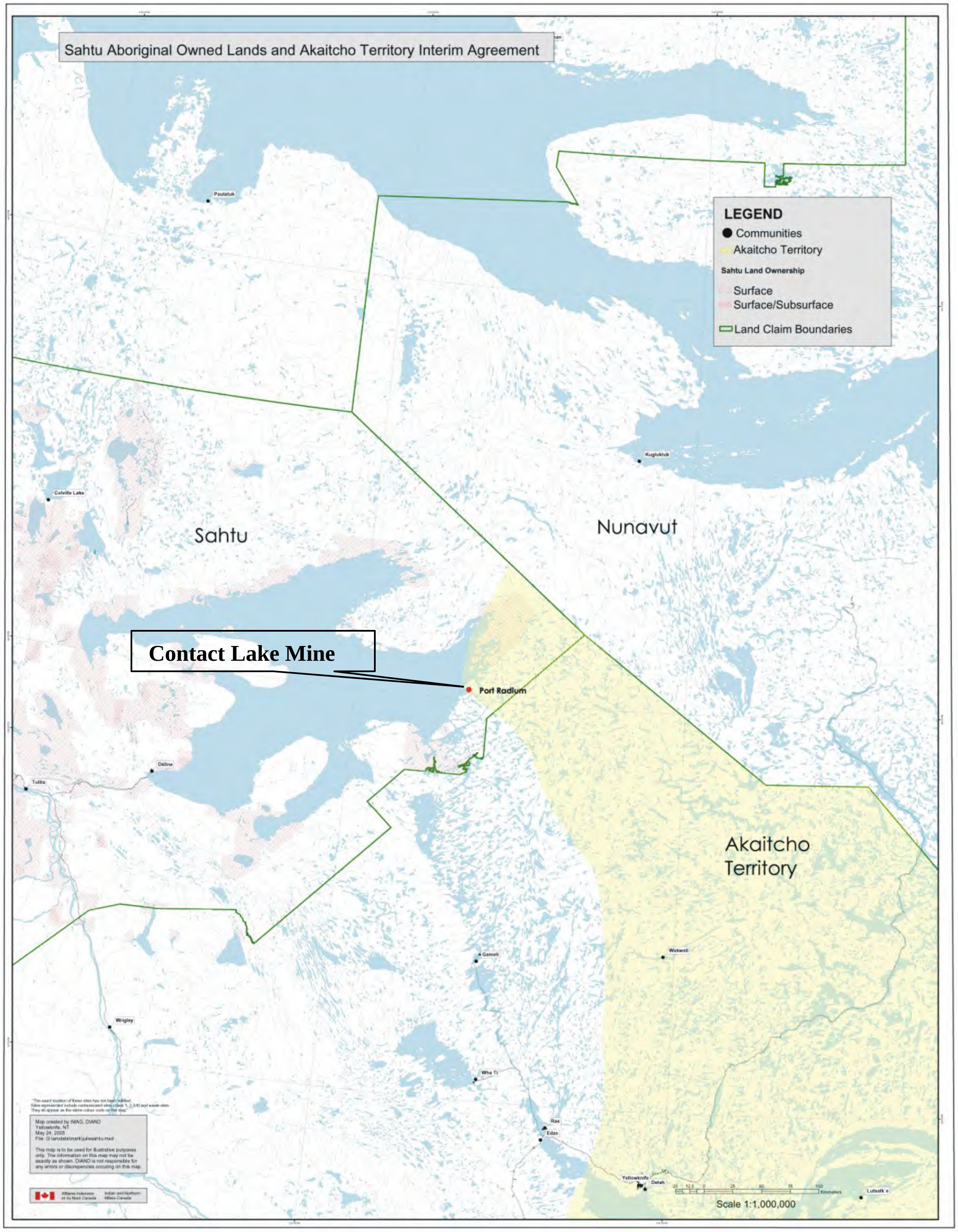
- To protect and conserve the wildlife and environment of the settlement area for present and future generations;
- To directly involve communities and designated Sahtu organizations in land use planning; and,
- To encourage the self-sufficiency of the Sahtu and to enhance their ability to participate fully in all aspects of the economy specifically by protecting and promoting the existing and future social, cultural and economic well-being of the participants.

The Sahtu Land Use plan, developed under the principles and objectives of the Sahtu Dene and Metis Land Claim Agreement (INAC 1993) and the Mackenzie Valley Resource Management Act (MVRMA 1998) indicates that the Contact Lake site is in a Special Management Zone where most land uses are possible (SLUPB 2007). Currently, there are no apparent 'Conservation Areas' in the Contact Lake area, so although the plan is still under review, the site will be managed in accordance with the Special Management Zone terms and conditions including but not limited to:

- The maintenance of the ecological integrity of the area;
- The monitoring and management of infrastructure so as to prevent and/or rectify any negative environmental effects; and,

The monitoring and management of activities in the area so that the migration routes of migratory or semi-migratory wildlife species is not blocked (SLUPB 2007).

FIGURE 1.2-1
SAHTU AND AKAITCHO CLAIMS TERRITORY INTERIM CLAIMS MAP



Source: Indian and Northern Affairs Canada.

1.2.1.7 Site Objectives

The following site objectives for the remediation of the Contact Lake Site were developed in accordance with the Federal Policies and Sahtu Dene and Metis Comprehensive Land Claim Agreement principles listed above and were agreed on by community members during consultation meetings (refer to Section 1.2.2.6):

- Minimize human health and safety risks at the Contact Lake Mine site;
- Protect fish, wildlife and vegetation;
- Protect Great Bear Lake and Contact Lake water quality;
- Minimize environmental impacts during remediation;
- Minimize long term care and maintenance;
- Return the site to its original condition where possible; and,
- Is cost-effective.

1.2.1.8 Remediation Planning Team

The technical team responsible for the development of the plan, conducting studies and reporting on the necessary technical information includes members of INAC staff, in Yellowknife and Ottawa, community members from Délı̨nę, as well as engineers, scientists and firms registered in the Northwest Territories, listed as shown below:

- Délı̨nę Remediation Team;
- INAC, Contaminants and Remediation Directorate (CARD);
- INAC, Water Resources;
- Public Works and Government Services Canada; and,
- SENES Consultants Limited.

1.2.2 Community Involvement and Consultation

1.2.2.1 Guiding Principles to Community Involvement and Consultation

As discussed above, the Northern Affairs Program Contaminated Sites Management Policy specifies that “INAC will promote First Nation, Inuit and northerner participation and partnership in the identification, assessment, decision-making and remediation/risk management processes relating to contaminated sites” (INAC 2002a). The guidelines indicate that every effort should be made to incorporate local knowledge on many different levels by for example creating working groups and interviewing elders and other age groups of the local people (INAC 2006b).

In addition to the federal policies and guidelines, a major objective of the Sahtu Dene and Metis Comprehensive Land Claim Agreement is "to provide the Sahtu the right to participate in decision making concerning the use, management and conservation of land, water and resources" (INAC 1993). The Land Claim Agreement (INAC 1993) and the *Mackenzie Valley Resource Management Act* (MVRMA 1998) guiding principles for consultation include:

- Providing the party to be consulted with:
    - notice of the matter in sufficient form and detail to allow the party to prepare its views on the matter;
    - a reasonable period for the party to prepare those views; and,
    - an opportunity to present those views to the party having the power or duty to consult.
- The party with the duty to consult must:
    - consider, fully and impartially, any views so presented.

1.2.2.2 Contact Lake Mine Site Community Involvement and Consultations

The community involvement and consultation process for the Contact Lake Mine site was undertaken to ensure that the community of Délı̨nę was included in all aspects of the work leading up to the remediation of the Contact Lake Mine site. Local people were hired to work at the site as bear monitors and to help collect samples throughout the site assessment phase of work. Local people were interviewed so that an understanding of the historical and future land uses of the area could be determined. The remediation team from Délı̨nę was created at the request of INAC so that formal decision making could be done by the local people. The formal consultation process was initiated in February of 2007 when the first meeting took place in Délı̨nę.

1.2.2.3 Traditional Knowledge

Many Traditional Knowledge studies have been conducted with elders, hunters and trappers residing in Délı̨nę regarding the Sahtu area (e.g. historical use, native wildlife populations, and local conditions). Although most studies have focused on the overall Sahtu area and larger mine sites (Silver Bear and Port Radium) some specific information to Contact Lake was collected. Historically, Sahtúot'ı̨nę travelled through the Contact Lake area while they were hunting caribou and moose (Personal Communication with H. Ferdinand). Moose tracks were detected during a site visit in 2007 indicating that moose still traverse the area. Currently, the Contact Lake site is not visited very often by the Sahtúot'ı̨nę because of the isolated location and lack of direct water access from Great Bear Lake (Personal Communication with C. Yukon and L. Tucho). Sahtúot'ı̨nę who travel Great Bear Lake in the summer, typically stay at locations on Great Bear Lake and do not traverse from Great Bear Lake to Contact Lake. If the area around

Contact Lake is visited, the mine site is generally avoided because of concern with potential contamination issues created by the historical mining (Personal Communication with the Délįnę Remediation Team).

1.2.2.4 Traditional Burial Sites

Interviews and a GIS mapping project were conducted by the Délįnę Uranium Team during the clean up of Port Radium to identify all traditional burial sites in the area. No traditional burial sites have been identified in the Contact Lake area (Interview with H. Ferdinand) but there is some north of the site mostly around Echo Bay and Cameron Bay. Based on the distance (~14 km) of these burial sites from Contact Lake the burial sites would not be impacted during the remediation activities.

1.2.2.5 Meetings, Site Tours, and Public Presentations

The meetings and site tours that involved community members and members from the technical team (listed above) were as follows:

- February 2007 – An initial meeting took place where the Contact Lake physical and environmental site issues were presented and discussed with the Chief and Council of Délįnę.
- June 2007 – A consultation meeting took place where the Contact Lake physical and environmental site issues were presented and discussed with the community of Délįnę.
- September 2007 – A site tour took place so that the Délįnę Remediation Team could become familiar with the site and have a better understanding of the scale and scope of the proposed remediation plan.
- November 2007 – An evaluation meeting took place where remediation options were presented, discussed, and decided upon.
- February 2008 – A public presentation took place in Délįnę so that the Délįnę Remediation Team could present the preferred remediation options to the community and solicit feedback. INAC team members provided support to the remediation team during this community meeting.

1.2.2.6 Evaluation of Remediation Options

The overall approach to evaluating remediation options for the site was as follows:

Prior to the evaluation meeting in November 2007:

1. The site was divided into various aspects and issues as outlined in the Mine Site Reclamation Guidelines for the Northwest Territories (INAC 2006b).

2. For each aspect and issue, remediation options were recommended by SENES Consultants Limited with input from INAC, CARD (see Table 6.1-1, Chapter 6).

During the Meeting in November 2007:

3. A site overview was presented followed by a presentation and discussion of the site goals and the potential remediation options.
4. The site objectives used during the evaluation of the remediation options are stated above (see section 1.2.1.6 Site Objectives). The goals were agreed upon during the meeting with the Délı̨nę Remediation Team.
5. The potential remediation options were then presented for each site issue and where appropriate additional options were added as recommended by the Délı̨nę Remediation Team.
6. The options were then ranked on how well they met site goals and best practices:
    - Good - met objective;
    - OK - partially met objective; or,
    - Bad - did not meet objective.
7. The options were then determined as:
    - P = preferred;
    - A = acceptable; or,
    - NA = not acceptable.
8. Where the community preferred remediation option agreed with the INAC preferred remediation option, the option was accepted. If the community preferred option was in conflict with the INAC preferred option, more discussion was required to come to a resolution. Once an agreement was obtained, the option in question was accepted.

The presentation and meeting minutes, including the evaluation tables that were filled out during the meeting are provided in Appendix A and B.

Following the meeting in November 2007:

9. The preferred options were compiled in a preferred Remedial Action Plan as described in Chapter 6.

1.2.2.7 Future Community Involvement and Consultation

Additional meetings will be held with the Délı̨nę Remediation Team to ensure that they are informed of upcoming activities regarding the remediation of the Contact Lake Mine site and to solicit their input. Any deviations from the preferred options will be discussed along with the progress of the remediation action plan. To assist in communicating progress of the site, there will be opportunities for site tours throughout the remediation phase of the project and post remediation.

1.3 OVERVIEW OF AVAILABLE INFORMATION

Information on the environmental conditions on the site and historic activities has been obtained through site monitoring and assessment programs conducted for the site since the early 1990s to 2007, which includes:

- environmental monitoring and assessments by EBA Consultants Limited and by Thurber Environmental Consultants Limited in 1993 (EBA 1993a; Thurber 1993);
- water sampling by INAC's Water Resources Division partnered with CARD, from 2002 to 2005 (Gartner Lee 2005);
- compilation of site data and report on environmental conditions by Gartner Lee Limited in 2005 (Gartner Lee 2005);
- site characterization and sampling by SENES Consultants Limited in 2006 and 2007 (SENES 2007a; 2007c); and,
- a quantitative human health and ecological risk assessment by SENES Consultants Limited in 2007 (SENES 2007b).

An overview of these programs is presented in the following paragraphs.

In 1992, EBA Environmental Consultants Limited was retained by Public Works and Government Services Canada to conduct an environmental assessment of the Contact Lake Mine to determine environmental conditions at the site (EBA 1993a). Water, tailings, sediment and waste rock were sampled for this study and EBA identified arsenic, bismuth, mercury, silver, uranium, and potentially copper as contaminants of concern at the Contact Lake Mine. Elevated levels of gamma radiation were also found at the areas where tailings had been deposited and in localized hotspots in the waste rock. Arsenic, bismuth, mercury, silver, and uranium and were found to be major metal contaminants in the waste rock and tailings, while concentrations of cobalt and copper were also slightly elevated. Arsenic and zinc were found to be slightly elevated in the surface waters at the mine, while metal concentrations in Contact Lake reflected background levels, suggesting that the mine was not impacting the major receiving water body. EBA also determined the human health risk potential from the Contact Lake Mine to be medium, such that the site would likely warrant remedial action.

INAC's Water Resources Division partnered with CARD to sample surface water, groundwater and soil quality on the site to augment the record of site conditions (INAC 2006c; Gartner Lee

2005). Sampling was conducted on five occasions in the period extending from 2002 to 2005 (September 2002; June and August 2003; September 2004; August 2005).

The 2005 report compilation of environmental quality conditions on site identified the following potential site hazards (Gartner Lee 2005):

- Physical Hazards - the primary physical hazards at this site were identified as the existing surface openings (ventilation shaft, a mine adit open to surface), some of the remaining buildings that are deteriorating, and site debris.
- Chemical & Radiological Hazards - based on past operations, it was estimated that about 29,000 cubic meters of waste rock along with an estimated 1,500 cubic meters of uncontained tailings remained on site. Sampling indicated some elevated metal levels in surface runoff and in the local ponds. Evidence of isolated hydrocarbon staining on site was also noted.

In July of 2006 a field investigation and site assessment program was conducted at the Contact Lake Mine by SENES Consultants Limited (SENES 2007a). Figure 1.3-1 illustrates the location and nature of the sampling program. Supplementary investigations were also completed in June and August of 2007 (SENES 2007c). These investigations were implemented under the auspices of the Federal Contaminated Sites Action Plan (FCSAP). A Site Investigation Plan was designed in keeping with INAC's approved Detailed Work Plan (DWP) for the site, and in accordance with a Work Breakdown Structure (WBS) that was developed by INAC and Public Works and Government Services Canada (PWGSC) with input from FCSAP's expert advisors including Health Canada (HC), Environment Canada (EC) and the Department of Fisheries and Oceans (DFO) Canada.

The primary objective of the 2006 site assessment was to collect information on existing site conditions to characterize in detail the site's physical and environmental status. Samples of surface water, sediment, edible fish, soil, waste rock, tailings and terrestrial vegetation were collected in different areas of the site and analyzed for metals and some uranium-238 series radionuclides (radium-226 and lead-210). Petroleum hydrocarbons (PHCs) and polychlorinated biphenyls (PCBs) in soil, waste rock and sediment were also measured at various areas at the site. Additional sampling was conducted during the 2007 field season to supplement the 2006 dataset. The June program focused on the collection of additional surface water and sediment samples for chemical and radiological characterizations, waste rock samples to assess bioavailability, soil samples to delineate PHC and metal impacted areas and to confirm the absence of PCBs, tank sampling at the fuel storage area to assess the nature and quantity of residual materials, sampling of paint and building materials to test for PCBs, lead and DDT (dichloro-diphenyl-trichloroethane), and visual inspections of relevant surface features. The August program focused on additional sediment sampling at the fuel storage area at the East Arm of Great Bear Lake to delineate PHC and metal impacted sediments and to assess sediment toxicity. Samples were collected for metal and PHC determinations, as well as a benthic survey and toxicity tests.

The information obtained through the site assessments was used in the development of the human health and ecological risk assessment, and as input to the development of remedial issues and options tables and the preferred remediation plan.

The human health and ecological risk assessment was completed in May 2007 (SENES 2007b) and a summary of the assessment is presented in Chapter 5. The overall conclusions of the assessment were as follows:

- The results of the overall assessment indicated that individuals who might visit the Contact Lake Mine site on a short-term basis, even if taking home locally collected food for subsequent consumption would not experience any adverse health effects.
- From an ecological perspective the assessment showed that there are localized areas in the vicinity of the Tailings Pond that could have potential for an adverse effect on small individual terrestrial animals (e.g. hare, mink, and muskrat) if using this habitat. Large animals such as bear, moose and caribou are not expected to be adversely affected by the existing site conditions.

Use of Environmental Quality Guidelines in Human Health and Ecological Risk Assessment

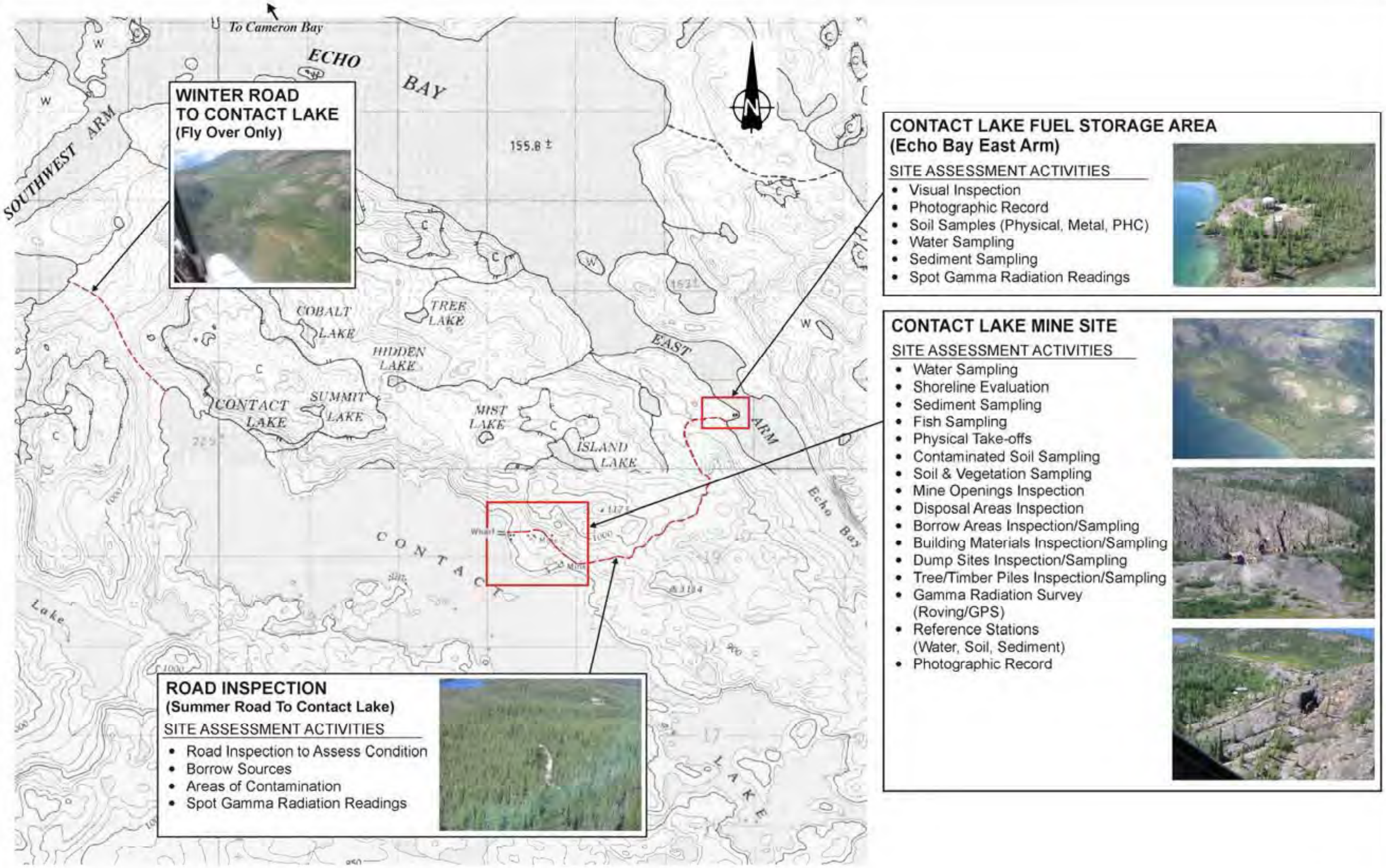
Prior to conducting the human health and ecological risk assessment, a screening process was completed to identify “constituents of potential concern” (COPC) (typically metals at mine sites) that would be carried through the assessment. This involved comparing available environmental data for the Contact Lake Mine to background levels and applicable environmental quality guidelines. As a first step, data were compared to background levels. If the constituent concentration was at least 1.2 times greater than these levels, the constituent was carried to the next step where comparisons were made to Canadian Environmental Quality Guidelines (CEQGs). If the constituent concentration exceeded the CEQG value and if appropriate toxicity data were available for that constituent, then the constituent was considered to be a COPC and was carried through the risk assessment.

In identifying COPC, water quality data have been compared to CEQG developed for the protection of freshwater aquatic life by the Canadian Council of Ministers of the Environment (CCME 1999) in the case of metals. Analogous guidelines have not been developed for radionuclides by CCME. Sediment quality data have been compared to benchmarks developed by the CCME (Interim Sediment Quality Guideline (ISQG); CCME 1999) and Canadian Nuclear Safety Commission (Lowest Effect Level (LEL); Thompson *et al.* 2005) in the case of metals and radionuclides. Guidelines for PHCs in sediments have not been developed. CCME soil guidelines developed for residential/parkland land use (CCME 2000) were used to assess metals, PHC, polyaromatic hydrocarbon (PAH), and PCB levels in soils, waste rock and tailings, collectively. Specific guidelines for waste rock and tailings have not been developed. Terrestrial vegetation data collected for browse and forage were compared to phytotoxicity levels obtained from Davis *et al*. (1978), McBride (1994), and Langmuir *et al*. (2004). The reader is referred to SENES (2007b) for further details on the COPC screening process.

Once the COPC were identified, a pathways model was used to estimate the COPC exposure levels (intakes or doses) to terrestrial ecological and human receptors. Exposure levels were in turn compared to appropriate benchmarks (total daily or incremental reference doses) in the case of radiation and toxicity reference values (total exposure) for non-radionuclide constituents. For aquatic ecological species, a pathways model was not employed but the total exposure from water was compared to a toxicity reference value.

It should be noted that in cases where guidelines for specific environmental media or materials have not been developed, comparisons are often made to other existing and related guidelines in order to obtain some perspective on the measured concentrations. For instance, radionuclide concentrations measured in freshwater may be compared to Canadian drinking water quality guidelines (Health Canada 2006a); PHC concentrations in sediments to soil quality guidelines for residential/parkland land use (CCME 2000; 2008); and, metals in waste rock and tailings to soil quality guidelines for residential/parkland land use (CCME 2000; 2008).

FIGURE 1.3-1
OVERVIEW OF 2006 SITE ASSESSMENT PROGRAM



WINTER ROAD TO CONTACT LAKE
(Fly Over Only)

CONTACT LAKE FUEL STORAGE AREA
(Echo Bay East Arm)

SITE ASSESSMENT ACTIVITIES

- Visual Inspection
- Photographic Record
- Soil Samples (Physical, Metal, PHC)
- Water Sampling
- Sediment Sampling
- Spot Gamma Radiation Readings

CONTACT LAKE MINE SITE

SITE ASSESSMENT ACTIVITIES

- Water Sampling
- Shoreline Evaluation
- Sediment Sampling
- Fish Sampling
- Physical Take-offs
- Contaminated Soil Sampling
- Soil & Vegetation Sampling
- Mine Openings Inspection
- Disposal Areas Inspection
- Borrow Areas Inspection/Sampling
- Building Materials Inspection/Sampling
- Dump Sites Inspection/Sampling
- Tree/Timber Piles Inspection/Sampling
- Gamma Radiation Survey (Roving/GPS)
- Reference Stations (Water, Soil, Sediment)
- Photographic Record

ROAD INSPECTION
(Summer Road To Contact Lake)

SITE ASSESSMENT ACTIVITIES

- Road Inspection to Assess Condition
- Borrow Sources
- Areas of Contamination
- Spot Gamma Radiation Readings

1.4 STRUCTURE OF REMEDIATION PLAN

In addition to this introductory chapter, the following information is provided in this report:

- Chapter 2 provides additional details on current land use and the history of the site including former operations and past closure activities;
- Chapter 3 provides a detailed description of the major physical site components, their current status, and potential issues and concerns;
- Chapter 4 provides a description of the environmental setting in which the site is located and results from the 2006 and 2007 assessment work;
- Chapter 5 provides a summary of the human health and ecological risk assessment that was completed for the Contact Lake Mine site;
- Chapter 6 presents the proposed remediation plan including the process, guiding principals, and proposed remediation action for each major component;
- Chapter 7 provides a discussion of post-remediation monitoring activities;
- Chapter 8 comments on the remediation schedule; and,
- Chapter 9 provides a list of cited references.

2.0 LAND USE AND HISTORY OF SITE AND SURROUNDING AREA

2.1 HISTORICAL LAND USES

Most historical Land Use studies have focused on the overall Sahtu region and larger mine sites (i.e. Silver Bear and Port Radium) and not specifically Contact Lake. The following discussion provides an overview of the historical land use of the Sahtu Region with some specific details regarding the Contact Lake site.

The Sahtu area was part of the traditional territories of several First Nation groups, including the Dogrib, Hare, Slavey, Yellowknives, and Inuit. In the centre of this region, the Sahtu Dene people practiced traditional lifestyles by hunting caribou, trapping fur-bearing animals, and catching fish from Great Bear Lake (MacDonald *et al.* 2004). The Contact Lake site specifically, was traversed by the Sahtu Dene and caribou hunting was conducted in the area (Personal Communication with H. Ferdinand). More recently, the term Sahtúot’į̨nę̨ has been adopted to refer to the aboriginal people of this district (CDUT 2005).

The first European settlement was established in 1799, when the Northwest Company built a trading post at the head of the Bear River, the site of traditional annual meetings for the people living in the Sahtu. This site came to be known as Fort Franklin after the Franklin expedition used the post as its winter headquarters in 1825. In the 1950s, the establishment of a Roman Catholic Mission and a school drew Dene people who were traditionally semi-nomadic, to settle permanently at the site. Today, the community is known by its Dene name of Délinę, which means “place where the river flows” (CDUT 2005).

In 1930, radium, pitchblende, and silver were discovered in the vicinity of Port Radium. Soon thereafter (i.e. early 1930s), mining operations were developed at this location to extract uranium ore. Activities were initiated to explore for and develop other mines in the immediate region including the Echo Bay Mine, the Contact Lake Mine, the El Bonanza and Bonanza Mines, all of which were primarily developed to extract silver. None of these mines are currently in operation and responsibility for the sites presently resides with the crown.

During the 1950s, interest in tourism and sport fishing increased within the watershed. To meet the expanding demand for services, a total of five fishing lodges were established on Great Bear Lake. With the increased fishing pressure on large, trophy-sized lake trout, fisheries management agencies and stakeholders took steps to limit fishing due to the sensitivity of the lake trout population to over-harvesting (including catch-and-release fishing on trophy-sized fish) (MacDonald *et al.* 2004).

In 2005, with the rapid worldwide rise in mineral prices including base and precious metals and uranium, exploration activities began again in the Sahtu region (see Section 2.4).

2.2 MINING HISTORY

2.2.1 Mine Operation and Production

The Contact Lake Mine was operated for various periods from 1930 to 1980 and presently exists as an abandoned or orphaned site. The site was predominantly mined for silver and to a lesser extent for uranium. The history of the mine is briefly summarized here from Silke (2006a), Gartner Lee (2005) and EBA (1993b) with references as cited in the original text.

Mineral claims at Contact Lake were first staked in 1931 by Tom Creighton of the Northern Aerial Minerals Exploration Company. In 1932, the property was acquired by an Ontario mining group that financed the property into development through the creation of Bear Exploration and Radium Limited (Day 1933; Humphries 2000). High-grade silver was found on surface and via a short adit underground, indicating the potential for a profitable production operation. Milling commenced in November 1935 and continued until December 1935; resumed in May 1936 and continued until August 1936; resumed again in November 1936 and continued until the summer of 1937; resumed in December 1937 and continued until June 1939 when the operation was shut down due to a drop in the price of silver (The Northern Miner Aug. 27th 1936; Mar. 18th 1937; June 17th 1937; Dec. 30th 1937). From 1935 to 1939, 10,855 tons of ore were milled on-site and 357,920 ounces of silver were produced. This included the silver content of 550 pounds of silver nuggets (8,800 ounces of silver) (The Northern Miner Mar. 18th 1937). In 1938, the recovery of pitchblende concentrate became another focus of the operation. Records indicate that during the last year of operation (1938-1939), 6,933 pounds of pitchblende were recovered (Bear Exploration & Radium Limited 1939).

The International Uranium Mining Company Limited acquired the property in 1942 and completed a diamond drilling, geological mapping and prospecting program from 1944 to 1945 that focused on the uranium content of the deposit (Lord 1951). The property was reopened in 1946 with the intent of mining uranium ore-bodies through three shaft levels. Although some ore was sent out in bulk shipments, no uranium production was attained (The Toronto Star June 18th 1946) and despite the indication of a sizeable ore body, work ceased in August 1949 (Mining Inspection Services 1948-1949). Late in 1949, the company was reorganized as Acadia Uranium Mines Limited who conducted additional diamond drilling below the exploited level of the ore shoot from which previous production was obtained (James Millar and Associates 1965).

The underground workings were reactivated in 1969 by Ulster Petroleum Limited as previous work suggested that both the ore reserves and the old mill tailings could harvest a large amount of silver value (James Millar and Associates 1965; Byrne 1969). The purpose of the 1969 exploration and development program was to verify the tonnage and value of the underground deposit. At the end of the program, it was recommended that a deal be made with Echo Bay Mines Limited for the milling of stockpiled ores and tailings from Contact Lake at their nearby milling plant at Port Radium, but when negotiations stalled in August 1969, operations stopped and all equipment was removed by the contractor (Byrne 1969). An agreement between Ulster Petroleum Limited and Echo Bay Mines Limited was finally reached in 1975, in which Echo Bay Mines Limited was to perform exploration work to acquire full interest in the property. The work was to be completed by 1977 at which time 1,200 tons of stockpiled surface ore and tailings had been milled at the Echo Bay Mine to produce approximately 50,000 ounces of silver (Brophy *et al.* 1983). In 1979, 4,900 tons of additional ore were removed from the underground mine at Contact Lake, which were also milled at the Echo Bay Mine to produce approximately 270,000 ounces of silver (Brophy *et al.* 1983). In 1981, final ore reserves at Contact Lake were estimated by Echo Bay Mines Limited to consist of 700 tons of undeveloped ore and 7,350 tons of underground broken ore containing in total 350,000 ounces of silver (National Mineral Inventory).

New mineral claims were staked in 1996 by Lane Dewar and Trevor Tweed, and in April 2005 mineral rights for the property were acquired by Alberta Star Development Corporation to undertake a geophysical survey of the region (Silke 2006a). See Section 2.4 for mineral claim details.

2.2.2 Transportation During Mining

Access during mining was by fixed wing all season plane (pontoon or ski) to Contact Lake, or by access from Great Bear Lake in the summer using a boat/barge or by road in the winter.

Summer access utilized a dock constructed on the south shore of the East Arm of Echo Bay, about 10 km southeast of Branson’s Lodge in Cameron Bay (Byrne 1969). From there, overland transport was carried out over a 4 km all weather haul road that traversed the rock ridge separating Great Bear Lake from Contact Lake in a south western direction.

Winter access was achieved off the ice from Great Bear Lake in the West Arm of Echo Bay, at a point about 5 km southwest of Branson’s Lodge, where a 1.6 km long on-land winter route that ran across a low rising saddle provided access to the west end of Contact Lake and then allowed for access across the ice on Contact Lake to the site.

2.2.3 Decommissioning Status

While some mine closure measures have been carried out in the past including covering the raise opening with a large timber crib, blocking shaft access with timbers and the cage, sealing the adit access with a timber barrier, the Contact Lake mine site has not been officially decommissioned and to date, and limited effort has been directed towards the remediation or “closure” of the site.

2.3 CURRENT LAND USES

The nearest community to Contact Lake in the Sahtu Dene and Metis Land Claim is Délı̨nę, approximately 263 km to the west (see Figure 2.3-1). Délı̨nę residents today maintain strong links to their traditional Dene way of life and Great Bear Lake remains the central defining feature of the community and the traditional territory of the Sahtúot'ı̨nę.

As people continue to harvest the plants and animals of the region for food and fuel, Great Bear Lake provides not only physical sustenance for the people of Délı̨nę, but also the spiritual and cultural sustenance that comes from practicing the skills and lifestyle of their ancestors. While caribou and fish are harvested most frequently, smaller animals and various plants and berries are also important traditional foods.

Due to its isolated location, and lack of direct water access from Great Bear Lake, land use activities in the vicinity of the Contact Lake Mine site have been limited (Personal Communication with C. Yukon and L. Tucho). Sahtúot'ı̨nę who travel Great Bear Lake in the summer, typically stay at locations on Great Bear Lake and do not traverse from Great Bear Lake to Contact Lake.

The site has been visited by INAC staff over recent years; however, as there are no licenses associated with the site, no formal INAC inspections have taken place. Site sampling programs were carried out by EBA Consultants Limited in 1992 and by INAC from 2002 through 2006.

Mineral exploration activities were initiated in the region in 2005 and became more active in 2006.

2.4 ACTIVE MINERAL CLAIMS

The following table (Table 2.4-1) lists the Mineral Claims that are in the direct vicinity of the Contact Lake Mine site and includes the owner and dates of validation. Refer to Figure 2.4-1 to locate the area of land/water that coincides with each of the listed Mineral Claims.

TABLE 2.4-1
MINERAL CLAIMS IN THE CONTACT LAKE AREA

Mineral Claim Number	Owner	Issue Date	Expiry Date
F91856	Alberta Star Development Corp.	2005-04-07	2007-04-18
F91857	Alberta Star Development Corp.	2005-04-18	2007-04-18
F97537	Cooper Minerals Inc.	2007-05-10	2009-05-10
F92294	Cooper Minerals Inc.	2005-09-23	2007-09-23

Notes: Source NORIM (2005)

In addition to these Mineral Claims, there is an Active Mineral Lease being held by Alberta Star Development Corp. The lease is within the dotted lines between mineral claims F91856 and F97537 and F92294 (Figure 2.4-1). The lease number is 4752 and is valid from 2005-11-25 to 2026-11-25.

Land use permits have been issued to Alberta Star Development Corp. (Land Use Permit #S2005C002; valid from 2005-08-25 to 2010-08-24) and Cooper Minerals Inc. (Land Use Permit #S07C-002; valid from 2007-07-26 to 2012-07-25) in association with their Mineral Claims. These land use permits are Mining Exploration Permits and allow for drilling/polarization and resistively testing in the area.

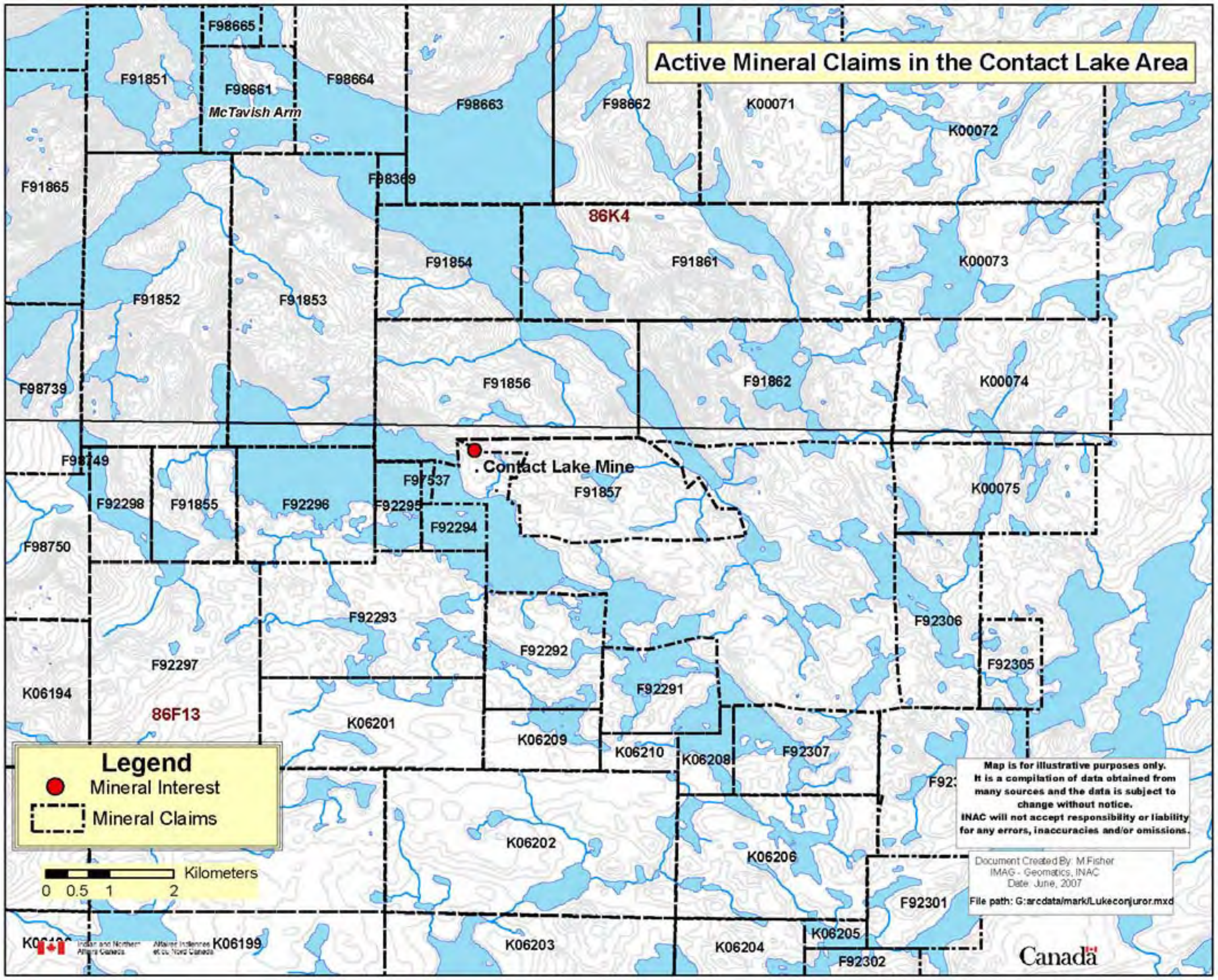
2.5 MINING HERITAGE VALUES

The NWT Mining Heritage Society has toured the Contact Lake Mine site and has identified several pieces of mining equipment with potential heritage value. These have been documented in a report prepared by R. Silke (2006b) and include nine ore cars, a flat deck car, two jaw crushers and an aluminum mine cage.

2.6 SITE ACCESS

At present, access to the site is by air, either fixed wing planes with floats or skis, depending on the time of year and conditions, or by helicopter. In addition, past access has included the use of winter and summer routes via the West and East Arms, respectively, of Echo Bay on Great Bear Lake. On site roads and trails exist only to a limited extent. The primary roads/trails connecting to the mine site include the 4 km route connecting the Great Bear Lake fuel depot to mine site and the 0.5 km route connecting the camp on Contact Lake to the mine. The off-site winter road route from the West Arm of Echo Bay to Contact Lake does not connect with the mine site.

FIGURE 2.4-1
ACTIVE MINERAL CLAIMS IN THE CONTACT LAKE AREA



3.0 DESCRIPTION OF THE MINE FEATURES

3.1 OVERVIEW OF SURFACE FACILITIES

The Contact Lake Mine site consists of the Main Mine/Mill Area with its related mine openings and support facilities including several buildings and wooden foundations, located on the north shore of Contact Lake; the Camp Area with former residences and mine associated infrastructure buildings, located southwest of the main mine/mill area; cabins located east of the main mine site; the Fuel Storage Area on Great Bear Lake, located northeast of the main mine/mill area; and, the roads connecting these facilities. The general locations of these areas are shown on Figure 3.1-1 and are described below.

3.2 MINE AND MILL AREA

The main mine/mill area is situated approximately 0.5 km north of Contact Lake and contains mine workings, mine waste, and mining infrastructure (see Figures 3.2-1, 3.2-2, and 3.2-3).

The main mine yard area was developed primarily from mine waste rock and acts as the base for most of the former mine and mill facilities. The mine yard is located at elevation 247 m a.s.l., at the edge of a steep rock face that rises to about elevation 268 m a.s.l. (about 20 m) immediately behind the mine yard. The width of the mine yard varies as it runs parallel to the cliff, from a minimum of about 20 m to a maximum of about 40 m. In total, the mine yard covers a surface area of less than 1 ha.

The facilities remaining on the main yard include, in addition to a small headframe/hoist building, several small wooden buildings including the former machine shop, electrical building, driving/storage shed, and engineering office/dry building. Ancillary buildings in the vicinity, but not directly located at the main yard area, include a small powder shed located near the tailings pond, a Quonset building located on the road to the camp, and a drill shack near the camp site.

Additional mine features include mine associated wastes such as mine development waste rock from the adit and shaft and exploration trenching, residual surface tailings, several large timber piles, a natural pond that acts as a site sump and collects tailings that have eroded, as well as miscellaneous waste/debris that remain at various locations across the site. Some hydrocarbon staining also remains on site.

3.3 CAMP SITE

The camp area, which includes 12 former residences and mine associated infrastructure buildings, is located between 100 m and 200 m north of Contact Lake and is about 0.5 km southwest of the main mine/mill area. Although the camp area included a temporary docking area and presumably obtained water from Contact Lake, little evidence of these features remain at this time. Note that a temporary dock was created on a rock ledge to aid in the 2006 and 2007 field program which will be removed after the remedial works are complete.

In addition to the main camp buildings, two small cabins are also located approximately 0.5 km to the east of the main mine/mill area, along the haul road from the fuel storage area to the mine site. A photograph from the air and a schematic of the camp area are provided on Figures 3.3-1a and 3.3-1b, respectively.

3.4 GBL FUEL STORAGE AREA AND DOCK

A 250,000 L above-ground storage tank and dock area are located on Great Bear Lake (East Arm of Echo Bay) northeast of the main mine/mill area. Materials delivered to the fuel storage area were hauled during the summer months to the main mine site via a 5 km road. A photograph and a schematic of the fuel storage area are provided shown on Figures 3.4-1a and 3.4-1b, respectively.

3.5 LOCAL ROADS

Roads and trails exist only to a limited extent. The primary roads/trails connecting to the mine site include the 5 km route connecting the GBL fuel depot to the main/mill area and the 0.5 km route connecting the camp on Contact Lake to the mine. The off site winter road route (1.6 km) from the West Arm of Echo Bay to Contact Lake does not connect with the mine site.

Camp roads are simple trails cut in front of the cabins and show little sign of fill placement. Connecting roads show evidence of some clearing, grading and fill placement. Natural re-vegetation of the roads and trails is occurring on these routes since last use, although some clearing has taken place to facilitate site assessment and exploration.

3.6 MINE WORKINGS

The Contact Lake Mine was accessed both by an adit and a shaft. The shaft is located at the yard level within the headframe building, and the adit is located in the immediate proximity to the headframe. An open cut proceeds from the adit level up the face of the cliff, culminating in two surface openings from the underground stopes at the top of the cliff. In line with these openings, but somewhat further removed from the face of the cliff, is a timber covered vent raise opening. Some minor surface exploration trenching was noted above and away from the mine site proper.

Extracts from Silke (2006a) as summarized the development of the Contact Lake Mine underground workings:

- the adit entrance was collared in 1932 and trenching was completed for a length of 8 m and a depth of 3 m and tunnelling was to a depth of about 30 m;
- underground development continued on the #1 zone in 1933 to a distance of about 137 m from the adit entrance along with 35 m of crosscutting;
- the #1 winze was sunk in early 1934 from the adit level to a depth of 38 m below the adit to the 2nd level where crosscutting and drifting was initiated;
- a vertical raise, which later became the #1 shaft, was driven in winter 1934/35 to surface from the 2nd level and the #1 shaft was lowered to the 3rd level in the summer of 1935;
- from 1936 to 1937, underground development was focused on developing known reserves within the eastern section of the three zones and opening of two new stopes on the 2nd and 3rd levels using shrinkage stoping;
- in 1938 and 39 exploration was carried out on the 2nd and 3rd levels;
- mine dewatering in 1946 allowed exploration of the #2 zone from the 2nd and 3rd levels;
- in 1948 a second winze from the 3rd to the 4th level was driven to a depth of 91 m; and,
- exploration in 1969 resulted in the enlargement of the 3rd level by slashing operations and a raise was driven 5.5 m into the #1 vein.

The Contact Lake ore body occurs in a shear feature within the granodiorite, which is locally filled with quartz-hematite and quartz-carbonate material within which silver, pitchblende and sulphide minerals occur. The mining method as noted above was shrinkage stoping, where the broken ore was used as a working surface to develop the stopes upwards. Once the upper part of the stope was reached with either a crown pillar or broken through to surface, the ore was removed leaving an empty stope. Over time, deterioration of the rock mass and any timber support occurs which allows the rock mass to unravel along shear zone parallel features and local jointing.

Specific illustrations of mine openings and crown pillar considerations are provided in the following photographs and figures:

- 3.6-1 View of mine site headframe and open cut from below waste rock area;
- 3.6-2 View of surface stope opening from air (view from east);
- 3.6-3 Close up view of headframe and open cut;
- 3.6-4 Close up view of open cut (at edge of cliff from mine yard looking up);
- 3.6-5 Close up view of west end of stope surface opening at top of cliff;
- 3.6-6 Looking from east to west across surface opening at top of cliff;
- 3.6-7 General overview from helicopter looking at rock cliff, open cut and mine site in background;
- 3.6-8 and 3.6-9 Sections of underground mine; and,
- 3.6-10 Close up view of headframe and shaft.

Mine Waste Rock

Mine waste rock from underground workings generated waste rock that was placed parallel and adjacent to the base of the cliff next to the adit and formed (as noted above) the mine yard and base for most of the mine buildings (see Figure 3.6-11). The surface of the waste pile and yard is generally flat until it slopes away from the yard area at its angle of repose or less. Waste rock slopes appear stable with no evidence of surface erosion. Estimated waste rock volumes range from 26,000 to 30,000 m^3.

Mill Tailings

From document reviews, 1969 estimates of tailings (see Figure 3.6-12) on site were in the order of 5,000 tons. This estimate was refined to 2,264 tons in 1973 by Bill Knudsen (Knudson 1973) of Echo Bay Mines. Subsequently, records indicate that 2,085 tons of tailings were removed by winter road to Echo Bay's Port Radium mill in 1975. The residual surface tailings remnants (less than 200 tons, 2264 less 2085) are thinly spread across the flat area below the waste rock pile that is bounded on each side by rock outcrops. The remaining surface tailings have likely been subject to sheet erosion over time with eroded materials migrating down gradient to a natural pond that acts as a natural sump. This pond is a natural stable structure that is bounded by rock outcrops on all sides.

FIGURE 3.1-1
GENERAL OVERVIEW OF CONTACT LAKE SITE ASPECTS

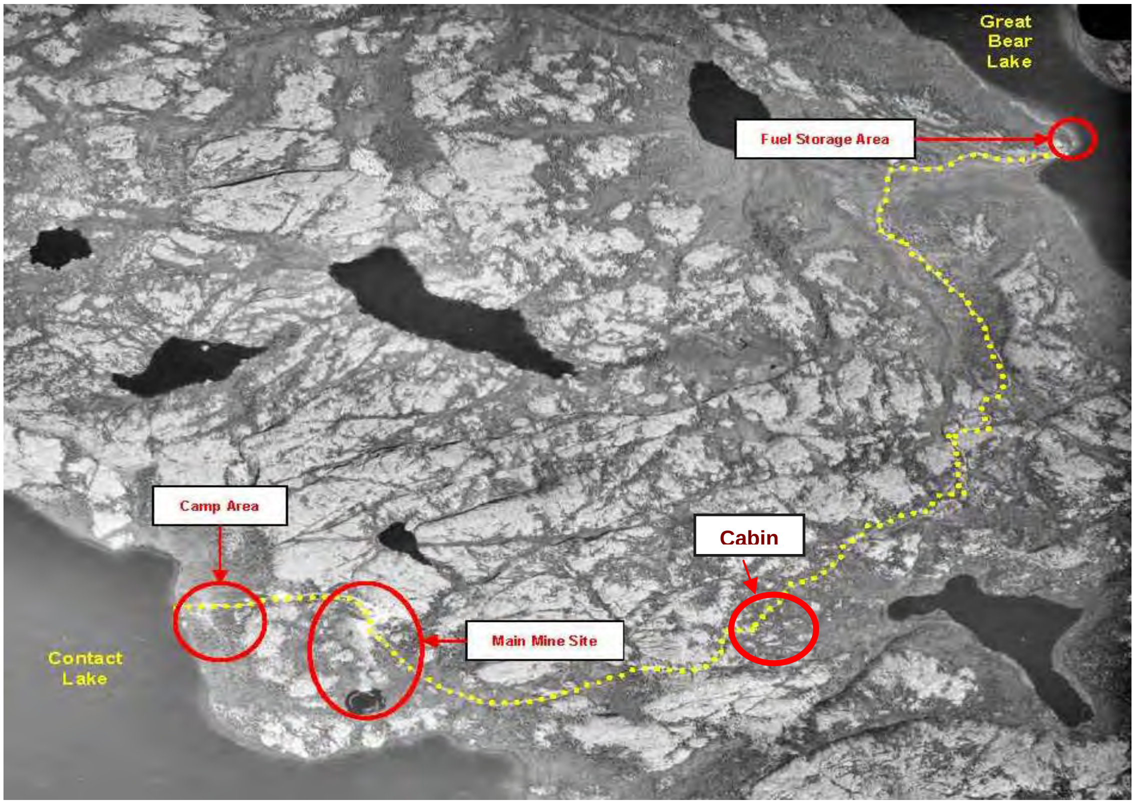


FIGURE 3.2-1
AERIAL VIEW OF CONTACT LAKE MAIN MINE/MILL AREA

FIGURE 3.2-2
PHOTOGRAPH OF CONTACT LAKE MAIN MINE/MILL AREA

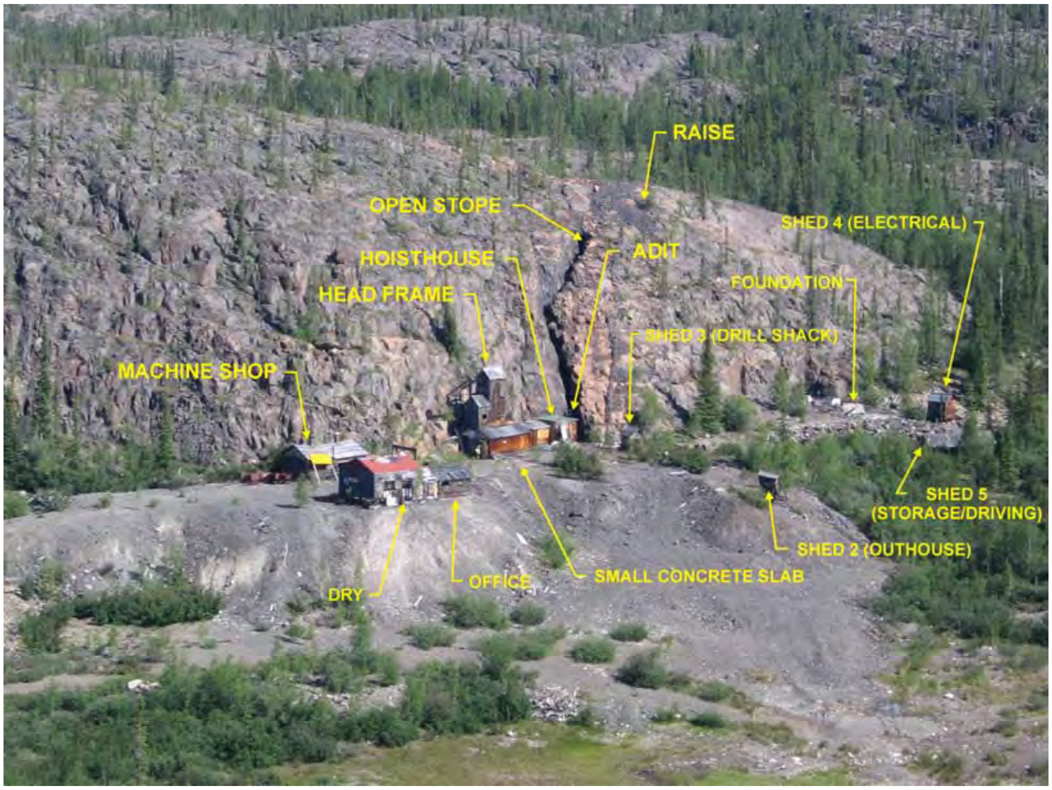


FIGURE 3.2-3
SCHEMATIC OF CONTACT LAKE MAIN MINE/MILL AREA

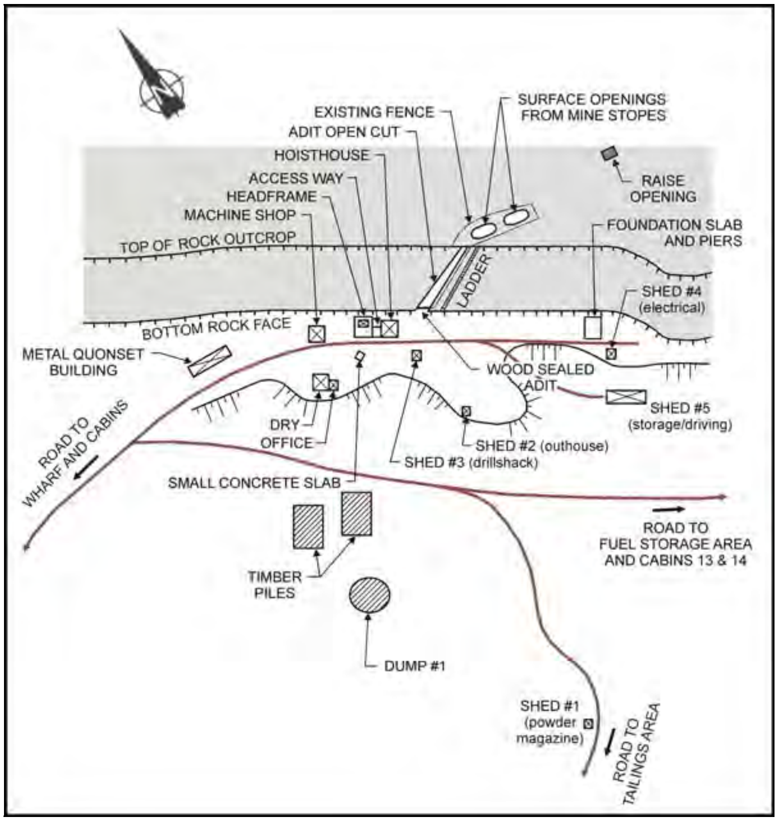


FIGURE 3.3-1
PHOTOGRAPH OF CAMP AREA AT CONTACT LAKE MINE

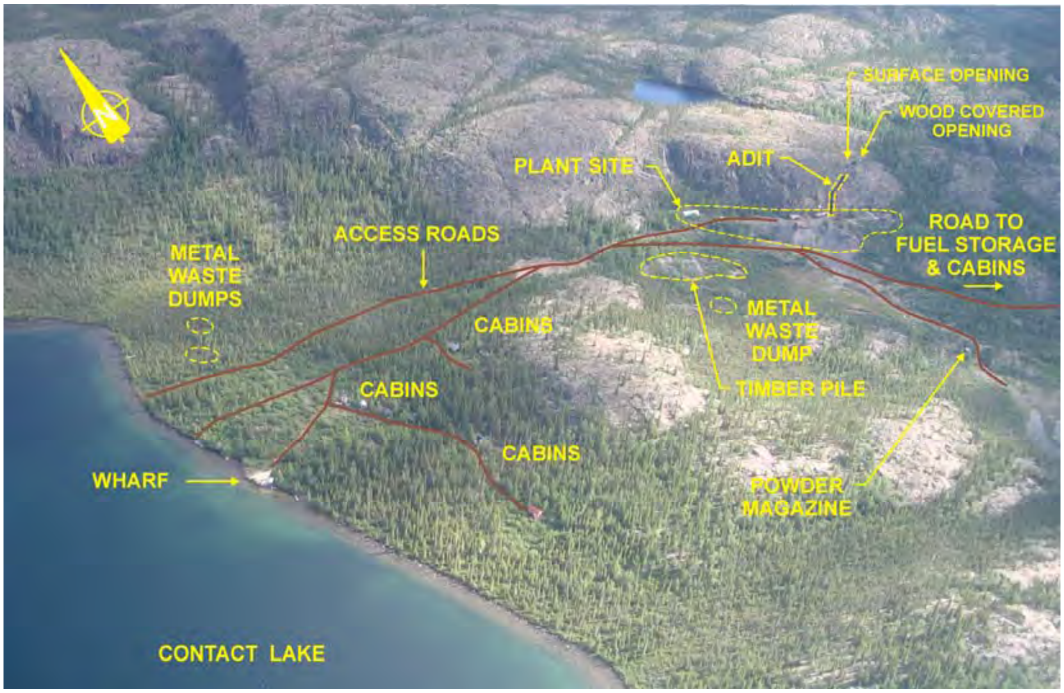


FIGURE 3.3-2
SCHEMATIC OF CAMP AREA AT CONTACT LAKE MINE

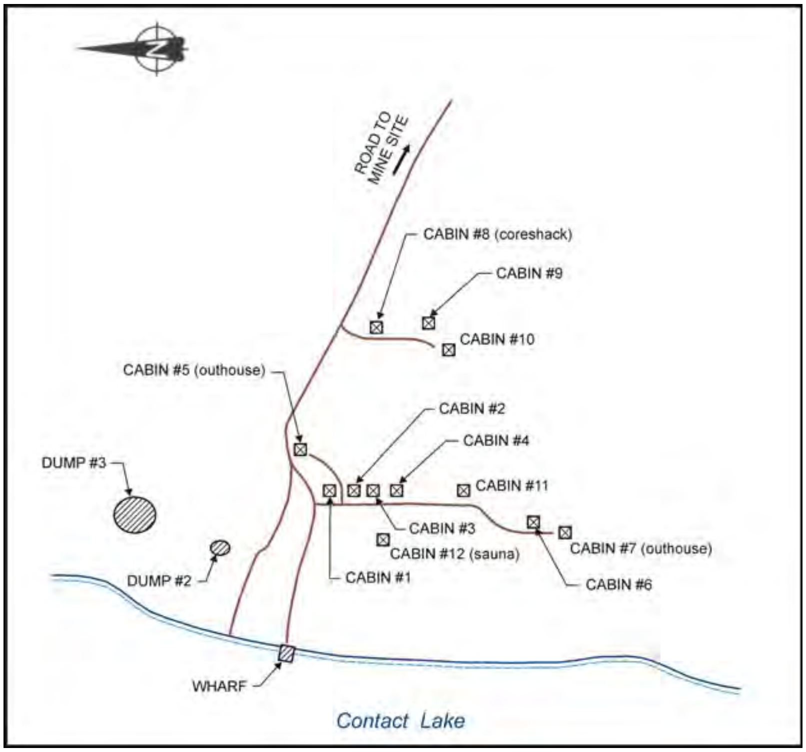


FIGURE 3.4-1
PHOTOGRAPH OF GBL FUEL STORAGE AREA AND DOCK

FIGURE 3.4-2
SCHEMATIC OF GBL FUEL STORAGE AREA AND DOCK

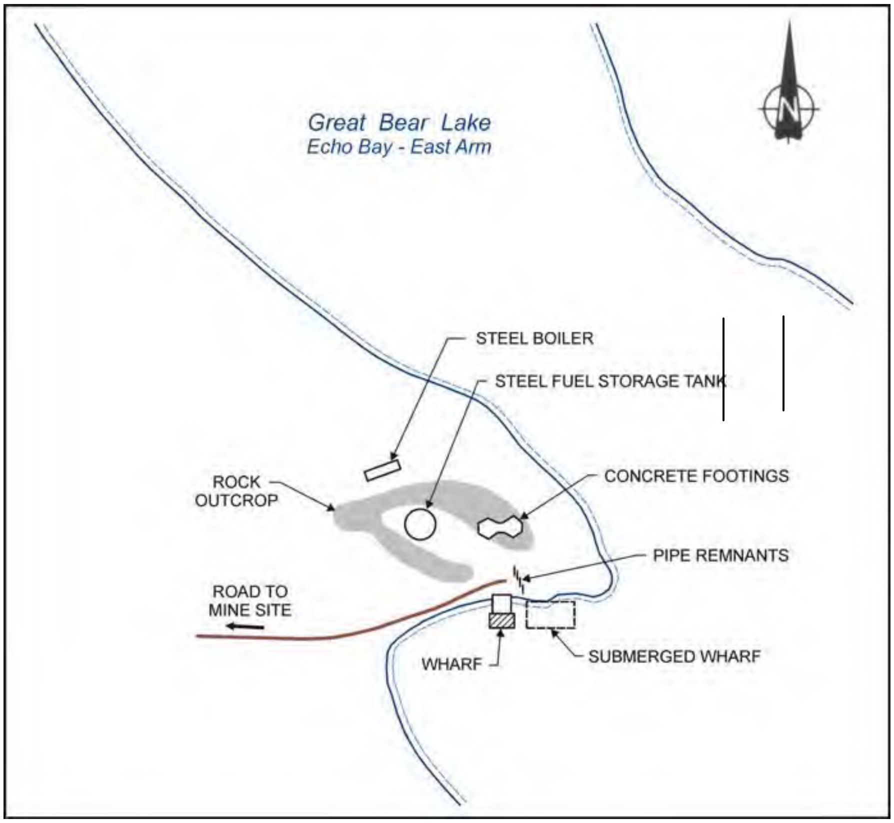


FIGURE 3.6-1
MINE SITE HEADFRAME AND OPEN CUT VIEWED FROM BELOW WASTE ROCK

Open Stope to surface – see Figure 3.1-4

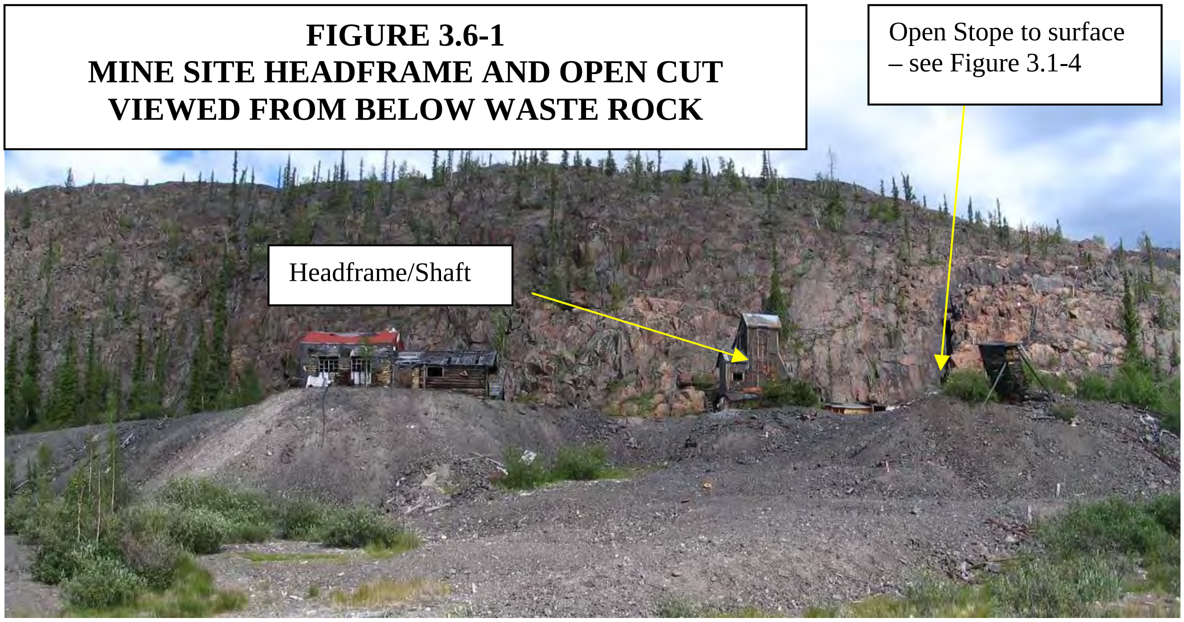
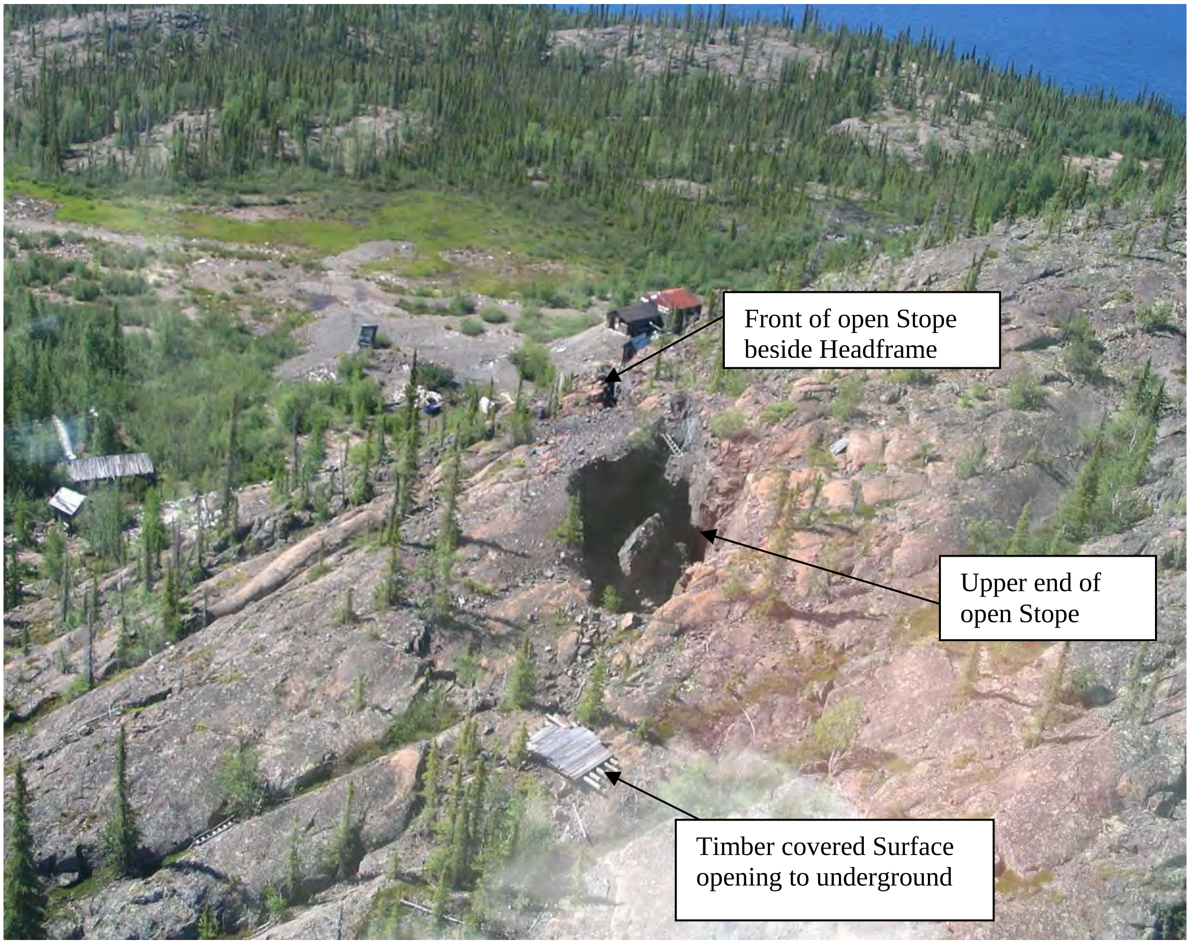


FIGURE 3.6-2
VIEW OF SURFACE STOPE OPENINGS FROM AIR



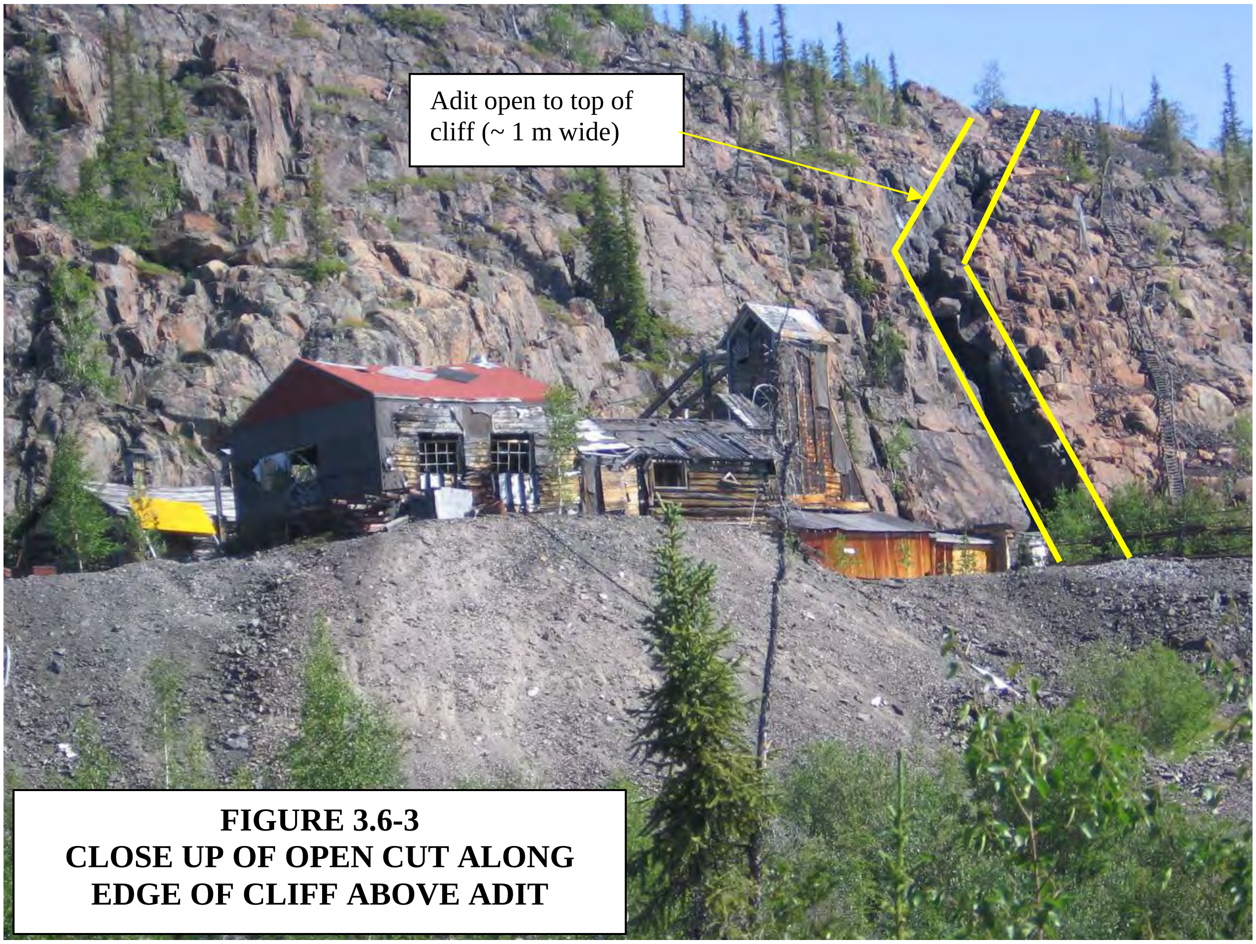


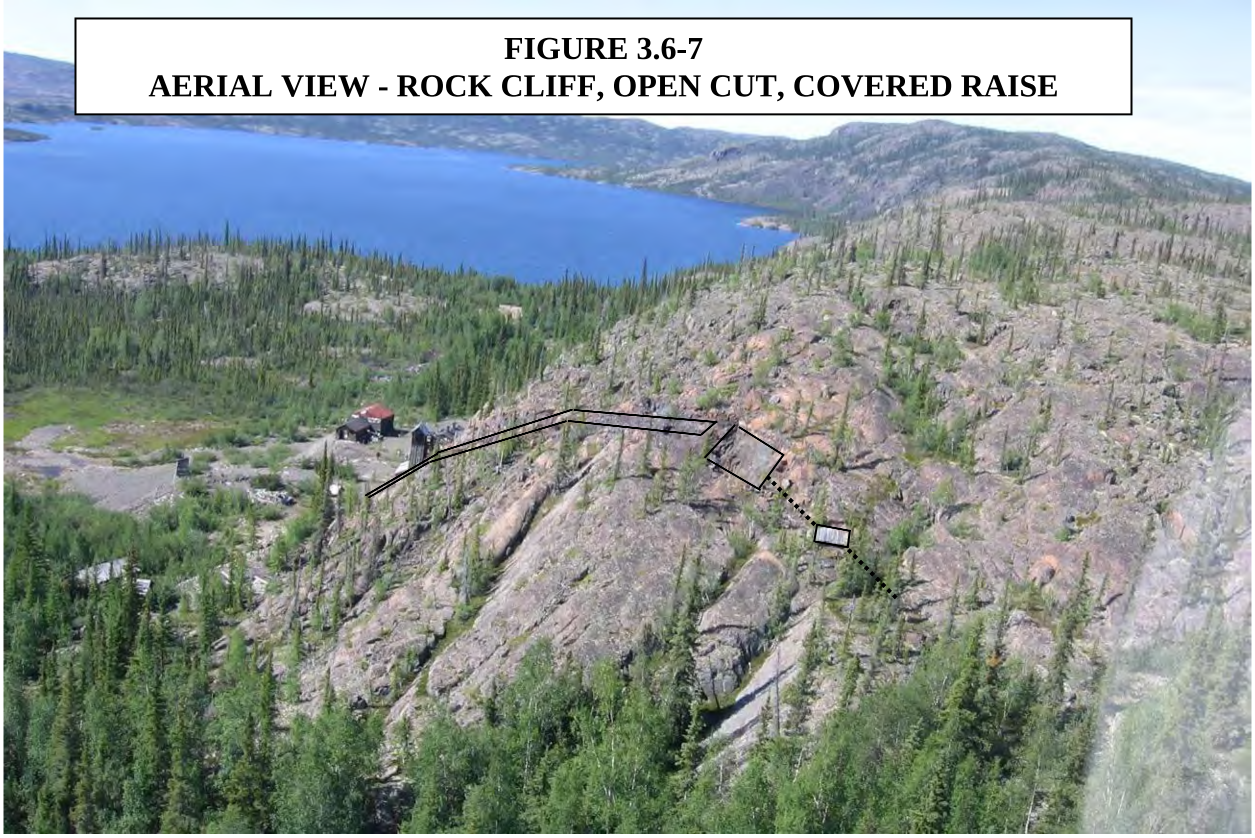
FIGURE 3.6-3
CLOSE UP OF OPEN CUT ALONG EDGE OF CLIFF ABOVE ADIT

FIGURE 3.6-4
CLOSE UP OF OPEN CUT ALONG EDGE OF CLIFF

FIGURE 3.6-5
CLOSE UP OF WEST END OF OPEN STOPE

FIGURE 3.6-6
EAST - WEST VIEW OF SURFACE OPENING

FIGURE 3.6-7
AERIAL VIEW - ROCK CLIFF, OPEN CUT, COVERED RAISE



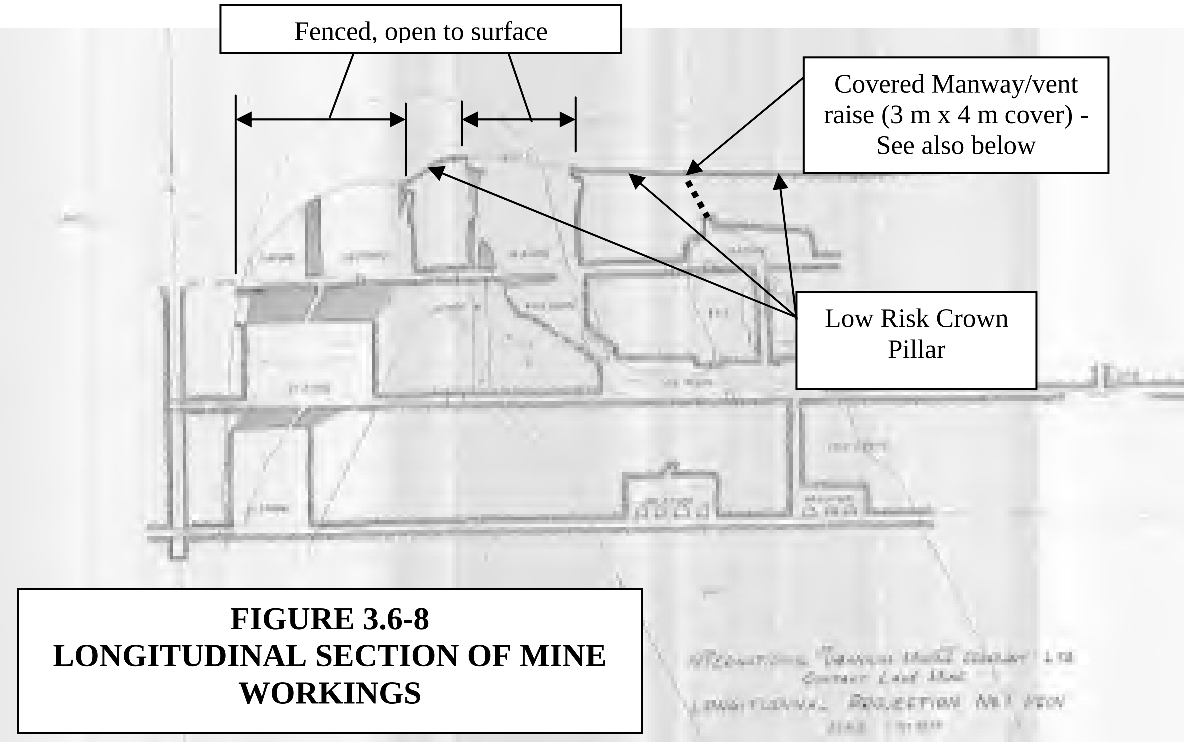


FIGURE 3.6-8
LONGITUDINAL SECTION OF MINE WORKINGS

FIGURE 3.6-9
LONGITUDINAL SECTION OF MINE WORKINGS

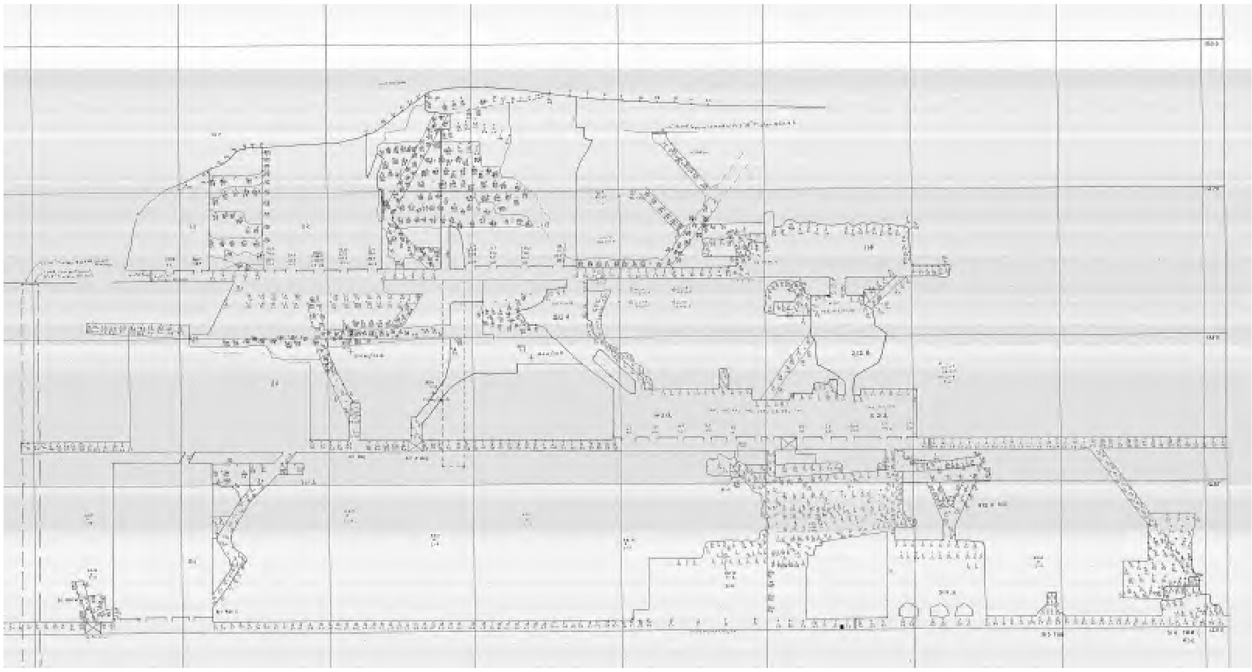
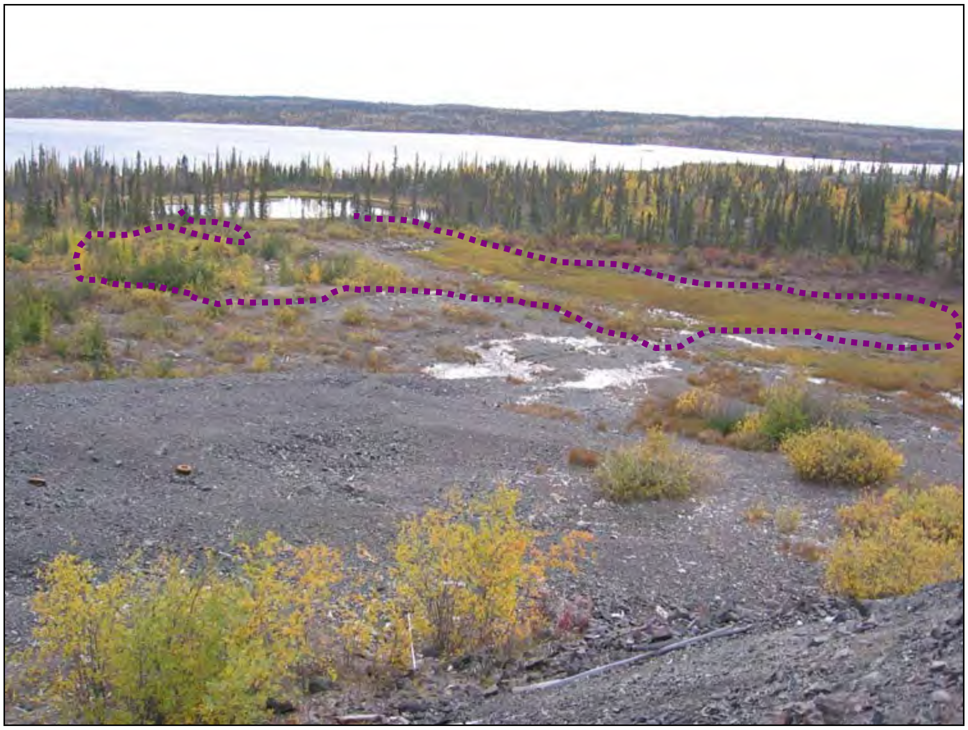


FIGURE 3.6-10
CONTACT LAKE HEADFRAME AND SHAFT

FIGURE 3.6-11
CONTACT LAKE WASTE ROCK

FIGURE 3.6-12
CONTACT LAKE SURFACE TAILINGS



4.0 DESCRIPTION OF ENVIRONMENT AND ENVIRONMENTAL SITE ASSESSMENT RESULTS

4.1 LOCATION AND PHYSICAL FEATURES

The location and setting of the Contact Lake Mine site were previously described in Sections 1.1.1 and 1.1.2. The site lies within the erosion-resistant Precambrian Shield of the Great Bear Lake watershed. The Precambrian shorelines are generally steep, rocky and irregular with sparse soil. The dominant physiographic feature of the area is Great Bear Lake, with a surface area of 31,000 km^2, a volume of 2,240 km^3 (or 2,240 million m^3) (Johnson 1975b), and a watershed of approximately 146,000 km^2 (Environment Canada 2002) that includes both Great Bear Lake and Great Bear River.

Great Bear Lake lies adjacent to three terrestrial ecozones, the Southern Arctic ecozone along its northern shore, the Taiga Plains to the west and south, and the Taiga Shield to the east. The Southern Arctic ecozone includes sprawling shrublands, wet sedge, meadows, and cold clear lakes, while the Taiga Plains ecozone is an area of low-lying plains centred on the Mackenzie River and its tributaries. The Taiga Shield in which Contact Lake is situated is at ecological crossroads (i.e. transitional area) where climate, soil, flora and fauna of the Arctic meet those of the northern temperate zone.

4.2 GEOLOGY

4.2.1 Bedrock Geology

The underlying rocks of the Precambrian Shield region are comprised of sedimentary and metamorphic deposits, with igneous intrusions forming dykes and sills (Johnson 1975a). These rocks can be classified into four main groups, including: complex sedimentary and volcanic rocks of the Echo Bay group; intrusions of diorite, grandiorite, and granite; relatively undisturbed conglomerate, sandstone, and quartzite of the Hornby Bay group; and mafic dykes and sills (Kidd 1933).

Review of geological information for the site shows that the Contact Lake property was mined for silver although there was also interest in uranium. The mine is underlain by granodiorite. Shear zones and tensional features are found within the granodiorite. The shear zones are locally filled with quartz, hematite, and carbonate. The mineralization occurs in small rich shoots within these shear zones and includes silver, pitchblende, and sulphides (Silke 2006a). The sulphides present are numerous and contain the following metals: antimony, arsenic, cobalt, copper, lead, and zinc. The deposit shares some similarities with the Echo Bay and Cross Fault mines, which are located approximately 15 km to the northwest.

4.2.2 Surficial Geology

In the Precambrian Shield region of the Great Bear watershed, which contains Contact Lake, soils are sparse and rocky outcrops abound. Thin layers of weathered sedimentary rock, glacial till, and alluvium can be found in small areas of lower elevation. In contrast, the soils of the Interior Plains region are far more substantial and occur over thick glacial till (Johnson l975a).

While site observations confirm extensive areas of bare rock outcrop at the Contact Lake Mine, sand and cobble deposits are also noted in the areas adjacent to the site and along the access road. These areas are generally well vegetated when compared to the more barren rock outcrops. The sparse vegetation covering much of the undisturbed areas of the site consists of lichen, grasses, bushes, and pine trees.

Site observations also indicate that waste rock was used to develop and form the basis for the main mine site yard and working area. In total, it is estimated that between 23,000 m^3 and 29,000 m^3 of mine waste rock covers an area of 2 ha. Additionally, waste rock may also have been used in the construction of some of the roadway immediately adjacent to the mine site.

4.3 CLIMATE

The Contact Lake Mine site is located within the Mackenzie District climate zone of the Arctic. The Mackenzie regional climate is characterized by long and cold winters, short and cool summers, large annual ranges in temperature, and little precipitation (Johnson 1975a). In winter, the region is dominated by the Arctic air mass, while in summer incursions of Pacific air are common.

Meteorological data are not available for the Contact Lake Mine site, but long-term temperature and precipitation data are available for the near-by Port Radium site, which is located about 14 km northwest of the Contact Lake Mine.

4.3.1 Temperature

An analysis of air temperature measurements collected at Port Radium between 1950 and 1974 (Johnson 1975a) showed that the maximum temperatures are typically recorded in July, with the highest reading on record being 29 °C. The mean air temperature in July for the period of record was 12 °C. The lowest air temperatures occurred in January, when the mean air temperature was –27 °C and the extreme low was –52 °C (Johnson 1975a). In summer, the sun was above the horizon for 24 hours per day between June 12 and 20; but, in December, the days were short with the sun barely appearing (Johnson 1975a). According to Johnson (1975a) there were only 60 frost free days per annum in the study area.

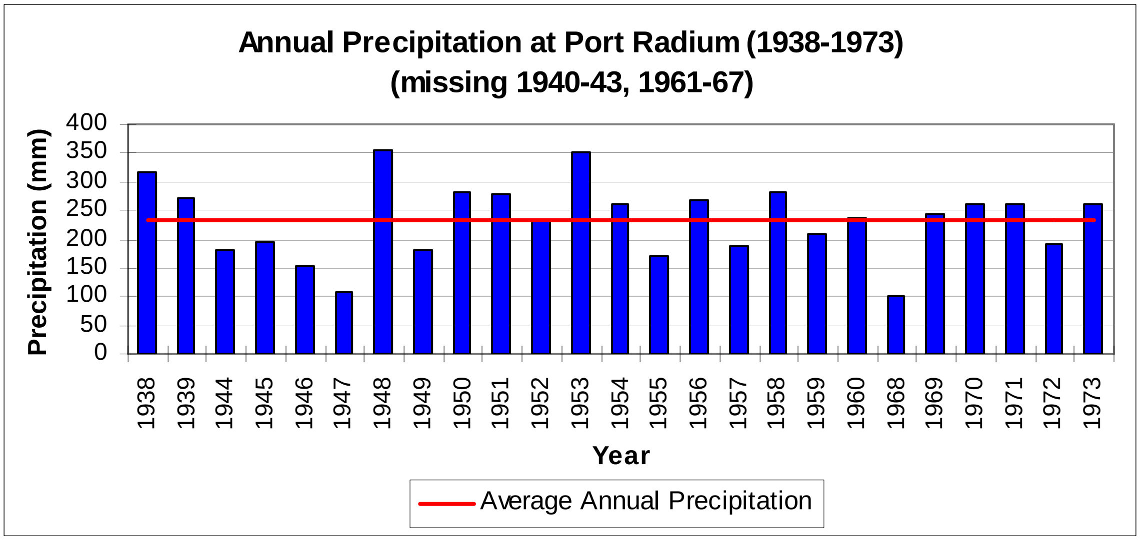
Changes in the climate of the Arctic and sub-Arctic regions have been a topic of intense investigation in recent years. The average temperature in the Arctic has risen at almost twice the rate as the rest of the world in the past few decades. As the world's climate changes, temperature changes are anticipated to be greater in the North and greater in winter than in summer. According to recent climate models run by Environment Canada, annual temperature increases of greater than 5 °C in the Arctic are possible by the year 2100. In the Mackenzie District, annual mean temperatures recorded from 1948 to 1999 show a clearly identifiable overall positive trend (about 1.5 degrees/century), comprised of a weak cooling trend into the seventies followed by a warming trend to 1999. Warming in this district has occurred mainly in winter and spring. There is a very weak warming trend exhibited in the summer, and temperatures in autumn have been gradually decreasing.

4.3.2 Precipitation

From climate data collected at Port Radium and Délı̨nę between 1938 and 1973 (Figure 4.3-1), it is apparent that annual precipitation is relatively low ranging between 102 and 355 mm (234 mm average recorded at Port Radium), with more than half falling as rain during the summer months, and close to half of the total precipitation lost through evaporation or evapo-transpiration. While southeast winds predominate in this region, summer storms lasting one to two days may arise from any direction (MacDonald *et al.* 2004).

Because of the year-to-year variability, precipitation trends are difficult to discern. Precipitation data collected for the Mackenzie District from 1948 to 1999 show that there is no clear trend in the long-term record of precipitation. On a seasonal basis, the warming in the winter in the Mackenzie District has been accompanied by a decrease in winter precipitation, while summer precipitation is somewhat higher and apparently more variable.

FIGURE 4.3-1
ANNUAL PRECIPITATION AT PORT RADIUM BETWEEN 1938 AND 1973



4.4 PERMAFROST

The Northwest Territories has a total area of about 1,346,000 km^2, with about 13 percent of this area being fresh water. The uniqueness of the Northwest Territories is that it is located within the permafrost region and access to most of its areas that depend on winter roads and air transport for access and supplies. More than 50 percent of the permafrost is classified as sporadic and discontinuous and is readily disturbed by construction resulting in ground thawing and potential physical instability. The Contact Lake Mine site borders on the area between discontinuous and continuous permafrost.

The presence of permafrost and the magnitude of ground temperature are dependent on many factors, such as air temperature, vegetation, snow cover, orientation of the terrain and ice content. As previously discussed, there is strong evidence that the mean annual air temperature is rising in the Northwest Territories. As ground temperature is very dependent on air temperature, it is expected that permafrost will degrade in some areas, including Contact Lake, as the mean annual air temperature rises. As the Contact Lake Mine site is generally in an area of limited surficial soils and exposed bedrock and since no structures will be built on surface as part of the site remediation, future changes in ground temperature and permafrost are not expected to affect the remedial works.

4.5 AIR QUALITY

Although site-specific measurements are not available for the Contact Lake Mine, air sampling from 2001 to 2003 at the nearby Port Radium site (located 14 km northwest) revealed excellent air quality that was well below the Ambient Air Quality Standard (AAQS) for the Northwest Territories, and other jurisdictions. The concentrations of conventional pollutants (i.e. total suspended particulate - TSP, sulphur dioxide - $SO_{2,}$ nitrogen oxides - NO_x) at the Contact Lake Mine are expected to be similar to Port Radium and therefore are expected to be low as there are no significant sources of these pollutants in the local study area. Furthermore, the site is small with a limited footprint of historically disturbed area, has been inactive for many years, and contains only limited features that are potentially subject to wind disturbance/erosion.

Based on the low atmospheric levels that have been measured at Port Radium, air concentrations of radionuclides and metals are also expected to be low at the Contact Lake Mine site. While persistent organic pollutants were not analyzed in the air at the Port Radium site or Contact Lake Mine, they are the result of long-range transport mechanisms and are not related to these sites.

Given the close proximity of the Contact Lake Mine site to the Port Radium mine site and the much smaller footprint of disturbed area relative to Port Radium, it is reasonable to conclude that the air quality at the Contact Lake site does not pose any concerns.

4.6 TERRESTRIAL RADIATION

4.6.1 Gamma Radiation Measurements

During the Contact Lake site assessment (SENES 2007a), roving gamma surveys of impacted areas (e.g. waste rock, tailings and mine site, camp, and vicinity areas) were completed to characterize terrestrial gamma radiation fields at the site. Surface gamma radiation measurements were collected using a Ludlum 2221 gamma radiation meter, having a 2” by 2” Sodium Iodide (NaI) detector, capable of integrating measurements over 1 second intervals. The detectors were held approximately 1 m above the ground surface (as per the accepted monitoring protocols for gamma radiation measurements) while the operator walked over selected areas of the site. The Ludlum instrument was interfaced with a Trimble GPS system that simultaneously recorded both geographic coordinates and the gamma radiation levels associated with that geographic coordinate. Gamma radiation levels were recorded in counts per second (cps) in the NaI detector and were converted to units of μR/h using a factor of 21.38 cps per μR/h for the specific instrument used in the survey. Former operating locations were measured using roving transects that varied depending on the site-specific features, but generally were in the order of about 3 to 5 metres apart. In undisturbed “background” areas, gamma radiation levels were collected at broader patterns subject to the physical topography and accessibility.

Figure 4.6-1 shows the gamma radiation levels as statistically summarized in 10 m grids, with both the mean value and the maximum single measurements within the grid shown. The area outlined in the figure shows blocks on the site with gamma radiation levels generally above 50 μR/h, which not surprisingly coincide with the locations of the waste rock and the tailings. The elevated gamma radiation levels in these areas are believed to be associated with the historic mining activities. The highest mean for a 10 m grid equalled 336 μR/h, while the highest individual measurement was 598 μR/h.

Outside of the former mining "affected area" as outlined in the figure, gamma radiation levels tend to be below 50 μR/h, with a few grids in the camp area having maximum measurements exceeding 50 μR/h, and only one grid with a mean level above 50 μR/h. There were two grids with mean levels above 50 μR/h on the road to the east of the affected area. Apart from these isolated locations, it can be seen that gamma radiation levels in undisturbed locations vary from <20 μR/h to over 50 μR/h at the outcrop.

The gamma radiation levels on the grids are summarized in Table 4.6-1. Measured gamma radiation levels average 92 μR/h in the area affected by mining operations at the Contact Lake site. The mean gamma radiation level for 10 m grids surveyed outside of this area (i.e. outside the affected area) was 21 μR/h. The mean for the area that was surveyed was 41 μR/h.

Table 4.6-2 summarizes the number of grid cells as categorized by gamma radiation level. As can be seen from Table 4.6-2, the terrestrial gamma survey found that only a very small portion of the waste rock and tailings areas (less than 200 m^2) had terrestrial gamma radiation measurements exceeding 250 µR/hr, less than a hectare (about 0.74 ha) had terrestrial gamma radiation measurements between 100 and 250 µR/hr, and that the remainder of the surveyed area, about 7.8 ha, had terrestrial gamma radiation measurements below 100 µR/hr.

