INITIAL ENVIRONMENTAL EVALUATION:

KING POINT QUARRY

(FINAL REPORT)

PREPARED BY:

PETER KIEWIT SON'S CO. LTD.

1983.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF EXHIBITS

[illegible]

1.0 EXECUTIVE SUMMARY

Beaufort oil is needed now in Canada. Large sums of money have been expended to locate potential petroleum reserves. Exploration on a large scale still continues in both the Canadian and U.S. Beaufort Sea areas. The production phase of development plans will start soon. Early production, or "first oil" may be achieved in the Canadian Beaufort region as early as 1986.

Earth filled islands are the main drilling platforms used in the shallow waters of the Beaufort Sea. Artificial island platforms will continue to be built for both exploration and production drilling. These islands are presently being built by foreign companies using dredging techniques. Using this technique, sand is dredged from the ocean floor and pumped or placed to form artificial islands. At depths greater than 25m, the cost effectiveness of conventional artifical islands becomes questionable. At these depths, material quantities become unmanageable in one season with any reasonable amount of equipment.

New techniques using stone to steepen the slopes of islands have great promise. By utilizing quarried stone, artifical island side slopes can be considerably steepened. Sand islands commonly have 5 or 7 to 1 slopes while stone islands can be built with slopes of 1½ or 2 to 1. Using stone, even shallow water islands can be built with 50% less material. Quarried stone islands are also considerably less errosive and more stable than sand islands. To date, sufficient quantities of stone have not been located to serve this potential market.

Peter Kiewit Son's Co. Ltd. has located large quantities of acceptable stone and propose to develop a rock quarry in the northern Yukon. The proposed quarry is about 9 miles south of King Point (Fig. 1.1). The physical development would consist of a rock quarry, 9 miles of haulroad to the sea, a dock and loading facility for loading rock into vessels, plus the necessary supporting camp and airstrip.

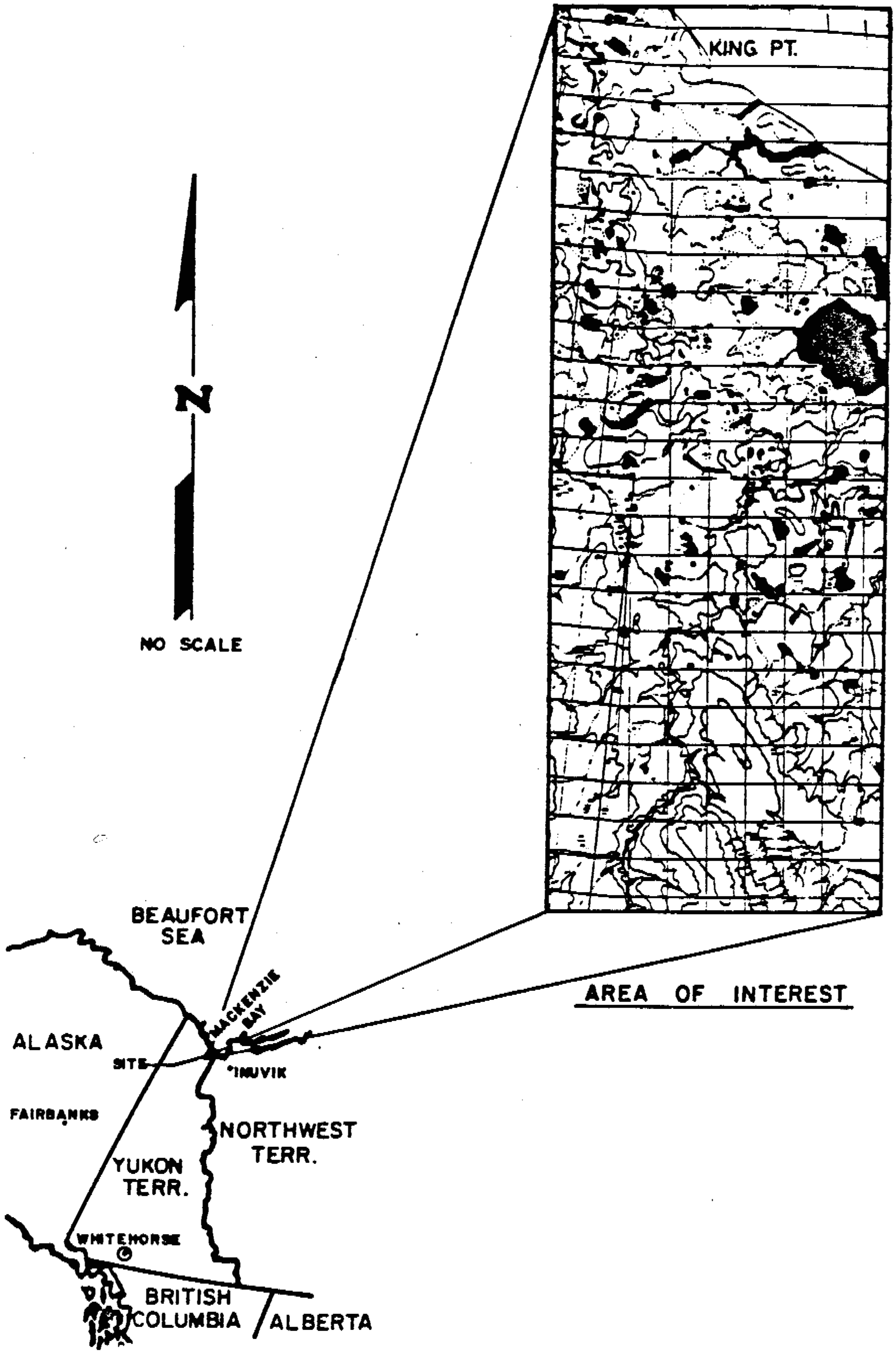


Fig. 1.1 Project area location

quarry life is expected to be 20-25 years. Total surface disturbance for the entire operation through quarry life would be approximately 1,400 acres. 566

Recent publications have reported on industries' concern over the growing costs of building artificial islands. The government of Canada is also concerned because of their significant participation in these costs. Kiewit believes that by using rock construction for both support of floating caissons and for complete islands, we can substantially improve upon current costs now experienced. In addition, rock construction will provide materials that are more stable and more capable of withstanding required loading.

The project will allow for the establishment of a new Canadian based method of artifical island development in both the Canadian and U.S. Beaufort. This method will allow Canadians to compete on both technological and cost basis with the current virtual monopoly enjoyed by foreign dredges now working in the Beaufort. If necessary approvals are gained in time the company estimates an initial export market (sales in U.S. Beaufort) in the range of $80 million to $100 million annually. Subsequently, as exploration and development activity is established in the Canadian Beaufort, additional sales in this area are expected. Early permit responses are necessary before U.S. oil companies are forced to contract for other construction techniques because of the lack of rock.

The most important environmental impacts associated with this project are increased access and activity in a previously undisturbed area. Impacts may occur to caribou through increased stress related to activity along occassionally used migration corridors. Uncontrolled access could also cause increased hunting mortality.

Mitigation measures to be implemented include: normally accepted practices for processing sewage and refuse; strict control of access hunting and fishing activities in the project area; mandatory environmental education programs for all project personnel; monitoring programs to evaluate effects of the project and development of realistic environmentally useful mitigation programs.

As the result of project mitigation measures, most impacts will be returned to levels nearly equal to pre-project conditions. However, some residual impacts can be expected. These impacts, including temporary loss of 1,400 acres of wildlife habitat, increased access to the area and associated wildlife mortality, are not expected to have major impacts on the Yukon Beaufort Coast.

Primary public concerns will probably relate to possible project impacts on the Porcupine Caribou herd and possible impacts on the bowhead and beluga whales. Concerns may be expressed about haulroad traffic disrupting caribou migration and the effects of increased access on hunting mortality. Additional concerns may address effects of increased marine traffic on migrational patterns and use areas of bowhead and beluga whales.

Although the project area lies outside of the proposed National Park boundary, some comments may be received regarding this matter. Additional concerns may be voiced about industrial activities, in previously undisturbed areas.

Native groups such as COPE and CYI may express concerns about approving development of the Yukon coast before final settlement of pending land claims.

Kiewit, in accordance with IEE guidelines, relied on existing applicable data to prepare much of this document. Because of this and the short time period available to collect site specific data, some data gaps do exist. As an example, site specific geotechnical data was not available for the port area. In order to collect the necessary data, Kiewit plans to drill through the sea ice this winter. Kiewit believes there are no substantial knowledge or data gaps which would limit the proper evaluation of this project.

ACKNOWLEDGEMENTS

The following is a compilation of numerous publicly available documents, personal communication with knowledgeable experts and on-site field evaluations. In some instances, site specific information was lacking. However, information obtained in adjacent and/or similar areas was utilized if the data were indicated to be transferable to the project area.

Excerpts utilized in whole or in part within this document, unless otherwise noted, were from one of the following publications:

LGL Ltd. and ESL Ltd. 1982. A biological overview of the Beaufort and Northeast Chukchi seas. prep. for Dome Petroleum Ltd., Calgary.

EIS Task Force. 1976. Alaska natural gas transportation system - final environmental impact statement. BLM-USDI Washington, D.C.

Hydrocarbon development in the Beaufort Sea - MacKenzie Delta region. 1982. Environmental impact statement. Arctic Institute of North America, Calgary.

Arctic Gas Biological Report Series, Prepared by Northern Engineering Services Co. Ltd.

Allan R.B. and G.R. MacKenzie - Grieve. 1983. Water quality and biological survey of Stokes Point and King Point, Yukon - Beaufort Sea coast. Environment Canada, EPS - Pacific Region. Yukon Branch. (Draft Document)

2

2.0 PROJECT SETTING

2.1 DECLARATION

The proponent, Peter Kiewit Sons' Co. Ltd. (Kiewit), will be responsible for all statements and judgments brought forth in this Initial Environmental Evaluation (IEE). Questions or problems that may arise as a result of this IEE should be brought directly to the attention of the project coordinator Mr. John Loewen, at Suite 201, 1183 Finch Avenue West, Downsview, Ontario M3J 2G2.

2.2 NEED

Oil and gas exploration in the Chukchi-Beaufort Sea area has been successfully undertaken during the past 17 years. However, current information received from the Canadian Oil and Gas Land Administration (COGLA) indicates that potential onshore hydrocarbon discoveries in the area of our proposed quarry are relatively low.

Artificial islands are presently being built in the Arctic to serve as drilling platforms for exploration and development of hydrocarbon resources. Examples of such islands can be found in both the Alaskan and Canadian Beaufort Sea, where the construction of artificial islands has become the number one method for constructing drilling sites. The use of artificial islands has boomed since the first were built by Esso Resources Canada and Imperial Oil Limited in 1972. Esso now has 17 islands, and Imperial has nine. In addition Dome, SOHIO, Union Oil, Exxon, Arco, Gulf and Shell Oil have or are planning to build at least 20 more (Robertson, 1983).

At the present time 8 companies are actively involved in oil exploration and development off Alaska's north coast. Over the next six years each of these companies plan to build one or two islands per year on leases they now hold. Additional leases are scheduled to be sold soon in the same area. These new leases will require additional exploration/development islands.

Ice loading is the main reason artificial islands are preferred over the drilling platforms used in less hostile environments. The Beaufort Sea is frozen for up to eight months of the year. The tremendous pressure created by the moving ice quickly destroys conventional platforms and ships. In addition, construction costs for shallow-water islands have been less than the costs of using traditional exploration techniques in the area. After the artificial islands have been constructed, ice problems can be dealt with. For this reason islands in less than 25m of water are economically advantageous. In water at depths of 25m or more the cost effectiveness of conventional artificial islands becomes more questionable. At these depths, material quantities become unmanageable in one season with any reasonable amount of equipment. New technologies being developed to steepen the slopes of islands (use of rock) may provide an answer to this problem (Robertson, 1983).

Quarried rock islands offer several distinct advantages over methods presently utilized to construct artificial islands. At present, islands are being built using hopper dredging or sand suction techniques. Both these techniques utilize material from the bottom of the sea, require substantially more material for actual island construction (because of shallow side slopes), are more erosive and are more susceptible to material failure. Islands of quarried rock require approximately 50% less material to build (because of steeper side slopes), have better slope stability, have a higher density and are considerably more erosion-resistant.

Since offshore exploration began there has been a demand for quarried rock but to date no one has been willing to spend sufficient time or money to search out suitable material and permits, and develop the market and resource.

Different and competing ways of fulfilling the demands for artificial island fill materials include hopper dredging ocean floor material and sand suction techniques for pumping ocean floor material. Caissons by themselves are built to operate in specific depths of water. Unless the unit is to be used at depths it is designed for, the caisson drilling platforms need a base of varying depths to operate from. Underwater islands allow caisson units to be used in varying depths of water by providing a supporting platform between the sea bottom and the caisson.

The method of island construction depends on three factors: water depth, distance from the nearest land mass and availability of fill material. If island sites are close to shore two methods are commonly used. In winter months, fill can be trucked over ice roads to the site from onshore borrow areas. During ice-free periods fill can be loaded on to barges and then towed to the site. There the fill can be placed with floating equipment.

If island sites are in deeper water or are further from shore, the most common method now being used in the Canadian Beaufort Sea for underwater island construction is to use foreign owned and operated cutter suction dredges. Provided suitable fill material is located on the sea bottom the suction dredge draws sand and silt from the sea floor and transports the material by floating pipeline to the island site. If fill material is not located close enough to warrant a float pipe, the material can be pumped into a hopper-dredge or dump scow and towed to the site.

Quarried rock fill is particularly well suited for island construction when the only option involves the use of hopper dredges or dump scows. Since the quarried rock will build an island with less material and more stable material, haul costs are significantly reduced.

Economic and Social Benefits

This project would provide many substantial economic and social benefits to Canada and the North. If necessary Territorial and Federal approval can be gained in time (November 1, 1983), we have the opportunity to bid on a firm basis for the supply of rock material to form three islands in the U.S. Beaufort for a major oil company. One island is to be built in each of the next three summers. Initial indications suggest that the aggregate cost of these islands will be $175 million. Foreign exchange would bring cash to Canada.

The project will also allow for the establishment and development of new Canadian based technology for artificial island construction in both the Canadian and U.S. Beaufort. The availability of a technologically superior and less expensive method of artificial island formation will in time encourage exploration for and production of petroleum resources in the Beaufort.

Initial sites for the quarried sandstone islands will be in the U.S. Beaufort and we estimate an initial export market in the range of $80 million to $100 million annually. As explorations and development activity is expanded in the Canadian Beaufort we expect additional sales in this area. Depending on the results of exploration activities in the U.S. and Canadian Beaufort we expect the project to have a life in the range of 20 - 25 years. The project will result in the creation of a substantial number of jobs. Up to 400 people (primarily northern residents) will be directly employed at the King Point site. In addition we estimate the project will create the need for approximately 125 off site jobs (support, supplies, services, etc.). On site labour costs for 1984 could reach $25 million. The barging of fill material will create the need for large self unloading vesels. These vessels alone are estimated at $15-30 million each. It is contemplated that Canadian Steamship Lines Ltd. will sub-contract to supply these vessels. Canadian tug and barge firms would be subcontracted to provide the related barge and tug equipment necessary for the delivery of the processed stone slope protection and its placement at island sites.

In addition, we anticipate utilizing Northern firms for support services such as air services (approximately $250,000.00/year), catering (approximately $250,000.00/year) and miscellaneous supplies (approximately $2 million/year).

Employment for Canadians, northern people in particular, will result from this development. Our years of experience in the north have shown us that our work is more efficient and employee turnover is lower when we work with people already resident in the north, resulting in important cost savings. These savings have motivated us to train northern people when none were available with the skills we needed. The results have been excellent.

Our track record of working with native people is also proven. On our Duncan Project in Northern Quebec, an average of 22 native people were part of our project team for its entire 4-year duration. It was a continuous, productive, satisifactory association. On our current project at Nipawin, Saskatchewan, there are now 44 native people on the team in a variety of trades from rodbuster, truckdriver, and carpenter, to mechanic foreman.

Federal, Territorial or Regional Plans

The Yukon Territorial Government (YTG) has published a management plan for the Yukon coastal area. This plan recommends a zone of managed development east of the Babbage River. The YTG plan specifically mentions the possibility of a quarry and port in the area.

At this time we are unaware of any official Federal management plan for the project area. However, we understand the Federal position in present land claim negotiations suggests a managed development zone east of the Babbage also.

To the best of our knowledge, the Kiewit project proposal fits very nicely into Federal and Territorial plans for the area.

2.3 ALTERNATIVES

Quarry

Kiewit has considered three possible quarry sites which could economically serve the Beaufort Hydrocarbon development areas.

The most economical alternate was the Mount Conybeare site. The site is much closer to possible port locations (within 5 km) and the U.S. Beaufort market area. However, it is much farther from Canadian Beaufort activities. If the project was sited at Mount Conybeare, some of the economic and social benefits would no doubt go to U.S. interests. The major reasons for not selecting this site regards environmental concerns. Early in 1983 the Kiewit Company applied for a Land Use Permit for the area. The application was returned saying the area was in a proposed National Park and under the circumstances the government couldn't consider a permit let-alone act favorable on it. The project would also be within the calving area of the Porcupine Caribou herd.

The second site considered was at Mount Sedgwick. This site has excellent material available but requires a much longer haul road (54 km). The probable port area for this quarry site would be Stokes Point. The long haul road makes the project less feasible. In addition this site also lies within a major calving area for the Porcupine Caribou herd. The long haul road could also create more possible problems with the caribou in the area. This site is well within this proposed National Park.

Our third alternative is our proposed King Point Quarry site. Although the well cemented sandstones at this site are somewhat less desireable than the igneous material found at both Mount Conybeare and Mount Sedgwick, it is still of sufficient quality to use for island constuction. The haul road from the quarry to the proposed part at King Point is a moderate 20 km. From this site we could compete in both U.S. and Canadian Beaufort markets. This site is also more environmentally acceptable. The area is outside the proposed National Park, is outside major caribou calving and migration areas and is also outside major snow geese staging areas.

In addition to the King Point proposed port site we also considered using the Stokes Point Port site to haul quarried material to. This alternative has been rejected because of economical and environmental considerations. Distance from the proposed quarry site to Stokes Point is approximately 54 km. When considering the additional costs of building and maintaining this haul road and the costs of doubling haulage equipment numbers to maintain acceptable cycle time it is less likely we could remain economically competitive with present island building techniques. In addition this haul road would cross major caribou calving and migration areas as well as important snow geese staging areas. A good portion of the haul road would also be within this proposed National Park.

Port

Kiewit has considered three alternate port sites to develop in conjunction with its proposed quarry. These sites include King Point, Sabiene Point and Stokes Point.

Sabiene Point has been rejected because of environmental reasons. There is insufficient area of suitable elevation to build necessary port facilities. High bluffs of unconsolidated material overlook the sea at this location. The material is highly erodable. In order to construct adequate facilities at this site deep cuts would have to be made through these bluffs to the sea. Because of the highly erosive nature of this material one could expect massive sluffing and major erosion for several years. Haul roads would also have to cover considerable more patterned ground than a haul road to King Point.

As stated earlier in the Port Alternatives section we also considered using the Stoke Point area as a possible site for a port. Because of the previously stated economical and environmental problems we have rejected this possibility.

Our preferred alternative is the King Point site. This site is of moderate distance from the proposed quarry site. Because of superior terrain conditions we can avoid most problems of ice-rich and patterned ground with the haul road. The site offers a longer ice-free condition to possible Canadian Beaufort market areas than does the Stokes Point site. The shore line is also considerable more stable than the Sabiene Point site, and there is more than enough acceptable low lands next to the sea for construction of necessary quarry and port support facilities.

Combined Kiewit - Gulf Port at King Point

Kiewit has been requested to address possible impacts of a joint Kiewit - Gulf Port at King Point. Although we agree that this alternative is very logical and has merit, at the present time we lack a great deal of data needed to properly discuss this alternative.

We approached Gulf for any information they could furnish us regarding their possible use of King Point. Understandably, we were advised that no data was available regarding their possible use of King. They presently have an application pending for a port facility at Stokes Point. All their detailed engineering and planning efforts are going into their proposed Stokes Point site and until their application is officially acted upon they felt no need to consider in detail any less desirable sites.

Accordingly, for our discussion we are relying on public information available in Gulf's Stokes Point Application of March 10, 1983 and Gulf's discussion of possible King Point Port facilities in the Hydrocarbon Development in the Beaufort Sea Mackenzie Delta Region Environmental Impact Statement.

Both Kiewit and Gulf contemplate development of a Yukon Coast Port in 1984. Concurrent construction activities would occur but one could assume a smaller aggregate impact if respective facilities are constructed together rather than separately. No construction engineering or scheduling is available from Gulf at this time.

Gulf does propose building a small exploration base facility of possible limited duration. Gulf predicts the need for approximately 40 hectares of developed area while Kiewit requires 62 hectares. Again specific design information is not available but it is expected joint site development would eliminate some land use where overlapping needs occur. As an example, Gulf requires a STOL airstrip of approximately 610 metres where as Kiewit's have need for a 1200 metre runway. In this case one single runway would be developed. Other similar situations such as this are likely to occur.

Kiewit estimates the need for 2 million gallons of fuel storage and Gulf estimates the need for 2.5 million gallons of fuel storage. Total combined requirements are 4.5 million gallons of storage.

Kiewit estimates air traffic volume by 2 to 3 planes per day during the active shiping season. Air traffic estimates are not available from Gulf nor are primary use period estimates.

The size and design information for Gulf's warf and sea facilities is not available nor are estimates of ship traffic.

Kiewit predicts the need for 7 million gallons of water per year for its operation. We have located a suitable source for this water in a nearby fresh water lake. We estimate our needs would use about 5% of the lakes volume. If one uses an estimating figure of 17,500 gallons per man it appears Gulf would have need for an additional 1.75 million gallons of water. Combined requirements would still be well below 10% of lake volume.

Marine Wildlife Impacts

Marine wildlife could be affected by treated sewage, solid waste and wastewater disposal, air emissions, artificial illumination, the physical presence of artificial structures, human presence, and icebreaking. However, possible impacts on most marine wildlife in the vicinity of a Yukon coast shorebase are expected to be negligible. Disposal of sewage and solid wastes, and air emissions will conform to regulatory guidelines, and industry will encourage personnel to avoid sensitive coastal marine habitats.

Human presence, landfill sites, airborne noise an artifical illumination at a Yukon coast base may attract polar bears, Arctic foxes and terrestrial mammals despite the implementation of mitigative measures. The combination of these sources of attraction may have a minor impact on local fox populations if some animals are destroyed. Similarly, regional impacts on polar bears are expected to be minor, while local impacts could increase to moderate.

Aircraft over land disturb birds more than those over the sea. Over the sea, the noise would most likely affect moulting and staging ducks. However, since the potential shorebase sites have not been identified as important areas for moulting ducks, the possible impacts of regulated air traffic on ducks along the coast are expected to be minor.

Assuming a protected harbour is built at the King Point Site, there will be a need for dredging of a basin, and the dredge spoils would likely be used for constructing a breakwater-causeway or stockpile areas. In general, the impacts of dredging on water quality and most wildlife are expected to be negligible because the activities and subsequent effects will be local and of short duration. Impacts of dredging will include the destructon of the local benthic in fauna in borrow areas, but are expected to be minor on local epibenthic invertebrate populations since recolonization would be rapid.

Possible effects of dredging on fish may include a local alteration of marine spawning habitat and removal or burial of benthic food sources. Disturbance of feeding habitats may result in negligible to minor impacts on local fish populations, while disturbance or loss of spawning areas may cause minor to moderate impacts on some species. Based on experience elsewhere in the Beaufort Sea, the impact of fish entrapment in dredges is expected to be negligible.

Terrestrial Wildlife Impacts

The attraction of other scavengers to a shorehouse development should be minimized by careful handling of food and incineration of wastes, although some mammals such as foxes, wolves and wolverines may have to be destroyed if they become a nuisance or exhibit the behavioural traits of rabid animals. Some birds may be killed in collisions with structures at these sites. However, impacts on the regional populations of these species should be negligible to minor.

Some terrestrial species may be affected by increasing levels of airborne noise from aircraft landing at King Point, or operating in the area, or travelling between the airport and other locations in the Beaufort region. Affected species may include: caribou during spring migration, calving and post-calving; moose; nesting raptors; staging geese; moulting ducks and ground nesting birds.

To reduce or avoid adverse air traffic effects on the Porcupine caribou herd, overflights of spring migrating, calving and post-calving caribou will be prohibited whenever possible between early May and early August. Also, between August 15 and September 30, overflights of traditional geese staging ares such as the North Slope and parts of the Mackenzie Delta, will be avoided to the extent possible. If these and other mitigative measures are followed, potential impacts of aircraft disturbance on terrestrial birds and mammals will be confined to the immediate vicinity of a King Point and should vary from negligible to minor.

In conclusion, it would appear combining Kiewit and Gulf Port requirements would cause minor impacts to the King Point area. By combining facilities it also appears that lesser impacts would occur than if constructed as separate facilities.

No Development

Under no development scenario one could expect:

- Area will remain in its near prestine condition, no environmental impacts
- Oil Companies would continue to rely on foreign firms for the construction of artificial islands
- Associated impacts of sea dredging would continue
- Canada would lose nearly $100 million/year in positive foreign exchange
- Loss of significant employment potential
- Loss of approximately $25 million/year in wages to Northerners
- Loss of approximately $3.5 million/year in Northern business opportunities
- Loss of associated training and development potential
- Loss of Canadian ship building and marine service business

Development at a Later Date

- Same environmental impacts associated with contemporary develoment but at a later date
- Opportunity to study possible environmental impacts and initiate more environemtally useful mitigation measures
- Significant loss (if not total loss) of U.S. Beaufort business opportunities and attendant positive foreign exchange
- Partial loss of Canadian Beaufort business opportunities
- Partial loss of employment, training and development opportunities

- Partial loss of wages to Northerners
- Partial loss of business opportunities to Northerners
- Partial loss of Canadian ship building and marine services business opportunities

2.4 ASSOCIATED PROJECTS

Several ancillary activities can be considered spin offs of the Kiewit Quarry and King Point Port development. More detailed information about the following can be found elsewhere in this document.

Crushing operations	-	Section 3.0
Waste rock & disposal	-	Section 3.0
Multi-use port	-	Section 2.0
Service Industries	-	Section 4.0
Improved access	-	Section 5/6

3

4

3.0 PROJECT DESCRIPTION

3.1 DEVELOPMENT PLAN

Quarry

The Kiewit Quarry will be developed in several overlapping phases, each closely linked to the results of the other (Fig. 3.1-1). Phase One will include the mobilization of men and equipment to the site for the initial construction of the temporary camp and equipment assembly. Phase Two will involve the construction of selected key permanent camp and shop buildings. In addition, the necessary utilities will be brought on line. Phase Three will be directed at establishing the permanent shops and King Point and at the Quarry. During this stage, work would begin on the Deep Creek bridge and assembly of grading equipment on site. Phase Four would include the actual quarry development and haul road construction from the quarry to King Point. Following completion of the Haul Road, work will begin on the balance of the shop yards, access roads and other camp facilities.

Anticipated work force size are listed in Table 3.3-1.

Rotation schedules for project personnel will be set up on a four week in - one week out basis. In addition, during fall hunting seasons the rotation schedule will be modified to provide more time out for those Northerners who wish to take part in traditional hunting activities.

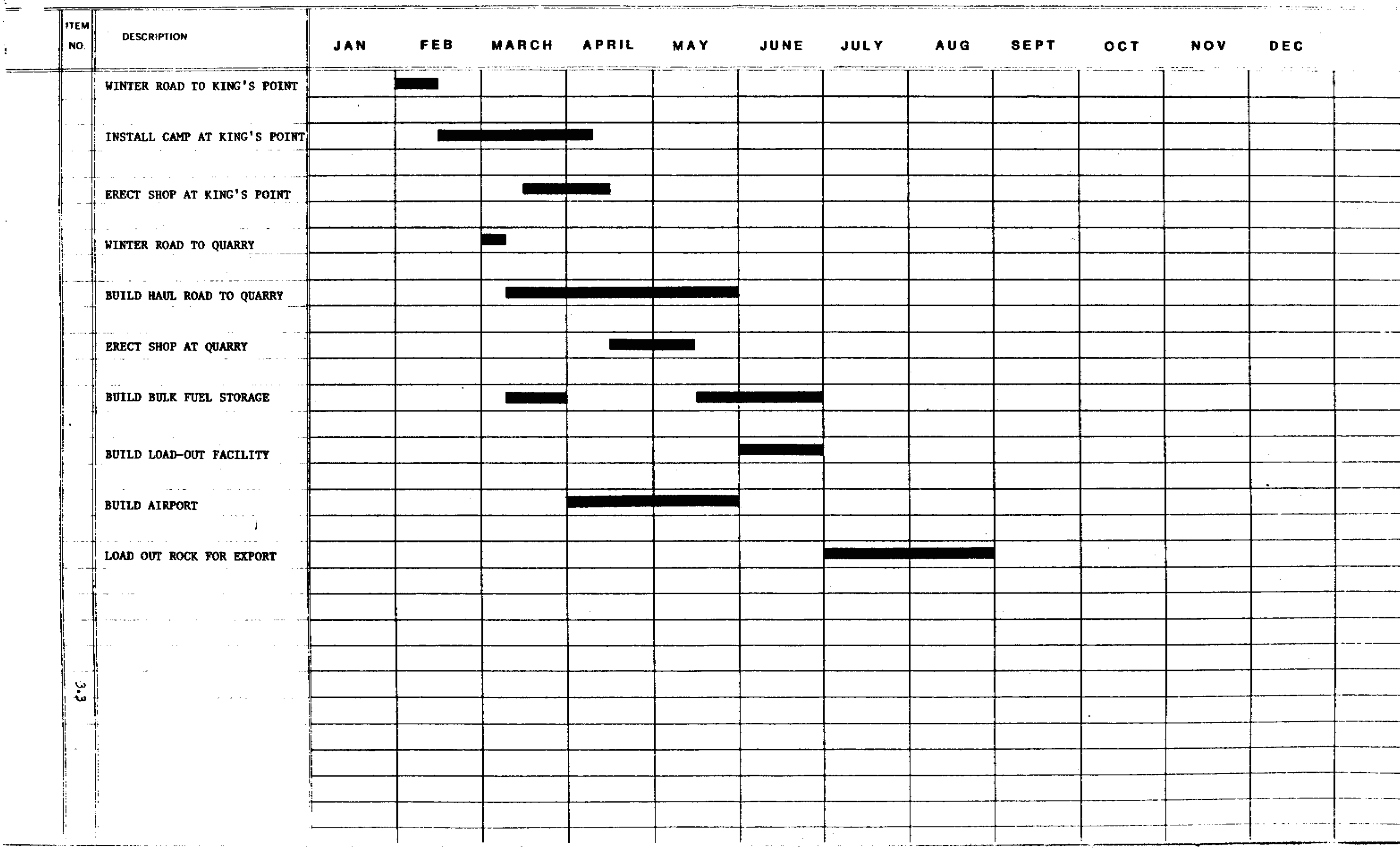
Our intention is to recruit our work force from the communities of Old Crow, Aklavik, Dawson and Inuvik. Airline service will be arranged between these communities and the project site. The service will be appropriate for the transportation needs of employees from these communities. This service will be arranged with airlines already operating in the area.

Table 3.3-1. Anticipated Work Force

	Initial Construction	1 Million Tonne Per year Production	2 Million Tonne Per Year Production
Primary Work Force	300	175	185
30% Rotation Allowance	100	52	56
Tug Crews	-	40	80
TOTAL	400	267	321

KIEWIT QUARRY ARCTIC PROJECT

Fig. 3.1-1. SCHEDULE OF DEVELOPMENT 1984



Port

The proposed King Point port facility is located along the Babbage Bight of the Yukon coastline. The proposed port location was chosen due to 1) low natural contours to sea level that will minimize ground disturbance for inland access; 2) the lack of any major rivers nearby which would cause heavy sediment deposition; 3) deep water access close to the shoreline, reducing the required channel dredging; and 4) large open area close to the shore for development of shoreside storage of quarry material and support facilities.

The initial port development is designed for the loading and shipping of Kiewit Quarry products during the ice-free season. The Facility will be designed to ship 1,000,000 tonnes during the first season (1984) and 2,000,000 tonnes per year in a maximum situation.

The loadout season will consist of a 60-day period when vessels can transport the quarry material to U.S. sites. The proposed shipping corridors are shown in Fig. 3.1-2.

Additionally, the initial development design has excellent potential for expansion to a multi-user facility capable of a variety of operations - either for ice protection for non-ice class hulls during the winter months or for operational support during the summer and early winter periods.

The initial port layout will allow for expansion to the east for additional storage and docking capabilities. In addition, there is considerable area for expansion for laydown and storage along the shoreline.

The expected lifetime of the port facility will largely depend upon the activities of exploration and future production developments in the Beaufort Sea which currently has good development potential.

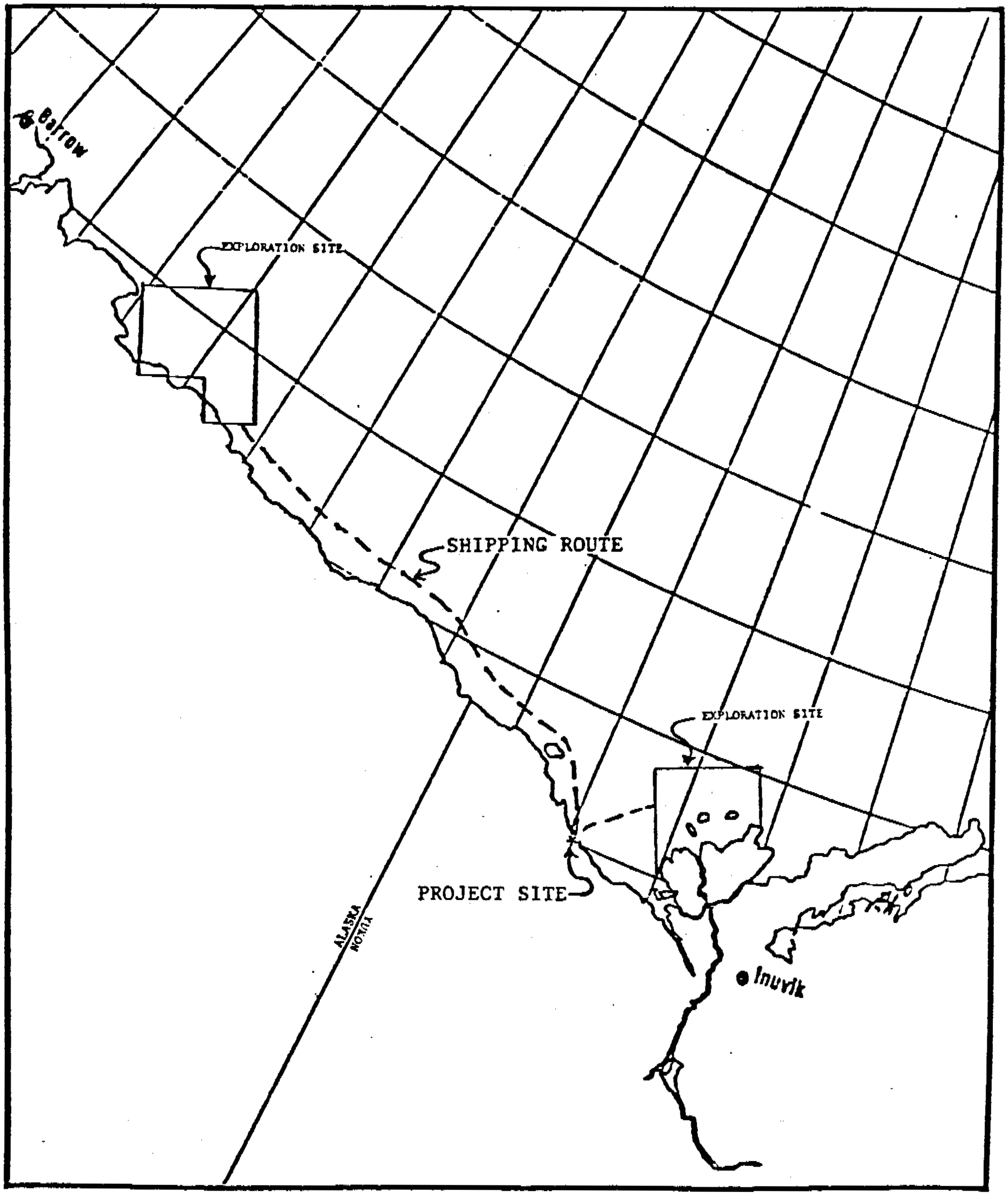


Fig. 3.1-2. Proposed shipping corridors.

3.2 PRE-CONSTRUCTION DETAILS

Quarry

Kiewit has conducted various levels of investigation on the proposed quarry project site. These studies include extensive drilling of the quarry area to determine geologic information, haul road permafrost studies to quantify the extent of permafrost along the haul road and its effect on haul road construction, operation and maintenance; aerial photo interpretation, literature review of permafrost construction techniques; and interviews with people experienced in the construction of roads and ports in permafrost areas (Exhibit I & II).

Port

Kiewit has similarly conducted preliminary investigations of the proposed King Point port area. These studies, including complete bathymetric soundings offshore of King Point to the -11^{o} meter contour line, were conducted in August 1983. In addition, the available literature on King Point oceanography and climatology has been researched.

A geotechnical study at King Point will be conducted during the 1983-84 winter to determine exact engineering requirements of the area. This study will investigate subsoil make-up and permafrost conditions in and around the port and breakwater area.

3.3 CONSTRUCTION, OPERATION AND MAINTENANCE DETAILS

General Project Details

(a & b) The development scenario and its timing are presented in section 3.1. Project life is estimated at 20 years.

Very quick permit and approval time frames are required by this project to allow mobilization for the 1983-84 winter construction seasons. If these permit time frames are met, Kiewit will be able to take advantage of the winter construction season to build haul roads, camp and port facilities without damaging the tundra vegetation and permafrost.

(c) The quarry will supply almost all local materials required for haul road construction operation and maintenance as well as product required for marine construction. The quarry and the waste rock disposal area are located on Exhibit 1.

The geotechnical data for the quarry suggest that a 20% reject is probable. The actual value will vary depending on the construction market of this quarry by product.

Potential gravel borrow areas have been located (Exhibit 1) along the haul road. The quantities available at these sites are limited and would be reserved for topping of the haul road and parking area.

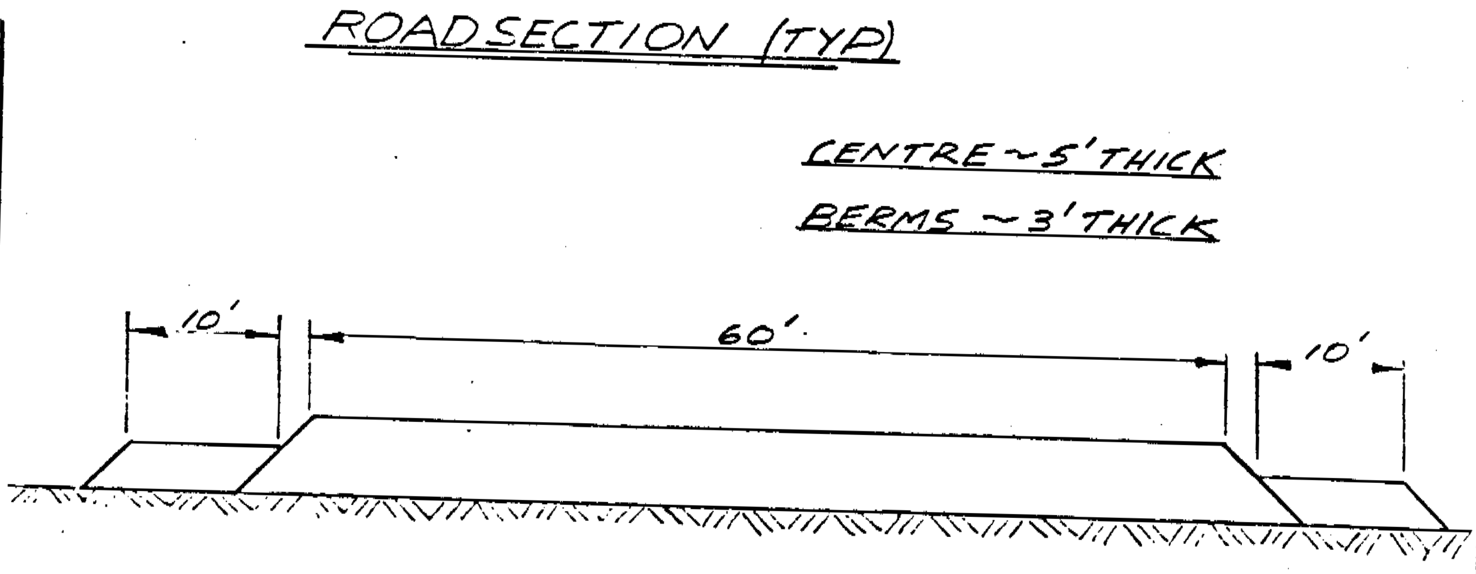
(d) Permafrost engineering specifications require that the haul road and camp area be constructed on a 1.7 m (5 ft.) pad minimum depth of blanket material over the native ground. No cuts are planned in either the haul road or camp/airstrip complex. This no cut decision will require some additional fill in some areas.

It is anticipated that additional insulation material will be required at the toe of the haul road slope (Fig. 3.3-1).

Our camp and shop buildings at King Point will be pile founded.

(e) The initial construction camp will be located at King Point. This will also be the location for the first temporary shop facility and equipment assembly point. The construction camp is designed for 70 people.

(f) Fresh water for the project will be obtained from a 15 ha lake (Exhibit 1), which has a depth of 11.6 m (38 ft.). Water quality tests have been conducted but analysis is not complete at this time. This water source appears adequate for all



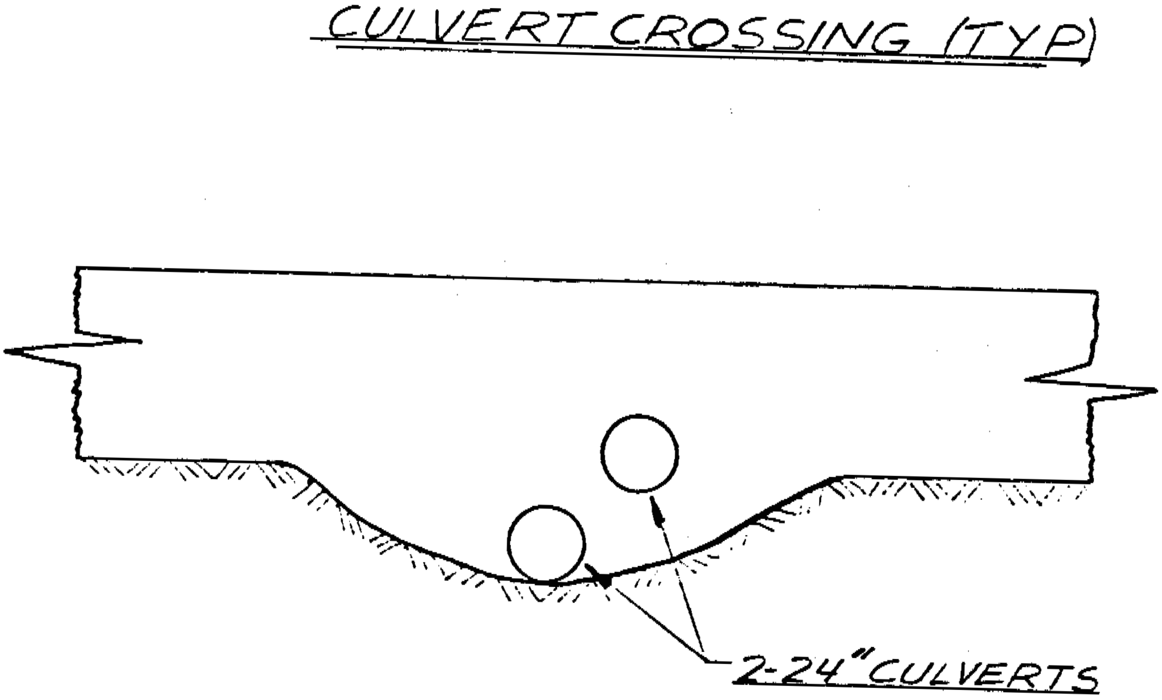


Fig. 3.3-1. Road cross-section and culvert placement.

