__SUMMARY DOCUMENT__
(December, 1982)

__ADDENDA__
TO THE INITIAL ENVIRONMENTAL EVALUATION
(June, 1981 to December, 1982)

LIST OF DOCUMENTS

A SUMMARY OF THE BOREALIS
INITIAL ENVIRONMENTAL EVALUATION
AND ITS ADDENDA

ADDENDUM ONE
REPORT OF ENVIRONMENTAL FIELDWORK
for 1981--1982

ADDENDUM TWO
SHIPPING AND DEVELOPMENT OF WEST

ADDENDUM THREE
ENVIRONMENTAL IMPLICATIONS OF THE PRELIMINARY
FEASIBILITY STUDY BY SCOTT-ORTECH MINING LIMITED

ADDENDUM FOUR
MICROBAC LABORATORIES, INC.
BATCH LEACHING TEST STUDY

ADDENDUM FIVE
FLORA and VEGETATION
of the
ROCHE BAY AREA, MELVILLE PENINSULA,
NORTHWEST TERRITORIES,
CANADA

ADDENDUM SIX
COMMUNITY DISCUSSION
ON DAMMING THE AYAQUATALIK RIVER

A SUMMARY OF THE BOREALIS INITIAL ENVIRONMENTAL EVALUATION AND ITS ADDENDA

December, 1982

A SUMMARY OF THE BOREALIS INITIAL ENVIRONMENTAL EVALUATION AND ITS ADDENDA

Prepared by Borealis Exploration Limited and its consultants.

This document is to be read in conjunction with the Borealis Exploration Initial Environmental Evaluation (I.E.E.), the Addenda to the I.E.E. (Addenda), and the Preliminary Feasibility Study of the Borealis Roche Bay Magnetite Project prepared by Scott-Ortech Mining Limited (Scott-Ortech Study).

1. INTRODUCTION

1.1 PURPOSE OF THIS SUMMARY DOCUMENT

This document is intended as a summary of the environmental impacts of the Borealis Roche Bay Magnetite Project. Since the study of nature and the study of man are methodologically distinct, it was decided that the impacts of the project would be handled in two separate studies:

1. The I.E.E.: a report restricted to non-socio-economic environmental impacts of the project.
2. The Socio-Economic Study: a report restricted to the socio-economic impacts of the project.

This document is a summary of the environmental issues discussed in the I.E.E. and its Addenda.

The summary must be read in conjunction with:

1. The Initial Environmental Evaluation for the Borealis Project (I.E.E.), April, 1981.
2. The Preliminary Feasibility Study of the Borealis Roche Bay Magnetite Project prepared by Scott-Ortech (Scott-Ortech Study), May, 1982. It should be noted that the Scott-Ortech report is preliminary in nature, subject to final engineering, although, at this time,

we believe it to be quite accurate with respect to environmental considerations.

3. The Addenda to the Initial Environmental Evaluation (Addenda). The Addenda address the questions raised by the RERC subsequent to the June 1981 hearing as well as several other matters of environmental signficance which had come to the attention of Borealis Exploration Limited. The addenda are as follows:

Addendum I: An update on the field work performed by the EERCS in the summer field programs of 1981 and 1982. (Enclosed herewith)

Addendum II: A statement on the Company's position on shipping and on the development of the Company's iron deposits in western Melville Peninsula. (Submitted June, 1982)

Addendum III: A description of the plot plan as developed by Scott-Ortech Mining Limited and the environmental alternatives considered in the evolution of that plan. (Submitted June, 1982)

Addendum IV: A report on leach tests performed on the tailings from Deposit B. (Submitted July, 1982)

Addendum V: A study prepared by Mr. Dennis Jaques, Ecosat Geobotanical Surveys Inc., Vancouver, entitled "Flora and Vegetation of the Roche Bay Area, Melville Peninsula, Northwest Territories, Canada: Accompanied by a LANDSAT computer map of the vegetation cover." (Submitted July, 1982)

Addendum VI: A discussion of community opposition to the proposal to dam the Ajaqutalik River for the purpose of generating hydroelectricity. (Submitted June, 1982)

1.2 THE GEOGRAPHIC AREAS OF IMPACT

The development area (see Figs. 1.2-1 and 1.2-2) is an area of approximately 66 km^2 located on Melville Peninsula 65 km southwest of Hall Beach. The development area includes the areas of the Adler, B, and C deposits and the peninsula extending into the western reaches of Roche Bay (the Roche Bay Peninsula). The mills, tailings disposal areas, and waste rock disposal areas will be located near the deposits on the Precambrian shield. The town site, storage facilities, docking facilities, airstrips, etc. will be located on the peninsula (see Fig 1.2-3).

Except for the environmental effects of shipping and the possibility of air and water contamination, which should be adequately covered by existing regulatory mechanisms, the environmental impacts of this project should be limited to the development area.

The environmental impacts of shipping will extend to the shipping route (see Fig. 1.2-2).

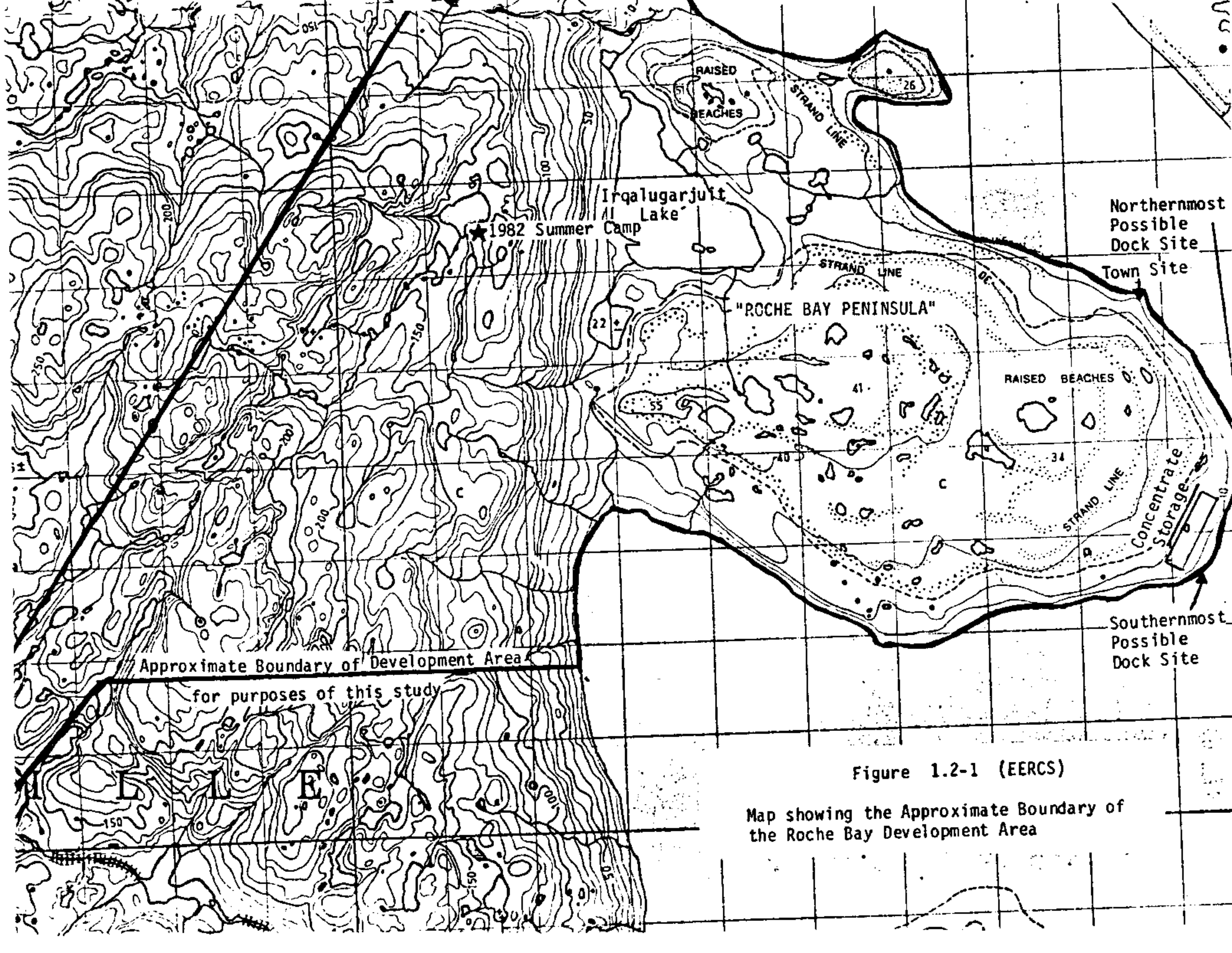
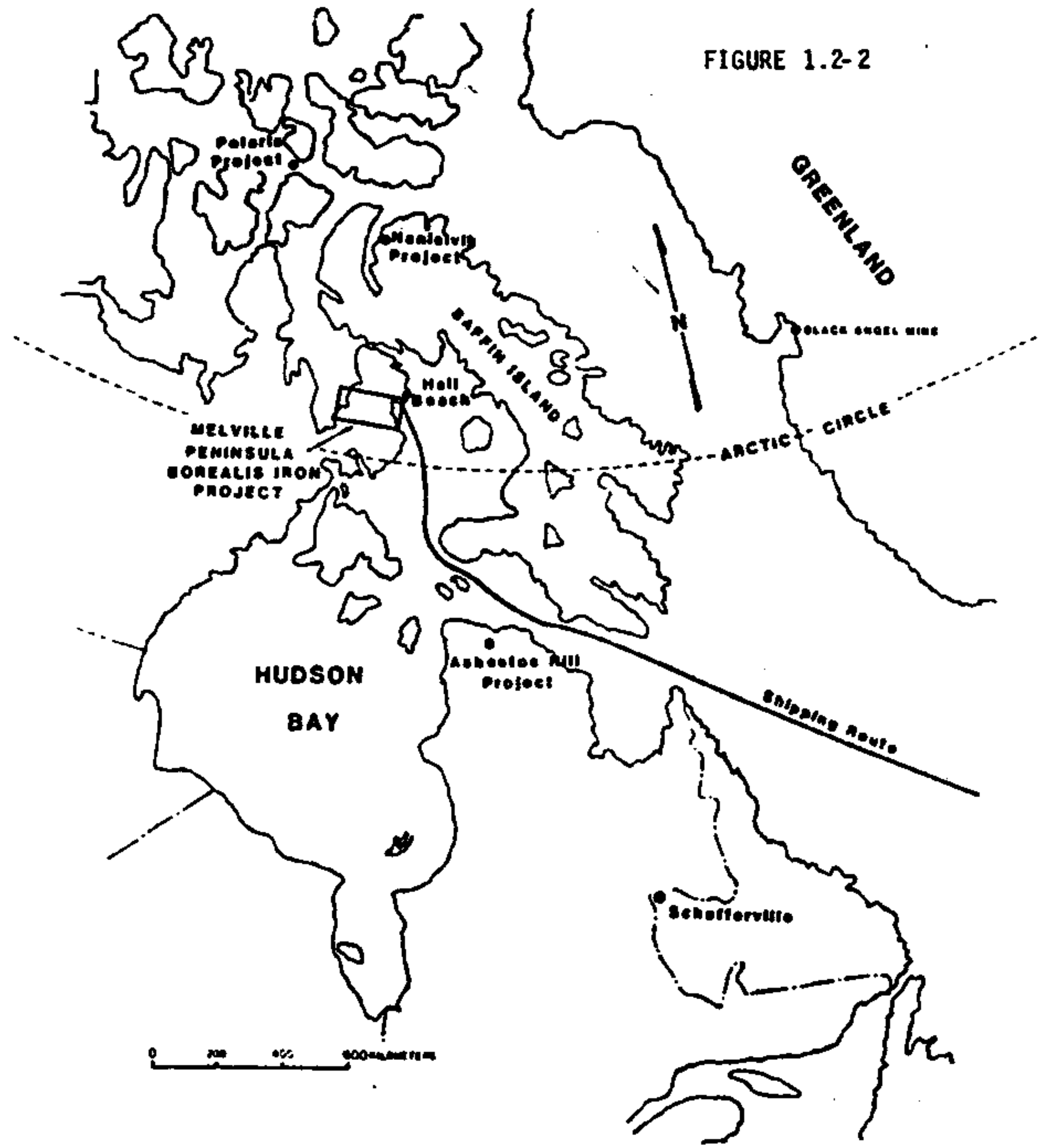


Figure 1.2-1 (EERCS)

Map showing the Approximate Boundary of the Roche Bay Development Area

FIGURE 1.2-2


GREENLAND
N
Polaris Project
Nanisivik Project
BAFFIN ISLAND
Hall Beach
ARCTIC CIRCLE
MELVILLE PENINSULA
BOREALIS IRON PROJECT
HUDSON BAY
Asbestos Hill Project
Shipping Route
Schefferville
0
200
400
600 KILOMETERS

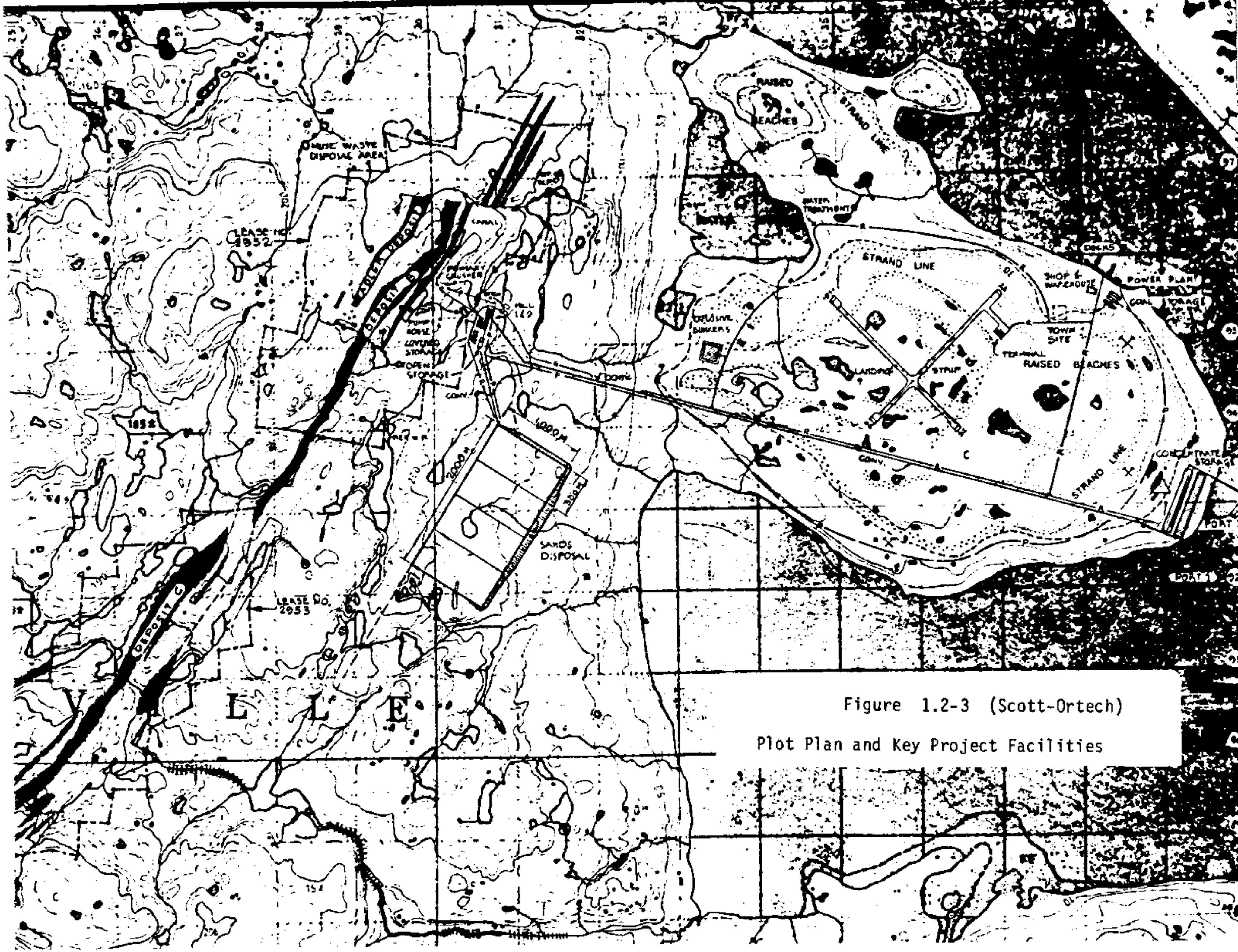


Figure 1.2-3 (Scott-Ortech)

Plot Plan and Key Project Facilities

1.3 SUMMARY OF CONCLUSIONS

The only major unanswered question with respect to the potential environmental impact of the Borealis project concerns possible disturbance to sea mammals along the shipping route due to ship noise. Fortunately, there is considerable research now in progress, stimulated by the Beaufort Sea exploration and the Arctic Pilot Project plan to ship year round, which will be helpful in determining the impact of ship noise on sea mammals. It should be noted, however, that Borealis will ship in conventional non-ice-class vessels, and all iron ore will be shipped during the open season. The limitation to open water shipping will work to minimize the total impact on sea mammals. However, further research is required before we can predict with confidence the impact of shipping on sea mammals and suggest ways by which any possible negative impact might be mitigated.

Largely because of the dry magnetic processing, the limited geographic area of impact, and the sparse vegetation and barren terrain in the development area, the non-shipping environmental impacts will be quite limited and are adequately covered by existing regulatory mechanisms.

2. TERRAIN AND VEGETATION

The development area is in a region of polar semi-desert. Moreover it is relatively barren compared to the areas to the south, north, and west of it.

There are three quite distinct subdivisions within the development area:

1. The Precambrian plateau;
2. the Roche Bay Peninsula;
3. the escarpment between the plateau and the peninsula.

The Precambrian plateau terrain consists mainly of Precambrian rock, with some areas of dwarf shrub and dwarf shrub-lichen associations, as well as some dwarf shrub-heath-moss and sedge meadow associations.

The Roche Bay Peninsula is an area of raised limestone beaches alternating with ponds and areas of cushion plant-lichen, cushion plant-sedge-moss, and sedge meadow associations.

The escarpment is the area where the peninsula meets the Precambrian plateau. This area also includes the terrain around the Irqalugarjuit Lake, filled with a wet sedge-meadow association. This escarpment area contains most of the sensitive terrain, and efforts will be made to avoid building on this terrain.

All major structures will be built on limestone shale or on the Precambrian plateau.

For a mapping of the sensitive areas see Fig 2-1 and the Ecosat report (Addendum V).

For a listing of the vascular plants identitied in the development area see Table 2-1.

3. WILDLIFE

3.1 BIRDS

3.1.1 Raptors

Rough-legged hawks and snowy owls are sighted in the development area. Peregrine falcons are sighted only rarely (a single sighting in three seasons), and gyrfalcons and eagles are not sighted at all. Rough-legged hawks do not nest in or near the development area. Snowy owls might occasionally nest on the Roche Bay Peninsula, but no nests were found there.

Provided that existing regulatory mechanisms concerning air and water quality control are enforced, the mining project should have no effect on these species.

3.1.2 Sea Birds

There are no fulmars or kittiwakes regularly occurring in the Roche Bay area, and no alcids except for black guillemots.

Provided that existing regulatory mechanisms concerning

Table 2-1 (EERCS)

Vascular plants collected at the west end of the peninsula and on the escarpment

Arctagrostis latifolia
Alopecurus alpinus
** Antennaria angustata
Armeria maritima
Astragulus alpinus
Braya purpurascens
Cardamine bellidifolia
Carex atrofusca
** C. capillaris
* C. glareosa
* C. maritima
C. membranacea
C. misandra
C. nardina
C. rupestris
C. scirpoidea
C. stans
Cassiope tetragona
Cerastium alpinum
Chrysanthemum integrifolium
Chrysosplenium tetandrum
Draba corymbosa
D. lactea
Dryas integrifolia
** Dupontia Fisheri
* Elymus arenarius
** Epilobium anagallidifolium
E. latifolium
Eriophorum angustifolium
E. Scheuschzeri
** Equisetum arvense
* E. variegatum
Eutrema Edwardsii
Hierochloe alpina
Juncus albescens
J. biglumis
J. castaneus
Lesquerella arctica
Luzula confusa
Luzula nivalis
Lycopodium selago
Melandrium apetalum
* Mertensia maritima
Minuartia rubella
Oxyria digyna
* Oxytropis arctobia
O. Maydelliana
Papaver radicatum
Pedicularis capitata
P. lanata
P. sudetica
Pleuropogon Sabinei
Poa arctica
Polygonum viviparum
Potentilla hyparctica
* P. Vahliana
Puccinellia phryganodes
* Ranunculus nivalis
Salix arctica
S. herbacea
S. reticulata
* S. Richardsonii
Saxifraga aizoides
S. caespitosa
S. cernua
* S. foliolosa
S. hieracifolia
S. Hirculus
S. nivalis
S. oppositifolia
S. rivularis
S. tricuspidata
Silene acaulis
** Stellaria longipes
Vaccinium uliginosum
Woodsia glabella

* Not seen by D. Jaques
** Not indicated as occurring in this region on distribution maps consulted by D. Jaques or in Porsild (1964)

(All but four of the specimens were collected by Beth Tipping, 80 Riverhead Dr., Rexdale, Ont. The other four, Arctagrostis latifolia, Chrysosplenium tetandrum, Poa arctica and Saxifraga hieracifolia, are in our possession, as are all specimens collected elsewhere.)

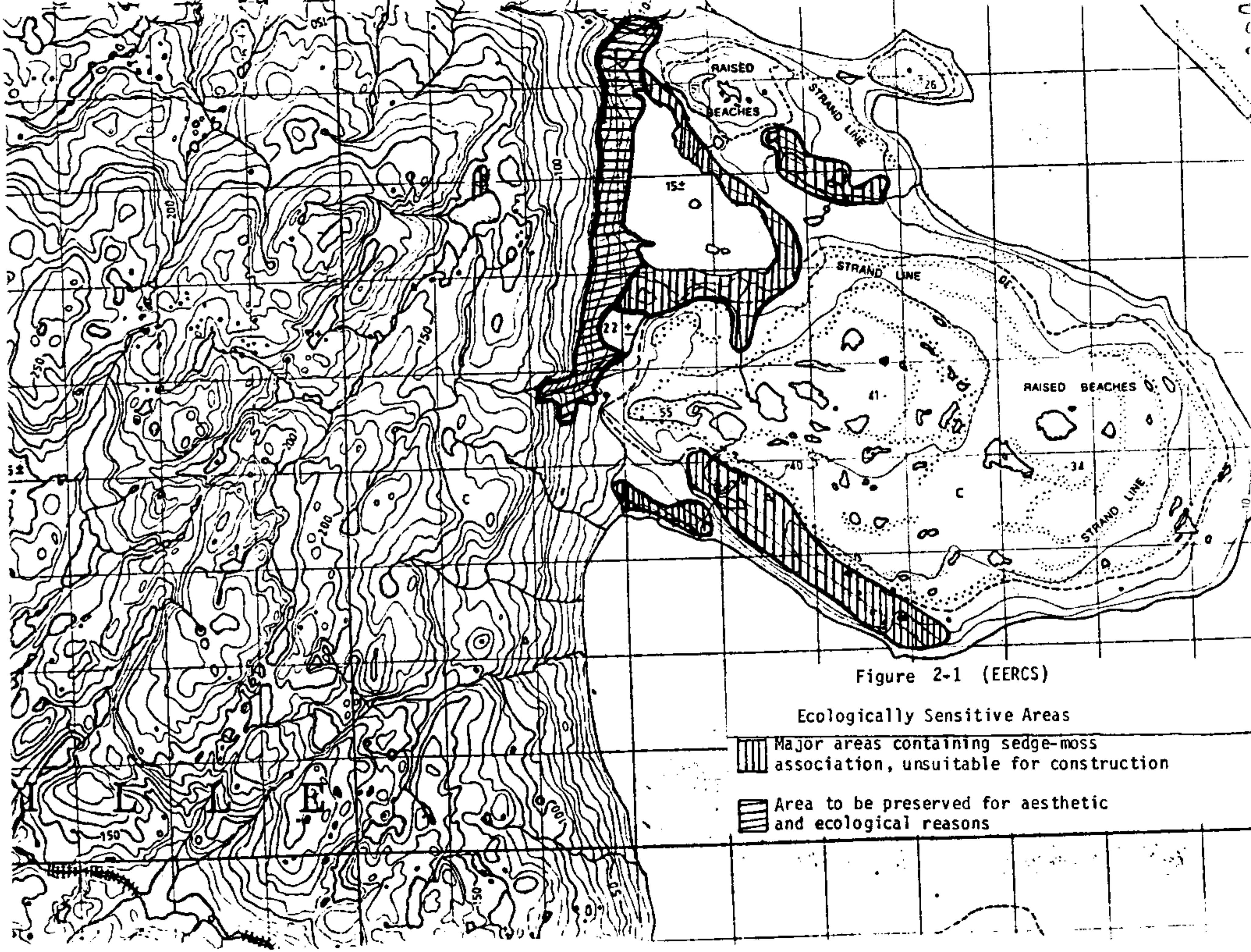


Figure 2-1 (EERCS)

Ecologically Sensitive Areas

air and water quality control are enforced, the mining project should have no effect on these species.

3.1.3 Gulls and Terns

Glaucous gulls, herring and/or Thayer's gulls, Sabine's gulls, and arctic terns were observed in the Roche Bay area, but none nests within the development area in significant numbers.

The mining project should have no negative effects on gulls and terns, provided that air and water quality are controlled. Because gulls are scavengers, however, the presence of organic wastes, garbage dumps, etc. in the Roche Bay area will attract non-breeding birds.

3.1.4 Waterfowl

Waterfowl in the Roche Bay area in summer include snow geese, Canada geese, brant, common eider, king eider, and oldsquaw.

The development area is not a common nesting area for any waterfowl except oldsquaw.

The mining activity should have little effect on waterfowl because the area is not a nesting area for significant numbers of birds, it is not a staging area, and it seems to be a stopover point only in some years. The very few nesting geese seem to be concentrated around the Irqalugarjuit Lake, which (as indicated in Section 2) should not be disturbed by the operation of the mine. Therefore, waterfowl should not be adversely affected by the Borealis development, provided that existing regulatory mechanisms for control of air and water contamination are enforced.

3.1.5 OTHER BIRDS

For the other species of birds sighted during the EERC field seasons see Table 3.1. The mine should not have negative impact on these birds if air and water quality is maintained.

3.2 CARIBOU

The development area is of little importance to caribou or to the Inuit of the region for caribou hunting. The low number of caribou in this area, which is also low relative to the number of caribou occurring in other areas north and south of Roche Bay, is a reflection of the scarcity of preferred vegetation types in the development area. EERCS studies indicate that fewer than 100 caribou enter the development area annually.

At present, it appears that the mining project should have little or no impact on the few caribou in the area as long as the animals are not hunted or harassed, the few areas of preferred vegetation near the mine site are left largely intact, and the existing regulatory mechanisms are enforced to avoid damage to the surrounding areas of more abundant

Birds observed in the Roche Bay development area or on the adjacent sea water in 1980, 1981, and 1982

Species	X, nesting in development area, or date of earliest observation of nesting in development area	Abundance in development area A, abundant C, common O, occasional R, rare	Abundance in development area relative to other areas within 80 km of Roche Bay
Arctic loon	-	O to C	less to equal
Red-throated	July	C to A	equal
Common loon	-	R	?
Black guillemot	-	O	?
Canada goose	X	O	less
Brant goose	-	O	less
Snow goose	X	O	much less
Oldsquaw duck	July 20	C	equal
Common eider	?(nesting near)	O to C (on ocean)	less (on ocean)
King eider	Aug. 8	C to A (on ocean)	less to equal (on ocean)
Rough-legged hawk	-	O	less
Peregrine falcon	-	R	less
Snowy owl	-	O to C	less
Willow ptarmigan	X	R to O(but more may come in winter)	less
Rock ptarmigan	X	(as above)	less
Sandhill crane	-	R (flying over)	?
Semi-palmated plover	X	O to C	less to equal
Golden plover	July 8	C to A	less to equal
Black-bellied plover	July 8	C	equal
Turnstone	?(probably)	O	less
Pectoral sandpiper	-	R	?
White-rumped sandpiper	X	O to C	much less
Baird's sandpiper	June 26	A	equal to more
Dunlin	-	R to O	?
Red phalarope	X	O	less
Pomarine jaeger	-	R to O	less
Parasitic jaeger	-	R to O	less
Long-tailed jaeger	July 8	C to A	equal
Glaucous gull	-	O	less
Herring gull	X	C to A	less to equal
Thayer's gull	X	C to A	less to equal
Sabine's gull	-	O	much less
Arctic tern	?	O	less
Black guillemot	-	O (on ocean)	less
Horned lark	June 26	C	equal
Raven	May 26	O	less to equal
Water pipit	X	O	less to equal
Lapland longspur	X	C to A	equal to more
Snow bunting	X	C	less to equal

vegetation.

3.3 POLAR BEAR

There are no denning areas near Roche Bay and polar bears occur in this area rarely to occasionally and mostly during winter.

The mine project should have no negative impact on polar bear ecology or movement, provided that polar bear are not hunted or harassed in the area and provided that their food sources are not negatively affected by pollutants.

Bears may, however, be attracted to the area by kitchen smells and garbage, in which case the impacts will likely be negative, but not necessarily for the bears.

3.4 SEA MAMMALS

The only sea mammals occurring in Roche Bay through the winter have been ringed seals. In some years, but not in others, ringed seals den on Roche Bay. Bearded seals and walrus sometimes have come into the mouth of Roche Bay in August, September, and October. Bearded seals and walrus have been common in Foxe Basin near Roche Bay and beluga whales, narwhals, and possibly bowhead whales have occasionally or rarely come near Roche Bay (see Table 3.4-1).

There will be no shipping during the denning season, and therefore the denning of seals should not be affected.

Table 3.4-1 (EERCS)

Marine mammals known to occur in or near Roche Bay

Part I: Mammals occurring in Roche Bay

Species	Denning in Roche Bay	* Abundance in Roche Bay	Abundance in Roche Bay relative to other areas within 80 km
Polar Bear	-	R to O	equal?
Ringed Seal	some years	O to C	variable
Beluga Whale (possibly)	-	very rare	less

Part II: Mammals occurring in the mouth of Roche Bay

Species	Denning in the mouth of Roche Bay	Abundance in the mouth of Roche Bay	Abundance in the mouth of Roche Bay relative to other areas within 80 km
Polar Bear	-	R to O	equal?
Ringed Seal	some years	O to C	variable
Beluga Whale (possibly)	-	very rare	less
Bearded Seal	-	R	less
Walrus	-	R	less

Part III: Mammals occurring in Foxe Basin near Roche Bay

Species	Denning near Roche Bay	Abundance near Roche Bay
Polar Bear	-	R to O
Ringed Seal	some years	C to A
Beluga Whale	-	R to O
Bearded Seal	maybe	O to C
Walrus	maybe	O to A
Narwhal	-	R to O
Bowhead Whale	-	very rare

* A- abundant
C- common
O- occasional
R- rare

Other sea mammals should not be negatively affected by the mine development itself, provided that existing regulatory mechanisms are enforced to monitor air and water quality.

It is possible, however, that ship noise will adversely affect sea mammals along the shipping route to the Atlantic Ocean. Although sea mammals persist in some areas of heavy ship traffic, whether sea mammals in the Arctic will adapt to ships of the size and frequency planned for the Borealis project is not certain at this time. Nor is it clear what sort of noise reduction procedures might be used to mitigate possible negative impacts. Fortunately, considerable research is now in progress, stimulated by the Beaufort Sea exploration and the Arctic Pilot Project plan to ship year round, which will be helpful in determining the impact of ship noise on sea mammals. It should be noted, however, that Borealis will ship in conventional non-ice-class vessels, and all iron ore will be shipped during the open season. The limitation to open water shipping will minimize the total impact on sea mammals. At this time, however, no confident predictions can be made about the impact of ship noise on sea mammals.

3.5 OTHER MAMMALS

Largely because of the relative sparsity of vegetation in the development area, the numbers of arctic fox, arctic wolf, arctic hare, and arctic ground squirrel are less than or equal to the numbers of these animals in surrounding areas (See Table

Table 3.5-1 (EERCS)

Terrestrial mammals known to occur in the mine development area

Species	Nesting or denning in development area (X - yes) (- - no)	Abundance in development area A - abundant C - common O - occasional R - rare	Abundance in development area relative to other areas within 80 km of Roche Bay
Polar Bear	–	R	less
Arctic Fox	X	O	less to equal
Arctic Wolf	–	R	less
Arctic Hare	X	O	less to equal
Arctic Ground Squirrel	X	O to C	equal
Lemming	X	probably variable (rare in '81 and '82)	?
Barren Ground Caribou	–	O to C	less

3.5-1). None of these animals is abundant in the development area, and the proposed mining operation should not interfere with these mammals except possibly to attract fox and wolves as scavengers.

3.6 FISH

Two species of fish are important for human food in the Roche Bay area--lake trout and arctic char. Char are common in the Ajaqutalik River south of the development area and in the Irqalugarjuit Lake system in the develoment area. In the development area anadromous char can go upstream only as far as the escarpment. However, there are populations of small char or char-like fish in the lakes up on the Precambrian plateau. These populations are "landlocked" because they cannot get to the sea and back.

The fish in the Ajaqutalik River should not be affected by the mining development as long as air and water quality are monitored and mine water is not released into that drainage system. Nor should harmful quantities of pollutants be released into the Irqalugarjuit Lake drainage system (see Addendum III and Scott-Ortech Study). There will be negative effects on some "landlocked" fish when the small lakes in the mining areas are drained to begin mining. In addition, there could be negative effects on the fish in the Irqalugarjuit or other drainage systems if, by diverting runoff, the water

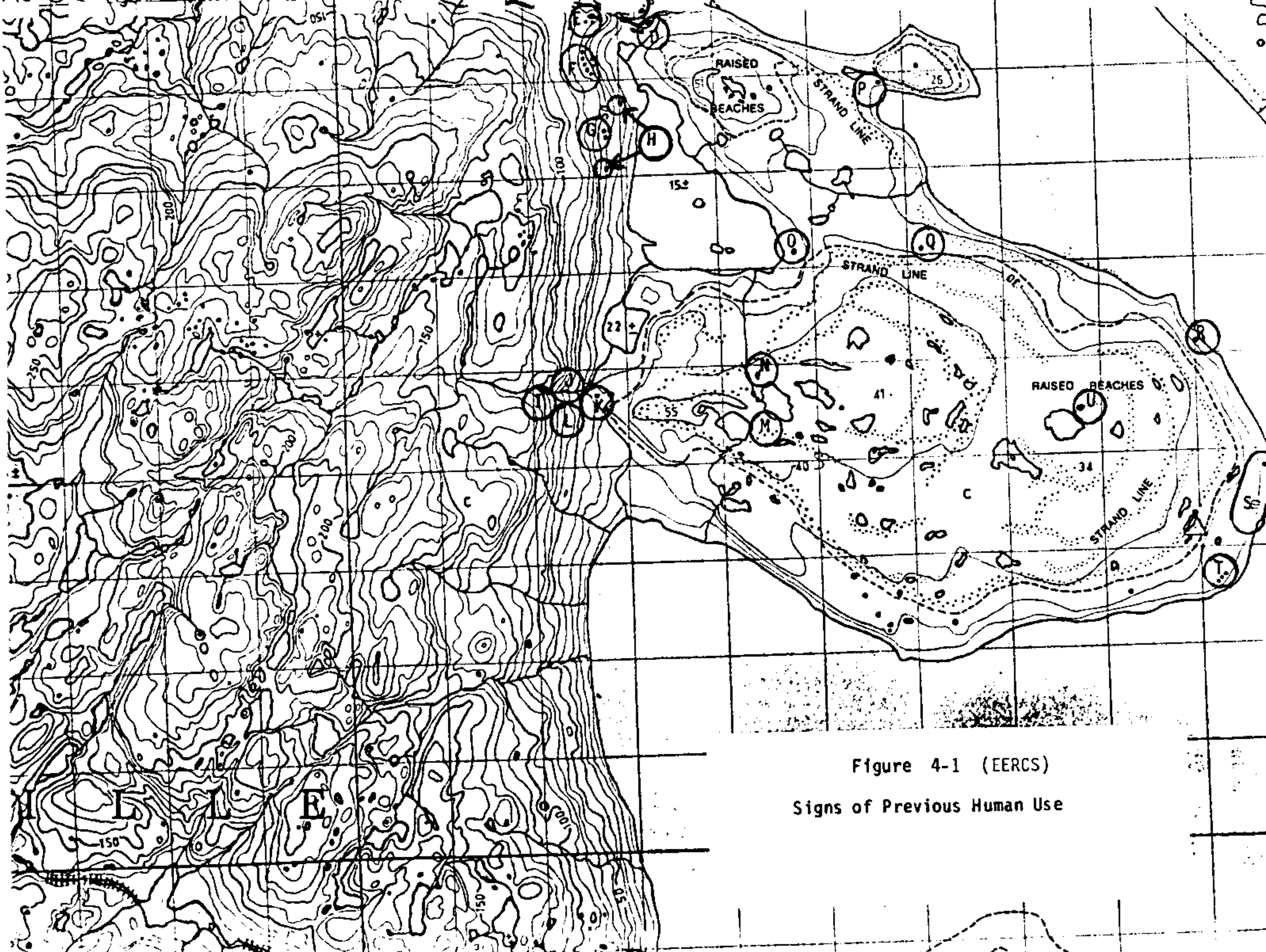


Figure 4-1 (EERCS)

Signs of Previous Human Use

In the event that it becomes necessary to disturb an archaeological site, the Company will give six month's notice to the archaeological community so that the site can be catalogued and evaluated.