FIGURE 4.6-1
PROCESSED GAMMA RADIATION LEVELS (10 m GRIDS) (μR/h)

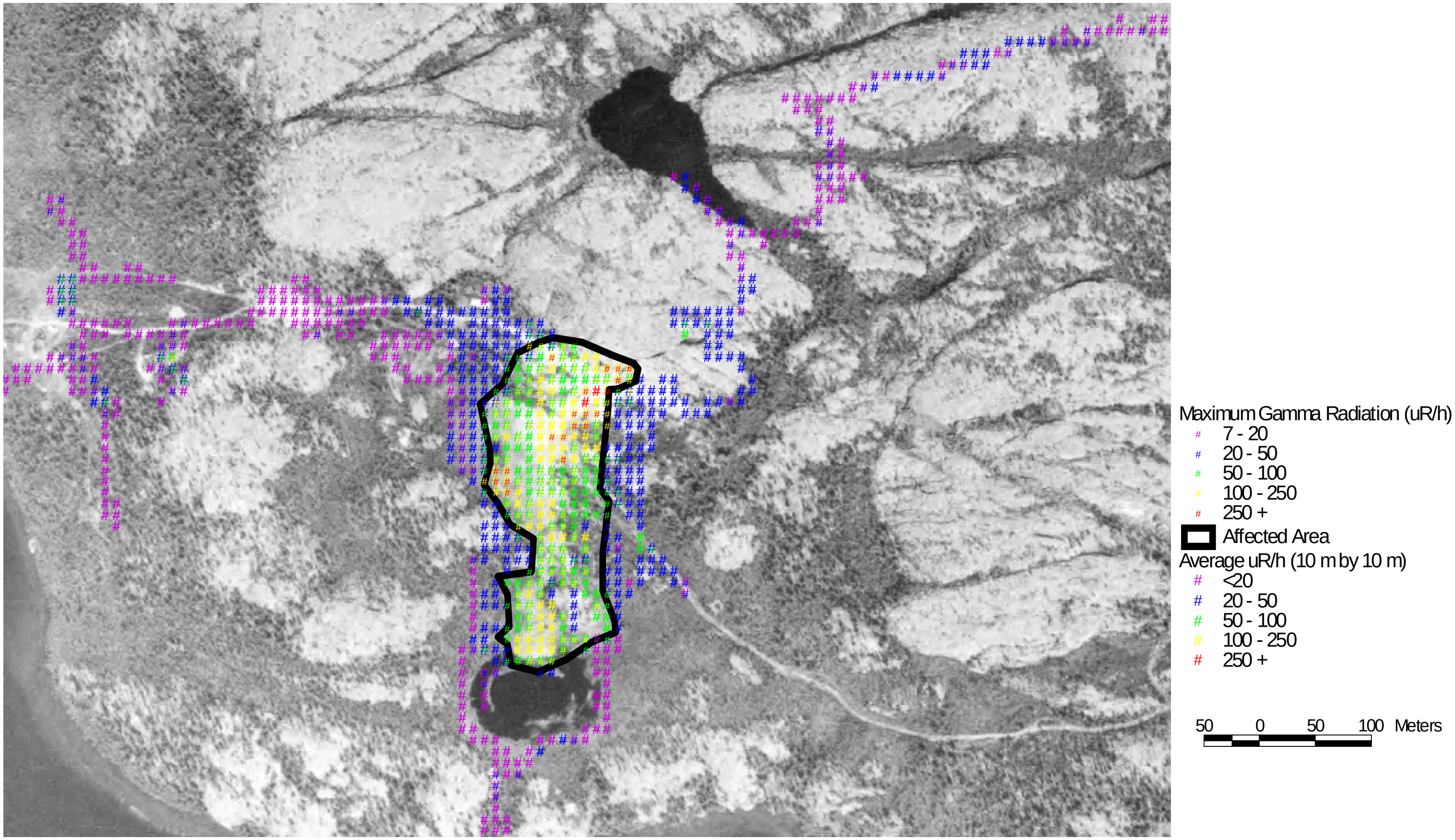


TABLE 4.6-1
SUMMARY OF MEAN GAMMA RADIATION LEVELS (μR/h) ON 10 m GRIDS

Area	Number	Mean	Minimum	Median	95th	Maximum
Affected Area	239	92	16	84	182	336
Remainder	616	21	6	19	43	76
All	855	41	6	23	119	336

TABLE 4.6-2
SUMMARY OF NUMBER OF 10 m GRIDS BY MEAN GAMMA RADIATION CATEGORY

Area	<20 (μR/h)	20 - 50 (μR/h)	50 - 100 (μR/h)	100-250 (μR/h)	over 250 (μR/h)
Affected	1	22	140	74	2
Remainder	344	268	4	0	0
All	345	290	144	74	2

4.6.2 Radon

Given the location and setting of the Contact Lake Mine site and the limited radiological sources associated with the site, no program was established for the collection of outdoor radon. However, an extensive database exists (e.g. Elliot Lake camp, northern Saskatchewan mines, etc.), which shows that in the absence of a major radiological source (e.g. large uranium tailings facilities) outdoor radon is not elevated above the background level typical of the area. Radon monitoring at Port Radium also confirmed that outdoor radon was generally at background levels on and adjacent to the site and thus not a concern. Based on this experience it can be safely concluded that radon is not an issue at the Contact Lake Mine site.

4.7 TERRESTRIAL VEGETATION

A recent report by Macdonald (2004) provides a good overview of the terrestrial environment of the Great Bear Lake watershed. Hence, only a brief overview of terrestrial vegetation found in the study area is provided below.

4.7.1 Local Vegetation

The Contact Lake study area lies within the north-eastern fringes of the subarctic boreal forest zone and the Canadian Shield. It is located 66 km south of the Arctic Circle and 70 to 120 km southwest of the northern limit of trees. As the climate in the region is dominated by long, dark and cold arctic winters, relatively low precipitation, and moderately warm summers with 24 hours of day light, the growing season lasts about 3.5 to 4 months from late-May/early-June to about mid-September (Johnson 1975; MacDonald *et al*. 2004).

The mine site and surrounding area consists of typical subarctic coniferous and mixed boreal forest. The vegetation ground cover in most habitats is closed-mat except for considerable areas with exposed bedrock and sparse vegetation, and areas impacted by mining activities. Forest floors are well-developed with shrubs, berries, Labrador tea, herbs, lichens and mosses. Well-drained hills and slopes are dominated by white spruce, paper birch and black spruce, and poorly drained depressions; lowlands and wetlands by black spruce, paper birch, scattered larch and balsam poplar. Forests climb up on mountainous slopes to meet the tree line in higher elevations and on plateaus that contain a transition zone of forest and tundra, and parcels of arctic tundra with alpine character. Thus, the study area and the adjacent land provide different ecosystems bordering and intermingling with each other within a relatively small area.

4.7.2 Soil and Vegetation Sampling Programs

Terminal leaves and twig samples of several terrestrial plant species (green alder, dwarf birch, paper birch, willow, Labrador tea, wild raspberry, balticus rush, and shrubby cinquefoil), along with local surface materials in which they were growing, were collected during the 2006 sampling program (SENES 2007a) from nine different locations: two control sites situated along the shoreline of Contact Lake about 1 km to the east and west of the main mine site and seven other sites (contaminated/disturbed) down slope of the main waste rock pile and in front of the headframe (see Figure 4.7-1 for locations of contaminated/disturbed sites). Samples were analyzed for metal and radionuclide content.

Soil

Mean moisture levels and concentrations of metals measured in soils (0-5 cm) collected from each site were calculated for the respective groups of contaminated/disturbed sites (n=7) and control sites (n=2) (see Table 4.7-1). Ratios of the mean values were calculated for each element from the geometric means of the contaminated/disturbed and control sites and are presented in Table 4.7-1 and Figure 4.7-2.

Soil samples collected at contaminated/disturbed sites were comprised of a mixture of soils, tailings, and/or waste rock. Soil metal concentrations were reported for all elements, except for tin and thallium, which were below detection limit in all samples from both contaminated/ disturbed and control sites.

Ratios of the contaminated/disturbed and control sites (see Figure 4.7-2) indicate that the concentrations of several elements were consistently higher at sites with waste rock and tailings than at the control sites. The highest ratios were observed for arsenic, bismuth, copper and manganese. On average, uranium was about 20 times higher in the contaminated/disturbed sites than the control sites. The measured levels of several of the metals reported in Table 4.7-1 on soil samples were very similar to those measured in tailings at the site (see SENES 2007a). To provide context for interpreting the results, it is noted that the concentrations of several metals (i.e. arsenic, copper, mercury, nickel and zinc) exceeded the Canadian Council of Ministers of the Environment (CCME) soil quality guideline values for residential/parkland use of the site (CCME 1999). These observations are not surprising as the samples contained mineralized soils with tailings and/or waste rock materials. Guidelines, however, have not been developed specifically for waste rock or tailings that would provide a more appropriate comparison.

Vegetation

Mean concentrations of metals measured in four plant species (alder, birch, cinquefoil, and willow) collected from each site were calculated for the respective groups of contaminated/disturbed sites (n=7) and control sites (n=2) (see Table 4.7-2). Other plant species were only found at a small subset of the sites (e.g. sedge, which only occurred at the contaminated/disturbed sites) and were thus not included in the calculation of the mean values. Ratios of the geometric mean concentration of each metal measured in the four plant species at the contaminated/disturbed sites versus the control sites were also calculated and are summarized in Table 4.7-2. Separate ratios for each of the four plant species were also calculated and summarized in Figure 4.7-3. Mean concentrations of antimony, silver, beryllium, selenium, tellurium, tin, thallium and vanadium were below the method detection limit at all or most of the sites and thus ratios for these metals were not calculated.

The comparison of metal ratios included in Table 4.7-2 indicated that concentrations of arsenic, cobalt, nickel and uranium were substantially higher in plants at the contaminated/disturbed sites than at the control sites, while concentrations of bismuth and molybdenum are slightly elevated at the contaminated/disturbed sites. Of the four plant species (see Figure 4.7-3), alder showed the lowest levels of accumulation of arsenic, cobalt and uranium at the contaminated/disturbed sites relative to the control sites as well as relative to the other plant species. Much higher ratios of arsenic, cobalt and uranium were generally observed for birch, cinquefoil and willow, demonstrating the ability of these plants to accumulate these metals. For example, the concentration of arsenic in birch was 25 times higher at the contaminated/disturbed sites relative to the control sites. Although nickel was elevated in all four species at the contaminated/disturbed sites, the ratios were similar between the four species. Other elements, such as bismuth, copper, and manganese that were elevated in soils/tailings/waste rock at the contaminated/disturbed sites (refer to Figure 4.7-1) showed little accumulation in vegetation. The maximum ratio of about 7 was observed for bismuth in cinquefoil.

Sedge species were also sampled from Sites 2 and 5 (see Figure 4.7-1 from locations) downslope of the major waste rock pile and from areas of standing water at the foot of the pile to determine if sedge exposed to run-off from the waste rock pile accumulates significant levels of metals relative to other contaminated/disturbed sites. The metal ratios were generally close to one indicating no significant accumulation of metals from run-off. Two elements, titanium and barium, had much higher concentrations at Site 5.

A summary of the lead-210 and radium-226 levels measured on individual vegetation samples from the contaminated/disturbed areas on the mine site are presented in Table 4.7-3. The results of the vegetation sampling were considered in the 2006 site-specific risk assessment (SENES 2007b), which is summarized in Chapter 5.

FIGURE 4.7-1
ILLUSTRATION OF SAMPLING LOCATIONS

Notes: Elevated photo of the Contact Lake Mine showing sampling sites for the vegetation and soil collections. Arrow shows the general direction of surface water flowing downslope from the waste rock pile. Supplemental samples of sedges were taken from areas of standing water at the foot of the pile (adjacent to the arrow shown in the picture).

TABLE 4.7-1
SUMMARY OF METAL CONCENTRATIONS IN SOILS COLLECTED AT CONTACT LAKE MINE SITE IN JULY 2006

Element	Contaminated/Disturbed Sites [1]					Control/Reference Site [1]					Ratio
	N	GM	GSD	Min.	Max.	N	GM	GSD	Min.	Max.	
Moisture [2]	7	29.2	24.3	1.1	59.5	2	79.3[1]	6.79[2]	74.5	84.1	-
Aluminum	7	12512	1.30	7670	15400	2	757	1.24	649	883	16.5
Arsenic	7	485	1.58	258	788	2	15.9	2.76	7.77	32.7	30.4
Barium	7	115	1.26	87.9	172	2	28.1	1.06	26.9	29.3	4.1
Beryllium	7	0.7	1.18	0.49	0.76	2	0.05	2.00	<0.06	0.08	13.4
Bismuth	7	167	1.90	63.5	373	2	5.19	2.60	2.64	10.2	32.1
Boron	7	8.5	1.75	5.5	28	2	14.2	2.29	7.9	25.5	0.6
Cadmium	7	0.1	2.46	0.05	0.63	2	0.34	1.13	0.31	0.37	0.4
Calcium	7	12625	1.22	9090	16500	2	18537	1.17	16600	20700	0.7
Chromium	7	17.6	1.23	12	22.3	2	1.84	1.63	1.3	2.6	9.6
Cobalt	7	175	1.47	101	361	2	11.7	2.40	6.33	21.8	14.9
Copper	7	3235	1.37	2040	5600	2	92.2	2.47	48.6	175	35.1
Iron	7	40167	1.35	27100	54200	2	1617	1.89	1030	2540	24.8
Lead	7	41.2	1.58	24.6	90.9	2	4.34	1.37	3.47	5.44	9.5
Magnesium	7	10638	1.33	6730	14300	2	3246	1.34	2640	3990	3.3
Manganese	7	18182	1.79	7270	35700	2	592	2.07	354	989	30.7
Mercury	7	7.0	1.99	2.13	14	2	0.42	1.69	0.29	0.61	16.6
Molybdenum	7	2.1	1.93	1.17	5.4	2	1.77	2.96	0.82	3.81	1.2
Nickel	7	121	1.45	78.7	214	2	5.89	2.09	3.5	9.9	20.5
Potassium	7	765	1.24	611	1140	2	611	1.06	586	638	1.3
Selenium	7	0.4	1.39	0.3	0.7	2	0.20	1.00	0.2	0.2	2.2
Silver	7	140	1.32	94	197	2	10.0	2.67	5	20	14.0
Sodium	7	69.2	1.18	55	91	2	62.4	1.81	41	95	1.1
Strontium	7	10.6	1.91	4.8	31.3	2	28.9	1.46	22.1	37.9	0.4
Thallium	7	<0.1	-	<0.1	<0.1	2	<0.10	-	<0.1	<0.1	-
Tin	7	<2	-	<2	<2	2	<2	-	<2	<2	-
Titanium	7	154	1.42	121	333	2	14.6	1.45	11.2	18.9	10.6
Uranium	7	190	1.64	97.9	406	2	9.66	2.13	5.65	16.5	19.6
Vanadium	7	34.4	1.26	23.2	42.3	2	2.39	1.52	1.78	3.22	14.4
Zinc	7	209	1.20	158	291	2	53.6	1.98	33	87	3.9

Notes:

[1] Concentrations are reported in mg/kg dry weight

[2] Values for moisture are an arithmetic mean with standard deviation

N – number of samples; GM – geometric mean; GSD – geometric standard deviation; Min. – minimum; Max. - maximum.

Ratio – (GM of Contaminated/Disturbed Sites)/GM of Control/Reference Sites).

FIGURE 4.7-2
RATIO OF GEOMETRIC MEAN METAL CONCENTRATION IN SOIL AT CONTAMINATED/DISTURBED SITES (n=7) RELATIVE TO CONTROL SITES (n=2)

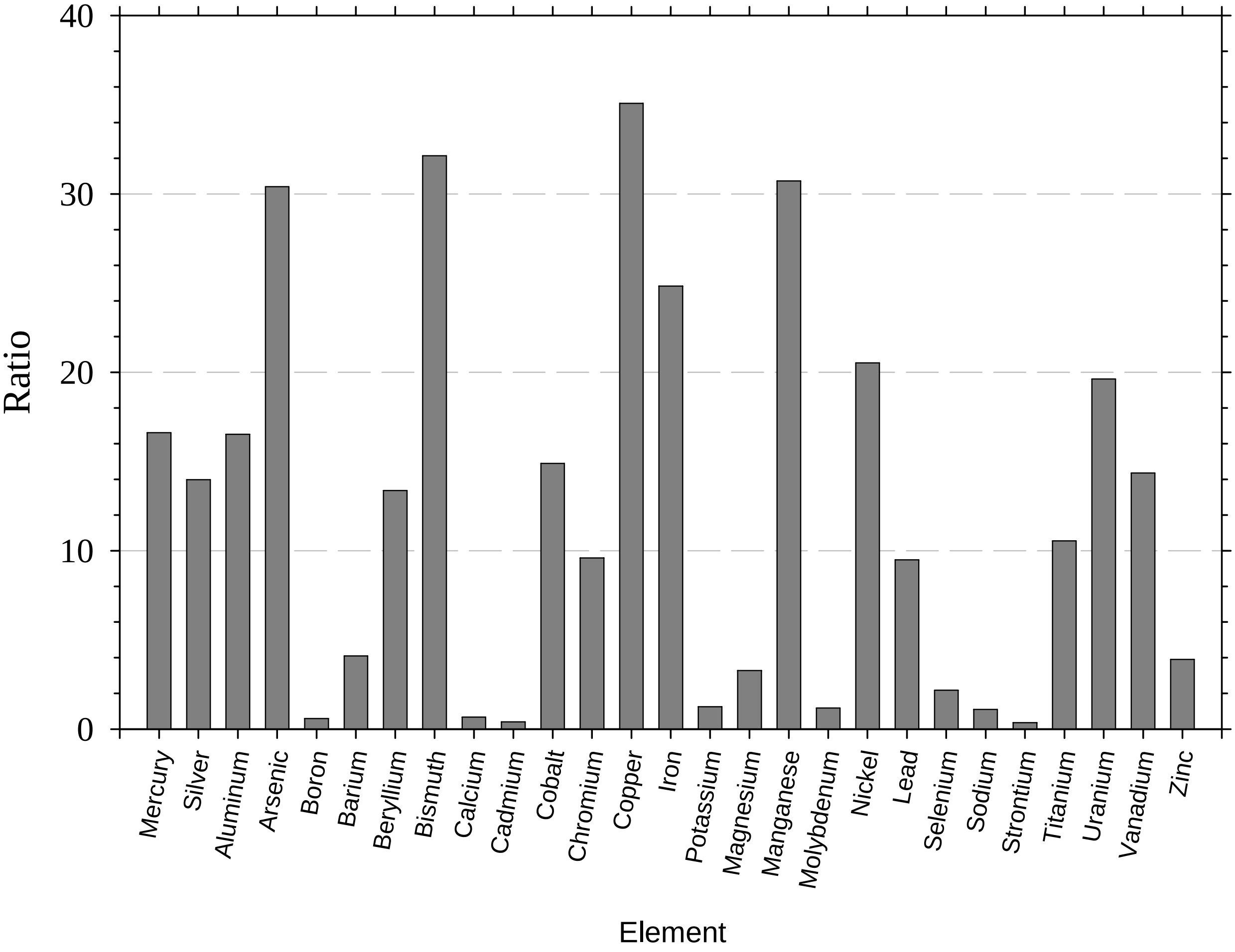


TABLE 4.7-2
SUMMARY OF METAL CONCENTRATIONS AND MOISTURE IN VEGETATION COLLECTED AT CONTACT LAKE MINE SITE IN JULY 2006

Metal	Contaminated/Disturbed Sites [1]						Control/Reference Sites [1]				Ratio
	N	GM	GSD	Min.	Max.	N	GM	GSD	Min.	Max.	
Moisture [2]	27	54.0	7.95	17.2	62.2	7	55.9	2.00	53.2	58.3	0.97
Aluminum	27	8.40	2.15	4.00	82.0	7	4.94	1.60	4.00	14.00	1.70
Antimony	27	<0.06	-	<0.06	0.82	7	<0.06	-	<0.06	<0.06	-
Arsenic	27	1.20	1.97	0.50	4.49	7	0.09	1.81	<0.05	0.16	14.1
Barium	27	9.11	2.88	2.21	124	7	5.50	3.46	1.79	52.0	1.66
Beryllium	27	<0.05	-	<0.05	0.06	7	<0.05	-	<0.05	<0.05	-
Bismuth	27	0.12	3.41	0.04	3.63	7	0.03	1.82	<0.02	0.07	3.40
Boron	27	48.3	1.54	24.8	148	7	21.4	1.84	8.30	46.6	2.26
Cadmium	27	0.03	4.77	<0.02	0.74	7	0.03	4.18	<0.02	0.22	1.17
Calcium	27	8752	1.26	6030	15200	7	7978	1.28	5220	11800	1.10
Cesium	27	0.02	2.33	<0.02	0.24	7	0.02	3.50	<0.02	0.19	0.93
Chromium	27	0.34	2.40	0.10	2.20	7	0.36	1.75	0.20	0.90	0.95
Cobalt	27	0.71	2.29	0.20	3.19	7	0.07	2.26	<0.01	0.21	10.6
Copper	27	8.60	1.84	4.80	58.6	7	4.44	1.18	3.50	5.20	1.94
Iron	27	48.9	1.72	30.0	253	7	28.6	1.18	23.0	39.0	1.71
Lead	27	0.71	4.32	0.12	63.0	7	0.87	2.46	0.19	2.84	0.82
Magnesium	27	2206	1.35	1230	3760	7	2916	1.24	2340	4390	0.76
Manganese	27	203	1.82	51	553	7	144	1.36	94	224	1.40
Molybdenum	27	0.99	2.17	0.23	6.25	7	0.33	2.06	0.07	0.64	2.98
Nickel	27	3.34	1.72	1.10	9.00	7	0.53	1.42	0.30	0.80	6.30
Phosphorus	27	1163	1.32	739	2000	7	973	1.24	706	1240	1.19
Potassium	27	6622	1.29	4020	10500	7	5352	1.28	3910	7010	1.24
Rubidium	27	8.92	1.76	3.80	30.5	7	7.02	2.05	3.40	18.6	1.27
Selenium	27	<0.10	-	<0.10	0.20	7	<0.10	-	<0.10	<0.10	-
Silver	27	<1	-	<1	55	7	<1	-	<1	<1	-
Sodium	27	7.50	3.47	1.00	209	7	4.91	1.59	3.00	10.0	1.53
Strontium	27	11.8	1.43	6.26	20.9	7	9.82	1.76	4.04	20.6	1.20
Tellurium	27	<0.08	-	<0.08	<0.08	7	<0.08	-	<0.08	<0.08	-
Thallium	27	<0.06	-	<0.06	<0.06	7	<0.06	-	<0.06	<0.06	-
Tin	27	<1	-	<1	<1	7	<1	-	<1	<1	-
Titanium	27	0.31	1.95	0.16	1.72	7	0.18	1.58	0.12	0.46	1.71
Uranium	27	0.46	4.59	0.07	24.7	7	0.04	2.31	0.01	0.17	11.9
Vanadium	27	<0.06	-	<0.06	2.26	7	<0.06	-	<0.06	<0.06	-
Zinc	27	62.7	2.60	14.2	346	7	76.6	2.59	28.7	263	0.82

Notes:

[1] Concentrations are reported in mg/kg dry weight; birch, willow, alder and cinquefoil samples were pooled in preparing summary statistics presented in this table.

[2] Values for moisture are an arithmetic mean with standard deviation

N – number of samples; GM – geometric mean; GSD – geometric standard deviation; Min. – minimum; Max. - maximum.

Ratio – (GM of Contaminated/Disturbed Sites)/(GM of Control/Reference Sites)

FIGURE 4.7-3
RATIO OF METAL CONCENTRATION IN FOUR PLANT SPECIES AT DISTURBED SITES (n=7) RELATIVE TO CONTROL SITES (n=2)

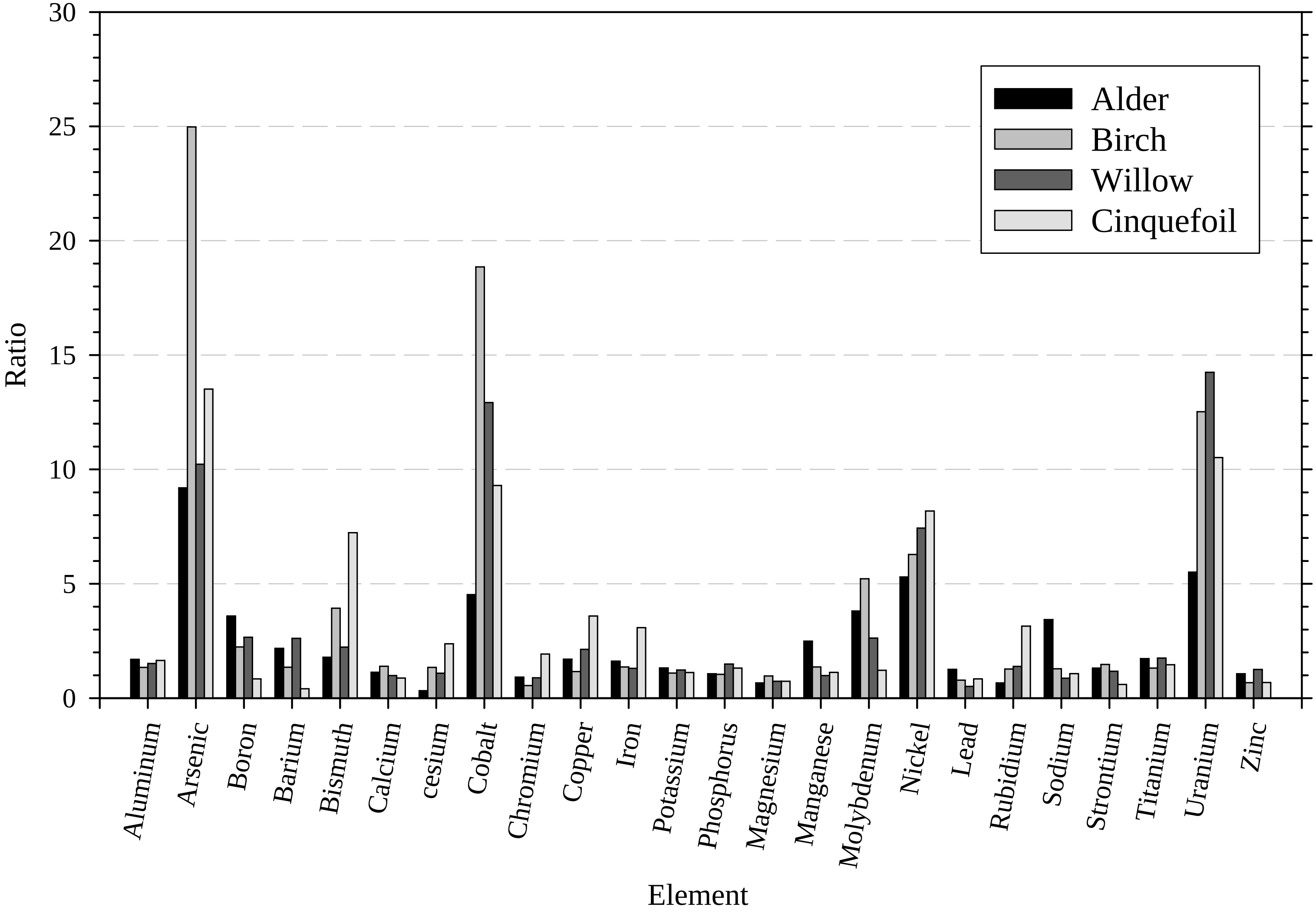


TABLE 4.7-3
SUMMARY OF RADIONUCLIDE LEVELS IN VEGETATION SAMPLES COLLECTED IN THE VICINITY OF THE CONTACT LAKE MINE SITE

Vegetation Samples	**Concentration (Bq/g)**	
	Pb-210	**Ra-226**
Sample ID	Bq/g	Bq/g
2 CL06-1-paper birch	0.06	0.092
3 CL06-1-willow	0.02	0.011
4 CL06-1-alder	0.02	0.009
5 CL06-1-cinquefoil	0.14	0.11
6 CL06-1-raspberry	0.05	0.017
8 CL06-2a-sedge	0.03	0.042
9 CO06-2-raspberry	0.02	0.012
10 CL06-2-sedge	0.02	0.008
11 CL06-2 willow	0.01	0.001
12 CL06-2-alder	0.02	0.014
14 CL06-3-paper birch	0.02	0.022
15 CL06-3-alder	0.01	< 0.001
16 CL06-3-willow	0.02	0.003
17 CL06-3-cinquefoil	0.09	0.09
18 CL06-3-sedge	0.03	0.007
19 CL06-3-lab tea	0.03	0.021
21 CL06-4-willow	0.01	< 0.001
22 CL06-4-dwarf birch	0.03	0.019
23 CL06-4-alder	0.03	0.003
24 CL06-4-sedge	0.05	0.059
27 CL06-4-sedge (dup)	0.09	0.059
28 CL06-4-cinquefoil	0.02	0.088

Note: < indicates less than detection limit
All measurements in Bq/g dry weight

4.8 TERRESTRIAL WILDLIFE

The current state of knowledge regarding wildlife in the Great Bear Lake watershed is summarized in a report by Macdonald (2004). A brief summary of the information contained in Macdonald (2004), updated with more recent information on the status of bird and animal species in the Northwest Territories (ENR 2007), is presented below.

4.8.1 Wildlife Biodiversity

The area around Great Bear Lake naturally provides a large variety of habitats and rich species diversity of vegetation, wildlife and birds including boreal and tundra species. No large scale inventories of terrestrial species present in the Great Bear Lake watershed have been undertaken to establish the current biodiversity, however, the Environment and Natural Resources (ENR) (previously known as Resources, Wildlife and Economic Development (RWED)) branch of the Government of the Northwest Territories maintains a database on terrestrial plants and animals by ecozone (ENR 2007). ENR evaluates the status of each species based on their numbers, distribution and the extent of threats to their populations and habitats.

Of the 54 mammals potentially present in the Great Bear Lake watershed, 37 are considered to be "secure" indicating that there is a large enough population and a wide enough distribution that there is no immediate concern for the species, and 7 species are considered to be "sensitive" (barren land caribou, woodland caribou, wolverine, grizzly bear, fisher, little brown bat, and collard pika) due to small numbers or threats to the habitat. Ten species were listed as "undetermined" because data were not available to assess their status. No mammals were identified in the "may be at risk" or "at risk" categories. Characteristic wildlife in the Great Bear Lake watershed includes caribou, moose, black bear, wolf, red fox, snowshoe hare and beaver. Surveys of the caribou herds indicate that the Bluenose-East and Bluenose-West herds to the north appear to have stable numbers, but the Bathurst herd appears to have undergone a significant decline.

Of the 190 bird species potentially present in the watershed, 106 species are "secure", 25 are "sensitive" (northern pintail, lesser scaup, long-tailed duck, white-winged scoter, surf scoter, least sandpiper, semipalmated sandpiper, black tern, red phalarope, red-necked phalarope, American golden-plover, Caspian tern, lesser yellowlegs, peregrine falcon (anatum), tundra peregrine falcon, American pipit, olive-sided flycatcher, blackpoll warbler, barn swallow, boreal chickadee, American tree sparrow, white-throated sparrow, Harris's sparrow, short-eared owl), 2 species "may be at risk" (gray-headed chickadee and rusty blackbird), and 1 species is "at risk" (Eskimo curlew). The remaining 56 species were listed as "undetermined". Birds common to the area include spruce grouse, raven, osprey and waterfowl. Assessments of waterfowl indicate that populations of pintail and scoters are much lower than historic levels, although mallard and Canada goose numbers remain relatively stable.

During the July 2006 site assessment at Contact Lake (SENES 2007a), signs of several wildlife species were observed at the site. Tracks from caribou, moose, grizzly and black bear were noted, while two red-throated loons (*Gavia stellata*) were seen nesting on the tailings pond. Several loon chicks were also seen. The pond was evaluated to determine the presence of fish, but was found to be unsuitable for fish due to the poor water and sediment quality (Section 4.10). No minnows or submerged aquatic insects were observed in shoreline surveys of the pond.

4.8.2 Species at Risk in Canada

Of the mammal and bird species that may potentially occur specifically within the project area, 7 have been designated as "species at risk" in Canada (see Table 4.8-1). Assessments for candidate species are conducted by the Committee on the Status of Endangered Species in Canada (COSEWIC) who provide recommendations on the levels of protection needed to allow the recovery of declining species. Candidate species are listed under specific classifications depending on their numbers and the health of the population as follows (Macdonald 2004):

Extinct:	a species no longer exists.
Extirpated:	a species no longer exits in the wild in Canada, but occurs elsewhere.
Endangered:	a species faces imminent extirpation or extinction.
Threatened:	a species likely to become endangered if limiting factors are not reversed.
Special Concern:	a species that may be particularly sensitive to human activities or natural events.

Species protected under the *Species at Risk Act* (SARA) are listed on Schedule 1 of SARA. SARA also includes endangered and threatened species on Schedule 2 and species of concern on Schedule 3 that are under review for inclusion on Schedule 1.

TABLE 4.8-1
TERRESTRIAL SPECIES AT RISK POTENTIALLY OCCURRING WITHIN THE PROJECT AREA

Terrestrial Species at Risk potentially within project area [1]	**COSEWIC Designation**	**Schedule of SARA**	**Government Organization with Primary Management Responsibility [2]**
Eskimo Curlew [3]	Endangered	Schedule 1	EC
Woodland Caribou (Boreal population)	Threatened	Schedule 1	Government of NWT
Peregrine Falcon (*anatum-tundrius* complex [4])	Special Concern	Schedule 1 (*anatum*) Schedule 3 (*tundrius)*	Government of NWT
Short-eared Owl	Special Concern	Schedule 3	Government of NWT
Wolverine (Western population)	Special Concern	Pending	Government of NWT
Grizzly Bear	Special Concern	Pending	Government of NWT
Rusty Blackbird [5]	Special Concern	Pending	Government of NWT

[1] The Department of Fisheries and Oceans has responsibility for aquatic species.

[2] Environment Canada has a national role to play in the conservation and recovery of Species at Risk in Canada, as well as responsibility for management of birds described in the *Migratory Birds Convention Act* (MBCA). Day-to-day management of terrestrial species not covered in the MBCA is the responsibility of the Territorial Government. Thus, for species within their responsibility, the Territorial Government is best suited to provide detailed advice and information on potential adverse effects, mitigation measures, and monitoring.

[3] There have been no reliable sightings of Eskimo Curlew since 1998 and the National Recovery Team for this species has determined that recovery is not feasible at this time.

[4] The *anatum* subspecies of Peregrine Falcon is listed on Schedule 1 of SARA as threatened. The *anatum* and *tundrius* subspecies of Peregrine Falcon were reassessed by COSEWIC in 2007 and combined into one subpopulation complex. This subpopulation complex was listed by COSEWIC as Special Concern.

[5] Newly listed by COSEWIC in April 2006.

4.9 HYDROLOGY AND HYDROGEOLOGY

A recent review of the state of aquatic knowledge of the Great Bear Watershed (MacDonald *et al.* 2004) provides a comprehensive overview of limnological, hydrological and environmental conditions and of the structure and function of the aquatic ecosystem of Great Bear Lake. The following hydrology/hydrogeology descriptions are summarized from MacDonald *et al*. (2004).

4.9.1 Physical Limnology

The Contact Lake Mine site is near the eastern shores of Great Bear Lake in the vicinity of Echo Bay. Great Bear Lake is the largest fresh water lake wholly contained within the borders of Canada. The statistical attributes of the lake include it being the ninth largest lake in the world by volume, the nineteenth deepest lake in the world, and holding the largest mass of cold fresh water in the world. The lake is characterized by its clear waters, maximum recorded Secchi depth 30 m, and simple food web. The total water volume is approximately 2.24 billion m^3 with a drainage area to water surface area ratio of 4.7 to 1, which is smaller than most lakes.

Precipitation in the Great Bear watershed is in the order of 230 mm/yr (102 to 355 mm/yr), half of which falls as rain in the summer months. The evaporation rate is about half that of precipitation, and thus the flow of surface water into lakes occurring in the area is generally small. Great Bear Lake has a slow turnover rate and a 124-year residence time. Furthermore, Great Bear Lake is an isothermal, un-stratified lake, and this lack of temperature variance means it is well mixed. During summer storms, water from shallow areas circulates and mixes with deeper water, and on average Great Bear Lake turns over once every 3 years (Johnson 1975a). Great Bear Lake is ice covered from December to May, but sheltered bays and shallow water can be frozen by November. Ice formation can continue to April, and ice is not off the lake until July.

Limited limnological information exists for Contact Lake, which is located approximately 49 km hydrologically upstream from Great Bear Lake (Gartner Lee 2005). The general limnological parameters that were measured in Contact Lake in July 2006 (SENES 2007a) are typical of similarly sized oligotrophic Shield lakes, with temperatures being stable and around 16 ^{o}C, pH averaging about 7, dissolved oxygen at about 10 mg/L, and conductivity being on average 0.03 S/cm.

4.9.2 Regional Hydrology

As noted above, the drainage area of Great Bear Lake is very small compared to the total area of the lake, which limits the influence of inflows from contributing basins. Great Bear Lake receives inflow from six major sub-watersheds: Johnny Hoe, Camsell, Sloan, Dease, Haldane and Whitefish. The Camsell River is the largest tributary contributing 21% of total drainage at 3.083 billion m^3/yr. Johnny Hoe is the next largest contributor with 12% of the total drainage at

1.287 billion m^3/yr. The response of the river system and the timing of peak flow is typical of peak flows that are the direct result of snow melt and runoff. Peak flow usually occurs in mid- to late-May. Soon after the peak, flow begins to subside to low levels for the rest of the year.

Great Bear Lake water levels have been recorded since 1938, with continuous measurements starting in 1963. Data from Port Radium and Hornby Bay indicate that the extreme range in the lake level elevation is one meter. The lowest mean daily water elevation was 155.57 m a.s.l. in April 1948 and the highest was 156.59 m a.s.l. in August 1961. The majority of water levels range from between 155.8 and 156.4 m a.s.l. Water levels can also be affected by “seiche” wind effects and barometric changes.

4.9.3 Site Hydrology

The Contact Lake Mine site is located south of and between Great Bear Lake’s Echo Bay East and West Arms in an area that hosts no major streams or rivers in the immediate vicinity. Rainfall and snowmelt pond and accumulate in localized depressions to the point where they reach steady state conditions. The site borders on the area between discontinuous and continuous permafrost. Runoff from the area reflects the influence of permafrost and winter snowmelt during the spring freshet, coupled with the rugged surface profiles and shallow soil cover. As a result, as with other areas around the eastern end of Great Bear Lake, there is virtually no flow in either late summer or in the winter.

Figure 4.9-1 outlines the boundaries of the small drainage area (less than 0.25 km^2) around the Contact Lake Mine as well as the watershed of Contact Lake (approximately 50 km^2). As can be seen more clearly in Figure 4.9-2, the mine site drainage area consists of a small valley located at the east side of the mine site that slopes towards Contact Lake. The valley is bounded by a steep rock face on its northern end and shallower rock outcrops on its eastern and western flanks. It terminates in a small natural pond in the immediate vicinity of Contact Lake.

Site inspections of the area in July 2006 (SENES 2007a) found no evidence of discharge from Upper Lake at the head of this drainage area. As seen on Figure 4.9-3, when Upper Lake discharges the flow by-passes the mine site proper as it drains towards the tailings pond through a drainage path east of the mine site area. A very small surface water flow was noted emerging from local surficial till at the edge of the waste rock and from the toe of the waste rock pile. A discontinuous and very small flow was noted in one part of the drainage channel from the tailings pond to Contact Lake.

4.9.4 Site Hydrogeology

Similarly to other sites in the region, the Contact Lake Mine site is characterized by extensive bedrock outcroppings and shallow surface soils. Surficial soils may serve as periodic drainage pathways from areas such as the valley to the east of the mine site (Upper Lake discharge) and depressions between rock outcrops below the tailings pond. Within bedrock outcrops, which predominate throughout the site, fractures would be the primary mechanism of groundwater flow. During the site visit in July 2006 (SENES 2007a), no evidence of groundwater flow was noted, although the shallow surficial soils between rock outcrops down gradient of the tailings were saturated.

A detailed site-specific water balance and quantitative characterization of flows from the site has not been carried out and is considered to be inappropriate given the lack of meteorological, hydrological and hydrogeological data for the site. However, in quantitative terms, surface flows from the impacted area of the mine site are small relative to the drainage basin of Contact Lake (in the order of 1/200th, based on area). Similarly, groundwater flows are anticipated to be relatively minor. Furthermore as indicated below, the incremental metal loadings to Contact Lake associated with the mine site drainage area are considered to be minimal. Collectively, these observations suggest that further characterization of the hydrology and hydrogeology at the Contact Lake mine is not warranted (SENES 2007a).

Discussion on Potential Loadings to Contact Lake

A preliminary and conservative evaluation to determine the magnitude of potential loadings to Contact Lake was conducted in the SENES 2006 site assessment (SENES 2007a) to determine if further modelling is warranted. Using conservative assumptions to evaluate potential annual loadings of metals and radionuclides from the local mine site drainage area to Contact Lake were estimated and then converted to respective incremental concentrations in Contact Lake according to the following equation:

$$\textit{Incremental Concentration in Contact Lake} = m/V$$

where:

m = the total annual mass of metal or radionuclide in the runoff from the mine site on an annual basis in µg; and,

V = the annual runoff to Contact Lake from all sources (i.e. not just the mine site).

The incremental concentrations were compared to applicable water quality criteria (e.g. CWQG-FAL) to determine the relative magnitudes of potential loadings contributed to Contact Lake by the mine site. In all cases, the contributions attributable to the mine were determined to be a small fraction of the applicable criterion. The parameters for which the greatest contributions were found were arsenic (site drainage could contribute up to 1.9 % of the 5 µg/L criterion for arsenic) and copper (site drainage could contribute up to 2.4 % of the 2 µg/L criterion for copper).

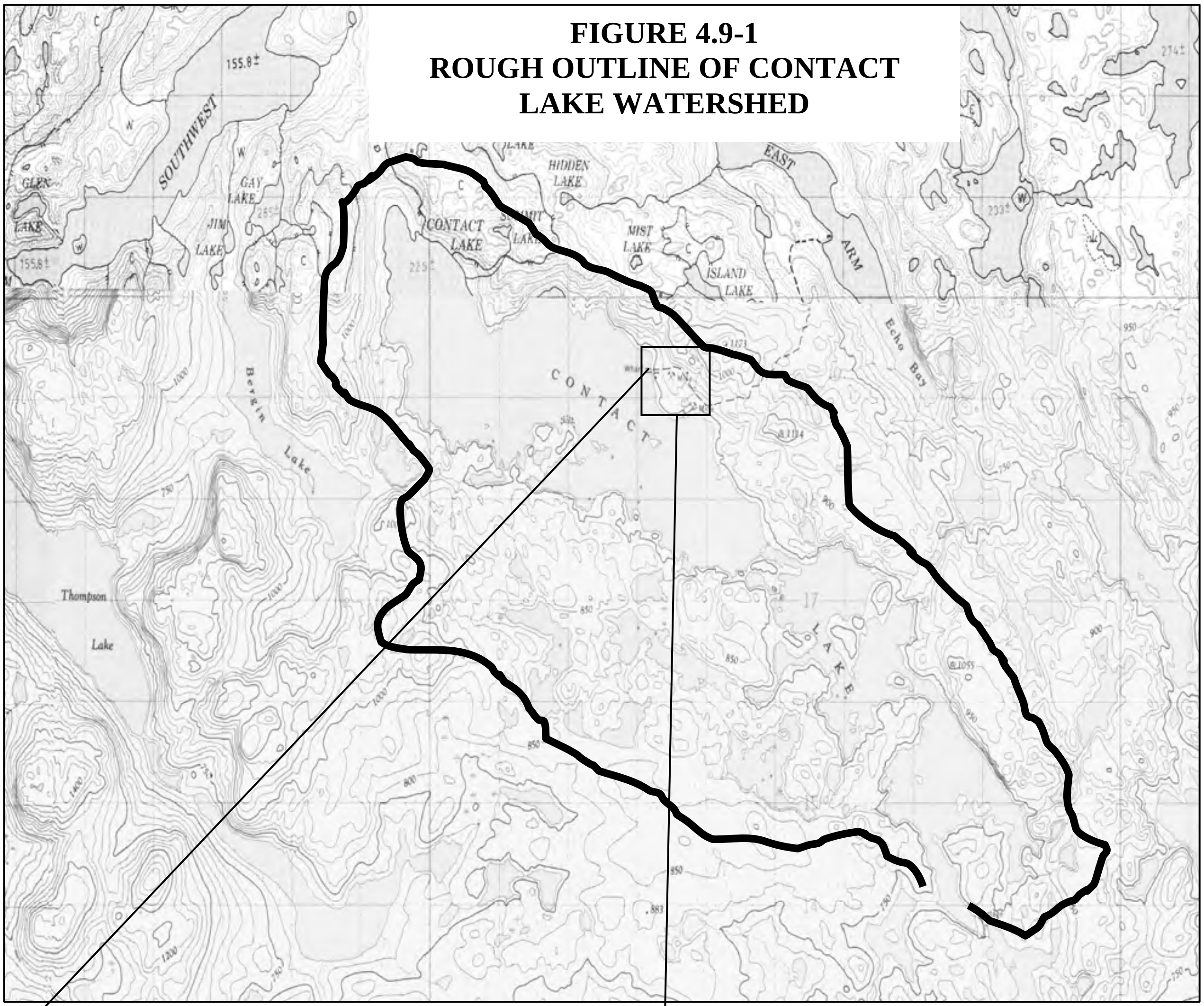


**FIGURE 4.9-1
ROUGH OUTLINE OF CONTACT
LAKE WATERSHED**

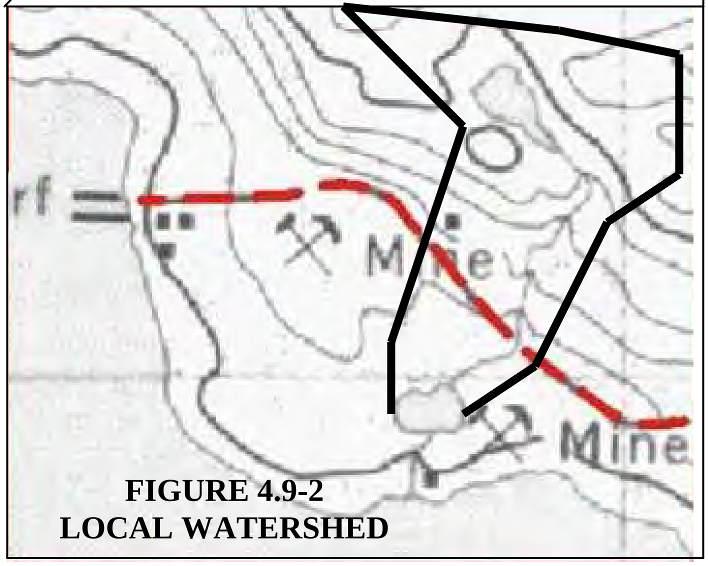
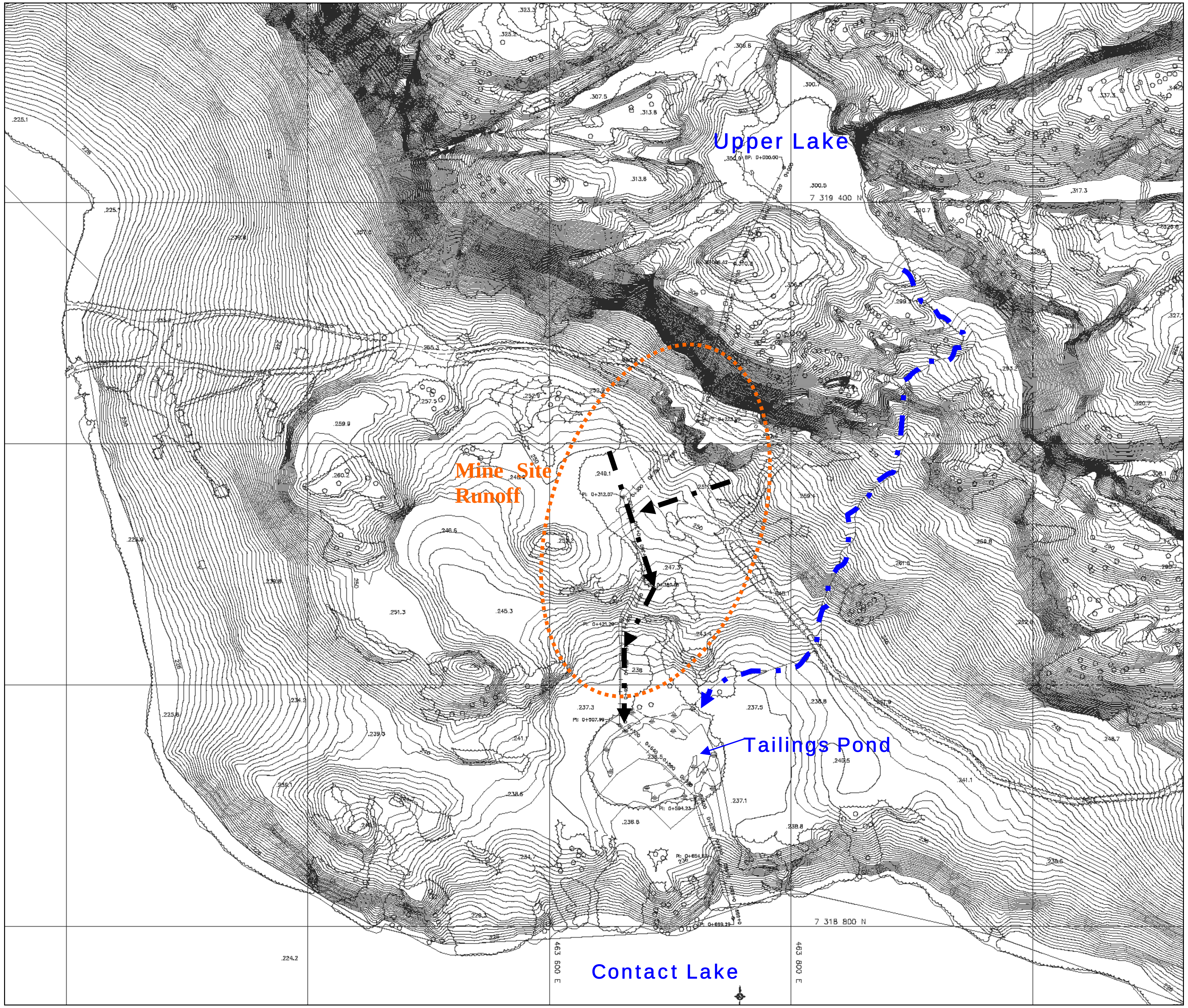


**FIGURE 4.9-2
LOCAL WATERSHED**

FIGURE 4.9-3
UPPER LAKE AND MINE SITE DRAINAGE



4.10 WATER AND SEDIMENT QUALITY

Ambient environmental monitoring has been carried out on Great Bear Lake for several decades including monitoring of contaminant levels in water, sediment and biota. Water quality monitoring has been carried out by Environment Canada as part of the routine surveillance network while a number of specific surveys have been completed on portions of Great Bear Lake and/or its tributaries. A review of much of the historic data has been summarized by MacDonald *et al.* (2004).

Several sampling programs have also been conducted at the Contact Lake Mine site. In 1993, environmental monitoring and assessments were carried out by EBA (1993a) and by Thurber (1993) and on four occasions from 2002 to 2004, INAC's Water Resources Division partnered with CARD to sample surface water, sediment, groundwater and soil quality on the site to augment the record of site conditions. The results from these programs were compiled into a report by Gartner Lee Limited in 2005 (Gartner Lee 2005). Additional water and sediment samples were collected again by INAC in August 2005.

Most recently, site assessment programs were completed at the Contact Lake Mine site in July 2006 and June 2007 by SENES Consultants Limited (SENES 2007a; 2007c), which included the collection of surface water and sediment samples for the analysis of metals and some uranium-238 series radionuclides (radium-226 and lead-210), as well as petroleum hydrocarbons. A brief review of water and sediment quality at the Contact Lake Mine site is presented in the following sections.

The water and sediment quality data collected through INAC (2002-2004, 2005) and the 2006 site assessment program (SENES 2007a) were previously summarized and used in the human health and ecological risk assessment (HHERA) that was completed by SENES in 2007 (SENES 2007b). Although results from the 2007 supplementary site assessment program (SENES 2007c) were not incorporated into the risk assessment, the results were similar to those reported for the 2006 program. The risk assessment identified the following as being constituents of potential concern (COPC): antimony, arsenic, barium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, uranium, vanadium, zinc, lead-210 and radium-226.

4.10.1 Water Quality

4.10.1.1 Receiving Lakes

A statistical summary of the data to 2006 was generated as part of the HHERA and is shown on Table 4.10-1. As seen in this table, mean concentrations of metal constituents in Great Bear Lake and Contact Lake locations were generally similar. A comparison of mean constituent concentrations to Canadian Environmental Quality Guidelines (CEQGs) for the protection of freshwater aquatic life and drinking water (CCME 1999; Health Canada 2006a; 2006b) shown on Table 4.10-2, indicates that all metal and radionuclide concentrations measured in Contact Lake and Great Bear Lake were below available guideline values. The data collected to 2006 were used in the SENES HHERA (SENES 2007b), which suggests that there are no issues associated with Contact Lake or Great Bear Lake water quality. Additional samples collected in the 2007 sampling program (SENES 2007c) confirmed that the values used in the HHERA were appropriate.

In 2007 four regional lakes were also sampled (SENES 2007c). Metal concentrations were generally consistent between the four lakes and below the CEQGs.

The results of the water sampling programs indicate that water quality of receiving waters in the vicinity of the Contact Lake Mine site is not adversely affected by the former mine.

4.10.1.2 Site Surface Water Drainage

A summary of surface water quality data at the mine site based on data collected by SENES in 2006 (2007a) and previously by INAC (2002–2004; 2005) is presented on Table 4.10-3 (Upper Lake; tailings pond; on-land water). These data were used in the HHERA. Results obtained from the 2007 site monitoring program (SENES 2007c) were similar to those obtained from the 2006 program (SENES 2007a) confirming that these values were appropriate for the HHERA.

Given the upgradient topographic elevation of Upper Lake with respect to the mine, water quality in the lake was expected to remain largely uninfluenced by the mine site. This was reflected in the COPC concentrations that were measured in Upper Lake in 2006 and 2007 which where well below CEQGs, with the exception of copper (note that some other COPC reported exceedences in prior years, see Table 4.10-3). The copper concentration in Upper Lake is several times higher than the concentrations measured in Contact Lake. Since Upper Lake is upgradient of the mine, this result indicates that copper is likely a naturally elevated element.

Concentrations of COPC measured in the tailings pond (see Table 4.10-3) were elevated for most constituents including arsenic, barium, copper, manganese, nickel, strontium, and uranium. In comparing mean COPC concentrations measured in the tailings pond to available guideline values (see Table 4.10-4), the CEQG for the protection of freshwater aquatic life was exceeded for arsenic, cadmium, copper, and silver, and the CEQG for drinking water quality was exceeded for manganese, uranium, lead-210 and radium-226, although radionuclide concentrations were below guideline values during the 2006 and 2007 site assessment programs.

Constituent concentrations measured in the waste rock seepage were also elevated and in most cases were more than twice as high as in the tailings pond (see on-land water on Table 4.10-3). This was particularly true for silver; however, radionuclide levels (lead-210 and radium-226) were actually much lower in the waste rock seepage.

During the 2006 and 2007 site assessment programs (SENES 2007a; 2007c) a number of surface water samples were collected. One group of samples were collected from between the mine site and the Tailings Pond, while another group was collected from between the tailings pond and Contact Lake. Analytical results found concentrations of arsenic, copper, and uranium at the toe of the waste rock to be higher that those in Upper Lake, and that these concentrations increased in down gradient samples prior to the tailings pond. Concentrations of arsenic, copper, silver and uranium that exceeded CEQGs in the tailings pond, decreased in the samples between the pond and Contact Lake and were below detection limits at the edge inflow to Contact Lake. These results indicate that the waste rock and surface tailings at the mine site are impacting localized on-site runoff water quality particularly with respect to arsenic, copper, and uranium levels. These results were incorporated into the 2006 risk assessment (SENES 2007b), which is summarized in Chapter 5.

4.10.1.3 Groundwater

As part of the August 2005 water sampling program, INAC sampled four shallow groundwater wells between the tailings pond and Contact Lake. Samples were collected from between 0.3 to 0.6 m below ground surface and reported by INAC Water Resources (INAC 2006c). The groundwater samples were analyzed for dissolved metals, general chemistry (including nutrients and physical parameters), and radionuclides. Efforts to sample groundwater at these wells during the July 2006 site assessment program (SENES 2007a) were not successful due to the damaged state of the wells, shallow water depths and insufficient water volumes.

The results for dissolved metals are summarized and compared to CEQGs for drinking water on Table 4.10-5. As shown on Table 4.10-5, COPC identified in groundwater at the Contact Lake Mine site in 2005 were aluminum, arsenic, iron, manganese, and uranium, which exceeded the respective drinking water CEQGs. Concentrations of most metals increased in groundwater sampled with distance downslope from the Tailings Pond toward Contact Lake, including aluminum, arsenic, copper, iron, lead, nickel and zinc, which had higher levels in water from CL-W4 (proximal to Contact Lake) than from CL-W1 (proximal to the Tailings Pond). This is the opposite of the results in the surface water where metals decrease in concentration with distance downslope from the Tailings Pond toward Contact Lake. The reason for this may be that the wells were shallow, only sampled one year, and were sampled immediately after installation. Large ranges in concentration were also observed for most metals, except for mercury and silver, which were undetectable in all well waters. These results are not surprising given that the samples represent near surface water (within 1 m of surface) associated with a discontinuous permafrost zone above the bedrock. Overall, groundwater impacts are not expected. Note that due to its proximity to the lake, the nature of the site rock and permafrost, and the location of the sample wells in the shallow discontinuous permafrost, these water samples are not considered to represent an operable groundwater system as defined in the FSCAP site scoring program. In addition, due to the proximity of the abundant and readily available drinking water quality surface waters of Contact Lake groundwater consumption was not considered in the risk assessment (SENES 2007b).

INAC Waters (INAC 2006c) also reported that a total of 11 radionuclides were detected in the three well waters that were sampled (CL-W1, CL-W2, CL-W3) for radionuclides. Of these, four parameters, lead-210, polonium-210, radium-226, and thorium-230, were noted to exceed drinking water CEQGs, although the result for radium-226 was suspect. INAC also stated that the highest radionuclide level that was detected in the groundwater was thorium-234, with concentrations ranging from 3 to 6 Bq/L, which is well below the drinking water CEQG of 20 Bq/L for thorium-234 and as a result poses no concern. As noted above, the area tested is not an operable groundwater source and thus was not considered in the HHERA. Shoreline water sampling confirms that neither surface nor groundwater inflow is having an effect on Contact Lake.

4.10.2 Sediment Quality and Submerged Tailings

4.10.2.1 Sediment Quality

A few sediment samples were collected by INAC during the 2005 field program including two samples from the Contact Lake shoreline and one sample from Upper Lake. During the July 2006 site assessment program (SENES 2007a), sediment samples were collected from several of the locations where water samples were collected, including three locations in Contact Lake (background and shoreline regions), one location in Upper Lake, and one location near the former fuel storage area in the East Arm of Echo Bay of Great Bear Lake. A summary of metal COPC concentrations measured in sediments collected from Contact Lake and the East Arm of Echo Bay by INAC (2006c) and SENES (2007a) is presented on Table 4.10-6. These data were used in the HHERA. Additional sediment samples were collected from Contact Lake and Great Bear Lake in July and August of 2007 during the supplementary site assessment program (SENES 2007c).

Concentrations of metals and radionuclides measured in sediments from Upper Lake, the background region of Contact Lake, and the East Arm of Echo Bay of Great Bear Lake were generally similar with a few exceptions, including lead, which was much higher in Great Bear Lake and copper and zinc, which were much higher in Upper Lake (see Table 4.10-6). Relative to sediments collected from the Contact Lake shoreline in the vicinity of the mine site, almost all COPC concentrations were higher in the background region of the lake (see Table 4.10-6) suggesting that areas close to the former mine are not adversely affected.

Mean constituent concentrations measured in sediments from waterbodies at the Contact Lake Mine were compared to sediment toxicity benchmarks (Lowest Effect Level (LEL) and Severe Effect Level (SEL)) on Table 4.10-7. The SEL toxicity benchmarks were not exceeded for any constituent in sediments from Great Bear Lake or the background and shoreline areas of Contact Lake. However, the LEL was exceeded for copper, lead, nickel and vanadium in sediments from Great Bear Lake, and for arsenic, nickel and vanadium in the background region of Contact Lake, while all constituent concentrations were below benchmarks in sediments collected from the shoreline of Contact Lake. In Upper Lake, both the LEL and SEL were exceeded for copper, and the LEL for arsenic and lead-210.

During the June 2007 sediment campaign (SENES 2007a), sediments were collected from two locations in the East Arm of Great Bear Lake. One sample was collected just off the dock near the tank farm (CL-7-EA). The second “offshore” station (CL-16-EA) was located approximately 200 m to the north of the dock. At the offshore station (CL-16-EA), petroleum hydrocarbon (PHC) results were below criteria for all fractions (see Table 4.10-8), but at the nearshore station in close proximity to the dock (CL-7-EA), measurable levels of the F2 and F3 fractions of PHCs were reported in both of the “duplicate samples” collected. In addition, metals such as arsenic, copper, lead, and zinc exceeded levels at which negative effects in benthic organisms have been reported and radium-226 slightly exceeded the LEL for one of the duplicate samples at this location.

Based on the June 2007 results, additional sediment sampling was conducted at the East Arm of Great Bear Lake in August 2007 (SENES 2007d) to further delineate metals and PHC contamination and to assess sediment toxicity by conducting a benthic survey (also see discussion in Section 4.11.3) and toxicity tests. Sampling was conducted in the area surrounding the dock and at a background location along the east shore of the East Arm of Great Bear Lake, across the bay and remote from the dock. Sampling at the dock location used a 5 x 5 grid that covered an approximate area of 2700 m^2, while a single parallel shoreline transect was sampled at the background location.

The August 2007 results (SENES 2007d) indicated that the highest metal (arsenic, cadmium, chromium, copper, lead, nickel, vanadium, and zinc) and PHC (F2 and F3 fractions) concentrations were generally measured along the first and second parallel transects within 15 m of the shore, and from the first to the fourth perpendicular transects extending 20 m west and 10 m east of the dock. Thus, contaminated sediments were mainly found to occur in a localized area of about 450 m^2 in the immediate vicinity of the dock. The elevated levels of chromium, nickel and vanadium in the exposure area were thought to be natural and not the result of mining activities as they were similar to concentrations measured in the background area.

Weight-of-evidence based comparisons of invertebrate endpoints (total density, taxon richness, EPT (Ephemeroptera-mayflies, Plecoptera-stoneflies, Tricoptera-caddisflies)) and density of major groups between the exposure and background areas sampled in the East Arm of Great Bear Lake did not support a case of “effect” in the exposure area. The sediment toxicity tests for the midge *Chironomus tentans* and the amphipod *Hyalella azteca* showed comparable results and the general conclusion using a weight-of-evidence approach was that sediment toxicity on invertebrates occurs in the area within the immediate vicinity of the dock (approximately 10 m southwest of the dock), but not in the more distant offshore sediments (approximately 30 m directly offshore from the dock). Refer to Section 4.11.3 Great Bear Lake East Arm Sampling for a more thorough description of results.

Collectively, the sediment sampling results at the East Arm of Great Bear Lake show that remediation of the area around the dock with elevated metal and PHC concentrations is not warranted.

4.10.2.2 Submerged Tailings

Tailings samples were collected from the tailings pond by INAC and SENES during the 2005 and 2006 field studies, respectively (INAC 2006c; SENES 2007a). COPC concentrations measured in tailings samples are summarized on Table 4.10-9 and compared to LEL and SEL toxicity benchmarks on Table 4.10-10.

A comparison of Table 4.10-9 to Table 4.10-10 indicates that concentrations of most COPC measured in the tailings samples were much higher than concentrations measured in Echo Bay of Great Bear Lake and Contact Lake sediments. The concentrations of arsenic, copper, manganese, lead-210 and radium-226 were about 100 times higher in the tailings than in the sediments. Both the LEL and SEL toxicity benchmarks were exceeded for copper, lead-210 and radium-226, while the LEL benchmark was exceeded for arsenic, lead, and vanadium. These results were incorporated into the 2006 risk assessment, which is summarized in Chapter 5 (SENES 2007b).

TABLE 4.10-1
SUMMARY OF WATER QUALITY DATA FOR RECEIVING WATERS AT THE CONTACT LAKE MINE SITE
(Data from 2002 to 2006)

COPC	Units	No. of Obs.	No. of Obs. < DL	Minimum	Maximum	Mean	Standard Deviation
East Arm of Echo Bay, Great Bear Lake							
Antimony	µg/L	4	3	0.05	0.1	0.06	0.03
Arsenic	µg/L	4	0	0.3	0.5	0.35	0.10
Barium	µg/L	4	0	21.4	22.2	21.8	0.3
Cadmium	µg/L	4	4	0.025	0.025	0.03	0.00
Chromium	µg/L	0	-	-	-	-	-
Cobalt	µg/L	4	4	0.05	0.05	0.05	0.00
Copper	µg/L	4	0	0.6	0.9	0.73	0.13
Lead	µg/L	0	-	-	-	-	-
Manganese	µg/L	4	0	1	1.6	1.25	0.26
Mercury	µg/L	0	-	-	-	-	-
Molybdenum	µg/L	4	0	0.3	0.4	0.35	0.06
Nickel	µg/L	4	0	0.2	0.3	0.23	0.05
Selenium	µg/L	4	3	0.15	0.3	0.19	0.07
Silver	µg/L	4	4	0.05	0.05	0.05	0.00
Strontium	µg/L	4	0	96.8	97.9	97.4	0.49
Uranium	µg/L	4	0	0.3	0.4	0.33	0.05
Vanadium	µg/L	4	0	0.5	0.6	0.53	0.05
Zinc	µg/L	4	1	0.2	2.2	1.33	0.84
Lead-210	Bq/L	2	1	0.025	0.05	0.038	0.018
Radium-226	Bq/L	2	2	0.005	0.005	0.005	0.000
Contact Lake (Background)							
Antimony	µg/L	4	0	0.2	0.7	0.45	0.29
Arsenic	µg/L	4	4	0.1	0.1	0.10	0.00
Barium	µg/L	4	0	4.4	9.2	6.60	2.56
Cadmium	µg/L	4	4	0.025	0.025	0.03	0.00
Chromium	µg/L	0	-	-	-	-	-
Cobalt	µg/L	4	4	0.05	0.05	0.05	0.00
Copper	µg/L	4	0	0.7	0.8	0.73	0.05
Lead	µg/L	0	-	-	-	-	-
Manganese	µg/L	4	0	0.4	0.5	0.45	0.06
Mercury	µg/L	0	-	-	-	-	-
Molybdenum	µg/L	4	0	0.3	1	0.68	0.38
Nickel	µg/L	4	0	0.1	0.1	0.10	0.00
Selenium	µg/L	4	4	0.15	0.15	0.15	0.00
Silver	µg/L	4	4	0.05	0.05	0.05	0.00
Strontium	µg/L	4	0	8.7	8.9	8.78	0.10
Uranium	µg/L	4	0	0.1	0.1	0.10	0.00
Vanadium	µg/L	4	0	0.1	0.2	0.18	0.05
Zinc	µg/L	4	0	1.2	5	2.65	1.67
Lead-210	Bq/L	4	4	0.025	0.025	0.025	0.000
Radium-226	Bq/L	4	4	0.005	0.005	0.005	0.000

TABLE 4.10-1 (Cont'd)
SUMMARY OF WATER QUALITY DATA FOR RECEIVING WATERS AT THE CONTACT LAKE MINE SITE
(Data from 2002 to 2006)

COPC	Units	No. of Obs.	No. of Obs. < DL	Minimum	Maximum	Mean	Standard Deviation
Contact Lake (Offshore and Shoreline)							
Antimony	µg/L	6	3	0.05	1.3	0.29	0.50
Arsenic	µg/L	6	4	0.1	0.8	0.28	0.30
Barium	µg/L	6	0	3	6.8	4.47	1.43
Cadmium	µg/L	6	5	0.025	0.3	0.08	0.11
Chromium	µg/L	3	0	0.05	5	1.85	2.74
Cobalt	µg/L	5	4	0.05	0.2	0.08	0.07
Copper	µg/L	6	0	0.7	3.5	1.67	1.38
Lead	µg/L	3	2	0.05	0.5	0.32	0.24
Manganese	µg/L	6	0	0.3	58.4	11.7	23.2
Mercury	µg/L	3	3	0.005	0.01	0.01	0.00
Molybdenum	µg/L	6	1	0.1	0.5	0.27	0.16
Nickel	µg/L	6	1	0.05	1	0.31	0.38
Selenium	µg/L	5	5	0.15	0.5	0.22	0.16
Silver	µg/L	6	3	0.05	0.4	0.16	0.15
Strontium	µg/L	6	0	8.3	11.8	9.23	1.28
Uranium	µg/L	6	0	0.1	1.3	0.37	0.48
Vanadium	µg/L	6	2	0.05	0.6	0.29	0.21
Zinc	µg/L	6	3	0.2	5	2.77	2.03
Lead-210	Bq/L	3	2	0.025	0.09	0.047	0.038
Radium-226	Bq/L	3	3	0.005	0.005	0.005	0.000

Notes: All measurements below the detection limit (DL) were assumed to be one-half of the DL.

No mercury measurements were available from 2006, while the 2006 chromium and lead measurements were invalidated and not included due to contamination issues.

TABLE 4.10-2

COMPARISON OF MEAN CONSTITUENT CONCENTRATIONS IN RECEIVING WATERS AT THE CONTACT LAKE MINE SITE TO AVAILABLE GUIDELINES

(Data from 2002 to 2006)

COPC	Unit	CEQG Aquatic Life	CEQG Drinking Water	Mean Measured Concentrations		
				East Arm of Echo Bay, GBL [a]	Contact Lake (Background) [a]	Contact Lake (Offshore & Shoreline) [a]
Antimony	µg/L	-	6	0.06	0.45	0.29
Arsenic	µg/L	5	10	0.35	0.10	0.28
Barium	µg/L	-	1000	21.8	6.60	4.47
Cadmium	µg/L	0.017	5	0.03	0.03	0.08
Chromium	µg/L	8.9	50	-	-	1.85
Cobalt	µg/L	-	-	0.05	0.05	0.08
Copper	µg/L	2 [b]	1000	0.73	0.73	1.67
Lead	µg/L	1 – 2 [c]	10	-	-	0.32
Manganese	µg/L	-	50	1.25	0.45	11.7
Mercury	µg/L	0.026	1	-	-	0.01
Molybdenum	µg/L	73	-	0.35	0.68	0.27
Nickel	µg/L	25 – 65 [d]	-	0.23	0.10	0.31
Selenium	µg/L	1	10	0.19	0.15	0.22
Silver	µg/L	0.1	-	0.05	0.05	0.16
Strontium	µg/L	-	-	97.4	8.78	9.23
Uranium	µg/L	-	20	0.33	0.10	0.37
Vanadium	µg/L	-	-	0.53	0.18	0.29
Zinc	µg/L	30	5000	1.33	2.65	2.77
Lead-210	Bq/L	-	0.1	0.038	0.025	0.047
Radium-226	Bq/L	-	0.6	0.005	0.005	0.005

▨	Concentration is greater than the Canadian Environmental Quality Guideline (CEQG) for the protection of aquatic life (CCME 1999).
Underline	Concentration is greater than the Canadian Environmental Quality Guideline (CEQG) for drinking water (Health Canada 2006a; 2006b).

[a] Hardness of Contact Lake is ~ 25 mg/L; and, Echo Bay is ~ 75 mg/L.

[b] Copper guideline is for water hardness of 0 – 120 mg/L as $CaCO_3$.

[c] Lead guideline is 1 µg/L for water hardness of < 60 mg/L as $CaCO_3$ and 2 µg/L for water hardness of 60 – 120 mg/L as $CaCO_3$.

[d] Nickel guideline is 0.025 mg/L for water hardness of <60 mg/L as $CaCO_3$ and 0.065 mg/L for water hardness of 60 – 120 mg/L as $CaCO_3$.

[e] Drinking water guidelines for copper, manganese and zinc are for aesthetic concerns.

[f] Chromium and lead concentrations from 2006 samples were not used due to a contamination problem.

"-" no data available.

TABLE 4.10-3
SUMMARY OF WATER QUALITY DATA FOR SURFACE WATERS AT THE CONTACT LAKE MINE SITE
(Data from 2002 to 2006)

COPC	Units	No. of Obs.	No. of Obs. < DL	Minimum	Maximum	Mean	Standard Deviation
Upper Lake							
Antimony	µg/L	4	1	0.05	1.7	0.91	0.73
Arsenic	µg/L	4	1	0.5	0.5	0.50	0.00
Barium	µg/L	4	0	4.9	14.6	8.63	4.19
Cadmium	µg/L	4	3	0.05	0.3	0.11	0.13
Chromium	µg/L	1	1	0.15	0.15	0.15	-
Cobalt	µg/L	3	3	0.05	0.05	0.05	-
Copper	µg/L	4	0	6.4	8	6.93	0.74
Lead	µg/L	2	2	0.05	0.5	0.28	-
Manganese	µg/L	4	0	3.2	40	12.8	18.2
Mercury	µg/L	2	2	0.005	0.01	0.01	-
Molybdenum	µg/L	4	2	0.05	2.6	0.99	1.12
Nickel	µg/L	4	1	0.3	0.5	0.38	0.10
Selenium	µg/L	3	3	0.5	0.5	0.50	-
Silver	µg/L	4	2	0.05	0.4	0.20	0.18
Strontium	µg/L	4	0	3.1	5	3.85	0.81
Uranium	µg/L	4	0	0.2	0.5	0.28	0.15
Vanadium	µg/L	4	3	0.05	0.5	0.20	0.21
Zinc	µg/L	4	4	5	5	5.00	-
Lead-210	Bq/L	3	3	0.01	0.025	0.020	0.009
Radium-226	Bq/L	2	2	0.005	0.005	0.005	-
Tailings Pond							
Antimony	µg/L	3	0	0.3	2.1	1.30	0.92
Arsenic	µg/L	3	0	16.8	54	29.9	20.9
Barium	µg/L	3	0	21.2	37	29.5	7.9
Cadmium	µg/L	3	2	0.025	0.3	0.12	0.16
Chromium	µg/L	2	1	0.05	3	1.53	2.09
Cobalt	µg/L	3	1	0.05	3.3	1.18	1.83
Copper	µg/L	3	0	13.5	39	22.2	14.6
Lead	µg/L	2	1	0.05	2	1.03	1.38
Manganese	µg/L	3	0	17.5	763	281.4	417.7
Mercury	µg/L	2	1	0.01	0.03	0.02	0.01
Molybdenum	µg/L	3	0	0.5	1.6	1.20	0.61
Nickel	µg/L	3	0	1.6	5.1	2.83	1.97
Selenium	µg/L	2	2	0.15	0.15	0.15	0.00
Silver	µg/L	3	1	0.05	0.6	0.25	0.30
Strontium	µg/L	3	0	48.5	64	53.9	8.7
Uranium	µg/L	3	0	27.9	75.1	47.7	24.5
Vanadium	µg/L	3	1	0.3	0.6	0.47	0.15
Zinc	µg/L	3	1	0.7	8	4.57	3.67
Lead-210	Bq/L	2	0	0.05	4	2.03	2.79
Radium-226	Bq/L	2	0	0.07	4	2.04	2.78

TABLE 4.10-3 (Cont'd)
SUMMARY OF WATER QUALITY DATA FOR SURFACE WATERS AT THE CONTACT LAKE MINE SITE
(Data from 2002 to 2006)

COPC	Units	No. of Obs.	No. of Obs. < DL	Minimum	Maximum	Mean	Standard Deviation
On-land Water							
Antimony	µg/L	7	0	0.2	6.2	2.60	2.34
Arsenic	µg/L	7	0	10.2	173	76.2	73.8
Barium	µg/L	7	0	15.9	49	31.1	13.8
Cadmium	µg/L	7	7	0.025	0.15	0.06	0.04
Chromium	µg/L	3	0	0.5	3.2	1.77	1.36
Cobalt	µg/L	7	0	0.1	21.1	4.67	7.59
Copper	µg/L	7	0	10.6	196	77.3	80.0
Lead	µg/L	4	0	0.2	3	1.68	1.20
Manganese	µg/L	7	0	20.7	1600	362.8	582.4
Mercury	µg/L	4	2	0.01	0.49	0.19	0.23
Molybdenum	µg/L	7	0	0.4	6.3	2.46	2.14
Nickel	µg/L	7	0	1.2	22	8.60	8.49
Selenium	µg/L	6	6	0.15	0.5	0.44	0.14
Silver	µg/L	7	0	0.1	29.7	6.90	10.88
Strontium	µg/L	7	0	45.4	74.3	61.4	11.1
Uranium	µg/L	7	0	17.4	196	100.1	69.0
Vanadium	µg/L	7	0	0.4	4.5	1.39	1.45
Zinc	µg/L	7	3	2.1	23	10.30	8.12
Lead-210	Bq/L	6	4	0.01	0.26	0.07	0.10
Radium-226	Bq/L	5	2	0.0025	0.28	0.08	0.12

Notes: All measurements below the detection limit (DL) were assumed to be one-half of the DL.

No mercury measurements were available from 2006, while the 2006 chromium and lead measurements were invalidated and not included due to contamination issues.

TABLE 4.10-4

COMPARISON OF MEAN CONSTITUENT CONCENTRATIONS IN SURFACE WATERS AT THE CONTACT LAKE MINE SITE TO AVAILABLE GUIDELINES

(Data from 2002 to 2006)

COPC	Unit	CEQG Aquatic Life	CEQG Drinking Water	Mean Measured Concentrations [a]	
				Tailings Pond	Upper Lake
Antimony	µg/L	-	6	1.30	0.91
Arsenic	µg/L	5	10	29.9	0.50
Barium	µg/L	-	1000	29.5	8.63
Cadmium	µg/L	0.017	5	0.12	0.11
Chromium	µg/L	8.9	50	1.53	0.15
Cobalt	µg/L	-	-	1.18	0.05
Copper	µg/L	2 [b]	1000	22.2	6.93
Lead	µg/L	1 – 2 [c]	10	1.03	0.28
Manganese	µg/L	-	50	281.4	12.8
Mercury	µg/L	0.026	1	0.02	0.01
Molybdenum	µg/L	73	-	1.20	0.99
Nickel	µg/L	25 – 65 [d]	-	2.83	0.38
Selenium	µg/L	1	10	0.15	0.50
Silver	µg/L	0.1	-	0.25	0.20
Strontium	µg/L	-	-	53.9	3.85
Uranium	µg/L	-	20	47.7	0.28
Vanadium	µg/L	-	-	0.47	0.20
Zinc	µg/L	30	5000	4.57	5.00
Lead-210	Bq/L	-	0.1	2.03	0.020
Radium-226	Bq/L	-	0.6	2.04	0.005

▨	Concentration is greater than the Canadian Environmental Quality Guideline (CEQG) for the protection of aquatic life (CCME 1999).
Underline	Concentration is greater than the Canadian Environmental Quality Guideline (CEQG) for drinking water (Health Canada 2006a; 2006b).

[a] Hardness of Tailings Pond is ~ 115 mg/L; Upper Lake is ~ 15 mg/L.
[b] Copper guideline is for water hardness of 0 – 120 mg/L as $CaCO_3$.
[c] Lead guideline is 1 µg/L for water hardness of < 60 mg/L as $CaCO_3$ and 2 µg/L for water hardness of 60 – 120 mg/L as $CaCO_3$.
[d] Nickel guideline is 0.025 mg/L for water hardness of <60 mg/L as $CaCO_3$ and 0.065 mg/L for water hardness of 60 – 120 mg/L as $CaCO_3$.
[e] Drinking water guidelines for copper, manganese and zinc are for aesthetic concerns.
[f] Chromium and lead concentrations from 2006 samples were not used due to contamination problem.
"-" no data available.

TABLE 4.10-5
SUMMARY OF DISSOLVED METAL CONCENTRATIONS IN GROUNDWATER AT THE CONTACT LAKE MINE SITE IN AUGUST 2005
(Data from INAC August 2005)

Constituent	**Units**	**CEQG Drinking Water**	**CL-W1**	**CL-W2**	**CL-W3**	**CL-W4**
Aluminum	µg/L	100	8.1	89.3	223	307
Arsenic	µg/L	10	7.8	10.6	3.7	13.7
Copper	µg/L	1000 *	4.7	11.4	9.1	11.0
Iron	µg/L	300 *	<50	97	175	441
Lead	µg/L	10	<0.1	0.4	0.3	3.6
Manganese	µg/L	50	897	35.4	91.1	203
Mercury	µg/L	1	<0.02	<0.02	<0.02	<0.02
Nickel	µg/L	-	1.7	0.9	1.4	4.2
Silver	µg/L	-	<0.1	0.1	<0.1	<0.1
Uranium	µg/L	20	18.7	39.1	18.3	7.4
Zinc	µg/L	5000	5.3	1.3	2.7	45.1

▨ Concentration is greater than the Canadian Water Quality Guideline (CEQG) for drinking water (Health Canada 2006a; 2006b)

* aesthetic objective

TABLE 4.10-6
SUMMARY OF SEDIMENT QUALITY DATA FOR WATERBODIES AT THE CONTACT LAKE MINE SITE
(Data from 2005 and 2006)

COPC	Units	No. of Obs.	No. of Obs. < DL	Minimum	Maximum	Mean	Standard Deviation
East Arm of Echo Bay, Great Bear Lake							
Metals							
Antimony	µg/g dw	3	3	0.1	0.1	0.10	0.00
Arsenic	µg/g dw	3	0	3	18.2	8.83	8.19
Barium	µg/g dw	3	0	70	219	147	74.6
Cadmium	µg/g dw	3	0	0.11	0.36	0.27	0.14
Chromium	µg/g dw	3	0	18.4	46.8	32.8	14.2
Cobalt	µg/g dw	3	0	8.7	17.9	13.7	4.66
Copper	µg/g dw	3	0	14	122	57.0	57.3
Lead	µg/g dw	3	0	11.5	107	45.3	53.5
Manganese	µg/g dw	3	0	259	389	339	70.0
Mercury	µg/g dw	3	1	0.005	0.06	0.03	0.03
Molybdenum	µg/g dw	3	2	0.5	2	1.00	0.87
Nickel	µg/g dw	3	0	16.1	39.9	28.5	11.9
Selenium	µg/g dw	3	1	0.15	0.6	0.45	0.26
Silver	µg/g dw	3	0	0.6	5.2	2.17	2.63
Strontium	µg/g dw	3	0	14	30	22.0	8.00
Vanadium	µg/g dw	3	0	26.5	53.3	39.5	13.4
Zinc	µg/g dw	3	0	58	198	122	70.7
Radionuclides							
Lead-210	Bq/g dw	1	0	0.08	0.08	0.08	-
Radium-226	Bq/g dw	1	0	0.06	0.06	0.06	-
Contact Lake (Background)							
Metals							
Antimony	µg/g dw	5	5	0.1	0.1	0.10	0.00
Arsenic	µg/g dw	5	0	5.8	14.6	10.3	4.07
Barium	µg/g dw	5	0	72	275	158	104
Cadmium	µg/g dw	5	0	0.15	0.21	0.18	0.03
Chromium	µg/g dw	5	0	20.3	72.5	41.3	28.2
Cobalt	µg/g dw	5	0	8.8	22.1	15.0	6.28
Copper	µg/g dw	5	0	36	49	42.8	5.63
Lead	µg/g dw	5	0	9.7	21.1	14.4	6.07
Manganese	µg/g dw	5	0	464	2050	900	651
Mercury	µg/g dw	5	1	0.005	0.01	0.01	0.00
Molybdenum	µg/g dw	5	2	0.5	3	1.60	1.08
Nickel	µg/g dw	5	0	15.5	49.7	30.5	17.4
Selenium	µg/g dw	5	2	0.15	0.6	0.40	0.23
Silver	µg/g dw	5	0	0.2	0.7	0.36	0.21
Strontium	µg/g dw	5	0	12	26	17.4	6.99
Vanadium	µg/g dw	5	0	31.8	78.9	50.4	25.0
Zinc	µg/g dw	5	0	83	134	107	24.9
Radionuclides							
Lead-210	Bq/g dw	2	0	0.02	0.07	0.05	0.04
Radium-226	Bq/g dw	2	0	0.06	0.09	0.08	0.02

TABLE 4.10-6 (Cont'd)
SUMMARY OF SEDIMENT QUALITY DATA FOR WATERBODIES AT THE CONTACT LAKE MINE SITE
(Data from 2005 and 2006)

COPC	Units	No. of Obs.	No. of Obs. < DL	Minimum	Maximum	Mean	Standard Deviation
Contact Lake (Shoreline)							
Metal							
Antimony	µg/g dw	3	3	0.1	0.1	0.10	0.00
Arsenic	µg/g dw	3	0	3	4.8	4.13	0.99
Barium	µg/g dw	5	0	30	250	83.8	93.3
Cadmium	µg/g dw	5	1	0.08	1.5	0.41	0.61
Chromium	µg/g dw	5	0	9.8	33	17.1	9.79
Cobalt	µg/g dw	5	0	4.4	16	7.46	4.84
Copper	µg/g dw	5	0	11	27	16.2	6.38
Lead	µg/g dw	5	0	6.2	21	9.90	6.24
Manganese	µg/g dw	5	0	424	820	593	143
Mercury	µg/g dw	3	1	0.005	0.01	0.01	0.00
Molybdenum	µg/g dw	5	4	0.25	0.8	0.51	0.19
Nickel	µg/g dw	5	0	8.2	33	14.2	10.5
Selenium	µg/g dw	3	2	0.15	0.4	0.23	0.14
Silver	µg/g dw	5	2	0.25	0.4	0.32	0.08
Strontium	µg/g dw	5	0	8	46	17.8	16.1
Vanadium	µg/g dw	5	0	17.4	71	31.2	22.8
Zinc	µg/g dw	5	0	42	100	60.6	22.8
Radionuclides							
Lead-210	Bq/g dw	3	1	0.09	0.9	0.50	0.41
Radium-226	Bq/g dw	3	1	0.02	0.11	0.07	0.05
Upper Lake							
Metal							
Antimony	µg/g dw	3	3	0.1	0.1	0.10	-
Arsenic	µg/g dw	3	0	15	17.6	16.1	1.35
Barium	µg/g dw	4	0	130	192	167	26.4
Cadmium	µg/g dw	4	0	0.46	0.7	0.56	0.10
Chromium	µg/g dw	4	0	18.7	28	21.6	4.40
Cobalt	µg/g dw	4	0	7	29.2	19.1	11.3
Copper	µg/g dw	4	0	250	341	302	40.2
Lead	µg/g dw	4	0	4	7.3	6.30	1.56
Manganese	µg/g dw	4	0	402	520	453	51.1
Mercury	µg/g dw	3	2	0.005	0.01	0.01	0.00
Molybdenum	µg/g dw	4	0	1.6	3	2.15	0.60
Nickel	µg/g dw	4	0	13	18.6	16.2	2.37
Selenium	µg/g dw	3	0	1.6	1.7	1.67	0.06
Silver	µg/g dw	4	0	1.2	2.9	2.28	0.76
Strontium	µg/g dw	4	0	18	21	19.5	1.29
Vanadium	µg/g dw	4	0	8.7	14.4	12.4	2.55
Zinc	µg/g dw	4	0	232	293	253	27.5
Radionuclides							
Lead-210	Bq/g dw	2	0	0.09	1.5	0.80	1.00
Radium-226	Bq/g dw	2	0	0.08	0.25	0.17	0.12

Notes: DL = detection limit

TABLE 4.10-7
COMPARISON OF MEAN CONSTITUENT SEDIMENT CONCENTRATIONS IN RECEIVING WATERS AT THE CONTACT LAKE MINE SITE TO AVAILABLE GUIDELINES
(Data from 2005 and 2006)

COPC	Unit	Sediment Quality Guidelines		Mean Measured Concentrations			
		CNSC LEL [a]	CNSC SEL [a]	East Arm of Echo Bay, GBL	Contact Lake Offshore	Contact Lake Shoreline	Upper Lake
Metal							
Antimony	µg/g dw	-	-	0.10	0.10	0.10	0.10
Arsenic	µg/g dw	10	346	8.83	10.3	4.13	16.1
Barium	µg/g dw	-	-	147	158	83.8	167
Cadmium	µg/g dw	-	-	0.27	0.18	0.41	0.56
Chromium	µg/g dw	48	115	32.8	41.3	17.1	21.6
Cobalt	µg/g dw	-	-	13.7	15.0	7.46	19.1
Copper	µg/g dw	22	269	57.0	42.8	16.2	302
Lead	µg/g dw	37	412	45.3	14.4	9.90	6.30
Manganese	µg/g dw	-	-	339	900	593	453
Mercury	µg/g dw	-	-	0.03	0.01	0.01	0.01
Molybdenum	µg/g dw	13.8	1238	1.00	1.60	0.51	2.15
Nickel	µg/g dw	23	484	28.5	30.5	14.2	16.2
Selenium	µg/g dw	1.9	16.1	0.45	0.40	0.23	1.67
Silver	µg/g dw	-	-	2.17	0.36	0.32	2.28
Strontium	µg/g dw	-	-	22.0	17.4	17.8	19.5
Vanadium	µg/g dw	35.2	160	39.5	50.4	31.2	12.4
Zinc	µg/g dw	-	-	122	107	60.6	253
Radionuclides							
Lead-210	Bq/g dw	0.6	14.4	0.08	0.05	0.50	0.80
Radium-226	Bq/g dw	0.9	21	0.06	0.08	0.07	0.17

▨	Concentration is greater than the LEL toxicity benchmark.
Underline	Concentration is greater than the SEL toxicity benchmark.

[a] CNSC = Canadian Nuclear Safety Commission; LEL = Lowest Effect Level (Thompson *et al.* 2005); SEL = Severe Effect Level (Thompson *et al.* 2005).

TABLE 4.10-8
PHC LEVELS IN SEDIMENTS COLLECTED FROM THE CONTACT LAKE STUDY AREA
(Data from 2006 and 2007)

Location & Sample ID	Period	Benzene	Ethylbenzene	Toluene	Xylenes, Total	F1 (C_6-C_{10})	F2 (C_{10}-C_{16})	F3 (C_{16}-C_{34})	F4 (C_{34}-C_{50})	Total Purgeable Hydrocarbons	Total Extractable Hydrocarbons
Upper Lake											
CL-1a	Jul2006	<0.02	<0.02	<0.02	0.04	-	-	-	-	<1	120
CL-1b	Jul2006	<0.02	<0.02	<0.02	<0.02	-	-	-	-	<1	130
Tailings Pond											
CL-3	Jul2006	<0.02	<0.02	<0.02	<0.02	-	-	-	-	<1	80
Contact Lake											
CL-8a	Jul2006	<0.02	<0.02	<0.02	<0.02	-	-	-	-	<1	100
CL-8b	Jul2006	<0.02	<0.02	<0.02	<0.02	-	-	-	-	<1	60
CL-8	Jun2007	<0.005	<0.01	<0.05	<0.1	<10	<50	<50	<50	-	-
CL-9a	Jul2006	<0.02	<0.02	<0.02	<0.02	-	-	-	-	<1	<10
CL-9b	Jul2006	<0.02	<0.02	<0.02	<0.02	-	-	-	-	<1	<10
CL-22	Jun2007	<0.02*	<0.02*	<0.05	<0.1	<30*	<70*	<70*	<70*	-	-
CL-220 (dup of CL-22)	Jun2007	<0.005	0.01	<0.05	<0.1	<10	<60*	<60*	<60*	-	-
CL-23	Jun2007	<0.005	<0.01	<0.05	<0.1	<10	<50	<50	<50	-	-
CL-25	Jun2007	<0.005	<0.01	<0.05	<0.1	<10	<50	<50	<50	-	0
East Arm of Great Bear Lake											
CL-7a-EA	Jul2006	<0.02	<0.02	<0.02	<0.02	-	-	-	-	<1	20
CL-7b-EA	Jul2006	<0.02	<0.02	<0.02	<0.02	-	-	-	-	<1	20
CL-7-EA	Jun2007	<0.02	0.03	0.08	<0.1	<40*	203*	187*	<80*	-	-
CL-70a-EA (dup of CL-7-EA)	Jul2006	<0.02	<0.02	<0.02	<0.02	-	-	-	-	<1	80
CL-70b-EA (dup of CL-7-EA)	Jul2006	<0.02	<0.02	<0.02	<0.02	-	-	-	-	<1	50
CL-70-EA (dup of CL-7-EA)	Jun2007	<0.01*	0.02*	0.06	<0.1	<30*	1800*	554*	67*	-	-
CL-16-EA	Jun2007	<0.005	<0.01	<0.05	<0.1	<10	<50	<50	<50	-	-

Notes:

Concentrations are reported in microgram per gram dry weight (µg/g dw); < - less than reportable detection limit (RDL); dup – duplicate sample.

All samples for BTEX-F1 analyses were received and analyzed past the recommended hold time.

* RDL raised due to high moisture content of sample.

TABLE 4.10-9
SUMMARY OF SEDIMENT QUALITY DATA FOR THE TAILINGS POND AT THE CONTACT LAKE MINE SITE
(Data from 2005 and 2006)

COPC	Units	No. of Obs.	No. of Obs. < DL	Minimum	Maximum	Mean	Standard Deviation
Tailings Pond							
Metals							
Antimony	µg/g dw	3	0	1	1.3	1.10	0.17
Arsenic	µg/g dw	3	0	771	875	817	53.1
Barium	µg/g dw	5	0	240	285	265	19.4
Cadmium	µg/g dw	5	0	0.1	3.9	1.52	1.95
Chromium	µg/g dw	5	0	31	50.3	42.7	9.03
Cobalt	µg/g dw	5	0	180	210	198	11.24
Copper	µg/g dw	5	0	3060	5620	4398	1181
Lead	µg/g dw	5	0	55	62	59.2	3.06
Manganese	µg/g dw	5	0	21600	28500	25880	2930
Mercury	µg/g dw	3	0	6.9	7.2	7.00	0.17
Molybdenum	µg/g dw	5	0	2.8	3	2.92	0.11
Nickel	µg/g dw	5	0	182	230	206	18.8
Selenium	µg/g dw	3	0	0.7	0.7	0.70	0.00
Silver	µg/g dw	5	0	280	494	395	78.9
Strontium	µg/g dw	5	0	12	15	13.2	1.10
Vanadium	µg/g dw	5	0	90	97	94.0	2.85
Zinc	µg/g dw	5	0	330	360	342	13.0
BTEX Compounds							
Toluene	µg/g dw	1	1	0.01	0.01	0.01	-
Radionuclides							
Lead-210	Bq/g dw	3	0	6.9	9	7.93	1.05
Radium-226	Bq/g dw	3	0	4.9	6.9	5.83	1.01

Notes: DL = detection limit

TABLE 4.10-10
COMPARISON OF MEAN CONSTITUENT SEDIMENT CONCENTRATIONS IN THE TAILINGS POND AT THE CONTACT LAKE MINE SITE TO AVAILABLE GUIDELINES
(Data from 2005 and 2006)

Constituent	**Unit**	**Sediment Quality Guidelines**		**Mean Measured Concentrations**
		CNSC LEL [a]	**CNSC SEL [a]**	**Tailings Pond**
Metals				
Antimony	µg/g dw	-	-	1.10
Arsenic	µg/g dw	10	346	817
Barium	µg/g dw	-	-	265
Cadmium	µg/g dw	-	-	1.52
Chromium	µg/g dw	48	115	42.7
Cobalt	µg/g dw	-	-	198
Copper	µg/g dw	22	269	4398
Lead	µg/g dw	37	412	59.2
Manganese	µg/g dw	-	-	25880
Mercury	µg/g dw	-	-	7.00
Molybdenum	µg/g dw	13.8	1238	2.92
Nickel	µg/g dw	23	484	206
Selenium	µg/g dw	1.9	16.1	0.70
Silver	µg/g dw	-	-	395
Strontium	µg/g dw	-	-	13.2
Vanadium	µg/g dw	35.2	160	94.0
Zinc	µg/g dw	-	-	342
BTEX Compounds				
Toluene	µg/g dw	-	-	0.01
Radionuclides				
Lead-210	Bq/g dw	0.6	14.4	7.93
Radium-226	Bq/g dw	0.9	21	5.83

▨	Concentration is greater than the LEL benchmark.
Underline	Concentration is greater than the SEL benchmark.

[a] CNSC = Canadian Nuclear Safety Commission; LEL = Lowest Effect Level (Thompson *et al.* 2005); SEL = Severe Effect Level (Thompson *et al.* 2005).

4.11 AQUATIC BIOTA

The structure of the aquatic ecosystem of Great Bear Lake is discussed in depth in the "*State of the Aquatic Knowledge of Great Bear Watershed*" report prepared by MacDonald *et al.* (2004). As noted by the authors of this report, a number of focussed studies have been conducted to collect basic scientific data on the aquatic organisms in the watershed. Also, a great deal of traditional knowledge exists on the aquatic resources of Great Bear Lake and several broad surveys have been completed on fish and other species in the lake and its tributaries.