KIEWIT QUARRY
BEAUFORT SEA
DEVELOPMENT

domestic use for the camp and shop at King Point. The total estimated yearly usage is less than 5% of the present lake volume.

(g) A mechanical sewage treatment plant will be used for the permanent camp. This system, manufactured by Ecodyne Corp. - Smith and Loveless Division, has proven satisfactory, both for the quality of water discharged and trouble-free operation. Treated water from this operation would be discharged into the King Point lagoon.

(h) To minimize the traffic on the haul road, quarry products will be handled by large hauling equipment. Equipment would vary because of different types of material being hauled and the need for smaller equipment during the initial construction of the haul road and access road facilities. We are contemplating 85 ton end dumps and bottom dump tractors pulling 2 trailers, that would have a 250 ton total capacity. We are also considering end dump trucks to a maximum of 150 ton capacity. Because of the size of these units the number required would be few, probably not exceeding 15 of the bottom dump units and a total of 10 end dump units. Loading would be accomplished by 10 cubic yard size front end loaders and up to 20 yard size front shovels. Support equipment would include track type tractors of the larger size manufactured and haul road maintenance equipment, water trucks, etc. The overall program contemplates a large crusher set up that would be utilized for crushing 5" minus material that can be conveyor loaded onto marine vessels. Drilling would be accomplished utilizing rotary type drills and some percussion drills. Support equipment would include water trucks, powder trucks, mechanics trucks, service trucks, fuel trucks, cranes and tire trucks, as well as smaller vans and pickups for transportation of personnel. All camp and shop power, as well as power for the crushing units would be provided by portable generators.

(i) See 5/6 - **ENVIRONMENTAL IMPACTS AND PROPOSED MITIGATION MEASURES**

(j) Air traffic volume will vary with the season. At the peak of the construction and load-out season it is anticipated that two or three flights per day with Cariboo and Twin Otter type aircraft will be required. Occasional visits by other aircraft would likely be in addition to this. The airstrip would have a 1,363 m (4,000 ft.) long runway and be certified with a directional finding beacon and navigation lights. Arrival and departure paths would parallel the existing coastline and would avoid travel over the interior coastal plain wherever possible.

(k) Plans for handling petroleum products are included (Fig. 3.3-2). Storage of petroleum and explosives will be according to all relevant Territorial and Federal regulations.

(l) Kiewit will develop a plan for the project personnel to show how to respond to fuel spills in and around the project area. This plan will be developed with the cooperation of the appropriate regulatory organizations. The plan will have as a minimum a description of the spill types expected, the responsibilities of the personnel and their specific duties, counter measures for various types of spills, disposal of recovered spill material, and clean up and restoration plans.

The company will supply the necessary physical resources and training to project personnel for their effective prevention or control of environmental emergencies.

(m) Kiewit company policy stresses that all company operations be maintained in a safe and environmentaly sound conditions. It also stresses that these operations be managed in a cost efficient but effective manner. It is to the company's benefit that any environment, quarry/haulroad or port related problems be identified and corrected or mitigated as effectively as possible. With this policy

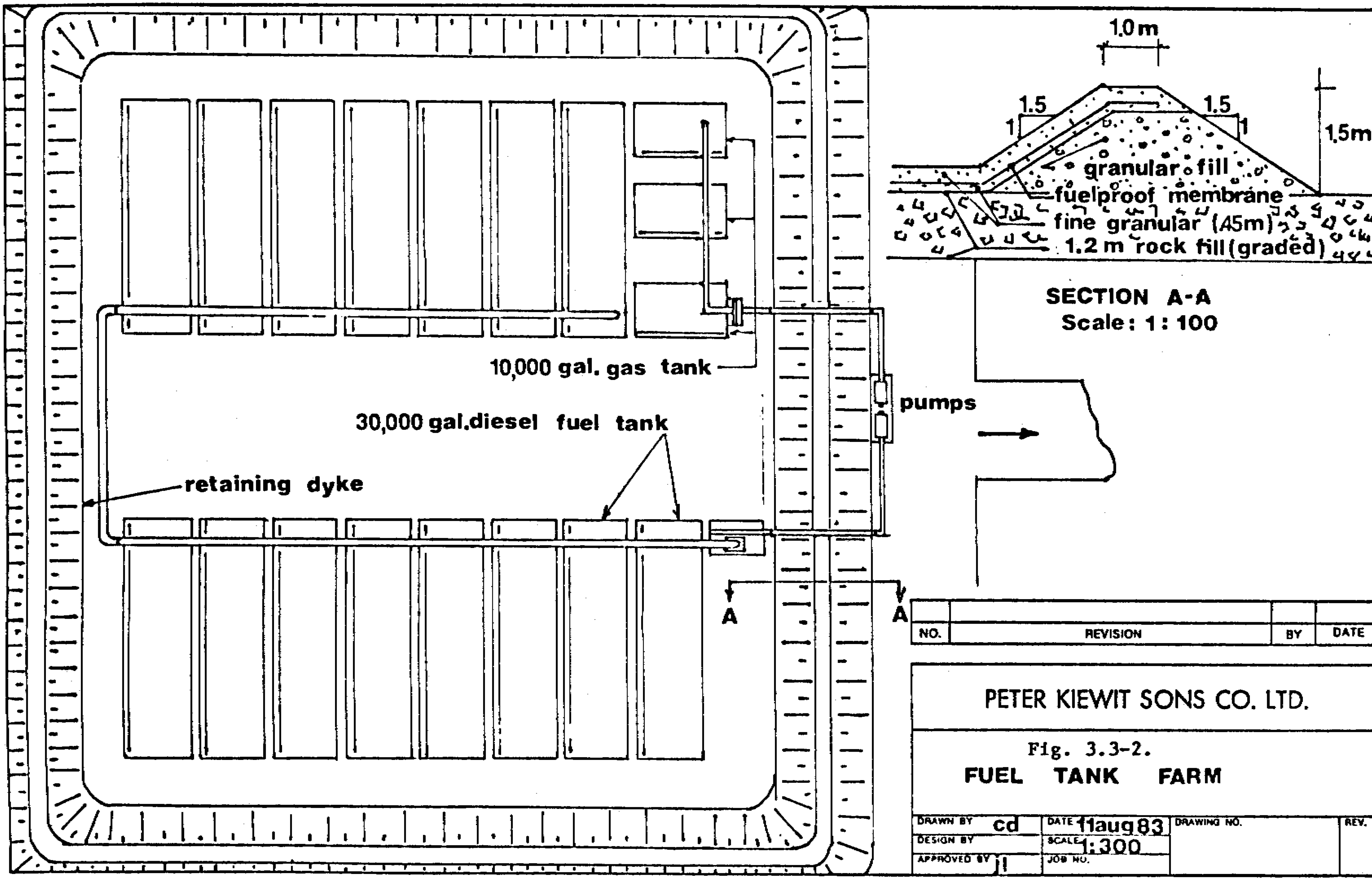


Fig. 3.3-2.
FUEL TANK FARM

in mind Kiewit will inspect daily all job related facilities for environmental (permafrost, erosion problem, etc.) and operational problems.

In addition, Kiewit will monitor the environmentally sensitive components of the project area. This will allow the continual assessment of the effectiveness of the environmental mitigation measures. It will also give a site and project specific reference point for future comparisons.

(n) Kiewit recognizes both safety concerns as well as potential impacts that employee hunting and fishing may have on area wildlife. Therefore, it will be the company policy to prohibit both hunting and fishing on the project area. Also, it will be against company policy for employees to be in possession of any type of firearm, (with the exception of firearms stored in the camp - to be used strictly if required, for bear protection).

Kiewit also recognizes the importance of establishing and maintaining good, safe working conditions for all of our employees. In line with this thinking, we will rigorously enforce a "dry camp" with no alcohol permitted.

Varience from these policies by any employee will be grounds for immediate dismissal.

Quarry - Specific Details

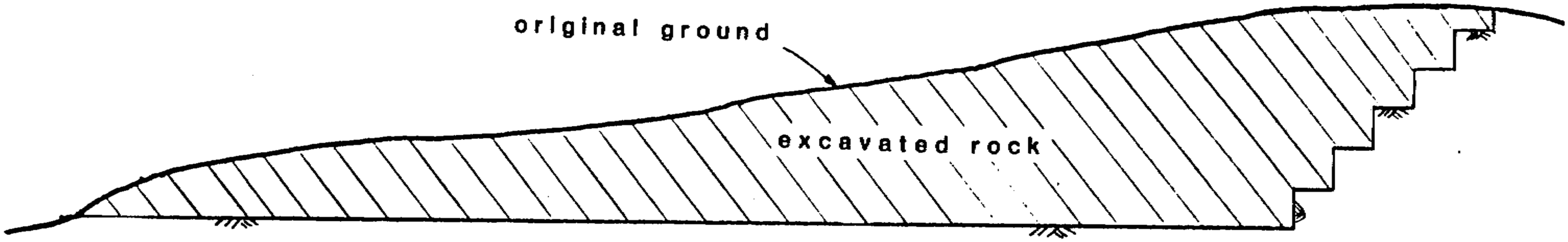
(1) The quarry area (Exhibit 1) would be developed from the northeast portion of the property to the south. Waste material will be disposed of along the northern and eastern boundary of the quarry excavation. The rock can generally be described as competent sandstone. Specific rock quality is presented on Table 3.3-2.

(2) The quarrying method would anticipate removal of the material by a typical bench and box cut method. (Fig. 3.3-3 & 4.) Waste rock disposal will take place as the material is excavated and/or processed through the crusher.

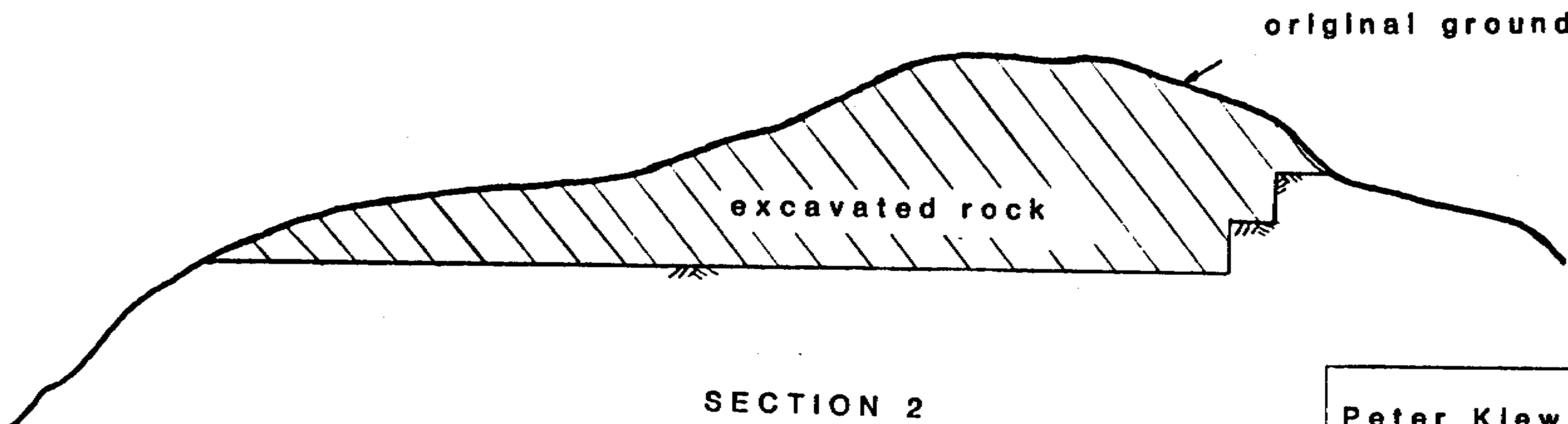
Table 3.3-2 Rock quality test results

TEST PROCEDURE	SAMPLE NUMBER 3-1	3-2	3-3	5	6-1	6-2	REMARKS
ASTM C88 - Soundness by use of Magnesium Sulphate[1]		No discernible loss by weight[4]		To be completed	No discernible loss by weight[4]		Maximum allowable loss - 15% Newfoundland DOT.
ASTM C127 - Specific Gravity and Absorption							
• Bulk specific gravity (dry surface)	2.51	2.47	2.51	2.44	2.51	2.50	
• Apparent specific gravity	2.61	2.58	2.61	2.65	2.57	2.60	
• Absorption	2.53 %	2.90 %	2.54 %	3.20 %	1.65 %	2.56 %	Maximum allowable absorption
• Bulk specific gravity (dry)	2.45	2.40	2.45	2.37	2.47	2.44	2% for concrete - no specification for rock or aggregate.
• Calculated density (dry) (no specification)	2.45 t/m^3	2.40 t/m^3	2.45 t/m^3	2.37 t/m^3	2.47 t/m^3	2.44 t/m^3	Minimum allowable - 2.6 t/m^3 Newfoundland DOT.
ASTM C131 - Los Angeles Abrasion[2]			29.7 %	38.7 %		31.1 %	Maximum allowable loss - 35% Newfoundland DOT.
ASTM C170 - Commpressive Strength[3]					Average of 4 12,974 psi 89.5 MPa		
Whole Rock Analysis			To be completed	To be completed		To be completed	

1 Testing was carried out on saw cut pieces of rock + 1"-3". Approximately 4,500 g were used.
2 Sample tested was of grading "A" without the 3/8" material. Because of sample size, the test results should be considered to be conservative.
3 Samples of the proper height to width ratio could not be obtained, therefore, compressive strength is only approximate.
4 Although there was no discernible loss by weight, a significant amount of scaling was noted. Any abrasive action applied to the scaling surfaces would cause noteable weight losses.



SECTION 1

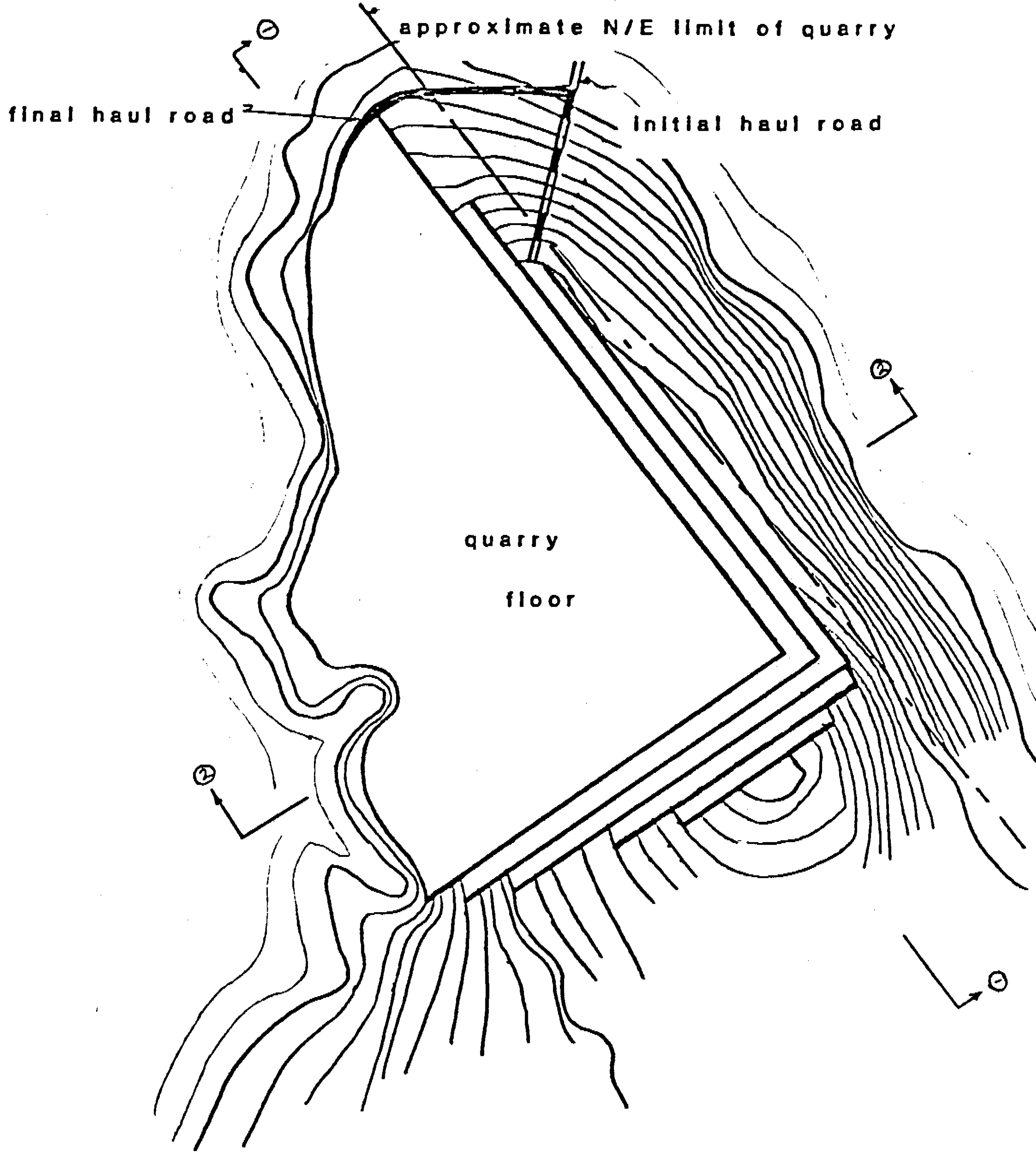


SECTION 2

Peter Kiewit Son's Co.

Fig. 3.3-3.

BENCH TYPE QUARRY



Peter Kiewit Son's Co.
Fig. 3.3-4.
QUARRY PLAN

Materials rejected by the crusher and/or from the quarry excavation process are generally of reasonable quality and are wasted primarily because of size. Fine material (under 1") is too small to be considered a merchantable product from the quarry production process. We would not anticipate any contamination of surrounding drainage courses from this material. If a limited quantity of poor quality material is found, it will be selectively buried in the waste pile to prevent future surface or subsurface contamination.

(3) The excavation plan is designed to use front shovel type equipment to aid in the sorting of rip rap size material as the excavation process takes place. The majority of the material excavated from the quarry will be processed through the crusher. Quarry and crusher operations would commence as soon in the spring each year, as weather conditions permit.

(4) Drainage and run-off from the quarry can be reasonably controlled by channelling run-off into existing water courses. Retention ponds will be used to settle sediments that might be carried into the drainage course prior to this run-off reaching any major water course. Exhibit 1 indicates the probable drainage courses to be utilized for run-off from the quarry area.

(5) Quantities of explosives will vary in the different layers of the quarry encountered, but we anticipate an average powder requirement of 1 pound per cubic yard. During the major portion of the production year, ammonium nitrate type explosive can be utilized, particularly in the larger diameter rotary drill holes. However, some use of packaged slurries may also be required.

(6) During the main production season, blasting would probably occur once per day at the quarry. Kiewit Company blasting regulations require that eachshot be designed prior to loading, that the delay sequences be laid out for the powdermen and that a continuous record of every shot be made. Results from each

blast are monitored so that future blasts can be based upon previous experience. Standard procedures will be followed to clear the blast area of all personnel prior to blasting. Proper protection will be provided for the licensed powdermen or blasters.

(7) Noise associated with the overall project will be similar to that associated with most other mining operations. Noise sources include drilling and loading equipment in the quarry, haul vehicles used to transport the product, as well as the crusher units in the quarry area. Blasting noise is, of course, limited in duration, but would be noticeable in the area of the quarry.

(8) There will be a stockpile area in the vicinity of the port load-out facility, capable of handling up to a half million tons of product, and seasonal stockpiling at the quarry. There will also be both conveying equipment used to load barges and self-unloading vessels, as well as equipment required to feed that conveying equipment. Drive-over unloading equipment will be utilized, to allow bottom dump trucks to be unloaded without having to drive over the dishcarged material. This is particularly important when hauling pit run product. Transportation to the port facility will be either by bottom dump and/or end dump hauling equipment. Due to the distance of the quarry to the port facility, we anticipate using equipment in the 150 to 250 ton per unit capacity. These bottom dump units would probably be a tractor pulling a trailer, which in turn would pull another trailer. End dump units of the smaller size will be used to handle rip rap and slope protection type materials. Use of this size equipment will minimize the number of trips required to haul the product.

(9) Restoration during the life of the project will generally be limited to repair of haul road and access road facilities and maintenance of drainage courses and settling ponds that are used to prevent solids from reaching drainage courses.

Waste material will be placed in the disposal area so as to blend into the existing land contours. Little, if any, material rehandling is planned.

Haul Road - Specific Details

(1) The size of the hauling units will require a 60 to 70 foot haul road width, the wider width used on corners, the narrower width used on straight aways. In addition to the haul road travel width we plan a 10 foot additional width as an insulating berm, on either side of the haul road. We will use the construction right of way, as our access to the quarry in the winter time. During haul road construction, a few detours would be required. Such as a detour around the construction of the Deep Creek bridge. We would also stay within future shop lay down areas, to eliminate, any construction traffic on the tundra areas that will not eventually be covered by quarry run material. We are anticipating all access roads to be constructed with embankment materials rather than excavating into the native material. Culvert drainage structures will be provided in all potential water courses. There is only one stream crossing. Deep Creek will be bridged by a 40 m (120 ft.) span bridge, founded on pile supported abutments. Culvert crossings will include a low level drainage culvert for use when full thaw conditions are present, as well as a secondary culvert, located higher in the haul road, which will allow for passage of any peak flows that might occur at initial thaw, when the lower culvert could be plugged with ice and/or snow (Fig. 3.3-1). Culvert crossings will be provided wherever it is likely that cross drainage might be required. Our surveys indicate that there are some 4 crossings where water is evident and some 12 others where presence of water might be anticipated any time during the summer season.

(2) In those few areas where some drainage might be channelled, adjacent to the toe of haul road fills, erosion control material will be provided to prevent any erosion occurring at the toe of the fill. The haul road centre line access roads,

camp sites and other permanent features, have all been located with erosion control and snow maintenance in mind.

(3) Rather than attempt to identify ice ridge zones beneath our haul road and service areas, we have decided to provide enough of a pad in the construction of the haul road and other features that we can safely traverse any type of permafrost that might be encountered. Our permafrost investigation has indicated to us that the variation of depth down to the permafrost is only plus or minus one foot along the entire route of our haul road.

(4) See **3.3 - CONSTRUCTION, OPERATION AND MAINTENANCE DETAILS: Haul Road - Specific Details (1).**

(5) Maintenance of the haul road under normal conditions, would consist of surface maintenance with motor patrol graders and the addition of additional surfacing material in those areas that experience some settlement during the first season. Previous experience in similar terrain suggest that maintenance problems in the second and third seasons will diminish and be limited to blade maintenance. Some surfacing material may be added periodically to reduce tire wear and to provide fine material for the blades to use in their maintenance work.

(6) Dust suppression will be handled by fine spraying with water.

(7) The haul road is one of the major components of the project. Its condition and maintenance is of primary concern to the viability of the project. For this reason, the haul road will be continually monitored by Kiewit construction supervisors. Any problems will receive prompt attention.

(8) Traffic volumes on the haul road would vary depending on the total quarry production and the product of the quarry. During maximum production haul road traffic will peak around 20 trips per hour one way. More normal conditions would require around 15 trips per hour. At the beginning or end of each season

when only one product is being hauled out, haul road trips could drop to 5 - 10 one way trips per hour.

In addition to these flows of the heavier units, there would be certain amount of traffic from small supervisory vehicles, haul road maintenance equipment, water trucks, etc.

Port - Specific Details

Construction of the port facility will begin after the haul road and quarry have been developed. Port construction will use a combination of pit run rock from the quarry and dredged material if suitable from the harbour development.

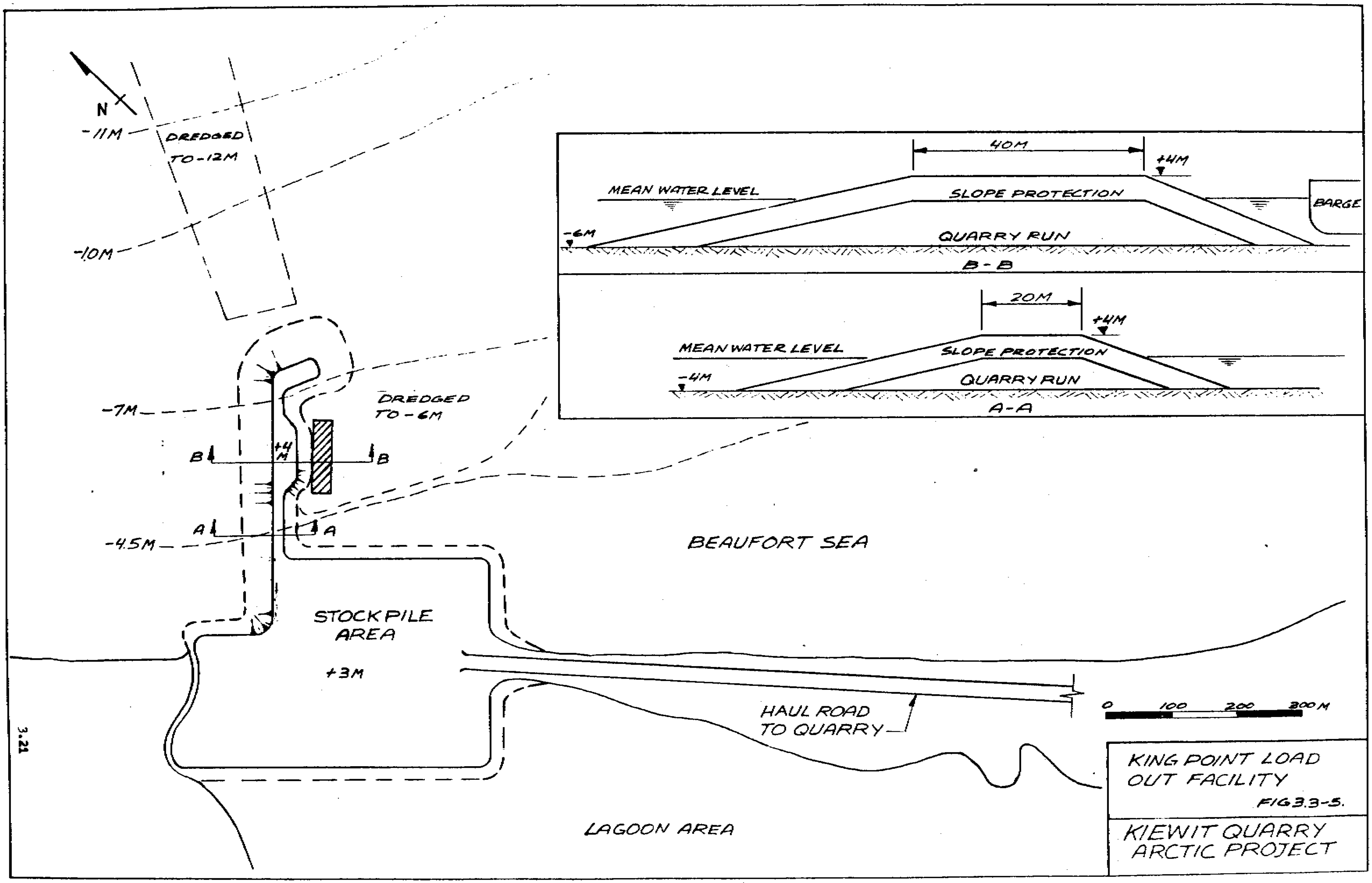
The breakwater will extend out into deep water (Fig. 3.3-5). This will reduce siltation in the harbour area and initial dredging requirements. A minimum harbour depth of -6° meter below high water will require the dredging of 250,000 m^3 of material. This will give adequate clearance for 100 x 400 ft. rock barges. In addition, 250,000 m^3 of dredging is required for docking bulk carriers which require a water depth of -12 meter below lowest low water.

As mentioned above, dredged material will be used for landfill for storage areas. However, if this material is unsuitable, it will be disposed of at sea in an environmentally sound manner and according to all laws and regulations.

The port has been designed to minimize maintenance dredging. It is expected that less than 10,000 m^3 of maintenance dredging will be required each shipping season to maintain the required meter harbour depth.

The location of the port has been chosen for its early springtime breakup pattern. Additionally, due to the mass rock used in our port development, this will withstand ice forces and movement during the winter period.

The King Point breakwater is designed to protect the port area and serve as a work platform for various operations. The exposed portion of the breakwater will


N
-11M
DREDGED
TO-12M
-10M
-7M
DREDGED
TO-6M
B
+4
M
B
A
A
-4.5M
STOCK PILE
AREA
+3M
BEAUFORT SEA
HAUL ROAD
TO QUARRY
LAGOON AREA
40M
+4M
MEAN WATER LEVEL
SLOPE PROTECTION
BARGE
-6M
QUARRY RUN
B-B
20M
+4M
MEAN WATER LEVEL
SLOPE PROTECTION
-4M
QUARRY RUN
A-A
0
100
200
300 M
KING POINT LOAD
OUT FACILITY
FIG 3.3-5.
KIEWIT QUARRY
ARCTIC PROJECT

be protected by armour rock. Specifications for the amount of armour protection are contingent on several factors: expected wave height, properties of the rock, acceptable damage, and slope of the breakwater, which have been studied.

The breakwater will have a creast elevation of four meters above still water. This will allow for the one meter wind set-up and three meters of wave run-up.

The crest width was determined by the equipment which is planned to be used on the breakwater. Where the breakwater is used as a causeway, a 20 meter causeway width is anticipated. Where the breakwater is used for loading and unloading, a width of 40 meters is required. this will allow trucks room for maneuvering and for other equipment, such as conveyor belts and additional space.

The shoreline of the breakwater is designed for stockpiling of quarried materials. The anticipated storage during the first season will be nominal. However, subsequent seasons may require from 200,000 to 500,000 tonnes of rock. From the stockpile area, the quarried material will be transported to the loading area by conveyor and/or end dump hauling equipment - depending on the size of rock being handled.

It is anticipated that in the 1984 season, approximately three vessels per week will be utilized for rock transport. The maximum traffic flow will depend on the demands of the client and can range up to eight vessels per week.

The King Point area shipping season will vary depending on ice flows and any restriction in barge traffic due to endangered marine mammals. It is expected that a 60-day season will be possible to the U.S. Beaufort.

3.4 ABANDONMENT

Quarry

(a) The quarry is designed to incorporate abandonment/rehabilitation planes as it progresses. This is illustrated by the waste rock disposal programme which will blend the contours of the waste rock disposal area with the natural contours. In addition, the quarrying technique will leave the quarry area with an irregularly shaped high wall.

Subject to the consultation and approval of the Canadian Wildlife Service and the Yukon Wildlife Branch, Kiewit proposes to build permanent cavities and ledges in the quarry high-wall. This area would offer increased nesting or roosting habitat for arctic raptors.

(b) After final development, seepage will drain into the quarry lake. If necessary, the lake will have a controlled flow from the lake to Quarry Creek. A lineal channel will be used if called for.

(c & d) All buildings, equipment, camp facilities etc., would be removed on final abandonment of the quarry. Solid waste material including waste metal will be buried in the waste rock disposal area at the quarry.

(e) If requested to do so, the haul road will be deactivated and all culverts and bridges removed. The surface of the road will be scarified to enhance natural invasion of vegetation.

Port

For all practical reasons, abandonment of the port facility is unlikely. However, if removal of the facility is required, the method utilized would be to remove the slope protection rock off the breakwater with assistance from available equipment. The core rock would be left in place and allowed to erode.

3.5 ENVIRONMENTAL EDUCATION

Peter Kiewit Sons, Co. Ltd. will provide an environmental education program for all personnel involved in the Kiewit Quarry project. This requirement for all workers will provide basic concepts of ecology, northern environments and game and fish regulations.

There will be various levels of environmental education according to the worker's responsibility or his potential for causing environmental change in the normal course of his duties.

Kiewit will have an environmental inspector whose responsibilities will be to ensure that the policies and procedures given in the environmental education program are followed. In addition, the environmental inspector will ensure that all activities of the project are carried out in compliance with relative regulations and guidelines and Kiewit's policy to minimize disturbance.

The following guidelines will be used in the development of an environmental education program:

(1) Peter Kiewit Sons, Co. Ltd., through its management, acknowledge the importance of environmental training as part of its responsibilities and will provide for this training in its Yukon quarry operation.

(2) Environmental training will be integrated with environmental inspection so that both programs can be upgraded as needed.

(3) All project personnel will be required to attend various environmental training sessions.

(4) The level of environmental training will increase as the potential for environmental damage increases.

(5) The environmental education program will be project-oriented and directed by environmental professionals.

4.0 EXISTING ENVIRONMENT AND RESOURCE USE

4.1 CLIMATE

The climate of the project area is within the Arctic zone. Normal upper level airflow over this region is westerly in summer and northwesterly in winter. Severe weather is often associated with abnormal departures from this pattern caused by major shifts in the circulation patterns of the upper atmosphere.

Winter

In winter, a semi-permanent upper air ridge over Alaska results in a relatively strong mean northwesterly flow of air aloft. At the surface, the project area remains in continuous snow and/or ice cover. As a consequence, Arctic air predominates and results in an anticyclonic circulation pattern or atmospheric high.

The cold dome of continental Arctic air over the region acts as an effective barrier against any penetration by maritime air masses. Migrating frontal lows are forced to follow trajectories around the edge of the continental Arctic air mass well to the north of the project area. Low pressure centers originating in the Aleutians, produce blizzards along the Coastal Plain. They occur primarily in January and March, but may also occur in other months of the winter.

The high pressure systems which are dominant in the project area from November to March originate over the polar ice pack in the Beaufort Sea or in northern Alaska. In February, these systems tend to stagnate over the valley resulting in prolonged cold spells.

Spring

Spring in the project area begins with the gradual eastward shift of the dominant high pressure system. High pressure systems still originate in the north and follow southeastward trajectories. In February these systems tend to stagnate over the Mackenzie Valley, by March they begin to move to the east of the Valley.

The eastward displacement of high pressure centers allows more frequent penetrations of frontal lows, bringing maritime Arctic and maritime polar air masses to the region, resulting in a general increase in instability.

Progression of spring is gradual from south to north and does not reach the project area until late April or early May.

In May, frontal lows from northern Alaska begin to follow trajectories through the project area and down the Mackenzie Valley, resulting in increased precipitation.

Summer

The semipermanent upper level ridge which lies over Alaska in winter shifts eastward to over the study area in the summer. The strong northwesterly flow of winter is replaced by weak westerlies. This produces a surface trough along the Coastal Plain.

With the break-up of the pack ice along the coast, the climate of the Coastal Plain becomes more maritime and the source region of the Arctic air mass is reduced to the area covered by the polar ice pack. Outbreaks of Arctic air are modified during their passage over the open water between the polar pack and the coast; then cloudiness and stable air become dominant features of the coastal climate.

From May to July, frontal lows follow a trajectory from northern Alaska through the project area. Cyclonic activity in the region usually reaches a peak in July and August, so that in August and September the region receives precipitation from storms which develop north of Alaska and travel along the coast.

Autumn

The autumn season, from September to December, is the reverse of the spring season. The summertime upper level ridge over the project area gradually begins to shift westward back to its winter position over Alaska. Airflows aloft change from relatively weak westerlies to a strong northwest flow by the end of the fall.

At the surface, outbreaks of cold Arctic air become more frequent and colder. As freeze-up begins along the coast in late September, steaming of open waterbodies introduces moisture into the atmosphere and results in overcast skies and snow flurries. Also, cyclonic activity generally begins to decline from the July peak.

Beginning in November, high pressure systems originating in either northern Alaska or over the Beaufort Sea travel southeastward. By December, anticyclonic circulation is reestablished as Arctic air once again dominates the region.

Temperature

The annual variation in mean daily temperatures along the Beaufort coast is less than at inland stations. Mean daily temperatures range from $-30.4^{o}C$ to $5.7^{o}C$ at Cape Parry, and from $-29.4^{o}C$ to $13.3^{o}C$ at Inuvik. Winter minimums and summer maximums are less extreme in the project area due to the moderating influence of the Beaufort Sea, and the heavier cloud cover in the summer which reduces daytime air temperatures. Annual cycles in mean daily air temperatures (averaged on a monthly basis) and monthly extremes at Shingle Point, Yukon, are summarized in Table 4.1-1.

Frost

The mean annual number of frost-free days in the study area averages around 35 days. The mean date of last frost averages around June 30, while the mean date of first frost is around August 10.

Table 4.1-1 Mean daily temperatures, extreme maximum temperatures, extreme minimum temperatures and mean monthly precipitation at Shingle Point, Yukon. (Beaufort Sea EIS 1982)

	Mean Daily Temp. (°C)	Extreme Maximum Temp. (°C)	Extreme Minimum Temp. (°C)	Mean Monthly Precip. (mm)
Jan	-24.9	1.7	-51.1	9.4
Feb	-27.3	0.6	-52.2	3.0
Mar	-23.5	5.0	-42.2	6.9
Apr	-16.3	8.9	-38.9	8.9
May	-4.2	20.0	-30.6	8.4
Jun	5.0	28.3	-8.9	19.3
Jul	10.6	27.8	-6.7	39.1
Aug	8.2	28.9	-5.6	39.4
Sep	1.7	18.3	-13.3	21.1
Oct	-7.9	15.0	-30.0	24.1
Nov	-18.9	7.8	-42.8	8.9
Dec	-24.1	1.7	-47.2	4.1

Precipitation

Precipitation along the project area is extremely variable. For any given month, precipitation may range from zero to almost double the mean monthly average. In general, coastal stations record measurable amounts of precipitation on 40 to 100 days per year, while precipitation occurs on about 90 to 130 days within the Mackenzie Delta Region. There are many days with small amounts of precipitation, but relatively few days with precipitation in excess of 2.5 mm.

It normally rains in the study area from May to October, with peak rainfall occurring during July and August. These are also the months when extreme 24 hour rainfalls are most likely to occur. Convective activity in the study area is relatively light and most rainfall is associated with large baroclinic disturbances. Thunderstorms seldom occur.

In general, most rainfall occurs as weak showers on most days with measurable precipitation. On the other hand, the passage of intense frontal low pressure systems may produce heavy downpours on only two or three days of the month which account for as much as 75% of the monthly total precipitation. Table 4.1-1 shows the mean monthly precipitation recorded at Shingle Point, Yukon.

Rainfall generally ends by early November and except for infrequent warm spells in January which may produce some freezing rain, only trace amounts of rain are likely to fall during November through April. Although snowfall occurs only on rare occasions during June, July and August, it may occur in any month of the year throughout the region. Most snow tends to fall beginning from late September through early November, with a secondary maximum snowfall occurring in March through April. Extreme variations in the timing and amount of snowfall arecommon. Occasional intrusions of moist maritime air, in conjunction with temperaturs of a few degrees below freezing, may produce record or near-record, 24 hour snowfalls in April, May and even August. However, such summertime snowstorms are so rare that they have minimal affect upon the mean monthly snowfall norms.

Snow falls a minimum of about 23 days of the year, with Shingle Point recording around 31. These snowfalls are most frequent in the months of October to December. The majority of snowstorms last less than 24 hours but may extend up to 72 hours. Snow pack ranges anywhere from a few centimeters to as much as 20 cm of recrystallized, low density "depth hoar" with an upper layer of higher density wind-packed snow.

In the open landscape of the study area, however, the ever-blowing winds constantly shift dry snow from place to place.

Typical snow cover cross section on the tundra commonly shows a succession of hard wind-packed layers overlying a coarse granular layer with little cohesion ("depth hoar"). The depth hoar results from the combination of initially loose freshly fallen snow becoming overlaid by a hard wind-packed layer, and by subsequent upward movement of water vapour along the temperature gradient, from the warmer ground surface to the colder snow surface. One or more ice layers can form in the snow pack as the result of the thaw, downward percolation of meltwater, and subsequent freezing. Ice layers tend to make the snow pack dense and cohesive.

Continuous snow cover (that is, months with no breaks in cover) generally lasts from November to May along the project area. The latest recorded date for snow cover along the project area ranges from June 20 to 25.

Freezing precipitation is most likely to occur during the months of May and October with little difference in the number of hours of freezing rain during spring and fall.

Wind

Observed winds are often influenced by local topography and vegetation cover and may not be applicable to other locations. Consequently, the limited wind pattern data recorded at the observation sites may not apply to the project area. However, the prevailing easterly winds at Shingle Point average about 13 knots windspeed. Westerly winds can be much more intense than the prevailing easterlies and have been measured as high as 80 knots at Barter Island.

Wind affects marine operations principally by generating high seas, by moving ice into areas where vessels operate and by reducing visibility needed for supporting aircraft. During the late summer and early fall when ice is usually well offshore, strong winds cause substantial waves when the fetch (extent of open water over which the wind blows) is large - often at its annual maximum. Winds may reduce visibility by causing blowing snow or by advecting sea fog into coastal areas. Finally, with low air temperatures, winds control the severity of freezing spray and wind chill.

High coastal lands and the sharp thermal contrast between the land and the sea strongly influence coastal winds. Circulations driven by temperature differences between the land and the sea result in onshore breezes in summer and offshore breezes from the pack ice edge or open water in the winter.

Estimates of extreme winds and the expected recurrence period or return periods of these winds are important design criteria applicable to marine operators. A Beaufort Sea study used pressure data from 1969 to 1978 to estimate extreme winds for ten locations north of Tuktoyaktuk. Results indicate that once every 50 years an extreme hourly average wind speed of 105 km/hr might be expected in the area.

The dominant wind direction ranges from northeast to southeast for both the offshore and coastal Beaufort during any month of the year. Over the Beaufort Sea, easterly winds are dominant and southerly winds are rare during the summer months, while a pronounced shift to westerly winds occurs between Barter Island and Shingle Point. From July to September, westerly to northwesterly winds in excess of 36 km/hr become persistent. Fifty percent of all strong winds with speeds exceeding 50 km/hr are from the west or northwest, and these winds are often responsible for multi-year pack ice intrusions into coastal Beaufort Sea waters. Wind data from Shingle Point are tabulated (Table 4.1-2) to include winds from a relevant direction sector exceeding 20 and 40 km/hr.

