# PRELIMINARY ASSESSMENT OF THE EFFECTS OF THE PROPOSED POLAR GAS PIPELINE AND OTHER HYDROCARBON DEVELOPMENT PROJECTS ON WATERFOWL OF THE NORTHERN MACKENZIE VALLEY

Peter N. Boothroyd

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Environment Canada
501 University Crescent
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R3T 2N6

## ABSTRACT

Aerial surveys were conducted in June, July and August, 1985 to determine numbers and distribution of waterfowl along the proposed Polar Gas pipeline route and Parsons Lake lateral in the Mackenzie River valley. Waterfowl densities were low along most of the route except for the segment on Richards Island in the Mackenzie Delta where tundra swans were most abundant. Possible scenarios of pipeline construction and oil and gas development in the Mackenzie Delta/Tuktoyaktuk Peninsula area are discussed and the potential effects on waterfowl are assessed. Recommendations are made with the intent of ensuring protection of waterfowl populations and important habitat.

# RÉSUMÉ

On a effectué des études par photographies aériennes en juin, juillet et août 1985 afin d'évaluer la population de sauvagine et en déterminer la distribution le long du trajet proposé pour le pipeline Polar Gas et le pipeline secondaire du lac Parsons dans la vallée du Mackenzie. La densité des populations de sauvagine était faible sur la plus grande partie du trajet, à l'exception de l'île Richards et du delta du Mackenzie où les cygnes siffleurs étaient très nombreux. Le rapport expose les scénarios possibles pour la construction du pipeline et l'exploitation du pétrole et du gaz dans la région du delta du Mackenzie et de la péninsule Tuktoyaktuk et il évalue les répercussions qu'ils pourraient avoir sur la sauvagine. Les recommandations ont pour but d'assurer la protection des populations de sauvagine et de leur habitat.

## ACKNOWLEDGEMENTS

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# 1. INTRODUCTION

In June 1984, Polar Gas applied to the National Energy Board for authorization to construct and operate a 914 mm outside-diameter natural gas pipeline, approximately 2120 km in length, from the Taglu Field on Richards Island, N.W.T. (Mackenzie Delta) along the Mackenzie River valley to a point near Edson, Alberta (Figure 1). Included as part of the proposed project is a 610 mm outside-diameter lateral pipeline originating from the gas reserves in the Parsons Lake, N.W.T. area and joining the main pipeline near Reindeer Depot. Five compressor stations and three heater stations are required along the pipeline to deliver gas at an initial average rate of about 22 X $10^6$ $m^3$/day (Polar Gas 1984).

With oil prices plummeting to below U.S.$15 per barrel in February 1986 and little potential for short-term growth in the current gas market, it is difficult to determine the timing for construction of the project. However, Polar Gas still anticipates that arctic gas will be required by the mid-1990s (K.G. Taylor, pers. comm.).

The Polar Gas application is not the first proposal for a pipeline to transport arctic gas to southern markets along the Mackenzie River valley. In 1974, the Mackenzie Valley Pipeline Inquiry was established to "examine the social, economic and environmental impact of a gas pipeline in the Northwest Territories and the Yukon, and to recommend the terms and conditions that should be imposed if the pipeline were built" (Berger 1977). Between May 1974 and November 1976, public hearings were held by Justice Thomas Berger which centered around two applications for a gas pipeline along the Mackenzie Valley - one by Canadian Arctic Gas Pipeline Limited (Arctic Gas) and the other

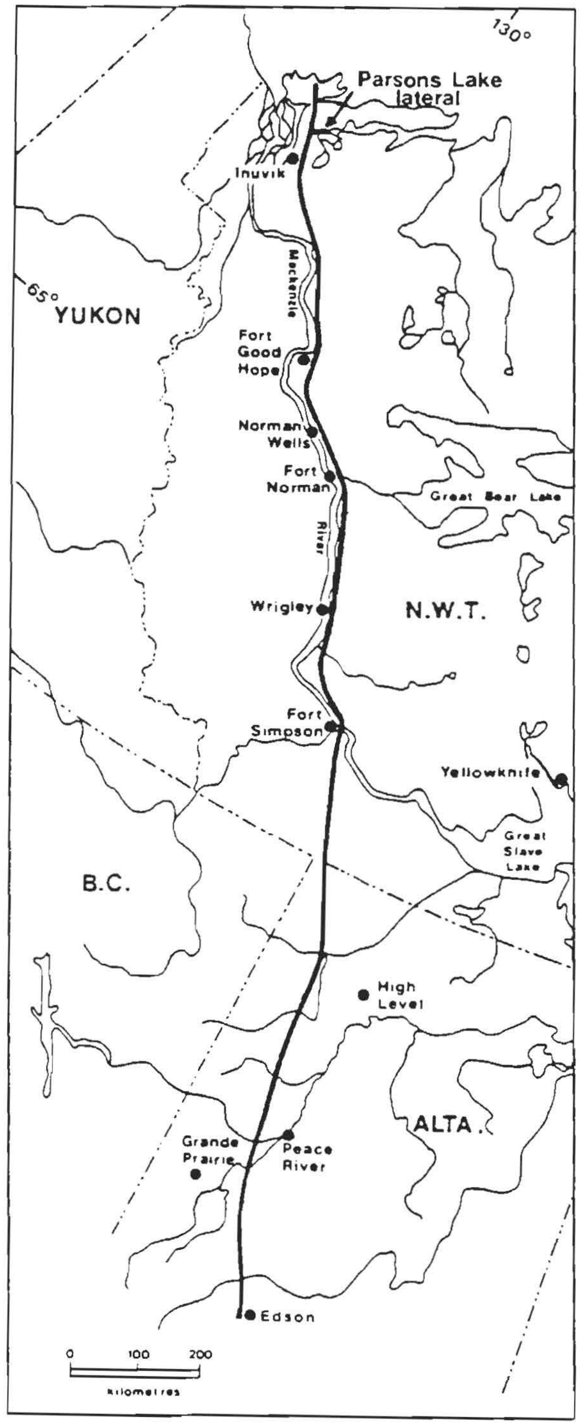


Figure 1. Proposed routes for the Polar Gas pipeline from Taglu, Richards Island to Edson, Alberta and the Parsons Lake lateral.

by Foothills Pipe Lines Ltd. (Foothills). Figure 2 shows the approximate routes proposed by Arctic Gas and Foothills in relation to the Polar Gas proposal.

Neither Arctic Gas nor Foothills received approval of their gas pipeline construction plans. However, in 1980, Esso Resources Canada Limited (Esso) and Interprovincial Pipe Line (NW) Ltd. (IPL) submitted an Environmental Impact Statement in support of their proposal to expand oilfield production at Norman Wells, N.W.T. and to construct a 324 mm diameter oil pipeline from there to Zama, Alberta (Figure 2). The project was approved and the pipeline constructed to deliver the increased production from the Norman Wells oilfield. Oil began flowing through the pipeline in May 1985.

As a result of the Arctic Gas and Foothills proposals and the Esso/IPL Norman Wells project, a large number of environmental baseline studies relating to birds have been conducted throughout the Mackenzie Valley region. These include studies carried out through the federal government's Environmental-Social Committee, Northern Pipelines, Task Force on Northern Oil Development (e.g. Poston et al. 1973, Watson et al. 1973, Poston 1977), studies conducted for the Arctic Gas-sponsored Environment Protection Board (e.g. Campbell 1973, Campbell and Shepard 1973) and studies funded directly by Arctic Gas (e.g. Salter 1974, Koski 1977).

Subsequent to the Polar Gas submission to the National Energy Board, CWS decided to conduct waterfowl surveys of portions of the proposed route even though similar work had already been carried out previously in the Mackenzie Valley, as mentioned above. The decision to conduct further surveys on waterfowl use was made for two basic

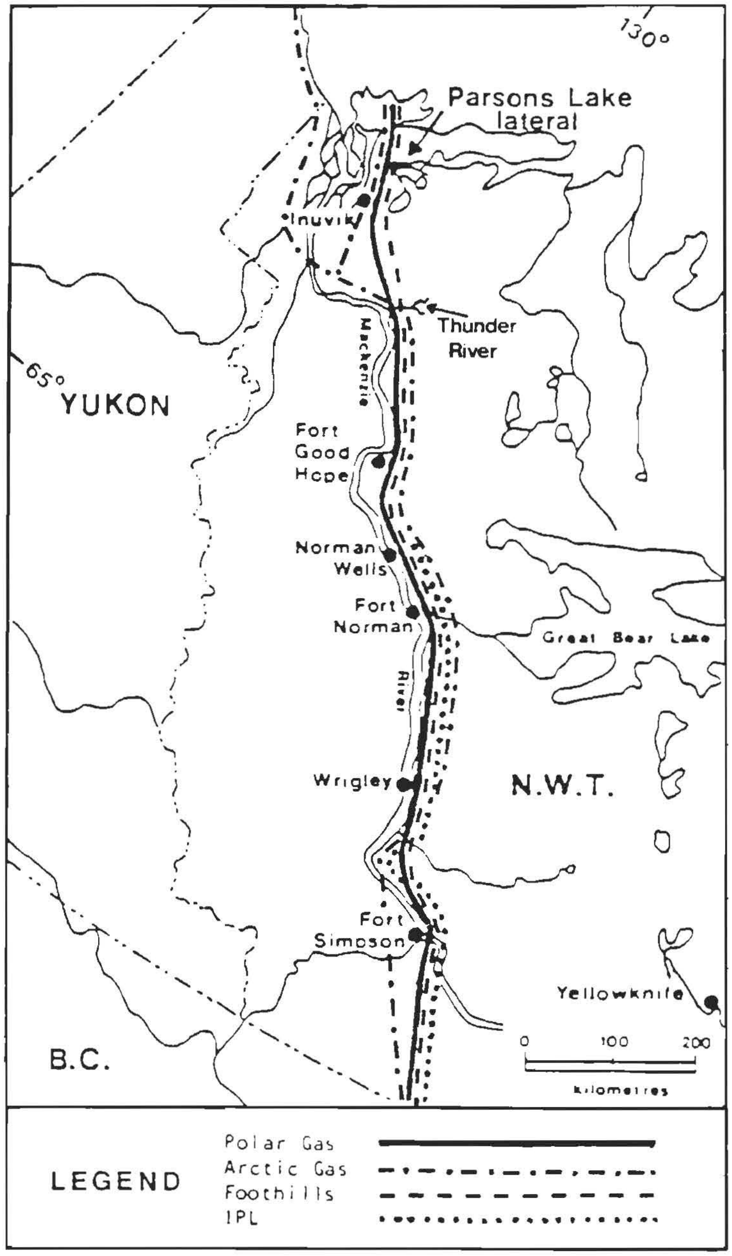


Figure 2. Locations of the IPL pipeline and proposed Arctic Gas and Foothills pipeline routes in relation to the Polar Gas route north of 60.

reasons. First, several segments of the proposed route differed significantly from the route originally proposed by Arctic Gas. For example, the Arctic Gas route passed to the west of Travaillant Lake (the Polar Gas route runs east of the lake) and the Parsons Lake lateral was located north of Parsons Lake (the Polar Gas lateral is situated on the south side of the lake) (Figure 2). In addition, Polar Gas has defined a number of alternative route segments which could possibly be considered should substantial concerns be identified along the preferred route. Secondly, the waterfowl data previously collected is ten or more years old and may not reflect present waterfowl population densities and distribution.

The main objective of this study was to obtain current data on waterfowl densities directly along the proposed mainline and lateral pipeline routes and to determine the potential impacts of the Polar Gas project on waterfowl. In view of the recent discoveries of oil made by Gulf Canada Resources Inc. on the Amauligak structure in the Beaufort Sea (Oilweek 1986a), the possibility of an oil pipeline being constructed from the northern tip of Richards Island, south through the Mackenzie River valley, has been enhanced. Therefore, consideration is also given in this report to the potential impacts of construction and operation of an oil pipeline and associated support facilities.

## 2. STUDY AREA

This study considers the portion of the proposed Polar Gas pipeline route extending from roughly 20 km south of the Thunder River crossing to the anticipated gas production area at Taglu on Richards Island (Figure 1). The eastern boundaries of the study area include the Parsons Lake area.

Within the study area, the pipeline route traverses a number of terrain types characterizing different physiographic regions as defined by Mackay (1963). Since terrain appears to have a major influence on habitat and numbers of waterfowl the following paragraphs describe how the study area is divided into the different physiographic regions. Figures 3a to 3e show the approximate physiographic region boundaries.

Heading southward from Taglu, the route crosses four kilometres of the alluvial portion of the Mackenzie Delta physiographic region before entering the Tununuk Low Hills section of the Pleistocene Coastlands physiographic region. The latter region consists mainly of Pleistocene fluvial and deltaic deposits. Numerous lakes dot the region and pingos are widespread. Most of the area lies below an elevation of 60 m a.s.l. with about 50 percent situated below 30 m a.s.l. Vegetation consists mostly of tundra and scrub tundra species; stands of black spruce (*Picea mariana*) and associated shrubs occur along stream courses (Figure 4).

At approximately km 235, the route crosses into the Caribou Hills physiographic region at North Storm Hills. As its name suggests, the region is hilly, reaching elevations of 260 m a.s.l. The hill slopes are cut by broad meltwater channels. Consequently, the area is well-drained and lakes are uncommon. Parsons Lake lies to

## LEGEND FOR FIGURE 3

● ● ● **approximate physiographic region boundary**
(Mackay 1963)

270 **proposed Polar Gas pipeline route**
on mainline - numbers represent distance in km as measured from the southernmost point of intersection with the alternate route (designated km 319.8 by Polar Gas (1984))

on Parsons Lake south lateral - numbers represent distance in km as measured from the mainline route

150 **alternate Polar Gas pipeline route**
numbers represent distance in km as measured from the southernmost point of intersection with the proposed mainline route

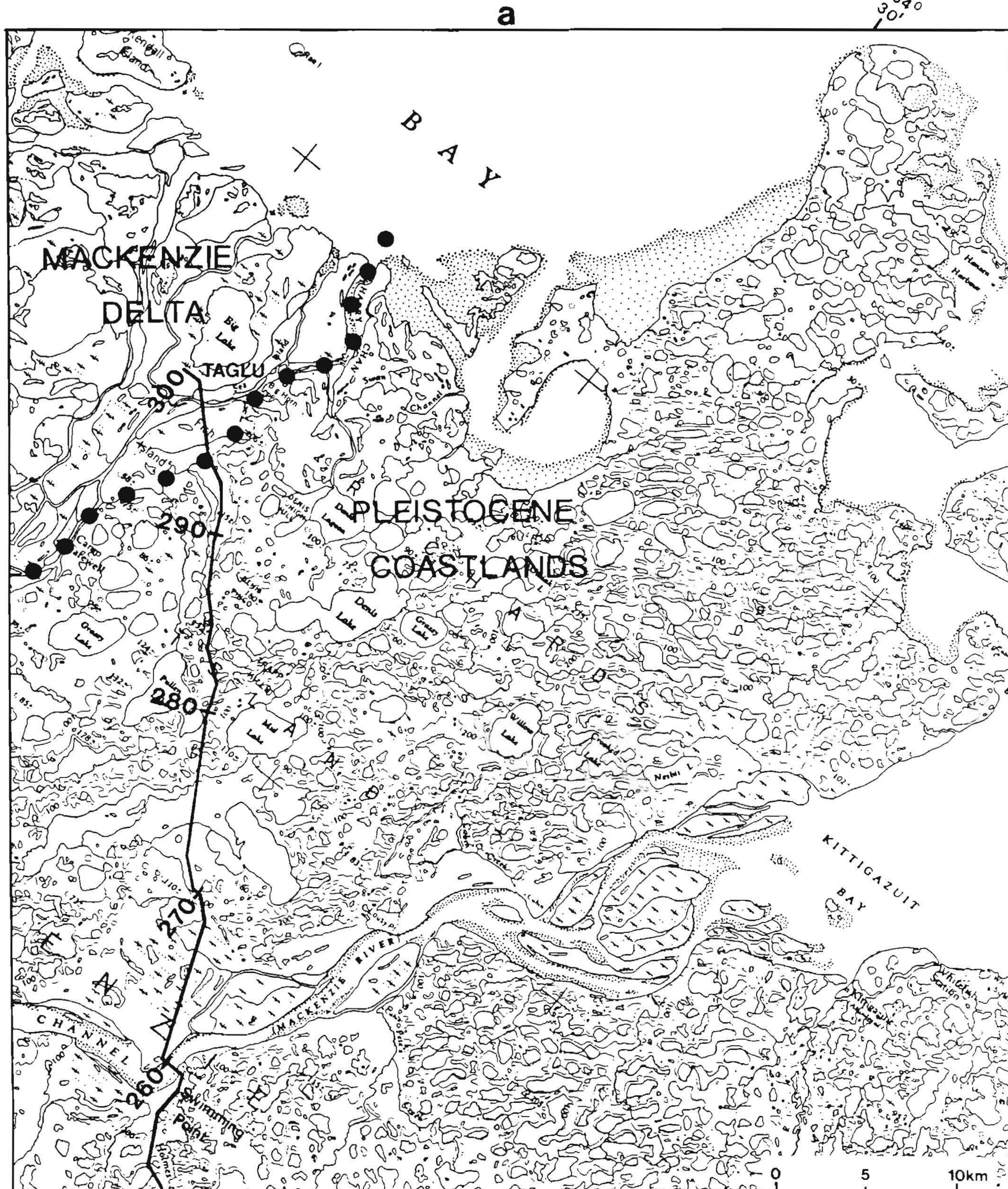


Figure 3. The Taglu - Thunder River portion of the Polar Gas route showing approximate physiographic region boundaries.