A brief synopsis of this information is presented below and focuses on aquatic plants, zooplankton, benthic invertebrates, and fish, all of which are considered in the ecological risk assessment. Both qualitative and quantitative observations were used in the assessment. In the absence of information specific to Contact Lake, regional data from Great Bear Lake and other surrounding waterbodies were useful for the risk assessment.

4.11.1 Aquatic Plants

No specific information was found with respect to aquatic plants that occur within Contact Lake. Based on information reported, the aquatic plants that occur within the Great Bear Lake and associated tributaries fall into three general categories, phytoplankton (free-living algae), periphyton (algae attached to bottom substrate), and aquatic macrophytes (vascular plants).

Although a number of studies have been conducted on Great Bear Lake, only one study by Moore (1980) provided detailed information on the structure of phytoplankton communities in Great Bear Lake. This investigator sampled three areas within the lake, including Echo Bay, Conjuror Bay, and the Keith Arm opposite Délı̨nę (formerly Fort Franklin) during the period from June 1976 to August 1978. The results of this investigation showed that the standing crop of phytoplankton in Great Bear Lake was among the lowest found in freshwater systems, ranging from 20 to 91 mg/m^3 (Moore 1980). The average densities for the three areas sampled were 51 mg/m^3 for Echo Bay, 76 mg/m^3 for Conjuror Bay, and 41 mg/m^3 for Délı̨nę. By comparison, algal biomasses in the lower Great Lakes generally exceed 1000 mg/m^3 (Moore 1980).

The limited data that were found on periphyton communities in Great Bear Lake suggest that these communities contribute substantially to total primary productivity of the lake (Duthie and Hart 1987). The periphyton communities of Great Bear Lake tended to be more diverse than the associated phytoplankton communities. Overall, 101 species of periphyton were recorded at the three sites that were sampled in Great Bear Lake (Moore 1980). With respect to macrophyte communities, Johnson (1975b) reported that *Equisetum* sp. beds occur in certain areas within the lake, typically where water is less than 1 m deep.

4.11.2 Zooplankton

No specific information was found with respect to zooplankton communities in Contact Lake.

A number of studies have been conducted to evaluate zooplankton communities in Great Bear Lake. The results of several studies that provided a comprehensive understanding of the structure of the community (Johnson 1975b; Moore and Sutherland 1981) suggest that Great Bear Lake has among the lowest diversity and density of zooplankton of any mainland lake in North America, with offshore areas generally being less productive than the nearshore environment.

4.11.3 Benthic Invertebrates

Benthic invertebrates inhabit the bottom substrates in lakes and rivers and represent fundamental components of aquatic food webs, particularly in the north where zooplankton communities tend to be less important (i.e. due to cold water conditions and low levels of nutrients).

Contact Lake

No specific information was found with respect to benthic invertebrates that occur within Contact Lake.

Great Bear Lake - Literature

While no information was located on benthic invertebrate communities in the riverine components of the Great Bear Lake watershed, the available data indicate that relatively diverse communities of benthic invertebrates occur in Great Bear Lake. Johnson (1975b) reported that a variety of benthic macroinvertebrates occurred in shallow water areas (i.e. <5 m deep), including amphipods, gastropods, caddisfly larvae, mayfly larvae, beetle larvae, and water boatmen. Stonefly larvae were commonly observed in shallow waters with bouldery substrates. The biota that were associated with soft substrates and distributed over a wider range of water depths included amphipods, mysids, clams, oligochaetes, and midges (Johnson 1975b).

The densities of benthic invertebrates differed substantially among the various water depths sampled in Great Bear Lake, with appreciable densities of benthic invertebrates occurring only in waters less than 20 m deep (Johnson 1975b). The highest densities (i.e. 400 organisms/m^2, all species combined) were found in waters between 1 and 5 m deep, either associated with beds of algae or *Equisetum* sp. Lower densities were observed in waters 5 to 10 m deep (350/m^2), 6 to 15 m deep (200/m^2), and 16 to 20 m deep (125/m^2) (Johnson 1975b).

Great Bear Lake East Arm - Sampling

A benthic survey conducted in the East Arm of Echo as part of the 2007 site assessment found the following species in the vicinity of the dock and at a reference site across the bay from the dock (SENES 2007d). In the survey forty-five taxa of benthic invertebrates were identified in 30 Petite Ponar field sub-samples from both the exposure area and background area. A total of 35 taxa were recorded for the exposure area and 36 taxa were for the background area. Of these numbers, 26 taxa were common to both areas, which is a high value. In general, comparisons of groups, including presence-absence between exposure and background areas were moderately similar (72%), with some exceptions.

Crustaceans (arthropods, mites, seed shrimps, water scud, etc.) are indicators of environmental quality, uncommon in communities of poor water quality. In the East Arm, this group was the most important of the major groups of invertebrates (mean values: 6,243/m^2 in the exposure area vs. 3,822/m^2 in the background area). The group of amphipod species includes *Gammarus lacustris* and *Diporeia hoyi*. Amphipods are common in unpolluted water bodies and are usually restricted to littoral benthos as general scavengers. In this case, *Gammarus lacustris* and *Diporeia hoyi*, which thrive in clean water and sediment, were responsible for the highest numbers of invertebrates in samples from the East Arm.

The Molluscs (snails, clams, etc.) were of second importance as major groups in the East Arm (mean values: 4,367 vs. 5,455/m^2 in the exposure and background areas respectively); just after the Crustaceans, and well ahead of the EPT group in importance. Among the taxa, the most important were the *Pisidium*, *Fossaria* and *Valvata* (8 on 10 ratings *In:* Klemm *et al.* 1990). These molluscs generally vary from facultative to very tolerant to organic wastes.

Dipterans (true flies) were the third group in importance in the East Arm at the exposure area and the background area (mean values: 3,956 vs. 2,599/m^2, respectively). Representative dipteran taxa from the East Arm included at least three Chironomidae taxa, mostly known to inhabit sand and silt, and tolerant to low levels of dissolved oxygen. These are *Stictochironomus*, *Monodiamesa* and *Procladius*, all facultative taxa, with a high to very high tolerance for organic wastes (7 to 9 on 10 ratings *In:* Klemm *et al.* 1990).

Oligochaeta (annelid worms), indicative of environmental stress in the aquatic environment, were similarly present between exposure area and background area (mean values: 382 vs. 450/m^2, respectively). The Oligochaeta were not a large group in the East Arm. The most common taxon in the samples was *Lumbriculus variegates* (all samples, Table 3.3-14), which is most common and widespread in North America. This large worm is ecologically somewhat similar to the tubificids (Peckarsky *et al.* 1990), which like *Ryacodrilus coccineus* is most facultative to tolerant (Klemm *et al*. 1990).

EPT (Ephemeroptera-mayflies, Plecoptera-stoneflies, Tricoptera-caddisflies) were a rather small invertebrate group in the East Arm although ecologically very important (Tricopterans only; mean values: 249 vs. 83/m^2 in the exposure and background areas respectively). The invertebrate species from this group are generally intolerant to metal contamination and organic enrichment; thus an indicator for good, clean sediment and water quality (Bode 1988, Klemm *et al.* 1990, Rosenberg and Resh 1993). It is of note that the exposure area had more EPT individuals than that in the background area. Only Tricopterans represented the EPT group with *Grensia praeterita* for the most part. Ephemeropterans and Plecopterans were absent in both exposure and background areas.

Nematoda (roundworms) are considered facultative invertebrates, having a wide range of tolerance that is frequently associated with moderate levels of organic contamination. The survey found that Nematan species were relatively infrequent in the East Arm (mean values: 6/m^2 vs. 12/m^2 in the exposure and background areas respectively).

In summary, a total of 26 invertebrate taxa on 36 (72%) were common to both exposure and background areas, which indicates a high similarity in community structures and functions between the two areas. The Crustaceans represented the highest number of invertebrates from a single group. This group is also an indicator of good sediment and water quality. The EPT group, which is also an indicator of good sediment and water quality, were also represented by individuals found in higher density in the exposure area than the background area.

Oligochaetes, which are most indicative of environmental stress in the aquatic environment, were found to be in similar numbers in the exposure and background areas. Likewise mollusc taxa and dipterans were found in similar densities in the exposure and background areas. These groups have a high to very high tolerance for organic wastes. In conclusion, it appears that there is not much difference between the dock area and the reference location and the weight-of-evidence comparisons of invertebrate endpoints (total density, taxon richness, EPT) and density of major groups suggests that there is no “effect” in the exposure area.

4.11.4 Fish

Great Bear Lake

In total, 29 fish species have been identified in Great Bear Lake (Johnson 1975b) and Great Bear River (Chang-Keu and Cameron 1980, McCart 1982). Insufficient information is currently available to determine the abundance of fish species utilizing habitats in Great Bear Lake. Studies conducted in the 1970’s by Johnson (1975b) indicated that lake trout and lake whitefish are the most abundant fish species in the pelagic zone (i.e. water column) of Great Bear Lake. Lake trout were found to be widely distributed according to depth, ranging between shallow surface waters to as deep as 400 m. Lake whitefish had a discontinuous distribution in Great Bear Lake and were confined to bays and generally absent from open waters, even in the shallowest reaches. Large spawning concentrations of whitefish occurred at the mouth of the Johnny Hoe River during October (Johnson l975b).

Lake ciscoes are one of the most abundant fish species in the lake and are broadly distributed throughout the lake (Falk and Dahlke 1974). Walleye in Great Bear Lake are restricted exclusively to the circular basin at the southern end of McVicar Arm, which has a maximum depth of 35 m and the largest mass of warm water within Great Bear Lake. Burbot have been encountered infrequently within Great Bear Lake, but appear to be widely distributed throughout the lake (Chang-Kue and Cameron 1980). Arctic grayling in the Great Bear watershed are concentrated in the upper reaches of the Great Bear River.

Contact Lake

As part of the Contact Lake Mine site assessment that was completed in July 2006 (SENES 2007a), fish were collected from Contact Lake for constituent analysis and a fisheries assessment. The objective was to collect 10 samples of predator fish species (lake trout) and 10 samples of one other common species that represents a different ecological niche within the lake. The goal was to test for the presence of relationships between the concentration of some metals and radionuclides and body size/age of the fish and to provide an estimate of the average concentration of the elements found in the lake population. A total of 14 lake trout and 1 sculpin were collected over a 3-day period (July 16th to 18th, 2006).

Contact Lake Fisheries Assessment

The results of the fisheries assessment indicated that Contact Lake supports a healthy population of lake trout. The limited gut contents of the lake trout suggested that in July they feed largely on invertebrates in the nearshore areas. Although lake trout were abundant in the lake, one lake trout showed significant spinal deformity (i.e. lordosis) compared to other lake trout from Contact Lake and Great Bear Lake. This fish also had a very high infestation of parasites in the muscle and swim bladder, which likely caused the deformity during growth. No whitefish were caught despite placing the nets in shallow sandy bays and changing net locations daily. The lack of whitefish may have been a reflection of the time of year of the study, or due to warm surface water temperatures.

Liver, muscle and gut content samples were analyzed for metal and radionuclide content. The metal concentrations are summarized in Table 4.11-1. The concentrations of most constituents were below the respective detection limits in all samples of both tissues. None of the detected metals were considered to be higher than normal.

Regression analysis was conducted using logged fork length and logged metal concentration in both tissues for all elements with detectable levels reported in all but a maximum of 2 samples. No significant relationship ($p>0.05$) was reported between tissue metal concentrations and fork length for any of the elements analysed. Mercury showed no increase with fork length in either muscle ($p=0.56$) or liver ($p=0.22$).

Radionuclide (i.e. radium-226 and lead-210) concentrations measured on fish tissue (muscle) and liver samples from fourteen fish were found to be below the detection limit for both radionuclides in fish tissue, and with a few exceptions in liver samples as well.

TABLE 4.11-1
SUMMARY OF METAL CONCENTRATIONS IN CONTACT LAKE FISH COLLECTED IN JULY 2006

Constituent	Lake Trout									
	Muscle (mg/kg ww)					Liver (mg/kg ww)				
	N	GM	GSD	Min.	Max.	N	GM	GSD	Min.	Max.
Moisture [1]	13	76.5	1.46	73.7	79.2	13	77.1[1]	1.99[2]	75	82
Aluminum	13	<3	-	<3	5	13	7.85	0.28	3	33
Antimony	13	<0.06	-	<0.06	<0.06	13	<0.06	-	<0.06	<0.1
Arsenic	13	0.07	0.25	<0.05	0.17	13	0.10	0.26	<0.09	0.29
Barium	13	<0.05	-	<0.05	0.07	13	<0.05	-	<0.05	0.07
Beryllium	13	<0.05	-	<0.05	<0.05	13	<0.05	-	<0.05	<0.05
Bismuth	13	<0.02	-	<0.02	0.02	13	<0.02	-	<0.02	<0.02
Boron	13	<0.6	-	<0.6	<0.6	13	<0.6	-	<0.6	<0.6
Cadmium	13	<0.02	-	<0.02	0.04	13	0.20	0.18	0.1	0.41
Calcium	13	172	0.20	91	358	13	75.4	0.10	49	104
Cesium	13	<0.02	-	<0.02	<0.02	13	<0.02	-	<0.02	<0.02
Chromium	13	<0.10	-	<0.10	<0.10	13	<0.10	-	<0.10	0.5
Cobalt	13	0.01	0.28	0.01	0.02	13	0.07	0.20	0.04	0.16
Copper	13	0.15	0.26	<0.10	0.3	13	12.8	0.37	2.5	49.5
Iron	13	<5	-	<5	9	13	207	0.16	109	369
Lead	13	<0.04	-	<0.04	0.12	13	<0.04	-	<0.04	0.08
Magnesium	13	255	0.03	228	305	13	152	0.08	103	208
Manganese	13	<0.2	-	<0.20	1.5	13	2.23	0.20	1.3	6.7
Mercury	13	0.12	0.20	0.06	0.23	13	0.12	0.27	0.06	0.37
Molybdenum	13	<0.02	-	<0.02	<0.02	13	0.14	0.12	0.09	0.2
Nickel	13	<0.10	-	<0.10	0.3	13	<0.10	-	<0.10	0.2
Phosphorus	13	2206	0.03	2000	2530	13	3037	0.07	1940	3570
Potassium	13	3582	0.04	3250	4360	13	2622	0.09	1960	3790
Rubidium	13	5.02	0.12	3.5	8.6	13	5.61	0.13	3.8	10.6
Selenium	13	0.30	0.07	0.2	0.4	13	1.59	0.17	0.9	3.6
Silver	13	<1	-	<1	<1	13	<1	-	<1	<1
Sodium	13	393	0.08	277	505	13	1020	0.07	764	1280
Strontium	13	0.06	0.24	0.03	0.19	13	0.03	0.17	<0.05	0.06
Tellurium	13	<0.08	-	<0.08	<0.08	13	<0.08	-	<0.08	<0.08
Thallium	13	<0.06	-	<0.06	<0.06	13	<0.06	-	<0.06	0.1
Tin	13	<1	-	<1	<1	13	<1	-	<1	<1
Titanium	13	0.09	0.18	0.05	0.24	13	0.09	0.27	<0.08	0.29
Uranium	13	<0.02	-	<0.02	<0.02	13	<0.02	-	<0.02	<0.02
Vanadium	13	<0.06	-	<0.06	<0.06	13	<0.06	-	<0.06	0.19
Zinc	13	6.41	0.10	5.1	11.5	13	32.2	0.09	23.1	47.8

Notes:

[1] Values for moisture are an arithmetic mean with standard deviation

N – number of samples; GM – geometric mean; GSD – geometric standard deviation; Min. – minimum; Max. - maximum.

TABLE 4.11-1 (Cont'd)
SUMMARY OF METAL CONCENTRATIONS IN CONTACT LAKE FISH COLLECTED IN JULY 2006

Constituent	Small Lake Trout		Sculpin	
	Whole Body (mg/kg ww)		Whole Body (mg/kg ww)	
	N	Observed Value		Observed Value
Moisture	1	76	1	76.6
Aluminum	1	<8	1	28
Antimony	1	<0.2	1	<0.2
Arsenic	1	<0.2	1	0.13
Barium	1	0.47	1	5.21
Beryllium	1	<0.10	1	<0.10
Bismuth	1	<0.05	1	<0.05
Boron	1	<2	1	<2
Cadmium	1	0.04	1	0.06
Calcium	1	2670	1	20000
Cesium	1	<0.05	1	<0.05
Chromium	1	0.3	1	0.3
Cobalt	1	0.03	1	0.08
Copper	1	0.5	1	2.6
Iron	1	<5	1	54
Lead	1	<0.1	1	0.52
Magnesium	1	257	1	459
Manganese	1	<0.5	1	19.9
Mercury	1	0.01	1	0.09
Molybdenum	1	<0.05	1	<0.06
Nickel	1	0.2	1	0.5
Phosphorus	1	3290	1	11200
Potassium	1	3040	1	207
Rubidium	1	3.5	1	<0.6
Selenium	1	0.4	1	<0.30
Silver	1	<3	1	<3
Sodium	1	746	1	292
Strontium	1	1.53	1	11.6
Thallium	1	<0.2	1	<0.1
Tellerium	1	<0.2	1	<0.2
Tin	1	<3	1	<3
Titanium	1	<0.2	1	1.28
Uranium	1	<0.5	1	<0.5
Vanadium	1	<0.10	1	0.45
Zinc	1	26.1	1	38.2

4.12 MINE AFFECTED WORKING AREAS

4.12.1 Waste Rock Chemistry & Bioavailability

An assessment of physical, radiological and chemical characteristics of waste rock was carried out as part of the 2006 site assessment program (SENES 2007a). This included visual inspection of the waste rock, selected waste rock sampling, as well as roving GPS and terrestrial gamma radiation measurements across the area covered by waste rock, which was discussed in Section 4.6. The waste rock samples collected during the 2006 site assessment (SENES 2007a) were assessed for their acid generation potential and metal leachability (ARD/ML). The analytical results showed that waste rock had limited ARD/ML potential. In addition, soil and rock samples were also collected for metal analysis for input into the site-specific risk assessment. Although the analytical results showed that the mineralized mine rock, as expected, exceeded many of the CCME guideline concentrations for metals in soil, the risk assessment found no concerns with respect to the metal levels in the rock. However, as CCME guidelines are intended for metals in a soil matrix, the comparison to mineral rock was not necessarily appropriate. Thus, during the 2007 supplementary site assessment (SENES 2007c) two additional waste rock samples were collected from the mine yard area that were submitted for sequential extraction analysis (e.g. assess bioavailability of metals) to assess the significance of the waste rock concentrations with respect to environmental fate and transfer.

A modified version of the sequential extraction test procedure developed by Tessier *et al.* (1979) was employed to partition metal binding in waste rock samples into six fractions. The test procedure measures the relative leachability of the metals from most readily leachable (step 1) to least leachable (step 6). The total metals content of each waste rock sample, derived by summing the individual fractions (steps), is shown on Table 4.12-1 (SENES 2007c). The average distributions of the trace elements amongst the individual fractions in the sequential extraction test are presented on Table 4.12-2 (SENES 2007c).

Besides the major elements (i.e. aluminum, calcium, iron, manganese, and potassium), the most prevalent trace elements in the waste rock were arsenic, barium, bismuth, cobalt, copper, nickel, silver, titanium and zinc (see Table 4.12-1). Of these trace elements, those that were found to be highly insoluble (i.e. associated with residual metals) included barium (91.1%), silver (97.8%) and titanium (97.6%). Those elements that were found to be quite insoluble (i.e. over 50% associated with steps 5 and 6) included copper (83.9%) and zinc (73.2%). The most leachable of the above list of trace elements (i.e. leached in steps 1 through 4) included arsenic (50%), bismuth (58.1%), cobalt (62.7%), and nickel (72.2%). Of the latter group, arsenic, cobalt and nickel are associated primarily with iron and manganese oxides and would only be released to the environment under anoxic (reducing) conditions.

Using the results of the 2007 bioavailability studies would result in slightly lower exposures for small animals in and around the Tailings Pond area than predicted in the 2006 risk assessment (SENES2007b) but would not change the findings of the risk assessment.

4.12.2 Residual Surface Tailings

An assessment of physical, radiological and chemical characteristics of mill tailings was carried out as part of the 2006 site assessment program (SENES 2007a). This included visual inspection of the tailings and selected tailings sampling, as well as roving GPS and terrestrial gamma radiation measurements across the area covered by tailings, which was discussed in Section 4.6. Results of the solids analyses including acid generating potential and metals content are summarized on Table 4.12-3 (SENES 2007a).

Six tailings samples were collected for the metal leaching/acid rock drainage (ML/ARD) assessment. Acid base accounting results for the tailings samples indicated that future generation of ARD is unlikely (the lowest NP/AP ratio was 12.7). As expected, compared to typical levels contained in granite, almost all tailings samples had elevated levels of mercury, silver, arsenic, cobalt, copper, molybdenum, nickel, lead, antimony, uranium, and zinc, and two samples had elevated chromium. Sulphide minerals that contain many of these metals were also present in the ore. Relative to Contact Lake waste rock, metal concentrations in tailings were found to be higher. Uranium was elevated in some tailings samples with concentrations ranging from 130 ppm to 360 ppm U.

The surface tailings sampling data was used in the risk assessment to assess potential human health and ecological risk as discussed in Chapter 5.

4.12.3 Designated Substances

A designated substance survey (DSS), including inspection for hydrocarbon contamination, was conducted at the Contact Lake Mine in July 2006 (SENES 2007a). A follow-up DSS was completed in June 2007 during the supplementary site assessment (SENES 2007c) to address information gaps that were identified in 2006 and to delineate the anticipated extent of contamination. The overall findings of the two surveys were as follows:

- *Asbestos Containing Material (ACM)* – Minor issue with some building materials having ACM. The most significant source of asbestos is a boiler located at the former fuel storage area.
- *Lead and Polychlorinated Biphenyls (PCBs) in Paint* – Of 6 paint samples collected from the interior of four structures, 2 samples procured from Cabin 6 and the dry were found to contain lead. In addition, a single paint sample procured from the main fuel storage tank

at the East Arm of Great Bear Lake reported a bulk lead concentration marginally above the GNWT guideline value of 0.06%. PCBs were also detected in this sample with a concentration of 0.15 μg/g, which is below the CCME soil criterion of 1.3 μg/g (note that a criterion for paint is not available).

- *Polychlorinated Biphenyls (PCBs) in Soil and Swipe Samples* – Of 18 soil samples that were collected from the mine site and dump areas, 16 samples reported concentrations below the detection limit and 2 samples had measurable concentrations well below the CCME residential/parkland land use criterion of 1.3 μg/g. Three swipe samples procured from two transformers and stain on a concrete slab reported concentrations below the detection limit.
- *Polyaromatic Hydrocarbons (PAHs) in Soil* – Concentrations of all PAHs analyzed in 9 samples collected from the Contact Lake Mine site were well below available CCME residential/parkland land use criteria.
- *Petroleum Hydrocarbons (PHCs) in Soil* – CCME residential/parkland or industrial/commercial land use criteria (published January 2008) were exceeded at 23 of 49 sample locations at the Contact Lake Mine site, the dumps associated with the camp areas and the fuel depot at the East Arm of Great Bear Lake. Soils were mainly impacted with the F3 PHC fraction (22 samples), but a few samples were also impacted with the F4 (6 samples), F2 (4 samples) and F1 (2 samples) fractions.
- *Petroleum Hydrocarbons (PHCs) in Liquid* – PHC analysis confirmed the presence of a diesel-like fuel product in the 100,000 L above–ground fuel tank.
- *Metals in Soil* – Soil samples for metal analysis were collected from the mine site, camp and dump areas from 45 locations. Of the 45 samples, 33 had at least one parameter exceeding CCME residential/parkland land use soil quality criteria. The most common parameters reporting elevated concentrations included arsenic, cobalt, copper, lead, nickel, silver and zinc, and in a few samples chromium and molybdenum as well.
- *Dichloro-diphenyl-trichloroethane (DDT) in Wood* - Of 8 bulk samples collected from wood frame structures at the Contact Lake Mine site, 2 samples (from Cabins #1 and #11) reported DDT levels above the CCME residential/parkland land use soil quality criterion of 0.7 μg/g (note that a criterion for wood is not available). Of the 14 swipe samples that were procured, 9 reported the presence of DDT. Tow of these swipe samples (from Cabins #5 and #11) had DDT concentrations above the CCME soil criterion.

The DSS results from 2006 and 2007 are discussed further in the following sections.

4.12.3.1 Asbestos-Containing Materials (ACM)

A total of 25 samples, including samples of roofing material, insulation paper, exterior siding paper, and vinyl flooring were analyzed for asbestos. Asbestos was reported to be present in 7 samples but none of the samples were found to contain friable asbestos. Based on the sizes of the structures and the limited amount of potentially affected materials (e.g. vinyl flooring, exterior siding paper and tarpaper), the surface area of materials containing asbestos is estimated to be in the order of 260 m^2. Assuming the material has an average thickness of 0.5 cm, this is equivalent to a volume of 1.3 m^3. On this basis asbestos is considered to be a minor issue.

4.12.3.2 Lead and PCBs in Paint

Exterior paint was not found on any of the buildings examined while interior paint was found on four structures, namely Cabins 2, 6, 9 and the dry. A total of 6 paint samples were procured from these structures and analyzed for lead and significant concentrations were reported in 2 of the samples (from Cabin 6 and the dry). Based on the sizes of the structures and the localized nature of the issue (e.g. painted surfaces), the surface area of materials containing lead paint is estimated to be in the order of 90 m^2. Assuming the material has an average thickness of 1 cm, this is equivalent to a volume of approximately 1 m^3. On this basis, lead is considered to be a minor issue.

One paint sample was also procured from the main fuel storage tank at the East Arm of Great Bear Lake, which was analyzed for lead and PCBs. The reported bulk lead concentration of 0.067% was marginally above the GNWT guideline of 0.06%. PCBs were also detected in the sample at a concentration of 0.15 μg/g, which is below the CCME soil criterion of 1.3 μg/g (a PCB criterion for paint is not available). This suggests that care must be taken if any work is carried out on the tank during remediation to ensure that workers are not exposed to lead and that the painted components of the tank are disposed of appropriately. It should be noted that given the relatively low bulk lead concentration it is unlikely that the paint application would be classified as leachate toxic under the Transportation of Dangerous Goods Regulation of 5 mg/L. Nonetheless, paint samples will be analyzed for leachable lead levels prior to disposal.

4.12.3.3 PCBs in Soil and Swipe Samples

Soil and swipe samples were collected from areas where PCB-containing equipment was suspected of having been used (e.g. electrical facilities) and where soil staining or staining on concrete slab was observed and from the three dumps. No significant PCB concentrations were reported in any of the 18 soil samples and 3 swipe samples that were analyzed. Low levels, well below the CCME residential/parkland land use criterion of 1.3 μg/g, were reported in 2 soil samples procured from the soil in the shop area and the soil encountered beneath the transformer pad at the Cabin 2 location. All other soil and swipe samples reported concentrations below the detection limit for PCB analysis and therefore deemed to be free of PCB impacts.

4.12.3.4 PAHs in Soil

Soil samples for PAH analysis were collected from areas that had visible staining or were identified from old drawings or photographs as former or existing tank or drum fuel/oil storage areas. No evidence of PAH impacts in soil were reported in any of the 9 samples that were analyzed and all parameter concentrations were well below applicable CCME residential/parkland land use criteria.

4.12.3.5 PHCs in Soil

Soil samples for PHC analysis were collected from the Contact Lake Mine site, the dumps associated with the camp areas and the fuel depot at the East Arm of Great Bear Lake. Petroleum hydrocarbon levels in samples collected in 2006 and 2007 were compared to CCME residential/parkland and industrial /commercial land use soil quality criteria published in January 2008 (CCME 2008). Samples from both years that reported PHC levels above either set of criteria are summarized on Table 4.12-4.

Of the 49 targeted samples that were analyzed for PHCs, 12 that were collected from the main mine site (mainly from machine shop, office/dry and sump/foundation areas), 7 that were collected from the three dumps and 2 that were collected from the fuel storage area, reported at least one of the PHC fractions F1 to F4 above the applicable soil quality criteria (see Table 4.12-4). The areas of impact and estimated volumes of potentially affected material include:

1) Dump Area 2 – 7.5 m^3 (F2 and F3);
2) Dump Area 3 – 19.5 m^3 (F3 only);
3) Mine Site - Machine Shop, Office/Dry – 150 m^3 (F2 to F4);
4) Mine Site – Sump/Foundation – 20 m^3 (F2 to F4); and,
5) East Arm Fuel Depot – 10 m^3 (F1 to F3).

Elevated F2 and F3 fraction PHCs were reported at the Dump #2 and Dump #3 areas. However, the soil analysed contained peat and, as such, the PHC results may have been influenced by the presence of naturally occurring organic material. Based on the absence of staining, PHC odours or evidence of vegetation stress, it is concluded that any impacts associated with PHCs present in the vicinity of the dump areas are likely to be minor. On the basis of the analytical results and site observations, it is likely that the application of risk based criteria to these areas would allow them to be risk managed after the removal of the debris present in the dumps sites. Elevated F3 and F4 fraction PHCs that were reported at the Dump #1 area will be addressed through the consolidation and disposal of materials occurring in the dump area.

At the main mine site, visual evidence and analytical results suggest that the upper 300 to 500 mm of surface materials in the area of the Machine Shop, the Office and area between these two buildings has been partially impacted by PHCs (a total area of about 300 m^2). The area around the sump pit associated with the foundation slab was also reported to be impacted to a distance consistent with the limits of the site access road where coarser rock is located. The area of PHC impact associated with the sump is estimated to be 40 m^2 and has a depth consistent with that observed at the Machine Shop (500 mm). The analytical results reported are sufficiently low and of a nature (F2 to F3) to justify the use of risk management to mitigate local concerns.

The extent of PHC impact at the fuel depot is in a limited localized area of approximately 15 m^2 and likely no deeper than 500 mm given the proximity of the bedrock surface (for a maximum volume of 7.5 m^3). It should be noted that this volume is very conservative and is based on the fact that though the depth of the impact may be minimal due to the near surface bedrock the entire footprint of the tank may be PHC impacted and as such the 500 mm used for the depth estimate is effectively a contingency value applied to the overall volume calculation.

INAC has developed risk based cleanup criteria that will be used to guide the remedial action as discussed in Section 6.2.7.

4.12.3.6 PHCs in Liquid

The results of the analysis on the liquid recovered from the 100,000 L above-ground fuel tank at the East Arm of Great Bear Lake confirmed the presence of a diesel-like fuel product. Based on site measurements it is estimated that the tank contains about 3,250 litres of this oily water. Although site observations and sampling confirmed impacted soil in the immediate area of the open drain valve indicating historical leakages from the tank, there was no visual evidence of current leakage from the tank.

4.12.3.7 Metals in Soil

Soil samples were procured from 45 locations at the mine site, camp and dump areas. Of the 45 samples analysed for metals, 33 reported at least one parameter above the CCME residential/parkland land use soil quality criteria. The most common parameters reporting elevated concentrations included arsenic, cobalt, copper, lead, nickel, silver and zinc, and in a few samples chromium and molybdenum as well. The potential contribution of the mining operation to elevated metals concentrations is apparent at the main mine site where most structures were built on a foundation of waste rock. However, elevated concentrations observed at some locations in the vicinity of the camp and dump areas (which are removed from the main mining operation) also suggest that mineralized soil originating from local parent rock, or from debris in the dumps, is contributing to the observed metals concentrations.

4.12.3.8 DDT in Wood

The DDT sampling program was implemented to assess whether wood frame structures contained measurable levels of DDT. The main areas of concern were the living quarters (i.e. Cabins #1 to #12) and select mine site features. In total, 8 bulk and 14 swipe samples were procured and analyzed for DDT. Two of the 8 bulk samples reported DDT levels above the CCME residential/parkland land use soil quality criterion of 0.7 μg/g. This guideline was used in the absence of any appropriate standard as there are not any existing standards or guidelines for DDT in wood. The elevated results were reported for Cabins #1 and #11. The results of the swipe testing reported 2 of 14 samples above the CCME soil quality criterion with measured concentrations of 3.68 μg/g (Cabin #11) and 2.61 μg/g (cabin #5).

TABLE 4.12-1
TOTAL METAL CONCENTRATIONS IN CONTACT LAKE WASTE ROCK SAMPLES COLLECTED IN JUNE 2007

Constituent	**Units**	**Sample #1 Total Steps #1-6**	**Sample #2 Total Steps #1-6**
Ag	µg/g	234.5	389.6
Al	µg/g	34719	43474
As	µg/g	3012.0	236.2
Ba	µg/g	552.2	463.6
Be	µg/g	1.4	2.1
B	µg/g	70.0	99.0
Bi	µg/g	19668.8	897.7
Ca	µg/g	4047	4458
Cd	µg/g	0.3	0.2
Co	µg/g	529.9	58.9
Cr	µg/g	24.0	30.0
Cu	µg/g	2916.7	2647.4
Fe	µg/g	55230	41514
K	µg/g	18203	20733
Li	µg/g	22	23
Mn	µg/g	24364	6394
Mo	µg/g	7.0	1.1
Ni	µg/g	281.8	62.4
Pb	µg/g	38	95
Sb	µg/g	25.1	25.7
Se	µg/g	1.8	1.5
Sn	µg/g	0.0	11.0
Sr	µg/g	26	44
Ti	µg/g	423	608
Tl	µg/g	26.0	0.0
U	µg/g	54.0	77.8
V	µg/g	49.6	67.4
W	µg/g	8.0	4.0
Y	µg/g	21.4	22.5
Zn	µg/g	341	225

TABLE 4.12-2
AVERAGE PERCENT EXTRACTED IN EACH STEP OF SEQUENTIAL TEST ON WASTE ROCK SAMPLES COLLECTED IN JUNE 2007

Analyte	Step 1 Water Soluble Metals	Step 2 Exchangeable Metals	Step 3 Metals Bound to Carbonates	Step 4 Metals Bound to Fe and Mn Oxides	Step 5 Metals Bound to Sulphides & Organics	Step 6 Residual Metals
Ag	0.36%	0.68%	0.03%	0.66%	0.46%	97.81%
Al	0.28%	0.03%	0.09%	1.63%	0.82%	97.15%
As	1.29%	0.43%	6.99%	41.33%	10.41%	39.55%
Ba	0.20%	0.84%	2.69%	4.00%	1.13%	91.15%
Be	0.35%	0.00%	1.17%	10.63%	1.17%	86.69%
B	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Bi	0.27%	0.01%	37.20%	20.63%	11.79%	30.11%
Ca	3.55%	17.83%	0.00%	0.00%	0.00%	78.63%
Cd	0.00%	12.08%	1.48%	32.88%	1.19%	52.37%
Co	1.20%	1.14%	20.03%	40.29%	16.07%	21.27%
Cr	0.00%	0.00%	0.00%	18.75%	1.67%	79.58%
Cu	0.58%	0.14%	11.15%	4.26%	29.89%	53.97%
Fe	0.32%	0.03%	0.12%	10.72%	3.05%	85.76%
K	0.20%	0.15%	2.38%	0.35%	0.10%	96.82%
Li	0.00%	0.00%	0.44%	0.00%	0.00%	99.56%
Mn	0.22%	0.18%	4.07%	42.31%	13.45%	39.78%
Mo	0.00%	0.00%	0.00%	8.57%	7.86%	83.57%
Ni	1.63%	1.93%	19.19%	49.44%	7.36%	20.46%
Pb	1.08%	0.12%	21.56%	37.81%	16.14%	23.30%
Sb	1.39%	0.00%	12.39%	11.63%	15.33%	59.25%
Se	0.00%	0.00%	85.00%	0.00%	0.00%	15.00%
Sn	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Sr	0.80%	3.66%	5.25%	6.51%	2.11%	81.66%
Ti	0.34%	0.03%	0.03%	0.22%	1.73%	97.64%
Tl	0.00%	0.00%	0.00%	30.77%	11.54%	57.69%
U	1.28%	0.78%	22.49%	28.05%	23.84%	23.57%
V	0.35%	0.00%	0.00%	3.55%	1.25%	94.86%
W	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Y	0.23%	0.00%	3.42%	20.08%	19.22%	57.04%
Zn	0.71%	0.10%	8.93%	17.07%	6.20%	67.00%

Note: Values reported in table are averages of percentage figures on two samples of waste rock collected at Contact Lake.

TABLE 4.12-3
SOLIDS ANALYSES ON CONTACT LAKE TAILINGS SAMPLES COLLECTED IN JULY 2006

Analysis	Units	Contact Lake Tailings 1	Contact Lake Tailings 2	Contact Lake Tailings 3	Contact Lake Tailings 4	Contact Lake Tailings 5	Contact Lake Tailings 6	Typical level in granite[1]
ABA Results								
Paste pH	units	8.51	8.80	8.59	8.89	8.68	8.67	
Fizz Rate	---	2	2	2	3	2	2	
Sample	weight(g)	1.96	2.02	2.05	2.01	2.05	2.00	
HCl added	mL	61.80	56.30	61.20	56.95	62.00	58.85	
HCl	Normality	0.10	0.10	0.10	0.10	0.10	0.10	
NaOH	Normality	0.10	0.10	0.10	0.10	0.10	0.10	
NaOH to	pH=8.3 mL	35.20	35.50	34.00	28.30	37.50	33.10	
Final pH	units	1.65	1.68	2.03	2.01	1.70	1.72	
NP	t CaCO3/1000t	67.9	51.5	66.3	71.3	59.8	64.4	
AP	t CaCO3/1000 t	5.3	3.8	1.6	3.4	2.8	3.1	
Net NP	t CaCO3/1000 t	62.5	47.7	64.7	67.8	57.0	61.3	
NP/AP	ratio	12.7	13.5	41.5	20.7	21.3	20.8	
S	%	0.15	0.11	0.054	0.093	0.057	0.062	
Sulphide	%	0.17	0.12	0.05	0.11	0.09	0.10	
SO4	%	< 0.4	< 0.4	0.4	< 0.4	< 0.4	< 0.4	
C	%	1.98	1.05	1.59	1.15	2.03	2.55	
Carbonate	%	1.20	0.94	1.00	1.29	0.99	1.42	
Carb. NP	t CaCO3/1000t	20.0	15.7	16.7	21.5	16.5	23.7	
Carb NP/NP	ratio	3.4	3.3	4.0	3.3	3.6	2.7	
ICP Metals - Strong Acid Digestion								
Hg	µg/g	**11.9**	**9.7**	**17.2**	**19.0**	**8.9**	**17.6**	0.08
Ag	g/t	**610**	**590**	**750**	**710**	**480**	**830**	0.05
Al	µg/g	52000	56000	56000	51000	57000	52000	
As	g/t	**390**	**400**	**740**	**830**	**570**	**490**	1.9
Ba	µg/g	1400	1600	1500	1000	1500	1400	
Be	µg/g	2.0	2.1	2.5	2.0	2.2	2.1	
Bi	g/t	300	210	340	1200	110	370	
Ca	µg/g	13000	12000	12000	14000	13000	13000	
Cd	g/t	0.17	0.10	0.21	0.17	0.10	0.17	4.5
Co	g/t	**140**	**140**	**410**	**180**	**130**	**190**	7
Cr	g/t	**84**	24	30	**67**	30	57	22
Cu	µg/g	**3400**	**5000**	**5700**	**3900**	**2700**	**3500**	30
Fe	µg/g	57000	55000	63000	55000	61000	56000	
K	µg/g	33000	36000	35000	32000	33000	32000	
Li	µg/g	20	22	26	20	22	22	
Mg	µg/g	15000	14000	16000	15000	16000	15000	
Mn	µg/g	22000	16000	25000	19000	21000	23000	
Mo	g/t	**12**	**6.4**	**7.0**	**8.5**	**6.1**	**7.8**	1
Na	µg/g	4600	5000	4200	3200	5000	4300	
Ni	g/t	**110**	**100**	**170**	**120**	**110**	**130**	15
Pb	g/t	**47**	**51**	**65**	**70**	41	**60**	15
Sb	g/t	**9.7**	**12**	**12**	**12**	**6.4**	**11**	0.2
Se	g/t	< 6	< 6	< 6	< 6	< 6	< 6	
Sn	g/t	4.1	3.3	4.4	**5.0**	3.3	4.0	1.5
Sr	µg/g	58	66	58	41	62	54	440
Ti	µg/g	590	590	540	340	610	540	
Tl	g/t	0.8	0.8	0.8	0.7	0.7	1.0	0.72
U	g/t	**270**	**280**	**240**	**360**	**130**	**190**	3
Zn	µg/g	**250**	**270**	**300**	**250**	**240**	**280**	60

TABLE 4.12-4

PHC CONCENTRATIONS IN SOIL SAMPLES WITH LEVELS IN EXCESS OF RECOMMENDED GUIDELINES

Samples Collected in 2006

Parameters	Soil Quality Guideline [1]		Shop-Soil1	Shop-Soil3	Office-Soil1	Office-Soil2	Office-Soil3	Cabin4	Hoist-1	Found.	Tank-2	Tank-5	Dump1-A	Dump1-B
	Res./ Park.	Ind./ Com.												
F1 (C6-C10)	-	-	<10 <10	<10	<10	<10	<10	<10 <10	<20	<10	<10	53	<10	<10
F1 (C6-C10)-BTEX	30	320	<10 <10	<10	<10	<10	<10	<10 <10	<20	<10	<10	**51!**	<10	<10
F2 (C10-C16 Hydrocarbons)	150	260	250 190	16	**1,400+**	19	250	13 24	<20	**1,200+**	**250,000+** **76,000+**	<20	<10	<10
F3 (C16-C34 Hydrocarbons)	300	1700	**30,000+** **28,000+**	**2100+**	**110,000+**	**510!**	**6,900+**	280 **340!**	**790!**	**29,000+**	**97,000+** **33,000+**	**910!**	**310!**	300
F4 (C34-C50 Hydrocarbons)	2800	3300	**15,000+** **15,000+**	350	**160,000+**	260	**6,900+**	240 300	2400	**16,000+**	<1,000 200	**5,500+**	1300	**37,000+**

Samples Collected in 2007

Parameters	Soil Quality Guideline [1]		Machine Shop-Soil2	Machine Shop-Soil3	Found.-Soil1	Found.-Soil3	Dump2-Soil17	Dump2-Soil18	Dump2-Soil19	Dump3-Soil20	Dump3-Soil21	Fuel Depot1	Fuel Depot2
	Res./ Park.	Ind./ Com.											
F1 (C6-C10)	-	-	<10	<10	<10	<10	<10	<40	<40	<10	<40	45	<10
F1 (C6-C10)-BTEX	30	320	<10	<10	<10	<10	<10	<40	<40	<10	<40	**45!**	<10
F2 (C10-C16 Hydrocarbons)	150	260	25	<10	28	<10	27	55	240	47	50	130	**6200+**
F3 (C16-C34 Hydrocarbons)	300	1700	**5900+**	**440!**	**1700!**	**490!**	**1400!**	**2300+**	**2000+**	**1300!**	**2300+**	**1100+**	**2000+**
F4 (C34-C50 Hydrocarbons)	2800	3300	830	200	620	58	520	660	400	630	580	430	<10

Notes:

All parameter values in µg/g (ppm) unless otherwise indicated.

[1] Canadian Soil Quality Guidelines for the Protection of Human Health and Environment (CCME 2008).

! Exceeds Residential/Parkland Land Use Recommended Guidelines (for coarse-grained soil).

\+ Exceeds Industrial/Commercial Land Use Recommended Guidelines (for coarse-grained soil).

4.13 ENVIRONMENTAL STATUS AND ISSUES SUMMARY

4.13.1 Physical Hazards

The Contact Lake Mine contains the typical physical hazards associated with small mines in the Canadian north including such features as mine openings to surface, buildings in various states of disrepair, as well as debris and scrap. Chemical hazards will be discussed in the following section under Environmental Conditions.

Mine Openings

Mine openings at the Contact Lake Mine site are well defined and visible and include a mine shaft and raise, several small pits and trenches, two surface open stopes and a long open vein. Access control measures are in place to various degrees to prevent access to the mine. A summary of their current status is as follows:

- **Mine Raise:** A 3 m x 4 m raise opening located at the top of the cliff above the mine site yard. The opening has a wood timber cover that covers most, but not all, of the opening. This opening represents a potential falling hazard.
- **Surface Open Stopes:** 2 open stopes varying in width from 1 m at the edge of the cliff to about 5 m. At present these opening are secured by a fence around their perimeter but remain a falling hazard.
- **Long Open Vein:** A surface opening approximately 1 m wide exists along the entire cliff face from the top of the cliff to the mine yard. Because of its location on the cliff face, this opening is virtually inaccessible.
- **Main Shaft:** A 1.5 m x 1.5 m shaft opening is located within the headframe building. The shaft is covered by 8” (20 cm) square timbers. The timbers are in solid state and access to the main shaft is prevented through this means. Beside the shaft, there is an opening of about 1.2 m x 1.2 m in dimension that is also covered by 8” (20 cm) square timbers. These timbers could likely be moved to allow access into the vertical opening below. These openings remain a falling hazard if the timbers are removed.
- **Pits and Trenches:** Shallow trench workings (excavation testing for mineralization at surface and therefore no workings below) generally less than 1 m in depth occur on the hillside above the mine site. Given their location and scale, these trenches do not represent a material hazard.

As part of the 2006 site assessment SRK reviewed the information on mine workings, and provided comments on their stability and noted that given the limited nature and depth of the mine workings, the risk of crown failure is low (SENES 2007a).

Buildings

The remaining mine and camp buildings and cabins at the Contact Lake Mine site are in various states of disrepair. Potential hazards that may exist if accessed include building collapse, residual debris, rotting floorboards, and protrusions. Over time these hazards will become more marked as buildings continue to deteriorate. An obvious safety hazard exists with respect to the former outhouse, which sits precariously over the edge of the waste rock and appears to be on the verge of collapse.

Asbestos containing materials are present in relatively small quantities in four building locations, namely the dry and three cabins (numbers 5, 6 and 14) that were used as living quarters. Lead paint is also present in the dry and in one of the cabins (number 6).

Blasting caps occurring at the Quonset building hut were removed in the summer of 2007.

Miscellaneous Waste and Debris

Scrap in the form of piping and metal pieces and mining equipment is observed throughout the site and in the water along the banks of East Arm (Great Bear Lake) and Contact Lake. Three surface dumps also occur at the site consisting of debris piles containing miscellaneous wood, metal and other scrap materials from either the mine or the camp (e.g. food type cans, rubber hose, glass wood stoves and drums). One dump is located at the main mine site, and two dumps at the dock area west of the mine.

Large stacks of unfinished timber are present to the west of the mine site that were presumably used to heat buildings and for underground shoring of shafts and drifts. Timbers also occur under the water as cribbing at the fuel storage area.

At the fuel storage area at Great Bear Lake, a large 250,000 L above-ground storage tank and dock area remain. The dock represents a physical hazard as well as a potential risk to fish habitat in the long term. Asbestos-containing material is present on a boiler at this site.

Waste Rock Pile

Field observations indicate that the waste rock pile is physically stable as slopes are generally at their natural angle of repose or less.

4.13.2 Chemical Hazards

Waste Rock

Field observations and laboratory analysis indicate that the waste rock is chemically stable. No observations of acid generation drainage are evident on the waste rock, which has been exposed in its current state for several decades. The waste rock contains elevated levels of antimony, arsenic, cobalt, copper, lead, mercury, molybdenum, silver, uranium, and zinc.

Exposed Mine Tailings

Field observations and laboratory analysis indicate that the exposed mine tailings are chemically stable. Acid base accounting data indicate that future generation of acid rock drainage from the tailings is unlikely. Tailings contain elevated levels of antimony, arsenic, cobalt, copper, lead, mercury, molybdenum, nickel, silver, uranium, and zinc, and in some areas elevated chromium.

Mine Water

Surface water at the mine site consisting of runoff that flows along the east toe of the waste rock pile and across the surface of the tailings as well as seepage from the waste rock pile contains elevated levels of metals.

Soil

Soils occurring in disturbed areas of the mine site contain elevated levels of most metals relative to areas undisturbed by mining activities. The metal levels in these soils also exceed soil quality guidelines for residential/parkland land use.

Localized pockets of PHCs are present at the Contact Lake Mine site and the former fuel storage depot at Great Bear Lake. Several locations within the immediate area of the former mine office, shop and mill area have elevated levels of F3 and F4 fraction PHCs indicative of diesel or heating fuel spills. In addition, elevated levels of F3 and some F4 fraction PHCs were found at the dump sites, which is likely from fuel containers that were disposed in these areas. At the fuel storage depot, significant quantities of F2 and F3 fraction PHCs occur in the area probably from a diesel fuel leak or spill.

There is limited evidence of impact on site from polycyclic aromatic hydrocarbons (PAHs) and no evidence of impact from PCBs.

Water and Sediments

Water and sediment quality data collected in 2006 at the Contact Lake Mine site were found to be similar to those reported in previous programs (2002 – 2005).

Concentrations of all metals in Contact Lake water are below applicable water quality guidelines, and radionuclides do not occur in detectable levels in either deep or shallow waters of the lake. While detectable levels of radionuclides occur in lake sediments, concentrations are below the sediment benchmarks recommended by the CNSC for use at mine sites in northern Saskatchewan (Thompson *et al*. 2005). Metal concentrations in Contact Lake sediments are similar to background levels, while concentrations of PHCs are very low and those of BTEX compounds (i.e. benzene, toluene, ethylene, xylene) are not detectable.

Relative to previous years, the waters of Upper Lake remain slightly acidic with elevated copper concentrations above applicable water quality guidelines. The concentration of silver, however, has fallen to non-detectable levels (i.e. < 0.1 µg/L). Measurable levels of radionuclides occur in Upper Lake sediments, but the concentrations are below the sediment effects level benchmarks recommended by the CNSC for use at mine sites in northern Saskatchewan (Thompson *et al*. 2005).

Arsenic, copper and uranium concentrations in the water column of the Tailings Pond exceed water quality guidelines, while arsenic, copper and zinc concentrations in the sediments exceed sediment quality benchmarks. Radionuclides are detected in both the water and sediments with sediment concentrations exceeding sediment guidelines (LEL). The results of the ecological risk assessment conducted in 2007 (SENES 2007b) indicate that there are some localized issues for aquatic organisms (phytoplankton and zooplankton), bottom feeding waterfowl and small mammals (hare, mink and muskrat) in and around the Tailings Pond.

Fish

Concentrations of metals in tissues (i.e. flesh and liver) of edible fish (lake trout) in Contact Lake are generally below detectable levels, while concentrations of metals with detectable levels are not considered to be higher than normal.

Other than the dock structure on the East Arm of Echo Bay in Great Bear, no structures exist that could potentially impact fish habitat.

Vegetation

Plants occurring in disturbed areas of the mine site contain elevated levels of arsenic, cobalt, nickel and uranium, and to a lesser extent bismuth and molybdenum, relative to areas undisturbed by mining activities.

There is little evidence to suggest that sedge species growing in the standing water at the foot of the major waste rock pile have elevated levels of contamination relative to the other disturbed sites.

4.13.3 Radiological Hazards

A total area of 8.5 ha was surveyed in 2006 (SENES 2007a) that included the camp site, mine site and immediate vicinity areas such as the wetlands and tailings area below the mine and the hillside above the mine between the mine openings and Upper Lake. The results of the survey show that the only 2 10m grids on the waste rock area have elevated terrestrial gamma radiation exceeding 250 µR/hr. This 200 m^2 area represents about 0.2% of the surveyed area. The survey also found 74 10x10m grids (7,400m^2) at the mine site and vicinity areas with grid averages of terrestrial gamma radiation between 100 and 250 µR/hr. This area represents about 9% of the surveyed area. Of these 74 grids about 20 (2000m^2) were located on the waste rock area.

Based on these small areas of slightly elevated terrestrial radiation levels and assuming a 200 hour per year intrusion/use scenario, the risk assessment determined that the site possesses minimal risks to humans and ecological receptors from potential radiological exposures (see Section 5).

There are no reclamation standards for the closure of uranium mine sites in the NWT. Thus it is reasonable to assume that reclamation standards will be drawn from precedents set at other sites, reclamation codes in other jurisdictions, CNSC dose limits and the application of the mine closure principles. This is discussed in more detail in Section 5 and 6.

4.13.4 Waste Disposal

A summary of potential local/off-site disposal material quantities is shown in Table 3.3-1 on the following page. Several practical and reasonable approaches exist by which to dispose of solid wastes in a reasonable and rational manner for this site. Local disposal areas can be constructed at each of the primary areas (e.g. the Contact Lake mine or the in the vicinity of the fuel tank at the East Arm of Great Bear Lake) in which approved waste materials can be buried and covered. Likely disposal areas at the mine site include the western toe of the waste rock pile at the mine site, or in pits excavated in the sandy area between the mine site and camp. Potential disposal options at the East Arm include placement of debris in the hollow at the exiting tank location prior to cover placement between two rock outcrops or burial in the sand and gravel deposits adjacent to the road connecting the East Arm to Contact Lake.

TABLE 4.13-1
POTENTIAL QUANTITIES OF MATERIALS THAT MAY REQUIRE DISPOSAL

Material	Volume (m^3)	Location
DDT impacted wood	2	Cabins 1, 5 and 11
Metal impacted soil	0[*]	
Dump Area 2 is 20 m^2 and Dump Area 3 is 65 m^2 (source of elevated metals is consistent with native soils having elevated metal concentrations)	25*	Dump areas 2 & 3 are located greater than 50 m from Contact Lake
Mite Site Area approximately 2900 m^2 (minerlaized mine rock used as surface material)	NA	Mine site is 500 m from the Contact Lake
Cabin #2 - 50 m^2 and #4 - 50 m^2 (native soils with elevated mineral concentrations consistent with a mine site)	25*	Cabins 2 and 4 are located approximately 35 m from Contact Lake
PHC impacted soils	180[**]	
Dump Area 2 - F2 and F3 impact - 25 sq.m. at 0.3 m dp.(co-contaminated with metals)	7.5*	Dump area 2 is located greater than 50 m from Contact Lake
Dump Area 3 - F3 impact - 65 sq.m. @ 0.3 m dp (co contaminated with metals)	19.5*	Dump area 3 is located greater than 50 m from Contact Lake
Mine Site Machine Shop & Office/Dry - 150 cu.m. of F2 to F4 impact	150	Mine site is more than 200 m from the Contact Lake
Mine Site Sump/Foundation - 20 cu.m. of F2 to F4	20	Mine site is more than 200 m from the Contact Lake
East Arm Fuel Depot - 10 cu.m. of F1 to F3	10	Large AST is greater than 25 m from the East Arm shoreline
ACM debris (1.3 m^3 of actual material bulking factor applied)	5	Cabins and mine buildings are more than 35 m from Contact Lake
Wood debris (landfill volume assumes bulking factor of 2)		
Non-lead impacted (assume no burning)	800	
Non-lead impacted (assume burning 5% residual)	20	
Lead impacted (can not burn)	90	
Dock Wood (can not burn due to water content)	70	
General Debris (includes material from dumps and assumes a bulking factor of 2)	200	
Metal impacted with lead paint (assumes a bulking factor of 3)	10	
Concrete slabs (75 m^2 of area over four locations)	35	
Oily Water in AST at East Arm	3.25	AST is more than 25 m from the East Arm

Maximum Volume of material to go into landfill	***1392***
Minimum Volume of material to go into landfill	***397***

Notes:

[*] - denotes what we believe are elevated analytical results consistent with a site where the background concentrations for metal parameters are higher than the CCME criteria and should be anticipated at mine sites where minerals are being extracted from the earth. In some instances the elevated metal concentrations are also related to the fact that mine rock was sampled and analysed and as such it is not surprising that these samples would report elevated metal concentrations. We are of the opinion that the issues with metal impacted soils can be mitigated as outlined in the Risk Assessment for the site.

[**] - denotes that under the Risk Assessment the PHC impacted soils can be excavated and placed into the site landfill or can remain in-situ and a clean fill cover placed overtop to mitigate the exposure risks. Volume not included in the minimum volume to landfill.

5.0 ECOLOGICAL AND HUMAN HEALTH RISKS

A site-specific ecological and human health risk assessment was carried out to better understand the potential for the Contact Lake Mine site to have any adverse effects on the local environment by assessing risks associated with chemical and radiological exposures to people and wildlife that may use the site (SENES 2007b). Both the ecological and human health assessments were based for the most part on site-specific information including measured contaminated levels in flora and fauna, soils, sediments and water both on-site and in the surrounding environment. For the human exposure assessment, assumptions were made, on a conservative basis, about the potential hypothetical exposure pathways associated with visits to the site for 200 hours per year since the site is remote from any community. The results and conclusions of that study are presented herein.

In carrying out the human health and ecological risk assessment, the general guidance of the Canadian Council of the Ministers of the Environment (CCME 1996) was followed. Key elements of such assessments include:

- receptor characterization – identification of potential receptors and their pathways of exposure;
- exposure assessment – quantification of the amount of contact between the receptors and the contaminants of concern;
- hazard assessment – examination of the potential effects of each contaminant on each receptor; and,
- risk characterization – evaluation of the potential for adverse effects on the receptors using information determined in the exposure and hazard assessments.

To assess the risks to animals and people from exposure to chemical and radiological contaminants on the Contact Lake Mine site, exposure/dose estimates were made for all potentially significant pathways including: direct gamma radiation; ingestion of fish, vegetation, water and/or game; and inadvertent ingestion of soils or sediments. Inhalation of radon and dust were determined to be minor pathways of exposure and were not included. For these exposure estimates, maximum levels of measured chemical and radiological contaminants in soil, sediment, water, fish, terrestrial vegetation and animals were used in these calculations. Similarly, only the impacted area wide average gamma levels was used in the radiation dose estimates. Consideration was also given to natural background levels of the chemical and radiological contaminants of potential concern. Where site-specific information was not available, conservative transfer factors based on literature values were used to determine the concentrations of the contaminants of potential concern in aquatic plants, benthic invertebrates, and terrestrial animals that were not harvested during the field investigations.

As per normal practice, contaminants present in water and food were assumed to be entirely available for intake into the body (i.e. to be 100% bioavailable). For contaminants present in soils and sediments, reduced bioavailability was taken into account to reflect the fact that not all chemical contaminants present in these materials are available for uptake to biota. For the radionuclide content of soils and sediments however, it was conservatively assumed that they are entirely bioavailable.

Ecological receptors were chosen to represent a wide range of exposure scenarios at the Contact Lake site. Consideration was given to whether the receptors served as a food source in the food chain (i.e. hare, ptarmigan, moose, caribou, duck) and whether the receptors were potentially the most exposed species (i.e. hare and ducks).

Since there are no permanent residences within the immediate Contact Lake study area, the potential effects of site use were assessed for hypothetical human receptors (adult and child) that could spend a portion of the year (200 hr/year) at the site. Human receptor considerations included lifestyle characteristics such as: recreational habits (e.g. time spent hunting or fishing at or near the site); diet, especially local foods (e.g. fish, caribou, moose, hare, wild fowl); sources of drinking water while near the site; and, for the most exposed individual it was assumed the entire time was spent on the mine affected area of the site for estimating exposure from gamma radiation. The dietary characteristics were gleaned from a survey on Dene and Métis communities (Receveur 1996).

It is noted that although the results of the risk assessment do not identify any significant risks with respect to human health and ecological species, closure and remedial actions are still necessary to meet best practice and INAC policy with respect to the remediation and closure of an abandoned mine site to minimize physical, chemical and radiological hazards; and stabilize and return the site to acceptable land use through the application of accepted engineering and site clean-up practices.

5.1 RISK ASSESSMENT APPROACH AND METHODOLOGY

Chemical Risks

In the first stage of the risk assessment, all available environmental data for the site were considered and used to identify constituents of potential concern (COPC) to be carried through the ecological and human health risk assessment. The COPC that were identified included: antimony, arsenic, barium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, uranium (chemical toxicity), vanadium, zinc, and petroleum hydrocarbons.

A pathways model was used to estimate exposure levels (intakes or doses) to selected ecological receptors and people from COPC in the environment taking into consideration the location and dietary characteristics of the receptors. The modelling used measured data from the site, however there were no measured data for berries, aquatic plants and benthic organisms, therefore transfer factors were used to estimate concentrations in those environmental media. Exposure estimates were then compared to toxicological reference values for metals to identify combinations of constituents and receptors that may experience potential adverse effects.

Radiological Risks

For radiological contaminants, maximum concentrations in water and sediments were converted into doses to aquatic receptors by the use of both internal and external dose conversion factors. For internally deposited radionuclides, the absorbed dose was multiplied by a factor that accounts for the relative biological effectiveness (RBE) of the different types of radiation. A range of RBE factors was used to encompass the uncertainty in the use of this factor. The two doses (i.e. internal and external) were added together and compared to a benchmark dose of 10 mGy/d, which is deemed to be protective for aquatic species.

Terrestrial gamma radiation is typically the primary contributor to potential radiological doses at abandoned mine sites. For terrestrial receptors, dietary characteristics were incorporated into the calculation of dose. The absorbed dose was calculated using dose conversion factors. External dose was calculated from exposure to gamma radiation, which took into account the length of time the terrestrial receptor would be present at the site. As discussed for the aquatic receptors, an RBE factor was applied to the absorbed dose to account for the relative biological effectiveness (RBE) of the different types of radiation. A range of RBE factors were used to encompass the uncertainty in the use of this factor and the doses to terrestrial receptors were then compared to a benchmark dose of 1 mGy/d.

Assessment of radiation exposures to members of the public is commonly based on estimation of the incremental (above-background) effects of the project or site[2]. Such assessments consider the radiation dose received from direct exposure to gamma radiation as well as the dose received from the inhalation and ingestion of radionuclides. The human receptor model converts radionuclide intake by the human receptors from the various pathways into a radiation dose. The Canadian guidelines for the management of naturally occurring radioactive materials (NORM) recommend a dose limit of 1 mSv/y for members of the public and incidentally exposed workers (employees whose regular duties do not include exposure to NORM sources) as a result of a work practice (Health Canada 2000). [For occupationally exposed workers, the dose limit is 20 mSv/y.] The guidelines also recommend a “dose constraint” of 0.3 mSv/y, to account for the

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[2] These sites were not mined for their uranium, and were not part of the uranium fuel cycle; therefore, the radioactive materials at the sites may be considered as NORM.

possibility of exposures from other sources without the annual limit being exceeded. When the estimated dose to a member of the public is less than 0.3 mSv/y and to the worker is less than 1 mSv/y, "no further action is needed to control doses or materials" (Health Canada 2000). If the estimated dose exceeds these constraints, then a more site-specific dose assessment should be undertaken to assess if the dose constraints will be exceeded.

Ingestion dose conversion factors (DCs) depend on the chemical form of the radionuclide and the consequent gut-to-blood transfer factor in accordance with ICRP Publication 72 (1996) recommended values and DCs for members of the public. The more conservative of the ICRP inhalation DCs (i.e., less soluble S type DCs) for members of the public were used in the risk assessment.

5.2 ECOLOGICAL RISK ASSESSMENT SUMMARY

The selection of the various ecological (aquatic and terrestrial) biota for inclusion in the ecological risk assessment (ERA) was based on scientific and community input with respect to species associated with the site. It should be noted that the ERA evaluates the effects on populations rather than individual species. For the aquatic environment, the species covered the entire food chain starting from aquatic plants and animals, through to fish. For the terrestrial environment, the species considered ranged from small local mammals (e.g. hare) through to large broad ranging mammals (e.g. bear, caribou, moose), as well as waterfowl (e.g. ducks) and terrestrial birds (e.g. grouse).

Exposure pathways included intake of COPC through the consumption of water, sediment, vegetation, soil or flesh at various stages of the food chain. Depending on the size of the home range for the species under consideration, the analysis was based on contaminant levels measured at specific locations on the site or on site-wide averages. The analysis also considered the length of time the various species would be present on the Contact Lake Mine site.

The assessment of risks to ecological species was based on comparison of estimated intakes of metals from all pathways to toxicity benchmarks. The results of the ERA were as follows.

Contact Lake

- There are no potential adverse effects in aquatic receptors exposed to radiological constituents in Contact Lake.
- Metal levels in the Contact Lake water column do not pose a risk to aquatic receptors.
- A number of sediment toxicity benchmarks were exceeded in one sample adjacent to the tailings pond inflow to Contact Lake indicating a potential for adverse effects in benthic organisms; however, at other locations in the lake, no potential adverse effects are

predicted. On a spatial basis therefore, it is unlikely that benthic communities are being affected in Contact Lake.

- Metal levels in fish from Contact Lake are similar to background and therefore there are no risks associated with eating fish from the lake.

Upper Lake

- There are no potential adverse effects in aquatic receptors exposed to radiological constituents in Upper Lake.
- Copper concentrations in the water column pose a potential risk to aquatic receptors (phytoplankton, zooplankton and fish) in Upper Lake.
- Copper and zinc concentrations exceed several sediment toxicity benchmarks, indicating that potential adverse effects may occur in benthic organisms in Upper Lake; however, Upper Lake is topographically upgradient of the mine site and visual observations at the site indicate that there is little appearance of mining activities near Upper Lake. The elevated levels of copper and zinc are likely a result of natural mineralization in the area.

East Arm of Echo Bay, Great Bear Lake

- There are no potential adverse effects in aquatic receptors exposed to radiological constituents in Great Bear Lake.
- Metal levels in the Great Bear Lake water column do not pose a risk to aquatic receptors;
- Some sediment benchmarks were exceeded in the area of the former dock on the East Arm of Great Bear Lake. Given that some of the elevated concentrations were only found in one or two of the three samples collected at this location, it is unlikely that adverse effects are occurring in benthic communities in the East Arm of Great Bear Lake.
- A sediment sampling program and a benthic survey were conducted in the area in 2007 (after the HHERA was completed) and the results supported the conclusion of the HHERA. The sediment results showed that the impacted sediments were localized to the dock area and the benthic survey results showed that benthic communities were not affected in the exposure area based on weight-of-evidence comparison of invertebrate endpoints and density results (Section 4.11.3).

Tailings Pond and Surrounding Area (including surface tailings and waste rock area)

- Levels of arsenic, copper, silver and uranium in the water column of the small tailings pond on site may have potential for adverse effects, primarily to phytoplankton and zooplankton in the pond.
- Exposure to metals such as arsenic and copper in sediments (submerged tailings) in the tailings pond has the potential to affect individual bottom feeding waterfowl and mink and muskrat but not populations of these species.

- There are no risks of adverse effects on terrestrial wildlife from radiation exposure.
- Arsenic and copper exposure in vegetation and soils around the tailings pond have the potential for adverse effects on individual hare but not on populations

In summary, radiation exposure does not pose a risk at the Contact Lake site. It is unlikely that benthic communities in waterbodies in the vicinity of the Contact Lake Mine site (Contact Lake and Great Bear Lake) are experiencing adverse effects from the presence of metals above CCME guidelines. There is a hypothetical possibility of adverse effects in individual small animals (e.g. hare, mink, muskrat, and bottom feeding waterfowl) if present and if they exclusively use the local habitat of the tailings pond and surrounding area. As the pond area is very small, therefore, populations of waterfowl and small animals will not be affected.

5.3 HUMAN HEALTH RISK ASSESSMENT SUMMARY

Exposure pathways considered in the analysis for the campers included drinking water and eating fish from Contact Lake or Great Bear Lake (depending on the camper location); eating berries from across the site, eating hare exposed to soils and vegetation with elevated COPC levels from near the Tailings Pond; eating ducks exposed to COPC in the Tailings Pond; and, eating larger animals (caribou and moose) that traverse the site as part of their range, and forage and drink from various areas across the site. With the exception of caribou, duck and moose, the human health risk assessment (HHRA) was based on measured contaminant levels in all other food and water sources. To facilitate the HHRA, a simple pathways model was used to predict COPC levels in caribou, duck and moose flesh. In addition to the dietary intake, the camper exposure scenario also considered direct exposure to gamma radiation while on site.

As the Contact Lake Mine site is fairly remote, scenarios were developed for hypothetical use situations to facilitate the assessment of potential risks to people who may visit the site. In this regard, two hypothetical scenarios were considered: one was for campers present on the Contact Lake site near the tailings pond, while the other was for a stay at the near the Tank Farm located on the East Arm of Great Bear Lake. Both of these scenarios assume an on-site duration of stay of 200 hours. Note that for the camper scenario at Contact Lake mine, the average terrestrial radiation level used the mine impacted site area with an average exposure rate of 94 µR/h over 2.4 ha, which is very conservative as this average is more than twice as high as the average of 42 µR/h over 8.6 ha for the mine and camp site measured areas. When considering the regional background area, this area average would be reduced even further.

Table 5.1 shows the estimated exposures for a hypothetical camper at the Contact Lake mine site. As seen in the table, the potential terrestrial gamma exposure used in the assessment is the largest contributor of potential dose, ranging from 70 to 79% of the total incremental dose.

TABLE 5.1
ESTIMATED INCREMENTAL RADIATION EXPOSURE FOR CAMPER 1

	Total Ingestion Dose (µSv/y)								**Terrestrial Gamma (µSv/y)**	**Total Dose (µSv/y)**
	Hare	**Duck**	**Moose**	**Fish**	**Caribou**	**Soil**	**Water**	**Berries**		
Adult	0.9	0.07	2.4	0.0	5.1	0.003	2.4	15.4	97	123[1]
Child	1.9	0.16	5.6	0.0	11.7	0.01	4.4	32.0	130	185[2]

Notes: Based on Port Radium data, inhalation/radon doses for radioactivity are trivial and therefore not evaluated.
Fish doses not calculated since measured radionuclide concentrations below the method detection limit (CNSC 2005).
Total incremental dose rounded to one significant figure, significant figures in other doses are for calculation only and do not indicate accuracy.
[1] – Lifetime risk of fatal cancer of 4.3 x 10^{-4} as compared to a lifetime risk of fatal cancer of 1.1 x 10^{-3} (for 300 µSv/y)
[2] – Lifetime risk of fatal cancer of 6.5 x 10^{-4} as compared to a lifetime risk of fatal cancer of 1.1 x 10^{-3} (for 300 µSv/y)

As seen in the table, incremental dose estimates is both well below CNSC guideline of 1000 µSv/y for public exposure, as well being below the Health Canada “dose constraint” of 300 µSv/y. Note that the dose from fish is zero because the radionuclide concentrations in fish were found to be below the detection limit. This methodology has been used by the CNSC (2005) in their assessment at an abandoned mine site in northern Ontario.

It should be noted that the dose calculations were based on measured and predicted levels at the Contact Lake Mine site (i.e., measured radionuclide concentrations in soil/sediment, water, aquatic vegetation, terrestrial vegetation and fish and predicted concentrations in other biota based on the levels in soil, water and other measured components) and that the dose calculations were not adjusted to remove baseline levels. The calculated doses therefore are conservative overestimates of the incremental dose from the Contact Lake Mine site.

The HHRA results show that:

- Gamma radiation was the primary contributor to the radiological dose to all hypothetical human receptors who were assumed to spend 200 hours per year on the Contact Lake Mine site and take food back to their communities and consume the food over a six-month period. A conservative estimate of the radiation dose to the potentially most exposed seasonal adult camper at Contact Lake mine site was 123 µSv/y and for the adult camper near Great Bear Lake was 29 µSv/y. These exposures are less than the Health Canada “dose constraint” of 300 µSv/y, and well below the Canadian Nuclear Safety Commission regulatory incremental dose limit of 1000 µSv/y for members of the public;
- For metals, the predicted intakes were below the acceptable intake levels for all non-carcinogenic contaminants of potential concern; and,

- Risk levels associated with the carcinogenic properties of arsenic were below risk levels from background exposure.

In summary, the presence of radionuclides and metals at the Contact Lake mine site are not a cause for concern under the exposure scenarios described above for campers or fishermen, or others, who might occasionally visit the site.

5.4 OVERALL CONCLUSION

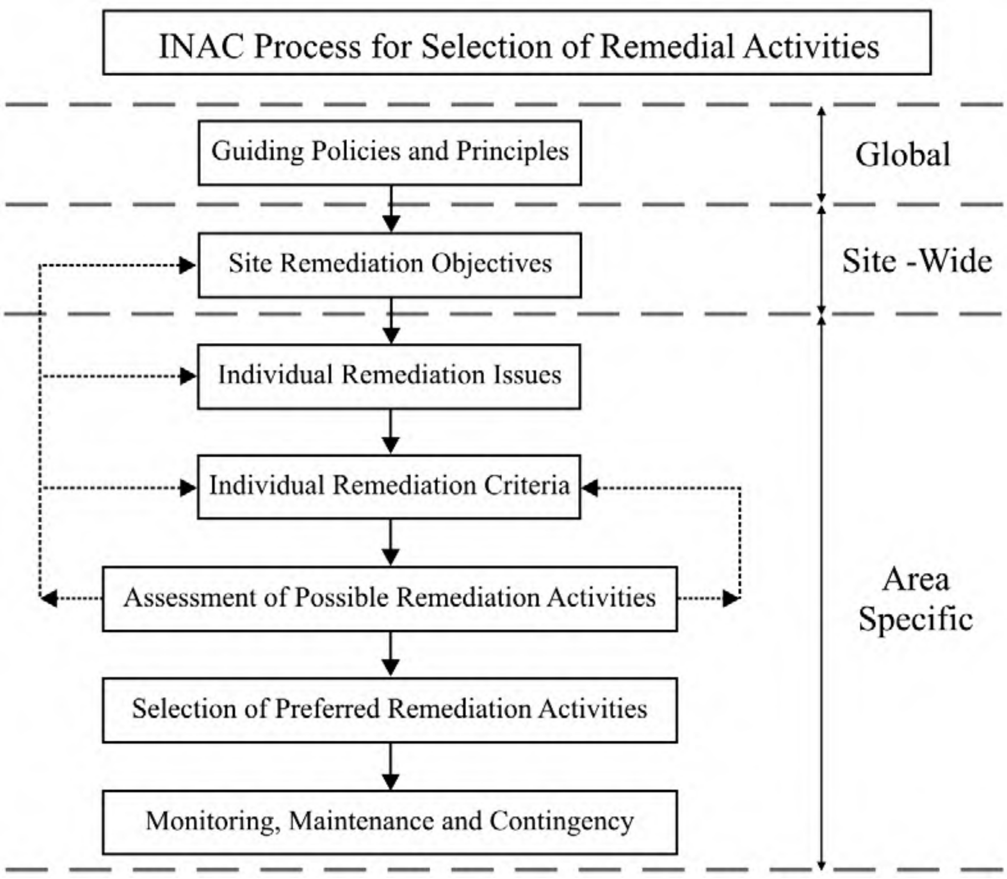
The results of the overall assessment indicate that individuals who might visit the Contact Lake Mine site on a short-term basis, even if taking home locally collected food for subsequent consumption would not experience any adverse health effects. From an ecological perspective, the assessment shows that there are localized areas impacted by surface and submerged tailings that could potentially result in adverse effects on a limited number of small individual terrestrial animals (e.g. hare, mink and muskrat). Large animals such as bear, moose, and caribou are not expected to be adversely affected by the existing site conditions. Not withstanding the findings of the HHERA (minimal to no risk to receptors), site remedial works should be carried out to reduce remaining sites hazards, stabilize and clean-up site conditions.

6.0 PROPOSED REMEDIAL ACTION PLAN

6.1 PROCESS FOR SELECTION REMEDIATION ACTIVITIES

The general INAC approach to remediation is illustrated in Figure 6.1-1 below. The specific process components carried out for the Contact Lake Mine site and its development of remediation activities is provided in the following discussion.

FIGURE 6.1-1
INAC'S APPROACH TO REMEDIATION



6.1.1 Process Approach and Considerations

The site consists of a number of types of features that have similar remediation issues. In order to enable the development of a coherent remediation plan, these features were grouped into like components that share similar characteristics and remedial issues. For each of these components, *remedial issues and concerns* were identified based on input from field studies, human health and ecological risk assessments as well as concerns identified by aboriginal communities.

Potential *remedial actions* were identified that can be used to address the outstanding remediation issues. These remedial actions were assessed with respect to the ability to fulfill the overall framework and site-specific remedial objectives. The preferred remediation action was then selected as most appropriate. In some cases, the preferred remediation option is indicated as tentative because additional research or design build are required (e.g. hydrocarbon remediation). Community consultation will be conducted following the determination of the most appropriate remediation option and/or following the design build proposal by the construction contractor. The remedial option will then be finalized in the specifications or during the remediation.

A list of *possible remediation options* was developed for each individual component of the site. The remediation options are essentially the work that is required to address the issues associated with that component. From the initial list of all possible options, some were determined 'Not Acceptable (NA)' because they do not meet the remediation goals. Some options were determined to be 'Acceptable (A)' and at least one option was determined to be 'Preferred (P)'. Ultimately, one set of *preferred remediation options* results from an alignment of reviews by First Nations, Federal Government and technical/engineering groups. Preferred remediation options were produced for each component of the site that, when combined, form the site remediation plan. Possible and preferred remediation options for each component of the site are discussed in the following sections of this report. Refer to Appendices A and B for community preferred options.

Monitoring, maintenance and contingency plans are necessary to: 1) monitor for possible impacts and quality control while the remediation work is underway (*monitoring activities*), 2) to ensure health and safety of workers during remediation (*health and safety monitoring*), 3) monitor the effectiveness of the work that was done after its completion *(performance monitoring*), 4) ensure that any required maintenance work is done to keep the remediation work up to specifications (*maintenance activities*), and 5) make sure that backup plans are ready in case something unexpected takes place (*contingency plan*).

6.1.2 General Objectives and Considerations

In general, the objective for any mine closure strategy is to assure:

- The protection of human health;
- Minimization of environmental effects; and,
- Restoration of the land to pre-mine conditions or a suitable alternative land use.

The Contact Lake Mine site is situated in a remote location where the key long-term issues for the site include assurance that:

- The site is safe from physical hazards (mine openings);

- The site is physically stable (waste rock is not exposed to wind and water erosion); and,
- The site is not causing material environmental damage.

To address these issues, the following technical reclamation guidance was considered appropriate for the remediation of the Contact Lake Mine site.

Physical Stability and Health and Safety

- Ensure all surface openings are sealed to industry/engineering standards (e.g. Ontario Mine Reclamation Code, or an acceptable alternative cap);
- Ensure crown pillars are stable or implement a suitable remedial action plan (fencing, backfill, monitoring etc.); and,
- Minimize physical risks associated with physical hazards.

Environmental Effects

- Meet receiving water quality criteria in Contact Lake and Great Bear Lake;
- Keep environmental effects as low as reasonably achievable (ALARA); and,
- Manage soils contaminated with hydrocarbons based on good practice and the results of a site-specific risk assessment.

Land Use

- Allow natural use of the land.

Note that if any "Species at Risk", as identified in Section 4.8, that are potentially present in the Great Bear Lake area are encountered during the remediation of the site, care will be taken to avoid disturbance of the species. The land use permit issued by the Sahtu Land and Water Board will outline monitoring and mitigation measures required if a Species at Risk is encountered. These measures will be followed during the remediation of the site.

Remediation of Radiological Risks

There are no reclamation standards for the closure of uranium mine sites in the Northwest Territories. However, reclamation guidance can be drawn from precedents set at other sites such as Port Radium in the NT, and the mines in northern Saskatchewan and the Elliot Lake mines in Ontario. In the case of the Port Radium Mine, the intervention threshold was exceedence of a 250 μR/h average over a 10x10m grid on easily accessible (flat) land. In the case of the Elliot Lake mines where 11 mines and 9 uranium tailings basins have been decommissioned and reclaimed over the past decade in close proximity to populations, site-specific surface gamma radiation criteria were established for peak gamma activity of 150 μR/h, with an average level not to exceed 100 μR/h in any 100 m by 100 m grid. Similar site-specific criteria were also considered in the development of decommissioning plans for the uranium mines in northern Saskatchewan, where due to the remoteness of the sites, the criterion for the peak gamma activity was 250 μR/h, with an average level not to exceed 100 μR/h in any 100 m by 100 m area. The standard that has been adopted for Contact Lake is to reclaim areas with elevated radiation levels, i.e. averaging more than 250 μR/h over a 10 m by 10 m grid area, to an average below 250 μR/h for the 10 m by 10 m area.

6.1.3 Remedial Components and Features

As described in earlier sections the Contact Lake Mine is comprised of three general site areas: the mine site proper and the camp site area at Contact Lake; and the dock and fuel storage area on Great Bear Lake.

From an overview perspective, the main features considered within the remediation plan include the:

- Mine Openings;
- Buildings and Infrastructure;
- Waste Rock;
- Tailings Area;
- Waste Disposal Areas;
- Fuel Storage Tanks;
- Contaminated Soils;
- Roadways; and,
- Miscellaneous Structures and Debris.

6.1.4 Review of Remedial Issues and Options

The current NWT Mine Site Reclamation Guidelines (INAC 2006b) provide a good overview of the potential reclamation requirements and provided the basis for selecting potential remedial options for the Contact Lake Mine. Based on the findings of the site and risk assessment studies the remedial issues and potential options are summarized on Table 6.1-1.

For many of the facilities listed in Section 3.0, the closure issues are clearly identified and there are few credible options. For these facilities, a short list of options is presented and a closure strategy is recommended.

For other facilities, there may be several credible options. For example, an on-land tailings deposit could be capped with low permeability soil, relocated to a new disposal area (on land or under water), vegetated in place, or left as is. For benign tailings, all options could be credible alternatives, and as such, the selection of an option may not be readily apparent.

The closure options considered vary by facility, but generally include the following options:

Leave As Is - The no action option is typically included for all facilities and may be adopted where:

- Facilities are stable and do not represent a physical or ecological hazard;
- Area has been, or is being, naturally reclaimed by native vegetation; and,
- The facility has historic or archaeological value.

Demolition and Site Restoration - This option would include the removal and management of all hazardous material (e.g. asbestos), recycling of saleable assets, dismantling of the building with disposal of refuse in an on-site landfill, reclamation of the disturbed area. This includes: breaking up and/or removal of concrete foundation walls and piers, application of soil cover as necessary and possible vegetation of the disturbed area with native species.

Burn and Site Restoration - This option would include the removal and management of all hazardous material (e.g. asbestos), recycling of saleable assets, controlled burning of the building with disposal of refuse in an on-site landfill, reclamation of the disturbed area. This includes: breaking up and/or removal of concrete foundation walls and piers, application of soil cover as necessary and possible vegetation of the disturbed area with native species. Burning is often suggested to reduce the quantity of waste requiring on-site landfilling.

Fencing - Fencing is often used to reduce hazards to people and animals. Fencing requires long-term care and maintenance, and is typically only considered as an interim measure or in cases where no credible remedial alternative is available (note that in some instances rock berms are created to act as warning barriers to open pits). Fencing is an option not normally favoured by the aboriginal communities as it intrudes on land use and presents potential risks to terrestrial species.

Backfilling - Backfilling of shafts, adits, trenches, pits and stopes is a common practice to reduce physical hazards. Mine waste is often a candidate backfill material, which is used to reduce the footprint of the surface waste disposal area.

Relocation or excavation to disposal - Wastes are often relocated when:

- The existing disposal area is not suitable; and,

- There are several waste areas and consolidation of these areas to one, or more, larger areas is practical.

Designed disposal areas are a common sense and economically viable consideration.

- For long-term stability, this could include items such as relocation of waste rock to improve the stability of the side slopes and allow for vegetation of the pile.

Dry Cover - Dry covers are applied to many facilities for a variety of reasons. These covers may be simple barriers to intrusion, low permeability covers to reduce infiltration, covers to control acid generation, covers to reduce surface gamma radiation fields or covers to support vegetation. Cover materials may include local borrow, imported clays and synthetic materials and mine waste rock. The selection of the cover material would depend upon the requirements for the cover and the availability of local borrow sources.

Wet Cover - Wet covers are often used to prevent dusting and acid generation.

Concrete Capping and Bulkheads - Various designs of cast-in-place, or pre-cast concrete plugs and caps are used to prevent access to mine workings. The selection of the preferred method would be a function of the characteristics of the opening (depth to bedrock, accessibility, size, availability of materials, etc.).

Bioremediation - Bioremediation refers to the on-site use of biological degradation to treat contaminated soils (typically hydrocarbon contamination) at the site prior to on-site disposal.

A key premise to the closure options is that there will be an on-site landfill available for disposal of contaminated soils, demolition debris, miscellaneous refuse, selected designated substances/materials (e.g. properly bagged asbestos waste). As an alternative, some or all of these materials could also be taken off site to a regional disposal area, should such be developed at for example Silver Bear. For other hazardous materials not suitable for on-site management, these wastes will be shipped off-site to as approved disposal facility (e.g. PCB liquids).

TABLE 6.1-1
REVIEW OF REMEDIAL ISSUES AND OPTIONS FOR CONTACT LAKE MINE SITE

Contact Lake, NT: Closure Issues and Options Review			
The Contact Lake Mine site includes a fuel depot on Great Bear Lake and a mine area and camp adjacent to Contact Lake. The site has been well characterized and both human health and ecological risks have been assessed. The site includes a large fuel storage tank, various mine support buildings, a mine shaft and raise, several small surface pits and trenches, an open stope, a waste rock pile, residual surface tailings, a natural pond with flooded tailings, some wood and metal waste Dumps and wharfs on both Contact and Great Bear lakes. The residual mine waste at the site contains elevated levels of metals and radioactivity. Monitoring at the site indicates that there are elevated levels of metals in the tailings pond, However, the overflow from the pond has no material effect on Contact Lake. Based upon the risk assessment, the primary areas of concern relate to the area around the waste pile and tailings pond which contain elevated levels of metals in in sediments and vegetation. A risk assessment found that there were no human health issues but indicated small populations of animals could be affected by the contamination around the tailings area. The effects are localized and would not significant effect on local animal populations. As a result, much of the focus of any remedial measure would be to control physical hazards and the adoption good practice for reclamation of the site. The current NWT Mine Site Reclamation Guidelines provide a good overview of the potential reclamation requirements. The following Table identifies all facilities of potential concern at the site and addresses potential issues and identifies a list of potential reclamation options that could be considered.			
COMPONENT	**SUB-COMPONENT/ISSUE**	**REMEDIATION METHODS**	**COMMENTS**
Mine Openings			
Mine Raise – 3 x 4 m	3 m x 4 m raise opening located at the top of the cliff above the mine site yard. The opening has a wood timber cover that covers most, but not all, of the opening. Potential falling hazard.	1) Leave as is (see note 1); 2) backfill with waste or local borrow; 3) provide engineered cap (see note 3); or 4) fence opening (see note 4).	Site access difficult for capping. Good practice would be to backfill shaft if capping is not practicable, but backfill access and volumes make this difficult. Likely that a cap is most reasonable in spite of access difficulty,
Surface Open Stopes - ranging from 1 to 5 m in width	2 open stopes varying in width from 1 m at the edge of the cliff to about 5 m in width. At present these openings are secured by a fence around their perimeter but remain a falling hazard.	1) Leave as is; 2) backfill with waste or local borrow; 3) provide engineered cap; or 4) fence area.	Site access is difficult. Openings too large for capping. Good practice would be to backfill the stopes or provide engineered caps. Given site access constraints and depth of opening, may be best to fence or barrier with rock.
Long Open Vein – approximately 1 m wide up cliff	Surface opening exits along the entire cliff face from the top of the cliff to the mine yard. Because of its location on the cliff face, this opening is virtually inaccessible.	1) Leave as is; 2) backfill with waste or local borrow; 3) provide engineered cap; or 4) fence area.	For all intents and purposes this aspect of the site is not accessible. It would be reasonable to leave this area as is.
Main Shaft - 2.7 x 2.7 m (includes shaft and adjacent opening)	1.5 m x 1.5 m shaft opening is located within the headframe building. The shaft is covered by 20 cm square timbers. The timbers are in solid state and access to the main shaft is prevented through this means. Beside the shaft there is an opening of about 1.2 m x 1.2 m in dimension that is also covered by 20 cm square timbers. These timbers could likely be moved to allow access in to the vertical opening below. These openings remain a falling hazard if the timbers are removed.	1) Leave as is; 2) backfill with waste or local borrow; 3) provide concrete bulkhead; or 4) fence openings.	Site access is good. Good practice would be to backfill the shaft or provide an engineered cap.
Pits and Trenches	Shallow trench workings on the hillside above the mine site generally less than 1 m in depth. Given their location and scale, these trenches do not represent a material hazard.	1) Leave as is; 2) backfill with waste or local borrow; or 3) fencing areas.	Good practice would be to leave as is or backfill where potential falling hazard exists. Given the shallow depths of the pits, no additional remedial action is likely warranted
Buildings and Infrastructure			
Shed 1 – Powder Magazine – 2.4 x 1.9 x 2.3 m	Wood frame building with plywood floor. Sheet metal over plywood roof and aspenite walls. Skid mounted.	1) Leave as is; 2) remove contents, burn building, dispose of metal in landfill (see note 7) and reclaim footprint; 3) remove contents, demolish building and dispose in landfill and reclaim footprint (see note 2)	Good practice would be to adopt Option 2 or 3.
Shed 2 – Outhouse – 2 x 1.5 x 2.1 m	Timber frame and board siding. Plywood roof and flooring. Timber cribbed waste area.	1) Leave as is; 2) remove contents, burn building and reclaim footprint; or 3) remove contents, demolish building and dispose in landfill (see note 7) and reclaim footprint.	Good practice would be to adopt Option 2 or 3.
Shed 3 - Drill Shack – 2 x 2 x 3 m	Timber frame with board siding and roof. Earth floor. Tarpaper roofing and horse hair chinking around door.	1) Leave as is; 2) remove contents, burn building and reclaim footprint; or 3) remove contents, demolish building and dispose in landfill (see note 7) and reclaim footprint.	Good practice would be to adopt Option 2 or 3.
Shed 4 - Electrical Building – 2.6 x 2.6 x 3.2 m	Wood frame building with board walls, ceiling and floor. Tarpaper roofing on white insulation paper on both exterior and interior. Transformer on ground besides building.	1) Leave as is; 2) remove contents, burn building and reclaim footprint; or 3) remove contents, demolish building and dispose in landfill (see note 7) and reclaim footprint.	Good practice would be to adopt Option 2 or 3.

TABLE 6.1-1 (Cont'd)
REVIEW OF REMEDIAL ISSUES AND OPTIONS FOR CONTACT LAKE MINE SITE

COMPONENT	SUB-COMPONENT/ISSUE	REMEDIATION METHODS	COMMENTS
Buildings and Infrastructure (Cont'd)			
Shed 5 - Storage – 3.7 x 9.0 x 3.3 m	Timber frame with timber siding and roof. Earth floor.	1) Leave as is; 2) remove contents, burn building and reclaim footprint; or 3) remove contents, demolish building and dispose in landfill (see note 7) and reclaim footprint.	Good practice would be to adopt Option 2 or 3.
Equipment Foundations: 3 piers raised to about 0.75 mm above slab on grade max	2 concrete pads-upper and lower level. Some PHC contamination was found.	1) Leave as is; 2) break equipment foundations to slab grade and dispose concrete elsewhere on sit; 3) break up foundations and cover rubble and slab with waste or soil; or 4) Option 3 & vegetate.	Good practice would be to adopt Option 2 or 3.
Small Building Slabs: one 5 x 6 m, one 5 x 9 m	2 concrete pads, one slab on grade, the other set in rock cut complete with sump. Some PHC contamination was found.	1) Leave as is; 2) cover slabs with waste rock or soil; 3) break up slab 4) break slab and cover slab with waste or soil; or 5) Option 4 & vegetate.	Good practice would be to adopt Option 2 or 3.
Headframe/Hoisthouse and Connecting Access Corridor: HF 5 x 6.5 x 12 m; Accessway 2 x 12 x 6 m; Hoist Area 2.5 x 4 x 3 m	Timber framing with wood siding and roof. Earth floor. Fiberglass insulation in hoist building only. Tarpaper on exterior of head frame (proper) only.	Remove contents and: 1) leave as is; 2) burn structure; 3) demolish and burn structure; or 4) demolish and dispose in landfill (see note 7) and reclaim footprint.	Good practice would be to adopt Option 2 or 3.
Cabin 1 - Living Quarters - 7.1 x 5.4 x 3.3 m	Timber frame with wood siding and roof. Tarpaper roofing material. Interior is particle board over drywall. Mould on drywall paper. One marine gas tank inside.	1) Leave as is; 2) remove contents, burn building and reclaim footprint; or 3) remove contents, flooring, old roofing and rubbish to landfill (see note 7) and reclaim footprint.	Good practice would be to adopt Option 2 or 3, including removal of contents.
Cabin 2 - Living Quarters - 4.4 x 3.0 x 3.0 m	Log construction with board and tarpaper roofing. Particle board floor. Press board walls and ceiling with white paint. Transformer on ground outside building.	1) Leave as is; 2) remove contents, burn building and reclaim footprint; or 3) remove contents, demolish building and dispose in landfill (see note 7) and reclaim footprint	Good practice would be to adopt Option 2 or 3.
Cabin 3 - Living Quarters - 8.0 x 4.7 x 3.0 m	Log construction. Board roofing and flooring. Building collapsing. Floor rotten. Drywall interior with mould. Tarpaper roofing.	1) Leave as is; 2) remove contents, burn building and reclaim footprint; and 3) remove contents, demolish building and dispose in landfill (see note 7) and reclaim footprint.	Good practice would be to adopt Option 2 or 3.
Cabin 4 - Living Quarters - 4.3 x 5.2 x 3.0 m	Log construction. Board roofing and flooring. Particle board interior walls with white paint. White paint as Cabin 2. Tarpaper roofing. Horsehair chinking.	1) Leave as is; 2) remove contents, burn building and reclaim footprint; and 3) remove contents, demolish building and dispose in landfill (see note 7) and reclaim footprint	Good practice would be to adopt Option 2 or 3.
Cabin 5 - Living Quarters - 2.5 x 1.5 x 2.5 m	Log construction with board siding. Wood flooring. Tarpaper exterior siding and roofing. Waste pit sides are caving in. Tarpaper contains traces of non-friable asbestos.	Remove materials with asbestos and: 1) leave as is; 2) remove contents, burn building and reclaim footprint; or 3) remove contents, demolish building and dispose in landfill (see note 7) and reclaim footprint	Good practice would be to adopt Option 2 or 3. Special care is required to manage the asbestos materials, which can be wrapped and disposed of in the on-site landfill.
Cabin 6 - Living Quarters - 3.5 x 6.0 x 3.3 m	Timber and wood frame building. Wood flooring. Particle board walls and ceiling. Tarpaper exterior walls and roofing. White paint as in Cabin 2. Siding paper contains traces of non-friable asbestos. Interior white paint contains lead.	Remove materials with lead and asbestos and: 1) leave as is; 2) remove contents, burn building and reclaim footprint; or 3) remove contents, demolish building and dispose in landfill (see note 7) and reclaim footprint.	Good practice would be to adopt Option 2 or 3. Special care is required to manage the asbestos materials, which can be wrapped and disposed of in the on-site landfill. The materials with leaded paint must be removed off-site or special approval gained for on-site disposal.
Cabin 7 - Outhouse – 1.5 x 1.5 x 1.8 m	Wood frame and siding. Tarpaper on exterior and roof.	1) Leave as is; 2) burn building and reclaim footprint; or 3) remove building and debris to landfill (see note 7).	Good practice would be to adopt Option 2 or 3.
Cabin 8 - Core Shack – 9.1 x 6.0 x 3.0 m	Log construction with board roof and floor. Green tarpaper roofing. Roof collapsing. Horsehair chinking. Core remains outside of building.	1) Leave as is; 2) remove contents, burn building and reclaim footprint; or 3) remove contents, demolish building and dispose in landfill (see note 7) and reclaim footprint. For Options 2 and 3 removal of contents includes relocation and disposal of core in existing waste rock area.	Good practice would be to adopt Option 2 or 3.
Cabin 9 – Living Quarters - 9.4 x 4.4 x 3.0 m	Log construction with board roofing and flooring. Back room is wood panel on drywall. Front room has drywall walls and ceiling.	1) Leave as is; 2) remove contents, burn building and reclaim footprint; or 3) remove contents, demolish building and dispose in landfill (see note 7) and reclaim footprint.	Good practice would be to adopt Option 2 or 3.