Inversions

Burns (1973) indicated the frequency of surface-based inversions found at Inuvik (Table 4.1-3). Low-level inversions also occur in which temperatures initially decrease with height for the first few hundred meters and are capped by a shallow inversion layer. These are common in the afternoon in this region, although there are no statistics on their frequency of occurrence.

Fog

Factors affecting fog formation vary with season and location. In summer, warm moist air flowing over coastal waters containing ice results in the formation of advection fog. Although the fog generally occurs at the edges of ice floes, light onshore winds may advect the fog over the adjacent land. Most fog along the project area occurs in August with a maximum of six to eight days of fog at Cape Parry during August. Conversely, the Delta area experiences a maximum of only two to three days of fog per month from October to February.

Ice fog is relatively uncommon in this region because its formation relies on the sublimation of moisture on airborne particles (mostly hydrocarbons) in cold air

Table 4.1-2. Wind data tabulation summay. Wind speeds greater than 20 and 40 km/hr, direction and percentages at Shingle Point.

Wind Direction	June (Speeds & %)		July (Speeds & %)		Aug. (Speeds & %)		Sept. (Speeds & %)		Oct. (Speeds & %)		Mean % Wind Direction	
	>20	>40	>20	>40	>20	>40	>20	>40	>20	>40	>20	>40
W - NW	2.8%	0.1%	3.2%	0.3%	7.0%	1.4%	9.1%	2.0%	9.7%	1.6%	6.4	0.6
NW - N	4.9%	0.3%	4.1%	0.3%	8.2%	1.4%	11.6%	2.5%	11.4%	1.7%	8.0	1.3
N - NE	4.8%	0.1%	3.7%	-	2.2%	-	4.3%	0.5%	2.8%	0.1%	3.5	0.2
NE - E	3.6%	-	3.0%	-	0.6%	-	2.5%	0.1%	1.6%	0.1%	2.2	-

Table 4.1-3 Seasonal differences in the frequency of surface-based temperature inversions observed at Inuvik airport, N.W.T. (Beaufort Sea EIS 1982)

Months	Time of Day (GMT)	Frequency of Inversions (%)
December-February	2300	58
	1100	67
March-May	2300	3
	1100	60
June-August	2300	0
	1100	61
September-November	2300	25
	1100	46

below $-30^{o}C$. Due to the naturally low moisture content of cold air masses and the lack of human activity in the area, ice fog is insignificant.

Steam fog is a winter phenomenon associated with open leads or tidal cracks in the ice cover along the coast and in leads of larger rivers. The fog forms when moisture from the open water condenses in the cold air, and is usually observed from October through April when mean monthly temperatures are well below freezing.

Ice crystal haze is normally associated with the clear skies and low temperatures of Arctic high pressure systems. Although such haze may extend over wide areas, it usually does not lower the visibility below 3 km. In the cold air, and especially in the areas where large amounts of moisture are increased through combustion of hydrocarbons, the moisture in the air precipitates out as thin needle-shaped crystals. Even with weak winds, needles colliding with one another or with the ground result in extremely fine snow which fills the air and provides the sinuous streams of snow dust. As wind strength increases, a fine snowy fog is created giving rise to limited visibility and "whiteouts". These whiteouts usually occur most frequently in late winter, early spring and autumn.

Generally visibility in the clear Arctic air is high. Although the sun does not rise above the horizon for up to three months during the winter at latitudes at the project area, reflection of moonlight from snow and ice and a long twilight period brighten the polar night.

During the summer, fog mostly limits visibility, particularly in coastal areas. As the summer progresses, fog becomes patchy over the sea and is most prevalent at the edge of ice floes. There is less fog in winter than in summer in the Beaufort region. Steam fog may form near leads or tidal cracks in the ice as cold Arctic air passes over warm open water. This form of fog is patchy and is usually found between October and April. Ice fog is not common in this region, but when the sun is low it can hamper visibility of the horizon and prevent visual flight rating aircraft operations.

Over the Beaufort Sea, low visibilities (1 km or less) are more frequent in summer than in winter, with least visibility occurring in July when it may be less than 1 km 15 to 20% of the time. However, the persistence of visibilities of less than 4 km is greatest during the fall and winter, and least in the summer, when they occur 20 to 30% of the time.

In general, the poorest flying conditions can be expected along the coast of the Beaufort region during summer and fall.

The persistence of limited visibility inland (fog, haze or whiteout) is greatest during the fall and winter and least during the summer.

Ice

The landfast ice zone lies adjacent to the coast where motion is inhibited by attachment to the shore. Starting in late September or October, the ice advances out from shore to about the 20 m depth contour over the continental shelf. The maximum winter extent of the landfast ice zone is generally reached between mid November and early March. The ice grows throughout the winter, reaching a maximum thickness of approximately 2 m by late April. Once the landfast ice reaches its maximum extent, it changes little until break-up commences even though flaw leads may be present along the extremities throughout the winter.

Break-up and clearance of ice from the shore-fast zone usually begins in May. A generally ice-free open water corridor exists along the coast from July through to the formation of new ice at the beginning of October.

Air Quality

Few, if any, air quality measurements have been made in the project area. However, since few local pollution sources exist, it is reasonable to assume that air quality is good. Recent evidence indicates that some pollution does occur from distant sources, most likely located in Eurasia. Smoke from tundra fires may, on rare occasions, cause some localized air pollution.

4.2 TERRAIN AND GEOLOGY

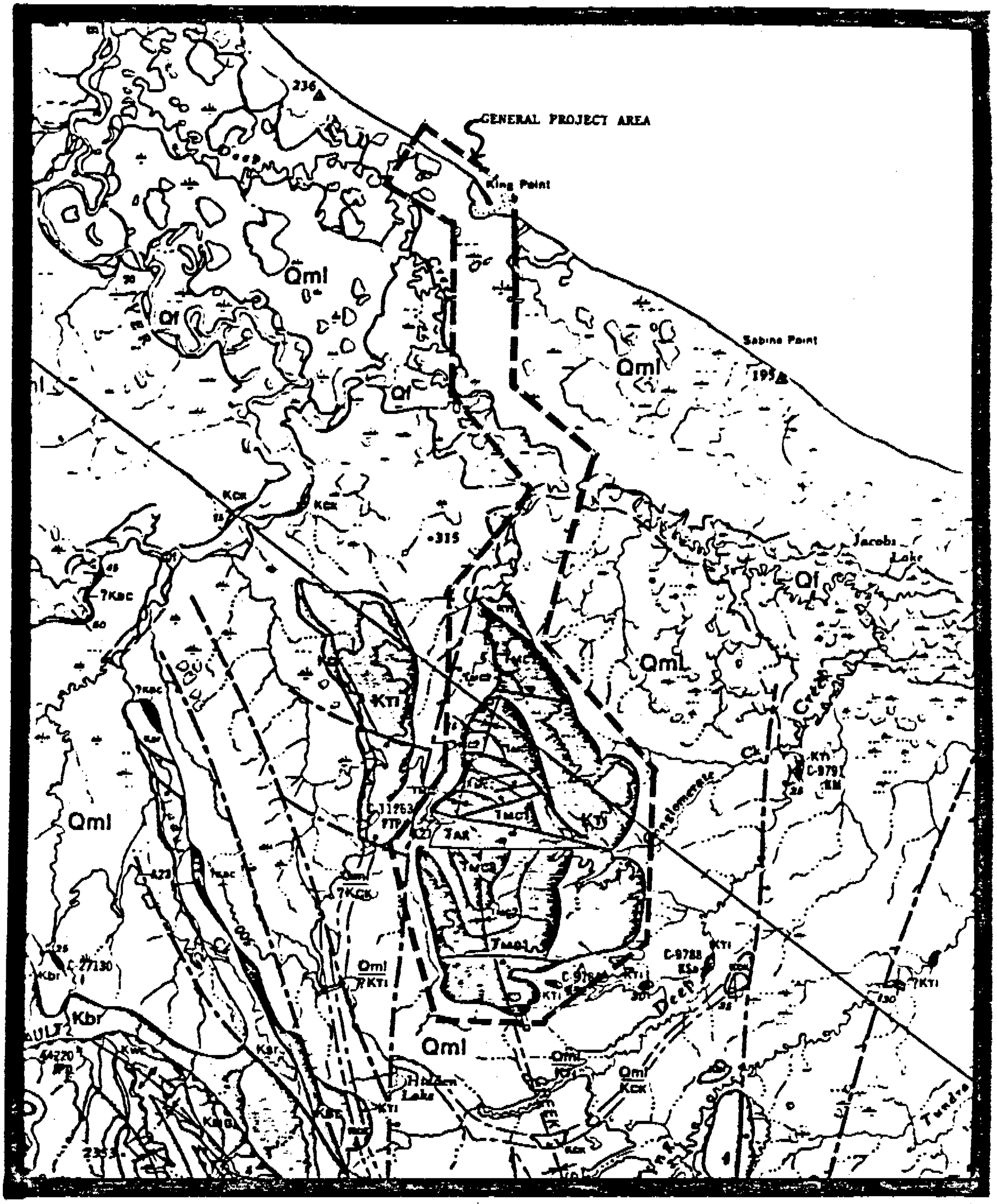
Physiography of the project area lies within the Arctic Coastal Plain Region. This region forms a relatively narrow border (around 15 km wide) adjacent to the Beaufort Sea and is referred to in the project area as the Yukon Coastal Plain.

The area's relatively smooth topography and low relief, generally less than 100 m (300 ft) elevation, tends to slope towards the ocean. In many places, however, this surface is either hummocky, due to the presence of glacial moraine deposits or is made irregular by the numerous lakes and distributory streams.

Bedrock underlying the Yukon Coastal Plain is largely concealed by relatively young deposits of marine and/or glacial origin and alluvium. Most beds have simple structure and are generally flat-lying or dip at low angles to the west or south. Bedrock geology in the project area has been described as Tertiary-Quaternary undivided, sand, gravel, and silt; generally can be considered as surficial materials. Surficial deposits in the project area consist chiefly of hummocky moraine of stony diamicton (till). They include complexes of end, lateral and kame moraines and are in part pre-Wisconsin in age (Fig. 4.2-1).

Project area soil development is generally considered to be weak or retarded. The Canadian soil classification system considers the project area soils to be Cryic Gleysols. These are poorly drained soils on level to gently sloping plains of glacial till. Soil texture is a gravelly loam-loam-silty clay with a medium acid pH.

Project area soils lie within the continuous permafrost zone. Although site specific permafrost surveys have not been conducted, an active layer in the project area is believed to extend from around 15 cm (0.5 ft) to over 200 cm (7 ft) depending upon vegetation cover. These soils tend to have a high ice content with



Legend

Scale 1:250,000

Qml - Hummocky or rigid moraine in area of Laurentide glaciation.
Qf - Fluviatile silt, sand and gravel, in part with cover of organic deposits.

Fig. 4.2-1. Geologic map. (Geologic Survey of Canada) well developed vein ice, ice crystals and ice lenses. Permafrost in this area extends to depths greater than 100 m.

The project is not within any recognized or anticipated areas of instability. Smooth to gently sloping topography will minimize potential construction and operation problems with mudflows, landslides, snowslides, etc. that are often associated with less hospitable terrain. Also, the project area is considered to be within seismic zone 2, the most active being zone 3 and the least active zone 0 (National Building Code of Canada 1980). Special, sensitive or unique geological or landform features within the project area, include the potential occurrence of thermokarst subsidence, active-layer detachment slides, retrogressive-thaw flow slides and the occurrence of a pingo in the vicinity of the haul road location.

Several small drainages originate in or transect the study area. These streams range from small tundra streams with seasonal flow to very short ditches with only sporadic flow. Most of the water supply for these streams comes from precipitation, surface permafrost-thaw processes, deep-lake drain and spring or ground water. Streams without any ground water sources include the Blow River and a large number of small streams (Deep, Conglomerate and "Quarry" Creeks). These streams drain the foothills and the Arctic Coastal Plain. They receive surface drainage from the surrounding tundra and from small lakes and bogs. Peak flows are associated with snowmelt in early summer or rainfall during late summer and fall. By October, most Arctic rivers cease to exhibit any measurable flow.

4.3 HYDROLOGY

Surface and ground water hydrology of the study area is dominated by the cold dry climate and permafrost. Streamflow essentially ceases during the long winter. Precipitation occurring as snow from September to May is stored in the snowpack until breakup, which is characterized by a dynamic flow period in late

May and early June. Most of the annual runoff occurs in this brief two to three week breakup period.

No flow records have been collected on streams within the study area, but based on other records on the North Slope, mean annual runoff is estimated to be about 0.5 cubic foot per second per square mile. A reconnaissance study of flood characteristics of streams in the Arctic National Wildlife Refuge (ANWR) found that maximum evident flood- peak discharge rates average about 40 cubic feet per second per square mile.

The primary cause of floods at the site is rapid spring snowmelt. The height of the floodflow is increased substantially by the presence of ice jams during spring breakup. In spring (May and June), melt water begins to accumulate and flow over the surface of the inland ice and on the deltas. As the river ice fractures and breakup begins, melt water combines with the increasing downstream flow of freshwater to rapidly flush the seawater from the lower rivers and deltas. Wide variations exist in the magnitude of spring flooding, as well as the likelihood of summer flooding, depending on whether river systems head in snowfields or flow through large lakes. As breakup continues, extensive flooding permits rapid movement of ice toward the sea, where flood water and block ice move onto and beneath the sea ice. Sediment loads are at their peak during flooding, and considerable deposition (several centimeters) of fine material may occur on the sea ice surface. The freshwater and sediments are soon drained through cracks and holes in the sea ice which develop with changes in the thermal regime. Following breakup, flooding drops off rapidly. Due to the low summer rainfall, there is little chance of summer flooding, but fall storms in the mountains can cause high water conditions.

Water Quality

Turbidity resulting from suspended sediments is the most viable impairment of water quality. Suspended-sediment concentrations are highest in the major streams and rivers during spring breakup and during periods of high summer flow. During low-flow periods, all the streams are essentially clear. Some of the shallow lakes also become turbid during the summer, when wind and wave action disturb bottom sediments. Aside from periods of turbidity, the water in most rivers and lakes is virtually colorless. Tea-colored waters, resulting from high concentration of dissolved organic materials, occur in some of the small tundra streams and lakes.

Water quality in lakes and streams is reduced in winter because of freeze concentration. The amount of concentration depends on the ratio of water to ice in a water body when maximum ice thickness is reached. Water in shallow lakes and river pools that freeze nearly to the bottom can become unpotable in late winter.

Dissolved oxygen in water is at or near saturation in the lakes and streams of the ANWR during summer, but levels of dissolved oxygen can be severely depressed under ice cover in winter, owing to the lack of reaeration and extended darkness that limits photosynthetic activity. Low dissolved-oxygen contents are most prevalent in water bodies that freeze nearly to the bottom.

4.4 TERRESTRIAL FLORA AND FAUNA

Flora

Project area vegetation lies within a single physiographic region - the Yukon Coastal Plain. This flat to slightly rolling terrain has been designated as herbaceous tundra.

Dominating the plant communities of the project area are the mosses, sedges and grasses. A detailed description of these vegetation communities is recounted below.

On the coastal plain the numerous ponds and lakes exhibit zones of vegetation. Through peat accumulation in which peat mosses (Sphagnum spp.) play an important role, the successive communities shift in on the water bodies which ultimately become peat filled. A common sequence includes pendent grass (Arctophila fulva) in deeper water, often mixed with mare's tail (Hippuris vulgaris) and Ranunculus pallasii, followed in shallower water by successive communities of cottongrass (Eriophorum angustifolium or E. scheuchzeri) Carex aquatilis the grass Dupontia fischeri, and several other sedges (Carex chordorrhiza; C. rariflora; C. rotundata; and C. membranacea). As peat mounds are built up and the sites become drier they are invaded by a number of species including woody species such as the prostrate willows (Salix pulchra; S. phlebophylla; S. rotundifolia; and S. reticulata), lingonberry (Vaccinium vitis-idea subsp. minus), and dwarf birch (Betula nana subsp. exilis).

Species of dwarf shrubs become more prominent under the improved drainage of the southern portion of the project area where the dominant vegetation consists of cottongrass tussock communities. Rounded tussocks 10-18 inches in height are formed by the sedge, Eriophorum vaginatum subsp. spissum. Associated are numerous species of mosses and lichens, cloudberry (Rubus chamaemorus), several species of grasses and such heaths as lingonberry, crowberry (Empetrum nigrum subsp. hermaphroditum), Labrador tea (Ledum palustre subsp. decumbens) and bearberry (Arctostaphylos rubra). Within the tussock community wherever lakes and associated swamps occur, the sedge and grass communities that dominate the coastal plain also occur.

Along streams, communities of tall shrubs 5-6 feet in height develop on banks and low alluvial terraces. The feltleaf willow (Salix alaxensis) is the most important species but others include Salix arbusculoides and S. glauca subsp. desertorum, and alder (Alnus crispa). Pernnial herbs form pioneer communties on stream-deposited silts and also occur within the shrub communities which succeed them. These species include fireweed (Epilobium latifolium), wormwood (Artemisia tilessii; A. alaskana; and A. arctica) and several legumes (Astragalus alpinus; Lupinus arcticus; and Oxytropis spp.).

The project area does not contain any known rare or unique vegetation, nor are there any plants of special economic, historic, social or scenic value. Similarly, there are no known plants listed on or proposed for listing as threatened or endangered within the proposed project area.

Species found within the project area do not provide any significant benefit to man as food or habitat with the possible exception of seasonal berry collecting. However, the vegetation does provide food and/or habitat for caribou, snowgeese, brown bear, numerous breeding waterfowl, passerines and small mammals.

Fauna

Mammals

Potential terrestrial mammal species for the northern Yukon area is presented in Table 4.4-1.

caribou (Rangifer tarandus granti)

Caribou are highly gregarious members of the deer family which usually occur in distinct populations or "herds". Most caribou herds undertake annual migrations which follow fairly predictable routes, although considerable variation can occur in some years. Large herds tend to occupy larger ranges and migrate longer distances than smaller herds. The central focal point of caribou migrations during spring is the calving grounds, which are traditional areas where the young are born.

Table 4.4-1 Potential terrestrial mammal species - King Point and project area. (From Youngman 1975)

Masked shrew	Sorex cinereus
Tundra shrew	Sorex tundrensis
Dusky shrew	Sorex obsurus
Arctic ground squirrel	Spermophilus parryii
Red-backed vole	Chethrionomys rutilus
Meadow vole	Microtus pennsylvanicus
Northern vole	Microtus oeconomus
Chestnut-cheeked vole	Microtus xanthognathus
Muskrat	Ondatra zibethicus
Siberian lemming	Lemmus sibiricus
Varying lemming	Dicsoutonyx torquatus
Coyote	Canis latrans
Wolf	Canis lupus
Arctic fox	Vulpes lagopus
Red fox	Vulpes vulpes
Black bear	Ursus americanus
Grizzly bear	Ursus arctos
Polar bear	Ursus maritimus
Ermine	Mustela erminea
Least weasel	Mustela nivalis
Mink	Mustela vison
Wolverine	Gulo gulo

River otter	_Lontra canadensis_
Lynx	_Felis canadensis_
Harbour seal	_Phoca vitulina_
Ringed seal	_Phoca hispida_
Moose	_Alces alces_
Caribou	_Rangifer tarandus_
Musk ox	_Ovibos moschabus_
Mountain sheep	_Ovis nivicola_

One caribou herd, the Porcupine, is associated with the study area. The Porcupine Herd (estimated at 110,000 animals in 1979) is one of the largest caribou herds in North America. It ranges over approximately 250,000 square kilometers in northeastern Alaska and northwestern Canada. In recent winters, the Porcupine Herd has wintered in both the central Yukon Territory and in the vicinity of Arctic Village, Alaska. Spring migrations usually begin in early April. The arrival date of pregnant cows on the traditional calving grounds seems to be dependent on snow conditions and location of wintering areas. The Porcupine Herd's calving grounds are international, extending along the Arctic foothills and coastal plain from the Babbage River in the Yukon Territory to the Canning River in Alaska.

Surrendi and DeBock (1976) suggested that the location of specific calving grounds used from year to year depends on the chronology of migration, and on the consistency of use and location of wintering areas. For example, during years when the amount of snow cover permits early spring migration, calving will probably occur further west along the Alaskan coast. In contrast, calving probably occurs primarily in the Yukon during years when conditions inhibit early migration.

Although the calving locations may vary from year to year, caribou appear to prefer well-drained and snow-free areas (Lent 1964, cited in Curatolo and Roseneau 1977). Studies conducted since 1971 have indicated that caribou tend to select calving grounds in the rolling foothills between the rugged mountains to the south and the snowbound lowlands of the Coastal Plain to the north (Curatolo and Roseneau 1977). Curatolo and Roseneau (1977) found that upland areas (180 m to 610 m ASL) were dominated by Eriophorum spp. tussock communities which provide an early source of green vegetation. These calving areas are also characterized by having early snow-melt and relatively low predator densities, which aid calf survival (Thompson et al. 1978).

Surveys conducted during 1972, 1973, 1974 and 1977 (McCourt et al. 1974, Roseneau et al. 1975, Bente 1977) indicate that caribou also calve on the Coastal Plain and that the distribution of cows may extend right to the beach. Nevertheless, the largest calving concentrations usually occur throughout the aforementioned foothills and at the junction of this area with the Coastal Plain. Surrendi and DeBock (1976) found that the calving area between the Malcolm and Spring rivers had mineral licks which were used extensively by subadults and lactating cows.

As calving progresses during June, the caribou tend to form nursery bands consisting of cows with calves and yearlings. They usually move slowly westward toward Alaska, and northward toward the coast as it gradually becomes free of snow (Doll et al. 1974, Bente 1977). Bull caribou do not usually merge with the cow/calf segment of the herd until late June or early July (Martell, pers. comm.). The herd gradually moves west to the Canning River-Barter Island area of the Alaskan North Slope, with most caribou having left the Yukon by the end of June. Large post-calving aggregations occur in the Alaska coastal region between the Canning River and Barter Island between June 30 and mid July each year (Roseneau and Curatolo 1975, Curatolo and Roseneau 1977, Bente 1977).

Immediately following the formation of post-calving aggregations, the caribou begin an eastward migration and re-enter the Yukon in early July along a corridor between the southern edge of the Coastal Plain (200 m contour) and the divide of the British Mountains. They continue to move eastward across the North Slope toward the head-waters of the Driftwood River in the northern Richardson Mountains, generally arriving by late July. Routes are usually restricted to the upland areas of the British and Barn mountain ranges, as the caribou tend to avoid the flat wet low-lying Coastal Plain to the north and Old Crow Flats to the south (Thompson et al. 1978).

By late July or early August the herd begins to disperse from the northern Richardson Mountain-Driftwood River region and moves westward to Alaska. The caribou move through a broad corridor bounded on the north by the southern slopes of the British Mountains and on the south by the Old Crow Range (Jakimchuk et al. 1974, McCourt et al. 1974, Doll et al. 1974, Roseneau and Curatolo 1975, Roseneau et al. 1975). Although this dispersal does not usually occur along the North Slope, a few groups move northward to the coast in most years. For example, about 2,000 caribou moved to the Coal Mine Lake area and the mouth of the Blow River in 1971 (Jakimchuk et al. 1974), while a herd of about 2,000 individuals was located near Shingle Point in 1972 (McCourt et al. 1974).

The southward fall migration may begin as early as the second week of September, and follows both the Old Crow and Richardson routes (Jakimchuk et al. 1974, McCourt et al. 1974). However, the timing of initiation of the southward migration may vary considerably between years and is probably related to the occurrence of the first major snow storm (Roseneau and Curatolo 1975). Since very few caribou are typically located on the North Slope during late summer, little activity occurs there during fall migration. However, occasionally caribou have been reported to remain at or return to the North Slope. For example, approximately 4,000 caribou were located in the uplands bordering the Mackenzie Delta between Big Fish River and Shingle Point in November 1973 (Doll et al. 1974).

wolves (Canis lupus)

Wolves are found throughout Yukons' North Slope, although population density is low on the coastal plain when compared to wintering areas farther south. They occupy large, stable home ranges and are not often observed in summer. In winter, wolves tend to congregate in areas of overwintering caribou and are more visible. Daily movement is dependent on availability of prey; some authors have reported the typical stalk involved 10-15 miles.

Density estimates for restricted geographic areas vary widely, but most fall within the range reported by Mech (1970) of three to 200 square miles per wolf. Mating occurs in March, and pups (usually four to seven to a litter) are born in dens two months later. Although wolves are known to den on the coastal plain no dens have been found in the study area.

Wolves prey principally upon caribou, moose, sheep, ground squirrels, birds and microtines. Stalking of prey distributes wolves throughout all habitat types, but they are typically associated with major drainage systems.

arctic Fox (Vulpes lagopus)

The Arctic fox is a small terrestrial mammal that ranges throughout the Arctic tundra, forest-tundra transition and landfast ice areas of North America. Arctic foxes use component habitats in relation to availability of prey species and in association with their own den sites. The movements and fluctuations observed in natural populations are believed to be related to the availability and abundance of prey (Macpherson 1969, Banfield 1974, Dickinson and Herman 1979).

Although this species is terrestrial throughout most of its range, Arctic foxes in coastal areas move onto the nearshore landfast ice during winter. During spring and summer, Arctic foxes occupy areas near the terrestrial breeding dens and remain there during the relatively snow-free period from May until August. All Arctic fox den sites reported by Nolan et al. (1973b) were in open areas with low relief. Den sites have been located in pingos on the Mackenzie Delta islands, in sand dunes, in frost heaves, and at the tops of banks of lakes, rivers and streams. Traditional den sites are usually located in sandy vegetated areas with a gentle slope (Macpherson 1969).

Arctic foxes are efficient scavengers and prey upon a variety of species. Primary food items include lemmings and other small rodents, ringed seal pups, seal and caribou carrion, and birds (especially their eggs and nestlings). The diet of

Arctic foxes changes with the seasonal availability of prey and the habitat occupied. For example, lemmings are the primary food source during summer (Chesemore 1968, Macpherson 1969, Banfield 1974). In the winter, inland populations depend primarily on lemmings, while coastal populations prey on seal pups and seal carrion on the landfast ice. Arctic foxes may follow caribou herds to take advantage of carrion left after wolf kills (Manning 1943, Macpherson 1969) or follow polar bears on the winter sea ice to scavenge on the remains of seals killed by them (Blood 1977). Arctic foxes are also known to scavenge at community garbage dumps.

Mating occurs in winter, and single litters containing four to 20 kits are produced in dens during May, June or early July. More than 50% of the offspring may die during the first six months, depending upon availabilty of prey species. Life expectancy is four to five years. Kits appear above ground some time in June and remain near the den until July or August, when adults start leading them on food-gathering trips.

The general distribution and movements of Arctic foxes in the southeastern Beaufort region are probably typical of most coastal populations (Macpherson 1969). Foxes in coastal areas generally move onto the sea-ice during winter and return to land-based dens in the spring, although Porsild (1945) noted that Arctic foxes on the Tuktoyaktuk Peninsula tend to follow the reindeer herd, presumably to feed on reindeer carrion and weak fawns.

Arctic foxes are relatively common residents of the Yukon North Slope. Ruttan (1974c) identified four distinct areas of denning habitat. The most suitable area (Class 1) occurs along the coastal plain between the Malcolm and Babbage/Crow rivers, and had a density of one den per 44 km^2 (Nolan et al. 1973b). Twenty-six of the 27 dens found in this area were Arctic fox dens, with the highest density of the dens occurring between the Firth and Spring rivers.

The coastal plain between the Alaska/Yukon border and the Malcolm River is considered Class 2 fox habitat (Nolan et al. 1973b), and is less productive than the aforementioned area because of the presence of low wet terrain. However, the density of dens recorded in this area was one per 41 km^2 (7 out of the 8 dens recorded in this area were Arctic fox) (Ruttan 1974). Similarly, the area between the Babbage/Crow River and the Blow River is also considered important habitat (Class 2) for Arctic fox (Nolan et al. 1973). Again, the low wet terrain limits its suitability for denning. Ruttan (1974) recorded three Arctic fox dens in this area and a density of one den per 495 km^2. The highest density of fox dens (one den/10.4 km^2) recorded during Ruttan's (1974) survey was on Herschel Island which provides Class 2 habitat for Arctic fox (Nolan et al. 1973). A total of nine Arctic fox dens and three coloured fox dens were observed.

wolverines (Gulo gulo luscus)

The wolverine may be found throughout the North Slope but is considered scarce along the coast. Animals commonly travel along gentle slopes or stream edges, and they may be found searching for food in any habitat. Following breeding in late spring to summer (May-July), birth of two to four young occurs in late February or March in snow dens.

Wolverines are reported capable of capturing prey as large as moose, but carrion (primarily caribou and moose), when available, is considered principal food. Ground squirrels, fish, rabbits, and microtines are also consumed.

brown bear or grizzly bear (Ursus arctos)

Barren-ground grizzly bears usually occupy zones of low relief and open tundra north of the boreal forest (Watson et al. 1973). The barren-ground grizzly bear is considered rare by the IUCN (Goodwin and Holloway 1972) and a "species at risk" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

The behaviour, distribution and movements of grizzly bears are closely associated with their diet and the availability of food. They are omnivorous, feeding on roots, berries, herbs, ground squirrels, fish and ungulates. Tundra-dwelling bears occupy low-lying coastal areas in June and ascend into the higher hilly areas a few kilometers inland during July, August and September (Pearson and Nagy, 1976). The seasonal distribution of grizzly bears on Richards Island was found to follow the above pattern (Slaney 1974). For example, occupation of the low-lying marshy areas coincided with the presence of nesting waterfowl and an abundance of sedges and herbs, while presence of bears in upland areas was concurrent with the presence of ground squirrels and berry-producing shrubs (Slaney 1974).

Den sites are particularly important to grizzly bears, and the availability of suitable sites can be a potential limiting factor in some areas (Pearson 1975). Grizzly bears normally den from mid October or November to April or May. During this time, pregnant females produce one to three cubs. Pearson (1972) reported a minimum breeding age of approximately 6 years for females and an average litter of 1.58 for the northern interior grizzly bears in the Yukon.

West of the Mackenzie Delta, Class 1 (high use) habitat for grizzly bear occurs in the Richardson Mountains, the Barn Range, and the British Mountains. The Coastal Plain north of these mountain ranges is designated as Class 2 (common use) habitat because bear sightings are infrequent and dens have not been found (Nolan et al. 1973). Pearson and Goski (1974) reported a density of one bear/65 km^2 on the Arctic coastal plateau of the northern Yukon Territory. Doll et al. (1974) and Ruttan and Wooley (1974) reported an apparent southward shift of this species from the coast during September.

polar bears (Ursus maritimus)

The polar bear is circumpolar in distribution and ranges throughout the Arctic. Individual polar bears often move long distances and cross international boundaries.

Although polar bears are essentially marine mammals that are adapted to live on the sea-ice, pregnant females occupy dens on land from early November to late March or April; the cubs are born in December or January (Schweinsburg et al. 1977). In the Canadian High Arctic, maternity dens occur only in snowdrifts on steep slopes or along stream banks near the sea (Harington 1968, Stirling et al. 1978).

Adult males, non-breeding females and subadults remain on the sea-ice throughout the winter and spring. During breakup, bears are forced ashore in some eastern arctic areas. These bears return to the ice as it forms again in the fall. In the western Arctic, bears almost always remain on the offshore pack-ice in the summer (Stirling et al. 1975).

Polar bears feed primarily on ringed seals, although bearded seals may be locally important (Stirling and Archibald 1977, Stirling and Latour 1975). Smith (1976) showed that predation by polar bears can have potentially important effects on ringed seal populations. Similarly, changes in ringed seal population levels can affect the numbers and distribution of polar bears. For example, Stirling et al. (1975, 1977) and Stirling (1978) have shown that reductions in the numbers of ringed seals and bearded seals in the eastern Beaufort Sea led to reduced numbers of polar bears. Reduced reproductive rates and emigration were associated with the decline in numbers of bears.

Polar bears are hunted throughout the Canadian Arctic under a community quota system administered by the Northwest Territories government. The polar bear hunt is culturally important to the Inuit and also provides a source of cash income from the sale of pelts.

Stirling (1978) estimated that between 1700 and 1800 polar bears occupied the Canadian Beaufort Sea and Amundsen Gulf areas in the period 1972-1974. This population declined to about 1200 animals in response to the decline in seal populations that occurred between 1974 and 1975 (Stirling 1978). There have been no recent studies to determine whether polar bear numbers have increased in response to the recovery of the seal population.

There is a differential distribution of age and sex classes on the winter ice during the period from late October to June. Highest numbers are found on the ice of the active or shear zone, which extends for 100-200 km beyond the landfast-ice (Fig. 4.4-1). Large numbers of bears are also found along the landfast-ice-edge (floe-edge). The bears in these two zones consist primarily of adult males, non-breeding females, subadults, and females accompanied by yearlings (Stirling et al. 1975b; Stirling 1978). The active ice zone and floe-edge are also used by bearded seals and by immature ring seals (Stirling et al. 1975a); the latter are the principal prey of polar bears (Stirling and Archibald 1977).

Pregnant females are in dens through the winter. They leave the maternity dens with their young-of-the-year in late March or April and move onto the landfast-ice where they prey on breeding ringed seals.

During the open-water period from July to October, polar bears move offshore with the polar pack-ice where they are able to continue to hunt seals. Only rarely do bears remain on land during this period (Stirling et al. 1975b).

muskoxen (Ovibos moschatus)

Muskoxen are known to occur in Canada, Alaska, and Greenland. The majority of the Canadian population inhabits the Arctic Archipelago, but substantial numbers occur on the Canadian mainland, particularly in the Thelon River Game Sanctuary and Bathurst Inlet region (Tener 1965).

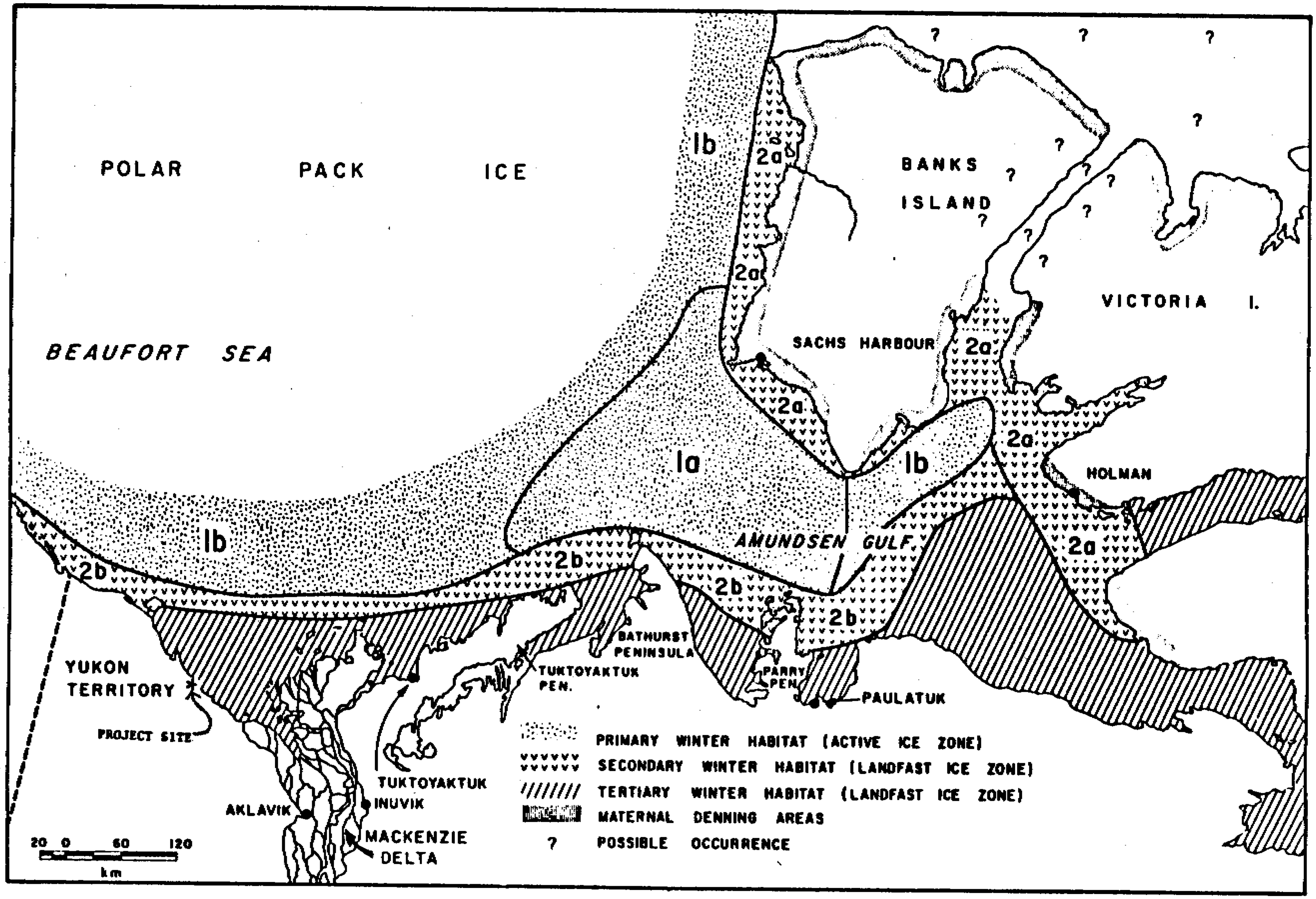


Fig. 4.4-1. Winter (November-December) distribution of polar bears in the E Beaufort Sea. 1a = heavily used primary habitat. 1b = less heavily used primary habitat. 2a = secondary habitat important to females with cubs. 2b = less heavily used secondary habitat. Based on sources cited in text and Stirling (pers. comm.) (from Biological Overview-Beaufort Sea 1982)

In summer, muskoxen occur in lowland areas where streams, ponds, and lakes permit maximum growth of vegetation. Wintering areas are usually located in higher terrain where winds tend to keep areas snowfree. The diet of this species consists primarily of sedges, willow and mosses.

The smaller number of muskoxen observed in the northern Yukon are probably stray animals from the population on the North Slope of Alaska. The Alaska muskoxen were transplanted to Barter Island and Kavik camp in 1969 and 1970 (Roseneau and Warbelow 1974). Surveys conducted in 1972 indicated that from one to possibly three lone adult muskoxen were present on the Yukon North Slope (Roseneau and Stern 1974). A group of six were reported near the Spring River in 1973 (Roseneau and Warbelow 1974).

Muskox have recently been reported near the project area (Scott 1983).

Birds

A total of 120 species have been recorded on or near the project area (Salter et al. 1980) (Table 4.4-2). The majority of birds in the area are migratory and are present only from May to September. Four common species are considered to be permanent residents - willow ptarmigan, snowy owl, common raven and gyrfalcon. Over 20 bird species occur offshore, primarily from late July to mid-September. Sixteen of the offshore species breed locally on coastal tundra or barrier islands, with distribution generally limited to within 60 km of shore.

Birds begin to use coastal lagoons with the occurrence of snowmelt in early June. During this period, river overflow covers the deltaic portions of the lagoons and provides the first open water of the season. Bird use remains at low levels until ice-out occurs, usually in late June to mid-July. Populations gradually increase through July until a peak is reached in August, then populations gradually decline. However, a second peak is observed in mid-September as birds begin staging for fall migration. Some birds are usually present until freezeup in late September or early October.