(a)

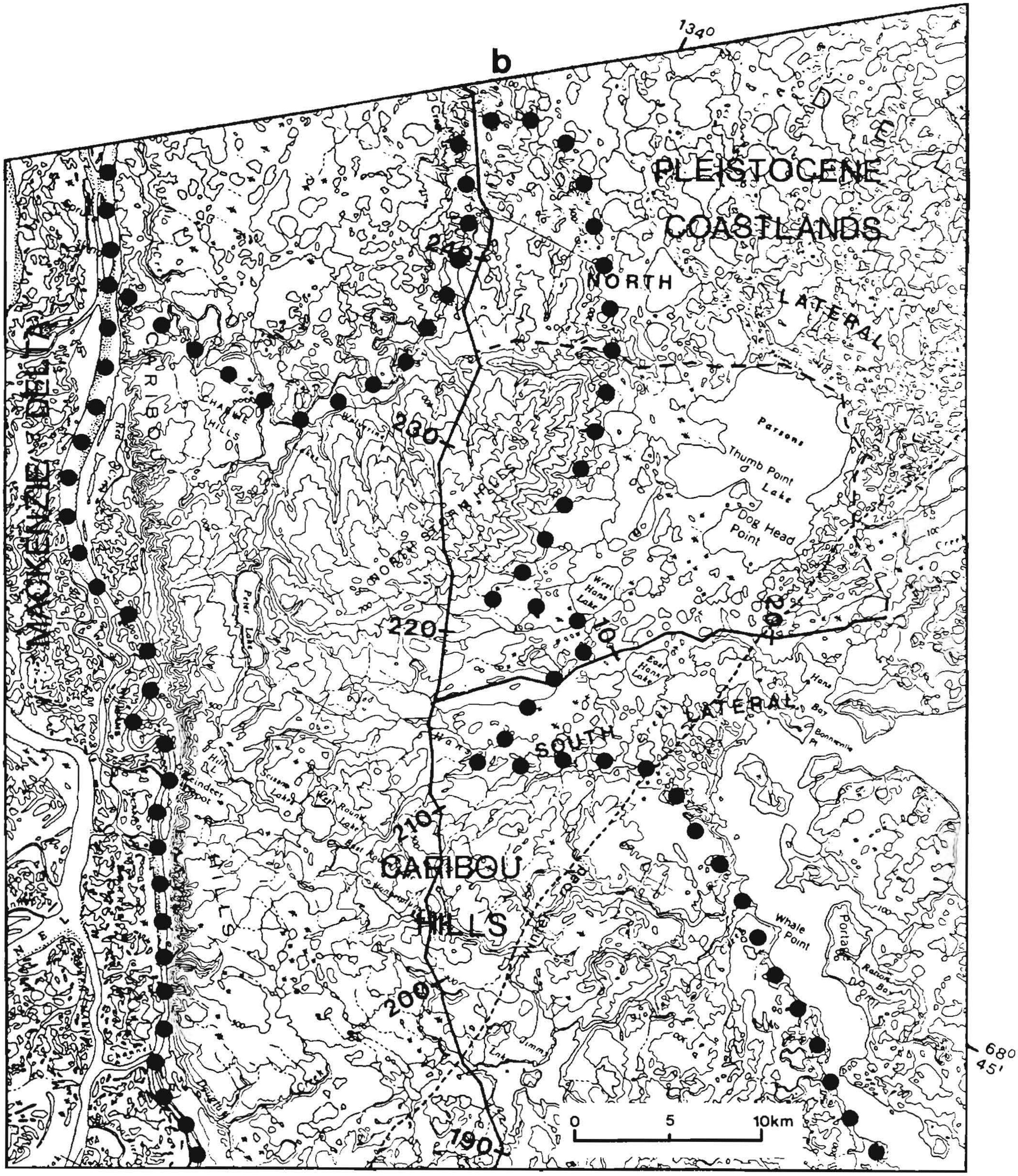


Figure 3 (cont'd) (b)

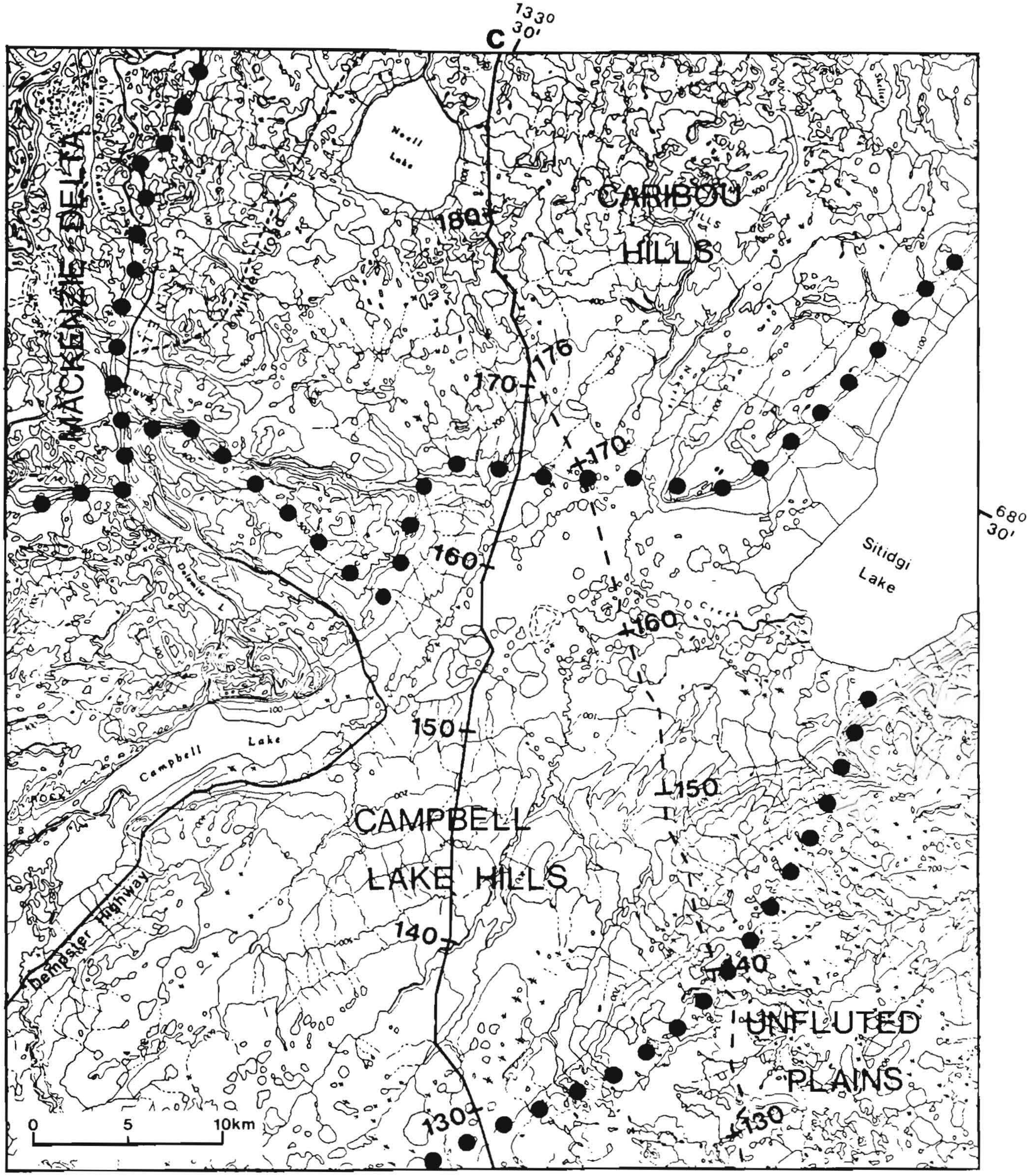


Figure 3 (cont'd)(c)

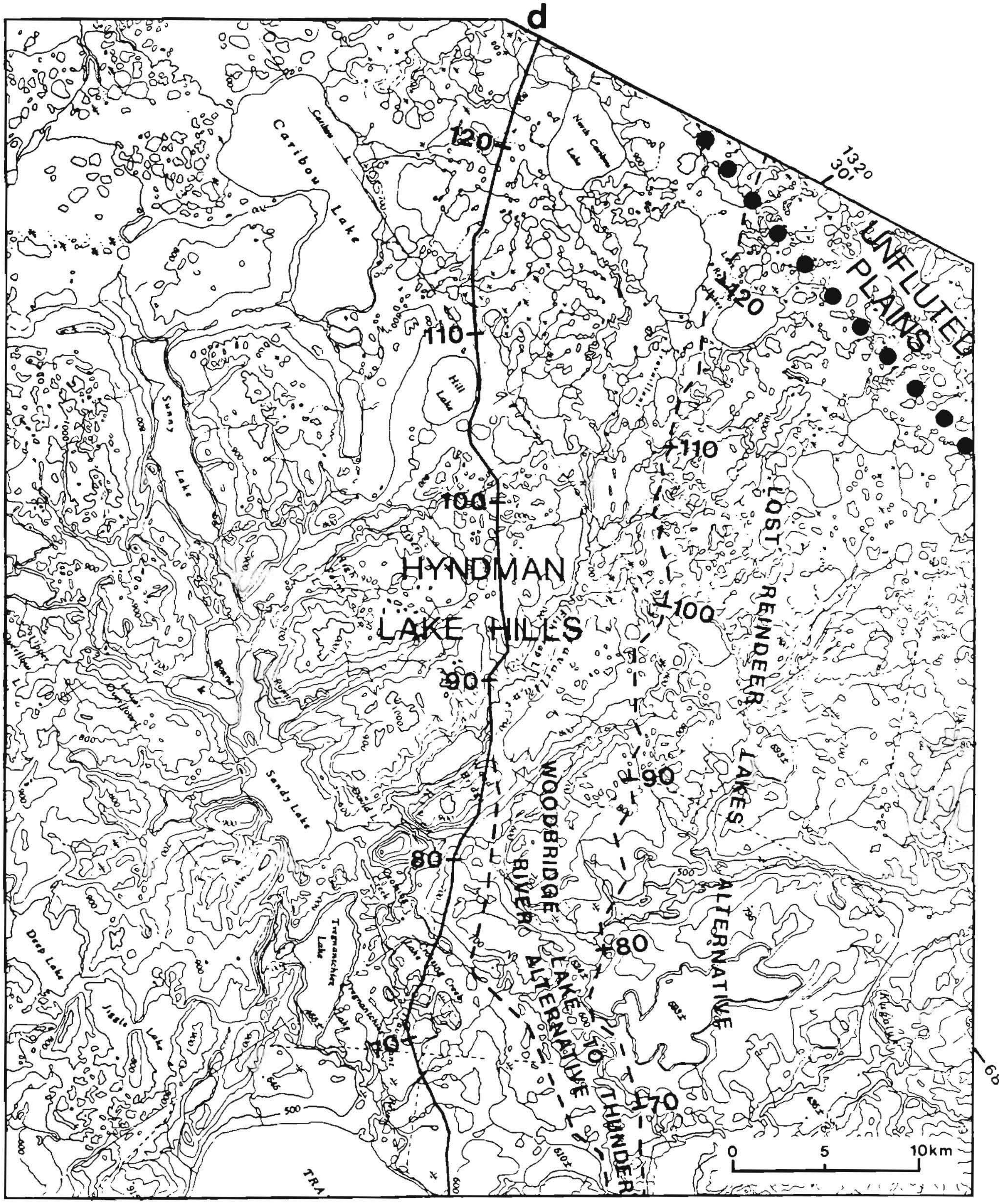


Figure 3 (cont'd) (d)