TABLE 6.1-1 (Cont'd)
REVIEW OF REMEDIAL ISSUES AND OPTIONS FOR CONTACT LAKE MINE SITE

COMPONENT	SUB-COMPONENT/ISSUE	REMEDIATION METHODS	COMMENTS
Buildings and Infrastructure (Cont'd)			
Cabin 10 - Outhouse - 1.2 x 1.2 x 1.8 m	Wood frame with tarpaper siding and roofing.	1) Leave as is; 2) remove contents, burn building and reclaim footprint; or 3) remove contents, demolish building and dispose in landfill (see note 7) and reclaim footprint.	Good practice would be to adopt Option 2 or 3.
Cabin 11 - Living Quarters – 7.0 x 5.5 x 3.5 m	Log construction. Board and tarpaper roofing. Not entered, as building is collapsing.	1) Leave as is; 2) remove contents, burn building and reclaim footprint; or 3) remove contents, demolish building and dispose in landfill (see note 7) and reclaim footprint.	Good practice would be to adopt Option 2 or 3.
Cabin 12 - Living Quarters – 4.8 x 6.0 x 2.5 m	Log construction. Board and tarpaper roofing. Wood flooring. Building collapsing.	1) Leave as is; 2) remove contents, burn building and reclaim footprint; or 3) remove contents, demolish building and dispose in landfill (see note 7) and reclaim footprint.	Good practice would be to adopt Option 2 or 3.
Cabin 13 - Living Quarters	Log construction with log roof and wood flooring. Roof collapsed.	1) Leave as is; 2) remove contents, burn building and reclaim footprint; or 3) remove contents, demolish building and dispose in landfill (see note 7) and reclaim footprint.	Good practice would be to adopt Option 2 or 3.
Cabin 14 - Living Quarters	Log construction with board floor and roof. Tarpaper roofing contains traces of non-friable asbestos.	Remove materials with asbestos and: 1) leave as is; 2) remove contents, burn building and reclaim footprint; or 3) remove contents, demolish building and dispose in landfill (see note 7) and reclaim footprint.	Good practice would be to adopt Option 2 or 3. Special care is required to manage the asbestos materials, which can be wrapped and disposed of in the on-site landfill.
Machine Shop – 4.8 x 8.0 x 3.4 m	Log construction with board and tarpaper roofing. Earth floor that is heavily stained. Fiberglass chinking.	1) Leave as is; 2) remove contents, burn building and reclaim footprint; or 3) remove contents, demolish building and dispose in landfill (see note 7) and reclaim footprint.	Good practice would be to adopt Option 2 or 3.
Office - 4.9 x 3.2 x 3.0 m	Log construction with concrete floor. Wood roofing with tarpaper. Some interior wood paneling. White insulation paper.	For structure options: 1) Leave as is; 2) remove contents, burn building and reclaim footprint; or 3) remove contents, demolish building and dispose in landfill (see note 7) and reclaim footprint. For concrete slab: 1) Leave as is; 2) cover slab with waste rock or soil; 3) break up slab; 4) break up slab and cover slab with waste or soil; or 5) Option 3 + vegetate.	Good practice would be to adopt Option 2 or 3 for both the structure and the slab.
Dry - 6.0 x 6.0 x 3.8 m	Timber frame with board siding. White insulation and tarpaper on exterior. Interior is wood with white insulation paper behind wood (as office). Wood floor with vinyl floor sheeting. Vinyl flooring contains non-friable asbestos. Siding paper contains traces of non-friable asbestos. Grey paint contains lead.	Remove materials with lead and asbestos and: 1) leave as is; 2) remove contents, burn building and reclaim footprint; or 3) remove contents, demolish building and dispose in landfill (see note 7) and reclaim footprint.	Good practice would be to adopt Option 2 or 3. Special care is required to manage the asbestos materials, which can be wrapped and disposed of in the on-site landfill. The materials with leaded paint must be removed off-site or special approval gained for on-site disposal.
Shower – 1.8 x 3.6 x 3.0 m	Particle board walls and wood floor.	1) Leave as is; 2) remove contents, burn building and reclaim footprint; or 3) remove contents, demolish building and dispose in landfill (see note 7) and reclaim footprint.	Good practice would be to adopt Option 2 or 3.
Quonset Hut – 6.0 x 14.6 x 3.0 m	Steel construction. Wood partition interior. Front room has wood floor. Back room has earth floor. Blasting caps found inside building.	1) Leave as is; or 2) remove contents, demolish building and dispose in landfill (see note 7) and reclaim footprint.	Good practice would be to adopt Option 2. Note - It is planned that blasting caps will be removed in summer 2007.
Waste Rock Disposal Area			
Main Waste Pile: 26,000 m^3 over 1.6 ha	The waste rock is found in the main waste pile but was also used as foundation material for the main mine yard and some roads. The waste rock is not acid generating. Water that comes in contact with the waste rock contains low levels of metals. The waste has elevated levels of radioactivity with uranium levels ranging from 6.9 ppm to 451 ppm. Gamma fields were elevated on areas covered with waste rock or tailings and at the former mine/mill buildings associated with the historic mining activities. The highest measured mean level on a 10 m grid equalled 336 μR/h while the highest individual measurement was 598 μR/h. On an area basis, only 200 m^2 averaged over 250 μR/h, and 0.74 ha measured between 100 and 250 μR/h	1) Leave as is; 2) cover flat surfaces, or 3) reslope, apply soil cover and vegetate.	Testing shows that waste is not acid generating with minimal metal leaching that result in some elevated metals concentrations surface water at the toe of the waste rock pile. Gamma fields were elevated. Mine rock exceeds CCME soil guidelines for metals. Either Option 1 or 2 would be considered good practice. Given a lack of environmental effects, leaving the waste as is would not be an unreasonable option. Practice at Port Radium was to cover flat accessible areas where gamma measurements were above 250 μR/h to reduce gamma fields. In larger sites practice has included actions to reduce gamma fields where area averages exceeded 100 μR/h in 100 x 100 m grids. This would take minimal cover at the site and can be completed.

TABLE 6.1-1 (Cont'd)
REVIEW OF REMEDIAL ISSUES AND OPTIONS FOR CONTACT LAKE MINE SITE

COMPONENT	SUB-COMPONENT/ISSUE	REMEDIATION METHODS	COMMENTS
Waste Rock Disposal Area (Cont'd)			
Waste Rock Runoff	Surface water runoff flows along the east toe of the waste rock pile, is joined by seepage from the pile, prior to flowing across the surface tailings and into the tailings containment area. This flow has elevated metal content.	1) Leave as is; 2) redirect runoff flow away from waste rock pile drainage area; or 3) remove waste rock from flow path.	Given the limited flows, contaminant loadings are extremely small. Nonetheless, isolating up gradient runoff from contact with the waste rock by redirecting the flow, if practical, would likely result in additional reduction in loading. Option 2 or 3, whichever is more practical would be preferred.
Tailings Area			
On land Tailings – Recorded remainder from gravity concentration 200 m^3; prior deposition and eroded tailings cover approximately 2 ha (@10 cm depth = 1000 m^3)	Uncontained tailings that remain on the sloped surface grading down to a small, natural tailings pond, which has a seasonal discharge. Tailings samples had elevated levels of mercury, silver, arsenic, cobalt, copper, molybdenum, nickel, lead, antimony, uranium, and zinc, and two samples had elevated chromium. Uranium was elevated in some tailings samples with concentrations ranging from 130 ppm to 360 ppm. Gamma fields as discussed above are elevated.	1) Leave as is; 2) cover in place; 3) apply soil cover and vegetate; 4) relocate to a new disposal area (e.g. mine shaft, edge of waste rock) and reclaim disturbed area; or 5) relocate to the natural tailings pond where the tailings would be covered with water.	Given the elevated gamma field and metal levels, Option 2, 3, or 4 would be considered good practice to minimize potential exposure. Given issues with contamination in the natural tailings pond, relocation of the surface tailings to the pond may not be an acceptable option. Given the additional environmental impact associated with sourcing up to 10,000m^3 of cover material for covering in place this option causes more harm than good and is likely not appropriate. Thus consolidation prior to coverage is likely the best remedial approach.
Surface Runoff through Tailings	Runoff through the tailings contains some elevated metals. The loading may be contributed to by the waste rock and the surface tailings, and natural removal of metals may be taking place. Gamma survey of surface tailings indicate gamma radiation measurements between 50 and 250 µR/h.	1) Leave as is; 2) redirect runoff flow away from tailings to reduce up gradient drainage area and increase overland flow transit time contact; or 3) remove tailings from flow path.	Good practice would be to adopt Option 2 or 3. If tailings were considered for relocation, they could be consolidated at the edge of the waste rock pile, or disposed of in the local downgradient pond.
Flooded Tailings-Unknown quantity located in a small natural basin.	An unknown quantity of tailings are present in a small, natural pond, which has a seasonal discharge into Contact Lake. Tailings properties are discussed above. The natural basin is stable with no man-made structures. No water quality impacts from discharges have been observed. Levels of arsenic, copper, silver and uranium in the Tailings Pond on site may result in potential adverse effects primarily in phytoplankton and zooplankton within the pond. Exposure to metals such as arsenic and copper in sediments in the Tailings Pond has the potential to affect bottom feeding waterfowl and mink and muskrat and arsenic and copper exposure in vegetation and soils around the Tailings Pond has the potential for adverse effects in hare.	1) Leave as-is; or 2) relocate to a new disposal area.	Option 1 is preferred. There is minimal justification for Option 2 as there are no impacts on downstream water quality. The concentrations of metals measured in Contact Lake during the 2006 campaign are generally below applicable Canadian Water Quality Guidelines (CWQGs) for the protection of freshwater aquatic life (FAL). Removal of the tailings would likely create greater impact than leaving them in place. Small populations of animals could be impacted from sediments and vegetation in the vicinity of the tailings pond but these impacts are not expected to have any material effect on local populations.
Waste Disposal Areas			
Dump #1, #2, #3	No evidence of formal landfill sites, pits, or buried disposal sites were noted during site investigations. Existing surface dumps #1, #2, and #3 at the site are simple debris piles containing miscellaneous wood, metal and other scrap materials from either the mine or the camp.	1) Leave as is; 2) apply cover; 3) apply cover and vegetate; or 4) relocate to a new disposal area.	All options are reasonable. Good practice would be to consolidate the existing dumps into a new landfill site constructed to accommodate contaminated soils and debris from demolition.
Miscellaneous Refuse	Scrap in the form of piping and metal pieces and mining equipment was observed throughout the site and in the water along the banks of East Arm (Great Bear Lake) and Contact Lake.	1) Collect and dispose of refuse in new landfill.	Good Practice.
Fuel Storage Area			
	250,000 L above-ground storage tank and dock area are located on Great Bear Lake.	1) Remove tank and reclaim disturbed area.	Good Practice.
	The dock and debris present on land hazards and potential navigation hazard and impact on fish habitat in the water of Echo Bay East Arm	1) Remove and dispose	Good Practice

TABLE 6.1-1 (Cont'd)
REVIEW OF REMEDIAL ISSUES AND OPTIONS FOR CONTACT LAKE MINE SITE

COMPONENT	SUB-COMPONENT/ISSUE	REMEDIATION METHODS	COMMENTS
Contaminated Soils			
Petroleum Hydrocarbons (PHCs)	Small areas at the Contact Lake Mine site and the East Arm fuel storage depot have hydrocarbon contaminated soils. Five locations within the immediate area of the former mine office, shop and mill area were found to have elevated levels of F3 and F4 fraction PHCs indicative of diesel or heating fuel spills. Two samples from the fuel storage area on the East Arm reported elevated PHC results. The sample at the Tank 5 location reported the presence of heavy oil. Elevated PHC results from the fuel storage area reported significant quantities of F2 and F3 fraction PHCs. This is indicative of a diesel fuel leak or spill. Given the concentration reported at the Tank 2 location, it is possible that free product is present in the soil.	1) Leave as is; 2) excavate to new disposal area; 3) cover in place with soil; 4) cover in place with waste rock; 5) bioremediate the soils on site (see note 6 below), or 6) off-site disposal (see note 7).	Good practice for the management of soils impacted with F3/F4 fraction hydrocarbons would be Option 2, consolidate and landfill on-site with a suitable cover of clean fill placed overtop of the impacted soil. While the volume of F2 impacted soil is not known at this time, given the shallow depth of soil cover and the limited area of staining, it is expected that the volume of impacted soil would be under 20 m^3. Site specific cleanup criteria are being calculated that will be used to guide the selection of the appropriate remedial actions.
Metals/Radioactivity	Soil samples collected at disturbed sites comprised of a mixture of soils, tailings, and/or waste rock, not surprisingly, contained elevated levels of most metals when compared to soil collected from control (reference) sites. Not unexpectedly, the metal levels in soil/tailings/waste rock from the disturbed areas were greater than CCME soil quality guidelines for parkland use.	1) Leave as is; 2) excavate to new disposal area and reclaim disturbed area; 3) cover in place with soil and vegetate; or 4) cover in place with waste rock.	See comments provided for on land tailings and waste rock.
Roadways			
	Roadway connecting the mine and camp with the fuel storage depot.	1) Leave as is; or 2) scarify and vegetate.	The roadways represent minimal concern and are being overgrown by native vegetation. Good practice would be to leave the roads as is and allow natural revegetation of the disturbed road areas. Any culverts along the roadway will be identified and removed at the end of remedial works to restore long term drainage to natural conditions..
Miscellaneous			
Great Bear Lake Wharf	The former wharf located on the east Arm of Echo Bay on Great Bear Lake consists of two components including an existing dock above the water line and remnants of wooden cribbing below the water line from a former dock.	1) Leave as is; or 2) remove and dispose in new landfill at mine site, or locally, or off-site.	Either option would be reasonable. In the short term the wharf may be rehabilitated in some manner to allow for servicing the site during decommissioning.
Contact Lake Dock	Located at Contact Lake consists of a temporary wooden deck made from old wharf sections.	1) Leave as is; 2) remove; 3) burn; or 4) dispose in new landfill at mine site.	The dock needs to be replaced with a temporary wharf for servicing the site during assessment and decommissioning.
Steel Boiler (Great Bear Lake)	Contains some asbestos insulation.	1) Decontaminate and dispose to landfill (see note 7).	Good practice would be to remove asbestos to on-site landfill and dispose boiler to on-site landfill.
Wooden Ladder (parallel to Adit on cliff face)	Existing ladder on cliff face in various state of disrepair poses safety hazard.	1) Leave as is; 2) remove; 3) burn; or 4) dispose in new landfill at mine site.	Good practice would be to remove and burn materials.
Wooden Debris Piles	Several large piles of timber in various states of rot are located at the mine site.	1) Leave as is; 2) remove; 3) burn; or 4) dispose in new landfill at mine site.	Good practice would be to leave as is or burn in place.

NOTES:

1) Leave as is - This option would be reasonable where there is no physical hazard. As a general rule, good practice is to dismantle structures and reclaim the site unless there is a heritage value in retaining the structure. For waste areas, standard practice is to vegetate the area; however, in some cases allowing site to revegetate naturally is a reasonable alternative.

2) Reclaim footprint of disturbed area - The objective is to restore the area to a pre-mine condition where practical. This would typically involve general grading, soil application if required and vegetation with native plants

3) There are several designs for concrete caps that can be implemented including cast-in-place caps or pre-cast concrete slabs. The choice will depend upon site conditions.

4) Fencing is generally not preferred for a permanent closure but could be adopted especially where alternative measures are not practicable.

5) Relocation of waste would be considered when the existing site is unsuitable for waste storage or when it is cost effective to consolidate the wastes.

6) Bioremediation should be considered when contaminant leaching and or ecological effects are projected and the material is suitable for bioremediation.

7) As an alternative to on-site disposal of site waste in a landfill to be constructed for closure, off-site disposal in Silver Bear landfill could be considered for any material to be landfilled.

6.2 OVERVIEW OF THE PROPOSED REMEDIATION PLAN

Based on the review of the site assessment program findings, the risk assessment, consideration of regulatory, engineering and precedent practice, as well as the community objectives/criteria and consultation meetings, the following summary of preferred remedial actions has been developed.

Detailed discussions of current site conditions were provided previously in Chapters 3 and 4 and associated risks in Chapter 5. Section 6.1 and Table 6.1-1 above summarized the issues and concerns associated with each site component and presented the range of possible remedial options.

The following sections discuss the preferred remedial options as identified through the various consultations with aboriginal stakeholders. For additional information on the consultation process and the selection of the preferred options see Appendix A and B.

6.2.1 Mine Openings

The issues associated with the Contact Lake Mine openings revolve around the potential physical hazards associated with deliberate entry into horizontal openings and the potential for falling risks associated with vertical openings. Various remedial measures that can be considered to mitigate these risks have been discussed in Section 6.1 and summarized by component in Table 6.1-1. The following remediation options were recommended and agreed to as the preferred options during the consultation process with the exception of the open stope closure:

- ***adit*** - backfill the adit entrance with local waste rock;
- ***shaft and raise*** **–** cap the existing vertical openings; and,
- ***open stope*** **–** alternative cap (not concrete) or fencing if cap is not possible.

In regard to the preferred remedial approach for the adit, it is noted that backfilling of the adit entrance is only to a limited height (e.g. 4 to 5 m) and it is not intended that the cut along the cliff face be backfilled above this height.

In regard to the preferred remedial approach for the mine shaft and raise it is noted that while access to the mine shaft does not pose a problem, the vent raise is located on the hill above the mine yard and that access by mechanical equipment may be difficult and create significant environmental disturbances. Capping construction approaches that minimize the need for heavy equipment travel to the top of the hill will need to be considered in the final design. In this respect, alternative approaches that may have merit if acceptable to regulatory authorities are the construction of a foam seal barrier plug within the raise or use of metal sheeting to cover the opening. Both approaches require further investigation as they may not meet mandatory strength requirements. Due to the inaccessibility of this location, the mandatory strength requirements may not be practical.

In regard to the open stope, the community preferred option was to blast and collapse the surface opening of the exposed stope. A review was completed by a professional mining engineer to determine whether blasting and collapsing would remove the physical hazard of falling (Appendix C). The study found that blasting may not completely fill the stope and that voids could be left creating a potential falling hazard and the requirement to return to the site. Blasting would also reduce the stability of the stope and the final opening would be approximately three times the original width. The study also discusses the health and safety issues involving the uncertainty and guesswork associated with drilling and blasting an open stope.

Using an alternative method for capping the opening will be considered such as plugging the open stope with a foam fill or capping with metal sheeting (similar methods proposed for closing the vent raise). The construction company that secures the remediation work will be required to design a cap (design build). A review of the cap design and possible detailed analysis will be required to assess the proposed capping method to determine if it is technically viable for such a large area and acceptable to regulatory authorities. If assurance of a permanent seal can not be provided by capping the open stope, fencing would be required around the open stope to the edge of the cliff face. However, it is not recommended to continue the fencing down the face of the cliff. INAC will present and discuss the selected remedial option with the community to ensure that the community understands the closure challenges and the remedial option.

6.2.2 Buildings and Infrastructure

The facilities remaining on the main yard include, in addition to a small headframe/hoist building, several small wooden buildings including the former machine shop, electrical building, driving/storage shed, and engineering office/dry building. Ancillary buildings in the vicinity, but not directly located at the main yard area, include a small powder shed located near the tailings pond, a Quonset building located on the road to the camp, and a drill shack near the camp site. The camp area, about 0.5 km southwest of the main mine/mill area, includes 12 former residences and mine associated infrastructure buildings located near the shore of Contact Lake. There are also two or three cabins located west of the mine site on the road to the fuel storage area at the East Arm of Great Bear Lake.

The issues associated with the Contact Lake buildings and infrastructure revolves around the potential physical hazards these features present in their current state and as they deteriorate further in the future. The various features and potential remedial measures to mitigate these risks have been discussed in Section 6.1 and summarized by component in Table 6.1-1. The following remediation option was recommended and agreed to as the preferred option during the consultation process:

- ***buildings*** **–** the preferred remediation approach is to demolish the buildings after removal of any designated substances, and dispose of demolition debris/residue in an approved manner.

As a stand alone site, building material and miscellaneous debris containing leachable lead paint greater than the TDGA criteria or PCB amended paint greater than CEPA criteria will be disposed of off-site as per applicable regulations. Asbestos will be double bagged as per current guidelines for disposal and disposed of in the non-hazardous waste landfill. Disposal options for hazardous materials at the Contact Lake site may be re-evaluated in combination with nearby sites to determine if more suitable disposal options exist. If alternative disposal options are identified, additional community consultations will take place on this matter.

6.2.3 Waste Rock

Waste rock quantities at the Contact Lake Mine are limited (estimated to be in the range of some 30,000 m^3) in keeping with the nature and scale of past operations (exploration, minimal mining).

The status and issues of waste rock at the Contact Lake Mine have been discussed in Section 6.1 and summarized in Table 6.1-1. As seen from the table, remedial issues are minor and related to small areas where the rock exhibits slightly elevated gamma radiation levels and runoff water with elevated metal content.

The following remediation options were recommended and agreed to as the preferred options during the consultation process:

- ***areas with elevated radiation levels*** **–** cover or re-grade the grid areas where the 10 m by 10 m grid average exceeds 250 µR/h to reduce the grid average for these areas to below 250 µR/h; and,

- ***impacted waste rock runoff water*** **–** improve surface grading at, and in the vicinity of, the toe of the waste rock pile to minimize off-site runoff contact with the mine waste rock and eliminate standing water at the toe of the waste rock pile.

Note that from a risk perspective, given the low levels and small surface areas of elevated terrestrial gamma radiation at the site there is no risk based requirement to cover any of the materials at the Contact Lake site (Section 5.2 and 5.3). Nonetheless, for best practice and to minimize exposure as per INAC policy, it is proposed to cover those grids where the grid average exceeds 250 µR/h. Should it be desired to cover areas where terrestrial gamma radiation exceeds 100 µR/h (on a 10 m x 10 m grid basis) an additional area of about 0.2 ha of waste rock would need to be covered. While this can be undertaken, it would require somewhere in the order of 1000 m^3 of cover material, and given that the potential incremental doses from such areas are minimal and that the risk reduction from such works would also be minimal, it is likely that covering these areas would not be justified from a cost/benefit risk reduction perspective.

In regard to potential cover materials, options include using local immediately adjacent waste rock with lower radiation levels, using relocated waste rock from areas below the main waste rock pile (see discussion below), or till materials from borrow areas adjacent to the site.

Acid rock drainage and sequential extraction tests (conducted to assess bioavailability of metals) indicated that the waste rock itself is not a major source of metal leaching in the pathway for metal uptake (Section 4.12.1). The risks related to the waste rock include ingestion of standing water containing elevated metal constituents and potential metal run-off to the tailings pond (Section 5.2). With respect to minimizing the potential for water contact with the waste rock, consideration should also be given to consolidating the waste rock surface materials (and tailings, see below) to reduce surface areas exposed to runoff. In this respect, the shallow deposits of scattered waste rock stretching out from beyond the lower waste rock fan toe into the wetland on the west and towards the bush on the east, could be excavated and relocated from their present position and placed on, or adjacent to a main waste rock pile proper. Grading improvements at the toe of the waste rock will ensure that no standing water remains at the toe. This has a twofold benefit in that it reduces potential washing/dissolution of metals from the rock and also minimizes the potential ingestion pathway from standing water. Based on the risk of water pooling and run-off associated with the waste rock and the large amount of till that would be required, covering the entire waste rock area is not warranted.

6.2.4 Surface and Submerged Tailings

Surface Tailings

From a review of the operating history it is known that some 200 m^3 of the 2400m^3 gravity mill tailings that had been stockpiled below the waste rock pile were not processed and remain on site. In addition to this amount, an unknown quantity of residual tailings remains scattered on surface between the former mill site location and the edge of the tailings pond. These residual tailings are in some cases found as a very shallow layer on surface as associated with runoff and erosion deposition, in other areas in thicker layers of about 200 mm, while in other areas in small piles. The total surface area below the mill and the pond is approximately 2 ha over most of which tailings can be assumed to be present based on the gamma radiation reading. Assuming an average depth of 5 cm over this area would result in an estimated quantity of approximately 1000 m^3 of tailings being present.

The status and issues associated with tailings at the Contact Lake Mine have been summarized in Table 6.1-1. As seen from the table, remedial issues include slightly elevated gamma radiation and elevated metal concentrations. The human health and ecological risk assessment found no potential risks associated with radiological aspects (Section 5.2 and 5.3). However, it noted that the elevated metal levels enter the ecological pathway through water, soil (tailings), and vegetation uptake, which while of no concern to large animals or humans, do exceed the ecological screening index for some metals in vegetation on the tailings, indicating the potential to have an effect on small terrestrial species, such as a hare, that may use the area as its exclusive habitat (Section 5.2). The risk assessment discussed that although there is a possibility of adverse effects on individual small animals, the impacted area (surface tailings area) is very small and therefore, populations of small animals will not be affected. Notwithstanding this finding, based on industry best practice, the following remediation options were recommended and agreed to as the preferred options during the consultation process with exception to the surface tailings:

- ***residual surface tailings*** **–** consolidate and cover tailings where practical to minimize potential exposures through metal uptake in vegetation and soil to reduce the risk to small terrestrial animals; and,

- ***surface water*** **–** improve drainage to minimize surface water runoff contact with the tailings so as to reduce potential metal release into the environment.

It is noted that the during the community consultation process, the community members selected a preferred remedial approach of covering the surface tailings in place. Based on the accepted practice of placement of 0.5 m of fill for simple cover intrusion barriers, this option would require somewhere in the order of 10,000 m^3 of cover materials to be excavated and hauled to the site. As noted above, such action would likely cause more harm (e.g. habitat destruction, erosion, etc) than good. The above recommended option will result in a reduction of the footprint of the impacted area and will reduce the risk of potential effects on local species, while at the same time minimizing the impact of the remedial works in undisturbed areas. INAC will present and discuss the selected remedial option with the community to ensure that the community understands this approach.

Submerged Tailings

A natural pond exists down gradient of the mine in which tailings have been deposited as a result of unconfined gravity discharge during operation and erosion of tailings during and after operation. Field observations indicate that the tailings remain on surface at the up gradient edge of the pond as well as within the pond. As a result of the tailings and impacted water flowing into the pond, the pond sediments exhibit tailings characteristics and the pond water quality exhibits exceedences of water quality guidelines for the protection of freshwater aquatic life, although at a lower level than the incoming surface runoff water. Based on these elevated metal concentrations the human health and ecological risk assessment found that as with the residual surface tailings, there was no concern to large animals or humans. There was however the potential for adverse effects on small individual terrestrial animals (such as mink and muskrat) that use the area as their exclusive habitat (Section 5.2). No downstream effects were observed in Contact Lake indicating that contamination is localized to the small tailings pond. Although potential risks exist, given the small spatial extent of the area and the conservative assumptions used in the risk assessment, there is no potential to impact the species population (SENES 2007b). The following remediation option was recommended and agreed to as the preferred option during the consultation process:

- ***tailings pond*** **–** leave as is (risk manage and monitor) and control source of potential additional metals entering into the pond by consolidating and covering the tailings above the tailings pond where practical.

In regard to the above recommendation it is noted that relocating and covering, tailings from the edge of the pond would be carried out as part of the recommended action with respect to surface tailings. It is also noted that the water quality measured at the shoreline of Contact Lake below the tailings pond meets all water quality criteria. Although the water quality guidelines were exceeded in the pond, the Contact Lake receiver is not being impacted. An estimation of potential loadings of metals and radionuclides to Contact Lake from the mine site (discussed in Section 4.9) also supports this conclusion as contributions attributable to the mine were determined to be a small fraction of the applicable criterion (e.g. site drainage could contribute up to 1.9% of the arsenic criterion and 2.4 % of the copper criterion). Removing the submerged tailings to mitigate an unlikely potential effect would likely do more harm than good, as it would result in significant impacts on the pond itself and likely result in the mobilization of tailings and the release of impacted tailings water containing elevated contaminants to Contact Lake.

6.2.5 Waste Disposal Areas

Three very small surface waste disposal sites remain at the Contact Lake Mine. Two of the sites are located in close proximity to each other just north of the camp site and contain domestic debris, primarily tin cans. The third waste dump area is in the vicinity of the mine site and contains an assortment of metal, wood, and barrel debris. No excavations are associated with these dumps. The estimated quantity of material at the dumps is provided in Table 3.3-1.

The status and issues associated with debris at the Contact Lake dumps have been summarized in Table 6.1-1. Based on the findings of the report and as summarized in the table, the dumps present very limited risks associated with physical hazards and minor metal and hydrocarbon contamination. The following remediation option was recommended and agreed to as the preferred option during the consultation process:

- ***waste disposal areas*** - consolidate waste and debris in a landfill along with some contaminated soil and building debris.

It is noted that the west end of the mine site offers an area that could be developed as a small landfill site. As well, disposal of relocated waste materials against the toe of the west end of the waste rock pile could also be used to safely burn materials and dispose of the ash. Waste disposed in this area can be covered by local waste rock from the pile, or with materials available from the relocation waste rock and/or tailings, or with local native borrow materials.

6.2.6 East Arm Fuel Storage Tank and Dock Area

A fuel storage tank remains along with a dock on the shore of the East Arm of Great Bear Lake. The fuel storage tank is essentially empty but contains some residual oily water. The dock is in a state of disrepair including both the remaining sand filled crib which may impact fish habitat as it continues to deteriorate while the submerged and exposed dock cribbing presents a hazard to navigation. Sediments in area in the immediate vicinity of the dock have been impacted by past activities.

The status and issues associated with this area have been summarized in Table 6.1-1. The issues associated with these features revolve around the potential risk associated with future leakage of oily water and the physical hazard and potential fish habitat degradation associated with the remaining dock structures. The area of impacted sediments is localized to the dock area and benthic testing shows that the current status of benthic communities in this area is comparable to those in background locations (Section 4.11.3). The following remediation options were recommended and agreed to as the preferred options during the consultation process with the exception of the impacted sediments:

- ***fuel storage tank*** – demolish and dispose of tank after removal and disposal of oily water;

- ***miscellaneous debris*** – pick up miscellaneous on land and in water debris and dispose in a consolidated disposal area;

- ***dock and crib structures*** – remove and dispose of these structures and debris in a landfill along with some contaminated soil and building debris; and,

- ***impacted sediments*** – leave as is as any intervention would do more harm than good.

In regards to the impacted sediments, the remediation options for the sediments were not presented during the community consultation meetings because additional work was pending (results of the benthic study). INAC will present and discuss the selected remedial option with the community to ensure that the community understands this approach.

The estimated quantities of materials for cleanup, demolition and disposal are provided in Table 3.3-1. While it is expected that the disposal of tank, dock, boiler and equipment and miscellaneous debris will be at the Contact Lake Mine site disposal area, disposal in an approved area more local to the East Arm may be an acceptable alternative. The disposal of oily water in the tank will be in accordance with the GNWT Environmental Protection Act on Used Oil and Waste Fuel Management Regulations (2003).

It is noted that the dock removal and removal of timber cribbing below the water line will be done so that disturbance to fish habitat and stirring of the impacted sediments is minimized.

6.2.7 Hydrocarbon Impacted Soils

Limited areas and quantities of hydrocarbon impacted soils and waste rock exist at the mine and related areas as shown in Table 3.3-1. The various locations and potential remedial issues and mitigation measures have been discussed in Section 6.1 and summarized by component in Table 6.1-1. Site-specific clean-up criteria are currently being developed that will determine how PHC contaminated soils from each impacted area identified at the site will be handled. Consultation and regulatory approval are still pending on this issue.

6.2.8 Miscellaneous Debris

As with other abandoned mine sites, miscellaneous equipment and debris remain at the Contact Lake Mine site including steel cables, tracks, drill steel, bars, as well as miscellaneous mine and surface equipment. There is also a limited amount of debris along the Contact Lake shoreline. The quantities of these materials are small being in keeping with the limited size and nature of the former exploration and mining activities. The estimated quantities of these materials are as shown in Table 3.3-1. The following remediation option was recommended and agreed to as the preferred option during the consultation process:

- ***miscellaneous debris*** - consolidate on land and shoreline waste and debris in a landfill along with some contaminated soil and building debris.

6.2.9 Roadway

Partially overgrown site roads connect the camp at Contact Lake to the mine and to the fuel depot area at the East Arm of Great Bear Lake. There are limited environmental issues associated with these roads. The following remediation option was recommended and agreed to as the preferred option during the consultation process:

- ***on site roads*** **–** after completion of the remedial works remove any culverts and return drainage to natural conditions then leave the road as is for natural re-vegetation.

The remediation plan for culvert removal will be developed to ensure proper stream channel design, fish passage (if required), and long-term stability of the stream bed and banks at each location.

If roads are upgraded for use, they will be scarified and left for natural re-vegetation at completion of the remedial works.

6.2.10 Conclusion

Physical and chemical hazards exist at the Contact Lake site and the remediation plan attempts to address these hazards.

The physical hazards of the site are addressed by the remediation options chosen for the buildings (demolition), small dumps and miscellaneous debris (consolidation), dock structure (removal), and mine openings (capping and/or fencing). The chemical hazards are addressed by the remediation options chosen for the buildings (removal of hazardous material prior to demolition), waste rock (covering the elevated gamma areas), and contaminated soil (consolidation in a landfill and/or treatment).

The risks identified in the HHERA were associated with the tailings pond and surrounding area (on-land tailings and waste rock). Although there are elevated metals in the water and sediment of the tailings pond, the risk associated with the pond is limited to individual small animals and not to populations of animals. Since the risk is minimal and the potential for redistribution of metals to Contact Lake is likely if the pond is disturbed, the pond will be left as is, risk managed, and monitored. The source of the metals to the tailings pond and the on-land risk to small individual animals is being addressed by the remediation options chosen for the on-land tailings (consolidation and covering) and the surface water runoff (improve drainage to minimize contact with waste rock and tailings and to eliminate standing water).

The conservation of fish habitat will be addressed by the removal of the dock on the East Arm of Echo Bay of Great Bear Lake and restoration of any culverts to ensure proper stream channel drainage and long-term stability of the stream bead and banks.

The remediation options presented in this report were based on the review of the site assessment program findings, the risk assessment, consideration of regulatory, engineering and precedent practice, as well as the community objectives/criteria and consultation meetings.

7.0 MONITORING

The remedial actions outlined in Section 6 will require a commitment to monitoring, both during the implementation phase of the project, and after the remediation is complete. As a first step and in keeping with INAC's "*Mine Site Reclamation Guidelines for the Northwest Territories*" (INAC 2006b) a 'Reclamation Completion Report' will be completed following the remediation of the site which will compare the actual remedial works completed to the RAP to ensure consistency.

Monitoring during implementation will include water quality monitoring in the environment around the site. The potential impact of the remediation work on wildlife would also be monitored. A designated health and safety officer would be on site at all times during the implementation, with the primary role of monitoring the health and safety of site workers. The monitoring could include dust monitoring, when there is any risk of airborne dust affecting site workers, gas monitoring for access closed spaces such as mine adits and any other occupational monitoring required ensuring a safe work place. As per the INAC's "*Mine Site Reclamation Guidelines for the Northwest Territories*" (INAC 2006b), a 'Performance Assessment Report' will be completed following the monitoring of the site to determine that site objectives and performance criteria are being met.

Monitoring after remediation is completed will assess the performance of the remedial measures compared with the original objectives and will allow any necessary maintenance or corrective action to be taken in a timely manner. The site is remote and difficult to access and therefore the design of the remedial measures was intended to minimize the need for maintenance and long term monitoring.

Two types of post-remediation monitoring are anticipated; performance monitoring and environmental monitoring. These are discussed in the following sections.

7.1 PERFORMANCE MONITORING

Performance monitoring will be required for all of the remediation measures that require construction including the cover on the exposed tailings, the landfill(s), any drainage controls, and the seals/barriers for mine openings. The performance of these facilities will be measured in terms of physical stability, erosion and sedimentation. Performance monitoring will be undertaken on an annual basis for a period of at least five years following completion of the remediation works. The monitoring will continue in the long term, but the results of monitoring in the immediate post-implementation phase will determine the frequency and scope of the longer term requirements.

The performance monitoring will include annual inspections by an appropriately qualified engineer of all civil works, landfills and mine seals. The inspections will assess the physical stability of the features and the performance with respect to erosion. The results of all inspections will be documented in annual reports to INAC, including any recommendations for maintenance or corrective actions.

On site water quality will be monitored. At a minimum, this would involve surface water monitoring in Upper Lake, runoff in the drainage area immediately downstream of the waste rock and any landfill area, as well as the existing small “tailings” pond. The landfill monitoring could also include surface or groundwater monitoring close to the disposal site, depending on the design of the landfill, the nature of materials disposed of and site conditions. No groundwater monitoring will be performed as this is not a pathway of concern for the Contact Lake Mine.

7.2 ENVIRONMENTAL MONITORING

Monitoring of environmental quality in Contact Lake and the East Arm of Great Bear Lake will continue in conjunction with the performance monitoring of remediation measures. Environmental monitoring will be undertaken on an annual basis during the implementation phase, and for a period of at least five years following completion of the remediation works. Surface water quality will be the primary focus of the environmental monitoring program and is expected to include water sampling at shoreline stations as well as stations in open water locations adjacent to the former mine features and where runoff from the mine site area enters the lakes.

Environmental monitoring will continue in the longer term, but the frequency and scope of the work will be reduced.

7.3 CARE AND MAINTENANCE

Long-term care and maintenance activities will include any activities that are required to ensure the ongoing integrity and performance of the remedial works and any additional works that may be required to ensure that the impacts of past site activities are mitigated within the context of best practice and the specific commitments of this remedial action plan.

8.0 REMEDIATION SCHEDULE

The remediation of the Contact Lake mine site is scheduled to occur in conjunction with the remediation of eight other sites including the five Silver Bear mine sites, the two El Bonanza mine sites, and the Sawmill Bay site. The remedial action plan will be submitted for screening by regulatory authorities to determine the permits or licences that may be required to implement the plan.

The following general project activities and milestones are anticipated for the design and implementation of the remedial plan.

- 2008 - preparation of detailed plans, engineering designs, specifications, cost estimates and contract tender documents, contract tendering, application for necessary permits.
- 2009 - initiate remediation of the site(s).
- 2011 - completion of remedial program.
- 2012 - begin post-remediation monitoring.

The schedule may change depending on procurement approach, contract award, and regulatory approval.

9.0 REFERENCES

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APPENDIX A

COMMUNITY CONSULTATION RECLAMATION OPTION ASSESSMENT TABLES

Contact Lake Mine Site

Indian and Northern Affairs Canada
Affaires indiennes et du Nord Canada

Contact Lake - Options for Clean Up

Canada

Site Objectives

- Minimize human health and safety risks
- Protect fish, wildlife and vegetation
- Protect water quality
- Minimize environmental impacts during remediation
- Return the site as close to original condition as possible
- Minimize long term care and maintenance
- Cost effective

☺ Good – Meets Goal

😐 OK - Somewhat meets goal

☹ Bad - Least likely to meet goal

Not Applicable

P= Preferred option

A= Acceptable option

NA= Not acceptable option

Contact Lake

Remedial Options Tables

Buildings at Contact Lake

Building conditions

- Safety Hazard
- Visual attraction to site
- Some chemical hazards (lead paint, DDT, asbestos)

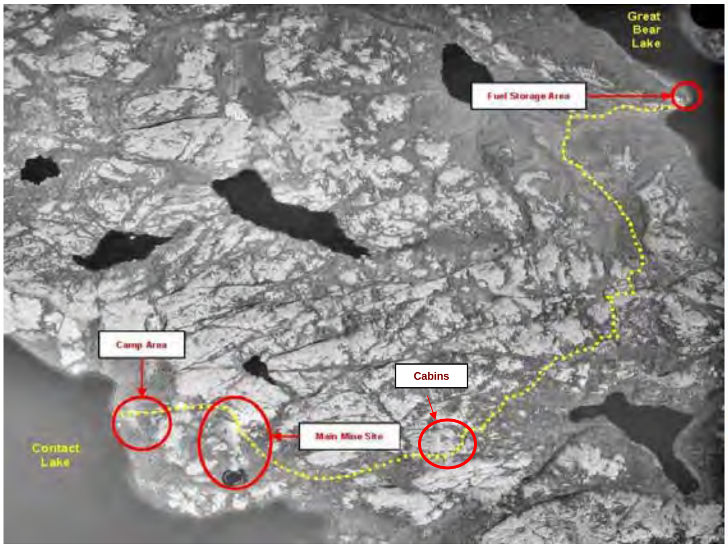
Buildings – Options

- Recycling of material where possible
- Removal of hazardous materials

1. Leave as is (transfer ownership)
2. Demolish buildings

Goals / Options Buildings (all options include decontamination)	Leave as is - for other use	Demolish buildings
Health and safety	Bad	OK
Protect fish, wildlife and vegetation	OK	OK
Protect water quality	NA	NA
Minimize environmental impacts during Remediation	Good	OK
Minimize Long term care and maintenance	Bad	Good
Return site to its original condition where possible	Bad	Good
Is cost effective	Good	OK
Acceptable / Preferred / Not Acceptable	Not Acceptable	Preferred

Roads



Roads – Existing Conditions

- Road connects mine and camp with fuel storage depot
- Roads are overgrown in many areas

Roads – Options

1. Leave as is (natural re-vegetation)
2. Scarify roads
3. Scarify roads and vegetate

Goals / Options Roads	Leave as is (natural re-vegetation) and remove culverts (as required)	Scarify all roads	Scarify all roads and vegetate
Health and safety	Good	OK	OK
Protect fish, wildlife and vegetation	OK	OK	Good
Protect water quality	Good	Bad	Bad
Minimize environmental impacts during Remediation	Good	Bad	Bad
Minimize Long term care and maintenance	Good	OK	OK
Return site to its original condition where possible	OK	OK	OK
Is cost effective	Good	OK	OK
A / P / NA	Preferred	Not Acceptable	Not Acceptable

Small Dumps and Debris

Small Dumps and Debris include:

- Three small dumps
- Old equipment, house hold garbage, vehicle parts
- Metal scrap

Dumps and Debris Conditions

- Small areas of soil with elevated metals (for example arsenic, lead, and zinc) and hydrocarbons (oil)
- No PCBs were detected
- Could be uptake of metals by wildlife and plants
- Physical hazard – could be injury to people and animals

Small Dumps and Debris – Options

All options include general clean up of the site

1. Leave as is
2. Cover with soil
3. Cover with soil and plant vegetation
4. Move to new landfill

Goals / Options **Dumps and Debris – All options include general site clean up**	Leave as is	Cover with soil	Cover with soil and plant vegetation	Move to new landfill (including soil with metals at dumps)
Health and safety	Bad	OK	OK	Good
Protect fish, wildlife and vegetation	Bad	OK	OK	OK
Protect water quality	Bad	OK	OK	Good
Minimize environmental impacts during remediation	Good	OK	OK	OK
Minimize Long term care and maintenance	Bad	OK	OK	OK
Return site to its original condition where possible	Bad	OK	OK	Good
Is cost effective	Good	OK	OK	OK
A / P / NA	Not acceptable	Not Acceptable	Acceptable	Preferred

---

Mine Openings

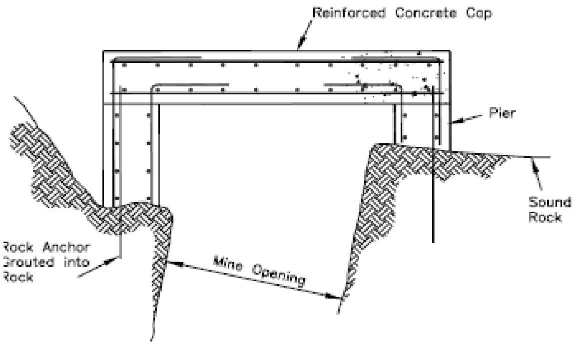
Environmental Conditions

- Contact Lake
  - 1 mine raise and 1 mine shaft
  - Falling hazards

Mine Openings – Options

1. Leave as is
2. Cap (e.g. concrete)
3. Build fence around openings

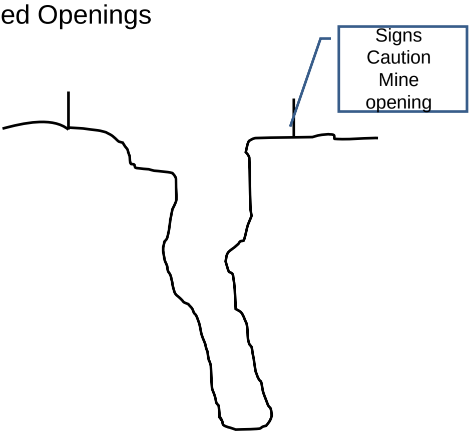
Option 2 – Cap



TYPICAL CROSS–SECTION OF CONCRETE CAP ON PIERS
FOR VERTICAL/INCLINED OPENING

Option 3

Fenced Openings



Goals / Options Mine openings (shafts and raises)	Leave as is	Cap	Build fence around areas
Health and safety	Bad	Good	OK
Protect fish, wildlife and vegetation	Bad	Good	Bad
Protect water quality	NA	NA	NA
Minimize environmental impacts during remediation	Good	OK	OK
Minimize Long term care and maintenance	Bad	Good	Bad
Return site to its original condition where possible	Bad	Good	Bad
Is cost effective	Good	OK	OK
A / P / NA	Not acceptable	Preferred	Not acceptable

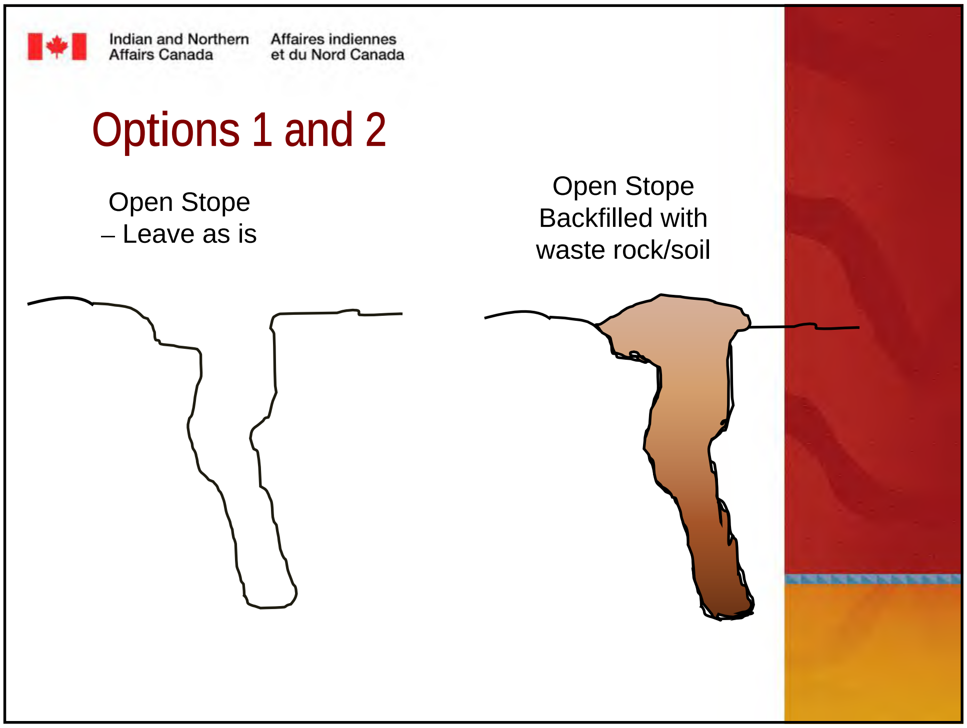
Large Mine Opening at Contact Lake

Environmental Conditions

- Large opening
- Falling hazard

Large Mine Opening – Options

1. Leave as is
2. Backfill with waste or local borrow
3. Cap with concrete (likely not practical)
4. Build fence around area
5. Build rock barrier around area
6. Blast and collape opening



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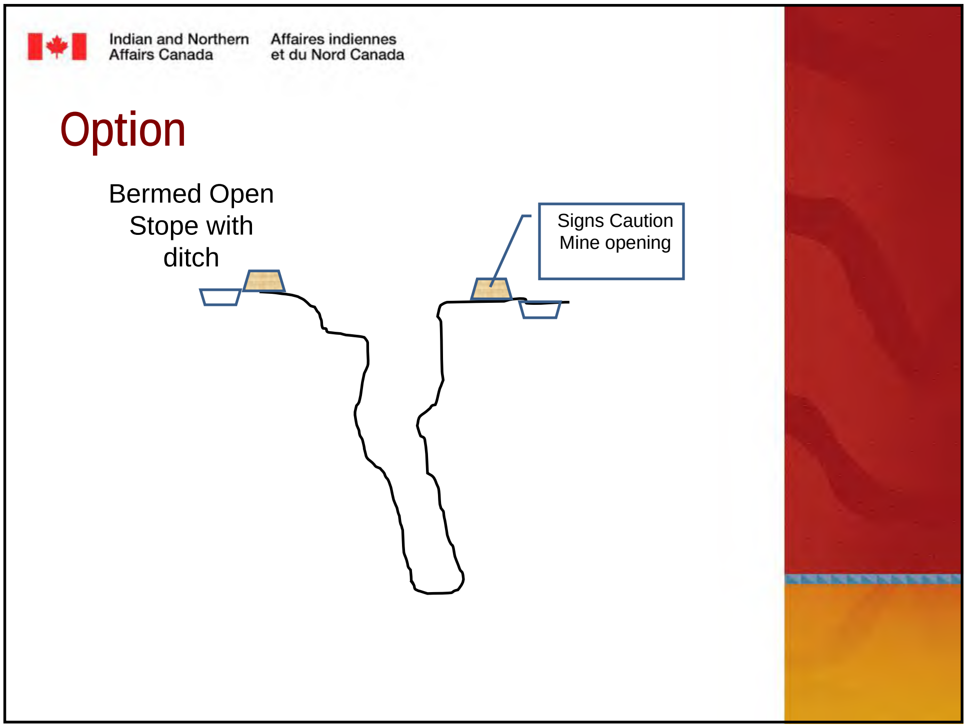
Options 1 and 2

Open Stope
– Leave as is

Open Stope
Backfilled with
waste rock/soil



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Option

Bermed Open
Stope with
ditch

Goals / Options Large Mine Opening at Contact Lake (stope)	Leave as is	Backfill with waste rock	Build fence around area	Build rock barrier around area	Blast and collapse opening
Health and safety	Bad	Bad	OK	Bad	OK
Protect fish, wildlife and vegetation	Bad	OK	OK	Bad	Good
Protect water quality	NA	NA	NA	NA	NA
Minimize environmental impacts during remediation	Good	Bad	OK	Bad	OK
Minimize Long term care and maintenance	Bad	Bad	Bad	Bad	OK
Return site to its original condition where possible	Bad	OK	Bad	Bad	OK
Is cost effective	Good	Bad	OK	OK	OK
A / P / NA	Not acceptable	Acceptable	Not acceptable *(see minutes)	Not acceptable	Preferred

Goals / Options Mine opening- Adit	Leave as is	Backfill entrance	Concrete bulkhead	Build fence around opening
Health and safety	Bad	Good	OK	OK
Protect fish, wildlife and vegetation	Bad	Good	OK	Bad
Protect water quality	NA	NA	NA	NA
Minimize environmental impacts during remediation	Good	OK	OK	OK
Minimize Long term care and maintenance	Bad	Good	OK	OK
Return site to its original condition where possible	Bad	OK	Bad	Bad
Is cost effective	Good	OK	OK	OK
A / P / NA	Not acceptable	Preferred	Acceptable	Acceptable (with wood)

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Dock at East Arm of Great Bear Lake

- Physical Hazard

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Contact Lake and Great Bear Lake Docks - Options

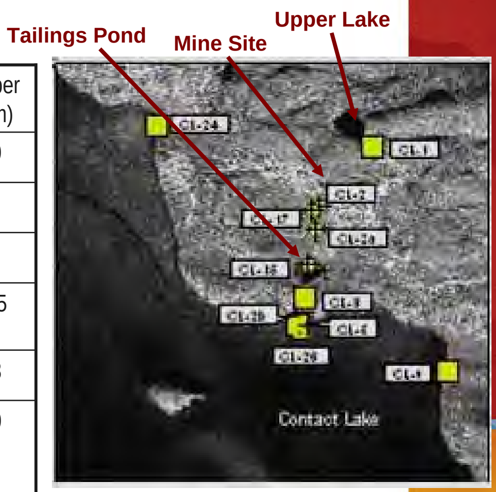
1. Leave as is
2. Remove docks and dispose of material

Goals / Options Docks at Great Bear Lake at Contact Lake Site	Leave as is	Remove and dispose material
Health and safety	Bad	Good
Protect fish, wildlife and vegetation	Bad	Good
Protect water quality	Good	OK
Minimize environmental impacts during remediation	Good	OK
Minimize Long term care and maintenance	Bad	Good
Return site to its original condition where possible	Bad	Good
Is cost effective	Good	OK
A / P / NA	Not acceptable	Preferred

Contact Lake Drainage

Contact Lake Drainage Water Quality

Sampling Site	Arsenic (ppm)	Copper (ppm)
Upper Lake	0.5	7.0
Waste Rock Area	237	50
Tailings Pond	27	18
Drainage from Tailings Pond	13	11.5
Contact Lake	0.2	0.8
Guideline (Freshwater for Aquatic Species)	5.0	2.0



Contact Lake Water Quality

- Modelling showed that loadings to Contact Lake are minimal
- Water quality improves as it gets closer to Contact Lake with all measurements meet the guidelines in Contact Lake water

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Risk Assessment Findings

- Metals in sediments in the Tailings Pond have some potential to affect bottom feeding waterfowl, mink and muskrat
- Metals in vegetation and soils around the Tailings Pond have some potential to affect small animals such as a hare
- The environmental conditions at Contact Lake are not expected to affect large animals such as bear, moose, and caribou
- Levels of radionuclides found at Contact Lake are not expected to affect animals
- The environmental conditions at Contact Lake are not expected to affect people

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Waste Rock at Contact Lake

Waste Rock Conditions

- Main Pile (26,000 m^3 over 1.6 hectares)
- Slopes appear to be stable
- Limited leaching of metals (e.g. arsenic)
- Waste Rock (non-acid generating)
- The waste rock has elevated levels of gamma radiation – 200 m^2 averaged over 250 uR/h

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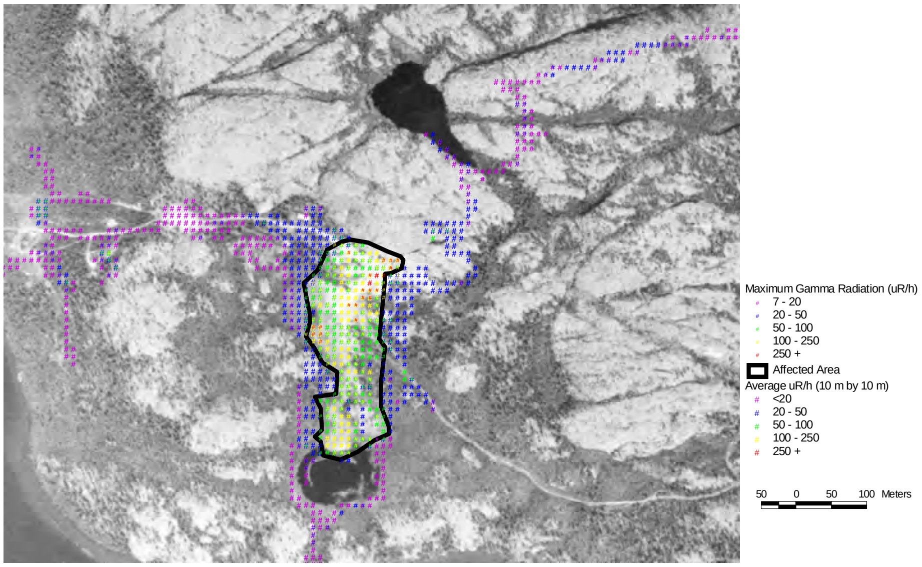

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Waste Rock – Options

1. Leave as is
2. Cover elevated gamma areas (to a level to be determined)
3. Cover entire waste rock pile
4. Redirect runoff flow away from waste rock pile
5. Improve drainage

Goals / Options Waste Rock Contact Lake	Leave as is (except for use in other areas)	Cover elevated gamma areas	Cover entire waste rock area	Redirect flow around waste rock
Health and safety	OK	Good	OK	OK
Protect fish, wildlife and vegetation	Bad	Good	OK	Good
Protect water quality	Good	Good	OK	Good
Minimize environmental impacts during remediation	Good	OK	Bad	Good
Minimize Long term care and maintenance	Good	OK	Bad	OK
Return site to its original condition where possible	Bad	Bad	Bad	OK
Is cost effective	Good	OK	Bad	OK
A / P / NA	Not Acceptable	Preferred*	Not Acceptable	Preferred*

On land tailings at Contact Lake

Tailings Conditions

- Small quantity of exposed tailings (200 m^3)
- The leach test showed that tailings are likely contributing metals (arsenic and copper) to water quality of the Tailing Pond
- Non-acid generating
- The tailings have some elevated levels of gamma radiation
- Plants were collected in the tailings area and had elevated levels of some metals

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Tailings – Options

1. Leave as is
2. Redirect runoff around tailings
3. Cover (with soil)
4. Complex cover
5. Move to a new disposal area (e.g. mine shaft or in tailings pond)

Goals / Options Exposed Tailings Contact Lake	Leave as is	Improve runoff	Cover exposed areas to Pond (soil)	Complex cover	Move tailings to a new disposal area	Move tailings into pond
Health and safety	OK	OK	Good	Good	Bad	Bad
Protect fish, wildlife and vegetation	Bad	OK	Good	Good	OK	OK
Protect water quality	Good	Good	Good	Good	OK	Bad
Minimize environmental impacts during remediation	Good	OK	OK	OK	Bad	Bad
Minimize Long term care and maintenance	OK	OK	OK	Bad	OK	Good
Return site to its original condition where possible	Bad	OK	Good	OK	OK	Good
Is cost effective	Good	OK	OK	Bad	Bad	OK
A / P / NA	Not acceptable	Preferred*	Preferred*	Acceptable	Not acceptable	Not acceptable

Tailings Pond Environmental Conditions

- Unknown quantity of tailings in small, natural pond
- Seasonal water discharge to Contact Lake
- Elevated metals in the water and sediment of the Tailings Pond (metals don't meet the guidelines)
- Water quality meets guidelines in Contact Lake water

Tailings Pond – Options

1. Leave as is and control source
2. Move tailings to a new disposal area

Goals / Options Tailings Pond Contact Lake	Leave as is (control sources above)	Move tailings to a new location
Health and safety	Good	Bad
Protect fish, wildlife and vegetation	Good	Bad
Protect water quality	Good	Bad
Minimize environmental impacts during remediation	Good	Bad
Minimize Long term care and maintenance	Good	OK
Return site to its original condition where possible	OK	OK
Is cost effective	Good	Bad
A / P / NA	Preferred	Not acceptable

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Hydrocarbons in soil

Hydrocarbons in Soil

- Oil and heating fuel in soil around the buildings and in the small dumps
  - Concern is with surface contact
  - Approximately 30 m^3
- Diesel in soil at the fuel storage area
  - Concern is with movement of diesel into nearby water
  - Approximately 7.5 m^3

Hydrocarbons in the Soil - Options

1. Relocate to landfill or off site (smaller quantities high risk areas)
2. Cover in place (less mobile hydrocarbons)
3. Alternative option used for more mobile hydrocarbons (Bioremediate or landfarm)

Issues will be addressed along with Silver Bear hydrocarbon remediation program

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Outstanding Issues for Discussion

- Sediment results from Great Bear Lake
- Hydrocarbon remediation program

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Contact Lake Mine Site Remediation Plan Community Consultations

November 13th , 14th 2007

By Julie Ward and Jessica Mace

Canada

Indian and Northern Affairs Canada   Affaires indiennes et du Nord Canada

Outline

- Location and History of the site
- Site assessment findings
  - Buildings and openings
  - Soil Quality
  - Water Quality
- Options for clean up
  - Description of options
  - Options tables

Canada

Site Location and History

- The abandoned Contact Lake mine site:
  - Located 275 km northeast of Déline on the north shore of Contact Lake, 14 km southwest of Port Radium
  - Developed in various stages from the 1930’s to 1970’s for silver and some uranium
    - The ore was milled for silver but never for uranium
    - Tailings and ore were transported to Port Radium for milling for uranium
    - No Waste Nuclear Substance License required from the Canadian Nuclear Safety Commission

Canada

Contact Lake Mine History

- 1931 – Staked as a silver mine
  - Bear Exploration and Radium Limited.
  - staking, exploration, development and construction of a 25 ton/day mill
  - Silver was milled up to the end of 1939
- 1942 – the International Uranium Mining Company Ltd. acquired the property explored until 1949
- 1969 – further exploration until it was abandoned in 1975
- 1979 – reported that about 4,500 tons of ore and/or tailings were transported to the Echo Bay mill at Port Radium in 1979.

Canada

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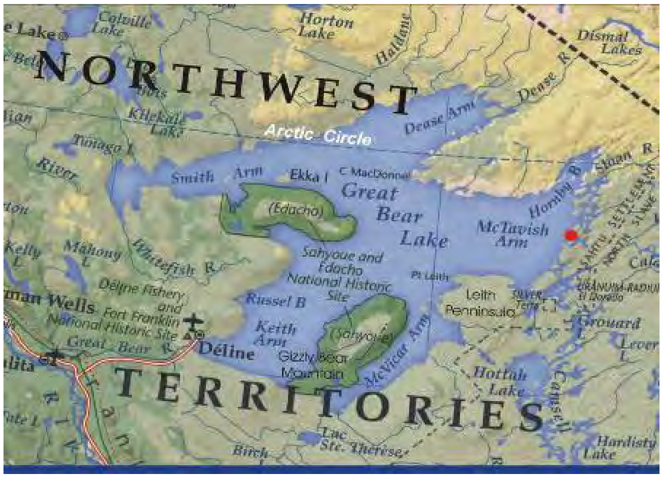
Location and Setting



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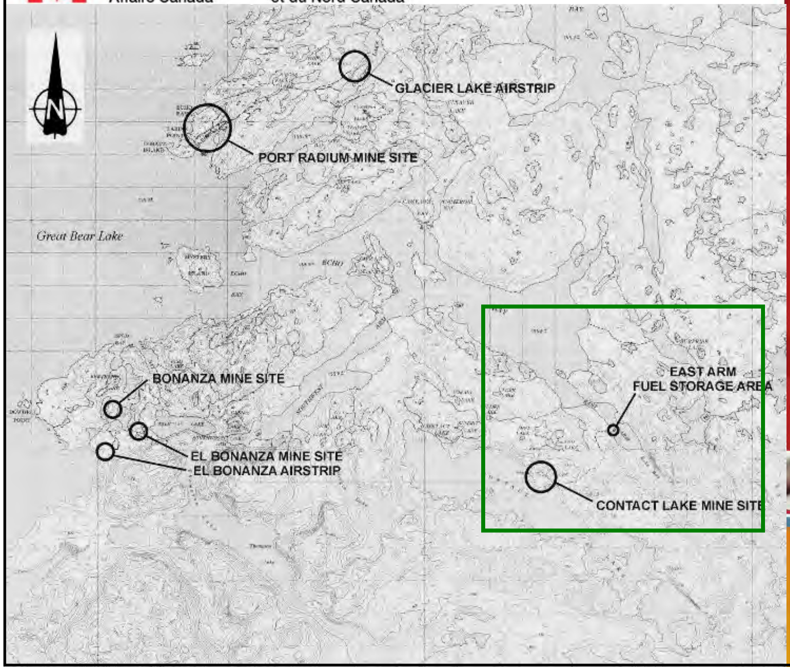

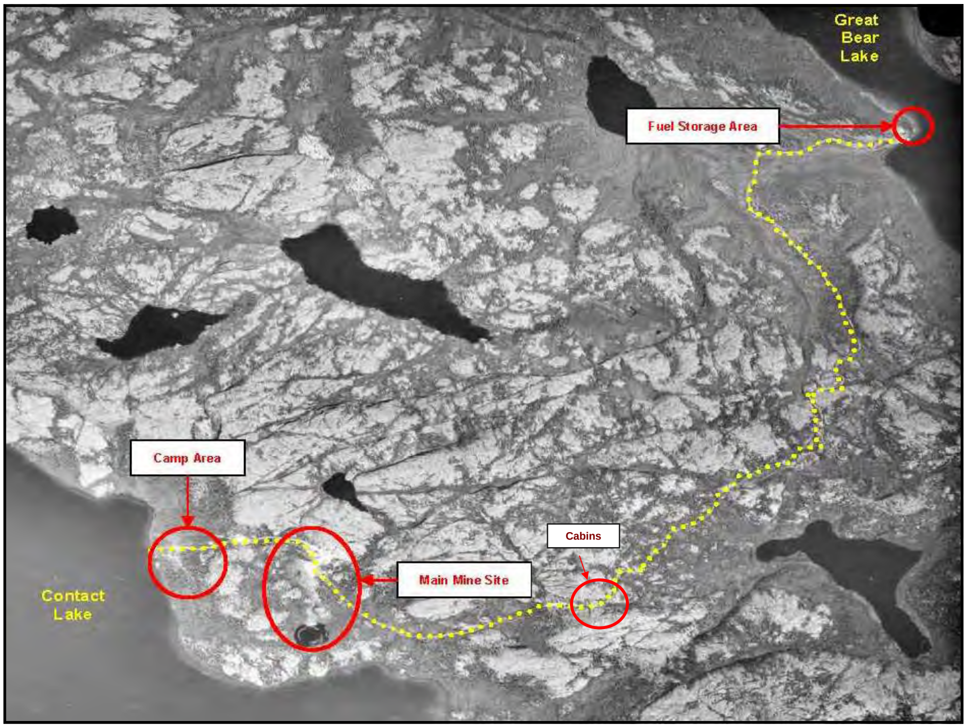

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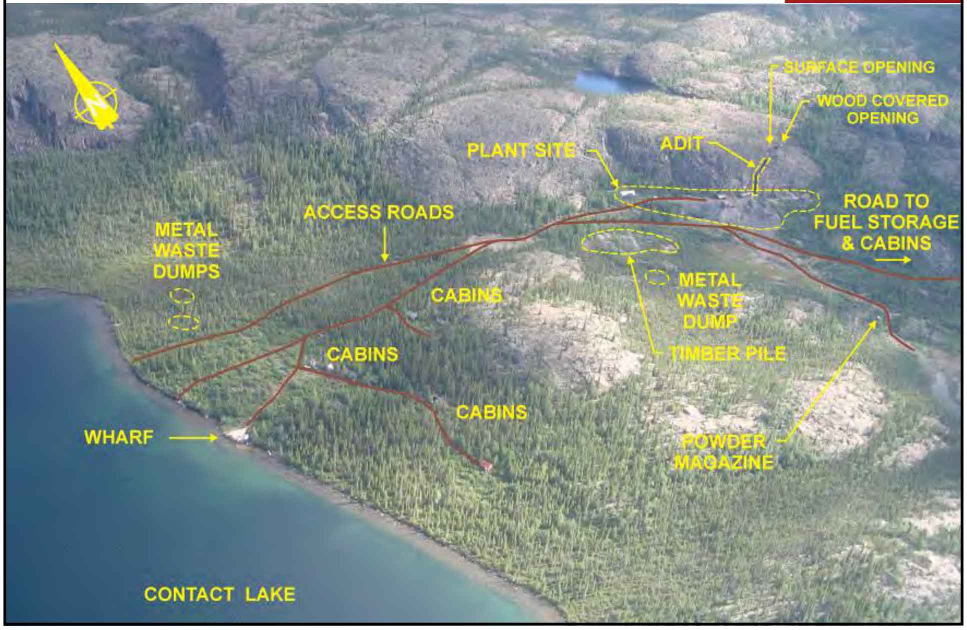

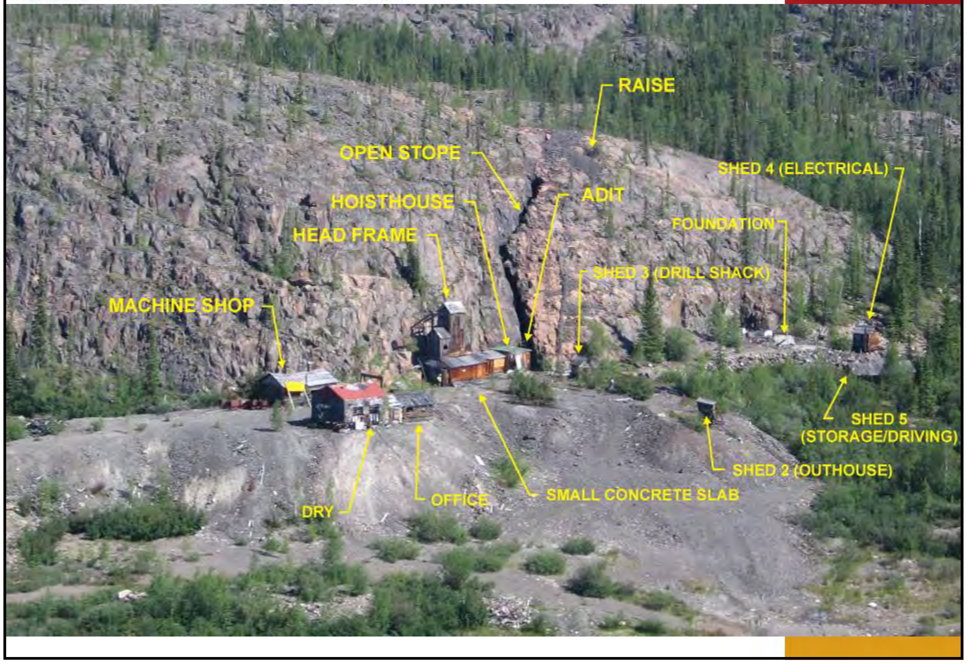
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SHED 4 (ELECTRICAL)
ADIT
HOISTHOUSE
FOUNDATION
HEAD FRAME
SHED 3 (DRILL SHACK)
MACHINE SHOP
SHED 5 (STORAGE/DRIVING)
SHED 2 (OUTHOUSE)
SMALL CONCRETE SLAB
OFFICE
DRY

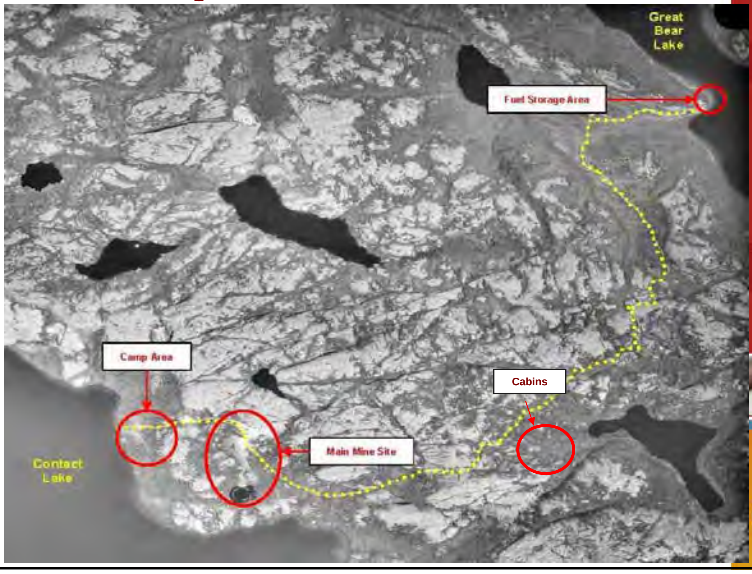

N
ROAD TO MINE SITE
FUEL STORAGE TANK
ECHO BAY EAST ARM
WHARF
CONCRETE FOOTINGS

Site Assessments

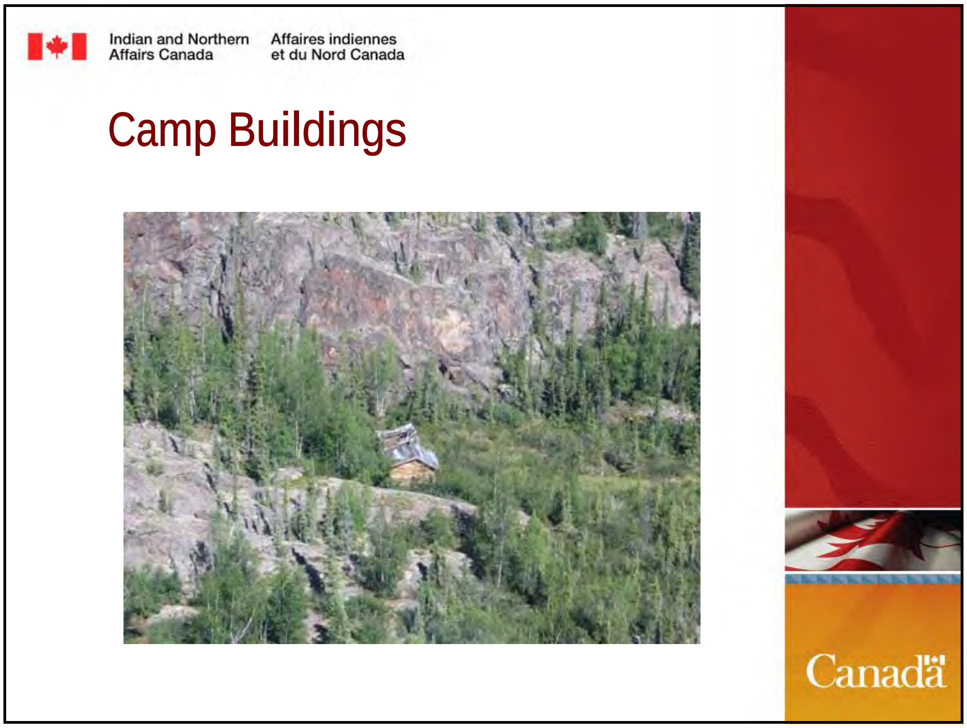
- Environmental monitoring & assessments 1993
- Surface water, groundwater, and soil samples from 2002 to 2005
- 2006 detailed site assessment program
- 2007 additional site assessment

Site Details

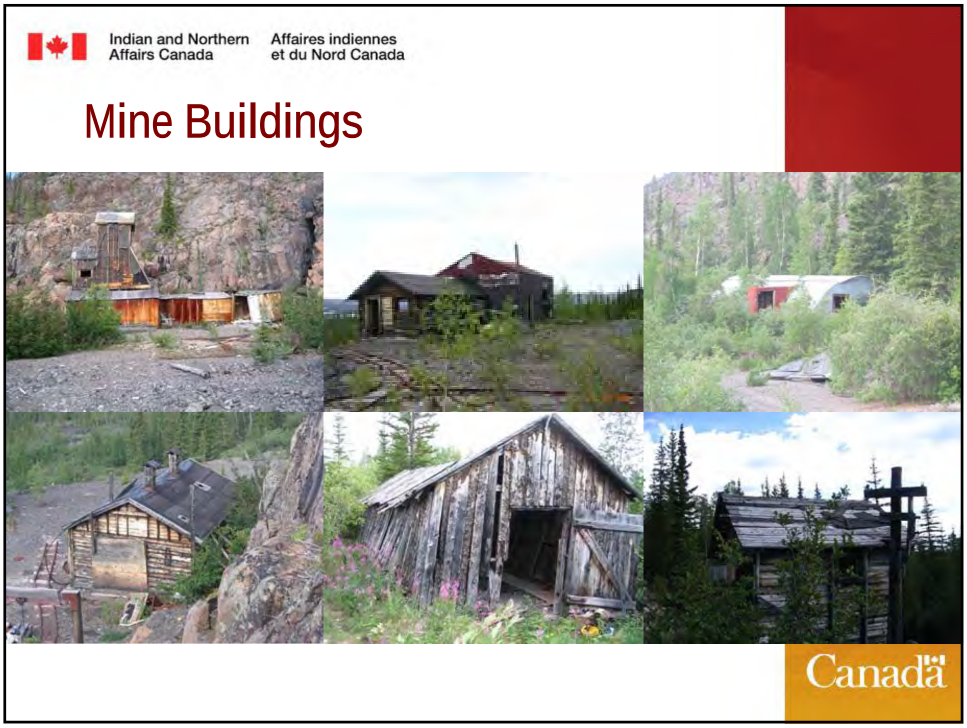
Buildings



Camp Buildings



Camp Buildings



Mine Buildings

Mine Buildings

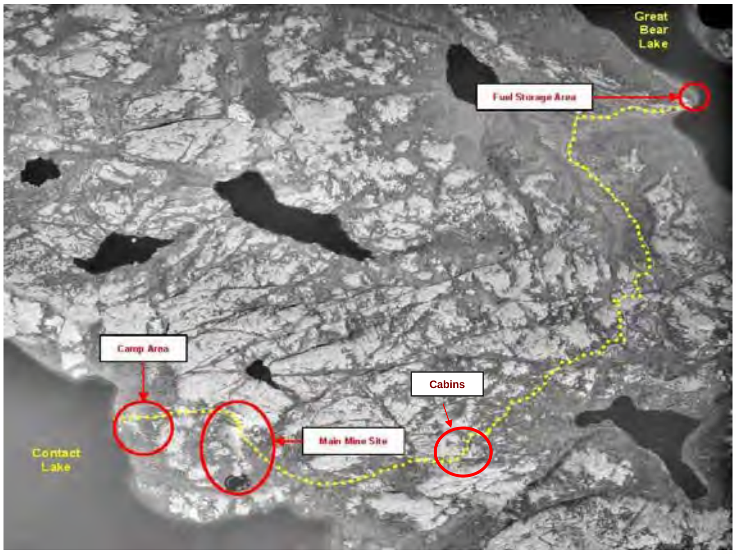
Building Conditions

- Safety Hazard
- Visual attraction to site
- Some chemical hazards (lead paint, DDT, asbestos)

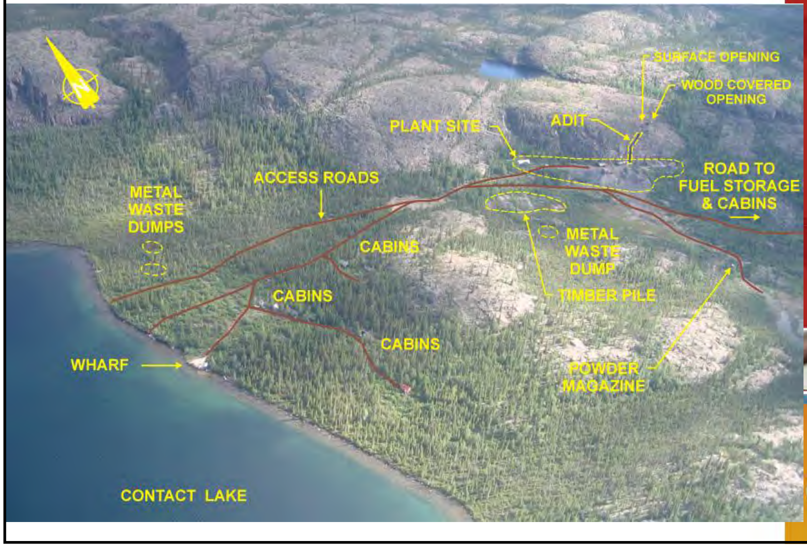
Roads – Conditions

- Overgrown
- Minimal environmental impact

Roads (between 5 and 7 km)



Dumps, Household and Metal Debris



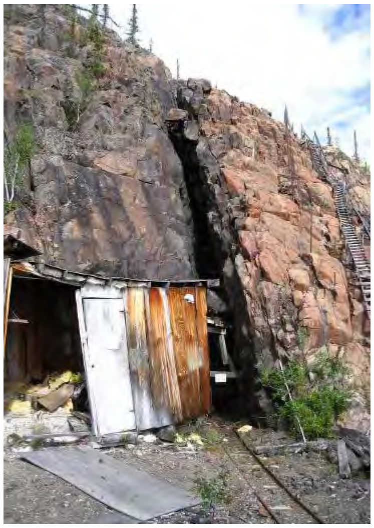
Dumps & Debris

Dumps and Debris Conditions

- Small areas of soil with elevated metals (for example arsenic, lead, and zinc) and hydrocarbons (oil)
- No PCBs were detected
- Could be uptake of metals by wildlife and plants
- Physical hazard – could be injury to people and animals

Mine Openings

Mine Openings



Mine Conditions

- Contact Lake
  - 1 mine raise, 2 open stopes, 1 mine shaft, and small pits and trenches
- Falling hazards

Docks

- Physical Hazard

Hydrocarbons in soil

Hydrocarbons in Soil

- Oil and heating fuel in soil around the buildings and in the small dumps
  - <30 m^3
- Diesel in soil at the fuel storage area
  - 7.5 m^3

Waste (Mine) Rock

Waste Rock Conditions

- Main Pile (26,000 m^3 over 1.6 hectares)
- Slopes appear to be stable
- Limited leaching of metals (e.g. arsenic)
- Waste Rock (non-acid generating)
- The waste rock has elevated levels of gamma radiation – 200 m^2 averaged over 250 uR/h

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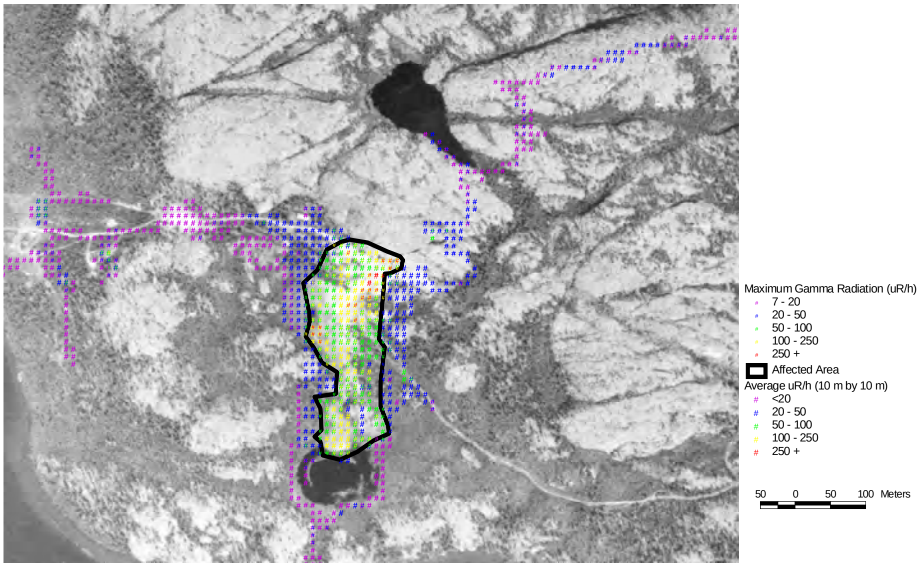

Bioavailability Test on Waste Rock

- Bioavailability Test – Acts like the digestive system of animals
- Showed that metals that are present are mostly bound to rocks
- Unlikely to be taken up by animals in the local area

On-Land Tailings

Tailings Conditions

- Small quantity of exposed tailings (200 m^3)
- The leach test showed that tailings are likely contributing metals (arsenic and copper) to water quality of the Tailing Pond
- Non-acid generating
- The tailings have some elevated levels of gamma radiation
- Plants were collected in the tailings area and had elevated levels of some metals

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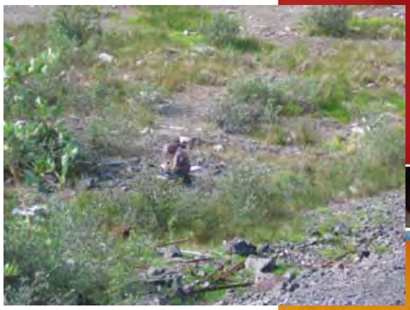
Soil and Plants

- Plants were collected including alder, birch, cinquefoil, and willow
- Soil was collected around the plants



Soil and Plant Conditions

- Some metals (arsenic, cobalt, nickel, and uranium) were elevated in the plants at the mine site compared to plants collected in background locations
- Metals in vegetation and soils around the Tailings Pond has some potential affects on small animals such as a hare

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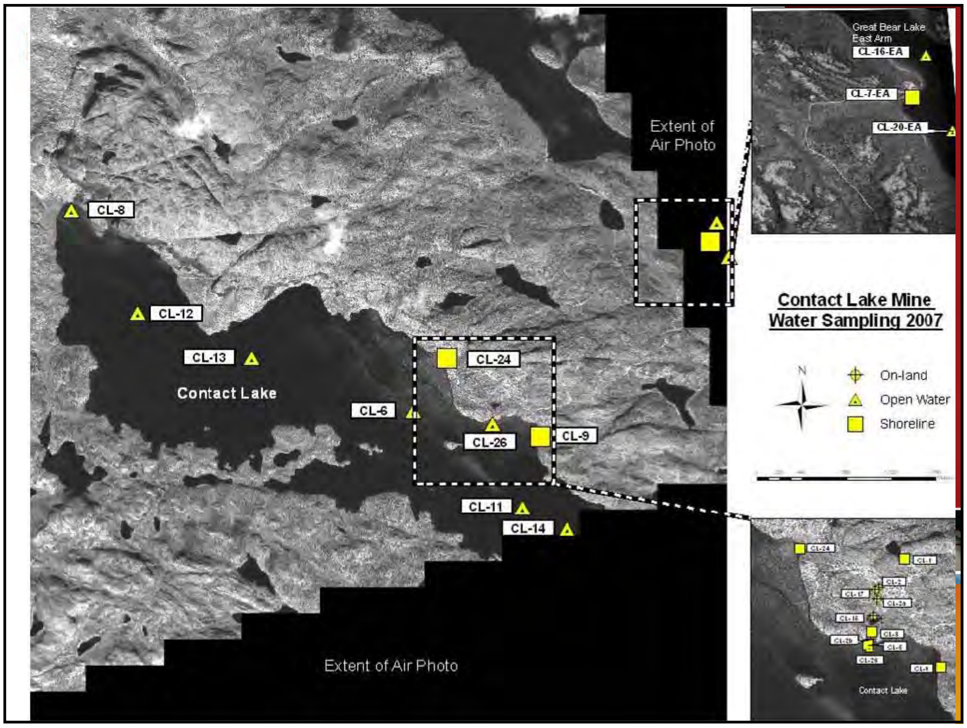
Definitions

- Guidelines – Numbers

Water and Sediment Quality

Water Samples

- Upper Lake
- Tailings Pond
- On-land in waste rock area and between Tailings Pond and Contact Lake
- Contact Lake
- East Arm of Echo Bay on Great Bear Lake



Contact Lake Mine Water Sampling 2007

Water Quality

Water Quality – Upper Lake

- Copper was above the guideline
- Radionuclides were not detected

Water Quality – Waste Rock area

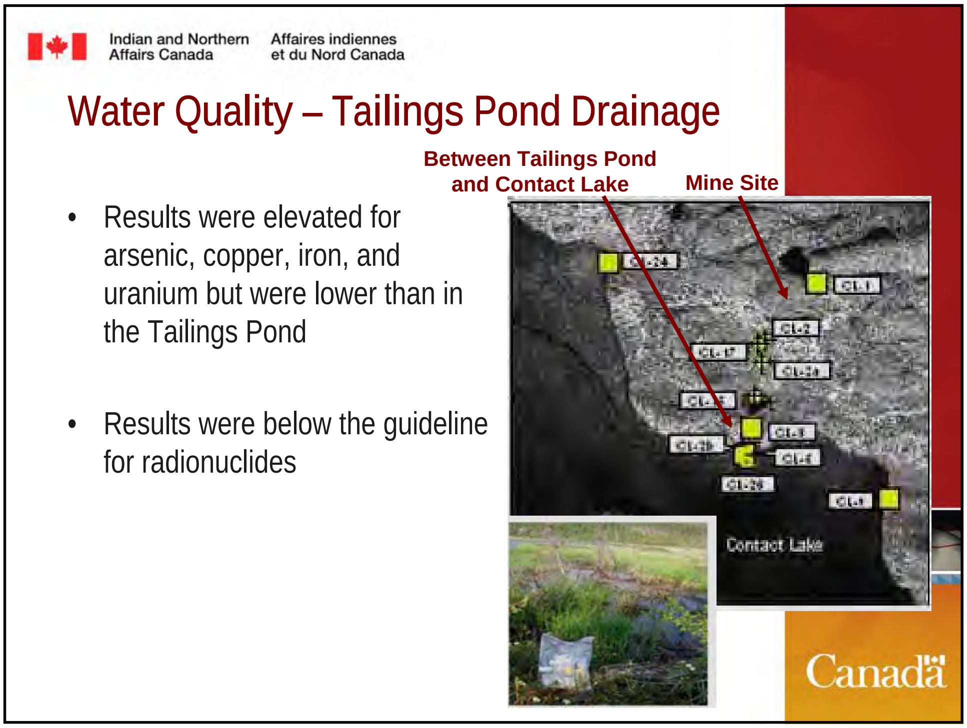
- Results were above guidelines for arsenic, copper, iron and uranium
- One sample (CL-2) was above the guideline for radionuclides

Mine Site

Waste Rock Area

Water Quality – Tailings Pond

- Results were elevated for arsenic, copper, silver and uranium
- Radionuclides were below the guideline



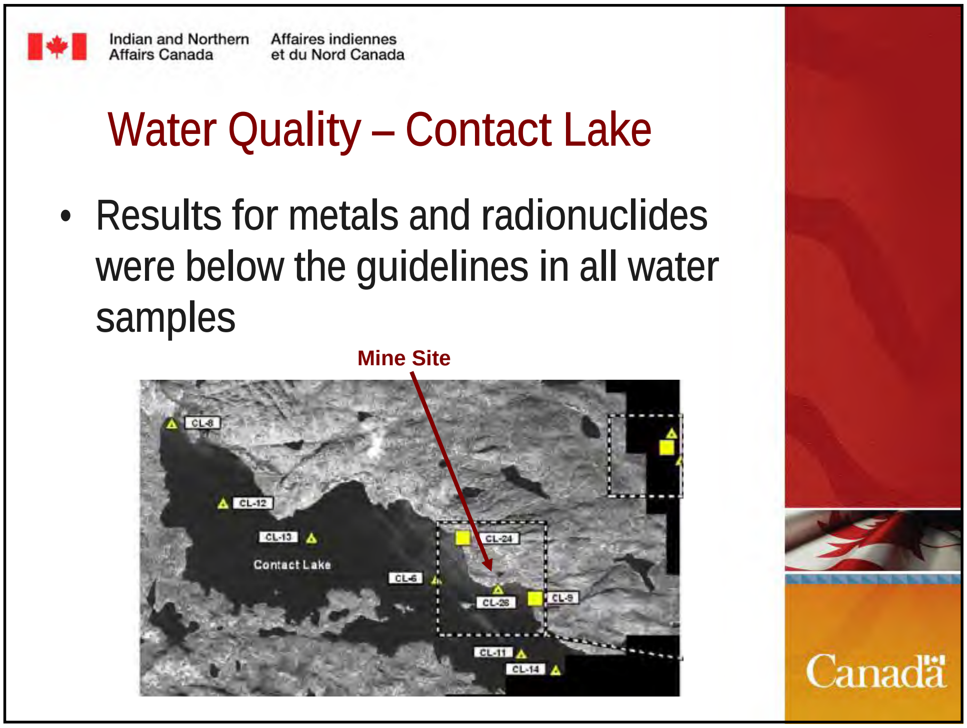
Indian and Northern Affairs Canada
Affaires indiennes et du Nord Canada

Water Quality – Tailings Pond Drainage

Between Tailings Pond and Contact Lake

Mine Site

- Results were elevated for arsenic, copper, iron, and uranium but were lower than in the Tailings Pond
- Results were below the guideline for radionuclides



Indian and Northern Affairs Canada
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Water Quality – Contact Lake

- Results for metals and radionuclides were below the guidelines in all water samples

Mine Site

Indian and Northern Affairs Canada
Affaires indiennes et du Nord Canada

Overall Picture – Contact Lake Water Quality

Sampling Site	Arsenic (ppm)	Copper (ppm)
Upper Lake	0.5	7.0
Waste Rock Area	237	50
Tailings Pond	27	18
Drainage from Tailings Pond	13	11.5
Contact Lake	0.2	0.8
Guideline (Freshwater for Aquatic Species)	5.0	2.0

Indian and Northern Affairs Canada
Affaires indiennes et du Nord Canada

Overall Picture – Contact Lake Water Quality

- Modelling showed that loadings to Contact Lake are minimal
- Water quality improves as it gets closer to Contact Lake with all measurements below the guidelines in Contact Lake water

Fisheries Assessment

- Fish nets were set at many locations in Contact Lake and trout were caught
- No metals or radionuclides were found to be higher than normal
- One trout had a spinal deformity that was believed to be associated with parasites, not the presence of the mine
- The results indicate that the mine site is not having an affect on the fish

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Definitions

- Ecological Risk Assessment
- Human Health Risk Assessment

Risk Assessment Findings

- Metals in sediments in the Tailings Pond have some potential to affect bottom feeding waterfowl, mink and muskrat
- Metals in vegetation and soils around the Tailings Pond have some potential to affect small animals such as a hare
- The environmental conditions at Contact Lake are not expected to affect large animals such as bear, moose, and caribou
- Levels of radionuclides found at Contact Lake are not expected to affect animals
- The environmental conditions at Contact Lake are not expected to affect people

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Sediment Quality in the East Arm of Echo Bay – Great Bear Lake

- At dock, results were above the guidelines for (e.g. arsenic and mercury)
- At dock, hydrocarbon results and radionuclides were elevated
- Away from the dock, the results were below the guidelines for all
- More study was required to determine effects
- Benthic study results are not complete

Water Quality in the East Arm of Echo Bay – Great Bear Lake

- Results for metals and radionuclides were all below guidelines in water samples

Overall Picture – Great Bear Lake

- Sediments had some metals, hydrocarbons, and radionuclides
- On-going study to determine the effects of the sediment
- Water quality was below the guidelines for all measurements
- Remediation options will be discussed further after results have been received

Concerns/Issues Identified

- Potential physical hazards from:
  - mine openings – shaft, raise, adit cut
  - old buildings
  - docks
- Scrap and debris piles
- Old fuel tanks and fuel/oil in the soil
- Hydrocarbons in the soil
- Elevated metals & radionuclides in mine rock and tailings
- Surface water quality at mine site
- Sediment quality in the east arm of Great Bear Lake

APPENDIX B

MINUTES FROM COMMUNITY CONSULTATON

MEETING NOTES
Remediation Action Plan and Consultations
Contact Lake, NT

ATTENDEES	**Julie Ward** **Jessica Mace** **Sharon Phippen** **Gerd Wiatzka** **Orlena Modeste** **Michael Neyelle** **Dolphus Baton** **Jimmy Dillon** **Dolphus Tutcho** **Judy Tutcho** **Bruce Kenny** **Tommy Betsidea** **Hughie Ferdinand**
DATE	**13th & 14th November 2007**
REF	**Contact Lake – Remediation Action Plan and Consultations**
LOCATION	**Deline, NT**

1 Notes

.1 Presentation to all attendees. Julie introduction and Jessica presentation detailed view of the site elements.
.2

Items	Questioner	Question	Person answering	Comments
Building and Equipment	Michael Neyelle	Would there be records on underground mining?	Julie	Yes, we have records. They will be incorporated into our remediation plans.
	Michael Neyelle	Would we be able to visit the site again?	Julie	Yes, there will be more site visits especially during or after the clean up. There is a site visit scheduled for Port Radium this year to celebrate the clean up.
	Michael Neyelle	When you say “dump” do you mean tailings?	Gerd	No, just household debris/camp waste, pieces of steel, rods, cable, just stuff that was left behind, wood debris over top of the mine, scrap timber, etc.

	Michael Neyelle	If they had PCB is the old days, they must have dumped them somewhere.	Gerd	At the Contact Lake site though we did not see any evidence of PCBs. For example, there were no transformers identified on-site and none of the soil or paint sample results came back with PCBs in them.
	Michael	Are there any photos of what the PCB's look like? If we had pictures, we might be able to identify the PCB's.	Julie	We have pamphlets we can distribute. PCBs are a thick liquid.
Docks	Dolphus Baton	Is this dock underwater? We didn't see this when we were walking.	Gerd	Yes the dock at the fuel storage area is under water and we didn't see it because we didn't walk to the fuel storage area where this photo was taken. We flew over the area but didn't get close enough to see it.
Hydrocarbons in soil	Dolphus Tutcho	How big are you are talking about when you say 7.5m^3?	Julie	Probably about the size of this room and about knee high.
Waste (Mine) Rock	Michael	How was the testing done, did you just test the top or did you drill down?	Gerd	No, this was all surface sampling. Acid-testing is done by crushing the rock and adding water, done as part of lab work. Geological records and other work that we have done in the area show that there is not much acid generation in the Sahtu area.
	Tommy	Is 250 uR/h a generic number?	Julie	No, this is the level we used at Port Radium. We chose this target level specifically for Port Radium to address the high levels. For this site, we are not choosing 250 uR/h but using it to show which areas are elevated (on the map). We (as a group) have to develop site specific criteria for this site.
	Michael	Seems to be more red further down the slope (on the Gamma map).	Gerd	We are looking at a 10 metre grid so the numbers you see lower down, are individual numbers not an average over the 10 metre grid. The red that is higher up and on the right side of the map are the areas where the average is higher (>100uR/h or >250 uR/h).
One land tailings	Jimmy	After so many years, why is nothing growing there again?	Jessica	The vegetation is actually growing on the tailings (as shown in this picture) because the rock has been broken up into smaller pieces (tailings). The vegetation is more sparse on the waste rock because the rocks are bigger and it's hard for things to grow there.

	Tommy	Since the hare is at risk (according to the risk assessment) and in the food chain, will it affect the larger animals?	Gerd	No, the larger animals are not expected to be impacted by the site conditions based on the risk assessment. There is a slide on this later and we will discuss it more. If the area was covered, the area (tailings) would not look as pretty. There would be lots of rocks and no vegetation like there is now.
			Julie	There is a trade off because there is already vegetation growing and if we cover it, we would probably use waste rock and the vegetation that has grown would be destroyed. But on the other hand, there are elevated metals in some of the vegetation and we may not want the small localized animals in the area to eat the vegetation and have the metals passed on to them.
Guidelines	Tommy	I heard that the guidelines were not understood very well.	Jessica	Lots of research has been done, and information from around the world is used by the Canadian Government to come up with generic guidelines that will protect the environment as much as possible. They are always being updated since more research is being done. Risk assessments are used so that guidelines can be adjusted for a specific site.
	Dolphus Tutcho	Can you drink water from the lake?	Jessica	Yes, the water in the lake (Contact Lake) is safe to drink. The water that flows on land at the site and in the tailings should not be drank because there are some metals above the Canadian Drinking Water Guidelines.
Fisheries Assessment	Tommy	How do we know that the parasite in the fish is not from the mine or water on site?	Gerd	There was one fish that had a parasite and we had an expert from DFO (Colin MacDonald) examine the fish. He determined that the parasites in the fish were natural. The kidney, liver, flesh & bone from the fish were tested and everything was clean (no elevated levels of contaminants).
Sediment	Jimmy Dillon	After the cleanup - can an issue be brought forward for more information (i.e. the sediment)? Can further cleanup be done?	Gerd Julie	INAC is responsible (as part of a license) for monitoring forever at Port Radium. After 5 years a monitoring study will be done, food, fish, etc. A discussion will be made after that to see how often the sampling will be done. INAC will have

				to decide after the cleanup of Contact Lake, how often the monitoring studies will be done. Yes, we can go back during the monitoring program and re-assess the site.
	Michael	What if after our cleanup another company comes in and doesn't keep the site clean?	Julie	The inspector will get a copy of the report, and will be responsible for taking up the incident with the new party. We are trying to work with the boards so that if someone goes in to the site and disturbs the site after the clean-up the boards will have the responsibility to go in and make them clean it up to the way we left it.
	Michael	What do you mean water quality is below the guidelines? What are you trying to conclude?	Julie Jessica	Sorry for the confusion – if something (i.e. arsenic) is above the guidelines, it may be a concern and if it is below the guideline (or within the guideline), it is not a concern. We are not trying to make conclusions but instead we are trying to provide you with the remediation options and information and have you decide what you would like done. "Meets the Guidelines" might be a better way of saying this. At this site, the water meets the guidelines and is safe to drink.
	Michael	Was any sediment testing done on the ice road?	Gerd	Took a sediment sample last year, small hit of hydrocarbon in the area.