Table 4.4-2 Potential bird species - King Point and project area. (from Salter et al. 1980)

(A = Abundant; C = Common; FC = Fair Common; U = Uncommon; R = Rare; VR = Very Rare; PR = Permanent Resident; SR = Summer Resident; SPM, FM or M = Spring or Fall Migrant; V = Visitant)

Species	Status	Species Account
Common loon *Gavia immer*	UV	31 May - 10 Sep
Yellow loon *Gavia adamsii*	UV	28 May - 17 Sep
Arctic loon *Gavia arctica*	C SR	31 May - 25 Sep
Red-throated loon *Gavia stellata*	FC SR	30 May - 12 Sep
Red-necked grebe *Podicepe grisegena*	VR V	-
Horned grebe *Podiceps auritus*	VR V	-
Whistling swan *Olor columbianus*	FC SR	19 May - 2 Oct
Canada goose *Branta canadensis*	R(SR?) U SPFM	28 May - 15 Sep
Brant *Branta bernicla*	U SR, C SPFM	27 May - 28 Sep
White-fronted goose *Anser albifrons*	U SPM, RV, CFM	15 May - 26 Sep
Snow goose *Chen caerulescens*	U SPM, VRV, AFM	13 May - 26 Sep

Species	Status	Species Account
Mallard Anas platyrhynchos	R SR	-
Pintail Anas acuta	FC SR, CM	17 May - 17 Sep
Green-winged teal Anas crecca	U SR	27 May - 17 Sep
American wigeon Anas americana	R SR	-
Northern shoveler Anas clypeata	VR SR	-
Canvasback Aythya valisineria	VR V	-
Greater, lesser scaup Aythya marila/A. affinis	C SR	26 May - 26 Sep
Common goldeneye Bucephala clangula	R V	-
Barrow's goldeneye Bucephala islandica	V RV	-
Oldsquaw Clangula hyemalis	A SR	28 May - 28 Sep
Harlequin duck Histrionicus histrionicus	R V	-
Common eider Somateria molliseima	U SR	3 Jun - 26 Sep
King eider Somateria spectobilis	U M	13 May - 7 Sep
White-winged scoter Melanitta deglandi	FC V	1 Jun - 6 Sep
Surf scoter Melanitta perspicillata	C V	29 May - 15 Sep
Black scoter Melanitta nigra	R V	-

Species	Status	Species Account
Red-breasted merganser *Mergus serrator*	U SR	26 May - 25 Sep
Sharp-shinned hawk *Accipiter striatus*	VR V	-
Red-tailed hawk *Buteo jamaicensis*	VR V	-
Rough-legged hawk *Buteo lagopus*	U SR	16 May - 29 Sep
Golden eagle *Aquila chrysaetos*	U SR	26 Apr - 25 Sep
Bald eagle *Haliaeetus leucocephalus*	VR V	-
Marsh hawk *Circus cyaneus*	U V	16 May - 18 Sep
Osprey *Pandion haliaetus*	VR V	-
Gyrfalcon *Falco rusticolus*	U PR	Year round
Peregrine falcon *Falco peregrinus*	R SR	-
Merlin *Falco columbarius*	VR V	-
American kestrel *Falco sparverius*	VR V	-
Willow ptarmigan *Lagopus lagopus*	A PR	Year round
Rock ptarmigan *Lagopus mutus*	FC SR	9 May - 22 Sep
Sandhill crane *Grus canadensis*	U V	20 May - 23 Sep
Semipalmated plover *Charadrius semipalmatus*	R(SR?)	-

Species	Status	Species Account
Killdeer <u>Charadrius vociferus</u>	VR V	-
American golden plover <u>Pluvialis dominica</u>	A SR	17 May - 16 Sep
Black-bellied plover <u>Pluvialis squatarola</u>	U M	30 May - 2 Sep
Ruddy turnstone <u>Arenaria interpres</u>	U M	18 May - 3 Sep
Common snipe <u>Capella gallinago</u>	FC(SR?)	26 May - 30 Aug
Whimbrel <u>Numenius phaeopus</u>	U SR	26 May - 30 Aug
Spotted sandpiper <u>Actitis macularia</u>	R(SR?)	-
Lesser yellowlegs <u>Tringa flauipes</u>	R V	-
Red knot <u>Calidris canutus</u>	VR V	-
Pectoral sandpiper <u>Calidris melanotos</u>	C SR	24 May - 19 Sep
White-rumped sandpipe <u>Calidris fuscicollis</u>	R M	-
Baird's sandpiper <u>Calidris bairdii</u>	FC SR	28 May - 9 Aug
Least sandpiper <u>Calidris minutilla</u>	U(SR?)	28 May - 29 Jul
Dunlin <u>Calidris alpina</u>	R V	-
Semipalmated sandpiper <u>Calidris pusilla</u>	A SR	27 May - 29 Aug
Sanderling <u>Calidris alba</u>	RV, UM	27 May - 5 Sep

Species	Status	Species Account
Long-billed dowitcher Limnodromus scolopaceus	U(SR?)	22 May - 25 Sep
Stilt sandpiper Micropalama limantopus	U SR	27 May - 22 Aug
Buff-breasted sandpiper Tryngites subruficollis	U SR	27 May - 27 Aug
Hudsonian godwit Limosa haemastica	R V	-
Red phalarope Phalaropus fulicarius	U SR	31 May - 5 Sep
Northern phalarope Lobipes lobatus	A SR	20 May - 17 Sep
Pomarine jaeger Stercorarius pomarinus	C SPM, R V	28 May - 26 Sep
Parasitic jaeger Stercorarius parasiticus	C VR	22 May - 28 Sep
Long-tailed jaeger Stercorarius longicaudus	C SR	20 May - 28 Sep
Glaucous gull Larus hyperboreus	C SR	11 May - 22 Oct
Iceland gull Larus glaucoides	VR V	-
Herring gull Larus argentatus	U V	-
Thayer's gull Larus thayeri	U V	21 May - 28 Sep
Mew gull Larus canus	R V	-
Bonaparte's gull Larus philadelphia	VR V	-
Little gull Larus minutus	VR V	-

Species	Status	Species Account
Ivory gull *Pagophila eburner*	VR V	-
Kithwake *Rissa sp.*	VR v	-
Sabine's gull *Xema sabini*	R V	-
Arctic tern *Sterna paradisaea*	A SR	27 May - 5 Sep
Murre *Uria sp.*	VR V	-
Black guillemot *Cepphus grylle*	R SR	-
Snowy owl *Nyctea scandiaca*	U PR	Year round
Short-eared owl *Asio flammeus*	U SR	15 May - 18 Sep
Common nighthawk *Chordeiles minor*	VR V	-
Common flicker *Colaptes auratus*	VR V	-
Say's phoebe *Sayornis saya*	R SR	-
Horned lakr *Eremophila alpestris*	U(SR?)	14 May - 12 Sep
Tree swallow *Iridoprocne biedor*	R V	-
Bank swallow *Riparia siparia*	R V	-
Barn swallow *Hirundo rustica*	VR V	-
Cliff swallow *Petrochelidon pyrrhonota*	R(SR?)	-

Species	Status	Species Account
Common raven Coruus corax	FC PR	Year round
Dipper Clinclus mexicanus	VR V	-
American robin Turdus migratorius	R(SR?)	-
Varied thrush Ixoreus naevius	R(SR?)	-
Swainson's thrush Cathamus ustulatus	VR V	-
Gray-cheeked thrush Catharus ,omo,is	U(SR?)	-
Wheatear Oenanthe oenanthe	R SR	-
Bluethroat Luscinia svecica	VR V	-
Yellow wagtail Motacilla flava	U SR	2 Jun - 25 Jul
Water pipit Anthus spinoletta	U(SR?)	10 May - 29 Sep
Red-throated pipit Anthus cervinus	VR V	-
Bohemian Waxwing Bombycilla garrulus	VR V	-
Northern shrike Lanius excubitor	VR V	-
Solitary vireo Vireo solitarius	VR V	-
Yellow warbler Dendroica petechia	U SR	27 May - 26 Jul
Yellow-rumped warbler Dendroica coronata	VR V	-

Species	Status	Species Account
Back poll warbler *Dendroica striata*	VR V	-
Northern waterthrush *Serius noveboracensis*	VR(SR?)	-
Wilson's warbler *Wilsonia pusilla*	VR(SR?)	-
Rusty blackbird *Euphagus carolinus*	VR V	-
Hoary/common redpoll *Carduelis hornemanni/C. flammea*	A SR	26 May - 28 Sep
Savannah sparrow *Passerculus sandwichensis*	C SR	26 May - 24 Sep
Dark-eyed junco *Junco hyemalis*	VR V	-
Tree sparrow *Spizella argorea*	A SR	28 May - 14 Sep
White-crowned sparrow *Zonotrichia leucophrys*	U SR	26 May - 24 Sep
Fox sparrow *Passerella iliaca*	U SR	26 May - 26 Jul
Lincoln's sparrow *Meloupiza lincolnii*	VR V	-
Lapland longspur *Calcarious lapponicus*	A SR	9 May - 23 Sep
Snow bunting *Plectrophenax nivalis*	FC SR	19 Apr - 28 Sep

gyrfalcon (*Falco rusticolus*)

The gyrfalcon breeds in small numbers throughout the Arctic. Fyfe (1976) considered the population of gyrfalcons in the Yukon and Northwest Territories to be stable, and of low to medium abundance.

Gyrfalcons are known to breed on the North Slope of the Yukon and Northwest Territories, and in the British and Richardson mountains (Platt 1975), 1976a). They nest in low numbers east of the Mackenzie Delta along the Horton and Anderson rivers. Gyrfalcons have also been observed in other areas of the coastal Beaufort region (e.g., Tuktoyaktuk Peninsula).

Gyrfalcons nest much earlier than other raptor species. Some adults remain near their nests all winter, and pair formation may occur in February or March (Platt 1976b, Roseneau et al. 1981). Egg-laying usually occurs during April and early May and most eggs hatch by mid June. Fledging occurs during August and the young remain with the adults for 5 to 6 weeks (Cade 1960, Platt and Tull 1977, Roseneau et al. 1981). These times vary considerably both from year to year and among geographic areas (Cade 1960, Tull and Koski 1981).

Gyrfalcons nest primarily on cliffs, bluffs and outcrops, but they will occasionally nest on man-made structures or in trees (Cade 1960, White and Cade 1971, Kuyt 1980). Eggs are laid in a scrape on a nest ledge or in an old stick nest of a rough-legged hawk, golden eagle or common raven (Cade 1960, Roseneau 1972, Campbell and Davies 1973). Clutch size is usually 3 or 4 eggs, but may range from 2 to 6 (Cade 1960).

Traditional use of nest sites by gyrfalcons is not as regular as that by peregrine falcons (Cade 1960, Roseneau 1972, Platt and Tull 1977). In consecutive years, gyrfalcons may shift from one nest site to a nearby alternative site on the same or a nearby nest cliff, or to a nest cliff much further away (Roseneau et al. 1981). Local shifts may be due to local snow conditions (Platt and Tull 1977) or to the collapse of nest ledges (Roseneau 1972). Large shifts probably occur in response to reduced prey availability (Roseneau 1972). It has also been suggested by some (and disputed by others) that gyrfalcons may not breed in years of low prey available (cf. Cade 1960, Roseneau 1972).

Gyrfalcons have a more specialized diet than do peregrine falcons. Gyrfalcons typically rely on only a few prey species for the bulk of their diet (Cade 1960, White and Cade 1971, Roseneau 1972). In summer, ptarmigan are often the principal prey and may constitute up to 70-90% of their diet; Arctic ground squirrels, and in some regions long-tailed jaegers, are also important (Cade 1960, Roseneau 1972). Ptarmigan are the main prey in winter (Platt 1976a, Walker 1977), but Arctic hares may be important in some areas. The extent of the hunting ranges used by gyrfalcons is variable. For example, Nelson (1978) observed a male in the Yukon that hunted 24 km from the nest, while Bente (1980) recorded a male in Alaska that hunted at or beyond 9 km from the nest, and a female that hunted only within 3 km of the nest.

peregrine falcon (Falco peregrinus anatum and F.P. tundrius)

Two subspecies of the peregrine falcon are generally recognized to occur in the study area. Falco peregrinus anatum breeds south of the treeline and is considered by COSEWIC to be 'endangered' in Canada, while Falco peregrinus tundrius breeds north of the treeline and is considered by COSEWIC to be 'threatened' in Canada. Both subspecies are considered 'endangered' under the United States Endangered Species Act (United States Dept. Interior 1973).

Both subspecies have declined over much of their North American breeding ranges since the second world war, primarily from a decline in productivity associated with the widespread use of pesticides (e.g., D.D.T.) (Hickey 1969, Cade and Fyfe 1970, Peakall 1976). However, with decreased use of pesticides in Britain, peregrine populations have increased (Ratcliffe 1980) and there is recent evidence to suggest that the numbers and productivity of both subspecies of peregrine falcon in Alaska have begun to recover slowly (Roseneau et al. 1981). In Canada, there is also evidence of a slow recovery for Falco peregrinus anatum in the north-central Yukon, although they are still heavily contaminated with pesticides. In general, peregrine populations appear to be holding their reduced levels elsewhere in Canada.

Cliffs provide the primary nesting habitat for peregrine falcons, but they have also been observed to nest on man-made structures (e.g., buildings), in trees, and on level ground (Cade 1960. Peregrine falcons are more limited by altitude in their choice of nest sites than are the other cliff-nesting raptors (cf. White and Cade 1971, Roseneau 1974). In Alaska, peregrines have not been recorded to nest at altitudes of greater than 800 m above sea level (Cade 1960), although they have nested above 900 m in the central Yukon (Mossop, pers. comm., cited in Roseneau et al. 1981).

Nest sites are often traditional, and may be used by successive pairs (Newton 1976). Unoccupied nests may remain unused for a few years (or longer) if an alternative nest site within a given territory is being used or if no birds are present, but the nest is likely to be occupied by new pairs at a future date (Ratcliffe 1980). Consequently, unoccupied historical sites have a protected status.

Peregrine falcons migrate south from the Beaufort region to winter. Banding returns indicate that northern peregrines winter mostly in Latin America. The fall departure of Falco peregrinus tundrius from the coastal Beaufort area has not been well documented.

Peregrine falcons feed primarily on birds taken in flight. They are opportunistic feeders, and take a wide variety of prey. Their principal prey includes shorebirds, waterfowl and passerines (Cade 1960). Peregrines also take some mammalian prey. Peregrines hunt primarily over open areas, such as large rivers, where prey have little opportunity to find cover. Hunting ranges of breeding peregrines vary in size; for example, a male peregrine in Arctic Alaska hunted over a territory with a radius of about 11 km (White 1974), while several anatum peregrines in interior Alaska and Canada hunted within 1.5 to 5 km of their nest sites (Roseneau et al. 1981). Further information on hunting is given in Tull and Koski (1981).

yellow-billed loon (Gavia adamsii)

No reliable estimates are available for the population of yellow-billed loons in the Canadian Arctic, but this species is primarily Eurasian and the North American population is not believed to be large (Palmer 1962). The main North American nesting areas of the yellow-billed loon appear to border or lie immediately east of the southeastern Beaufort Sea (LGL and ESL 1982). Spring migrants first arrive in the Beaufort and northeast Chukchi Seas during late May and early June (Richardson and Johnson 1981) and are occasionally observed in open leads during spring (Barry et al. 1981). Subadult yellow-billed loons remain in wintering areas during the breeding season (Palmer 1962).

In the Beaufort-Chukchi region, yellow-billed loons nest sparsely along most of the mainland coast except in the Mackenzie Delta-Liverpool Bay area and along the Yukon coast. They nest more commonly on Banks and Victoria Islands (Salter et al. 1980). In the early 1950's, an estimated 3,000 adults were reported to nest on Banks Island (Manning et al. 1956). This species is also locally abundant at some lakes on southeastern Victoria Island (Parmelee et al. 1967). The fall migration is relatively 'leisurely', and probably occurs along an offshore route from mid August to mid September (Smith 1973, Searing et al. 1975).

brant (Branta bernicla hrota and B.b. nigricans)

The brant is the most northerly-nesting goose species and has a circumpolar breeding distribution (Ogilvie 1978). Two subspecies of the brant nest in North America: the Atlantic brant (Branta bernicla hrota), which nests in northwest Greenland and in the eastern Canadian Arctic; and the black brant (Branta bernicla nigricans), which nests on the westernmost islands of the Arctic Archipelago and along the mainland coasts of the western Northwest Territories, Yukon and Alaska. The black brant is the common subspecies in the Beaufort region; the Atlantic brant is found in this region only as an irregular migrant.

Brant generally nest in coastal meadows, often just above high tide line, and many nests may be lost when storm surges occur during the nesting season (Barry, 1967). Nests are also often placed on the edge of freshwater or tidal pools or on small islets (Belrose 1976). Brant may nest in loose colonies, or nests may be widely dispersed (Barry 1964).

Brant feed almost exclusively on vegetation. They graze on sedges and other tundra vegetation during summer (Barry 1967), and feed very heavily on eelgrass in the winter (Bellrose 1976, Palmer).

Black brant winter along the coast of Baja California and the adjacent areas of Mexico (Bellrose 1976). The northward spring migration occurs along the Pacific coast to the major spring staging area at Izembek Bay near the tip of the Alaska peninsula in southwest Alaska. From Izembek Bay black brant migrate into the Beaufort-Chukchi area along various routes, both overland and coastal. Some brant fly from the Bering Sea to the Beaufort Sea along the Yukon-Koyukuk Basin and through Anaktuvuk Pass or possibly the Blow River Pass (Johnson et al. 1975). Others migrate from the Chukchi Sea to the Beaufort along the Kobuk, Noatak and Colville River drainages. The number of brant that use these overland routes is not known but is suspected to be substantial (cf. Richardson and Johnson 1981).

Spring migrant black brant in the northeast Chukchi-Beaufort Seas consist of birds that summer in the Beaufort region as well as those en route to summering areas to the northeast and east of the Beaufort Sea. It has been speculated that some brant destined for the Arctic Islands may use a coastal route to Point Barrow and then fly a direct offshore route toward Banks Island (Einarson 1965, Barry 1967). Other black brant may follow a coastal route through the northeast Chukchi and Beaufort Sea. However, most are likely to migrate overland across Alaska, then fly eastward along the coast after reaching the Beaufort Sea in northeast Alaska (cf. Richardson and Johnson 1981). At least 20,000 black brant must pass through the Beaufort Sea on route to summering areas east of the Beaufort (Bellrose 1976).

Spring migration of black brant into the northeast Chukchi and Beaufort Seas begins during late May and is rapid. By late May brant have begun to arrive at nesting areas throughout the southern Beaufort Sea and by early June the first brant have arrived at Victoria and Banks Islands (Barry 1967, Johnson et al. 1975, Johnson 1979, Richardson and Johnson 1981). Peak migration occurs during the first two weeks of June (Johnson et al. 1975, Searing et al. 1975, Johnson 1979).

Of the estimated 4,000 brant that breed along the Beaufort Sea coast from Demarcation Bay to Darnley Bay, about 2,000 breed in the vicinity of the Anderson River delta (CWS 1972). Smaller colonies occur near Paulatuk (500 birds), at the mouth of the Kugaluk River (400 birds), from Warren Point to Atkinson Point (500 birds), and on islands in the outer Mackenzie Delta (500 birds). Slaney (1974a) reported a colony of approximately 200 nesting brant at an inland location (Denis Lagoon) in the outer Mackenzie Delta. Scattered individuals nest at other locations along the Canadian Beaufort Sea coast, but total numbers are low. Bellrose (1976) estimates that approximately 17,000 black brant nest along the Alaskan North Slope. An estimated 10,000 brant also nest on western Banks Island.

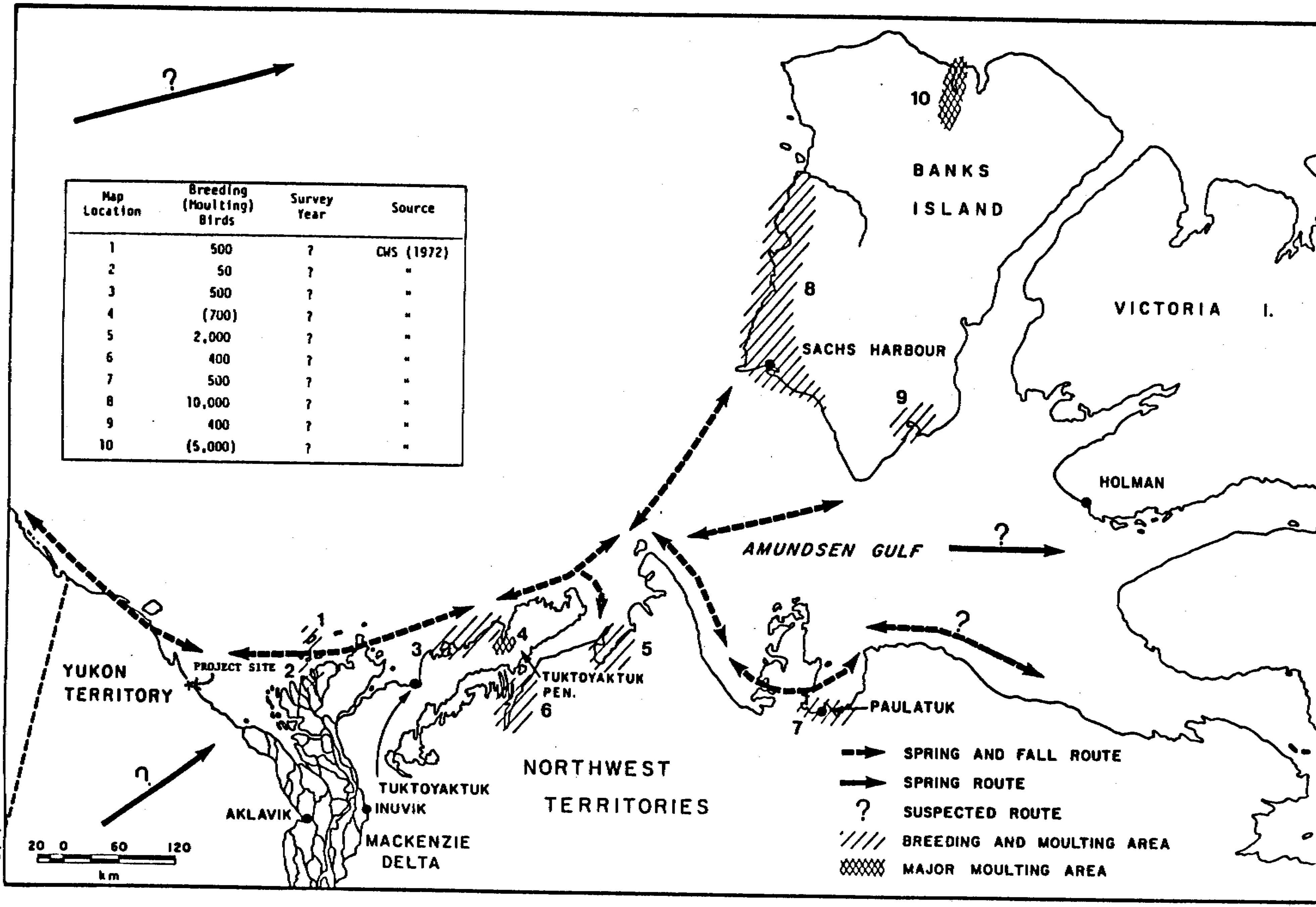
Brant begin nesting along the Beaufort Sea coast in early June. After hatching in early July, broods in coastal areas move to tidal flats where they feed on sedges and marine invertebrates. Adults moult during the brood-rearing period, but are capable of flight by mid August when the young have fledged (Barry 1967, Johnson et al. 1975).

Non-breeding birds also moult in coastal areas starting in early July (Barry, 1967). Major moulting areas for brant in the Beaufort and northeast Chukchi Seas are shown in Figure 4.4-2. In the Canadian Beaufort, the only area where substantial numbers of moulting brant (700 birds) have been reported is McKinley Bay (CWS 1972), but studies in recent years have recorded few moulting brant there (Searing et al. 1975, Boothroyd and Karasiuk 1981, Scott-Brown et al. 1981). Non-breeding birds have generally completed their moult by late July (Derksen et al. 1979).

The fall migration of black brant is almost entirely confined to coastal routes and retraces the coastal spring migration routes. The migration begins during mid to late August. Brant make frequent stops at lagoons and deltas to feed and rest. The more important fall staging areas in the Beaufort region include Cape Dalhousie, Mallik Bay, Tent Island, the Blow River delta, Phillips Bay and Demarcation Bay (Searing et al. 1975, Koski 1975a, 1977a & b, Barry et al. 1981). By early September, most brant have left the Beaufort Sea region (Searing et al. 1975, Timson 1976).

white-front goose (Anser albifrons)

The white-front is the first species of goose to arrive in the Beaufort Sea region each spring. The northward overland migration from the Gulf of Mexico and central Mexico is gradual and begins in early February. White-fronts first arrive in the Peace-Athabasca delta in northeastern Alberta during late April to mid May, and in the years from 1959 to 1964 they first arrived at the Anderson River from



Map Location	Breeding (Moulting) Birds	Survey Year	Source
1	500	?	CWS (1972)
2	50	?	"
3	500	?	"
4	(700)	?	"
5	2,000	?	"
6	400	?	"
7	500	?	"
8	10,000	?	"
9	400	?	"
10	(5,000)	?	"

Fig. 4.4-2. Major migration routes and breeding and moulting areas of brant in the eastern Beaufort Sea.
(from Biological Overview-Beaufort Sea 1982)

May 12 to 17 (Barry 1967). Spring migration to breeding areas east of the Mackenzie Delta occurs overland from the staging areas on the Mackenzie River (between Fort Good Hope and Arctic Red River) to the Kugaluk and Anderson Rivers, which are followed to the coast. Similarly, any birds that summer on the Alaskan North Slope migrate from the Mackenzie River staging areas via overland routes; few white-fronts use the Yukon coast as a spring migration corridor (Johnson et al. 1975, Salter et al. 1980, Richardson and Johnson 1981).

White-fronted geese begin nesting in late May or early June, and hatching occurs during the last week of June or the first week of July. About the time the young hatch, subadults that have been associated with nesting adults migrate to traditional moulting areas on large inland lakes, river channels and coastal flats along the eastern Beaufort Sea coast (Barry 1967, Parmelee et al. 1967, Kuyt 1974, Johnson et al. 1975). The largest moulting area in the Beaufort Sea is located on the Smoke-Moose River flats where in 1965, 20,000 moulting white-fronts were seen mixed with an equal number of Canada geese (Barry 1967). Other important moulting areas are located on the upper Kugaluk River (4,000; CWS 1972), Richards Island (4,000; Slaney 1974a), Anderson River (5,000; CWS 1972) and the Harrowby Bay area (3,200; CWS 1972). Non-breeding white-fronts have completed their moult by early August, while breeding adults with young are able to fly by about August 20 (Barry 1967).

The migration of white-fronted geese from the Beaufort Sea region is gradual, beginning possibly as early as mid August and continuing until late September or early October (Barry 1967). During the migration, large numbers stage in the Mackenzie Delta. In the outer Delta, the major concentration areas are Shallow Bay, Kittigazuit Bay, and the Ellice Island area. Other important staging areas include Phillips Bay, the Blow River delta and Tent Island (Koski 1975a, 1977a,b). In three of four years when August-September surveys were conducted in the outer Mackenzie Delta (1973-76), estimated peak numbers of more than 19,000 were recorded there (Koski 1977b). In the fourth year (1976), an estimated peak of only 12,500 was recorded; in that year large numbers (peak count of 18,000) staged on the Yukon North Slope. Since turnover rates are unknown, the total numbers of birds using these staging areas cannot be estimated, but they are likely to be considerably larger than the peak numbers mentioned above.

White-fronted geese that stage in the Mackenzie Delta include birds from the Anderson River delta area as well as birds from the Alaskan North Slope (Koski 1977b). Anderson River birds that stage in the Mackenzie Delta area are probably present by the fourth week of August (Koski 1977b). In late August and early September there is an influx of birds from Alaska. Migration watches indicate that most of the birds from Alaska travel along the North Slope inland from the coast (cf. Gollop and Davis 1974a, Johnson 1979, Salter et al. 1980). White-fronts are believed to travel non-stop from their Alaskan nesting and moulting grounds to Yukon-Mackenzie staging areas (Koski 1975a).

By the fourth week of September, most white-fronted geese have departed from the Beaufort Sea region (Koski 1977a, b).

snow goose (*Chen caerulescens caerulescens* and *C. c. atlantica*)

Two distinct subspecies of the snow goose are found in North America. The lesser snow goose (*Chen caerulescens caerulescens*) is the more common, and nests from Baffin Island to Wrangel Island, Siberia. The greater snow goose (*Chen caerulescens atlantica*) is restricted to islands in the Arctic Archipelago and western Greenland (Bellrose 1976).

Snow geese, particularly the lesser snow goose, frequently nest in dense colonies. Colonies are generally located in low grassy tundra on coastal plains, along broad shallow rivers near the coast, and inland on islands in shallow lakes.

Clutch sizes for snow geese generally are in the range of 3 to 5 eggs (Bellrose 1976). The incubation period varies between 19 and 24 days, and the young fledge within 45 days after hatching (Cooch 1958, Barry 1967, Ryder 1970).

During the brood-rearing period, large aggregations of moulting adults with young and moulting non-breeding birds usually occur in areas adjacent to breeding colonies. The use of specific brood-rearing areas appears to be traditional (Healey et al. 1980).

After flight is regained, even larger concentrations may occur in premigratory staging areas (Koski 1977b, Wypkema and Ankney 1979). Geese greatly increase their fat reserves and juveniles complete growth while on the staging areas. The energy reserves are important for their southward migration (Patterson 1974, Wypkema and Ankney 1979).

Snow geese feed almost entirely on vegetation. They feed primarily by grazing in terrestrial areas on the seeds, stems and roots of grasses and sedges, although they may also feed on berries and aquatic plants (Palmer 1976a, Prevett et al. 1979).

Snow geese that nest in the northeast Chukchi and Beaufort Sea areas migrate from their wintering grounds in California by overland routes. The main migration route is along the Mackenzie Valley. Many birds proceeding to the Banks Island colony stage along the Anderson River (80-100 km inland) or in the Kittigazuit Bay area of the Mackenzie Delta (as many as 75,000 snow geese; Barry cited in CWS 1972). The latter group fly along the Tuktoyaktuk Peninsula before crossing Amundsen Gulf to Banks Island (Barry 1967). Some birds migrating to Banks Island may take a more easterly route over Great Slave Lake (Hohn 1959) and reach the Arctic coast in the Parry Peninsula area. There are spring staging areas in Darnley Bay at the base of the Parry Peninsula and east of Sachs Harbour, Banks Island (CWS 1972). In addition to the geese summering in the eastern

Beaufort Sea, some of the few birds that nest along the North Slope may migrate down the Mackenzie Valley and then westward along the coast of Alaska (Johnson et al. 1975, Richardson and Johnson 1981).

Snow geese first arrive in the Beaufort Sea-Amundsen Gulf area during mid May. Adult snow geese arrive at their nesting grounds at Anderson River, Kendall Island and Banks Island during the last few days of May or the first days of June (McEwen 1958, Barry 1967). In breeding years egg-laying begins very soon after arrival of the colonies and is generally completed by mid June. Hatching takes place in late June or early July (McEwen 1954 & 1958, Barry 1967).

Snow geese may begin to leave the nesting and brood-rearing areas on Banks Island and the Anderson River as early as mid August. Some snow geese, presumably from both of these colonies, may stop and feed for several days at the Parry Peninsula and the mouth of the Horton River before proceeding to their main staging areas on the Mackenzie Delta and North Slope (Koski 1977a, b). The use of specific staging areas by snow geese is dependent upon weather conditions. In years when conditions are favourable on the North Slope, staging snow geese may spread as far west as the Canning River, Alaska, and the Mackenzie Delta area may be little used. However, when early freeze-up and snowfall prevent snow geese from staging on the North Slope, staging may be confined to the Mackenzie Delta (Koski 1977a, b). Areas that have consistently received heaviest use are the east side of Shallow Bay, the vicinity of the Blow and Walking Rivers, and the Malcolm River delta (Koski and Gollop 1974, Koski 1975a & 1977a, b). These staging areas are used by the entire western Canadian population of lesser snow geese which in fall has ranged from 200,000 to 500,000 birds in size.

In 1981, fall migration differed from that described above in that probably half the Banks Island snow geese staged on the Parry Peninsula and flew south from there. As in spring, weather was probably again the major contributing factor.

The movement from the colonies to the staging areas occurs about the third week of August and the peak of movement occurs during the first week of September. In normal years there is little eastward movement along the coast for two weeks after the birds arrive at the staging areas where they feed and accumulate fat reserves (Patterson 1974). Movement eastward from the North Slope staging areas normally begins during the second or third week of September (Gollop and Davis 1974a, Koski and Gollop 1974) and by October most geese are retracing spring migration routes southward (Johnson et al. 1975).

whistling swan (*Olor columbianus*)

The whistling swan is a North American waterfowl species that breeds in the subarctic and Arctic tundra from Bristol Bay, Alaska, east to Baffin Island. The species population in spring is approximately 90,000 birds, 60,000 of which summer in Alaska and the remaining 30,000 in Canada. Of the whistling swans that summer in Canada, approximately 21,000 are found in areas adjacent to the Beaufort Sea. The primary wintering grounds of the whistling swan are along the east and west coasts of the United States (Bellrose 1976); those that summer in the Beaufort Sea area winter along the east coast (Sladen 1973).

Nesting whistling swans are highly territorial and are widely distributed over their lowland tundra nesting habitat. Their nests are generally adjacent to, or on islands in, tundra ponds, lakes and sluggish rivers, and less often near sheltered tidal waters (Palmer 1976a). Many non-nesters also maintain territories.

The interval from the laying of the first egg to the fledging of the young is approximately 100 days. The male remains with the incubating female and assists the female in defence of the brood. Brood-rearing usually occurs in areas relatively close to the nest site (Bellrose 1976). Both adults moult during the brood-rearing period; the females moult before the males (Banko and MacKay 1964).

Subadults also return to the nesting grounds and these birds remain in small flocks (3 to 15 birds) throughout the breeding season. Subadults moult before the adults and when they regain flight they begin to congregate in coastal lowlands or near large inland lakes. These flocks are later joined by family groups. Flocks averaging about 50 birds then begin migrating from nesting areas to wintering areas. Whistling swans are noted for their long-distance non-stop migratory flights (Bellrose 1976).

Whistling swans feed mainly on the tubers and stems of aquatic plants, and usually in the shallow water of ponds, lakes and slow-moving streams (Bellrose 1976, Palmer 1976a).

Whistling swans migrate overland along the Mackenzie Valley and first arrive in the Mackenzie and Anderson River deltas in mid May (Barry 1967, Slaney 1974a & 1975) and on the Yukon North Slope in late May (Salter et al. 1980). Approximately 800 swans that nest on the Alaska North Slope migrate through the Mackenzie Delta region and along the Yukon North Slope (Sladen 1973). Over 500 were estimated to have flown west along the Yukon coast into Alaska during late May and early June 1975 (Richardson and Johnson 1981). Courtship and copulation occur at the northern spring staging areas along the Mackenzie River and the swans are ready to nest when they arrive in the Beaufort region. Soon after the swans arrive, they disperse to the nesting area and establish territories; nesting begins during late May or early June.

Pairs of territorial whistling swans are widely distributed over the tundra nesting habitat. Consequently, large numbers of nesting birds do not occur in a small area. About two-thirds of the Canadian population or about 20,000 whistling swans are known to summer between the west side of the Mackenzie Delta and the east side of the Anderson River delta (Bellrose 1976). Smaller numbers summer on the Yukon North Slope (200+; Mossop 1975), the Bathurst Peninsula (400+; CWS

1972) and the Parry Peninsula (200; CWS 1972). In addition to the birds in the Canadian Beaufort region, approximately 800 whistling swans summer on the Alaskan North Slope (Sladen 1973).

Both non-nesting and nesting swans remain on their territories throughout the brood-rearing and moulting period, which extends from early July to mid August for non-nesters and unsuccessful nesters, and to early September for successful nesters. During the breeding season non-territorial birds are found in small groups scattered throughout available habitat, but some subadults move to moulting areas during about the first week of July. For example, Slaney (1974a & 1975) noted 1,100 non-breeding swans in an area west of Mallik Bay in 1972, 950 in 1973 and 1,175 in 1974. CWS (1972) lists several important moulting areas for whistling swans within the coastal Beaufort region.

By mid September, both adults that have nested successfully and their young are capable of flight and join the subadult flocks. Prior to the fall migration, flocks stage in suitable habitats adjacent to the Beaufort Sea (Bellrose 1976). The areas used appear to be traditional, and congregations of birds are recorded by mid August, particularly along the outer Mackenzie Delta. The areas most consistently used are Mallik Bay, the vicinity of Kendall Island, Olivier Islands and along Shoalwater Bay (Koski 1975a & 1977a, b).

As fall progresses, the swans move inland to the inner Mackenzie Delta. Large flocks have been recorded in some areas in the inner Delta. Such areas may be used fairly consistently from year to year, but repeated surveys have not been conducted to identify the locations and the degree of use. The last swans to leave the outer Delta include a high proportion of adults with young (Koski 1977b). Whistling swans from the Alaskan North Slope migrate along the Yukon coast as freeze-up begins, and appear to join the Mackenzie Delta birds. Whistling swans leave the inner Delta from mid September to early October, although some have been recorded in the area as late as October 12 (Porsild 1943).

4.5 AQUATIC FLORA AND FAUNA

Flora

Numerous lakes and ponds in the project area exhibit successional vegetation zones related to water depth, drainage and soil aeration. Through peat accumulation in which peat mosses (Sphagnum spp.) play an important role, the successive communities shift in on the water bodies which ultimately become peat filled. A common sequence includes pendent grass (Arctophila fulva) in deeper water, often mixed with mare's tail (Hippuris vulgaris) and Ranunculus pallasii, followed in shallower water by successive communities of cottongrass (Eriophorum angustifolium or E. scheuchzeri) Carex aquatilis the grass Dupontia fischeri, and several other sedges (Carex chordorrhiza; C. rariflora; C. rotundata; and C. membranacea). As peat mounds are built up and the sites become drier they are invaded by a number of species including woody species such as the prostrate willows (Salix pulchra; S. phlebophylla; S. rotundifolia; and S. reticulata), lingonberry (Vaccinium vitis-idaea subsp. minus), and dwarf birch (Betula nan subsp. exilis).

Along streams crossing the coastal plain, communities of tall shrubs 5-6 feet in height develop on banks and low alluvial terraces. The feltleaf willow (Salix alaxensis) is the most important species but others include Salix arbusculoides and S. glauca subsp. desertorum, and alder (Alnus crispa). Perennial herbs form pioneer communities on stream-deposited silts and also occur within the shrub communities which succeed them. These species include fireweed (Epilobium latifolium), wormwood (Artemisia tilessii; A. alaskana; and A. arctica) and several legumes (Astragalus alpinus; Lupinus arcticus; and Oxytropis spp.).

These aquatic plant communities provide little recreational and commercial value. Also, the majority of project area lakes freeze solid during the winter months and contain no fish. However, these plant communities provide significant food and/or habitat for a number of native area wildlife.

Fauna

Lakes and tundra streams are common in the project area (Craig and McCart 1974). Most of the lakes are located along the coast and are generally thaw lakes. Some deeper foothill and mountain lakes, supply streams that flow through the coastal plain. Coastal plain lakes less than 2 meters in depth generally offer unsuitable winter fish habitat. Many are shallow and either freeze to the bottom by late winter or offer poor water quality conditions due to freeze concentration of dissolved solids and low dissolved oxygen levels. Lakes near the ocean may also be brackish due to saltwater intrusion of windblown ocean spray. Some of these shallow coastal lakes may be important as summer feeding areas for many freshwater, anadromous, and marine fish. This seasonal use is dependent on a suitable outlet for access.

As winter approaches, riffle areas freeze to the bottom and overwintering fish become isolated in deeper pools or spring areas. Winter flow through streambed alluvium is minimal or nonexistent. Ice accumulation on arctic rivers usually reaches maximum thickness between late March and early May.

Available overwintering habitat, such as deeper pools, is greatly reduced in early spring. Depth of these pools is important in their ability to overwinter fish; however, several other parameters affect their suitability for overwintering. These parameters ultimately affect dissolved oxygen concentration and include density of organisms in pool area, species' physiological tolerances, volume of the pool, temperature, organic matter, and the influence of springs. Overwintering habitat is perhaps the greatest limiting factor for arctic anadromous and freshwater fish population. Severe winter conditions in the Arctic drastically reduce available water supplies. During winter, overwintering water sources in streams are limited to spring areas, deeper isolated pools and brackish river delta areas.

Marine nearshore waters are important spawning and overwintering areas for many marine fishes, such as arctic cod and fourhorn sculpin. River deltas are believed to be important overwintering areas for many species of marine and freshwater fish. Suitability of delta overwintering areas depends on the salinity tolerances of species using the area.

The distribution and seasonal abundance of fish in lakes within the study area have not been well defined. Lakes sampled with other studies contain populations of lake trout, arctic char, and grayling. Coastal lakes near the Canning River Delta have been sampled during summer and have contained grayling, arctic char, arctic cisco, round whitefish, and fourhorn sculpin. Table 4.5-1 includes several fish species of the Beaufort Sea drainages.

The distribution and seasonal abundance of fish in Deep and "Quarry" Creeks have not been identified by the applicant. However, other studies have documented four species: Arctic grayling, Arctic char, Humpback whitefish and Broad whitefish. Only fry of grayling were found, suggesting that spawning and rearing areas only exist for this species.

Nearshore waters of the area have been reported to contain many marine and anadromous species, including arctic cisco, arctic char, boreal smelt, fourhorn sculpin, and arctic cod.

Anadromous Species

During the summer, coastal habitats become feeding grounds and migration routes for anadromous species. Over a period of about three or four months, anadromous fish accumulate much of the energy reserves required for spawning and overwintering, although these activities occur later in freshwater habitats usually well away from the coast.

During summer most anadromous species appear to use a narrow corridor within the brackish water immediately next to the shoreline. Shortly after break-

Table 4.5-1 Fish species of the Beaufort Sea drainages.

Common Name	Scientific Name	Spawning Period
Arctic grayling	Thymallus arcticus	Spring
Arctic char	Salvelinus alpinus	Fall
Lake trout	Salvelinus namaycush	Fall
Inconnu	Stenoclus ieucichtys	Fall
Humpback whitefish	Coregonus clupeaformis	Fall
Round whitefish	Coregonus cylinderaceum	Fall
Broad whitefish	Coregonus Nasus	Fall
Least cisco	Coregonus sarda	Fall
Northern pike	Esox lucius	Spring
Burbot	Lota lota	Winter
Fourhorn sculpin	Myoxocephalus quadricornis	Spring
Pond smelt	Mypomensus olidus	Spring

up, when land runoff begins to flow into the sea, anadromous species descend into nearshore habitats and (to varying degrees) disperse outward along the Beaufort Sea coast. In almost all fish surveys, most anadromous species appear to restrict themselves to nearshore waters which are less than 5 m deep (Craig and Haldorson 1980, Byers and Kashino 1980). The major factor affecting their distribution appears to be the presence of relatively warm brackish water, and Craig and Haldorson (1980) suggested that such water conditions may be necessary for these species to achieve optimal summer growth.

The distances travelled by anadromous fish along the coast and the timing of migrations varies with the species and their life history stage. For example, most mature anadromous fish do not spawn each year, and in some species the spawning segment of the population may either remain in freshwater habitats during the summer, or undertake short coastal migrations in the early summer, returning to spawning rivers early in the open water season (McCart 1980, Craig and Haldorson 1980). As a result, immature fish and mature non-spawners tend to be more prevalent in coastal waters compared to the season's spawning population. They migrate greater distances and remain for longer periods away from their native rivers.

The distance anadromous fish travel from natal streams varies with species. Arctic char and Arctic cisco apparently undertake the longest migrations of the anadromous species found in this region. For example, an Arctic char originally tagged in the Sagavanirktok River was recaptured 300 km away (Furniss 1975). Although this distance is probably larger than normal, studies elsewhere suggest that Arctic char and Arctic cisco probably travel 90 to 170 km away from their stream of origin during the summer. The latter species has been recorded migrating from the Tuktoyaktuk Peninsula up the Mackenzie River to Arctic Red River (Department of Fisheries and Oceans, unpubl. data).

Anadromous species utilize coastal habitats almost exclusively for feeding during the open water season, rather than for spawning or overwintering. There is overlap in the diet of most anadromous species, with epibenthic crustaceans, particularly mysids and amphipods, being dominant food. Although anadromous fish appear to depend on relatively few species of prey, food sources are apparently abundant in coastal environments of the Beaufort and northeast Chukchi region. Craig and Haldorson (1980) suggest that an annual immigration of prey species into coastal habitats results from the exchange between nearshore and offshore waters and that this migration may be critical in maintaining their abundance.

As indicated earlier most adult anadromous fish do not spawn in consecutive years. Adult populations generally consist of two components: mature non-spawning individuals which accumulate fat reserves during the summer and then return to freshwater in order to spawn during the fall. This separation of adult populations has been observed in Arctic char, Arctic cisco, least cisco, broad whitefish and humpback whitefish populations of the region (Craig and Haldorson 1980, Griffiths et al. 1975 & 1977, Kendel et al. 1975). Studies completed in the nearshore Beaufort Sea indicate that spawning individuals usually remain within or near freshwater spawning areas during the summer months.

Most anadromous fish overwinter in freshwater habitats. Some species, such as Arctic char, remain upstream near springs and well away from the coast throughout the winter (McCart 1980). Ciscos and whitefish may return to river delta overwintering areas after spawning in the fall, and these river delta habits occasionally include brackish-water environments.

Marine Species

In contrast to the available data base for anadromous species, much less is known about the marine species that inhabit the Beaufort Sea, owing largely to the nearshore emphasis of most studies. The information collected to date suggests that marine fish, as well as anadromous species, use nearshore habitats primarily for feeding during the summer months. Epibenthic invertebrates are the major prey items, although planktonic copepods are also important in the diet of some marine fish. However, unlike the anadromous fish, the occurrence of marine species in nearshore habitats is more sporadic. For example, occasionally large schools of Arctic cod may appear briefly in nearshore waters and be totally absent at other times in the same season.