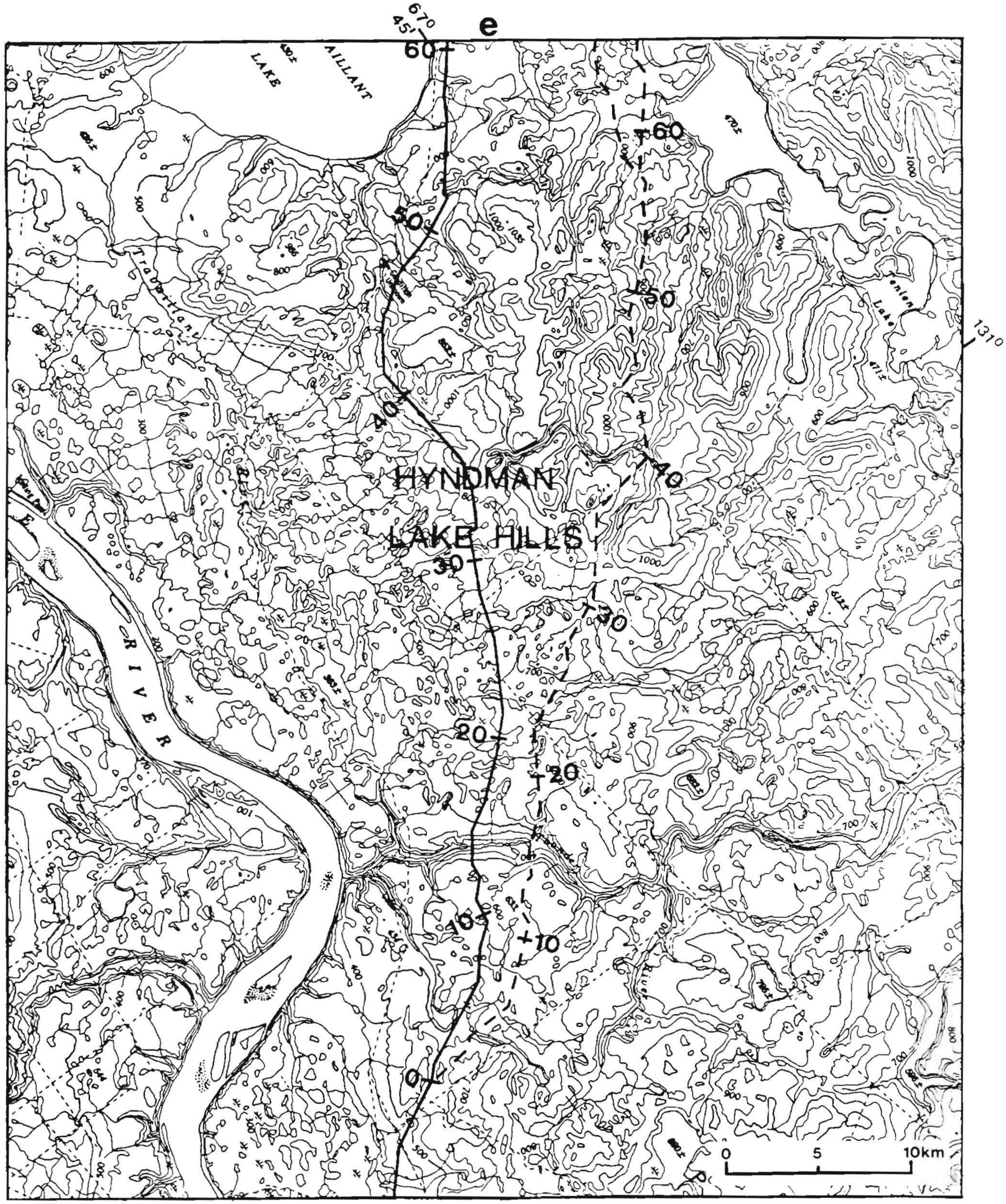


Figure 3 (cont'd)(e)

Figure 4. The Tununuk Low Hills section of the Pleistocene Coastlands physiographic region. Spruce trees mark the location of Holmes Creek.

the east of the North Storm Hills and is located in the Morainic Hills section of the Pleistocene Coastlands physiographic region. Hills are numerous although elevations are lower than in the North Storm Hills area. Many of the hills are capped with sand and gravel hillocks and numerous lakes border the Parsons lateral pipeline route.

South of the North Storm Hills, back in the Caribou Hills physiographic region, elevations decline as the main route traverses Noell Lake and crosses into the Campbell Lake Hills physiographic region near km 165. For a distance of 15-20 km, the route passes through the Campbell-Sitidgi Lake lowland section of this region. Located below 30 m a.s.l., the area has predominantly silty soils, poor drainage and many shallow lakes. This lowland depression is part of an old river course which flowed between Campbell and Sitidgi lakes. The divide between the two lakes is estimated at about 10 m a.s.l. and, consequently, this lowland received much use as a portage route from the Mackenzie River East Channel to the Eskimo Lakes. The pipeline route proposed by Foothills (the main Polar Gas alternative route) would have crossed several of the creeks which meander through the area (Figure 5).

South of the Campbell - Sitidgi Lake depression, elevations increase as the pipeline route traverses a bedrock-controlled upland area more typical of the Campbell Lake Hills physiographic region. There is much fluting of bedrock and ground moraine and vegetation cover begins to shift from open heath to open woodland. Large white spruce (*Picea glauca*) occur in areas of moist but well drained soils and scattered stands of black spruce, tamarack (*Larix laricina*), paper birch (*Betula papyrifera*) and poplar (*Populus*

Figure 5. One of several creeks meandering through the Campbell-Sitidgi Lake depression (Campbell Lake Hills physiographic region).

spp.) also occur.

The Campbell Lake Hills physiographic region grades into the Hyndman Lake Hills physiographic region a few kilometres north of North Caribou Lake (near km 130). This region is distinguished by higher terrain than adjacent areas, rocky escarpments, large Pleistocene valleys and numerous lakes. Elevations reach approximately 305 m a.s.l. and forest cover is more pronounced (Figure 6). The remainder of the pipeline route, contained within the study area considered in this report, traverses terrain of this type.

Figure 6. The well-forested Hyndman Lake Hills physiographic region. Travaillant Lake is at the top of the photo and a winter road is located at the bottom.

## 3. METHODS

Three aerial waterfowl surveys were conducted along portions of the proposed pipeline route during the summer of 1985. The surveys were flown in a Cessna 185 at airspeeds ranging from 135 to 160 km/h and at altitudes between 30 and 50 m above ground level.

The first survey was conducted on June 26 during the nesting period of most species. The survey commenced just south of where the proposed route crosses Thunder River and included an alternative alignment identified by Polar Gas. The survey proceeded north to a point on the west side of Big Lake on Richards Island and included a lateral route around Parsons Lake (Figure 3). The second survey was carried out on July 22 during the brood-rearing period. The survey began just south of Noell Lake, included the Parsons Lake area, as in the first survey, and ended on Richards Island. The third survey, conducted on August 26 during the early part of the fall staging period, covered the same route followed on the second survey.

During the first two surveys, two observers recorded all birds seen within 0.2 km of the survey aircraft. On the third survey, only one observer recorded birds observed one side of the aircraft. All observations were located on 1:50 000 scale National Topographic Series strip maps of the survey routes.

# 4. DESCRIPTION OF POLAR GAS AND OTHER POSSIBLE PIPELINES

## 4.1 Main Polar Gas Proposal

The following description of the proposed pipeline project is taken largely from Volume III. Facilities and Volume IV. Route Maps, Engineering and Construction Drawings of the Polar Gas application to the National Energy Board (Polar Gas 1984). These documents were also the source of the locations of facilities, such as compressor stations, landing strips, etc., and borrow material sources shown on Figures 7a to 7e. Figure 7 also shows the locations of similar facilities identified for the Arctic Gas and Foothills proposals. Finally, alternative routes identified by Polar Gas and a possible mid-sized oil pipeline route are also mapped on Figure 7 for comparison purposes.

The Polar Gas pipeline would originate at measurement facilities at Taglu and Parsons Lake where gas would be delivered to the pipeline system (Figures 7a and 7b). From Taglu, a 914 mm outside-diameter pipeline, 2120 km in length, would take the gas to the vicinity of Edson, Alberta, where it would connect with existing facilities for transmission to southern markets. A 610 mm outside-diameter pipeline, 25 km long, would deliver gas from the Parsons Lake area to the main pipeline. The entire pipeline system would be buried to a minimum depth of 0.6 m except at river crossings where minimum depth would be as much as 3.0 m. The gas would be chilled to 0°C, or lower, from Taglu to the vicinity of Fort Good Hope; from there, gas temperatures would range from 0°C to 10°C, depending on the thermal regime of the terrain.

Transportation of the gas (initially about $22 \times 10^6$ $m^3$ per

# LEGEND FOR FIGURE 7

## PIPELINE COLOUR CODES

| | |
|---|---|
| 260 | Polar Gas (1984) route & facilities [a/] |
| 130 | Polar Gas alternate route [a/] |
| | Canuck Engineering Ltd. (1981) route & facilities |
| | Arctic Gas route & facilities (Environment Protection Board 1974) |
| | Foothills (1975) route & facilities |

## FACILITIES [b/]

- potential borrow areas
- staging/stockpile sites
- construction camp
- compressor (gas)[c/] or pump (oil) station
- fuel storage site
- airstrip
- helipad
- dock/wharf
- access road

## NOTES

a/ see Figure 3 legend for explanation of km markers along the proposed and alternate Polar Gas routes

b/ for simplicity, only one symbol appears at sites identified by more than one company for the same purpose (eg. borrow area)

c/ compressor stations, and associated facilities located at compressor station sites along the Polar Gas route, would not be required initially; these sites would be used should Delta gas production be expanded after the pipeline is already in place

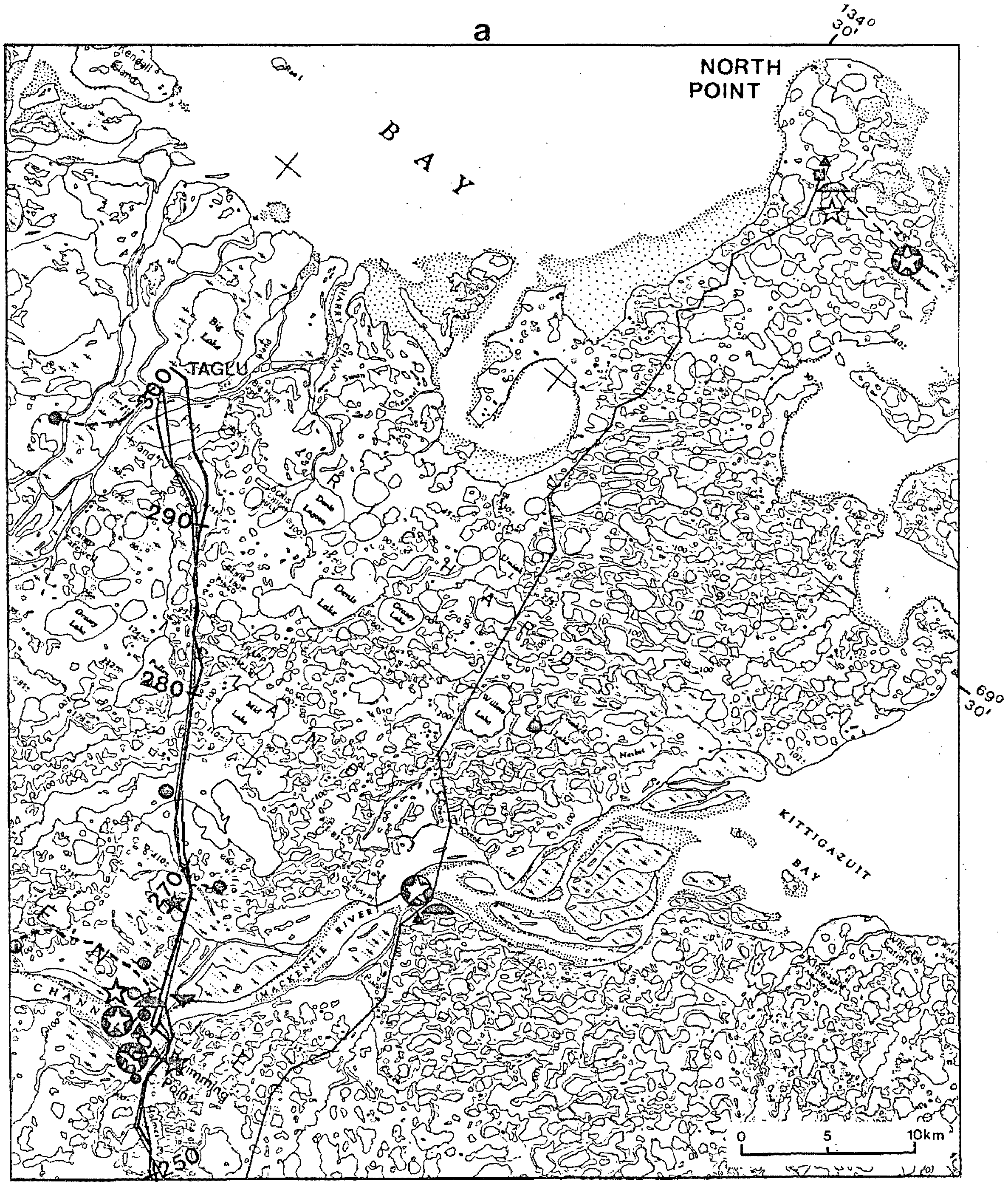


Figure 7. Mackenzie River Valley pipeline routes proposed by Polar Gas, Arctic Gas, Foothills and Canuck Engineering Ltd. showing locations of ancillary facilities.

(a)

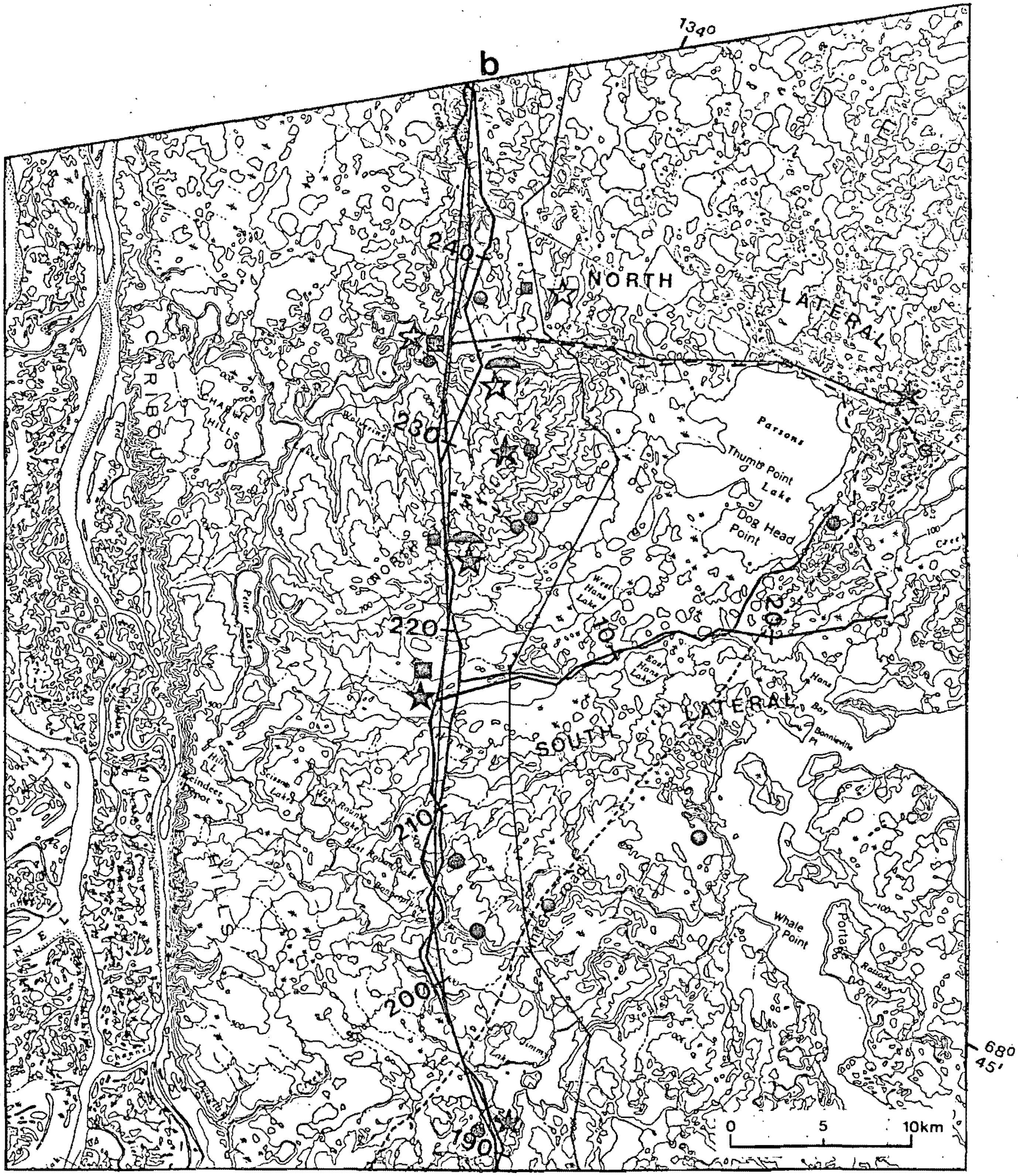


Figure 7 (cont'd) (b)

