Project Concept Desciription Of The Kaggavik (Ione Gull) Uranium Mine - Summary Report

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PROJECT CONCEPT DESCRIPTION OF THE KIGGAVIK(LONE GULL) URANIUM MINE

SUMMARY REPORT

Prepared by

BEAK CONSULTANTS LIMITED
and
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PROJECT CONCEPT DESCRIPTION OF THE
KIGGAVIK (LONE GULL) URANIUM MINE

SUMMARY REPORT

Baker Lake Area
District of Keewatin
Northwest Territories

N.T.S. 66-A-5 and A-6
Longitude 97°30'
Latitude 64°30'

Prepared by:

BEAK CONSULTANTS LIMITED
and
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1.0 INTRODUCTION

In 1974, Urangesellschaft Canada Limited began exploring for uranium in the Keewatin district of the Northwest Territories near the edge of the Thelon Sandstone Basin. During the first season's work, in the course of an airborne radiometric survey, the Kiggavik uranium deposit was discovered about 75 km west of Baker Lake. An exploration camp was established to investigate the airborne anomaly, and to carry out further exploration work and environmental studies on other potential uranium targets within the property boundaries. In 1977, exploration drilling started on the main uranium showing located just north of Pointer Lake (Figure 1) and a smaller showing located a few hundred metres to the east of it. These two mineral locations became known as the Main and Centre Zones. In 1986, a decision was made that the deposits were of sufficient interest to carry out a pre-feasibility engineering and environmental study, and explore marketing options. The pre-feasibility study focused on verifying the quality and quantity of uranium reserves present, the engineering problems which have to be overcome to make the project technically viable and economically attractive, and the environmental implications of developing a uranium ore body and associated infrastructure in the region. In 1987, the engineering pre-feasibility study was completed, along with the initial project concept description of which this report forms the summary. The project concept description, outlining the project concepts in very general terms so as not to prempt feasibility engineering studies, was prepared based on the pre-feasibility study and environmental studies carried out in the area over the last decade.

After the appropriate regulatory agencies have had a chance to review the project concept, discussions will be held to identify specific issues which may still be of concern to the regulatory agencies and the people of the Baker Lake area. During the spring, summer and autumn of 1988, further studies will be undertaken in conjunction with the engineering feasibility study to address those concerns, and an environment assessment report prepared and submitted in early 1989. At that time, another set of meetings will be held with the regulatory agencies and people of Baker Lake in order to explain the nature of the findings and answer any questions about the project and its effects on the local environment and its people. Following these discussions and the satisfactory addressing of all outstanding issues, it is expected that project approvals will be granted and the project will proceed to the developmental stage. Table 1 presents a timetable

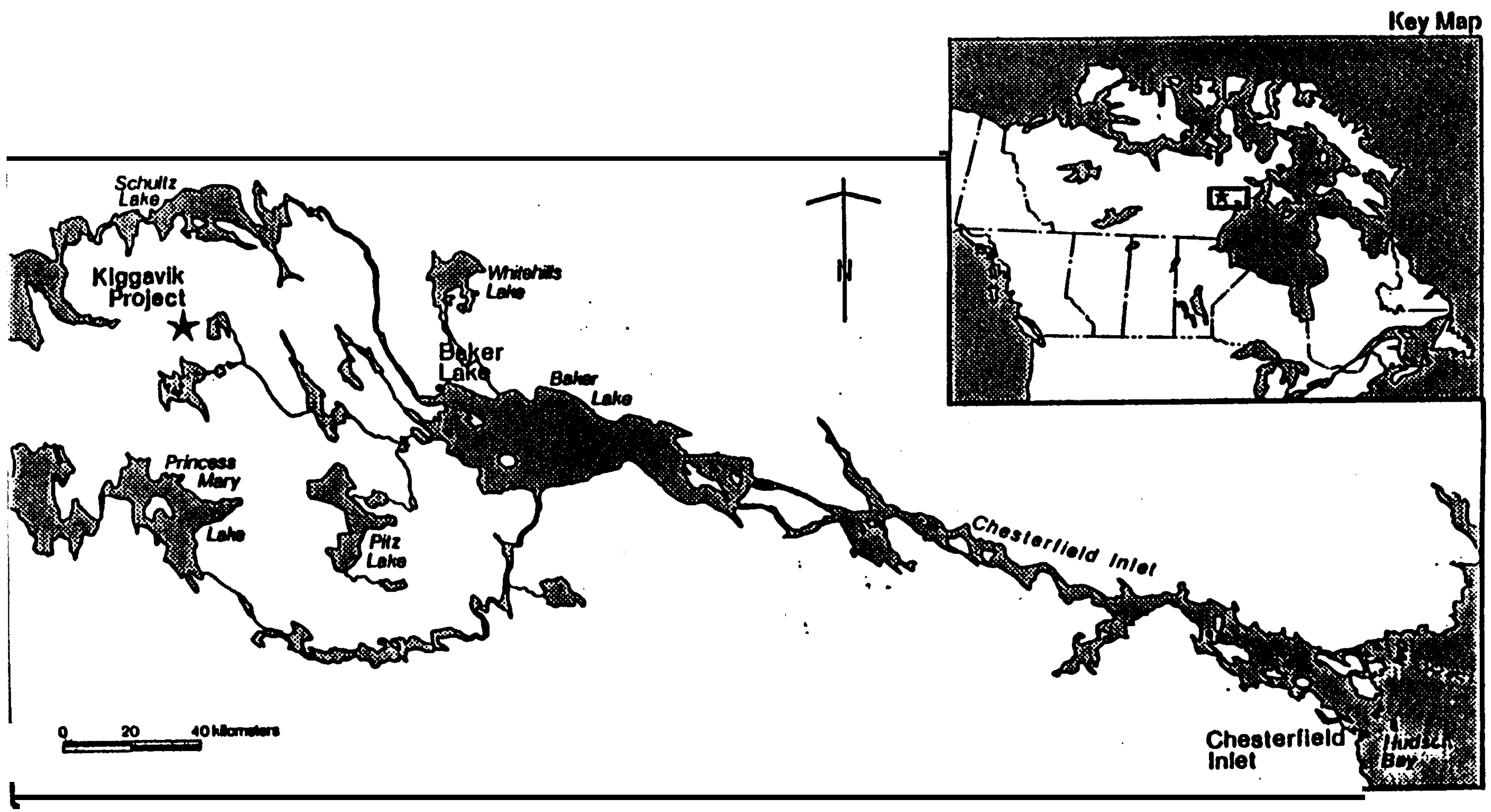
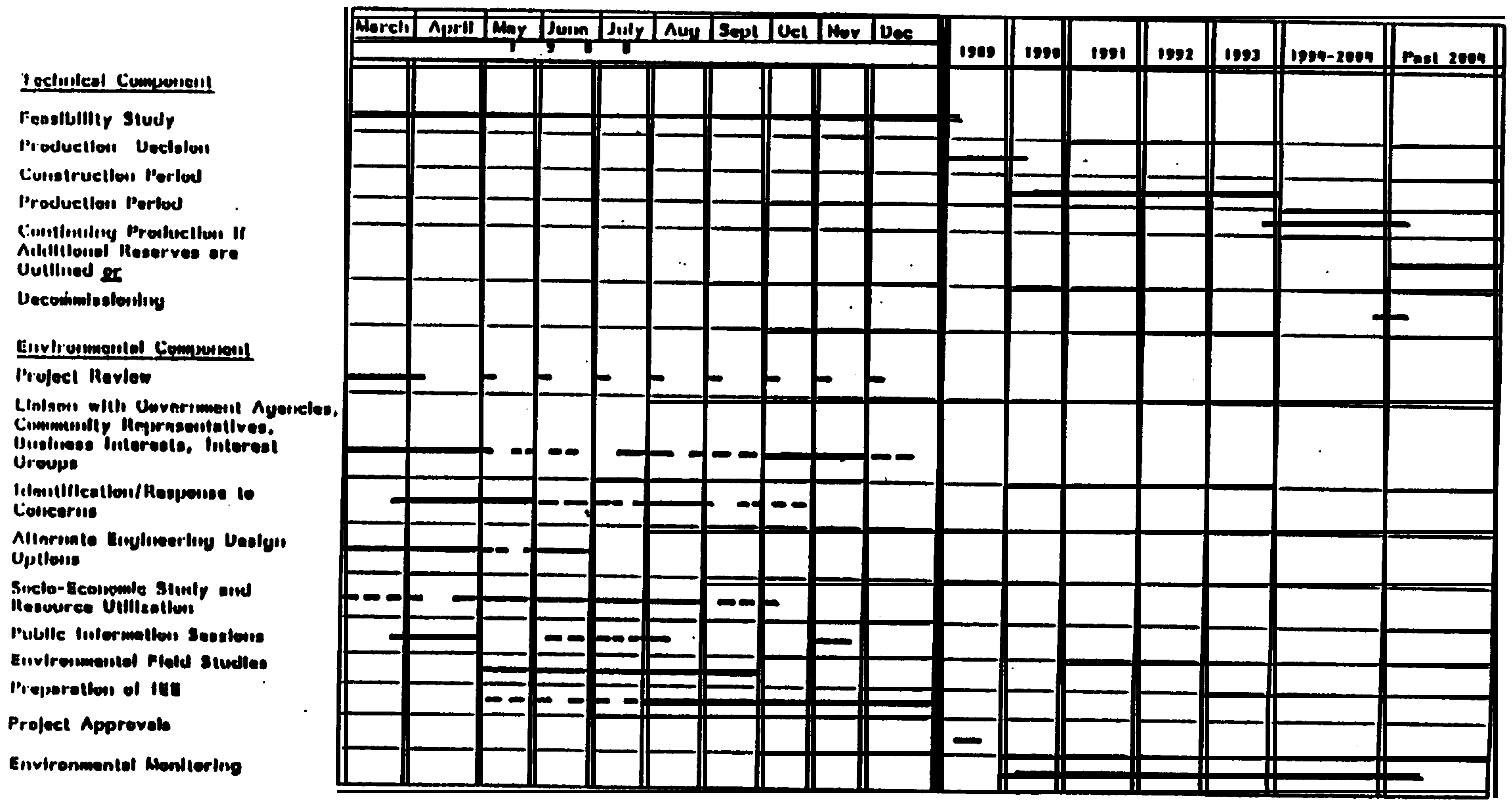