Some marine fish species spawn in nearshore habitats. Fourhorn sculpin, capelin, snailfish and herring are reported to spawn in coastal regions, although spawning areas for most of these species are generally in water greater than 2 m deep and somewhat outside the nearshore corridor used by anadromous species. Of these species, the fourhorn sculpin and snailfish spawn during the winter under the ice. Pelagic marine species such as the Arctic cod may also spawn in coastal habitats. Craig and Haldorson (1980) reported ripe and post-spawning marine fish in Stefansson Sound inside barrier islands. Other investigators suggest that Arctic cod spawn in widespread and non-specific offshore areas in winter (Tarbox and Moulton 1980).

There is extensive overwintering habitat for marine species throughout the Beaufort Sea. The presence of fourhorn sculpin, Arctic cod, snailfish and flounders under the ice in coastal habitats was recently documented by Craig and Haldorson (1980) and Tarbox and Thorne (1980). These species presumably move into deeper water as ice occupies the shallower nearshore habitats. The shallow areas are apparently repopulated when the ice cover eventually disappears in late spring.

mammals

The available information for selected species of marine mammal that regularly occurs in the Beaufort Sea is reviewed in the following species accounts. Maps showing distribution, migration routes and concentration areas are presented where appropriate.

white whale (Delphinapterus leucas)

The white whale is a small, toothed whale. It is a highly social species and large herds often occur in Arctic waters.

Substantial proportions of the North American population can be found in very restricted areas at certain times of the year. For example, large concentrations occur in the estuaries of certain arctic rivers (e.g., at least 7,000 in the Mackenzie River estuary—Fraker and Fraker 1979) in summer (late June to early August), and large compact herds have been observed in the eastern Arctic during fall migration.

White whales feed on a wide variety of fish and invertebrates of benthic and pelagic origin. In Arctic waters, the Arctic cod appears to be the major prey item (Vibe 1950, Davis and Finley 1979).

The white whale is a summer resident of the Beaufort Sea and this population winters in the Bering Sea (Braham et al. 1977a). The whales leave the Bering Sea in March and April, pass through the Chukchi Sea in mid to late April (Braham et al. 1977a) and finally migrate past the northwest coast of Alaska from late April to mid June. East of Point Barrow, Alaska, early migrants appear to travel far offshore through leads in the pack-ice (Fig. 4.5-1). Offshore routes presumably vary according to the location of lead systems, which may differ within or between years (Braham 1979). The early migrants reach the major lead west of Banks Island in May and travel south; some reach Amundsen Gulf by mid May (Fraker 1979a). The later migrants travel farther south in the Beaufort Sea and probably move directly to Amundsen Gulf (Fraker 1979a). Fraker (1979a) has estimated that as many as 3,000 white whales may be present in Amundsen Gulf by mid June. Very late migrants may go directly to the Mackenzie estuary.

Most white whales occur in three 'concentration areas' in the Mackenzie estuary during July, although there is some movement between areas and to and

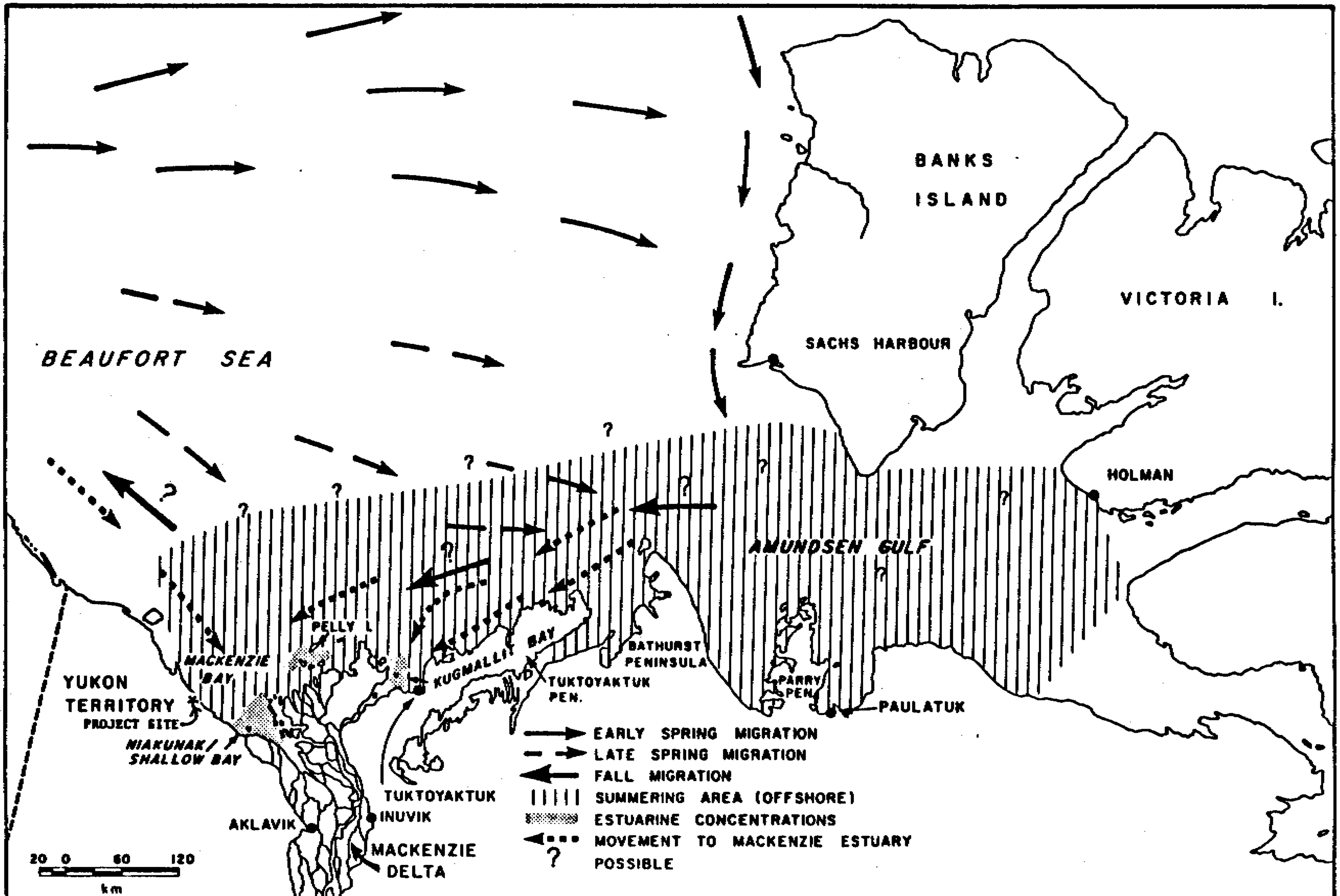


Fig. 4.5-1. Distribution and movements of white whales in the E Beaufort Sea. Based on sources cited in the text.(from Biological Overview-Beaufort Sea 1982)

Table 4.5-2 Maximum estimated numbers of white whales in the Mackenzie estuary 1972-1981.[1]

Year	Maximum Estimate
1972	1,500-2,000
1973	3,500-4,000
1974	3,500-4,000
1975	4,000
1976	5,500-6,000
1977	5,500
1978	6,600
1979	7,000
1980	4,500
1981	3,500

[1]Based on Fraker and Fraker (1979 & 1982).

from 'intermittent use' areas (Fraker 1977, Fraker et al. 1979). The three major concentration areas are in Kugmallit Bay, Niakunak Bay/Shallow Bay and the Garry-Pelly-Kendall Island area (Fig. 4.5-1). The last is apparently used later in the season and usually by fewer whales than Niakunak Bay/Shallow Bay or Kugmallit Bay. However, survey effort in the Garry-Pelly-Kendall Island area has been less intensive and the pattern of use in this area is not as well known as that of the other areas (Fraker and Fraker 1981).

Mackenzie Bay is used intermittently by white whales during the summer. Initially, whales must travel through Mackenzie Bay to reach the Niakunak Bay concentration area. Later in the season the Bay is apparently used by individuals moving to and from concentration areas (Fraker et al. 1979).

White whales apparently do not feed in the concentration areas since animals harvested in these areas usually have empty stomachs and feeding behaviour is not observed. However, feeding does occur in the areas used intermittently, and movements to and from these areas are likely for the purpose of feeding (Fraker et al. 1979).

White whale numbers in the Mackenzie estuary have been monitored since 1972. Maximum estimated numbers present have fluctuated from 1,500-2,000 in 1972 to 7,000 in 1979 (Table 4.5-2). The observed fluctuations are probably due to a variety of factors including variations in survey techniques, weather and whale behaviour.

By early August, the number of white whales in the Mackenzie estuary has declined greatly, although a few may be present into September (Fraker et al. 1978, Fraker and Fraker 1979). The distribution of whales outside of the Mackenzie estuary during July, August and September is poorly known.

White whales that summer in the Mackenzie estuary are hunted during spring migration by Inuit from northern Alaska. Inuit from Aklavik, Inuvik and

Tuktoyaktuk hunt them in the concentration areas in the estuary. Including animals struck but lost, Fraker (1979b) estimated that about 280 white whales from the Mackenzie stock are killed each year. This represents 4.0% of the 7,000 animals estimated by Fraker and Fraker (1979).

bowhead whale (Balaena mysticetus)

The Bowhead whale is an Arctic baleen whale that can exceed 18 m in length and weight over 50,000 kg. Bowheads are protected by endangered species regulations in both Canada and the United States. In addition, the International Whaling Commission considers all bowhead whale populations to be protected.

The bowhead is a skimming-type baleen whale adapted to feed by straining small animals from large volumes of water. In the western Arctic, bowheads consume euphausiids (90.3% of subsample volume in two specimens), gammarid amphipods, the hyperiid amphipod Parathemisto libellula, copepods, and, occasionally, small sculpins (Lowry et al. 1979). The presence of gammarid amphipods and sculpins, plus a report of polychaetes, gastropods, echinoideans, reptantian decapods, sand and gravel in one bowhead from the Chukchi Sea (Johnson et al. 1966) suggest that bowheads may also feed on or near the bottom, at least in nearshore waters.

During May and June, the western Arctic population of bowhead whales migrates to the southeastern Beaufort Sea region from wintering areas in the Bering Sea. East of Point Barrow, Alaska, early migrants are believed to move through offshore leads in the pack-ice, and eventually intercept and follow the major lead that develops west of Banks Island to Amundsen Gulf (Fig. 4.5-2). Late migrants may follow more southerly routes in the Beaufort Sea; some use the nearshore lead immediately north of the landfast-ice. However, the exact routes must vary from year to year due to annual differences in the pattern of lead development.

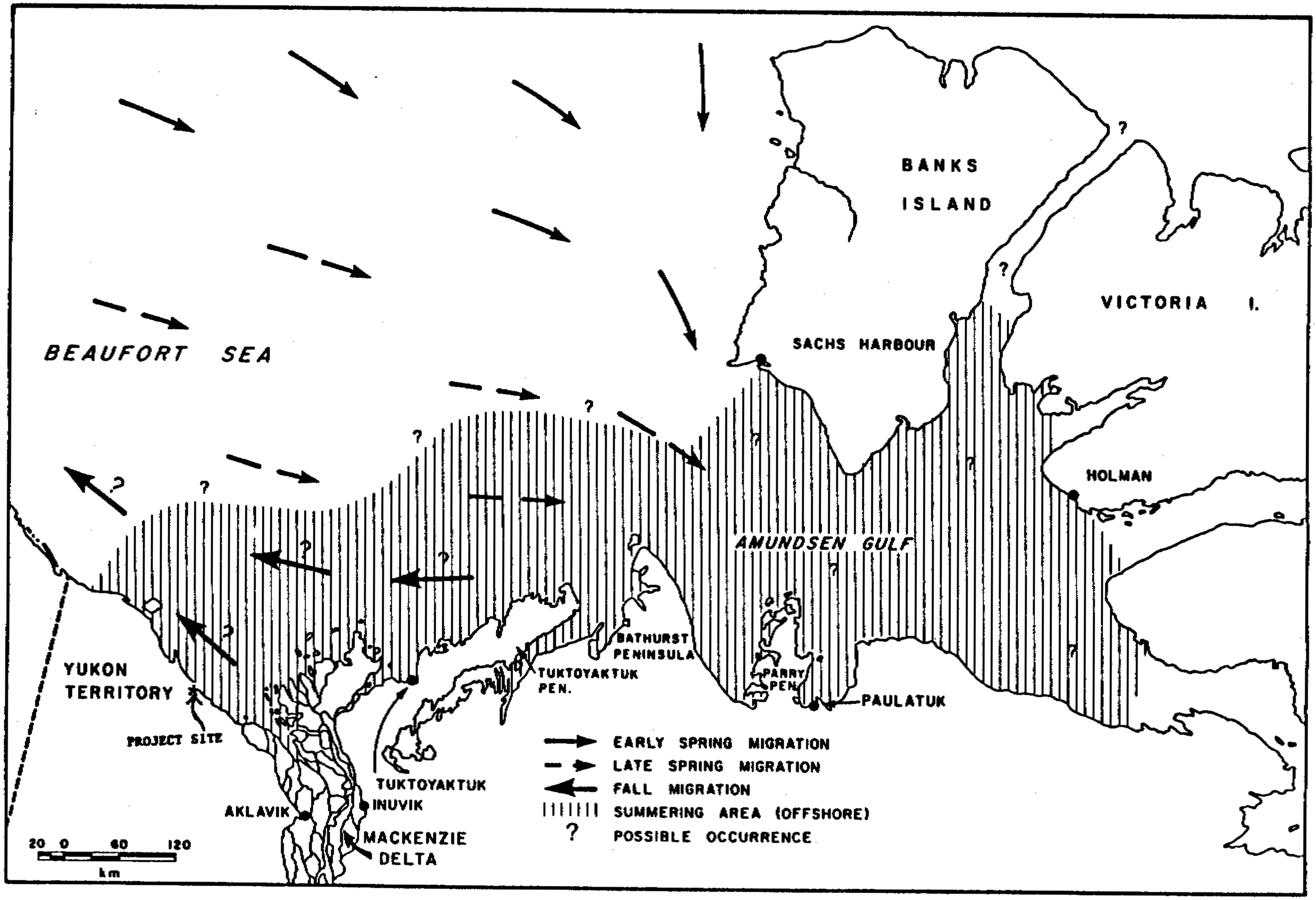


Fig. 4.5-2. Distribution and movements of bowhead whales in the E Beaufort Sea. Based on sources cited in the text. (from Biological Overview-Beaufort Sea 1982)

The first bowheads normally arrive in the southeastern Beaufort Sea/Amundsen Gulf region during the first half of May (Braham et al. 1980), and are relatively common there by mid June. As the season progresses, there is a westward extension of the range toward the Mackenzie estuary. The whales reach the area north of Kugmallit Bay around the beginning of August. The results of surveys of the area from the coast of the Tuktoyaktuk Peninsula east of Tuktoyaktuk and offshore to the 50 m depth contour done in August and early September 1980 indicated that the whales moved toward the Mackenzie estuary from offshore areas to the north, rather than moving westward near the coast of the Tuktoyaktuk Peninsula (Renaud and Davis 1981). In the southeastern Beaufort Sea, bowheads appear to occupy mainly the area landward of the 50 m depth contour, although whales clearly can be found north of this area as well (Fraker and Bockstoce 1980, Renaud and Davis 1981). Parts of Amundsen Gulf may also be important (Fraker and Bockstoce 1980).

Based on data from the annual fall hunt (Marquette 1978) and from recent fall surveys (Ljungblad et al. 1980, Ljungblad 1981), the westward fall migration out of the Beaufort Sea begins in late August and continues through October; however, bowheads have been observed in the vicinity of Point Barrow as late as early November. The most detailed studies of the fall migration north of Alaska were carried out in 1979 and 1980 by Ljungblad et al. (1980) and Ljungblad (1981). Most of the bowheads observed were between the 10 and 30 fathom (20-60 m) isobaths. Some bowheads were observed as far as 65 km from the coast, and hunters are known to go as far as 40 km offshore to pursue bowheads in the fall (Marquette 1978). There is also evidence that some whales migrate as far offshore as the edge of the polar pack. Two possibly important feeding areas have been identified along the Alaskan Beaufort coast. One is situated near the Canada-U.S. border; several whales were observed there in late September 1979 (Lowry and

Burns 1980, Ljungblad et al. 1980). The other area, described by Braham et al. (1977a), lies near the coast just east of Point Barrow.

walrus (Odobenus rosmarus)

The walrus is a large pinniped with a discontinuous circumpolar range. The majority of the Pacific walrus population winters on the pack-ice in the Bering Sea (Eley and Lowry 1978), although small numbers remain in the Chukchi Sea where they occur singly or in small herds of less than 15 (Burns 1965). In spring and summer, walruses follow the retreating edge of the pack-ice northward. The largest numbers apparently move into the NW Chukchi Sea (Burns 1965). However, recent aerial surveys have also found several tens of thousands of walruses associated with the edge of the pack-ice in the NE Chukchi Sea in early September (Estes and Gilbert 1978). Only a few walruses enter the western Beaufort Sea during the summer (Eley and Lowry 1978) and very few reach the eastern Beaufort Sea (Harington 1966).

ringed seal (Phoca hispida)

The ringed seal is the most widespread species of marine mammal in the North American Arctic. It occurs in all Arctic marine waters south to the limit of the winter ice in the Bering Sea. Ringed seals are the smallest of the pinnipeds with an average adult length of about 125 to 135 cm (Mansfield 1967).

The ringed seal is usually a permanent resident in most of its range; it overwinters under the sea-ice through which it maintains breathing holes (Degerbøl and Freuchen 1935, Smith 1973a). Ringed seals tend to be widely distributed and rarely occur in large or dense aggregations. Throughout most of its range in the eastern and central Canadian Arctic the ringed seal is thought to be sedentary, undertaking only local movements in response to changing ice conditions. However, in the western Arctic there is some evidence that regular, annual movements occur both along the northern coast of Alaska and in the Canadian sector of the Beaufort Sea (Smith 1976a, Smith and Stirling 1978).

The ringed seal is a particularly important element of Arctic marine systems. It is the animal taken in greatest numbers by Inuit in the Canadian Arctic. It is the main prey item of the polar bear, and numbers of polar bears are apparently directly determined by numbers of ringed seals (Stirling and McEwan 1975, Stirling and Archibald 1977, Stirling and Smith 1977, Stirling 1978). The Arctic fox is an important predator of ringed seal pups, at least in some areas (Smith 1976b), but the relationship between numbers of seals and numbers of foxes is unknown.

Stirling et al. (1975a, 1977, 1979 & 1980) have conducted surveys of seal populations in Amundsen Gulf and those parts of the Canadian Beaufort Sea lying within 160 km of the mainland coast and the west coast of Banks Island. They estimated that about 69,500 ringed seals were present in these areas in 1974. The numbers declined in 1975 and 1976 to about 32,000 in June 1976. By 1978 the numbers had recovered to 82,600, but then declined to 61,800 in 1979. No surveys for this area were flown in 1980. These estimates are corrected to account for temporal and seasonal variations in the haulout behaviour of ringed seals and for ice conditions, but they have not been corrected to account for animals that remain under the ice during peak haulout periods. The estimates should be considered preliminary but they represent the most accurate seal surveys conducted in Canada to date.

The distribution of ringed seals (Fig. 4.5-3) during the open water season from July to October is not well known. Concentrations occur along the south edge of the pack-ice north of Alaska and the Yukon, and in ice remnants along the coast (Eley and Lowry 1978). Some ringed seals remain in ice-free nearshore waters but the numbers and distribution of these animals are not known (Eley and Lowry 1978, M.A. Fraker, LGL Ltd., unpubl. data).

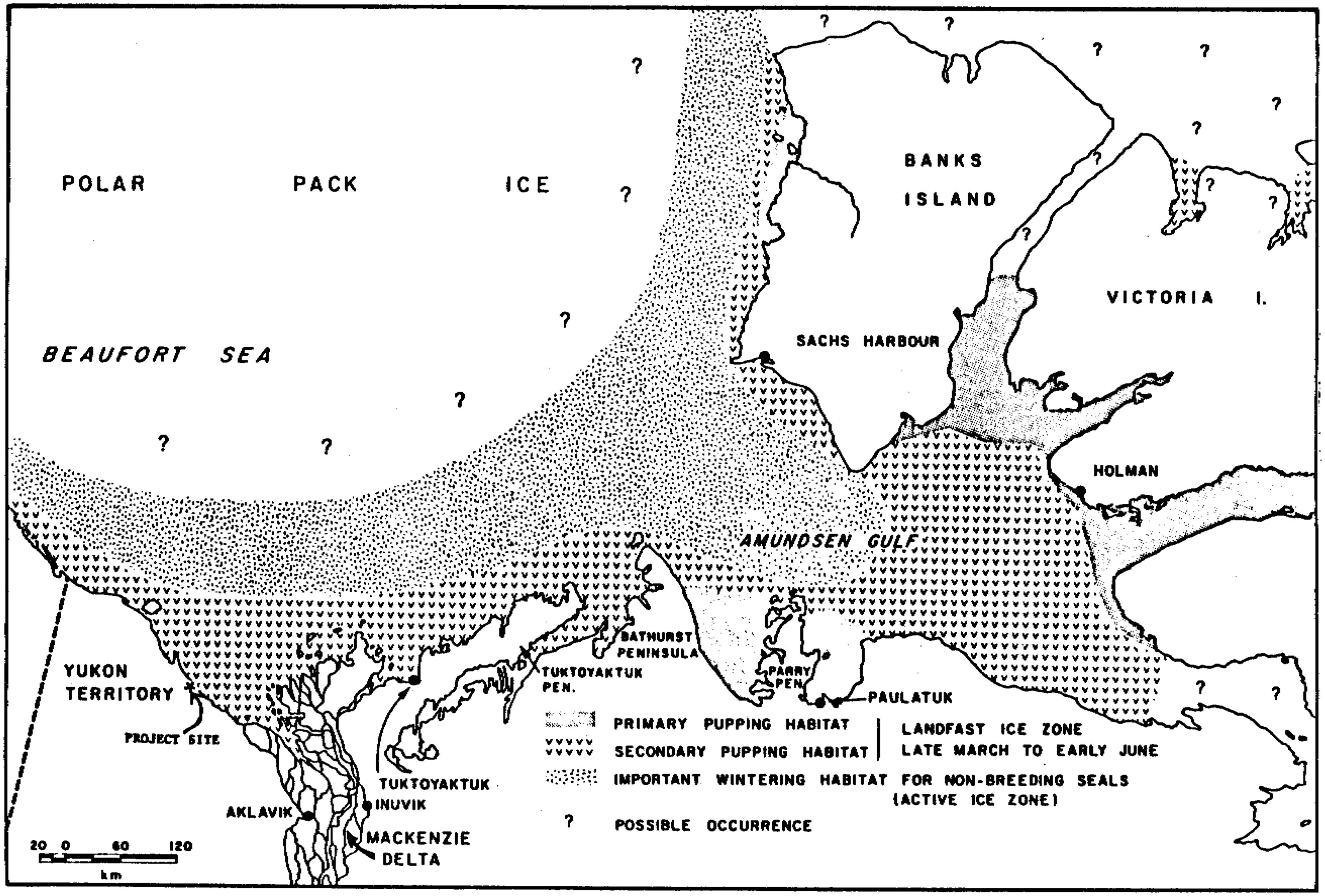


Fig. 4.5-3. Distribution of ringed seals in the E Beaufort Sea. Based on sources cited in the text. (from Biological Overview-Beaufort Sea 1982)

Large-scale movement of seals, many of them young-of-the-year, out of Amundsen Gulf during late summer has been described by Smith and Stirling (1978). Large numbers have been observed to pass Cape Bathurst, east of the Tuktoyaktuk Peninsula, and Herschel Island near the Yukon-Alaska border. T.G. Smith (person. comm.) speculates that the seals move offshore between these two points in order to avoid the turbid Mackenzie River plume.

bearded seal (*Erignathus barbatus*)

The bearded seal is a large solitary seal found throughout Arctic waters (Burns 1967, Mansfield 1967). Bearded seals are strongly associated with moving pack-ice, but the limit of the principal range in the Bering, Chukchi and Beaufort Seas is believed to be defined by the 200 m depth contour.

In some areas, bearded seals are quite sedentary and make only local movements in response to changing ice conditions (McLaren 1962, Fedoseev 1973), whereas in other areas regular long-distance movements occur (Burns 1967, Benjaminsen 1973, Stirling et al. 1975a, 1977 & 1979). There is some evidence to suggest differential distribution and movements of different age classes (Benjaminsen 1973, Potelov 1975).

The Bering Sea population of bearded seals is thought to total 300,000-450,000 individuals (Braham et al. 1977b). The requirement of bearded seals for suitable pack-ice conditions over shallow water results in an annual movement of the majority of these seals into the Bering Sea in winter (Burns and Frost 1979). The winter population in the Chukchi Sea is much smaller, with the highest densities occurring in the limited regions of persistent shear and flaw zones that parallel the Alaskan coast.

The Beaufort Sea is considered to be marginal winter habitat for bearded seals (Burns and Frost 1979). Winter populations in the Canadian Beaufort Sea (Fig. 4.5-4) have ranged from about 2,200 to 8,300 animals over the six-year period from

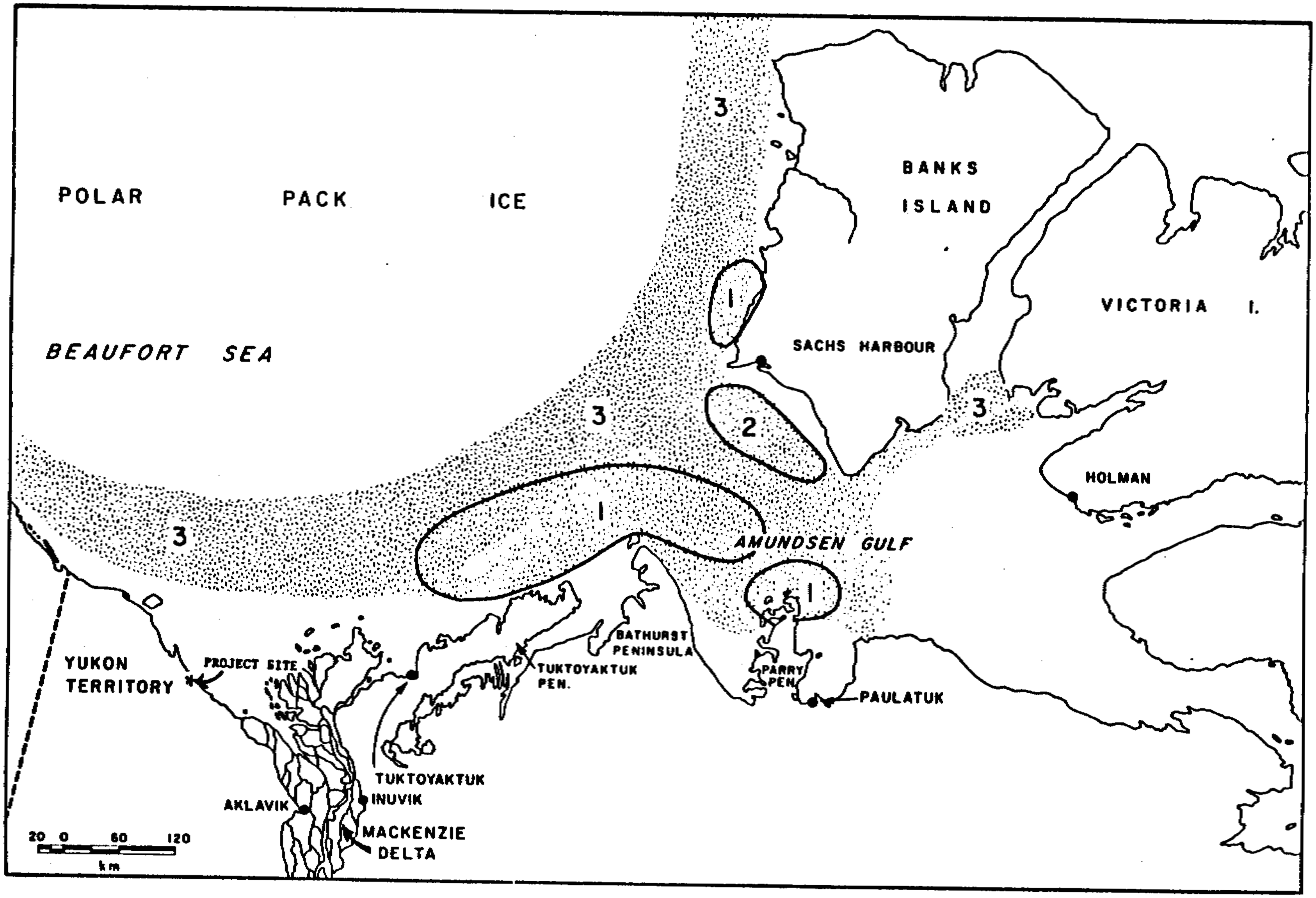


Fig. 4.5-4. Distribution of bearded seals in the active ice zone in winter (November-June). 1 = high density. 2 = medium density. 3 = low density. Based on Stirling et al. (1979) and Stirling (pers. comm.) (from Biological Overview-Beaufort Sea 1982)

1974 to 1979 (Stirling et al. 1979 & 1980). These estimates have been corrected to account for diurnal haulout patterns but not for animals that are below the ice at peak haulout periods.

Stirling et al. (1977 & 1979) noted a sharp decline in numbers of bearded (and ringed seals) in 1975 and 1976. The causes of this decline are not known but are thought to have been related to heavy ice conditions in the winter of 1974-75. It is believed that substantial numbers of bearded seals left the Beaufort Sea and moved into the Chukchi Sea in response to these ice conditions. Winter populations had more than regained their 1974 levels by 1978 (Stirling et al. 1979).

Little information on the numbers and distribution of bearded seals in the Beaufort Sea in the summer open-water period is available. The seals occur in open water overlying the continental shelf or in association with nearshore ice remnants. Summer populations in the western Beaufort Sea are higher than in the eastern Beaufort and are apparently augmented by seals from the Chukchi Sea (Burns and Frost 1979). Since the multi-year pack-ice in the Beaufort Sea is usually north of the shallow coastal shelf suitable feeding habitat for feeding bearded seals is not generally available (Burns and Frost 1979). I. Stirling (Canadian Wildlife Service) and T. Smith (Arctic Biological Station, pers. comm.) have noted certain nearshore areas (e.g., near Herschel Island and Cape Parry) where bearded seals are relatively common in summer (pers. comm.); there may also be other such areas.

Bearded seals are harvested by Inuit communities in the area. A total of 675 bearded seals were taken in the period January 1, 1977 to June 30, 1978 by five Alaskan communities (Matthews 1978 cited by Burns and Frost 1979). There are no recent harvest data from Canadian communities in the Beaufort Sea area.

birds

The following section summarizes the major activities and important habitats of the primary species of marine-associated birds that frequent the Beaufort seas.

In general, offshore routes are probably the most heavily used but also the least well documented. Major coastal and offshore migrants include loons, brant, oldsquaws, eiders, phalaropes, jaegers and murres. Snow geese, white-fronted geese, Canada geese, some brant, swans, diving ducks other than eiders and oldsquaw, dabbling ducks, most shorebirds, and terrestrial species migrate overland to reach the western Arctic nesting grounds. During late April and early May most offshore migrants travel along a broad front through the Beaufort Sea after passing Point Barrow, with specific routes probably related to the locations of ice leads. As spring progresses, later migrants probably follow a route closer to the mainland coast when moving through the Beaufort Sea.

From May through mid June, the most important areas in the Beaufort region for marine-associated birds are the patches of open water (less than 25 m deep) which provide feeding and resting areas for hundreds of thousands of spring migrants (Barry et al 1981). On June 5 and 9, 1980, Barry et al (1981) conducted aerial surveys along the edge of the fast ice areas between Herschel Island and Baillie Islands, along the Amundsen Gulf polynya and along the west coast of Banks Island north to Bernard Island. Oldsquaws, eiders, loons and glaucous gulls were the predominant species in areas of open water, and, with the exception of loons, most birds were observed within 1 to 2 km of the landfast ice edge (Barry et al 1981). The largest numbers of birds, predominantly eiders, were seen in leads off southwestern Banks Island, between Cape Kellett and Big River. Other important areas in spring include the ice edge between Cape Dalhousie and Baillie Island, and off Cape Parry and Booth Islands (Barry 1976). A similar trend was also recorded in 1981 during a survey on June 9 (Barry and Barry 1982).

In the entire Beaufort region, the largest concentration of nesting birds occurs in the Cape Lisburne-Cape Thompson area of Alaska. In the Canadian Beaufort Sea region the largest concentration of nesting birds is the snow goose colony located 16 km inland along the Egg River on southern Banks Island (Bellrose 1976, Barry 1976). This colony contained an estimated 198,000 nesting snow geese in 1981. Other colonies within the Canadian Beaufort region include a colony of about 800 murres at Cape Parry (Barry 1976, Ward 1979), brant and snow goose colonies on the Anderson River delta and Mackenzie Delta, and small colonies of gulls, terns and common eiders at various locations along the mainland coast and the western coasts of Banks and Victoria islands. In addition, numerous other species are widely dispersed during the nesting period at river deltas and in tundra areas adjacent to the coasts. From early June through July, the most important littoral zone nesting areas include the mainland between Blow River and Tent Island in Shoalwater Bay, Pelling Island, the seaward edge of the Kendall Island Bird Sanctuary, Swan Channel, the Anderson River delta and Cape Parry (Barry et al 1981).

There are several species of ducks, geese, swans and alcids which moult and are flightless for at least 2 to 3 weeks during their residence in the Beaufort (Tuck 1960, Bellrose 1976). The major species of birds that moult in these coastal marine areas include oldsquaws, female eiders, white-winged and surf scoters, greater scaup, brant, snow geese, thick-billed murres and black guillemots. Some species of waterfowl usually moult and rear their broods in sheltered bays and coastal lagoons along much of the mainland coast during the period from mid July to mid August (Barry et al 1981). In the eastern Beaufort, migration is both coastal and offshore, with many species believed to fly directly from the Arctic Islands toward Point Barrow. Migration may begin as early as late June, with a reverse (westward) migration of non-breeding jaegers (Johnson et al 1975) and a westward moult migration of male oldsquaws (Searing et al 1975). In July and early August, post-breeding male eiders migrate westward to moulting areas in the Bering Sea (Manning et al 1956, Thompson and Person 1963, Johnson 1971). Female phalaropes migrate westward in mid July, and male phalaropes and some juveniles follow during August (Parmelee et al 1967, Connors et al 1979). Female eiders and their young migrate westward during late August through September (Johnson 1971, Timson 1976). Brant begin to move westward in mid August (Searing et al 1975), while oldsquaws and loons migrate through coastal waters during September and October (Searing et al 1975, Johnson 1979). Staging areas used by brant and oldsquaw occur in littoral areas along the entire coastline of the Beaufort region, although concentration areas are only known to occur in barrier island lagoons, bays, and sheltered areas in Alaska (Johnson 1979). Brant are particularly abundant at Cape Halkett, Alaska (King 1970).

4.6 PRESENT LAND AND RESOURCE USE

Cultural, social and economic setting - There are no settlements near the project area. Settlements most likely to be affected by Kiewit's proposed quarry are Inuvik, Aklavik, and Old Crow.

Inuvik

Inuvik is the largest community in the Beaufort Sea region and the main government and business centre in the western Arctic. Inuvik's population in 1980 was 2,929. It was built as a planned northern community in the mid 1950's, the original intent being to provide a replacement for Aklavik as the government centre in the area. The community was also envisioned as a possible forward base for the exploration and development of the north's non-renewable resources.

Inuvik is a community quite different from most of the others in the region. It has a large, non-native population and many of its residents are employed in either civil service positions or in private business.

The community has had experience with rapid population growth as a result of oil industry activity and with the rapid declination of population growth and economic activity associated with the decision to turn down the Mackenzie Valley pipeline proposal of the mid 1970's. The community is generally looking forward to Beaufort Sea oil and gas development. Many see current problems that are not being fully addressed by government and ask why such matters are not being put right before large sums are spent on studies of possible, but still uncertain, future impacts on the community.

Ethnic distribution in Inuvik in 1980 consisted of 6.9% Indian, 17.9% Inuit and others, 75.2%.

Parents (and other family members) and professional educators share in the eduction and socialization of a community's residents. In Inuvik, the diverse backgrounds of its residents result in differences in the expected roles and influence of parents and other educators and in the direction or socialization. While they may be most evident between native and non-native segments of the population, changing values and demographic mix also result in "double socialization" and conflicting messages within segments of the population. For example, different generations of native residents consider different skills as being necessary for economic survival; so they differ in the value they place on formal school achievement versus renewable resource harvesting skills. Non-native residents also differ in the values they place on technical versus professional education, or practical experience versus academic learning. Conflicting messages about the importance of different types of education have been further aggravated by the uncertainties and instabilities of economic activity in the area. Differing levels of formal educational attainment have been noted by Inuvik residents as perhaps the single most important factor in the ability of town residents to particiate in not only the area's economic activity, but also in leadership roles in the community.

The dominance of the non-native members of the community in numbers, as well as in positions of influence in education and leadership systems in Inuvik, has meant an accelerated rate of transition from traditional systems to political structures of the larger society for the native people living in the town. Some native residents have off-set the discomfort of this rapid transition by alternating residents between Inuvik and more traditional communities such as Fort McPherson or Aklavik.

Inuvik residents have played a strong role in developing an Education Action Plan to address some of the changes in the education system made necessary by the increasing availability of wage employment. This plan supposedly would enable residents of the Inuvik region to successfully participate in the social and economic activities of their region, according to the terms of reference of the group that prepared it.

In regard to the effects of education on community tensions, Inuvik residents have noted that family problems, social pressures and living conditions have resulted in dropouts from the formal education process among the town's native residents. Because many native children drop out of high school, adult education upgrading programs must help students to build self-confidence and to learn to follow directions, as well as to teach the more conventional course content.

Inuvik has the most diversified local economy of any of the Beaufort Sea communities. Government employment provides the economic basis for the community but many residents are active in their own businesses. The oil and gas industry's recent Beaufort Sea exploration activities have contributed significantly to employment and incomes in the community. In 1980 approximately 33% of the cash income in Inuvik came from government employment, 10% from Dome/Canmiura employment and business contracts, .6% from trapping, .3% from social assistance, 1.7% from unemployment insurance, and 54% came from other unidentified sources.

As of mid 1981, Inuvik had an estimated 210 business enterprises in operation. They ranged in size from small holding companies through large construction and trucking businesses. Most performed a variety of service industry functions. Few businesses were highly specialized or limited to one activity.

In addition to oil and gas companies, native development organizations (principally C.O.P.E.'s Inuvialuit Development Corporation IDC) have recently emerged as important sources of economic activity and change in Inuvik. At present the opportunity exists for the IDC to become more involved with the oil and gas industry. However, it is not clear whether this can be done without undermining COPE initiatives in the land claim area or overloading IDC staff to the point where other corporate activities such as the expansion of the renewable resource industries in the region are jeopardized.

Aklavik

Aklavik, the second largest community in the Beaufort Sea region, is located on the Peel Channel of the Mackenzie River Delta some 36 miles west of Inuvik. Its population in 1980 was estimated to be 818.

The general area of the settlement was used seasonally by both Inuvialuit and Loucheux Dene prior to the movement of fur trade posts into the Mackenzie Delta. The origins of the present settlement lie in the establishment of a Hudson's Bay Company post at Pokiak, an Inuvialuit camp site, across the river from the site of the present community in 1912. The settlement was moved across the river in 1921 to facilitate the docking of river steamers and was given the name Aklavik.

During the fur trade boom which followed the First World War, Akalvik quickly became the trapping, trading, administrative and transportation centre of the entire western Arctic. A mission, residential school, hospital, and government airmail service were established in short order and people moved into the community and nearby trapping areas in large numbers. By the early 1930's a recognizable "Delta culture" was emerging, incorporting elements of the culture and values of Inuvialuit, Dene, Metis and non-native people.

Alaskan Eskimos also moved to the Aklavik area to participate in the muskrat trapping boom, and when white-fox fur prices dropped in the late 1930's and early 1940's, some Inuvialuit moved from Banks Island to the Delta to trap near Aklavik and Tuktoyaktuk. By the late 1940's and early 1950's the population of Aklavik and its associated network of trapping camps exceeded 1,500.

The community ceased to be the administrative and commercial centre of the Delta in the 1950's when Inuvik was built. At one time there were plans to move the entire population to Inuvik but residents resisted the proposed move and many chose to remain in Aklavik close to the good ratting areas in the western part of the Delta. When it became apparent that Alavik would not be abandoned, a fur garment cooperative was established by the federal government to improve the local employment situation and other renewable resources basd projects such as a sawmill were initiated at nearby sites. All but the fur garment project have ceased operation. Aklavik residents were employed by the oil and gas industry in exploration activities beginning in the late 1960's and some residents currently work for Dome and Esso. The local business sector has also benefited from Dome's efforts to expand the number of northern businesses supplying goods and services to its Tuktoyaktuk operations.

Aklavik's current population reflects the varied origins and backgrounds of its residents. GNWT estimates for 1978 indicate that some 45% of the population was Inuvialuit, 44% were Dene and the balance was "other," generally non-native. Population growth has been slow over the past two decades, averaging 1.8% per annum between 1961 and 1976, a growth rate well below that of Inuvik for the same period (6.4%). There is considerable in-migration and out-migration going on at present. Often the same individuals are involved in both types of population flows as they temporarily leave the community in search of other opportunities.

There are no recent data on employeemnt and income levels in the community although Territorial Employment Recent and Information Services compiled information on employment skills. Resource harvesting, particularly the trapping of white fox and coloured fox, contributes a significant amount of cash income to the local economy. The number of wage employment opportunities available in the community or filled by local residents at Dome and Esso work sites also provides considerable cash income for local residents. However, there are insufficient data available to place these sources of income in perspective against government sources such as transfer payments and social insurance payments.

The commmunity has an active business section and a number of local residents are employed in it on a permanent or casual basis. Most enterprises are service oriented and primarily geared to the needs of the local market (taxi, fuel sales, local building, retail merchandixe and food sales). A small but dynamic element in the business community is more expansive in outlook, seeking and special service opportunities within the oil and gas industry in the Delta area.

The Delta Fur - Aklavik Fur Garment Co-op, a government sponsored economic development project, is a significant source of employment and income for many of the women in Akalvik. It has had some financial difficulties in recent years and the Government of the Northwest Territories has been seeking a private buyer.

There is a long history of education, and many people in Aklavik appear to place a high value on their children's schooling. The Moose Kerr School offers Kindergarten to Grade 10. In 1980-81 it had an enrollment of 204 students, 62 of whom were in grade seven or above. The school had a staff of 12 and two classroom assistants in the same year. There was also an adult educator resident in the community, and three residents were attending Thebacha College (then AVTC) at Fort Smith in 1980-81.

Old Crow

Old Crow is being included in our discussion even though people from the community do not travel extensively to the Yukon coast. Harvest areas used by residents of Old Crow are not likely to be directly affected by Kiewit activities in the King Point area. However, population growth may promote change in Old Crow. Young people from Old Crow may be attracted by the urban lifestyle of Inuvik, hunters or recreationists from Inuvik may start to explore the Richardson Mountains and parts of the Old Crow Registered Trapping Area, and land use conflicts may develop.