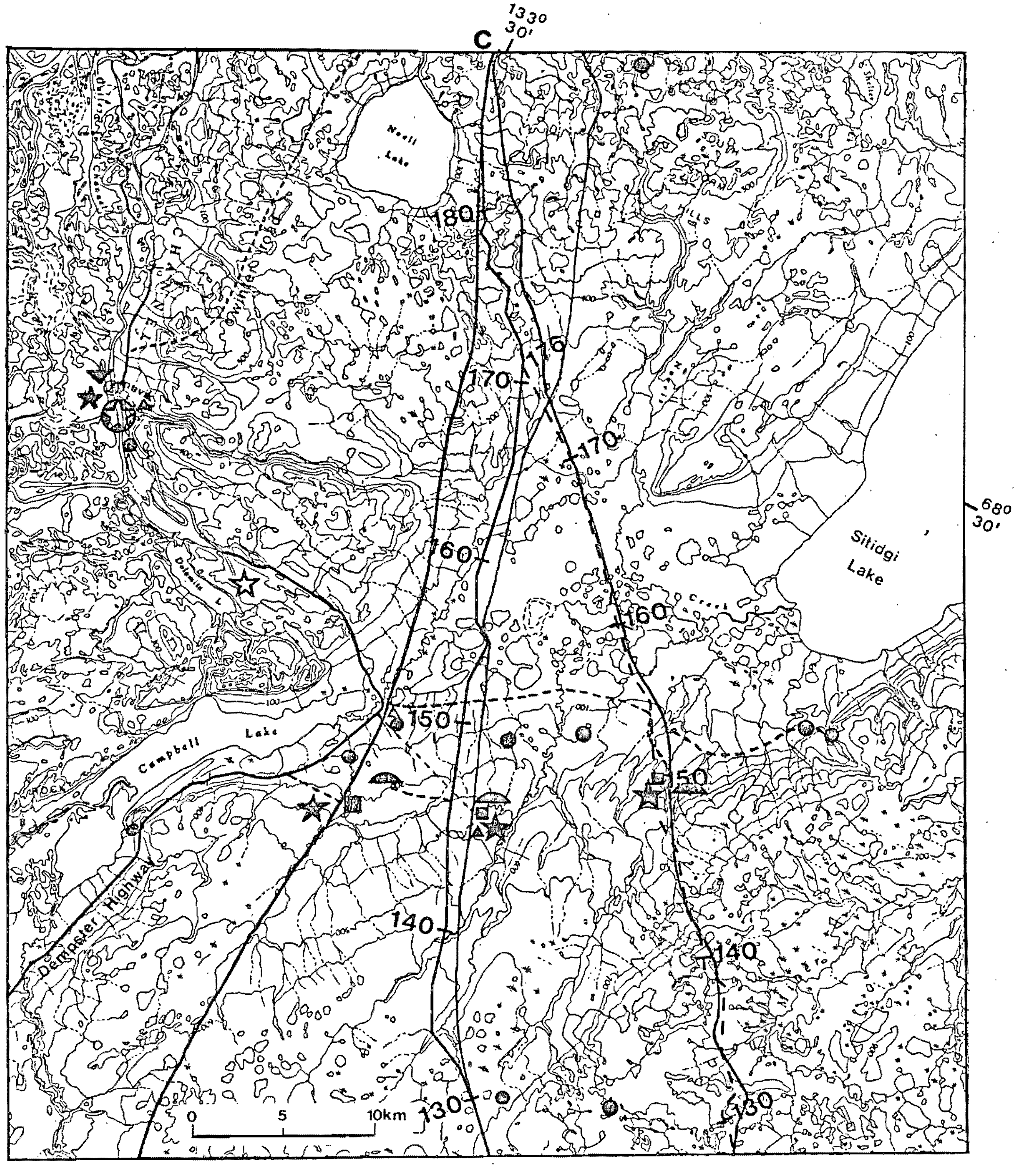


Figure 7 (cont'd) (c)

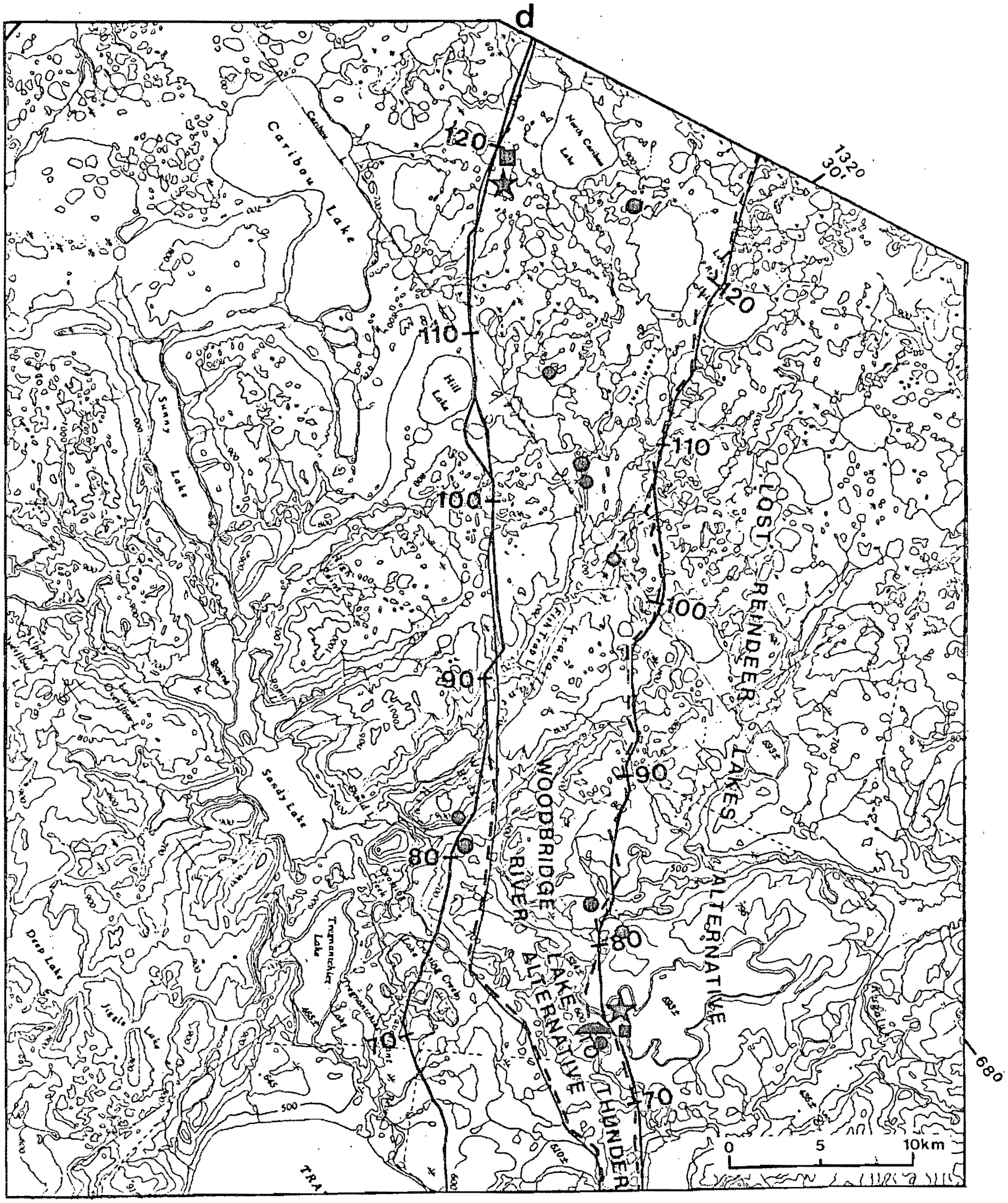


Figure 7 (cont'd) (d)

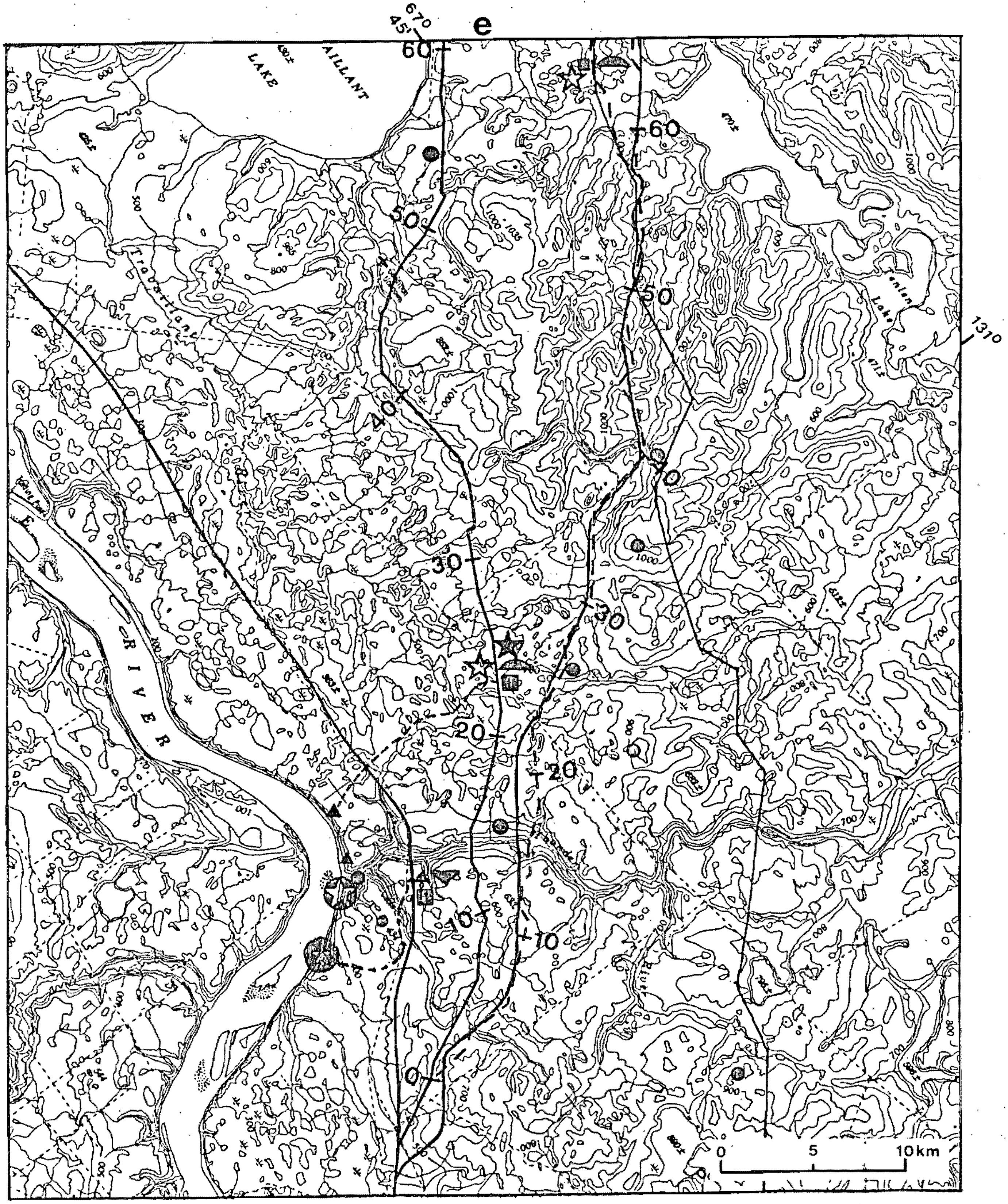


Figure 7 (cont'd) (e)

day) would require five compressor stations to be positioned between Taglu and Edson, Alberta. The northernmost station would be located approximately 85 km south of the southern limit of the study area considered in this report. Mainline valves would be placed at regular intervals along the route and would allow gas flow to be stopped in sections of the pipeline during emergencies. Locations of the mainline valves coincide with the planned locations of future compressor stations should an expansion of the pipeline be necessitated by further gas field development. The three northernmost future compressor stations, all equipped with gas-chilling facilities to regulate gas flow temperatures, would be located within the study area (Figures 7b, d and e). All compressor stations would be manned continuously and would include: self-contained accommodation; facilities for electrical generation, central heating, water treatment and sewage and waste disposal; and a helipad. Also, an airstrip would probably be constructed at each site (K.G. Taylor, pers. comm.).

Materials and fuels required for construction of the pipeline and associated facilities in the study area would be transported by barge to one of three staging sites on the Mackenzie River. These sites are located near the Thunder River inflow (Figure 7e), at Inuvik (not shown) and at Swimming Point on the Mackenzie River East Channel (Figure 7a). The pipeline itself would be constructed during the winter months. Materials would be moved from staging site locations along the right-of-way by truck using temporary winter roads.

Compressor stations require a 12 to 15-month period for construction. Therefore, all-weather road access would be needed to truck materials from staging sites to compressor station sites. At the

Thunder River compressor station site, the winter access road would be converted into an all-weather road (Figure 7e). For the site located near North Caribou Lake, the road would be built along the right-of-way and would probably be connected to the Dempster Highway at Campbell Lake (Figure 7c) (K.G. Taylor, pers. comm.).

For the site located at the junction of the main pipeline and the Parsons Lake lateral, there are several possibilities. By the time the additional compressor stations would need to be constructed, it is possible that year-round road access between Inuvik and Tuktoyaktuk may have replaced the existing winter road access along the Mackenzie River East Channel to Kittigazuit Bay. Surveys for such a road have been conducted by Public Works Canada along a route which roughly corresponds to that of the winter road shown in Figures 7b and 7c. Assuming the road did follow the same route as the winter road, an all-weather road could be constructed from where the winter road crosses the right-of-way to the compressor station site (Figure 7b). Alternatively, the road could be built along the Parsons Lake lateral right-of-way from the Inuvik-Tuktoyaktuk road. This option would be preferable should dock facilities be located at Hans Bay (Figure 7b), a possibility indicated in Volume 2. Development Systems of the Environmental Impact Statement for Hydrocarbon Development in the Beaufort Sea - Mackenzie Delta Region (Dome et al. 1982). A third possibility, involving considerably more kilometres, would be to extend the road, connecting the Dempster Highway to the North Caribou Lake compressor station, northwards along the pipeline right-of-way.

Figure 7 also shows the locations of possible borrow sources in the vicinity of the right-of-way and construction camps. Winter roads would provide access to the borrow areas used. Presently, it is not known which borrow areas would be selected and therefore winter road routes are not shown in Figure 7.

As stated earlier, the main pipeline would originate from the Taglu area. Not included in the Polar Gas submission are the extensive gas processing and other facilities required to prepare the gas for pipeline transmission and a system for gathering gas from the Niglintgak and other possible gas fields in the Delta region for transmission in the main pipline. These facilities would be owned and operated by the gas producing companies rather than by Polar Gas (K.G. Taylor, pers. comm.).