5. AIR POLLUTION

In a mining development of this kind there are two principal sources of air pollution:

1. iron ore dust;
2. power plant emissions.

5.1 IRON ORE DUST

In any dry process involving fines it is necessary to minimize the amount of air-borne dust in order to protect employees and equipment as well as the environment in general. The technology exists for preventing such dust from becoming air-borne and the methods by which dust will be eliminated in the crushing plant, the mills, and the conveyor systems are described in detail in Addendum III as well as in the Scott-Ortech study. Briefly, in the crushing plants and the mills the dust control system will consist of pick-up points, cyclones, baghouses, and fans. The conveyor systems will be covered, and the chutes in the concentrate storage buildings have been designed to minimize dust.

available for the operation of large-scale wind systems in the Arctic.

6. WATER QUALITY CONTROL

There are three major sources of water pollution in a standard open pit mining operation:

1. mine water;
2. tailings pond leachate;
3. domestic water sewage.

6.1 MINE WATER

Mine water may be contaminated by residues from blasting (principally ammonium nitrate), and therefore mine water will be pumped out of the pit and/or diverted by drainage canals so that these contaminants do not flow into the Irqalugarjuit Lake drainage system. If levels of contamination are high, the mine water will be treated in one of the existing ponds before release into Roche Bay. (See sections 3.6 and 8)

6.2 TAILINGS LEACHATE

Unlike most mine/processing complexes, there will be no tailings pond at the Borealis mine site. The tailings will be dry, and there will have been no chemical additives used in the processing. The tailings discard pile will physically and chemically resemble a pile of very coarse sand. Therefore, leaching would result, not from a cumulative filtration through a pond, but from the action of surface water over and through the non-frozen active layers of tailings.

To estimate the mine water leaching potential, samples from the Adler Deposit were tested (I.E.E) and samples from Deposit B were tested (Addendum IV). The results of these tests can be summarized as follows:

1. The tailings from both deposits are alkaline.
2. The tailings tested from the Adler Deposit are sufficiently alkaline for there to be no theoretical acid generating potential.
3. The tailings from Deposit B were found to have some theoretical acid-generating potential, but when tested using the prescribed microbiological test these tailings did not support acid generation. In other tests the leachate was analyzed to contain,

(a) when leached with a solution of pH 4.8:

Manganese	0.016	mg/l
Zinc	0.01	mg/l
Copper	0.01	mg/l
Iron	1.47	mg/l
Final pH	6.8	units

(b) when leached in a buffered acid (4.5 pH) solution:

Manganese	1.03	mg/l
Zinc	.38	mg/l
Copper	.15	mg/l
Iron	1.22	mg/l
Final pH	4.9	units

Water samples have been gathered and are being tested by Water Resources in order to determine baseline water quality in the area. The Company will do similar baseline testing next summer.

Regular monitoring of the tailings samples will continue and, if necessary, the leachate will be collected in a pond below the sand disposal area and treated before release into the water system.

6.3 DOMESTIC WATER SEWAGE

Sewage will be trucked to a sewage treatment area. Although there are available a variety of fairly sophisticated methods of sewage treatment, it is now thought that it would be best to examine the possibility of using one of the lakes on the peninsula as a lagoon. The difficulty with more complex systems is that they may not function properly, given arctic conditions and the difficulty of finding trained personnel in the north. When feasible, lagoons function well in the arctic.

6.4 CONCLUSIONS ON WATER QUALITY

The dangers of water contamination from mine water waste, tailings leachate, and domestic sewage are manageable using standard technology, and water quality can be adequately monitored with the existing regulatory mechanisms.

7. TAILINGS DISPOSAL

As discussed above, the tailings will not be disposed of in a pond. The sand tailings will be disposed of in a manner described in the Scott-Ortech Study and Addendum III, and in a location specified in the Scott-Ortech Study.

In the I.E.E. it was anticipated that the tailings would be very fine and that dust control at the tailings disposal site would be an environmental problem. In fact the tailings will be quite coarse (Addendum III) and there should be no dust control problems at the disposal site.

8. HYDROLOGY

Water waste and water contamination have been discussed above. There remain to be discussed hydrological issues concerning water levels in ecologically important drainage areas in the Roche Bay vicinity. The two most important such systems are the Ajaqutalik River and the Irqalugarjuit Lake system. The Ajaqutalik River should not be affected by mine development. Water levels in the Irqalugarjuit Lake system will be affected. Water will be used from that lake for domestic purposes, and water may be diverted from that system to avoid contamination by mine and mill sites. In addition, some ponds and lakes that feed into the system will be drained in order to mine the Adler and B deposits. Further studies will be required to determine the extent to which the levels in the Irqalugarjuit Lake system, or any other significant system, are reduced. If that reduction is severe, the Company will consider (1) an alternate source of domestic water, and (2) the treatment of mine water so that it may be returned to the original system safely.

9. CONCLUSIONS

1. Air and water quality will be maintained and existing regulatory mechanisms are sufficient to monitor air and water standards.
2. The impact on vegetation will be minimal because vegetation is very sparse in the development area as a whole and the few sensitive areas will not be used as construction sites.
3. The impact on wild life in general should be minimal, in part because the development area is sparsely vegetated and therefore low in wildlife populations, and in part because the existing regulatory mechanisms will be adequate to minimize the possibility of negative impacts on air and water.
4. The one outstanding major environmental concern is the effect of conventional open water shipping on sea mammals along the route to the Atlantic. However

conventional large scale shipping and sea mammals have coexisted in other parts of the world, and although it may be necessary to institute noise controls in sensitive areas, this should not be an insurmountable problem once more is understood about the effects of ship noise on sea mammals.

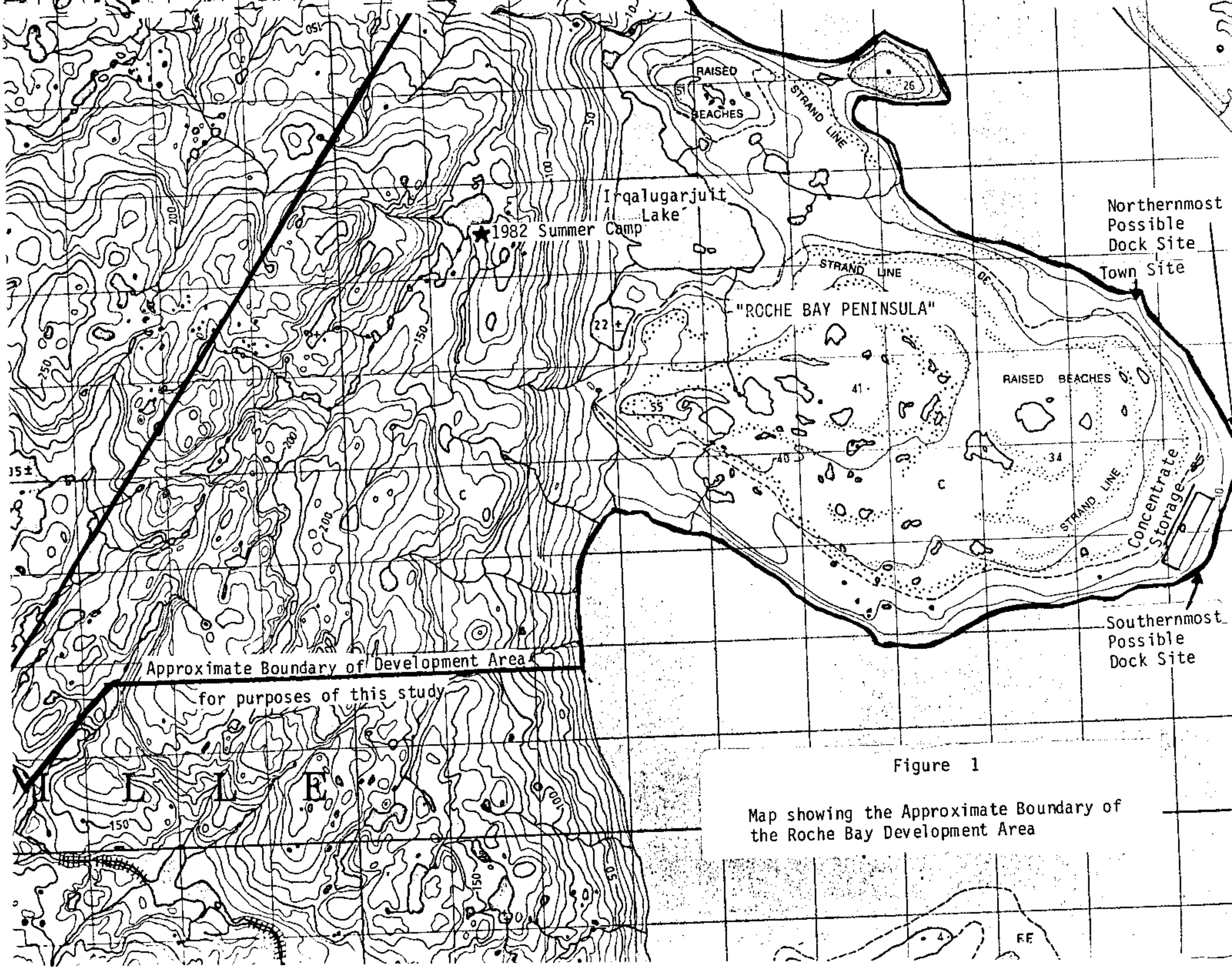


Figure 1

Map showing the Approximate Boundary of the Roche Bay Development Area

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SLIDES

1. Aerial view of Roche Bay Peninsula, looking north from an altitude of 5500 feet.

2. A typical limestone gravel beach, on the southwestern part of the peninsula, looking west

3. Aerial view of townsite location proposed by J. Haniliaq looking Southeast.

4. Gravel beaches 1/2 km west of proposed townsite, 300 m from shore, looking east.

5. Aerial view of northernmost possible port site, looking northwest.

6. The shore 1/2 km south of northernmost possible port site; looking north.

7. Aerial view of coast between the two possible port sites.

8. Aerial view of southernmost possible port site; looking east, showing cliff and permanent snowbank.

9. Limestone cliff at southernmost possible port site.

10. Aerial view of southernmost possible port site, looking north.

11. The Irqalugarjuit River where it turns north below the escarpment, looking north. Salix Richsardsonii, Epilobium latifolium, Oxytropis Maydelliana and heather are all abundant here.

12. The same site, looking north toward Irqalugarjuit Lake.

13. High cover dwarf shrub association near the top of the escarpment.

14 Lower cover dwarf shrub-lichen association typical of the Adler Deposit

15. Moderate cover mixed heath, very common throughout the upland part of the development area (classified as "dwarf shrub association"). Carex spp., Dryas integrifolia and lichens are abundant. Cassiope tetragona is common.

16. High cover mixed heath (classified as "dwarf shrub association"). This was more common on Deposit C, but does occur in many part of the area proposed for immediate development. Dryas integrifolia and lichens are abundant; Carex spp., Cassiope tetragona and Salix arctica are common.

17. High cover Cassiope heath (classified as "dwarf shrub-heath-moss association). This occurs commonly on sheltered slopes on the escarpment, Deposit C, and the southern half of Deposit B. Cassiope tetragona and Cetraria spp. are abundant; Salix arctica, Dryas integrifolia and Carex spp. are common.

18. Low cover "dwarf shrub associationa: typical of the northern half of Deposit B: Farther south, in the distance, the vegetation cover increases and Salix arctica becomes more common.

19. Looking north from the same position.

20. Looking west from the proposed crusher site toward the eastern slope of Deposit B. The low vegetation cover is typical of slopes on the northern part of Deposit B.

21. Looking southwest from the crusher site. In the foreground lichens and Dryas integrifolia are dominant. Two small slopi, sedge measows are visibl on Deposit B.

22. Aerial view of easter part of proposed Sand Disoposal Area, looking east twoard Roche Bay. Visible vegetation cover in the background ranges from bare rockland to sedge meadow.

23. Aerial view looking east over the valley and ridge south and southeast of the 1982 Borealis summer camp. The ridge is low cover (15-30%) dwarf shrub-lichen association.

24. Site A: Person is sitting on a "stone igloo" type fox trap. At least one cache is also visible.

25. Fish spears constructed of wood, straightened trap springs, plasitic snowmobiles parts, nails, and a wrench found at Site B.

26. Site D. Stone circle; and in the foreground is an apparent stone house dug out of the side of a slight slope.

27 Site D. Concentric circular stone walls. Tall door-post of outer wall in foreground (looking west.)

28 Site D. Concentric stone walls. Both outer doorposts are visible; the gray one has fallen over (looking S.W.)

29 Site D. Concentric stone walls. Looking N.E. from "rear" of structure.

30. Site D. Bright green vegetation indicates soil enriched in organic matter: Behind it are tent rings, come deeply embedded in soil.

31. Site F. Tent ring

32. Site G. Large "Stone igloo" wolf and fox trap. Person inside it is standing up. Person is standing inside a large "stone igloo" type wolf and fox trap. Many stones have fallen inside, enlarging the opening.

33. Site G. 1.8 metre-high "Stone-igloo" type wolf and fox trap built against an outcrop.

34. Site G. Stonehouse of "low-walled structure".

35. Site H. On the left is a low-wall. possibly used as an ambush shelter. On the right is a light-coloured rock placed on an outcrop possibly to mark the location.

36. Site I "Low walled strucutre" about 80 m above sea level, looking S.E.

37. Site I. Same structure looking N.E.

38. Site I. Same sturcuture looking N.W. Row of rocks probably delineated the sleeping area. Some rocks have apparently fallen off the wall.

39. Site L. "Low wall structure" or stone house about 40 m above sea level. Looing N.E.

40 Site L. Same under different light

41. Site L. Looking S.E.

42 Site L. Row of rocks is visible across center.

43. Site L. Long straight north-south row of rocks.

44. Site L. Elongated tent ring identified by archaeologist Ellen Bielowsky as a Paleo-Inuit dwelling.

45. Site R: Large tent ring, one half paved with flat stones. Tent ropes were probably tied to the outer circle of scattered boulders.

46. Site S Large elongated tent ring with flat rocks probably delineating two sleeping areas and a central cooking area.

47 Site S. Aerial view of stone houses about 100 m from shore at east most tip of Roche Bay peninsula. Four stone houses are visible near centre of photo.

48. North end of Site T: An Inuksuk on the same level as most of stone houses and tent rings. It is located at a place where the slope could be ascended easily and boats could be beached in the shelter of a slight bay.

1. METHODS

During the field seasons of 1980, 1981, and 1982, three methods of data gathering were employed:

1. interviews;
2. aerial surveys;
3. ground surveys.

1.1 INTERVIEWS

At least 21 hunters from Igloolik, Hall Beach, and Ignertok Point were systematically interviewed. The questions, as far as possible, were non-leading (e.g., "Where are the best places to hunt seals?" rather than "Are there seals in Roche Bay?"). The Inuit interviewed were asked about past conditions as well as present ones. We tried to ask each hunter about every important species of wildlife covered in this report. A great deal of information was obtained in this way, and it should be noted that their observations were quite consistent, with no major contradictions among the reports of different hunters.

Three Wildlife Officers in this area were also interviewed.

In addition, anyone encountered in the Roche Bay area was interviewed, and questions concerning wildlife in the development area were directed to the Hall Beach community as a whole in community and council meetings.

1.2 AERIAL SURVEYS

All flights for any purpose were flown at 500 ft above ground level, with one or two observers recording all sightings of wildlife and observations of vegetation cover, sea ice, and snow conditions. Different routes were flown on each flight. This resulted in more than 100% coverage of the development area during each of the months of June, July, and August in 1981 and 1982, and nearly 100% coverage in September. It also resulted in 25%-50% coverage of the areas between Roche Bay and Hall Beach, between the mine site and the Ajaqutalik River valley, and between the mine site and Sarcpa Lake. In 1981 we also thoroughly surveyed the entire Ajaqutalik River valley up to Sanguac Bend, and the areas east, west, north, and south of Hall Lake. No grid surveys were flown, except in certain areas north and south of Roche Bay that had previously been identified as goose nesting areas.

1.3 GROUND SURVEYS

All major ground survey routes are shown in Fig. 1.3-1. On these surveys we collected plants, noted any signs of wildlife, and recorded any observation pertinent to this report.

1.4 OBSERVERS

In 1981 two biologists were in the development area almost continuously from July 4 to September 5, and short one-day to three-day visits were also made by three biologists from Sarcpa Lake, Ralph Carter, Bruce Lyon, and Beth Tipping.

In 1982 only one biologist and three other observers were present in June, but 24 to 35 people were working throughout the development area from July 17 to September 15, and many of them

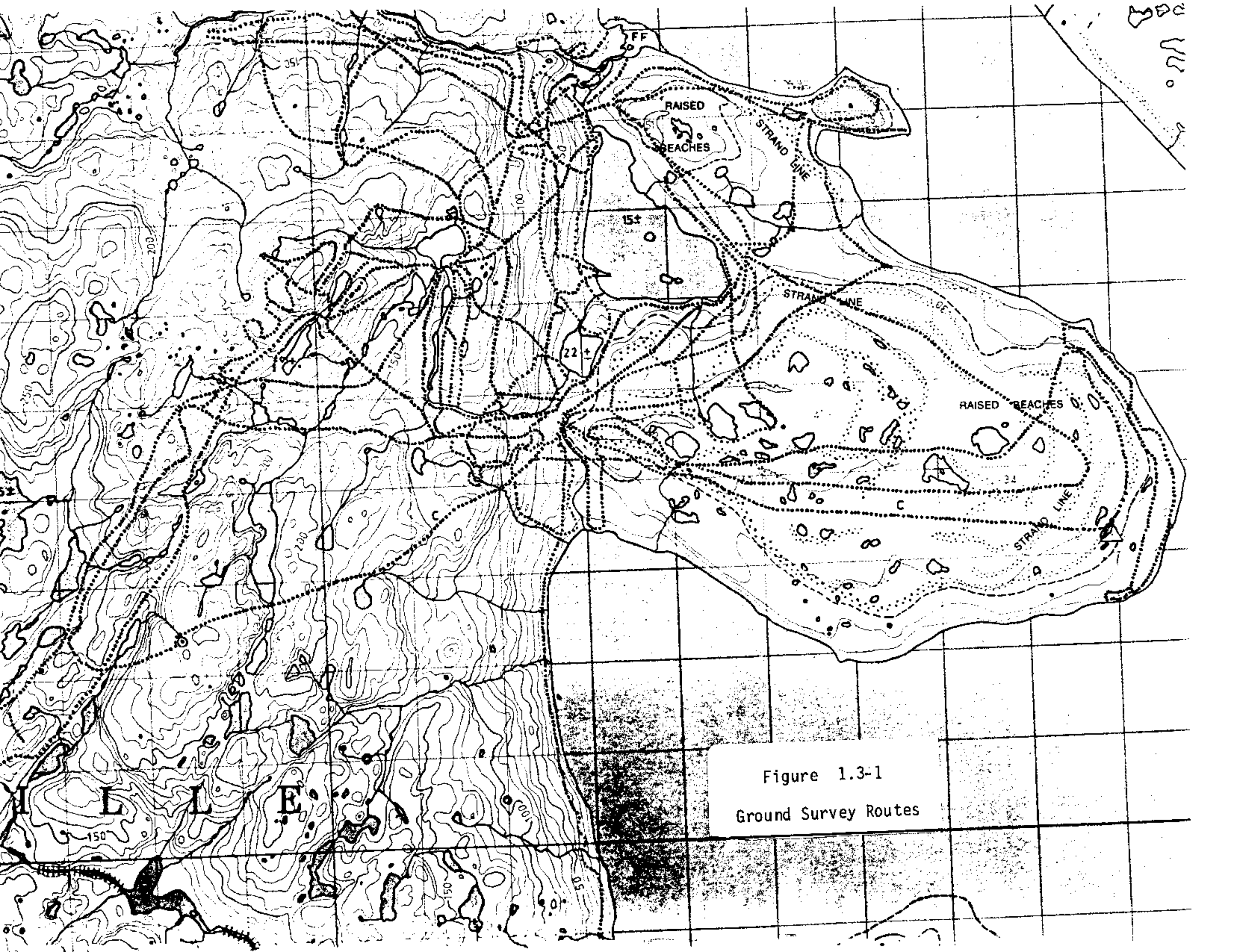


Figure 1.3-1

Ground Survey Routes

2. VEGETATION

2.1 INTRODUCTION

2.1.1 Summary

Vegetation is generally less abundant in the development area than in areas to the north, west, and south of it. Within the development area vegetation is most abundant on the escarpment, at the base of the Roche Bay Peninsula, and in the southwestern corner.

The development area basically consists of three main areas:

1. the Precambrian plateau, rising from about 130 m to 250 m above sea level;
2. the Roche Bay Peninsula, rising from sea level to about 55 m above sea level;
3. the escarpment, sloping quite steeply down to the base of the peninsula from the Precambrian plateau.

The Precambrian plateau has a substrate mainly of metamorphic rock, and some of it is only sparsely vegetated. Vegetation here consists mainly of dwarf shrub and dwarf shrub-lichen associations. A dwarf shrub-heath-moss association is extensive in the southwestern part, and sedge meadow associations occur in some valley bottoms throughout the plateau region. Vegetation is generally most abundant in the southwestern part of the plateau region, and least abundant on ridge tops at or near the north end of the iron deposits.

The Roche Bay Peninsula is an area of raised limestone beaches alternating with areas of cushion plant-lichen, cushion plant-sedge-moss, and sedge meadow associations. Significant sedge meadows occur mainly on the southwest and west of the peninsula.

The escarpment is between the peninsula and the plateau. It slopes up from the lower reaches of the Irqalugarjuit drainage system toward the plateau to the west. The lower part of the slope is largely covered with a wet sedge meadow association, while luxuriant dwarf shrub heath is the most common association near the top. The greatest variety of vegetation within the development area is found on the escarpment and at the base of the peninsula adjacent to it, in or near much sedge meadow association.

2.1.2 Species of Vegetation

For the sake of consistency, we have adopted the terminology of Dennis Jaques (Addendum V) to describe plant communities.

Seventy-eight species of vascular plants were collected within the development area (See Table 2.1-1). No attempt was made to identify mosses or to make a thorough list of lichens. Plants were identified by Beth Tipping and Cathy Montgomery, botanists doing research at Sarcpa Lake. Plants that were not found by Dennis Jaques are marked with an asterisk in species lists; those which, according to Jaques' literature search and Porsild (1964), have never been found in this area are marked with two asterisks. In some parts of the development area the lists of grasses, sedges, and rushes are incomplete, and a few other species of vascular plants may be missing, since a botanist was able to study only the western portion of the Roche Bay Peninsula and the escarpment.

2.2 THE PENINSULA

The "Roche Bay Peninsula" where construction of the airstrips, storage facilities, docks, etc. is planned, has a substrate of

Table 2.1-1: Vascular plants collected at the west end of the peninsula and on the escarpment

Arctagrostis latifolia
Alopecurus alpinus
** Antennaria angustata
Armeria maritima
Astragulus alpinus
Braya purpurascens
Cardamine bellidifolia
Carex atrofusca
** C. capillaris
* C. glareosa
* C. maritima
C. membranacea
C. misandra
C. nardina
C. rupestris
C. scirpoidea
C. stans
Cassiope tetragona
Cerastium alpinum
Chrysanthemum integrifolium
Chrysosplenium tetandrum
Draba corymbosa
D. lactea
Dryas integrifolia
** Dupontia Fisheri
* Elymus arenarius
** Epilobium anagallidifolium
E. latifolium
Eriophorum angustifolium
E. Scheuschzeri
** Equisetum arvense
* E. variegatum
Eutrema Edwardsii
Hierochloe alpina
Juncus albescens
J. biglumis
J. castaneus
Lesquerella arctica
Luzula confusa
Luzula nivalis
Lycopodium selago
Melandrium apetalum
* Mertensia maritima
Minuartia rubella
Oxyria digyna
* Oxytropis arctobia
O. Maydelliana
Papaver radicatum
Pedicularis capitata
P. lanata
P. sudetica
Pleuropogon Sabinei
Poa arctica
Polygonum viviparum
Potentilla hyparctica
* P. Vahliana
Puccinellia phryganodes
* Ranunculus nivalis?
Salix arctica
S. herbacea
S. reticulata
* S. Richardsonii
Saxifraga aizoides
S. caespitosa
S. cernua
* S. foliolosa
S. hieracifolia
S. Hirculus
S. nivalis
S. oppositifolia
S. rivularis
S. tricuspidata
Silene acaulis
** Stellaria longipes
Vaccinium uliginosum
Woodsia glabella

* Not seen by D. Jaques
** Not indicated as occurring in this region on distribution maps consulted by D. Jaques or in Porsild (1964)

(All but four of the specimens were collected by Beth Tipping, 80 Riverhead Dr., Rexdale, Ont. The other four, Arctagrostis latifolia, Chrysosplenium tetandrum, Poa arctica and Saxifraga hieracifolia, are in our possession, as are all specimens collected elsewhere.)

limestone and a surface of barren gravel beaches (about 35% of its area), alternating with areas of cushion plant-lichen and cushion plant-sedge-moss associations, and a few sedge meadows. Large expanses of rich vegetation are found only in three areas: along the Irqalugarjuit drainage system, along the southwest coast, and northeast of Irqalugarjuit Lake (See Fig. 2.2-1, and Fig. 2.2-2). These three areas are poorly drained, and are therefore less suited for construction (due to permafrost problems) than the rest of the peninsula. The limestone beaches contain less than 1% vegetation, while most of the depressions between them are 80%-100% vegetated, with occasional small ponds. Several portions of the peninsula are described individually below. These are the proposed port and town sites, and are located at the west end of the peninsula.

2.2.1 Proposed Town Site (1981)

At the point of land proposed as the town site (See Fig. 1) gravel beaches extend up from the shore for 300-400 m. Vegetation cover is less than 5%, with very little moss or sedge meadow, and only one small wet area, which contains a pond.

Many gravel ridges contain either no vegetation at all or scattered individuals of *Dryas integrifolia*, *Oxytropis arctobia*, *Saxifraga oppositifolia*, and *Cetraria* spp.

One hundred metres or more from shore a few pockets of cushion plant-sedge-moss associations were found:

Abundant:	Carex spp.
	Cetraria spp.
	Dryas integrifolia

Common:	Cetraria tilesii Oxytropis Maydelliana Saxifraga oppositifolia other lichens
Occasional:	Chrysanthemum integrifolium Salix arctica grasses and sedges mosses
Rare:	Pedicularis lanata

Species found on sparsely vegetated gravel and sand near the water's edge are as follows:

Abundant:	Dryas integrifolia Oxytropis arctobia
Common:	Carex spp. *Elymus arenarius Saxifraga oppositifolia Saxifraga tricuspidata other grasses lichens
Occasional:	Cerastium alpinum Draba spp. Epilobium latifolium Lesquerella arctica Oxytropis Maydelliana Papaver radicatum Salix arctica mosses

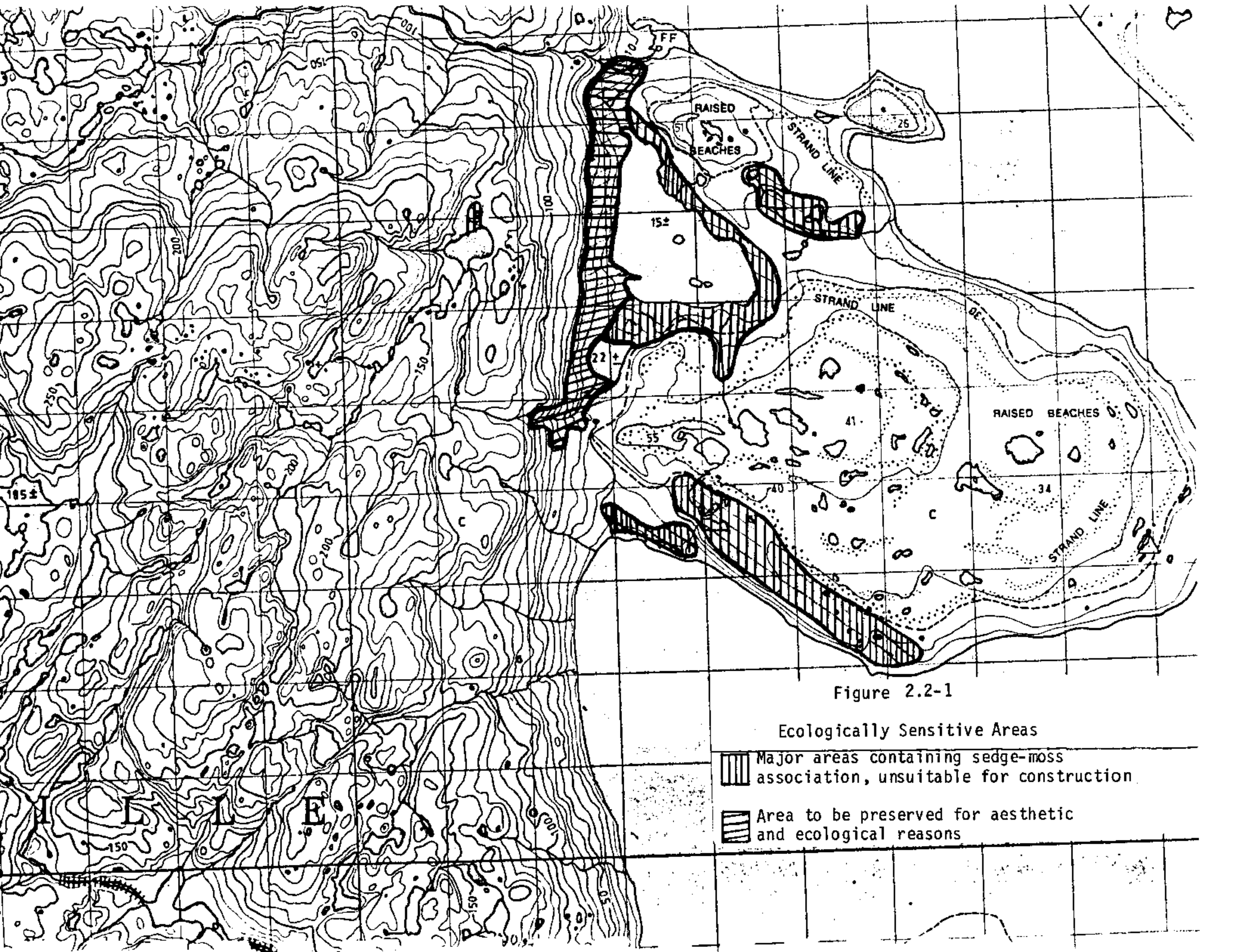


Figure 2.2-1

Ecologically Sensitive Areas

Major areas containing sedge-moss association, unsuitable for construction

Area to be preserved for aesthetic and ecological reasons

A few moist areas were found, containing the following species:

Most prevalent: Dryas integrifolia
sedges
mosses

Occasional: Epilobium latifolium
Melandrium apetalum
Oxyria digyna
Papaver radicatum
Polygonum viviparum
Salix reticulata
Saxifraga cernua
Saxifraga Hirculus

Rare: Lesquerella arctica

From the shore the terrain slopes up gradually, and is almost devoid of vegetation (very much less than 1%) up to 400 m from shore. The gravel beaches contain only occasional tiny clumps of Cetraria and other lichens.

2.2.3 Southernmost Possible Port Site

About 30 m from shore is a vertical cliff about 5 m high. Below it, a large permanent snow bank extends for about 1 km along the shore. No vegetation could be found below the cliff for more than 1 km, except where a few springs emerged from the ground, forming shallow pools around which mosses were abundant.

Above the cliff there is more vegetation, consisting mainly of cushion plant-sedge-moss association, with a few ponds and small sedge meadows alternating with barren gravel beaches (See Fig. 1, and Fig. 2.2-2).

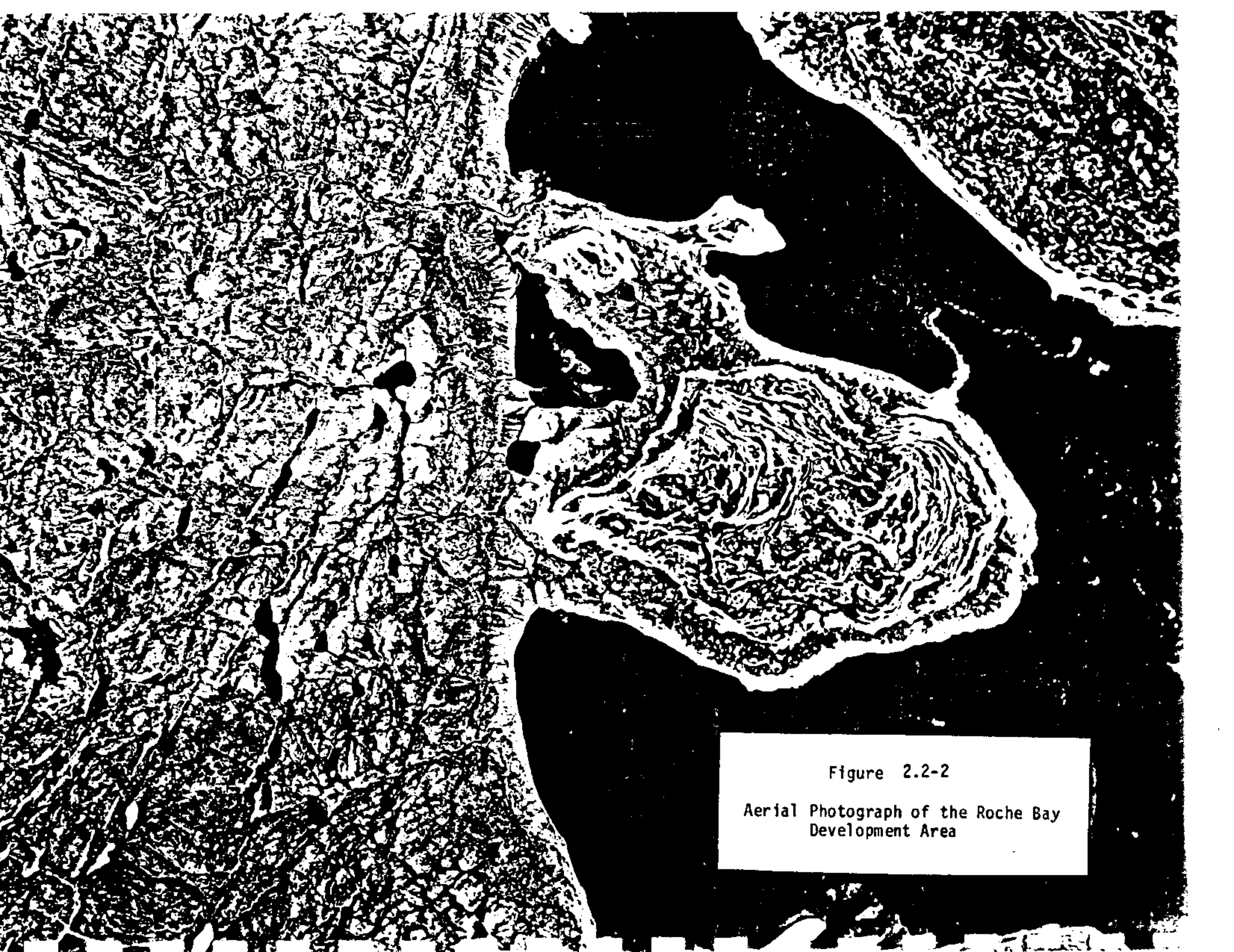


Figure 2.2-2

Aerial Photograph of the Roche Bay Development Area

2.3 THE WESTERN END OF THE PENINSULA AND THE ESCARPMENT

2.3.1 The Western End of the Peninsula

A border 500 m wide around Irqalugarjuit Lake (See Fig. 2.2-1) contains the richest and most varied vegetation in the development area. A variety of plant communities are found here. Beth Tipping, who had studied the vegetation at Sarcpa Lake for three years, commented that all communities occurring at Sarcpa Lake could also be found in this part of the develoment area, in small pockets at least, but that *Cassiope tetragona* was less abundant here than at Sarcpa Lake. Vegetation cover is over 90% almost everywhere in this area, except on a few limestone beaches and creek deltas, and on the Precambrian outcrops of the escarpment. One kilometre upstream from Irqalugarjuit Lake, for 1/2 km along the stream bed, drifting snow apparently gives winter protection, producing an abundance of *Salix Richardsonii* (a large woody willow) up to 1 ft high (Slide 11).