Figure : LOCATION MAP

(District of Keewatin Northwest Territories)

URANGESELLSCHAFT
Kiggavik Uranium Project
Baker Lake, Northwest Territories

able : PRELIMINARY KIGGAVIK GENERAL PROJECT SCHEDULE



for the various project-related activities leading to the project approval stage and the progress of the project following approvals and a production decision.

This report presents, in summary form, the project concept arising from the pre-feasibility study and its overlay on the database of environmental data collected in the area. As such, it represents the first of two submissions which form part of the environmental approvals process. Table 2 provides a chronological summary of various studies, reports and meetings which have provided the basis upon which this report has been prepared.

TABLE 2: HISTORY OF EXPLORATION AND ENVIRONMENTAL STUDIES IN THE KIGGAVIK PROJECT AREA

	Time Period
Exploration	
Surveys	1974-81
Discovery Main Zone and Centre Zone	1974
Exploration Drilling	1977-80-1985
Delineation Drilling	1986-87
Pre-Feasibiiity Study	1986-87
Environment	
Environmental Baseline Data	*1978-80 and 1986-87*
Terrain Disturbance Studies*	*1980*
Hydrological and Climatological Studies**	*1982-83*
Distribution of Radionuclides in Plants**	*1982*
Lichen Studies**	*1982*
Effects of Uranium Mill Tailings on Permafrost	1988
Contact with Government Agencies	Spring i986 and Winter 1987
Public Information Baiter Lake	Early 1987

* Study by INAC in cooperation with UG.

** Studies by Universities for INAC.

2.0 PROJECT CONCEPT

The development of the project concept during the pre-feasibility study involved addressing of the two major areas of how to conceptually design a uranium mine and mill complex which will both operate efficiently in the harsh climate of the Kiggavik region and, at the same time, result in a minimum of impact on the local environment In developing the concepts which form part of the engineering pre-feasibility study, the authors drew heavily on the experience of other uranium mine and mill developments in northern Canada, and on the years of environmental baseline data which had been collected in the project area.

Present planning is for a mining operation of more than 300,000 tonnes per year at an average ore grade of 0.5% uranium oxide (U_3O_8). This is expected to result in an average uranium production of 1,600 tonnes U_3O_8 per year. Production is expected to commence three to four years after environmental approvals and a final production decision is made.

The proposed development can be broken into a series of major components, including:

- **Mining:** two open pits with total material mined of approximately 15,000 tonnes/day.
- **Milling:** a processing plant treating 1,000 tonnes of ore per day and producing an average of approximately 1,600 tonnes U_3O_8 per year.
- **Waste Management System:** a tailings handling system capable of storing tailings for the life of the mine in an environmentally acceptable manner, coupled to a wastewater treatment system designed to meet all appropriate regulatory requirements.
- **Camp Site:** accommodation for a work force of about 250 people working an average of ten weeks on-site and three weeks off-site.
- **Transportation:** an airport capable of handling jet aircraft; a marine terminal with the ability to handle cargo ships and tankers or ocean-going barges; and a winter road facility for transporting construction and operating materials and supplies from the marine terminal to the Kiggavik mine site.

All major facilites, except the marine terminal, can be located on good sites within a 5 km (3 mile) radius of the proposed processing plant. Natural resources suitable for construction material in the form of gravel and sand deposits are available in the immediate area. There is also a good source of process and potable water, and an attractive site for the accommodation complex.

The overall development and operational concepts presented in this report are based upon both environmental and engineering considerations, and have put an emphasis on restricting the site development area to as small a size as practical, and to focus all interconnecting facilities to as few a number of transportation corridors as possible. Public and worker health and safety considerations are considered priorities, and only those project options which ensure a safe living and working environment are given consideration.

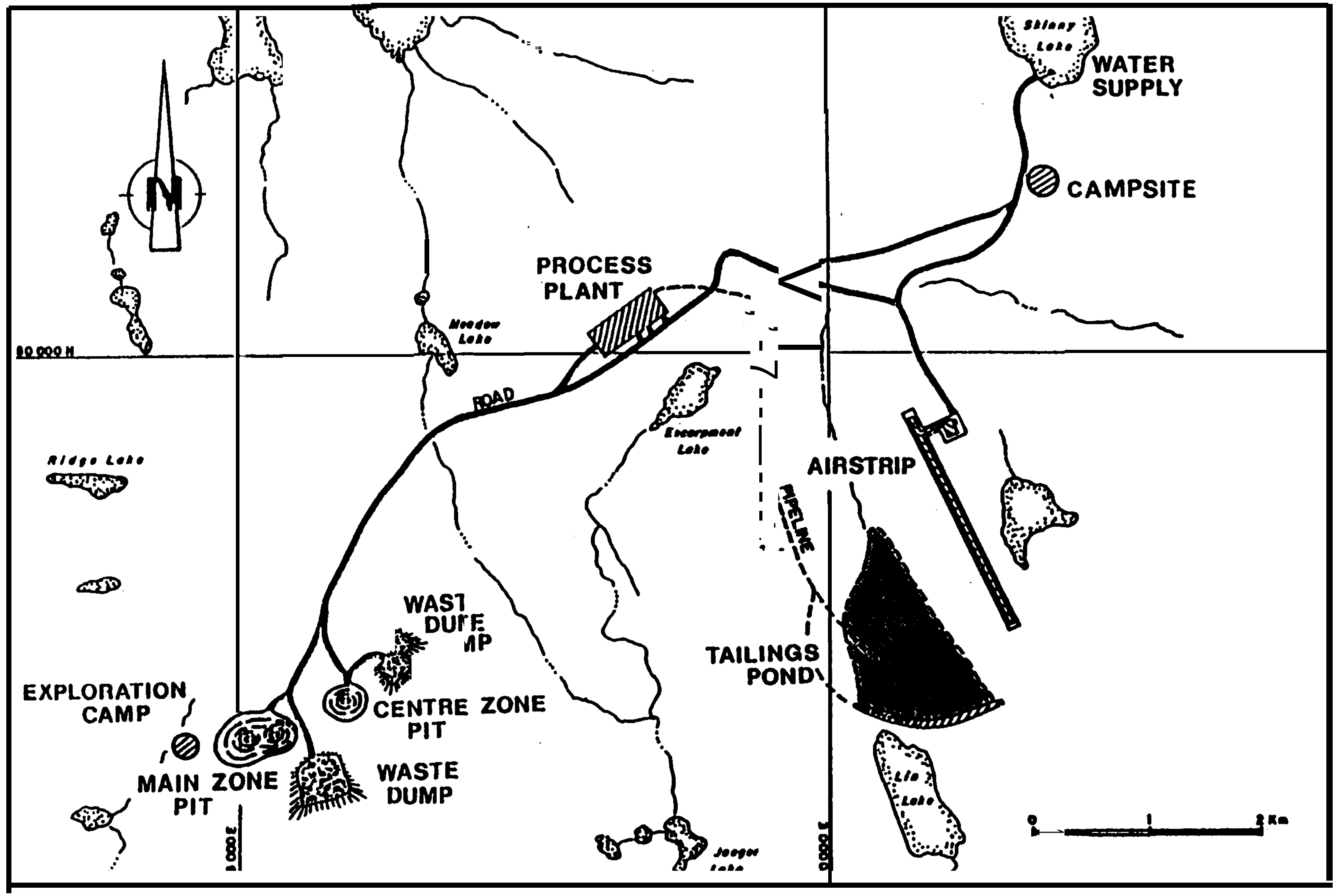
Thought has also been given, at the concept planning stage, to facility close-out and the concepts as presented are such that, upon decommissioning, there will be very little residual impact on the land.