Notes:

.1 Second presentation including remediation options tables was started here and led by Jessica.

Items	Questioner	Question	Person answering	Comments
Site Objectives			Michael	It has to be similar to Port Radium. Julie says it has to be a safe option, safe to humans and animals alike.
	Michael	At Port Radium, the dust was problem, how can the water quality not be affected with all the dust?	Julie	Public works was hired to keep the dust down on the site (by watering the roads etc.). There will be some impacts from the remediation work and you need to keep that in mind when you are deciding on the preferred remediation option. For example bringing in heavy equipment to do the work could disturb the roads that are already overgrown.
Buildings at site	Jessica	Are there any buildings that you would like to preserve or recycle?	Dolphus Tutcho	Most of the stuff would not be worth anything to recycle, it has been around too long.
			Michael Neyelle	Decisions have been made - demolish all buildings.
	Dolphus Tutcho	How would you get rid of the buildings? Burn them?	Julie	Bring in a piece of equipment in to demolish and then burn it or bury it. Once it is burned, the ash would have to be buried. The contractor would have to specify how they would demolish.
			Michael	The committee would prefer the buildings to be burned and then buried. Monitoring guidelines (for air) must be very strict. This would have to be added into the contract.
Roads	Michael	Haven't seen the whole road, would it be valid to make a decision without seeing the whole thing? Have the roads been tested?	Gerd	2 people walked from the tank farm to the mine site and took a sand and gravel sample from the area - no contamination detected.
	Hughie	Isn't there a culvert on the road?	Gerd	I think there might be one culvert but I didn't walk the road. If there is a culvert, it would be removed and the drainage would be restored.
			Michael	Do not want to bury or burn the debris close to water, might need the road to carry the waste to bury site.
	Michael	Main part I am worried about is the	Julie	Would have to go to the borrow pit, maybe could

		main site. Where would we get the material to bury the stuff?		use some of the waste rock. We will have to discuss further with you after the specifications for the work are designed.
Small dumps & debris	Tommy	Have all areas been tested, would it be a health hazard if it is moved?	Gerd	No, these are small areas of debris and soil and should not be a hazard if they are moved. You could take a back hoe and dig a ways down to find out if there is anything deeper.
			Jessica/Julie	Sampling will likely be done on-site during the clean up so the areas can be tested to make sure that the contaminated soil has been dug up. The areas would likely then be re-claimed with a clean soil cover.
	Michael	Did you try to identify all sites, you might have missed something?	Gerd	Yes, we tried to identify all of the debris sites and not miss anything. While the clean up is being done, they would look for any areas that were missed and address them at that time.
Mine Opening	Tommy	Are there any explosives?	Julie/Gerd	Blasting caps have been found at the Quonset hut, and have been destroyed. No one has been inside the actual mine. A mine inspection was hired this summer to destroy all blasting caps at Silver Bear, Port Radium, and Contact Lake. There is always a possibility that we have missed one and if one is found then, we will deal with the matter immediately.
			Jimmy	Expressed concern with the fence option. The large animals could get their antlers caught. This area is caribou and moose country.
	Tommy	Is there any kind of restriction against fences?	Julie	We do not have any restrictions.
Large Mine Opening				After a lot of discussion, the Remediation Team agreed that blasting and collapsing the whole area would be the best remediation option.
	Tommy	Is there no way to fill it	Julie	We could fill and fill, not sure where the end is, and it could still collapse.
			Jimmy	**Insert “Blast and Collapse Opening**”
			Tommy	***Suggestion of wooden (temporary) fence. If a fence is still required then it should be a wooden fence.**

	Michael	What is the perimeter of the hole?	Jessica	About the size of the room or a bit bigger. We don't have the dimensions at this time.
Adit opening				*Add Backfill "entrance only" option and this was the preferred option.
Dock @ East Arm (Fuel storage)			Julie	*Need to take extra precaution when removing the dock that is submerged so that sediment is not disturbed too much. This should be added in the contract.
	Tommy	What was done at Port Radium to protect the sediment?	Julie	A sediment boom was used, not 100%, maybe 80% effective.
Contact Lake Drainage	Jimmy	Were all the animals tested?	Gerd	A risk assessment was conducted and although not all the animals are tested (because it would be too intensive and too many animals would have to be killed to be tested) we have a good idea from running our risk assessment model what the impact would be on the animals in the area.
			Gerd	We can do some "drainage improvements" to have no standing water within the waste rock area. I will talk with engineer regarding this.
Waste Rock				**Preferred Option: *Cover elevated Gamma areas & redirect flow around waste rock. Combine the two, vegetate if possible.**
On Land tailings	Dolphus Tutcho	The main object is to protect the water @ Great Bear Lake. The water flowing from upper lake to Contact Lake gathers contaminants on its way to the tailings pond the water filters itself before it reaches Contact Lake. Why don't we just leave it as is?	Julie	There is a trade off because we may have other concerns besides the water quality in the lake, like the small local animals. The risk assessment does show that there is a 'potential risk' to small animals (hare) that live year round in the mine site area. We may want to cover the tailings area and the vegetation that is growing there because this is the pathway that the animals get the contaminants from.
			Gerd	Re-directing the water would be a good choice. If we cover the area we will require a lot of cover and that soil/sand cover could be washed into the lake.
	Michael	What if we combine – cover the tailings with soil and redirect runoff around tailings?	Jessica/Julie	We can combine those two options. We should discuss this further in an update meeting in the winter.

	Jimmy	If we push the tailings into the pond, isn't the pond shallow and it could cause problems?	Gerd	Yes the pond is shallow so it could potentially affect the water quality.
			Dolphus Tutcho/ Michael/ Hughie	We don't want to move the tailings around because it could make more of a mess than actually help clean up the site.
Tailings pond	Jimmy	What are the sediments?	Jessica	Now we are talking about the tailings (sediment) in the bottom of the pond.
	Michael	Would the sediment in the bottom of the pond cause a problem in the future with global warming?	Julie	There could be an effect but we will be monitoring the area and will find out if there are any changes.
			Gerd	Even if the temperature changes, it would probably not be significant enough for there to be a difference in the pond.
Hydrocarbons in soil	Tommy	Is still hazardous?		It is not considered hazardous if it is in the soil. If it is left over time some of the hydrocarbons will degrade.
Next Meeting				El Bonanza meeting on December 17th

APPENDIX C

MEMO REGARDING MINE STOPE MITIGATION

SRK Consulting
Engineers and Scientists

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Memo

To:	Gerd Wiatzka, SENES Consultants	**Date:**	7-Mar-08
cc:		**From:**	Dan Hewitt
Subject:	PWGSC Project #421365 Contact Lake Open Stope(s)	**Project #:**	1CS019.007.0004

Introduction

The open stopes at Contact Lake are a concern for safety and are covered under the NWT Mine Health and Safety Regulations for mitigation. This memorandum is based on the background information provided (attached) and without benefit of a site visit. The viability of backfilling a stope by widening the stope is examined and the use of urethane foam as a stope seal is discussed.

Stope Backfilling by Blasting the Perimeter

Filling a stope by blasting the walls is not a technically preferred option. Assuming rock expands 50% when blasted (swell factor), a volume of rock twice that of the existing stope would have to be blasted. In other words, the final opening width would be three times the original width.

The higher the stope, the greater the concern for guesswork and uncertainty associated with the drilling and blasting:

- Safety considerations for people drilling and blasting close to the edge of an open stope;
- The drill holes could encounter irregularities in the stope wall as well as adjacent drifts and raises;
- The widening would be done in several smaller blasts and the buildup of rock created by a previous blast may be too confining for the next blast; and
- Any difficulty with the drilling or blasting will be a challenge to correct.

Blasting the side of a stope may not completely fill the stope. Voids could be created by oversized blasted chunks hanging up in the stope and acting like a shelf within the stope. This would prevent complete filling which could result in settlement of the fill at a later date.

From a stability standpoint, widening a stope would reduce its stability. If a stope is already unstable, or has localized areas of instability, blasting and widening of the stope would make a bad situation worse.

Sealing an Open Stope with Expanding Urethane Foam

Section 17.03.(2) of the NWT Regulations stipulates that an open stope be "…either capped with a stopping of reinforced concrete or filled with material so that subsidence of the material will not pose a future hazard." Placing a seal of urethane foam in a stope does not meet the criteria for a stopping and has drawbacks as a bulk fill material.

If placed as a seal or capping near the top of the stope, it would have to be reinforced concrete. The Workers Compensation Board would expect an asbuilt report of the capping installation indicating the basis of design and assurance of the strength of the installation for public safety. Using foam as fill material in a stope has two main drawbacks: it is cost prohibitive and its compressive strength is quite low compared with rock fill.

Apart from the regulatory and strength aspects, the cost of expanding urethane foam is a major consideration. A high compressive strength urethane foam product (2070 kpa at a density of 96 kg/m^3) would cost approximately $680/m^3 according to Uretek Canada.

The cost of product to place a 1 m thick layer as a seal near the top of the 14 m wide stope would be about $10,000 per metre length of stope. A cost estimate for the entire stope can be easily be calculated, e.g. for a 2 m thick slab over a 20 m stope length the cost would be $10,000 x 2 x 20 = $400K. To completely fill a stope with average dimensions of, say, 3 m wide x 20 m high x 20 m long would cost $816,000. Labour, ancillary supplies, equipment and delivery to the site would be in addition to the product cost.

Closing

Concrete capping is an alternative to backfilling where the opening is not too large. Judging by the photos provided, the opening size and the extent of preparation work required because of the irregular ground conditions both go against choosing the concrete cap option. Fencing as described in the attached SRK letter would meet the Regulations for the short term.

For further discussion please contact me at (867) 445-8670.

Yours truly,

SRK Consulting (Canada) Inc.

Daniel Hewitt

Daniel Hewitt, P.Eng.
Principal Consultant

Contact Lake Background Information

1. Excerpt from 34336-47 - Final Draft – January 2008
   by SENES Consultants

2. Crown Pillar Stability and Geotechnical Aspects of the Contact
   Lake and El Bonanza Properties (draft) – December 2006
   by SRK Consulting

3.2 MINE WORKINGS

The Contact Lake Mine was accessed both by an adit and a shaft. The shaft is located at the yard level within the headframe building, and the adit is located in the immediate proximity to the headframe. An open cut proceeds from the adit level up the face of the cliff, culminating in two surface openings from the underground stopes at the top of the cliff. In line with these openings, but somewhat further removed from the face of the cliff, is a timber covered vent raise opening. Some minor surface exploration trenching was noted above and away from the mine site proper.

Extracts from Silke (2006a) as summarized the development of the Contact Lake Mine underground workings:

- the adit entrance was collared in 1932 and trenching was completed for a length of 8 m and a depth of 3 m and tunnelling was to a depth of about 30 m;
- underground development continued on the #1 zone in 1933 to a distance of about 137 m from the adit entrance along with 35 m of crosscutting;
- the #1 winze was sunk in early 1934 from the adit level to a depth of 38 m below the adit to the 2nd level where crosscutting and drifting was initiated;
- a vertical raise, which later became the #1 shaft, was driven in winter 1934/35 to surface from the 2nd level and the #1 shaft was lowered to the 3rd level in the summer of 1935;
- from 1936 to 1937, underground development was focused on developing known reserves within the eastern section of the three zones and opening of two new stopes on the 2nd and 3rd levels using shrinkage stoping;
- in 1938 and 39 exploration was carried out on the 2nd and 3rd levels;
- mine dewatering in 1946 allowed exploration of the #2 zone from the 2nd and 3rd levels;
- in 1948 a second winze from the 3rd to the 4th level was driven to a depth of 91 m;
- exploration in 1969 resulted in the enlargement of the 3rd level by slashing operations and a raise was driven 5.5 m into the #1 vein.

The Contact Lake orebody occurs in a shear feature within the granodiorite, which is locally filled with quartz-hematite and quartz-carbonate material within which silver, pitchblende and sulphide minerals occur. The mining method as noted above was shrinkage stoping, where the broken ore was used as a working surface to develop the stopes upwards. Once the upper part of the stope was reached with either a crown pillar or broken through to surface, the ore was removed leaving an empty stope. Over time, deterioration of the rock mass and any timber support occurs which allows the rock mass to unravel along shear zone parallel features and local jointing.

Specific illustrations of mine openings and crown pillar considerations are provided in the following photographs and figures:

- 3.2-1 View of mine site headframe and open cut from below waste rock area;
- 3.2-2 View of surface stope opening from air (view from east);
- 3.2-3 Close up view of headframe and open cut;
- 3.2-4 Close up view of open cut (at edge of cliff from mine yard looking up);
- 3.2-5 Close up view of west end of stope surface opening at top of cliff;
- 3.2-6 Looking from east to west across surface opening at top of cliff;
- 3.2-7 General overview from helicopter looking at rock cliff, open cut and mine site in background;
- 3.2-8 and 3.2-9 Sections of underground mine; and,
- 3.2-10 Close up view of headframe and shaft.

Mine Waste Rock

Mine waste rock from underground workings generated waste rock that was placed parallel and adjacent to the base of the cliff next to the adit and formed (as noted above) the mine yard and base for most of the mine buildings (see Figure 3.2-11). The surface of the waste pile and yard is generally flat until it slopes away from the yard area at its angle of repose or less. Waste rock slopes appear stable with no evidence of surface erosion. Estimated waste rock volumes range from 26,000 to 30,000 m^3.

Mill Tailings

From document reviews, 1969 estimates of tailings (see Figure 3.2-12) on site were in the order of 5,000 tons. This estimate was refined to 2,264 tons in 1973 by Bill Knudsen of Echo Bay. Subsequently, records indicate that 2,085 tons of tailings were removed by winter road to Echo Bay's Port Radium mill in 1975. The residual surface tailings remnants (less than 200 tons, 2264 less 2085) are thinly spread across the flat area below the waste rock pile that is bounded on each side by rock outcrops. The remaining surface tailings have likely been subject to sheet erosion over time with eroded materials migrating down gradient to a natural pond that acts as a natural sump. This pond is a natural stable structure that is bounded by rock outcrops on all sides.

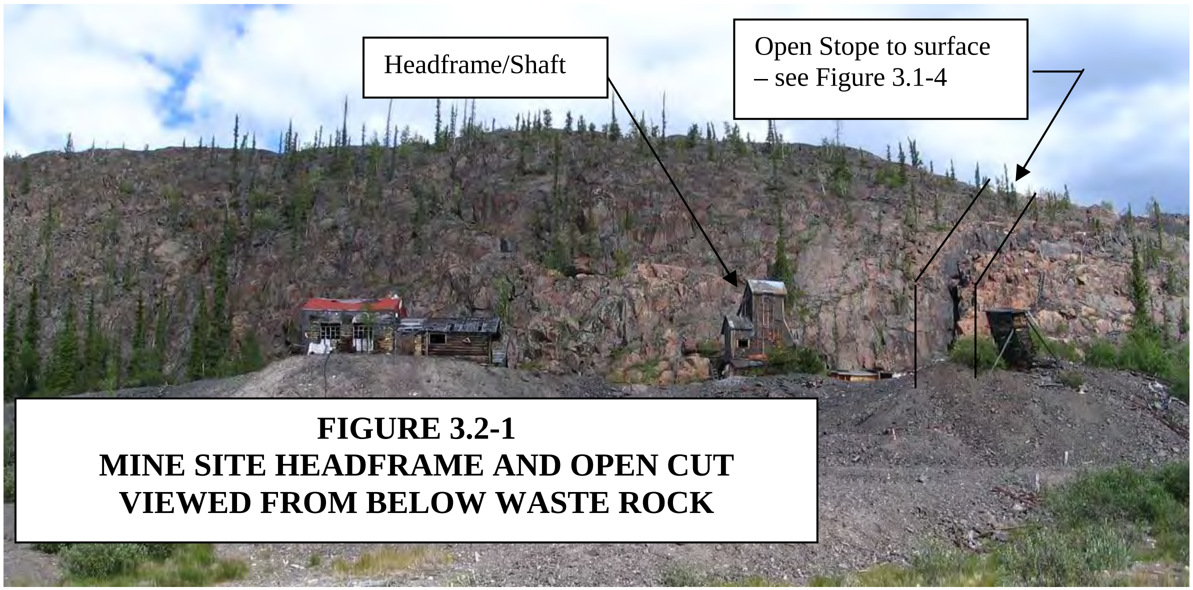
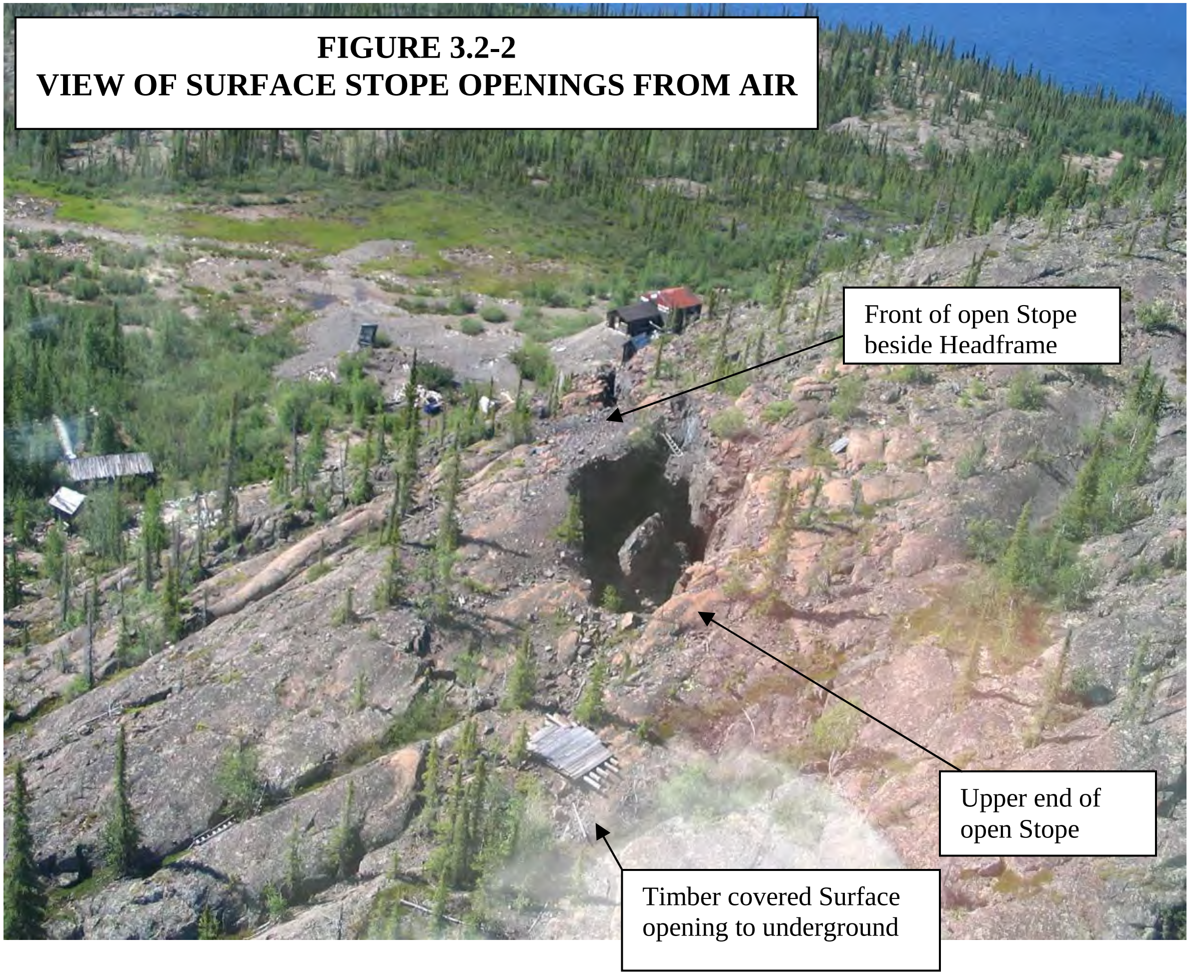


FIGURE 3.2-1
MINE SITE HEADFRAME AND OPEN CUT VIEWED FROM BELOW WASTE ROCK

FIGURE 3.2-2
VIEW OF SURFACE STOPE OPENINGS FROM AIR



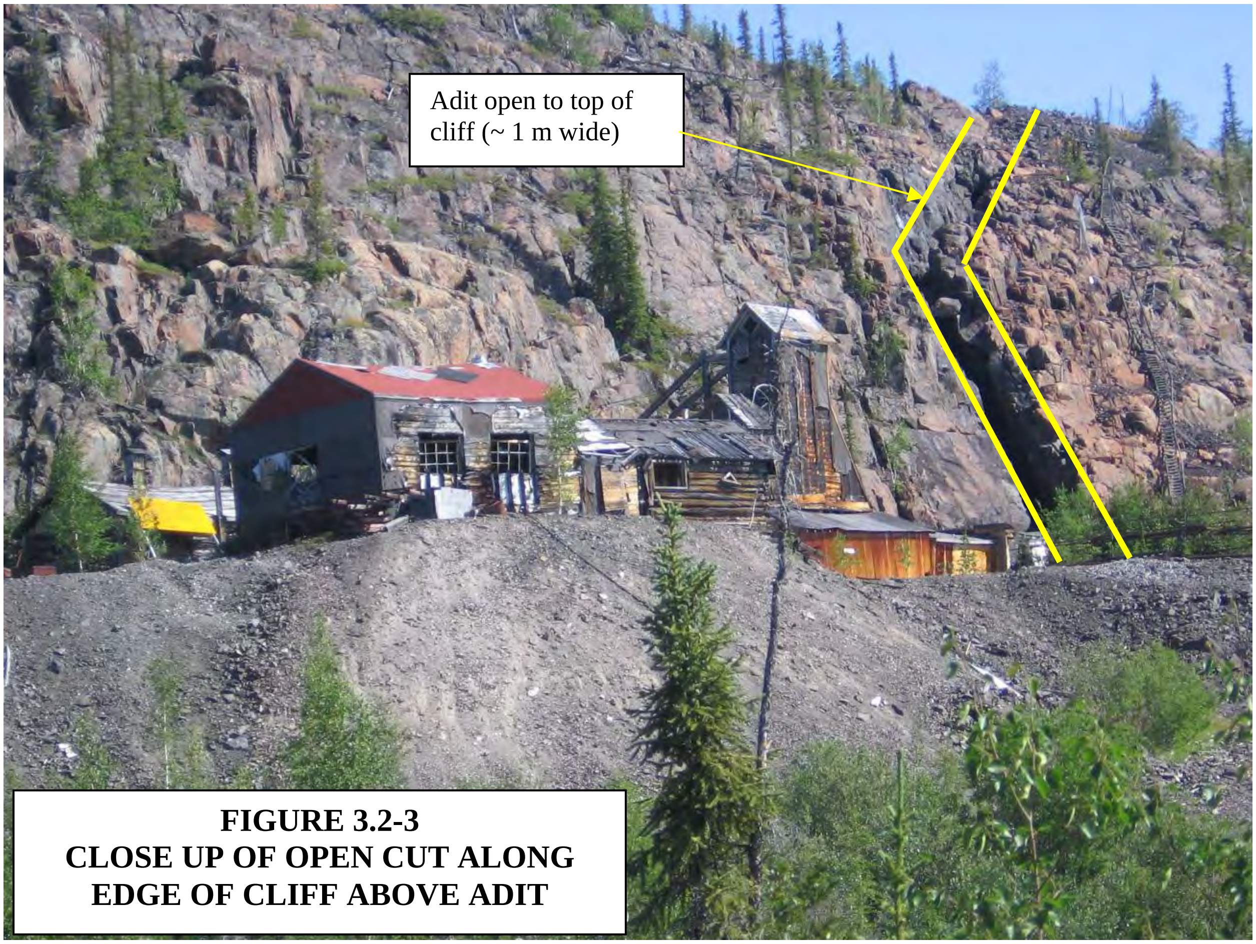


FIGURE 3.2-3
CLOSE UP OF OPEN CUT ALONG EDGE OF CLIFF ABOVE ADIT

FIGURE 3.2-4
CLOSE UP OF OPEN CUT ALONG EDGE OF CLIFF

FIGURE 3.2-5
CLOSE UP OF WEST END OF OPEN STOPE

FIGURE 3.2-6
EAST - WEST VIEW OF SURFACE OPENING

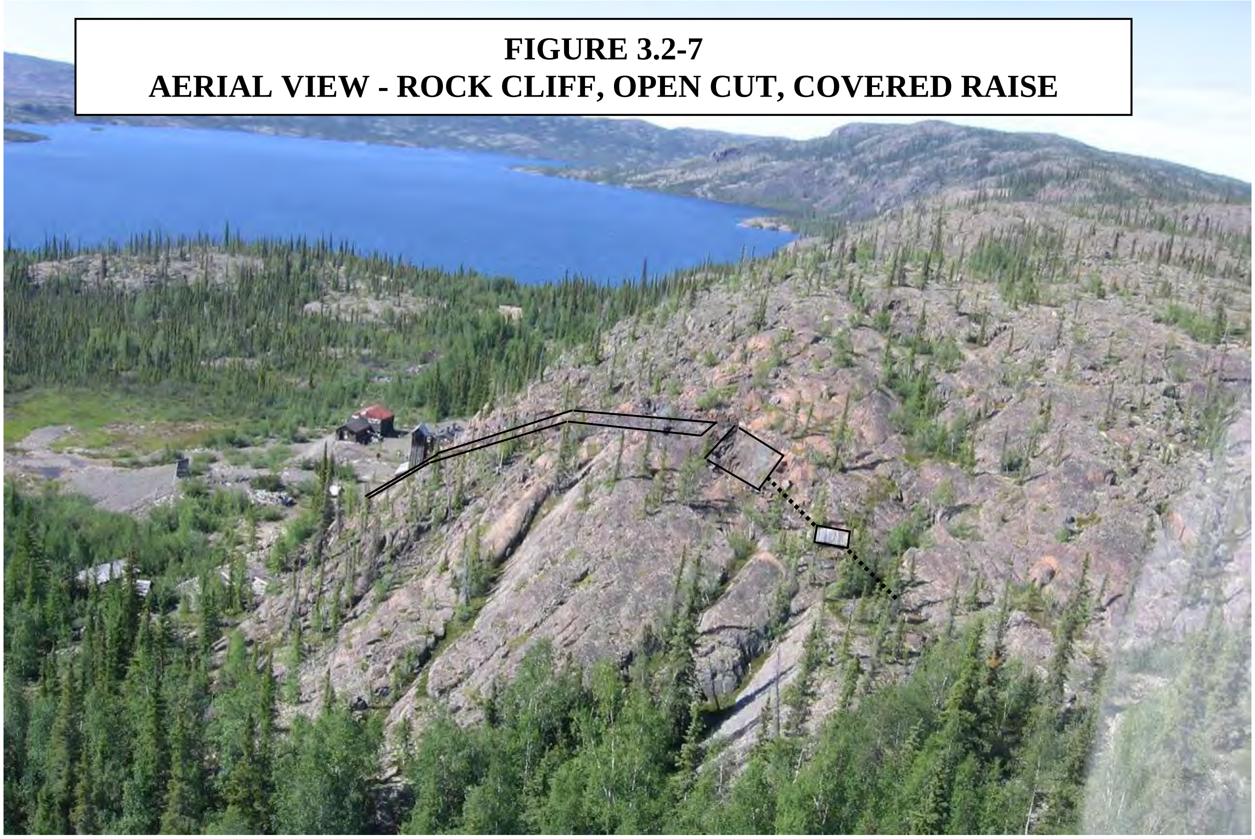


FIGURE 3.2-7
AERIAL VIEW - ROCK CLIFF, OPEN CUT, COVERED RAISE

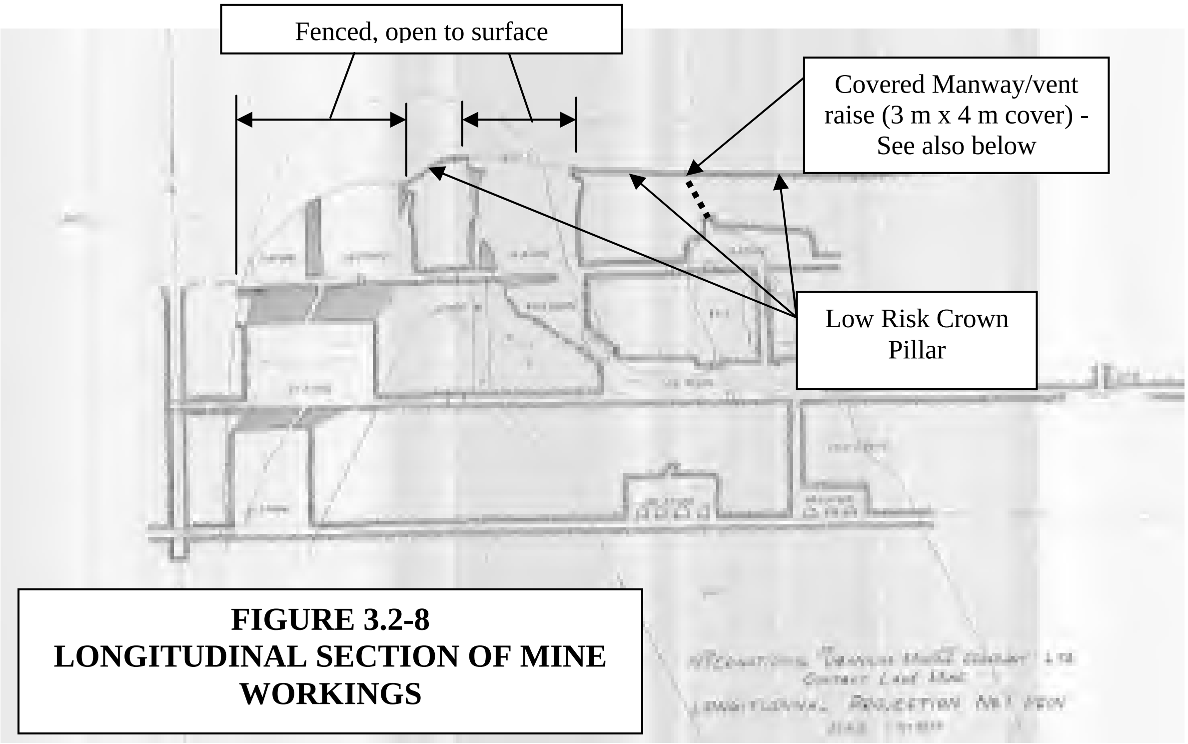


FIGURE 3.2-8
LONGITUDINAL SECTION OF MINE WORKINGS

FIGURE 3.2-9

LONGITUDINAL SECTION OF MINE WORKINGS

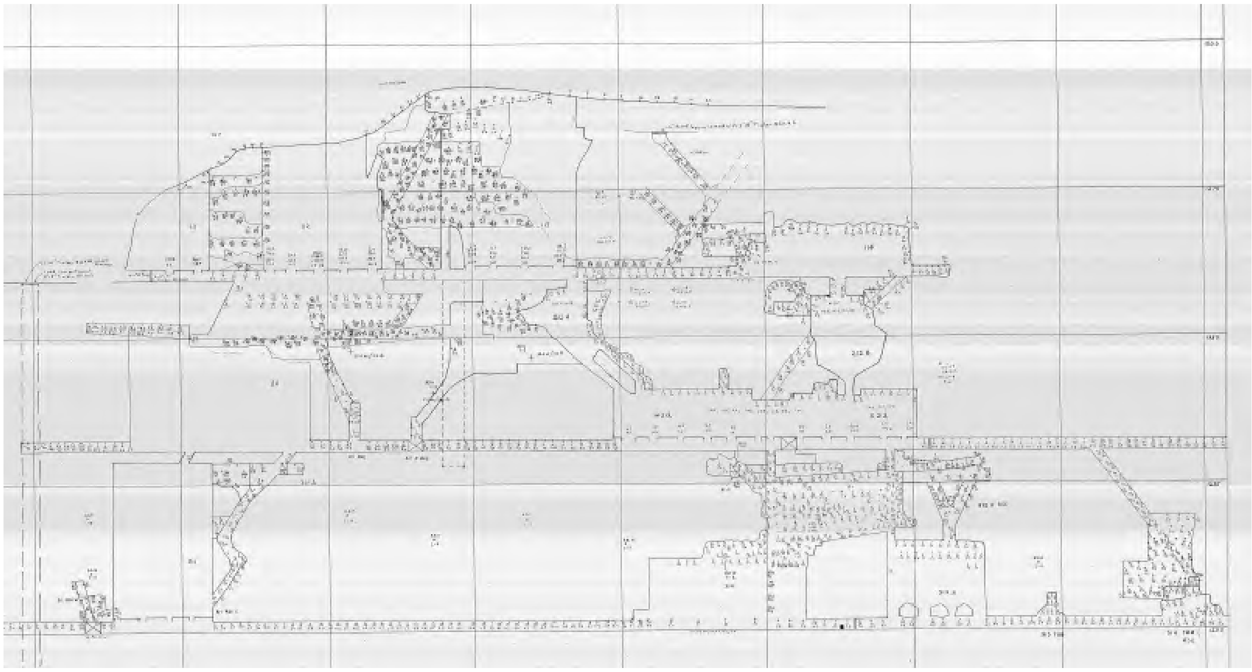


FIGURE 3.2-10
CONTACT LAKE HEADFRAME AND SHAFT

SRK Consulting
Engineers and Scientists

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Vancouver, B.C. V6E 3X2
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December 17, 2006

Draft

Senior Project Engineer, Manager Mining
121 Granton Drive, Unit 12
Richmond Hill, Ontario L4B3N4

Attention: Gerd Wiatzka

Dear Gerd,

Crown pillar Stability and Geotechnical Aspects of the Contact Lake and El Bonanza Properties

This letter report contains the findings of a desktop review of the crown pillar stability and other geotechnical aspects that may impact on remediation measures to mitigate these mining excavations. The various aspects of the properties are discussed separately below.

Contact Lake Property

The orebody occurs in a shear feature within the granodiorite, which is locally filled with quartz-hematite and quartz-carbonate material. Within these shear zones the silver, pitchblende and sulphide minerals occur. These features are steep dipping (80 - 90º) and vary in thickness.

In the Stope 111, 112 and the underlying 211, areas the ore zone width appears to be in the order of 1 – 1.5 m on average (see Figure 1). In the Stope 112A and 113 the ore zone thicknesses increase to as much as 4.0 m in width (see Figure 2). The longitudinal section provided in the literature does not reflect the total extent of underground mining, especially in the area above the adit opening close to the shaft.

The mining method was potentially a shrinkage based one, where the broken ore was used as a working surface to develop the stopes upwards. Once the upper part of the stope was reached with either a crown pillar or broken through to surface, the ore is removed leaving an empty stope. Over time, deterioration of the rockmass occurs and any timber support that was installed deteriorates and the rockmass unravelled along shear zone parallel features and local jointing.

In the steep dipping narrow vein area of the 111, 112 and 211 Stopes these stopes will over time stabilize due to broken blocks wedging between the walls and unravelling up to a point along the existing, unfavourably orientated features. Limited further break-back is expected to occur over the longer term. To secure this area, a fence can be placed 5 m back from the current opening edges and along possible unexposed crown pillar areas right down to the adit access area..

In the 112A and 113 Stope areas, as the mining width was substantially greater in parts of the stope, a larger amount of break-back has occurred in the upper area of the stope. As can be seen from Figure 2, large slabs have broken off parallel to the stope surface. Sections of these slabs have broken off and rotated, possibly stabilizing sections of the stope. Some further break-back is expected to occur, but this is expected to be limited to be 5 – 8 m either side. If the intention is to isolate this area using a fence, it should be placed.10 m back from the existing excavation edge and to extend 10 m beyond the end of the stope edge indicated on the longitudinal section.

The crown pillar above the 114 Stope is approximately 8 m thick with a stoping width of 1.5 m. This is expected to be stable over the long term. In this area, as in other areas, yearly inspections should be undertaken to ensure that no unexpected changes have occurred.

El Bonanza Property

Mineralization occurs within a narrow strip of altered volcanic and sedimentary rocks, within two hydrothermal quartz-carbonate veins. One of the veins was up to 2 m wide and these generally dip at greater than 65º.

The 1st Level was started at approximately 20 m below the surface exposure of the vein in the No 1 Shaft area, and it’s separation to surface in the No 2 Shaft area is around 25 m. In the No 2 shaft cross-cut a silver showing of 1.5 m was intersected. Further development on the 2nd level ultimately indicated that veins were narrower than the 1st level and surface showings. In 1965 stoping was undertaken on first level, but is uncertain the horizontal extent of these stopes and thus the potential height of the stopes. Based on the fact that 300 tons were added to the stockpile, one possible stope size that can be considered is 10 m long (length of intersection) x 1.5 m (showing width) thick x 8m in height. This option would indicate a substantial crown pillar of 12 -17 m and would be considered to be stable over the long term.

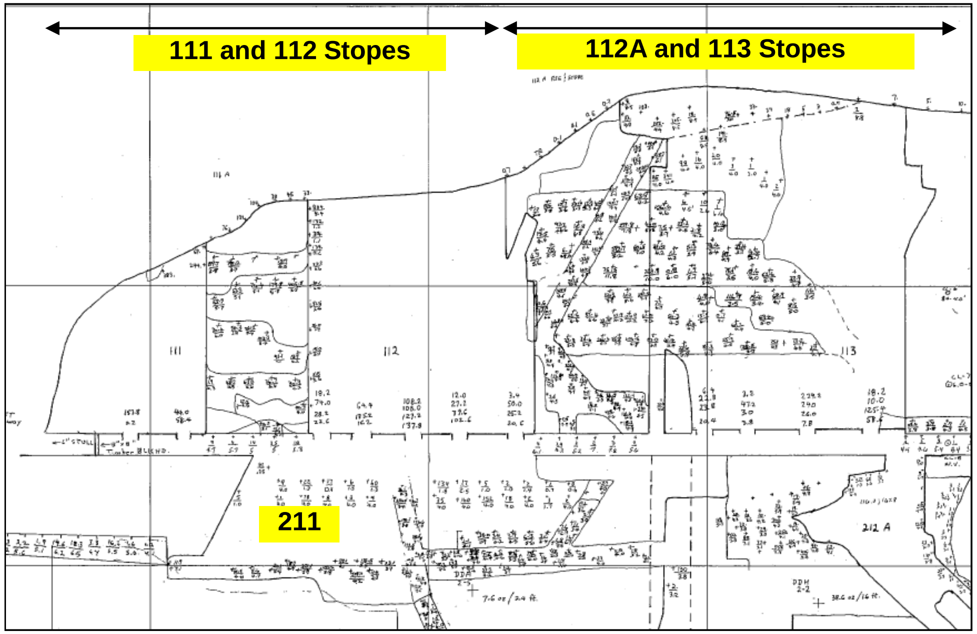
The overall geotechnical risks on this site, as relates to potential excavation instability, is considered to be low provided that all accesses are suitably sealed to prevent access.

Yours truly,

SRK Consulting (Canada) Inc.

Bruce Murphy
Principal Consultant, Mining Rock Mechanics

Stoping in the 111 and 112 Stope Areas



Stoping above the access adit. Once timber support fails the will be limited further failure.

SRK Consulting
Engineers and Scientists

SENES Consultants Limited

CONTACT LAKE

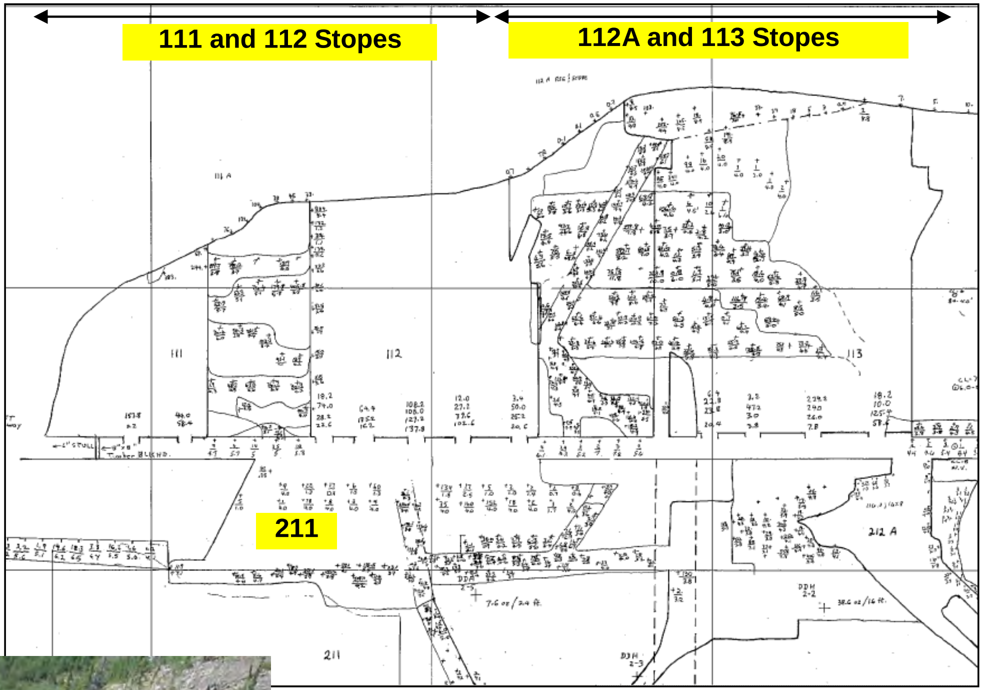
111 AND 112 STOPES

DATE:
December 2006

APPROVED:

FIGURE::
1

Stoping in the 112A and 113 Stope Areas



Stoping in the 112A and 113 was undertaken over substantially wider stoping width than the 111 Stope Area. Larger stopes have led to a greater degree of break-back.

This is not expected to get much dramatically larger due to verticality and that the failed sidewall material is potentially stabilizing the stope

SRK Consulting
Engineers and Scientists

SENES Consultants Limited

CONTACT LAKE

112A AND 113 STOPES

DATE:	APPROVED:	FIGURE::
December 2006		2

Appendix O-3

Report: El Bonanza Mine Remedial Action Plan with Project Update

Indian and Northern Affairs Canada
Affaires indiennes et du Nord Canada

EL BONANZA MINE REMEDIAL ACTION PLAN

Prepared By:

Contaminants and Remediation Directorate
Indian and Northern Affairs Canada

In Association With:

SENES Consultants Limited

March 2008

FINAL

EL BONANZA MINE
REMEDIAL ACTION PLAN

Prepared By:

Contaminants and Remediation Directorate
Indian and Northern Affairs Canada

In Association with:

SENES Consultants Limited
121 Granton Drive, Unit 12
Richmond Hill
Ontario

March 2008

EXECUTIVE SUMMARY

SENES Consultants Limited (SENES) was retained by Indian and Northern Affairs Canada (INAC) under Standing Offer Agreement No. 00-05-6007-1 to develop a Remedial Action Plan for the abandoned El Bonanza Mine site, which is located along the north-eastern shore of Great Bear Lake in the Northwest Territories. Primary development at the El Bonanza Mine occurred during the periods 1934-1936, 1956-1957, and in 1965. The area was mined for silver; however, silver production was only attained in 1935 after which operations were suspended due to low silver prices. This document also addresses the remedial needs associated with the Bonanza Mine and the former airstrip, in addition to the El Bonanza Mine site proper.

Community concerns

The community of Délı̨nę has expressed significant concerns with abandoned mine sites in the Sahtu Region. Although the El Bonanza site is small (less than 5 ha) in comparison to other nearby sites (i.e. Port Radium and Silver Bear Mines), there is still community concern around the past mining activities (exploration for silver) and the potential contamination to the local environment. The water quality of Great Bear Lake was the major concern expressed by the people of Délı̨nę along with the health of the vegetation and wildlife. The debris and the openings at the site were expressed as a concern in regards to human and wildlife health.

Remediation planning process

The proposed Remedial Action Plan is based on the results of environmental site investigations, human health and ecological risk assessment studies, best practices in mine closure, traditional knowledge, current use of the area, and community values. The plan takes the environmental status of the site, precedent practice, regulatory requirements, and site goals into consideration. Long-term monitoring and reporting will be carried out at the site to provide ongoing assurance that the remediation works continue to perform as intended.

Principles relevant to the El Bonanza Mine from Federal policy and guidance documents were combined with the principles of the Sahtu Dene and Metis Comprehensive Land Claim Agreement to provide the site-specific approach for the development of the Remedial Action Plan. The final remediation plan has been developed under the management of the INAC's Contaminants and Remediation Directorate (CARD), which has the mandate for management of all northern contaminated sites. The overall responsibility of the CARD is to minimize health and safety and environmental risks associated with the site and implement a remediation plan that meets the needs and concerns of INAC, its First Nation partners and all Northerners. In addition, a community involvement and consultation process was undertaken to ensure that the community of Délı̨nę is aware of the site issues and an active participant in the selection of the preferred closure options for the final remediation of the El Bonanza Mine site.

Proponents and regulators

INAC is the project proponent for the Remedial Action Plan and is responsible for securing appropriate approvals and resources, and implementation of the plan. The proposed works will need land and water licenses from the Sahtu Land and Water Board before they can be implemented.

Proposed remediation works

A summary of the Remedial Action Plan is presented in Table ES.1. The main elements of the plan include activities associated with remedial actions to secure the mine openings; eliminate hazards and risks associated with buildings, the fuel storage tanks, the waste disposal areas, and miscellaneous debris; and mitigate existing or potential environmental issues associated with waste rock, tailings and hydrocarbon impacted soils. Within this context, the components considered within the Remedial Action Plan include the following:

TABLE ES-1
SUMMARY OF PREFERRED REMEDIAL ACTION PLAN

Site Component	Preferred Remediation Method
Mine Openings	• Seal mine shafts with appropriate cap • Seal adit entrance with rock fill
Buildings and Infrastructure	• Remove designated substances for disposal • Demolish buildings • Dispose of debris in local landfill
Waste Rock	• Leave as is for natural re-vegetation
Waste Disposal Areas	• Consolidate waste disposal areas into one area
Fuel Storage Tanks	• Clean out, demolish and dispose
Hydrocarbon Impacted Soils	• Cover in place, or relocate for onsite/offsite disposal depending on level of concentrations
Miscellaneous Debris	• Clean up and dispose of debris and drums in onsite landfill
Shoreline Improvements	• Remove shoreline debris and dispose in local landfill • Remove culverts at inlet and outlet of Silver Lake and re-establish natural inlet and outlet
Roadways	• Upon remediation completion remove culvert(s) and leave as is for natural re-vegetation

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GLOSSARY OF TERMS

Aboriginal land claim: A claim to a specific area of land based on legal concepts of land title and the traditional use and occupancy of that land by aboriginal peoples who did not sign treaties, nor were displaced due to war or other means.

Acid generating: Material capable of or actually producing acidic drainage.

Acid Producing Potential (APP): The potential of a material to produce acid, generally stated as kg $CaCO_3$ equivalent per tonne of rock.

Acid Rock Drainage (ARD): Drainage of low pH water from mineral areas as a result of the oxidation of sulphur-bearing materials that may release metals into the environment and result in significant environmental impacts.

Adit: A nearly horizontal passage from the surface by which a mine is entered and dewatered. A blind horizontal opening into a mountain with only one entrance.

Aerial photography: Photographs taken from an aircraft either obliquely or vertically.

Aggregate: Sand, gravel, or crushed rock.

As low as reasonably achievable (ALARA): A concept in radiation protection according to which radiation exposures are kept as far below the regulatory limits as possible, taking into account the state of technology achievable and the cost of improvement in relation to: (1) benefit or risk to the environment and to public health and safety; (2) other societal and socioeconomic considerations; and, (3) the use of radioactive materials in the public interest in medical diagnosis and therapy, research, the manufacturer of consumer products, and the production of electricity by nuclear power reactors.

Algae: Photosynthetic plants that live and reproduce entirely immersed in water. They range in size from simple, single-celled organisms to huge kelps several metres long.

Alkalinity: The aggregate measure of the concentration of hydroxyl, carbonate and bicarbonate ions, and dissolved CO_2. Therefore, it is a general indicator of the acid-buffering capacity of the water body.

Alpha radiation: The least penetrating, but most strongly ionizing of the three principal forms of radiation from radioactive materials, alpha radiation will be halted by the outer layer of dead skin cells in human skin, or by a single sheet of paper. However, alpha radiation can damage live body cells if ingested or inhaled through food, water, air, etc.

Ambient: The natural surrounding (background) conditions in a given area.

Analyte: A compound or element being analyzed.

Analytic detection limit: The limit of measurement of a given parameter, below which variations in concentration are indistinguishable from one another.

Asbestos: A naturally occurring soft fibrous mineral commonly used in fireproofing materials and considered to be highly carcinogenic.

Assessment endpoint: A quantitative or quantifiable expression of the environmental value considered to be at risk in a risk assessment.

Back: The ceiling or roof in an underground mine.

Background radiation: The radiation in the natural environment, including cosmic rays and radiation from naturally radioactive elements. It is also called natural radiation.

Baseline: See “Environmental baseline”.

Basement: The undifferentiated rocks (commonly igneous and metamorphic) that underlie the rocks of interest (commonly sedimentary) in a given area. In many regions the basement is of Precambrian age.

Becquerel or Bq: A standard international unit of radioactivity, equal to one radioactive disintegration per second. The obsolete unit curie or Ci, based upon the amount of radioactivity in a gram of radium, equals 3.7 x 10^{10} Bq.

Bedrock: The solid rock that underlies gravel, soil or other surficial material.

Benthic: Refers to the bottom of a lake or river and/or the organisms that inhabit it.

Benthos: The whole assemblage of plants or animals living on the lake or river bottom; distinguished from *plankton*.

Best Management Practice (BMP): Methods that have been determined to be the most effective, practical means of preventing or reducing pollution from non-point sources.

Bioaccumulation: The net accumulation of a chemical by an organism as a result of uptake from all routes of exposure.

Bioavailability: Degree of ability to be absorbed and ready to interact in organism metabolism.

Biological diversity (biodiversity): The variety of different species, the genetic variability of each species, and the variety of different ecosystems that they form.

Biomagnification: The tendency of some chemicals to accumulate to higher concentrations at higher levels in the food web through dietary accumulation.

Biota: The animal and plant life of a region.

Bog: An acidic, poorly drained, rainwater fed peatland characterized by hummocks or sphagnum spp. mosses with Labrador tea usually being the dominant shrub. Bogs may be treed with stunted black spruce and tamarack (muskeg) or may be open (open bogs).

Boreal Forest: The predominantly coniferous forest of northern Canada.

Borehole: Hole made with drilling equipment typically to obtain samples.

Buffering capacity: The degree to which a given volume of water or soil is able to neutralize acids.

Carbonate: Any mineral containing carbonate (CO_3^{-2}) ions.

C**arcinogen:** An agent that has the potential to cause cancer.

Carnivore: An animal that eats the flesh of other animals.

Chlorite: A group of widely distributed usually greenish, metamorphic minerals that are usually associated with micas, which they resemble.

Clay: Soil particles that are smaller than silt (less than 0.002 mm in diameter).

Climatology: The study of weather conditions or long periods of time.

Collar: The mount or upper end of a mine shaft or drill hole.

Conductivity: A measurement of the electrical conductivity of a water body or sample in order to determine the amount of dissolved material present.

Conservative: As used in the term *conservative estimates*, this is considered pessimistic or an overestimate of the level, effect or hazard, as the case may be.

Contaminant migration: The movement of contaminants from one location to another.

Contamination: Elements both radioactive and non-radioactive that are present at levels above those normally found (i.e. above background).

Contingency plan: A prearranged plan to be implemented in the event of some unforeseen happening of serious concern.

Crown or surface pillar: A body of rock of variable geometry, which may or may not contain minerals. Located above the underground operations, it supports the surface above stopes.

Decommissioning: The act of removing a regulated facility from operation and operational regulation. This usually entails a certain amount of cleanup (decontamination).

Decontamination: The process of removing contaminants from equipment, personnel, buildings or water.

Delineate: To determine the outer limits and size of something (i.e. an ore body).

Dip: A vertical angle measured downward from the horizontal plane to the level of an inclined plane such as a tilted sedimentary rock unit (see strike).

Discharge: The volume of water passing a given point per unit time, usually expressed as m^3/s.

Dose: A general term used to describe the amount of radiation or chemical absorbed by a person or in some cases a particular organ. The term dose can be used to describe two concepts. The first concept is a physical quantity; for radiation, it is the amount of energy absorbed per unit mass of tissue (see absorbed dose) and for chemicals, it is the concentration in tissue.

Drainage basin: The area of land and water bodies therein, draining to a given point, usually a lake or river.

Ecological Risk Assessment: The application of a formal framework, analytical process, or model to estimate the effects of human actions(s) on a natural resource and to interpret the significance of those effects in light of the uncertainties identified in each component of the assessment process. Such analysis includes initial hazard identification, exposure and dose response assessments, and risk characterization.

Ecosystem: Any natural system in which there is an interdependence upon and interaction between living organisms and their physical environment. This interdependence is characterized by the transfer of energy between the organisms themselves and their physical environment in a complex series of cycles.

Element: A substance that is comprised of one and only one distinct kind of atom.

Environment: The sum of all external conditions, influences and forces affecting the development and life of organisms.

Environmental baseline: The data collection characterizing the “natural” environment in its pre-development or pre-impact state. This data is used as a base for determining potential and actual impacts in the defined impact area.

Environmental Assessment: An environmental analysis to determine whether a site/facility would significantly affect the environment and thus require a more detailed environmental impact statement.

Environmental Impact: A change in environmental conditions resulting from an action or development, which may be negative, positive, or neutral.

Erosion: The wearing down (weathering) and removal of soil, rock fragments and bedrock through the action of rivers, glaciers, sea and wind.

Evapotranspiration: The total return of water from the land to the atmosphere, including the process of evaporation from the soil to surface and transpiration from plants.

Exposure: The amount of radiation or pollutant present in a given environment that represents a potential health threat to living organisms.

Exposure Assessment: Identifying the pathways by which toxicants may reach individuals, estimating how much of a chemical an individual is likely to be exposed to, and estimating the number likely to be exposed.

Exposure Concentration: The concentration of a chemical or other pollutant representing a health threat in a given environment.

Exposure Pathway: The path from sources of pollutants via, soil, water, or food to man and other species or settings.

Fan: A mechanical device used as a means of forcing air into underground workings.

Fault: A fracture in bedrock along which movement has taken place.

Foot wall: The underlying surface of an inclined fault plane.

Fracture (geological): A crack, joint, fault or other break in rocks.

Rock fracture: The general term given to any non-sedimentary medicinal discontinuity thought to represent a surface or zone of mechanical failure.

Gamma radiation: The greatest penetrating power, but least ionizing, of the three principal forms of radiation from radioactive materials. Gamma radiation can completely penetrate and damage all body organs. Gamma radiation can be shielded effectively by several inches of lead, steel, or concrete, depending upon the shielding material and the energy and intensity of the gamma radiation.

Geochemistry: Refers to the chemical analysis of surface and subsurface water, rock alluvium, soil and plants.

Grade: The relative quantity or percentage of ore mineral content in an ore body (i.e. g/t Au or % U_3O_8).

Grading: The process of making a surface level or evenly sloped.

Groundwater: Water beneath the earth’s surface, accumulating as a result of infiltration and seepage, and serving as a source of springs and wells.

Habitat: The natural home of a plant or animal.

Hanging wall: The overlying surface of an inclined fault plane.

Hazard: Potential for radiation, a chemical or other pollutant to cause human illness or injury. Hazard identification of a given substance is an informed judgment based on verifiable toxicity data from animal models or human studies.

Hazard Assessment: Evaluating the effects of a contaminant or determining a margin of safety for an organism by comparing the concentration that causes toxic effects with an estimate of exposure to the organism.

Headframe: The structure surmounting the shaft that supports the hoist rope pulley, and often the hoist itself.

Heavy metals: Any metal with a high atomic weight (usually greater than 100). They are poisonous and tend to persist in living tissue once ingested, e.g. mercury, lead, cadmium and chromium.

Human Health Risk Assessment: The process of quantifying risks and determining the acceptability of those risks to humans.

Hydraulic head: A combined measure of the elevation and the water pressure at a point in an aquifer that represents the total energy of the water; since ground water moves in the direction of lower hydraulic head (i.e. toward lower energy), and hydraulic head is a measure of water pressure, groundwater can and often does flow 'uphill'.

Hydrogeology: The study of subsurface waters and related geologic aspects of surface water.

Hydrology: The study of the characteristics, occurrence, movement and utilization of water on or below the earth’s surface and within its atmosphere.

Impervious liner: A layer of clay or manmade material such as High-Density Polyethylene (HDPE), used to seal the bottom of containment structures in order to prevent percolation and migration of potential contaminants.

Incremental: Small increase.

Lay-down area: An open area for storing equipment or materials at a mine site prior to their use.

Leachate: The water that percolates through a porous medium such as soil and transports any salts or other dissolvable materials that may be found in the soil.

Leaching: Washing out of soluble substances by water passing down through rock or soil. In a milling sense, indicates the dissolving of ore minerals from the ground ore.

Limnological: Referring to the scientific study of lakes and their physical, chemical and biological components.

Loadings: Total mass of contaminants to a water body or to the land surface over a specified time.

Lower limit of detection: This is the lowest concentration of radioactive material in a sample that can be detected at the 95% confidence level with a given analytical system.

Macrophytes: Rooted aquatic vascular plants.

Maintenance Activities: Activities undertaken to ensure that conditions remain in the desired state.

Manway: A vertical opening that can be used by miners to exit the underground workings. A shaft compartment used to accommodate ladders, pipes and electric cables. Underground usually a small passage used as a travelway for miners, an airway and supply route.

Mean: The average value of the data.

Measurement endpoint: A quantitative summary of the results of a toxicity test, a biological monitoring study, or other activity intended to reveal the effects of a substance.

Mine drift: A horizontal (or near horizontal) passageway in a mine through or parallel to a vein, or a secondary passageway between shafts or tunnels.

Mineral: A naturally occurring inorganic, crystalline solid that has a definite chemical composition and characteristic physical properties.

Mineralization: The process by which a valuable mineral or minerals are introduced into a rock, resulting in a potential or actual ore deposit.

Mitigation: An action or design intended to reduce the severity or extent of an environmental impact.

Modeling: Using mathematical principles, information is arranged in a computer program to model conditions in the environment and to predict the outcome of certain operations.

Monitoring: Sampling, measurement, and/or inspection.

Neutralizing potential (NP): The potential of material to neutralize an acid or a base.

Ore: Naturally occurring rock material from which a mineral or minerals of economic value can be profitably mined.

Ore body: A continuous well-defined mass of material containing enough ore to make extraction economically feasible.

Outcrop: The part of a rock formation that appears at the surface of the earth, uncovered by water or overburden.

Overburden: Unconsolidated soil and rock material overlying bedrock.

Oxidation: The process of combining with oxygen, especially at the atomic level.

Particulate: Consisting of particles.

Pathway: The physical course a chemical or pollutant takes from its source to the exposed organism.

Pathways analysis: A method of estimating the transfer of contaminants (e.g. radionuclides released in water) and subsequently accumulating up the food chain to fish, vegetation, mammals and humans and the resulting radiological dose to humans.

PCB's: A group of manufactured chemicals including 209 different, but closely related, compounds made up of carbon, hydrogen, and chlorine. If released to the environment, they persist for long periods of time and can biomagnify in the food web. They are an organic toxicant suspected of causing cancer, endocrine disruption, and other adverse impacts on organisms.

Permafrost: Thermal conditions remaining below 0 ºC continuously for more than one year.

Permeability: Describes the ability of subsurface features to transport water.

pH: A number expressing the degree of alkalinity or acidity of a substance according to the hydrogen ion concentration. A substance is said to be "neutral" if its pH is 7, acidic if less than 7 and alkaline if greater than 7.

Phytoplankton: Any microscopic or near microscopic, free-floating autotrophic aquatic plant.

Pitchblende: The most common form of uranium. A mineral consisting of uranium oxide and two amounts of iodine, thorium, polonium and lead. Uraninite in massive form is called pitchblende.

Population: A group within a single species, the individuals of which can and do freely interbreed.

Porosity: The relative volume of open spaces within a rock or soil. (Usually expressed as a percentage of the total volume of the material occupied by the open spaces, or interstices.)

Porewater: Water contaminated and trapped within void spaces in soils or rocks.

Precipitation: The deposition of atmospheric moisture as rain, sleet, snow, hail, frost or dew.

Prospector: An individual engaged in the search for economic mineral deposits, identifying minerals or mineral properties visually or with the use of portable instruments.

Pyrite: A common yellow mineral with a brilliant metallic lustre often crystallizing into cubes. It is an important sulphur ore and is often associated with gold and copper.

Radiation: The emission and propagation of energy through space or matter in the form of electromagnetic waves (e.g. gamma rays) or fast-moving particles such as alpha and beta particles.

Radioactive: The condition of a material exhibiting the spontaneous decay of an unstable atomic nucleus into a stable or unstable nucleus (e.g. uranium-238 decays into thorium-234 (unstable) and polonium-210 decays into lead-208 (stable)).

Radionuclide: An element or isotope that is radioactive as a result of the instability of the nucleus of its atom (e.g. radium or uranium).

Radon: A radioactive element in the uranium-238 decay chain produced by the radioactive decay of radium-226. Radon occurs as an inert gas. The half-life of radon-222 is 3.8 days. Short-lived radon decay products or, daughters, are the principal radiation hazard in the underground mine. The decay of radon-222 and short-lived decay products produces lead-210.

Receptor: A human or ecological entity exposed to a contaminant released to the environment.

Reclamation: Restoration of a site to a beneficial use that may be for purposes other than the original use.

Remediation: The improvement of a contaminated site to prevent, minimize or mitigate damage to human health or the environment. Remediation involves the development and application of a planned approach that removes, destroys, contains or otherwise reduces the availability of contaminants to receptors of concern.

Remediation Issue: Issues of concern for a specific aspect of the site.

Risk: A measure of the probability that damage to life, health, property, and/or the environment will occur as a result of a given hazard.

Risk Assessment: Qualitative and quantitative evaluation of the risk posed to human health and/or the environment by the actual or potential presence and/or use of specific pollutants.

Risk Characterization: The last phase of the risk assessment process that estimates the potential for adverse health or ecological effects to occur from exposure to a stressor and evaluates the uncertainty involved.

Roentgen (R): The roentgen is a historical unit used to measure radiation exposure, the number of ionizations in a mass of air. The roentgen can only be used to describe the amount of X or gamma radiation, and only in air. In metric units, one roentgen is equal to depositing in dry air enough energy to produce 2.58×10^{-4} coulombs per kg.

Run-off: The part of rainfall that is not absorbed directly by the soil but is drained off in rills or streams.

Screening: A preliminary stage of the assessment process for quick evaluation of relatively simple and routine activities, or for determining the level of effort required for evaluating more complex projects.

Sediment: Loose, solid particles resulting from the breakdown of rocks, chemical precipitation or from organisms.

Seismic: Pertaining to, characteristic of, or produced by earthquakes.

Sievert or Sv: A unit of equivalent or effective dose. In theory, the unit Sv should only be applied at low doses and low dose rates. Equivalent and effective doses are frequently expressed as millisievert (mSv), equal to one-thousandth of a sievert, or as microsievert (µSv), equal to one-millionth of a sievert.

Slumping: Sagging or physical subsidence of materials.

Spalling: Material breaking off from a surface, typically due to freeze/thaw processes.

Staff Gauge: A pole or ‘staff” graduated in standard units of measurement for the purpose of measuring depth.

Stopes: Underground mine working from which ore has been extracted for processing and metal recovery.

Strike: Refers to the direction taken by a structural surface as it intersects the horizontal plane e.g. bedding or fault plane. The strike is at right angles to the direction of dip.

Structure (geological): Features produced by deformation or displacement of the rocks, such as a fold or fault.

Sulphides: Any mineral compound characterized by the chemical linkage of sulphur with a metal e.g. galena (PbS), pyrite (FeS_2).

Taiga: The northern forest of coniferous trees that lies just south of the arctic tundra.

Tailings: Finely ground rock particle material rejected from a mill after most of the recoverable ore minerals have been extracted.

Tailings Containment Area or TCA: An area designated for the purpose of receiving and containing milling residues.

Tank farm: An area designed to contain various size tanks holding various types of liquids or gases, most commonly propane or petro-chemicals.

Till: An unsorted heterogeneous mixture of rock debris carried and deposited directly by a glacier, with very little subsequent reworking by melt water.

Topographic map: A map showing elevations by means of contour lines (i.e. lines joining points of equal elevation).

Traditional knowledge: Refers to the ancient understanding of philosophy, events and things passed on orally through generations by aboriginal people.

Traditional land use: Refers to land use by aboriginal people that reflect the historic activities of their people prior to European settlement (i.e. hunting, fishing, gathering).

Traditional lifestyle: Refers to the lifestyle of aboriginal people prior to European settlement.

Uncertainty: A quantitative expression of error.

Uraninite: Black uranium ore, mineral commonly called pitchblende (composition ranges from UO_2 to U_3O_8).

Uptake: The process/act by which a contaminant (e.g. a radionuclide) enters a biological organism (e.g. inhalation, ingestion by humans).

Vent: An (vertical) opening used for input of fresh air or exhausting used air from underground.

Ventraise: See **Vent**.

Waste rock: That rock or mineral that must be removed from a mine to keep the mining scheme practical, but which has no economic value.

Watershed: A drainage area or basin into which all surface water from a particular area collects and is transported.

Winter Road: A substandard, seasonal road passable only during the winter when the ground, muskegs and lakes it passes over are frozen.

Zooplankton: Any microscopic or nearly microscopic animals that move passively in aquatic ecosystems.

UNITS AND ABBREVIATIONS

Bq	Becquerel (1 disintegration per second, or 27 pCi)
Bq/L	Becquerel per liter
g/m^3	grams per cubic metre
m	metre
m^2	square metre
m^3/y	cubic metres per year
μg/g	microgram per gram
μg/L	microgram per liter
μrem	microrem (1 x 10^{-6} rem, or 0.01 μSv)
μR/h	micro Roentgen per hour
μSv	microsievert (1 x 10^{-6} Sv, or 100 μrem)
μSv/y	microsievert per year
Sv	sievert (100 rem)

ACM	Asbestos Containing Material
DDT	Dicloro-diephenyl-trichloroethane
NaI	sodium iodide scintillation detector
PAH	Polyaromatic Hydrocarbon
Pb-210	lead-210
PCB	Polychlorinated Biphenyl Compound
PHC	Petroleum Hydrocarbon
Po-210	polonium-210
Ra-226	radium-226
SI	International System of Units
TCA	Tailings Containment Area
Th-230	thorium-230
U	uranium

CHEMICAL SYMBOLS

Aluminum	Al
Ammonia	NH_3
Arsenic	As
Barium	Ba
Beryllium	Be
Cadmium	Cd
Calcium	Ca
Chloride	Cl
Chromium	Cr
Cobalt	Co
Copper	Cu
Iron	Fe
Lead	Pb
Lithium	Li
Magnesium	Mg
Manganese	Mn
Molybdenum	Mo
Nickel	Ni
Phosphorous	P
Potassium	K
Selenium	Se
Silver	Ag
Sodium	Na
Strontium	Sr
Sulphate	SO_4
Vanadium	V
Zinc	Zn

1.0 INTRODUCTION

1.1 OVERVIEW OF THE PROJECT

This Remedial Action Plan was developed to address human health, ecological, and environmental concerns associated with the El Bonanza abandoned mine site. It is intended to be a supporting document for assisting in regulatory decisions and funding decisions, and will provide the basis for development of tender documents and technical designs for the implementation of the remediation.

The proposed Remedial Action Plan is based on the results of environmental site investigations, human health and ecological risk assessment studies, best practices in mine closure, traditional knowledge, current use of the area, and community values. The plan takes the environmental status of the site, precedent practice, regulatory requirements, and site goals into consideration. Long-term monitoring and reporting will be carried out at the site to provide ongoing assurance that the remediation works continue to perform as intended.

1.1.1 Location

The abandoned El Bonanza Mine is located on the Dowdell Peninsula of Great Bear Lake. The coordinates of the site are 66°00’28” N latitude and 118°07’50” longitude (UTM Zone 11W 0451251 7320762) with an estimated elevation of 178 m above mean sea level. The site is approximately 435 km north-northwest of Yellowknife, 9 km southwest of Port Radium and 12 km west of the former Contact Lake Mine. Situated within the boundaries of the Sahtu Dene and Metis Comprehensive Land Claim Agreement, the nearest potentially affected community is Délı̨nę, approximately 260 km to the west, on the shores of Great Bear Lake.[1] The general and vicinity locations of the site are presented in Figures 1.1-1 and 1.1-2.

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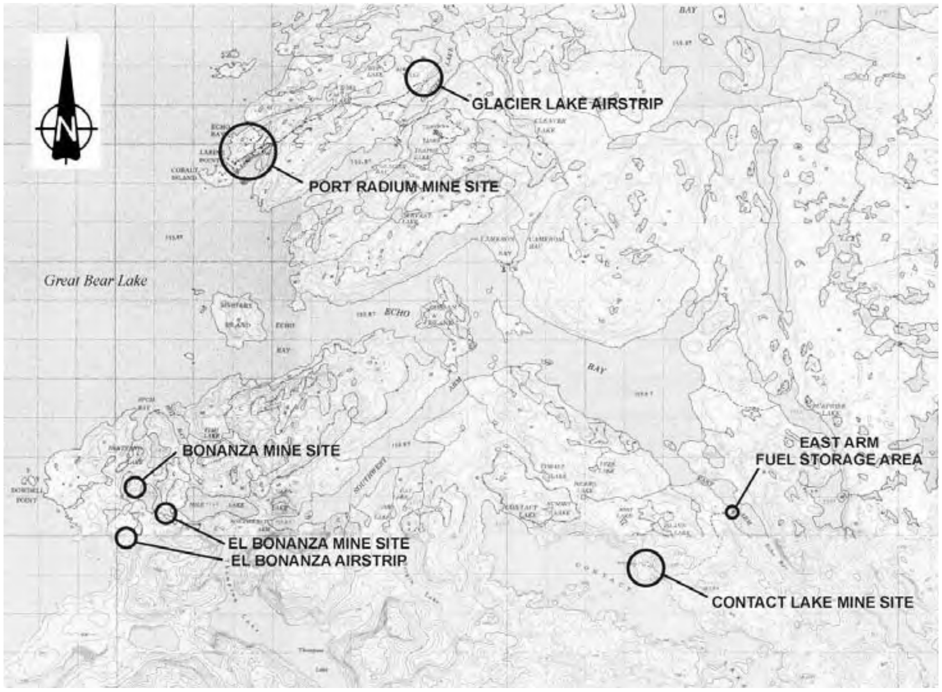
[1] The Tłîchô community of Gameti (Rae Lakes) is located roughly 210 km to the south of El Bonanza. Although closer than Délı̨nę, the residents of Gameti have limited interactions with sites in the near vicinity of Great Bear Lake. Residents of Délı̨nę, on the other hand, travel, hunt and fish around the perimeter of Great Bear Lake. On this basis, Délı̨nę is considered to be the nearest potentially affected community to the El Bonanza site.

FIGURE 1.1-1
GENERAL SITE LOCATION MAP

FIGURE 1.1-2
VICINITY SITE LOCATION MAP



1.1.2 Setting

The site is characterized by the barren and rugged relief of the eastern shores of Great Bear Lake that feature rock outcrops and sheer cliffs that rise rapidly from the lake’s shoreline (see Figure 1.1-3a & b). Peak elevations in the region around the site rise to more than 456 m a.s.l (above sea level), or approximately 300 m above Great Bear Lake, while peak elevations at the site proper rise to about 217 m a.s.l or about 60 m above Great Bear Lake. Natural flat lying land is, for the most part, non-existent at the site and the surrounding areas. Soil cover is generally sparse and, to the degree that it exists, very shallow.

Exposed bedrock predominates the area in general, and in the area of the former mine site, although some of the parts of the site are covered by waste rock. Sparse vegetation consisting of lichen, grasses, bushes, and pine trees cover the undisturbed areas of the site.

FIGURE 1.1-3a
SITE SETTING

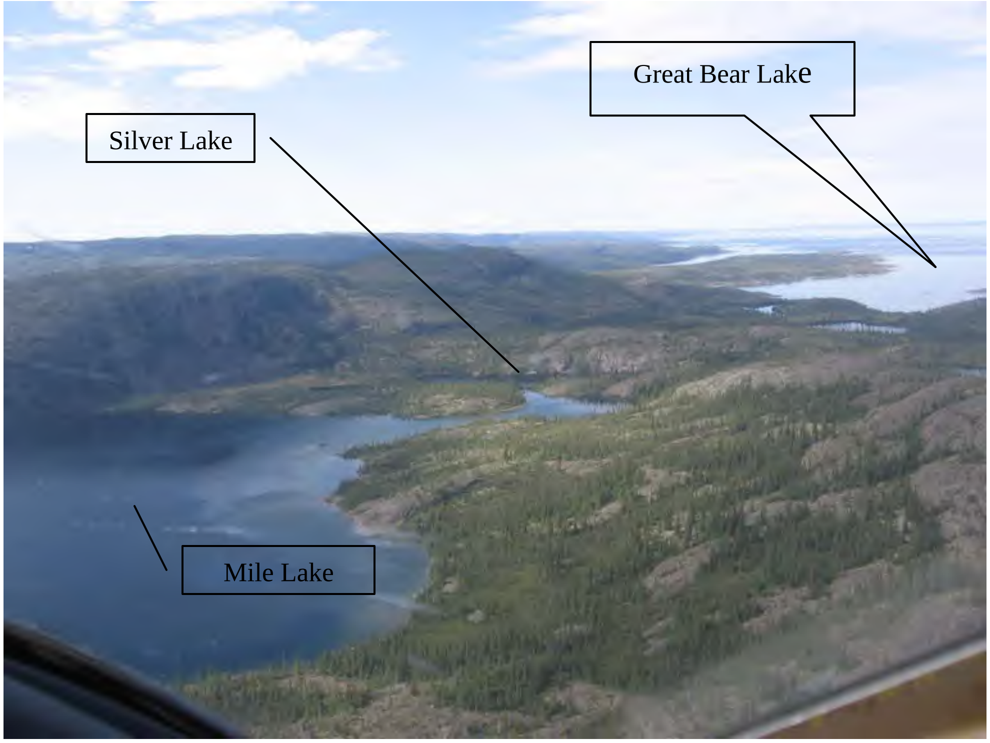
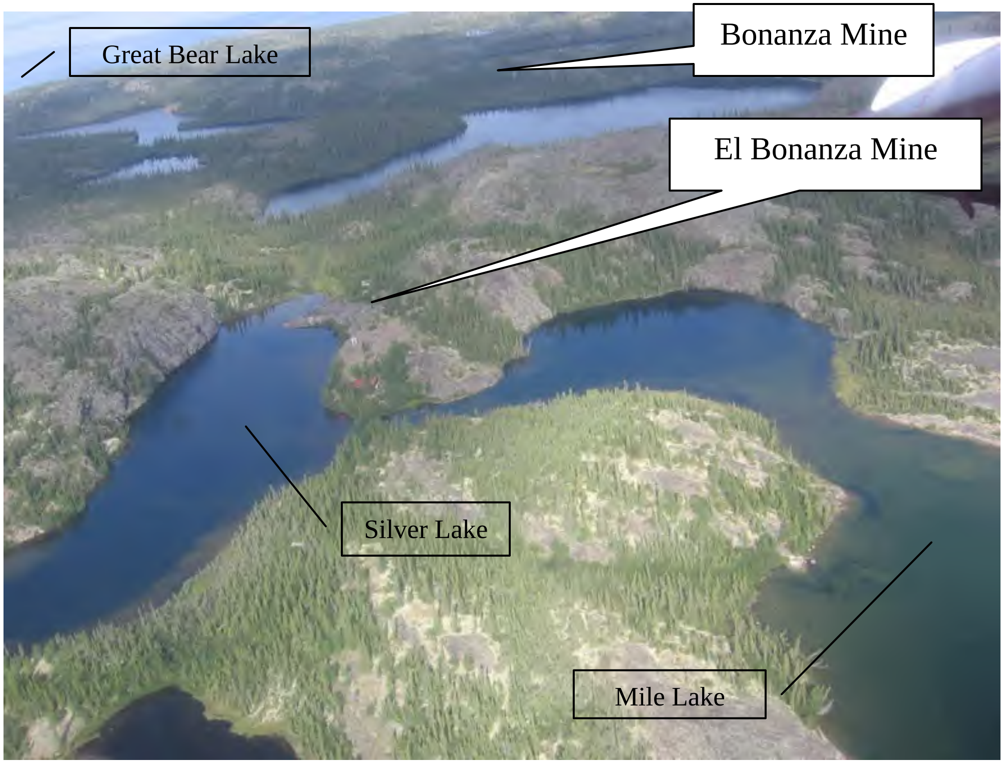


FIGURE 1.1-3b
SITE SETTING



1.1.3 Operation

Primary development at the El Bonanza Mine occurred during the periods 1934-1936, 1956-1957, and in 1965. Silver production was only attained in 1935 and operations were subsequently suspended due to low silver prices. It presently exists as an abandoned or orphaned site.

1.1.4 Community Concerns

The community of Délinę has expressed significant concerns with abandoned mines sites in the Sahtu Region. Although the El Bonanza site is small (less than 5 ha) in comparison to other nearby sites (i.e. Port Radium and Silver Bear Mines), there is still community concern around the past mining activities (exploration for silver) and the potential contamination to the local environment. The water quality of Great Bear Lake was the major concern expressed by the people of Délinę along with the health of the vegetation and wildlife. The debris and the openings at the site were expressed as a concern regarding human and wildlife health.

1.2 INAC'S RESPONSIBILITIES

Indian and Northern Affairs Canada (INAC) is the project proponent for the remediation of the El Bonanza Mine. It is INAC's responsibility to develop the Remedial Action Plan, obtain appropriate approvals, secure resources, and implement the plan by a consistent approach to closure of all INAC contaminated sites in the Northwest Territories region. Following remediation, INAC is responsible for the implementation of a long-term monitoring plan that is suitable for the site.

1.2.1 Approach to Preparation of the Remedial Action Plan

1.2.1.1 Overview

Section 39 of the *Northwest Territories Waters Act* (1992) identifies INAC authority to manage environmental contamination and risk to human health and safety. Abandoned contaminated sites are sites where historic endeavours cannot be identified or held responsible to address existing environmental contamination.

The El Bonanza Mine site is considered an abandoned site under the management of the Contaminants and Remediation Directorate (CARD) of INAC in Yellowknife. CARD works within a broader management system for all northern contaminated sites. This being the case, CARD must follow several guiding documents while developing the final Remedial Action Plan for the El Bonanza Mine. The following federal policies or guidance documents provide a broad context as to how CARD approaches remediation of contaminated sites in Northern Canada:

- A Federal Approach to Contaminated Sites (CSMWG 2000);
- Northern Affairs Program Contaminated Sites Management Policy (INAC 2002a); and,
- Treasury Board Federal Contaminated Sites Management Policy (Treasury Board 2002).

Although the INAC Mine Site Reclamation Policy for the Northwest Territories (INAC 2002b) and the Mine Site Reclamation Guidelines for the Northwest Territories (INAC 2006b) were not intended for abandoned properties such as the El Bonanza Mine, some parts of the policy are generally applicable and have also been considered.

The overall responsibility of CARD is to minimize health and safety and environmental risks associated with the site by implementing a Remedial Action Plan that meets the needs and concerns of INAC, its First Nation partners and all Northerners.

1.2.1.2 Regulatory

Currently, INAC has no land use permits or water licences associated with the El Bonanza Mine site. The remediation of the El Bonanza Mine will likely require a Type “A” Land Use Permit as the equipment and camp requirements may exceed one or more of the threshold limitations triggering a type A license such as the use of equipment with net weight exceeding 10 tonnes, use of a campsite for more than 400 person days, or use of a petroleum fuel storage container with a capacity equal to or exceeding 4,000 L (Appendix A, Sahtu Land and Water Board 2004).

The remediation plan will take into account the Department of Fisheries and Ocean’s Policy for the Management of Fish Habitat (1986), which has an overall objective of gaining habitat for Canada’s fisheries resources through the restoration of existing fish habitat and other methods. In addition, the remediation of the El Bonanza Mine site will follow federal acts including the Species at Risk Act (SARA) and Canadian Environmental Protection Act (CEPA).

Once the remediation of the site is complete, long-term monitoring suitable for the site conditions and remediation options will occur as identified through the Federal Approach to Contaminated Sites (CSMWG 2000).

It is noted that the Canadian Nuclear Safety Commission (CNSC), which administers the 1997 Nuclear Safety and Control Act, will not be regulating this site since uranium was not mined at this site.

1.2.1.3 General Principles

Principles, relevant to the El Bonanza Mine, from Federal policy and guidance documents were combined with the principles of the Sahtu Dene and Metis Comprehensive Land Claim Agreement to provide the site-specific approach for the development of the Remedial Action Plan.

Federal and Sahtu guiding principles for the El Bonanza Mine Remedial Action Plan are listed below.

1.2.1.4 Federal Policies

The following principles were adopted for the El Bonanza Remedial Action Plan from federal policy and guidance documents referenced above. Specifically:

- Meet the overall INAC objective to contribute to a safer, healthier, sustainable environment for Aboriginal peoples and northern residents by striving to preserve and enhance the ecological integrity of the environment (INAC 2002a);
- Take immediate and reasonable action to protect the environment and the health and safety of persons (Treasury Board 2002);
- Meet federal and INAC policy requirements and legal obligations regarding the management of contaminated sites (INAC 2002a);
- Ensure sound environmental stewardship of federal real property by avoiding contamination and by managing contaminated sites in a consistent and systematic manner that recognizes the principle of risk management and results in the best value for the Canadian taxpayer (Treasury Board 2002);
- Provide a scientifically valid, risk management based framework for setting priorities, planning, implementing and reporting on the management of contaminated sites (INAC 2002a);
- Develop a Remedial Action Plan to be sufficiently flexible to allow adjustments as the remediation progresses, including the flexibility to adapt to new and improved technologies and methodologies (INAC 2002b); and,
- Adopt solutions tailored to the northern environment and peoples wherever possible (INAC 2006a – management framework).

1.2.1.5 Partnerships with First Nations

The following principles regarding partnerships with First Nations were adopted from the policy and guidance documents referenced above specifically for the El Bonanza Mine Remedial Action Plan:

- Promote Aboriginal and northern participation and partnership (INAC 2002a; INAC 2006b);
- Promote respect and sharing of knowledge, experience and resources in partnerships/teamwork with clients and partners;
- Promote the social and economic benefits that may accrue to First Nations and northern communities (INAC 2002a);
- Plan, where appropriate, the scale and pace of remediation/risk management in keeping with northern and Aboriginal capacity to be involved (INAC 2002a); and,
- Incorporate economic opportunities, to the extent possible, for northern and Aboriginal communities in the management and remediation of the site (INAC 2002a).

1.2.1.6 Sahtu Dene and Metis Comprehensive Land Claim Agreement

The El Bonanza Mine site is within the Sahtu Dene and Metis Comprehensive Land Claim Agreement (see Figure 1.2-1) that was signed in 1993 (INAC 1993). The Land Claim Agreement was signed to, among other things, “recognize and encourage the way of life of the Sahtu Dene and Metis which is based on the cultural and economic relationship between them and the land”. The following principles were adopted from the Sahtu Dene and Metis Comprehensive Land Claim Agreement specifically for the El Bonanza Mine Remedial Action Plan:

- To protect and conserve the wildlife and environment of the settlement area for present and future generations;
- To directly involve communities and designated Sahtu organizations in land use planning; and,
- To encourage the self-sufficiency of the Sahtu and to enhance their ability to participate fully in all aspects of the economy specifically by protecting and promoting the existing and future social, cultural and economic well-being of the participants.

The Sahtu Land Use plan, developed under the principles and objectives of the Sahtu Dene and Metis Comprehensive Land Claim Agreement (INAC 1993) and the Mackenzie Valley Resource Management Act (MVRMA 1998) indicates that the El Bonanza Mine site is in a Special Management Zone where most land uses are possible (SLUPB 2007). Currently, there are no apparent ‘Conservation Areas’ in the El Bonanza area, so although the plan is still under review, the site will be managed in accordance with the Special Management Zone terms and conditions including, but not limited to:

- The maintenance of the ecological integrity of the area;
- The monitoring and management of infrastructure so as to prevent and/or rectify any negative environmental effects; and,

- The monitoring and management of activities in the area so that the migration routes of migratory or semi-migratory wildlife species is not blocked (SLUPB 2007).

1.2.1.7 Site Objectives

The following site objectives for the remediation of the El Bonanza Mine site were developed in accordance with the Federal Policies and Sahtu Dene and Metis Comprehensive Land Claim Agreement principles listed above and were agreed on by community members during consultation meetings in December 2007 (refer to Section 1.2.2.6):

- Minimize human health and safety risks at the El Bonanza Mine site;
- Protect fish, wildlife and vegetation;
- Protect Great Bear Lake, Mile Lake and Silver Lake water quality;
- Minimize environmental impacts during remediation;
- Minimize long-term care and maintenance;
- Return the site to its original condition where possible; and,
- Be cost-effective.

1.2.1.8 Remediation Planning Team

The technical team responsible for the development of the plan, conducting studies and reporting on the necessary technical information includes members of INAC staff, in Yellowknife and Ottawa, community members from Délı̨nę, as well as engineers, scientists and firms registered in the Northwest Territories, listed as shown below:

- Délı̨nę Remediation Team;
- INAC, Contaminants and Remediation Directorate (CARD);
- INAC, Water Resources;
- Public Works and Government Services Canada; and,
- SENES Consultants Limited.

1.2.2 Community Involvement and Consultation

1.2.2.1 Guiding Principles to Community Involvement and Consultation

As discussed above, the Northern Affairs Program Contaminated Sites Management Policy specifies that "INAC will promote First Nation, Inuit and northerner participation and partnership in the identification, assessment, decision-making and remediation/risk management processes relating to contaminated sites" (INAC 2002a). The guidelines indicate that every effort should be made to incorporate local knowledge on many different levels by, for example, creating working groups and interviewing elders and other age groups of the local people (INAC 2006b).

In addition to the federal policies and guidelines, a major objective of the Sahtu Dene and Metis Comprehensive Land Claim Agreement is “to provide the Sahtu the right to participate in decision making concerning the use, management and conservation of land, water and resources” (INAC 1993). The Land Claim Agreement (INAC 1993) and the Mackenzie Valley Resource Management Act (MVRMA 1998) guiding principles for consultation include:

- Providing the party to be consulted with:
    - notice of the matter in sufficient form and detail to allow the party to prepare its views on the matter;
    - a reasonable period for the party to prepare those views; and,
    - an opportunity to present those views to the party having the power or duty to consult.
- The party with the duty to consult must:
    - consider, fully and impartially, any views so presented.

1.2.2.2 El Bonanza Mine Site Community Involvement and Consultations

The community involvement and consultation process for the El Bonanza Mine site was undertaken to ensure that the community of Délı̨nę was included in all aspects of the work leading up to the remediation of the El Bonanza Mine site. Local people were hired to work at the site as bear monitors and to help collect samples throughout the site assessment phase of the work. Local people were interviewed so that an understanding of the historical and future land uses of the area could be determined. The remediation team from Délı̨nę was created at the request of INAC so that formal decision making could be done by the local people. The formal consultation process was initiated in February of 2007 when the first meeting took place and involved Chief and Council. In June of 2007, presentations were made at a community meeting in Délı̨nę, and in September of 2007, the Délı̨nę remediation team was taken to the site for a familiarization and awareness tour.

1.2.2.3 Traditional Knowledge

Many Traditional Knowledge studies have been conducted with elders, hunters and trappers residing in Délı̨nę regarding the Sahtu area (e.g. historical use, native wildlife populations, and local conditions). Although most studies have focussed on the overall Sahtu area and larger mine sites (Silver Bear and Port Radium) some specific information to El Bonanza was collected. Historically, Sahtúot’ı̨nę travelled through the El Bonanza site from the airstrip to the

El Bonanza Mine while they were hunting caribou (Personal Communication with H. Ferdinand). Currently, the El Bonanza site is not visited very often by the Sahtúot'ı̨nę because of the isolated location (Personal Communication with C. Yukon and L. Tucho). If the area around El Bonanza is visited, the mine site is generally avoided because of concern with potential contamination issues created by the historical mining (Personal Communication with the Délı̨nę Remediation Team).

1.2.2.4 Traditional Burial Sites

Interviews and a GIS mapping project were conducted by the Délı̨nę Uranium Team during the clean up of Port Radium to identify all traditional burial sites in the area. No traditional burial sites have been identified in the El Bonanza area (Interview with H. Ferdinand) but there are some north of the site mostly around Echo Bay and Cameron Bay. Based on the distance (~ 9 km) of these burial sites from El Bonanza, the burial sites would not be impacted during the remediation activities.

1.2.2.5 Meetings and Site Tours and Public Presentations

The meetings and site tours that involved community members and members from the technical team (listed above) were as follows:

- February 2007 – An initial meeting took place where the El Bonanza physical and environmental site issues were presented and discussed with the Chief and Council of Délı̨nę.
- June 2007 – A consultation meeting took place where the El Bonanza physical and environmental site issues were presented and discussed with the community of Délı̨nę.
- September 2007 – A site tour took place so that the Délı̨nę Remediation Team could become familiar with the site and have a better understanding of the scale and scope of the proposed Remedial Action Plan.
- December 2007 – An evaluation meeting took place where remediation options were presented, discussed, and decided upon.
- February 2008 – A public presentation took place in Délı̨nę so that the Délı̨nę Remediation Team could present the preferred remediation options to the community and solicit feedback. INAC team members provided support to the remediation team during this community meeting.

1.2.2.6 Evaluation of Remediation Options

The overall approach to evaluating remediation options for the site was as follows:

Prior to the evaluation meeting in December 2007:

1. The site was divided into various aspects and issues as outlined in the Mine Site Reclamation Guidelines for the Northwest Territories (INAC 2006b).
2. For each aspect and issue, remediation options were recommended by SENES Consultants Limited with input from INAC, CARD (see Table 6.1-1, Chapter 6).

During the Meeting in December 2007:

3. A site overview was presented followed by a presentation and discussion of the site goals and the recommended remediation options.
4. The site objectives used during the evaluation of the remediation options are stated above (see Section 1.2.1.7 Site Objectives). The goals were agreed on during the meeting by the Délı̨nę Remediation Team.
5. The recommended remediation options were then presented for each site issue and were deleted if not relevant and/or additional options were added as recommended by the Délı̨nę Remediation Team.
6. The options were then ranked on how well they met site goals and best practices:
   - Good - met objective
   - OK - partially met objective
   - Bad - did not meet objective
7. Then, the options were determined as:
   - P = preferred
   - A = acceptable
   - NA = not acceptable
8. Where the community preferred remediation option agreed with the INAC preferred remediation option, the option was accepted. If the community preferred option was in conflict with the INAC preferred option, more discussion was required to come to a resolution. Once an agreement was obtained, the option in question was accepted.

The presentation including the evaluation tables that were filled out during the meeting are provided in Appendix A. The meeting minutes from the evaluation meeting are included in Appendix B.

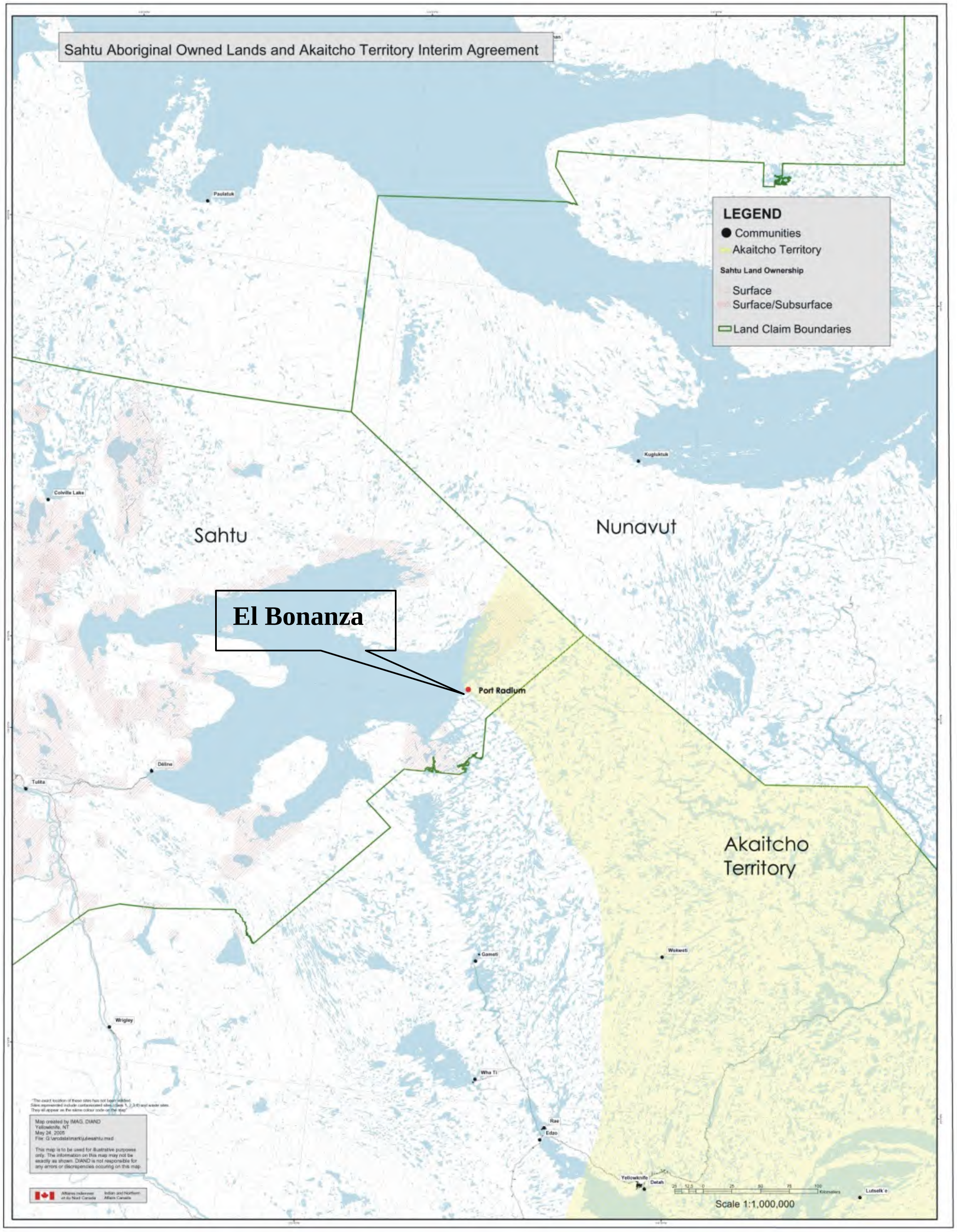
Following the meeting in December 2007:

9. The preferred options were compiled in a preferred Remedial Action Plan as described in Chapter 6.

1.2.2.7 Future Community Involvement and Consultation

Additional meetings will be held with the Délı̨nę Remediation Team to ensure that they are informed of upcoming activities regarding the remediation of the El Bonanza Mine site and to solicit their input. Any deviations from the preferred options will be discussed along with the progress of the Remedial Action Plan. To assist in communicating progress of the site, there will be opportunities for site tours throughout the remediation phase of the project and post remediation.

FIGURE 1.2-1
SAHTU AND AKAITCHO TERRITORY INTERIM CLAIMS MAP



Source: Indian and Northern Affairs Canada.

1.3 OVERVIEW OF AVAILABLE INFORMATION

An Enhanced Phase I Environmental Site Assessment of the El Bonanza Mine was conducted in 2004 by Golder Associates Limited (Golder 2005) for CARD that included, in addition to a preliminary physical characterization of the site, a limited sampling program of environmental media including surface soil, lake sediments, surface water and mine rock. The assessment concluded that a number of potential environmental concerns and physical hazards may be associated with the site as noted below.

Environmental Concerns

- Mine rock exceeds soil quality guidelines for metals and the western stockpile may have some potential to generate acid;
- Seven drums (approximately 1,400 L) of mixed products were noted at the site;
- Soil at the airstrip tank farm exceeds soil quality guidelines for petroleum hydrocarbon (PHC) fractions F2 and F3;
- Arsenic levels are elevated in soil at the equipment dump at the airstrip; and,
- Water present in the shafts exceeds surface water quality guidelines for aluminum and zinc.

Physical Hazards

- Two mine shafts, two unidentified openings and one adit;
- Four buildings in varying degrees of disrepair; and,
- Scrap metals and general debris.

In July 2006 a field investigation and site assessment program was conducted at the El Bonanza Mine by SENES Consultants Limited (SENES 2007a). Figure 1.3-1 illustrates the location and nature of the sampling program. A supplementary field investigation was completed the following year in June (SENES 2007c). These investigations were implemented under the auspices of the Federal Contaminated Sites Action Plan (FCSAP). Prior to initiation of the field work, a Site Investigation Plan was designed in keeping with INAC’s approved Detailed Work Plan (DWP) for the site, and in accordance with a Work Breakdown Structure (WBS) that was developed by INAC and Public Works and Government Services Canada (PWGSC) with input from FCSAP’s expert advisors including Health Canada (HC), Environment Canada (EC) and the Department of Fisheries and Oceans (DFO) Canada.