The area on the west, northwest, and southwest of Irqalugarjuit Lake should be left undisturbed as much as possible for aesthetic reasons (Slides 12, 31), as well as to preserve water quality, wildlife habitat and archaeological sites. Preservation should extend from the south bank of the Irqalugarjuit River canyon on the south to the mouth of the Irqalugarjuit River on the north (See Fig. 2.2-1). Due to the large percentage of wet meadow, much of this area is not suitable for construction in any case.

About 1-1/2 km south of Irqalugarjuit Lake the sparsely vegetated raised limestone beaches on the peninsula and escarpment extend westward almost to the edge of the Precambrian upland, providing the most suitable route for a conveyor belt and road (i.e., firm substrate but with possible snow drifting).

2.4 THE UPLAND AND THE IRON DEPOSITS

According to our aerial surveys and the infrared satellite photograph, vegetation on the iron deposits is similar in abundance to that found elsewhere on the eastern Melville Precambrian upland, except on the Adler deposit and the north part of Deposit B, where the elevation is higher, and there is more glacial drift and less vegetation than elsewhere.

On the upland the plant cover varies from 15% to 90%. It also varies in thickness (i.e. plant height and density), but is not luxuriant anywhere except on some sheltered slopes of Cassiope heath (Slides 14-17). Everywhere the four most abundant types of plants are Dryas integrifolia, Cetraria spp., Carex spp., and Cassiope tetragona. In richly vegetated areas Salix arctica and Salix reticulata are also abundant. In most areas the dominant plant is Dryas integrifolia. In some areas Carex or Cetraria are dominant. On occasional sheltered slopes Cassiope tetragona is dominant.

The vegetation cover is thicker on slopes than on hilltops. Most high level areas contain much bare gravel and clay (up to 70%), whereas on some slopes the only unvegetated places are protruding rocks, and between the rocks the plant cover is quite thick due to the protection and moisture provided by snowdrifts (Slide 17).

Using Dennis Jaques' classification of plant associations (Addendum V, pp. 5-8), this is how we would describe sites on which mine facilities are planned:

Adler Deposit (Slide 14): Mainly low cover dwarf shrub-lichen association (15%- 30% plant cover) and bare rock,

B Deposit, northern half (Slides 18-20): Mainly bare rock and dwarf shrub-lichen association (15%-40% plant cover), with a few areas of dwarf shrub association (50%-80% plant cover), and patches of sedge meadow,

B Deposit, southern half: Bare rock and dwarf shrub-lichen association on high level areas; many areas of dwarf shrub association (50%-80% plant cover); dwarf shrub-heath-moss association (50-75% plant cover) in sheltered areas on slopes; sedge meadow association along some stream beds,

Crusher site and mill site (Slide 21): Dwarf-shrub association (50%-80% plant cover),

Sands disposal area: Dwarf shrub-lichen association (15%-30% plant cover) on high level areas; dwarf shrub association (50-80% plant cover) on slopes and depressions; small areas of sedge meadow and bare lichen-covered rockland (Slide 22).

Vegetation on the north end of Deposit C near the "gorge river" drainage system, flowing into the southwestern corner of Roche Bay, and towards the Ajaqutalik Valley, is similar to that on Deposit B, but farther south on Deposit C it is generally more abundant than upland vegetation to the north and east, with dwarf shrub-heath-moss associations occurring extensively even on high level areas, and plant cover ranging up to 90% in many areas.

In open, level areas plants bloomed earlier in 1981 than in level areas on the lowlands, indicating an earlier snow melt on the upland.

The following list gives the relative abundance of plants in the vicinity of the Adler and B deposits and in areas to be occupied by the crusher, mill, and conveyor systems:

Abundant: Carex spp.
Dryas integrifolia
lichens

Common: Carex nardina
Cassiope tetragona (abundant on some slopes, rare to occasional in other areas)
Cetraria tilesii
Eriophorum angustifolium (in wet areas only)
Polygonum viviparum
Salix arctica
S. reticulata
Saxifraga oppositifolia

Occasional: Chrysanthemum integrifolium
Melandrium apetalum
Oxytropis Maydelliana
Saxifraga Hirculus
Silene acaulis
**Stellaria longipes

Rare: Astragalus alpinus
Dactylina arctica
Epilobium latifolium
Eutrema Edwardsii
Lycopodium selago
Oxyria digyna
Papaver radicatum
Pedicularis capitata
Pedicularis lanata
*Salix Richardsonii
Salix herbacea (in snowbeds only)
Saxifraga cernua
S. nivalis (in snowbeds only)
Vaccinium uliginosum
Woodsia glabella

Species collected but relative abundance not noted:

Arctagrostis latifolia
Carex misandra
C. scirpoidea
C. stans
Draba corymbosa
D. lactea
Luzula confusa
L. nivalis
Poa arctica
Alectoria sp.

(This list is undoubtedly incomplete since no botanist accompanied us on the upland.)

Sedge meadows are not uncommon on the plateau, but usually ocur as narrow bands along stream beds. In the wettest areas the most common plants were Carex spp., Dryas integrifolia, Eriophorum angustifolium, Polygonum viviparum, Salix arctica, S. reticulata, and Saxifraga Hirculus.

2.5 COMPARISON OF OBSERVATIONS WITH THE REPORT BY DENNIS JAQUES (ADDENDUM V)

Most of our observations are in agreement with those of Dennis Jaques. His overall description of the vegetation (especially p. 20) agrees with our observations. His LANDSAT computer map is especially useful in distinguishing areas of wetland vegetation from well-drained areas. This makes it valuable for planning purposes. There were just two respects in which we felt the map could be misleading.

1. It leads the reader to overestimate the amount of vegetation on the peninsula. Many of the areas coloured reddish-brown (cushion plant-lichen association, 5%-35% plant cover) are nearly

devoid of vegetation, with scattered individual cushion plants or lichens separated by many metres of barren gravel (See Fig. 2.2-2, Slide 2). Thus we felt that many reddish-brown areas should have been coloured white. However this should not affect mine planning, since Jaques classified the reddish-brown areas as one of the least sensitive units and recommended their use as construction sites. We agree.

Also, areas indicated in yellow (cushion plant-sedge-moss association, 65%-100% plant cover) are actually pockets of cushion plant-sedge-moss association interspersed between raised beaches, with the barren beaches comprising about 50% of the area (See Fig. 2.2-2, and Slide 1). The soil layer in these pockets is probably shallow, with limestone beneath it, but we agree with Jaques that further evaluation is necessary to determine their suitability for construction.

2. Although the computer map identifies areas of sedge meadow accurately, it is innaccurate in distinguishing between areas of high and low biomass within the "well-drained terrestrial vegetation" categories on the Precambrian upland. For example, the Adler deposit and the ridge east of the Borealis 1982 summer camp are coloured yellow ("high cover"), whereas they actually have a plant cover of less than 30% (Slides 14, 23); careful examination reveals that many areas coloured purple ("low to moderate cover") are actually bands along creek beds and in small valleys, in which vegetation is more abundant than on surrounding areas marked in yellow (high cover). Also the large expanses of purple in the area of Deposit C suggest that vegetation is less abundant there than on Adler and B deposits, while in fact the opposite is true. Our observations indicated that areas of "high-cover dwarf shrub-lichen and dwarf shrub-heath-moss association" were considerably less extensive than the areas marked in yellow on Jaques' computer map, and areas of "low-moderate-cover dwarf shrub-lichen association" were much more extensive, at least in the area proposed for immediate

development, than is indicated by the purple on his map. This may have a bearing on mine planning, since Jaques classified purple areas as one of the least sensitive units, while he recommended that yellow areas be "evaluated further and subdivided into low-, moderate- and moderately high-sensitivity units."

We recommended disregarding the distinction between purple and yellow areas on the upland, and instead offer our own observation, from extensive field studies, that all of the upland areas on which facilities are currently planned are "low-moderate-cover," except for some sheltered slopes on the southern half of Deposit B. (This excludes, of course, the highly sensitive sedge meadows, which are identified accurately on Jaques' map. A more detailed description of proposed construction sites is given above in section 2.4, "The Upland and the Iron Deposits.") Another upland area of well-drained "high cover" is near the proposed conveyor belt route. This is a 100 m-wide band of dwarf shrub-heath-moss association along the south side of the Irqalugarjuit River canyon. We have recommended that this be left undisturbed (See Section 2.3, "The Western End of the Peninsula and the Escarpment," above.)

With respect to Jaques' recommendation mentioned above, the only areas of "moderately high sensitivity and limitation to construction" that we observed, within the "well-drained terrestrial vegetation" category, were areas in which the surface material is a thick (approximately 1-2 m) layer of clay. These areas are quite common in the region of the deposits, crusher and mill. They support dwarf shrub-lichen and dwarf shrub associations, are strewn with protruding boulders, and appear dry and hard in dry weather. But when heavy vehicles are driven on them, the ground shakes visibly, revealing that beneath the surface is a thick layer saturated with water. (In one of these areas a hole 42 inches [1.2 m] deep was dug on July 19, 1982, without contacting permafrost.) Some vehicles break through the hard surface layer and become deeply mired in the wet clay below. In the spring these areas are more easily recognized, because the surface lay is wet and slippery. This substrate may be unsuitable for road building, and these areas must be identified and tne problem dealt with in planning roads.

It should be mentioned that Dr. Jaques collected plants in several locations around Roche Bay, some of which are more abundantly vegetated than the development area. Thus, some of the species he found may not occur in the development area.

3. BIRDS

3.1 RAPTORS

3.1.1 Summary

The only raptorial birds recorded in any numbers on or near the Roche Bay development area from 1979 to 1982, as determined from several information sources and the observations of several biologists, are rough-legged hawks and snowy owls. In addition, there were three separate sightings of a peregrine falcon during the 1982 field season. Rough-legged hawks do not nest in or near the development area. Snowy owls may occasionally nest on the Roche Bay Peninsula, but no nests were found there. The mining project in the Roche Bay area should not affect these species.

A careful search was made for raptor nests, using aerial surveys of a large region around Roche Bay. The aerial survey covered an area from just south of Roche Bay and the Ajaqutalik River to just north of the Kingora River, and from the mouth of Roche Bay to about 10 mi (16 km) west of Sarcpa Lake. Also extensive ground surveys were made by several observers within the development area, with some surveys south to the Ajaqutalik River and west to Sarcpa Lake. The only raptors found nesting in the surveyed region were rough-legged hawks and snowy owls.

3.1.2 Rough-legged Hawk (*Buteo lagopus*)

One pair of rough-legged hawks was found nesting west of Sarcpa Lake about 22 mi (37 km) west of the iron deposits. A different nest, about 6 mi (9 km) farther west, was found to be occupied the following year, possibly by the same birds. Another pair of rough-legged hawks nested near where the Kingora River flows into western Hall Lake, about 7 mi (11 km) north of the development area. This pair nested on a cliff at the same location in 1978 and 1981, but not in 1979, 1980, or 1982, according to Jerry Nielson, who was in that area each of those years.

Rough-legged hawks were occasionally seen flying in the development area as early as June 2, and usually near the escarpment where the Roche Bay Peninsula meets the Precambrian plateau.

Very thorough ground and aerial surveys indicated that no rough-legged hawks have nested in the development area, or closer than about 7 mi (11 km) from the development area for more than 5 years. Nor did Inuit hunters know of any nests in the area.

3.1.3 Peregrine Falcon (*Falco peregrinus*)

Peregrine falcons are very rare in or near the development area. Biologists in the Sarcpa Lake area saw no falcons in 1979, 1980, or 1981. Inuit hunters had seen them rarely, if ever, around Roche Bay, although one hunter could indicate where he had seen a single falcon north of Hall Lake, 32 mi (41 km) north of the development area, and another reported seeing one about 50 mi (80km) south of Roche Bay.

We saw none in 1980 or 1981, but on May 28, 1982 one peregrine falcon was observed flying south along the escarpment at the west end of the Roche Bay Peninsula.

By June 15, 1982 observers at Sarcpa Lake, 16 mi (26 km) west of the iron deposits, sighted a flying peregrine falcon.

Chris O'Brien reported peregrine falcons on July 22 and August 5, 1982. Both sightings were made near Deposit C in the southwestern part of the development area. Two sightings were also reported by Borealis personnel working on Deposit B in late July.

Each of these 1982 observations were of a lone bird, usually flying , and they may all have been sightings of the same bird.

As stated above, we found no evidence that peregrine falcons nest in or near the development area.

3.1.4 Gyrfalcons and Eagles

No gyrfalcons or eagles have been observed in or near the Roche Bay development area by anyone interviewed or by people in the area since 1980.

3.1.5 Snowy Owls (*Nyctea scandiaca*)

Snowy owls are common on vegetated parts of the low flat terrain in the general Hall Beach-Roche Bay area.

Our earliest observation of a snowy owl in the Hall Beach-Roche Bay area was on June 26, although some owls probably stay in this area through the winter.

During the summers of 1980, 1981, and 1982, snowy owls were seen rarely on the Precambrian plateau, but one or more were observed on the Roche Bay Peninsula during most aerial or ground surveys. However, no nests were found and no young-of-the-year were observed in the development area.

Snowy owls were observed to be about as common on low ground along the south shore of Roche Bay as on the Roche Bay Peninsula, but they were more common in the area north of Roche Bay to Hall Beach.

The development and operation of the mine and facilities at Roche Bay should have no effect on snowy owls in this area, as these birds adapt to humans, moving vehicles, aircraft, etc. when they come south during the winter, and have been known to nest quite close to facilties at an occupied DEW line station. In any case few if any snowy owls nest in the development area.

3.2 SEA BIRDS: FULMARS, KITTIWAKES, AND ALCIDS

3.2.1 Summary

There are no fulmars, kittiwakes, or alcids regularly occurring in the Roche Bay area except for the black guillemot (*Cepphus grylle*).

> The most distinctive feature of the marine avifauna of northern Fox Basin...was the absence of fulmars, kittiwakes, and alcids (murres, auks, dovekies, and puffins) other than Black Guillemots; in fact all species which are completely dependent on the presence of cliffs for nesting sites.... The nature of the coast in Foxe Basin prevents the sea birds, which require extensive cliff nesting sites, from becoming residents. (Ellis and Evans, 1960).

Our observations confirmed this statement.

3.2.2 Observations

On July 25, 1981 two black guillemots were observed near the mouth of Roche Bay. These were observed during a trip by canoe across Roche Bay near its mouth, and then on to the west end of the south arm of Roche Bay.

These birds nest under or among boulders near shore, and a few could have been nesting along the shore of Roche Bay, although no nests were observed there.

Black guillemots are full-year residents of the Arctic, and winter in polynyas, near floe edges, and wherever there is open ocean water. Inuit from Hall Beach say that some guillemots winter in the general Roche Bay area (probably in the polynya east of the mouth of Roche Bay).

Other species of sea birds (fulmars, kittiwakes and other alcids) are occasionally seen in the Foxe Basin-Roche Bay area, but these are always non-breeders or birds migrating to other areas. Black guillemots are thus the only true seabirds to be found regularly near the development area.

The mining project will have no effect on these species, as long as no harmful pollutants are released into Roche Bay from the mine or from ships.

3.3 GULLS AND TERNS

3.3.1 Summary

Glaucous gulls (Larus hyperboreus), herring gulls (Larus argentatus), Thayer's gulls (Larus thayeri), Sabine's gulls (Xema sabini), and arctic terns (Sterna paradisiaca) were observed in the Roche Bay area, but none nest within the development area in significant numbers.

3.3.2 Observations

The most common species of gulls in the Arctic and in the development area are herring or Thayer's gulls, which could not usually be accurately identified. Two pairs of these birds appeared to be nesting about 3 mi (4.8 km) apart on large rocks in small lakes on the Roche Bay Peninsula. No large colonies were located in or near Roche Bay, although about 30 were nesting about 5 mi (8 km) southwest of Hall Beach, and these were the only gull nesting in the development area.

The first glaucous and herring or Thayer's gulls were observed in the Roche Bay area on June 12, and Sabine's gulls on June 14. Arctic terns were observed first on June 17.

Glaucous gulls were seen occasionally throughout the development area, usually on lower land near the sea.

Sabine's gulls were also observed occasionally within the development area, usually on the peninsula, but they were not observed to nest there. This species was much more numerous north of Roche Bay, and many nested between Roche Bay and Hall Beach.

Arctic terns were observed frequently in the development area, and most frequently on the peninsula. They were occasionally seen in flocks of 50 or more, flying and circling, over the land near sea level as well as over the Precambrian plateau 500 ft above sea level. These flocks were not nesting birds. Several flocks were also seen feeding over the ocean, but not in the western half of Roche Bay. No nests were observed in the development area, but a few arctic terns may nest on the peninsula.

Development and operation of the mine and facilities at Roche Bay should have no negative effects on gulls and terns. Because gulls are scavengers, the presence of organic wastes, garbage dumps, etc. in the Roche Bay area will attract non-breeding birds.

3.4 WATERFOWL

3.4.1 Summary

Waterfowl summering in the Roche Bay area include snow geese (*Chen caerulescens*), Canada geese (*Branta canadensis*), brant (*Branta bernicla*), common eider (*Somateria mollissima*), king eider (*Somateria spectabilis*), and oldsquaw (*Clangula hyemalis*).

Oldsquaw ducks nest throughout the development area each year, and small numbers of snow geese and Canada geese nest there occasionally. Only one nesting eider duck was observed, but many non-breeding eiders of both species were observed in flocks on Roche Bay.

The mining project should have no negative effects on waterfowl, provided that harmful air emissions and water pollution in the area are rigidly controlled.

3.4.2 Observations

a. Prior to Nesting and Open Water. According to interviews with Inuit and wildlife officers the situation with respect to snow geese, swans and ducks in the early spring is variable. In some years there are virtually no snow geese within the development area, but in other years there are many. For example, in 1982 several hundred used Roche Bay as a stopping over area in their migration north.

During the 1982 field season waterfowl were first observed near Roche Bay on May 28, 1982. This group consisted of about 50 greater snow geese and one Canada goose. The group landed briefly on the still frozen small lake south of Irqalugarjuit Lake, where the Roche Bay Peninsula meets the escarpment. Other flocks of geese were flying north over Roche Bay at this time.

b. Greater Snow Goose. On June 1, 1982 about 50 snow geese began feeding on vegetation exposed on the escarpment slope by wind action. Geese were probably feeding there because the snow had been swept away earlier than in surrounding areas.

By June 9 there was still no open water in the development area, but there were now between 200 and 400 greater snow geese, feeding from time to time on exposed vegetation on the escarpment.

By mid-June the number of geese coming to feed had decreased considerably. At this time Hall Lake and Roche Bay remained fully frozen over, as did almost of all the ponds and lakes in the area. The snow cover in most parts of the development area was more than 80%.

By June 21 about 40% of the land surface north of Roche Bay was free of snow, and snow geese were apparently feeding in other areas. After July 3 no more snow geese were seen in the development area, except one pair, which nested near the extreme southwestern portion.

In 1981 snow geese did not stop over in Roche Bay in late winter/early spring as they did in 1982, and as they have in many other years according to Inuit hunters in the region.

c. Snow Goose Nesting. The Roche Bay area was surveyed in 1979, by Reed and Stephansson, and in 1980, 1981 and 1982 by EERCS. No snow geese were observed nesting within the development area in 1979 or 1980. In 1981 six pairs of snow geese nested near Irqalugarjuit Lake in the development area; and in 1982 one pair nested by a lake in or near the southwest corner of the area.

d. Snow Goose Migration. In 1981 and 1982 the few snow geese in the development area had left by the end of August. Snow geese were staging for the fall migration in an area about 8-10 km southwest of Hall Beach, and flocks occasionally flew over the development area.

e. Snow Geese: Comments. From the observations of four years in the Igloolik-Hall Lake-Roche Bay region we can say that snow goose nesting density varies greatly from year to year from one part of the region to another. This is confirmed by the observations of Inuit hunters in the region. In 1980 and possibly in 1979 (based on observations along the north shore of Roche Bay) many snow geese nested between Hall Like and Roche Bay. In 1980, 60 pairs of snow geese were observed with young in this area (Fig. 3.4-1).

In 1980, nortnern Melville Peninsula (the Igloolik area) had a late snow melt, as did parts of adjacent northern Baffin Island. Hence, possibly, the nesting areas that many of these geese were accustomed to use, and were heading for, were unsuitable that year, and the geese were forced to nest farther south than they would have otherwise. Snow geese are known to have changed their traditional nesting areas in similar circumstances elsewhere (R. Kerbes, personal communication).

In 1981 and 1982 the snow melted at a more "normal" time on the lowlands of eastern Melville Peninsula and northern Baffin Island, and the number of snow geese nesting on parts of nortnern Baffin Island and northeastern Melville Peninsula increased, according to the observations of many Inuit hunters of those regions. Also the number nesting between Hall Lake and Roche Bay during those years decreased to about 10 pairs.

The number of snow geese nesting south of Roche Bay also apparently varies from year to year. In 1981 and 1982 between 10

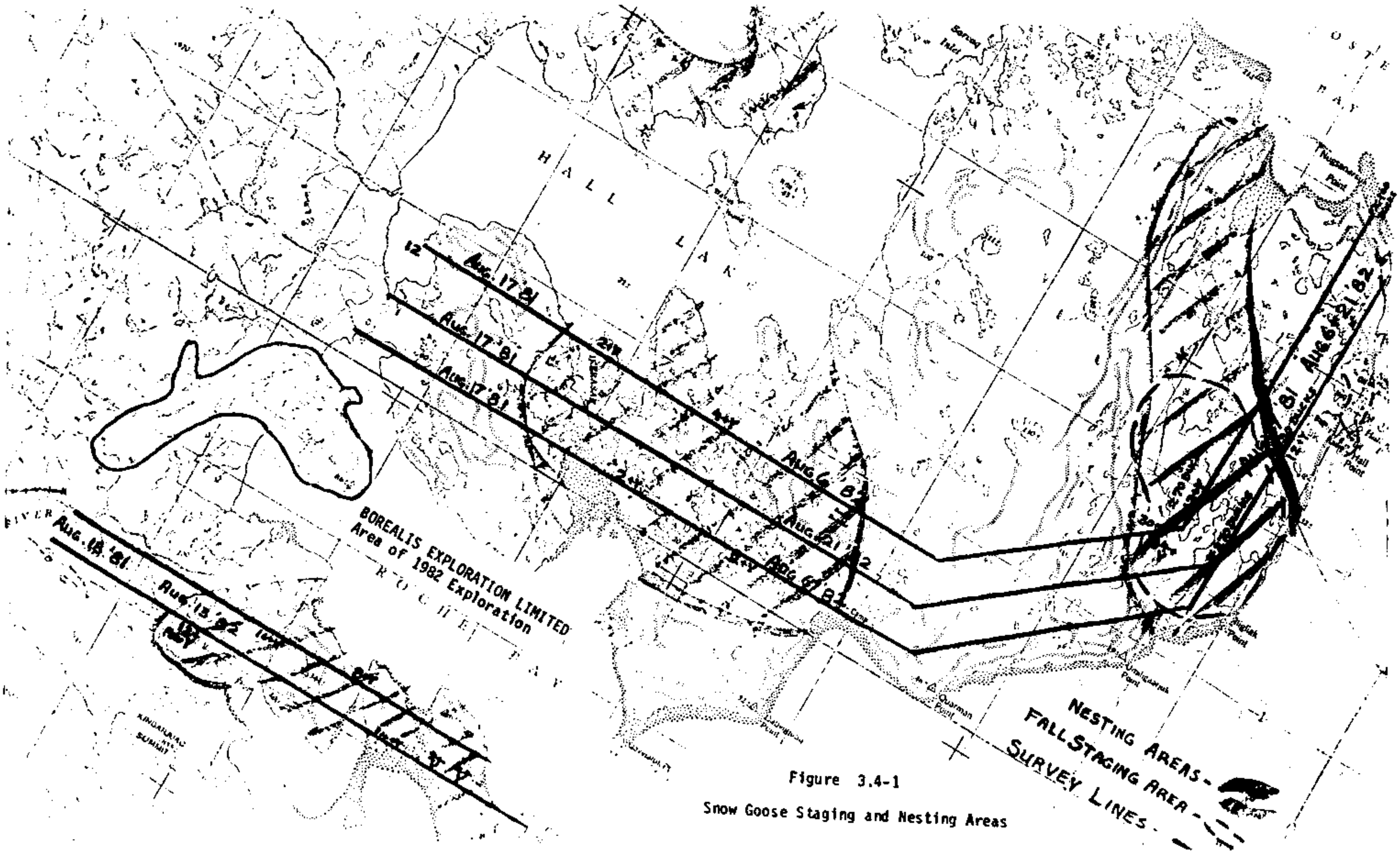


Figure 3.4-1

Snow Goose Staging and Nesting Areas

and 20 pairs nested south of Roche Bay, but one Inuk hunter said that none nested there in 1980.

Thus from four years of observations the number of snow geese nesting in the development area has been very small compared to the number nesting just outside it. This is probably directly related to the relative abundance of suitable vegetation in those areas.

f. Canada Goose. Very few Canada geese nest in or near the development area, and very few geese of this species have been seen near this area, except those flying over it during migration.

In four years of observations only two pairs were observed nesting in the development area. This was in 1981, when a much larger than normal number of snow geese also nested in this area, as discussed above.

g. Brant. The earliest brant observations were in the Hall Beach-Roche Bay area on June 8, when eight landed on a pond near the coast at Hall Beach. Brant were observed on one occasion in the development area, but flew off when an observer approached.

h. Eider Duck. Both common and king eider were observed on the water of Roche Bay in flocks. These birds were non-breeders and numbered in the hundreds or the thousands, usually in large flocks.

No common eiders were observed nesting in the development area in four years of observation, but they were observed nesting near Roche Bay, outside the development area. (One was nesting about 200 m south of the Inuit settlement at Ignertok Point.)

Many king eiders nest near the development area, north and south of Roche Bay, but only one pair was seen nesting within the development area. This nest was on northwestern Roche Bay Peninsula, in a sensitive area, which should not be disturbed by mine development.

i. Oldsquaw. Oldsquaw was the most common species of waterfowl throughout the development area in four years of observation. This species was found nesting near lakes from sea level, on the Roche Bay Peninsula, to the highest parts of the Precambrian plateau near the iron deposits.

In 1982 an oldsquaw nested about 100 m from one of the tents in the summer exploration camp on the plateau.

j. Swan. In 1980 and 1981 up to eight pairs of whistling swans were holding territory near southern Hall Lake. In 1982 two pairs were observed with young near southern Hall Lake. However, this species has not been observed in or near the development area.

3.4.3 Conclusions

The only waterfowl consistently occurring and nesting in the Roche Bay development area are oldsquaw ducks. In four years of observation only a small number of snow geese were seen nesting in the development are from time to time, as well as a smaller number of Canada geese.

The number of oldsquaw occurring and nesting in this area was estimated to be about equal to their general abundance throughout eastern Melville Peninsula. However, for all other species, the numbers occurring and nesting in the development area were much below their numbers both north and south of it.

Many non-breeding eider ducks were found in Roche Bay in summer, but their abundance here was no greater than their abundance near shore in Foxe Basin both north and south of Roche Bay.

From observations of waterfowl reaction to disturbance factors in the development area, and from observations discussed in the I.E.E., the mine development should have no significant disturbing effects on waterfowl, as long as pollution of water is prevented.

The six pairs of snow geese found nesting in the development area in 1981 were in a sensitive area unsuitable for construction. Those feeding on the escarpment in late winter and early spring were also in a sensitive area which should not be disturbed. These geese fed near the early spring exploration camp several times.

Thus, if measures are taken to prevent air and water pollution, the mine should have no effect on waterfowl ecology in the region.

3.5 OTHER BIRDS

3.5.1 Summary

The birds discussed in this section are widely distributed across the Arctic, often from Alaska to Greenland. Some species are occasional visitors to the development area in the course of migrations, and all except one breed in the Arctic. The presence of a mine should have no effect on these species in the development area.

3.5.2 Introduction

The birds observed in or near the Roche Bay development area in 1980, 1981, and 1982 are listed in Table 3.6?.

Some of these have been discussed previously. Observations of the others in and near the development area are given below:

3.5.3 Arctic Loon (*Gavia arctica*).

Arctic loons were observed in the development area in lakes on the Roche Bay Peninsula, or flying over it. Most arctic loons were observed on Irqalugarjuit Lake where up to five were sighted at one time.

None was observed nesting in the development area and those observed were usually in an area that should not be disturbed.

3.5.4 Red-throated Loon (*Gavia stellata*).

Red-throated loons were observed on lakes and flying throughout the development area, including the Roche Bay Peninsula and the Precambrian plateau. This species was the most abundant of the loons in the Roche Bay area, and nested near lakes in all parts of this area.

They normally nest in sensitive areas near lakes, which should rarely be disturbed by development or mining operations. We have observed them nesting near DEW line stations and near frequently used arctic roads and airstrips, so that activity around the mine site should not seriously disturb those nesting in the development area.

3.5.5 Common Loon (*Gavia immer*)

A single individual of this species was observed on a lake in, or very near, the southwest corner of the development area, by Chris O'Brien, who was able to make positive visual identification. This species does not normally occur in this region.

3.5.6 Willow and Rock Ptarmigan (*Lagopus lagopus* and *Lagopus mutus*)

As far as could be determined from field observations, both of these species occur and nest in the development area, on the Precambrian plateau. They also occur on the escarpment, and on the sloping sides of the iron deposits.

They were very uncommon in this area in 1981, and more common in 1982, and droppings indicate that many may winter on and near the escarpment.

Activity around the mine site should not seriously disturb ptarmigan. When on a nest, or with young, female ptarmigan of both species will tolerate the close approach of men and vehicles.

3.5.7 Sandhill Crane (*Grus canadensis*)

On June 26, 1982, four sandhill cranes were observed flying south along the escarpment past the west end of Roche Bay. They circled several times over the west end of the south arm of Roche Bay, calling frequently, and then continued flying south. We never observed this species in or near the development area on any other occasion. Sandhill cranes may migrate past this area but what we observed was not a normal migration flight.

3.5.8 Shore Birds

Of the nine species of shore birds observed in the Roche Bay development area in 1981 and 1982, golden plover and Baird's sandpiper were the most common, and black-bellied plover were quite common. All other species were much less abundant. Species other than those listed may occur in the area briefly during migration.

All species of shore birds known to nest in the development area are also known to nest in other areas where human and vehicle activity is quite frequent, even quite close to their nest sites, so that the development and operation of a mine and associated facilities in this area should have no significant disturbance effect on them, provided that overall environmental effects caused by the release of gaseous, chemical, or dust pollutants are avoided, in accord with existing regulatory mechanisms.

The shore-bird situation in the development area was very similar in 1981 and 1982, except that golden plovers were slightly less common in the area in 1982, and Baird's sandpipers were more common in 1982. This probably resulted from a change in some minor ecological variable, such as the later melt of snow and ice in 1982, compared to 1981, in this area.

a. Semipalmated Plover (*Charadrius semipalmatus*). Semipalmated plovers occurred and nested on the western part of the Roche Bay Peninsula in 1982, and were observed there occasionally in 1981. The nesting observed was in a sensitive area which should not be disturbed by activity or development in this area.

b. Golden Plover (*Pluvialis dominica*). Golden plovers occurred and nested in all parts of the development area, including the Roche Bay Peninsula, the escarpment and the Precambrian plateau. They are the most common species of plover in the development area, and are most noticeably abundant on the Precambrian plateau, the escarpment, and the western part of the Roche Bay Peninsula.

Except for where the Roche Bay Peninsula meets the escarpment, this species appeared to be slightly less abundant in the development area than in the Sarcpa Lake area to the west.

Development and mining activity should not cause a significant change in the numbers or ecology of this species in the development area, as this species occurs and nests in other areas where there is human and vehicular activity before they begin to nest each year.

c. Black-bellied Plover (*Pluvialis squatarola*). Black-bellied plovers occur and nest in the development area mostly on the eastern half of the Roche Bay Peninsula. They are quite common, and usually found near the coast, as they are in much of the surrounding region.

As with golden plovers, mining and development activity in the Roche Bay area should have no significant effect on the numbers or ecology of this species in the development area if the existing regulatory mechanisms that control the release of any significant dust, gaseous or chemical pollution are applied.

d. Turnstone (*Arenaria interpres*). Turnstones in small numbers were observed in the development area occasionally, always on the Roche Bay Peninsula. A very few may have nested in the development area, although this was not observed.

This species is much more abundant just south of Roche Bay.

As this species is apparently occasional in the development area, with no nesting locations known here, all we can say is that their numbers and ecology in the Roche Bay region will not be affected by activity in the development area, if the existing regulatory mechanisms are applied to assure that there are no pollution problems.

e. White-rumped Sandpiper (*Calidris fuscicollis*). White-rumped sandpipers occurred in small numbers throughout the development area, and nested in this area. They were observed all the way from sea level to the Precambrian plateau near the iron deposits.

f. Baird's sandpiper (*Calidris bairdii*). Baird's sandpipers were abundant throughout the development area, from sea level on the Roche Bay Peninsula to the highest parts of the Precambrian plateau near the iron deposits. They nest throughout the development area, and were slightly more abundant in this area than in most other areas examined in this region.

g. Pectoral Sandpiper (*Calidris melanotos*). Pectoral sandpipers were observed rarely within the development area, and those sighted did not exhibit territorical behaviour, so that they were probably non-breeding wanderers.

h. Dunlin (*Calidris alpina*). Dunlins were seen only occasionally in the development area, and in other areas on Melville Peninsula.

i. Red Phalarope (*Phalaropus fulicarius*). A few red phalaropes were observed in the development area mostly on the eastern part of the Roche Bay Peninsula where nesting was observed.

3.5.9 Perching Birds

Horned larks (*Eremophila alpestris*), Lapland longspurs (*Calcarius lapponicus*), and snow buntings (*Plectrophenax nivalis*) were quite common in the development area, and all nest in this area. Horned larks were more common on the Roche Bay Peninsula than on the Precambrian plateau, and snow buntings were more common on the plateau than on the peninsula. The distribution of Lapland longspurs was more uniform.

Water pipits (*Anthus spinoletta*) were sighted near streams on the escarpment and on the Precambrian plateau.

3.5.10 Raven (*Corvus corax*)

A pair of ravens nested on a cliff that was the side of a narrow deep canyon, above a waterfall, in the development area in 1982. This nest was found in the summer of 1981, and ravens were seen flying near it on at least one occasion.

In 1982, they nested here in late winter, and the nest contained three or four small young on May 26. At least three young were successfully reared by these ravens in 1982.

These ravens were the only ones seen in the development area in 1981 and 1982, although others were occasionally seen flying near it. Their nest may be used annually by ravens.

A settlement or development producing organic wastes in any quantity usually attracts ravens, which are scavengers.

3.5.11 Jaegers

Parasitic and/or pomarine jaegers (*Stercorarius parasiticus*, *Stercorarius pomarinus*) and long-tailed jaegers (*Stercorarius longicaudus*) occur in the development area, mainly on the peninsula. The last are the most common, and nest on the peninsula.

Most sightings of jaegers within the development area were on the peninsula, in both 1981 and 1982. Long-tailed jaeger were common there. They appeared to be evenly distributed all over the peninsula, and nested there. The first sighting of a nest was on July 8, and nests were later found on all parts of the peninsula.

It is difficult to distinguish between parasitic and pomarine jaegers in their summer plumage; one or both species were seen. They were seen only occasionally, and there is no evidence that they nest in the development area. However, pomarine or parasitic jaegers were observed nesting just north of the mouth of Roche Bay in 1981.

Long-tailed jaegers occur north and south of Roche Bay with about the same frequency. Thus, jaegers are at least as common elsewhere in this region as in the development area.

Observations in other areas indicate that mining and development should not be a significant disturbance to these species.