The location of the planned development project is shown in Figures 1 and 2.

The project concept, presented in the following sections, was developed in the pre-feasibility study by Strathcona Mineral Services (S MS) which borrowed heavily from their experience in Arctic mining at Nanisivik and from new technologies developed for uranium mining in northern Saskatchewan.

2.1 Ore Reserves

Geological reserves established by UG in the Main and Centre Zones total approximately 48 million pounds of uranium oxide (lbs of U_3O_8), at an average grade of 0.6% U_3O_8. Mineable reserves including external dilution have been calculated within two open pits at 37.2 million lbs of U_3O_8 at a diluted grade of 0.5% U_3O_8. Prospects for some addition to current reserves are considered good. At least two other zones on the property have also been partially explored and shown to contain mineralization of ore grade, and other potentially favorable geophysical targets remain to be investigated by diamond drilling.



F ure 2: KIGGAVIK PROJECT PREFERRED SITE 2 OUT

2.2 Mining

The Kiggavik uranium deposits include two major zones, the Main and the Centre Zones (see Figure 2). A significant positive feature for the project is that both of these zones can be mined by relatively simple open pit methods. Preliminary designs for these two areas are considered to be conservative and generally conventional Bench heights in the ore zone have been reduced to 3 or 6 metres to assist in separating ore from waste. For the same reason, ore will be extracted using a relatively small backhoe machine as compared to large f rent-end loaders for the waste. Approximate final depths of the presently planned pits are 162 metres for the Main Zone and 100 metres for the Centre zone.

Generally, wall rock conditions on the outside of the pit are expected to be very competent, particularly as permafrost conditions are anticipated to persist to substantial depths. Within the ore zone, intense clay alteration is common, and articulated ore trucks with high traction capability are planned to be used throughout much of the year. Permafrost conditions which are present in the pit are expected to reduce this traction problem. Ore trucks will be used for two months during the year to haul limestone over a winter road from a proposed limestone quarry in the area.

Ore production of approximately 1,000 tonnes per day, has been scheduled to maximize grade in the early years of operation. Hence, initial production will come from the high grade Centre Zone, followed by the higher grade part of the Main Zone. The early mining out of the Centre Zone has the added advantage of leaving this pit available for consideration for tailings or waste rock disposal.

2.3 Milling and Processing

Preliminary metallurgical test work was carried out on samples from the deposit, to determine the suitability of the ore to normal treatment processes and to establish a preliminary flow sheet (Figure 3). The results of this work showed that no significant treatment problems are anticipated and, because of the simplicity of the mineralization, a standard uranium process technique can be used. Based on these data, the sizing of all major process equipment was completed. Tests were also carried out on local water and limestone resources to ensure their suitability for process use.

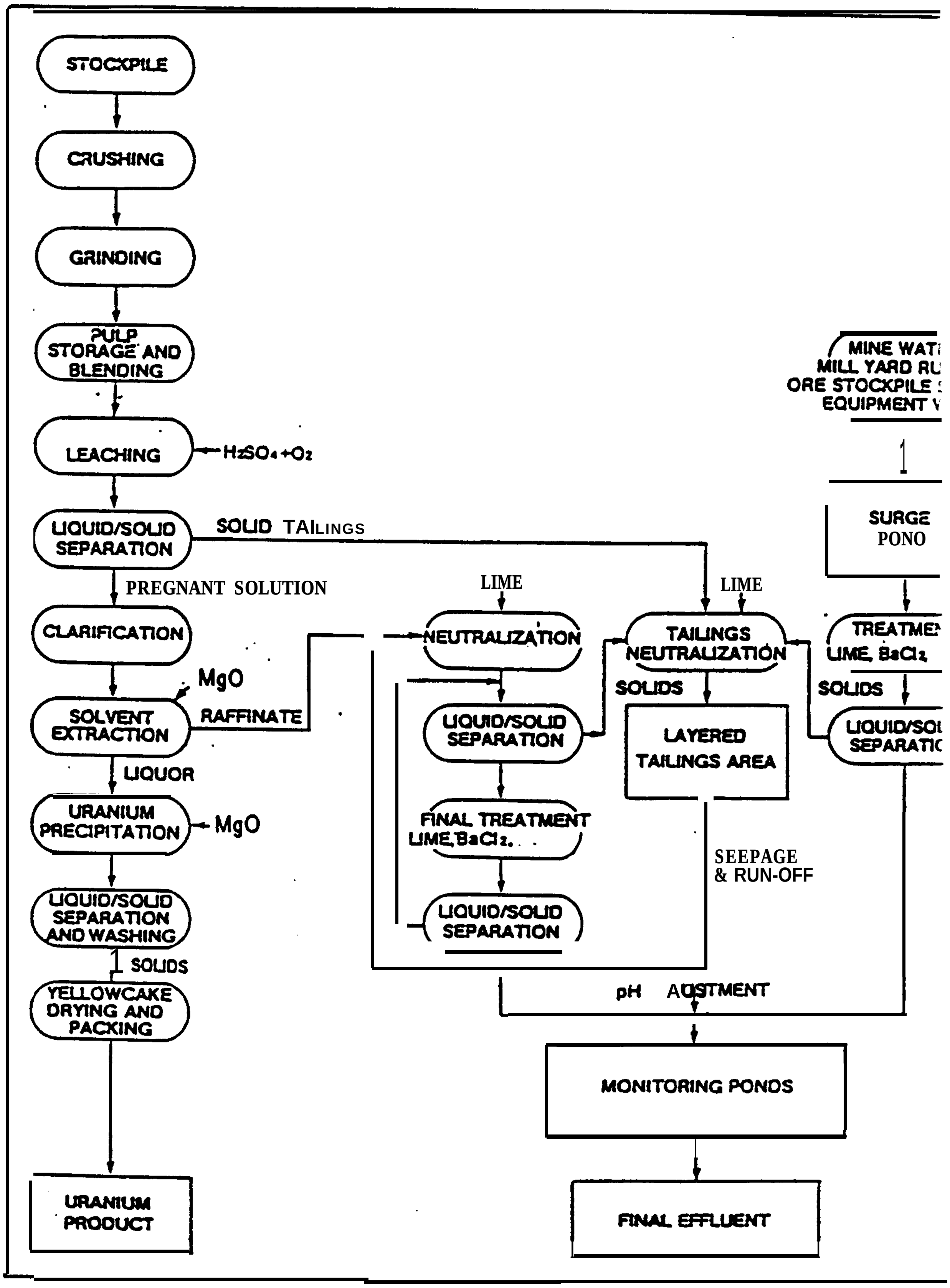


Figure 3: KIGGAVIK GENERAL PROCESS FLOWSHEET

Products from the process plant consist of uranium oxide (yellowCake), which will be drummed for shipment to southern Canada and the tailings which consist of ground-up waste rock and remnants of process chemicals.

The milling and process facility is likely to consist of four major modules - a crushing system, the main concentrator building, the counter-current washing thickeners and the solvent extraction building which has been designed as a separate structure to isolate the risk of fire. Adjacent to this complex would be located the power plant, lime plant, acid plant and the service building.

A good source of water is available for the Kiggavik project at Skinny Lake, with the distance to the processing plant being 5 km. The lake is a relatively large one, with a deep pool at the south end of the lake from where the water would be drawn. Despite requirements that will average 80 m^3 per hour, the total drawdown over a year will only be approximately 1 m prior to the annual runoff during the month of June. A simple wet well installation is planned at the site in which submersible pumps will be located.

Analysis of the proposed local water supply from Skinny Lake showed very low hardness and slight acidity (pH 6) due to lack of buffering salts. It is very acceptable as process and potable water.

The total water requirements for the project are shown in Figure 4 at average use rates. All contaminated runoff within the mine and mill areas would be contained and directed by a system of berms to surge ponds in each location. The berms direct uncontaminated runoff around the managed operating areas. From the surge ponds, the contaminated water is pumped to the mill where as much as possible is used in the process, and the balance is added to excess tailings water for treatment and discharge to the environment In this manner, use of freshwater from Skinny Lake is minimized along with effluent quantities discharged to the Pointer Lake drainage system, which in turn discharges via Judge Sisson's Lake and the Anigaq River system to Baker Lake.