The primary objective of the 2006 site assessment (SENES 2007a) was to collect information on existing site conditions to further characterize the site’s physical and environmental status. In carrying out the work, observations and measurements were made of the physical features and conditions of the site including: conditions of remaining buildings, mine openings, waste rock, debris and tanks; habitat conditions at the shoreline and culverts in the immediate vicinity of the site; as well as surface measurements of terrestrial gamma radiation across the site. Samples of surface water, sediment, soil, waste rock, and terrestrial vegetation were collected in different areas of the site and analyzed for metals and, where appropriate, for PHCs and polychlorinated biphenyls (PCBs) (e.g. in soil, waste rock and sediment at selected locations).

The 2007 field program (SENES 2007c) was focussed on providing supplementary information on site aspects pursuant to the findings of the 2006 site assessment program. The supplementary program included: collection of additional surface water and sediment samples for chemical and radiological characterizations, additional waste rock sampling to assess metal bioavailability, and additional soil sampling to delineate PHC and metal impacted areas and to confirm the absence of PCBs; sampling of tanks and drums at the airstrip to assess the nature and quantity of residual materials; sampling of paint and building materials to test for PCBs, lead and DDT (dichloro-diphenyl-trichloroethane); and, additional visual inspections of relevant surface features.

The information obtained through the 2006 site assessment was used in the development of the human health and ecological risk assessment. The 2007 site assessment information confirmed the assumptions of the risk assessment, and provided additional site-specific information for input to the development of remedial issues and options tables and for the preferred Remedial Action Plan.

The human health and ecological risk assessment was completed for the El Bonanza Mine in May 2007 (SENES 2007b). Overall, the assessment indicated that individuals who might visit the El Bonanza Mine site on a short-term basis, even if taking home locally collected food for subsequent consumption, would not experience any adverse health effects. From an ecological perspective, the risk assessment shows that the site poses no risk of adverse effects to large animals such as bear, moose, and caribou and only a minimal potential risk of adverse effects on individual small local species (grouse/ptarmigan), but no adverse effects on populations.

Use of Environmental Quality Guidelines in Human Health and Ecological Risk Assessment

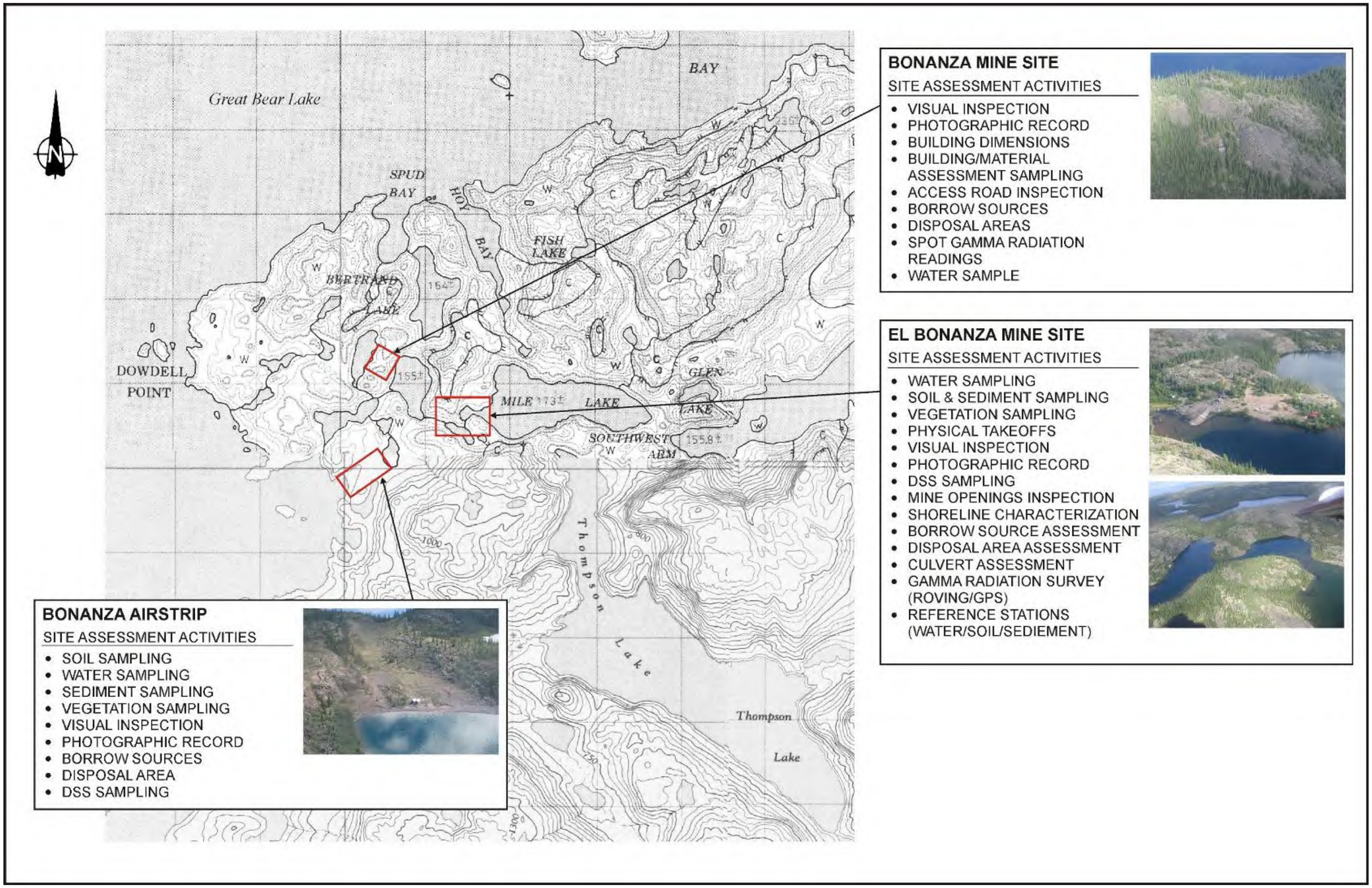
Prior to conducting the human health and ecological risk assessment, a screening process was completed to identify “constituents of potential concern” (COPC) (typically metals at mine sites) that would be carried through the assessment. This involved comparing available environmental data for the El Bonanza Mine to background levels when possible and applicable environmental quality guidelines. As a first step, data were compared to background (baseline) levels. If the constituent concentration was at least 1.2 times greater than these levels, the constituent was carried to the next step where comparisons were made to Canadian Environmental Quality Guidelines (CEQGs). If the constituent concentration exceeded the CEQG value and if appropriate toxicity data were available for that constituent, then the constituent was considered to be a COPC and was carried through the risk assessment.

In identifying COPC, water quality data were compared to CEQG developed for the protection of freshwater aquatic life by the Canadian Council of Ministers of the Environment (CCME 2007). This was the case for metals, but analogous guidelines have not been developed by the CCME for radionuclides. Sediment quality data were compared to toxicity benchmarks developed by the CCME (Interim Sediment Quality Guideline (ISQG); CCME 2007) and Canadian Nuclear Safety Commission (Lowest Effect Level (LEL); Thompson *et al.* 2005). This was the case for metals, but guidelines for PHCs in sediments have not been developed. CCME soil quality guidelines developed for residential/parkland land use (CCME 2000; 2008) were used to assess metals, PHC, polyaromatic hydrocarbon (PAH), and PCB levels in soils and waste rock, collectively. Specific guidelines for waste rock have not been developed. Terrestrial vegetation data collected for browse and forage were compared to phytotoxicity levels obtained from Davis *et al.* (1978), McBride (1994), and Langmuir *et al*. (2004). The reader is referred to SENES (2007b) for further details on the COPC screening process.

Once the COPC were identified, a pathways model was used to estimate the COPC exposure levels (intakes) to terrestrial ecological and human receptors. Exposure levels were in turn compared to appropriate benchmarks such as toxicity reference values. For aquatic ecological species, a pathways model was not employed but the water concentration was compared to the appropriate toxicity reference value for a given representative species.

It should be noted that in cases where guidelines for specific environmental media or materials have not been developed, comparisons are often made to other existing and related guidelines in order to obtain some perspective on the measured concentrations. For instance, radionuclide concentrations measured in freshwater may be compared to Canadian drinking water quality guidelines (Health Canada 2006a); PHC concentrations in sediments to soil quality guidelines for all land use scenarios (CCME 2000; 2008); and, metals in waste rock and tailings to soil quality guidelines for residential/parkland land use (CCME 2000; 2008).

FIGURE 1.3-1
OVERVIEW OF 2006 SITE ASSESSMENT PROGRAM



BONANZA MINE SITE

SITE ASSESSMENT ACTIVITIES

- VISUAL INSPECTION
- PHOTOGRAPHIC RECORD
- BUILDING DIMENSIONS
- BUILDING/MATERIAL ASSESSMENT SAMPLING
- ACCESS ROAD INSPECTION
- BORROW SOURCES
- DISPOSAL AREAS
- SPOT GAMMA RADIATION READINGS
- WATER SAMPLE

EL BONANZA MINE SITE

SITE ASSESSMENT ACTIVITIES

- WATER SAMPLING
- SOIL & SEDIMENT SAMPLING
- VEGETATION SAMPLING
- PHYSICAL TAKEOFFS
- VISUAL INSPECTION
- PHOTOGRAPHIC RECORD
- DSS SAMPLING
- MINE OPENINGS INSPECTION
- SHORELINE CHARACTERIZATION
- BORROW SOURCE ASSESSMENT
- DISPOSAL AREA ASSESSMENT
- CULVERT ASSESSMENT
- GAMMA RADIATION SURVEY (ROVING/GPS)
- REFERENCE STATIONS (WATER/SOIL/SEDIEMENT)

BONANZA AIRSTRIP

SITE ASSESSMENT ACTIVITIES

- SOIL SAMPLING
- WATER SAMPLING
- SEDIMENT SAMPLING
- VEGETATION SAMPLING
- VISUAL INSPECTION
- PHOTOGRAPHIC RECORD
- BORROW SOURCES
- DISPOSAL AREA
- DSS SAMPLING

1.4 STRUCTURE OF REMEDIAL ACTION PLAN

In addition to this introductory chapter, the following information is provided in this report:

- Chapter 2 provides additional details on current land use and the history of the site including former operations and past closure activities;
- Chapter 3 provides a detailed description of the major site components, their current status, and potential issues and concerns;
- Chapter 4 provides a description of the environmental setting in which the site is located and a summary of environmental site assessment results;
- Chapter 5 provides a summary of the human health and ecological risk assessment that was completed for the El Bonanza Mine site;
- Chapter 6 presents the proposed Remedial Action Plan including the process, guiding principals, and proposed remedial action for each major component;
- Chapter 7 provides a discussion of post-remediation monitoring activities;
- Chapter 8 comments on the remediation schedule; and,
- Chapter 9 provides a list of cited references.

2.0 LAND USE AND HISTORY OF SITE AND SURROUNDING AREA

2.1 HISTORICAL LAND USES

Most historical land use studies have focussed on the greater Sahtu region and larger mine sites (i.e. Silver Bear and Port Radium) and not specifically El Bonanza. The following discussion provides an overview of the historical land use of the Great Bear Lake Region (also known as the Sahtu) (CDUT 2005) with some specific details regarding the El Bonanza site.

The Sahtu area that includes the El Bonanza Mine site was part of the traditional territories of several First Nation groups, including the Dogrib, Hare, Slavey, Yellowknives, and Inuit. In the centre of this region, the Sahtu Dene people practiced traditional lifestyles by hunting caribou, trapping fur-bearing animals, and catching fish from Great Bear Lake (MacDonald *et al.* 2004). The El Bonanza site specifically, was traversed by the Sahtu Dene and caribou hunting was conducted in the area (Personal Communication with H. Ferdinand). More recently, the term Sahtúot'įnę has been adopted to refer to the aboriginal people of this district (CDUT 2005).

The first European settlement was established in 1799, when the Northwest Company built a trading post at the head of the Bear River, the site of traditional annual meetings for the people living in the Sahtu. This site came to be known as Fort Franklin after the Franklin expedition used the post as its winter headquarters in 1825. In the 1950s, the establishment of a Roman Catholic Mission and a school drew Dene people who were traditionally semi-nomadic, to settle permanently at the site. Today, the community is known by its Dene name of Délįnę, which means "place where the river flows" (CDUT 2005).

In 1930, radium, pitchblende, and silver were discovered in the vicinity of Port Radium. Soon thereafter (i.e. early 1930s), mining operations were developed at this location to extract uranium ore. Activities were initiated to explore for and develop other mines in the immediate region including the Echo Bay Mine, the Contact Lake Mine, the El Bonanza and Bonanza Mines, all of which were primarily developed to extract silver. None of these mines are currently in operation and responsibility for the sites presently resides with the crown.

During the 1950s, interest in tourism and sport fishing increased within the watershed. To meet the expanding demand for services, a total of five fishing lodges were established on Great Bear Lake. With the increased fishing pressure on large, trophy-sized lake trout, fisheries management agencies and stakeholders took steps to limit fishing pressure due to the sensitivity of the lake trout population to over-harvesting (including catch-and-release fishing on trophy-sized fish) (MacDonald *et al*. 2004).

In 2005, with the rapid world wide rise in mineral prices including base and precious metals and uranium, exploration activities began again in the Sahtu region. For example, mining exploration activities including drilling/polarization and resistivity testing, have been ongoing in the region of the nearby Contact Lake site since 2005.

2.2 MINING HISTORY

2.2.1 Mine Operation and Production

El Bonanza Mine

The El Bonanza area was mined for silver and presently exists as an abandoned or orphaned site. Primary development at the El Bonanza Mine occurred during the periods 1934-1936, 1956-1957, and in 1965. Silver production, however, was only attained in 1935 after which operations were suspended due to low silver prices. The history of the mine is briefly described here from Silke (2006a; 2006b) and Golder (2005) with references as cited in the original text.

Rich silver was discovered at the El Bonanza property in 1931 by Spud Arsenault, on behalf of Eldorado Gold Mines Limited, who staked the 'Bonanza' and 'St. Paul' claim groups. In 1934, the eastern half of the 'Bonanza' claim group and the entire 'St. Paul' claim group were acquired by the El Bonanza Mining Corporation Limited, a wholly-owned subsidiary of Eldorado Gold Mines Limited (The Toronto Star February 7th 1934; Lord 1951; Lang 1951). The eastern half of the 'Bonanza' claims constitutes the El Bonanza Mine, while the western half, which was retained by Eldorado Gold Mines Limited, constitutes the Bonanza Mine. The western deposit is located 1 km northwest of the El Bonanza Mine (Lord 1951; Lang 1951).

Surface and underground work that included the sinking of two shafts into the Bonanza and Spud veins was conducted at the El Bonanza Mine in 1934 and 1935 (Scott 1935; Sanche 1972). In 1935, 6,610 pounds (3 metric tons) of high-grade silver ore were hand picked from the Bonanza vein through the second shaft and were shipped to the Cominco smelter in Trail, BC (Lord 1951; Pasieka 1977). The ore yielded an incredible 30,175 ounces (855 kg) of silver (Pasieka 1977). Another 50 tons were reported as being stockpiled at the shaft workings in September 1935 (The Northern Miner Sept. 19th 1935). Stockpiled ore was to be shipped to the nearby Eldorado Mine for milling and operations were scheduled to commence between 1935-1936 (Scott 1935). However, operations, were subsequently suspended (Lord 1951) due to a drop in the price of silver (Pasieka 1977).

Minor uranium showings at El Bonanza resulted in the expropriation of the property from Eldorado Gold Mines Limited by the federal government from 1940 to 1950 for strategic purposes (Golder 2005). No record of uranium being mined at the El Bonanza Mine has been found, indicating that the pitchblende deposit was not substantial, as this resource would have almost certainly been developed given the proximity of the deposit to the Port Radium mill. Upon release by the federal government in 1950, J.J. Gray purchased control of the El Bonanza Mining Corporation Limited from Eldorado Gold Mines Limited with plans to re-develop the mine (Pasieka 1977; NORMIN 2005). A new program of underground development was initiated in 1956 (McGlynn 1971), but failed to discover silver deposits of economic importance (Anderson-Thompson 1956; Johnston 1957).

In 1965, the property was re-opened by S.E. Midgely (Sanche 1972) but no information on activities undertaken is available. As of 1965, approximately 1,000 tons of ore containing 50 ounces of silver per ton were reported as being stockpiled on surface (NORMIN 2005). Further work was conducted in 1967 or 1969 that included some dewatering of a shaft and surface underground drilling (Sanche 1972; NORMIN 2005). The eastern shaft was dewatered again in 1972 when another 2,500 tons of ore containing 60 ounces of silver per ton were stockpiled (NORMIN 2005).

NORMIN (2005) reported that rock geochemical surveys were conducted by Du Pont of Canada Exploration Limited in 1974, and that the property was optioned to Nightwatch Resources in 1977 who leased it to Echo Bay Mines Limited (1978–1981) to conduct further drilling and dewatering of the eastern shaft, and to map and conduct geophysical surveys of the area. No economic silver was encountered, and as a result, no further work was recommended on the property (Moffet 1981).

Bonanza Mine

With respect to the Bonanza Mine, work was conducted by Eldorado Gold Mines Limited from 1937-1938 to explore for silver potential. This included sinking of a short shaft and some limited lateral work (Bowdidge 1984) that lead to the extraction of a small amount of silver, which was shipped to and treated at the Eldorado mill at Labine Point (i.e. the Port Radium mine) (Hoefer and Magrum 1988). The Bonanza Mine was re-staked by H. Arden in 1982 and optioned to O.P. Resources Limited in 1984. O.P. Resources Limited carried out further exploration work that confirmed the existence of high-grade silver deposits at the mine site but did not discover further silver deposits in the surrounding area (Bowdidge 1984; Magrum 1988). In 1988 the property was optioned to Octan Resources Incorporated and that year more exploration work was conducted that included trenching, drilling and bulk sampling of 1,500 pounds (680 kg) of ore (Hoefer and Magrum 1988). The property reverted back to H. Arden in 1990 and no further records of work at the site have been identified (NORMIN 2005).

2.2.2 Transportation During Mining

Past access to the mine has been either by air or by boat. Air access may have included fixed wing plane landing at the airstrip at Great Bear Lake, or landing on either Great Bear Lake in the vicinity of the airstrip or landing on Mile Lake in the vicinity of the mine. Access roads were constructed to connect both from Mile Lake and Great Bear Lake to the mine. The road connecting the site with Great Bear Lake and the gravel airstrip at Great Bear Lake is about 1.5 km in length. Access to the Bonanza site likely occurred across the ice on the small lakes between Great Bear Lake and the mine site. Evidence of a former trail remains in the vicinity of the mine.

2.2.3 Decommissioning Status

The El Bonanza Mine (and the Bonanza Mine) have not been officially decommissioned and to date, limited effort has been directed towards the remediation or "closure" of the mine and associated infrastructure.

2.3 CURRENT LAND USES

The nearest community to El Bonanza in the Sahtu Dene and Metis Land Claim is Délı̨nę, approximately 263 km to the west. Délı̨nę residents today maintain strong links to their traditional Dene way of life and Great Bear Lake remains the central defining feature of the community and the traditional territory of the Sahtúot'ı̨nę.

As people continue to harvest the plants and animals of the region for food and fuel, Great Bear Lake provides not only physical sustenance for the people of Délı̨nę, but also the spiritual and cultural sustenance that comes from practicing the skills and lifestyle of their ancestors. While caribou and fish are harvested most frequently, smaller animals and various plants and berries are also important traditional foods.

Due to its isolated location, current land use activities in the vicinity of the El Bonanza Mine site have been limited (Personal Communication with C. Yukon and L. Tucho). Sahtúot'ı̨nę who travel Great Bear Lake in the summer, typically stay at locations on Great Bear Lake and do not traverse from Great Bear Lake to El Bonanza.

Development work at the El Bonanza Mine ceased in the 1960s, but exploration to establish an economic silver ore body continued into the early 1980s (Silke 2006a). In 2005, mineral exploration activities were initiated in the region, which became more active in 2006 and 2007.

2.4 ACTIVE MINERAL CLAIMS

The following table (Table 2.4-1) lists the Mineral Claims that are in the direct vicinity of the El Bonanza Mine site and includes the owner and dates of validation. Refer to Figure 2.4-1 to locate the area of land that coincides with each of the listed Mineral Claims.

No land use permits are currently issued for the El Bonanza area.

TABLE 2.4-1
MINERAL CLAIMS IN THE EL BONANZA AREA

Mineral Claim Number	Owner	Issue Date	Expiry Date
F91863	Alberta Star Development Corp.	2005-08-26	2007-08-26
F91864	Alberta Star Development Corp.	2005-08-26	2007-08-26
F98380	Hunter Bay Resources Inc.	2005-09-30	2007-09-30
F98760	Hunter Bay Resources Inc.	2006-02-14	2008-02-14

Source: NORMIN (2005).

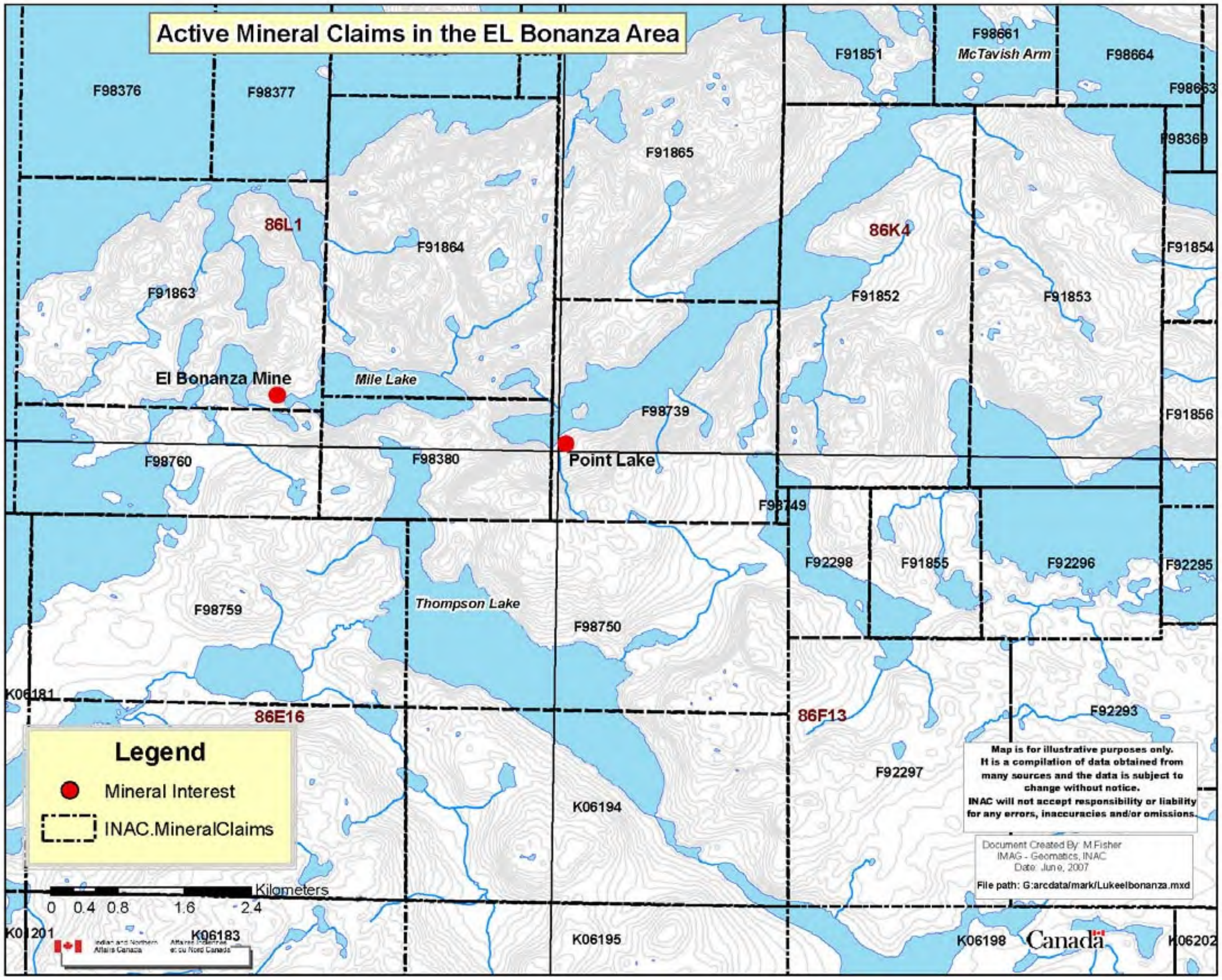
2.5 MINING HERITAGE INTERESTS

The NWT Mining Heritage Society has toured the Bonanza and El Bonanza mine sites and has identified several pieces of mining equipment with potential heritage value. These have been documented in a report prepared by R. Silke (2006c) and include a flat bed car at the Bonanza Mine, and two galvanized steel ore buckets, one ore car consisting of the box only, and an Athey Wagon half-track at the El Bonanza Mine.

2.6 SITE ACCESS

At present, access to the site is by air to Mile Lake, by either fixed wing planes with floats or skis, depending on the time of year and conditions, or by helicopter. In addition, past access has included the use of a 1.5 km road connecting the site with Great Bear Lake (refer to Figure 3.1-1 in next section). An abandoned gravel airstrip at Great Bear Lake has partially re-vegetated and has been eroded in many areas. As such, the airstrip is not useable in its current condition.

FIGURE 2.4-1
ACTIVE MINERAL CLAIMS IN THE EL BONANZA AREA



Map is for illustrative purposes only.
It is a compilation of data obtained from many sources and the data is subject to change without notice.
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Date: June, 2007

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3.0 DESCRIPTION OF THE MINE SITE FEATURES

3.1 OVERVIEW OF SURFACE FACILITIES

The El Bonanza Mine site consists of the El Bonanza Mine proper with its related mine shafts, adits, and support facilities including several buildings and wooden foundations, located on Mile Lake and Silver Lake; the Bonanza Mine headframe and cabins located near Whale Lake; the Airstrip and Fuel Storage area on Great Bear Lake; and, the roads connecting these facilities. The general locations of these areas are shown on Figure 3.1-1 and are described below.

FIGURE 3.1-1
GENERAL OVERVIEW OF EL BONANZA SITE ASPECTS

Legend:
Blue dashed line indicates water flow from Mile Lake to Great Bear Lake.
Orange dotted line indicates road from Great Bear Lake to El Bonanza Mine.
Red dashed line indicates access road to Bonanza Mine.

3.2 EL BONANZA MINE SITE FEATURES

An overview of the El Bonanza Mine site is shown on Figure 3.2-1. The mine is located at the base of a rock ridge and glacial till outcrop at the east end of Mile Lake, and immediately adjacent and encroaching on a small lake (Silver Lake) that receives discharge from Mile Lake and drains toward Great Bear Lake. The footprint of the mine and former surface facilities adjacent to Silver Lake is very small. Only limited evidence of former activities associated with a small former dock remains at Mile Lake.

Important features of the El Bonanza Mine site are outlined on Figures 3.2-2 and 3.2-3. Visual observation indicates that the mine workings were excavated in the rock outcrop and mine workings include three small shafts, one small adit, two mine waste rock piles from mining activities, and various small and shallow surface trenches cut in the rock above the mine.

The buildings on site were generally constructed of logs or timber with wooden floors, and wood roofs finished with tarpaper roofing. Standing wooden mine and camp facilities include 8 buildings and 1 shed. In addition, remnants of 6 partially or completely demolished former buildings remain exposed to various degrees. Buildings still standing on site include the dry, headframe and shop, outhouse, warehouse, radio shack, bunkhouse, fuel storage shed and one building whose use is unknown. The kitchen and office building was burned down, while only the floor of the coreshack remains. The powerhouse, core storage, and two buildings whose past uses are unknown remain on-site in a demolished state.

Timbers in miscellaneous stacks occur at various locations throughout the site. Scrap metal in the form of piping, drums and metal fragments and mining equipment also occur throughout the site, as well as in the water along the banks of Great Bear Lake (in the area of the airstrip and fuel storage area), Silver Lake and Mile Lake. Two dump sites containing discarded food cans, scrap metal, rubber hoses, glass, wood stoves and drums also occur at the mine site, and a third one along the access road southwest of the main mine site.

FIGURE 3.2-1
AERIAL PHOTOGRAPH OF EL BONANZA MINE SITE

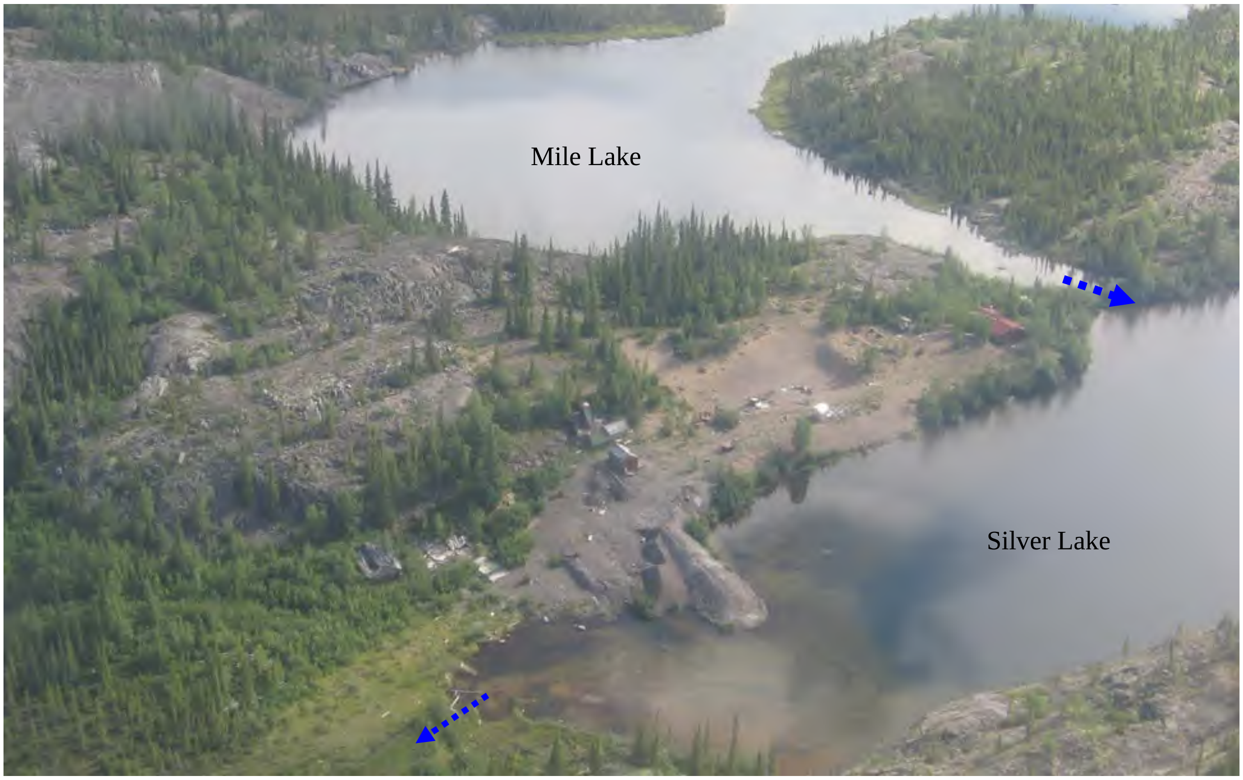


FIGURE 3.2-2
EL BONANZA MINE SITE FEATURES

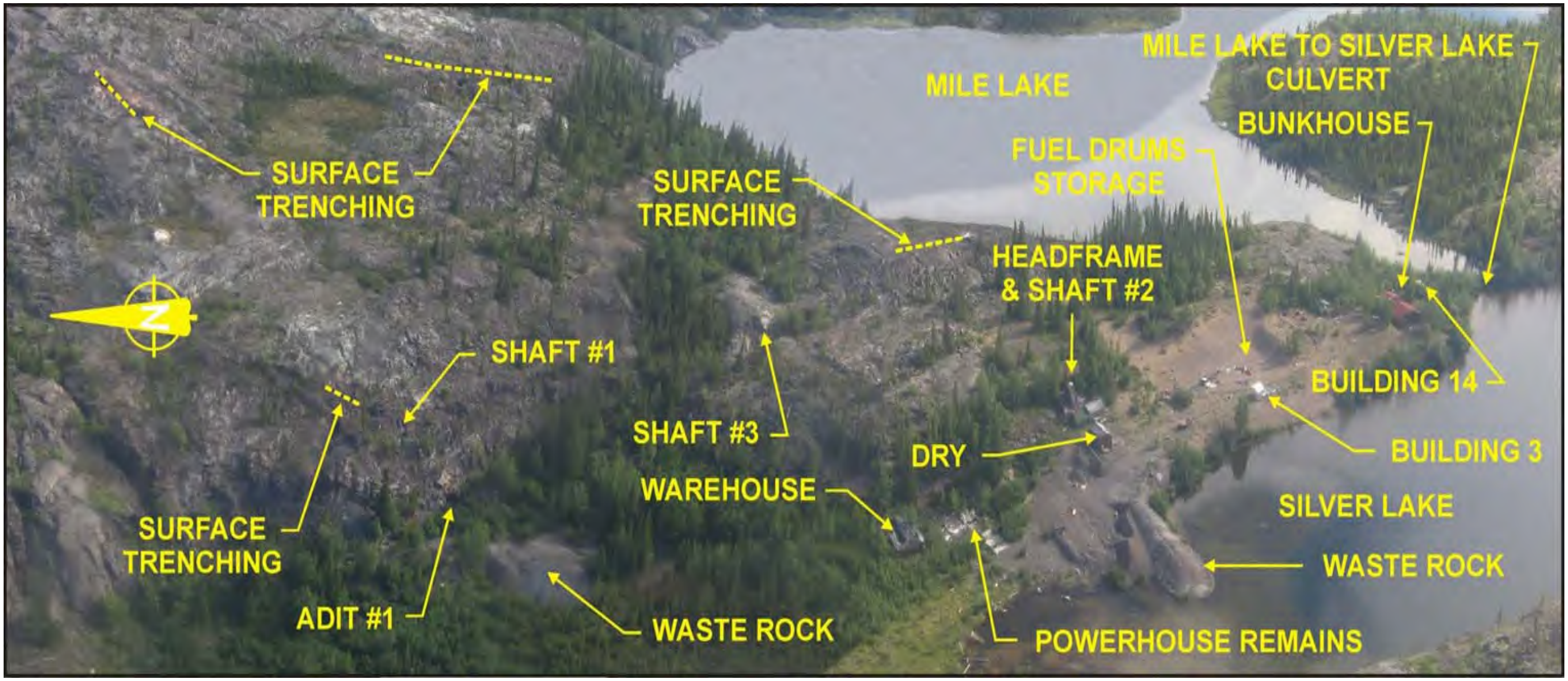
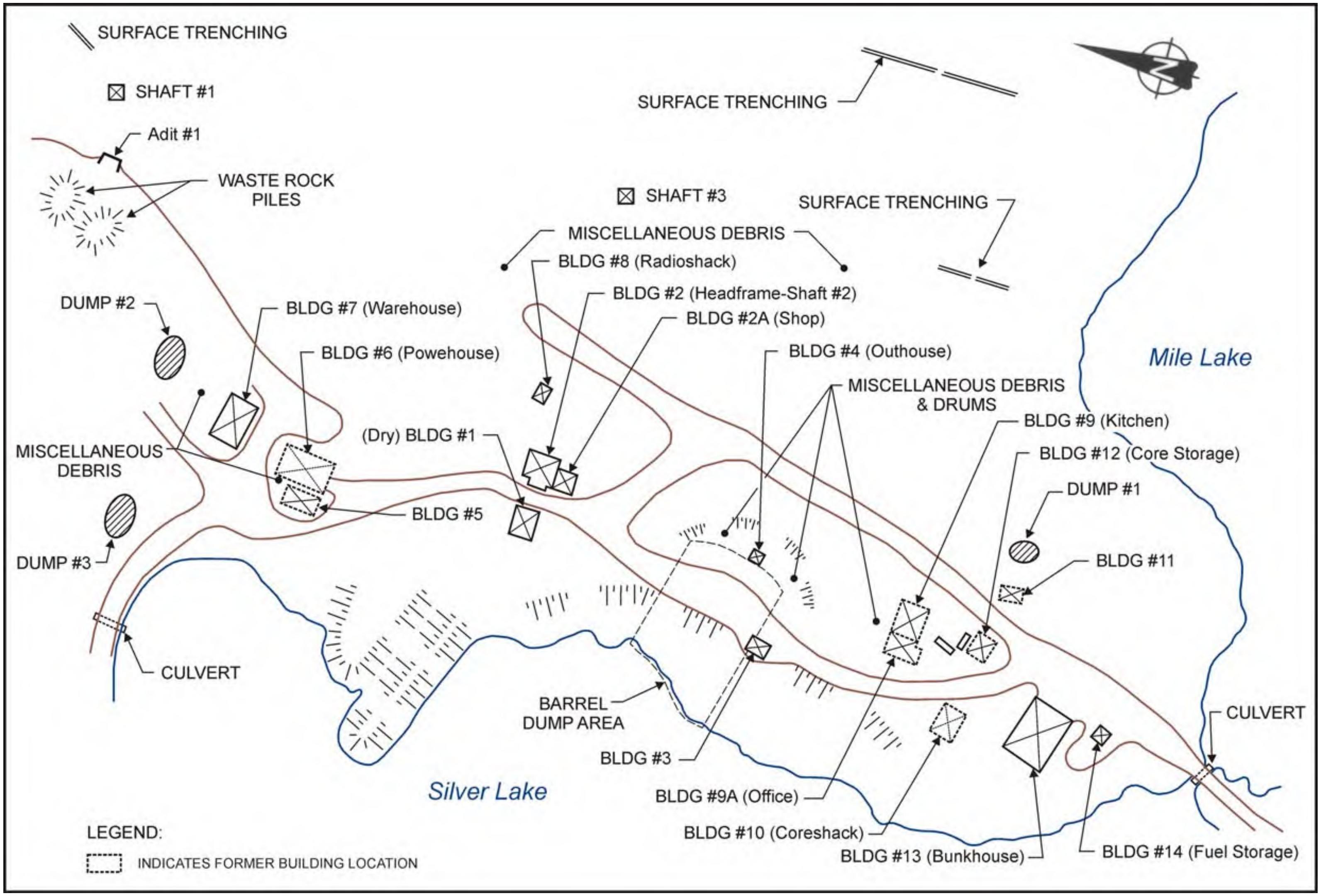


FIGURE 3.2-3
SCHEMATIC OF EL BONANZA MINE SITE FEATURES



3.3 BONANZA MINE SITE FEATURES

The Bonanza Mine site, shown from an aerial view on Figure 3.3-1, is located on the eastern side of Whale Lake. Features of the site, which are outlined on Figures 3.3-1, 3.3-2 and 3.3-3, include a headframe, waste rock pile, surface trenches and miscellaneous mine equipment (e.g. drill steel, empty drums, pumps, hoses and water tanks). The general construction of the headframe is log and timber with earth floors, tarpaper roofing and insulation paper on some interior walls.

Additional features associated with the mine but removed from the mine site proper include a blacksmith shop and cabin area. The former blacksmith shop (Building 1) has collapsed but is believed to have been of wood frame construction likely with a wooden floor and wood roof covered with tarpaper roofing (wood and timbers and roofing material was found throughout the location). The cabin area includes an existing log cabin (Cabin 1) with a wooden floor and tarpaper roofing. The remnants of a second cabin (Cabin 2), which had burned to the ground, were observed to the west of the first cabin. Also observed in the vicinity of the cabins were two small dumps containing drums (used as wood stoves), tin cans, wood and glass.

FIGURE 3.3-1
AERIAL PHOTOGRAPH OF BONANZA MINE SITE

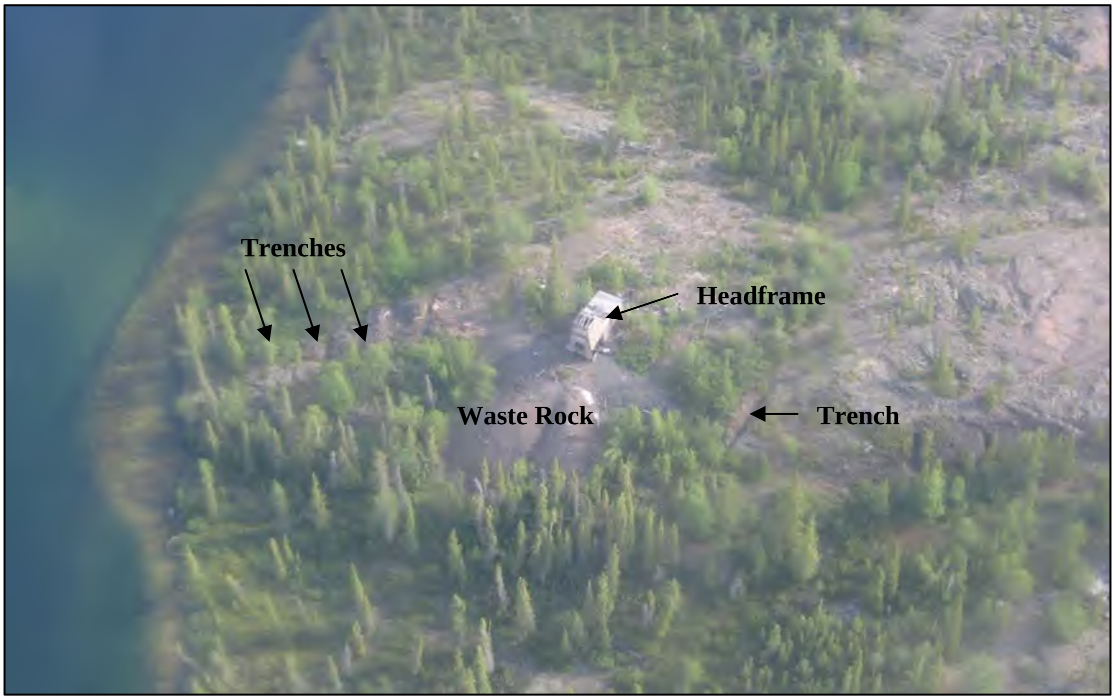


FIGURE 3.3-2
BONANZA MINE SITE FEATURES

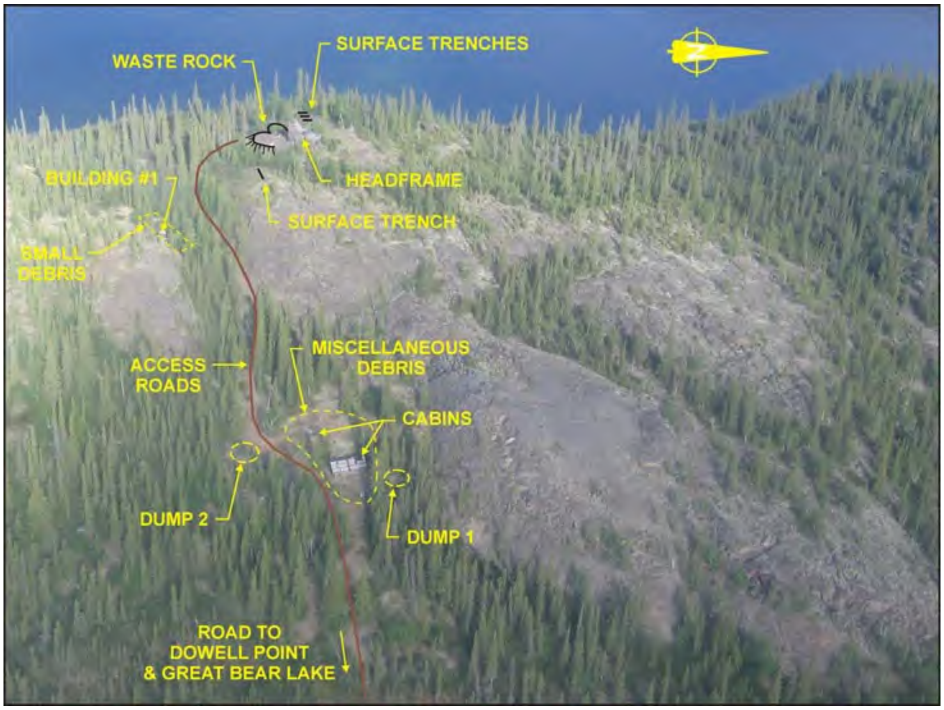
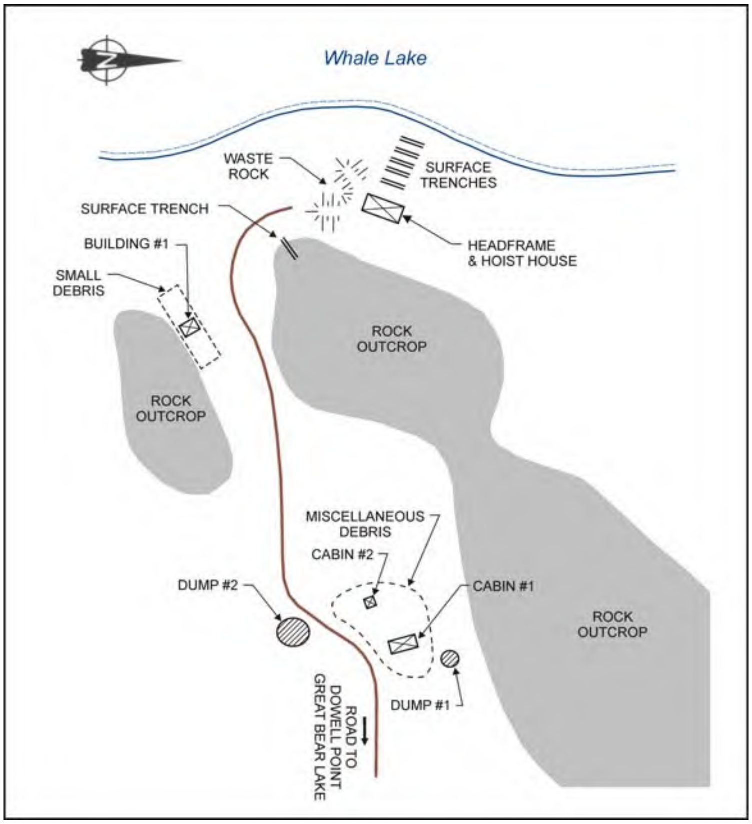


FIGURE 3.3-3
SCHEMATIC OF BONANZA MINE SITE FEATURES



3.4 AIRSTRIP FEATURES

In addition to the two mine sites, a short gravel and stone abandoned airstrip, shown on Figure 3.4-1 is located approximately 1.5 km southwest of the mine on the shore of Great Bear Lake (66°00'28" N latitude and 118°07'50" longitude - UTM Zone 11W). Other than grading of local materials, little else was done to develop the airstrip, which is at the stage of natural re-vegetation.

Two 100,000 L vertical above-ground storage tanks and an associated piping network suggest that fuel was previously stored in this area. Two 40,000 L cylindrical above-ground storage tanks lying on their sides that were likely being transported either on or off site, as well as assorted equipment and materials, also remain at the airstrip. A narrow overgrown road connects the El Bonanza Mine site with the airstrip (see Figure 3.1-1). Airstrip features are shown on Figures 3.4-1, 3.4-2, and 3.4-3.

FIGURE 3.4-1
AERIALPHOTOGRAPH OF EL BONANZA AIRSTRIP

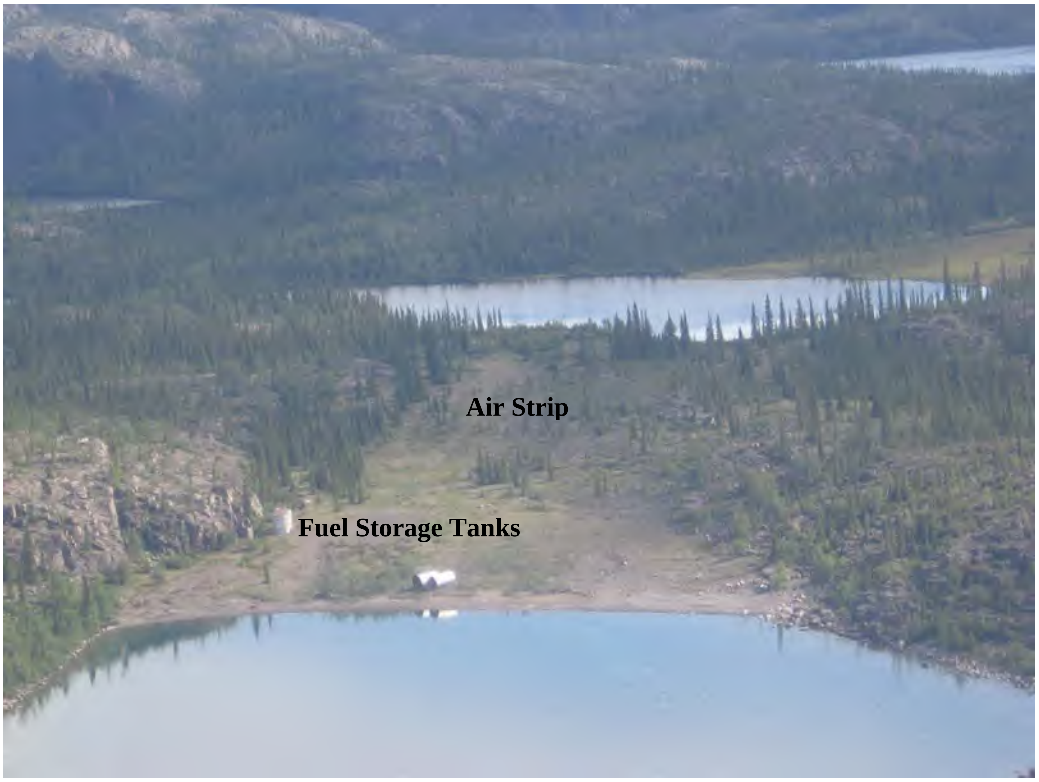
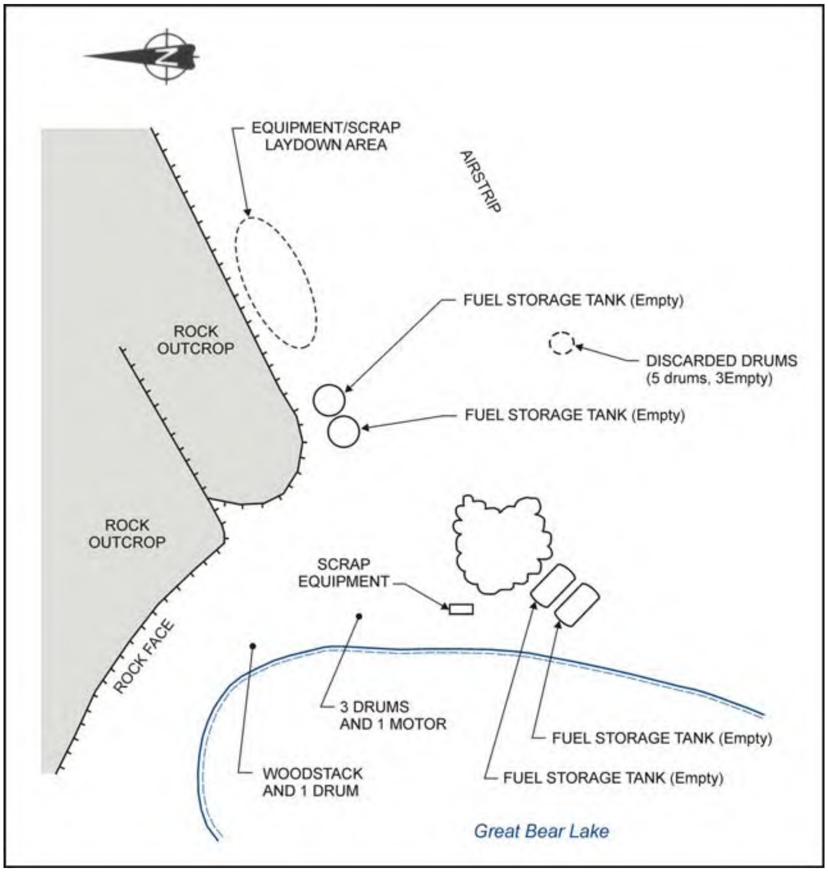


FIGURE 3.4-2
AIRSTRIP FEATURES

FIGURE 3.4-3
SCHEMATIC OF AIRSTRIP FEATURES



3.5 LOCAL ROADS AND CULVERTS

Local Roads

Onsite and access roads were constructed by grading and filling using local glacial fill materials. The road network shown on Figure 3.1-1 included a short stretch connecting Mile Lake to Silver Lake, and roads connecting both the El Bonanza Mine and the Bonanza Mine to Great Bear Lake.

The main access road from the El Bonanza Mine to Great Bear Lake, stretching approximately 1.5 km in length, is overgrown with local vegetation in various locations but appears to be in a generally sound and stable condition. The access road to the Bonanza Mine was generally not developed as a road but rather just cleared trail that allowed access that is now overgrown to various degrees.

Culverts

Culverts exist at the inlet and outlet of Silver Lake. Debris is found in and around the culverts including both wood and logs in the culverts and steel drums in front of the culvert outlet.

A representative from the Department of Fisheries and Oceans (DFO) visited the site in August 2005. During this site visit, juvenile grayling were observed in Mile Lake and near the mouth of the stream immediately downstream of the mine site. The small creeks and marshes to the west of the site, which connect Mile Lake to Great Bear Lake, are likely important fish spawning, rearing, and feeding habitats (Watson 2005).

The culvert that connects Mile and Silver lakes likely forms a significant barrier for fish migration in the spring and possibly year-round. The DFO recommended that the culvert be removed to fully re-establish connectivity between the two water bodies. The closure plans should be developed to ensure proper stream channel design, fish passage, and maintenance of the current water level in Mile Lake (Watson 2005).

3.6 MINE WORKINGS

Three shafts, one adit, and several areas with surface trenches and small test pits are found at the El Bonanza Mine site. The No. 1 shaft is located on the side of a steeply sloping hill at the edge of a cliff, above the adit located at the base of the cliff. The No. 2 shaft is located in the headframe, and the No. 3 shaft is located uphill from the headframe. Pictures of the shafts are presented on Figures 3.6-1 to 3.6-3, while examples of surface pits and trenches are shown on Figure 3.6-4.

The development of the El Bonanza Mine is briefly summarized here from NORMIN (2005) and Silke (2006a; 2006b):

- Two shafts were sunk approximately 700 feet (215 m) apart in the Bonanza vein; a west shaft (No. 1) with levels at 80 and 160 feet (25 and 50 m) in 1934, and an east shaft (No. 2) to 84 feet (26 m) in 1935;
- A total of 1,750 feet (530 m) of lateral work was carried out on the Bonanza vein;
- A third shaft (No. 3) was sunk to about 30 feet (9 m) on the Spud vein north of the No. 2 shaft in 1935;
- In 1956, the east shaft (No. 2) was repaired and deepened and two levels were established at 135 and 150 feet (40 and 45 m), drilling was carried out to the north, and the west shaft (No. 1) was reportedly sunk to 180 feet (55 m) with no attempt to mine horizontally; and,
- Further work that included dewatering of mine works and surface and underground drilling was conducted throughout the 1960's and 1970's.

At the Bonanza property, a short shaft was sunk in 1937 to a depth of 100 feet (30 m) and approximately 300 feet (91 m) of lateral advance was performed. Pictures of the shaft and surface trenching at the Bonanza Mine are shown on Figures 3.6-5 and 3.6-6.

FIGURE 3.6-1
EL BONANZA NO. 1 SHAFT

FIGURE 3.6-2
EL BONANZA NO. 2 SHAFT

FIGURE 3.6-3
EL BONANZA NO. 3 SHAFT

FIGURE 3.6-4
EXAMPLES OF EL BONANZA PITS AND TRENCHES

FIGURE 3.6-5
BONANZA SHAFT

FIGURE 3.6-6
EXAMPLES OF BONANZA TRENCHES

3.7 MINE WASTE ROCK

Two waste rock deposits are located at the El Bonanza Mine with a combined estimated volume of 3,000 m^3 and one at the Bonanza Mine with an estimated volume of 600 m^3. The first pile at El Bonanza is located adjacent to the No. 1 shaft at the east end of the site. Limited erosion has taken place since the placement of the pile and existing slopes appear stable. No sources of seepage or standing water were observed in the vicinity of the pile during the July 2006 site assessment (SENES 2007a). The second El Bonanza waste rock pile is located adjacent to the No. 2 shaft on the main portion of the mine site. Slopes appear to be stable and on-land erosion minimal. A portion of the waste rock pile extends into Silver Lake to a depth of approximately 1 m. Due to the size of Silver Lake, erosion from wave action is not expected to be a significant issue. Pictures of the El Bonanza waste rock piles are provided on Figures 3.7-1 and 3.7-2. The small waste rock pile at the Bonanza Mine is located immediately adjacent to the Bonanza shaft/headframe and can be seen on Figure 3.3-1. A discussion of results related to the chemistry of the waste rock is provided in Section 4.12.1.

FIGURE 3.7-1
EL BONANZA NO. 1 ADIT WASTE ROCK PILE

FIGURE 3.7-2
EL BONANZA NO. 2 SHAFT WASTE ROCK PILE

4.0 DESCRIPTION OF ENVIRONMENT AND ENVIRONMENTAL SITE ASSESSMENT RESULTS

4.1 LOCATION AND PHYSICAL FEATURES

The location and setting of the El Bonanza Mine site were previously described in Sections 1.1.1 and 1.1.2. The site lies within the erosion-resistant Precambrian Shield of the Great Bear Lake watershed. The Precambrian shorelines are generally steep, rocky and irregular with sparse soil. The dominant physiographic feature of the area is Great Bear Lake, with a surface area of 31,000 km^2, a volume of 2,240 km^3 (or 2,240 million m^3) (Johnson 1975b), and a watershed of approximately 146,000 km^2 (Environment Canada 2002) including both Great Bear Lake and Great Bear River.

Great Bear Lake lies adjacent to three terrestrial ecozones, the Southern Arctic ecozone along its northern shore, the Taiga Plains to the west and south, and the Taiga Shield to the east. The Southern Arctic ecozone includes sprawling shrublands, wet sedge, meadows, and cold clear lakes, while the Taiga Plains ecozone is an area of low-lying plains centred on the Mackenzie River and its tributaries. The Taiga Shield, in which the El Bonanza site is situated, is at ecological crossroads (i.e. transitional area) where climate, soil, flora and fauna of the Arctic meet those of the northern temperate zone.

4.2 GEOLOGY

4.2.1 Bedrock Geology

The underlying rocks of the Precambrian Shield region are comprised of sedimentary and metamorphic deposits, with igneous intrusions forming dykes and sills (Johnson 1975a). These rocks can be classified into four main groups, including: complex sedimentary and volcanic rocks of the Echo Bay group; intrusions of diorite, grandiorite, and granite; relatively undisturbed conglomerate, sandstone, and quartzite of the Hornby Bay group; and, mafic dykes and sills (Kidd 1933).

Review of geological information for the site shows that the El Bonanza property was explored and developed for silver (Silke 2006a). The mineralization occurs in quartz carbonate veins that are located within siliceous metavolcanics. These veins host silver as well as sulphides that contain the following metals: antimony, arsenic, copper, nickel, and zinc. Uranium was also noted as being present (Silke 2006a). The ore zone is sandwiched between granite and granodiorite.

4.2.2 Surficial Geology

In the Precambrian Shield region of the Great Bear watershed, which contains the El Bonanza Mine, soils are sparse and rocky outcrops abound. Thin layers of weathered sedimentary rock, glacial till, and alluvium can be found in small areas of lower elevation. In contrast, the soils of the Interior Plains region are far more substantial and occur over thick glacial till (Johnson l975a).

While site observations confirm extensive areas of bare rock outcrop at the El Bonanza Mine, sand and cobble deposits are also noted in the areas adjacent to the site and along the access road. These areas are generally well vegetated when compared to the more barren rock outcrops. The sparse vegetation covering much of the undisturbed areas of the site consists of lichen, grasses, bushes, and pine trees.

Two waste rock deposits are located at the El Bonanza Mine site with a total estimated volume of approximately 3,000 m^3. One waste rock area is located at the west end of the site and the other on the main part of the mine site where it partially extends into Silver Lake. An additional waste rock pile occurs at the Bonanza Mine immediately adjacent to the shaft/headframe with an estimated volume of 600 m^3.

4.3 CLIMATE

The El Bonanza Mine site is located within the Mackenzie District climate zone of the Arctic. The Mackenzie regional climate is characterized by long and cold winters, short and cool summers, large annual ranges in temperature, and little precipitation (Johnson 1975a). In winter, the region is dominated by the Arctic air mass, while in summer incursions of Pacific air are common.

Meteorological data are not available for the El Bonanza Mine site, but long-term temperature and precipitation data are available for the near-by Port Radium site, which is located about 9 km northeast of the El Bonanza Mine.

4.3.1 Temperature

An analysis of air temperature measurements collected at Port Radium between 1950 and 1974 (Johnson 1975a) showed that the maximum temperatures are typically recorded in July, with the highest reading on record being 29 °C. The mean air temperature in July for the period of record was 12 °C. The lowest air temperatures occurred in January, when the mean air temperature was –27 °C and the extreme low was –52 °C (Johnson 1975a). In summer, the sun was above the horizon for 24 hours per day between June 12 and 20; but, in December, the days were short with the sun barely appearing (Johnson 1975a). According to Johnson (1975a) there were only 60 frost free days per annum in the study area.

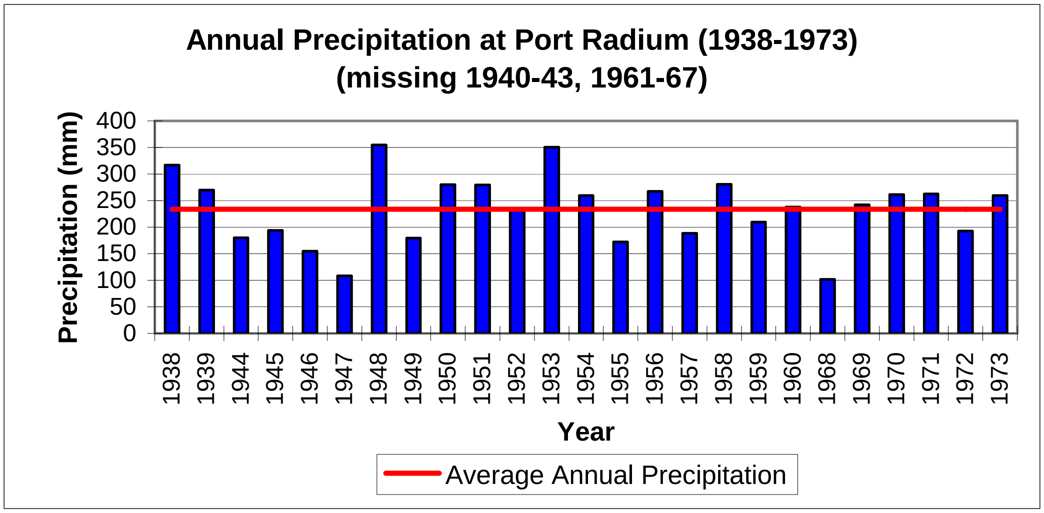
Changes in the climate of the Arctic and sub-Arctic regions have been a topic of intense investigation in recent years. The average temperature in the Arctic has risen at almost twice the rate as the rest of the world in the past few decades. As the world's climate changes, temperature changes are anticipated to be greater in the North and greater in winter than in summer. According to recent climate models run by Environment Canada, annual temperature increases of greater than 5 °C in the Arctic are possible by the year 2100. In the Mackenzie District, annual mean temperatures recorded from 1948 to 1999 show a clearly identifiable overall positive trend (about 1.5 degrees/century), comprised of a weak cooling trend into the seventies followed by a warming trend to 1999. Warming in this district has occurred mainly in winter and spring. There is a very weak warming trend exhibited in the summer, and temperatures in autumn have been gradually decreasing.

4.3.2 Precipitation

From climate data collected at Port Radium and Délı̨nę between 1938 and 1973 (Figure 4.3-1), it is apparent that annual precipitation is relatively low ranging between 102 and 355 mm (234 mm average recorded at Port Radium), with more than half falling as rain during the summer months, and close to half of the total precipitation lost through evaporation or evapotranspiration. While southeast winds predominate in this region, summer storms lasting one to two days may arise from any direction (MacDonald *et al.* 2004).

Because of the year-to-year variability, precipitation trends are difficult to discern. Precipitation data collected for the Mackenzie District from 1948 to 1999 show that there is no clear trend in the long-term record of precipitation. On a seasonal basis, the warming in the winter in the Mackenzie District has been accompanied by a decrease in winter precipitation, while summer precipitation is somewhat higher and apparently more variable.

FIGURE 4.3-1
ANNUAL PRECIPITATION AT PORT RADIUM BETWEEN 1938 AND 1973



4.4 PERMAFROST

The Northwest Territories has a total area of about 1,346,000 km^2, with about 13 percent of this area being freshwater. The uniqueness of the Northwest Territories is that it is located within the permafrost region and most of its areas depend on winter roads and air transport for access and supplies. More than 50 percent of the permafrost is classified as sporadic and discontinuous and is readily disturbed by construction resulting in ground thawing and potential physical instability. The El Bonanza Mine site borders on the area between discontinuous and continuous permafrost.

The presence of permafrost and the magnitude of ground temperature are dependent on many factors, such as air temperature, vegetation, snow cover, orientation of the terrain and ice content. As previously discussed, there is strong evidence that the mean annual air temperature is rising in the Northwest Territories. As ground temperature is very dependent on air temperature, it is expected that permafrost will degrade in some areas, including the El Bonanza area, as the mean annual air temperature rises. As the El Bonanza Mine site generally resides in an area of limited surficial soils and exposed bedrock and since it is not expected that structures will be built on surface as part of the site remediation, future changes in ground temperature and permafrost are not expected to affect the remedial works.

4.5 AIR QUALITY

Although site-specific measurements are not available for the El Bonanza Mine, air sampling from 2001 to 2003 at the nearby Port Radium site (located 9 km northeast) revealed excellent air quality that was well below the Ambient Air Quality Standard (AAQS) for the Northwest Territories, and other jurisdictions. The concentrations of conventional pollutants (i.e. total suspended particulate - TSP, sulphur dioxide - $SO_{2,}$ nitrogen oxides - NO_x) at the El Bonanza Mine are expected to be similar to Port Radium and therefore are expected to be low as there are no significant sources of these pollutants in the local study area. Furthermore, the site is small with a limited footprint of historically disturbed area, has been inactive for many years, and contains only limited features that are potentially subject to wind disturbance/erosion.

Based on the low atmospheric levels that have been measured at Port Radium, air concentrations of radionuclides and metals are also expected to be low at the El Bonanza Mine site. While persistent organic pollutants were not analyzed in the air at the Port Radium site or El Bonanza Mine, they are the result of long-range transport mechanisms and are not related to these sites.

Given the close proximity of the El Bonanza Mine site to the Port Radium Mine site and the much smaller footprint of disturbed area relative to Port Radium, it is reasonable to conclude that the air quality at the El Bonanza site does not pose any concerns.

4.6 TERRESTRIAL RADIATION

4.6.1 Gamma Radiation Measurements

Although minor uranium showings had reportedly been discovered in the El Bonanza area, no record or evidence of uranium being mined at the El Bonanza Mine has been found, indicating that the pitchblende deposit was not substantial (Golder 2005). Nonetheless, because nearby sites such as the Port Radium Mine that had been mined for uranium, and the Contact Lake Mine that had some ores with slightly elevated uranium content, a site-wide roving gamma survey was carried out at El Bonanza to measure terrestrial gamma radiation at the time of the 2006 site assessment program (SENES 2007a). The survey included measurements on the mine site proper and in the immediate vicinity of the site and found no areas with elevated terrestrial gamma radiation. Additional comments on the survey methodology and findings are presented below.

The field measurements were collected using a Ludlum 2221 gamma radiation meter, having a 2” by 2” Sodium Iodide (NaI) detector, capable of integrating measurements over 1 second intervals. The detector was held approximately 1 m above the ground surface (as per the accepted monitoring protocols for gamma radiation measurements) while the operator walked over selected areas of the site. The Ludlum instrument was interfaced with a Trimble GPS system that simultaneously recorded both geographic coordinates and the gamma radiation levels associated with that geographic coordinate. Gamma radiation levels were recorded in counts per second (cps) in the NaI detector and were converted to units of μR/h using a factor of 21.38 cps per μR/h for the specific instrument used in the survey. Former operating locations were measured using roving transects that varied depending on the site-specific features, but generally were in the order of about 3 to 5 metres apart. In undisturbed “background” areas, gamma radiation levels were collected at broader patterns subject to the physical topography and accessibility.

The individual gamma radiation data were statistically summarized to 10 m grids. These data are shown on Figure 4.6-1 and summarized on Table 4.6-1. The highest individual measurement was 29 μR/h, the highest calculated grid result was 17 μR/h, and the mean of the grid results was 11 μR/h. From a risk perspective, these levels are considered within the range of background for the area and pose no incremental risk to human health or ecological receptors.

TABLE 4.6-1
CALCULATED GAMMA RADIATION LEVELS
FOR 10 M BY 10 M GRIDS (μR/h)

Number of Grids	Mean	Minimum	Median	95th	Maximum
313	11	7	11	14	17

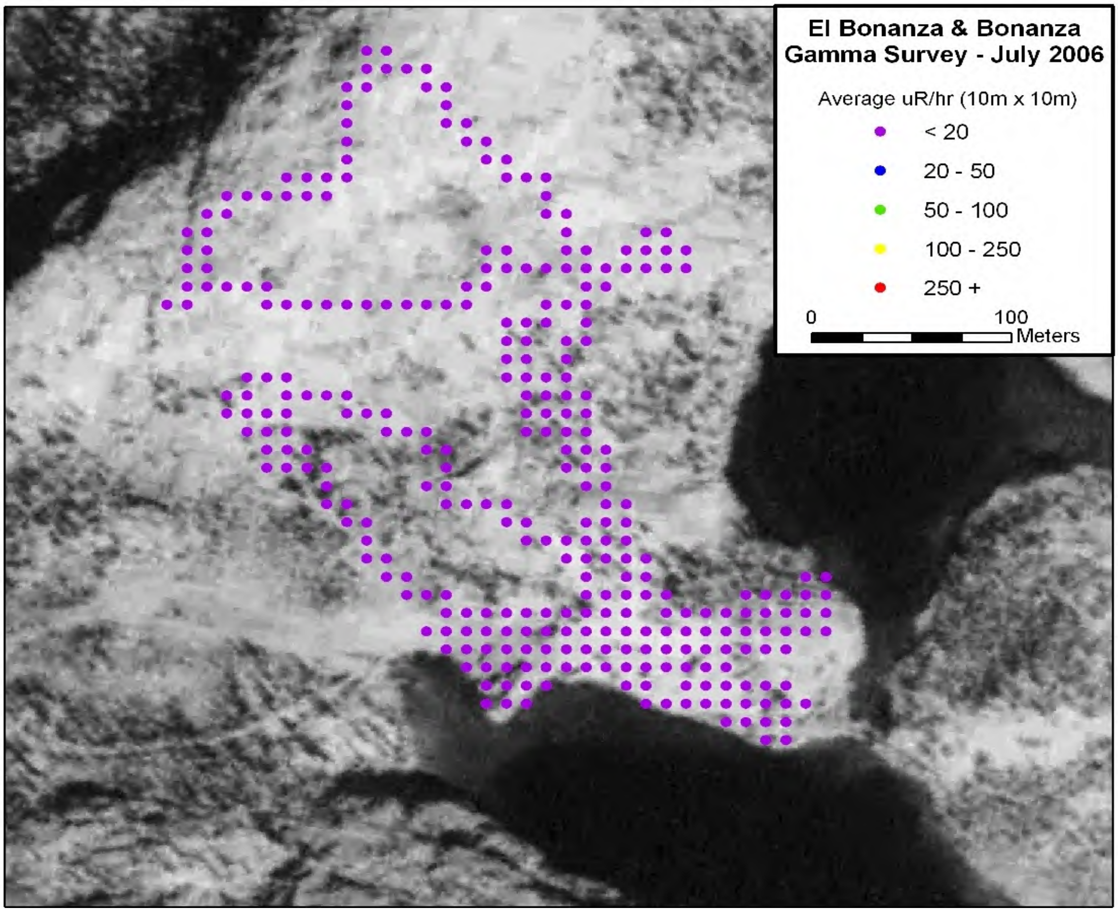
The number of grid cells corresponding to each gamma radiation level is shown on Table 4.6-2. As can be seen, gamma radiation levels throughout the site were <20 µR/h.

TABLE 4.6-2
RANGES OF CALCULATED GAMMA RADIATION LEVELS FOR 10 M BY 10 M GRIDS (µR/h)

Grids in Range (µR/h)				
< 20	**20 – 50**	**50 – 100**	**100-250**	**> 250**
313	0	0	0	0

In addition to the measurements recorded via the integrated roving gamma meter GPS system, spot elevations were also measured using a hand held gamma meter at the Bonanza site and at the airstrip. The readings observed in this fashion were generally in the range of 12 µR/h or lower. As indicated by these measurements, terrestrial gamma radiation at the El Bonanza Mine site is generally in the range of natural background levels for this region.

FIGURE 4.6-1
PROCESSED GAMMA RADIATION LEVELS (µR/h)



4.6.2 Radon

Given the location and setting of the El Bonanza Mine site and the limited radiological sources associated with the site, no program was established for the collection of outdoor radon. However, numerous studies at other sites (e.g. Elliot Lake camp, northern Saskatchewan mines, etc.) have shown that in the absence of a major radiological source (e.g. large uranium tailings facilities) outdoor radon is not found to be elevated above the background level typical of the area. Radon monitoring at Port Radium confirmed that outdoor radon was generally at background levels on and adjacent to the site. Based on this information and the lack of radiological sources at El Bonanza (e.g. no tailings), radon is not expected to be above background levels at the El Bonanza Mine site.

4.7 TERRESTRIAL VEGETATION

A recent report by Macdonald (2004) provides a good overview of the terrestrial environment of the Great Bear Lake watershed. Hence, only a brief overview of terrestrial vegetation found in the study area is provided below.

4.7.1 Local Vegetation

The El Bonanza study area lies within the northeastern fringes of the subarctic boreal forest zone and the Canadian Shield. It is located 52 km south of the Arctic Circle and 70 to 120 km southwest of the northern limit of trees. As the climate in the region is dominated by long, dark and cold arctic winters, relatively low precipitation, and moderately warm summers with 24 hours of day light, the growing season is about 3.5 to 4 months from late-May/early-June to about mid-September (Johnson 1975; MacDonald *et al*. 2004).

The mine site and surrounding area consists of typical subarctic coniferous and mixed boreal forest. The vegetation ground cover in most habitats is closed-mat except for considerable areas with exposed bedrock and sparse vegetation, and areas impacted by mining activities. Forest floors are well developed with shrubs, berries, Labrador tea, herbs, lichens and mosses. Well-drained hills and slopes are dominated by white spruce, paper birch and black spruce, and poorly drained depressions, lowlands and wetlands by black spruce, paper birch, scattered larch and balsam poplar. Forests climb up on mountainous slopes to meet the tree line in higher elevations and on plateaus that contain a transition zone of forest and tundra, and parcels of arctic tundra with alpine character. Thus, the study area and the adjacent land provide different ecosystems bordering and intermingling with each other within a relatively small area.

4.7.2 Soil and Vegetation Sampling Programs

During the El Bonanza site assessment conducted in July 2006 (SENE 2007a), plants along with the surface materials in which they were growing were collected to assess the significance of the terrestrial exposure pathway of inorganic contaminants. Terminal leaves and twigs from several plant species (green alder, dwarf birch, paper birch, willow, Labrador tea, wild raspberry, balticus rush, and shrubby cinquefoil) and surface soils (0 to 5 cm) were collected from a total of 11 sites across the study area and were sampled for metal content (see Figures 4.7-1 and 4.7-2 for some site locations). Sampling sites were situated next to all major mine features including waste rock piles and disturbed ground. For example, two sites were established along the face of the waste rock on the main mine site (see Figure 4.7-1), and included terrestrial plants on the slope of the waste rock and emergent macrophytes (i.e. sedges) growing in the submerged foot of the waste rock. For those plants, exposure could occur from run-off and leachate from the waste pile, or from the aquatic pathway. Three sites were situated on the airstrip; however, because of the reduced number of species present, only willow, birch and alder were collected from the airstrip sites.

Metal Concentrations in Soils

Metal concentrations measured in surface soils collected from the El Bonanza Mine site in July 2006 are summarized on Table 4.7-1. Detectable levels were reported for all elements except tin and thallium, which were below the detection limit in all samples. Moisture levels ranged from 0.9% in the well drained, sandy waste rock on the mine site to 86.3% in the wetland.

No obvious trends of contamination were indicated by the metal concentrations in the surface soils. The highest levels of uranium (23.4 mg/kg dry weight) were found at Site 8 on the airstrip, followed by 21.5 mg/kg dw at Site 5 in the wetland. Uranium levels at Site 4, which is immediately adjacent to Site 5, ranged from 10.5 to 12.8 mg/kg dw in duplicate samples. Arsenic levels ranged from 3.84 to a maximum of 26.6 mg/kg dw, with the highest levels found at Site 4, in the wetland, and Site 7, below the small waste pile at the El Bonanza adit. This variation was probably due to the single grab-sample nature of the sampling conducted in this study and indicates that large-scale contamination is not present at any of the sampled site features (for more details the reader is referred to SENES (2007a)).

Wide variation was also noted in zinc concentrations which ranged from a minimum of 82 mg/kg dw to a maximum of 9,070 mg/kg dw (see Table 4.7-1). The lowest zinc concentrations of 82 and 90 mg/kg dw were measured in duplicate samples collected at Site 2 along the face of the waste rock, followed by concentrations of 277 and 361 mg/kg dw measured in duplicate samples collected at Site 1 at the main mine site. The highest zinc concentrations of 9,070 mg/kg dw and 4,910 mg/kg dw were measured at Sites 6 and 7, respectively, below the small waste rock pile at the El Bonanza adit, followed by concentrations of 1,280 mg/kg along the face of the waste rock (Site 3) and 1,100 mg/kg dw at Site 9 on the airstrip. Based on this data set, zinc was the only COPC considered in the HHERA that was found to marginally exceed the screening index value for wildlife ingesting soil and vegetation (i.e. grouse/ptarmigan at mine site; see Chapter 5 for further discussion).

For the purposes of the HHERA, soil results from the 2006 site assessment (SENES 2007a) were combined with data collected during the Phase I Environmental Site Assessment (Golder 2005) and divided into two broad sites, i.e. the mine site and the airstrip. Based on this dataset, zinc concentrations at the mine site averaged (arithmetic mean) 1,217 mg/kg dw and the reasonable maximum value of 6,778 mg/kg dw (i.e. 95th percentile) was used in the HHERA. Zinc concentrations at the airstrip averaged 233 mg/kg dw and a reasonable maximum (i.e. maximum) of 1,100 mg/kg dw was used in the HHERA. These zinc concentrations are all in excess of the residential/parkland land use guideline for zinc in soil of 200 mg/kg. However, elevated zinc concentrations with respect to the guidelines and reference areas are found throughout the site (i.e. mine site and airstrip) as well as in other media (e.g. sediments) and are likely largely due to natural mineralization occurring in the area.

Metal Concentrations in Vegetation

Metal levels measured in plant samples collected from the El Bonanza study area in July 2006 are reported on Tables 4.7-2 (paper and dwarf birch, and willow), 4.7-3 (alder and Labrador tea), and 4.7-4 (sedge and cinquefoil). The concentrations of several metals, including silver, beryllium, bismuth, selenium, tellurium and thallium were below the detection limit in all samples. Other metals, such as arsenic, uranium, and vanadium had measurable levels in a very small number of samples, but the concentrations were close to the respective detection limits.

Trends in the metal concentrations were examined using two statistical methods. One-way analysis-of-variance (ANOVA) was used to determine if any plant species accumulated metals to a higher concentration than others, and whether the concentrations in plants at some sites were higher than at other sites. Metals with most observations below the detection limits were not included in the analysis. The results of the first analysis indicated that significant differences between species were observed for a small subset of the trace metals, notably barium, cadmium, cesium, cobalt, molybdenum, and zinc. The highest concentrations of cadmium, magnesium and zinc were found in willow, while the highest levels of molybdenum and cesium were found in sedge.

The second analysis was completed for birch, alder and willow to determine differences between sites. No particular site was identified by high concentrations of any metal using the data from these three species and the site with the maximum concentration varied between metals.

However, significant inter-site differences were reported for several metals. Of the trace elements, cesium, lead and zinc were highest at Site 3, which is adjacent to waste rock (see Figure 4.7-1). Site 3 also had some of the highest concentrations observed for other metals, as well as Site 2, which had the highest levels of cobalt, chromium and titanium. Other sites near waste rock piles, such as 6 and 7 (see Figure 4.7-2), however, did not show any signs of elevated concentrations. The lack of strong trends and uniform concentrations in the individual soil and plant samples indicated that no sites, or plant species, stood out as being highly contaminated.

The results of the vegetation sampling were considered in the 2006 site-specific risk assessment (SENES 2007b), which is summarized in Chapter 5. As was mentioned previously with respect to soils, of all the COPC identified for the HHERA, zinc was the only metal that was found to marginally exceed the screening index value for wildlife ingesting soil and vegetation (i.e. grouse/ptarmigan at mine site; see Chapter 5 for further discussion). As seen on Tables 4.7-1 to 4.7-3, zinc was measured in all six vegetation types that were analyzed from across the site. Zinc concentrations varied from a low of 44 mg/kg dry weight (dw) in Labrador tea and sedge to a high of 283 mg/kg dw in willow followed by 276 mg/kg dw in birch (paper and dwarf). For the purposes of the HHERA, the 2006 site assessment data were grouped by vegetation type (forage (birch, willow, alder) and browse (Labrador tea, sedge, cinquefoil)) and location (mine site and airstrip). Based on this data set, zinc concentrations at the mine site averaged 162 mg/kg wet weight (ww) in browse and 28 mg/kg ww in forage with a reasonable maximum concentration used in the HHERA of 479 mg/kg ww (95th percentile) for browse and 74 mg/kg ww (maximum) for forage. Only browse samples were collected at the airstrip, which had an average zinc concentration of 54 mg/kg ww, while the reasonable maximum (i.e. maximum) used in the HHERA was 87 mg/kg ww.

FIGURE 4.7-1
PHOTO OF THE EL BONANZA MINE SITE SHOWING SAMPLING SITES 1, 2 AND 3

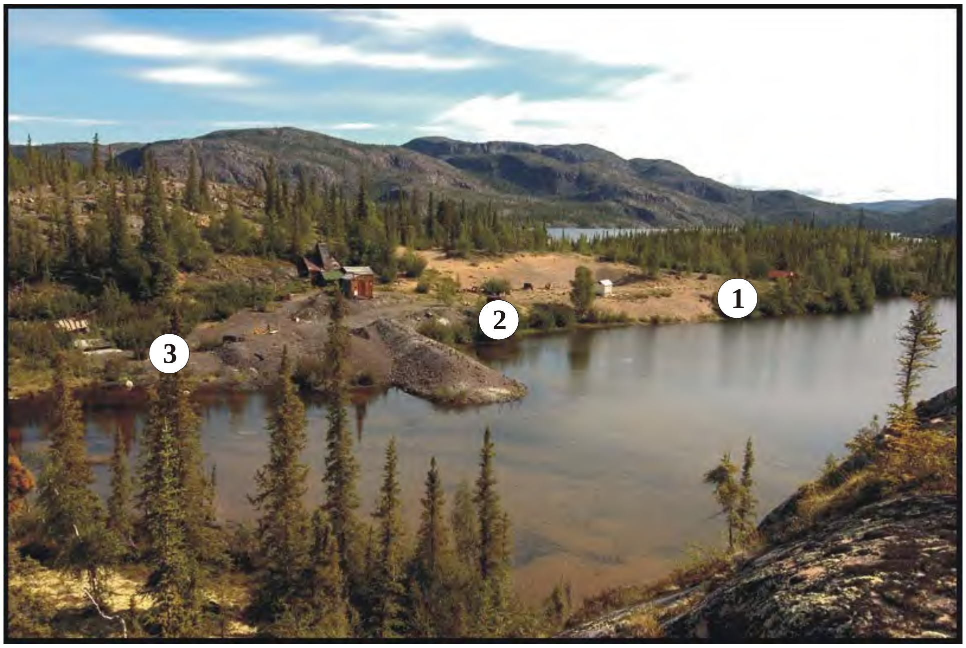


FIGURE 4.7-2
PHOTO OF THE EL BONANZA MINE SITE SHOWING SAMPLING SITES 4, 5, 6, 7 AND 11

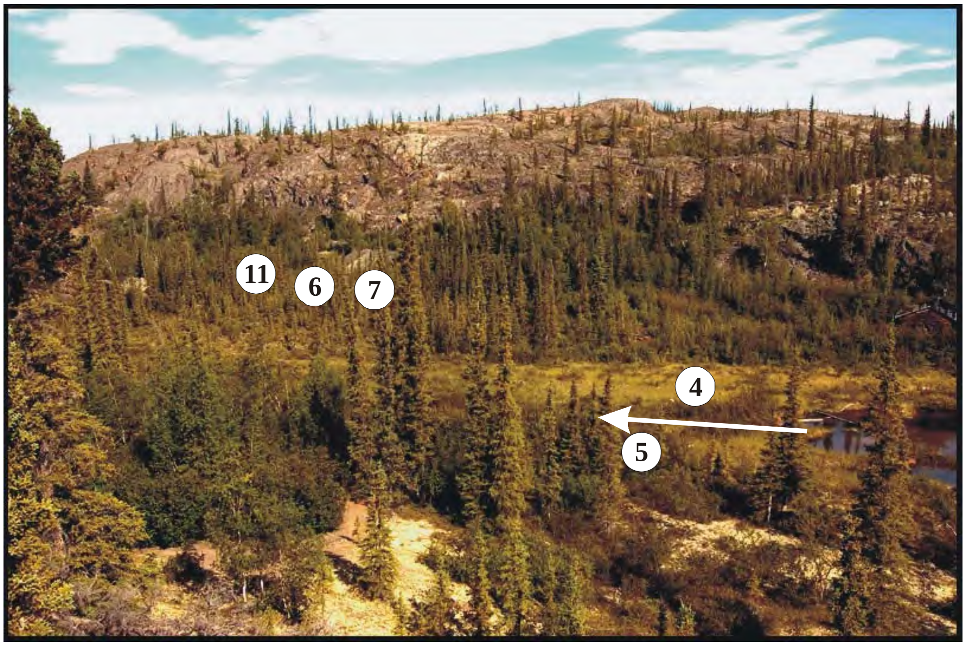


TABLE 4.7-1
SUMMARY OF MOISTURE AND METAL CONCENTRATIONS IN SOILS AT EL BONANZA MINE SITE
(Data from July 2006)

Constituent	El Bonanza [1]				
	N	GM	GSD	Minimum	Maximum
Moisture [2]	13	34.7	32.5	0.9	86.3
Aluminum	13	6147	1.72	2250	16400
Arsenic	13	10.7	1.95	3.84	26.6
Barium	13	92.7	2.29	37.8	667
Beryllium	13	0.54	2.03	0.29	4.12
Bismuth	13	0.63	4.11	0.08	5.7
Boron	13	6.19	1.85	2.1	19.4
Cadmium	13	1.39	4.32	0.19	20.9
Calcium	13	11156	1.82	4600	34700
Chromium	13	9.74	1.47	5.1	18.1
Cobalt	13	28.7	2.50	6.3	140
Copper	13	92.9	1.80	47.3	306
Iron	13	13905	1.98	4920	46600
Lead	13	37.0	2.46	11.5	185
Magnesium	13	4100	1.86	1960	20000
Manganese	13	1521	2.43	567	8680
Mercury	13	0.12	1.83	0.03	0.22
Molybdenum	13	1.83	1.77	0.58	4.56
Nickel	13	13.8	1.52	6.9	29.4
Potassium	13	741	1.29	481	1050
Selenium	13	0.51	3.00	0.1	1.8
Silver	13	1.35	3.20	<1	11
Sodium	13	53.7	1.47	27	117
Strontium	13	18.5	2.53	6.66	86.6
Thallium	13	<0.20	-	<0.20	<0.20
Tin	13	<4	-	<4	<4
Titanium	13	246	1.67	142	491
Uranium	13	6.25	2.50	1.47	23.4
Vanadium	13	16.4	1.55	7.05	33.1
Zinc	13	595	3.81	82	9070

Notes:

[1] Concentrations are reported in mg/kg dry weight.

[2] Values for moisture are an arithmetic mean with standard deviation

GM – geometric mean

GSD – geometric standard deviation

TABLE 4.7-2
SUMMARY OF MOISTURE AND METAL CONCENTRATIONS IN BIRCH AND WILLOW COLLECTED AT EL BONANZA
(Data from July 2006)

Constituent	**Birch (Paper and dwarf)** [1]						**Willow** [1]			
	N	**GM**	**GSD**	**Min.**	**Max.**	**N**	**GM**	**GSD**	**Min.**	**Max.**
Moisture [2]	12	57.0	1.72	54.6	59.2	11	60.1	2.73	56.8	66.6
Aluminum	12	7.06	0.44	1.5	48	11	7.39	0.38	<3	26
Antimony	12	<0.06	-	<0.06	<0.06	11	<0.06	-	<0.06	<0.06
Arsenic	12	<0.05	-	<0.05	0.64	11	0.04	0.31	0.025	0.13
Barium	12	31.7	0.18	17.7	64.3	11	6.19	0.46	1.02	26.3
Beryllium	12	<0.06	-	<0.06	<0.06	11	<0.06	-	<0.06	<0.06
Bismuth	12	<0.02	-	<0.02	<0.02	11	<0.02	-	<0.02	<0.02
Boron	12	29.7	0.29	8	83.4	11	18.23	0.28	4.4	40.4
Cadmium	12	0.13	0.49	0.04	1.34	11	1.13	0.61	0.19	12.9
Calcium	12	7171	0.15	3840	15200	11	9526	0.14	4820	14700
Cesium	12	0.02	0.26	<0.02	0.05	11	0.04	0.54	<0.02	0.21
Chromium	12	0.29	0.35	0.1	1.2	11	0.18	0.26	0.1	0.5
Cobalt	12	0.07	0.66	<0.01	0.51	11	0.25	0.44	0.05	1.18
Copper	12	4.90	0.06	3.9	6.1	11	5.78	0.07	3.8	6.7
Iron	12	43.8	0.21	26	104	11	37.6	0.20	24	115
Lead	12	0.17	0.43	0.06	0.9	11	0.15	0.31	0.05	0.49
Magnesium	12	2487	0.12	1760	3640	11	2958	0.17	1630	4560
Manganese	12	156	0.26	40.5	336	11	187	0.41	21.3	627
Molybdenum	12	0.09	0.57	<0.02	0.95	11	0.38	0.27	0.11	1.01
Nickel	12	0.83	0.17	0.5	1.4	11	0.70	0.36	0.2	1.9
Phosphorus	12	1661	0.19	806	3160	11	1167	0.11	852	1660
Potassium	12	6104	0.08	4630	9500	11	8889	0.17	4190	16800
Rubidium	12	7.06	0.11	5	11.7	11	12.1	0.26	4.5	42.3
Selenium	12	<0.10	-	<0.10	<0.10	11	<0.10	-	<0.10	<0.10
Silver	12	<1	-	<1	<1	11	<1	-	<1	<1
Sodium	12	3.15	0.30	<2	7	11	3.53	0.51	<2	27
Strontium	12	9.55	0.27	3.96	36.3	11	10.2	0.25	3.5	21.9
Tellurium	12	<0.08	-	<0.08	<0.08	11	<0.08	-	<0.08	<0.08
Thallium	12	<0.06	-	<0.06	<0.06	11	<0.06	-	<0.06	<0.06
Tin	12	<1	-	<1	1	11	<1	-	<1	<1
Titanium	12	0.22	0.46	0.1	1.75	11	0.28	0.39	0.12	1.31
Uranium	12	<0.02	-	<0.02	0.05	11	<0.02	-	<0.02	0.03
Vanadium	12	<0.06	-	<0.08	0.09	11	<0.06	-	<0.06	0.07
Zinc	12	276	0.32	103	1040	11	283	0.46	81.3	1390

Notes:

[1] Concentrations are reported in mg/kg dry weight

[2] Values for moisture are an arithmetic mean with standard deviation

GM – geometric mean

GSD – geometric standard deviation

TABLE 4.7-3
SUMMARY OF MOISTURE AND METAL CONCENTRATIONS IN ALDER AND LABRADOR TEA COLLECTED AT EL BONANZA
(Data from July 2006)

Constituent	Alder [1]					Labrador Tea [1]				
	N	GM	GSD	Min.	Max.	N	GM	GSD	Min.	Max.
Moisture [2]	10	53.4	7.32	43.5	71.1	4	56.2	11.30	48.6	73
Aluminum	10	11.3	0.30	5	40	4	11.4	0.29	6	24
Antimony	10	<0.06	-	<0.06	<0.06	4	<0.06	-	<0.06	<0.06
Arsenic	10	<0.05	-	<0.05	0.22	4	0.05	0.31	<0.05	0.09
Barium	10	7.23	0.19	2.91	12.1	4	56.0	0.10	44.3	69
Beryllium	10	<0.06	-	<0.06	<0.06	4	<0.05	-	<0.05	<0.05
Bismuth	10	<0.02	-	<0.02	<0.02	4	<0.02	-	<0.02	<0.02
Boron	10	19.8	0.40	3.6	57	4	25.1	0.12	17.9	32
Cadmium	10	<0.02	-	<0.02	0.08	4	<0.02	-	<0.02	<0.02
Calcium	10	7986	0.14	3930	10900	4	5323	0.07	4420	6290
Cesium	10	0.07	0.66	<0.02	1.16	4	<0.02	-	<0.02	<0.02
Chromium	10	0.18	0.26	0.1	0.6	4	0.20	0.25	0.1	0.4
Cobalt	10	0.09	0.48	0.02	0.32	4	0.02	0.48	<0.01	0.05
Copper	10	6.33	0.11	4.8	11.3	4	5.52	0.07	4.9	6.9
Iron	10	38.6	0.17	24	92	4	26.0	0.19	17	46
Lead	10	0.19	0.23	0.07	0.47	4	0.16	0.07	0.14	0.2
Magnesium	10	1751	0.09	1260	2430	4	1025	0.04	940	1130
Manganese	10	139	0.31	33.4	400	4	54.9	0.55	11.2	166
Molybdenum	10	0.63	0.34	0.19	2.89	4	0.02	0.38	<0.02	0.05
Nickel	10	0.66	0.24	0.4	1.6	4	0.48	0.28	0.2	0.9
Phosphorus	10	1276	0.14	808	2030	4	1097	0.06	922	1290
Potassium	10	4645	0.08	3880	7550	4	4908	0.05	4350	5770
Rubidium	10	14.31	0.15	9.5	23.1	4	9.44	0.07	8.2	11
Selenium	10	<0.10	-	<0.10	<0.10	4	<0.10	-	<0.10	<0.10
Silver	10	<1	-	<1	<1	4	<1	-	<1	<1
Sodium	10	4.16	0.35	<2	9	4	3.31	0.35	<2	6
Strontium	10	9.86	0.26	4.89	31.1	4	6.74	0.20	4.4	11.7
Tellurium	10	<0.08	-	<0.08	<0.08	4	<0.08	-	<0.08	<0.08
Thallium	10	<0.06	-	<0.06	<0.06	4	<0.06	-	<0.06	<0.06
Tin	10	<1	-	<1	<1	4	<10	-	<1	<1
Titanium	10	0.23	0.32	0.1	1.09	4	0.38	0.30	0.2	0.94
Uranium	10	<0.02	0.17	<0.02	0.03	4	<0.02	-	<0.02	<0.02
Vanadium	10	<0.06	-	<0.06	0.07	4	<0.06	-	<0.06	<0.06
Zinc	10	72.4	0.41	24.9	333	4	44.2	0.19	25.9	67.3

Notes:

[1] Concentrations are reported in mg/kg dry weight

[2] Values for moisture are an arithmetic mean with standard deviation

GM – geometric mean

GSD – geometric standard deviation

TABLE 4.7-4
SUMMARY OF MOISTURE AND METAL CONCENTRATIONS IN SEDGE AND CINQUEFOIL COLLECTED AT EL BONANZA
(Data from July 2006)

Constituent	Sedge [1]					Cinquefoil [1]				
	N	**GM**	**GSD**	**Min.**	**Max.**	**N**	**GM**	**GSD**	**Min.**	**Max.**
Moisture [2]	4	48.6	27.5	7.5	64.6	4	56.5	1.34	54.7	57.9
Aluminum	4	13.5	0.32	5	28	4	9.21	0.35	5	30
Antimony	4	<0.06	-	<0.06	0.09	4	<0.06	-	<0.06	<0.06
Arsenic	4	0.12	0.17	0.07	0.18	4	0.08	0.41	<0.05	0.21
Barium	4	30.1	0.28	12	53.6	4	54.0	0.25	27.7	105
Beryllium	4	<0.06	-	<0.06	<0.06	4	<0.06	-	<0.06	<0.06
Bismuth	4	<0.02	-	<0.02	0.02	4	<0.02	-	<0.02	<0.02
Boron	4	11.6	0.30	4.6	24.6	4	39.5	0.12	26.1	47
Cadmium	4	0.03	0.37	<0.02	0.06	4	0.07	0.89	<0.02	1.21
Cesium	4	0.08	0.81	<0.02	0.71	4	0.03	0.56	<0.02	0.2
Chromium	4	0.55	0.32	0.2	1	4	0.20	0.43	<0.10	0.4
Cobalt	4	0.14	0.41	0.04	0.37	4	0.03	0.76	<0.01	0.31
Copper	4	5.52	0.27	2.2	8.4	4	5.49	0.05	4.8	6.5
Iron	4	88.1	0.20	61	162	4	48.1	0.13	35	71
Lead	4	0.33	0.23	0.15	0.47	4	0.28	0.40	0.13	0.99
Magnesium	4	667	0.32	239	1240	4	1460	0.11	1080	1830
Manganese	4	437	0.25	253	900	4	95.3	0.27	39.7	157
Molybdenum	4	0.81	0.83	0.05	3.77	4	0.62	0.29	0.35	1.52
Nickel	4	0.62	0.07	0.5	0.7	4	0.39	0.30	0.2	1
Phosphorus	4	956	0.22	492	1680	4	1192	0.06	1030	1410
Potassium	4	7691	0.48	1470	15700	4	8320	0.07	7060	10200
Rubidium	4	9.09	0.66	1	30.4	4	13.3	0.11	10.4	17.6
Selenium	4	<0.10	-	<0.10	<0.10	4	<0.10	-	<0.10	0.2
Silver	4	<1	-	<1	<1	4	<1	-	<1	<1
Sodium	4	18.5	0.09	14	22	4	9.30	0.27	4	16
Strontium	4	6.32	0.27	4.08	15.8	4	8.98	0.20	5.77	15.6
Tellurium	4	<0.08	-	<0.08	<0.08	4	<0.08	-	<0.08	<0.08
Thallium	4	<0.06	-	<0.06	<0.06	4	<0.06	-	<0.06	<0.06
Tin	4	<1	-	<1	<1	4	<1	-	<1	<1
Titanium	4	0.77	0.39	0.22	1.65	4	0.46	0.50	0.16	1.58
Uranium	4	0.02	0.28	<0.02	0.03	4	<0.02	-	<0.02	0.04
Vanadium	4	<0.06	-	<0.06	<0.06	4	<0.06	-	<0.06	0.1
Zinc	4	44.4	0.20	24.3	68	4	65.2	0.30	37.8	163

Notes:

[1] Concentrations are reported in mg/kg dry weight

[2] Values for moisture are an arithmetic mean with standard deviation

GM – geometric mean

GSD – geometric standard deviation

4.8 TERRESTRIAL WILDLIFE

The current state of knowledge regarding wildlife in the Great Bear Lake watershed is summarized in a report by Macdonald (2004). A brief summary of the information contained in Macdonald (2004), updated with more recent information on the status of bird and animal species in the Northwest Territories, is presented below.