R.A. Owens Environmental Services Ltd. (1986) and Dome et al. (1982) indicate the array of production facilities required. Gas wells would be clustered at pads located near the geographic centre of each producing gas field. Initially, one or more of these pads would be situated in the Taglu, Niglintgak and Parsons Lake areas (Figure 8). Metering facilities, storage tanks, emergency power units and shelter, and production control equipment would be included at each pad site. Flowlines would connect the production pads to central processing facilities located in each of the three areas. Gas processing includes the removal of excess water, carbon dioxide, hydrogen sulphide and liquid hydrocarbons from the raw gas and subsequent compression and cooling to produce a gas which meets pipeline transmission requirements. Once this infrastructure is in operation, further development activities can be expected. Ongoing production drilling would occur at each of the production sites initially selected to replace wells that become exhausted. Additional

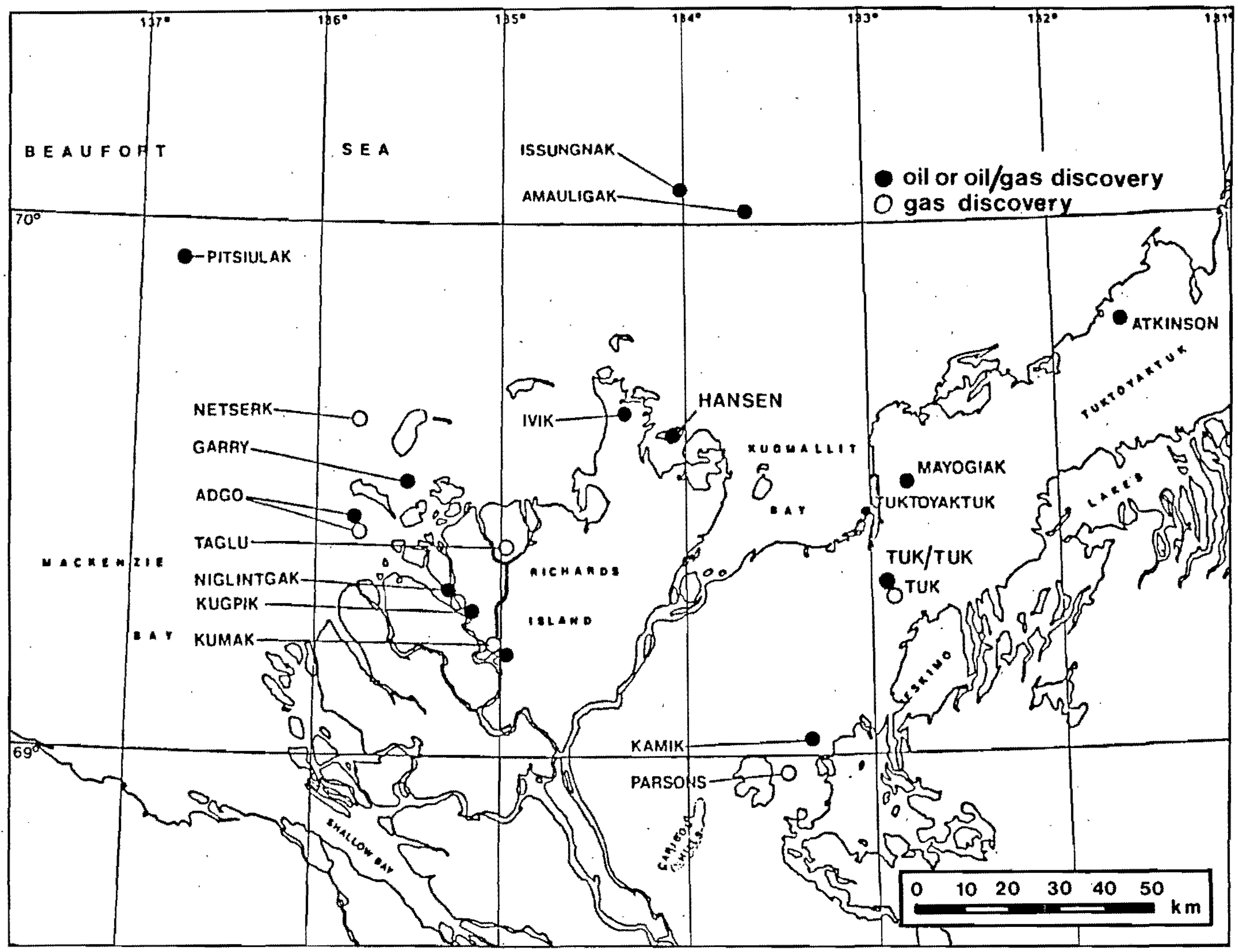


Figure 8. Locations of potential onshore and offshore oil and gas production fields in the Mackenzie Delta/Beaufort Sea region.

production drilling, at new locations by operators not involved in initial production, is predictable and would likely result in the construction of additional processing and associated facilities. Should an oil pipeline originating from the Mackenzie Delta also be in place (see section 4.3), flowlines would be installed to carry hydrocarbon liquids, produced as a byproduct at gas processing facilities, to crude oil processing plants. Likewise, additional flowlines would be required to transport gas produced at oil production sites to the gas processing plants. Other support facilities which can be expected to be located in the vicinity of oil and gas production sites are wharves, airstrips, helipads, construction camps, borrow pits and a network of roads servicing each facility. Figure 9 shows the layout of facilities in place at the Prudhoe Bay hydrocarbon field in Alaska. Figure 10 indicates hypothetically how facilities might be arranged at the Parsons Lake field.

## 4.2 Polar Gas Alternate Routes

Figure 7 shows possible alternate routes identified by Polar Gas. The main alternate route, referred to by Polar Gas as the "Lost Reindeer Lakes Alternative", follows almost exactly the route selected by Foothills in their proposal. A short alternate route, identified as the "Woodbridge Lake to Thunder River Alternative", connects the Lost Reindeer Lakes Alternative, near km 57, to the mainline route, near km 85 (Figure 7d). The Woodbridge Lake to Thunder River Alternative was selected by Canuck Engineering Ltd. (1981) as part of a possible route for an oil pipeline from the Mackenzie Delta area to Edmonton, Alberta.

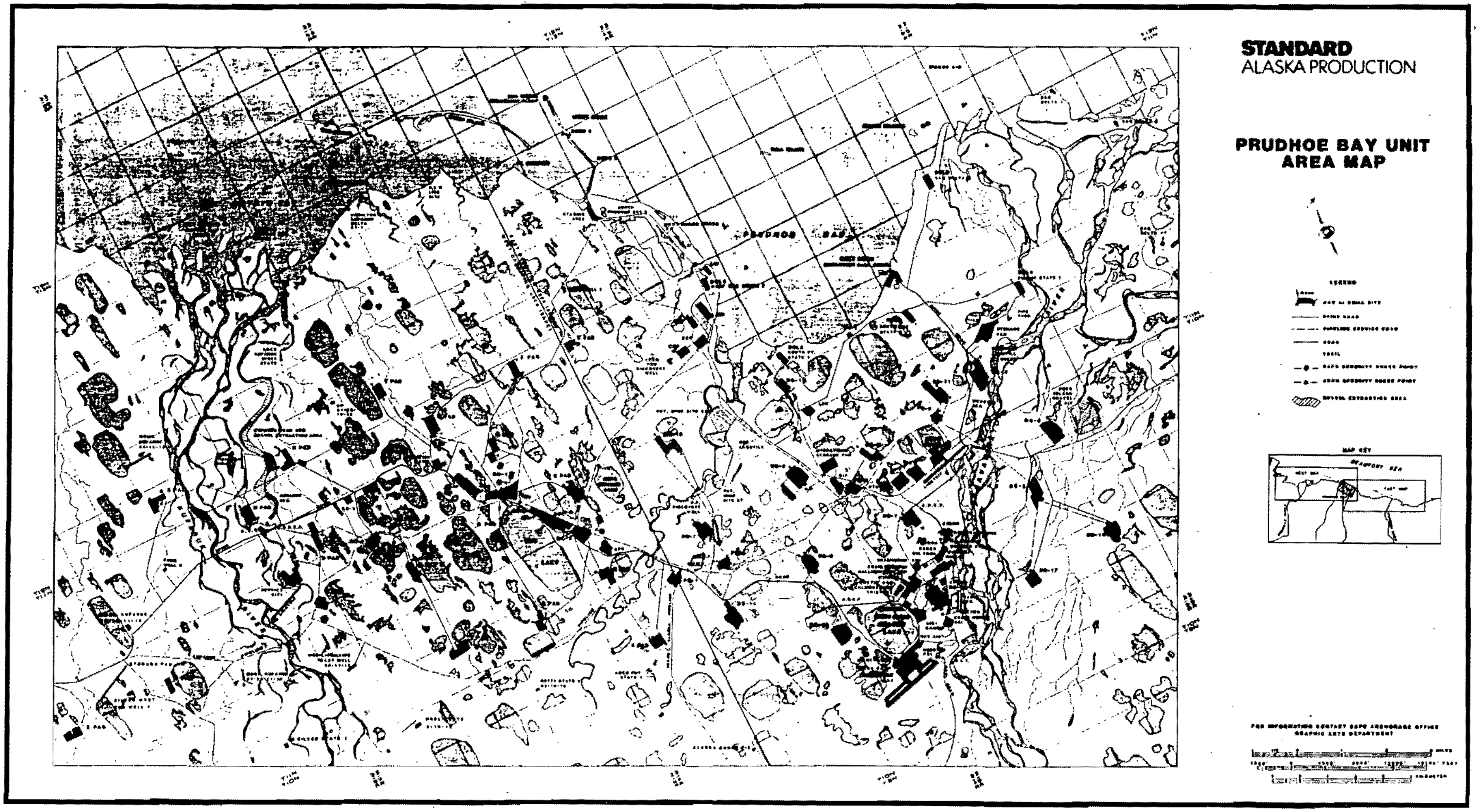


Figure 9. Layout of oil production and support facilities at Prudhoe Bay, Alaska.
Source: Standard Alaska Production Company

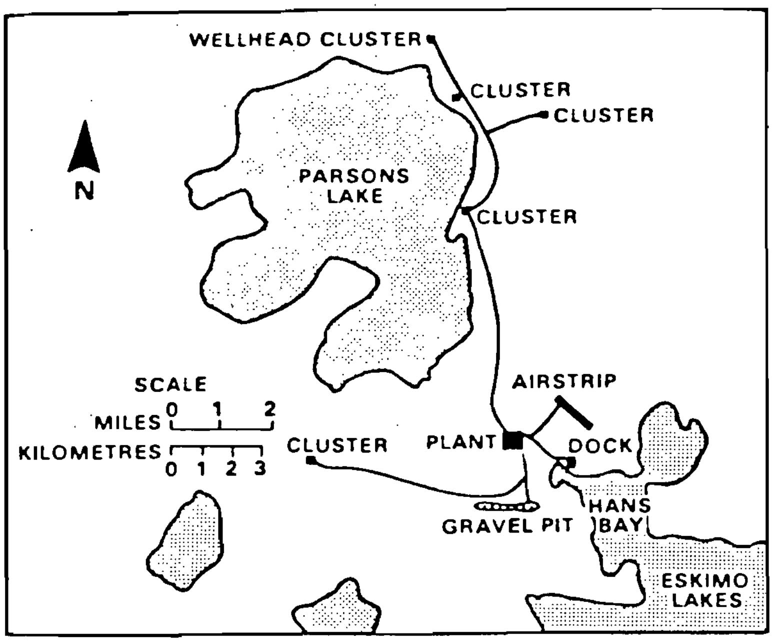


Figure 10. Hypothetical layout of gas production facilities at Parsons Lake, N.W.T.

Source: Dome et al. (1982)

This pipeline possibility is discussed further in the following section (4.3).

## 4.3 Mid-Sized and Small Oil Pipelines

Consideration has been given by some northern oil and gas operators to the feasibility of a mid-sized pipeline (400-600 mm outside-diameter) to carry both onshore and offshore oil reserves from the Mackenzie Delta/Beaufort Sea area to southern markets. The following possible scenario is taken from R.A. Owens Environmental Services Ltd. (1986) except where otherwise referenced.

Offshore oil likely would be brought to North Point, on Richards Island, where it would enter an onshore pipeline system (Figure 7a). The main onshore pipeline would traverse Richards Island and proceed south along the Mackenzie River valley in a corridor which closely parallels that proposed for the Polar Gas pipeline. The North Point - Thunder River portion of a possible pipeline route, identified by Canuck Engineering Ltd. (1981) for Esso, is shown in Figures 7a to 7e.

A 400 to 600 mm diameter oil pipeline could carry between 15 000 and 47 000 $m^3$/day. To be economically viable, connection of the pipeline to more than one producing field would be necessary. Both offshore and onshore reserves could be candidates. The offshore oil discovery currently showing the most promise is the Amauligak structure (Figure 8). According to Mr. K. Caldwell, a Gulf vice-president responsible for exploration, "the Amauligak structure has the necessary characteristics to be the lead project of Beaufort Sea development" (Oilweek 1986a). The Amauligak I-65 delineation well flowed crude oil at rates that were limited by the capacity of the test equipment. Oilweek (1986a) stated that wells drilled to date on the Amauligak structure indicate a potential of between 700 and 800 million barrels of proven recoverable oil. Other wells that could be connected to an offshore pipeline system are Issungnak, Nipterk, and Pitsiulak (Figure 8). Tarsuit could be another possibility although the results of recent tests at this structure have been "disappointing" (Oilweek 1985). In the Mackenzie Delta, Niglintgak, Kugpik and Kumak are candidates for an onshore pipeline system with Ivik situated adjacent to the point of origin of the main pipeline (Figure 8). Recent drilling by Esso at their Hansen well (at Hansen Harbour) yielded favourable results (Esso 1986). The Adgo and Garry offshore wells could also be connected to the gathering system near Niglintgak. On the Tuktoyaktuk Peninsula, another gathering pipeline could tap the Kamik well (near Parsons Lake), the Tuk/Tuktuk structure and possibly the Mayogiak and Atkinson discoveries (Figure 8).

Esso also has considered the possibility of a smaller oil pipeline (roughly 300 mm outside-diameter) which would carry oil from onshore Mackenzie River delta reserves to southern markets via an interconnection with I.P.L.'s pipeline at Norman Wells (R.A. Owens Environmental Services Ltd. 1986). Possible production sites for this pipeline are located on Richards Island and the Tuktoyaktuk Peninsula: Ivik, Kumak, Kugpik, Niglintgak, Atkinson, Tuk/Tuktuk, Mayogiak and Kamik (Figure 8).