2.4 Waste Management System

Care has been taken in the design of the tailings containment area and in the treatment of the aqueous effluent and atmospheric emissions To ensure that aqueous effluent discharged off-site meets regulatory requirements, monitoring ponds and recirculation

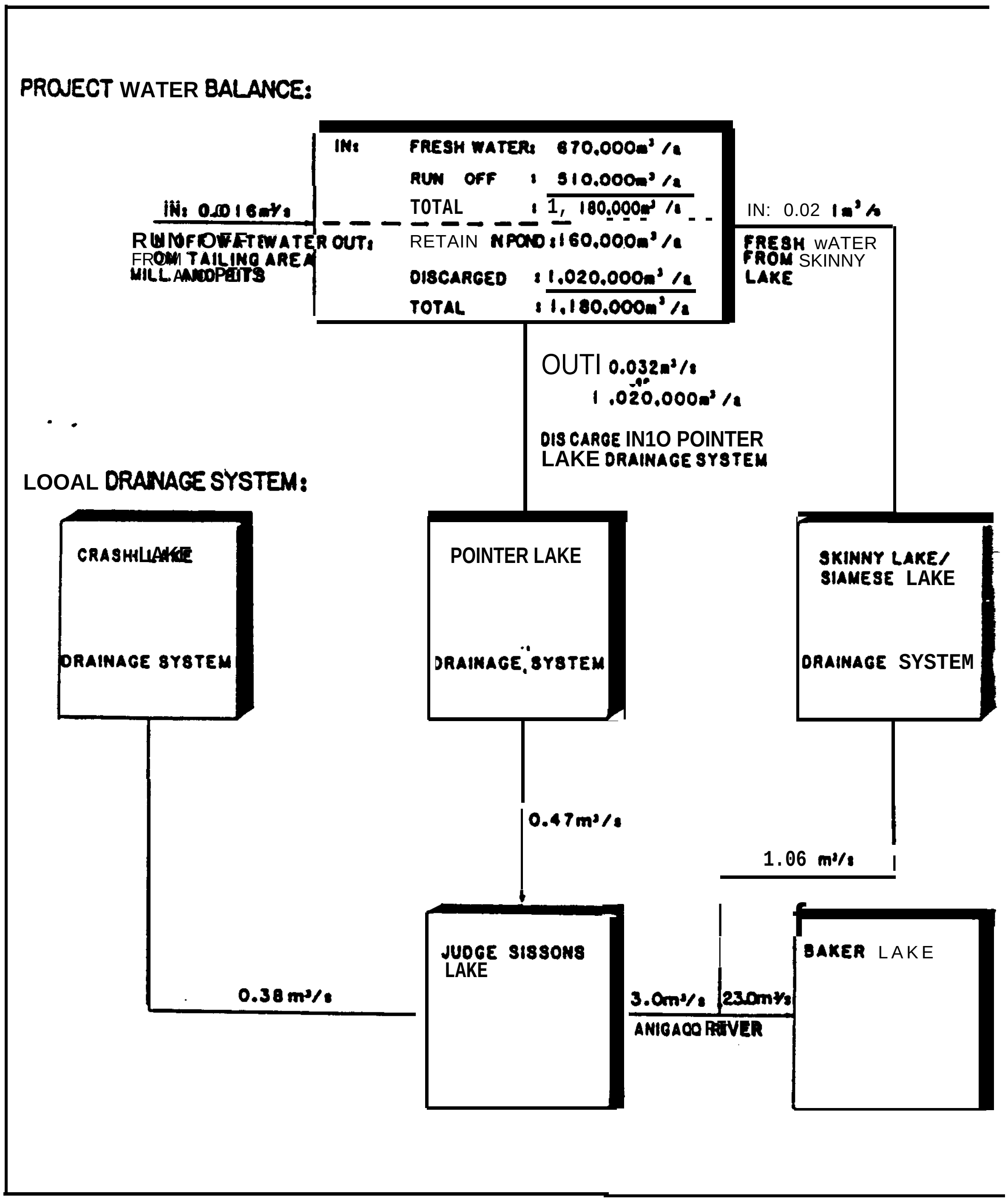


Figure 4: PROCESS WATER BALANCE AND LOCAL DRAINAGE SYSTEM (Schem

techniques will be incorporated in the design layout. All statics and vents from the facility will be designed such that atmospheric releases are minimized and, for that material which is released, adequate dispersion occurs.

Within a section of the concentrator building, all residues and aqueous effluents are combined and neutralized with lime to precipitate acid, trace metals and radionuclides in four tanks which overflow to a gravity line to the tailings pond. The tailings are expected to settle in the pond to a minimum of 70% solids, and excess water, together with the stored runoff water from the general plant area, wiii be pumped back to the wastewater treatment plant located within the mill complex.

This tailings decant and runoff water, often being pumped back to the mill complex, is further treated in four tanks by staged additions of lime and barium chloride to precipitate radium-226 from solution to meet the Federal Government regulations for radionuclides, trace elements and process chemicals. The resultant precipitate is removed from the liquor in a thickener, and suspended solids in the overflow are removed by sand bed filters.

The clarified liquor is treated with a small addition of sulphuric acid to adjust its pH to 7.0, as required for discharge, and to match the natural runoff, and then is stored for 24 hours in one *of* a series of monitoring ponds until analysis confirms that the water meets all regulations and can be discharged. Should a batch not meet discharge specifications for any parameter, it would be returned to be recycled for further treatment. Thus, the only point at which process water and site runoff can leave the mine and miii complex is through either evaporation in the tailings pond or through the radium treatment circuit.

The location of the proposed tailings management area and wastewater treatment system is shown in Figure 2.

Treated water flows are expected to be of the order of 40 L/s, and will be discharged into the Pointer Lake watershed. After mixing in Pointer Lake, effluent parameters are expected to have been diluted, as shown in Figure 4. This is based on unit aerial water yields of 10 L/s/km^2 estimated for the area. Routine verification monitoring would be carried out on the receiving stream at the outlet of Pointer Lake and at the outlet of Judge Sisson's Lake.

A return water system from the tailings to the mill for batch treatment will result in no surface discharge from the tailings management area. All potential tailings basin locations evaluated as part of the alternative siting study were located in headwater areas, and were all expected to be underlain by permafrost. At the preferred site, keying of the downstream dam wall into permafrost is possible, and thus groundwater seepage from the tailings basin to downstream areas is not expected to occur.

2.5 Sea Transportation and Docks

A key concept for this project is the assumption that a dock facility can be located capable of handling cargo vessels and fuel tankers arriving from Montreal. Field investigation of all proposed sites has not yet been carried out.

However, discussions have taken place with shipping companies that have gone through Chesterfield Inlet to Baker Lake using very small ships to deliver supplies to the Baker Lake community. In addition, the proposed program has been reviewed with shipping representatives of Imperial Oil and, after having done their own research, they express confidence that the fuel tanker fleet they use to service northern Canada would be able to arrive in the general area of a proposed dock close to the entrance of Baker Lake.

As an earlier alternative, dock sites in the Baker Lake area have been examined. This would probably mean using barge traffic from Churchill, or else transferring cargo from ship to barge near Chesterfield Narrows. This would involve more handling, including rail transport to Churchill and subsequent transfer to barges, which our analysis indicates to be a more costly alternative.

Another option is to use large barge% 120 m in length, direct from Montreal to Chesterfield Narrows. Such barges have been used in previous construction programs, and they are particularly suited for lengthy items such as structural steel and bulky items such as prefabricated housing.

The proposed dock construction at the marine terminal is very standard consisting of steel sheet piling containing granulated fill. With a width of 90 m and with the assumed water depth of 7.5 m, a dock constructed in this manner would be capable of handling a 10,000 tonne vessel.

Storage areas would be located behind the dock for reagents and other materials to await the winter road season. Fuel storage facilities as described previously, will also be located in this area, as well as some temporary accommodation for personnel working at the dock site.

2.6 overland Transportation

The Kiggavik site is located about 80 km (50 miles) from tide water and 200 km (120 miles) from a site being evaluated for a marine terminal, where 10,000-tonne tankers and 3,000-tonne. freighters can be accommodated. The bulk of materials and supplies, along with construction equipment, would be transported from Atlantic coast ports or overseas locations during the open water period, which lasts about 75 days. Storage facilities will be constructed at the marine terminal and, during the winter months, the materials, supplies and equipment will be transported overland to the Kiggavik site via a winter road. This form of transportation, which is less environmentally damaging and is much less expensive to build and maintain than a permanent road, is well established in northern Canada as an efficient transport system even over long distances.

The routing of the winter road segments from the marine terminal to Baker Lake and from Baker Lake to the Kiggavik site has not been finally determined. The route from the marine terminal is expected to go overland past Chesterfield Narrows and across the ice on Baker Lake.

It is about 90 km from the west end of Baker Lake to Kiggavik. The winter road for this segment would cross a combination of lakes, rivers and land, with the final route likely to be based on using lake ice to the maximum extent possible. In general, few problems are envisaged with the winter road.

The season for the winter road is anticipated to be January to March and, assuming 80 days are available during that period, there will be approximately 400 to 500 vehicle trips to be made using tractor-trailer combinations to move a total of about 13,000 tonnes Of dry cargo. There will be a further 13,000 tonnes of fuel to be moved with a fleet of tankers.

2.7 Airport

The construction of an airport facility, capable of handling jet aircraft for the transportation of personnel, perishable foodstuffs and urgent freight is required as part of the site infrastructure.