Old Crow is situated on the north bank of the Porcupine River just west of the mouth of the Old Crow River in the isolated northern portion of the Yukon. The community is some 280 km (176 miles) west of Inuvik and 800 km (497 miles) north of Whitehorse.

In 1981 the community had an estimated population of 219. Most residents (about 65%) are Loucheux Dene (Vunta Kuntchin) or of Loucheux Dene background. Their ancestors have lived in the area for many generations although the origins of the present community are more recent, stemming from the establishment of a fur trade post at the mouth of the Old Crow River in 1894. Some residents still have strong family ties with Loucheux Dene in Fort McPherson as a result of the fur-trade era in the lower Mackenzie-northern Yukon area.

Old Crow has not changed much in terms of total population over the past decade. It had a population of 206 in 1971, 224 in 1976 and, as noted above 219 in 1981. Although factual data are not at hand, it is believed that the slow growth and recent slight decline in the community's population reflect a number of factors, particularly high infant mortality, a number of deaths as a result of accidents and violence and some out-migration to other northern communities. No recent information is available on the size and charactersitics of the labour force.

The 1976 Census data indicate that nearly half of the population was under 20 years of age. There is no reasons to believe that the current situation is much different.

Old Crow is a traditional resource harvesting community. Most residents depend upon resource harvesting for a considerable portion of their food supply and much of their cash income. Residents harvest the Porcupine caribou herd, often travelling a considerable distance to intercept it, and fish for local consumption in the Porcupine and Old Crow rivers. Most trappping activities are focussed on the muskrat population of the Old Crow flats, a low-lying, marshy area some 15 miles north of the community. Data on the community's resource harvest in recent years and additional information on the resource harvesting portion of the community's economy are presented in Chapter 5.

There are few permanent wage employment activities in Old Crow. The Band office, the Co-op store, a small motel, and the provision of local services provide most of the job opportunities for local residents. Other employment opportunities are provided by the health, education and public safety activities of government in the community, but Old Crow residents have not generally attained sufficient education and training to fill many of these positions to date.

Old Crow has a good school offering Kindergarten to Grade 10. In 1979, the latest year for which data are readily available, it had an enrollment of 56 students and a complement of four teachers. The local nursing station is staffed by one nurse and has a two bed capacity. Other medical services are provided by a doctor on regular visits from Inuvik. There is also a two man RCMP detachment stationed in Old Crow.

The Band Council is the most important community organization in Old Crow. It represents the community in land claim matters through the Council of Yukon

Indians. The community is not a member of the Beaufort Sea Community Advisory Committee.

In more recent years there has been less need for the community to become involved in resource development issues. Local priorities have turned instead to the settlement of outstanding land claims through negotiations conducted on the community's behalf by the Council of Yukon Indians.

An important fact that should be taken into account when considering the merits of development of the Yukon coast is that much of the population of the Beaufort Sea communities is young, under the age of 20. This suggests that the local and regional economy should be greatly expanded so that the current generation of young people and their descendants will be able to find meaningful work. It appears few young people will want to support themselves and their families entirely or largely through hunting, trapping, and fishing. Even the present population has become strongly reliant on income sources other than the harvesting of renewable resources.

Attitudes (Old Crow, Aklavik) Toward Development.

Early, informal visits have been taken to Old Crow and Aklavik. Initial and nearly unanimous reactions of residents visited with lead us to believe that citizens of both communities have little fear of possible impacts associated with the project proposal and would welcome the opportunities associated with the project.

Formal visits are being scheduled to both Old Crow and Aklavik. The purpose of these visits will be to make the residents more aware of our proposal and to solicit their concerns.

Cultural History

Cultural history of the study area - It has been noted that the region is a harsh land that is frozen for much of the year, and is capable of supporting only limited plant and animal life. Many migratory species are found in the region but only for brief periods of time which is usually during the short summer.

In aboriginal times the semi-nomadic band was the unit of social organization best suited to the region's physical and biological environments. Because resources were not abundant, bands were small and typically separated from each other. In general terms, aboriginal peoples accepted the natural world as it was, and concepts of physicaly altering the environment to suit human purposes had little place in native cultures.

Early explorers, whalers and traders were also forced to accept the region on its own terms, but in more recent times, new technology and sophisticated support systems have made it possible to overcome many of the limitations formerly imposed by nature.

Although people have lived in the region for some 4000 years, major social, economic and technological change has occurred only within the last 100 years, during which the region became a hinterland to larger metropolitan centres in southern Canada, the United States and Europe.

The search for whale oil and baleen brought whalers to the region in the late 1800's. By the time commercial whaling activity ceased aroung 1910, the Eskimo population of the Mackenzie Delta region had been virtually wiped-out by disease.

The fur trade was introduced among the Dene in the mid-nineteenth Century by the Hudson's Bay Company; whalers subsequently stimulated Eskimos to join in the trade. Trapping was compatible with native culture, although it tended to localize formerly nomadic populations. During the 1920's, when fur prices were high, the native population which had reoccupied the lands of the Mackenzie Delta and adjacent coasts prospered. In later years fur prices were often depresssed, but people were still generally able to turn to the land for the bulk of their food supply and some of their clothing materials.

By the mid 1940's the fur company was no longer capable of providing the cash income to which native people had become accustomed when fur prices were high. A return to the semi-nomadic, self-sufficient lifestyle of aboriginal times was no longer possible on any major scale. The economic circumstances of native people had become very difficult.

New initiatives beginning in the 1950's helped to partially remedy this situation and, at the same time, set in motion new forces of change. The construction of the Distant Early Warning Line (the DEW-line), and a new administrative centre (Inuvik) for the western Arctic, provided employment and exposed native people to values and lifestyles characteristic of the wage economy.

Such major construction projects and government's decision to make better health and education services available in the north, precipitated the rapid urbanization of the region's population between 1955 and 1965. In area after area people were encouraged to abandon their traditional camps and to move into settlements where they could be closer to health facilities and schools. Within a short period the region's native population was struggling with the problems of living in groups much larger than the traditional band, adapting to settlement life, and searching for new ways to earn money to meet growing cash income needs.

The performance of native people during the construction of the DEW line and Inuvik suggests a ready acceptance of wage employment as a means of earning income. Had these two major projects been followed by more opportunities of a similar scale, the effective and experienced segment of the northern native labourforce would probably now be considerably larger than it actually was. The major problem in the creation of a modern northern labour force has not historically been the attitudes of northern people, but the fact that whether or not jobs would be available was rarely a predictable matter. Until recent years, when employment in oil and gas exploration became more generally available, was employment was often less secure as a source of income than trapping, and people had to journey as far away as the Great Slave Lake Railway to find it with any regularity.

The construction of Inuvik as the key government centre in the western Arctic, and the increased range of services available in the north were accompanied by an influx of non-native people into the Beaufort region. Most went to Inuvik to fill government positions. Some were posted to smaller communities as government administrators, nurses, teachers and adult educators.

By the late 1960's, if not earlier, interests in the south were dominant in determining the conditions under which the Beaufort region would continue to evolve.

Well before oil and gas exploration got underway in the region, in the 1960's many native people were concerned that settlement life, non-native education, and wage employment was changing and perhaps undermining their culture. The influx of the oil and gas industry raised the prospect of further outside dominance of the region. Native people organized political interest groups and have lobbied for the recognition of their aboriginal rights and the settlement of their land claims.

Much of the change that has occurred in the region in the past decade has been associated with the activities of the oil and gas industry. Early discoveries in the Mackenzie Delta and the prospect of pipelines along the Mackenzie Valey resulted in a boom in Inuvik in the early through mid 1970's. The community's population grew, and business people and elected officials made substantial investments on the assumption that there would be continuing growth. When the Arctic Gas pipeline proposal was turned down by government in 1977, the boom collapsed. Inuvik's population dropped by 10% within a year, some businesses went bankrupt and the town found that it had serviced land and facilities in excess of its requirements.

Palentology - No palentological sites are known to exist in the study area.

Archaeology - Some of the oldest human artifacts ever located in North America were found near Old Crow, Yukon. These consist of bone artifacts, dated variously from Early Wisconsin to late Middle Wisconsin Times. Other northern Yukon Material is much more recent, although still comparatively ancient. The British Mountain complex includes a site at Engigstciak on the Firth River and a site near the Babbage River.

Archaeological sites are rarely found on the coastal plains. They are usually found associated with major drainages such as the Babbage (J. Cing-Mars personnel com.). The National Museum of Man in Ottawa has been contacted by Kiewits to assist in the location of possible sites in this area. At the present time no archaeological sites are known to exist in the study. Since the project area is located in the coastal plains away from any major drainages it is doubtful any sites exist in the area.

Historical sites - Whaling cabins at King Point are the only known historical sites in the project area. These cabins are the only remaining visible evidence of the early whaling industry in the area. The cabins have been highly vandalized and probably have no intrinsic historical value (J. Cing-Mars personal com.).

Traditional Area Uses

King Point is located approximately 60 km west of Niakunak (Shallow Bay) which is one of the more important white whale concentration areas. Small numbers of people from Aklavik, Inuvik, and Holman Island were found whaling at Niakunak in July of 1981, albeit further to the east, from Shingle Point to Bird Camp. Whaling has not declined between 1964-65 and 1979-80 despite socio-economic changes that could result in people doing other things in July and August. The establishment of a port King Point would increase vessel traffic in waters known to be frequented by whales during their fall migration out of the Beaufort.

People do not trap or hunt regularly in the vicinity of King Point owing to its distance from the settlements. In June, Inuvik people may take boats through Reindeer Channel and go toward Shingle Point for caribou, but they do not go as far as King Point. If caribou cannot be found closer to town, Aklavik hunters will travel along the coast by skidoo or boat through this area. In 1981, for example, two Aklavik men journeyed as far westward as the Firth River, where a concentration of some 2,000 caribou had been reported. The establishment of a port at King Point should not severely interfere with traditional activities because the area is already one of marginal use.

The harvest of fishery and wildlife resources is impartial to the cash economy of communities along the coast of the Beaufort Sea and provides social, nutritional and cultural benefits for the Inuvik. Although resource harvesting patterns have changed since the Inuvik settled in permanent villages and acquired modern fishing, hunting and trapping equipment, harvests continue in many of the coastal marine areas and on the nearshore sea ice of the Beaufort Sea.

Whaling

The whale hunt is of social and cultural importance to the Inuvik, and provides them a source of meat, muktuk and oil. White whale products are used primarily for domestic purposes although some intrasettlement trading also occurs (Brakel, 1977). Whaling in the Mackenzie Valley typically begins in late June when the whales arrive and continues intensely for about three weeks.

Whaling has been and continues to be an important activity for Aklavik residents, In the 11 year period from 1969-70 to 1978-79, an average of about 29 beluga whales had been taken every summer with very little year to year variation. Six domestic whaling camps have been used at Niakunak on Mackenzie Bay stretching from King Point on the west to Tattirgak near the entrance to Shallow Bay. In July 1981, the Wildlife Officer from Aklavik encountered at least nine families in the Bird Camp-Shingle Point area.

Beluga whaling continues to be an important summer activity for the people of Inuvik who use camps at Kendall Island and on Kugmallit Bay. Over the past six years, the average number of whales taken from Kendall Island and all the camps in the Kugmallit Bay area except Tuktoyaktuk was 52.5 with a standard deviation of 14.5. A 1,500 pound Beluga whale represents about 651 pounds of blubber and muktuk and 230 pounds of meat. The average whale harvest, therefore yields about 34,178 pounds of blubber and muktuk and about 12,548 pounds of meat. Kittigazuit and East Whitefish Station are also used by Inuvik residents as summer fish camps.

Hunting

The project area is a hunting area for residents of both Aklavik and Inuvik. Caribou are hunted along the coast mainly during the summer, but are also taken during the fall and winter. Harvest numbers are not available for the project site. Common consensus is that harvest in the area is negligible because of the distance from either community. Caribou harvest by community is furnished in Table 4.6-1.

Moose are hunted along the Babbage River. During fall, winter, and spring, residents of Aklavik hunt caribou and Dall sheep in the Richardson Mountains. In summer caribou are also hunted along the coast and near Coal Mire Lake (primarily north of Rat River).

Polar bears are hunted during the winter and spring on sea ice by residents of Aklavik and Inuvik. The harvest of this species in Canada has been regulated on a community quota system administered by the Northwest Territories government since 1967. Bears reported and exported by residents of Aklavik and Inuvik are taken on three permits of other communities. Individual settlements divide the allotment permits within the community between sport and commercial hunting. According to the Beaufort Sea - Mackenzie Delta Hydrocarbon Development EIS 4 bears were reported for export by residents of Aklavik betwen 1971 and 1981 and 53 bears were exported by residents of Inuvik over the same period. In addition

Table 4.6-1. Caribou harvest for Arctic Red River and Inuvik (1964 - 1979).

Community	1964 -65	1965 -66	1966 -67	1967 -68	1968 -69	1969 -70	1970 -71	1971 -72	1972 -73	1973 -74	1974 -75	1975 -76	1976 -77	1977 -78	1978 -79	1979 -80
Arctic Red River	774[a]	647[a]	477[a]	996[a]	541[a]	465[d]	427[a]	688[a]	674[b]	1300[d]	917[b]	145[b]	N/R	114[d]	187[d]	147[d]
Inuvik	133[a]	52[a]	72[a]	328[a]	139[b]	150[b]	110[a]	149[a]	195[b]	273[b]	344[b]	134[b]	N/R	140[e]	245[e]	263[e]

a = General Hunting Licence Returns, cited in bissett (1974)
b = General Hunting Licence Returns, kill statistics
c = Data from Usher (1975), tables
d = Data from Yukon Game Branch
e = Data: P. Latour NWT Wildlife Service, pers. comm.
N/R = no recorded harvest or unknown

this also states that the sale of polar bear hides is not important to the cash economy of Aklavik or Inuvik.

Trapping

Trapping provides a full-time occupation or an income supplement for a large number of native people from Aklavik and Inuvik. The general movement of people from distant camps to larger settlements has resulted in a decline in the number of men trapping for their primary source of income, and an increase in the number of people trapping part-time. Ever since the advent of the snowmobile, trapping areas near the communities receive greater harvest pressures than less accessible areas. Part-time trappers are usually wage earners, but they use day trip traplines that can be covered within a day from communities.

Arctic fox are the only fur bearer harvested in the King Point area and are trapped by residents of both Inuvik and Aklavik. Although the Arctic fox is essentially a terrestrial mammal throughout its range, residents of several coastal communities trap this species for its white fur during winter and spring when they occur off shore on land fast ice. The sale of white fox pelts provides an important source of cash income for residents of Inuvik. A small number of furs may also be retained and used within the communities for production of native crafts. Mean annual harvest of white fox from 1971 to 1981 was 58 and 707 for Aklavik and Inuvik respectively.

From 1974 - 1980, less than 1% of the total income derived from trapping in Aklavik came from the sale of white fox ($9,984.00 of $1,024,597.00). For the same six year period approximately 5% of the trapping income in Inuvik came from the sale of white fox ($100,000.00 of $1,977,749.00).

Fishing

Most domestic and commercial fishing is concentrated in areas such as the Calville and Mackenzie River Deltas, in small river outlets and in coastal lakes. In contrast, little fishing is done in the Beaufort Sea coastal waters even though most species captured occur in marine coastal waters in the summer. A small amount of fishing does occur along the Yukon coast. Although estaimtes are not available due to lack of catch records, whitefish represent the greatest proportion of fish harvested.

Data indicated that 1,000 to 3,000 Arctic char, ciscos, broad whitefish, and iconnue were taken annually (1971 - 1973) in the most important coastal domestic fisheries along the Yukon coast and on Herschel Island (Steigenbeuger et al. 1974). More recent data (1978 - 1980) suggests that 700 to 1,500 kg of char, ciscos, and whitefish are taken annually from Shingle Point.
Delta communities also report that utilization from this region is limited to incidental harvests during hunting and whaling trips. Arctic char have been harvested from the Firth River drainage and Nunaluk Lagoon in past years, but these areas have not been utilized recently.

The Department of Northern Affairs and National Resources initiated a fishery at Shingle Point in 1960. A total of 8,200 kg of unspecified fish were harvested in 1960, and an additional 5,500 kg were harvested in 1961 before closure of the fishery for economic reasons. No other commercial fishing has been conducted in this region to date.

No data were available on sport fishing in this area. Residents of Inuvik and Aklavik report that sport fishing has been conducted for Arctic char in several Yukon streams by hunting parties and by a few fly-in fishermen landing float planes on lakes in the area to fish nearby streams.

National Parks, Wilderness Or Recreational Areas

There are no known territorial or national parks, wilderness or recreational areas, game preserves, geological reserves or other recreational areas present or proposed in the project area.

A portion of the northern Yukon, including part of the coastal area and most of Herschel Island, has been proposed as a National Park. The proposed park area lies approximately 25 km west of the Kiewit project area (Fig. 4.6-1). The proposed park includes the Canadian segment of the calving grounds of the Porcupine caribou herd and coastal zones which support migrant and staging waterfowl.

Mineral, Oil And Gas Potential

The Kiewit Quarry project area lies just within the southwestern boundary of the Mackenzie Basin. The Mackenzie Basin is considered to be an area which has good hydrocarbon potential. However, Kiewit activities will not preclude the exploration or development of hydrocarbon resources in the area.

No other potentially developable minerals are known to occur in the project area.

4.7 HYDROGRAPHY

Detailed bathymetric soundings of the sea floor were done by Kiewit for the project area. Data accumulated were obtained at considerable cost and specific information is considered to be a marketable product and of proprietary nature. However, it can be concluded from these studies that the project area sea bottom is a flat, gradual slope to the offshore with no obstructions. The deep water line contours converge close to the shore at the west end of King Point, eliminating any shoaling problems.

The port will be equipped with Coast Guard standard navigational aids. Also, the breakwater projection is planned in such a way for protection from ice flow, if any, which will occur from the Northwest to Northeast directions.

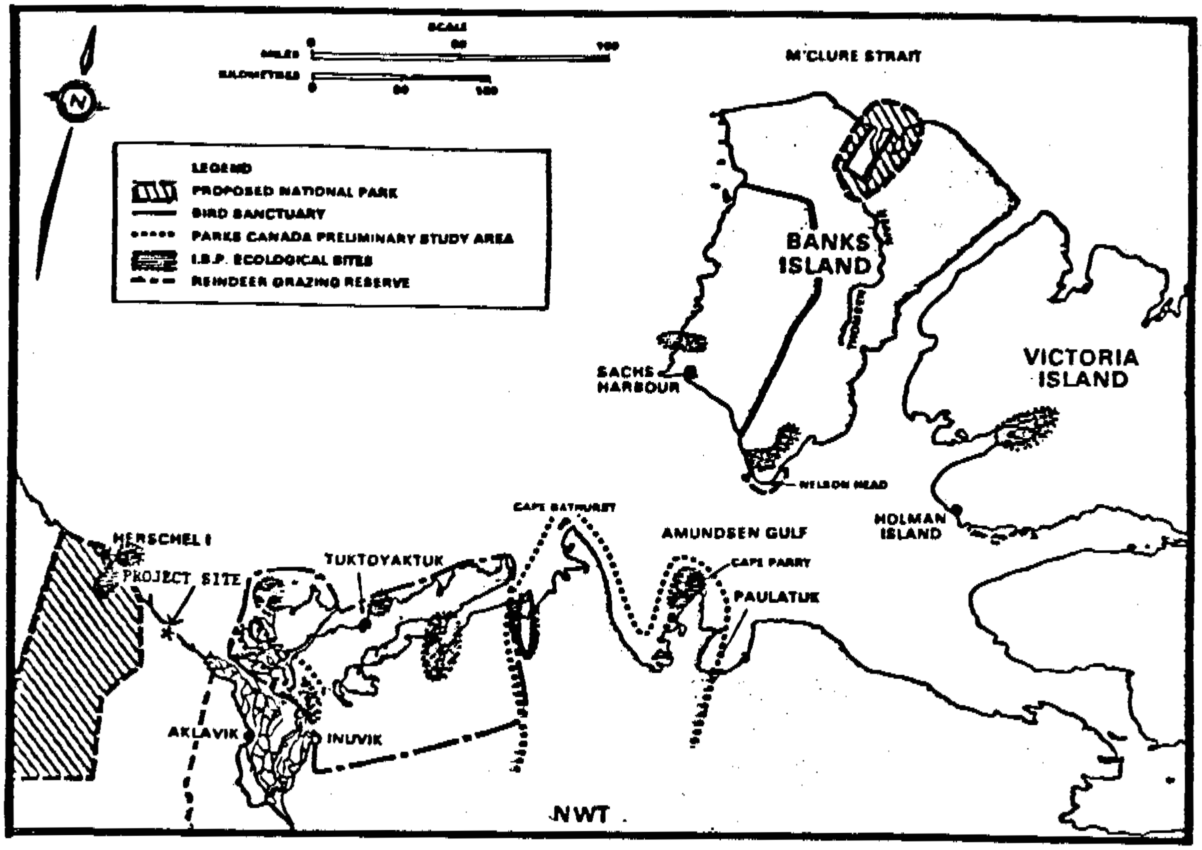


Fig. 4.6-1. Location of special interest areas near the project site. (Beaufort Sea EIS 1982)

4.8 & 9 PHYSICAL AND CHEMICAL OCEANOGRAPHY, LIMNOLOGY, WATER QUALITY AND/OR FLUVIOLOGY

Tides within the Beaufort Sea project area are generally less than 1 meter and water levels tend to be substantially influenced by wind and air pressure.

Storm surges are caused by winds driving the surface water onto the shallow continental shelf waters. The resulting high waters flood the adjacent low-lying lands of the southeastern Beaufort Sea. Storm surges, which raise sea levels by 0.5 m over a few days, are frequent during persistent westerly or northwesterly winds.

The pattern of surface circulation on the inshore continental shelf of the southeastern Beaufort Sea tends to be controlled by winds, and modified by the Mackenzie River outflow, interactions with the underlying water layer, and local bathymetry. The mean response of these currents to either strong northwesterly or easterly winds has been examined during surface drifter studies. Easterly winds tend to drive drifters northwestward past the edge of the continental shelf, while westerly winds move drifters toward the shore and eastward. Studies also indicated that inshore drifter movements were generally aligned with the trend of the coastline.

Surface waters of the nearshore and continental shelf zones of the southeastern Beaufort Sea respond quickly to local winds, typically within one day. these surface movements are more subject to change near the coastline. Low frequency or subtidal variations in the surface and near-surface circulation occur in the southeastern Beaufort Sea on time scales ranging from one day to several years. Near the shore and on the continental shelf in summer, variations in the wind appear to control the surface layer circulation. However, other factors such as river flow characteristics, water stratification, local bathymetry, and proximity to the coastline tend to modify these surface currents. As a result, the normal assumption that surface currents move at 3% of the local wind only provides a rough estimate of the surface circulation in the region. However, daily current within the project area generally averages around 1 to 2 knots.

Utilizing Shingle Point wind data, (Section 4, Table 4.1-2) wind speeds greater than 20 km/h occur on an average of 14% of the time from June through October. These wind speeds will produce waves higher than 0.7 m. Furthermore, during the majority of the time, the direction of the waves is most frequently from the NW. to N. side. There are however, waves from the N. to NE direction as well from the NE to E.

Chemical characteristics of both the King Point near shore and lagoon have been studied by Allan and Mackenzie-Grieve (1982). Their nearshore salinity and temperature data suggest that no vertical column structuring or horizontal patterns existed. This suggests that localized mixing is occurring which is typical of the open coastal waters.

The King Point lagoon had higher water temperatures and lower salinity and conductivity values than the nearshore samples. This study also suggested that the lagoon is well mixed with regards to temperature and salinity.

Data gathered at seven sites for King Point water chemistry, concentrations of oil and grease, and extractable metals in the sediment are found in Tables 4.8 & 9-1,2.

4.10 GEOLOGICAL OCEANOGRAPHY, LIMNOLOGY AND/OR FLUVIOLOGY

The project area at King Point possesses favourable, natural contours to sea level elevation. There appears to be no evidence of bank erosion within the immediate vicinity of the King Point Bar. However, the beach east and west of the project area is adjacent to steep banks of unstable, frozen soils. These soils sustain a high rate of sediment deposition.

Table 4.8 & 9-1. Water chemistry data collected at King Point, August 6-7, 1982.
(from Allan and Mackenzie-Grieve, 1982)

King Point Station	Description	Date	Local Time	Sample Depth (m)	Temperature (°C)	Oxygen (mg/1)	O_2 Saturation (%)	Conductivity (100umhos/cm)	Salinity (°/oo)	Non-filterable Residue (mg/1)
1-1	lagoon	82-08-07	1100	0	10.0	10.4	95.3	71	6.5	5
1-2				2.8	10.0	10.4	95.3	71	6.5	5
2-1	lagoon	82-08-07	1517	0	10.4	10.6	98.0	68	6.2	4
2-2				3.3	10.1	10.5	96.2	69	6.2	5
3-1	lagoon	82-08-07	1255	0	10.0	10.5	96.3	75	7.0	5
3-2				2.5	9.8	10.5	96.2	78	7.0	12
4-1	sea	82-08-06	1307	0	7.0	10.5	104.2	271	29.6	4
4-2				4.5	6.4	10.6	103.5	269	29.3	6
5-1	sea	82-08-06	1839	0	8.1	10.5	106.9	281	30.0	6
5-2				4.5	7.1	10.6	105.5	272	29.8	5
6-1	sea	82-08-06	1744	0	8.2	10.3	104.7	278	29.6	4
6-2				4.5	7.0	10.7	106.2	271	29.5	4
7-1	sea	82-08-06	1551	0	7.9	10.5	108.6	305	32.9	5
7-2				4.5	7.0	10.5	106.6	301	33.1	10
8-1	sea	82-08-06	1445	0	7.6	10.5	108.9	308	34.1	5
8-2				4.5	7.0	10.6	108.4	308	34.1	4

Table 4.8 & 9-2. **Concentrations of oils and grease and extractable metals in the sediment samples collected at King Point. (from Allan and Mackenzie-Grieve, 1982)**

Sample Number	Oils & Grease (mg/kg)	Extractable Metals (mg/kg)													
		Ag	Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg	K
1-1	232	5.	28400	19.7	59.8	286.	.9	8410	>.3	14.4	45.6	34.2	37500	.32	6670
1-2	278	5.	28400	20.2	73.2	294.	1.0	8210	7.5*	14.8	45.6	36.1	38500	.26	6380
1-3	330	5.	28600	19.9	66.1	286.	.9	8120	>.3	13.5	45.3	34.3	38500	.30	6770
2-1	498	5.	25700	18.6	52.1	282.	.9	9280	>.3	16.8	41.8	34.6	35700	.34	5740
2-2	434	5.	26700	18.3	49.5	289.	.8	9680	>.3	9.2	42.7	34.3	36200	.33	5960
2-3	263	5.	27200	19.8	69.0	294.	.9	9540	6.3*	13.8	43.4	35.5	36700	.39	6170
3-1	714	5.	21200	15.8	53.6	240.	.7	9530	>.3	9.9	34.9	27.1	28900	.34	4640
3-2	637	5.	22400	16.1	42.7	249.	.7	9600	>.3	16.8	37.1	29.2	28900	.29	5110
3-3	555	5.	22000	15.9	43.0	250.	.7	9230	>.3	10.3	35.9	26.9	29200	.25	5040
4-1	69	5.	17800	16.1	37.1	199.	.6	11100	>.3	10.6	28.3	19.8	28000	.25	3890
4-2	145	5.	19000	16.6	41.6	186.	.6	12100	>.3	12.8	30.5	22.8	28700	.28	4290
6-1	141	5.	13100	18.3	21.1	295.	.4	11200	>.3	11.5	22.4	11.9	27100	.26	2550
6-2	285	5.	15800	11.0	23.4	189.	.5	11300	>.3	14.6	26.9	17.0	25300	.26	3270
6-3	465	5.	16100	10.1	26.5	184.	.5	10900	>.3	9.5	27.3	17.7	25800	.26	3200
7-1	177	5.	24200	19.3	46.9	463.	.7	8410	>.3	10.7	39.9	28.5	34500	.26	5480
7-2	163	5.	25200	19.5	52.8	437.	.8	7940	>.3	15.6	42.4	30.8	35300	.26	5810
7-3	257	5.	29000	17.5	56.0	468.	.8	7490	>.3	18.2	47.4	35.5	35500	.27	6810
8-1	343	5.	24500	13.6	48.7	286.	.7	11300	>.3	16.8	39.1	30.1	31200	.23	5390
8-2	209	5.	21600	14.1	46.7	282.	.6	11300	>.3	15.8	35.5	27.6	28600	.26	4870
8-3	114	5.	20500	16.6	56.3	225.	.6	6980	>.3	9.2	35.3	27.4	27500	.31	4900

*Results suspected of contamination after collection.

Table 4.8 & 9-2. Concentrations of oils and grease and extractable metals in the sediment samples collected at King Point (continued). (from Allan and MacKenzie-Grieve, 1982)

Sample Number	Extractable Metals (mg/kg) Mg	Mn	Mo	Na	Ni	P	Pb	Si	Sn	Sr	Ti	V	Zn
1-1	8150	473.	>.8	2610	38.	1260.	13.	4300.	>3.	66.8	139.	88.	138.0
1-2	8340	478.	>.8	2550	40.	1260.	16.	4820.	>2.	67.6	140.	88.	143.0
1-3	8090	469.	>.8	2560	38.	1300.	12.	3620.	>2.	67.2	139.	87.	140.0
2-1	8070	503.	>.8	1910	41.	1190.	15.	5980.	>2.	64.4	141.	81.	136.0
2-2	8240	515.	>.8	2350	35.	1180.	10.	5160.	3.	67.2	145.	83.	134.0
2-3	8360	520.	>.8	2820	38.	1200.	13.	5120.	>2.	67.4	145.	85.	136.0
3-1	7320	417.	>.8	2000	31.	1120.	9.	3530.	>2.	57.9	139.	67.	115.0
3-2	7370	422.	>.8	1830	37.	1120.	13.	3860.	>2.	58.5	152.	71.	117.0
3-3	7260	418.	>.8	1600	30.	1130.	8.	4940.	>2.	57.5	144.	69.	115.0
4-1	5880	498.	>.8	2130	26.	1290.	7.	4940.	>2.	61.6	100.	55.	96.6
4-2	6340	530.	>.8	2050	30.	1290.	8.	4910.	>2.	64.0	109.	57.	107.0
6-1	5090	531.	>.8	1020	22.	1680.	7.	6020.	>2.	55.0	130.	44.	85.8
6-2	6200	481.	>.8	1600	28.	1100.	9.	6700.	>2.	47.9	153.	48.	86.0
6-3	6470	474.	>.8	1540	26.	986.	6.	5890.	>2.	48.4	145.	48.	88.6
7-1	7020	466.	>.8	2760	33.	1300.	9.	6040.	2.	63.6	161.	82.	121.0
7-2	7230	482.	>.8	2780	37.	1270.	12.	5990.	3.	61.5	159.	85.	127.0
7-3	7970	492.	>.8	3810	41.	1120.	15.	5430.	>2.	65.0	168.	95.	135.0
8-1	7670	401.	>.8	2310	36.	997.	11.	4480.	>2.	63.6	149.	74.	106.0
8-2	7130	361.	>.8	2090	33.	944.	13.	5930.	>2.	61.7	148.	70.	108.0
8-3	6460	328.	>.8	1880	28.	945.	9.	4150.	>2.	51.5	164.	73.	117.0

The sea floor has an abundance of coarse gravel with deep water contours in close proximity to the shore. These conditions indicate the presence of fairly active currents and low sediment deposition on the west end of the King Point Bar.

4.11 REFERENCES

Terrain and Geology

National Building Code of Canada. 1980. (Supplement) Assoc. Comm. Nat. Build. Code, Nat. Res. Counc. Can. Ottawa.

Marine Mammals

Braham, H.W., B. Krogman, and C. Fiscus. 1977. Bowhead (Balaena mysticetus) and beluga (Delphinapterus Leucas) whales in the Bering, Chukchi and Beaufort seas. Envir. Assess. of the Alaskan Cont. Shelf, Vol. 1:134-160. NOAA, U.S. Dept. Comm., Boulder, Col.

Burns, J.J. and K.J. Frost, 1979. The natural history and ecology of the bearded seal Erignathus barbatus. Final report OCSEAP Contract 02-5-022-53. Alaska Dept. Fish and Game, Fairbanks, 77 pp.

Davis, R.A. and K.J. Finley, 1979. Distribution, migration, abundance and stock identify of eastern arctic white whales. Paper presented to Int. Whal. Comm., Cambridge, June 1979. 55 pp.

Degerbøl, M. and P. Freuchen. 1935. Mammals. Report Fifth Thule Expedition, 1921-24. Vol. 2, No. 4-5.

Eley, T. and L. Lowry (eds.). 1978. Marine mammals. pp. 134-151. In: Interim systhesis: Beaufort/Chukchi. Outer Cont. Shelf Envir. Assess. Prog., NOAA, Boulder, Col. 362 pp.

Fraker, M.A. 1977. The 1977 whale monitoring program, Mackenzie estuary, N.W.T. Unpubl. F.F. Slaney and Co. Ltd., for Imperial Oil Ltd., Calgary.

Fraker, M.A. 1978. The 1978 whale monitoring program. Mackenzie estuary, N.W.T. Unpubl. F.F. Slaney and Co. Ltd. for Esso Resources Canada Ltd., Calgary.

Fraker, M.A. 1979. Spring migration of bowhead (Balaena mysticetus) and white whale (Delphinapterus leucas) in the Beaufort Sea. Fish. Mar. Serv. Tech. Rep. 859. 36 pp.

Fraker, M.A. and P.N. Fraker. 1979. The 1979 whale monitoring program, Mackenzie estuary. Unpubl. LGL Ltd. rep for Esso Resources Canada Ltd., Calgary. 51 pp.

Fraker, P.N. and M.A. Fraker. 1981. The 1980 whale monitoring program, Mackenzie Estuary. Unpubl. LGL Ltd. rept. for Esso Resources Canada Ltd., Calgary.

Harington, C.R. 1968. Denning habits of the polar bear (Ursus maritimus Phipps). Can. Wildl. Serv. Rep. Ser. 5. 30 pp.

Johnson, C.H., C.H. Fiscus, B.T. Ostenson, and M.L. Barbour. 1966. Marine mammals, pp. 877-924. In: N.J. Wilimovsky and J.N. Wolfe (eds.), Environment of the Cape Thompson region, Alaska. U.S. Atomic Energy Commission, Oak Ridge, Tenn. 1250 pp.

Lentfer, J.W. 1975. Polar bear denning on drifting sea ice. J. Mamm. 56:716-718.

LGL Ltd. and ESL Ltd. 1982. A biological overview of the Beaufort and Northeast Chukchi seas. Prep. for Dome Petroleum Ltd., Calgary.

Ljungblad, D.K., M.F. Platter-Reiger, and F.S. Shipp Jr. 1980. Aerial surveys of bowhead whales, North Slope, Alaska. Tech. Doc. 314. Naval Oceans Systems Center, San Diego, Calif. 181 pp.

Ljungblad, D.K. 1981. Aerial surveys of endangered whales in the Beaufort Sea, Chukchi Sea and Northern Bering Sea. Tech. Doc. 449. Naval Oceans Systems Center, San Diego, Calif. 292 pp.

Lowry, L.F. and J.J. Burns. 1980. Foods utilized by bowhead whales near Barter Island, autumn 1979. Mar. Fish. Rev. 42(9-10):88-91.

Lowry, L.F., K.J. Frost and J.J. Burns. 1979. Feeding of bearded seals in the Bering and Chukchi seas and implications with respect to carrying capacity. Abstract. Paper presented at 3rd Biennial Conf. on the Biology of Marine Mammals. Seattle, Wash., October 1979.

Marquette, W.M. 1978. The 1976 catch of bowhead whales, Balaena mysticetus, by Alaskan Eskimos. Mar. Fish. Rev. 40(11):18-27.

Schweinsburg, R.R., I. Stirling, S. Oosenburg and H. Kiliann. 1977. A status report on polar bear studies in Lancaster Sound. Unpubl. Rep. by N.W.T. Fish and Wildl. Serv., Yellowknife, to Norlands Petroleums Ltd., Calgary. 83 pp.

Smith, T.G. 1973. Population dynamics of the ringed seal in the Canadian eastern Arctic. Fish. Res. Board Can. Bull. 181:1-55.

Smith, T.G. 1976. Predation of ringed seal pups (Phoca hispida) by the Arctic fox (Alopex lagopus). Can. J. Zool. 54:1610-1616.

Smith, T.G. and I. Stirling. 1975. The breeding habitat of the ringed seal (Phoca hispida). The birth lair and associated structures. Can. J. Zool. 53:1297-1305.

Smith, T.G. and I. Stirling. 1978. Variation in the density of ringed seal (Phoca hispida) birth lairs in the Amundsen Gulf, Northwest Territories. Can. J. Zool. 56:1066-1070.

Stirling, I. 1978. A review of population ecology studies of polar bears conducted in the western Canadian Arctic from 1971 through 1977, for the purpose of evaluating management practices. Unpubl. rep. by Canadian Wildl. Serv. to Northwest Territories Fish and Wild. Serv., Yellowknife. 68 pp.

Stirling, I., D. Andriashek, P. Latour and W. Calvert. 1975. The distribution and abundance of polar bears in the eastern Beaufort Sea. Beaufort Sea Project Tech. Rep. No. 2 Dept. of the Environment, Victoria, B.C. 59 pp.

Stirling, I., W.R. Archibald, and D. DeMaster. 1977. Distribution and abundance of seals in the eastern Beaufort Sea. J. Fish. Res. Board Can. 34:967-988.

Vibe, C. 1950. The marine mammals and the marine fauna in the Thule District (northwest Greenland) with observations on ice conditions in 1939-41. Meddelelser om Grøland 150(6):1-116. (6):1-116.

Birds

Banko, W.E. and R.H. Mackay. 1964. Our native swans. In: J.P. Linduska (ed.). Waterfowl tomorrow. U.S. Dep. Interior, Fish Wildl. Serv. pp. 155-164.

Barry, T.W. 1967. Geese of the Anderson River Delta, Northwest Territories. Unpubl. Ph.D. thesis, Univ. Alberta, Edmonton. 212 pp.

Barry, T.W. 1976. Seabirds of the southeastern Beaufort Sea: summary report. Beaufort Sea Tech. Rep. 3a. Can. Dept. Envir., Victoria, B.C. 41 pp.

Barry, T.W., S.J. Barry, and B. Jacobson. 1981. Sea-bird surveys in the Beaufort Sea, Amundsen Gulf, Prince of Wales Strait and Melville Sound - 1980 season. Prepared for Dome Petroleum Ltd., and Esso Resources Canada Ltd., Calgary and Canadian Wildlife Service, Edmonton. 59 pp.

Bellrose, F.C. 1976. Ducks, geese and swans of North America. Stackpole Books, Harrisburg, Pa. 544 pp.

Bente, P.J. 1980. Nesting behaviour and hunting activity of the gyrfalcon, Falco rusticolus, in south-central Alaska. Unpubl. M.S. thesis, Univ. Alaska, Fairbanks. 103 pp.

Boothroyd, P.N. and D.J. Karasiuk. 1981. Preliminary environmental assessment of proposed harbour sites at McKinley Bay and Baillie Islands, Northwest Territories (MS).

Cade, T.J. 1960. Ecology of the peregrine and gyrfalcon populations in Alaska. Univ. California Publ. Zool. 63:151-290.

Cade, T.J. and R. Fyfe. 1970. The North American peregrine survey, 1970. Can. Field-Nat. 84:231-245.

Campbell, R.W. and B. Davies. 1973. Nesting raptor survey in the western Canadian Arctic, 1972. Section 1. 47 pp. In: Environment Protection Board. Towards an environmental impact assessment of the portion of the Mackenzie gas pipeline from Alaska to Alberta. Interim Rep. 3. Appendix III, ornithology. Winnipeg.

Connors, P.G., J.P. Myers and F.A. Pitelka. 1979. Seasonal habitat use by arctic Alaskan shorebirds. Studies in Avian Biology 2:101-111.

Cooch, F.G. 1958. The breeding biology and management of the blue goose (Chen caerulescens). Unpubl. Ph.D. thesis, Cornell Univ., Ithaca, N.Y. 235 pp.

CWS (Canadian Wildlife Service). 1972. Arctic ecology map series, critical wildlife areas: descriptive reports. Can. Dep. Environ., Ottawa. 324 pp. + maps.

Derksen, D.V., M.W. Weller and W.D. Eldridge. 1979. Distribution ecology of geese moulting near Teshekpuk Lake, National Petroleum Reserve-Alaska. pp. 189-207. In: R.L. Jarvis and J.C. Bartonek (eds.). Management and biology of Pacific flyway geese. OSU Book Stores, Inc., Corvallis, Ore.

Fyfe, R.W. 1976. Status of Canadian raptor populations. Can. Field-Nat. 90:370-375.

Hickey, J.J. (ed.). 1969. Peregrine falcon populations: their biology and decline. Univ. Wisconsin Press, Madison. 596 pp.

Hohn, E.O. 1959. Birds of the mouth of the Anderson River and Liverpool Bay, Northwest Territories. Can. Field-Nat. 73:93-114.

Johnson, S.R. 1979. Avian ecology in Simpson Lagoon, Beaufort Sea, Alaska. In: Beaufort Sea Barrier Island-Lagoon Ecological Process studies. OCSEAP/NOAA, Boulder, Col. 111 pp.

Johnson, S.R., W.J. Adams, and M.R. Morrell. 1975. The birds of the Beaufort Sea: part 1, a literature review; part 2, observations of 1975 spring migration. LGL Ltd. Rep. for Beaufort Sea Project, Can. Dept. Envir., Victoria, B.C. 310 pp.

Koski, W.R. 1975a. A study of the distribution and movements of snow geese, other geese, and whistling swans on the Mackenzie Delta, Yukon North Slope, and Alaskan North Slope in August and September, 1974, including a comparison with similar data from 1973. Arctic Gas Biol. Rep. Ser. 30:1-58.

Koski, W.R. 1977a. A study of the distribution of snow geese, other geese, and whistling swans on the Mackenzie Delta, Yukon North Slop, and Alaskan North Slope in August and September 1975. Arctic Gas Biol. Rep. Ser. 35:1-54.

Koski, W.R. 1977b. A study of the distribution and movements of snow geese, other geese, and whistling swans on the Mackenzie Delta, Yukon North Slope, and Alaskan North Slope in August and September 1976. Unpubl. LGL Ltd. Rep. for Canadian Arctic Gas Study Ltd., Calgary, Alberta. 69 pp.

Koski, W.R. and M.A. Gollop. 1974. Migration and distribution of staging snow geese on the Mackenzie Delta, Yukon and eastern Alaskan North Slope, August and September, 1973. Arctic Gas Biol. Rep. Ser. 27(1):1-38.

Kuyt, E. 1974. Waterfowl populations in coastal Beaufort Sea, part II. In: T.W. Barry and E. Kuyt. Seabird populations in the coastal Beaufort Sea. Can. Wildl. Serv. Interim Rep. A-3. 23 pp.