Identification of onshore and offshore wells which would be selected as production sites and routes for main and gathering pipelines is, of course, highly speculative at present. Figure 11

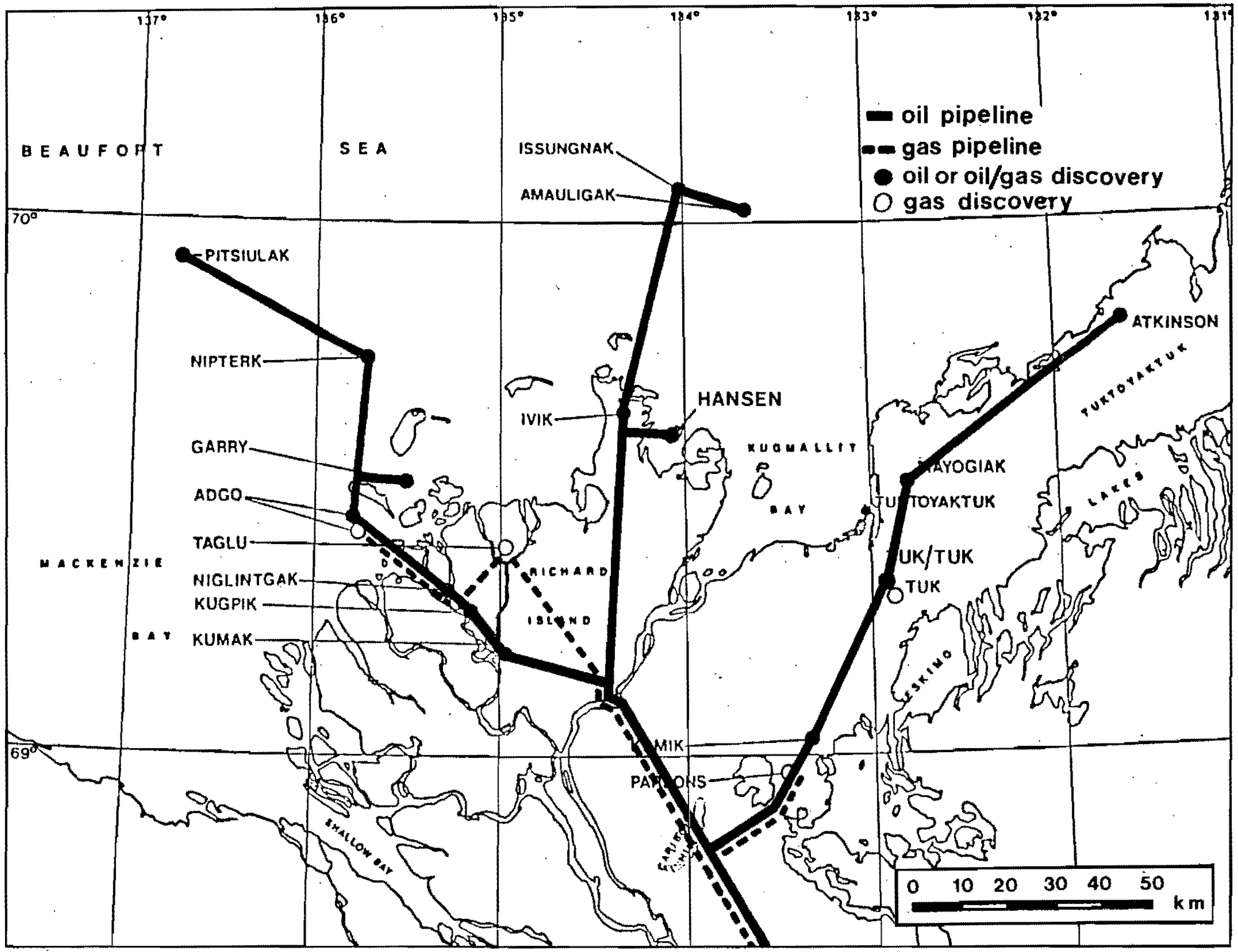


Figure 11. Possible pipeline routes in the Beaufort Sea, Mackenzie Delta and Tuktoyaktuk Peninsula regions.

shows possible pipeline routes and production sites based on information contained in Dome *et al*. (1982), Canuck Engineering Ltd. (1982), R.A. Owens Environmental Services Ltd. (1986) and Oilweek (1986b). An array of support facilities, such as airstrips, processing plants, roads, etc., would be required if one of these oil pipeline configurations was constructed. These were already discussed in section 4.1.

## 5. RESULTS AND DISCUSSION

Waterfowl observations recorded during the three aerial surveys conducted in 1985 were summarized by physiographic region to facilitate analysis and comparison with similar data collected by other researchers. Table 1 and Figure 3 indicate the breakdown of the 300-km pipeline route into segments by physiographic region. The locations of all birds observed during the surveys are shown on maps in Appendices I, II and III.

### 5.1 June Surveys

On June 26, the highest number of geese[a/] (1.30 birds/km$^2$) and tundra swans (0.71 birds/km$^2$) occurred in the Tununuk Low Hills/delta route segment (Table 2). Most of the swans were observed on Richards Island (Figure 12). Diving ducks[b/] were most numerous in the Hyndman Lake Hills segment (2.10 birds/km$^2$) while waterfowl in general appeared to be distributed throughout the main pipeline route (Figures 13 and 14).

Figures 12, 13, and 14, also show the locations of swans, diving ducks and total waterfowl, respectively, observed along the Polar Gas Lost Reindeer Lakes alternative route. A Wilcoxon matched-pairs signed-ranks test (Siegel 1956) was performed on waterfowl densities calculated for the 0-170 km segments of the main and alternative routes. No significant difference ($\alpha = 0.05$) was

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a/ geese observed: Canada goose, greater white-fronted goose, Pacific brant, snow goose

b/ although oldsquaw, eider spp., scoter spp. and red-breasted merganser are sea ducks, they have been lumped together with scaup spp. as diving ducks for simplicity of analysis

Table 1. Classification of Polar Gas pipeline route segments by physiographic region.

| Route segment[a] | Physiographic region[b] | Section |
|---|---|---|
| 0 - 130 km | Hyndman Lake Hills | - |
| 130 - 150 km | Campbell Lake Hills | - |
| 150 - 170 km | Campbell Lake Hills | Campbell-Sitidgi Lake lowland[c] |
| 170 - 220 km | Caribou Hills | Noell Lake[d] |
| 220 - 240 km | Caribou Hills | North Storm Hills[d] |
| 240 - 296 km | Pleistocene Coastlands | Tununuk Low Hills[c] |
| 296 - 300 km | Mackenzie Delta | - |

[a] see Figure 3 for physiographic region boundaries
[b] Mackay (1963)
[c] designation given by Mackay (1963)
[d] designation used by author in Tables 2, 6 and 8.

Table 2. Numbers and distribution of waterfowl along the Polar Gas pipeline route by physiographic region - June 26,1985.

| Pipeline route segment[a] | Hyndman Lake Hills 0 - 130 km | Campbell Lake Hills 130 - 150 km | Campbell-Sitidgi Lake Lowland 150 - 170 km | Noell Lake 170 - 220 km | North Storm Hills 220 - 240 km | Tunuñuk Low Hills/Delta 240 - 300 km | TOTAL ROUTE |
|---|---|---|---|---|---|---|---|
| Area surveyed ($km^2$) | 52.0 | 2.2 | .[b] | 8.4 | 2.2 | 24.0 | 98.8 |
| Tundra swan | 9 (0.17)[c] | 1 (0.45) | . | 3 (0.36) | -[d] | 17 (0.71) | 30 (0.30) |
| Greater white-fronted goose | - | - | . | - | - | - | - |
| Snow goose | - | - | . | - | - | 10 (0.42) | 10 (0.10) |
| Brant | - | - | . | - | - | 6 (0.25) | 6 (0.06) |
| Canada goose | 2 (0.04) | - | . | - | - | 15 (0.63) | 17 (0.17) |
| Dark goose spp. | 1 (0.02) | - | . | - | - | - | 1 (0.01) |
| Green-winged teal | - | - | . | - | - | - | - |
| Mallard | 3 (0.06) | - | . | - | - | - | 3 (0.03) |
| Northern pintail | - | - | . | - | - | 2 (0.08) | 2 (0.02) |
| Northern shoveler | 1 (0.02) | - | . | - | - | - | 1 (0.01) |
| American wigeon | - | - | . | 2 (0.24) | - | - | 2 (0.02) |
| Unidentified dabblers[e] | 32 (0.62) | - | . | - | - | - | 32 (0.32) |
| Scaup spp. | 33 (0.63) | - | . | 10 (1.19) | - | 28 (1.17) | 71 (0.72) |
| Eider spp. | - | - | . | - | - | 2 (0.08) | 2 (0.02) |
| Oldsquaw | - | - | . | - | - | 1 (0.04) | 1 (0.01) |
| Scoter spp. | 5 (0.10) | - | . | - | - | 2 (0.08) | 7 (0.07) |
| Red-breasted merganser | 1 (0.02) | - | . | - | - | - | 1 (0.01) |
| Unidentified divers[f] | 70 (1.35) | 2 (0.90) | . | - | - | 1 (0.04) | 73 (0.74) |
| Unidentified ducks | 10 (0.19) | 2 (0.90) | . | - | - | 7 (0.29) | 19 (0.19) |
| TOTAL WATERFOWL | 167 (3.21) | 5 (2.25) | . | 15 (1.79) | - | 91 (3.79) | 278 (2.81) |

a/ see Figure 3 for physiographic region boundaries
b/ segment not surveyed due to forest fire
c/ birds/$km^2$
d/ no birds observed
e/ dabblers: green-winged teal, mallard, northern pintail, northern shoveler, American wigeon
f/ divers: scaup spp., eider spp., oldsquaw, scoter spp., red-breasted merganser

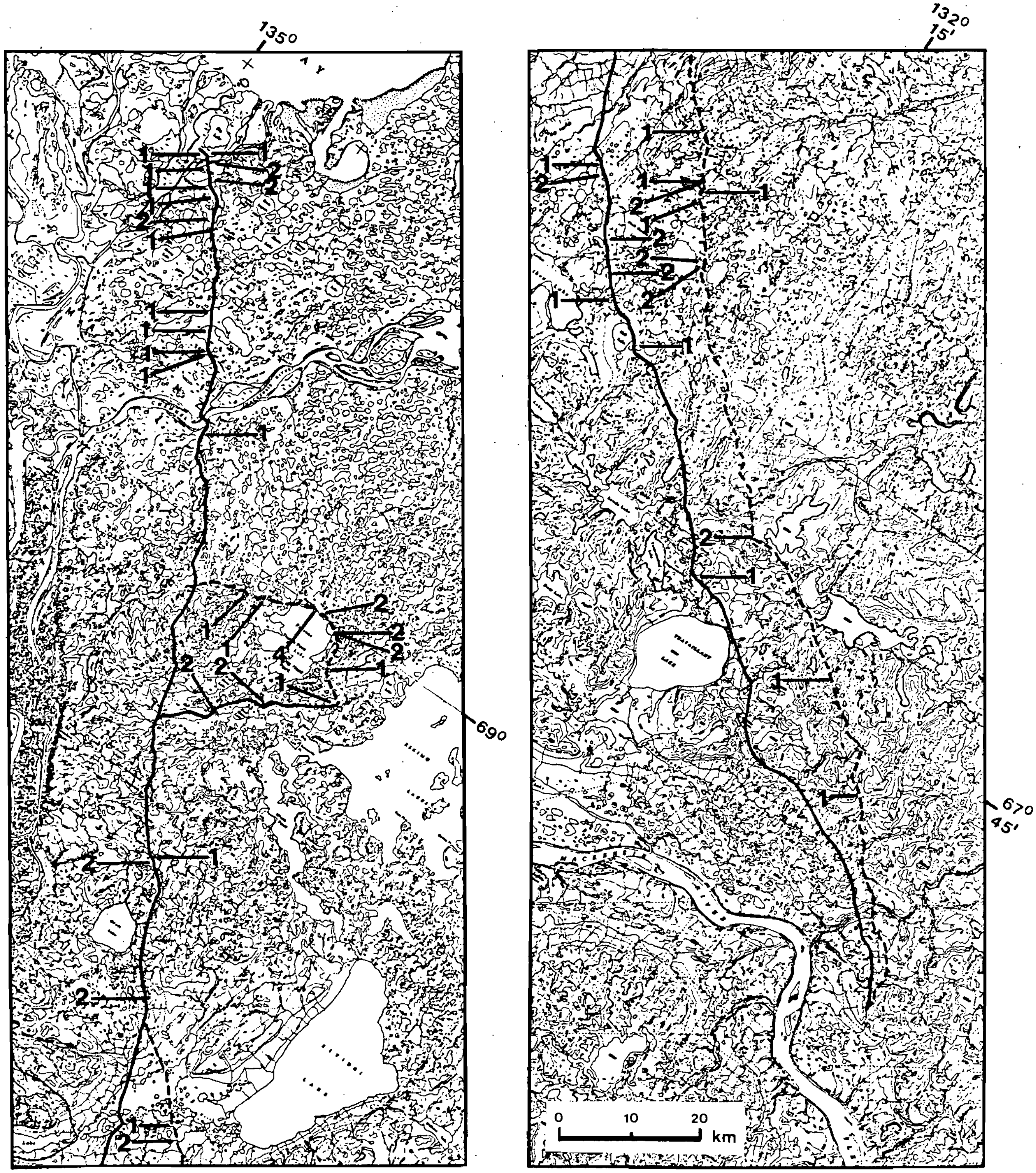


Figure 12. Locations of tundra swans observed during the June 26, 1985 aerial survey of the Polar Gas pipeline route.

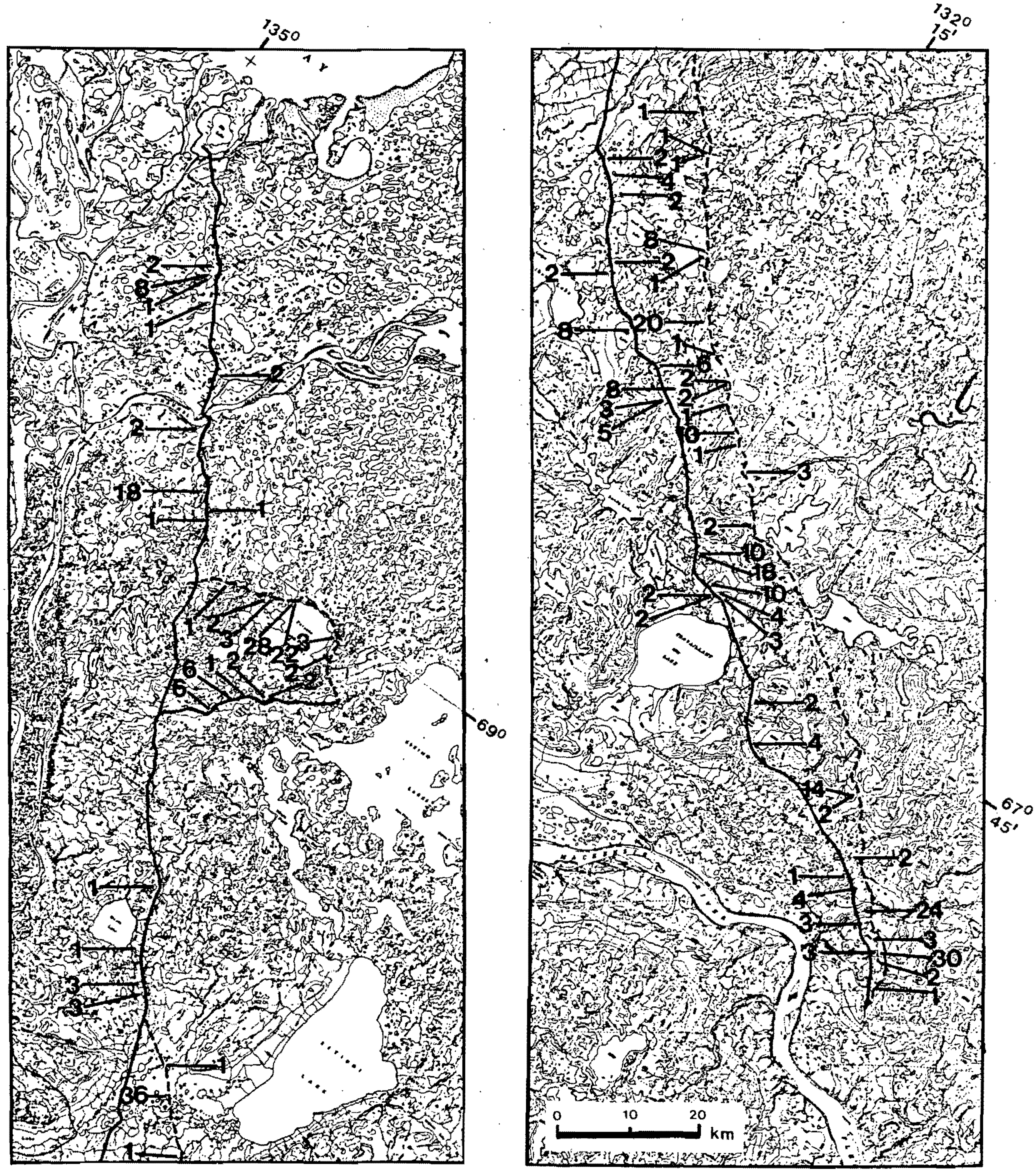


Figure 13. Locations of diving ducks observed during the June 26, 1985 aerial survey of the Polar Gas pipeline route.