A series of three alternative sites for runway construction were evaluated. Based upon both environmental and geotechnical considerations, the preferred site for the airport was located within 3 km of both the processing plant and the town site (Figure 2). The site is a drumlin with dimensions of 4,500 m in length and 800 m in width, in which the longitudinal axis has a bearing of north-northwest which fortunately is the direction of the prevailing and probably strongest winds. A runway of 2,000 m in length along the axis of the drumlin will have a natural and continuous gradient of 0.45%. The average runway elevation will be at 187 m.

Flight approaches from the southeast are clear of all obstacles, while the northwest approach would be over a slight ridge on which the processing plant and campsite are located, but the Ministry of Transport has confirmed that the elevations are well within the limits for licencing the airport for landings from both directions.

Although the location of the air strip is good, the composition of the drumlin will mean that the runway must be built on top of the existing surface. A drumlin, by definition, is a glacial remnant of finely ground rock, and the resulting fine sand, silt and clay, when saturated, has very little bearing strength. Consequently, it will be necessary to cover this area with various components of fill to a depth of 13 m, which approximates the maximum depth of the thaw in the runway material. The total volume to be moved from a proposed borrow area near Skinny Lake will be about 300,000 m^3 to provide a runway surface of 40 m in width and 2,000 m in length, as well as the space required for taxiway, apron and airport building areas. Suitable material is available to the west of Skinny Lake, and would likely be transported to the airport site by a combination of trucks and large scraper units.

The airport will have basic navigation equipment, which includes a non-directional beacon, a visual approach slope indicator system (VASI) and the usual approach lights and rotating beacons.

A small airport terminal will accommodate passenger traffic and freight handling facilities, Other requirements at the airport will include mobile equipment for runway maintenance, standby power and fuel storage and handling systems for aircraft fuel.

2.8 Worker Health and Safety

Good operating and housekeeping principles will be adopted throughout the project to ensure that workers are not exposed to levels of radioactivity higher than the government-controlled safety limits. Workers will be issued with appropriate protective clothing where necessary, and all personnel will be required to wear radiation monitors which are regularly processed by the Department of Health and Welfare. In addition, a medical record system will be set up to include appropriate monitoring and surveillance systems.

3.0 ENVIRONMENTAL COMPONENT OF THE PROJECT

In order to evaluate the environmental interactions of the proposed development with the natural environment of the Kiggavik study area, it is necessary to have an understanding of the environment as it presently exists. During the last ten years, in conjunction with exploration activities in the area, data on the atmospheric, terrestrial and aquatic environments were collected.

The Keewatin District of the Northwest Territories, where the Kiggavik site is situated, is frequently referred to as "the tundra barrens west of Hudson Bay". The following sections provide a brief synopsis of the natural environment of the project area.

3.1 Atmospheric Environment

The site area is dominated by an Arctic continental climate. The snow-free period is limited to July and August. The onset of spring, defined hereby the date the daily mean temperature rises above O°C, occurs during the first two weeks of June, while fall, defined by the date the mean daily temperature falls below 0°C, begins during the last two weeks in September. Hence, the area is characterized by long, cold winters, very short transitional seasons and short, warm summers.

The controlling factors which determine the climate are the character of the solar energy input, the topography and nature of the ground surface and the dominant weather systems. A summary of the climatic data for Baker Lake, the closest meteorologic station to the site, is shown on Figure 5.

At latitude 65°N (Baker Lake 65°1 g'), the total available sunshine varies from 134 hours (4.3 hr/day) in December to 628 hours (20.9 hr/day) in June. While fog can occur throughout the year, the greater incidence of blowing snow during the winter months of December through March make them the worst months for reduced visibility. This, together with the limited hours of daylight, may be of critical importance to wintertime operational planning.

The mean annual precipitation is 235 mm, with maximum precipitation occurring during the summer months, June to September.

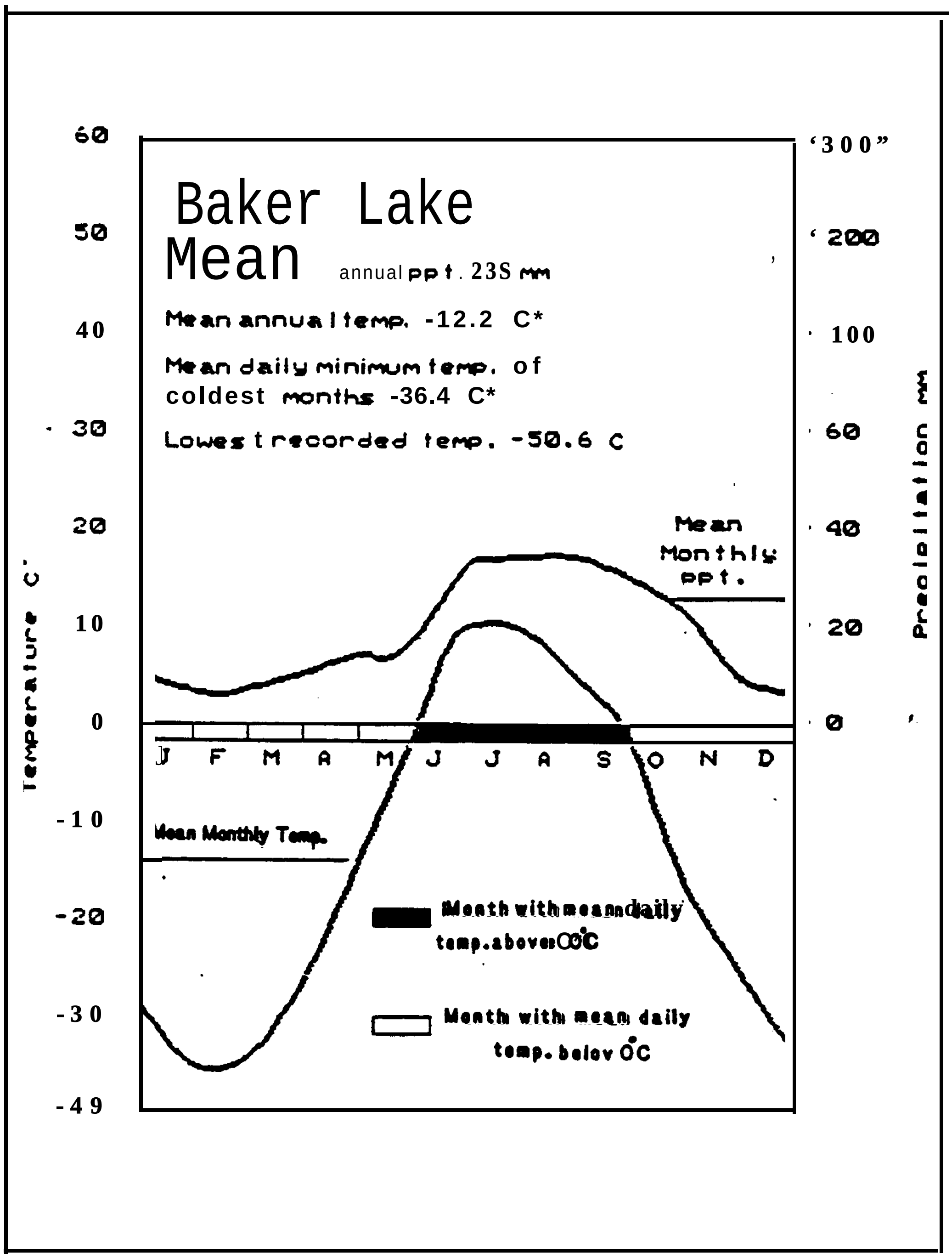


Figure 5: SUMMARY CLIMATOLOGICAL DAJA

The dominance of winds from the sector north through northwest is evident. During the winter months of December through March, winds from north, north-northwest or northwest blow (on average) for more than SO% of the time. Northerly winds prevail during every month of the year (except September, north-northwest).

Due to the frequency of calms, especially during the winter months, the annual mean wind speed of 21.6 km/hr probably understates the actual likely wind speeds. For the dominant directions of north, north-northwest and northwest (occurring 45.2% of the time), the annual means are 27.9, 29.5 and 25.0 km/hr, respectively. The lowest mean wind speeds occur for winds from the south, south-southwest and southwest at 13.7, 13.6 and 13.1 km/hr, respectively, but winds from these three directions occur only 4.4% of the time. Calms occur throughout the year, but are most likely during February through April and in July.

In order to evaluate how the project may affect the local environment, and how the project design may be affected by the local climate, it is first necessary to evaluate the representativeness of the Baker Lake data to the Kiggavik area.

The Kiggavik site lies at an elevation of 180 m approximately 75 km west-northwest of the Baker Lake station (elevation 12 m).

The intervening terrain is undulating and contains numerous lakes and river valleys oriented in a northwesterly direction. The highest ground between the project site and Baker Lake rises to 230 m, approximately 30 km due east of the site.

In general terms, considering the amount of data and length of record available at Baker Lake and its close proximity (compared to other similar operations in the Canadian North), the Kiggavik site can probably be considered to be well represented by Baker Lake data, especially as the terrain is oriented in roughly the same direction as the prevailing wind.