4.8.1 Wildlife Biodiversity

The area around Great Bear Lake naturally provides a large variety of habitats and rich species diversity of vegetation, wildlife and birds including boreal and tundra species. No large scale inventories of terrestrial species present in the Great Bear Lake watershed have been undertaken to establish the current biodiversity, however, the Environment and Natural Resources (ENR) (previously known as Resources, Wildlife and Economic Development (RWED)) branch of the Government of the Northwest Territories maintains a database on terrestrial plants and animals by ecozone (ENR 2007). ENR evaluates the status of each species based on their numbers, distribution and the extent of threats to their populations and habitats.

Of the 54 mammals listed in the ENR database that are potentially present in the Great Bear Lake watershed, 37 are considered to be “secure” indicating that there is a large enough population and a wide enough distribution that there is no immediate concern for the species, and 7 species are considered to be “sensitive” (barren land caribou, woodland caribou, wolverine, grizzly bear, fisher, little brown bat, and collard pika) due to small numbers or threats to the habitat. Ten species were listed as “undetermined” because data were not available to assess their status. No mammals were identified in the “may be at risk” or “at risk” categories. Characteristic wildlife in the Great Bear watershed includes caribou, moose, black bear, wolf, red fox, snowshoe hare and beaver. Surveys of the caribou herds indicate that the Bluenose-East and Bluenose-West herds to the north appear to have stable numbers, but the Bathurst herd appears to have undergone a significant decline.

Of the 190 bird species listed in the ENR database that are potentially present in the watershed, 106 species are “secure”, 25 are “sensitive” (northern pintail, lesser scaup, long-tailed duck, white-winged scoter, surf scoter, least sandpiper, semipalmated sandpiper, black tern, red phalarope, red-necked phalarope, American golden-plover, Caspian tern, lesser yellowlegs, peregrine falcon (anatum and tundrius), American pipit, olive-sided flycatcher, blackpoll warbler, barn swallow, boreal chickadee, American tree sparrow, white-throated sparrow, Harris’s sparrow, short-eared owl), 2 species “may be at risk” (gray-headed chickadee and rusty blackbird), and 1 species is “at risk” (Eskimo curlew). The remaining 56 species were listed as “undetermined”. Common birds found in the Great Bear watershed include spruce grouse, raven, osprey and waterfowl. Assessments of waterfowl indicate that populations of pintail and scoters are much lower than historic levels, although mallard and Canada goose numbers remain relatively stable.

During the July 2006 El Bonanza Mine site assessment (SENES 2007a), signs of several wildlife species were observed at the site. Signs from moose, caribou, grouse and several cottontail rabbits were observed and a black bear was seen moving between the buildings on the main portion of the site. Plants that had been browsed by large herbivores, probably moose, were observed at sites where soil and vegetation samples were collected.

4.8.2 Species at Risk in Canada

Of the mammal and bird species that may potentially occur specifically within the project area, 7 have been designated as "species at risk" in Canada (see Table 4.8-1). Assessments for candidate species are conducted by the Committee on the Status of Endangered Species in Canada (COSEWIC) who provide recommendations on the levels of protection needed to allow the recovery of declining species. Candidate species are listed under specific classifications depending on their numbers and the health of the population as follows (Macdonald 2004):

Extinct: a species no longer exists.
Extirpated: a species no longer exits in the wild in Canada, but occurs elsewhere.
Endangered: a species faces imminent extirpation or extinction.
Threatened: a species likely to become endangered if limiting factors are not reversed.
Special Concern: a species that may be particularly sensitive to human activities or natural events.

Species protected under the *Species at Risk Act* (SARA) are listed on Schedule 1 of SARA. SARA also includes endangered and threatened species on Schedule 2 and species of concern on Schedule 3 that are under review for inclusion on Schedule 1.

As indicated on Table 4.8-1, the species of greatest concern are the Eskimo curlew, which is endangered and the woodland caribou, which is threatened. There have been no sightings of the Eskimo curlew since 1998 and the National Recovery Team for this species has determined that recovery is not feasible at this time. The woodland caribou was considered in the site-specific risk assessment that was conducted for the El Bonanza Mine site (SENES 2007b), as signs of caribou have been observed at the site. The risk assessment did not identify any risks to woodland caribou.

TABLE 4.8-1
TERRESTRIAL SPECIES AT RISK POTENTIALLY OCCURRING WITHIN THE PROJECT AREA

Terrestrial Species at Risk potentially within project area [1]	**COSEWIC Designation**	**Schedule of SARA**	**Government Organization with Primary Management Responsibility [2]**
Eskimo Curlew [3]	Endangered	Schedule 1	EC
Woodland Caribou (Boreal population)	Threatened	Schedule 1	Government of NWT
Peregrine Falcon (*anatum-tundrius* complex [4])	Special Concern	Schedule 1 (*anatum*) Schedule 3 (*tundrius)*	Government of NWT
Short-eared Owl	Special Concern	Schedule 3	Government of NWT
Wolverine (Western population)	Special Concern	Pending	Government of NWT
Grizzly Bear	Special Concern	Pending	Government of NWT
Rusty Blackbird [5]	Special Concern	Pending	Government of NWT

[1] The Department of Fisheries and Oceans has responsibility for aquatic species.

[2] Environment Canada has a national role to play in the conservation and recovery of Species at Risk in Canada, as well as responsibility for management of birds described in the *Migratory Birds Convention Act* (MBCA). Day-to-day management of terrestrial species not covered in the MBCA is the responsibility of the Territorial Government. Thus, for species within their responsibility, the Territorial Government is best suited to provide detailed advice and information on potential adverse effects, mitigation measures, and monitoring.

[3] There have been no reliable sightings of Eskimo Curlew since 1998 and the National Recovery Team for this species has determined that recovery is not feasible at this time.

[4] The *anatum* subspecies of Peregrine Falcon is listed on Schedule 1 of SARA as threatened. The *anatum* and *tundrius* subspecies of Peregrine Falcon were reassessed by COSEWIC in 2007 and combined into one subpopulation complex. This subpopulation complex was listed by COSEWIC as Special Concern.

[5] Newly listed by COSEWIC in April 2006.

4.9 HYDROLOGY AND HYDROGEOLOGY

A recent review of the state of aquatic knowledge of the Great Bear Watershed (MacDonald *et al.* 2004) provides a comprehensive overview of limnological, hydrological and environmental conditions and of the structure and function of the aquatic ecosystem of Great Bear Lake. The following hydrology/hydrogeology descriptions were summarized from MacDonald *et al.* (2004) and site-specific descriptions from the SENES site assessment report (SENES 2007a).

4.9.1 Physical Limnology

Great Bear Lake is the largest freshwater lake wholly contained within the borders of Canada. The statistical attributes of the lake include it being the ninth largest lake in the world by volume, the nineteenth deepest lake in the world, and holding the largest mass of cold freshwater in the world. The lake is characterized by its clear waters, maximum recorded Secchi depth of 30 m, and simple food web. The total water volume is approximately 2.24 billion m^3 with a drainage area to water surface area ratio of 4.7 to 1, which is smaller than most lakes.

Precipitation in the Great Bear watershed is in the order of 230 mm/yr (102 to 355 mm/yr), half of which falls as rain in the summer months. The evaporation rate is about half that of precipitation, and thus the flow of surface water into lakes occurring in the area is generally small. Great Bear Lake has a slow turnover rate and a 124-year residence time. Furthermore, Great Bear Lake is an isothermal, un-stratified lake, and this lack of temperature variance means it is well mixed. During summer storms, water from shallow areas circulates and mixes with deeper water, and on average Great Bear Lake turns over once every 3 years (Johnson 1975a). Great Bear Lake is ice covered from December to May, but sheltered bays and shallow water can be frozen by November. Ice formation can continue to April, and ice is not off the lake until July.

4.9.2 Regional Hydrology

As noted above, the drainage area of Great Bear Lake is very small compared to the total area of the lake, which limits the influence of inflows from contributing basins. Great Bear Lake receives inflow from six major sub-watersheds: Johnny Hoe, Camsell, Sloan, Dease, Haldane and Whitefish. The Camsell River is the largest tributary contributing 21% of total drainage at 3.083 billion m^3/yr. Johnny Hoe is the next largest contributor with 12% of the total drainage at 1.287 billion m^3/yr. The response of the river system and the timing of peak flow is typical of peak flows that are the direct result of snow melt and runoff. Peak flow usually occurs in mid- to late-May. Soon after the peak, flow begins to subside to low levels for the rest of the year.

Great Bear Lake water levels have been recorded since 1938, with continuous measurements starting in 1963. Data from Port Radium and Hornby Bay indicate that the extreme range in the lake level elevation is one meter. The lowest mean daily water elevation was 155.57 m a.s.l. in April 1948 and the highest was 156.59 m a.s.l. in August 1961. The majority of water levels range from between 155.8 and 156.4 m a.s.l. Water levels can also be affected by “seiche” wind effects and barometric changes.

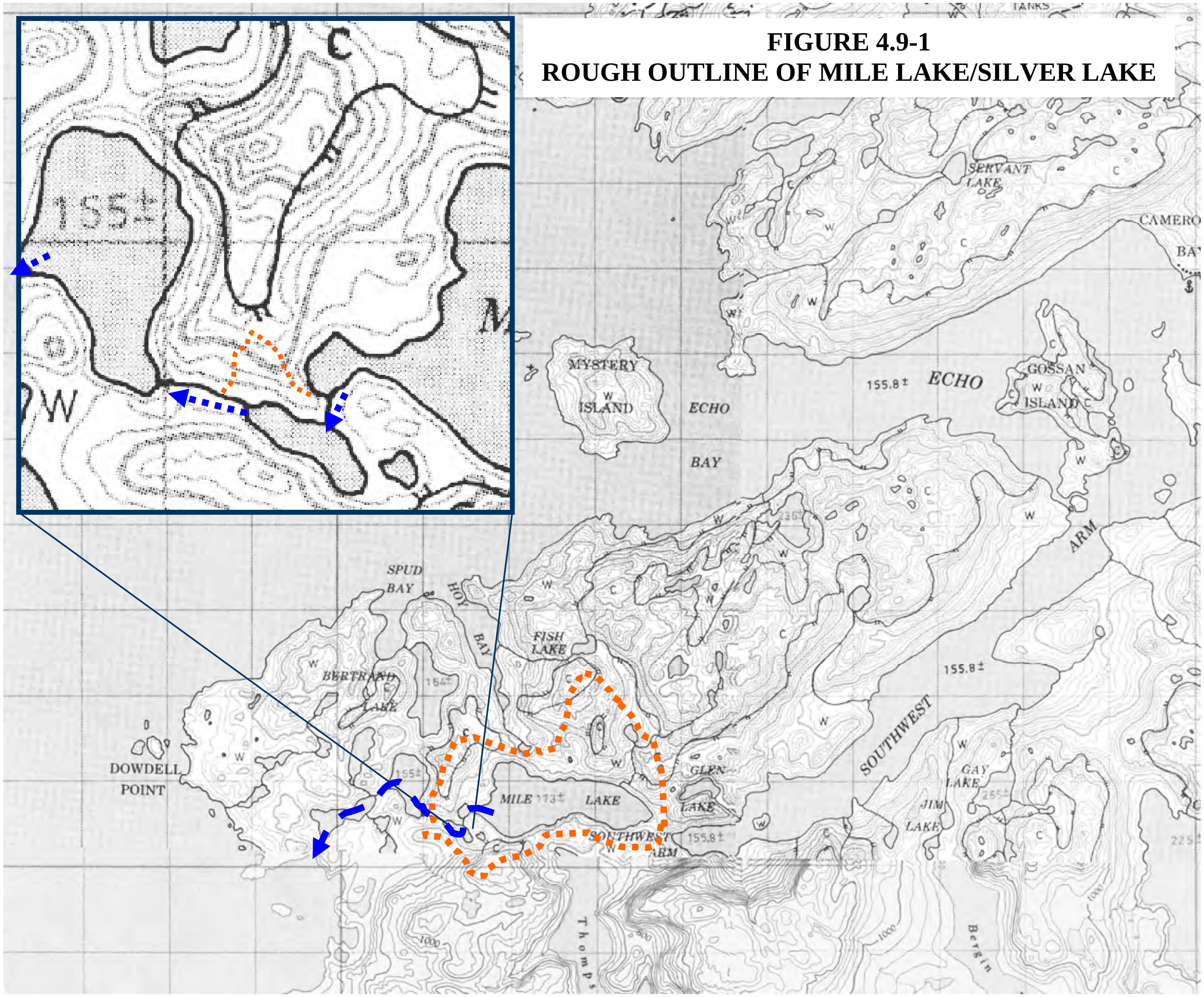
4.9.3 Site – Hydrology

The El Bonanza Mine site is located in a small watershed that hosts no major streams or rivers in the immediate vicinity. Rainfall and snowmelt pond and accumulate in localized depressions to the point where they reach steady state conditions. Runoff from the area reflects its rugged surface profiles and shallow soil cover and, as with other areas around the eastern end of Great Bear Lake, there is virtually no flow in either late summer or winter.

Figure 4.9-1 outlines the boundaries of the small drainage area of the El Bonanza Mine and the local watershed. As can be seen, due to its location, the watershed in the immediate area of the mine is extremely small (313 ha) with virtually all vicinity surface runoff bypassing this area and draining either to the north and east of the mine to Mile Lake or to the west of the mine to the stream draining toward Great Bear Lake.

At the time of the July site inspections (SENES 2007a) no evidence of surface water runoff surface flows were observed in the area above the site. Lake water flows were observed through the culvert connecting Mile Lake and Silver Lake and the culvert discharging Silver Lake to the stream flowing toward Great Bear Lake. Debris in the culvert connecting Mile Lake and Silver Lake was observed that may form a barrier for fish migration in the spring and possibly year-round. The Department of Fisheries and Oceans (DFO) has recommended the removal of the culvert to re-establish connectivity between the two lakes.

FIGURE 4.9-1
ROUGH OUTLINE OF MILE LAKE/SILVER LAKE



4.9.4 Site – Hydrogeology

Similarly to other areas in the region, the El Bonanza Mine site is characterized by extensive bedrock outcroppings and shallow surficial soils.

In bedrock outcrops, bedrock fractures would dominate any potential groundwater flow. During the site visit in July 2006 (SENES 2007a) when site inspections were carried out across the entire area of the El Bonanza site, no evidence of groundwater flow was noted.

Flow through surficial soils is periodic and in localized drainage pathways. In the case of the El Bonanza Mine site, two such areas are the sandy hillside located adjacent and east of the mine and the creek floodplain draining Silver Lake.

4.10 WATER AND SEDIMENT QUALITY

Ambient environmental monitoring has been carried out on Great Bear Lake for several decades including monitoring of contaminant levels in water, sediment and biota. Water quality monitoring has been carried out by Environment Canada as part of the routine surveillance network while a number of specific surveys have been conducted on portions of Great Bear Lake and/or its tributaries. A review of much of the historic data has been summarized by MacDonald *et al.* (2004).

Sampling programs have also been conducted at the El Bonanza Mine site in support of site assessments that were completed by Golder Associates Limited in July 2004 (Golder 2005) and SENES Consultants Limited in July 2006 (SENES 2007a) and June 2007 (SENES 2007c) where full details can be referenced. A brief review of the results of these surveys is presented below.

The water and sediment quality data collected through Golder (2005) and the 2006 site assessment program (SENES 2007a) were previously summarized and used in the human health and ecological risk assessment (HHERA) that was conducted by SENES in 2007 (SENES 2007b). The risk assessment identified the following as being constituents of potential concern (COPC): antimony, arsenic, barium, cadmium, chromium, cobalt, copper, lead, manganese, molybdenum, nickel, selenium, silver, strontium, uranium (chemical toxicity), vanadium, zinc and petroleum hydrocarbons (F2 and F3 fractions). The following discussions of water and sediment quality focus on these COPC.

4.10.1 Water Quality

Water samples were collected from Silver Lake, Mile Lake and Great Bear Lake at the airstrip, as well as the stream downstream of Silver Lake during the summer of 2006 (SENES 2007a).

Some additional water samples were collected earlier in July 2004 (Golder 2005). Samples were analyzed for metals and radionuclides (radium-226 and lead-210). A statistical summary of the data to 2006 was generated as part of the HHERA and is shown on Table 4.10-1 while mean COPC concentrations from this data set are compared to Canadian Environmental Quality Guidelines (CEQGs) for the protection of freshwater aquatic life on Table 4.10-2. Radionuclide levels in water were below detection limits and the results are not shown. The waterbodies mentioned above were sampled again in July 2007 during the supplementary site assessment program (SENES 2007c), as well as four other small lakes in the vicinity of the El Bonanza, Bonanza and airstrip sites.

The stream discharging from Silver Lake represented the only on-land water source sampled at El Bonanza as no evidence of surface water runoff and surface flows were observed in the area above the site during the 2006 and 2007 site assessments (SENES 2007a; 2007c). Lake water flows were observed through the culvert connecting Mile Lake and Silver Lake and the culvert discharging Silver Lake to the stream flowing toward Great Bear Lake.

As can be seen from Tables 4.10-1 and 4.10-2, mean COPC concentrations measured in Mile Lake, Silver Lake, Great Bear Lake at the airstrip, as well as the stream downstream of Silver Lake, were generally low and below applicable CEQGs and were also comparable between waterbodies. Measurements in many cases were below respective detection limits, especially for cadmium, cobalt and selenium that were below detection limits in all samples analyzed from the sites. The only COPC that exceeded a CEQG was copper. The CEQG for copper was exceeded in Mile Lake and equaled in Silver Lake. The reasonable maximum silver concentrations measured at these sites, shown on Table 4.10-1, were used in the HHERA. Cadmium is not included on Table 4.10-2 because as shown on Table 4.10-1, all measured concentrations were below the method detection limit, which is greater than the cadmium CEQG value of 0.00017 mg/L. Thus comparisons to the guideline value are meaningless. In 2007 (SENES 2007c), all COPC concentrations measured in Mile Lake, Silver Lake and Great Bear Lake at the airstrip, as well as four vicinity lakes and the stream downstream of Silver Lake, were below applicable CEQG. Concentrations of PHC that were measured in surface waters in 2007 only were below applicable guidelines (available for benzene, ethylbenzene and toluene) in all samples.

The results of the 2007 sampling program confirmed the findings of the 2006 site-specific risk assessment (SENES 2007b) that the water pathway presents no risk to human health or the ecology.

TABLE 4.10-1
SUMMARY OF WATER QUALITY DATA FOR COPC IN SURFACE WATERS AT THE EL BONANZA MINE SITE AND ABANDONED AIRSTRIP
(Data from 2004 and 2006)

COPC	Units	No. of Obs.	No. of Obs. < DL	Minimum	Maximum	Mean	Standard Deviation
El Bonanza Mine Site – Mile Lake							
Antimony	mg/L	4	2	0.00005	0.0006	0.0002	0.0003
Arsenic	mg/L	4	4	0.0001	0.0002	0.0001	-
Barium	mg/L	4	0	0.0046	0.0063	0.0053	0.0007
Cadmium	mg/L	4	4	0.000025	0.00005	0.00003	-
Chromium	mg/L	1	1	0.0004	0.0004	-	-
Cobalt	mg/L	4	4	0.00005	0.0001	0.00006	-
Copper	mg/L	4	0	0.0014	0.0080	0.0031	0.0033
Lead	mg/L	1	1	0.00005	0.00005	-	-
Manganese	mg/L	4	1	0.0001	0.0017	0.0008	0.0007
Molybdenum	mg/L	4	0	0.0002	0.0006	0.0003	0.0002
Nickel	mg/L	4	1	0.0001	0.0002	0.0002	0
Selenium	mg/L	4	4	0.00015	0.00020	0.00016	-
Silver	mg/L	4	4	0.00005	0.00020	0.00009	-
Strontium	mg/L	4	0	0.0102	0.0107	0.0105	0.0002
Uranium	mg/L	4	4	0.00005	0.00005	0.00005	-
Vanadium	mg/L	4	0	0.0003	0.0004	0.0004	0.0001
Zinc	mg/L	4	0	0.0014	0.0080	0.0033	0.0032
El Bonanza Mine Site – Silver Lake							
Antimony	mg/L	8	1	0.00005	0.002	0.0006	0.0007
Arsenic	mg/L	8	5	0.0001	0.0036	0.0008	0.001
Barium	mg/L	8	0	0.0059	0.0183	0.0088	0.0044
Cadmium	mg/L	8	8	0.000025	0.0001	0.00004	0
Chromium	mg/L	2	2	0.0004	0.0004	0.0004	0
Cobalt	mg/L	8	7	0.00005	0.0002	0.00008	0.00005
Copper	mg/L	8	0	0.0013	0.005	0.002	0.001
Lead	mg/L	2	1	0.00005	0.0007	0.0004	0.0005
Manganese	mg/L	8	0	0.0072	0.026	0.012	0.0059
Molybdenum	mg/L	8	0	0.0002	0.0034	0.001	0.001
Nickel	mg/L	8	2	0.0001	0.0005	0.0002	0.0001
Selenium	mg/L	8	8	0.00015	0.0002	0.0002	0
Silver	mg/L	8	8	0.00005	0.0002	0.00009	0
Strontium	mg/L	8	0	0.0095	0.0116	0.0110	0.0008
Uranium	mg/L	8	0	0.0001	0.0011	0.0002	0.0004
Vanadium	mg/L	8	2	0.00005	0.0006	0.0003	0.0002
Zinc	mg/L	8	0	0.0019	0.010	0.005	0.004

TABLE 4.10-1 (Cont'd)
SUMMARY OF WATER QUALITY DATA FOR COPC IN SURFACE WATERS AT THE EL BONANZA MINE SITE AND ABANDONED AIRSTRIP
(Data from 2004 and 2006)

COPC	Units	No. of Obs.	No. of Obs. < DL	Minimum	Maximum	Mean	Standard Deviation
Stream Downstream of Silver Lake							
Antimony	mg/L	2	0	0.0010	0.0012	0.0011	0.0001
Arsenic	mg/L	2	0	0.0003	0.0003	0.0003	0
Barium	mg/L	0	0	-	-	-	-
Cadmium	mg/L	2	2	0.000025	0.000025	0.000025	0
Chromium	mg/L	0	0	-	-	-	-
Cobalt	mg/L	2	2	0.00005	0.00005	0.00005	0
Copper	mg/L	2	0	0.0014	0.0014	0.0014	0
Lead	mg/L	0	0	-	-	-	-
Manganese	mg/L	0	0	-	-	-	-
Molybdenum	mg/L	2	0	0.0017	0.0019	0.0018	0.0001
Nickel	mg/L	2	2	0.00005	0.00005	0.00005	0
Selenium	mg/L	2	2	0.00015	0.00015	0.00015	0
Silver	mg/L	2	2	0.00005	0.00005	0.00005	0
Strontium	mg/L	0	0	-	-	-	-
Uranium	mg/L	2	0	0.0001	0.0001	0.0001	0
Vanadium	mg/L	0	0	-	-	-	-
Zinc	mg/L	2	0	0.0049	0.0049	0.0049	0
Abandoned Airstrip – Great Bear Lake							
Antimony	mg/L	5	0	0.0004	0.0011	0.00076	0.0003
Arsenic	mg/L	5	0	0.0003	0.0015	0.00056	0.0005
Barium	mg/L	5	0	0.021	0.026	0.024	0.002
Cadmium	mg/L	5	5	0.000025	0.000025	0.000025	0
Chromium	mg/L	0	-	-	-	-	-
Cobalt	mg/L	5	4	0.00005	0.0002	0.00008	0.00007
Copper	mg/L	5	0	0.0007	0.0012	0.0008	0.0002
Lead	mg/L	0	-	-	-	-	-
Manganese	mg/L	5	0	0.0005	0.0053	0.0016	0.002
Molybdenum	mg/L	5	0	0.0012	0.0019	0.0015	0.0003
Nickel	mg/L	5	0	0.0002	0.0009	0.0004	0.0003
Selenium	mg/L	5	5	0.00015	0.00015	0.00015	0
Silver	mg/L	5	2	0.00005	0.0001	0.00008	0.00003
Strontium	mg/L	5	0	0.0847	0.0865	0.0854	0.0007
Uranium	mg/L	5	0	0.0003	0.0004	0.0004	0.00004
Vanadium	mg/L	5	0	0.0003	0.0005	0.0004	0.00008
Zinc	mg/L	5	0	0.0021	0.0060	0.0038	0.002

Notes: – indicates data not available or could not be calculated; one-half the detection limit (DL) was used for measurements less than the DL; concentrations are for total metals.

TABLE 4.10-2

COMAPRISON OF MEAN COPC CONCENTRATIONS IN WATER AT THE EL BONANZA MINE SITE TO AVAILABLE GUIDELINES

(Data from 2004 and 2006)

COPC	Unit	CEQG Aquatic Life	CEQG Drinking Water [e]	Mean Measured Concentrations [a]			
				Mile Lake	**Silver Lake**	**Stream Downstream of Silver Lake**	**Airstrip – Great Bear Lake**
Antimony	mg/L	-	0.006	0.0002	0.0006	0.0011	0.00076
Arsenic	mg/L	0.005	0.01	0.0001	0.0008	0.0003	0.00056
Barium	mg/L	-	1	0.0053	0.0088	-	0.024
Chromium [f]	mg/L	0.0089	0.05	-	0.0004	-	-
Cobalt	mg/L	-	-	0.00006	0.00008	0.00005	0.00008
Copper	mg/L	0.002 [b]	1	0.0031	0.002	0.0014	0.0008
Lead [f]	mg/L	0.001 [c]	0.01	-	0.0004	-	-
Manganese	mg/L	-	0.05	0.0008	0.012	-	0.0016
Molybdenum	mg/L	0.073	-	0.0003	0.001	0.0018	0.0015
Nickel	mg/L	0.025, 0.065 [d]	-	0.0002	0.0002	0.00005	0.0004
Selenium	mg/L	0.001	0.01	0.00016	0.0002	0.00015	0.00015
Silver	mg/L	0.0001	-	0.00009	0.00009	0.00005	0.00008
Strontium	mg/L	-	-	0.0105	0.0110	-	0.0854
Uranium	mg/L	-	0.02	0.00005	0.0002	0.0001	0.0004
Vanadium	mg/L	-	-	0.0004	0.0003	-	0.0004
Zinc	mg/L	0.03	5	0.0033	0.005	0.0049	0.0038

▨ Concentrations greater than Canadian Environmental Quality Guideline (CEQG) for the protection of freshwater aquatic life (CCME 2007).

Underline Concentrations greater than Canadian Environmental Quality Guideline (CEQG) for drinking water (Health Canada 2006a; 2006b).

[a] Hardness of Mile Lake, Silver Lake and stream is approximately 30 mg/L; hardness of Great Bear Lake at the airstrip is approximately 70 mg/L.

[b] Copper guideline is for water hardness of 0 – 120 mg/L as $CaCO_3$.

[c] Lead guideline is for water hardness of < 60 mg/L as $CaCO_3$.

[d] Nickel guideline is 0.025 mg/L for water hardness of <60 mg/L as $CaCO_3$ and 0.065 mg/L for water hardness of 60 – 120 mg/L as $CaCO_3$.

[e] Drinking water guidelines for copper, manganese and zinc are for aesthetic concerns.

[f] Chromium and lead concentrations from 2006 samples were not used due to contamination problem.

"-" no data available.

4.10.2 Sediment Quality

Initial sediment samples had been collected in July 2004 (Golder 2005). In the summer of 2006 (SENES 2007a) sediment samples were collected from Silver Lake, Mile Lake and Great Bear Lake at the airstrip from several of the locations where water samples were collected. Samples were analyzed for total metals and petroleum hydrocarbons. A statistical summary of the data to 2006 was generated as part of the HHERA and is shown on Table 4.10-3. On Table 4.10-4, mean COPC concentrations, are compared to two sets of sediment quality guidelines. Sediment toxicity benchmarks developed by the Canadian Council of Ministers of the Environment (CCME) include the Interim Sediment Quality Guideline (ISQG) and the Probable Effect Level (PEL) (CCME 2007). The ISQG represents the concentration below which adverse biological effects are expected to occur rarely while a PEL defines the level above which adverse effects are expected to occur frequently. Sediment toxicity benchmarks developed by the Canadian Nuclear Safety Commission (CNSC) are also provided on Table 4.10-4 and include the Lowest Effect Level (LEL) and the Severe Effect Level (SEL) (Thompson *et al*. 2005). These benchmarks were developed for mining applications in northern Saskatchewan and cover a wider range of metals than those proposed by the CCME.

Based on the recommendations of the HHERA Silver Lake, Mile Lake and Great Bear Lake at the airstrip were sampled again in July 2007 during the supplementary site assessment program (SENES 2007c). The 2007 program included the same parameters as the 2006 program with the exception of PHCs where individual petroleum hydrocarbon compounds and fractions (BTEX and fractions F1 to F4) were analyzed as opposed to total hydrocarbons.

As can be seen from Tables 4.10-3 and 4.10-4, the highest mean COPC concentrations were measured in Mile Lake or Silver Lake with the exception of nickel, which was highest in Great Bear Lake at the airstrip. The mean concentrations of most COPC were comparable between Mile Lake and Silver Lake, although manganese was an order of magnitude higher in Silver Lake and barium almost twice as high, while copper and zinc were almost twice as high in Mile Lake. Total hydrocarbon concentrations were also noticeably higher in Mile Lake (725 mg/kg dry weight (dw)) relative to Silver Lake (129 mg/kg dw) and Great Bear Lake (21 mg/kg dw).

With respect to sediment quality guidelines shown on Table 4.10-4, in Great Bear Lake, nickel was the only COPC that exceeded a toxicity benchmark value (LEL), and Great Bear Lake was the only location where the mean nickel concentration exceeded a sediment quality guideline. Nickel concentrations were measured at two shoreline stations in Great Bear Lake and ranged from 11 to 58.9 mg/kg dw. The LEL was exceeded at only one of the two stations, which is located at the south end of the bay. When this station was sampled again in 2007, the average of three separate samples was only 9.6 mg/kg dw. Based on the available information it is not clear why nickel levels were elevated at this station, and there is no way to support any speculative statements in this regard other than to note that the higher levels appear to be localized and may be due to natural attenuation or localized impact from past activities. In Mile Lake, exceedences were noted for cadmium (ISQG), copper (ISQG and LEL), vanadium (LEL) and zinc (ISQG and PEL). Concentrations ranged from 0.58 to 0.73 mg/kg dw for cadmium, 93 to 108 mg/kg dw for copper, 42.4 to 49.5 mg/kg dw for vanadium and 500 to 950 mg/kg dw for zinc. In Silver Lake, the mean copper concentration exceeded the ISQG and the LEL, zinc exceeded the ISQG and arsenic equalled the ISQG. Copper concentrations ranged from 4 to 189 mg/kg dw, zinc from 41 to 553 mg/kg dw, and arsenic from 0.4 to 23 mg/kg dw. Metal concentrations in Silver Lake have been influenced by mining activities, as Silver Lake is located immediately downstream of the mine and the waste rock pile from the mine protrudes into the lake. The highest metal concentrations in Mile Lake were measured at the station located closest to the mine, which suggests that metal levels in this area of Mile Lake may have been influenced by mining activities or local runoff from the mining area with naturally elevated metals. One of the recommendations of the HHERA was to collect additional sediment samples from Mile Lake.

In 2007, no exceedences of sediment toxicity benchmarks were reported for metal COPC, including nickel, in any samples collected from Great Bear Lake. In Mile Lake, exceedences were noted for copper and zinc at both stations that were successfully sampled in 2007 (ELB-4-ML and ELB-10-ML). Concentrations were observed to be generally higher at ELB-4-ML (which is located closest to the mine). Arsenic concentrations exceeded the ISQG and LEL at both stations, while the ISQG was exceeded for zinc at ELB-10-ML and the PEL at ELB-4-ML. Metal concentrations were generally lower at ELB-4-ML in 2007 relative to 2006. An attempt was also made to sample a third station farther away (ELB-11-ML) but sediments in the area were scarce and a sample could not be obtained.

In Silver Lake, arsenic, cadmium, copper, selenium, vanadium, and zinc concentrations exceeded a benchmark value in at least one of three samples collected. However, the highest measured levels of several metals were reported on stations located near the centre of Silver Lake where the water depth is greater than 10 m. Much lower metal levels were measured on samples collected from shallow water near the waste rock pile that extends into the lake and at the outlet of the lake. Furthermore, no exceedences of sediment quality guidelines were reported on samples collected at either of these shallow stations. This suggests that sediment quality in the littoral zone (shallow near shore water), where benthic activity is greatest, is not impaired.

With respect to petroleum hydrocarbon compounds and fractions measured in 2007, BTEX (benzene, toluene, ethylbenzene and total xylene) levels in all sediment samples analyzed were below detection limits with the exception of a single sample collected from Silver Lake. This sample was collected from station ELB-5-SL, which is located in the middle of the lake, and had measurable levels of ethylbenzene (0.09 µg/g) and toluene (0.19 µg/g). Although guidelines for petroleum hydrocarbons in sediments have not been developed, it is noted that the measured ethylbenzene concentration slightly exceeded the CCME residential/parkland land use guideline for soil of 0.082 µg/g while the toluene concentration was below the criterion (0.37 µg/g) (CCME 2008). The ethylbenzene and toluene concentrations measured at station ELB-5-SL are inconsistent with previous results (from 2006), which reported all BTEX concentrations as being below detection limits at this station. All BTEX compounds were also reported as being below detection limits at all other stations that were sampled in Silver Lake in both 2006 and 2007. Based on these observations, it appears as though the ethylbenzene and toluene levels reported for station ELB-5-SL are likely the result of sample contamination. All concentrations of petroleum hydrocarbon fractions F2 and F4 were less than detection limits in all samples, but measurable levels of the F3 fraction were reported in sediments from Mile Lake and Silver Lake. All of the measured F3 fraction concentrations, with one exception, were below the CCME residential/parkland land use guideline for soil of 300 µg/g (CCME 2008). The sampling location that reported F3 levels in excess of the soil quality guideline was station ELB-8-SL, which is located at the outflow of Silver Lake and downstream of the mine. Concentrations of the F3 fraction in duplicate samples collected from this station ranged from 111 µg/g, which is below the soil quality guideline, to 451 µg/g.

The results of the 2004 and 2006 sediment sampling were considered in the site-specific risk assessment (SENES 2007b) as summarized in Chapter 5. The 2007 supplementary site assessment program focussed on some of the issues that were identified in the risk assessment and the results confirmed that the sediment pathway presents no risk to human health or the ecology.

TABLE 4.10-3

SUMMARY OF SEDIMENT QUALITY DATA FOR THE EL BONANZA MINE SITE AND ABANDONED AIRSTRIP ON GREAT BEAR LAKE

(Data from 2004 and 2006)

COPC	Units	No. of Obs.	No. of Obs. < MDL	Minimum	Maximum	Mean	Standard Deviation
El Bonanza Mine Site – Mile Lake							
Antimony	mg/kg dw	3	3	0.1	0.1	0.1	-
Arsenic	mg/kg dw	3	0	4.2	5.5	4.7	0.7
Barium	mg/kg dw	3	0	88	109	100	11
Cadmium	mg/kg dw	3	0	0.58	0.73	0.66	0.08
Chromium	mg/kg dw	3	0	27.7	30.2	28.6	1.39
Cobalt	mg/kg dw	3	0	9	15.9	11	4
Copper	mg/kg dw	3	0	93	108	101	8
Lead	mg/kg dw	3	0	14.7	15	15	0.2
Manganese	mg/kg dw	3	0	263	361	300	53
Molybdenum	mg/kg dw	3	0	3	3	3	0
Nickel	mg/kg dw	3	0	20.2	22.4	21.1	1.1
Selenium	mg/kg dw	3	0	0.7	1.4	1.1	0.4
Silver	mg/kg dw	3	0	0.4	0.4	0.4	0
Strontium	mg/kg dw	3	0	15	18	16	2
Uranium	mg/kg dw	0	0	-	-	-	-
Vanadium	mg/kg dw	3	0	42.4	49.5	44.9	4.0
Zinc	mg/kg dw	3	0	358	370	364	6
Hydrocarbon, Total Extractable	mg/kg dw	2	0	500	950	725	318
El Bonanza Mine Site – Silver Lake							
Antimony	mg/kg dw	14	11	0.1	0.3	0.13	0.06
Arsenic	mg/kg dw	14	0	0.5	23	5.9	8.2
Barium	mg/kg dw	14	0	17	1200	179	333
Cadmium	mg/kg dw	14	0	0.03	1.9	0.41	0.61
Chromium	mg/kg dw	14	0	7.4	49.1	17.1	14.4
Cobalt	mg/kg dw	14	0	3	29.5	7.7	7.5
Copper	mg/kg dw	14	0	4	189	45	72
Lead	mg/kg dw	14	0	2.5	33	11	8.9
Manganese	mg/kg dw	14	0	236	38600	4071	10308
Molybdenum	mg/kg dw	14	8	0.5	16	3.8	6.4
Nickel	mg/kg dw	14	0	5.4	41.7	13	11
Selenium	mg/kg dw	14	0	0.1	3	0.7	1
Silver	mg/kg dw	14	2	0.05	1	0.36	0.33
Strontium	mg/kg dw	12	0	6	20	10	5.2
Uranium	mg/kg dw	2	2	20	20	20	0
Vanadium	mg/kg dw	14	0	13.4	94.6	31.5	29.1
Zinc	mg/kg dw	14	0	41	553	196	194
Hydrocarbon, Total Extractable	mg/kg dw	10	0	31	290	129	75
Abandoned Airstrip – Great Bear Lake							
Antimony	mg/kg dw	6	6	0.1	0.1	0.1	-
Arsenic	mg/kg dw	6	0	1.8	2.9	2.1	0.44
Barium	mg/kg dw	6	0	32	64	42.5	12
Cadmium	mg/kg dw	6	0	0.03	0.06	0.05	0.01
Chromium	mg/kg dw	6	0	14.1	37.5	21.8	9.2
Cobalt	mg/kg dw	6	0	6.4	15.8	10.4	4.6
Copper	mg/kg dw	6	0	12	39	19	10
Lead	mg/kg dw	6	0	6.1	14.8	8.0	3.4
Manganese	mg/kg dw	6	0	526	1120	721	219
Molybdenum	mg/kg dw	6	6	0.5	0.5	0.5	0
Nickel	mg/kg dw	6	0	11	58.9	24	19
Selenium	mg/kg dw	6	6	0.15	0.15	0.15	0
Silver	mg/kg dw	6	0	0.1	0.2	0.2	0.05
Strontium	mg/kg dw	6	0	10	17	13	3
Uranium	mg/kg dw	0	0	-	-	-	-
Vanadium	mg/kg dw	6	0	23.2	62.3	35.0	15.3
Zinc	mg/kg dw	6	0	68	131	99	30
Hydrocarbon, Total Extractable	mg/kg dw	4	1	5	30	21	12

TABLE 4.10-4
SEDIMENT QUALITY IN DIFFERENT AREAS AT EL BONANZA MINE SITE
(Data from 2004 and 2006)

COPC	Unit	Sediment Quality Guidelines				Mean Measured Concentrations		
		CCME [1]		CNSC [2]		Mile Lake	Silver Lake	Great Bear Lake - Airstrip
		ISQG	PEL	LEL	SEL			
Antimony	mg/kg dw	-	-	-	-	0.1	0.13	0.1
Arsenic	mg/kg dw	5.9	17	10	346	4.7	5.9	2.1
Barium	mg/kg dw	-	-	-	-	100	179	42.5
Cadmium	mg/kg dw	0.6	3.5	-	-	**0.66**	0.41	0.05
Chromium	mg/kg dw	37.3	90	48	115	28.6	17.1	21.8
Cobalt	mg/kg dw	-	-	-	-	11	7.7	10.4
Copper	mg/kg dw	35.7	197	22	269	**101**	**45**	19
Lead	mg/kg dw	35	91.3	37	412	15	11	8.0
Manganese	mg/kg dw	-	-	-	-	300	4071	721
Molybdenum	mg/kg dw	-	-	13.8	1238	3	3.8	0.5
Nickel	mg/kg dw	-	-	23	484	21.1	13	**24**
Selenium	mg/kg dw	-	-	1.9	16.1	1.1	0.7	0.15
Silver	mg/kg dw	-	-	-	-	0.4	0.36	0.2
Strontium	mg/kg dw	-	-	-	-	16	10	13
Uranium	mg/kg dw	-	-	104.4	5874.1	-	20	-
Vanadium	mg/kg dw	-	-	35.2	160	**44.9**	31.5	35.0
Zinc	mg/kg dw	123	315	-	-	**364**	**196**	99

Notes:

[1] CCME = Canadian Council of Ministers of the Environment (CCME 2007); ISQG – Interim Sediment Quality Guideline; PEL – Probable Effect Level.

[2] CNSC = Canadian Nuclear Safety Commission (Thompson *et al.* 2005); LEL = Lowest Effect Level; SEL = Severe Effect Level.

Bold	Concentration is greater than ISQG.
Bold	Concentration is greater than ISQG and/or LEL.
Bold	Concentration is greater than PEL.
Bold	Concentration is greater than PEL and/or SEL.

4.11 AQUATIC BIOTA

The structure of the aquatic ecosystem of Great Bear Lake is discussed in depth in the "*State of the Aquatic Knowledge of Great Bear Watershed*" report prepared by MacDonald *et al.* (2004). As noted by the authors of this report, a number of focussed studies have been conducted to collect basic scientific data on the aquatic organisms in the watershed. Also, a great deal of traditional knowledge exists on the aquatic resources of Great Bear Lake and several broad surveys have been completed on fish and other species in the lake and its tributaries. Only a brief synopsis of this information is presented below.

The information presented in the following sections focuses on aquatic plants, zooplankton, benthic invertebrates, and fish, all of which are considered in the ecological risk assessment, and both qualitative and quantitative observations may be used in the assessment. In the absence of information specific to waterbodies within the El Bonanza area, regional data from Great Bear Lake and other surrounding waterbodies can be useful.

4.11.1 Aquatic Plants

No specific information was found with respect to aquatic plants that occur within Mile Lake or Silver Lake. Based on reported information, the aquatic plants that occur within the Great Bear Lake and associated tributaries fall into three general categories, phytoplankton (free-living algae), periphyton (algae attached to bottom substrate), and aquatic macrophytes (vascular plants).

Although a number of studies have been conducted on Great Bear Lake, only one study by Moore (1980) provided detailed information on the structure of phytoplankton communities in Great Bear Lake. This investigator sampled three areas within the lake, including Echo Bay, Conjuror Bay, and the Keith Arm opposite Delı̨nę (formerly Fort Franklin) during the period from June 1976 to August 1978. The results of this investigation showed that the standing crop of phytoplankton in Great Bear Lake was among the lowest found in freshwater systems, ranging from 20 to 91 mg/m^3 (Moore 1980). The average densities for the three areas sampled were 51 mg/m^3 for Echo Bay, 76 mg/m^3 for Conjuror Bay, and 41 mg/m^3 for Délı̨nę. By comparison, algal biomasses in the lower Great Lakes generally exceed 1000 mg/m^3 (Moore 1980).

The limited data that were found on periphyton communities in Great Bear Lake suggest that these communities contribute substantially to total primary productivity of the lake (Duthie and Hart 1987). The periphyton communities of Great Bear Lake tended to be more diverse than the associated phytoplankton communities. Overall, 101 species of periphyton were recorded at the three sites that were sampled in Great Bear Lake (Moore 1980). With respect to macrophyte communities, Johnson (1975b) reported that *Equisetum* sp. beds occur in certain areas within the lake, typically where water is less than 1 m deep.

4.11.2 Zooplankton

No specific information was found with respect to zooplankton communities in Mile Lake or Silver Lake.

A number of studies have been conducted to evaluate zooplankton communities in Great Bear Lake. The results of several studies that provided a comprehensive understanding of the structure of the community (Johnson 1975b; Moore and Sutherland 1981) suggest that Great Bear Lake has among the lowest diversity and density of zooplankton of any mainland lake in North America, with offshore areas generally being less productive than the nearshore environment.

4.11.3 Benthic Invertebrates

Benthic invertebrates inhabit the bottom substrates in lakes and rivers and represent fundamental components of aquatic food webs, particularly in the north where zooplankton communities tend to be less important (i.e. due to cold water conditions and low levels of nutrients).

No specific information was found with respect to benthic invertebrates that occur within Mile Lake or Silver Lake.

While no information was located on benthic invertebrate communities in the riverine components of the Great Bear Lake watershed, the available data indicate that relatively diverse communities of benthic invertebrates occur in Great Bear Lake. Johnson (1975b) reported that a variety of benthic macroinvertebrates occurred in shallow water areas (i.e. <5 m deep), including amphipods, gastropods, caddisfly larvae, mayfly larvae, beetle larvae, and water boatmen. Stonefly larvae were commonly observed in shallow waters with bouldery substrates. The biota that were associated with soft substrates and distributed over a wider range of water depths included amphipods, mysids, clams, oligochaetes, and midges (Johnson 1975b).

The densities of benthic invertebrates differed substantially among the various water depths sampled in Great Bear Lake, with appreciable densities of benthic invertebrates occurring only in waters less than 20 m deep (Johnson 1975b). The highest densities (i.e. 400 organisms/m^2, all species combined) were found in waters between 1 and 5 m deep, either associated with beds of algae or *Equisetum* sp. Lower densities were observed in waters 5 to 10 m deep (350/m^2), 6 to 15 m deep (200/m^2), and 16 to 20 m deep (125/m^2) (Johnson 1975b).

4.11.4 Fish

Great Bear Lake

In total, 29 fish species have been identified in Great Bear Lake (Johnson 1975b) and Great Bear River (Chang-Keu and Cameron 1980; McCart 1982). Insufficient information is currently available to determine the abundance of fish species utilizing habitats in Great Bear Lake. Studies conducted in the 1970's by Johnson (1975b) indicated that lake trout and lake whitefish are the most abundant fish species in the pelagic zone (i.e. water column) of Great Bear Lake. Lake trout were found to be widely distributed according to depth, ranging between shallow surface waters to as deep as 400 m. Lake whitefish had a discontinuous distribution in Great Bear Lake and were confined to bays and generally absent from open waters, even in the shallowest reaches. Large spawning concentrations of whitefish occurred at the mouth of the Johnny Hoe River during October (Johnson l975b).

Lake ciscoes are one of the most abundant fish species in the lake and are broadly distributed throughout the lake (Falk and Dahlke 1974). Walleye in Great Bear Lake are restricted exclusively to the circular basin at the southern end of McVicar Arm, which has a maximum depth of 35 m and the largest mass of warm water within Great Bear Lake. Burbot have been encountered infrequently within Great Bear Lake, but appear to be widely distributed throughout the lake (Chang-Kue and Cameron 1980). Arctic grayling in the Great Bear watershed are concentrated in the upper reaches of the Great Bear River.

Mile Lake and Silver Lake

A representative from the Department of Fisheries and Oceans (DFO) visited the El Bonanza Mine site in August 2005. During this site visit, juvenile grayling were observed in Mile Lake and near the mouth of the stream immediately downstream of the mine site. The small creeks and marshes to the west of the site, which connect Mile Lake to Great Bear Lake, were identified as likely important fish spawning, rearing, and feeding habitats (Watson 2005).

4.12 MINE AFFECTED WORKING AREAS

4.12.1 Waste Rock Chemistry and Bioavailability

An assessment of physical, radiological and chemical characteristics of waste rock was carried out as part of the 2006 site assessment program (SENES 2007a). This included visual inspection of the waste rock, selected waste rock sampling, as well as roving GPS and terrestrial gamma radiation measurements, which were discussed in Section 4.6. Waste rock samples were collected from both piles located at the El Bonanza Mine (adjacent to the No. 1 and No. 2 shafts) as well as the pile located at the Bonanza Mine (in the immediate vicinity of the headframe).

The samples were assessed for acid rock drainage and metal leachability (ARD/ML). The 2006 analytical results indicated that waste rock at both mine sites is neither acid generating nor metal leaching. Relative to typical abundances encountered in granitic rocks, the waste rock at both mine sites had elevated levels of antimony, arsenic, copper, cobalt, silver, tin and zinc, as well as molybdenum and lead in waste rock from the El Bonanza Mine. Higher concentrations of arsenic, lead and molybdenum were measured in waste rock from El Bonanza relative to waste rock from Bonanza. All El Bonanza and Bonanza waste rock samples showed no evidence of uranium concentrations above “typical” background soil levels of about 1-10 ppm (μg/g). Nearly all radiounuclide concentrations were below detection limits. The reader is referred to the 2006 site assessment report (SENES 2007a) for a complete listing of the results.

The results of the metal analysis were used in the site-specific risk assessment (SENES 2007b). Although the analytical results showed that the mineralized mine rock, as expected, exceeded many of the CCME guideline concentrations for metals in soil (residential/parkland land use; CCME 2007), the risk assessment found no concerns with respect to the metal levels in the rock. However, as CCME guidelines are intended for metals in a soil matrix, the comparison to mineral rock was not necessarily appropriate. Thus, during the 2007 supplementary site assessment (SENES 2007c) three additional waste rock samples were collected from the El Bonanza Mine site that were submitted for sequential extraction analysis (i.e. to determine bioavailability of metals) to assess the significance of the waste rock concentrations with respect to environmental fate and transfer.

A modified version of the sequential extraction test procedure developed by Tessier *et al.* (1979) was employed to partition metal binding in waste rock samples into six fractions. The test procedure measures the relative leachability of the metals from most readily leachable (step 1) to least leachable (step 6). The total metals content of each waste rock sample, derived by summing the individual fractions (steps), is shown on Table 4.12-1. The average distributions of the trace elements among the individual fractions in the sequential extraction test are presented on Table 4.12-2.

Besides the major elements (i.e. aluminum, calcium, iron, manganese, and potassium), the most prevalent trace elements in the waste rock were barium, copper, lead, titanium and zinc (see Table 4.12-1). Of these trace elements, those that were found to be highly insoluble (i.e. associated with residual metals; Step 6) included antimony (100%), barium (76.8%), boron (81.0%), chromium (81.6%), lithium (99%), nickel (79.4%), silver (86.8%), strontium (79.4%), titanium (98.8%), vanadium (90.7%) and tungsten (83.5%). Those elements that were found to be quite insoluble (i.e. over 50% associated with steps 5 and 6) included arsenic (59.2%), beryllium (70.9%), cadmium (63.2%), cobalt (75.3%), copper (69.9%), tin (66.7%), uranium (62.0%), yttrium (72.1%), and zinc (73.7%). The most leachable of the above list of trace elements (i.e. leached in steps 1 through 4) included bismuth (100%), molybdenum (100%), and selenium (90.2%). All three metals in the latter group, however, were measured in very low levels in the waste rock.

In 2007, SENES (2007b) undertook an ecological risk assessment for several exposure scenarios using monitoring data from the El Bonanza Mine site. In the assessment, ingestion of contaminated soils from across the site was considered with no application of a bioavailability factor. While waste rock was not specifically identified in the assessments, the fact that ingestion of the onsite soil matrix (which had similar metals content as that measured in waste rock explicitly) was included in the exposure analyses, it may be considered that ingestion of waste rock was addressed defacto. The soil ingestion pathway was shown to be the major contributor to the total exposure estimates relative to other pathways such as terrestrial vegetation and water. Therefore, if the findings of the Tessier results were applied to the soil exposure pathway, calculated intakes would be much lower than those shown with the risk assessment. It is thus concluded that waste rock poses a low risk of having adverse effects on terrestrial wildlife.

TABLE 4.12-1
TOTAL METAL CONCENTRATIONS IN EL BONANZA WASTE ROCK SAMPLES
(Data from June 2007)

Constituent	Units	Sample #1 Total Steps #1-6	Sample #2 Total Steps #1-6	Sample #3 Total Steps #1-6
Ag	µg/g	200.8	181.6	0.6
Al	µg/g	37762	32305	28189
As	µg/g	35.4	17.4	5.2
Ba	µg/g	533.5	1419.0	192.1
Be	µg/g	2.7	2.8	0.5
B	µg/g	43.0	55.0	42.0
Bi	µg/g	2.5	2.6	2.4
Ca	µg/g	10325	8036	9856
Cd	µg/g	4.5	0.7	0.1
Co	µg/g	24.6	22.6	4.8
Cr	µg/g	46.0	31.0	49.0
Cu	µg/g	120.4	196.8	9.5
Fe	µg/g	33709	44670	11991
K	µg/g	12863	7069	4475
Li	µg/g	72	63	18
Mn	µg/g	6489	26822	1859
Mo	µg/g	<0.5	<0.5	1.5
Ni	µg/g	15.6	25.5	7.7
Pb	µg/g	414	82	35
Sb	µg/g	1.6	2.0	1.0
Se	µg/g	2.9	3.6	2.7
Sn	µg/g	9.0	8.0	<6
Sr	µg/g	52	46	54
Ti	µg/g	1220	722	2527
Tl	µg/g	4.0	19.0	<3
U	µg/g	6.1	6.1	1.6
V	µg/g	54.3	82.4	49.1
W	µg/g	27.0	9.0	5.0
Y	µg/g	15.3	23.2	14.4
Zn	µg/g	3025	954	363

TABLE 4.12-2
AVERAGE PERCENT EXTRACTED IN EACH STEP OF SEQUENTIAL TEST ON WASTE ROCK SAMPLES
(Data from June 2007)

Analyte	**Step 1 Water Soluble Metals**	**Step 2 Exchangeable Metals**	**Step 3 Metals Bound to Carbonates**	**Step 4 Metals Bound to Fe and Mn Oxides**	**Step 5 Metals Bound to Sulphides & Organics**	**Step 6 Residual Metals**
Ag	0.4%	0.1%	0.0%	11.4%	1.4%	86.8%
Al	0.4%	0.0%	0.1%	2.0%	1.4%	96.0%
As	1.6%	0.2%	4.9%	34.0%	15.9%	43.3%
Ba	1.3%	6.2%	6.0%	5.2%	4.6%	76.8%
Be	0.5%	0.0%	1.2%	27.5%	3.9%	67.0%
B	0.0%	0.0%	0.0%	19.0%	0.0%	81.0%
Bi	0.0%	33.3%	0.0%	66.7%	0.0%	0.0%
Ca	2.4%	4.8%	0.0%	0.0%	0.0%	92.8%
Cd	0.8%	7.0%	10.4%	18.6%	13.3%	49.9%
Co	0.5%	0.4%	3.0%	20.7%	2.4%	72.9%
Cr	0.0%	0.0%	0.0%	15.6%	2.8%	81.6%
Cu	1.7%	3.0%	11.5%	13.9%	29.6%	40.3%
Fe	0.7%	0.0%	0.2%	8.3%	2.5%	88.3%
K	0.2%	0.1%	6.1%	0.4%	0.2%	92.9%
Li	0.0%	0.0%	0.3%	0.5%	0.1%	99.0%
Mn	0.7%	0.1%	9.9%	26.9%	4.6%	57.8%
Mo	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
Ni	0.9%	5.5%	4.3%	7.8%	2.1%	79.4%
Pb	1.9%	0.1%	20.5%	39.5%	6.8%	31.2%
Sb	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
Se	0.0%	0.0%	90.2%	0.0%	0.0%	9.8%
Sn	0.0%	0.0%	0.0%	0.0%	0.0%	66.7%
Sr	1.2%	3.1%	7.0%	6.6%	2.6%	79.4%
Ti	0.3%	0.0%	0.1%	0.1%	0.7%	98.8%
Tl	0.0%	0.0%	5.3%	17.5%	0.0%	43.9%
U	0.0%	0.0%	19.7%	18.4%	2.2%	59.8%
V	0.6%	0.0%	0.1%	6.6%	2.1%	90.7%
W	0.0%	6.7%	2.5%	4.9%	2.5%	83.5%
Y	0.2%	0.0%	8.4%	19.2%	8.5%	63.6%
Zn	1.5%	0.1%	7.0%	17.7%	9.2%	64.5%

4.12.2 Designated Substances

A designated substance survey (DSS), including inspection for hydrocarbon contamination, was conducted at the El Bonanza Mine and outlying areas in July 2006 (SENES 2007a). A follow-up DSS was completed in June 2007 during the supplementary site assessment (SENES 2007c) to address information gaps that were identified in 2006 and to delineate the anticipated extent of contamination. The overall findings of the two surveys were as follows:

- *Asbestos-Containing Material (ACM)* – Minor issue with a gasket at the airstrip found to contain asbestos and a small heat shield with ACM located in Building 3 at El Bonanza.
- *Lead in Paint* – Paint was only found on one structure, the interior of the bunkhouse at El Bonanza. Neither of the 2 samples collected from the bunkhouse had measurable levels of lead (<100 ppm). Of the 4 paint samples collected from the four above-ground-storage tanks at the airstrip, 2 had leachable lead levels above the Transportation of Dangerous Goods – Clear Language criterion of 5 mg/L. The single paint sample collected from the Bonanza Mine from a 205 L drum reported a bulk lead concentration above the GNWT guideline value of 0.06%.
- *Polychlorinated Biphenyls (PCBs) in Paint* – White and blue paint samples collected from the bunkhouse at El Bonanza had non-detectable levels of PCBs.
- *Polychlorinated Biphenyls (PCBs) in Soil* – One soil sample collected from a visible surface stain near the former powerhouse at El Bonanza reported a PCB concentration (2.7 μg/g) above the CCME residential/parkland land use criterion of 1.3 μg/g. The remaining 22 soil samples collected from El Bonanza and Bonanza, including 4 samples collected from around the PCB impacted soil, reported PCB levels below the guideline and in most cases below the method detection limit.
- *Polychlorinated Biphenyls (PCBs) in Swipe Samples* - Of 3 swipe samples procured from the powerhouse transformer, one reported highly elevated PCB concentrations while 2 had non-detectable levels. 2 other swipe samples procured from potentially impacted hard surfaces at El Bonanza and Bonanza reported non-detectable PCB levels.
- *Polyaromatic Hydrocarbons (PAHs) in Soil* – Concentrations of all PAHs analyzed in 8 soil samples collected from El Bonanza were below available CCME residential/parkland land use criteria.
- *Petroleum Hydrocarbons (PHCs) in Soil* – CCME residential/parkland or industrial/commercial land use criteria (published January 2008) were exceeded at 25 of 55 sample locations at El Bonanza, at 7 of 21 sample locations at the airstrip, and in 3 of 8 sample locations at Bonanza. Soils were mainly impacted with the F2 (23 samples) and F3 (33 samples) fractions, but several samples also had F4 contamination (11 samples) and a few F1 contamination (4 samples). One soil sample collected from the shop (Building 2A) at El Bonanza also had elevated levels of benzene, toluene and

ethylbenzene, and one soil sample collected from Drum-L1 at El Bonanza had elevated levels of benzene.

- *Petroleum Hydrocarbons (PHCs) in Liquid* – PHC analysis confirmed the presence of diesel fuel in both 205 L drums located at the airstrip.
- *Metals in Soil* – Of 26 soil samples collected at El Bonanza, 14 had at least one parameter exceeding CCME residential/parkland land use criteria including arsenic, barium, copper, lead, silver and zinc. Of 28 soil samples collected at the airstrip, 7 had at least one parameter exceeding land use criteria, typically copper and zinc, but in a few cases arsenic, cobalt, lead, nickel and silver as well. Of 8 soil samples collected at Bonanza, 5 had at least one parameter exceeding land use criteria, typically copper, lead and zinc, but in a few samples arsenic, cobalt, chromium and nickel as well.
- *Dichloro-diphenyl-trichloroethane (DDT) in Wood* - Of 12 samples collected from wood frame structures at El Bonanza and Bonanza, 2 were found to have DDT levels above the CCME residential/parkland land use soil criterion of 0.7 µg/g (note that a criterion for wood is not available). The elevated results were reported at the warehouse and Building 13.

The DSS results from 2006 and 2007 are discussed further in the following sections.

4.12.2.1 Asbestos-Containing Materials

A total of 20 samples, including samples of tarpaper roofing, insulation paper and cement and a paper gasket, were analyzed for asbestos. Asbestos was detected in 2 samples. The first positive result was from the white insulation paper found on the ground near the location of former Building 3. The second positive result was for a paper gasket sampled at the airstrip. Neither of the samples contained friable asbestos and the total surface area of affected material is estimated to be less than 1 m^2. On this basis, the presence of asbestos at the El Bonanza site is considered to be a very minor issue.

4.12.2.2 Lead and PCBs in Paint

No external paint was observed on any of the remaining structures at El Bonanza and Bonanza. The bunkhouse (Building 13) at El Bonanza was the only structure observed to have any interior paint. Paint samples analyzed for lead (2 samples) and PCBs (2 samples) reported levels below respective method detection limits.

The results of leachable lead testing conducted on paint samples collected from the four fuel tanks at the airstrip reported concentrations of lead above the Transportation of Dangerous Goods Regulation – Clear Language criterion of 5 mg/L in 2 of the 4 samples tested. The paint on Tanks #3 and #4 reported values of 73.4 mg/L and 117 mg/L, respectively, while the lead values for Tanks #1 and #2 were 0.5 mg/L and <0.1 mg/L, respectively.

Bulk lead was also reported at a concentration of 0.40% in paint collected from a 205 L drum at the Bonanza Mine, which is above the GNWT guideline value of 0.06%. Based on this result, it was conservatively assumed that other 205 L drums located at the Bonanza Mine have elevated levels of lead in paint. However, it should be noted that at the relatively low bulk concentration reported, it is unlikely that the paint application would be classified as leachate toxic under the Transportation of Dangerous Goods Regulation standard of 5 mg/L. Nonetheless paint samples should be analyzed for leachable lead levels prior to disposal.

4.12.2.3 PCBs in Soil and Swipe Samples

One soil sample collected from a visible surface stain adjacent to a collapsed structure at El Bonanza where a transformer was found, believed to be the former powerhouse (Building 6), reported a PCB concentration (2.7 μg/g) above the CCME residential/parkland land use criterion of 1.3 μg/g. The results, however, from 4 soil samples collected from around the transformer in the vicinity of the collapsed structure reported PCB concentrations below the criterion. Furthermore, the results from an additional 13 soil samples collected from across the main mine site reported PCB concentrations either below the method detection limit or at very low concentrations. Analyses confirmed that PCBs were not present in the 5 soil samples collected at the Bonanza Mine (i.e. all samples reported non-detectable concentrations). These results indicate that the PCB contamination is localized and based on visual inspection the volume of impacted soil is estimated to be 0.1 m^3.

In addition to soil testing for PCBs, 3 swipe samples were procured from the powerhouse transformer, which is empty and dry. One of the swipe samples reported highly elevated PCB concentrations while the other 2 samples reported non-detectable levels. Based on this information, it can be concluded that the transformer will require management appropriate for PCB-contaminated equipment. Additional swipe samples were procured from a stained area of a work bench in the warehouse (Building 7) at El Bonanza and an oil-stained water pump at the hoist house at Bonanza. Both swipe samples reported non-detectable levels of PCBs.

4.12.2.4 PAHs in Soil

Eight soil samples were collected from El Bonanza for PAH analysis. All samples reported all parameter concentrations below CCME residential/parkland land use criteria and thus, no issues with respect to PAHs are identified at El Bonanza.

4.12.2.5 PHCs in Soil

Petroleum hydrocarbon levels measured in soil samples collected in 2006 and 2007 were compared to CCME residential/parkland and industrial/commercial land use soil quality criteria published in January 2008 (CCME 2008). Samples from both years that reported PHC levels above either set of criteria are summarized in Table 4.12-3 for the main mine site at El Bonanza, the airstrip and the Bonanza Mine.

Of the 55 targeted samples analyzed for PHCs from the main mine site at El Bonanza, 25 reported the presence of at least one of the PHC fractions F1 to F4 above the applicable soil quality criteria (see Table 4.12-3). Four areas of impact and estimated volumes of potentially affected material include:

1) Dumps #2 and #3 – 60 m^3 (F2 to F4);
2) The Powerhouse area – 40 m^3 (F2 and F4);
3) The Headframe/Shop area – 15 m^3 (F2 to F4); and,
4) The Bunkhouse/Fuel Storage Shed – 300 m^3 (F1 to F4).

One soil sample collected from the shop (Building 2A) also had elevated levels relative to criteria of benzene, toluene and ethylbenzene, and one sample collected from Drum-L1 had elevated levels of benzene.

Of the 21 targeted samples analyzed for PHCs from the airstrip, 7 reported the presence of at least one of the PHC fractions F1 to F4 above the applicable soil quality criteria (see Table 4.12-3). It has been estimated that 30 m^3 of impacted airstrip soils are distributed between the following three areas:

1) A stained area adjacent Tank #1 (F2 and F3);
2) Localized staining on the soil beneath drums D1 and D2 (F2 and F3); and,
3) Adjacent Tank #3 (F2 and F3).

Of the 8 soil samples analyzed for PHCs from the Bonanza Mine, 3 samples collected from Building 1 and the hoist house were found to have PHC levels above the applicable criteria (see Table 4.12-3), as follows:

1) The Hoist House – 1 m^3 (F3 only); and,
2) Building #1 - 5 m^3 (F2 to F4).

4.12.2.6 PHCs in Liquids

The four above-ground storage tanks (ASTs) present at the airstrip were visually inspected and/or dipped to determine if the tanks contained residual PHC product. Three of these tanks (ASTs #1, #2 and #4) were dry with no evidence of sludge present. Although the fourth AST (#3) was found to contain some PHC product, the volume is believed to be relatively small (i.e. <1 m^3).

Two 205 L drums at the airstrip containing liquid were analyzed for PHCs and the analysis confirmed that the PHC fractions that are present are consistent with diesel fuel.

4.12.2.7 Metals in Soil

Of the 26 soil samples analysed for metals from El Bonanza collected adjacent to buildings and from small dump areas, 14 were reported to have at least one of the following parameters at a concentration above the CCME residential/parkland land use soil quality criteria: arsenic, barium, copper, lead, silver or zinc. This is in keeping with the nature of the area which is heavily influenced by the presence of mineralized mine rock. Elevated metals were generally found in soils collected from the powerhouse (Building 6), headframe and shop (Buildings 2 and 2A), kitchen and office (Building 9), fuel storage building (Building 14) and dumps (1 and 2).

Of the 28 samples collected at the airstrip, 7 were reported to have at least one parameter at a concentration above the CCME residential/parkland land use soil quality criteria. Copper and zinc exceeded respective criteria in most samples, but arsenic, cobalt, lead, nickel or silver also reported levels above criteria in a few samples. Based on results from 2006 and 2007, the footprint of soils with elevated metals concentrations is believed to be restricted to a relatively small surface area (i.e. in the order of 100 m^2) occurring in two zones along the north side of the airstrip, one toward the east end and one toward the west end.

The results of the metals testing on soil from the Bonanza Mine adjacent to cabins found that 5 of 8 samples had at least one parameter at levels exceeding CCME residential/parkland land use soil quality criteria. Metals exceeding criteria typically included copper, lead and zinc, and in a few samples arsenic, cobalt, chromium, and nickel as well.

4.12.2.8 DDT in Wood

The DDT sampling program was implemented to confirm whether wood frame structures contained measurable levels of DDT. In general, the areas of concern were the structures at the El Bonanza main mine site and the Bonanza Mine.

Of 8 samples collected from the main mine site, 2 were found to have DDT levels above the CCME residential/parkland land use soil quality criterion of 0.7 µg/g. This guideline was used in the absence of any appropriate standard, as there are no guidelines or criteria for DDT in wood. The elevated results were reported at the warehouse and Building 13.

Of the 4 wood samples analyzed from the Bonanza Mine, all had DDT concentrations below the method detection limit. As such, the wood samples at Bonanza are considered to be free of DDT.

TABLE 4.12-3
PHC CONCENTRATIONS IN SOIL SAMPLES WITH LEVELS IN EXCESS OF RECOMMENDED GUIDELINES

EL BONANZA MAIN MINE SITE (SAMPLES COLLECTED IN 2006 AND 2007)

Parameters	**Soil Quality Guideline [1]**		**Bldg-6 (Power house**	**PWRH -PHC1 (Power house)**	**PWRH -PHC2 (Power house)**	**PWRH -PHC3 (Power house)**	**PWRH -PHC4 (Power house)**	**PWRH -PHC5 (Power house)**	**Bldg-13 (Bunk house)**	**Bldg-13 Soil22 (Bunk house)**	**Bldg-13 Soil25 (Bunk house)**	**Bldg-14 (Fuel shed)**	**Bldg-14 Soil27 (Fuel shed)**	**Bldg-14 Soil28 (Fuel shed)**	**Bldg-14 Soil29 (Fuel shed)**
	Res./ Park.	**Ind./ Com.**													
Benzene	0.03	0.03	<0.002 <0.002	<0.02	<0.02	<0.02	<0.02	<0.02	<0.002	<0.04	<0.02	<0.002 <0.002	<0.02	<0.02	<0.04
Toluene	0.37	0.37	0.03 0.02	0.04	<0.02	<0.02	<0.02	<0.02	<0.02	<0.04	<0.02	<0.02 <0.02	<0.02	<0.02	<0.04
Ethylbenzene	0.082	0.082	<0.02 <0.02	0.03	<0.02	<0.02	<0.02	<0.02	<0.02	<0.04	<0.02	<0.02 <0.02	<0.02	<0.02	<0.04
o-Xylene	-	-	<0.04 <0.04	0.02	<0.02	<0.02	<0.02	<0.02	<0.04	<0.04	<0.02	<0.04 <0.04	<0.02	<0.02	<0.04
p+m-Xylene	-	-	<0.02 <0.02	0.16	<0.04	<0.04	<0.04	<0.04	<0.02	<0.08	<0.04	<0.02 <0.02	<0.04	<0.04	<0.08
Total Xylenes	11	11	<0.04 <0.04	0.19	<0.04	<0.04	<0.04	<0.04	<0.04	<0.08	<0.04	<0.04 <0.04	<0.04	<0.04	<0.08
F1 (C6-C10)	-	-	<10 <10	<10	<10	<10	<10	<10	<10	320	<10	35 36	99	<10	460
F1 (C6-C10)-BTEX	30	320	<10 <10	<10	<10	<10	<10	<10	<10	**320!**	<10	**35!** **36!**	**99!**	<10	**460+**
F2 (C10-C16 Hydrocarbons)	150	260	<100 <100	**980+**	**210!**	150	**3200+**	**730+**	**430+**	**6300+**	**1700+**	**5700+** **5300+**	**4100+**	**1200+**	**7800+**
F3 (C16-C34 Hydrocarbons)	300	1700	**15000+** **12000+**	**30000+**	**6500+**	**7200+**	**1000+**	**8500+**	**3300+**	**2000+**	**1200!**	**8000+** **7000+**	**980!**	**1700!**	**1100!**
F4 (C34-C50 Hydrocarbons)	2800	3300	**10000+** **8500+**	**32000+**	**23000+**	**6400+**	2300	**8100+**	**23000+**	180	47	960 750	41	140	<10

Notes:

Data summarized from 2006 site assessment report (SENES 2007a) and 2007 supplementary site assessment report (SENES 2007c).

All parameter values in µg/g (ppm) unless otherwise indicated.

[1] Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (CCME 2007; CCME 2008).

! Exceeds Residential/Parkland Land Use Recommended Guidelines (for coarse-grained soil).

\+ Exceeds Residential/Parkland and Industrial/Commercial Land Use Recommended Guidelines (for coarse-grained soil).

TABLE 4.12-3 (Cont'd)
PHC CONCENTRATIONS IN SOIL SAMPLES WITH LEVELS IN EXCESS OF RECOMMENDED GUIDELINES

EL BONANZA MAIN MINE SITE (SAMPLES COLLECTED IN 2006 AND 2007)														
Parameters	**Soil Quality Guideline [1]**		**Bldg-2A (Shop)**	**HF – Soil2 (Hoist house)**	**Dump-2a**	**Dump-2b**	**Dump-3a**	**Dump2-Soil8**	**Dump2-Soil9**	**Dump2-Soil10**	**Barrel Dump-B**	**Barrel Dump-D**	**Barrel Dump-E**	**Drum-L1**
	Res./ Park.	**Ind./ Com.**												
Benzene	0.03	0.03	**0.15+**	<0.02	<0.002	<0.002	<0.002	<0.002	<0.002	<0.04	<0.002	<0.002	<0.002	**1.3+**
Toluene	0.37	0.37	**1.7+**	<0.02	<0.08	<0.06	<0.02	<0.02	<0.02	<0.04	<0.02	<0.02	<0.02	<0.02
Ethylbenzene	0.082	0.082	**0.40+**	<0.02	<0.08	<0.06	<0.02	<0.02	<0.02	<0.04	<0.02	<0.02	<0.02	0.03
o-Xylene	-	-	1.7	<0.02	<0.2	<0.1	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	0.04
p+m-Xylene	-	-	0.31	<0.04	<0.08	<0.06	<0.02	<0.02	<0.02	<0.08	<0.02	<0.02	<0.02	0.03
Total Xylenes	11	11	2.0	<0.04	<0.2	0.1	<0.04	<0.04	<0.04	<0.08	<0.04	<0.04	<0.04	0.08
F1 (C6-C10)	-	-	<10	<10	<40	<30	<10	<10	<10	<20	<10	<10	<10	18
F1 (C6-C10)-BTEX	30	320	<10	<10	<40	<30	<10	<10	<10	<20	<10	<10	<10	18
F2 (C10-C16 Hydrocarbons)	150	260	**980+**	13	<40	**3500+**	<200	**240!**	**180!**	66	**360+**	16	28	**790+**
F3 (C16-C34 Hydrocarbons)	300	1700	**47000+**	**960!**	**710!**	**3300+**	**20000+**	210	**1700!**	**3000+**	210	**2800+**	**6800+**	**41000+**
F4 (C34-C50 Hydrocarbons)	2800	3300	**20000+**	480	210	180	**3700+**	25	800	**3400+**	<10	660	**4800+**	**340000+**

Notes:

Data summarized from 2006 site assessment report (SENES 2007a) and 2007 supplementary site assessment report (SENES 2007c).

All parameter values in µg/g (ppm) unless otherwise indicated.

[1] Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (CCME 2007; CCME 2008).

! Exceeds Residential/Parkland Land Use Recommended Guidelines (for coarse-grained soil).

\+ Exceeds Residential/Parkland and Industrial/Commercial Land Use Recommended Guidelines (for coarse-grained soil).

TABLE 4.12-3 (Cont'd)
PHC CONCENTRATIONS IN SOIL SAMPLES WITH LEVELS IN EXCESS OF RECOMMENDED GUIDELINES

AIRSTRIP AND BONANZA MINE SITE (SAMPLES COLLECTED IN 2006 AND 2007)

Parameters	**Soil Quality Guideline [1]**		**Air-16**	**Air-17**	**Air-17a**	**Air-19**	**Air-23**	**Air-P002**	**Air-P007**	**Bldg-1**	**Bldg-1 Soil4**	**HF-Soil1**
	Res./ Park.	**Ind./ Com.**	**(Air strip)**	**(Air strip)**	**(Air strip)**	**(Air strip)**	**(Air strip)**	**(Air strip**	**(Air strip**	**(Black smith)**	**(Black smith)**	**(Hoist house)**
Benzene	0.03	0.03	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.02	<0.02
Toluene	0.37	0.37	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.03	<0.02	<0.02
Ethylbenzene	0.082	0.082	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
o-Xylene	-	-	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.02	<0.02	<0.02
p+m-Xylene	-	-	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.04	<0.04	<0.04
Total Xylenes	11	11	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
F1 (C6-C10)	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
F1 (C6-C10)-BTEX	30	320	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
F2 (C10-C16 Hydrocarbons)	150	260	**2100+**	140	17	**500+**	**1200+**	**1200+**	**1000+**	**3000+**	11	<10
F3 (C16-C34 Hydrocarbons)	300	1700	**3600+**	**580!**	**340!**	**430!**	**360!**	**310!**	**2100+**	**22000+**	**1400!**	**510!**
F4 (C34-C50 Hydrocarbons)	2800	3300	10	30	<10	<10	<10	<10	<10	**60000+**	1400	180

<u>Notes:</u>

Data summarized from 2006 site assessment report (SENES 2007a) and 2007 supplementary site assessment report (SENES 2007c).

All parameter values in µg/g (ppm) unless otherwise indicated.

[1] Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (CCME 2007; CCME 2008).

! Exceeds Residential/Parkland Land Use Recommended Guidelines (for coarse-grained soil).

\+ Exceeds Residential/Parkland and Industrial/Commercial Land Use Recommended Guidelines (for coarse-grained soil).

4.13 SUMMARY OF ENVIRONMENTAL STATUS AND ISSUES

4.13.1 Physical Hazards

The El Bonanza (and Bonanza) Mine contains the typical physical hazards associated with small mines in Northern Canada including such features as mine openings to surface, buildings in various states of disrepair, as well as debris and scrap.

Underground Mine

None of the access points to the underground have been permanently sealed. A summary of their current status is as follows:

- **El Bonanza No. 1 Shaft –** 2.4 x 1.8 m (8 x 6 ft) opening situated on side of a cliff. No headframe, partially covered by planking with no fencing. Shaft extends to a depth of 50 m from surface opening to base of cliff and connecting to the adit. Potential falling hazard, however, due to location inadvertent access to the area is improbable.
- **El Bonanza No. 2 Shaft –** 3.0 x 1.8 m (10 x 6 ft) opening located on the main mine site in the headframe building. Shaft partially blocked by 2” timber but no permanent capping. The shaft was reported to extend a depth of 45 m. Water and ice is at about 3 m (10 ft) from surface. Potential falling and drowning hazard.
- **El Bonanza No. 3 Shaft –** 2.7 x 1.5 m (9 x 5 ft) opening located on an accessible hillside approximately 50 m (164 ft) north of the main mine site. The shaft was a shallow excavation extending a reported depth of 9 m with a solid ice plug at a depth of 1.5 m (5 ft) at the time of inspection.
- **El Bonanza No. 1 Adit –** Located immediately below No. 1 Shaft with access from ground level. Risk of falling rock and potential falling hazard (into No. 1 Shaft).
- **Bonanza No. 1 Shaft –** 1.2 x 2.4 m (4 x 8 ft) timbered shaft opening in state of disrepair and rot, with no cap. While the shaft is under a small headframe it is open to the weather and partially filled with water. The reported depth of the shaft is 30 m. Potential falling and drowning hazard.

The surface trenches at both El Bonanza and Bonanza are for the most part very shallow, with limited hazard potential.

As part of the 2006 site assessment, SRK reviewed the information on mine workings and provided comments on their stability and noted that given the limited nature and depth of the mine workings, the risk of crown failure is low.

Buildings and Infrastructure

Remaining mine buildings, sheds and cabins (10 standing and 8 either gone or demolished) at El Bonanza and Bonanza are in various states of disrepair. Potential hazards include building collapse, residual debris, rotting floor boards, and protrusions.

Waste Rock Disposal Areas

The waste rock piles (2 areas at El Bonanza and 1 area at Bonanza) onsite are of modest dimensions, with limited aerial extent and modest height. Existing slopes are generally at their natural angle of repose with no evidence of surface erosion. Long-term stability of these piles should not be an issue of concern.

Waste Disposal Areas

Miscellaneous metal and wood debris remains throughout the site. In addition, approximately 50 empty barrels remain on land and about 15 remain in water that will require management.

Airstrip

Two 100,000 L vertical above-ground fuel storage tanks and two 40,000 L cylindrical above-ground fuel storage tanks lying on their side remain at the airstrip, along with assorted equipment and materials.

Roadways and Culverts

Roadways are in state of natural re-growth and represent minimal environmental concern. Culverts are also associated with the roadways that may pose a fisheries concern. The Department of Fisheries and Oceans (DFO) has recommended removal of the Silver Lake culverts, in particular the culvert that connects Mile Lake and Silver Lake, as it likely forms a significant barrier to fish migration in the spring and possibly year-round.

4.13.2 Chemical Hazards

Contaminated Soils

Soil is impacted with relatively low levels of PCBs in one location (outside Building 6 - powerhouse) near a former transformer. Based sampling results, the volume of impacted soil is estimated to be 0.1 m^3.

Residual PHC contamination in the form of heating oil, diesel and heavy oils occurs near Buildings 2 (hoist house), 2A (shop), 6 (powerhouse), 13 (bunkhouse) and 14 (fuel storage) and two of the dump sites and the drum storage area at the main mine site at El Bonanza, near

Building 1 (blacksmith) and the hoist house at Bonanza, and at the airstrip. Areas with PHC contamination are believed to be localized at the mine sites, the drum areas and the airstrip area. It has been estimated that a total volume of PHC impacted soil (mainly F2 to F4) of 415 m^3 occurs at El Bonanza, 6 m^3 at Bonanza and 30 m^3 at the airstrip (see Tables 4.13-1 and 4.13-2).

As expected when dealing with mineralized areas, multiple metal parameters at various locations have concentrations above the CCME residential/parkland land use criteria. Metals typically reported with elevated concentrations are copper, lead, and zinc and in some cases arsenic, barium, cobalt, chromium, nickel or silver as well. Visual observations of the area indicated that metal concentrations are heavily influenced by the presence of mine rock or mineralized soil generated from the local parent rock either through natural erosion or the mining operations themselves.

Waste Rock Disposal Areas

Field observations and laboratory analysis suggest that the waste rock is chemically stable. No observations of acid rock drainage occur around the waste rock, which has been exposed in its current state for several decades, and laboratory acid base accounting suggests that the rock is neither acid generating nor metal leaching.

Water and Sediments

Initial sampling undertaken at the El Bonanza Mine site in 2004 (Golder 2005) indicated COPC concentrations in Silver Lake adjacent to the mine site were only slightly higher than in background water collected in Mile Lake, with the exception of one sample collected near the waste rock pile that exceeded CEQGs for some elements. Sediment samples collected in 2004 at the same locations as the water samples showed the presence of PHCs, and one sample collected near the waste rock pile had a zinc content greater than the CCME no effects sediment quality guideline.

The 2006 and 2007 monitoring programs involved the collection of shoreline and water column samples at vicinity lakes and water samples in a local stream. The results of the sample analyses indicated that water quality parameters measured in the samples from Silver Lake, Mile Lake, Great Bear Lake and other vicinity lakes, as well as the local stream flowing from Silver Lake, are all below their respective guidelines for the protection of freshwater aquatic life. The results of the 2007 water sampling indicates that the concentrations of metals in the water column in Silver Lake and Mile Lake were lower than 2006, thus confirming the conclusion of the 2007 site-specific risk assessment that there are no human health or ecological water quality concerns.

The results from the 2006 sediment sampling program were used in the 2007 site-specific risk assessment and sediment sampling during the 2007 supplementary site assessment focussed on issues that were identified through the risk assessment with respect to metal and petroleum hydrocarbon contamination in Silver Lake and Mile Lake. Sediment quality data from the 2007 survey at the El Bonanza site indicated that the highest measured levels of several metals (e.g. arsenic, cadmium, copper, lead, molybdenum, nickel, selenium, vanadium and zinc) were reported on stations located near the centre of Silver Lake where the water depth is over 10 m. Much lower metal levels were measured on samples collected from shallow water near the waste rock pile that extends into the lake and at the outlet of the lake. These data suggest that sediment quality in the littoral zone (shallow nearshore water), where benthic activity is greatest, is not impaired.

Petroleum hydrocarbon analyses showed that most of the CCME fractions analyzed were below the reported method detection limits. Only the F3 fraction was found at measurable levels. There are no sediment quality guidelines against which the measured levels can be compared. However, it is noted that the measured F3 fraction concentrations, with one exception, are below the CCME guideline of 400 µg/g dw for soil invertebrates. Based on our experience on other similar assessments, we believe that the hydrocarbon levels measured in the sediments of Silver Lake and Mile Lake do not pose a risk to benthic communities.

Based on the results of the 2007 sediment analyses, it as concluded that additional sediment quality sampling or benthic community survey work was not justified on either Silver Lake or Mile Lake. The 2007 sediment sampling results confirmed that the sediment pathway presents no risk to human health or the ecology.

4.13.3 Radiological Hazards

A radiation survey of the site conducted in July 2006 (SENES 2007a) confirmed that terrestrial gamma radiation levels at and in the vicinity of the El Bonanza Mine site are generally at background levels and thus pose no concerns with respect to radiological exposure.

4.13.4 Waste Disposal

A summary of potential local/offsite disposal material quantities is shown on Table 4.13-1 for the El Bonanza Mine and Table 4.13-2 for the Bonanza Mine. Several practical approaches exist by which to dispose of solid wastes in a reasonable and rational manner for this site. Local disposal areas can be constructed at each of three primary areas (e.g. the El Bonanza Mine, the Bonanza Mine, and the airstrip) in which approved waste materials can be buried and covered. Likely disposal areas include the edge of the hillside sand cut or in the waste rock piles at the El Bonanza Mine; at the toe of the waste rock, in the small surface trenches, or near the dump at the cabin at the Bonanza Mine; and, anywhere in the gravel deposit at the airstrip. Given the small quantities of materials that will be generated in total, the mine site disposal areas could also accommodate disposal of waste from the airstrip or conversely the airstrip disposal area could be used as a repository for waste from the mine sites.

TABLE 4.13-1
POTENTIAL QUANTITIES OF MATERIALS FROM EL BONANZA THAT MAY REQUIRE DISPOSAL

Material	Volume (m^3)	Location
DDT impacted wood	2	Bunkhouse and Warehouse
Metal impacted soil (Note that the mine site area of impact may be greater than shown below)	0*	
Dump Area 2 is 45 m^2 (source of elevated metals is consistent with native soils or mine rock having elevated metal concentrations)	*15**	Approximately 5 m from marsh area adjacent Silver Lake
Powerhouse 60 m^2 (source of elevated metals is consistent with mine rock or native soils with background concentrations above the CCME criteria)	*18**	Approximately 8 m from marsh area adjacent Silver Lake
Kitchen (Bldg.9) - 70 m^2 (source of elevated metals is consistent with native soils having naturally occuring elevated metals)	*20**	Approximately 10 m from Silver Lake
Headframe - 50 m^2 (mine rock is the source of sampled material)	*15**	Approximately 15 m from Silver Lake
Airstrip - 100 m^2 (source of elevated metals likely due to native soil having elevated metal parameter concentrations)	*50**	Over 100 m from the Great Bear Lake
PHC impacted soils	445**	
Airstrip Tanks and drums - F2 and F3	*30***	Over 100 m from the Great Bear Lake
Headframe and Shop - F2 to F4	*15***	Approximately 15 m from Silver Lake
Powerhouse Area - F2 to F4	*40*	Approximately 8 m from marsh area adjacent Silver Lake
Bunkhouse and Fuel Shed - F1 to F4 (F1 fraction is mainly at the shed with a small amount at the Bunkhouse on the order of 20% of the volume however this needs better definition to confirm)	*300***	Less than 5 m from Mile Lake
Dump #2, #3 - F2 to F4	*60***	Approximately 5 m from marsh area adjacent Silver Lake
PCB impacted soils (see Note 1)	0.1	Approximately 8 m from marsh area adjacent Silver Lake
ACM debris (0.5 m^3 of actual material bulking factor applied)	1	
Wood debris (landfill volume assumes bulking factor of 2)		
Non-lead impacted (assume no burning)	290	
Non-lead impacted (assume burning 5% residual)	14.5	
Lead impacted (can not burn)	0	
General Debris (includes material from dumps and assumes a bulking factor of 2)	118	
Metal impacted with lead paint (assumes a bulking factor of 3)	7.5	
Diesel Fuel in Drums and Tanks	1025 L	No water issue anticipated in four of the fuel drums however the 200 L of product in the AST may have sufficient water that will require decanting prior to incineration. Lead was never used as an additive in diesel fuel (unlike gasoline) and as such it would not be anticipated that the diesel fuel would contain lead).
Oily Water in drums	820 L	

Maximum Volume of material to go into landfill	***853.5***
Minimum Volume of material to go into landfill	***143***

Notes:

* - denotes what we believe are elevated analytical results consistent with a site where the background concentrations for metal parameters are higher than the CCME criteria and should be anticipated at mine sites where minerals are being extracted from the earth. In some instances the elevated metal concentrations are also related to the fact that mine rock was sampled and analysed and as such it is not surprising that these samples would report elevated metal concentrations. We are of the opinion that the issues with metal impacted soils can be mitigated as outlined in the Risk Assessment for the site.

** - denotes that under the Risk Assessment the PHC impacted soils can be excavated and placed into the site landfill or can remain in-situ and a clean fill cover placed overtop to mitigate the exposure risks. Volume not inlcuded in the minimum volume of material to be placed in landfill.

1 - The transformer on site will have to be drummed and shipped off site as hazardous waste unless the contents are swiped clean and the rags and liquid shipped as hazardous material and the transformer box can go to the on-site landfill otherwise the entire transformer box needs to be shipped off site.

2 - two overpacks will be required on site; one to deal with a leaking drum of diesel fuel and the second for a drum of carbide at Mile Lake

TABLE 4.13-2
POTENTIAL QUANTITIES OF MATERIALS FROM BONANZA THAT MAY REQUIRE DISPOSAL

Material	Volume (m^3)	Location
DDT impacted wood	0	
Metal impacted soil	0*	
Dump Area 1 is 40 m^2 and Dump Area 2 is 100 m^2 (source of elevated metals is consistent with native soils having elevated metal concentrations)	*42**	More than 100 m from nearest Lake
Cabin #1 - 30 m^2 and #2 - 5 m^2 (native soils with elevated mineral concentrations consistent with a mine site)	*17.5**	More than 100 m from nearest Lake
PHC impacted soils	6**	
Hoist House - 1 cu.m. of F3 impact	*1*	More than 100 m from nearest Lake
Building 1 - 5 cu.m. of F2 to F4	*5*	More than 100 m from nearest Lake
ACM debris	0	
Wood debris (landfill volume assumes bulking factor of 2)		
Non-lead impacted (assume no burning)	160	
Non-lead impacted (assume burning 5% residual)	5	
Lead impacted (can not burn)	0	
General Debris (includes material from dumps and assumes a bulking factor of 2)	84	
Metal impacted with lead paint (assumes a bulking factor of 3)	0.5	

Maximum Volume of material to go into landfill	***250.5***

Minimum Volume of material to go into landfill	***89.5***

Notes:

* - denotes what we believe are elevated analytical results consistent with a site where the background concentrations for metal parameters are higher than the CCME criteria and should be anticipated at mine sites where minerals are being extracted from the earth. In some instances the elevated metal concentrations are also related to the fact that mine rock was sampled and analysed and as such it is not surprising that these samples would report elevated metal concentrations. We are of the opinion that the issues with metal impacted soils can be mitigated as outlined in the Risk Assessment for the site.

** - denotes that under the Risk Assessment the PHC impacted soils can be excavated and placed into the site landfill or can remain in-situ and a clean fill cover placed overtop to mitigate the exposure risks. Volume not included in minimum volume estimate for material to be placed in landfill.

5.0 ECOLOGICAL AND HUMAN HEALTH RISKS

A site-specific ecological and human health risk assessment was carried out in 2006 to assess the potential of the El Bonanza Mine site to have any adverse effects on the local environment. The assessment included consideration of potential risks associated of chemical exposures to people and wildlife that may use the site (SENES 2007b). Both the ecological and human health assessments were based, for the most part, on site-specific information including measured contaminated levels in flora and fauna, soils, sediments and water both on-site and in the surrounding environment. For the human exposure assessment, assumptions were made, on a conservative basis, about the potential hypothetical exposure pathways associated with visits to the site for 200 h per year since the site is remote from any community. The results and conclusions of that study are presented herein.

In carrying out the human health and ecological risk assessment, the general guidance of the Canadian Council of the Ministers of the Environment (CCME 1996) was followed. Key elements of such assessments include:

- receptor characterization – identification of potential receptors and their pathways of exposure;
- exposure assessment – quantification of the amount of contact between the receptors and the contaminants of concern;
- hazard assessment – examination of the potential effects of each contaminant on each receptor; and,
- risk characterization – evaluation of the potential for adverse effects on the receptors using information determined in the exposure and hazard assessments.

To assess the risks to animals and people from exposure to chemical contaminants on the El Bonanza Mine site, exposure estimates were made for all potentially significant pathways including: ingestion of fish (assumed to be at same concentration as fish from Contact Lake), vegetation, water and/or game; and inadvertent ingestion of soils or sediments. Inhalation of dust was determined to be minor pathways of exposure and was not included. For these exposure estimates, maximum levels of measured chemical contaminants in soil, sediment, water, fish, terrestrial vegetation and animals were used in these calculations. Consideration was also given to natural background levels of the chemical contaminants of potential concern. Where site-specific information was not available, conservative transfer factors based on literature values were used to determine the concentrations of the contaminants of potential concern in aquatic plants, benthic invertebrates, berries, and terrestrial animals that were not harvested during the field investigations.

As per normal practice, contaminants present in water, soil/sediments, and food, were assumed to be entirely available for intake into the body (i.e. to be 100% bioavailable).

Ecological receptors were chosen to represent a wide range of exposure scenarios at the El Bonanza Mine site. Consideration was given to whether the receptors served as a food source in the food chain (i.e. hare, grouse/ptarmigan, moose, caribou, duck) and whether the receptors were potentially the most exposed species (i.e. hare and ducks).

Since there are no permanent residences within the immediate El Bonanza study area, the potential effects of site use were assessed for hypothetical human receptors (adult and child) that could spend a portion of the year (200 hr/year) at the site. Human receptor considerations included lifestyle characteristics such as: recreational habits (e.g. time spent hunting or fishing at or near the site); diet, especially local foods (e.g. fish, caribou, moose, hare, wild fowl); and, sources of drinking water while near the site. The dietary characteristics were gleaned from a survey on Dene and Metis communities (Receveur 1996).

It is noted that although the results of the risk assessment did not identify any significant risks with respect to human health and ecological species, closure and remedial actions are still necessary to meet best practice and INAC policy with respect to the remediation and closure of an abandoned mine site to minimize physical and chemical hazards; and stabilize and return the site to acceptable land use through the application of accepted engineering and site clean-up practices.

5.1 RISK ASSESSMENT APPROACH AND METHODOLOGY

In the first stage of the assessment, all available environmental data for the site were considered and used to identify constituents of potential concern (COPC) to be carried through the ecological and human health risk assessment. The COPC identified for the risk assessment included: antimony, arsenic, barium, cadmium, chromium, cobalt, copper, lead, manganese, molybdenum, nickel, selenium, silver, strontium, uranium (chemical toxicity), vanadium, zinc, and petroleum hydrocarbons (F2 and F3 fractions).

A pathways model was used to estimate exposure levels (intakes) to selected ecological receptors and people from COPC in the environment taking into consideration the location and dietary characteristics of the receptors. The modelling used measured data from the site, however, there were no measured data for berries, aquatic plants and benthic organisms and terrestrial animals, therefore, transfer factors were used to estimate concentrations in those environmental media. Exposure estimates were then compared to toxicological reference values to identify combinations of constituents and receptors that may experience potential adverse effects.

5.2 ECOLOGICAL RISK ASSESSMENT SUMMARY

The selection of the various ecological (aquatic and terrestrial) biota for inclusion in the ecological risk assessment (ERA) was based on scientific and community input with respect to species associated with the site. It should be noted that the ERA evaluates the effects on populations rather than individual species. For the aquatic environment, the species covered the entire food chain starting from aquatic plants and animals, through to fish. For the terrestrial environment the species considered ranged from small local mammals (e.g. hare) through to large broad ranging mammals (e.g. bear, caribou, moose), as well as waterfowl (e.g. ducks) and terrestrial birds (e.g. grouse/ptarmigan).