Table 3.6: Birds observed in the Roche Bay development area or on the adjacent sea water in 1980, 1981, and 1982

Species	X, nesting in development area, or date of earliest observation of nesting in development area	Abundance in development area A, abundant C, common O, occasional R, rare	Abundance in development area relative to other areas within 80 km of Roche Bay
Arctic loon	-	O to C	less to equal
Red-throated	July	C to A	equal
Common loon	-	R	?
Black guillemot	-	O	?
Canada goose	X	O	less
Brant goose	-	O	less
Snow goose	X	O	much less
Oldsquaw duck	July 20	C	equal
Common eider	?(nesting near)	O to C (on ocean)	less (on ocean)
King eider	Aug. 8	C to A (on ocean)	less to equal (on ocean)
Rough-legged hawk	-	O	less
Peregrine falcon	-	R	less
Snowy owl	-	O to C	less
Willow ptarmigan	X	R to O(but more may come in winter)	less
Rock ptarmigan	X	(as above)	less
Sandhill crane	-	R (flying over)	?
Semi-palmated plover	X	O to C	less to equal
Golden plover	July 8	C to A	less to equal
Black-bellied plover	July 8	C	equal
Turnstone	?(probably)	O	less
Pectoral sandpiper	-	R	?
White-rumped sandpiper	X	O to C	much less
Baird's sandpiper	June 26	A	equal to more
Dunlin	-	R to O	?
Red phalarope	X	O	less
Pomarine jaeger	-	R to O	less
Parasitic jaeger	-	R to O	less
Long-tailed jaeger	July 8	C to A	equal
Glaucous gull	-	O	less
Herring gull	X	C to A	less to equal
Thayer's gull	X	C to A	less to equal
Sabine's gull	-	O	much less
Arctic tern	?	O	less
Black guillemot	-	O (on ocean)	less
Horned lark	June 26	C	equal
Raven	May 26	O	less to equal
Water pipit	X	O	less to equal
Lapland longspur	X	C to A	equal to more
Snow bunting	X	C	less to equal

4. CARIBOU

This section is lengthy and detailed because of the great importance of caribou to the local Inuit, both as a food resource and as essential to the preservation of the Inuit culture.

4.1 INTRODUCTION

In summary the caribou situation in the Roche Bay area is as follows:

1. The immediate Roche Bay area, including the area to be developed as a major iron mine with related facilities, is of little importance to caribou or to the Inuit as a region for caribou hunting.

2. In winter caribou are distributed mainly to the south and north of Roche Bay, with a few occurring just south of the mine site. A very few occur occasionally in the development area.

3. In spring female caribou are in calving areas at least 40 mi (65 km) from the development area. A few other caribou move into the development area, the number present at any one time varying from approximately 5 to 35.

4. Fewer than six caribou occur in the development area on any given day in the early summer, but this number increases to about 20 as fall approaches. These caribou appear mostly in the southwestern part of this area but spread more eastward in fall.

5. Although a few caribou can be found passing through the mine site area at any given time of the year, the only apparent

"migrations" in the development area occur in early spring and in fall, when a few juveniles and young males travel slowly through. A very few pregnant females occasionally travel through the area in early spring. The number of caribou passing through the mine site area appears to be less than 100 annually, in groups of 15 of less.

6. The main factor determining caribou distribution and abundance in this region is the distribution and abundance of the types of vegetation preferred by caribou. The low number of caribou in this area, which is also low relative to the number of caribou occurring in other areas north and south of Roche Bay, is a reflection of the scarcity of preferred vegetation types in the mine site area, relative to the quantity of preferred vegetation elsewhere.

7. Based on all the data available from caribou surveys on Melville Peninsula from 1972 to 1980, and our surveys in 1981 and 1982, it is estimated that roughly between 5,000 and 15,000 caribou can be found on the eastern half of the entire Melville Peninsula throughout the year. Our studies indicate less than 100 entering the Roche Bay development area through the year. Rough estimates of caribou numbers within the development area were obtained by multiplying the maximum and minimum number of caribou observed on any days during each seasonal time period by a ratio of: the area of the development area (66 sq km), divided by the approximate area observed on any day's surveys, while taking vegetation distribution and abundance into account.

8. At present, it appears that the development and operation of a mine and related facilities in the Roche Bay area should have little or no effect on the caribou situation in that area. Evidence indicates few caribou will be affected in any case, and that these few caribou can adapt to much or all of the development and operation of the mine, as long as they are not harassed there.

4.2 VEGETATION AND ITS INFLUENCE ON CARIBOU DISTRIBUTION

Studies of the vegetation of the Roche Bay area were conducted by EERCS, B. Tipping, and D. Jaques. Vegetation is probably the main factor governing the distribution of caribou, since most caribou occur mainly where their preferred food species are most abundant and most readily available during each season of the year.

Most vegetation types preferred by caribou (i.e. the vegetation of known winter ranges, and places where caribou were seen most frequently in summer) were found to be less extensive and abundant in the proposed development area than in areas north and south of Roche Bay, in the Ajaqutalik River valley, and around Sarcpa Lake (20 km west of the mine site).

Caribou abundance and distribution in the immediate Roche Bay development area is proportional to the distribution, abundance, and availability of preferred vegetation types there. Thus caribou were found mainly in the southwest corner of the development area and, in early spring and late fall, in the well-vegetated area where the Roche Bay Peninsula contacts the Precambrian plateau.

4.3 CARIBOU NUMBERS AND DISTRIBUTION

4.3.1 Population of Caribou in Southern Melville Peninsula

Surveys to determine the caribou population of southern Melville Peninsula have produced widely varying estimates (see I.E.E.). Some of the variation can be accounted for by the fact that some of these surveys covered only a small area, and other surveys based their calculations on unconventional assumptions. Considering the two most recent government sponsored surveys, 1976 and 1980, we see that by a careful examination of the data, the results of the studies are not so varied as they might at first appear.

From the data obtained by the 1976 survey, using the number of calves observed, increasing this by 10% to account for the number of females which had lost their calves or had not yet given birth, then increasing this number by 20% to allow for caribou on transect that were missed by observers, the approximate number of maternal females on the large southern Melville calving area is obtained.

Using this number of females with the population proportions used in the 1976 survey report, the population estimate is about 11,000. Using this number of females with the population proportions calculated from our observations of other eastern Arctic calving areas over 15 years, the population estimate is about 16,000 caribou for southern Melville Peninsula.

A survey in the same area in 1980 by the N.W.T. regional biologist for Keewatin estimated a population about 10,000 caribou for southern Melville, which is quite similar (considering the allowance for error in these surveys) to the estimate based on the actual number of calves observed in the 1976 survey.

4.3.2 Population of Caribou in the Development Area

In any case, the Roche Bay development area is in a region where up to 6,000 caribou may occur (mostly south of Roche Bay), but our observations as well as information obtained from Inuit in the area indicate that fewer than 100 enter the development area each year.

As indicated elsewhere, the development area is relatively barren of vegetation as well as of caribou compared to areas south or even north of it.

The immediate Roche Bay area, and particularly the area to be developed for the Borealis iron mine and related facilities, is of little importance to caribou. This conclusion is based on:

1. aerial surveys in the Roche Bay area in late summer, 1980;
2. thorough studies from late winter/early spring to fall/early winter in 1981 and 1982;
3. information provided by several Inuit who frequently camp and hunt in the Roche Bay area.

Our studies also indicate that the caribou situation in the Roche Bay area has been quite constant over the last three years in terms of the number of caribou occurring there and seasonal changes in their distribution and numbers.

The main reason why the immediate Roche Bay area is of little importance to caribou is, as mentioned above, the relative scarcity of preferred vegetation in most parts of that area.

Observations of the small numbers of caribou in the immediate Roche Bay area indicate why this area, including the mine site is of little importance to Inuit hunters relative to other areas nearby. If Inuit of this region (particularly from Hall Beach or Ignertok Point) wish to harvest caribou, they usually go to the coastal area well south of Roche Bay or, in winter, north of Roche Bay to the Hall Lake area. Some Inuit occasionally hunt caribou in the Ajaqutalik River Valley just south of the mine site, mainly in late summer and in winter. The vegetation in these areas is much better for caribou, and caribou are therefore much more abundant in these areas than in any part of the mine site area.

a. Winter. Most caribou on eastern Melville Peninsula winter along the east and southeast coast of southern Melville, north to about 5 mi (8 km) south of Roche Bay. This has been the situation for more than 30 years, according to all previous surveys, wildlife officers on Melville Peninsula, and many Inuit of the region.

However, in the last five years caribou in numbers significant to the people of Hall Beach have been wintering just north of Roche Bay, generally in the Hall Lake area. According to older Inuit, caribou once wintered in that area in significant numbers, but stopped wintering there about 40 years ago. Occasional caribou began to reappear in winter in the early 1970s and they have begun to occur in significant numbers south and east of Hall Lake since about 1977.

A few caribou are also found in winter in part of the Ajaqutalik River valley, which lies just south of the mine site, and these animals are hunted mostly by Inuit from Hall Beach or Inuit travelling between Hall Beach and Repulse Bay.

Thus, although Roche Bay lies between the two major winter ranges in this region, few caribou are found in the development area itself during winter, according to local Inuit. This is not surprising in view of the relative scarcity of vegetation.

Inuit say that a few caribou sometimes occur in winter on the escarpment where the Precambrian shield meets the Roche Bay Peninsula or at the base of the peninsula itself. Simeonie Irqittuq reported that he once saw 15 caribou in that area at one time.

Information on caribou from mid-September to late May was based on interviews. No field research was done by EERCS between mid-September and late May; hence, we have no direct observations of winter distribution. This is an area that was well observed by Inuit hunters and the interviews were extensive, and we feel that this information is reliable.

b. Late Winter and Early Spring (Late May and June). In the Roche Bay development area, caribou were usually found on the Precambrian plateau at this time, mainly in the southern part of the development area. A few occur at times through the northern part of the mine site area, and occasionally, a few (up to five at one time) were observed where the Roche Bay Peninsula meets the Precambrian plateau. Caribou were using this contact zone in late May and early June, when some vegetation was exposed by wind and the snow had begun to soften.

From frequent travelling throughout the development area, and several aerial survey flights over all or part of it in 1982, we estimated that the number of caribou occurring throughout the development area during that period varied between roughly 5 and 35. These caribou were located mostly in the southern half of the mine site area.

In 1981 no pregnant female caribou or new calves were observed in, or within, 40 mi (64 km) of the development area after we first arrived on June 13.

On June 2, 1982 a pregnant female was observed where the Roche Bay Peninsula meets the Precambrian plateau. It went west up onto the plateau and disappeared from view. On June 8 two pregnant females were observed in this same area. Another observer, Chris O'Brien, said he also saw two pregnant females in the area just west of the south arm of Roche Bay at the end of May and in early June, possibly the same two. Because caribou calve from about May 30 until July 3, with most caribou calving during the second week in June, these two caribou must have been close to calving. However, no calves were seen in the Roche Bay development area until August 10, 1982, when a cow and calf were observed west of the development area. In 1981 the first caribou calf sighted near the development area was observed on July 7, about 5 mi (8 km) west of the iron deposits. The first calf to enter the development area was observed on the western side of the iron deposits on August 26.

To recapitulate, in 1981 only one cow with calf was observed in the development area before the end of the field season in September. In 1982 three cows with calves were observed all near the southwest edge of the area.

Thus no caribou have been calving in or near the development area, and very few pregnant female caribou pass through the development area en route to calving areas, at least after late May.

Calving areas: The nearest edge of the main caribou calving area for Melville Peninsula is located 40 mi (64 km) from the southwestern edge of the iron deposits. The calving area is a very large area, covering about 11,125 sq km (about 4,345 sq mi) according to a survey in 1976. This southern calving areas is just west of the major winter range near the east Melville coast, and most if not all caribou that go to this calving area are probably from south or west of the Roche Bay area.

Until 1981 this southern calving area was thought, in the literature, to be the only calving area on Melville Peninsula. In 1981, however, EERCS discovered two previously unknown calving areas in northwest Melville Peninsula. (Note that a very late snow melt on the uplands of Melville Peninsula in spring, 1982, caused a significant change in the northern calving area locations and in the caribou movements northwest of the Roche Bay area.) One of these nearest to the Roche Bay development area is northeast of Garry Bay, about 50 mi (80 km) away. The other is farther north of the Garry Bay calving area. This calving area appears to be used mainly by caribou wintering near the western

Melville Peninsula coast, but it might also be used by females wintering north of Roche Bay if there are any such females. For caribou wintering on the winter range north of Roche Bay, the distances to the Garry Bay calving area and the southern calving area are about equal. It is not known whether any pregnant females winter north of Roche Bay, and if so, which calving area they use. However, the Roche Bay development should have little or no effect on them in any case, for the following reasons:

The Inuit say that the caribou wintering north of Roche Bay travel west in late winter. They apparently remain in this area through March and April, but we found that they had all left by late May 1982. If there are pregnant female caribou wintering north of Roche Bay, and if they go west to the Garry Bay area in the north, they will not pass through the Roche Bay development area. If they go to the south Melville calving area, then the observation that they go west in late winter, and the fact that some Inuit hunters go west of Hall Lake to the Sarcpa Lake area to hunt caribou in late winter and early spring, together with the scarcity of caribou in the Roche Bay area in late winter and early spring, indicate that most or all caribou wintering north of Roche Bay must go as far west as Sarcpa Lake before going elsewhere. Thus, activity in the Roche Bay development area would have little or no effect on caribou wintering north of Roche Bay, no matter which calving area they use.

c. Summer and Fall/Early Winter. During the first half of the summer (July) there were very few caribou in the development area, fewer than six at any one time. These appeared to be juveniles and younger adult males. They were observed only on the Precambrian plateau. They were generally scattered over this area, but occurred most often in the southwestern part, where the greatest abundance of preferred vegetation is found.

In the two years of observations the numbers of caribou observed increased toward late summer. In August 1981 roughly 4-15 caribou were present at any one time. In 1981, the increase in numbers was first seen west of the development area as early as July 7, but an increase within the development area was not evident until mid-August.

In 1982 the number of caribou observed in the development area began increasing noticeably on August 10 and continued increasing to the 1981 level or higher by August 23. The final number (roughly 4-20) remained in this general area until the end of the field season (mid-September).

In the summer of 1981 the first caribou to go east onto the Roche Bay Peninsula was a male on July 21. At least two other caribou, one- or two-year-old animals, went onto the peninsula in late August.

In 1982 adult male caribou were observed on the low flat land north of Roche Bay on August 22, and what appeared to be fresh tracks of one caribou were observed on eastern Roche Bay Peninsula on August 31. On September 6, two young males were observed on the western part of the peninsula.

Thus, evidence indicates that for the most part the small number of caribou in the development area in spring leave this area, but, by late summer, a few caribou come into the area again, mostly from the west or southwest. Through the summer and fall most caribou in this area were observed in the southwestern part, where their preferred vegetation is more abundant. A few of these caribou continue moving east, going onto the Roche Bay Peninsula by fall.

According to Inuit of this region, a few more caribou move onto the Roche Bay Peninsula by early winter, and Simeonie Irqittuq considered it significant that he saw a group of 15 caribou at one time on western Roche Bay Peninsula in October, 1981.

Several Inuit who hunt in this area (including Simon Nattaq, past president of the Hall Beach Hunters and Trappers Association, and Joe Curley, Mayor of Hall Beach) said that in the last five years caribou have been coming east into this area in late September and October, basically following the richly vegetated Ajaqutalik River valley along its most easterly 5-10 mi (8-16 km). Consequently, more caribou are found near the coast around Roche Bay at this time than at any other time of the year.

Then, in October, some of these caribou go north or northeast, through or past the development area, they say, travelling to the wintering area south and east of Hall Lake. When the ice on Roche Bay becomes solid, some caribou go north or northeast across the ice.

As discussed above, very few of the caribou in the development area in the summer are cows with calves.

Thus, it appears that small numbers of caribou will tend to come into the develpment area during the summer, past the mine site. If they are not harassed, they will probably adapt to the disturbances as well as caribou have adapted to DEW line stations in this part of the Arctic, and as well as caribou adapted to drilling rigs and associated noise and activity in this area in 1982 (as discussed below).

In any event, caribou are more abundant during summer and fall south of Roche Bay, north of the mine site area (west of Hall Lake), and 10 mi (16 km) west of the mine site than within the development area itself, according to Inuit hunters interviewed and our own observations.

4.4 MIGRATIONS

4.4.1 Present Patterns

As discussed above, most caribou moving through the Roche Bay development area are juveniles and males in small numbers. They move very slowly, and often linger in or near the area for many days. A very few pregnant females (two or three) were observed in the area in the beginning of the calving period in 1982, but they moved on, apparently westward.

The main direction of caribou movement through or near the development area is toward the west, northwest and north (mainly northwest) in spring, and toward the northeast in the fall.

In mid-June, 1981, there was a movement of male and juvenile caribou northwestward across the Ajaqutalik River and past the development area. These animals were generally scattered or in small groups, and very few of them (about 30) travelled through the development area, mostly the southwestern corner. A few animals travelled north along the escarpment up the west coast of Roche Bay, fewer than 20, as indicated by their tracks. The situation was probably similar to the spring of 1982, when up to 35 caribou were lingering in this area, while moving slowly west or northwest.

In the late summer and fall a few caribou (possibly about 20 or 30) again travelled slowly into or through the area, apparently coming from the west.

Then in September and October, as mentioned earlier, caribou move into, or very near, the development area, basically from the west. Some of these then go north, through or near the development area, a few of them travelling across the ice on Roche Bay. One old Inuk reported that about 50 years ago there was a regular annual migration in early winter across the ice of

Roche Bay, in the other direction, from the wintering area north of the bay to the wintering area south of it. Caribou are again wintering north of Roche Bay, but at present there is no southerly migration across the ice of Roche Bay.

4.4.2 Effects of the Development on Migration

At present, the number of caribou migrating through the development area is small; hence, the mine and associated facilities, as planned, will not interfere with any major caribou migrations.

These developments may discourage the small number of caribou that travel a route that passes under the proposed elevated conveyor line in the early spring or in the fall/early winter. There has been a significant amount of research on the effects of such structures on caribou, and the literature was discussed at length in the I.E.E. Caribou have been tested with simulated raised pipelines, and 6% were found, on first contact, to go under them, and 12% over them on overpasses. Unfortunately most tests were not continued long enough to indicate the rate of adaptation of those caribou that avoided these structures when first exposed. Also these simulated pipelines were silent with no moving parts, unlike the proposed conveyor. However in the I.E.E. we also discussed the adaptability of caribou to man-made disturbances, mentioning observations such as that of a wild caribou going into an abandoned large metal building in the Arctic and others grazing very near a flapping wind sock, heavy equipment at work, or large aircraft landing and taking off. Caribou do adapt to these situations, provided that they are not harassed.

Thus, while the reaction of caribou to the overhead conveyor system cannot be predicted with confidence, the indications are that caribou will adapt to the development. In addition, it should be noted that the total number of caribou affected will be small. The evidence indicates that the mine and facilities will influence the travel routes of less than 100 caribou each year and if any caribou cannot adapt to the mining operation, they can avoid it by making a minor detour in their travels.

4.5 CARIBOU DISTURBANCE RESULTING FROM 1982 DEVELOPMENT WORK

In the I.E.E. we listed the structures and human activities that will likely be present during the construction and operation of the Roche Bay development. We also discussed previous research and personal observations of the reactions of caribou to such disturbances, and their apparent adaptability to such things. That discussion needs no amendments except to add a comment on the reactions of caribou to the summer exploration program of 1982.

In 1982 caribou were sighted in the development area nearly every day of the summer project, in spite of eight large and small motor vehicles moving daily, frequent low flights by small fixed-wing aircraft and helicopters, a camp housing 25-35 people, operation of a pneumatic drill for several hours each day, the steady operation of one or two large diamond drills, and daily loud blasting in the area. Some caribou remained for several days on or near the iron deposits, where the diamond drilling, pneumatic drilling, and blasting was occurring. One of the groups of caribou included two cows with new calves. At least one caribou approached to within a few yards of the diamond drill, in spite of its continuous loud noise, and remained close to it for several days, apparently licking the calcium chloride drilling salt that was nearby.

Because caribou in this area apparently tolerated the loud blasting, they may also tolerate the blasting in the mine.

It should be noted that more caribou came into the development area during the summer program in 1982 than in the same period in 1981, when there were very few people and no ground vehicles or machinery operating in the area.

4.6 RECOMMENDATIONS

The mine and related facilties as presently planned should have little if any effect on the caribou situation in the Roche Bay area, as long as three conditions are met:

1. The few areas of preferred vegetation within or near the development area are left largely intact, by minimizing physical damage to them as well as pollution in the form of liquid or fine dust particles.

2. Harmful gaseous emissions are minimized, to avoid damage to surrounding areas of more abundant vegetation.

3. There is no harassment or hunting of caribou within or near the development area. "Wild animals are as wild as we teach them to be" (Valerius Geist). In any area where caribou are hunted by people, the caribou will learn to avoid all signs of people, as they do near arctic settlements. But in areas where caribou are not harassed, they quickly adapt to people and all manner of activity, machinery, and structures, as they do around DEW line stations, where they are not hunted.

5. MARINE MAMMALS

5.1 SUMMARY

Interviews with Inuit hunters revealed that in the last 5 years:

1. the only sea mammals occurring in Roche Bay through the winter have been ringed seals;

2. bearded seals and walrus sometimes have come into the mouth of Roche Bay in August, September, and October;

3. bearded seals and walrus have been common in Foxe Basin near Roche Bay;

4. beluga whales, narwhals, and possibly bowhead whales have only occasionally come near Roche Bay.

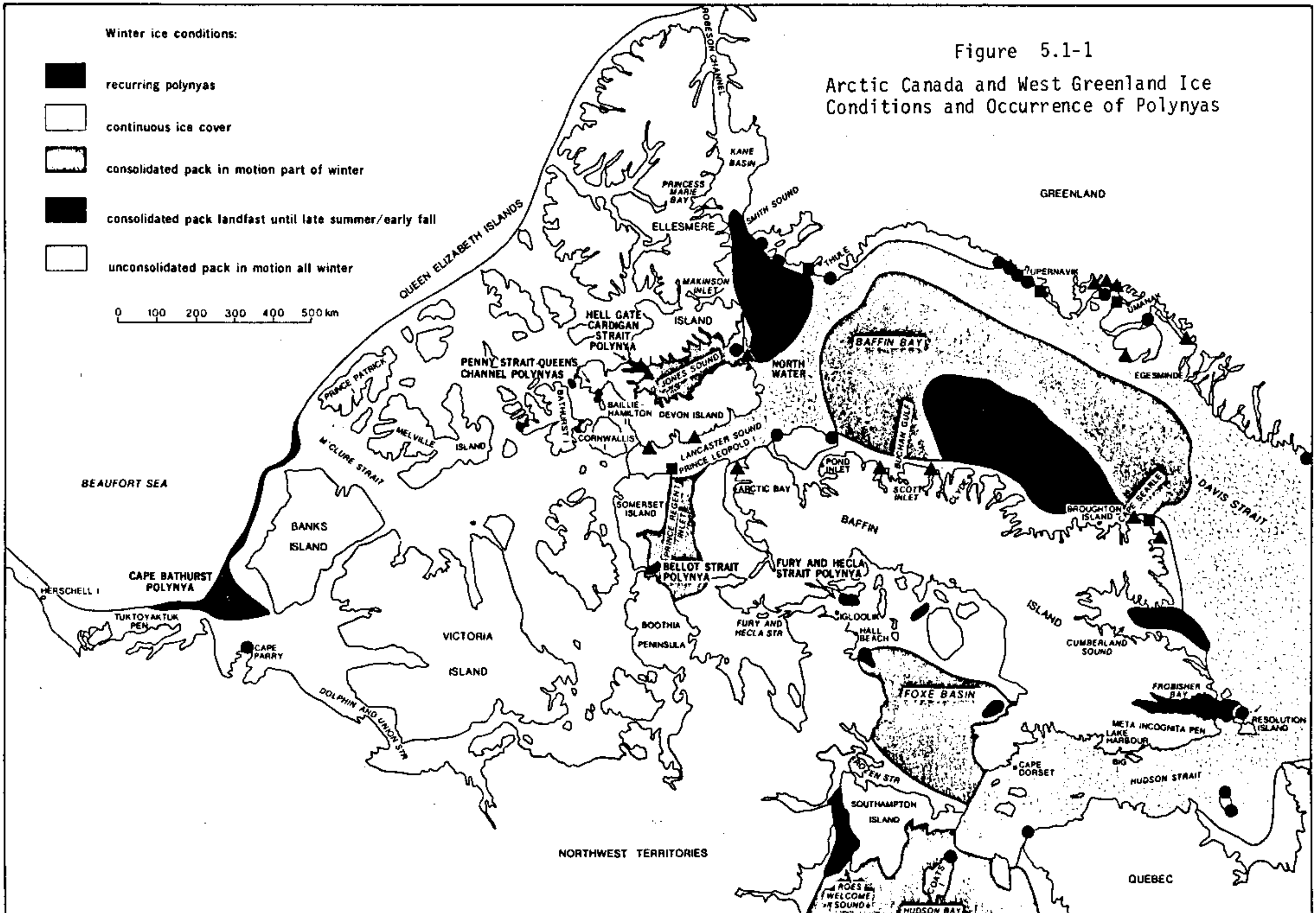
5.1.1 Historical Patterns

In the past, beluga whales did come into Roche Bay occasionally to feed, according to one old Inuk hunter, but many Inuit and two Wildlife Officers say that beluga whales have not come into Roche Bay in many years.

In the last four years, narwhal have been travelling past the mouth of Roche Bay, probably at a distance of more than 7 km east of the mouth, in late July. Before 1979 this did not occur, and sightings of narwhal in western Foxe Basin were apparently uncommon.

Figure 5.1-1

Arctic Canada and West Greenland Ice Conditions and Occurrence of Polynyas



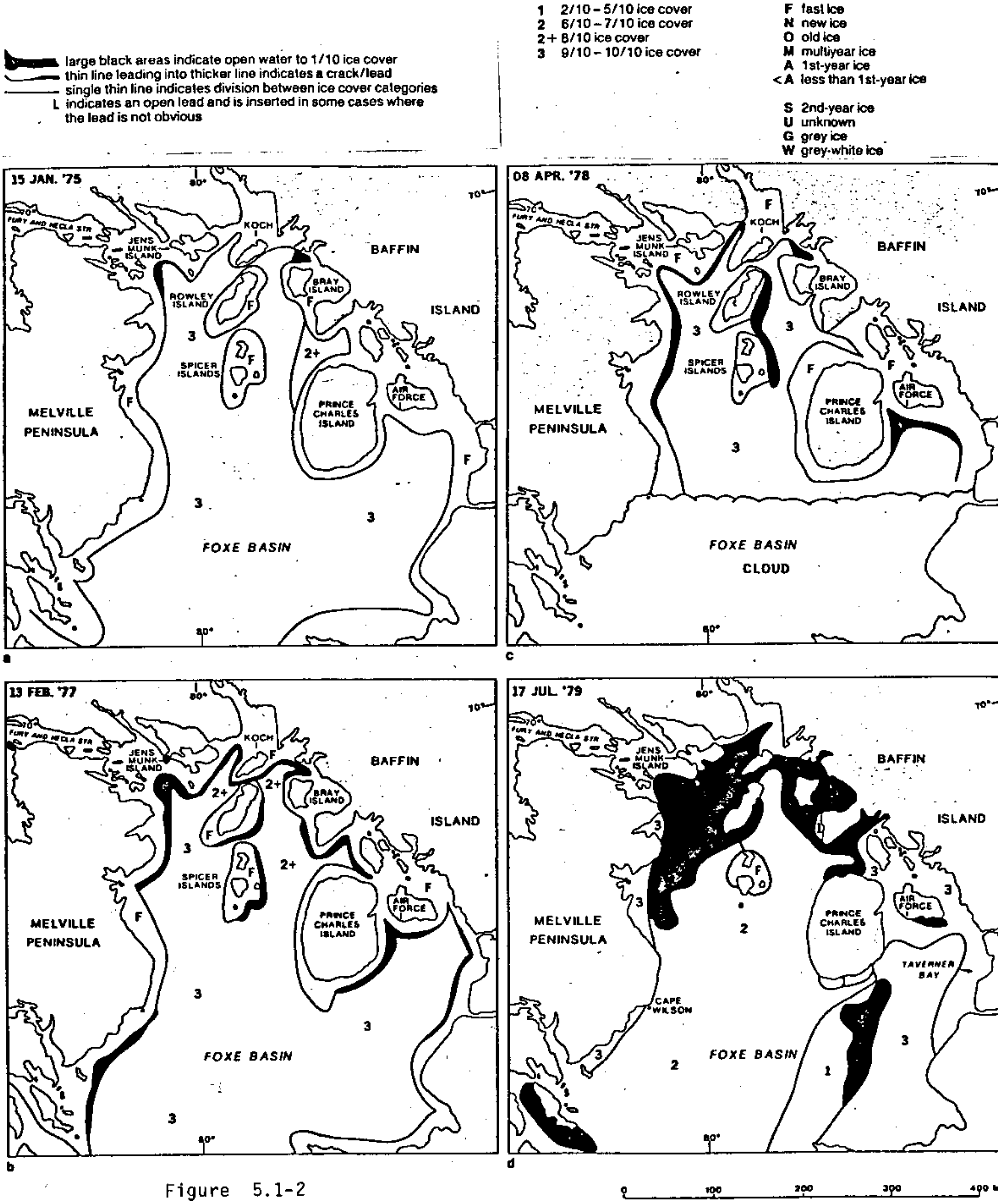


Figure 5.1-2

Maps of the Foxe Basin Polynyas, Showing Ice Conditions during Particular Months and Years as Indicated

Bowhead whales have been observed occasionally in Foxe Basin, but almost always more than 25 km from the mouth of Roche Bay. However, one Inuit hunter said a large whale was seen in Roche Bay in about 1978. It appears that on very rare occasions large whales come into other bays in the area; for example, a large whale was seen in the mouth of Foster Bay, north of Hall Beach, in 1973. Such bays are not the usual habitat of large whales.

5.1.2 Influence of Ice Conditions on Sea Mammal Distribution

As indicated in the I.E.E., sea mammal distribution in the Arctic is largely dependent on sea ice conditions. Because large bays contain the most stable, long-lasting sea ice, they are often favourable habitats for ringed seals, but not for other species. This is because ringed seals are adapted for living under extensive areas of unbroken ice. They systematically maintain breathing holes through such ice. They can thus overwinter in much of the Arctic that is inaccessible to other marine mammals except in summer (A. W. Mansfield, personal communication).

Other sea mammals such as bearded seals, walrus, and whales are dependent on broken ice conditions and/or open water for their survival. They live and feed in areas of moving ice and open water, and thus are seen in Roche Bay only in August, September, and October. In winter these sea mammals are found in larger water bodies where the ice is less stable, or at polynyas (areas of open water surrounded by ice; See Fig. 5.1-1 and Fig. 5.1-2).

Thus, while ringed seals inhabit Roche Bay all year, bearded seals, walrus, and any whales in the area can occur there only in late summer or fall when the bay is mostly ice free. During the rest of the year these species are most abundant near the polynya that extends past the mouth of Roche Bay. (See the discussion of polynyas below.)

5.1.3 Species Which May Be Affected

The only sea mammals likely to be affected near the development area are the ringed seal. Other sea mammals, including bearded seal, walrus, beluga whale, and narwhal may be affected along the shipping route (See Table 5.1-1).

5.2 RINGED SEALS (*Pusa Hispida*)

5.2.1 Introduction

In some years ringed seals den in Roche Bay, but this situation is extremely variable. For example, in 1981 and 1982 there were no ringed seals or very few denning in Roche Bay. Similarly, the number of ringed seal during other parts of the year varies. Some years they are quite common and other years they are rare.

5.2.2 Factors Affecting Denning

The suitability of an area such as Roche Bay for ringed seal denning is based on several factors that vary from year to year. Hence, the abundance of ringed seals in Roche Bay, and the abundance of baby seals, would be expected to vary considerably from year to year. Interviews with Inuit hunters confirmed that this is the case. While Roche Bay has been noted for its abundance of ringed seals in some years, very few seals are found there in other years. In 1981 and 1982, ice on Roche Bay was smooth, with relatively shallow snowdrifts, and as expected, seal hunting was poor on Roche Bay in both those years.

Other factors currently unknown may also cause fluctuations in ringed seal distribution. While the abundance of ringed seals in June is usually determined by the amount of fast ice present in an area (McLaren, 1958, 1966), it was noted in a later publication that ringed seal numbers vary considerably from year

Table 5.1-1: Marine mammals known to occur in or near Roche Bay

Part I: Mammals occurring in Roche Bay

Species	Denning in Roche Bay	* Abundance in Roche Bay	Abundance in Roche Bay relative to other areas within 80 km
Polar Bear	-	R to O	equal?
Ringed Seal	some years	O to C	variable
Beluga Whale (possibly)	-	very rare	less

Part II: Mammals occurring in the mouth of Roche Bay

Species	Denning in the mouth of Roche Bay	Abundance in the mouth of Roche Bay	Abundance in the mouth of Roche Bay relative to other areas within 80 km
Polar Bear	-	R to O	equal?
Ringed Seal	some years	O to C	variable
Beluga Whale (possibly)	-	very rare	less
Bearded Seal	-	R	less
Walrus	-	R	less

Part III: Mammals occurring in Foxe Basin near Roche Bay

Species	Denning near Roche Bay	Abundance near Roche Bay	-
Polar Bear	-	R to O	
Ringed Seal	some years	C to A	
Beluga Whale	-	R to O	
Bearded Seal	maybe	O to C	
Walrus	maybe	O to A	
Narwhal	-	R to O	
Bowhead Whale	-	very rare	

* A- abundant
C- common
O- occasional
R- rare

to year in a given area, even when sea ice and snow conditions are the same.

While Roche Bay is important to Inuit as a hunting spot for ringed seals and baby seals ("silver jars"), it is no more important than Foster Bay and the two bays south of Roche Bay, which also contain seal dens in abundance in some years. This sort of annual variation in seal denning patterns is probably common in the many bays on eastern Melville Peninsula.

For ringed seals the main factors necessary for successful denning are:

(1) ice that remains stable well into June;

(2) snowdrifts deep enough to provide a den on top of the ice.

Both of these factors can vary from year to year in any given location, and in fact do vary in Roche Bay.

Deep bays like Roche Bay provide the necessary stable land-fast ice in most years, but snow conditions on the ice vary.

In areas where ice conditions are normally adequate for denning, pairs of breeding seals remain throughout the winter, maintaining territories and breathing holes with the intention of building dens and raising young. However, if the snow conditions on the ice are not adequate, most seals recognize this and leave before their young are born in April.

The depth of snowdrifts is determined by three factors which can vary from year to year: snowfall, winds, and breakup of new ice in early winter, usually by storms. The breakup of new ice enhances snow drifting by creating a rough ice surface. In fact, ship traffic in early winter should be of benefit to the seals by breaking up the new ice, providing a rough ice surface to make the snow drifting conditions better for denning.

In the years when ringed seals den on Roche Bay, they could be negatively affected by any shipping that occurred before spring breakup.

5.2.3 Shipping and Ringed Seals

Borealis will ship only during the open water season. That is, shipping will not begin before the ice goes out of Roche Bay in the spring, and therefore there should be no interference with seal denning. It is possible, however, that shipping noise, per se, could disturb seal mammals in other ways, and this is discussed in greater detail below.

5.2.4 Conclusions

Except for the possible negative impact of shipping noise, which will be discussed below, the Borealis operation should not interfere with sea mammals if:

(1) there is no shipping before spring breakup;

(2) there are no harmful pollutants released that might negatively affect the seals' food supplies.

In fact, shipping early in winter could benefit seals by breaking up the new ice and thus providing a rough surface to make snow drifting conditions better for denning.

5.3 BEARDED SEALS (*Erignathus barbatus*) AND WALRUS (*Odobenus rosmarus*)

5.3.1 Summary

According to interviews, bearded seals and walrus are seldom found far into Roche Bay, although they may be common at the mouth of Roche Bay and to the east of Roche Bay.

5.3.2 Preferred Habitat of Bearded Seals and Walrus

Bearded seals and walrus usually prefer areas of unstable moving ice to large areas of open water, since they need a solid surface to "haul out" on. When these mammals go into areas of open water without "hauling out" sites, it is probably for only a short time. In 1981 and 1982 we observed that when the ice moved out of Roche Bay, it did so relatively quickly, leaving the Bay ice-free for the rest of the summer. Foxe Basin, on the other hand, contained drifting ice pans throughout the summer, making it a more suitable habitat for walrus and bearded seals. This may be one reason why these animals are found more often just east of Roche Bay, or at its mouth, than very far into it.