Differences in the meteorological conditions between the project site and Baker Lake are likely to be caused by the higher elevation of the site, the effect of Baker Lake during the ice-free season, and the siting of the Baker Lake Station at the head of the lake and Chesterfield Inlet.

Considering only the difference in elevation, mean temperature and minimum temperatures may be expected to be up to 1'C lower at Kiggavik. The higher elevation would also lead to a slight increase in wind speed and, during frontal passage of summer storms, a greater incidence of low cloud/fog and a slight increase in precipitation.

3.2 Terrestrial Environment

As part of the 1986 environmental studies, an Ecologic Land Survey (ELS) was carried out over an approximate 1,200 km^2 in an area located 85 km west of Baker Lake, Northwest Territories, and centred on the Kiggavik project site (Figure 6).

Field traverses in the vicinity of the Kiggavik base camp and the Skinny Lake area were made. These traverses planned from review *of* aerial photography were used to assist in the identification of areas potentially sensitive to disturbance by project activities.

A number of representative soil pits were *dug on* various landforms in the Kiggavik area, and complete pedological descriptions made. Samples of each horizon described were taken for subsequent chemical and physical analyses. At each site, where a soil pit was excavated, a 10 m x 10 m vegetation plot was established. A list of all species occurring on the plot and estimates of percentages cover were made.

The surficial materials in the study area can be grouped into three major deposits:

- glacial deposits including tills and glaciofluvial materials;
- fluvial deposits resulting from activity within the last few thousand years; and
- organic deposits resulting from the gradual accumulation of peat materials.

Minor deposits of lacustrine materials have been recognized in the Squiggly Lake area, and along shorelines of larger lakes where ice-pushed sandy materials may occur. Their occurrence is of limited areal extent.

Soils of the Kiggavik study area are predominantly Cryosols, and are characterized by a shallow active layer (30 to 50 cm), various amounts of ice in the perenially frozen horizons and a cold soil climate. *Cryogenic* processes, especially cryoturbated soils, are

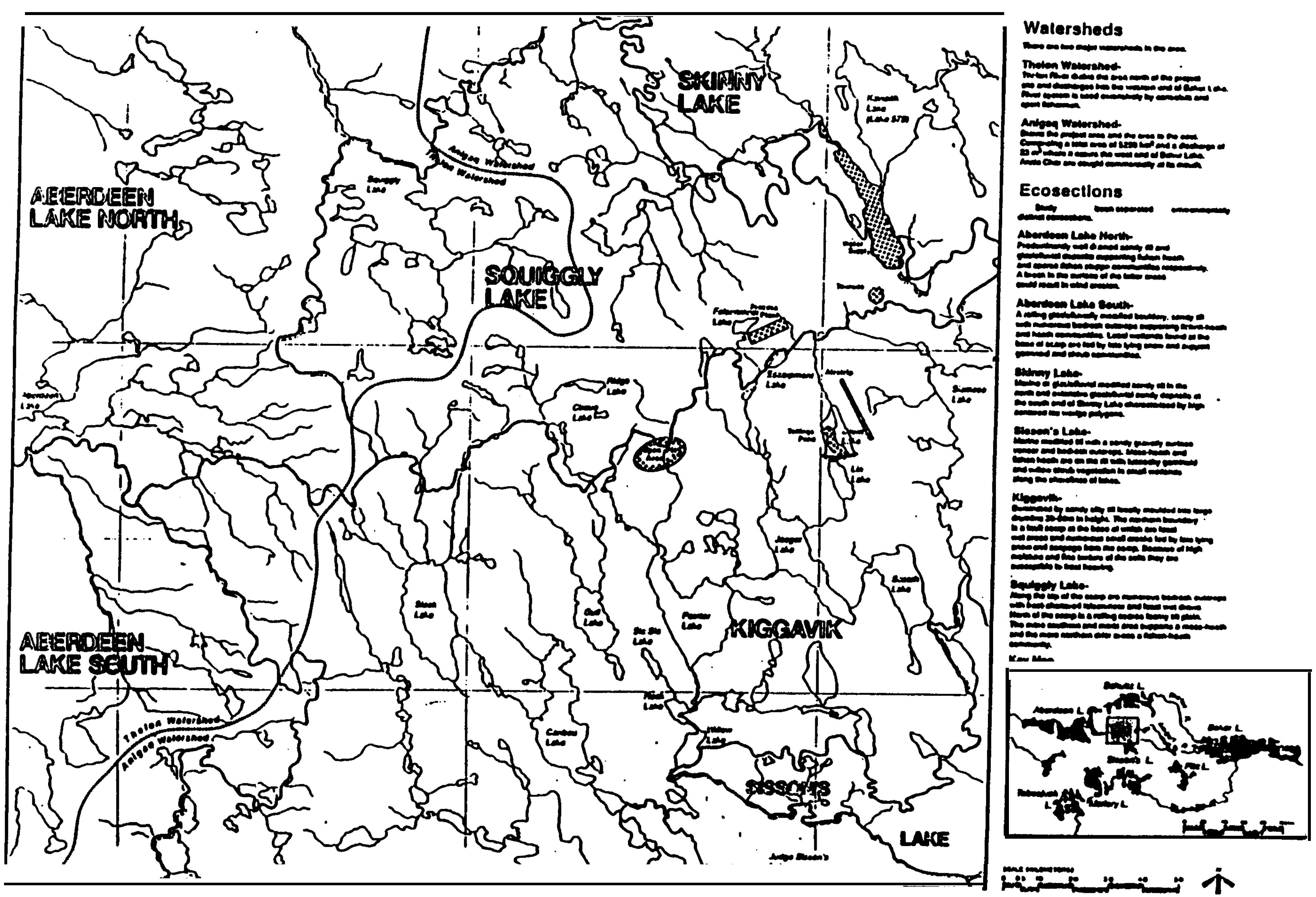


Figure 6: ENVIRONMENTAL BASEL NE MAP

often recognized or associated with patterned ground features such as sorted and non-sorted nets, circles, polygons, stripes and hummocks.

A total of six ecosections were identified in the study area. These ecosections have been generalized from the 177 ecosites representing distinctive land areas with similar landforms, soils and vegetation characteristics. A brief summary description of each of the ecosections is presented in the legend on Figure 6.

393 Aquatic Environment

The aquatic environment of the study area can best be described by its physical drainage system and its chemical characteristics.

3.3.1 Surface Water Drainage

The Kiggavik site is located within the central Keewatin District in an area drained by Baker Lake, which flows into the Chesterfield Inlet and Hudson Bay. Major water resources in the region include the TheIon River, including two large waterbodies - Schultz Lake to the north and Aberdeen Lake to the west. Judge Sisson's Lake is a relatively large regional lake south of Kiggavik, and drains the Kiggavik area. Judge Sisson's Lake flows into the Anigaq River. Both the Anigaq River and the Thelon River flow eastward into the western end of Baker Lake. Numerous smaller lakes, ranging from small, shallow ponds to deeper lakes with surface areas exceeding 25 km^2 are distributed throughout the region.

Runoff and streamflow characteristics in the region are governed by topography, soil and plant communities and meteorological conditions The cold Arctic climate results in the development of a thick layer of ice on surface water for about eight months of the year. Runoff is negligible and stream flow is greatly diminished or, in some cases, arrested under these conditions. Approximately 42% of the 235 mm of precipitation falling at Baker Lake is snow, with the remainder falling as rain in summer and early fall.

Snowmelt is the largest source of water to regional watersheds. Peak runoff occurs when meltwater exceeds the storage capacity of upland and lowland (wetland) soils. Storage capacity is low in late spring before the surface soils have thawed. [n summer, a deeper frostline in the soils, and evaporation of soii water result in greater storage of water in the basin and reduced runoff. A schematic representation of the physical flow regime in the Kiggavik area is presented in Figure 4.

3.3.2 Water Quality

Within the region bounded by Schultz Lake, Aberdeen Lake, Baker Lake and Judge Sisson's Lake, limnological investigations were conducted by Urangesellschaft Canada Limited. The Department of Fisheries and Oceans has conducted extensive limnological investigations on experimental lakes at their Saqvaqjuac research site, 36 km north of the settlement of Chesterfield Inlet.

Regional surface water is ice-covered for much of the year, with larger lakes such as Schultz and Judge Sisson's covered until late June or early July. The lakes are generality homogeneous in temperature with depth, during the ice-free season, with typical maximum temperatures of 8 to 12°C in larger lakes, and 15°C in smaller, shallow lakes.

Oxygen depletion occurs over winter, as observed in Judge Sisson's Lake. Surface waters in the region are very dilute and slightly acidic, with low concentrations of dissolved ions.

3.3.3 Lake Sediments

Lake bottom substrates vary from rock, boulder and sand in shallower areas to soft light to dark brown, organic-rich sediments in deeper depositonal areas. Lake sediments in shallow areas (less than 2 m deep) have characteristic parallel ridges and valleys formed from ice action roughly at right angles to the shoreline. The elevation difference between ridges and valleys is typically about 50 cm near shore, and diminishes with depth.