LGL Ltd., and ESL Environmental Sciences Ltd. 1982. A biological overview of the Beaufort and Northeast Chukchi Seas. Prep. for Dome Petroleum Ltd., Calgary.

Manning, T.H., E.O. Hohn, and A.H. Macpherson. 1956. The birds of Banks Island. Nat. Mus. Can. Bull. No. 143. 137 pp.

McEwen, E.H. 1954. Report on white fox, snow geese and white whales. July 1954. MS in files of Can. Wildl. Serv., Edmonton.

McEwen, E.H. 1958. Observations of the lesser snow goose nesting grounds. Egg River, Banks Island. Can. Field-Nat. 72:122-127.

Mossop, D. 1975. Waterfowl counts and observations from the coastal plain, Yukon Territory 1975. Unpubl. Rep., Yukon Game Branch, Whitehorse. 6 pp.

Nelson, R.W. 1978. Gyrfalcon ecology and behavior in the north central Yukon. 1978. Prog. Rep. 1 to World Wildlife Fund (Canada), Toronto. 36 pp.

Newton, I. 1976. Population limitation in diurnal raptors. Can. Field-Nat. 90:274-300.

Ogilvie, M.A. 1978. Wild geese. Buteo Books, Vermillion, S.D. 350 pp.

Palmer, R.S. 1962. Handbook of North American birds. Vol. 1: loons through flamingoes. Yale Univ. Press, New Haven and London. 567 pp.

Parmelee, D.F., H.A. Stephens, and R.H. Schmidt. 1967. The birds of southeastern Victoria Island and adjacent small islands. Nat. Mus. Can. Bull. 222.

Peakall, D.B. 1976. The peregrine falcon (Falco peregrinus) and pesticides. Can. Field-Nat. 90:301-307.

Platt, J.B. 1975. A study of diurnal raptors that nest on the Yukon North Slope with special emphasis on the behaviour of gyrfalcons during experimental overflights by aircraft. Arctic Gas Biol. Rep. Ser. 30(2). 40 pp.

Platt, J.B. 1976a. Gyfalcon nest site selection and winter activity in the western Canadian Arctic. Can. Field-Nat. 90:338-345.

Platt, J.B. and C.E. Tull. 1977. A study of wintering and nesting gyrfalcons on the Yukon North Slope during 1975 with emphasis on their behaviour during experimental overflights by helicopters. Arctic Gas Biol. Rep. Ser. 35(1). 90 pp.

Ratcliffe, D. 1980. The peregrine falcon. Buteo Books, Vermillion, S.D. 416 pp.

Birds (continued)

Richardson, W.J. and S.R. Johnson. 1981. Waterbird migration near the Yukon and Alaskan coast of the Beaufort Sea. I. Timing, routes and numbers in spring. Arctic 34:108-121.

Roseneau, D.G. 1972. Summer distribution, numbers, and feeding habits of the gyrfalcon (Falco rusticolus L.) on the Seward Peninsula, Alaska. Unpubl. M.S. thesis, Univ. Alaska, Fairbanks. 124 pp.

Roseneau, D.G. 1974. A continuation of studies of raptorial bird nesting sites along proposed pipeline routes in Alaska. Unpubl. Rep. to Canadian Arctic Gas Study Ltd., Calgary. 69 pp.

Roseneau, D.G., C.E. Tull and R.W. Nelson. 1981. Protection strategies for peregrine falcons and other raptors along the proposed Northwest Alaskan gas pipeline route. Unpubl. LGL Alaska Res. Assoc., Inc., Rep. for Northwest Alaskan Pipeline Co. and Fluor Northwest, Inc., Fairbanks. 328 pp.

Ryder, J.P. 1970. Timing and spacing of nests and breeding biology of Ross' goose. Unpubl. Ph.D. thesis, Univ. of Saskatchewan, Saskatoon. 240 pp.

Salter, R.E., M.A. Gollop, S.R. Johnson, W.R. Koski and C.E. Tull. 1980. Distribution and abundance of birds on the Arctic coastal plain of northern Yukon and adjacent Northwest Territories, 1971-76. Can. Field-Nat. 94:219-238.

Scott-Brown, M., L. Allen and N. Rowe. 1981. Waterbird surveys McKinley Bay, Northwest Territories. Unpubl. Rep. by Environmental Management Associates for Canadian Wildlife Service and Dome Petroleum Limited. 30 pp. and Appendices.

Searing, G.F., E. Kuyt, W.J. Richardson and T.W. Barry. 1975. Seabirds of the southeastern Beaufort Sea: aircraft and ground observations in 1972 and 1974. Beaufort Sea Proj. Tech. Rep. 3b, Can. Dept. Envir., Victoria, B.C. 257 pp.

Sladen, W.J.L. 1973. A continental study of whistling swans using neck collars. Wildfowl 24:8-14.

Slaney, F.F. and Co. Ltd. 1974a. 1972-74 environmental program, Mackenzie Delta, N.W.T., Canada. Vol. 4, birds. Unpubl. Rep. for Imperial Oil Ltd., Gulf Oil Canada Ltd., Shell Canada Ltd., and Canadian Arctic Gas Study Ltd., Calgary. 133 p + figures, tables and appendices.

Springer, A.M. and D.G. Roseneau. 1978. Ecological studies of colonial seabirds at Cape Thompson and Cape Lisburne, Alaska, pp. 839-960. In: Envir. Assess. Alaskan Cont. Shelf, Annu. Rep. Prin. Invest., March 1978. Vol. 2. NOAA/OCSEAP, Boulder, Col. 960 pp.

Birds (continued)

Timson, R.S. 1976. Late summer migration at Barrow, Alaska. pp. 364-399. In: Environ. Assess. Alaskan Cont. Shelf. Quart. Rep. Prin. Invest., Vol. 1, April-June 1976. BLM/NOAA, OCSEAP, Boulder, Col.

Tuck, L.M. 1960. The murres - their distribution, populations and biology - a study of the genus Uria. Can. Wildl. Serv., Ottawa, Can. Wildl. Serv. Rep. Ser. 3. 260 pp.

Tull, C.E. and W.R. Koski. 1981. Birds of the Mackenzie Valley. Rep. by LGL Ltd., Edmonton, for Hardy Associates (1978) Ltd., Calgary. 121 pp.

U.S. Dep. Interior. 1973. Threatened wildlife of the United States. Res. Publ. No. 114. U.S. Dep. Interior, Bur. Sport Fish. Wildl., Washington. 289 pp.

Walker, W. 1977. Chlorinated hydrocarbon pollutants in Alaska gyrfalcons and their prey. Auk 94:442-447.

Ward, J.G. 1979. Bird and mammal surveys in the Cape Parry area, Northwest Territories, June-August 1979. Unpubl. Rep. by LGL Ltd. for Dome Petroleum Ltd. 40 pp.

White, C.M. 1974. Hunting range of a breeding peregrine falcon on Franklin Bluffs, Sagavanirktok River. Interim Rep. to U.S. Fish Wildl. Serv., Anchorage. 5 pp.

Wypkema, R.C.P. and C.D. Ankney. 1979. Nutrient reserve dynamics of lesser snow geese staging at James Bay, Ontario. Can. J. Zool. 57:213-219.

Fish

Byers, S.C. and R.K. Kashino. 1980. Survey of fish populations in Kugmallit Bay and Tuktoyaktuk Harbour, N.W.T. Unpubl. rep. for Dome Petroleum Limited, Calgary, Alberta.

Craig, P.C. and L.J. Haldorson. 1980. Beaufort Sea barrier island-lagoon ecological process studies. Final report, Simpson Lagoon. Part 4. Fish. Res. Unit 467. In: Environ. Assess. Alaskan Cont. Shelf, Final Rep. Prin. Invest. BLM/NOAA, OCSEAP, Boulder, Col.

Furniss, R.A. 1975. Inventory and cataloguing of arctic area waters. Alaska Dept. Fish and Game. Annual Report 16:1-47.

Griffiths, W., P.C. Craig, G. Walder and G. Mann. 1975. Fisheries investigations in a coastal region of the Beaufort Sea (Nunaluk Lagoon, Y.T.). Arctic Gas Biol. Rep. Ser., 34(2):219 pp.

Griffiths, W., J. Den Beste and P.C. Craig. 1977. Fisheries investigations in a coastal region of the Beaufort Sea (Kaktovik Lagoon, Barter Island, Alaska). Arctic Gas Biol. Rep. Ser. 40(2):190 pp.

Kendel, R.E., R.A.C. Johnston, U. Lobsiger and M.D. Kozak. 1975. Fishes of the Yukon Coast. Beaufort Sea Tech. Rep. No. 6, Environ. Canada, Victoria, B.C. 114 pp.

McCart, P.J. 1980. A review of the systematics and ecology of Arctic char, Salvelinus alpinus, in the western Arctic. Can. Tech. Rep. Fish. Aquat. Sci. 935:89 pp.

Tarbox, K. and R. Thorne. 1979. Measurements of fish densities under the ice in the Beaufort Sea near Prudhoe Bay, Alaska. In: Environmental Studies of the Beaufort Sea - winter 1979. Unpubl. rep. by Woodward-Clyde Consultants for Prudhoe Bay Unit, December 1979.

Terrestrial Mammals

Banfield, A.W.F. 1974. The mammals of Canada. Univ. of Toronto Press, Toronto. 438 pp.

Bente, P.J. 1977. Summary report of investigations of the Porcupine caribou herd in northeastern Alaska and the Yukon Territory. 1977. Prep. for Canadian Arctic Gas Pipelines Ltd. Renewable Resources Consulting Services Ltd. Unpubl. Rep. 19 pp.

Blood, D.A. 1977. Birds and marine mammals. The Beaufort Sea and the search for oil. Beaufort Sea Projects. Dept. of Fisheries and Environment. 124 pp.

Chesemore, D.L. 1968. Notes on the food habits of Arctic foxes in northern Alaska. Can. J. Zool. 46:1127-1130.

Curatolo, J.A. and D.G. Roseneau. 1977. The distribution and movements of the Procupine caribou herd in northeastern Alaska and the Yukon Territory, 1976. Renewable Resources Consulting Services Ltd. Unpubl. Rep. submitted to Northern Engineering Services Ltd. 59 pp.

Dickinson, D.M. and T.B. Herman. 1979. Management of some terrestrial mammals in the Northwest Territories for sustained yields. Unpub. Rep. prep. for Science Advisory Board of N.W.T. 71 pp.

Doll, D., W.P. McCrory, and J.D. Feist. 1974. Distribution and movements of the Porcupine caribou herd in the Yukon, 1973. Chapt. 1 In: K.H. McCourt and L.P. Horstman (eds.). Studies of large mammal populations in northern Alaska, Yukon, and Northwest Territories, 1973. Arctic Gas Biol. Rep. Ser. vol. 22. 56 pp.

Goodwin, H.A. and C.W. Holloway. 1972 Mammalia. IUCN Red Data Book. Vol. 1. IUCN, Morges.

Jakimchuk, R.D., E.A. DeBock, H.J. Russell, and G.P. Semenchuk. 1974. A study of the Porcupine caribou herd, 1971. Chapter 1 In: R.D. Jakimchuk (ed.), The Porcupine Herd - Canada. Renewable Resources Consulting Services Ltd., Can. Arctic Gas Study Ltd. Biol. Rept. Series Vol. 4.

Lent, P.C. 1971. Muskox and snow cover on Nunivak Island, Alaska. In: A.O. Haugen (ed.). Proceedings of the Snow and Ice in Relation to Wildlife and Recreation Symposium. Iowa State University. pp. 50-57.

Macpherson, A.H. 1969. The Dynamics of Canadian arctic fox populations. Can. Wildl. Service Rep. Series, No. 8 Environment Canada, Ottawa. 52 pp.

Manning, J.H. 1943. Notes on the mammals of south and central West Baffin Island. J. Mammal. 24(1):47-59.

McCourt, K.H., H.J. Russell, D. Doll, J.D. Feist, and W. McCrory. 1974. Distribution and movements of the Porcupine caribou herd in the Yukon, 1972. In: R.D. Jakimchuk (ed.). The Porcupine Herd - Canada. Renewable Resources Consulting Services Ltd., Arctic Gas Biol. Rept. Series, Vol. 4.

Mech, L.D. 1970. The wolf: the ecology and behaviour of an endangered species. Natural History Press, Garden City, New York. 384 pp.

Nolan, J.W., B.C. Goski and G. Wilde. 1973b. Atlas of Arctic Fox habitat maps. Part of a wildlife habitat inventory of the Mackenzie Valley and the northern Yukon. Can. Wildl. Serv. Rep.

Pearson, A.M. 1972. Population characteristics of the northern interior grizzly in the Yukon Territory, Canada. In: S. Herrero (ed.). Bears - Their Biology and Management. International Union for the Conservation of Nature and Natural Resources, No. 23. pp. 32-36.

Pearson, A.M. 1975. The northern interior grizzly bear, Ursus arctos L. Can. Wildl. Serv. Rep. Series 34:1-86.

Pearson, A.M. and B.C. Goski. 1974. The life history of the Arctic grizzly bear (Ursus arctos L.) in northern Yukon Territory. Unpubl. Can. Wildlife Serv. manuscript. 20 pp.

Pearson, A.M. and J.A. Nagy. 1976. The Arctic coastal grizzly bear and the potential impact of the proposed Inuvik-Tuktoyaktuk highway. Can. Wildl. Service, Unpubl. Rept. CWS-24-76, Edmonton. 9 pp.

Roseneau, D.G., J.A. Curatolo, and G. Moore. 1975. The distribution and movements of the Porcupine Caribou herd in northeastern Alaska and the Yukon Terriotyr, 1974. In: R.D. Jakimchuk, editor. Studies of large mammals along the proposed Mackenzie Valley gas pipeline route from Alaska to British Columbia. Arctic Gas, Biological Report Series, Volume Thirty-Two. Chapter III. 104 pp.

Ruttan, R.A. 1974c. Arctic fox on north slope of the Yukon Territory, 1972. In: R.A. Ruttan and D.R. Wooley. Studies of furbearers associated with proposed pipeline routes in the Yukon and Northwest Territories. Arctic Gas Study Biological Report Series Vol. 9. Chapt. 4. 104 pp.

Ruttan, R.A. and D.R. Wooley. 1974. A study of furbearers associated with proposed pipeline routes in the Yukon Territory and Mackenzie River Valley, 1971. Rep. prep. by Renewable Resources Consulting Services Ltd., Arctic Gas Biological Report Series, Volume 8. 118 pp.

Scott, S. 1983. Personnel Communications. Peter Kiewit, Sons Co. Ltd.

Slaney, F.F. and Co. Ltd. 1974a. Volume 5. Mammals Environmental Program Mackenzie Delta, N.W.T., Canada. Prep. for Imperial Oil Ltd., Gulf Oil Canada Ltd., Shell Canada Ltd., and Canadian Arctic Gas Study Ltd.

Surrendi, D.C. and E.A. DeBock. 1976. Seasonal distribution, population status and behavior of the Porcupine Caribou Herd, Can. Wildl. Serv., Mackenzie Valley Pipeline Investigations, Ottawa. 144 pp.

Thompson, D.C., K.H. McCourt, and R.D. Jakimchuk. 1978. An analysis of the concerns for the Porcupine Caribou Herd in regard to an elevated pipeline on the Yukon coastal plain. Prep. by Renewable Resources Consulting Services Ltd. for Dome Petroleum Ltd.

Watson, G.H., W.H. Prescott, E.A. DeBock, J.W. Nolan, M.C. Dennington, H.J. Poston and I.G. Stirling. 1973. An inventory of wildlife habitat of the Mackenzie Valley and Northern Yukon. Environmental-Social Program, Northern Pipelines Rep. No. 73-27. 152 pp.

Youngman, P.M. 1975. Mammals of the Yukon Territory. National Museum of Canada, Publications in Zoology, No. 10. 192 pp.

5/6 ENVIRONMENTAL IMPACTS AND PROPOSED MITIGATION MEASURES

The following sections discuss potential direct and indirect environmental impacts of both general and specific nature, relative to the proposed Kiewit Quarry project. However, although these impacts are recognized, not all of them are anticipated to occur. Included within each section are various mitigation measures that can be used to ameliorate the suspected problems during the life of the project.

The definitions used to assist in assessing the degree of possible impacts were modified from definitions used in The Beaufort Sea Production Environmental Impact Statement (1982) and are shown in Table 5/6-1.

5/6-1 MARINE RESOURCES

Common Wastes and Disturbances

Disturbances to the marine environment could occur from treated sewage, solid waste, waste water disposal, air emissions, noise, artificial illuminations, artifical structures and human presence.

Waste Water Disposal

The discharge of treated waste water into coastal marine waters is an acceptable method of disposal, and long term detrimental effects to the marine system have been minimal (ESL 1982). In confined waters, waste build up can create areas of high organic loading reducing oxygen levels while increasing nutrient levels which could stimulate primary production.

Kiewit will use a mechanical water treatment system. This system will discharge treated water to the King Point lagoon and will cause negligible impacts to the environment.

Table 5/6-1. Definitions used for determing the impact of the proposed Kiewit Quarry/King Point Port complex.

Major Impact	=	When a regional population or environmental component is affected to a level which would cause a decline in abundance and/or a change in distribution beyond which natural recruitment from unaffected areas would not return that population or component or other dependent population or component to its former level within several generations.
Moderate Impact	=	When a portion of a regional population or environmental component is affected to a level that would result in a change of abundance and/or distribution to that specific population or environmental component or to a dependent population or environmental component, but is unlikely to affect the integrity of the regional population or environmental component.
Minor Impact	=	When a specific group of individuals of a population in a localized area and over a short period (one generation) may be affected, but other trophic levels are not likely to be affected in a manner which is considered regionally significant, or the integrity of the population itself is not significantly affected.
Negligible Impact	=	When the degree of the anticipated effects are less than minor.

Air Emissions

Air emissions are possible from several sources: fuel combustion, solid waste incineration and fuel tanks. Fuel combustion includes all air emissions associated with land or marine based usage of powered equipment. On the basis of emission factors available for the combustion of diesel fuel (Belyea et al 1966, Work and Warner 1981), the total quantity of various emissions have been estimated in Table 5/6-2.

The air emissions resulting from the combustion of diesel fuel would be released to the atmosphere from a large number of widely separated sources. As a result, any long term impacts to the air quality are unlikely.

The solid waste material from the project will be burned if possible. Material which is non-combustible will be buried in the waste rock disposal area. This incineration will produce some emissions. These emissions can cause negligible short term impacts only during unfavourable meteorological conditions.

Fuel Storage

As required, diesel and other fuels, will normally be stored in dyked tank storage areas (Fig. 3.3-2). The dyked area would have sufficient capacity to contain at least 110% of the storage capacity of the tanks in compliance with Federal regulations. Impermeable liners would be employed and covered with overburden during construction of the dykes.

Although habitat made unavailable to wildlife as a result of the area occupied by fuel storage facilities will be negligible, fuel storage is of concern because of the potential for tank rupture and/or leaks which allow fuel to enter aquatic environments. Locating fuel storage areas away from important wildlife habitat, preventing potential leaks from entering waterbodies and the construction of

Table 5/6-2. Estimated emissions from the combustion of diesel fuel.

Pollutant	Emission Factors (% wt. of fuel)	Approximate Emissions tonnes/year
Particulates	1.69	270.4
Sulphur Oxides	0.69	110.4
Nitrogen Oxides	3.38	540.8
Hydrocarbons	4.92	787.2
Carbon Monoxide	0.92	147.2

impervious dykes around fuel storage areas will ensure that impacts on mammals will be negligible.

The possibility of fuel leakage into water bodies is a concern which should be mitigated by measures similar to those previously described. Assuming no spills occur, impacts on birds would be negligible. If spills were to occur, impacts on birds could range from negligible to major, depending on the circumstances. However, these kinds of of impacts would not be considered to be a "normal" event associated with the operations.

Evaporation of volatile light-ends from liquid fuel storage tanks may release a very small amount of hydrocarbons. These volatile hydrocarbons would be rapidly dispersed in the atmosphere surrounding storage sites, and would not pose a safety hazard or have adverse impacts on local biological resources.

Ice fog can form when exhausts containing large quantities of water vapour are emitted where air temperatures are less than -30°C. Ice fog will then persist when there are temperature inversions and periods of calm. Under these conditions, there will be a reduction of visibility at ground level which could affect air traffic.

Meteorological data required to identify conditions during which ice fog may accumulate include frequency and duration of periods with sustained temperatures less than -30°C, occurrence of calm wind conditions and mean maximum afternoon mixing heights and frequency of temperature inversions. Although not all these data are available for the Kiewit Quarry/King Point Port, some general statements can be made regarding the frequency of ice fog formation.

Ice fog is most likely to form from December to March when temperatures less than -30°C are most frequent. Also, ice fog is more likely to accumulate at inland locations rather than along the coast where calm conditions are less frequent. In general, mixing heights tend to be low in the Arctic, and are a minimum from December through February at Inuvik. This is also when there are frequent temperature inversions which would favour the accumulation of ice fog.

Artificial Structures

Any artificial structure in a marine environment will have some influence on the coastline. The typical direction of sediment transport on this section of the Yukon coast is illustrated by the King Point bar build up on the east side. The port as designed, will have a minor influence on this process.

Disposal of sewage and solid waste, and air emissions will conform to regulatory guidelines. In addition Kiewit will encourage off duty personnel to adhere to government regulations to minimize the potential for impacts on sensitive coastal marine habitats.

Noise

Airborne noise from aircraft operations may temporarily disturb certain marine mammals, such as breeding ringed seals, possibly hauled-out ringed seals and bearded seals, and denning Arctic foxes. However, the potential impacts of overflights on breeding and hauled-out seals would probably be negligible since STOL aircraft and helicopters would usually fly at altitudes greater than 305 m (1,000 ft.) and because the turbojets would be at even higher altitudes within a few kilometres of the airport. However, disturbance of denning Arctic foxes could result in a minor impact on the local population because this area is an important denning location for this species. Airborne noise from the base operations and air traffic may also contribute to the potential attraction of polar bears, Arctic foxes and other mammals to King Point.

The potential for significant aircraft disturbance on birds is much greater over land than over the sea. Over the sea, the species most likely to be affected by airborne noise are moulting and staging ducks. Although present evidence indicates that ducks in marine areas are not particularly sensitive to aircraft disturbance (Gollop et al 1974a), studies have not been conducted in areas subject to heavy air traffic. However, since the potential shorebase sites have not been identified as important areas for moulting ducks (Barry et al 1981), the potential impacts of regulated air traffic on ducks along the coast are expected to be minor.

In general, underwater industrial noise along the Yukon coast is expected to leave most local marine mammal populations unaffected, hence impacts are expected to be negligible. The number of seals and white whales which may be able to detect underwater sound from operations at the base would be relatively small because of their low hearing sensitivities and widespread distribution. Although conspecific communication between some individuals may be temporarily interrupted, the potential impacts of this form of disturbance would probably not be more than negligible.

Underwater noise originating from the shorebase area may have some effect on bowhead whales, particularly during late summer and fall before and during their autumn migration. Unfamiliar sounds may temporarily disturb whales, while increased ambient noise levels may reduce their communication distances. There have been a relatively large number of bowheads observed along the Yukon coast between Herschel Island and Shingle Point during August and September. From 1 to 7 whales are usually sighted with most individuals being seen within 3.2 km of the shore (Fraker and Bockstoce 1980). Consequently, a large fraction of the fall migrant bowheads may detect low frequency underwater sounds produced in the vicinity of King Point by vessels and aircraft approaching or leaving the area. Bowhead whales appear to be tolerant of a certain level of industrial noise. They have been observed in large numbers nearing operating machinery in the Beaufort

Sea (ESL 1982). There is evidence to suggest that bowheads may be less sensitive to underwater noise disturbances created by Alaskan Inuit whalers during fall than in spring. Ambient noise levels are usually greater in fall and may account for the apparent decrease in sensitivity of bowheads to underwater noise at this time. The potential impacts of the levels of underwater noise created at King Point on the bowhead population would probably be negligible, while increased activities after that time could result in negligible to minor local disturbance effects. However, industry-sponsored whale monitoring programs will be continued. From these, mitigative measures will be derived and implemented as development of the Beaufort region progresses. Consequently, potential adverse impacts of shorebased or offshore activities on whales will be minimized. Such a program has proved to be very successful at Tuktoyaktuk (Fraker and Fraker 1982).

Dredging

There will be a need for dredging of a basin, and the dredge spoils will be used for constructing a breakwater-causeway. Kiewit has estimated that 250,000 m^3 of material might eventually be dredged to create the required anchorage.

In general, the potential impacts of dredging at a Yukon coast shorebase on water quality and most resources are expected to be negligible because the activities and subsequent effects will be local and of short duration. Possible impacts of dredging on local benthic infauna may approach moderate due to direct mortality of organisms in the borrow areas and the fact that recovery of some populations in excavated sites may require several generations over a period of one to three years. On the other hand, recolonization of the basin, causeway and breakwater by epibenthic species would likely occur quickly, and rock used for construction of parts of these structures will provide a hard substrate for colonization by additional species which are not common to the area. Nevertheless, potential impacts of dredging on local epibenthic invertebrate populations are expected to be minor.

Possible effects of dredging on fish may include a local alteration of marine spawning habitat and removal or burial of benthic food sources. Disturbance of feeding habitats may result in negligible to minor impacts on local fish populations, while disturbance or loss of spawning areas may cause minor to moderate impacts on some species of the local marine fish population, particularly sculpins and possibly flounder. The potential impact of fish entrainment in dredges is likely to be negligible, due to the small percentage of the local populations which could be affected.

5/6.2 TERRESTRIAL AND FRESHWATER RESOURCES

It is recognized that certain land areas associated with and adjacent to the King Point site are biologically important. Hence, mitigative measures will be identified to ensure that possible impacts of this development scenario are minimized.

Common Wastes and Disturbances

General

Human presence, air emissions, sewage and solid waste disposal, artificial illumination, and stationary airborne noise at King Point or a rock quarry site are not expected to result in impacts greater than negligible or minor on most terrestrial resources. Some species of mammals and birds including grizzly bears, red foxes, tundra wolves, wolverines, ravens and gulls may be attracted to the King Point base and to the quarry. This attraction may result from human presence, solid waste disposal practices, or airborne noise, despite the application of mitigative measures. Also, some northern grizzlies may be attracted to these developments during the summer. Although mitigative measures will include building a bear proof fence around the waste incinerator to reduce the potential for bear-human contact and bear scavenging of waste, monitoring of bears, sedation and removal of problem animals. Some individuals may have to be destroyed for reasons of human safety. Possible effects of King Point development on grizzly bears will depend on the numbers of bears in the area and the effectiveness of mitigative measures (LGL 1982). If the proposed mitigative measures are largely successful, the regional impacts on grizzly bears would likely be minor although the local impact on this population could approach moderate.

The attraction of other scavengers, both bird and mammal, to shorebase development should be minimized by careful handling of food and incineration of wastes. In general, there should be little direct mortality of other mammal and bird species as a result of activities at the King Point shorebase or associated rock quarry. Some mammals such as foxes, wolves and wolverines, may have to be destroyed if they become a nuisance or exhibit the behavioural traits of rabid animals. Some birds may be killed in collisions with structures at these sites. However, impacts on the regional populations of these species should be negligible or minor.

Some terrestrial species may be affected by increasing levels of airborne noise from aircraft landing at the Yukon coast shorebase, operating in the area, or travelling between the airport and other locations in the Beaufort region. These include: caribou during spring migration, calving and post-calving; nesting raptors; staging geese; moulting ducks and ground nesting birds.

To reduce or avoid adverse air traffic effects on the Porcupine caribou herd, overflights of spring migrating, calving and post-calving caribou will be prohibited whenever possible between early May and early August. If such overflights are considered essential, altitudes greater than 600 m asl would be maintained as recommended by Miller and Gunn (1979) unless there is a risk to human safety. Between August 15 and September 30, all overflights of traditional staging areas of snow geese and white-fronted geese, for example, on the North Slope and parts of the Mackenzie Delta, will be avoided to the extent possible. In addition, aircraft flights over active raptor nest sites would be of altitudes of 300 to 500 m above nest sites (see Roseneau et al 1981, LGL 1982) whenever possible during the nesting period from Februry 15 to August 31, the timing depending on species. If these mitigative measures are followed, potential impacts of aircraft disturbance on terrestrial birds and mammals will be confined to the immediate vicinity of the King Point shorebase and should vary from negligible to minor.

Climate

Climate would impose serious limitations upon transportation systems in northern Canada during mobilization and stockpiling prior to construction, during the winters of construction, and throughout the years of operation of the proposed quarry. The lack of roads necessitates barge transportation on the Mackenzie River and along the Beaufort Sea coast for heavy equipment and massive materials and supplies. Barging is also Kiewit's preferred method of shipping and will be employed even if access highways were available (Fig. 5/6-1). Heavy reliance on aircraft would be essential for movements of large volumes of air-transportable equipment, supplies, and personnel, and for resupply, and emergency repair services throughout the life of the project.

Low ground visibility impedes landing and take-off of aircraft, especially in the region of the Arctic coast, and the total weather complex makes aircraft maintenance difficult, impedes search and rescue in case of accidents, and is a threat to survival of passengers and crew. Flying conditions are generally

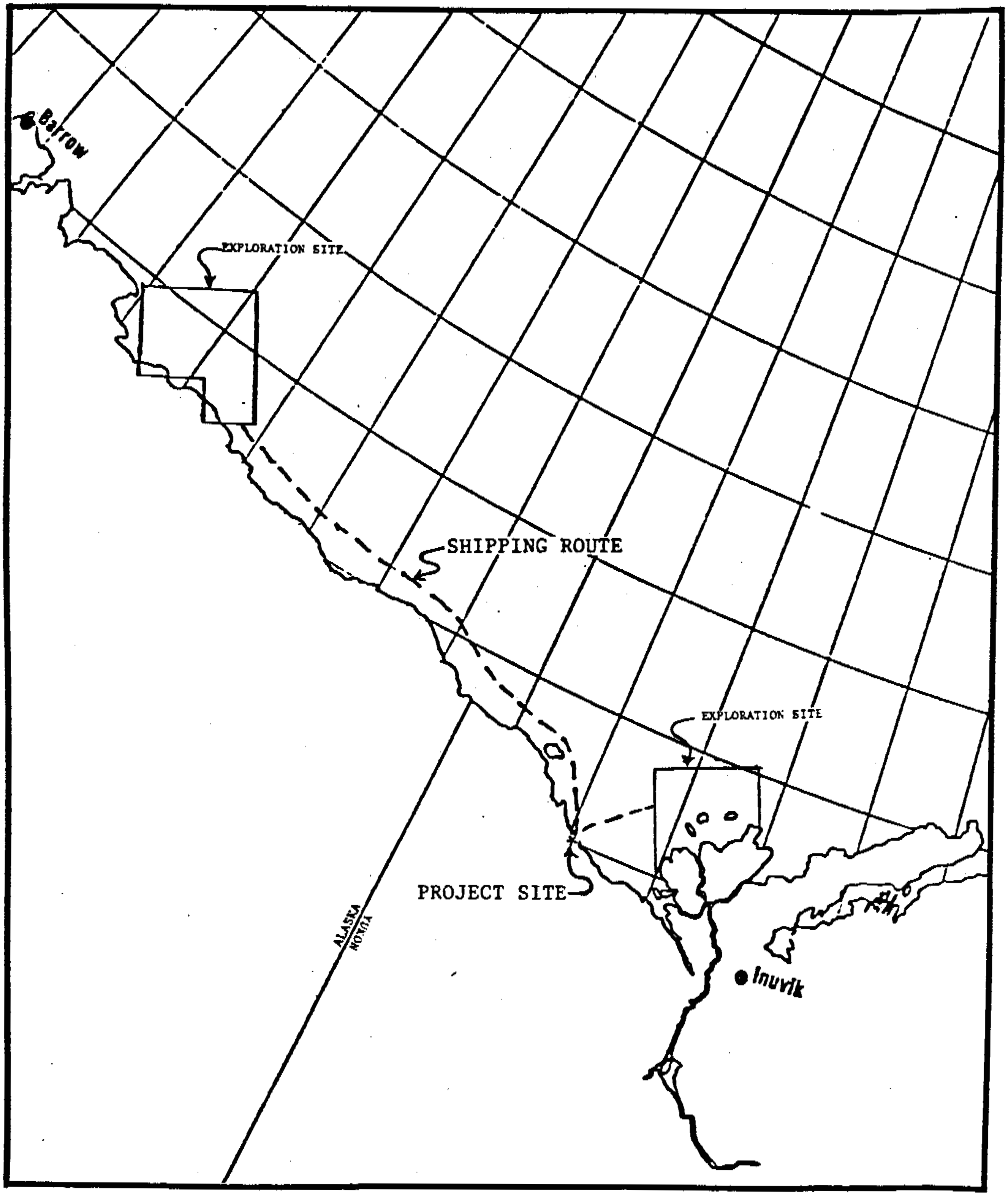


Fig. 5/6-1. Proposed shipping corridors.

favorable in the far North from late February, when the sun appears, until the summer warm season, when water is open in lakes and the ocean, and the incidence of foggy days increases. In the maritime climate of the Beaufort Sea coast summer weather is characterized by coolness, cloudiness, persistent winds, and fog. Along the coast, rapid changes in visibility due to onset of advection fog makes flying uncertain and may cause long and unpredictable delays in meeting flying schedules.

The short-term impact of climate on marine shipping would operate through the same conditions of poor visibility that hamper air traffic. Poor visibility (vision reduced to less than fifty yards) occurs an average of 11-15% of the June to October open water season.

The Beaufort Sea coast is ice-locked for 9 or more months each year. The open water shipping season lasts for only 2 or 3 months in most years, rarely extends for longer periods into the autumn season, and in some years navigation is essentially impossible at any time with any measure of safety. By early July melting has normally freed the shorefast ice and under suitable wind patterns the ice pack will drift away and free the shipping lanes. The ice may be under pressure and be held inshore for longer than normal periods or may drift away and unpredictably return to trap barges and ships.

For delivery of rock to U.S. waters, the critical stretch of coastline is that between Herschel Island and Barter Island. Due to the wind-driven, clockwise circulation of the Arctic Gyre, the ice sweeps southwestward along the Arctic Archipelago and may keep ice jammed on the coast much of the summer. Access to the coast from Point Barrow eastward along Alaska and the Yukon, in any given year may be limited. Mean open water season is around 60 days. Shipping on the Mackenzie River, which would be utilized by the Applicant in large part, normally does not require ice breaker support but it is needed in some years to gain access to the ocean and work along the stock-piling in a single shipping season prior to construction one or more years.

A program will be instituted to monitor the presence of sea ice (icebergs, ice islands, etc.) within the project area. This will entail the use of state-of-the-art electronic equipment and air reconnaissance. Information gained from this monitoring should provide an advanced warning system sufficient to mitigate possible problems.

Terrain And Geology

Right-of-way clearing, grading, site preparation and construction activities have been known to cause problems related to both surface stability (permafrost integrity, thaw settlement, frost heave and thermal erosion) and slope stability (permafrost integrity, slumping and shallow hydraulic erosion).

Thaw settlement and thermal erosion can occur where there are ice-rich soils and where site preparation and construction activities remove above-ground vegetation and at least a portion of the insulative organic layer. Where some of the organic layer remains and mineral soils are not exposed, thaw settlement will likely be shallow and thermal erosion will be very localized. Deeper thaw settlement and thermal erosion could occur where construction exposes ice-rich mineral soils.

Arctic construction techniques will be optimized to reduce the exposure of mineral soils, including: winter scheduling of all major construction (haul road, camp, airstrip, etc.); the use of protective gravel & sand pads for road construction, airstrip, camp and quarry facilities.

Preventative or remedial measures, including the use of fill and drainage control structures, including culverts, diversion berms, berm breaks and dispersion structures, will be employed to minimize drainage alterations and prevent hydraulic erosion on rights-of-way and other disturbed surfaces.

Locations for the haulroad and other facilities were chosen to lessen the impact on the terrain by avoiding, wherever possible, areas with poor drainage, steep slopes or those having unique or sensitive landform features. In particular, the pingo described in Section 4.2 will be avoided. In addition, the haulroad is designed to include: no cuts (all fill), thus keeping the surface integrity intact; a minimum of five feet sand and gravel bed to prevent thawing of the subgrade material; an extended (10 feet on either side of the roadbed) toe of the slope to act as a buffer, and the inclusion of culverts in the roadbed to prevent ponding. (Detailed road design cross section can be found in Section 3 - PROJECT DESCRIPTION). Special attention will also be given to unchannelled surface drainage and erosion control measures along the haulroad and at the Deep Creek crossing. Surface stability of all aspects of the project will be accomplished through daily operational inspections and maintenance.

Subsequent to quarry development, all areas will be cleaned up. The pit will be shaped to blend into the natural contour of the land; the haulroad will remain intact unless instructed to deactivate it; and all buildings will be removed unless instructed otherwise. Natural flows and drainages in all pre- and post-quarry disturbance areas will be returned whenever possible. In general, impacts on surface stability, geology and soils resulting from site preparation, construction, operation and abandonment are considered to be minimal.

Hydrology

Surface disturbance resulting from clearing, grading, construction and other related development activities may interrupt the surface and subsurface drainage, resulting in localized surface ponding, channelization and blockage of subsurface flow. Disruption of the surface may also cause increased surface erosion and sedimentation near water bodies.

Measures proposed to minimize erosion, siltation and drainage problems are provided both in Section 3 - PROJECT DESCRIPTION and in Section 5/6 - ENVIRONMENTAL IMPACTS AND PROPOSED MITIGATION MEASURES - Terrain And Geology. Specific procedures will include winter scheduling of construction to minimize potential for hydraulic erosion, breaching of temporary water crossings such as ice bridges and fill prior to spring freshet, and maintaining, where feasible, buffer strips of undisturbed land between all water bodies and the project's disturbance area.

Project area water quality, drainage patterns and surface and ground water discharge will remain virtually unaltered and impacts are anticipated to be minimal.

Flora

Vegetation types in the project area are widespread and highly repetitive. The disturbance caused by the proposed project into such areas would present no threat to the major plant components. Exceptions which might occur would be small isolated populations within specialized habitats. These habitats are not known to exist in the project area, however, their occurrence would be remotely possible.

Initial construction will disturb vegetation by clearing or burial with rock gravel or sand pads. Indirect disturbances may result from drainage alterations and localized erosion.

Insulation of permafrost by the vegetation will, however, be maintained by gravel & sand pads along the haulroad, camp site, airstrip and other facilities. Alteration of surface drainage patterns along the haulroad may contribute to ponding. Ponding could result in localized mortality of species intolerant of flooding but may improve the growth of certain sedges and other semi-aquatic plants. Ponding along the haulroad should, however, be neglible due to its design features (Section 3 - PROJECT DESCRIPTION) and the addition of culverts as needed.

During abandonment of the project site, all of the equipment and structures will be removed unless requested otherwise. Drainage and erosion control measures will be established to encourage the return of vegetation similar to that found in surrounding areas. These activities could disturb some previously revegetated areas and may result in local losses of existing natural vegetation. Drainage and erosion control measures will be established during abandonment to ensure that newly disturbed areas undergo natural revegetation. Physical erosion control measures may include grading to stable slope angles and the construction of berms, berm breaks and water diversion ditches.

Immediate objectives will be to promote soil stability and encourage the reestablishment of natural plant communities. It is expected that natural revegetation will continue and, except on sites where gravel is not removed, natural vegetation cover will be reestablished.

Impacts to vegetation within the project area are expected to be minor and localized.

Quarry and Haul Road

Birds and mammals may be affected by the construction and operation of roads, quarries and gravel pits. Impacts may result from direct disturbance, habitat reduction or loss through increased public access, or interactions with vehicles or facilities. Disturbance may cause: increased energy expenditures which may affect the bioenergetics of certain species; behaviour that may result in increased mortality of adults and juveniles; and exclusion of some species from important habitats. Habitat reductions could result from industrial land use,change in water levels, and the dusting of local vegetation. There could also be reduced access by animals to some habitats. Some birds and mammals could be killed by industrial activities such as moving vehicles, but most losses would occur through increased access to areas by hunters and trappers. Direct mortality due to industrial activity is expected to have a negligible impact rating for mammal or bird species, while potential cumulative impacts from disturbance, habitat loss and increased human access could range from negligible to moderate, depending on the species and mitigative measures employed.

Disturbance: The species most likely to be affected by disturbances are caribou, raptors and waterfowl.