Although bearded seals are able to maintain breathing holes (Nelson, 1975; Stirling *et al.*, in Stirling and Cleator, 1981), "they avoid areas of fast ice" (Davis, in Peterson, 1981), and in winter they "are more abundant in areas where open water occurs continuously or at least periodically" (Stirling *et al.*, in Stirling and Cleator, 1981). "Walrus overwinter in areas of pack ice where the water is shallow and the ice is thin enough that they can break it with their heads in order to maintain breathing holes" (*ibid.*).

In summer, walrus tend to move around Foxe Basin, following the drifting pack ice. Since the location of the pack ice depends on wind direction, which varies considerably, the occurrence of walrus near Roche Bay in summer has been occasional and irregular for many years.

In the fall when no floating ice can be found, bearded seals and walrus need an island to haul out on. One such island is South Ooglit Island near the mouth of Roche Bay, which is known as a traditional hauling out site for walrus. Thus, groups of walrus can sometimes be found in and near the mouth of Roche Bay in the fall.

For a discussion of the winter distribution of these species, see the discussion of the polynya, below.

5.3.3 Conclusions

These species should not be affected by the mine itself; but since they sometimes occur near Roche Bay during the shipping season, shipping could affect them if ship noise itself causes a negative impact (see below) or if the release of pollutants into the water adversely affects the bearded seals' or walrus' food supply.

5.4 WHALES

5.4.1 Beluga Whales (Delphinapterus leucas)

As stated above, beluga whales have not been observed in Roche Bay for many years, and apparently few occur near it. Mansfield (1962) did not consider their range to include adjacent Parry Bay or central Foxe Basin. As far as could be learned from local Inuit, the occurrence of beluga whales near Roche Bay is neither regular nor predictable. Their range does include Foxe Basin, but no regular migrations go through any part of the basin, according to Davis, Finley, and Richardson (1980).

The only likely source of disturbance to beluga whales from the mine project would be harmful pollutants or direct disturbance from the noise or motion of ships.

5.4.2 Narwhal (*Monodon monoceros*)

Generally, narwhals prefer deep water more than do beluga whales; hence, they would not be expected to enter Roche Bay, nor have they ever been known to enter Roche Bay.

Foxe Basin is considered by some to be outside the known range of narwhal (Davis, Finley, and Richardson, 1980). Inuit hunters interviewed in the Hall Beach-Roche Bay area in the mid 1970s told about species of sea mammals occurring in that area, but made no mention of narwhal. Banfield (1974) did consider the west side of Foxe Basin, including Parry Bay, to be within the normal range of narwhal, but not to be on any regular migration routes.

Then in July 1979, Reed and Dupuis of the Canadian Wildlife Service observed a group of narwhal near Hall Beach, and since that time narwhal have moved along the west side of Foxe Basin annually around the end of July. They have not been observed near Roche Bay, however, and may be following the polynya-lead zone, which extends from southeast of the mouth of Roche Bay north past Igloolik.

Thus, in recent years an apparently small number of narwhal migrate past the mouth of Roche Bay (about 10-40 km to the east) around the end of July. They appear to spend little time in the area. Their travel route will be crossed by ships to and from Roche Bay, but annual shipping from the mine will not begin until August, according to present plans. If these plans are not changed, the mining project will not disturb them.

5.4.3 Bowhead Whales (*Balaena mysticetus*)

Bowhead whales enter Foxe Basin each year as the sea ice melts (Nelson, 1975), but their numbers are very small. Very few, if any, bowhead whales come near Roche Bay, according to Inuit in that region, although Joe Curley saw a large unidentified species of whale in Roche Bay in 1978.

Part of a large whale skull and one cervical vertebra were found on northern Roche Bay Peninsula. The skull part is the entire posterior or occipital surface, whose approximate measurements are 60 cm high (dorso-ventrally) and 73 cm wide, from outer posterior edge of one orbital arch to the other. The occipital bone is about 60 cm high and 44 cm wide. The cervical vertebra was found about 3 km from the skull, and had a centrum about 12.5 cm in diameter, and measured about 45 cm from the end of one transverse process to the other. The skull and vertebra could be from the same animal. These remains indicate that a large whale was once in Roche Bay, many years ago.

Generally the mine project and shipping to and from Roche Bay should have no effect on bowhead whales in Foxe Basin, unless they are disturbed by noise from ship traffic or if pollution negatively affects their food source.

5.5 THE PARRY BAY POLYNYA EAST OF ROCHE BAY

5.5.1 Location

The polynya, located about 29 km east of the mouth of Roche Bay, is one of the polynyas of Foxe Basin, where water remains open through most of the winter (see Fig. 5.1-1).

Most polynyas are created and maintained by winds and/or water currents. Sometimes a feature on the ocean floor acts to divert currents, resulting in a polynya. The contour of the ocean floor may cause two ocean flow patterns or currents to interact near Roche Bay, but this has not been verified in the field.

5.5.2 The Importance of Polynyas to Sea Mammals

Polynyas are very important to sea mammals. Without polynyas, no sea mammals except ringed seals could exist through the winter in many parts of the Arctic.

The locations where polynyas occur often contain an abundance of the species on which these sea mammals feed. Hence, polynya zones are often important to sea mammals in summer as well as winter.

Polynyas of northern Foxe Basin "support high densities of walrus, bearded seals, and ringed seals on a year-round basis" (Stirling *et al.*, in Stirling and Cleator, 1981, citing Manning, 1943; Loughrey, 1959; Anders, 1965; Mansfield, 1967). It is not stated by the authors whether the Parry Bay polynya is included in "northern Foxe Basin," but evidence from Inuit hunters indicates that the three species occur there commonly through much of the year. It is probably critical for the winter survival of many bearded seals and walrus, and therefore the maintenance of the general population of these species in the Roche Bay region. It is probably also important for many ringed seals (mostly nonbreeding juveniles) and for a few polar bears. It may be important to some black guillemots as well.

This polynya is important to the Hall Beach Inuit because sea mammals are more abundant and accessible at the polynya in winter, spring, and fall than they are in other areas close to Hall Beach. For much of the summer, however, sea mammals are more abundant in other parts of Foxe Basin, which are easily accessible to these Inuit.

5.5.3 Conclusion

Ship traffic to and from Roche Bay will be going through or south of this polynya zone. This may not have any effect for much of the summer, when most sea mammals have gone to other parts of Foxe Basin; but it could be of significance in late summer, fall, and early winter, when many sea mammals return to this area. Ship traffic may also be of some benefit by keeping a greater amount of water surface open longer around the polynya, but could be detrimental if it disturbs the sea mammals there.

The only negative impact the mining project near Roche Bay could have on this polynya would be through its shipping activities, and possibly through the release of ecologically harmful chemicals into Roche Bay. Existing regulatory mechanisms should prevent the release of harmful pollutants. Possible ship disturbance will be discussed below. Presently, a relatively small quantity of annual ship traffic through or near the Parry Bay polynya (and through other polynyas in the eastern Arctic) for many years now has had no apparently disturbing effects on birds or sea mammals in these areas. Whether this would be the case with heavy traffic is not known.

5.6 NOISE DISTURBANCE FROM SHIPPING

5.6.1 Introduction

Within the last few years there has been a considerable amount of attention directed toward the effects of shipping on sea mammals in the Beaufort Sea, Arctic Islands, and Lancaster Sound. This research is of particular concern because year-round or ice-class shipping is being contemplated. Within this context there have been several questions raised, of which one may be of particular importance in evaluating the environmental impacts of the Borealis Project, namely, the effect of ship noise on sea mammals.

Efforts are being made to determine how sea mammals will, in fact, react to the noise of shipping. Two areas of concern have been identified thus far:

1. The major sensory modality of sea mammals is underwater sound. They use sound signals for social communication, food finding, predator avoidance, and possibly echolocation (Norris, in Peterson, 1981). Ship noise may mask these sound signals.

2. Very loud noise from ships may cause distress and even pain (Norris, ibid.).

Given the context of these investigations, most of these studies are concerned with large, powerful LNG tankers operating under full power to break ice. Open-water shipping produces considerably less noise than do ice-breaking operations largely because ice cover reflects and amplifies sound, and the noise created by breaking ice is very great. In the case of conventional shipping, the second factor will not likely be a major concern, except possibly for animals at very close range. However, the first factor could be very important, since ships could be passing directly through important ringed seal, bearded seal, and walrus habitats.

5.6.2 Review of the Workship on "The Question of Sound from Icebreaker Operations"

At the 1981 workshop on "The Question of Sound from Icebreaker Operations" (Peterson, ed., 1981), several observations were cited concerning the effects of open-water shipping on marine mammals. Terhune (ibid., pp. 274-275) cited two authors who "believe that heavy ship traffic is responsible for Baird's beaked whale and minke whales altering their migratory pathways." From his own observations he reported that "The vocalization of harp seals are known to have decreased following the arrival of a vessel." This may have been a vocalization change or, possibly, a large number of seals may have left the area. Norris (p. 327) commented that "baleen whales apparently tolerate shipping activity to a limited point beyond which they abandon their normal habitat."

On the other hand, Leggat (ibid., p. 327) noted that "whales presently live in other oceans where shipping noise is as high or possibly higher than that proposed by an LNG carrier"; Norris commented that "evidence exists that whales are present in calving lagoons along with cannery boat traffic", and Brodie added, "Evidence from eastern Canadian coastal waters suggests that whales will occur in shipping lanes if their food is present. The abandonment of heavy traffic areas by whales may be the result of depleted fish stocks".

Thus, opinion is divided on this point, and Leggat (ibid. p.337) concluded that "anecdotal accounts exist for both habituation to noise or industrial activity and disturbance resulting in abandonment of traditional habitat for different marine mammals."

Discussion of sound production by marine mammals, their full hearing capabilities, and how they could be affected by ships' noise "was much hampered at the workshop by lack of information on the critical range of communication for individual species and the function of their 'vocalization'" (ibid., p. 337). All that can be said at present, from measurements that have been made, is that noise from ships is probably not detrimental to the use of sound by sea mammmals at certain ranges, whereas at closer ranges it probably is.

Calculations made on the basis of Terhune's figures (ibid. p.274) indicate that an LNG tanker moving through open water at 14.4 knots would probably not mask marine mammal vocalizations at a distance of 91 km (100 kyd). At 9.1 km (10 kyd) the interference would be significant assuming maximum tanker sound production. However these figures are based on certain unproven assumptions concerning the hearing and signal detection abilities of sea mammals (ibid., p. 336), and studies are continuing in an attempt to resolve these and other unanswered questions raised at the workshop.

The preliminary report of a study at the mouth of Admiralty Inlet (LGL, 1982) indicates that beluga whales, and possibly some narwhals, began to swim rapidly away from an ice-breaking ore carrier 2 hrs before it reached the ice edge, i.e., while it was still in open water, and 1 hr before it became visible on the horizon. The animals returned to their normal behaviour the next day, as soon as the ship's noise was no longer detectable underwater. This was the first ship to arrive in the spring. Whetner these whales will adapt to such a disturbance if it is continuous or repeated, or how quickly they will adapt, has yet to be determined.

During the workshop, it was also pointed out that arctic sea mammals are quite adaptable, since one of their main adaptations to the arctic seas is their ability to take advantage of sudden short-term changes in their environment. This is in agreement with our own observations in the I.E.E. To what extent these animals will be able to adapt to ship's noise in any particular situation is still open to question.

5.6.3 Current and Projected Noise Levels

Sea mammals in the Roche Bay area are already exposed to small amounts of sea traffic. Inuit use motorized canoes to pursue them and shoot at them, and at least four to six ships pass each year en route to and from Hall BOeach and Igloolik. The marine mammals have apparently adapted to this level of disturbance. However, this does not indicate that they will adapt to the steady ship traffic (up to one per day) through the entire shipping season as proposed for the Roche Bay project, or to the larger ships that are planned. Alternatively, their adaptation to the increased shipping may be to flee the area until after a ship has passed, then return within hours, as did beluga and narwhal in the LGL study discused above.

The situation for the Borealis Project is quite different from that of the Arctic Pilot Project LNG tankers. On the one hand, Borealis shipping will be conventional shipping during open water, and the additional noise projected from shipping through ice will be avoided. Figures presented by Terhune (ibid.) indicate that the noise level of an LNG tanker, when breaking ice under full power is about 20 decibels/micropascals greater than that produced by the same vessel travelling through open water at 14.4 knots; i.e., the sound travels about ten times farther through ocean water when the ship is breaking ice than when travelling through open water. On the other hand, the Borealis project will be using larger ore carriers than any anticipated for ice-class operation on the Arctic Pilot Project. However, they will probably not be larger than some tankers envisioned for the Beaufort Sea.

There are, however, areas where shipping concentration is as high or higher than that proposed for the Borealis project and which remain acceptable habitats for sea mammals. For example, the Gulf of Oman carries a great many very large oil tankers, and yet remains a breeding ground for whales. Similarly, the St. Lawrence, which is probably one of the heaviest shipping lanes in the world, remains a habitat for sea mammals.

In the St. Lawrence the whales come down the north channel, which is the main shipping channel. The whales thus come within a few kilometres of the main pilot station where any ship of any size is required to dock and acquire a pilot.

Again, in the Saguenay Fiord where the cliffs are quite high and the fiord is narrow and thus likely to reflect sound, whale populations persist despite heavy shipping.

This is not to say that the sea mammal populations in these areas have not been adversely affected by shipping. Perhaps the populations would have been much greater if there had been no shipping in the St. Lawrence. In addition, it is important to stress, as noted above, that these observations of continued sea mammal activities have not been the result of carefully quantified and scientifically validated studies.

5.6.4 Summary on Ship Noise

In summary, there exists a significant data gap that must be filled before a confident prediction can be made about the effects of ship noise on sea mammals. Further studies are now in progress, including studies in Strathcona Sound, studies in the Mackenzie Delta by Esso, and studies by the U.S. Bureau of Land Management on whales in the Beaufort Sea. These studies should help to determine whether ship noise adversely affects sea mammals and what mitigative measures might be used to minimize possible negative impacts. It may, for example, be possible to avoid particularly sensitive areas, like the Parry Bay Polynya, or it may be possible to decrease or modify ship noise when passing through or near these areas. But before such mitigative measures can be undertaken, a more thorough and researched understanding of the problem is necessary.

This is the only major unanswered question with respect to the potential environmental impact of the Roche Bay project.

5.7 CONCLUSIONS AND RECOMMENDATIONS

Only ringed seals commonly come into Roche Bay. They should not be affected during denning. However, ringed seal and other species of sea mammal may be affected by pollution if their food sources are threatened, and therefore the existing regulatory mechanisms must be implemented to prevent pollution of the waters of Roche Bay by ships, or by any facilities on land.

Sea mammals may also be affected by ship noise as well. From the evidence indicated above, we would expect sea mammals in the shipping area to adapt to an increase in shipping in this area if ship noise does not mask their own communications. Whether they will in fact adapt to the shipping is, however, not certain at this time.

6. OTHER MAMMALS

6.1 POLAR BEARS (URSUS MARITIMUS)

6.1.1 Summary

There are no denning areas near Roche Bay. Polar bears were fairly common in the Roche Bay area before 1965, then uncommon until 1981. Since then, they have become much more common in the area during winter. The mine development should have no effect on the polar bears in the area.

6.1.2 Population Distribution on Melville Peninsula

According to previous reports (Anders, 1965) polar bears were fairly common along the east coast of Melville Peninsula before 1965. But they were seen much less frequently in that region from about 1965 to 1981, and some Hall Beach hunters travelled many miles to Committee Bay to hunt bears. Hall Beach hunters have had an annual quota of only seven bears recently, and have been unable to obtain that number in some years. However, during the 1981-1982 winter season they obtained their annual quota by December, mostly from south of Hall Beach through the Roche Bay area and still farther south, and during the 1982-1983 season they had already killed four bears in that area by November 7.

a. Spring, Summer, and Fall. Polar bear distribution in summer depends mainly on the presence of pack ice and sea mammals. Pack ice distribution in Foxe Basin is dependent partly on wind conditions, which vary from year to year.

One polar bear was seen near Amitioke Peninsula, about 10 mi (16 km) south of the mouth of Roche Bay, in mid-July, 1981. This is probably related to the reported fact that much pack ice had drifted to the east shore of Melville Peninsula near Amitioke Peninsula in July, 1981.

In mid-August, 1981, one polar bear was seen on the coast about 10 mi (16 km) south of Hall Beach, and it stayed in that general area for several days according to Inuit from Hall Beach.

One polar bear was seen moving west near northern Hall Lake about 25 mi (40 km) from the mine site in the summer of 1981 (Peter Bannon, personal communication) and a polar bear was seen swimming west across the northern part of Hall Lake about Sept. 1, 1981 (Jerry Neilson, personal communication). In the fall of 1981 a polar bear travelling past the fish camp on the west shore of Hall Lake dug up some buried garbage, but did little damage to the buildings (Jerry Neilson, personal communication).

However, no polar bears were seen in the Roche Bay area or in any part of the development area during the spring or summer of either 1981 or 1982.

b. Winter. Bears visit Roche Bay more often in winter than in summer. Inuit report that one or more bears are seen in Roche Bay each winter, but many more than usual were seen in or near Roche Bay during the winter of 1981-1982. There have also been more than the usual number of polar bear sighted thus far during the current winter. Also, according to Inuit hunters, at least two of the 1980-1981 quota were taken in Roche Bay (at least one of these in late fall), and, as mentioned above, bears were taken in or near Roche Bay in 1981-1982 as well. During the current season (1982-1983), Hall Beach hunters had shot four bears by November 7. Three of these bears were shot in Roche Bay or at its mouth, and tracks of another bear were also seen in Roche Bay (Richard Immaroituk, personal communication).

Tracks of one bear were seen in late May 1982 on the ice of Roche Bay north of the Borealis development area (Brian Weir, personal communication), and when people first arrived at Sarcpa Lake in 1982, about June 2, they found one set of polar bear tracks going west (Beth Tipping, personal communication).

In the winter of 1965 polar bears were seen on two occasions at Hall Lake, about 7 mi (11 km) north of the development area (Simeonie Irqittuq, personal communication), but sightings in that area have apparently been rare since then. As mentioned above, three were known to pass through that area in the summer and fall of 1981, but no recent winter sightings in the Hall Lake area have been reported.

Polar bears are often more abundant in winter near polynyas than in the surrounding area because of the greater abundance in polynyas of sea mammals, including juvenile ringed seals, and the accessibility of kelp, a seaweed that polar bears feed on extensively throughout the winter.

6.1.3 Travel Routes

As discussed in the I.E.E., the nearest denning area (or core area) is on northern Simpson Peninsula, about 140 mi (225 km) to the west-northwest of the development area. The three recent reports of polar bears travelling across or past Hall Lake, and the set of tracks heading west near Sarcpa Lake, indicate that some polar bears travel far inland, possibly crossing Melville Peninsula toward this core area on Simpson Peninsula.

The bears seen in and near northern Hall Lake may have been heading for the Airalijaq-Napata Lakes drainage system, which empties out of a valley extending across Melville Peninsula to Garry Bay on the west coast. At less than 650 ft (200 km) above sea level, this valley is the lowest elevation in central Melville Peninsula, and furnishes a nearly straight east-west route through the high Melville plateau. It is also one of the shortest routes (64 mi, 102 km long) across Melville Peninsula, from Foster Bay on the east to Garry Bay on the west. Garry Bay is directly across Committee Bay from the denning area on Simpson Peninsula. Committee Bay, between the Melville and Simpson peninsulas, remains mainly ice covered throughout the year, providing adequate conditions for polar bear travel. The fact that three bears were reported passing Hall Lake in 1981 suggests that this valley, extending from Airalijaq and Napata Lakes to Garry Bay, may be the "polar bear pass" of Melville Peninsula.

The alternate route across Melville Peninsula from Roche Bay through Sarcpa Lake to Alangnardjuk Inlet on the west coast may be the route which the bear that passed Sarcpa Lake might have been taking. This route is shorter (57 mi, 91 km), but bears using it would have to cross very high terrain, up to 1400 ft (430 m) above sea level.

6.1.4 Conclusions

It is impossible to say at this time whether polar bears will continue to be generally uncommon in the Roche Bay area, or whether the much greater number in the area in the past two seasons indicates a return to the situation before 1965. However, there are no regular denning areas in the Roche Bay region, and the mine development should have little negative effect on polar bear ecology or movement if Roche Bay remains free of detrimental pollutants.

Bears may, however, be attracted by the smell of food, garbage, etc. But polar bears should have no harmful effects on the mining operation or on people in the Roche Bay area if precautions such as discussed in the I.E.E. and in pamphlets published by N.W.T. Wildlife Service are followed.

6.2 ARCTIC FOX, ARCTIC WOLF, ARCTIC HARE, ARCTIC GROUND SQUIRREL, AND BROWN AND COLLARED LEMMINGS

6.2.1 Summary

Largely because of the relative sparsity of vegetation in the development area, the numbers of arctic fox, arctic wolf, arctic hare, and arctic ground squirrel are less than or equal to the numbers of these animals in surrounding areas (see Table 6.3-1). None of these animals is abundant in the development area, and the proposed mining operation should not interfere with these mammals, except possibly by attracting arctic fox and arctic wolves as scavengers.

6.2.2 Arctic Wolf (*Canis lupus*)

All the evidence and observations during the 1981 and 1982 seasons indicates that arctic wolves are rare in the Roche Bay area although with an increase in the caribou population there may be more arctic wolves in the future.

a. Observations. In 1981, about six old droppings were found on predator scent marking sites located on the southwest corner of the Roche Bay Peninsula and near the shore of Roche Bay about 100 m south of where the peninsula meets the escarpment. These droppings indicated that a wolf or dog had been at these sites, probably in 1980.

In 1981, a set of tracks was found just north of the southwest corner of the south arm of Roche Bay near Nunakpariarvik, a place where some Inuit camp for a few days every summer. These tracks indicated that a wolf or large dog had been in that area, probably earlier that summer.

In 1982, Simeonie Irqittuq of Hall Beach told us that a relative had found a wolf den in an area south of the Ajaqutalik River and about 7 km downstream from Sanguac Bend (about 13-16 km southwest of the southwest corner of the development area). The same relative also shot three wolves in that area at about the same time.

Otherwise, no wolves were observed in or near the development area, or the Sarcpa Lake area in 1980, 1981, or 1982.

As discussed in the I.E.E., wolves were considered to be rare in eastern Melville Peninsula. The area where the den was reported may now be suitable for wolf denning for the following reasons: (1) the Inuit report an increasing number of caribou in the general Roche Bay area; (2) evidence indicates that there are at least some caribou found in the Ajaqutalik River valley all year; and (3) the main Melville Peninsula calving area is just south of part of the Ajaqutalik River Valley. However, a factor that may discourage wolves from denning in this area is the occasional presence of Inuit travelling through, who will hunt most animals they encounter, including wolves.

b. Conclusions. Arctic wolves are now rare in the development area. The presence of people, vehicles, etc. will probably prevent them from coming into the development area if they are hunted near it. In the Arctic, if they are not hunted or harassed, they will occasionally come to garbage dumps near areas of human habitation.

6.2.3 Arctic Fox (*Alopex lagopus*)

Arctic fox occur occasionally or commonly throughout the development area. They were observed on the western part of the Roche Bay peninsula, on the escarpment, and on the Precambrian plateau near the iron deposits. (A "blue phase" arctic fox was observed on northwestern Roche Bay Peninsula.)

Foxes may den in the development area, and if they do, it is most likely in the southwestern part. In 1982 a fox den was found near the development area, near the southwestern corner of Roche Bay, by Chris O'Brien, who was camping in that area.

Inuit sometimes trap fox in winter in the development area.

On August 3, 1981 an arctic fox exhibited unusual behaviour by coming into our camp during the day and boldly approached one person. This person became suspicious, chased the fox, and threw a rock at it. The fox would run away when chased, but would come back toward its "attacker" as soon as the pursuit stopped. An Inuk at the camp then shot and wounded the fox after it had pursued his young son, who had come to the aid of the first person it attacked and had pelted it with rocks. After it was wounded, the fox ran away. Two people pursued the fox, and one person saw it about 100 m away and fired two shots at it. When that person stopped to reload his gun, the fox came toward him at a slow run. It ran past him about 2 m away then circled toward him, and was shot and killed.

There are three possible explanations for this behaviour.

1. Several arctic foxes became very tame around the tourist fishing camp on the west shore of Hall Lake about 20 km north of the 1981 Borealis camp. One of them may have learned to associate people with handouts of food there, and then travelled 20 km south to the Borealis camp.
2. A game officer interviewed said "strange behaviour" is apparently a normal occasional occurrence among arctic foxes.
3. There is the possibility that the fox was rabid. Rabies was first observed in the wild in the eastern Canadian Arctic, and outbreaks of this disease occur among carnivorous animals in

different regions unpredictably. We were not able to send the carcass of the fox killed at the camp away for testing, and so we buried the remains as deep as possible.

Arctic foxes are no danger to people, unless they are rabid, and they will come into camps and garbage dumps if there is any organic waste in those places.

Human activity in the development area should not disturb foxes, as they adapt to people, and become "tame" quite quickly, if not harassed.

The development of the mine should have little impact on the population of arctic fox in the area unless perhaps, like the Hall Lake fishing camp, it will attract some foxes as scavengers.

6.2.4 Arctic Ground Squirrel (*Citellus parryi*)

Arctic ground squirrels occur throughout the development area, and are common near the escarpment, and on western Roche Bay Peninsula.

They quickly adapted to the presence of our camp and to stationary machinery, taking shelter under recently unloaded fuel drums only when people or vehicles came closer than about 3 m.

The first ground squirrels were observed when work began in the development area on May 26, 1982. At that time two were seen on the base of the Roche Bay Peninsula, even though the land was mostly snow covered and fully frozen. They remained active until at least Sept. 12, 1982.

Ground squirrels are not used by Inuit in the region, and development and mining activity should not affect them.

6.2.5 Arctic Hare (*Lepus arcticus*)

Arctic hare are seen occasionally in the upland parts of the development area and may occur elsewhere in the area as well. Arctic hare appear to be more common south of Roche Bay, however, as six were observed in a group on June 8 or 9 east of the mouth of the Ajaqutalik River

Arctic hare are occasionally shot for food when sighted by Inuit. Otherwise, they are of little importance.

Mining activity should have no significant effect on the arctic hare in the Roche Bay area.

6.2.6 Brown (*Lemmus trimucronatus*) and Collared Lemmings (*Dicrostonyx groenlandicus*)

Lemmings were rarely seen in the development area in the 1981 and 1982 field seasons. However, the population of lemmings is extremely variable throughout the Arctic from year to year, and so no extrapolations should be made from the observations of two field seasons.

Lemming nests and burrows indicate that they were previously common to abundant in the development area, though in 1981 and 1982 they were rare. It is well known that the lemming population fluctuates extremely and irregularly throughout the whole arctic region.

Lemmings are of no direct importance to the Inuit, but they are very important as food for many predators, especially hawks, owls, and foxes.

Development and mining activities should have no effect on lemmings in the Roche Bay area.

6.2.7 Conclusions

The smaller mammals of the arctic region, namely arctic ground squirrel, arctic hare, and lemmings, should not be negatively affected by the mining development, provided that the areas of relatively rich vegetation on the escarpment and surrounding Irqalugarjuit Lake are not disturbed and that the existing regulatory mechanisms are applied to prevent environmental damage.

Table 6.3-1: Terrestrial mammals known to occur in the mine development area

Species	Nesting or denning in development area (X - yes) (– - no)	Abundance in development area A - abundant C - common O - occasional R - rare	Abundance in development area relative to other areas within 80 km of Roche Bay
Polar Bear	–	R	less
Arctic Fox	X	O	less to equal
Arctic Wolf	–	R	less
Arctic Hare	X	O	less to equal
Arctic Ground Squirrel	X	O to C	equal
Lemming	X	probably variable (rare in '81 and '82)	?
Barren Ground Caribou	–	O to C	less

7. FISH

Two species of fish are important for human food in the Roche Bay area, arctic char (*Salvelinus alpinus*) and lake trout (*Salvelinus namaycush*).

Lake trout occur and apparently breed in Irqalugarjuit Lake and the two smaller lakes on that drainage system at the west end of the Roche Bay Peninsula in the Borealis development area.

Anadromous arctic char also occur in the Irqalugarjuit Drainage system, as far as the small lake south of Irqalugarjuit Lake, and in the Ajaqutalik River system near the development area.

According to several Inuit who fish in this area, the Ajaqutalik River system is indeed an important river system for arctic char, contrary to the opinion recorded in Anders, 1965. Most Inuit who fish in the Ajaqutalik River system say that this river stops flowing in winter, but they nevertheless frequently catch large char in winter by fishing through the ice in several deep places in the river.

Borealis has abandoned its plans for damming the Ajaqutalik River for the production of hydroelectric power, and most or all activity at the mine site should in no way affect the Ajaqutalik River system as long as no harmful pollutants are released in the southwestern part of the development area.

Although in the development area anadromous char can go upstream only as far as the significant waterfalls, which occur on the two large creeks running down the escarpment north and south of the lakes on the west end of the Roche Bay Peninsula, and on the "gorge river" system, which drains into the southwestern corner of Roche Bay, there are populations of arctic char in the lakes up on the Precambrian plateau within the development area in both the Irqalugarjuit drainage system and the "gorge river" system. These populations are "landlocked," because they cannot get to the sea and back.

From test fishing in the Irqalugarjuit drainage system above the escarpment, it appears that there are many landlocked arctic char smaller than 13 cm, and landlocked arctic char larger than 30 cm are probably few. Some of the lakes on the Precambrian plateau contain significant quantities of aquatic vegetation, which may serve as food for fish.

Borealis' plans, based on the Scott-Ortech Preliminary Feasibility Study, include draining some of the lakes on or immediately adjacent to the iron deposits on the Precambrian plateau which might be damaged by the mining operation, and diverting runoff. This may affect any creeks crossing them, any of five small lakes draining into the Irqalugarjuit drainage system, and the main channel of the "gorge river" system.

In addition, if any major east-facing slopes near the iron deposits were to be removed, the snow covered area which drains into the Irqalugarjuit system might be reduced. However, specific plan for mining these deposits will not be made till all plans on grade and constitution of the ore bodies to depth have been completed. When final plans are made, they should include hydrological engineering studies necessary to minimize disturbance to these drainage systems, to fish, and to the environment generally.

Roche Bay is an important area for many arctic char from the Hall Lake-Ikerasak system, the Ajaqutalik River, and the Irqalugarjuit system; this is one of the reasons why great care must be taken to implement existing regulatory mechanisms to ensure that harmful quantities of pollutants are not released into the Irqalugarjuit drainage system, the "gorge river" system, or into Roche Bay directly.

8. WEATHER IN THE ROCHE BAY AREA DURING THE FIELD SEASONS

Generally, the weather patterns in the Roche Bay area are typical of weather patterns in that part of the eastern Canadian Arctic. General weather data are outlined on pp. 40 and 41 of the I.E.E., and are included in the Scott-Ortech feasibility study.

Normal weather for this region includes the possibility of snow every month of the year, with at least one snowfall to be expected in July or the first half of August, to judge from the experience of 1979-1982.

In most years Roche Bay, west of the tip of the peninsula, remains frozen well into July.

In 1982, ice on larger lakes in the development area remained suitable for landing aircraft up to the size of Twin Otter until about June 25. By then shore leads were open and small ponds in the area were opening.

The Ajaqutalik River was still frozen over solid on June 10, but had opened by late June. Small creeks began to show a small occasional flow in early or mid-June, whenever a period of significant snow melt occurred.

Because the entire development area is on or near the coast, or on high ground that slopes quite steeply up from the coast to as high as 250 m, this area can get more rain and fog in summer than areas farther inland. Air masses from Hudson Bay and Foxe Basin, forced aloft when they move against the high coastal escarpment, are the cause of this. Another result of two air masses meeting over the development area can be freezing rain along the high escarpment, as was observed in June 1982.

Winds in the development area were mainly from the west or northwest, throughout the 1981 and 1982 field seasons. Strong winds (50-100 km/hr and stronger) were quite frequent during the summer of 1981, but were not so frequent in the summer of 1982. The part of the development area close to the escarpment is considered a very windy place by the Inuit of the region.

One factor contributing to the wind force near the escarpment is the fact that different air masses with different wind directions often meet along the escarpment, as observed in 1981 and 1982, producing strong vortices along the resulting wind shear line.

Winds in the development area can thus be hazardous to low-flying aircraft near the escarpment, but could possibly be utilized as an excellent power source for wind-power generators, if these prove to be functional and reliable in this environment.

9. EVIDENCE OF PREVIOUS HUMAN USE

9.1 INTRODUCTION

The Roche Bay area has probably been occupied from the "Palaeo-Eskimo" period, by pre-Dorset cultures, through the Dorset and Thule cultures, by Inuit, to the present day; a small Inuit community still exists at Ignertok Point at the southeastern tip of Roche Bay. Eastern Melville Peninsula, especially north of Roche Bay, has long been noted for its significant archaeological sites. The development area at Roche Bay has many archaeological sites, mostly on the peninsula and the escarpment, and these are outlined on the accompanying map (Figure 9.4-1), with descriptions and comments following. Some sites are probably very old, but the historical-archaeological significance of the Roche Bay development area may be small, considering the many other archaeological sites in this region generally.

9.2 SUMMARY

In the Roche Bay development area, archaeological sites are found from near sea level to about 150 m above sea level. Some of the sites on raised beaches at higher elevations seem very old, but some may have been built during the last 20-50 years. Jack Haniliaq of Hall Beach said that some Inuit will put a camp on high ground at certain times of the year in some areas to spot caribou. Simon Nattaq and four other Inuit from Hall Beach also thought camps and structures far above sea level in the Roche Bay area may be related to caribou hunting.

Some of the larger sites near Roche Bay, mostly the ones near sea level, were in regular use from the earliest memories of some of the oldest Inuit in the region until about 20 to 30 years ago. The extent of some sites and the richness of the vegetation growing on them indicate probable long-term use. With this area inhabited even before the Dorset culture, some sites may have been used for a long, long time.

For dating these structures, identification of artifacts and carbon dating are the only means that can produce reasonable age estimates, and to obtain an age/culture estimate from samples of bone or wood, a reasonable quantity has to be tested. The situation is further confused because Inuit have often used tools and dwelling structures of previous generations or cultures. For example, some Inuit younger than 40 years old today were born and raised in dwellings very similar, if not identical, to Thule culture sod, stone, and whalebone shelters.

No attempt has been made to excavate the sites in the development area or to date them other than from surface appearances, structures, and in one case by an artifact found on northern Roche Bay Peninsula. No site has been disturbed and nothing has been moved. The personnel involved in exploratory and development activities associated with the Borealis magnetite project at Roche Bay have taken measures to avoid disturbing any known sites.

9.3 TYPES OF STRUCTURES

The map shows the locations of archaeological sites in or near the Roche Bay development area, and brief descriptions of the land surface at each site, and of structures exposed at the surface, are given below. Some of the mapped locations may not be precisely accurate since we did not have survey equipment to determine our exact positions.

In our site descriptions we have used several terms that are defined as follows:

1. Tent Ring (Slides 31, 44, 45): A circle of stones. These rings vary in size from what may have been a temporary shelter for one person to what was probably a seasonal shelter for a family. Many tent rings have a row of flat stones across the center, probably designating the sleeping area (Slide 15). At least one tent ring had the sleeping area paved with flat stones (Slide 45).

2. Stone Houses: Some structures in the Roche Bay area appear to be small Thule type dwellings. They may have the interior dug out to create a floor 30 cm or more lower than the surrounding ground or walls up to 80 cm high, or both.

3. Low-walled Structures (Slides 34, 36-42): Circles of rock, probably for dwellings, with walls often built of two rows of fairly small rocks. These are about 30-50 cm high. These structures vary in size but are often small, with the same diameter as temporary one-man shelters.

The rock walls of the low-walled structures are usually in place, indicating that no tent material had been pulled from under them, yet they do not seem high enough to be significant as walls, or to have supported a roof. Possibly they provided adequate sleeping shelters when only short poles were available. Skins might have been supported on the edges by the short walls, and held up by poles made from dwarf willow, caribou antlers, or bones, etc. However, there are generally no signs of any rocks outside these structures for holding the tent skins down, or of things that could have been used as support poles.

In some low-walled structures the floor was dug down below the level of the substrate supporting the walls.

section. These are placed side by side with room for a fox between them. On top is placed a third flat-sided rock, leaving room for a fox beneath. One end of the "square tunnel" is then blocked with a rock, and boulders are piled in a mound over this structure. Rocks are placed so that a flat slab of rock will drop to seal the open end of the "square tunnel" when a fox goes in and pulls on bait at the other end.