The surficial light to dark brown sediments are typically 2 to 10 cm thick, and usually have an underlying layer of tan or grey deposits.

3.4 Biological Components of the Project Environment

3.4.1 Vegetation

The study area lies within the low Arctic ecosystem, and is characterized by a continuous vegetation cover broken only by bedrock outcropping or active aggraded surfaces. This continuous vegetative cover is composed of a variety of foliose, squamulose and fruticose lichens, together with various moss species in the surface ground layers, by ericaceous shrub and heath species, and by a variety of herbs, grasses and sedges.

Vegetation conditions vary "over the study area, but are generally related to various soil substrate types, and reflect differences in moisture conditions.

3.4.2 Caribou

Two major barren-ground caribou (Rangifer tarandus greenlandicus) populations occur regionally: the Beverly herd and the Kaminuriak herd.

The Beverly herd winters in the boreal forest between Great Slave Lake and Lake Athabasca. Occasionally, small groups winter on the tundra south of Aberdeen Lake in the Majorie Hills area (Marjorie, Mallory, Wharton and Princess Mary Lakes). In spring, the animals migrate northeastward into the high lands between the TheIon and Dubawnt River valleys. Calving generally occurs northeast or south of Beverly Lake, as far north as the Carry Lakes, and as far eastward as Deep Rose Lake. The herds then move southwestward to pass between Sand Lake on the north and Princess Mary Lake on the south. Traditional crossings of the TheIon River occur between Beverly and Aberdeen Lakes, along the fingers of land in Aberdeen Lake, or across the three fingers of land between Aberdeen and Schultz Lakes. The Kaminuriak herd ranges south of Baker Lake. The calving area is in the Kaminuriak and Kaminiak Lake areas. Post-calving aggregations are in the lower Kazan River and the Yathkyed and Hanik Lake areas. Major traditional crossings are in the Kazan Falls area and Thirty Mile Lake.

The Kiggavik site itself is generally unaffected by the Kaminuriak herd and only to a limited extent by the Beverly herd. Studies carried out in the Kiggavik area in the late 1970's and early 1980's confirm regional survey results that, although the main herd is located well to the north, west and southwest, a few animals, primarily male bulls, do separate from the main herd and venture through and lightly use the Kiggavik area.

3.4.3 Birds and Other Species

The most important small mammal species of the area include red-backed vole (Clethrionomys rutilus), brown lemming (Lemmus sibiricus), greenland collared lemming (Dicrostonys torquatus) and meadow vole (Microtus pennsylvanicus). other species observed in the Kiggavik area during the studies included wolf (Lupus hudsonicus), Arctic fox (Alopex lagopus innuitus), grizzly bear (Ursus arctos horribilis), ermine (Mustela ermines richardson i), Arctic hare (Lupus arcticus) and Arctic ground squirrel (sPermophilus parryii). Muskox (Ovibus moschatus), masked shrew (Sorex cinereus) and wolverine (Gulo gulo luscus) are known to occur in the area.

Numerous avifaunal species are known to frequent the Kiggavik area; however, species diversity is iow (47.2 birds/ha). Studies in the area indicate that the most commonly observed species include Lapland longspur, horned lark, herring gull, oldsquaw, dunlin, golden plover, Baird's sandpiper, Arctic tern, ptarmigan and Canada goose. Four species of raptors are known from the area, including peregrine falcon, snowy owl, short-eared owi and rough-legged hawk. The peregrine falcon and rough-legged hawk have been observed east of the Kiggavik site.

3.4.4 Fish

Mean and maximum water depths of study area lakes dictate, to a large degree, the fish populations found in the lakes. Lakes with a mean depth of under 1 m tend to be fishless within the study area, likely due to winter habitat limitations. Ice cover tends to be from 1 to 2 m thick on most lakes.

Those lakes with mean depths greater than 2 m tend to provide the best habitat conditions for fish. in these lakes, both species diversity and relative abundance appear considerably greater than in the shallow lakes. The four major species (lake trout, Arctic grayling, round whitefish and cisco) are broadly distributed within the study area, where habitats are suitable, and are typical of the fish fauna found in similar Arctic environments.

The distribution and relative abundance of major fish species in study area lakes are presented in Table 3.

The lakes in the study area, the distribution of which is illustrated in Figure 7, may be broadly classified intro

- the escarpment headwater lakes which have small isolated populations;
- the tundra plain lakes at a slightly lower elevation and generally shallower than the headwater escarpment lakes which have sparse and, in many cases, transitory fish populations; and
- the regional mainstream lakes which, being larger and deeper than the first two groups, support more diverse and larger fish populations.

Because of the cold mean water temperatures in these lakes, fish growth rates and productivity are very low.

3.5 Environmental Baseline Radiation Levels

Natural background radiation exposure from uranium minerals occurs through three major routes. The first is through exposure to radon gas and its airborne decay products. The second is through exposure to gamma radiation arising from the decay of gamma-emitting radionuclides found principally in the soil, on the ground surface and in vegetation. The third route is internal through ingestion of water and food stuffs containing radionuclides.

In order to measure background levels of radon gas found around the study area, a series of radon detectors were deployed. Measurement of background gamma radiation was carried out through the use of scintillometer surveys. Levels of radionuclides in vegetation were monitored using moss samples, while watershed input was monitored using lake sediments and fish tissue.

There is a gamma radiation anomaly in the study area associated with the surface expression of the ore body. Gamma radiation levels are at about the 0.03 mr/h level in the general study area, increasing to 0.5 to 5 mr/h over the ore body.

Lake	Lake Trout	Arctic Grayling	Round Whitefish	Cisco
Escarpment	A	C	A	
Felsemeer	A	A	A	
Meadow Ridge (80 North)	A			
Cirque		A		
Drum		A		
Lin		A		
Sik Sik				
caribou	S	C		
Willow	C	C		
Sissons	A	S	C	C
Pointer	S	S		C
Scotch	A		A	
Skinny	A	S	A	C
Kavisilik	A	S	C	A
Squiggly *	A	S	A	

A = Abundant
C = Common
S = Scarce

* = Lake outside project development area.

Table 3: DISTRIBUTION AND RELATIVE ABUDANCE OF MAJOR FISH SPECIES IN STUDY AREA LAKES

Figure 7: GENERALIZED CLASSIFICATION OF STUDY AREA LAKES

Background radon gas levels over continental air masses are generally found to range from 1 to 10 Bq/m^3, whereas the levels in the Kiggavik area were found to range between 2 to 80 Bq/m^3.

These anomalous radiation levels associated with the ore body do not appear to be reflected in the lake water, vegetation or fish in the areas that were sampled. Anomalously high radiation levels were noted in a small seepage stream draining the area of the ore body.

4.0 ENVIRONMENTAL INTERACTIONS

4.1 Atmospheric Interactions

The operation of a mine and milling complex at the Kiggavik site will result in the release of a variety of materials to the atmosphere The facility will be designed such that these emissions will be at concentrations prescribed by regulations for the atmospheric conditions in the project area. The downwind concentrations will be controlled such that no significant environmental or public health effects occur. The major sourçes of atmospheric releases that must be monitored and controlled through proper facility design include:

- open pit,
- mill complex,
- acid plant, and
- tailings area.

4.2 Terrestrial Interaction

Increasing attention has been focused on the effects on Arctic ecosystems of major construction operations. Although relatively little is known about the impact of major development activities on Arctic ecosystems, if potential problems resulting from the development can be identified early, steps can be taken to minimize the degree of disturbance and encourage a rapid return to natural conditions. During the development of the project, disturbance to the terrestrial community is expected to occur due to both direct disturbance because of construction activities, and potentially indirect disturbance related to drainage system alterations.

The possibility of using existing natural basins as tailings ponds or reservoirs raises the question of potential instability on the adjacent confining slopes. This is to be evaluated further during the engineering feasibility study stage.

Although two major caribou populations occur regionally, the Kiggavik site itself is generally unaffected by the Kaminuriak population, and only to a limited extent by the Beverly population. Scattered individuals have been observed in the study area notably along the top of the escarpment. The development, as proposed, is not expected to have any effect on the herds in the area.

Peregrine falcons are known to nest in the Skinny Lake area along the escarpment. Development is not planned for the areas utilized by the falcons, and they are not expected to be affected.

4.3 Aquatic Interaction

The aquatic environment in the project area and along transportation corridors to the site can potentially be affected by a range of operations. These can generally be broken down into chemical effects on lakes and streams, physical effects related primarily to changes in flows and water levels, blockage of migration routes and siltation effects related to construction activities, and effects on standing fish stocks related to fishing.

Water quality will be controlled by federal mining and milling effluent standards. Discharge of effluent at these levels may have short-term minor effects in the first receiving lakes related to changes in ionic strength, but measurable ecological effects are not expected to occur beyond Pointer Lake.