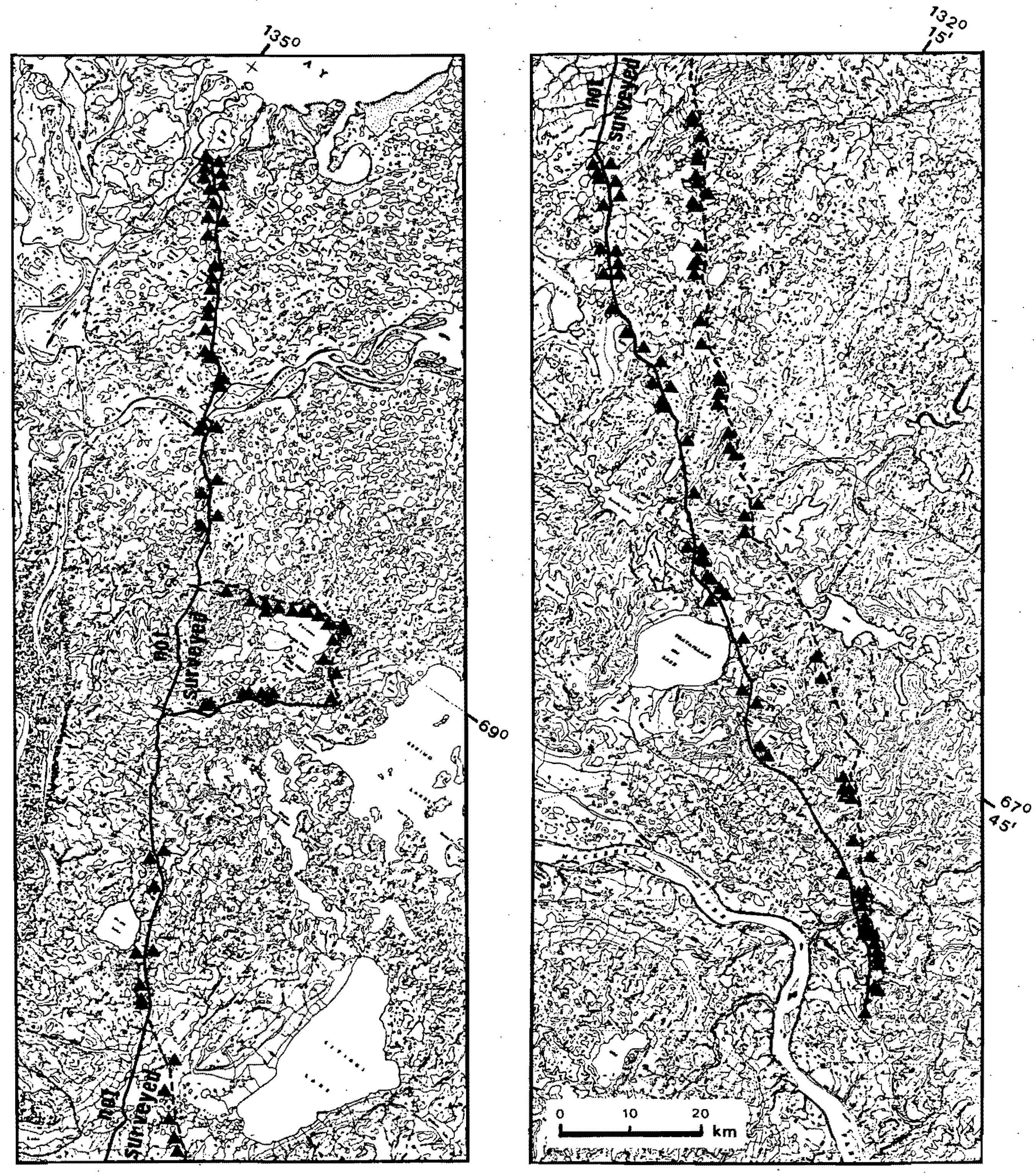


Figure 14. Locations of all waterfowl observed during the June 26, 1985 aerial survey of the Polar Gas pipeline route.

found between waterfowl densities of the two routes. Therefore, from a strictly waterfowl population basis, there would probably be no advantage in selecting the Lost Reindeer Lakes alternative over the proposed route.

The results of late-June aerial waterfowl surveys, conducted by other researchers along routes similar to the proposed Polar Gas route, were compared to the results of the present study (Table 3). More detailed data for some of these surveys are given in Appendices IV to VI. Unfortunately, only the observations reported by Wiseley et al. (1977) are comparable to the 1985 observations. Salter (1974) surveyed only the 150-270 km segment of the 300-km route omitting the northernmost 30 km of productive Mackenzie River delta habitat. In contrast, the survey conducted by Slaney (1974) was restricted to a 40-km corridor on Richards Island. The Poston (1977) survey was not conducted along a linear route as was done by the other researchers. Instead, Poston surveyed individual wetlands in order to obtain total population counts. Numbers of birds observed during his study were, therefore, much higher than the numbers observed along linear routes.

Mean density of waterfowl (2.91 birds/km$^2$) observed over the 300-km section of the route by Wiseley et al. (1977) was almost identical to the figure determined in the present study (2.81 birds/km$^2$). The number of swans observed in each study was similar. However, Wiseley recorded larger numbers of dabblers and divers whereas more geese were observed in this study.

Since the survey conducted by Slaney (1974) in 1973 included only the Richards Island route section, Slaney's results can be

Table 3. Comparison between waterfowl numbers and densities observed along the Mackenzie River valley by various researchers and similar data collected on June 26, 1985.

| | Boothroyd | Poston[a] | Salter[b] | Slaney[c] | Wiseley[d] |
|---|---|---|---|---|---|
| Survey date | June 26 1985 | June 22-27 1973 | June 30 1973 | June 18-21 1973 | June 20 1975 |
| Area surveyed (km$^2$) | 98.8 | 34.0 | 43.4 | 71.2 | 117.9 |
| Tundra swan | 30 (0.30)[e] | 114 (3.35) | 8 (0.18) | 19 (0.27) | 32 (0.27) |
| Greater white-fronted goose | -[f] | •[g] | - | 2 (0.03) | • |
| Snow goose | 10 (0.10) | • | - | - | • |
| Brant | 6 (0.06) | • | - | - | • |
| Canada goose | 17 (0.17) | • | - | 2 (0.03) | • |
| Dark goose spp. | 1 (0.01) | - | - | - | - |
| Green-winged teal | - | • | - | - | - |
| Mallard | 3 (0.03) | • | - | 5 (0.07) | 17 (0.14) |
| Northern pintail | 2 (0.02) | • | - | 12 (0.17) | 28 (0.24) |
| Northern shoveler | 1 (0.01) | • | - | 4 (0.06) | • |
| American wigeon | 2 (0.02) | • | - | 7 (0.10) | 5 (0.04) |
| Unidentified dabblers[h] | 32 (0.32) | 298 (8.76) | • | - | 1 (0.01) |
| Scaup spp. | 71 (0.72) | • | 14 (0.32) | 27 (0.38) | 135 (1.15) |
| Eider spp. | 2 (0.02) | • | - | - | • |
| Oldsquaw | 1 (0.01) | • | 10 (0.23) | 7 (0.10) | 41 (0.35) |
| Scoter spp. | 7 (0.07) | • | - | 33 (0.46) | 59 (0.50) |
| Red-breasted merganser | 1 (0.01) | • | - | 2 (0.03) | • |
| Unidentified divers[i] | 73 (0.74) | 888 (26.12) | • | - | 13 (0.11) |
| Unidentified ducks | 19 (0.19) | • | - | 20 (0.28) | 2 (0.02) |
| TOTAL WATERFOWL | 278 (2.81) | 1 300 (38.24) | 32 (0.74) | 181 (2.54) | 343 (2.91) |

a/ 0-10 & 170-270 km segments only (Poston 1977)

b/ 150-270 km segment only (Salter 1974)

c/ 260-300 km segment only (Slaney 1974)

d/ 0-300 km surveyed, 260-300 km segment different from present study (Wiseley et al. 1975)

e/ birds/km$^2$

f/ no birds observed

g/ species not recorded

h/ dabblers: green-winged teal, mallard, northern pintail, northern shoveler, American wigeon

i/ divers: scaup spp., eider spp., oldsquaw, scoter spp., red-breasted merganser compared to the 1985 data collected for the Tununuk Low Hills/Delta route segment (Table 4). Similar densities of swans were recorded in both studies. Higher densities of dabblers and geese were reported by Slaney whereas diver density was higher in 1985. Forty-three white-fronted geese were observed during Slaney's 1973 study; none were observed in June 1985. Black brant and snow geese were observed in 1985 whereas none were recorded in 1973.

Table 5 gives the results of the June 26 survey of the proposed Polar Gas Parsons Lake lateral route. Data are also presented for a lateral route which traverses the northern shoreline of Parsons Lake. This route was patterned after a route included in the Arctic Gas proposal. Finally, results of a survey conducted by Slaney (1974) in 1973 are also included in Table 5 for comparison with data for the southern lateral route. Figure 14 gives the locations of waterfowl seen on June 26, 1985.

Waterfowl density was higher along the northern route (7.50 birds/km$^2$) than the southern (proposed) route (2.20 birds/km$^2$) in 1985. Waterfowl density recorded in 1973 along the southern route (5.39 birds/km$^2$), was roughly midway between the two 1985 densities. Swans occurred in lower density in 1973 than along either route in 1985. More dabbling ducks were observed in 1973 and divers were also numerous.

Overall, on June 26, 1985, waterfowl density along the southern Parsons lateral was a little lower than along the Tununuk Low Hills/Delta segment of the main route. Waterfowl density along the northern lateral route was, however, higher than the main route.

Table 4. Waterfowl numbers and densities observed on Richards Island in 1973 and 1985.

| | June | | July | |
|---|---|---|---|---|
| | Boothroyd June 26 1985 | Slaney [a/] June 18-21 1973 | Boothroyd July 22 1985 | Slaney July 19-23,25 1973 |
| Area surveyed ($km^2$) | 24.0 | 71.2 | 24.0 | 71.2 |
| Tundra swan | 17 (0.71) [b/] | 19 (0.27) | 36 + 2 [c/] (1.50) (0.08) | 43 + 11 (0.60) (0.15) |
| Greater white-fronted goose | - [d/] | 43 (0.60) | 5 (0.21) | - |
| Snow goose | 10 (0.42) | - | - | - |
| Brant | 6 (0.25) | - | - | - |
| Canada goose | 15 (0.63) | 2 (0.03) | - | - |
| Dark goose spp. | - | - | - | - |
| Green-winged teal | - | - | - | - |
| Mallard | - | 5 (0.07) | - | - |
| Northern pintail | 2 (0.08) | 12 (0.17) | 7 (0.29) | 8 (0.11) |
| Northern shoveler | - | 4 (0.06) | - | - |
| American wigeon | - | 7 (0.10) | - | - |
| Unidentified dabblers [e/] | - | - | - | 6 + 12 (0.08) (0.17) |
| Scaup spp. | 28 (1.17) | 27 (0.38) | - | - |
| Eider spp. | - | - | - | - |
| Oldsquaw | 1 (0.04) | 7 (0.10) | - | 11 (0.15) |
| Scoter spp. | 2 (0.08) | 33 (0.46) | 5 (0.21) | 20 (0.28) |
| Red-breasted merganser | - | 2 (0.03) | - | - |
| Unidentified divers [f/] | 1 (0.04) | - | 28 (1.17) | 33 + 35 (0.46) (0.49) |
| Unidentified ducks | 7 (0.29) | 20 (0.28) | - | 7 + 7 (0.10) (0.10) |
| TOTAL WATERFOWL | 91 (3.79) | 181 (3.54) | 81 (3.38) | 128 + 65 (1.80) (0.91) |

a/ Slaney (1974)
b/ birds/$km^2$
c/ 36 + 2 = 36 adults and 2 young
d/ no birds observed
e/ dabblers: green-winged teal, mallard, northern pintail, northern shoveler, American wigeon
f/ divers: scaup spp., eider spp., oldsquaw, scoter spp., red-breasted merganser

Table 5. Waterfowl numbers and densities observed along Parsons Lake lateral routes in 1973 and 1985.

| | Boothroyd | | | | | | Slaney [a] | |
|---|---|---|---|---|---|---|---|---|
| | June 26 1985 | | July 22 1985 | | August 26 1985 | | June 18-21 1973 | July 19 23,25 1973 |
| | N[b] | S[b] | N | S | N | S | | |
| Area surveyed ($km^2$) | 10.0 | 10.0 | 10.0 | 10.0 | 5.0 | 5.0 | 49.9 | 63.4 |
| Tundra swan | 13 (1.30)[c] | 5 (0.50) | 6 + 3[d] (0.60)[e] | 11 + 3 (1.10) | 7 (1.40) | 3 (0.60) | 10 (0.20) | 36 + 7 (0.57) |
| Greater white-fronted goose | -[f] | - | 2 (0.20) | - | - | - | 30 (0.60) | - |
| Snow goose | - | - | - | - | - | - | - | - |
| Brant | - | - | - | - | - | - | - | - |
| Canada goose | - | - | - | - | - | - | - | - |
| Dark goose spp. | - | - | - | - | - | - | - | - |
| Green-winged teal | - | - | - | - | - | - | - | - |
| Mallard | 1 (0.10) | - | - | - | - | - | 2 (0.04) | - |
| Northern pintail | - | - | - | - | - | - | 11 (0.22) | 48 + 8 (0.76) |
| Northern shoveler | - | - | - | - | - | - | - | - |
| American wigeon | - | - | - | - | - | - | 6 (0.12) | - |
| Unidentified dabblers[g] | - | - | - | - | - | - | - | - |
| Scaup spp. | 27 (2.70) | 10 (1.00) | - | - | - | - | 101 (2.03) | 104 + 58 (1.64) |
| Eider spp. | - | - | - | - | - | - | - | - |
| Oldsquaw | - | 1 (0.10) | - | - | - | - | 24 (0.48) | 43 + 144 (0.68) |
| Scoter spp. | - | - | 1 (0.10) | - | - | 9 (1.80) | 78 (1.57) | 13 + 48 (0.21) |
| Red-breasted merganser | - | 6 (0.60) | - | - | - | - | 2 (0.04) | - |
| Unidentified divers[h] | 34 (3.40) | - | 1 (0.10) | 13 (1.30) | - | - | - | 64 (1.01) |
| Unidentified ducks | - | - | - | - | - | - | 5 (0.10) | 3 (0.05) |
| TOTAL WATERFOWL | 75 (7.50) | 22 (2.20) | 10 + 3 (1.0) | 24 + 3 (2.40) | 7 (1.40) | 11 (2.20) | 269 (5.39) | 311 + 265 (4.91) |

a/ Slaney (1974)

b/ N = north route, S = south route (see Figure 3)

c/ birds/$km^2$

d/ 6 + 3 = 6 adults and 3 young

e/ adult birds/$km^2$ only

f/ no birds observed

g/ dabblers: green-winged teal, mallard, northern pintail, northern shoveler, American wigeon

h/ divers: scaup spp., eider spp., oldsquaw, scoter spp., red-breasted merganser

## 5.2 July Surveys

As in June, the highest density of waterfowl (3.38 birds/$km^2$), and swans in particular (1.50 birds/$km^2$), occurred in the northernmost segment (Tununuk Low Hills/Delta) of the main pipeline route on July 22 (Table 6, Figure 15). Overall, waterfowl density in July was similar to what was observed in June, although only the northern 130 km (km 170-300) of the route was surveyed. One brood of swans (2 young) were seen in a small lake about five kilometres south of Swimming Point (Mackenzie River East Channel).