This type of fox trap was also found on or near the slope of the escarpment.

8. Caches: Varying from a pile of boulders probably randomly placed over items of storage, to "stone-igloo" type structures apparently carefully built over items to be stored; caches are sometimes built against large boulders or rock outcrops, and often near dwellings and campsites.

Some apparent caches were the general size and shape of human burials, but no bones or artifacts were found in or near them.

9. Inuksuks: At the development site these varied from a single rock stood on end to a stack of rocks piled one on top of another. (Some similar structures have been built recently in this area as survey claim markers.) Inuksuks are usually built on hilltops or prominent rock outcrops, and above important or frequently used campsites. Their main purpose in the Roche Bay area appears to have been for marking specific locations or travel routes.

10. Straight Rows of Rocks (Slide 43): Rows of rocks, one or two layers deep, with the rocks almost all touching one another, were found in several places on the Roche Bay Peninsula near its western end, and on the escarpment slope. All rows of rocks on the escarpment were running north-south, and were near dwelling shelters or caches. They varied from about 2-45 m in length with the rocks being from 15-30 cm in diameter. Occasionally a row of

rocks was two layers high for all or part of its length, but one layer wide. Seldom was one row of rocks close to another.

We asked several Inuit in the region what these structures were for but they said that the only purpose they knew of building small rock walls was as blinds for hunting caribou. The rows of rocks would not have fulfilled that purpose, and so their true purpose is unknown to us.

9.4 BRIEF DESCRIPTIONS OF SITES LOCATED ON MAP

<u>Site A</u> (Slide 24)

Located at contact zone where dry, well vegetated, gently rolling terrain meets very rugged metamorphic rock outcrop; about 60 m above sea level and about 100 m from a small river where it goes through a deep waterfall canyon (making water accessible here only with difficulty). Observed structures at this site consist of five tent rings, five caches, two "stone-tunnel" fox traps, three "stone-igloo" fox traps, two in excellent condition and one collapsed (Slide 1), and an inuksuk about 1 m high on the hilltop just west of the main structures.

<u>Site B</u>

Located on low, fairly level sand-clay base near the sea coast and near a small river, this site ranged from about 30 to 180 m from shore. Structures at this site included six tent rings and five caches. This site is in use occasionally into 1982, and two three-barbed fish spears constructed of modern materials were found there (Slide 25).

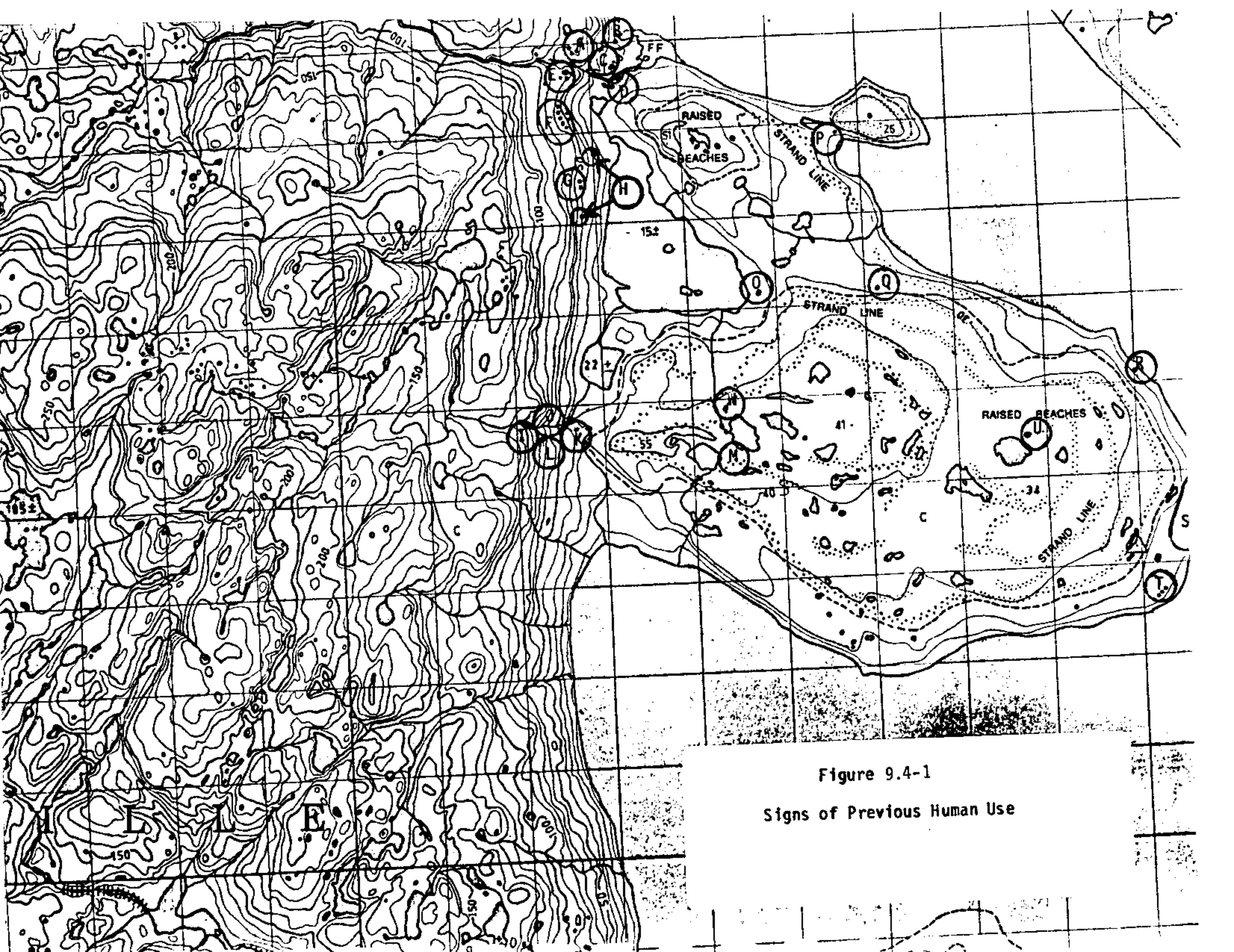


Figure 9.4-1

Signs of Previous Human Use

Site C

Located on the top and the north-facing slope of a hill formed from sand and clay, whose elevation rises from about 5 m to about 15 m above sea level. This site is about 300 m from the present coastline, and about 30 m from a small river.

Structures at this site are 16 tent rings and ten caches. (Some of the caches are very large, and may once have been stone houses.)

Site D (Slides 26-30)

Located partly on soil of mixed sand, clay, and organic matter and partly on gravel, close to two small rivers at an elevation of about 10 m.

This is the largest archaeological site found in the Roche Bay development area. Visible structures include about 15 tent rings and "low-walled structures," and about five or more "stone-house" structures (Slide 26). Among these are two "group meeting shelters." One of these is a very large tent ring, oval or elongated, and divided into several sections or rooms. The other is west of the main site, quite close to the stream and the escarpment (Slides 27-29). It is a large, generally circular, "stone-house" structure about 5 m in diameter and built as an inner circle within an outer circle, with the two walls separated by about 80 cm. Parts of the outer wall are over 1 m in height. The inner wall was not this high, but many rocks have apparently fallen off it, so it may once have been. (We have never before seen a structure like this, and Ellen Bielowski, an archaeologist from the Prince of Wales Northern Heritage Center in Yellowknife, said that it was remarkable and that she had never seen anything like it before. At this site, there were several caches, including at least three built with large boulders and having rectangular inside caverns about 60 cm by 120 cm. (They contained nothing but the atlas vertebra of a caribou.) Also at this site were two straight stone walls about 120 cm long and 1.5 m apart, parallel with one another and each at present highest at its center (about four rocks high).

Fragments of seal, walrus, and caribou bones were found at this site. The species of plants found here indicated that the soil throughout most of this site had been enriched with more organic matter than at any of the other sites we found (Slide 30).

<u>Site</u> <u>E</u>

Located south of Site A, about 60 m south of the deep waterfall canyon on the east-west river. This site is near a small, well-vegetated area beside a pond, but some structures at this site are on the rugged Precambrian rock outcrop just east of the vegetated area.

Structures observed at this site were: six tent rings and "low-walled structures" on the vegetated area, two or three "stone-tunnel" fox traps, and two "stone-igloo" fox traps.

Both "stone-igloo" fox traps are built against vertical rock faces about 1 m high, and on a ridge just above and behind one of them are five long stones placed on end, so that they are visible from a distance.

<u>Site</u> <u>F</u> (Slide 31)

Located mostly on raised beaches between 50 and 100 m above present sea level, on a relatively gently sloping part of the escarpment between the peninsula and the Precambrian plateau, this site is distributed in several locations over a very large area and is probably several small sites that were occupied at different times. All of these sites are close to present-day vegetation, but few are close to water.

Structures observed at the sites in this location are: many tent rings, usually from two to four in a particular location; many caches; and several structures that appeared to be caches, but having a slightly curved rock row as a wall (1.2-2 m long and two rocks, i.e. about 25-40 cm, high), parallel to the side of the "cache" and varying from 1-40 m from it, or with the "wall" running out from the "cache."

These structures could be the "blinds" built for caribou hunting in this area mentioned by some Inuit hunters in the region. Also small camps at this altitude could be built there for spotting and hunting caribou in spring or fall, as Jack Haniliaq said was done in this area.

Site G (Slides 32-34)

Located on the sloping escarpment in an area where raised beaches and dry, smooth vegetated land intersect the rugged Precambrian rock outcrops. One structure here was built against a vertical face on a rock outcrop.

Structures observed here included one "stone-igloo" wolf and fox trap about 1.5 m high, still mostly standing with three caches and one tent ring near it (within about 50 m).

About 200 m to the south of these is another "stone-igloo" wolf and fox trap (Slide 32) about 1.8 m high, built against a vertical rock outcrop reaching the same height. Near this is a cache, and about 40 m to the south is a low-walled structure or stone house, with part of a wall about 0.6 m high, and a row of rocks across the middle designating the sleeping platform (Slide 34).

Site H

Located at the bottom of very large jagged steeply sloping rock outcrops, where the Precambrian outcrop meets the top of a well-vegetated slope.

Two of the structures are "ambush shelters," made by building a small wall of rocks and boulders in the front of a natural crevice or niche (Slide 35). A rock is set on end in a conspicuous place near each shelter, probably to mark its location. There is also a small curved wall, about 2 m long and nearly 1 m high, among the outcrops (Slide 35).

These structures possibly served as ambush points for hunting caribou which travel along the escarpment mostly in spring and fall. (From our observations and the accounts of Inuit hunters in this region, relatively few caribou travel this route now compared to the number travelling here annually about 50 years ago.)

The other structure is a tent ring about 600 m south of the shelters. It is located on a well-vegetated shelf at the base of the steep outcrop, where it juts out toward Irqalugarjuit Lake. The tent ring is on the south side of the jutting outcrop, is 2 m by 3 m, and must be very old since the rocks are imbedded deeply in soil.

Site I (Slides 36-38)

Located on a patch of vegetated soil on a Precambrian rock outcrop beside a deep creek canyon with a waterfall, about 80 m above sea level.

At this site there was a "low-walled structure" with parts of the wall about 60 cm high and a row of rocks across the center marking a sleeping platform. Ellen Bielowski, the archaeologist, said that the Inuit who built it must have been influenced by the Thule culture.

About 80 m to the west of this and 20 m south of the creek canyon, in an area of deeper soil, was a tent ring with only the tops of the rocks showing.

Site J

Located downstream from Site I and 20 or 30 m below it in elevation, is a large cache. It contained part of a walrus jaw.

Site K

Located about 150 m south and southeast of where Irqalugarjuit River turns from flowing east to north, and about 300 m east of Site J.

Structures include four tent rings and stone houses, two or three small rings of stone that might have been caches, and two or three normal stone caches. The tent rings must be quite old, as the stones are deeply imbedded in soil. One tent ring has the floor dug down to two levels so that the apparent entrance and cooking area is today more than 30 cm below the bottom of the outside ring of rocks. The stone houses were very small, less than 2 m in diameter.

Site L (Slides 39-44)

Located on the escarpment slope, mostly on raised beaches between about 50 and 70 m above the present sea level. This site is extensive, but structures are quite evenly distributed.

Structures include at least six tent rings and one substantial "low-walled structure" with an obvious sleeping platform (Slides 39-42). There are several caches, one structure that might have been a fox trap, and at least two straight rows of rocks running north-south, one of which is about 45 m long (Slide 43).

Ellen Bielowski said that one of the tent rings at this site was a classic example of a palaeo-Eskimo dwelling 2000-4000 years old.

Site M

Located on and near raised beaches in gently rolling terrain about 45 m above sea level, structures here include one or two tent rings, and a straight row of rocks running north-south.

Site N

Located on a high raised beach area in gently rolling terrain about 45 m above sea level, just east of a fairly large well-vegetated basin is a small basin (1 m diameter approximately) containing about 40 small (5-15 cm) rocks of a composition excellent for flaking and making hard and sharp tools. The accumulation in one location of so many rocks of types which are otherwise uncommon in the development area is unnatural and most likely indicates gathering and storage of these rocks by man for tool making.

Note that the location of this site is about 200 m east of, and just north of a line paralleling the airstrip on the most southwesterly ridge on the Roche Bay Peninsula.

Site O

Located on a dry slope just east of the wet sedge meadow beside Irqalugarjuit Lake is a straight row of rocks, sometimes two rocks high, running northeast for about 18 m, with a small circle of rocks at the southwest end of the row. The row runs up the slope near the north end of some raised beaches.

Site P

Located in a small vegetated pocket, about 10 m above sea level, is the posterior or occipital surface of the skull of a whale. (For a description see section 5.4.3, above.) This whale may have died from natural causes, or may have been killed by Inuit, as the remains here are very close to a small shallow bay, which is the type of situation used by the Thule Inuit for trapping whales.

Note that a whale cervical vertebra with a centrum about 12.5 cm in diameter, and about 45 cm from top of one transverse process to the other, was found about 3 km east southeast of the skull. This could be from the same animal.

Site Q

Located on raised beaches on nearly flat terrain about 30 m above sea level are two large tent rings (seen from aircraft).

Site R (Slie 45)

Located near the water below a 5 m limestone cliff. The structure at this location is a large tent ring about 3 m in diameter. The sleeping platform is delineated by rocks that have moss growth between and over them. There are other rocks in a loose ring around this tent ring about 2 m away, probably to hold ropes. The tent ring was somewhat square in shape.

Site S (Slides 46-48)

Located close to the water's edge and on a ridge a few metres higher, with mostly bare limestone at the north, and good vegetation starting 150 m inland at the south end. A small spring provides the only fresh water available for some distance, after snow and ice has melted.

Several tent rings, including double tent rings, and stone houses (Slide 47) are scattered along the shore for a distance of about 1 km. One of the tent rings is elongated, apparently containing two sleeping areas, one at each end (Slide 46). The middle was probably used as tne cooking area.

Also in this general area, near shore, is a large inuksuk (Slide 48), about 1 m high. Near this was a stone cache containing the remains of a caribou that was probably shot the previous year.

Site T

Located just above limestone cliffs whose vertical faces vary from about 3-7 m high, and which parallel the southeast coast of the Roche Bay Peninsula at a distance of about 30 m. This location is quite barren, with bare limestone gravel covering much of the land surface, but 150 m inland the vegetation cover becomes greater than 50%.

Structures here include six or eight dwellings, most of them low-walled structures with walls two layers high. Most of these were small with the interior diameter being about 2 m or less. These structures do not have the floors dug down, but are built on a slope with the entrance at the lowest point.

At the north end of this site, a tall (over 1 m) inuksuk stands at the top of the cliff, marking a very easy climbing route.

Because of prevailing wind direction, a very large snowdrift is located below the cliffs here, and it often lasts through the summer according to Inuit in this region. Jack Haniliaq said the snowdrift was obviously a summer drinking water supply for this camp.

Site U

Located on nearly flat land, with vegetation (cushion plant-sedge-moss association) alternating with raised beaches, this site is about 300 m south of the Borealis automatic weather recording station.

Structures at this site are three tent rings, and a larger oblong tent ring, apparently divided into four rooms. Its boundary is marked by many rocks, and it is about 3 m long and 2 m wide, with the ends rounded. One division is marked by a curved row of rocks, which makes a ring out of one end. The next division is marked by another row of rocks going from one wall to the other, curved in the same direction as the first, but with the left end (proceeding from the first division wall) much closer to the first division wall than the right end. The third division is marked by a straight row of rocks from one wall to the other, with a short row extending about 40 cm from the centre of the row at a right angle to it, toward the centre of the other, rounded end. The third division wall is closer to the second than to the end wall.

Site V (Not included on map)

Reported to be located on Deposit B, on the north side of a small stream on a small flat area at line 31, 3 + 20 E. This structure would be an elongated tent ring, about 2 m long and 1.5 m wide. It is apparently a simple tent ring, with no rock visible inside it. The rocks are lichen covered.

9.5 CONCLUSION

There are about 22 archaeological sites in the development area. Because of their location most will not be disturbed by the mining development. If it becomes necessary to disturb an archaeological site, we recommend that the Company give six months notice to the archaeological community so that those sites which may be affected can be catalogued and evaluated.

ADDENDA TO I.E.E.
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ADDENDUM TWO

This section deals with the Company's position on year round shipping and on the development of the western deposits.

2.1 SHIPPING

As stated in the I.E.E. Borealis will not be shipping year round. Borealis will be shipping only during the open season in conventional ore carriers. In effect this means a shipping season of 62 days with some possibility of an expansion to 103 days for some ice breaker assisted shipping.

It would not be economically feasible to ship iron in ice class vessels. Iron is a low unit value commodity and the costs of ice class shipping could exceed the value of the product.

Borealis has found it necessary to restate this position repeatedly because it is clear that many northerners believe that year round shipping is being considered for the Borealis project. For example in Northern Perspectives (Volume 9, Number 2, 1981) it is assumed that Borealis will be shipping concentrate year round. The Company responded to this article and a copy of the article and the Company's response are attached to this Addendum.

In summary, the Borealis Roche Bay Magnetite Project is only economically feasible using large scale conventional shipping. The Company has no intention of attempting ice class shipping of iron ore not only for environmental reasons but also because year round shipping would not be economically feasible.

2.2 DEVELOPMENT OF THE WEST

It is understood by Borealis that endorsement of the environmental safety of the development on east Melville Peninsula in no way entails or implies approval of a development in the West. If and when Borealis does decide to mine the West it would be tantamount to the opening of a new mine and would require the same sort of careful consideration by the government and the communities as the opening of the original mine.

The economic feasibility of this project on the East Melville Peninsula in no way depends on the development of the West. In fact the twenty year economic analysis for the feasibility study is concerned only with the mining of one of the three lease areas on the East—Lease 2952. Lease 2952 contains about 10% of the estimated iron ore reserves in the Borealis Melville Peninsula mineral leases and, because it is rather lower in grade than the average, Lease 2952 contains only 7% of the estimated contained iron.

This issue was also raised in Northern Perspectives (Volume 9, Number 2, 1981). A reprint of the article and the Company's response to the article are attached to this addendum.

As a corollary, it is also understood that approval for an iron operation in the vicinity of Roche Bay does not in any way entail approval for extracting any other minerals from these lease areas.

ADDENDUM THREE

3 ENVIRONMENTAL IMPLICATIONS OF THE PRELIMINARY FEASIBILITY STUDY BY SCOTT-ORTECH MINING LIMITED

With the completion of the preliminary engineering work by Scott-Ortech Mining Ltd, there is a clearer definition of the environmental impacts of the project.

This addendum should be read in conjunction with the "Preliminary Feasibility Study for the Borealis Roche Bay Magnetite Project" prepared by Scott Ortech Mining, Ltd and dated April 1982.

That study is concerned with the mining of the Adler and B Deposits. It should be noted that the Adler and B deposits located in Lease no. 2952 have been selected for mining because of their proximity to port. These deposits are not the largest on the east (C alone contains more ore than Adler and B combined) and Adler and B do not have the highest grade. In fact Adler and B contain only 10% of the estimated ore reserves on the Borealis Melville Peninsula leases and only about 7% of the estimated contained Fe units.

Every effort has been made to locate all major structures either on bed rock or on raised limestone shale. With the exception of the road and the major concentrate conveyor there seems to be no need to traverse or to build on sedge meadow areas and the sedge meadow area on the conveyor-road route has been minimized.

Drawing I-SK-03 [1] represents the engineers' plans at this time for the location of all major facilities. These site selections are tentative —

drilling and other geotechnical work will be required to verify suitability for building sites.

The Scott Ortech Study discusses these facilities in greater detail. This addendum is concerned primarily with environmental impacts of the processing and the siting of major facilities.

3.1 PROCESSING

The process developed in the Scott-Ortech Study is a dry magnetic separation process which except for two qualifications is essentially similar, for environmental purposes, to the very broad description included in the Initial Environmental Evaluation.

The two qualifications concern the granulametics of the tailings and the dust control systems in the mills.

3.1.1 Tailings

It was stated in the I.E.E.that the tailings material, overwhelmingly silica, would be very fine in texture, as fine as the concentrate. In fact, however, the tailings will be quite coarse because non-magnetics are being separated out during the crushing and grinding sequences. Examination of the proposed flow chart (Drawing I-SK-06) will show that about half the silica is separated out after crushing to 1/4 inch. The following is a profile of the granulametrics of the tailings from a recent series of tests:

ESTIMATED PARTICLE SIZE DISTRIBUTION
OF
BOREALIS PROJECT SAND DISCARDS

ON SCREEN NO.		WEIGHT %
1/ 6 Mesh		19.3
12 Mesh		16.6
20 Mesh		9.2
50 Mesh		14.6
100 Mesh		12.0
200 Mesh		11.6
325 Mesh		10.7
Pan		6.0
	Total	100.0

1/ Top Size approximately 4 mesh.

It is clear that the tailings will not resemble a fine powdered silica but instead will resemble a very coarse beach sand. Accordingly, dust control at the tailings site will be greatly simplified.

3.1.2 Dust control in the mills

In any dry process involving fines it is necessary for the protection of the employees, the equipment, and the outside environment to severely limit the amount of air borne dust.

In the I.E.E. the methods by which dust is to be controlled in the processing were not specified. In the Scott-Ortech study these methods are identified and ample provision is made to collect dust from the working environments and to minimise emissions to the atmosphere. Dust will be collected, reprocessed, if appropriate, for further iron removal, and disposed of with the sands (IV-38)

The processing of the ore can be divided into three stages, (Drawing I-SK-06) These four stages are:

a. Crushing plant: Crushing in the gyratories to 3" and magnetic cobbing.

b. Mill One: Crushing in cone crushers to 4 mesh and magnetic separation.

c. Mill Two: Grinding in rod and ball mills to 200 mesh with repeated magnetic separation.

Dust control in these areas will be accomplished as follows:

a. Crushing plant (See IV-20 and Appendix A): Dust will be controlled via multiple pick up points, a cyclone, baghouse, and fan. If the

3.2 LOCATIONS OF MAJOR FACILITIES AND ENVIRONMENTAL ALTERNATIVES

3.2.1 Mine Site

a. Drainage: There are two principal drainage alternatives. The main drainage system of this area, flows through the largest lakes at the west end of the Roche Bay peninsula, and into the north arm of Roche Bay,. The lower part of this drainage system and the place where it enters Roche Bay are known by Inuit of the region as "Irqalugarjuit" because of its importance for arctic char and lake trout spawning. Contamination of this drainage system by mine or mill waste should be avoided. Any such contamination may affect the fish population. Also the largest lake in this system,"Irqalugarjuit Lake", will probably be a water source for the town. The other drainage alternative, which is the recommended alternative, would be to divert the run-off from the mine and mill areas into a drainage canal to the South that would empty directly into the south arm of Roche Bay without passing through other fresh water lakes. The south arm of Roche Bay according to both the Company's environmentalists, and the local Inuit residents, is of much less ecological importance. Consequently, the plans have been designed to avoid contaminating the Irqalugarjuit area.

In order to avoid disturbing the ecology of the Irqalugarjuit drainage area it will be necessary to dig diversion canals to carry water off the orebody and into water sources that empty directly into the bay without going into the lakes and rivers in the area (See IV-4). In addition the small ponds and lakes on the mine site will be drained prior to the commencement of mining so that the fish bearing waterways will not be contaminated by ammonium nitrate from the blasting. Residues will be diverted and carried directly into the bay rather than in the local lakes and rivers where the ammonium nitrate residues, which are a fertilizer, may have a distabilizing effect on the ecology.

Since the mine is in an area of deep permafrost (to an estimated 450m with an active layer in the bedrock areas of probably less than .2 m there will be no water table in the traditional sense and since the deposits are at the top of incline run-off into the pit should be minimal. There will, however, be some water accumulating in the pit and three 250 HP pumps have been included in the plan (See IV-10 and Appendix A). Water pumped out of the pit will discharge into a pipeline that runs from the pit to a water treatment plant (if so required) and then diverted away from the inland waterways. (See IV-10).

b. Waste rock disposal: In the first few years of mining the amount of waste rock will be nominal although as the depth of the pit increases waste rock will be mined in order to provide benched walls to the pit. The final disposition place of this rock has not been determined but the most likely location for this waste rock is in the valley to the west of the fault line between Adler and B.

3.3.2 Positioning of the Mills

There were three major alternatives for the positioning of the processing mills: Near the mine site, at the base of the hill, and at the dock site. The two lower locations were rejected because there were no suitable waste disposal sites of any size on the peninsula and it would be too costly to convey the tailings back up 700 vertical feet to the possible waste disposal sites.

Once having made the decision to locate the processing on top of the hill there were several alternatives for the location of the Crusher Plant, Mill One and Mill Two.

The two principal considerations for site selection then became to minimise material transport cost and to provide competent foundations for crushers, mills, and other heavy loads on the granitic and metamorphic rocks expected near the surface in this area (IV-34)

In order to confirm the appropriateness of the selected sites studies should be done of specific sites before making final decisions as to location. These studies would include core drilling to determine the condition of the substrate, and the presence of any ice layers or pockets below these sites, .

a. The crushing plant will be located in a central position near the mine site. The final location of the crushing plant is not fixed although, the site proposed in Drawing I-SK-03 would seem to be satisfactory. The crushing plant should be near the mine site to minimize truck haulage and be so situated to enable the approach roads to be located on solid bed rock. In addition the Primary crusher should be located where there is a suitable incline for gravity feed.

The company's environmental consultants, Elliott Environmental Research and Consulting Service, Calgary Alberta, have also stressed the need to have all mill site areas drain into a channel that empties directly into Roche Bay rather than into the Irqalugarjuit Lake area. If tests indicate that wastes from these areas are environmentally problematic this water will have to be treated before discharge in the bay. With adequate dust contol however it is not anticipated that there will be significant amounts of tailings material in this drainage water.

b. Mill One and Mill Two. Once having determined that the mills should be on the hill there were two types of considerations that guided the final choice in addition to locating these structures on a granitic and metamorphic rock base.

1. The mills must be located in an area that would minimize conveyor distances to the waste disposal sites and to the docks. In effect, the location of the main concentrate conveyor tends to determine the location for the mill. (See discussion of conveyor routes.)
2. The mills should be located to avoid water or air born wastes contaminating critical waterways.

1. The mill site was chosen because of it proximity to the sand disposal site and it's location with respect to the optimal conveyor line to the dock.

2. Essentially no water born or air born wastes from the mills are

anticipated. The air borne wastes have been discussed above. There is no water involved in the processing of the ore. Any waste water from the mills will then be proportional to the number of workers and the amount of equipment maintenance in the mill area. Each Mill building complex will be supplied with a sump and holding tank for such liquid wastes and these wastes will be collected and trucked away to be treated as is waste water from the town site and other facilities on the peninsula. (IV-39)

3.3.3 The Concentrate Conveyor

For reasons already discussed in the Initial Environmental Evalution, the decision was made to use conveyor systems whenever feasible instead of trucks. Once that decision was made the location of the main concentrate conveyor from the mine site to the dock area determined the location of the mill buildings themselves.

In the attached Drawing-3.3.3 an alternative conveyor route was suggested by Scott-Ortech and, as a corollary an alternative mill site. Since Scott-Ortech did not have first hand knowledge of the terrain or access to other vegetation studies the Company's environmental consultants were asked for their suggestions on the location in Drawing 3.3.3. On the basis of their suggestions an alternative plot plan was selected. Their comments on the proposed conveyor route were:

> "Our proposed conveyor system consists of a straight line from the primary crusher to the mill site on the Melville plateau, then a straight line from the mill site to the dock storage site at the east end of the Roche Bay peninsula, as does Scott-Ortech's. However, the

west end of our conveyor route is about one mile (1.5 km) south of the Scott-Ortech conveyor route, and crosses this route on the peninsula, terminating at the north end of the dock-storage area proposed by Scott-Ortech (or at the south end of a similar storage area at our proposed dock site).

Our reasons for proposing this conveyor route change are both physical and ecological. The Scott-Ortech route goes down a very steep rugged mass of metamorphic bedrock at the edge of the Melville plateau, then down a wet, slowly slipping sedge meadow slope below this, then across a wet, well-vegetated valley about 1/2 km wide, where the main creek divides into many channels, and finally climbs over the highest ridge on the peninsula. (The distance between this peninsula ridge and the equivalent hight on the edge of the plateau on this route is about 1 km.)

Our selected route goes down a part of the plateau-edge which is less steeply sloping, and on its south side a broad cut in the plateau edge makes a convenient road route. It descends to cross a narrower, drier valley which contains a single fairly small creek, then onto the peninsula south of the high ridge.

After passing the high ridge on the west part of the peninsula, both routes are physically and ecologically very similar, and do not pass through areas of major ecological importance.

Another conveyor route goes more than a mile from the mill site to the sand-tailings disposal site on the Scott-Ortech proposal. Our proposed mill site is much closer to the disposal site, and so requires a much shorter conveyor system here.

The lush "snow-patch' vegetation indicates that snow cover is deeper where the Scott-Ortech main conveyor route crosses the wet valley between the plateau and the peninsula, than where our route crosses this valley, probably because of differences in snow drifting.

On the advice of the Company's environmentallists the conveyor route was altered. Again, of course, the final routing will depend on geotechnical work.

3.3.4 Sand Disposal Site

Once having determined that there were no areas on the peninsula adequate to take the volumes of sand likely to be generated, areas on the hills were examined. There exists an area (marked on Drawing 3.3.3) south of the selected site which would accomodate over sixty years of tailings. This area was rejected because it is nearly three miles from the mine site. The area selected should remain useable for ten years and it can be extended in the direction of the larger site by extending the base conveyor.

Neither site drains into the ecologically sensitive Irqualugarjuit drainage system and the use of the nearer site does not preclude the later use of the more distant site.

In the opinion of the Company's environmental consultants the selected sand tailings disposal site is probably the most ecologically practical site between the deposits and the peninsula and coast, as long as its boundaries are such that drainage carries any significant silt or soluble elements away from the Irqalugarjuit drainage system.

The method for tailings disposal using a system of stationary and shiftable conveyors and trippers (See IV-32) is probably less environmentally problematic than trucking the sand and allows for a more structured and controlled land fill.

3.3.5 The Concentrate Shipping Dock Site.

The concentrate dock is located at the end of the peninsula in order to maximize turning distance and to minimize the movement of the large ships into either of the "arms" of Roche Bay. An alternative site on the south shore of Roche Bay was suggested in an independent shipping study but this site was rejected in part because it was felt that the south shore of Roche Bay may be more ecologically sensitive than the peninsula jutting out into the bay.

3.5 OFF SITE FACILITIES

An offsite facility is considered to be any facility not actually engaged in the creation of a product but which is necessary for the operation to function. The off site facilities therefore include, in addition to the town site, the airstrips, the general freight dock, the power plant, the shops and warehouses on the peninsula, and the water treatment facilities. It was not the purpose of the preliminary engineering report to precisely locate each of these facilities although tentative selections have been made.

3.5.1 Town site

"Town site" in this context refers to the bunkhouse community which will be required for the rotational work force. (See IV-35). The Company's town site will be located either on bedrock or on limestone shale in part so that ecologically more sensitive terrain is not disturbed. The town site should also be located in an area where northerners would choose to live. In an earlier plan the town site was located west of the peninsula on the hills near Deposit C. This site was criticized by the residents of Hall Beach because it was too far from the mine facilities and too far from the water. The site suggested in the Scott-Ortech study is close to the site suggested by several Hall Beach Inuit during visits to the property last summer. The Hall Beach Hamlet Council has been asked to send the Company a more detailed description of where the town site should be located on the peninsula. Final determination of the town site will be made after the Hall Beach Hamlet Council has replied to this request. (A fuller discussion of the town site will be presented in the Company's Socio Economic Impact Study.)

3.5.2 Airfield

Airfield facilities are located near the town site on the limestone-shale areas of the peninsula. The siting was done in conjunction with Nordair. The relatively flat and apparently stable ground in this area should provide an excellent site with minimal damage to the permafrost.

3.5.3 Power Plant

As a result of the Scott-Ortech work and discussions with local Inuit where strong opposition to damming the Ayaquatalik river were voiced, (See Addendum Six) the energy sources for the project were reevaluated. First it was found that the energy needs of the project will be greater than originally anticipated and second that the major source of non-fossil fueled energy is no longer under consideration because of local opposition. Consequently, the decision was made that a coal fired plant would be needed.

The power station will be a coal-fired power station of 70 MW nominal capacity. (See IV-36) The power plant itself will be located on barges rather than on the peninsula itself, in part, to minimize damage to the permafrost.

The coal is stored in three storage piles on shore, adjacent to the power plant. Total storage of coal is 200,000 tonnes, based on the published heating value of Nova Soctia coal. It is anticipated that Nova Scotia coal will be used. Emission control systems are allowed in the pricing for the power station. Nova Scotia coal is characterised as low ash, but fairly high in organic sulphur, so a scrubber system and perhaps electrostatic precipitation will be considered. This problem is solvable by established technology.

Coal handling and pulverising systems are included with fire protection and dust suppression systems.

Ash disposal is by truck to the sand disposal area.

A diesel-powered emergency generator will be provided to ensure redundancy of electrical supply for boiler and equipment operation.

The Company will continue to examine the possibilities of Wind Power on Melville Peninsula. There is certainly sufficient wind to justify such a system if and when the technology for large scale wind systems in arctic conditions is proven sound.

3.5.4 Water Supply System

Irqalugarjuit Lake and the drainage system coming into that part of the peninsula are significant sources of fresh water, and that lake, according to several Inuit in this region, is deep enough so that it never freezes to the bottom. At this time it is anticipated that this lake would be a suitable source of fresh water for the town site. (IV-37)

3.5.5 Roads

Location of year-round roads will require further study although there will be some road along the main conveyor routes so that the conveyors can be serviced and there will be roads in the mine area. The building material for these roads will probably be limestone-shale. The peninsula is made up largely of this material and there are several sites marked on the maps from which such material could be taken for road construction. The limestone shale has been proven, in Hall Beach as in other places, to be a very stable road building material which tends to compact well under use.

3.5.6 General Purpose dock

The general purpose dock will be located near the power plant and the town site to facilitate the handling of material. It is necessary to have a general purpose dock because the docking facilities for the iron concentrate are highly specialized structures and in order to load the required amount of tonnage they will be needed exclusively for the shipment of iron ore.

NOTES TO ADDENDUM THREE

1/ Except where noted, all references in this addendum are to the Scott Ortech Study.

MICROBAC LABORATORIES, INC.
ERIE TESTING LABORATORY DIVISION
2401 West 26th Street, Erie, Pennsylvania 16506
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AIR • FUEL • WATER • FOOD • WASTES

BATCH LEACHING TEST STUDY

FOR

ASSESSMENT OF LEACHING POTENTIAL

OF

BOREALIS MINE TAILINGS

July 19, 1982

INTRODUCTION

A laboratory scale study was conducted of mine tailing samples generated by Borealis Exploration and supplied to us by Mr. Mike Ross of Eriez Magnetics in order to determine what potential existed for adverse impact on the environment by rainfall leaching to the tailings.

Results of this study can be used, together with a thorough understanding of the hydrogeologic characteristics of the disposal site, to determine if these tailings could adversely effect the environment.

Two samples obtained from Eriez Magnetics are as follows:

#1 Bulk tailings from Magnetic separation of iron ore. These tailings were sampled from a larger bulk sample and ground to pass through a 9.5 mm (0.375 inch) sieve.

#2 -200 mesh fraction obtained from sieving of the coarse tailings as received.

This second sample was analyzed, not to predict leachate quality, but to predict " worst case" since leachability is generally proportional to particle size. That is, the smaller the particle, the more contaminated the leaching media should become.