4.4 Socio-economic Considerations

The socio-economic effects of the project will be commensurate with the employment potential of the project and the expected project duration. These impacts are expected to focus directly on employment in the Keewatin and northern business opportunities. The effects may be expected to be both of a local nature affecting primarily the residents of Baker Lake and of a more regional nature extending to several communities throughout the Territories through direct employment and business opportunity.

In order to ensure that benefits of the project accrue to the local and territorial population, Urangesellschaft will institute a series of company polices. This will include:

1. the preparation of a Human Resources Development Plan in cooperation with the government of the Northwest Territories
2. the development of a general hiring policy for Urangesellschaft and its contractors;

3. Urangesellschaft will evaluate the feasibility of air charter links to selectee communities in the eastern Keewatin and the availability of occupational skills within the local labour force(s); and
4. Urangesellschaft will work with the Government of the Northwest Territories to assemble referral lists of Urangesellschaft and/or contractor employees.

From these lists, qualified northern residents will be placed in a labour pool that could help to provide employment during the construction phase of the project for various positions, including trades helpers, equipment operators and labourers. Qualified and interested labour pool members would then be in a good position for continuing employment at the mine and mill facility following completion of construction activities.

In addition to providing direct employment, the project is. expected to offer the opportunity for northern business participation. In order to ensure this, Urangesellschaft proposes to develop a series of project policies that will:

1. *encourage* the Northwest Territories government to develop a list of northern vendors, contractors and other businesses in a position to supply goods and services to the mining industry;
2. based upon this list and businesses who present their qualifications to Urangesellschaft directly, the company will maintain an internal list of qualified contractors and vendors that will be updated on a regular basis;
3. in order to assist local businesses, the company will, at periodic intervals, prepare a brief status report on upcoming activities;
4. all contracts will be tendered by invitation only; and
5. to facilitate local business involvement, Urangesellschaft will, where possible, ensure the size of individual contracts are not so large as to exclude northern businesses from bidding.

4.5 Potential Mitigation Measures

The project is conceptually designed such that residual impacts have only very local impacts on wildlife and fishery resources which are not expected to have an effect on individuals dependent upon hunting, trapping or fishing for their livelihood. If, however, a negative impact is identified directly associated with the project, Urangesellchaft will:

- meet with the affected individuals to discuss the nature of the problem; and
- undertake all reasonable actions to mitigate against the impact.

4.6 Summary of Impacts and Mitigating Measures

The following general conclusions may be drawn concerning the development of the Kiggavik Project to the west of Baker Lake.

4.6.1 Atmospheric

1. On "the basis of studies carried out to date it would appear that if air emissions from various project processes are controlled with modern 'state of the art' technologies the impact on the surrounding environment should be insignificant.

2. Releases of radon gas and radioactive dust from open pit and haul road operations should be at iow enough levels so as to not preclude the development and operation of the mine. This area will require more detailed investigation specifically as it relates to worker health and safety considerations.

4.6.2 Terrestrial

1. The project site area contains a mixture of terrestrial environments that are sensitive to disturbance. The site layout is such however, that the site can be developed around sensitive areas such that no major vegetation or landform disturbance need occur.

2. Based upon the nature of the conceptual development outlined, no significant impacts on wildlife populations in the area are expected as a result of site development and operation.

4.6.3 Aquatic

1. If the mill can operate such that levels of water quality parameters in the discharge do not exceed those levels set by government, then any readily measurable effects on the aquatic environment should be localized to Jaeger

Lake and the stream connecting Jaeger and Pointer Lakes. These effects tile be minor, and the system should recover following decommissioning.

2. Regulations will be set in place to avoid over-fishing in local lakes, and thus protect these local populations.

3. Local drainage disturbance during construction of site roads need not result in anything but minor impacts of a local and short-term nature.

4. No. ecological or contamination effects of the proposed development are predicted that may affect the fishery in the Baker Lake area.

4.6.4 Socio-economic

The project has the potential to bring to the region significant economic benefits if it is carried out in a proper manner. In order to assure this, a series of project policies will be implemented, incl-

- working with local authorities and the local communities in order that they will know what types of employment will be available and can gain the necessary training;
- offer preferential employment opportunities to local persons if the interest and necessary *ills are available;
- offer preferential opportunities to local businesses providing that the quality of product and price are competitive and
- work with the local communities to ensure a smooth transition into employment during project development and into alternative employment in the decommissioning phase of the project.

To mitigate against loss of any archaeological resources, archaeological studies of facility locations and corridors will be carried after siting has been identifed and prior to project development.

5.0 DECOMMISSIONING CONCEPTS

After the anticipated minimum ten-year operational life, and in the event that no additional mineable reserves are located, it wiii be necessary to carry out decommissioning of the Kiggavik mine and milling facility. Decommissioning is the process of returning the land to a state as dose to the way it was found as is reasonably practicable.

5*1 Open Pits

The open pit would be allowed to flood such that a small but deep lake would be formed. This lake may naturally or could be induced to become meromictic. Consideration would need to be given as to the influence of deep permafrost on the non-circulating water deep in the flooded pit. Monitoring will be carried out to verify that residual trace element and radionuclide movement is principally downward into the deep waters of the lake and not out of the lake.

5.2 Waste Rock

The waste rock runoff water will be monitored to ensure that trace levels of uranium and other elements do not contaminate the downstream environment The waste rode at decommissioning would be left uncovered with the expectation that precipitation seepage into the waste rock would allow ice and permafrost build-up in the pile to within a couple of metres of the surface. The large surface cavities in the rock pile are expected to provide ideal denning sites for some mammals in the area.

The subgrade ore which is stored in a separate area on the upstream side of the open pit Wiii be milled or left. If it is left, it wiii be covered with dean waste to a depth of 2 m, with the anticipation that permafrost will set up in the subgrade ore and the active layer be restricted to the clean overlying waste rock. This concept Wiii be monitored. However, as subgrade ore is placed on the upstream side of the pit in case of a future thaw, it is expected that the majority of contaminants leaching from the pile would be trapped in the deep non-circulating waters of the pit lake. Measurable natural seepage from uraniferous bedrocks presently takes place in the area of the proposed open pits without any significant environmental effect being observed downstream.

5.3 Mill Site

All of the mill complex buildings and equipment will be removed and used elsewhere, or sold as scrap after decontamination. The site would be leveled such that only concrete pads were left. These are expected to eventually frost shatter and blend in with the landscape. The area of the mill will be monitored to ensure that no spills are left and contaminant levels are reduced to regulated levels. Culverts and bridges will be removed and roads broken up to allow the establishment of native vegetation.

5.4 Tailings Management Area

The tailings dam will be reinforced with waste rock to a level which precludes washout if the permafrost were to thaw in the future. The surface of the tailings will be covered with 1 to 2 m of till such that the tailings are completely within the permafrost zone. The surface will then be gently contoured such that sheet or gully erosion does not occur and allowed to revegetate. This concept, which is subject to a more detailed review during the feasibility stage of the project, is expected to meet regulatory requirements as it is expected to create a situation where any post-operational release of radionuclides from the project area would be less than operational releases, and these releases would continue to decrease with time.

5.5 Facility Infrastructure

The campsite and marine terminal, if they are to be decommissioned, would be treated in the same manner as the mill, with buildings being removed or sold as scrap and the area being returned to as natural a condition as practical. Also, the airstrip surface, if not required, will be broken up and allowed to revegetate naturally.

5.6 Post-Closure

Monitoring would follow decommissioning. The company would submit to an inspection by regulatory authorities to ensure that the activities had complied with licence conditions. After site decommissioning has been approved, the company would monitor the site under the supervision of the regulatory authorities for a given time period in order to demonstrate compliance. After that period, the land would revert to the original owner.

6.0 PROJECT SCHEDULE

A general long-term program for Kiggavik for the purpose of this project, assuming positive developments as the project proceeds, can be summarized as follows:

- 1988-89 - completion of full feasibility study and environmental approvals
- 1989-90 - production decision
- 1990-93 - construction period
- 1993/94-2003/4 - production and mining of presently defined mineable reserves
- 2004- . continuing production if additional mineable reserves are defined, otherwise decommissioning and site rehabilitation

The inland location of Kiggavik has much to do with the unusually long period leading up to the attainment of commercial production.

No permanent access to the site results in a much longer construction period than for locations that would have continuous year-round access. Most of the equipment and material required for the project will likely be shipped from Montreal to the proposed dock stie, with arrival in late summer of each year. In the case of items with long delivery, they would have to be ordered many months before leaving Montreal. Once off-loaded, material must then await the winter road season from January to March in the following year, with the exact length of the season depending very much upon ice conditions. Delivery of equipment and supplies to the project site could take six to nine months from the time of leaving Montreal.

Following a review of this project concept description by the appropriate regulatory agencies and a review of their concerns about the project concept, modifications will be made and additional data will be collected to be used in the preparation of an environmental assessment for presentation in early 1989.