During some springs, portions of Porcupine caribou herd migrate into and through potential Yukon coast shorebase sites such as Stokes Point and King Point (Fig. 5/6-2). Most years only a few of the animals that migrate via the Richardson route would likely encounter the proposed haul road. The portion of the Porcupine herd that uses the Richardson route can vary markedly from year to year. For example, in 1978, less than 5% of the herd followed this route, compared to more than 50% in 1974 (LGL 1982). Within the proposed King Point shorebase area, spring migration generally begins in late April and continues until late July. Early migrants (April-May) are mainly females, while bulls follow at a more leisurely pace in mid June to July. 5/6.19

Calving generally occurs between the last week of May and mid June. In most years, the eastern extremity of the calving ground would include proposed Mount Sedgewick quarry site, and haul road route and the proposed shorebase sites, although only scattered calving activity generally occurs in the vicinity of the latter area (Fig. 5/6-3,4 & 5). In late June and early July, large post-calving groups begin an eastward movement from Alaska across the northern Yukon to the Richardson Mountains. The Mount Sedgewick quarry site and haul road routes connecting the quarry with proposed shorebase sites are almost directly perpendicular to the primary movement corridor used during these eastward post-

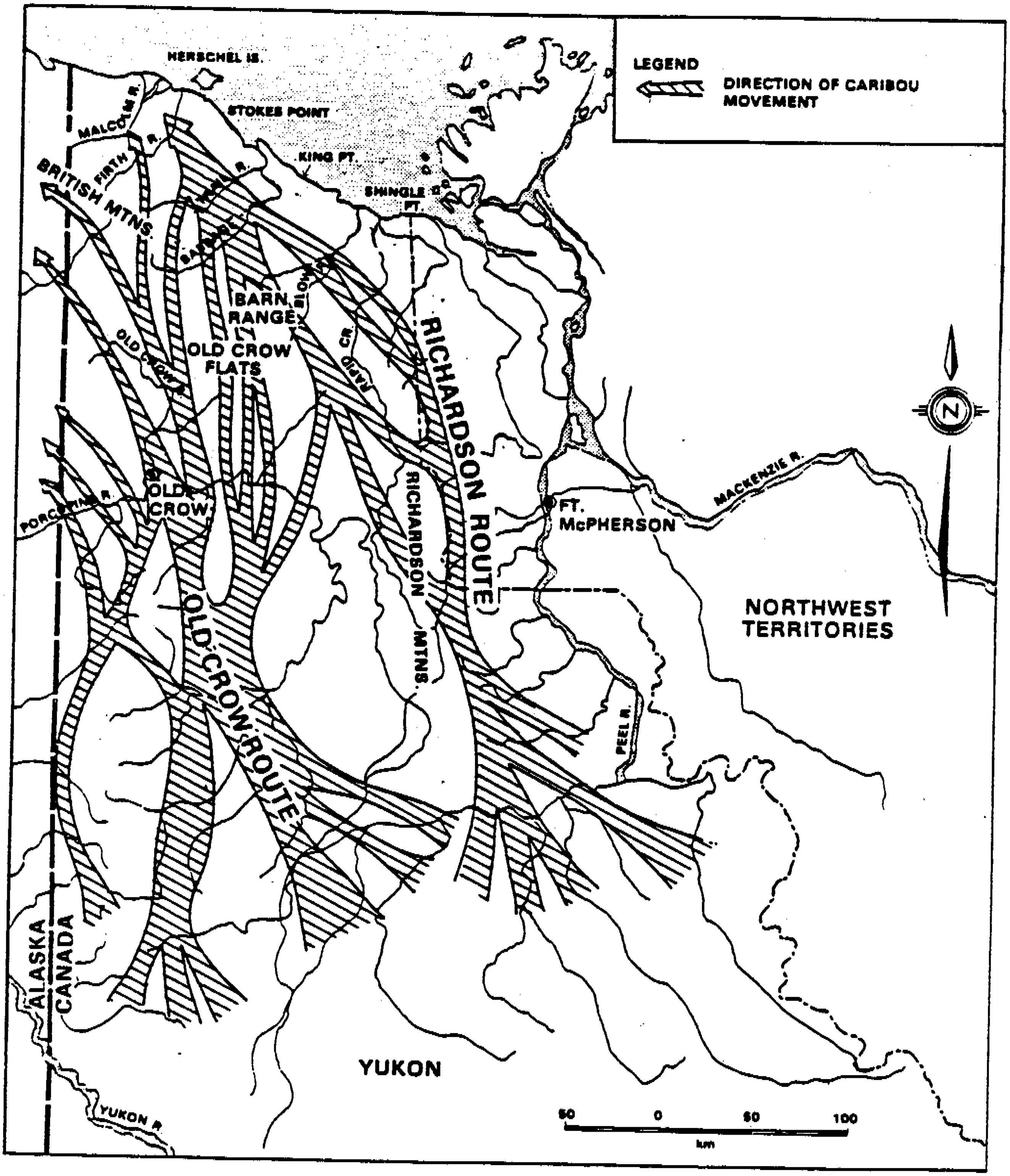


Fig. 5/6 - 2. Porcupine caribou herd - spring migration routes. (Beaufort Sea EIS 1982)

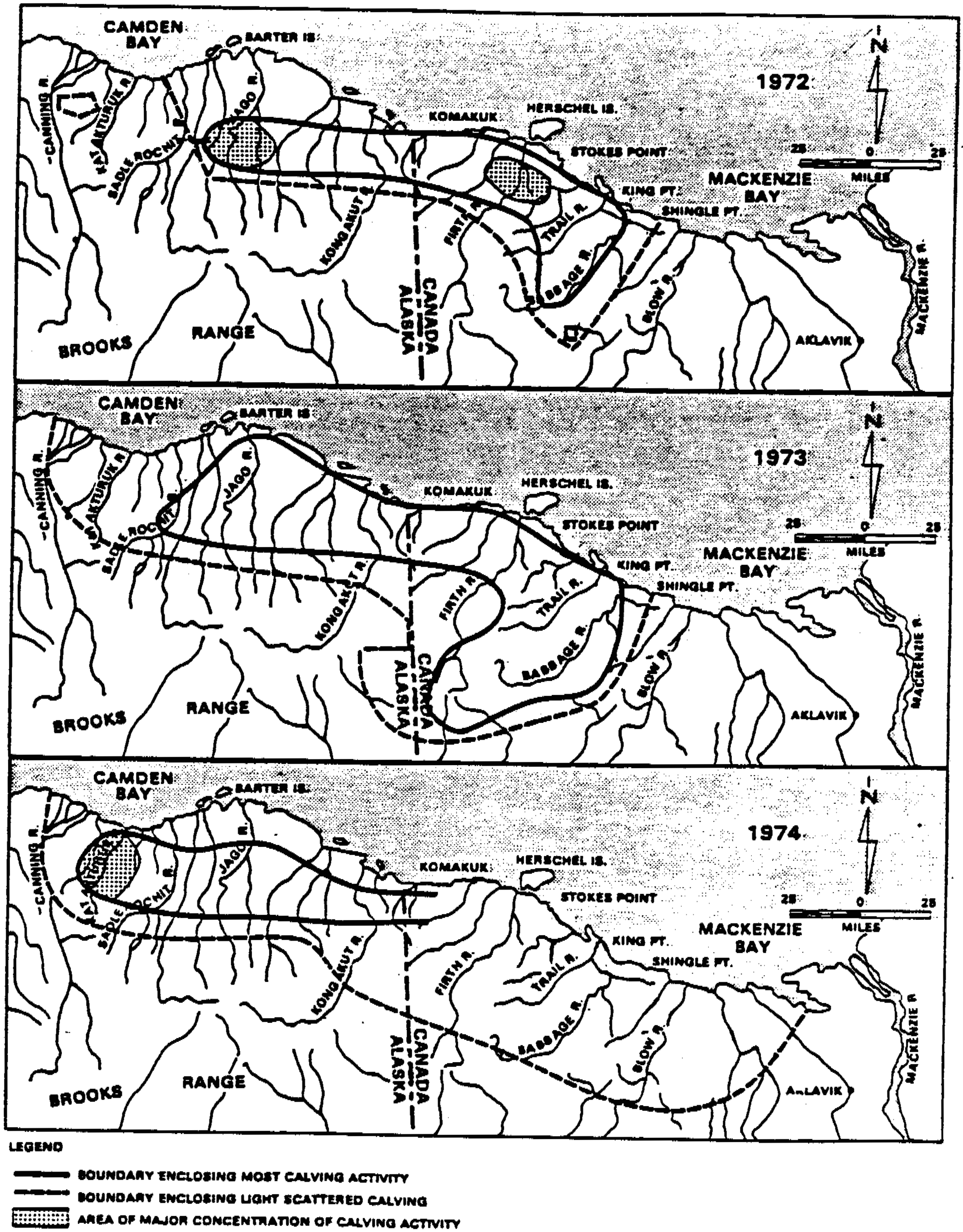


Fig. 5/6 - 3. Porcupine caribou herd calving areas - 1972 to 1974. (Beaufort Sea EIS 1982)

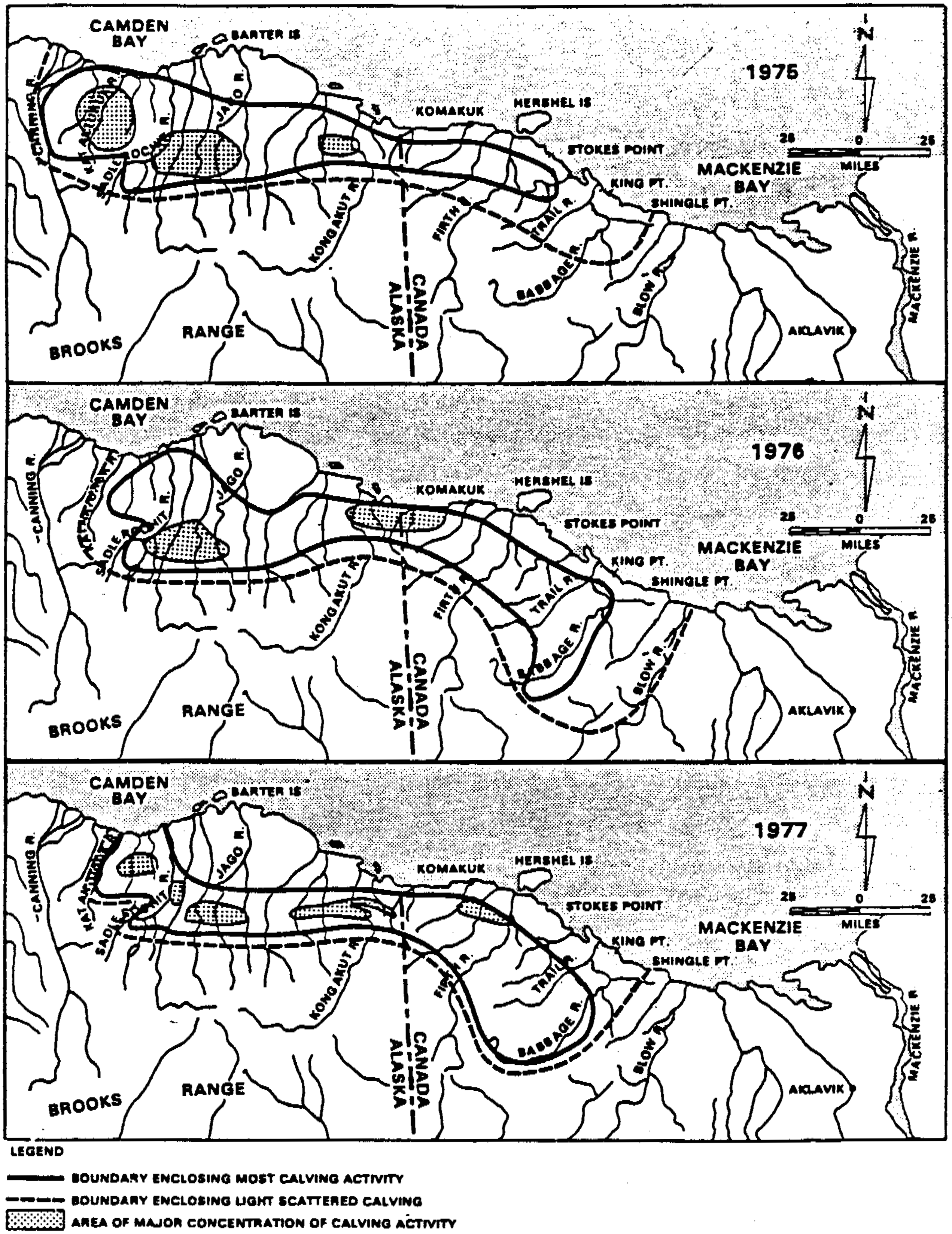


Fig. 5/6 - 4. Porcupine caribou herd calving areas - 1975 to 1977. (Beaufort Sea EIS 1982)

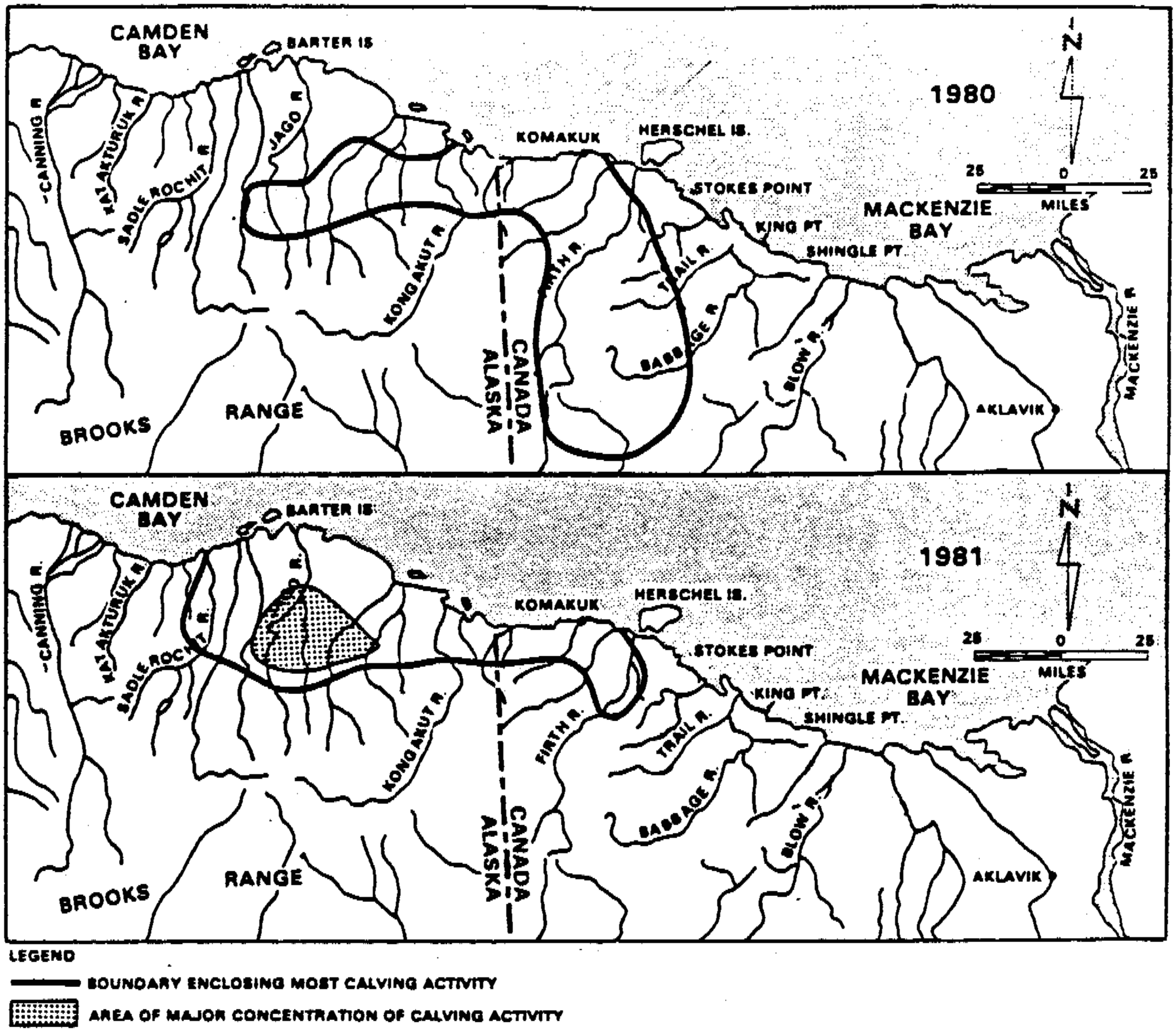


Fig. 5/6 - 5. Porcupine caribou herd calving areas - 1980 and 1981. (Beaufort Sea EIS 1982) calving movements, but few caribou are expected to encounter the shorebase facilities. Later movements of the caribou herd are generally south of the propsed facilities, while scattered groups usually remain in the northern Yukon during August.

The physical presence of a road and quarry are not expected to be a major source of disturbance to the caribou, however, the activities of personnel and vehicles are of potential concern (LGL 1982). To avoid disturbing caribou several mitigations measures have been incorporated into the project design. The haul road berm will be of sufficient height to avoid permafrost damage but low enough to give the caribou the visual clearance to cross (Cameron et al 1976). In addition, haul road traffic has been reduced by doubling the capacity of the rock haulers.

Blasting at the quarry site will be carried out at times and under conditions that will minimize disturbance to the caribou. Disturbance to caribou will be reduced further by use of an education program for all industry personnel and by employing restrictions on vehicle operations. Several additional mitigation measures have been evaluated in terms of cost and benefit (caribou mitigation). When monitoring data indicates a conflict with the haul road and caribou, all traffic would be restricted. Up to three week delays could be experienced twice a year. These delays would cut production by 40 - 60% and make the quarry unprofitable.

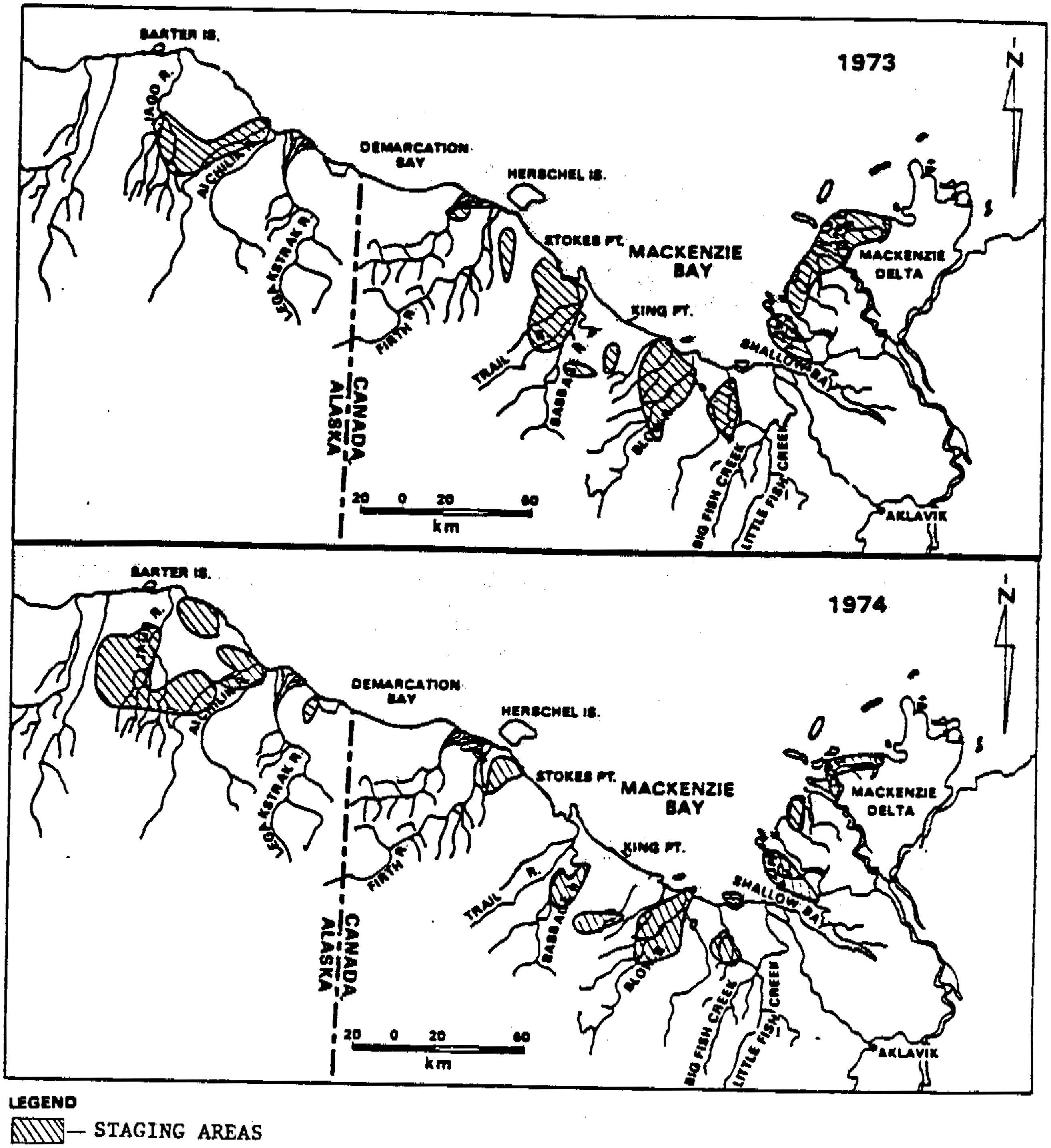
Successful implementation of these mitigative measures should reduce the potential degree of impact of disturbance from industry activity on the roads and at the quarry on caribou to a minor level.

Disturbance of raptors is only likely if activities such as aircraft traffic, heavy construction, or blasting occur near nest sites during the pre-nesting and nesting period, or if personnel approach nest sites. Blasting and human on-foot encroachment are the activities most likely to disturb these species since there is evidence that many raptors can tolerate modest levels of traffic activity when it is distant from nest sites (LGL 1982).

Mitigative measures that will be implemented to reduce disturbance to nesting raptors will include identifying active and historic raptor nest and perch sites. If for engineering reasons, facility placement restrictions cannot be met in some instances, alternative solutions will be sought through consultation with appropriate government regulatory agencies. Overall, the impacts of activities along the route on regional populations of raptors would likely be minor. The disturbance caused by quarrying and the quarry haul road could result in minor to perhaps moderate local impacts on nesting peregrine falcons, gyrfalcons and golden eagles, depending on their abundance and distribution where activity is most intense.

Possible disturbance of autumn staging geese is of concern with respect to a quarry and haul road. Also, nesting and moulting ducks, as well as nesting loons, shorebirds and passerines may be disturbed by air traffic and activities associated with road construction and operation.

From mid August until early October in most years, 200,000 to 500,000 lesser snow geese (the entire western Canadian population) stage on the Yukon and Alaskan north slopes and along the coast of the Northwest Territories (Fig. 5/6-6,7); Campbell and Weber 1973, Koski and Gollop 1974, Koski 1975, 1977b). Although they generally stage in the Mackenzie Delta, Koski (1977b) has observed an estimated 18,000 white-fronted geese in association with snow geese along the North Slope between Shallow Bay and King Point. A few Canada geese also stage along this part of the North Slope (Koski 1977b), while black brant stage and rest at coastal lagoons and river deltas along the Yukon coast during their westward fall migration (Koski 1977a).



LEGEND

— STAGING AREAS

Fig. 5/6 - 6. Snow goose staging areas - 1973 and 1974. (Beaufort Sea EIS 1982)

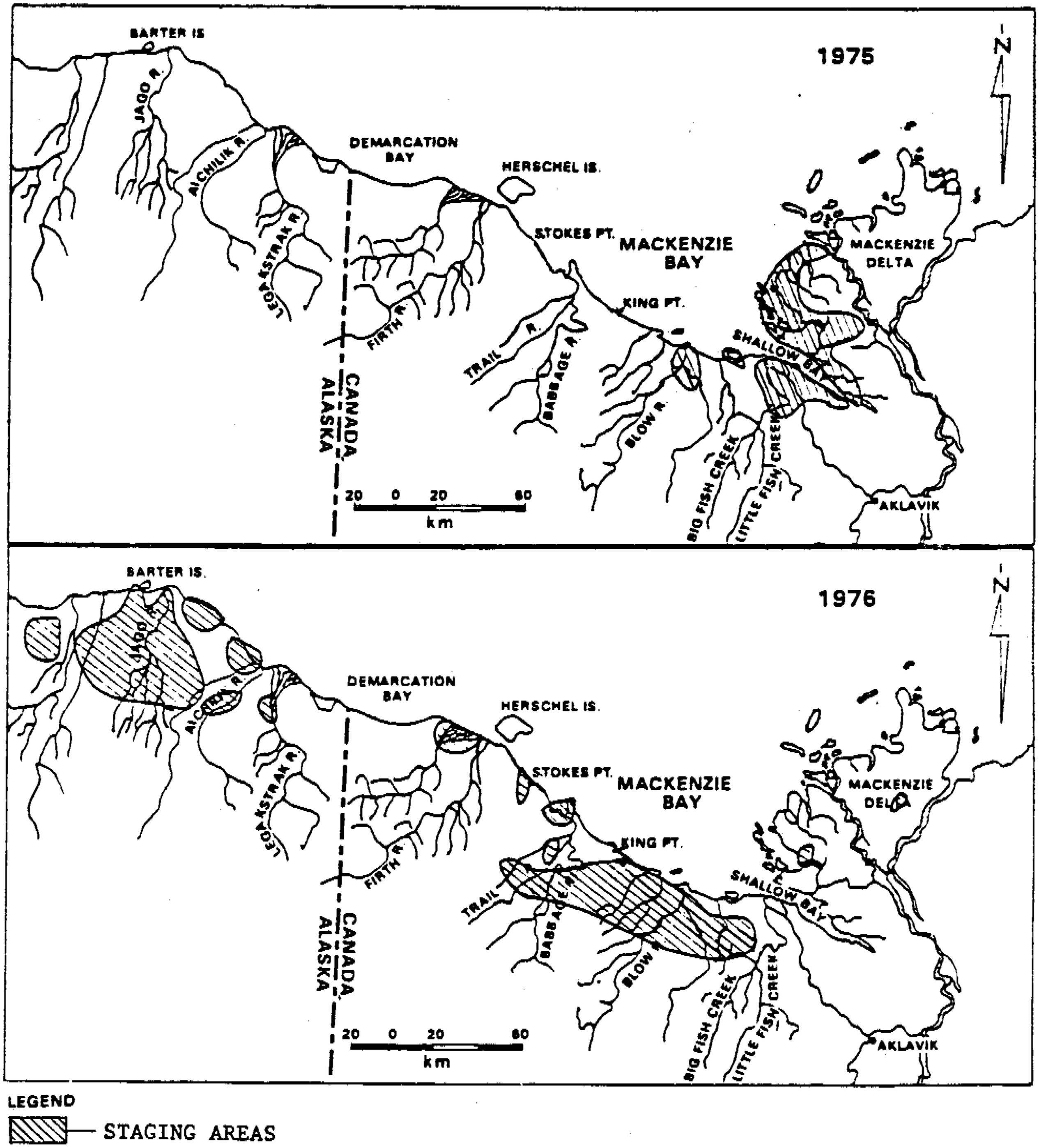


Fig. 5/6 - 7. Snow goose staging areas - 1975 and 1976. (Beaufort Sea EIS 1982)

Most studies of disturbance on autumn staging geese have dealt with disturbance by aircraft. These show that white-fronted geese and particularly snow geese are very sensitive to this form of disturbance (LGL 1982). There are no comparable data on the effects of construction and operation of roads, borrow sites and camps on autumn staging geese. The results of experiments using gas compressor noise simulators suggest that snow geese may be sensitive to these ground-based sources of disturbance and would stay away from these activities (ESL 1982).

Birds, particularly loons and waterfowl, that attempt to nest or moult along the road and adjacent to shorebase facilities may be displaced or experience decreased productivity as a result of disturbance.

5/6.3 HABITAT REDUCTION

Habitat Reduction: Reduction or loss of habitat for birds, mammals and fish may occur directly by destruction or modification of habitats, or indirectly by exclusion as a result of disturbance. Direct habitat loss could occur when roads and facilities are constructed, and from alterations in surrounding habitats if drainage patterns are changed, or if dusting of habitats occurs.

Terrestrial Resources

Roads could produce the most extensive direct and indirect losses of habitat, while comparatively little habitat loss would result from the King Point development and rock quarry. Mitigative measures for roads would include the design and routing of roads to minimize changes in water levels and drainage patterns.

There would be an insignificant direct loss of caribou habitat due to project activities, but indirect loss by the possible construction of migration routes either by disturbance or physical or psychological barriers presented by the road is of potential concern. The quarry haul road would be perpendicular to migration routes. However, recent data on the effects of the Dempster Highway on the Porcupine caribou herd, derived from a joint three year project between the Yukon Government and the Canadian Wildlife Service, indicated that caribou had little difficulty crossing the highway, even at steep gravel banks (Russell 1982). In fact, two of the major crossing sites documented during their study had the highest, steepest berms. Russell (1982) concluded that for the years of their study, the road environment did not appear to impede caribou movements, although he cautioned that they had not had the opportunity to measure crossing characteristics under deep snow conditions. On this basis, it is assumed that caribou would have little difficulty crossing these future proposed roads and possible exclusions from preferred habitat due to barrier effects should have no more than a minor impact on the herd.

Direct habitat loss could also result from road construction if fox, wolf, wolverine and grizzly bear dens were destroyed. Den sites are often traditional, and suitable denning sites are few in some areas. Assuming successful implementation of mitigative measures, the potential impacts of habitat loss on these and other mammal species are expected to be negligible.

Where possible, the proposed roads will avoid low-lying wet areas which are preferred habitat of loons, most ducks and shorebirds, and will avoid rock outcrops and cliffs favoured by nesting raptors. The quarrying activity is the only operation likely to represent a direct threat to some raptor habitat. Mitigative measures designed to minimize direct habitat loss to ground-nesting birds (such as the prevention of dusting and changes to drainage patterns) and cliff-nesting and tree-nesting raptors have been discussed previously. Successful implementation of these measures will reduce potential impacts of direct habitat loss on birds to negligible or minor levels. Indirect habitat loss could occur in the vicinity of project activities as a result of disturbance. This may have a greater effect on nesting and moulting birds than direct habitat loss.

Aquatic Resources

The main concern to acquatic resources related to site preparation and construction is the possibility of erosion and sedimentation of lakes and streams. During the open water season, some sedimentation can be anticipated in all water bodies adjacent to disturbed sites which have not been adequately stabilized.

The effects of suspended sediment on aquatic organisms have been studied extensively and are summarized by Cordone and Kelly (1961), Cairns (1971), Phillips (1971), Hynes (1973), and Brown (1975). Other studies have dealt specifically with the Beaufort Sea onshore region, including Brunskill et al (1973), McCart and deGraaf (1974), Porter et al (1974), Rosenberg and Snow (1975) and McCart et al (1979). The major effects of suspended sediments reported in these studies include: reduced primary production resulting from lower light penetration; reduced overall density of invertebrates; replacement of sensitive invertebrates species by more tolerant ones; reduced invertebrate species diversity; mortality of juvenile fish from clogging of gill membranes; reduced spawning success caused by declines in intergravel flow, smothering of eggs, or coating of gravel substrates; reduced emergence of fry as a result of blocked intergravel spaces; reduced escape habitat for fry in spaces between stones; and in extreme cases, interference with normal migratory activity of adult fish. With respect to the last point, such interference is considered extremely unlikely. Ambient suspended sediment loads in the Mackenzie mainstream commonly exceed 2,000 mg/L wihout adversely affecting migration.

Of greatest concern are sediment introductions which can affect the spawning, incubation, and emergence of fish, particularly the domestic, commercial, and sports species. Though spring spawners (e.g. grayling, pike, walleye) are important to the fishery of the region, these species are less sensitive to the effects of sediment than the fall spawning species (e.g. whitefish, ciscoes, char, lake trout). Spring spawners commonly spawn during spring discharge when ambient sediment loads are high; however, eggs of these species mature and emerge without the hazards of dewatering, low oxygen levels, or freezing. Eggs of fall spawners, on the other hand, are deposited at low water prior to freeze-up when ambient sediment loads are low, but the eggs remain in the gravel through winter, and dewatering, low dissolved oxygen, and freezing take a heavy toll on egg survival. For fall spawners, sedimentation can furthur reduce egg survival, and may significantly affect local populations.

Adult fish have been shown to tolerate suspended sediment concentrations in excess of 20,000 mg/L. A sediment concentration consistently lethal to adult fish has not yet been determined (Phillips 1971). Rearing juveniles, however, particularly when they are newly emerged, may be more sensitive to suspended sediment levels than adult fish. A smaller gill size and a limited ability to avoid areas of high suspended sediment concentrations play an important role in this sensitivity.

The lower trophic levels are extremely sensitive to increases in suspended sediment concentrations. However, they display high recovery rates once concentrations decline and freshet conditions scour the substrate clean. Because of restocking from unaffected areas and high reproductive potential, these trophic levels recovery rapidly from localized population reductions caused by sedimentation.

Most northern fish are slow growing, late maturing, and long lived. Since numbers will quickly be restored to original levels through recruitment from subsequent year classes, a reduction in a single year class will have little overall effect on population levels. Unless wide-scale sedimentation of a major spawning area continues through a full generation, recovery from the effects of sedimentation will be rapid, requiring less than a single generation to restore the original population structure.

Areas used as spawning, rearing, and overwintering habitat are considered the most sensitive to suspended sediments. Sediments with high organic concentrations during winter would probably result in oxygen depletions sufficient to reduce the survival rates of overwintering eggs and fish. As a consequence, waterbodies supporting both spring and fall spawning species and providing overwintering habitat for fish may remain sensitive to sediment introductions during all but summer months.

The effects of sediment in this region will be greatest in clear streams, lakes, and springs providing spawning, rearing, or overwintering habitat. Streams and lakes along the Yukon coast support large numbers of fish during the winter months (Craig and McCart 1974). The waterbodies provide spawning habitat for both spring and fall spawners. With the exception of a brief period at breakup, most streams and deep lakes in these areas are relatively clear year round.

Except where slope stabilization difficulties are encountered, the duration of effects resulting from site preparation and construction will usually be limited to a single open water season. Some localized sedimentation, with a potential for lasting several years, may occur near bank failures or where mechanical slope stabilization techniques are not wholly effective. These effects should, however, be promptly corrected once the problem areas are identified. Routine surveillance and inspection of project facilities will locate erosion problems and identify areas requiring further maintenance work.

A number of mitigative measures will ensure that sediment introductions during preparation, construction and operation are kept to a minimum. Facilities located adjacent to waterbodies (Deep Creek Bridge) will generally be prepared and stabilized during the winter months. Areas of sensitive terrain will be avoided during the final site selection. Except at stream crossings, direct deposition of soil material either in streams or on the ice will be avoided. Effective measures will be developed to stabilize actively eroding terrain, and to identify and repair these areas promptly, if required. The size of areas disturbed during site preparation and construction will be kept to a minimum.

Assuming the generally localized and brief nature of most sediment introductions, the rapid recovery of lower trophic levels and their widespread cosmopolitan distribution, and the use of the proposed mitigative measures, the effects of sedimentation resulting from site preparation on regional fish populations would be minor.

Increased Access

The Yukon North Slope is presently relatively inaccessible to people, especially during the spring and summer, the times of particular importance to mammal and bird populations. Harvesting and disturbance from increased access could result in a marked increase in potential impacts on some terrestrial mammals (particularly caribou), waterfowl, raptors and freshwater and anadromous fish. It is recognized that governments have the ultimate responsibility for the management of natural resources. The increased access to this region may require new regulations and an effective enforcement program to minimize adverse impacts of increased harvesting pressure.

5/6.4 REFERENCES

Barry, T.W., S.J. Barry and B. Jacobsen, 1981. Sea-bird surveys in the Beaufort Sea, Amundsen Gulf, Prince of Wales Strait and Melville Sound - 1980 Season. CWS Edmonton, Alberta. 59 pp.

Brown, R.P., 1975. Effects of turbidity and suspended materials in aquatic environments, a critical review of the literature 1936-1974. Prepared for Office of Dredged Material Research, U.S. Army Engineers Waterways Experimental Station. Vicksburg, Miss. Working draft.

Brunskill, G.J., D.M. Rosenberg, N.B. Snow, G.L. Vascotto, and R.W. Wageman, 1973. Ecological studies of aquatic systems in the Mackenzie-Porcupine drainages in relation to proposed pipeline and highway developments. Environmental Social Committee, Northern Pipelines, Task Force on Northern Oil Development, Winnipeg. Report No. 73-40. 131 p.

Cairns, J., Jr. 1971. Suspended solid standards for the protection of aquatic organisms. Purdue University Engineering Bulletin No. 129(1); 16-27.

Cameron, R.D. and K.R. Whitten, 1976. First interim report on the effects of the Trans-Alaska Pipeline on caribou movements. Joint State/Federal Fish and Wildl. Advisory Team Spec. Rep. No. 2. 53 p.

Campbell, R.W. and W.C. Weber, 1973. Abundance and species composition of birds in selected areas along the pipeline route - 1972. In: Towards an environmental impact assessment of the portion of the Mackenzie gas pipeline from Alaska to Alberta, Appendix 4. Environment Protection Board, Winnipeg, Manitoba. 42 p.

Cordone, A.J. and D.W. Kelley, 1961. The influences of inorganic sediment on the aquatic life os treams. California Fish and Game Bulletin 47; 89-228.

Craig, P. and P.J. McCart, 1974. Fall spawning and overwintering areas of fish populations along routes of proposed pipeline between Prudhoe Bay and the Mackenzie Delta. 1972-1973. Chapter 3, 36 p. In: P.J. McCart (ed.), fisheries research associated with proposed gas pipeline routes in Alaska, Yukon and Northwest Territories Arctic Gas Biol. Rep. Ser. Vol. 15.

ESL Environmental Services Ltd. 1982. The biological effects of hydrocarbon and exploration and production related activities on marine flora and fauna. Prep. for Dome Petroleum Ltd., Calgary.

Gollop, M.A., J.E. Black, B.E. Felske and R.A. Davis, 1974a. Disturbance studies of breeding black brant, common eiders, glaucous gulls and Arctic terns at Nunaluk Spit and Phillips Bay, Yukon Territory, July 1972. Arctic Gas Biol. Rep. Ser. 14(4); 153-201.

Hynes, H.B.N., 1973. The effects of sediment on the biota in running water, p. 652-663. In: Proceedings, Ninth Canadian Hydrology Symposium, Fluvial Processes and Sedimentation. University of Alberta, Edmonton. Inland Waters Directorate, Department of Environment, Ottawa.

Koski, W.R., 1975. A study of the distribution and movements of snow geese, other geese and whistling swans on the Mackenzie Delta, Yukon North Slope, and Alaskan North Slope in August and September, 1974, including a comparison with similar data for 1973. Arctic Gas. Biol. Rep. Ser. 30(1); 98 p.

Koski, W.R., 1977a. A study of the distribution of snow geese, other geese, and whistling swans on the Mackenzie Delta, Yukon North Slope, and Alaskan North Slope in August and September 1975. Arctic Gas Biol. Rep. Ser. 35; 1-54.

Koski, W.R. 1977b. A study of the distribution and movements of snow geese, other geese and whistling swans on the Mackenzie Delta, Yukon North Slope, and eastern Alaskan North Slope in August and September 1976. Unpubl. Rep. by LGL Ltd. for Canadian Arctic Gas Study Ltd., Calgary, Alberta. 69 p.

Koski, W.R. and M.A. Gollop, 1974. Migration and distribution of staging snow geese on the Mackenzie Delta, Yukon and eastern Alaskan North Slope, August and September 1973. Arctic Gas Biol. Rep. Ser. 27, Ch. 1, 38 pp.

LGL Ltd., Environmental Research Associates, 1982. King Point development impact statement. Report prepared for Dome Petroleum Ltd., Calgary, Alberta. 82 pp.

McCart, P. and D. deGraaf, 1974. Effects of disturbance on the benthic fauna of small streams in the vicinity of Norman Wells, N.W.T., Chapt. 4, 29 p. In: P.J. McCart (ed.), Fisheries Research Associated with Proposed Gas Pipeline Routes in Alaska, Yukon, and Northwest Territories. Arctic Gas Biol. Rep. Ser. Vol. 15.

McCart, P., P.M. Gross, R. Green, D. Mayhood, P.T.P. Tsui, and R.H. Green, 1979. Effects of siltation on the ecology of Ya-Ya Lake, Northwest Territories. Environmental Studies No. 13. A report prepared for Northern Affairs Program, Department of Indian Affairs and Northern Development by Aquatic Environments Limited, Calgary. 286 p.

Miller, F.L. and A. Gunn, 1979. Responses of Peary caribou and muskoxen to turbo-helicopter harassment. Prince of Wales Island, Northwest Territories, 1976-77. Can. Wildl. Serv., Occas. Paper No. 49. 90 pp.

Phillips, R.W., 1971. Effects of sediment on the gravel environment and fish production. In: Proceedings, Symposium on Forest Land Uses and Stream Environment, Oregon State University, Corvallis, 19-21 October, 1970. p. 64-74.

Porter, T.R., D.M. Rosenberg, and D.K. McGowan, 1974. Winter studies of the effects of a highway crossing on the fish and benthos of the Martin River, Northwest Territories. Resource Management Branch, Fisheries and Marine Service, Department of the Environment, Winnipeg. Technical Report Series No. CEN/T-74-3. 50 p.

Rosenberg, D.M., and N.B. Snow, 1975. Ecological studies of aquatic organisms in the Mackenzie and Porcupine river drainages in relation to sedimentation. Fisheries and Marine Service, Department of the Environment, Winnipeg. Technical Report No. 547. 86 p.

Roseneau, D.G., C.E. Tull and R.W. Nelson, 1981. Protection strategies for peregrine falcons and other raptors along the planned northwest Alaskan gas pipeline route. Unpubl. Rep. by LGL Ecol. Res. Assoc., Inc., Fairbanks, for Northwest Alaskan Pipeline Co., and Fluor Northwest Inc., Fairbanks, 2 volumes. 332 pp.

Russel, D., 1982. Threats to northern habitats - the Dempster Highway and the Porcupine caribou herd. Paper presented at the 46th Federal-Provincial Wildlife Conference, June 1-4, 1982. Whitehorse, Yukon.

7.0 RESIDUAL IMPACTS

TABLE 7.0-1. RESIDUAL IMPACTS TO THE ENVIRONMENT - KIEWIT QUARRY AND KING POINT DEVELOPMENT

(MO. = MODERATE IMPACT, MI. = Minor Impact, NE. = Negligible Impact)

POTENTIAL IMPACTS	MARINE MAMMALS					TERRESTRIAL WILDLIFE								FISH			INVERTEBRATE	
	White Whale	Bowhead Whale	Ringed Seal	Bearded Seal	Polar Bear	Arctic Fox	Wolf	Grizzly Bear	Caribou	Loons	Snow Geese	Raptors	Shore-Birds	Anadrom-ous	Fresh Water	Plankton	Epibenthic Invert.	Infauna Invert.
KING POINT PORT																		
Human Presence					MO	MI	NE	MO	MI	NE	MI	MI	MI					
Solid Waste					MO	MI	NE	MO										
Treated Sewage			NE	NE										NE	NE	NE	NE	NE
Waste Water Disch.			NE	NE										NE	NE	NE	NE	NE
Air Emissions					NE	NE	NE	NE	NE	NE	NE	NE	NE					
Noise																		
- Airborne	NE	NE	NE	NE	MI	MI	MI	MI	MI	NE	NE	NE	NE					
- Water																		
Artificial Illum.	NE	MI	NE	NE	MI	MI	MI	MI	NE	NE	NE	NE	NE					
Dredging	NE	NE	NE	NE														
KIEWIT QUARRY & CAMP																		
Human Presence & Access						MI	MI	MO	MI		MI	MO		MI	MI			
Solid Waste						MI	MI	MO										
Sewage																		
Air Emissions						NE	NE	NE	NE	NE	NE	NE						
Noise																		
- Airborne						MI	MI	MO	MI	MI	MI	MI						
Phy. Presence/ Artificial Illum.						MI	MI	MO	MI	NE	NE	MI						
KIEWIT QUARRY HAUL ROAD																		
Habitat Loss						MI	NE	NE	NE	MI	MI	MI		MI	MI		MI	MI
Disturbance						NE	NE	MI	MI	MI	MI	MO						
Access						NE	NE	NE	MI		NE	NE		NE	NE			

8.0 ANNEXES

8.1 INFORMATION GAPS

The following are guideline requests which were not completed due to gaps in the available data.

Section 2.3: Alternatives

- Kiewit did not have access to specific data for Gulf's King Point Alternative.

Section 3.2: Pre-Construction Details

- Geotechnical and permafrost studies will be conducted for the camp and port area during the winter of 1983-84.

Section 4.1: Climate

- No site specific data.

Section 4.2: Terrain & Geology

- A derivative map is not included with this IEE. However, the site characteristic (soil, permafrost, drainage patterns, etc.) have been considered during the Project design.

Section 4.3: Hydrology

- Missing information in 4.3(a) & 4.3(b) due to a lack of site specific data.

Section 4.5: Aquatic Flora and Fauna

- No site specific data were mapped for areas of fish spawning nursery or over wintering in the Quarry or Deep Creek drainages (4.5(c)). The literature indicates some spring spawning and rearing our details were insufficient to map.

Section 4.9: Chemical Oceanography, Limnology, Fluviology and Water Quality

- No useable data could be located for total dissolved phosphate, detergents, and ph in the ocean water column. Nor could site specific data for chlorinated organics and petroleum hydrocarbons for the ocean bottom sediments be located.