The first testing which was performed was the acid producing potential test. Each sample was analyzed in duplicate for total sulfur. Results are as follows:

	Bulk tailings	-200 Fraction
% Sulfur	0.25	0.12
% Sulfur	0.24	0.12
	0.245	0.12

Assuming a 1:1 Conversion of the sulfur to sulfuric acid, a potential exists for acid production at the following levels:

Bulk: 16 lbs/ton tailings   -200 mesh: 7.35 lbs/ton tailings

The acid consumption test was then performed and the following results were obtained:

Acid Consuming Ability

Bulk	-200 Mesh
13 lbs/ton	16 lbs/ton
14 lbs/ton	16 lbs/ton

It is apparent at this point that the -200 Fraction has a greater ability to consume acid than to produce acid, so the -200 mesh could not be a source of acid drainage. However, the bulk tailings have a theoretical potential to produce 16 pounds of sulfuric acid per ton and only 13.5 per ton potential to consume acid. In order to determine if all of the sulfur is available to produce sulfuric acid, the bulk tailings were submitted to the microbiological confirmation test.

The testing procedure followed was as supplied by Neil Bryant, Administrator, Inland Water, Water Resources, Yellowknife NWT, Canada.

The following results were obtained; (Sample 1 and 2 are duplicates).

	Sample 1 Dissolved Fe mg/l	pH	Sample 2 Dissolved Fe mg/l	pH
After 24 hours	179	2.5	179	2.75
48 hours	216	2.5	235	2.70
72 hours	202	2.7	192	2.80
50% additional tailings added				
144 hours	285	2.7	260	2.75
168 hours	155	2.7	150	2.75
50% additional tailings added				
192 hours	20	4.2	24	4.4
310 hours	0.16	6.4	0.21	6.1

Test Terminated

According to the interpertation scheme supplied by Mr. Bryant, the material cannot be a source of acid mine drainage.

Additional testing which was done on both the bulk sample and the -200 mesh fraction was the waste leachability testing.

Several procedures and leaching solutions exist which attempt to simulate and predict the quality of leachate formed when rainwater or the ground water comes in contact with an exposed fill (tailings). The United States has adopted a procedure for evaluating whether a waste is hazardous. Environment Canada has published a proposed procedure for evaluating waste leachability (draft copy form only). This draft document contains six different leaching methodologies of which two would definately not be appropriate. They are the 4:1 and 20:1 synthetic leachate procedures. These two procedures attempt to simulate the leachate produced when an inorganic waste (tailings) is landfilled with municipal wastes. Since this is not the case, those procedures were eliminated from our list of choices.

Of the four remaining procedures, two utilize distilled water and two utilize acidic (pH 4.5) solution.

Since the objective of the study was to determine if the tailings have the potential to adversely effect the environment, our desire was to use the harshest leaching media. It was determined that the waste when leached in distilled water only produced a pH of 7.7, which would not be an optimum pH for metal leaching and the results from the microbiological confirmation testing were not yet available. We, therefore, eliminated the two distilled water leaching solutions.

The remaining two choices utilized an acidic solution buffered at pH 4.5, one with a liquid to solid ratio of 4:1 and the other at 20:1. Since it had previously been determined that the composite tailings had the potential to consume acid at a level of 13.5 pounds sulfuric acid/ton, it was decided that the leaching solution should supply as much acid as possible (ie. 20:1 ratio rather than 4:1 ratio).

The bulk tailings and the -200 mesh fraction were, therefore, leached for 24 hours in a buffered acid (4.5 pH) solution using square polyethylene bottles, mounted on a tumbler turning at a speed of 2 rpm (This method of agitation has been found to be most satisfactory by Environment Canada. See P. L. Cote and T. W. Constable, Evaluation of Expermental Conditions in Batch Leaching Procedures).

Results of the analysis of the samples and the finished leaching solutions are as follows:

	Bulk Tailings		Tailings Leachate		-200 Mesh Tailings		-200 Mesh Leachate	
Silver	<5	ppm	<0.01	mg/l	<5	ppm	<0.01	mg/l
Manganese	161	ppm	1.03	mg/l	156	ppm	1.66	mg/l
Zinc	11.8	ppm	0.38	mg/l	15.6	ppm	0.97	mg/l
Copper	13.0	ppm	0.15	mg/l	31.2	ppm	0.62	mg/l
Nickel	9.47	ppm	0.03	mg/l	8.91	ppm	0.06	mg/l
Chromium	9.47	ppm	<0.01	mg/l	11.1	ppm	<0.01	mg/l
Iron	>100	ppm	1.22	mg/l	>100	ppm	0.20	mg/l
Cadmium	9.47	ppm	<0.02	mg/l	<9	ppm	<0.02	mg/l
Lead	<25	ppm	<0.1	mg/l	<45	ppm	<0.1	mg/l
Thallium	<25	ppm	<0.1	mg/l	<45	ppm	<0.1	mg/l
Beryllium	<2.37	ppm	<0.01	mg/l	<4.45	ppm	<0.01	mg/l
Molybdenum	<23.7	ppm	<0.1	mg/l	<44.5	ppm	<0.1	mg/l
Aluminum	3730	ppm	<0.1	mg/l	3227	ppm	<0.1	mg/l
Barium	23.7	ppm	<0.5	mg/l	<44.5	ppm	<0.5	mg/l
Titanium	94.7	ppm	<0.4	mg/l	<150	ppm	<0.4	mg/l
Mercury	<0.3	ppm	<0.001	mg/l	<0.5	ppm	<0.001	mg/l
Selenium	<2.37	ppm	<0.01	mg/l	<4.45	ppm	<0.01	mg/l

	Bulk Tailings		Tailings Leachate		-200 Mesh Tailings		-200 Mesh Leachate	
Arsenic	10.9	ppm	<0.005	mg/l	9.35	ppm	<0.005	mg/l
Sodium	---------- In Leachate as sodium acetate----------							
Potassium	>100	ppm	5	mg/l	<100	ppm	11	mg/l
Calcium	1400	ppm	72	mg/l	3960	ppm	110	mg/l
Magnesium	>100	ppm	2.9	mg/l	>100	ppm	4.2	mg/l
Vanadium	<50	ppm	<0.2	mg/l	<50	ppm	<0.2	mg/l
Cobalt	<200	ppm	0.01	mg/l	<200	ppm	<0.01	mg/l
Phosphorus	>5	ppm	<0.01	mg/l	>5	ppm	0.04	mg/l
SiO_2	<1000	ppm	2.23	mg/l	>1000	ppm	2.60	mg/l
Final pH			4.9	Units			5.3	Units

The following table shows percentage of metal in tailings which leached and absolute weight in mg/kg of tailings.

	Bulk Tailings		-200 Mesh	
	% Leached	mg/kg drywaste	% Leached	mg/kg drywaste
Iron	0.022	24.4	0.0044	4
Manganese	12.8	20.6	21	33.2
Zinc	64	7.6	124	19.4
Copper	23	3	39	12.4
Nickel	6	0.6	13	1.2

The above information would suggest that if the tailings were leached with a solution of pH 4.5, considerable iron, manganese, zinc and copper could be released. However, the tailings do show the capacity to buffer the acidic solution. If the rainfall pH in the storage area were slightly acidic the waste may be capable of neutralizing the acidity and preventing leaching of those four metals.

Because of that possibility, and because the results of the microbiological confirmation test became available, we additionally performed the 20:1 distilled water leachate and analyzed and found the following:

Initial pH distilled water 4.8 (CO_2 dissolved)

Manganese	0.016	mg/l
Zinc	<0.01	mg/l
Copper	<0.01	mg/l
Iron	1.47	mg/l
Final pH	6.8	Units

In conclusion:

1.) The tailings will not be a source of acid mine drainage.
2.) The tailings have the capacity to neutralize acidic rainfall.
3.) Very few elements are leached from the tailings in the laboratory procedure.

FLORA and VEGETATION

of the

ROCHE BAY AREA, MELVILLE PENINSULA,

NORTHWEST TERRITORIES,

CANADA:

Accompanied by a LANDSAT computer
map of the vegetation cover.

A report submitted by: Mr. Dennis Jaques, President
Ecosat Geobotanical Surveys Inc.
858 Handsworth Road
North Vancouver, B.C. V7R 2A2

Submitted to: Borealis Exploration Ltd.
#800 630 - 8th Avenue S.W.
Calgary, Alberta T2P 1G6

June 2, 1982

TABLE of CONTENTS

LIST of FIGURES

LIST of TABLES

Vegetation of the Roche Bay Area,
Melville Peninsula, Northwest Territories

1. Introduction

The Roche Bay study area is located in the Mid-Arctic Wetland Region as defined by Zoltai (1979). Figure 1 shows the general location of the study area on the east shore of central Melville Peninsula. No published information is available on the vegetation of the Roche Bay area or of areas nearby. However, ecologically similar areas have received extensive study. The most significant past works describing similar arctic vegetation and floras are those by Aleksandrova (1971), Britton (1966), Polunin (1959), Porsild (1957), Porsild and Cody (1980), Muc (1977), Svoboda (1977) and Barrett (1972). This present study describes field observations and analyses conducted from July 3 through July 8, 1981. The vegetation was mapped using LANDSAT computer compatible tape data for an image obtained on August 20, 1975 (#11123-16222). This satellite image was analyzed on the McDonald-Dettwiler and Associates Image Analysis System (Richmond, B.C.) using a cluster analysis program adapted from the method defined by Ball and Hall (1965).

2. Flora of the Roche Bay Area

Plant collections made by the author in July, 1981, field observations at that time, and study of the distribution maps of Porsild and Cody (1980) indicate the presence of 190 vascular plant, moss and lichen species in the Roche Bay area. These species are listed in Appendix I. Species actually collected or noted in the area during field study number 128. The other species are likely to exist in the area and may be found upon further investigation. Of the 128 known species, 92 are vascular plants, 21 are mosses, and 15 are lichens. A considerably larger number of mosses and lichens could be added to this list if careful study were made of the area.

3. Plant Associations

The plant species growing in the study area are found in groupings which are controlled by environmental factors. The major factors controlling their abundance and distribution include topography, parent materials,

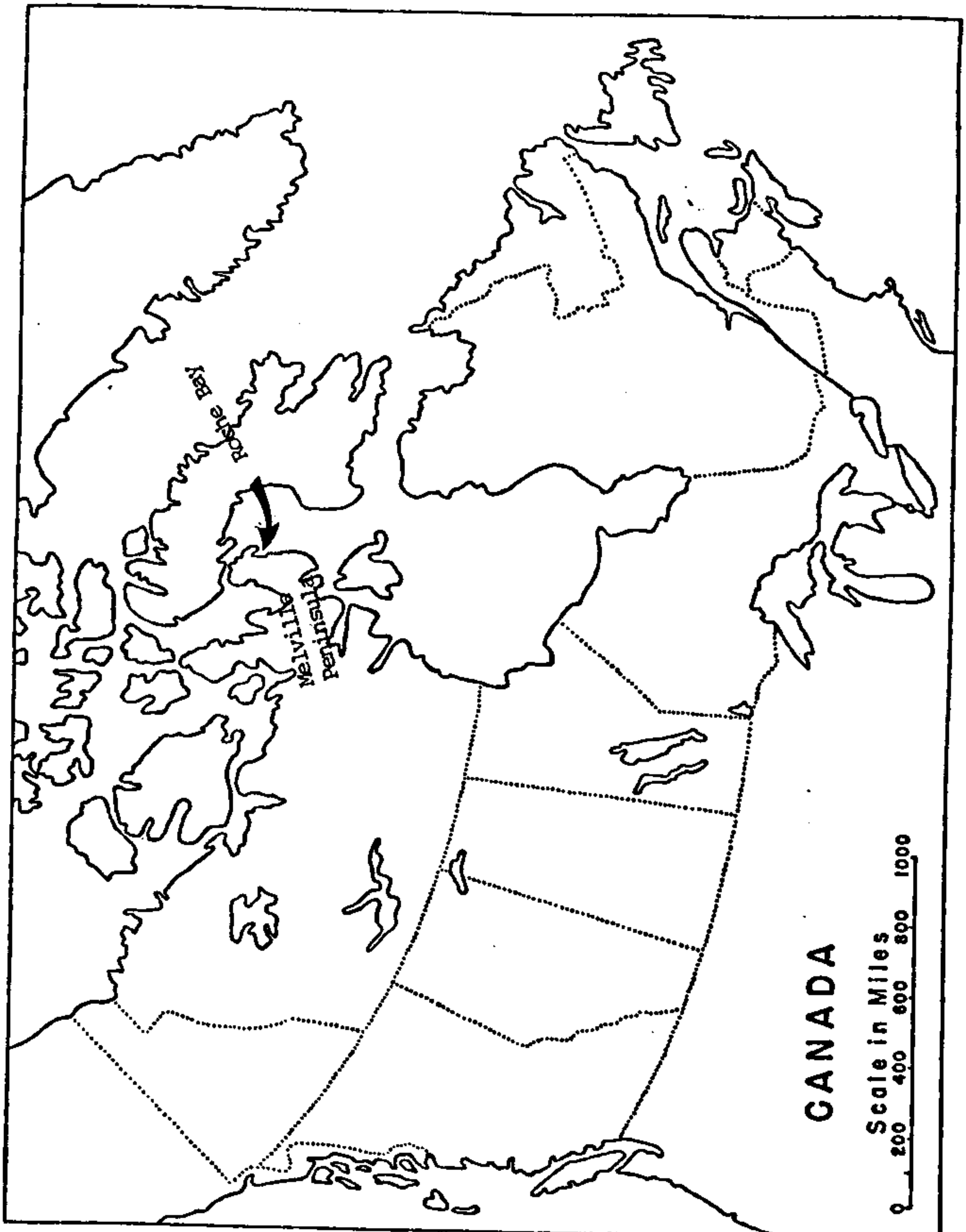


Figure 1. Location of the Melville Peninsula, Northwest Territories. The arrow points to Roche Bay; the detailed study area.

climate, animal influences and historical factors such as glaciation and past climatic conditions. Complex interactions among all of these factors, along with the growth and development characteristics of the plants themselves determine the large diversity of plant associations found throughout the study area.

The major controlling factor is climate. The mid-arctic climate limits plants to herbaceous species only. No trees are found in the area. A feature of the climate which exerts strong control on the plant life is permafrost. Continuous permafrost has developed throughout the study area and it extends to great depths into the earth. The surface active layer varies from 8 to 10 cm in depth to over 90 cm, depending upon slope, aspect, parent material type and texture and the type of vegetation cover. Maxwell (1980) has included the Roche Bay area in the South Central Macroclimatic Region.

The next most important factor is parent materials. Bedrock and surficial material types combine to produce distinctive surface conditions which, along with the macroclimatic conditions, determine the make-up of plant associations. Figure 2 shows the distribution of major bedrock lithological types. A major fault separates the crystalline Precambrian granites and gneisses from the Paleozoic dolomites and limestones. The Precambrian crystalline rocks form an upland region of moderate relief. The Precambrian crystalline bedrock occurs in the western portion of the study area--west of the escarpment formed by the fault contact. The Paleozoic sedimentary rocks form a generally level lowland east of the fault contact.

Weathering and deposition processes have modified or covered the surface of the local bedrock with various types of surficial materials. The types of surficial materials found in the study area include:

1) Residual deposits
   a) crystalline Precambrian material
   b) calcareous Paleozoic material
2) Colluvium
   a) crystalline Precambrian material
   b) calcareous Paleozoic material
3) Marine--beach deposits
4) Alluvial lacustrine
   a) lacustrine predominant
   b) alluvial slopes
   c) alluvial outwash

Figure 2. Bedrock of the Roche Bay area, Melville Peninsula, Northwest Territories (after Trettin 1974)

LEGEND

UPPER ORDOVICIAN

uOu — *Unnamed reefal unit: dolomite, brown, sucrosic and bituminous, thin bedded, containing biohermal structures*

MIDDLE ORDOVICIAN

mOB — *BAD CACHE RAPIDS FORMATION: limestone, dark brown, micritic, uniform to nodular bedded, massive weathering*

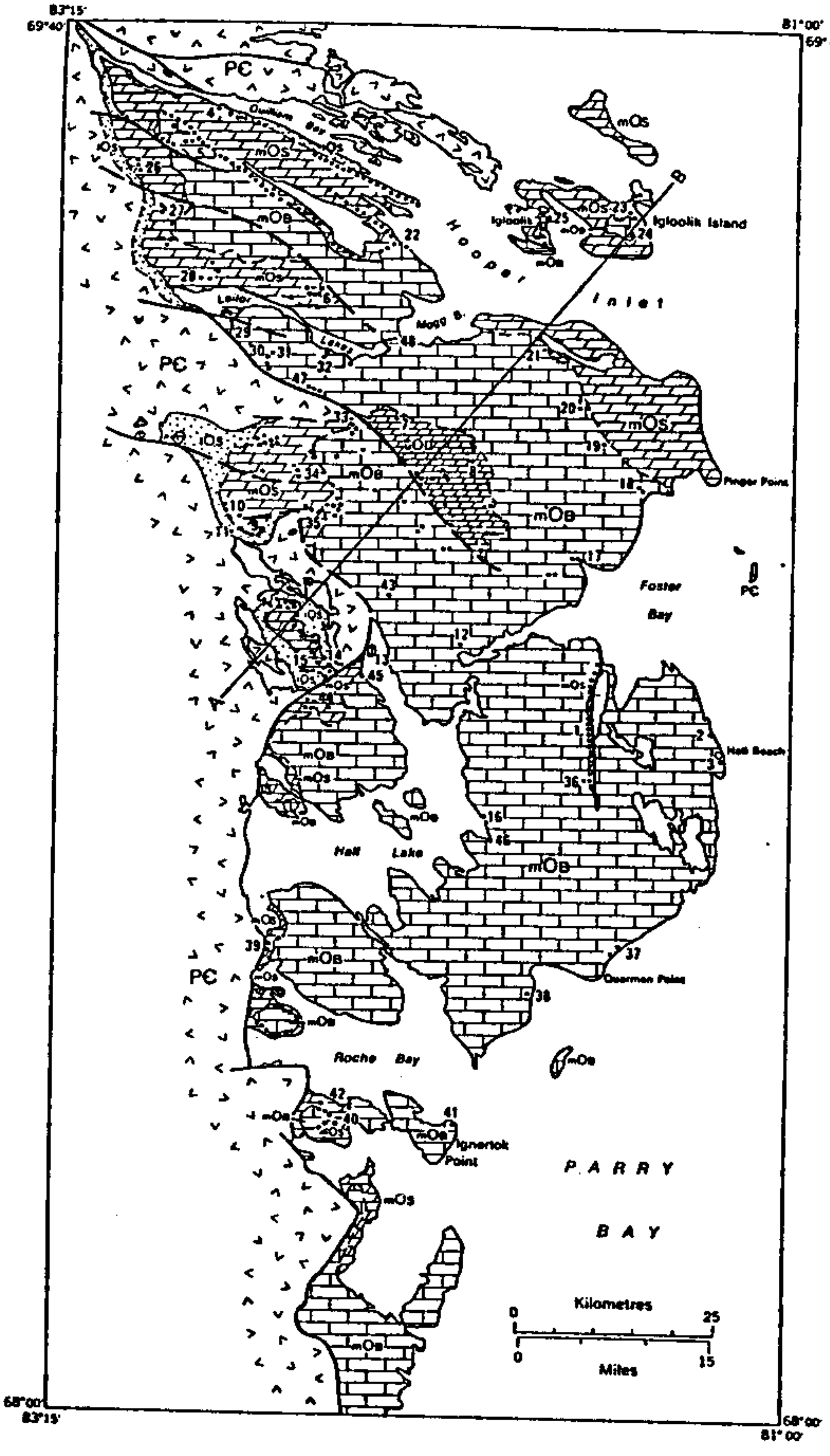
mOs — *SHIP POINT FORMATION (units 3 and 4): dolomite, grey and tan, microsucrosic, thin uniformly bedded*

LOWER (?) ORDOVICIAN

lOs — *SHIP POINT FORMATION (units 1 and 2): sandstone, red and grey, medium grained, and dolomite, tan, sucrosic, massive weathering, containing small algal mounds*

PRECAMBRIAN

Gneissic rocks undivided


83°15'
69°40'
81°00'
69°40'
PC
mOS
Hooper Inlet
Igloolik Island
Igloolik
mOB
Foster Bay
Finger Point
Hall Beach
Hall Lake
Roche Bay
Ignertok Point
PARRY BAY
Kilometres
0
25
Miles
0
15
68°00'
83°15'
68°00'
81°00'

5) Moraine
   a) upland crystalline ground moraine
   b) lowland calcareous ground moraine
6) Organic
   a) wet organic deposits
   b) dry organic deposits

These parent material types develop distinctive soil types and vegetation cover types.

The complexity of interacting environmental factors has resulted in a bewildering array of plant assemblages. Only the most abundant and the most significant of those assemblages are described in this study. These are defined in a framework which simplifies the diversity but maintains the distinctiveness of ecological units.

3.1 Precambrian Upland Plant Associations

Five major plant associations are found developing on the Precambrian upland region. These are the following:

1) Dwarf shrub-lichen;
2) Dwarf shrub;
3) Dwarf shrub-heath-moss;
4) Sedge meadows; and
5) Snow beds.

Figure 3 shows a stereo view of the Dwarf shrub-lichen and Dwarf shrub associations. These two associations are found where snow cover is light to shallow. Both associations are made up of plant communities which form according to differences in bedrock minerology and depth of snow cover. The Dwarf shrub-lichen Association is found where snow cover is light or non-existent. *Dryas integrifolia* is the dwarf shrub which dominates this Association. Common vascular plant species which form a significant quantity of the total cover with *Dryas* include *Carex rupestris* and *Carex nardina*. Locally, on the most exposed sites, *Hierochloe alpina* is abundant. Numerous lichen species are quite abundant with the following species being predominant: *Cetraria nivalis*, *Cetraria cucullata*, *Cetraria tilesii* and *Thamnolia vermicularis*. Several other plant species are found in moderate abundance in this Association. These species are *Silene acaulis*, *Polygonum viviparum*, *Oxytropis maydelliana* and *Astragalus alpinus*. Total vegetation cover is quite low in this Association, ranging from 15 to 30 percent. Bare rock and residual bedrock fragments form most of the ground cover.

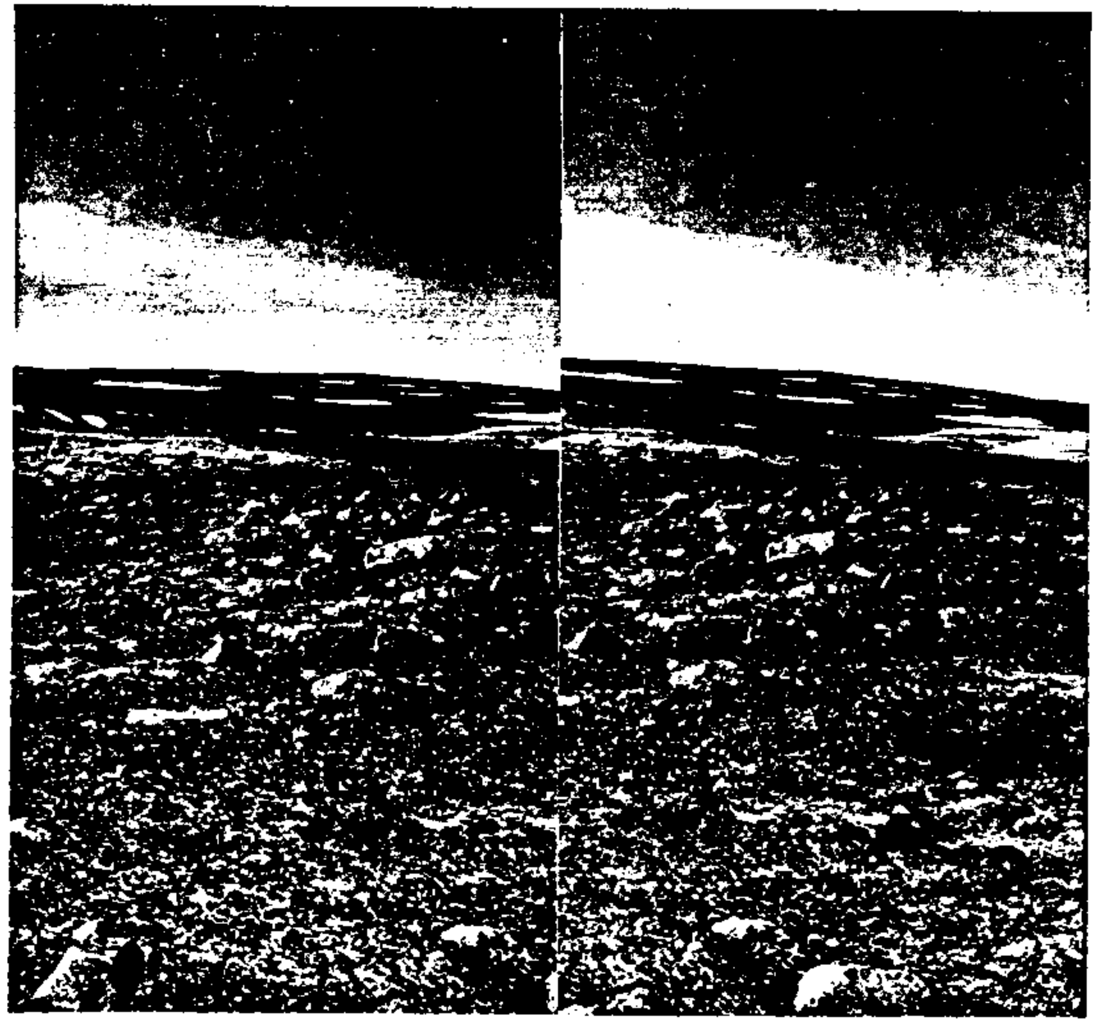


Figure 3. Stereo view in the foreground of the Cushion plant - lichen Vegetation Association on raised beach deposits formed from Paleozoic bedrock. In the background the barren PreCambrian Upland region can be seen. Examples of the Snowbed Association are clearly visible. Surrounding these snowbeds are stands of the Dwarf shrub - lichen and Dwarf shrub Associations.

Where snow cover is somewhat deeper but not usually persistent all winter, the Dwarf shrub Association develops. Total vegetation cover is significantly higher than in the previous association (i.e. 50-80%). However, only a few species make up over 90 percent of the total vegetation cover. These are *Dryas integrifolia, Carex misandra, Saxifraga oppositifolia, Carex nardina, Cetraria* spp., *Thamnolia vermicularis* and *Alectoria* sp. A nearly complete mat of dwarf shrub cover exists on these well drained sites. Numerous other species are characteristically found in this Association but their total combined cover is very low.

The Dwarf shrub-heath-moss Association develops where snow cover is light to moderate but persistent until June in most years. This Association can develop on residual bedrock, moraine, alluvial or colluvial deposits where snow cover conditions are favorable. Depending upon surficial material texture, slope and soil moisture conditions, different plant species will be found. However, the dwarf shrub, *Dryas integrifolia,* the heath, *Cassiope tetragona,* and the mosses, *Rhacomitrium lanuginosum* and *Tomenthypnum nitens* dominate in this Association. Several other species are abundant in this Association and are always found with the dominant species. These species include *Carex misandra, Carex rupestris, Saxifraga oppositifolia, Cetraria* spp., *Thamnolia vermicularis* and *Alectoria* sp. Numerous other less common species occur in the Association. *Luzula nivalis* and *Salix arctica* are conspicuous and regularly occurring species. Total plant cover is quite high in this Association, ranging from 50 to 75 percent.

Included within the Dwarf shrub-heath-moss Association are plant communities affected by cryoturbation. These sites are usually somewhat wetter and possess finer-textured soils than the norm for the Association. Unsorted stripes and circles form in this community type. *Dryas integrifolia* dominates along with *Oxytropis maydelliana, Cassiope tetragona, Carex rupestris, Carex scirpoidea, Saxifraga oppositifolia, Pedicularis lanata, Salix arctica* and *Salix reticulata.* The wet depressions formed between the raised microsites of this community type are dominated by sedges and mosses. These sedge and moss species are *Carex membranacea, Carex misandra, Ditrichium* sp. and *Drepanocladus* spp.

The Sedge Meadow Association develops on nearly level or gentle slopes where drainage is imperfect. Moderately deep to deep organic deposits are characteristic of this Association. Many sites possess patterned ground polygon features. Total plant cover is very high, ranging from 80 to over 100 percent. Total cover is almost always near or exceeding 100 percent because of the dense vascular plant and moss growth characteristic of these sites. The dominant plant species are *Carex aquatilis* and *Bryum* spp. Locally, many other species can gain dominance over or co-dominance with these species. These plants include the following: *Carex membranacea, Eriophorum angustifolium, Eriphorum scheuchzeri, Ditrichium flexicaule, Tomenthypnum nitens, Salix reticulata, Salix arctica* and *Dryas integrifolia.* Many other species of vascular plants, mosses and lichens are found in this Association.

The Snowbed Association develops in topographic depressions or lee slopes where snow accumulations are heavy and snow cover remains until late in the growing season. Generally concentric rings of distinctive plant communities develop in the Snowbed Association, depending upon the relative timing of snow-melt. In some years portions of this Association will remain snow covered throughout the entire growing season. Where snow cover melts first and the growing season is the longest for the Snowbed Association, *Salix herbacea* dominates the plant cover. Common species include *Oxyria digyna, Alopecurus alpinus, Carex membranacea, Polygonum viviparum, Poa arctica, Festuca brachyphylla* and *Saxifraga cernua.* Numerous other vascular plant species are found, but lichens and mosses are rare. Where snow cover is deeper and the growing season is shorter, these species are replaced in the environmental continuum by *Saxifraga oppositifolia, Oxyria digyna, Luzula nivalis, Alopecurus alpinus, Poa arctica, Poa alpigena* and *Carex misandra.* Mosses are more common. Total plant cover, which is 50 to 75 percent in the previously described plant community, is only 20 to 30 percent in this Snowbed Association. Where snow cover is even heavier, very few plant species exist and then their total cover is quite low (i.e. ca. 15%). The species dominating in the latest-melting snowbeds include *Phippsia algida, Saxifraga cernua, Oxyria digyna,* and *Bryum* sp.

3.2 Paleozoic Lowland Plant Associations

Six major plant associations are found in the study area on the Paleozoic lowlands. These are:

1) Cryoturbated sedge-moss;

2) Hummocky sedge-moss;
3) Wet sedge-moss;
4) Cushion plant-lichen;
5) Cushion plant-sedge-moss; and
6) Salt marsh.

Figures 4 and 5 show examples of all of these except the Salt Marsh Association.

Figure 4 shows a raised beach complex with barren beach ridge crests, slopes and depressions, sometimes filled with permanent water bodies. Figure 5 shows an undifferentiated alluvial-lacustrine plain deposit area with a similar development of moderately well drained alluvial-lacustrine surficial materials and depression areas of poorly drained organic deposits. Figure 4 illustrates the gradient from well drained to poorly drained areas which produces the Cushion plant-lichen Association on the driest portions of the area, the Cushion plant-sedge-moss Association on less rapidly drained and wetter areas, the Hummocky sedge-moss Association in imperfectly drained areas, and the Wet sedge-moss Association on the most poorly drained portions of the area. Lakes and ponds are found where open water prevails.

Figure 5 shows essentially the same gradient and distribution of plant associations on alluvial-lacustrine deposits. In this case, however, the Cryoturbated sedge-moss Association largely replaces the Hummocky sedge-moss Association. The other plant associations remain the same and maintain their relative positions along the environmental gradient.

Figure 6 shows a close-up view of these plant associations as they develop on the marine raised beaches. Figure 7 shows a close view of the Wet sedge-moss Association. Figure 8 is a graphic illustration of the differences in these associations. It shows a highly compressed example of the Cushion plant-lichen, Cushion plant-sedge-moss, Hummocky sedge-moss, and Wet sedge-moss associations. A vehicle track across these plant associations and the basic environmental relationships of each association are illustrated.

The Cushion plant-lichen Association develops on the crests and open slopes of beach ridges or alluvial-lacustrine deposits. Very little winter snow cover remains on this Association. The regosolic soils warm early in the season and possess a deep active layer in the permafrost. Lichens dominate the cover of this Association. The dwarf shrub, *Dryas integrifolia*, is significant, although its cover rarely exceeds 10 percent, because it

Figure 4. Aerial oblique view of a raised beach complex in the Paleozoic Lowland region of Roche Bay. The Cushion plant - lichen, Cushion plant - sedge - moss, Hummocky sedge - moss and Wet sedge - moss Associations are illustrated in this scene. Shallow lakes and ponds are very abundant.

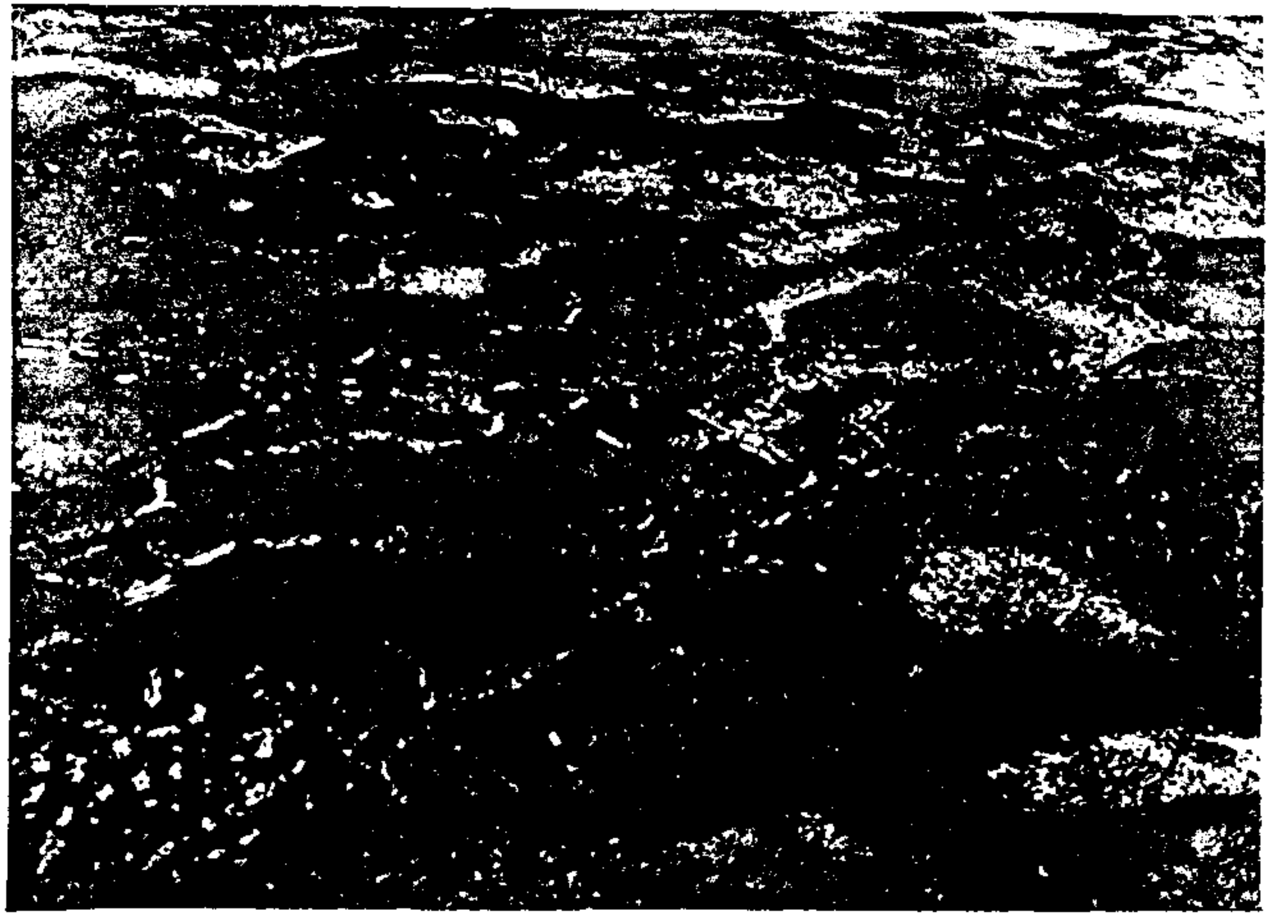


Figure 5. Aerial oblique view of an alluvial-lacustrine deposit complex in the Paleozoic Lowland region of Roche Bay. The Cushion plant - lichen and Cushion plant - sedge - moss Associations are limited to isolated mounds of disintegrated beach material. The Cryoturbated sedge - moss and Wet sedge - moss Associations are abundant in these environments; as are very shallow lakes.