Exposure pathways included intake of COPC through the consumption of water, sediment, vegetation, soil or flesh at various stages of the food chain. Depending on the size of the home range for the species under consideration, the analysis was based on contaminant levels measured at specific locations on the site or on site-wide averages. The analysis also considered the length of time the various species would be present at the El Bonanza site.

The assessment of risks to ecological species was based on comparison of estimated intakes of metals from all pathways to toxicity benchmarks. The results of the 2006 ecological assessment for aquatic receptors highlighted that:

Silver Lake

- In general, sampling in the vicinity of the El Bonanza site found no risk of adverse effects to aquatic biota with the exception of copper in Silver Lake; and,
- Examination of the sediment data indicate that the exceedences of the sediment toxicity benchmarks in Silver Lake (copper and zinc) occurred in only the open (deep) water sample location (i.e. ELB-5-SL) and not at the near-shore locations, indicating that benthic organisms will not experience adverse effects since benthic activity generally occurs in the shallower water column, and is minimal in deeper water locations.

Mile Lake

- For Mile Lake, sediment samples were taken from one sample location near the mouth of Silver Lake. Thus, the exceedence of the PEL for zinc at this sampling location may be restricted spatially to this area. The HHERA recommended that additional sediment samples should be collected in Mile Lake to determine the spatial extent of the exceedence and to determine whether the elevated zinc levels are simply due to natural mineralization. Based on this recommendation, additional sediment samples were collected from Mile Lake during the 2007 supplementary site assessment program. The results of the 2007 program indicated that the very high zinc concentrations, in excess of the PEL value, are localized to one area occurring in the vicinity of the mine site. By comparison, zinc concentrations measured in the offshore area were lower and below the PEL although higher than the ISQG.

East Arm of Echo Bay, Great Bear Lake

- The sediment samples in Great Bear Lake were collected at two locations in the beach area at the end of the airstrip, which found nickel levels above the PEL value only. Thus this exceedence of the sediment toxicity benchmark is unlikely to result in adverse effects in benthic communities since this is a relatively small area (limited spatially) and the substrate is sandy and unlikely to support benthic organisms.

Based on the findings of the 2006 ecological assessment, additional water and sediment samples were collected in 2007. The analytical results of the 2007 water samples found that the concentrations of metals in the water column in Silver Lake and Mile Lake were lower than 2006 and confirmed the conservative results of the risk assessment. The sediment quality data from the 2007 survey at the El Bonanza site indicated that the highest measured levels of several metals (e.g. arsenic, cadmium, copper, lead, molybdenum, nickel, selenium, vanadium and zinc) were reported on stations located near the centre of Silver Lake (i.e. ELB-5-SL and ELB-6-SL) where the water depth is over 10 m. Much lower metal levels were measured on samples collected from shallow water near the waste rock pile that extends into the lake (ELB-7-SL) and at the outlet of the lake (ELB-8-SL). No exceedences of sediment quality benchmark values were reported on samples collected at either of these shallow stations. These data suggest that sediment quality in the littoral zone (shallow nearshore water), where benthic activity is greatest, is not impaired.

Petroleum hydrocarbon analyses showed that most of the CCME fractions analyzed were below the reported method detection limits. Only the F3 fraction was found at measurable levels. There are no sediment quality guidelines against which the measured levels can be compared. However, it is noted that the measured F3 fraction concentrations, with one exception, are below the CCME guideline of 400 µg/g dw for soil invertebrates. Based on SENES' experience on other similar assessments, it is believed that the hydrocarbon levels measured in the sediments of Silver Lake and Mile Lake do not pose a risk to benthic communities. The results of the 2007 sediment analyses indicate that follow up sediment quality sampling or benthic community survey work is not justified on either Silver Lake or Mile Lake.

The assessment of exposure to terrestrial wildlife indicated that there are no risks of adverse effects for large terrestrial animals and waterfowl at the El Bonanza site. The risk assessment found a marginal exceedence (1.4 vs. 1) of the lowest effect toxicity reference value for the grouse/ptarmigan based on zinc exposure. Given that in keeping with the methodology for carrying out a risk assessment it was assumed that the grouse/ptarmigan spent all of its time on the area represented by the reasonable maximum soil and vegetation concentration, the calculations ensure an exposure that is overestimated. In reality, the grouse/ptarmigan moves around the site area and would generally be exposed to the average concentration rather than the reasonable maximum. Thus, exposures would be much lower since the soil zinc concentrations would be 1,217 vs. 6,778 mg/kg and the vegetation concentrations would be 162 vs. 479 mg/kg. Using these exposures would result in a screening index value below 1. Thus, while the risk assessment demonstrated an increased risk of an adverse effect using the very conservative assumptions and maximal sample values, it is unlikely that any effects on populations of grouse/ptarmigan would actually be observed at the site under actual existing conditions.

5.3 HUMAN HEALTH RISK ASSESSMENT

Exposure pathways considered in the analysis for the campers included drinking water and eating fish from Silver Lake and Mile Lake or Great Bear Lake (depending on the camper location); eating berries from across the site, eating hare exposed to soils and vegetation with elevated COPC levels from near Silver Lake and Mile Lake; eating ducks exposed to COPC in the Silver Lake and Mile Lake or Great Bear Lake (depending on the camper location); and, eating larger animals (caribou and moose) that traverse the site as part of their range, and forage and drink from various areas across the site. With the exception of caribou, duck and moose, the HHRA was based on measured contaminant levels in food and water sources. As noted above, no fish were collected at the site and therefore it was assumed that fish caught at the Contact Lake Mine were representative of fish at the El Bonanza site. To facilitate the human health risk assessment (HHRA), a simple pathways model was used to predict COPC levels in caribou, duck and moose flesh. The scenario also considered the campers taking food back to their communities for consumption over a six-month period.

The HHRA results show that:

- For the hypothetical El Bonanza Mine camper exposure scenario, the predicted metal intakes were below the acceptable intake levels for all non-carcinogenic COPC; and,
- Risk levels associated with the carcinogenic properties of arsenic were below risk levels from background exposure. In addition, cadmium and chromium were assessed as carcinogens via the inhalation pathway and were considered to represent an insignificant risk.

In summary, the presence of COPC at the El Bonanza Mine site are not a cause for concern under the exposure scenarios described above for campers or fishermen, or others, who might occasionally visit the site.

5.4 OVERALL CONCLUSION

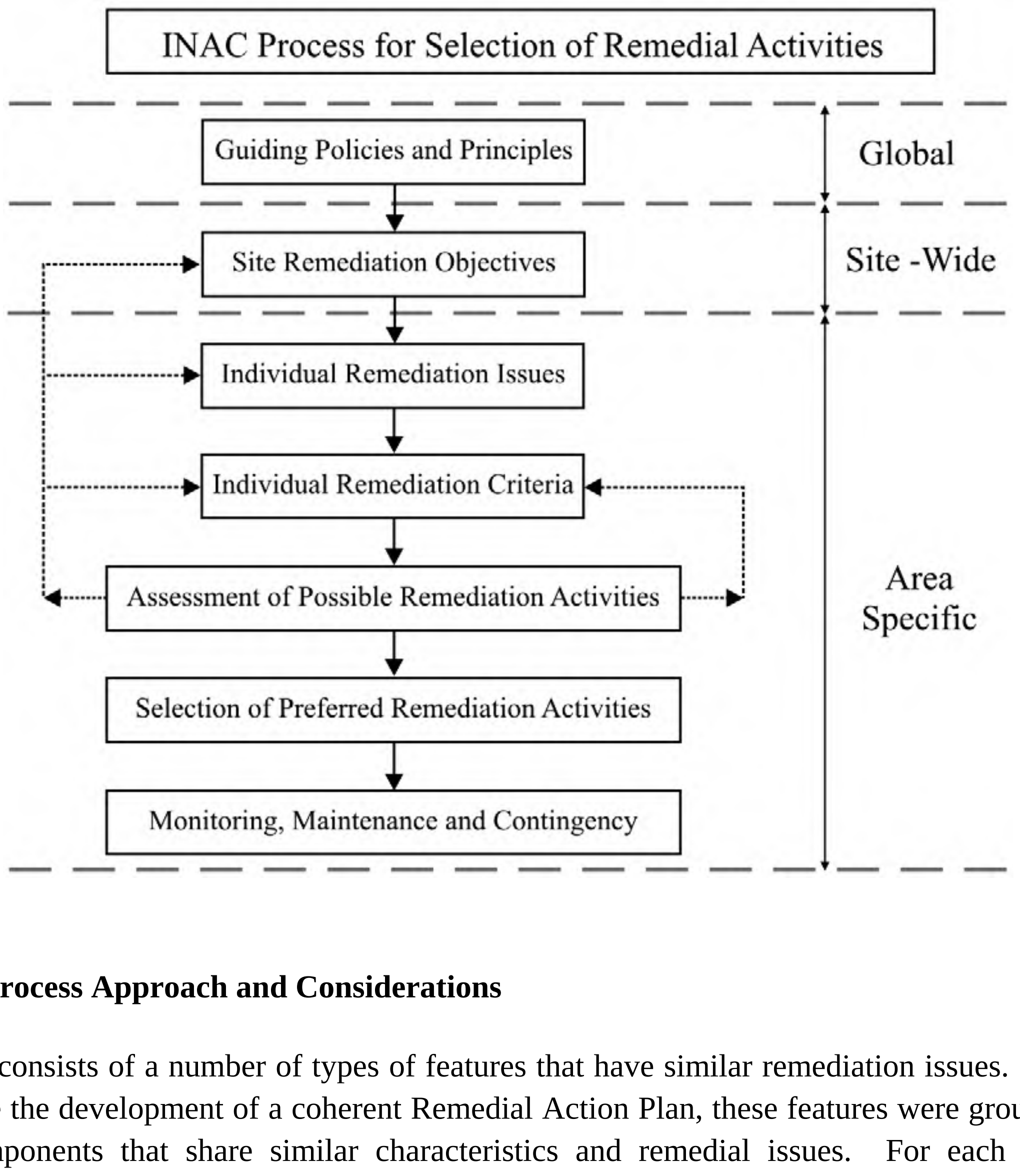
The results of the overall assessment indicate that individuals who might visit the El Bonanza Mine site on a short-term basis, even if taking home locally collected food for subsequent consumption, would not experience any adverse health effects. From an ecological perspective, the risk assessment shows that the site poses no risk of adverse effects to large animals such as bear, moose, and caribou and only a minimal potential risk of adverse effects on individual small local species (grouse/ptarmigan), but no adverse effects on populations.

6.0 PROPOSED REMEDIAL ACTION PLAN

6.1 PROCESS FOR SELECTION OF REMEDIATION ACTIVITIES

The general INAC approach to remediation is illustrated in Figure 6.1-1 below. The specific process components carried out for the El Bonanza Mine site and its development of remediation activities is provided in the following discussion.

FIGURE 6.1-1
INAC'S APPROACH TO REMEDIATION



6.1.1 Process Approach and Considerations

The site consists of a number of types of features that have similar remediation issues. In order to enable the development of a coherent Remedial Action Plan, these features were grouped into like components that share similar characteristics and remedial issues. For each of these components, *remedial issues and concerns* were identified based on input from field studies, human health and ecological risk assessments, as well as concerns identified by Aboriginal communities. Potential *remedial actions* were identified that can be used to address the outstanding remediation issues. These remedial actions were assessed with respect to the ability to fulfill the overall framework and site-specific remedial objectives. The preferred remedial action was then selected as most appropriate. In some cases, the preferred remediation option is indicated as tentative because additional research or design build are required (e.g. hydrocarbon remediation). Community consultation will be conducted following the determination of the most appropriate remediation option and/or following the design build proposal by the construction contractor. The remedial option will then be finalized in the specifications or during the remediation.

A list of *possible remediation options* was developed for each individual component of the site. The remediation options are essentially the work that is required to address the issues associated with that component. From the initial list of all possible options, some were determined 'Not Acceptable (NA)' because they do not meet the remediation goals. Some options were determined to be 'Acceptable (A)' and at least one option was determined to be 'Preferred (P)'. Ultimately, one set of *preferred remediation options* resulted from an alignment of reviews by First Nations, Federal Government and technical/engineering groups. Preferred remediation options were produced for each component of the site that, when combined, form the site Remedial Action Plan. Possible and preferred remediation options for each component of the site are discussed in the following sections of this report. Refer to Appendices A and B for community preferred options.

Monitoring, maintenance and contingency plans are necessary to: 1) monitor for possible impacts and quality control while the remediation work is underway (*monitoring activities*), 2) to ensure health and safety of workers during remediation (*health and safety monitoring*), 3) monitor the effectiveness of the work that was done after its completion *(performance monitoring*), 4) ensure that any required maintenance work is done to keep the remediation work up to specifications (*maintenance activities*), and 5) make sure that backup plans are ready in case something unexpected takes place (*contingency plan*).

6.1.2 General Objectives and Considerations

In general, the objective for any mine closure strategy is to assure:

- The protection of human health;
- Minimization of environmental effects; and,
- Restoration of the land to pre-mine conditions or a suitable alternative land use.

The El Bonanza Mine site is situated in a remote location where the key long-term issues for the site include assurance that:

- The site is safe from physical hazards (mine openings);
- The site is physically stable (waste rock is not exposed to wind and water erosion); and,
- The site is not causing material environmental damage.

To address these issues, the following technical reclamation guidance was considered appropriate for the remediation of the El Bonanza Mine site.

Physical Stability and Health and Safety

- Ensure all surface openings are sealed to industry/engineering standards (e.g. Ontario Mine Reclamation Code, or an acceptable alternative cap);
- Ensure crown pillars are stable or implement a suitable remedial action plan (fencing, backfill, monitoring etc.); and,
- Minimize physical risks associated with physical hazards.

Environmental Effects

- Meet receiving water quality criteria in Mile Lake, Silver Lake and Great Bear Lake;
- Keep environmental effects as low as reasonably achievable (ALARA); and,
- Manage soils contaminated with hydrocarbons based on good practice and the results of a site-specific risk assessment.

Land Use

- Allow natural use of the land.

Note that if any “Species at Risk”, as identified in Section 4.8, that are potentially present in the Great Bear Lake area are encountered during the remediation of the site, care will be taken to avoid disturbance of the species. The land use permit issued by the Sahtu Land and Water Board will outline monitoring and mitigation measures required if a Species at Risk is encountered. These measures will be followed during the remediation of the site.

6.1.3 Remedial Components and Features

As described in earlier sections, the El Bonanza Mine is comprised of three general site areas: the El Bonanza Mine site proper on Silver Lake and Mile Lake; the Bonanza headframe and cabins on Whale Lake; and, the Airstrip and Fuel Storage area on Great Bear Lake.

From an overview perspective, the main features considered within the Remedial Action Plan include the:

- Mine Openings;
- Buildings and Infrastructure;
- Waste Rock;
- Waste Disposal Areas;
- Fuel Storage Tanks;
- Contaminated Soils;
- Miscellaneous Debris; and,
- Roadways and Culverts.

6.1.4 Review of Remedial Issues and Options

The current NWT Mine Site Reclamation Guidelines (INAC 2006b) provide a good overview of the potential reclamation requirements and provided the basis for selecting potential remedial options for the El Bonanza Mine. Based on the findings of the site and risk assessment studies, the remedial issues and potential options are summarized on Table 6.1-1.

For many of the facilities listed in the previous section, the closure issues are clearly identified and there are few credible options. For these facilities, a short list of options is presented and a closure strategy is recommended.

For other facilities, there may be several credible options. For example, petroleum hydrocarbon contaminated soils could be covered in place with soil or waste rock, or the soil could be bioremediated on site and the disturbed area reclaimed.

The closure options considered vary by facility, but generally include the following options:

Leave As Is - The no action option is typically included for all facilities and may be adopted where:

- Facilities are stable and do not represent a physical or ecological hazard;
- Area has been, or is being, naturally reclaimed by native vegetation; and,
- The facility has historic or archaeological value.

Demolition and Site Restoration - This option would include the removal and management of all hazardous material (e.g. asbestos), recycling of saleable assets, dismantling of the building with disposal of refuse in an onsite landfill, and reclamation of the disturbed area. This includes: breaking up and/or removal of concrete foundation walls and piers, application of soil cover as necessary and possible vegetation of the disturbed area with native species.

Burn and Site Restoration - This option would include the removal and management of all hazardous material (e.g. asbestos), recycling of saleable assets, controlled burning of the building with disposal of refuse in an onsite landfill, and reclamation of the disturbed area. This includes: breaking up and/or removal of concrete foundation walls and piers, application of soil cover as necessary and possible vegetation of the disturbed area with native species. Burning is often suggested to reduce the quantity of waste requiring onsite landfilling.

Fencing - Fencing is often used to reduce hazards to people and animals. Fencing requires long-term care and maintenance, and is typically only considered as an interim measure or in cases where no credible remedial alternative is available (note that in some instances rock berms are created to act as warning barriers to open pits). Fencing is an option not normally favoured by the Aboriginal communities as it intrudes on land use and presents potential risks to terrestrial species.

Backfilling - Backfilling of shafts, adits, trenches, pits and stopes is a common practice to reduce physical hazards. Mine waste is often a candidate backfill material, which is used to reduce the footprint of the surface waste disposal area.

Relocation or Excavation - Wastes are often relocated when the existing disposal area is not suitable or there are several waste areas, which could be consolidated into one, or more, larger areas. A key premise to the closure options is that there will be an onsite landfill available for disposal of contaminated soils, demolition debris, miscellaneous refuse, and selected designated substances/materials (e.g. properly bagged asbestos waste). As an alternative, some or all of these materials could be removed to offsite disposal areas. In some cases, required wastes need to be shipped offsite to an approved disposal facility (e.g. PCB liquids).

Designed disposal areas are a common sense and economically viable consideration. Issues to be considered include proper location, long-term stability, and final cover and vegetation where appropriate.

Dry Cover - Dry covers are applied to many facilities for a variety of reasons. These covers may be simple barriers to intrusion, low permeability covers to reduce infiltration, covers to control acid generation, covers to reduce surface gamma radiation fields or covers to support vegetation. Cover materials may include local borrow, imported clays and synthetic materials and mine waste rock. The selection of the cover material would depend upon the requirements for the cover and the availability of local borrow sources.

Wet Cover - Wet covers are often used to prevent dusting and acid generation.

Concrete Capping and Bulkheads - Various designs of cast-in-place, or pre-cast concrete plugs and caps are used to prevent access to mine workings. The selection of the preferred method would be a function of the characteristics of the opening (depth to bedrock, accessibility, size, availability of materials, etc.).

Bioremediation - Bioremediation refers to the onsite use of biological degradation to treat contaminated soils (typically hydrocarbon contamination) at the site prior to onsite disposal.

TABLE 6.1-1
REVIEW OF REMEDIAL ISSUES AND OPTIONS FOR EL BONANZA MINE SITE

El Bonanza, NT: Closures Issues and Options Review

The El Bonanza and Bonanza Mine sites include an airport, camp facilities, and ancillary support buildings. The site has been well characterized and both human health and ecological risks have been assessed. The work has shown that there are physical hazards at the site and some residual fuels and chemicals that will need to be managed. The site also has some contaminated soils and waste that exceed CCME soil quality guidelines. The risk assessment concluded that there are no risks to terrestrial animals or waterfowl and minimal risks to aquatic biota. Based upon the risk assessment, there is little work required to protect the environment and as such the focus of any remedial measure would be to control physical hazards and adopt good practice for reclamation of the site. The current NWT Reclamation Guidelines provide a good overview of the potential reclamation requirements. The following Table identifies all facilities of potential concern at the site and addresses potential issues and identifies a list of potential reclamation options that could be considered.

COMPONENTS/FEATURES	SUB-COMPONENT/ISSUE	REMEDIATION METHODS	COMMENTS
Mine Openings			
El Bonanza No. 1 Shaft - Uncollared shaft, partially covered at the upper edge of steep cliff.	2.4 x 1.8 m opening situated on side of a cliff; potential falling hazard; inadvertent access to the area is improbable.	1) Leave as is (see note 1); 2) backfill with waste or local borrow; 3) provide engineered cap (see note 3); or 4) fence opening (see note 4).	Site access difficult for capping or fill placement. Due to location fencing may be only practical solution (Option 4).
El Bonanza No. 2 Shaft - Wooden collared open shaft in headframe, partially plank covered.	3.8 x 1.8 m opening located on the main mine site in the headframe building; water and ice at about 3 m from surface; potential falling and drowning hazard.	1) Leave as is; 2) backfill with waste or local borrow; 3) provide engineered cap; or 4) fence opening.	Site access is good. Good practice would be to provide engineered cap (Option 3).
El Bonanza No. 3 Shaft - Exposed collared timbered shaft in rock outcrop.	2.7 x 1.5 m opening located on an accessible hillside 50 m north of the main mine site. This is a shallow excavation with solid ice plug at a depth of 1.5 m.	1) Leave as is; 2) backfill with waste or local borrow; 3) provide engineered cap; or 4) fence opening.	Site access is good. Good practice would be to provide engineered cap (Option 3).
El Bonanza No. 1 Adit - Uncollared and open adit at base of cliff. Adit connects with vent raise from No. 1 Shaft at about 6 m in.	1.8 x 1.5 m opening located immediately below No. 1 Shaft with access from ground level. Adit only enters cliff for about 6 m before being partially filled with loose broken rock. Falling rock and potential falling hazard (into No. 1 Shaft).	1) Leave as is; 2) backfill with waste or local borrow; 3) provide concrete bulkhead; or 4) fence opening.	Site access is good. Good practice would be to backfill the adit (Option 2).
Bonanza Shaft - Timber lined exposed shaft open to weather and cribbing and framework in advanced state of decay.	1.2 x 2.4 m timber lined shaft, headframe in place but shaft open to weather and is not currently capped. Shaft is partially filled with water and frozen underneath surface. Potential exists for someone to fall into shaft and drown.	1) Leave as is; 2) backfill with waste or local borrow; 3) provide engineered cap; or 4) fence opening.	Site access is good. Good practice would be to provide engineered cap (Option 3).
Trenches: El Bonanza & Bonanza. Small Test Pits: El Bonanza.	Shallow surface trenches <1 m deep and from 3 to 10 m in length are located at both El Bonanza and Bonanza. Several test pits in rock ridge at El Bonanza, ranging from 1.5 x 2.7 m to 3 x 5 m. Minor falling hazard associated with these elements.	1) Leave as is; 2) backfill with waste or local borrow; or 3) fence opening.	Good practice would be to leave as is (Option 1) or backfill where potential falling hazard exists (Option 2).
Buildings and Infrastructure			
El Bonanza - Existing Building 1 – Dry - 3.6 x 5.5 x 2.5 m.	Timber and log construction with tarpaper roofing.	1) Leave as is; 2) remove contents, burn building and reclaim footprint; or 3) remove contents, demolish building and dispose in landfill (see note 7) and reclaim footprint (see note 2).	Good practice would be to adopt Option 2 or 3.
El Bonanza - Existing Building 2 – Headframe - 6.2 x 7.6 x 6.7 m.	Timber and log construction with tarpaper roofing.	1) Leave as is; 2) remove contents, burn building and reclaim footprint; or 3) remove contents, demolish building and dispose in landfill (see note 7) and reclaim footprint.	Good practice would be to adopt Option 2 or 3.
El Bonanza - Existing Building 2A – Shop - 6.2 x 7.6 x 6.7 m.	Timber and log construction with tarpaper roofing.	1) Leave as is; 2) remove contents, burn building and reclaim footprint; or 3) remove contents, demolish building and dispose in landfill (see note 7) and reclaim footprint.	Good practice would be to adopt Option 2 or 3.
El Bonanza - Existing Building 3 – Use unknown - 2.7 x 2.7 x 2.4 m.	Wood frame with aluminum siding. Particle board interior walls.	1) Leave as is; 2) remove contents, siding to landfill, burn building and reclaim footprint; or 3) remove contents, demolish building and dispose in landfill (see note 7) and reclaim footprint.	Good practice would be to adopt Option 2 or 3.
El Bonanza - Existing Building 4 – Outhouse on its side – 1.2 x 1.2 x 2.1 m.	Wood frame with plywood siding and roof lying on its side in sand at toe of slope.	1) Leave as is; 2) remove contents, burn building and reclaim footprint; or 3) remove contents, demolish building and dispose in landfill (see note 7) and reclaim footprint.	Good practice would be to adopt Option 2 or 3.

TABLE 6.1-1 (CONT'D)
REVIEW OF REMEDIAL ISSUES AND OPTIONS FOR EL BONANZA MINE SITE

COMPONENT	SUB-COMPONENT/ISSUE	REMEDIATION METHODS	COMMENTS
Buildings and Infrastructure (cont'd)			
El Bonanza - Former Building 5 – Use unknown - 4.5 x 3 m.	Wood frame and floor on steel skid. Building demolished.	1) Leave as is; or 2) remove flooring and frame to landfill (see note 7), burn wood framing and sections.	Good practice would be to adopt Option 2.
El Bonanza - Residual elements from former Building 6 - Powerhouse – 4 x 8 m (not standing, remainder on ground).	Demolished wood frame building. Tarpaper roofing and siding (on ground beside destroyed structure).	1) Leave as is; 2) remove debris and scrap from rubble and burn wooden components; or 3) dispose of old roofing and rubbish to landfill (see note 7) and reclaim footprint.	Good practice would be to adopt Option 2 or 3.
El Bonanza - Existing Building 7 – Warehouse – 6 x 10 x 2.2 m.	Wood frame, siding, roofing and flooring. Insulation paper on exterior and interior. Tarpaper roofing. Oil furnace.	1) Leave as is; 2) remove contents, burn building and reclaim footprint; or 3) remove contents, demolish building and dispose in landfill (see note 7) and reclaim footprint.	Good practice would be to adopt Option 2 or 3.
El Bonanza - Existing Building 8 – Radio shack - 1.6 x 1.3 x 2 m.	Wood frame with wood exterior, floor and roof. Tarpaper roofing. Interior drywall walls.	1) Leave as is; 2) remove contents, burn building and reclaim footprint; or 3) remove contents, demolish building and dispose in landfill (see note 7) and reclaim footprint.	Good practice would be to adopt Option 2 or 3.
El Bonanza - Former Building 9 – Kitchen and office footprint - 8 x 5 m.	Building burned down.	1) Leave as is; or 2) remove residual base materials and debris to landfill (see note 7).	Good practice would be to adopt Option 2.
El Bonanza - Former Building 10 – Core shack – 4 x 4 m.	Building gone. Only floor remains, consisting of wood with tarpaper covering.	1) Leave as is; or 2) remove residual base materials and debris to landfill (see note 7).	Good practice would be to adopt Option 2.
El Bonanza - Former Building 11 – Use unknown - 1.5 x 2.4 x 2.1 m.	Wood frame with tarpaper roofing.	1) Leave as is; 2) remove contents, burn building and reclaim footprint; or 3) remove contents, demolish building and dispose in landfill (see note 7) and reclaim footprint.	Good practice would be to adopt Option 2 or 3.
El Bonanza - Former Building 12 – Core storage – 5 x 5 m.	Wood frame and wood floor is all that remains.	1) Leave as is; or 2) burn wood frame and flooring and dispose of cores and debris to landfill (see note 7).	Good practice would be to adopt Option 2.
El Bonanza - Existing Building 13 – Bunkhouse – 5 x 10 x 2.4 m.	Wood frame with plywood walls, floor and roof. Red tarpaper on roof.	1) Leave as is; 2) remove contents, burn building and reclaim footprint; or 3) remove contents, demolish building and dispose in landfill (see note 7) and reclaim footprint.	Good practice would be to adopt Option 2 or 3.
El Bonanza - Existing Building 14 – Shed for fuel storage - 1.5 x 2.7 x 1.8 m.	Wood frame with plywood walls and roof.	1) Leave as is; 2) remove contents, burn building and reclaim footprint; or 3) remove contents, demolish building and dispose in landfill (see note 7) and reclaim footprint.	Good practice would be to adopt Option 2 or 3.
Bonanza - Existing Cabin 1 – Cabin formerly used as living quarters – 7.3 x 4.2 x 3 m.	Log cabin with board and tarpaper roofing. Wood floor. Moss and mud chinking.	1) Leave as is; 2) remove contents, burn building and reclaim footprint; or 3) remove contents, demolish building and dispose in landfill (see note 7) and reclaim footprint.	Good practice would be to adopt Option 2 or 3.
Bonanza - Former Cabin 2 – Living quarters - 1.8 x 2.4 m.	Log cabin. Burned down.	1) Leave as is; or 2) remove foundation and debris to landfill (see note 7).	Good practice would be to adopt Option 2.
Bonanza - Former Building 1 – Likely Blacksmith shop - 5 x 15 m.	Timber structure with tarpaper roof. Ten drums with hydrocarbon odour in soil sample. Scattered debris.	1) Leave as is; 2) remove contents, burn building and reclaim footprint; or 3) remove contents, demolish building and dispose in landfill (see note 7) and reclaim footprint.	Good practice would be to adopt Option 2 or 3.
Bonanza - Existing Headframe – 4.0 x 8.8 x 6.7 m.	Timber and wood building. Earth floor.	1) Leave as is; 2) remove contents and burn headframe and building and reclaim footprint; or 3) remove contents, demolish headframe and dispose in landfill (see note 7) and reclaim footprint.	Good practice would be to adopt Option 2 or 3 unless there was a desire to retain the headframe as an historic artifact.
Waste Rock Disposal Areas			
El Bonanza - Adit/No. 1 Shaft Waste Rock Pile - adjacent to the side of the cliff, from development of Adit and No. 1 Shaft, two distinct separate areas totalling ~1,500 m^3.	Limited erosion. Existing slopes appear stable. Non-acid generating. Minimal metals leaching with background gamma fields. As expected, mine rock exceeds CCME soil guidelines for metals.	1) Leave as is; or 2) reslope, apply soil cover and vegetate.	Waste is unlikely to be acid generating and did not leach elevated levels of metals in simple leach tests, and gamma fields were at background. Either Option 1 or 2 would be considered good practice given that there are no significant environmental issues.

TABLE 6.1-1 (Cont'd)
REVIEW OF REMEDIAL ISSUES AND OPTIONS FOR EL BONANZA

COMPONENT	SUB-COMPONENT/ISSUE	REMEDIATION METHODS	COMMENTS
Waste Rock Disposal Areas (Cont'd)			
El Bonanza – No. 2 Shaft Waste Rock Pile - developed in association with shaft and underground exploration and extended out from shaft area across land and into Silver Lake ~1,500 m^3.	Limited erosion. Existing slopes appear stable. A portion of the waste rock pile extends into Silver Lake to a depth of approximately 1 m. Non-acid generating. Minimal metals leaching with background gamma fields.	1) Leave as is; or 2) reslope, apply soil cover and vegetate.	Waste is unlikely to be acid generating and did not leach elevated levels of metals in simple leach tests. Gamma fields were at background. Mine rock exceeds CCME soil guidelines for metals. Either Option 1 or 2 would be considered good practice given that there are no significant environmental issues.
Bonanza No. 1 Shaft Waste Rock Pile - primary waste rock pile located adjacent to headframe ~600 m^3, waste rock from local trenching adjacent to trenches.	Limited erosion. Existing slopes appear stable. Non-acid generating. Minimal metals leaching with background gamma fields.	1) Leave as is; or 2) reslope, apply soil cover and vegetate.	Waste is unlikely to be acid generating and did not leach elevated levels of metals in simple leach tests. Gamma fields were at background. Mine rock exceeds CCME soil guidelines for metals. Either Option 1 or 2 would be considered good practice given that are no significant environmental issues.
Waste Disposal Areas			
El Bonanza Area - Barrel Dump Area – 7.3 x 46 m.	This is the main flat sandy area of the site where drums are randomly spread either individually or in groups across the area. 36 drums in total; 9 drums with some product.	Remove product for appropriate disposal and crush drums and: 1) leave as is; 2) apply cover; 3) apply cover and vegetate; or 4) relocate to new disposal area (see note 5).	Good practice would be to adopt Option 3 or 4.
El Bonanza - Debris Dump #1 – 1.5 x 4.5 m.	Dump with cans, 2 drums, wood, glass and ash.	Remove product for appropriate disposal and crush drums and: 1) leave as is; 2) apply cover; 3) apply cover and vegetate; or 4) relocate to new disposal area.	Good practice would be to adopt Option 3 or 4.
El Bonanza - Debris Dump #2 – 9.1 x 4.5 m.	Mine cores, drums, stoves, rubber hoses, wood, drill equipment, and bulldozer.	Remove product for appropriate disposal and crush drums and: 1) leave as is; 2) apply cover; 3) apply cover and vegetate; or 4) relocate to new disposal area.	Good practice would be to adopt Option 3 or 4.
El Bonanza - Debris Dump #3 – 1.5 x 3 m.	Drums, pumps, motors, chain, rubber hoses and electrical cables.	Remove product for appropriate disposal and crush drums and 1) leave as is; 2) apply cover; 3) apply cover and vegetate; or 4) relocate to new disposal area.	Good practice would be to adopt Option 3 or 4.
Bonanza - Debris Dump #1 – 4 x 5 m.	1 drum, tin cans, water storage drums.	Remove product for appropriate disposal and crush drums: and 1) leave as is; 2) apply cover; 3) apply cover and vegetate; or 4) relocate to new disposal area.	Good practice would be to adopt Option 3 or 4.
Bonanza - Debris Dump #2 – 6 x 8 m.	2 empty drums, miscellaneous refuse.	Crush drum and remove debris for appropriate disposal and: 1) leave as is; 2) apply cover; 3) apply cover and vegetate; or 4) relocate to new disposal area.	Good practice would be to adopt Option 2 or 3.
El Bonanza and Bonanza - Miscellaneous refuse.	Trash, steel and miscellaneous refuse is located around the site surfaces and in water, particularly in Silver Lake.	Remove refuse from land and water including lakes and streams and dispose of in onsite landfill (see note 7) disposal area.	Good Practice.
Airstrip - Fuel Tanks			
	Two 100,000 L vertical above-ground storage tanks. Two 40,000 L cylindrical above-ground storage tanks lying on their sides. Assorted equipment and materials.	Remove tanks and assorted equipment and reclaim disturbed area.	Good Practice.
Airstrip – Equipment and Debris			
	A variety of mill equipment pieces (angle iron frames, conveyor frames, etc.) are at the airstrip as well as several empty 205 L drums, miscellaneous piping, and scrap caterpillar engine.	Remove debris and assorted equipment for disposal in landfill (see note 7).	Good Practice.
Contaminated Soils			
El Bonanza - Petroleum Hydrocarbons (PHCs).	Typically small areas with stained soils. There are elevated PHC levels near buildings 2, 2A, 6, 13 and 14, at the dump site location 2b and 3a and at the drum storage area samples D, E and drum L-1. Building 2A also contains hydrocarbons from fuel oils.	1) Leave as is; 2) excavate to new disposal area; 3) cover in place with soil; 4) cover in place with waste rock; or 5) bioremediate the soils on site (see note 6) and reclaim disturbed area.	Good practice would be to adopt Option 3, 4 or 5.

TABLE 6.1-1 (Cont'd)
REVIEW OF REMEDIAL ISSUES AND OPTIONS FOR EL BONANZA

COMPONENT	SUB-COMPONENT/ISSUE	REMEDIATION METHODS	COMMENTS
Contaminated Soils (cont'd)			
El Bonanza – Polychlorinated Biphenyls (PCBs).	A PCB exceedence was encountered in one sample taken from the area of the former powerhouse.	1) Leave as is; 2) excavate to new disposal area; 3) cover in place with soil; 4) cover in place with waste rock; or 5) bioremediate the soils on site (see note 6).	Good practice would be to adopt Option 2.
Bonanza - Petroleum Hydrocarbons (PHCs).	Small area at Building B1 and hoist house has elevated levels of PHCs.	1) Leave as is; 2) excavate to new disposal area; 3) cover in place with soil; 4) cover in place with waste rock; or 5) bioremediate the soils on site and reclaim disturbed area.	Good practice would be to adopt Option 3, 4 or 5.
El Bonanza – Metals.	Site wide - most areas contain one or more metals above CCME soil quality guidelines for residential/parkland land use. This would appear to be related to geology and use of mine rock as fill.	1) Leave as is; 2) excavate to new disposal area and reclaim disturbed area; 3) cover in place with soil and vegetate; or 4) cover in place with waste rock.	The metal contamination is not impacting the environment and as such Option 1 (leave as is) would be considered a good practice.
Bonanza - Metals.	Site wide - Most areas contain one or more metals above CCME soil quality guidelines for residential/parkland land use.	1) Leave as is; 2) excavate to new disposal area and reclaim disturbed area; 3) cover in place with soil and vegetate; or 4) cover in place with waste rock.	The metal contamination is not impacting the environment and as such Option 1 (leave as is) would be considered a good practice.
Airstrip – Metals.	Some areas contain one or more metals above CCME soil quality guidelines for parkland use. The metal contamination is not impacting the environment and as such Option 1 (leave as is) would be considered a good practice.	1) Leave as is; 2) excavate to new disposal area and reclaim disturbed area; 3) cover in place with soil and vegetate; or 4) cover in place with waste rock.	The metal contamination is not impacting the environment and as such Option 1 (leave as is) would be considered a good practice.
Roadways			
	Connecting Airstrip and El Bonanza and Bonanza Mines. Existing roads are overgrown in many areas.	1) Leave as is; or 2) scarify and vegetate.	The roadways represent minimal concern and are being overgrown by native vegetation. Good practice would be to leave the roads as is and allow natural vegetation of the disturbed road areas.
Culverts			
	Culverts exist at the inlet and outflow of Silver Lake. Debris is located in and around the culverts including both wood and logs in the culverts and steel drums in front of the outlet culvert.	1) Remove debris and leave as is; or 2) remove debris and culvert and create new channel.	Option 2 would be considered good practice.

NOTES:

1) Leave as Is - This option would be reasonable where there is no physical hazard. As a general rule, good practice is to dismantle structures and reclaim the site unless there is a heritage value in retaining the structure. For waste areas, standard practice is to vegetate the area however, in some cases allowing site to re-vegetate naturally is a reasonable alternative.
2) Reclaim footprint of disturbed area - The objective is to restore the area to pre-mine conditions where practical. This would typically involve general grading, soil application if required and vegetation with native plants.
3) There are several designs for concrete caps that can be implemented including cast-in-place caps or pre-cast concrete slabs. The choice will depend upon site conditions.
4) Fencing is generally not preferred for a permanent closure but could be adopted especially where alternative measures are not practicable.
5) Relocation of waste would be considered when the existing site is unsuitable for waste storage or when it is cost effective to consolidate the wastes.
6) Bioremediation should be considered when contaminant leaching and or ecological effects are projected and the material is suitable for bioremediation.
7) As an alternative to onsite disposal of site waste in a landfill to be constructed for closure, offsite disposal in Silver Bear landfill could be considered for any material to be landfilled.

6.2 OVERVIEW OF THE PROPOSED REMEDIATION PLAN

Based on the review of the site assessment program findings, the risk assessment, consideration of regulatory, engineering and precedent practice, as well as the community objectives/criteria and consultation meetings, the following summary of preferred remedial actions has been developed.

Detailed discussions of current site conditions were provided previously in Chapters 3 and 4. Section 6.1 and Table 6.1-1 above summarized the issues and concerns associated with each site component and presented the range of possible remedial options.

The following sections discuss the preferred remedial options as identified through the various consultations with aboriginal stakeholders. For additional information on the consultation process and the selection of the preferred options see Appendix A and B.

6.2.1 Mine Openings

The issues associated with the mine openings revolve around the potential physical hazards associated with deliberate entry into horizontal openings and the potential for falling risks associated with vertical openings. Various remedial measures that can be considered to mitigate these risks have been discussed in Section 6.1 and summarized by component in Table 6.1-1. The following remediation option was recommended and agreed to as the preferred option during the consultation process:

- ***adit*** **-** backfill the adit entrance with local waste rock;
- ***shafts*** **–** concrete cap the easily accessible vertical openings. Cap the No. 1 Shaft in a safe manner.

In regard to the preferred remedial approach for the adit, it is noted that local waste rock in front of the adit is easily accessible and can be placed in such a manner as to completely seal the adit opening.

In regard to the preferred remedial approach for the mine shafts it is noted that while access to the El Bonanza No. 2 and 3 shafts and the Bonanza mine shaft does not pose a problem, access to, and work at, the El Bonanza No.1 shaft, especially with heavy equipment, would be very difficult as the it is located at the edge of a cliff.

Given that No. 1 shaft is located on the edge of a cliff capping or sealing construction approaches that minimize the need for equipment travel up to the top of the hill will need to be considered in the final design. Examples of unique approaches that could be considered include rock bolting a prefabricated steel (or otherwise approved material) grid plate of appropriate dimensions in place over the opening. Subject to final selection and design, such a barrier could be installed manually with the use of appropriate equipment (e.g. hoisting tackle of helicopter sling). Another approach that may be considered is the sealing of the opening with a foam sealant plug that would be covered by sacrete to protect it from deterioration by sunlight. Such an approach would also prevent the falling hazard.

In the event that these approaches are deemed un-acceptable, either technically or for other reasons, fencing may be the only alternative

Note that there are several small test pits and trenches that pose minimal risk to the environment and hazard to human health. While no special measures are considered necessary to deal with either the pits or the trenches, if work on other aspects of the site brings equipment to the proximity of the pits they could likely be easily backfilled with the excavated materials adjacent to the pits.

6.2.2 Buildings and Infrastructure

The facilities still standing at the El Bonanza Mine site include 8 buildings and 1 shed, while 6 partially or completely demolished former buildings also remain exposed to various degrees. Buildings still standing on site include the dry, headframe and shop, outhouse, warehouse, radio shack, bunkhouse, fuel storage shed, and one building whose use is unknown. The kitchen and office building was burned down, while only the floor of the coreshack remains. The powerhouse, core storage, and two buildings whose past uses are unknown remain onsite in a demolished state. In addition, a headframe remains at the Bonanza Mine as well as a collapsed blacksmith shop and cabin area that have been removed from the mine site proper. The cabin area includes an existing log cabin and the remnants of a burned second cabin.

The issues associated with the El Bonanza and Bonanza buildings and infrastructure revolve around the potential physical hazards these features present in their current state and as they deteriorate further in the future. The various features and potential remedial measures to mitigate these risks have been discussed in Section 6.1 and summarized by component in Table 6.1-1. The following remediation option was recommended and agreed to as the preferred option during the consultation process:

- ***buildings*** – to demolish the buildings after removal of any designated substances (such as DDT impacted window sill, painted surfaces, etc.) and dispose of demolition debris/residue in an approved manner.

Building material and miscellaneous debris containing leachable lead paint greater than the TDGA criteria or PCB amended paint greater than CEPA criteria will be disposed of off-site as per applicable regulations. Asbestos will be double bagged as per current guidelines for disposal and disposed of in the non-hazardous waste landfill. Refrigeration units will be disposed of according to the applicable regulations (i.e. Federal Halocarbon Regulations). Disposal options for hazardous materials at the El Bonanza site may be re-evaluated in combination with nearby sites to determine if more suitable disposal options exist. If alternative disposal options are identified, additional community consultations will take place on this matter.

6.2.3 Waste Rock

Waste rock quantities at the El Bonanza and Bonanza Mine are limited in keeping with the nature and scale of past operations (exploration, minimal mining). At El Bonanza the waste rock is located in two piles (combined volume ~3,000 m^3), one adjacent to the No. 1 adit and the other adjacent to the No. 2 shaft. A portion of the second pile extends into Silver Lake to a depth of approximately 1 m. The waste rock pile at the Bonanza Mine (~ 600 m^3) is located immediately adjacent to the Bonanza shaft. The status and issues associated with the waste rock piles have been discussed in Section 6.1 and summarized in Table 6.1-1. As seen from the table, remedial issues are minor and related to elevated metal content. Waste rock in Silver Lake is not having a negative impact on water quality.

The following remediation option was recommended and agreed to as the preferred option during the consultation process:

- ***waste rock*** - leave the waste rock pile as is unless the rock is used for other purposes such sealing the adit opening.

Vegetation over flat waste rock areas could be enhanced with the addition of fertilizer and appropriate seeding.

6.2.4 Waste Disposal Areas

Three very small surface waste disposal sites remain at the El Bonanza Mine and two more at the Bonanza Mine. At El Bonanza, two of the dumps occur at the main mine site and the third along the access road southwest of the main mine site. Discarded food cans, scrap metal, rubber hoses, glass, wood stoves and drums are found in these dumps. At Bonanza, the two small dumps containing drums (used as wood stoves), tin cans, wood and glass occur in the vicinity of the cabins. In addition, a barrel dump area occurs at the El Bonanza Mine where 36 barrels are spread over the main sandy flat area of the site. Of the 36 barrels in the dump, 9 were found to contain some product. In addition to these areas, some waste debris can also be found at scattered locations around the mines and at the airstrip (see below). The estimated quantity of material at the dumps is provided on Tables 4.13-1 and 4.13-2.

The status and issues associated with waste disposal areas at El Bonanza and Bonanza have been summarized in Table 6.1-1. Based on the findings of the report and as summarized in the table, the dumps present very limited risks associated with physical hazards and minor metal and hydrocarbon contamination. Based on the consultation process the preferred remedial approach was as noted below:

- ***waste disposal areas*** - consolidate waste, debris and some contaminated soil found in the dump areas in a landfill in accordance with current waste disposal regulations.

6.2.5 Airstrip and Fuel Storage Tank Area

The El Bonanza Mine includes, in addition to the two mine sites areas, a short gravel and stone abandoned airstrip located approximately 1.5 km southwest of the El Bonanza Mine on the shore of Great Bear Lake. A number of fuel storage tanks also remain in this area including, two 100,000 L vertical above-ground storage tanks and two 40,000 L above-ground storage tanks lying on their sides.

The status and issues associated with this area have been summarized in Table 6.1-1. The issues associated with these features revolve around the potential risk associated with leakage of oily water. The following remediation option was recommended and agreed to as the preferred option during the consultation process:

- ***fuel storage tank*** **–** demolish and dispose of tank after removal and disposal of contents (in accordance with relevant guidelines);
- ***drums and miscellaneous debris*** **–** dispose of drum contents (in accordance with relevant guidelines) and pick up and dispose of drums and miscellaneous debris in a consolidated disposal area; and,
- ***metal contaminated soil*** **–** excavate metal contaminated soil and dispose of in a consolidated disposal area.

The tanks that have leachable lead paint will be disposed of according to TDGA regulations. The estimated quantities of materials for cleanup, demolition and disposal are provided on Tables 4.13-1 and 4.13-2.

6.2.6 PCB and Hydrocarbon Impacted Soils

A limited amount of PCB contaminated soil was found around a transformer at the powerhouse. The PCB contaminated soil will be disposed of according to regulations. The transformer itself will also be removed and disposed of in accordance with applicable regulations. As shown on Tables 4.13-1 and 4.13-2, limited areas and quantities of hydrocarbon impacted soils were identified near several buildings, one of the dumpsites and the drum storage area at El Bonanza and the airstrip.

The various locations and potential remedial issues and mitigation measures have been discussed in Section 6.1 and summarized by component in Table 6.1-1. Based on the consultation process the tentative preferred remedial approaches were identified to be consistent with the Contact Lake (and Silver Bear) approach, which considered:

- ***impacted soils*** **–** cover in place or move to onsite landfill or excavate and treat.

Site-specific clean-up criteria are currently being developed that will determine how PHC contaminated soils from each impacted area identified at the site will be handled. Consultation and regulatory approval are still pending on this issue.

6.2.7 Miscellaneous Debris

As with other abandoned mine sites, miscellaneous equipment and debris remain at the El Bonanza and Bonanza mine sites and in the water along the banks of Mile Lake, Silver Lake, and Great Bear Lake to various degrees. The issues associated with miscellaneous debris revolve around the potential physical hazards associated with stepping on or falling over these materials and potential fish habitat degradation. Materials noted included scrap metal in the form of equipment components and parts, piping and steel rods, drums and containers, miscellaneous metal fragments, and various mining and motorized equipment components. The quantities of these materials are small being in keeping with the limited size and nature of the former exploration and mining activities. The estimated quantities of these materials are as shown on Tables 4.13-1 and 4.13-2. The following remediation option was recommended and agreed to as the preferred option during the consultation process:

- ***miscellaneous debris*** - to collect and consolidate waste and debris in a landfill along with some contaminated soil and building debris.

The clean-up and disposal of miscellaneous debris will also include removal of debris from nearshore lake areas, especially Silver Lake.

6.2.8 Roadway and Culverts

Partially overgrown onsite roads connect the mine sites to Great Bear Lake and to each other. There are limited environmental issues associated with these roads. However, the two culverts that are located at the inlet and outlet of Silver Lake may present a potential obstruction to fish migration and DFO has recommended that these culverts be removed. The following remediation option was recommended and agreed to as the preferred option during the consultation process:

- ***onsite roads and culverts*** – after completion of the remedial works, remove any culverts and return drainage to natural conditions then leave the road as is for natural re-vegetation.

If roads are upgraded for use, they will be scarified in accordance with mining regulations (Ontario Regulation 240/00) and left for natural re-vegetation at completion of the remedial works. If additional culverts are found along former roads, they will be removed and plans for remediation will ensure proper stream channel design, fish passage (if required), and long-term stability of the stream beds and banks at each location. Wherever possible, fish habitat enhancement features will be incorporated into the remediation design.

6.2.9 Metal and PHC Impacted Sediments

The proposed Remedial Action Plan that has been developed for El Bonanza does not include remediation of lake sediments. Sediment quality data from the 2006 and 2007 surveys at the El Bonanza Mine site (SENES 2007a; 2007c) indicated that the highest measured levels of several metals (e.g. arsenic, cadmium, copper, lead, molybdenum, nickel, selenium, vanadium and zinc) were reported on stations located near the centre of Silver Lake (i.e. ELB-5-SL) where the water depth is over 10 m. Much lower metal levels were measured on samples collected from shallow water near the waste rock pile that extends into the lake (ELB-7-SL) and at the outlet of the lake (ELB-8-SL). Furthermore, no exceedences of benchmark values were reported on samples collected at either of these shallow water stations. A few guideline values were exceeded at the shallow station ELB-6-SL, which is located adjacent to the inflow from Mile Lake, but the metal concentrations were generally much lower than at the deep water station. These data suggest that sediment quality in the littoral zone (shallow near shore water), where benthic activity is greatest, is not impaired.

Petroleum hydrocarbon analyses showed that most of the CCME fractions analyzed were below the reported method detection limits. Only the F3 fraction was found at measurable levels. There are no sediment quality guidelines against which the measured levels can be compared. However, it was noted that the measured F3 fraction concentrations, with one exception, were below the CCME guideline of 400 µg/g dw for soil invertebrates. Based on experience from other similar assessments, the hydrocarbon levels measured in the sediments of Silver Lake and Mile Lake are not believed to pose a risk to benthic communities.

Despite some elevated metal and F3 PHC concentrations, sediment quality in Silver Lake and Mile Lake does not appear to be posing a risk to the benthic communities present within in each and consequently remedial action for sediments is not warranted.

6.2.10 Conclusion

Physical and chemical hazards exist at the El Bonanza and Bonanza mine sites and the remediation plan attempts to address these hazards.

The physical hazards of the site are addressed by the remediation options chosen for the buildings (demolition), mine openings (backfilling or capping), waste disposal areas and miscellaneous debris (consolidation), and tanks and drums (demolition and/or disposal). The chemical hazards are addressed by the remediation options chosen for the buildings (removal of hazardous material prior to demolition), waste rock (leave as is), contaminated soil (consolidation in a landfill and/or treatment) and tanks and drums (disposal of residual fuel and hazardous material prior to demolition and/or disposal of containers).

The results of the HHERA indicated that individuals who might visit the El Bonanza Mine site on a short-term basis, even if taking home locally collected food for subsequent consumption, would not experience any adverse health effects. From an ecological perspective, the risk assessment showed that the site poses no risk of adverse effects to large animals such as bear, moose, and caribou. Using extremely conservative assumptions that overestimate exposure, the HHERA predicted a minimal potential risk of adverse effects on individual small local species (grouse/ptarmigan), but no adverse effects on populations.

The conservation of fish habitat will be addressed by the removal of any culverts to ensure proper stream channel drainage and long-term stability of the stream bead and banks.

The remediation options presented in this report were based on the review of the site assessment program findings, the risk assessment, consideration of regulatory, engineering and precedent practice, as well as the community objectives/criteria and consultation meetings.

7.0 MONITORING

The remedial actions outlined in Chapter 6 will require a commitment to monitoring, both during the implementation phase of the project, and after the remediation is complete. As a first step and in keeping with INAC's "*Mine Site Reclamation Guidelines for the Northwest Territories*" (INAC 2006b) a 'Reclamation Completion Report' will be completed following the remediation of the site which will compare the actual remedial works completed to the RAP to ensure consistency.

Monitoring during implementation will include water quality monitoring in the environment around the site. The potential impact of the remediation work on wildlife would also be monitored. A designated health and safety officer would be on site at all times during the implementation, with the primary role of assuring and monitoring the health and safety of site workers. The monitoring could include dust monitoring, when there is any risk of airborne dust affecting site workers, gas monitoring for access to closed spaces such as mine adits, and any other occupational monitoring required to ensure a safe work place. As per the INAC's "*Mine Site Reclamation Guidelines for the Northwest Territories*" (INAC 2006b), a 'Performance Assessment Report' will be completed following the monitoring of the site to determine that site objectives and performance criteria are being met.

Monitoring after remediation is completed will assess the performance of the remedial measures compared with the original objectives and will allow any necessary maintenance or corrective action to be taken in a timely manner. The site is remote and difficult to access and therefore the design of the remedial measures is intended to minimize the need for maintenance and long-term monitoring.

Two types of post-remediation monitoring are anticipated; performance monitoring and environmental monitoring. These are discussed in the following sections.

7.1 PERFORMANCE MONITORING

Performance monitoring will be required for all of the remediation measures that require construction including the landfill(s), any drainage controls, and the seals/barriers for mine openings, and any shoreline works. The performance of these facilities will be measured in terms of physical stability, erosion and sedimentation. Performance monitoring will be undertaken one year following remediation and then every 3 to 5 years, up to a period of 20 years following remediation, depending on recommendations from the Sahtu Land and Water Board. Considering the extremely low level of ecological risk that the site poses and the absence of any material ecological issues over the last many decades, more frequent monitoring during the post-remediation phase is not warranted.

The performance monitoring will include inspection by an appropriately qualified engineer of all civil works, landfills and mine seals one year following completion of the works and every 3 to 5 years thereafter as mentioned above. The inspections will assess the physical stability of the features and the performance with respect to erosion. The results of all inspections will be documented in annual reports to INAC, including any recommendations for maintenance or corrective actions.

7.2 ENVIRONMENTAL MONITORING

It is expected that monitoring of environmental quality in Mile Lake, Silver Lake, the stream discharge from Silver Lake, and Great Bear Lake at the airstrip will be carried out in conjunction with the performance monitoring of remediation measures. Environmental monitoring will be undertaken on an annual basis during the implementation phase, and for a period of at least five years following completion of the remediation works. Surface water quality will be the primary focus of the environmental monitoring program and is expected to include water sampling at shoreline stations as well as stations in open water locations adjacent to the former mine features.

Environmental monitoring will continue in the longer-term, but the frequency and scope of the work will be reduced.

7.3 CARE AND MAINTENANCE

Long-term care and maintenance activities will include any activities that are required to ensure the ongoing integrity and performance of the remedial works and any additional works that may be required to ensure that the impacts of past site activities are mitigated within the context of best practice and the specific commitments of this Remedial Action Plan.

8.0 REMEDIATION SCHEDULE

The remediation of the two El Bonanza Mine sites is scheduled to occur in conjunction with the remediation of seven other sites including the five Silver Bear Mine sites, the Contact Lake Mine site, and the Sawmill Bay site. The Remedial Action Plan will be submitted for screening by regulatory authorities to determine the permits or licences that may be required to implement the plan.

The following general project activities and milestones are anticipated for the design and implementation of the Remedial Action Plan.

- 2008 - preparation of detailed plans, engineering designs, specifications, cost estimates and contract tender documents, contract tendering, application for necessary permits.
- 2009 - initiate remediation of the site(s).
- 2011 - completion of remedial program.
- 2012 - begin post-remediation monitoring.

The schedule may change depending on procurement approach, contract award, and regulatory approval.

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APPENDIX A

Community Consultation Reclamation Option Assessment Tables

El Bonanza Remediation Plan Community Consultations

Presented By Jessica Mace, INAC Project Officer

Acknowledgements: SENES Consultants Ltd. produced many of the maps, figures and photographs for this presentation

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El Bonanza

Remedial Options Tables

Building Include:

- Head Frames
- Office
- Camp Buildings
- Workshops
- Warehouses

Buildings

Building conditions

- Safety Hazard
- Visual attraction to site
- Some chemical hazards (lead paint, DDT & asbestos)

Buildings – Options

- Recycling of material where possible
- Removal of hazardous materials

1. Leave as is
2. Demolish buildings

Goals / Options Buildings (all options include removal of hazardous material)	Leave as is - for other use	Demolish buildings
Health and safety	Bad	Good
Protect fish, wildlife and vegetation	Bad	Good
Protect water quality	na	na
Minimize environmental impacts during Remediation	Good	OK
Minimize Long term care and maintenance	Bad	Good
Return site to its original condition where possible	Bad	Good
Is cost effective	Good	OK
A / P / NA	NA	P

Indian and Northern Affairs Canada
Affaires indiennes et du Nord Canada

Roads

Roads – Existing conditions

- Road connects former airstrip and El Bonanza and Bonanza Mines
- Roads are overgrown in many areas

Roads – Culverts

- Two culverts at Silver Lake
- Water levels are different by about 1 foot between Mile Lake and Silver Lake
- Water drainage and fish movement is effected because wooden debris and drums around culverts
- DFO would like drainage restored
- Additional culvert on roadway to airstrip

Roads – Options

All options include removing culverts and restoring original drainage

1. Leave as is (natural re-vegetation)
2. Scarify roads

Goals / Options Roads (options include removal of culverts)	Leave as is (natural re-vegetation)	Scarify roads
Health and safety	Good	OK
Protect fish, wildlife and vegetation	OK	Good
Protect water quality	OK	Good
Minimize environmental impacts during Remediation	Good	OK
Minimize Long term care and maintenance	Good	Good
Return site to its original condition where possible	Bad	Good
Is cost effective	Good	OK
A / P / NA	A	A

Empty Transformer and PCBs in Soil

- Empty transformer at former power house and small area of PCB contaminated soil
- Concentration of 2.7 ppm
- Disposal:
  - Excavate soil with PCBs and dispose appropriately
  - Disposal of transformer according to regulations

Small Dumps and Site Debris

Waste includes:

- Small dumps
- Old equipment, house hold garbage, vehicle parts
- Scattered debris at the sites

Waste Includes:

- Some barrels with diesel fuel
- Four tanks at the former airstrip (2 standing up and 2 lying down)
- One large tank has minimal amount of fuel/water mixture

Small Dumps and Debris Conditions

- Some elevated metals and hydrocarbons associated with dump areas
- Could be uptake of contaminants by wildlife and plants
- Physical hazard – could be injury to people and animals

Small Dumps and Debris – Options

All options include proper disposal of fuel found in barrels and tank.

1. Leave as is
2. Cover with soil
3. Cover with soil and plant vegetation
4. Move to new landfill

Goals / Options Dumps and debris (includes proper disposal of fuel)	Leave as is	Cover with soil	Cover with soil and plant vegetation	Move to new landfill (reclaim disturbed areas)
Health and safety	Bad	Ok	Ok	Good
Protect fish, wildlife and vegetation	Bad	Ok	Ok	Good
Protect water quality	Ok	Ok	Ok	Good
Minimize environmental impacts during remediation	Good	Ok	Ok	Ok
Minimize Long term care and maintenance	Ok	Ok	Ok	Ok
Return site to its original condition where possible	Bad	Ok	Ok	Good
Is cost effective	Good	Ok	Ok	Bad
A / P / NA	NA	A	A	P

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Mine Openings-
Vertical Openings (not including Shaft #1)

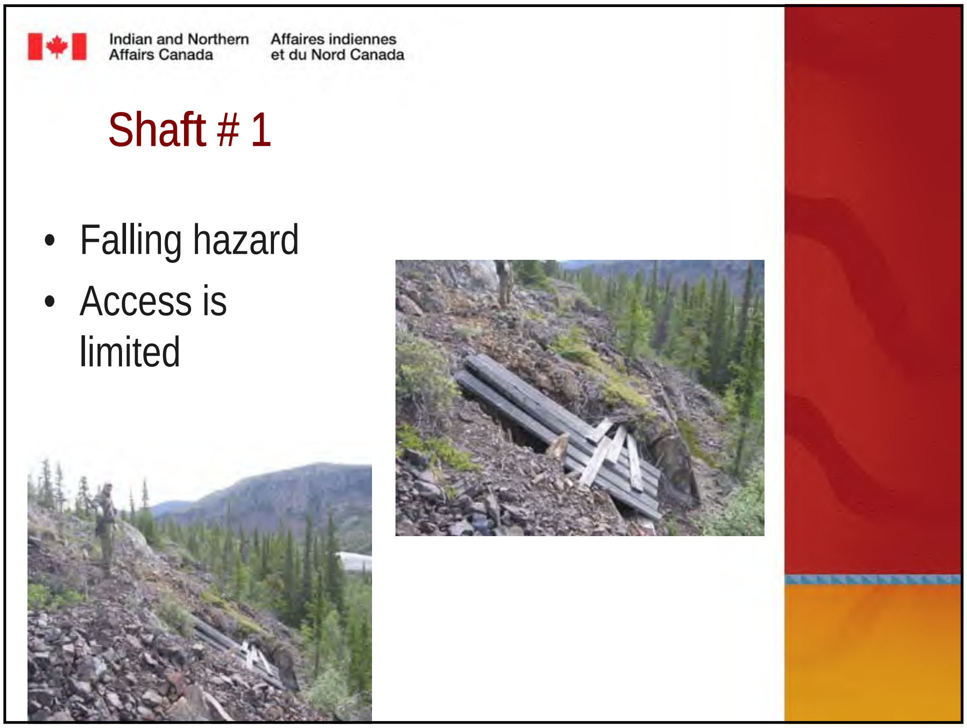
Vertical Openings Conditions

- El Bonanza and Bonanza
  - 3 shafts (not including Shaft #1) and some small pits and trenches
- Shaft #3 water elevated in aluminum and zinc
- Falling hazards

Vertical Mine Openings and Small Pits – Options

1. Leave as is
2. Backfill with waste or soil and rock
3. Cap with concrete
4. Build fence around openings

Goals / Options Vertical Mine openings e.g. shafts and raises	Leave as is	Concrete cap	Backfill with soil or rock	Build fence around areas
Health and safety	Bad	Good	Ok	Ok
Protect fish, wildlife and vegetation	Bad	Good	Ok	Bad
Protect water quality	na	na	na	na
Minimize environmental impacts during remediation	Good	Good	Ok	Ok
Minimize Long term care and maintenance	OK	OK	Ok	Bad
Return site to its original condition where possible	Bad	Ok	Ok	Bad
Is cost effective	Good	Ok	Ok	Ok
A / P / NA	NA	P	A	NA



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Shaft # 1

- Falling hazard
- Access is limited

Goals / Options Shaft #1	Leave as is	Cap – safe method	Backfill with soil or rock	Build fence around areas
Health and safety	Bad	Good	Bad	Bad
Protect fish, wildlife and vegetation	Bad	Good	Ok	Bad
Protect water quality	na	na	na	na
Minimize environmental impacts during remediation	Good	Ok	Bad	Ok
Minimize Long term care and maintenance	Good	Ok	Bad	Bad
Return site to its original condition where possible	Bad	Good	Good	Bad
Is cost effective	Good	Ok	Bad	Ok
A / P / NA	NA	P	NA	NA

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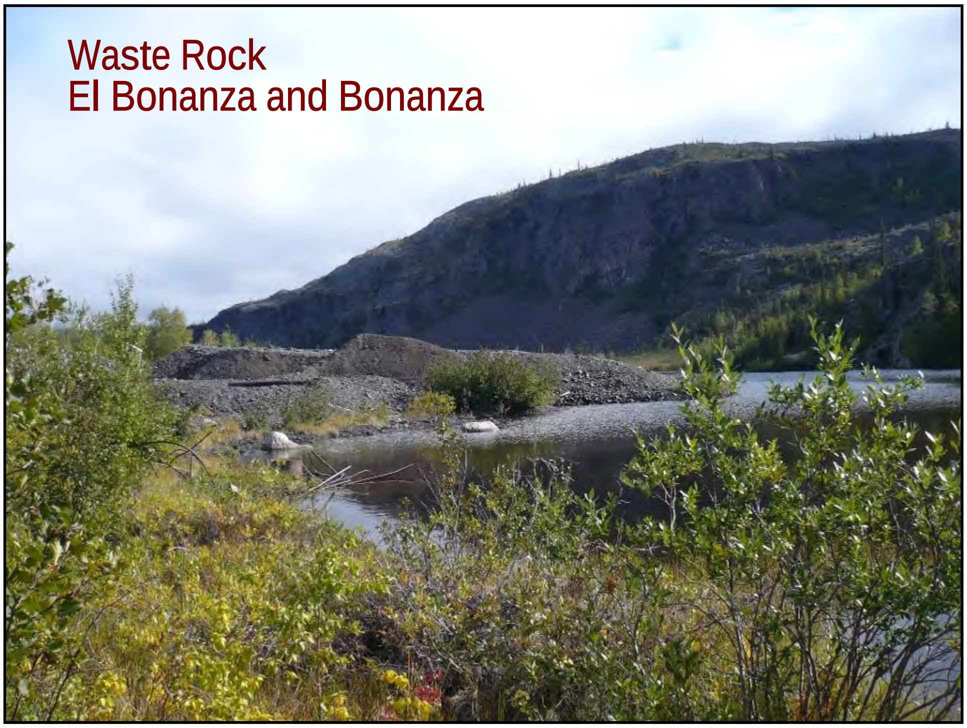
Mine Openings - Adit

Goals / Options Mine opening- Adit	Leave as is	Backfill opening	Concrete bulkhead	Build fence around opening
Health and safety	Bad	Good	Good	Ok
Protect fish, wildlife and vegetation	Bad	Good	Good	Ok
Protect water quality	na	na	na	na
Minimize environmental impacts during remediation	Good	Ok	Ok	Good
Minimize Long term care and maintenance	Good	Good	Ok	Bad
Return site to its original condition where possible	Bad	Good	Ok	Bad
Is cost effective	Good	Ok	Bad	Ok
A / P / NA	NA	P	A	NA

Waste Rock
El Bonanza and Bonanza



Waste Rock Conditions

- El Bonanza (3000 m^3)
- Bonanza (600 m^3)
- Non-acid generating
- Slopes appear to be stable
- No evidence of metal leaching
- Gamma levels not elevated
- Water quality meets guidelines in nearby water

Waste Rock – Options

1. Leave as is
2. Re-slope, cover, and vegetate

Goals / Options Waste Rock	Leave as is	Re-slope, cover, and vegetate
Health and safety	Good	Ok
Protect fish, wildlife and vegetation	Good	Ok
Protect Water Quality	Good	Bad
Minimize Environmental Impacts during Remediation	Good	Ok
Minimize Long term care and maintenance	Good	Ok
Return site to its original condition where possible	Bad	Ok
Is cost effective	Good	Ok
A / P / NA	P	A

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Hydrocarbon Contaminated Soil Conditions

- Small areas of stained soil around buildings and drum storage area
  - Gasoline, diesel & oil in soils ~ 355m^3
- Small area of stained soils around dump locations
  - Diesel and oil in soil ~60m^3
- Soil associated with tanks
  - Diesel and oil in soil ~30m^3

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Hydrocarbons in the Soil - Options

1. Excavation to landfill or off site (smaller quantities high risk areas)
2. Cover in place (less mobile hydrocarbons)
3. Alternative option used for more mobile hydrocarbons (Bioremediate or landfarm)

Issues will be addressed along with Silver Bear hydrocarbon remediation program

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Outstanding Issues

- Hydrocarbons (oil and diesel) in Soil

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Thank You

El Bonanza Remediation Plan Community Consultations

Presented By Jessica Mace, INAC Project Officer

Acknowledgements: SENES Consultants Ltd. produced many of the maps, figures and photographs for this presentation

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Outline

- History and Location
- Site Issues
- Options for clean up
  - Description of options
  - Options tables

Location and History

- Located on Great Bear Lake, 263 km northeast of Déline, 9 km southwest of Port Radium
- Silver was discovered in 1931 by an employee of the Eldorado Gold Mines
- Development at the mine was in 1934-1936, 1956-1957, and 1965
- Additional drilling done in 1978-1981 by Echo Bay Mines Limited

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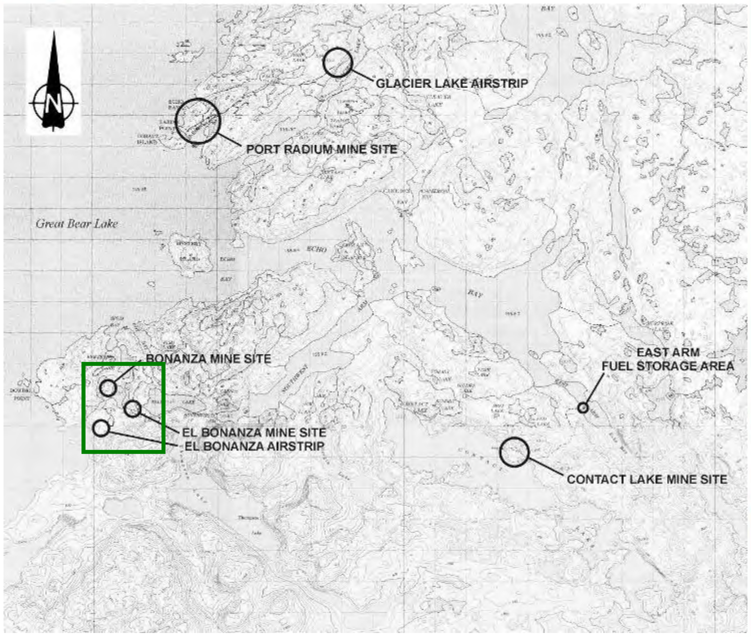

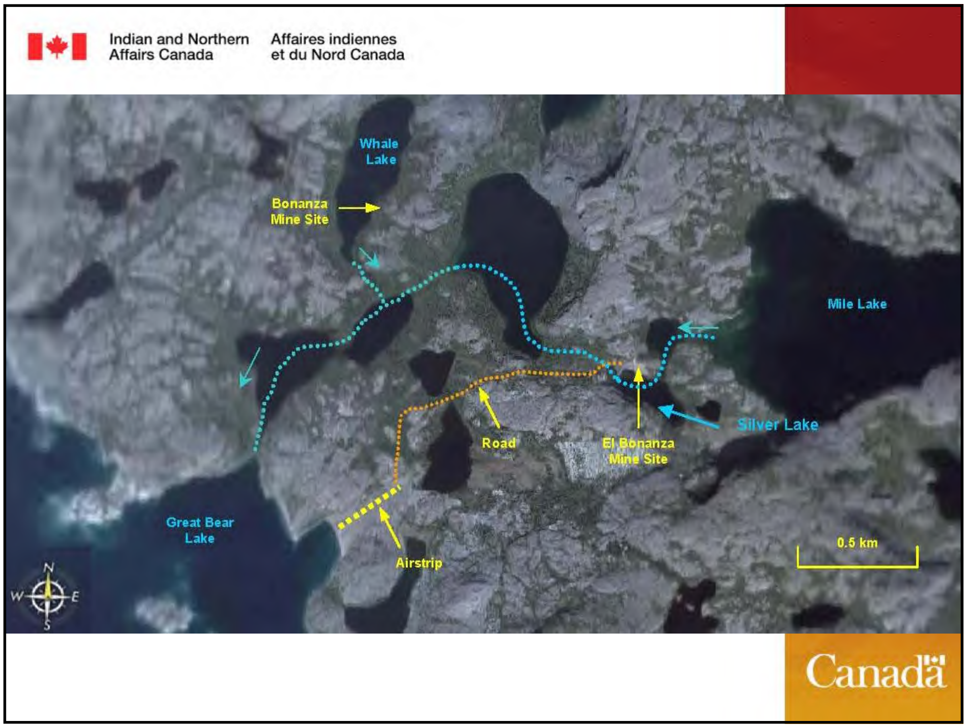

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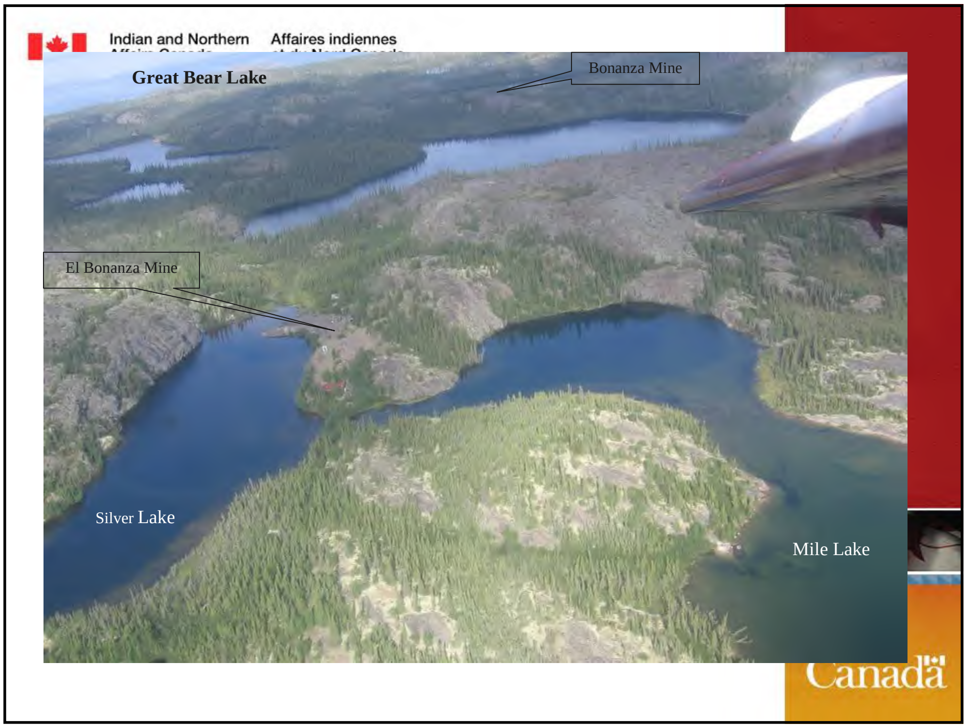

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Site Assessments

- 2004 – Initial Environmental Monitoring & Assessments
- 2006 & 2007 – Site Assessment Program

SITE DETAILS

El Bonanza Overview

- Located 1.5 km from Great Bear Lake between Mile and Silver Lakes.
- Wooden buildings
- Mine openings
- Small waste rock piles
- No tailings
- Small Dumps and Site debris

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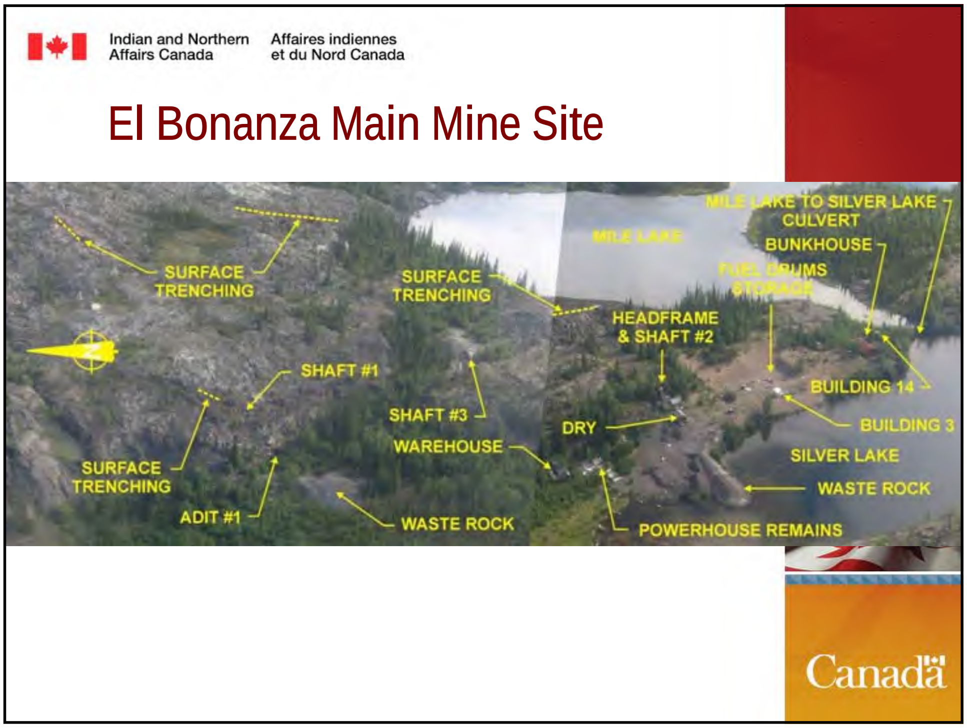
El Bonanza



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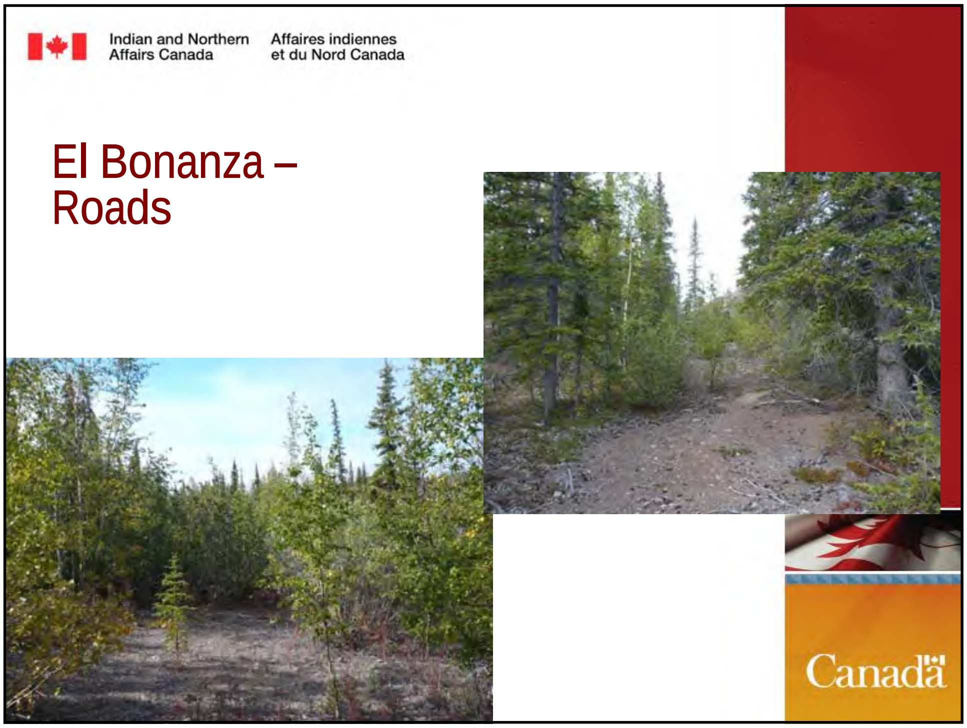
El Bonanza Main Mine Site

Building conditions

- Safety Hazard
- Visual attraction to site
- Some chemical hazards (lead paint, DDT, asbestos)
- Gasoline, diesel & oil contaminated soils ~ 355m^3

El Bonanza Sheds and Collapsed Buildings



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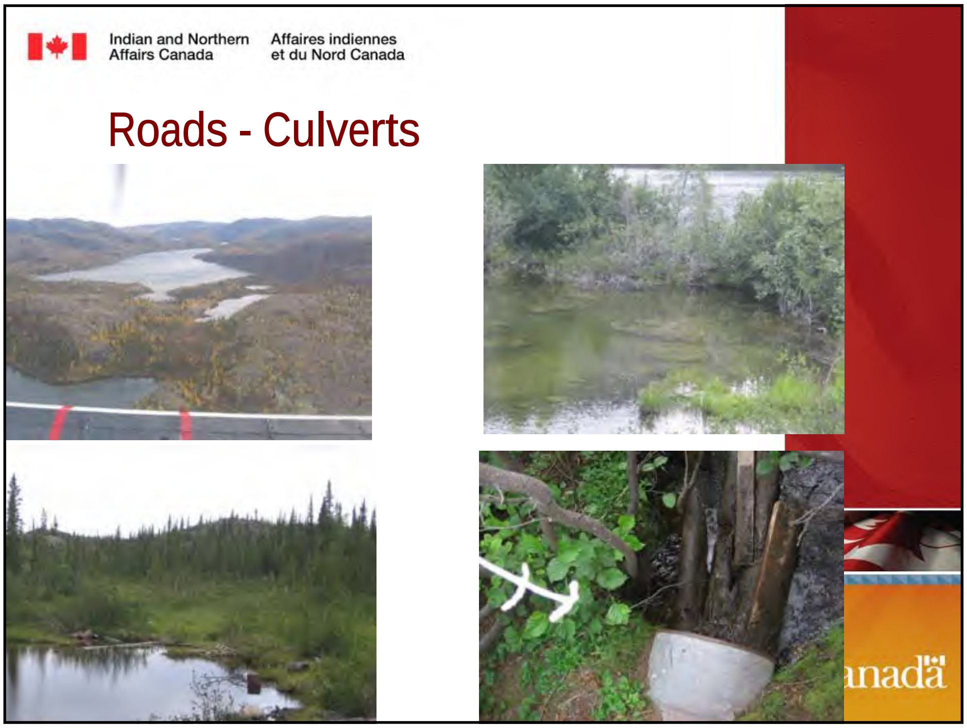
El Bonanza – Roads



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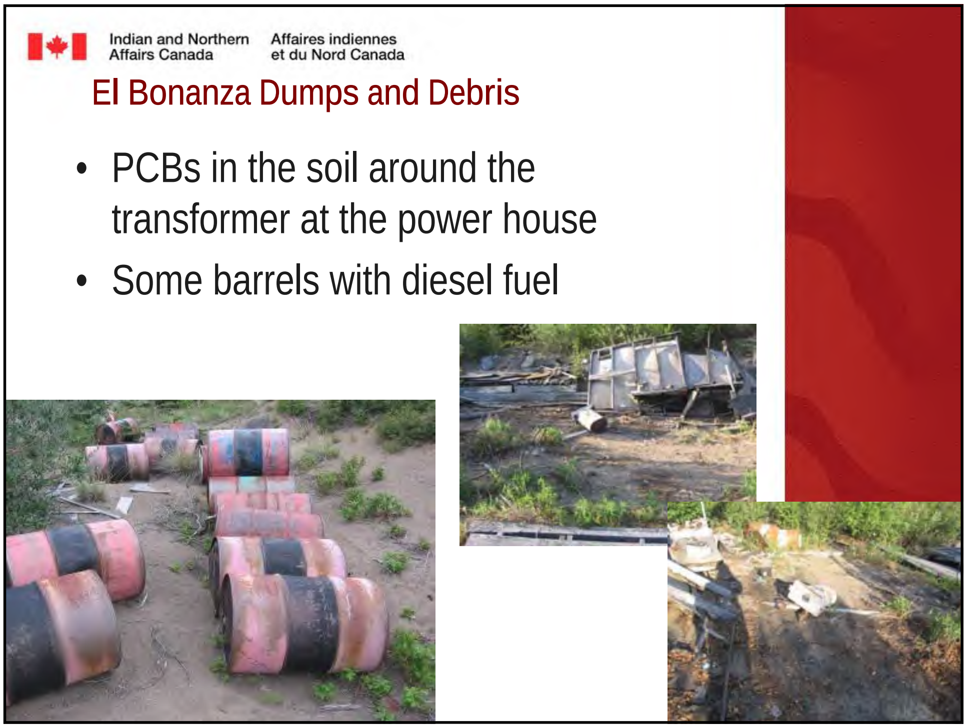
Roads - Culverts

El Bonanza Dumps and Debris

- Six small dumps
- Equipment, garbage, vehicle parts
- Metals in the soil (e.g. copper, silver, lead and zinc
- Diesel and oil in the soil ~60m^3



El Bonanza Dumps and Debris

- PCBs in the soil around the transformer at the power house
- Some barrels with diesel fuel

El Bonanza Mine Openings – 3 vertical mine openings

- Falling hazards

El Bonanza Pits

- Falling Hazards
- Elevated aluminum and zinc in water in one pit (#3)

El Bonanza Mine Opening – one Adit

El Bonanza Waste Rock

- El Bonanza (3000 m^3)
  Bonanza (600 m^3)
- Non acid generating

- Slopes appear to be stable
- No evidence of metal leaching
- No elevated gamma readings

Bioavailability Test on Waste Rock

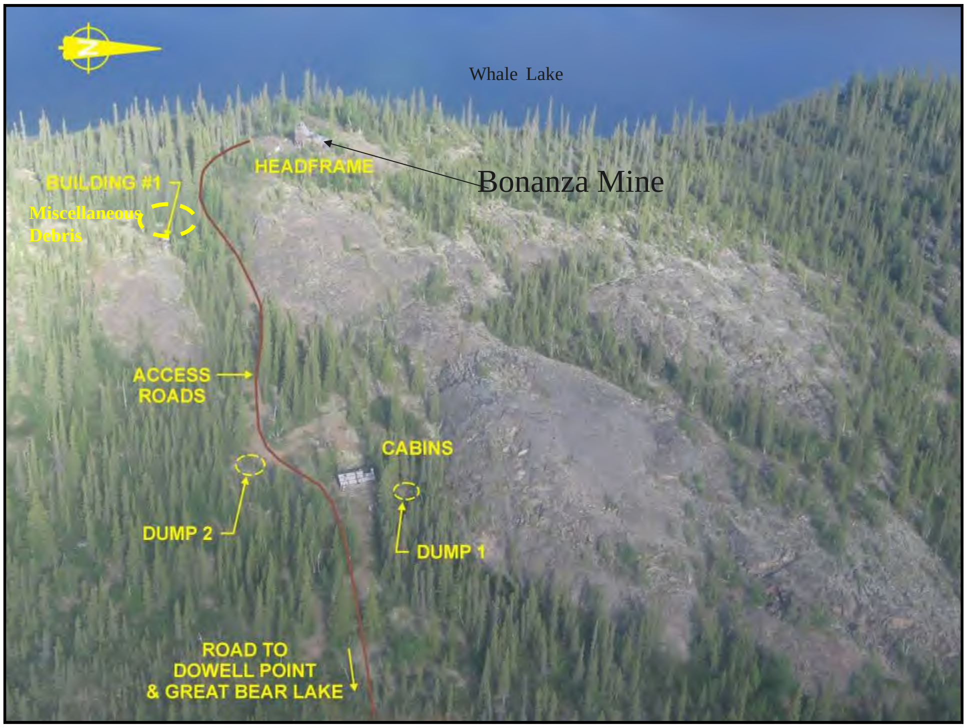
- Bioavailability Test – Acts like the digestive system of animals
- Showed that metals that are present are mostly bound to rocks
- Unlikely to be taken up by animals in the local area

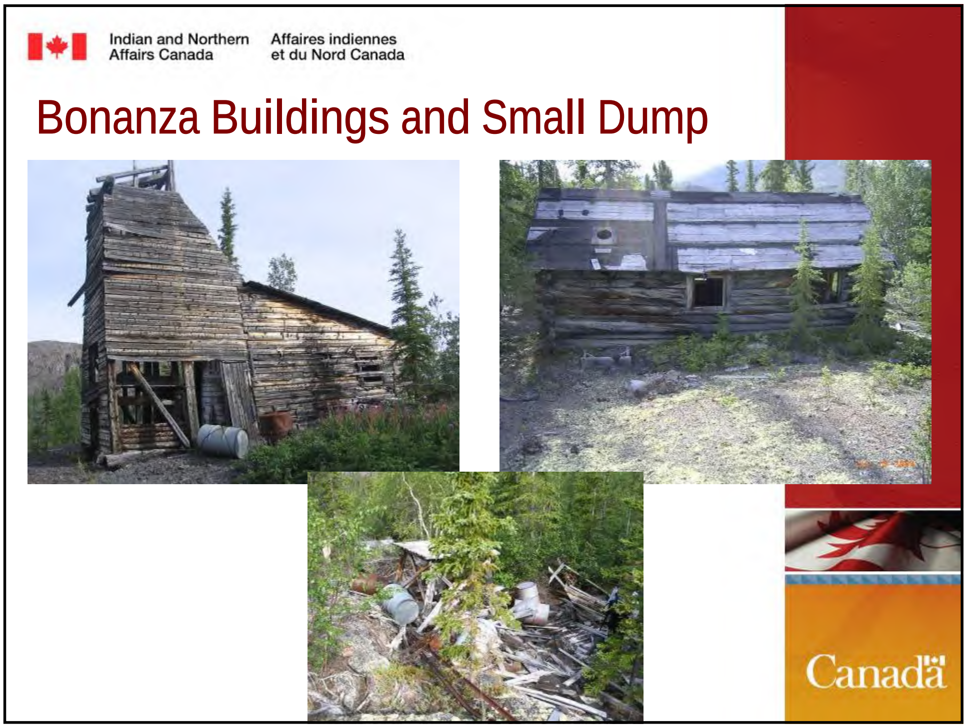
Silver Lake Conditions

- Waste rock in water is Non-Acid Generating
- Some elevated levels of metals in the sediments of Silver Lake
- Water quality meets guidelines in lake and on-land

Bonanza Overview

- Located 1 km from the El Bonanza site, on the shore of Whale Lake
- A small wood head frame and log cabin
- One shaft
- Small waste rock pile
- Small Dump and Site debris
- Oil contaminated soils ~6m^3





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Bonanza Buildings and Small Dump

Bonanza Mine Openings and Waste Rock

Whale Lake Conditions next to Bonanza Mine

- Water quality meets guidelines

Airstrip Overview

- Located on GBL, 1.5 km from the El Bonanza Mine Site and 1 km from the Bonanza Mine Site
- Former “airstrip” is sand and gravel
- Four fuel tanks (one with minimal amount of fuel)
- Site debris with some metals in the soil (~100m^2)
- Hydrocarbon (diesel and oil) contaminated soil ~30m^3

Airstrip Overview

Airstrip Physical Overview

Great Bear Lake Water Quality (next to airstrip)

- Water samples meet guidelines
- Sediment samples meet guidelines

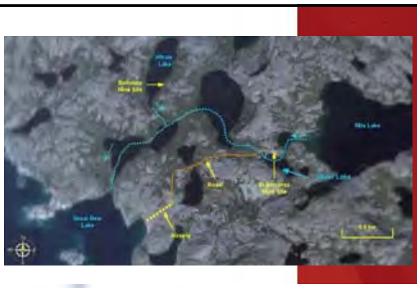
Risk Assessment Findings

- Small animals eating and drinking from the site would be at minimal risk due to site conditions

- Large animals such as bear, moose, and caribou would not be affected by the site conditions

- People who visit the El Bonanza Mine site, and take home local food, would not experience health effects

Overall Water Quality



- Water sample results from all lakes and on-land meet guidelines

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El Bonanza Mine Site Summary

- Wooden buildings
- Roads with culverts
- Mine openings
- Small waste rock piles
- No tailings
- Small Dumps and Site debris with some metals and PCBs in the soil
- Hydrocarbons in the soil

APPENDIX B

Minutes from Community Consultation

ATTENDEES
Julie Ward
Jessica Mace
Sharon Phippen
Gerd Wiatzka
Dolphus Baton
Joe Tetso
Jimmy Dillon
Tommy Betsidea
John Tutcho
Michael Neyelle
Jane Modeste

DATE **17th December 2007**

REF **El Bonanza – Remediation Action Plan and Consultations**

LOCATION **Yellowknife NT**

1 Notes

.1 Presentation to all attendees. Jessica introduced and presented detailed view of the site elements.
.2

Items	Questioner	Question	Person answering	Comments
Buildings/Head Frame		Environmental impacts	Jessica	We want to try not to disrupt the environment more than necessary when cleaning up the site. If we have to bring in heavy equipment to take down the buildings a road will likely have to be built, which would cause some environmental impact.
			Gerd/Julie	There is a possibility that a road will not need to be built. Smaller equipment could be used and that could be flown in.
	Julie Ward			Do you want to leave any of the buildings on the site (e.g. for historical value)?

			Dolphus Baton	Don't want to save anything, this is what the cleanup is about, we are not talking about saving the buildings. We do not want anything left on site.
				Demolish buildings was the preferred option
Roads\Culvert	Jimmy Dillon	Will the culvert be taken out for the fish to get by?	Jessica	Yes, the culverts will be removed and the natural drainage will be restored. DFO visited the site that is what they though should be done.
	Dolphus Baton	Are we going to leave the roads as is after the cleanup?	Gerd/Julie	The road will only be used for moving equipment and then it could be restored back to its natural state.
	Tommy			We want people from our community to be working, if we leave as is, no one would be working, if we scarify, then the people would have employment.
			Julie	This is true, but we have to find what is right for the environment, then we go to the Deline Land Corp, and ask how we incorporate this option into the work and employment for the community.
			Gerd	I hear that both options (leave roads as is or scarify) are acceptable. We could leave it up to the technical people to decide what is best in each case. For example, for the areas of the road that were not impacted during the clean-up and still overgrown, they could be left as is. For the areas that were disturbed during the clean-up, they could be scarified.
Empty Transformer and PCBs in Soil			Jessica	This does not need to be rated because we will be disposing of the empty transformer and PCB contaminated soil according to regulations.
	Michael	How big is the transformer?	Gerd	About 2 feet by 1 foot.
	Tommy	Are there more transformers around the site?	Gerd	We only found one transformer when we were at the site. There is potential that more transformers are on-site.
			Julie	During the clean up there will be a site resident engineer and they will be looking out for other transformers and material (e.g. hazardous

				waste) that may require regulated disposal.
Small Dumps and Site Debris	Michael	What do you mean by incinerating the fuel in barrels?	Jessica	The fuel (diesel) can be burned as long as it meets the regulations (i.e. does not contain any lead, glycol, etc.) and the barrels and tanks can be taken apart and disposed with other debris around the site.
	Michael	Where do we get the soil from to cover over the dumps?	Julie	We would have to take it from another area of the site.
	Joe	How many different dump sites are there?	Jessica	8 small sites with not a lot of debris
	John	Does this option (move the debris to landfill) include the fuel?	Jessica	Every option includes addressing (according to regulations) the hazardous material in the dumps and that includes the fuel.
			Gerd	Even the leave as is option includes addressing the fuel at the site because it is a hazardous material.
Mine Openings/vertical Openings	Joe	What was done at Terra?	Jessica	The preferred option was to cap the deep openings and to backfill the shallow openings.
				Shaft #1 may have to be dealt with differently because access is limited.
				Preferred Option for Vertical Openings: Cap (with concrete) all deep openings and backfill shallow openings
Shaft #1	Joe	What was done at Terra for the steep vertical opening?	Gerd	The shaft at Terra was not on as steep of a surface as this one.
			Gerd	The cap is to prevent anyone from falling in. We could put something up (e.g. metal plate) that you could bolt in. We are looking into a new technology, where a type of foam could be used to plug the opening.
	Joe	How deep is the shaft?	Gerd	40 to 50 meters. If the shaft is filled in, it would protect you from the hole, but not from the slope of the hill. You could put a fence around the shaft, but it would still be hazardous to health and safety.
				Gerd to look into the foam option with Julie's input.
Mine				Just one at this site.

Openings/Adit				
			Gerd	Adjust table so that it reads “Backfill Entrance” instead of “Backfill” because the whole adit does not need to be filled, just the entrance so that people cannot enter.
	Tommy	Will there be a lot of environmental impact building a road to the adit since the area is overgrown?	Gerd	The nearby waste rock could be used (showed photo of waste rock that is about 200 m away) to backfill the entrance to the adit so there wouldn’t be too much environmental impact.
			John	Recommendation to Land and Water Board that we don’t want anyone to mess with our cleanup.
	Joe	Could you do the concrete bulkhead in this case?	Gerd	You could, but would be very expensive and there would be no value added since blocking off the entrance by backfilling would have the same effect.
Waste Rock	Joe	Is the waste rock contaminated?	Gerd/Jessica	No, the waste rock is non-acid generating, slopes appear to be stable, no gamma elevated. Water at the site (including the water adjacent to waste rock) meets the guidelines.
			Joe	Should just leave as is then, from a health & safety aspect since it is not a health and safety problem.
			Tommy	Do not like leaving anything as it is because the site is not being returned to its original condition.
			Jessica	I understand what you are saying because leaving the waste rock as is, is not returning the site to its original condition. The problem is that if we move the waste rock, we could create an environmental impact.
	John	Biggest issue is the climate change. Will that affect the rock in the area?	Gerd	No, the rocks will not change with climate change.
			Gerd	You can say leave as is as “acceptable” and then we can look into possibly placing some soil on the top of the waste rock piles and hopefully re-vegetation would occur faster returning the site back to its original condition.
			Julie	If we do that though, we would still have to find

				soil from another place and that would cause some impact elsewhere.
			Joe	I think to leave as is, is the preferrerd option because if the water quality is good, then we don’t want to move things around.
				Decision: Leave as is was the preferred option. Re-slope, cover, and vegetate was an acceptable option.
Hydrocarbons in the Soil- Options			Jessica	The remediation options for hydrocarbons will be discussed in a meeting during the winter months along with the hydrocarbon remediation options for the Silver Bear and Contact Lake mine sites.