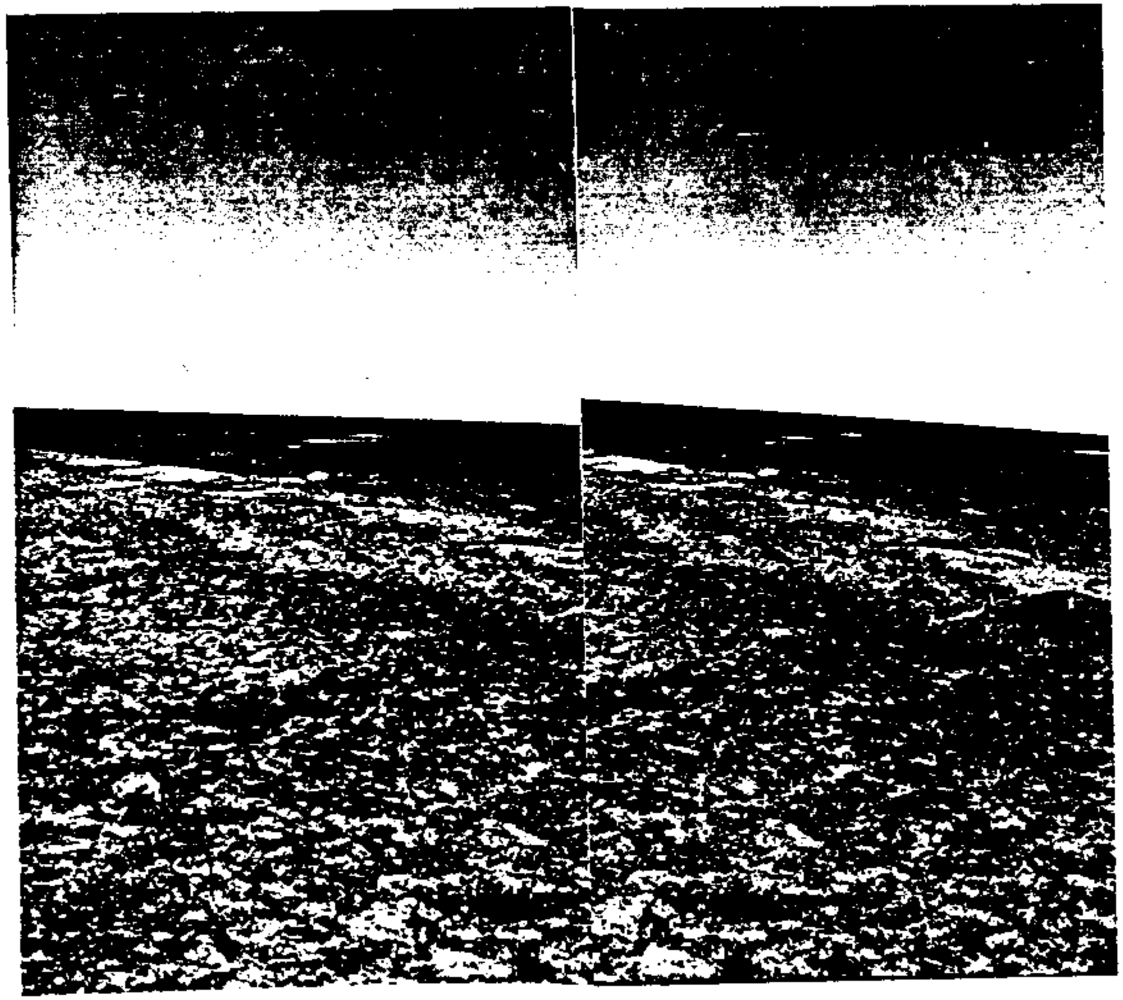


Figure 6. Stereo view of a raised beach site in the Paleozoic Lowland region. The immediate foreground is occupied by the Cushion plant - lichen Association. As one proceeds to the pond in the right center of the scene, one progressively encounters the Cushio plant - sedge moss Association; then the Hummocky sedge - moss Association; and lastly the Wet sedge - moss Association surrounding the pond itself.

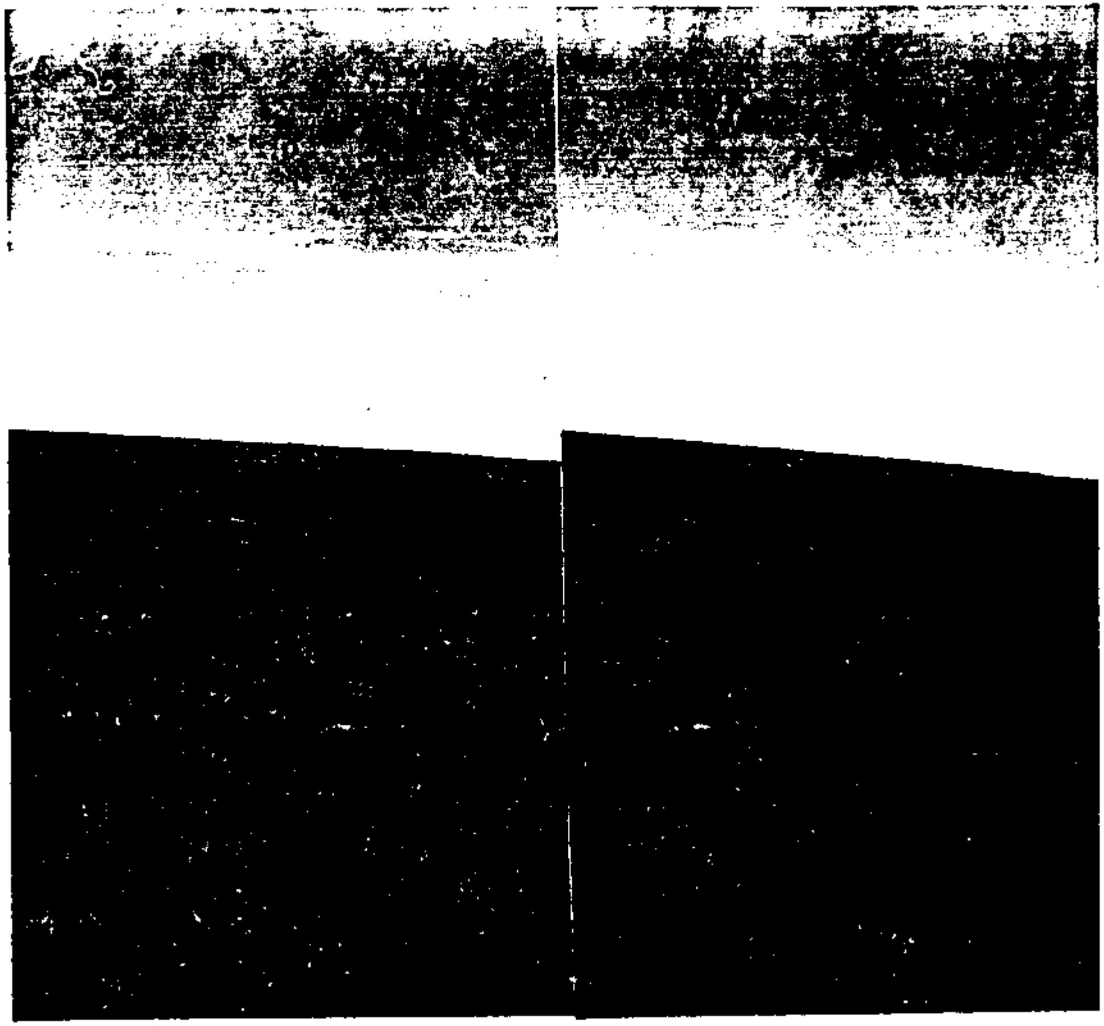


Figure 7. This stereo ground scene shows an example of the Wet sedge - moss Association.(in the immediate foreground). Note the standing water clearly visible within the sedge plants. A moderately deep organic layer is characteristic of such sites; as is a relatively shallow permafrost active layer. An area of barren Paleozoic rock outcrop is seen in the background.

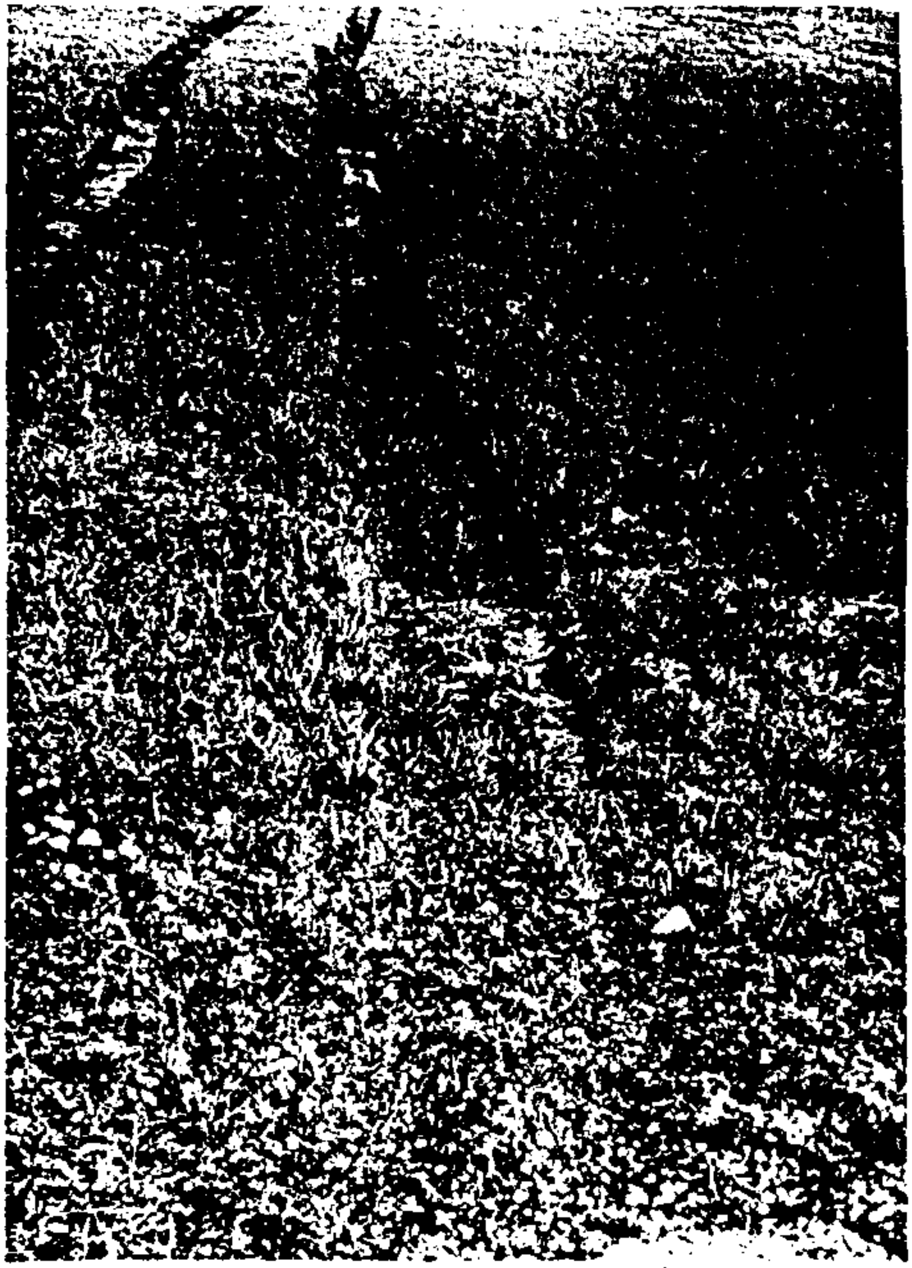


Figure 8. This scene shows a small section of a raised beach complex on the Paleozoic Lowlands near Roche Bay. The vehicle track shows the drainage and plant cover differences between the Cushion plant - lichen Association seen in the foreground and the Wet sedge - moss Association in the central background depression.

forms dense mats with extensive root systems. The dominant lichens are *Alectoria pubescens, Thamnolia vermicularis, Hypogymnia subfusca, Rhizocarpon geographicum, Cetraria nivalis,* and *Umbilicaria arctica.* Common vascular plants include *Saxifraga oppositifolia, Carex nardina, Salix arctica* and *Minuartia rubella.* Total plant cover is low, ranging from 5 to 35 percent.

The Cushion plant-sedge-moss Association occupies less rapidly drained sites. Plant cover is high (i.e. 65 - 100%), soils are brunisolic cryosols, and the active layer is somewhat thinner than in the Cushion plant-lichen Association. *Dryas integrifolia* is still the dominant plant. However, mosses and several vascular plant species contribute significant amounts of cover to the total. These important species include *Distichium capillaceum, Oncophorus wahlenbergii, Rhacomitrium* sp., *Mnium* sp., *Bryum* sp., *Ditrichium flexicaule, Tomenthypnum nitens, Carex rupestris, Saxifraga oppositifolia, Carex misandra, Salix arctica, Pedicularis lanata* and *Polygonum viviparum.*

The Hummocky sedge-moss Association develops largely on imperfectly drained sites and on slope deposits which are saturated with melt-water throughout June and July in most years. *Carex aquatilis* completely dominates this association. Hummocks of mosses develop abundantly throughout stands of the Association. The dominant moss species are *Cinclidium arcticum* and *Drepanocladus revolvens.* Quite frequently these moss hummocks support a moderate cover of *Salix arctica.* Other common species found in this Association include *Eriophorum angustifolium, Arctagrostis latifolia, Carex membranacea, Carex misandra* and *Polygonum viviparum.* Winter snow cover is moderately deep in this Association and the total plant cover is very high (i.e. 85 to over 100%).

The Cryoturbated sedge-moss Association is largely restricted to level alluvial-lacustrine deposits and is significantly wetter and more poorly drained than the Hummocky sedge-moss Association. Nearly barren frost-boils are characteristic of this Association. Sedges form a dense cover on the stable sites between frost boils. The dominant plant species in this Association are *Carex aquatilis, Carex membranacea, Eriophorum triste* and *Drepanocladus revolvens.* Shallow lakes and ponds are abundant in and characteristic of this Association. Patterned ground features, especially non-sorted nets, are common. Snow cover is moderate throughout the winter and the sites are wet throughout most of the growing season (i.e. June through August). Other common species which contribute significant amounts of cover include *Salix arctica, Carex misandra, Juncus biglumis, Arctagrostis latifolia, Ditrichium flexicaule,* and *Cinclidium arcticum.*

The Wet sedge-moss Association is commonly found adjacent to ponds or streams and in sites which are wet with surface water cover throughout the growing season. Total vegetation cover is somewhat less than in either of the previous associations because of the deleterious effects the high water content has on plant growth. Total cover varies from 20 to 60 percent, generally. The dominant species include *Carex aquatilis, Dupontia fischeri,* and *Eriophorum angustifolium,* almost to the exclusion of all other species. However, *Eriophorum scheuchzeri, Arctagrostis latifolia, Drepanocladus revolvens* and *Campylium stellatum* contribute significant amounts of plant cover in local situations.

The Salt Marsh Association develops immediately adjacent to the coast where lagoons, spits, low shorelines and beaches are directly influenced by the salt water. Unique plant communities are found on these sites and together they make up the Salt Marsh Association. Figure 9 shows a typical salt marsh dominated almost exclusively by *Puccinellia phyraganodes.* Other common associates with *Puccinellia* include *Carex ursina, Carex subspathacea, Honkenya peploides, Cochlearia officinalis* and *Stellaria humifusa.* Mosses include: *Meesia triquetra, Cinclidium stellatum and Caliergon giganteum.*

4. Vegetation Mapping

The LANDSAT satellite computer map of the study area has been generated at a 1:50,000 scale and is included with this report. Ten map units were identified from the 20 August 1975 LANDSAT image. Table 1 lists the vegetation types for each LANDSAT map unit on the Precambrian upland region and Table 2 lists the same for the Paleozoic lowland region.

The map units identified from the LANDSAT imagery exhibit strong correlations with the vegetation associations defined by the field survey and analysis in sections 2 and 3 of this report. The map units can be grouped into three broad categories. These are: 1) water-dominated sites, 2) poorly to imperfectly drained wetland vegetation, and 3) well to

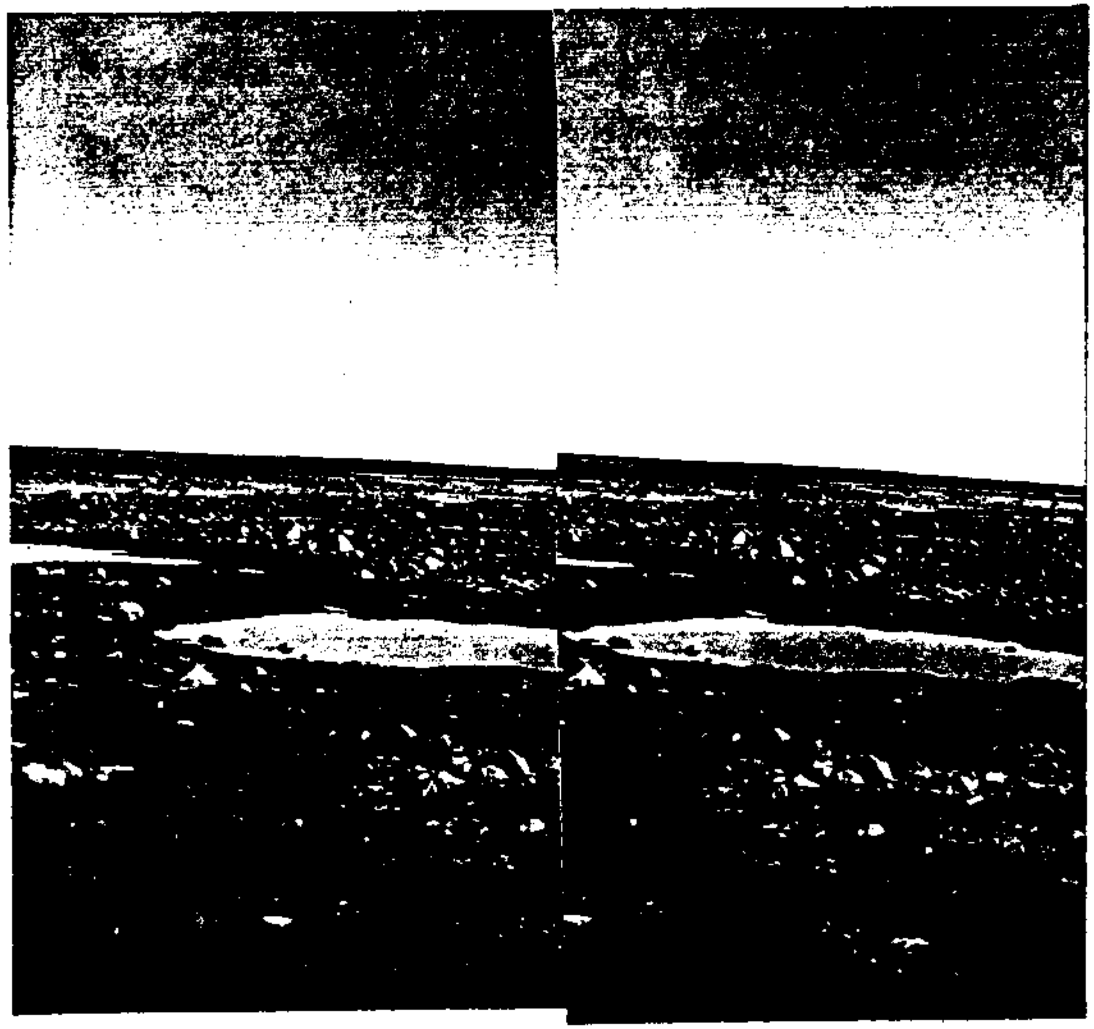


Figure 9. Stereo view of the Salt Marsh Association. The dominant plant cover is goose grass (*Puccinellia phryganodes*). This association is always located within about 1 km of the open ocean or lagoons and estuaries where tidal and wind action periodically saturate the sites with salt water or salt water spray.

Table 1. LANDSAT-mapped vegetation cover types on the Precambrian Upland region.

LANDSAT Map Unit Color	Vegetation Characteristics
Black	Deep, clear oligotrophic ponds and lakes; and north slopes of bare dark amphibolite rocklands.
Blue	Shallow ponds and lakes.
Brown (Grayish)	Bare dark amphibolite rocklands; Lichen-dominated.
White	Bare light felsic rocklands; Lichen-dominated.
Reddish Brown	Low to moderate cover Dwarf shrub-lichen on felsic rockland.
Purple	Low to moderate cover Dwarf shrub-lichen Association on dark amphibolite rockland.
Yellow	High cover Dwarf shrub-lichen Association and Dwarf shrub-heath-moss Association.
Dark Green	Wet Sedge meadow Association saturated with water on surface.
Light Green	Sedge meadow Association of moderate biomass and moderately thick organic layer; and Snow Bed Association.
Red	Sedge meadow Association; high biomass and very thick organic layer.

Table 2. LANDSAT-mapped vegetation cover types on the Paleozoic Lowland region.

LANDSAT Map Unit Color	Vegetation Characteristics
Black	Deep, clear oligotrophic ponds, lakes and ocean.
Blue	Shallow ponds, lakes and estuaries.
Brown (Grayish)	Shallow water with low cover of Wet sedge-moss Association.
White	Bare beach ridges and rock outcrop.
Reddish Brown	Cushion plant-lichen Association
Yellow	Cushion plant-sedge-moss Association.
Light Green	Low to moderate biomass; Cryoturbated and Hummocky sedge-moss associations.
Red	High biomass Cryoturbated sedge-moss and Hummocky sedge-moss associations and Salt Marsh Association.
Dark Green	Wet sedge-moss Association.
Purple	Wet sedge-moss Association with high cover of surface water.

rapidly drained terrestrial vegetation.

In the Precambrian Upland region the water-dominated category includes the black and the blue LANDSAT map units. The wetland vegetation category is represented by the dark green, light green and red map units. The terrestrial vegetation is represented by the brown, white, reddish brown, purple and yellow and some of the black map units.

In the Paleozoic Lowland region the three broad categories are represented by different groupings of LANDSAT map units. The water-dominated category includes the black, blue and grayish brown LANDSAT map units. The wetland vegetation category includes the light green, red, dark green and purple LANDSAT map units. The terrestrial vegetation category includes the white, reddish brown and yellow LANDSAT map units.

The vegetation map shows that the Precambrian Upland and Paleozoic Lowland regions are largely covered by the well to rapidly drained terrestrial vegetation category in the area of the magnetic ore body and on the peninsula where facilities are proposed. The map units representing water and wetland categories are much less abundant in this area. These two categories are found concentrated in five general areas outlined by, largely, the light and dark green map units on the LANDSAT vegetation map. The most significant concentrations of the wetland vegetation and water categories are found 1) in the two major depressional areas in the Precambrian Upland region; 2) downslope and east of the major fault delineating the contact between the Precambrian Upland and Paleozoic Lowland regions; 3) the area surrounding the large lake in the northwest section of the Paleozoic Lowlands; and 4) the southcentral section of the Paleozoic Lowland region. Map units of the wettest organic types and with high intensity of patterned ground are very uncommon throughout this entire area. Where they do occur they are clearly located on the LANDSAT map.

5. Summary

Eleven major vegetation associations have been described in the area of Roche Bay, Melville Peninsula, Northwest Territories. Five of these are unique to the crystalline bedrock of the Precambrian Upland region and six to the Paleozoic Lowland region. These vegetation associations exhibit characteristic features of plant species composition, soil type, drainage condition, organic layer thickness, permafrost active layer depth, patterned ground features, microclimate, snow depth and duration, and animal use.

LANDSAT imagery was used to produce a computer map of vegetation types in the Roche Bay area. Sixteen different vegetation map units and two water map units were identified and mapped. These specific vegetation and water map units were grouped into broad land type categories. The well to rapidly drained terrestrial vegetation category is much more abundant throughout the study area than the water and wetland categories. The distribution of each map unit is shown on the LANDSAT computer map.

6. Recommendations

1) The vegetation map and descriptive data provided by this report should be used in preliminary planning of site and route location for all facilities, structures, and operations for the proposed Borealis Iron Ore mine. This should be done using the preliminary vegetation map and guidelines outlined below.

The following vegetation associations as defined by the LANDSAT map units are extremely sensitive to disturbance and possess severe limitations to construction. These should be avoided in any construction activity:

Precambrian Upland region--blue, dark green, light green and red.

Paleozoic Lowland region--black, blue, light green, dark green, purple and red.

Vegetation associations with moderate limitations to construction and moderate sensitivity to disturbance include portions of the yellow map unit in both the Precambrian Upland and Paleozoic Lowland regions. At the present time, this map unit should be used cautiously to identify facility locations and transportation corridors. This map unit should be evaluated further and subdivided into low, moderate, and moderately high sensitivity units for detailed facility planning.

The vegetation associations with moderately low to low sensitivity to disturbance and few limitations to construction include the remaining LANDSAT map units. These are listed in descending order from the least sensitive type to the most sensitive type for both the Precambrian Upland and Paleozoic Lowland regions. Facilities and transportation corridors should be located in areas with the least sensitive map units in preference to all others:

Precambrian Upland region--grayish brown, white, reddish brown, and purple.

Paleozoic Lowland region--white and reddish brown

2) The map and descriptive data should be refined through field survey. The parent material, physical, chemical and engineering characteristics of each vegetation association should be sampled and described. A detailed biophysical map of the study area should be completed at an appropriate scale to be used for detailed planning of preliminary facilities and transportation corridor location. The Canada Committee on Ecological Land Classification system and methodology should be used. A combination of existing aerial photography, LANDSAT imagery and field survey methods should be used to do this mapping.

3) The habitat relationships of all significant wildlife should be evaluated and mapped as related to the biophysical inventory identified in #2, above. The biophysical analysis of habitat potential should be used to guide detailed and site specific field surveys of wildlife populations. Potential impacts of the proposed project on all wildlife species should be evaluated using the system of Thomas (1977) as elaborated by Short and Burnham (1982).

4) A thorough literature survey should be conducted and a report prepared to identify the most significant and relevant biophysical data available for similar arctic environments. This survey should produce an overall environmental evaluation framework for planning impact assessment. The survey should include data on vegetation, soils, wildlife and fisheries, slope stability, erosion hazard, reclamation, limnology, permafrost-patterned ground, surficial materials, archaeological resources, native resource use, hydrology and sea ice conditions.

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APPENDIX

Plant species to be found in the Roche Bay area, Melville Peninsula

(Those species preceeded by an asterisk have been seen in the field or collected as voucher specimens by the author. Systematic treatment and order follows that of Porsild and Cody (1980).)

Vascular Plants

* *Alopecurus alpinus*
Arabis arenicola
* *Arctagrostis latifolia*
* *Arctophila fulva*
Arctostaphylos alpina
Arenaria humifusa
* *Armeria maritima*
* *Astragalus alpinus*
* *Braya purpurascens*
Calamagrostis lapponica
Campanula uniflora
* *Cardamine bellidifolia*
* *Cardamine pratensis*
Carex amblyorhyncha
* *Carex aquatilis*
* *Carex atrofusca*
* *Carex bigelowii*
Carex glareosa
* *Carex lachenalii*
Carex maritima
* *Carex membranacea*
* *Carex misandra*
* *Carex nardina*
* *Carex rupestris*
Carex saxatilis
* *Carex scirpoidea*
* *Carex subspathacea*
Carex ursina
* *Cassiope tetragona*
* *Cerastium alpinum*
* *Cerastium beeringianum*
Cerastium regelii
* *Chrysanthemum integrifolium*
* *Chrysosplenium tetrandrum*
* *Cochlearia officinalis*
* *Colpodium vahlianum*
* *Crepis nana*
* *Cystopteris fragilis*
Deschampsia brevifolia
Diapensia lapponica
* *Draba alpina*
Draba cinerea
* *Draba corymbosa*
Draba glabella
* *Draba lactea*
Draba nivalis
Draba subcapitata
* *Dryas integrifolia*
Dryopteris fragrans
Elymus arenarius
Empetrum nigrum
Epilobium arcticum
* *Epilobium latifolium*
Equisetum arvense
* *Equisetum variegatum*
* *Erigeron humilis*
* *Eriophorum angustifolium*
Eriophorum callitrix
Eriophorum russeolum
* *Eriophorum scheuschzeri*
Eriophorum triste
* *Eriophorum vaginatum*
* *Eutrema edwardsii*
* *Festuca baffinensis*
* *Festuca brachyphylla*
* *Hierochloe alpina*
* *Hierochloe pauciflora*
Hippuris vulgaris
Honckenya peploides
* *Juncus albescens*
* *Juncus biglumis*
* *Juncus castaneus*
* *Kobresia myosuroides*
* *Kobresia simpliciuscula*
* *Ledum decumbens*
* *Lesquerella arctica*
Loiseleuria procumbens
* *Luzula nivalis*
* *Luzula confusa*
Luzula wahlenbergii
* *Lycopodium selago*
Matricaria ambigua
Melandrium affine
* *Melandrium apetalum*
Mertensia maritima
Minuartia biflora

Appendix, continued

Vascular Plants

* *Minuartia rossii*
* *Minuartia rubella*
* *Oxyria digyna*
Oxytropis arctica
Oxytropis arctobia
Oxytropis hudsonica
* *Oxytropis maydelliana*
* *Papaver radicatum*
Parrya arctica
Pedicularis arctica
* *Pedicularis capitata*
Pedicularis flammea
* *Pedicularis hirsuta*
* *Pedicularis lanata*
* *Pedicularis sudetica*
* *Phippsia algida*
* *Pleuropogon sabinei*
Poa abbreviata
* *Poa alpigena*
* *Poa arctica*
Poa glauca
* *Polygonum viviparum*
Puccinellia langeana
* *Potentilla hyparctica*
Potentilla nivea
Potentilla pulchella
Potentilla vahliana
* *Puccinellia phryganodes*
Pyrola grandiflora
Ranunculus aquatilis
* *Ranunculus hyperboreus*
Ranunculus nivalis
Ranunculus pedatifidus
Ranunculus pygmaeus
Ranunculus sulphureus
Rhododendron lapponicum
* *Salix arctica*
Salix arctophila
* *Salix herbacea*
Salix lanata
* *Salix reticulata*
* *Saxifraga aizoides*
* *Saxifraga caespitosa*
* *Saxifraga cernua*
Saxifraga foliolosa
* *Saxifraga hieracifolia*
* *Saxifraga hirculus*
* *Saxifraga nivalis*
* *Saxifraga oppositifolia*
* *Saxifraga rivularis*
* *Saxifraga tricuspidata*
* *Senecio congestus*
* *Silene acaulis*
Stellaria calycantha
Stellaria crassipes
Stellaria edwardsii
Stellaria humifusa
Stellaria laeta
* *Stellaria monantha*
* *Tofieldia coccinea*
* *Tofieldia pusilla*
* *Trisetum spicatum*
* *Vaccinium uliginosum*
Vaccinium vitis-idaea
* *Woodsia glabella*

Bryophytes

Aulacomnium palustre
Brachythecium sp.
Bryum sp.
Calliergon giganteum
Campylium stellatum
Cinclidium arcticum
Dicranum spp.
Distichium capillaceum
Ditrichum flexicaule
Drepanocladus spp.
Grimmia sp.
Meesia triquetra
Mnium spp.
Onchophorus wahlenbergii
Orthothecium strictum
Pogonatum alpinum
Polytrichum spp.
Tomenthypnum nitens
Rhacomitrium lanuginosum
Tortula ruralis

Appendix, continued

Lichens

Alectoria nigricans
Cladonia arbuscula
Cladonia spp.
Cetraria cucullata
Cetraria delisii
Cetraria islandica
Cetraria nivalis
Cetraria tilesii
Dactylina arctica
Lecanora spp.
Parmelia centrifuga
Rhizocarpon geographicum
Thamnolia vermicularis
Umbilicaria arctica

ADDENDUM SIX

During the meeting in Hall Beach and Igloolik during the last calendar year other issues were raised which are directly relevant to matters raised in the I.E.E. This addendum is concerned with the discussions, in Hall Beach, on the possibility of producing hydroelectric power on the Ayaquatalik River.

As discussed in the I.E.E. the Ayaquatalik River seems to be suitable for hydroelectric power generation. The Company had intended to begin a detailed study of the power potential of that river. That study would however have taken some years and it was the Company's position was that while hydroelectric power might be preferable it was not intrinsically necessary to the project. It was also noted in the I.E.E. that a library search indicated little char in the Ayaquatalik River (Anders 1965) because of the presence of rapids and because of the distance of the lakes from the mouth of the river.

However, discussions with the Inuit of Hall Beach have indicated that the river is in fact rich in Char. Accordingly the people of Hall Beach are opposed to any damming of the river because it may interfer with their fishing. Attached are notes of a meeting with the Hall Beach Community Council dated July 23, 1981.

Therefore, the Company has altered it's plans to accomodate local opinion in this matter. There are no plans for damming the Ayaquatalik River. In effect this means that, barring the future possibility of wind power, the project must depend on fossil fuels for power generation.

HALL BEACH SETTLEMENT COUNCIL MEETING

JULY 23,1981

Present:

Joe Curley, Mayor

Albert Nubiyak, Deputy Mayor

Joanna Aula, Assistant Secretary Manager

Simeonie Irquittuq, Councillor

Simeonie Kaenerk, Councillor

David Kanatsiak, Councillor

Annie Nattaq, Councillor

Chana Cox, Borealis Exporations Ltd.

Clive and Crystall Elliott, Elliott Environmental

Beth Tipping, observer

Simeonie Issigaitok, observer

Notes taken by Crystal Elliott

Interpreters: Joanna Aula and Richard Immarqituk

Q(Council): Can Chana Cox answer questions?

A: Yes

Q(Council): When will the mine start?

A: Intended date 1985

Q(Council): What's the purpose of this meeting? Where does the town think the town should be, and the road, and the dam?

Simeonie Irqittuq: The road is good. The dam is bad because of the fish that live there.

Clive Elliott: The Dam site was changed to minimize damage to vegetation. If a passage is built for char it won't hurt them, and having a reservoir may even improve the river for them.

Simeonie Kaenerk: -at all the deeper parts of the river there are char

-the dam will be useless in winter,

-only the deepest parts stay thawed all year.

-it's barren above the dam site.

-doesn't want dam: prefers generator.

Joe Curley: People and HTA had a meeting and all said they don't want a dam.

Chana Cox: Thanked them. Dam not essential.

Crystal Elliott: Borealis only wanted the dam to prevent air pollution and use of petroleum resources--i.e. to preserve the environment. A dam is more expensive than a generator.

Simeonie Irqittuq:--doesn't want dam.

-no opinion on town site.

Chana Cox: Borealis doesn't care where the town goes. "You tell us."

Richard: If mine will last 500 years a town will be needed.

Chana: People in Yellowknife and IDC said a town might hurt other town and Hall Beach might not want it, and workers should be flown in and out.

Simeonie Irqittuq: If mine will last 500 years there would be a town, and it's nicer at Roche Bay with the nice mountains, and if there's a road people could hunt by motorcycle.

Chana: Is Nunakpariavik (as shown on site plan) a good place? Is it too far from the mill? Are the wind and snow conditions good there?

S. Kaenerk: Elliott's camp site would be a better location.

Crystal: Would river mouth at Irkalugarjuit be good?

Chana: Too far from mine.

Council: Dock site would be a good place. There's little snow and the land is less rough. Winds blow from the North all the time.

Chana: Don't people mind ships and airplanes right beside the town?

Council(consensus): The dock site is a good town site.

Chana: Will it harm Inuit culture to have whites living together with Inuit?

Joanna: Its already been harmed.

S. Irqittuq: Inuit culture has survived so far, so that shouldn't be a problem.

Chana: What is the best way to cross the Ikerasak River? Don't want to harm fish.

Joe Curley: Hall Beach people want a road.

-Birds can move around and are only there in the summer anyway; but fish are there all year.

S. Kaenerk: Having it along the shore is a good idea.

Road should be K as long as bridge is built so that fish can cross.

Chana: Yellowknife hasn't approved the road.

S. Irqittuq: He crosses the river often and the fish are still there.

Chana: Where is a good place to get water if town is at dock site?

Council: Biggest lake at Irqalugarjuit is OK It won't freese; is deep.

Chana: This mine uses no chemicals or waer, but produces dust. Dust on snow makes it melt too fast and means town should be upwind from mine. Engineers have told Borealis that there is a solution to the dust problem.

S. Irqittuq: There's always sand blowing there, so snow is never white.

Chana: Please feel free to talk to the Elliotts; they're here partly to learn from you.

Albert Nubiyak: Dam would not be good--the river does not flow in winter.

Meeting adjourned.