The density of swans in the Tununuk Low Hills /Delta segment in July (1.50 birds/$km^2$) was more than twice the density observed in June (0.71 birds/$km^2$). Wiseley et al. (1975) observed a similar increase in swan density in July over the entire 300-km route (Table 7). Slaney (1974) indicated that swan density in July was double that in June on Richards Island (Table 4). However, Poston (1977) and Salter (1974) showed a decrease in swan density. This is probably because the Richards Island segment of the route, having the highest swan density and therefore the greatest influence on overall density, was not included in the surveys conducted by those researchers.

Waterfowl density along the proposed Parsons southern lateral route in July (2.40 birds/$km^2$) was similar to what was observed in June (2.20 birds/$km^2$) although swan density had doubled from 0.50 to 1.10 birds/$km^2$) (Table 5, Figure 15). However, density of all waterfowl (including swans), along the northern lateral route, was reduced in July from 7.50 to 1.00 birds/$km^2$. One swan brood (three young) was observed on each route. Slaney (1974) observed an overall decrease in waterfowl density from June to July in 1973. Swan

Table 6. Numbers and distribution of waterfowl along the Polar Gas pipeline route by physiographic region - July 22, 1985.

| Pipeline route segment[a] | Hyndman Lake Hills 0 - 130 km | Campbell Lake Hills 130 - 150 km | Campbell-Sitidgi Lake Lowland 150 - 170 km | Noell Lake 170 - 220 km | North Storm Hills 220 - 240 km | Tununuk Low Hills/Delta 240 - 300 km | TOTAL ROUTE |
|---|---|---|---|---|---|---|---|
| Area surveyed ($km^2$) | •[b] | • | • | 18.0 | 2.2 | 24.0 | 44.2 |
| Tundra swan | • | • | • | 12<br>(0.67)[c] | -[d] | 36 + 2[e]<br>(1.50)[f] | 48 + 2<br>(1.09) |
| Greater white-fronted goose | • | • | • | - | - | 5<br>(0.21) | 5<br>(0.11) |
| Snow goose | • | • | • | - | - | - | - |
| Brant | • | • | • | - | - | - | - |
| Canada goose | • | • | • | - | - | - | - |
| Dark goose spp. | • | • | • | - | - | - | - |
| Green-winged teal | • | • | • | - | - | - | - |
| Mallard | • | • | • | - | - | - | - |
| Northern pintail | • | • | • | - | - | 7<br>(0.29) | 7<br>(0.16) |
| Northern shoveler | • | • | • | - | - | - | - |
| American wigeon | • | • | • | - | - | - | - |
| Unidentified dabblers[g] | • | • | • | - | - | - | - |
| Scaup spp. | • | • | • | 18<br>(1.00) | - | - | 18<br>(0.41) |
| Eider spp. | • | • | • | - | - | - | - |
| Oldsquaw | • | • | • | - | - | - | - |
| Scoter spp. | • | • | • | 1<br>(0.06) | - | 5<br>(0.21) | 6<br>(0.14) |
| Red-breasted merganser | • | • | • | - | - | - | - |
| Unidentified divers[h] | • | • | • | 2<br>(0.11) | - | 28<br>(1.17) | 30<br>(0.68) |
| Unidentified ducks | • | • | • | - | - | - | - |
| TOTAL WATERFOWL | | | | 33<br>(1.83) | - | 81<br>(3.38) | 114 + 2<br>(2.58) |

a/ see Figure 3 for physiographic region boundaries
b/ not surveyed
c/ birds/$km^2$
d/ no birds observed
e/ 36 + 2 = 36 adults and 2 young
f/ adult birds/$km^2$ only
g/ dabblers: green-winged teal, mallard, northern pintail, northern shoveler, American wigeon
h/ divers: scaup spp., eider spp., oldsquaw, scoter spp., red-breasted merganser

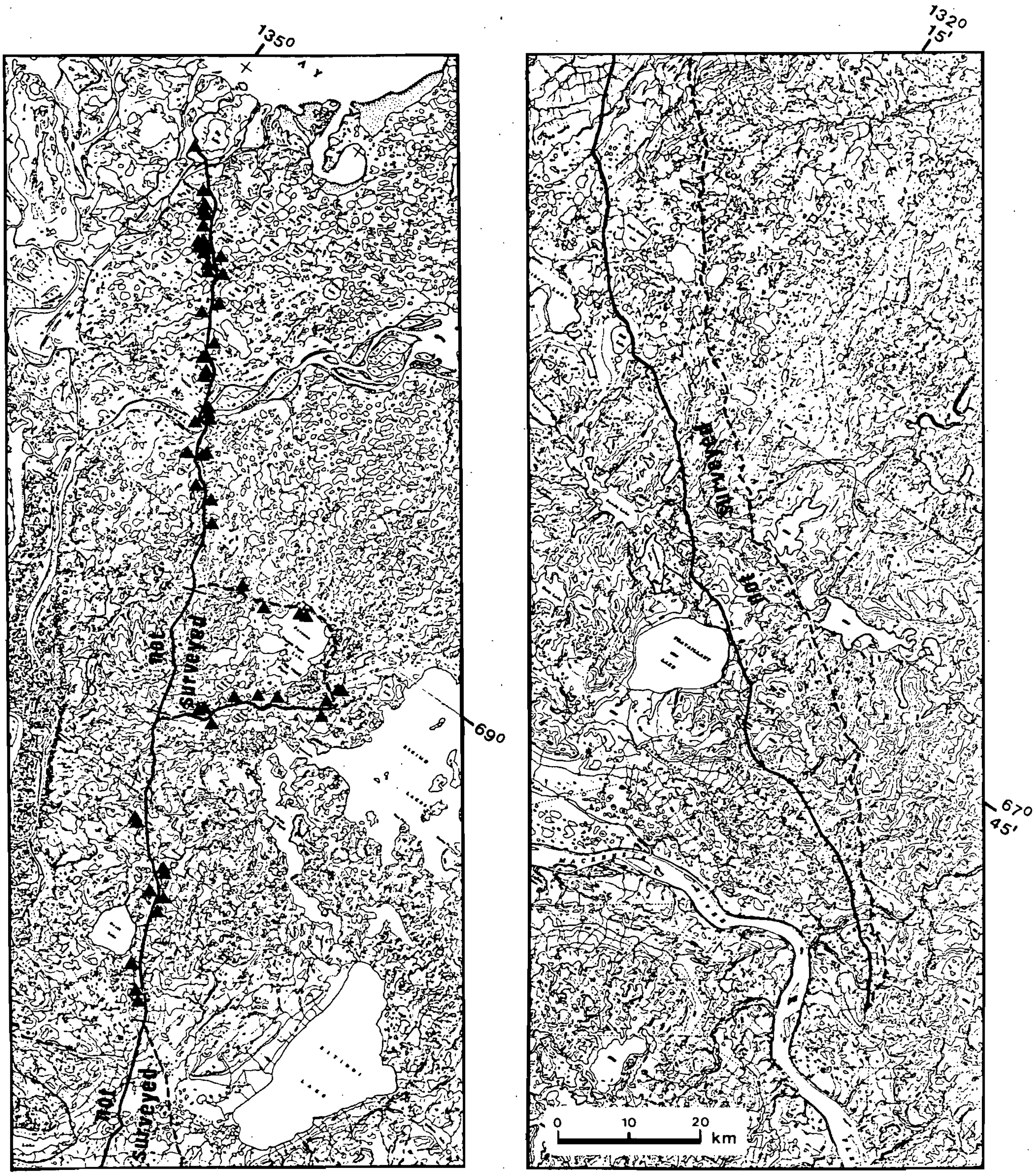


Figure 15. Locations of waterfowl observed during the July 22, 1985 aerial survey of the Polar Gas pipeline route.

Table 7. Comparison between waterfowl numbers and densities observed along the Mackenzie River valley by various researchers and similar data collected on July 22, 1985.

| | Boothroyd | Poston[a] | Salter[b] | Slaney[c] | Wiseley[d] |
|---|---|---|---|---|---|
| | July 22 1985 | July 21-27 1973 | August 1 1973 | July 19-23,25 1973 | July 31 1975 |
| Area surveyed (km$^2$) | 44.2 | 10.0 | 43.4 | 71.2 | 117.9 |
| Tundra swan | 44 + 2[e] (1.09) (0.05)[f] | 20 + 5 (2.00) (0.50) | 4 (0.09) | 43 + 11 (0.60) (0.15) | 53 (0.45) |
| Greater white-fronted goose | 5 (0.11) | •[g] | -[h] | - | • |
| Snow goose | - | • | - | - | • |
| Brant | - | • | - | - | • |
| Canada goose | - | • | - | - | • |
| Dark goose spp. | - | 2 (0.20) | - | - | - |
| Green-winged teal | - | • | - | - | 2 (0.02) |
| Mallard | - | • | - | - | 4 (0.03) |
| Northern pintail | 7 (0.16) | • | - | 8 (0.11) | 44 (0.37) |
| Northern shoveler | - | • | - | - | • |
| American wigeon | - | • | - | - | - |
| Unidentified dabblers[i] | - | 125 + 15 (12.50) (1.50) | • | 6 + 12 (0.08) (0.17) | 24 (0.20) |
| Scaup spp. | 18 (0.41) | • | - | - | 243 (2.06) |
| Eider spp. | - | • | - | - | • |
| Oldsquaw | - | • | 25 (0.58) | 11 (0.15) | 56 (0.47) |
| Scoter spp. | 6 (0.14) | • | - | 20 (0.28) | 88 (0.75) |
| Red-breasted merganser | - | • | - | - | • |
| Unidentified divers[j] | 30 (0.68) | 136 + 3 (13.60) (0.30) | • | 33 + 35 (0.46) (0.49) | 87 (0.74) |
| Unidentified ducks | - | • | 71 (1.64) | 7 + 7 (0.10) (0.10) | 170 (1.44) |
| TOTAL WATERFOWL | 114 + 2 (2.58) (0.05) | 283 + 23 (28.30) (2.30) | 106 (2.44) | 128 + 65 (1.80) (0.91) | 771 (6.54) |

a/ 0-10 & 170-270 km segments only (Poston 1977)

b/ 150-270 km segment only (Salter 1974)

c/ 260-300 km segment only (Slaney 1974)

d/ 0-300 km surveyed, 260-300 km segment different from present study (Wiseley *et al.* 1975)

e/ 44 + 2 = 44 adults and 2 young

f/ birds/km$^2$

g/ species not surveyed

h/ no birds observed

i/ dabblers: green-winged teal, mallard, northern pintail, northern shoveler, American wigeon

j/ divers: scaup spp., eider spp., oldsquaw, scoter spp., red-breasted merganser density, however, had doubled (Table 5). The large numbers of waterfowl broods, and birds in general, recorded by Slaney were a result of the survey methodology used. Several straight-line transects were flown approximately 1.6 km apart along a corridor which included possible Parsons lateral routes. These transects would have crossed several ponds and lakes throughout their length resulting in increased opportunities to observe broods. In contrast, the 1985 surveys were flown directly along the proposed pipeline route which was selected, obviously, so as to avoid crossing lakes and ponds.

5.3 August Surveys

Except for a few ducks, swans and dark geese were the only waterfowl observed on August 26 (Table 8, Figure 16). Most of the swans, and all of the dark goose observations were accounted for by two staging flocks (140 swans, 100 dark geese) on a lake at km 287 (Appendix III). The other swans were located either along the northernmost 20 km of the route (Richards Island) or near Noell Lake (km 185-195).

Numbers of waterfowl were similarly reduced along the northern and southern Parsons lateral routes (Table 5, Figure 16).

No surveys were conducted in late August by the researchers cited in sections 5.1 and 5.2. Therefore, waterfowl density and distribution observed in 1985 cannot be compared directly with similar data collected in previous years. However, a review of the literature indicates that, during the fall staging and migration period, which generally begins by mid-August, the majority of waterfowl concentrate in coastal areas along the outer Mackenzie Delta rather than inland

Table 8. Numbers and distribution of waterfowl along the Polar Gas pipeline route by physiographic region - August 26, 1985.

| Pipeline route segment[a/] | Hyndman Lake Hills 0 - 130 km | Campbell Lake Hills 130 - 150 km | Campbell-Sitidgi Lake Lowland 150 - 170 km | Noell Lake 170 - 220 km | North Storm Hills 220 - 240 km | Tununuk Low Hills/Delta 240 - 300 km | TOTAL ROUTE |
|---|---|---|---|---|---|---|---|
| Area surveyed ($km^2$) | •[b/] | • | • | 9.0 | 1.1 | 12.0 | 22.1[c/] |
| Tundra swan | • | • | • | 10 (1.11)[d/] | -[e/] | 149 (12.42) | 159 (7.19) |
| Greater white-fronted goose | • | • | • | - | - | - | - |
| Snow goose | • | • | • | - | - | - | - |
| Brant | • | • | • | - | - | - | - |
| Canada goose | • | • | • | - | - | - | - |
| Dark goose spp. | • | • | • | - | - | 100 (8.33) | 100 (4.52) |
| Green-winged teal | • | • | • | - | - | - | - |
| Mallard | • | • | • | - | - | - | - |
| Northern pintail | • | • | • | - | - | - | - |
| Northern shoveler | • | • | • | - | - | - | - |
| American wigeon | • | • | • | - | - | - | - |
| Unidentified dabblers[f/] | • | • | • | - | - | - | - |
| Scaup spp. | • | • | • | - | - | - | - |
| Eider spp. | • | • | • | - | - | - | - |
| Oldsquaw | • | • | • | - | - | - | - |
| Scoter spp. | • | • | • | - | - | - | - |
| Red-breasted merganser | • | • | • | - | - | - | - |
| Unidentified divers[g/] | • | • | • | - | - | - | - |
| Unidentified ducks | • | • | • | - | - | 6 (0.50) | 6 (0.27) |
| TOTAL WATERFOWL | | | | 10 (1.11) | - | 255 (21.25) | 265 (11.99) |

a/ see Figure 3 for physiographic region boundaries
b/ not surveyed
c/ only one observer used on this survey
d/ birds/$km^2$
e/ no birds observed
f/ dabblers: green-winged teal, mallard, northern pintail, northern shoveler, American wigeon
g/ divers: scaup spp., eider spp., oldsquaw, scoter spp., red-breasted merganser

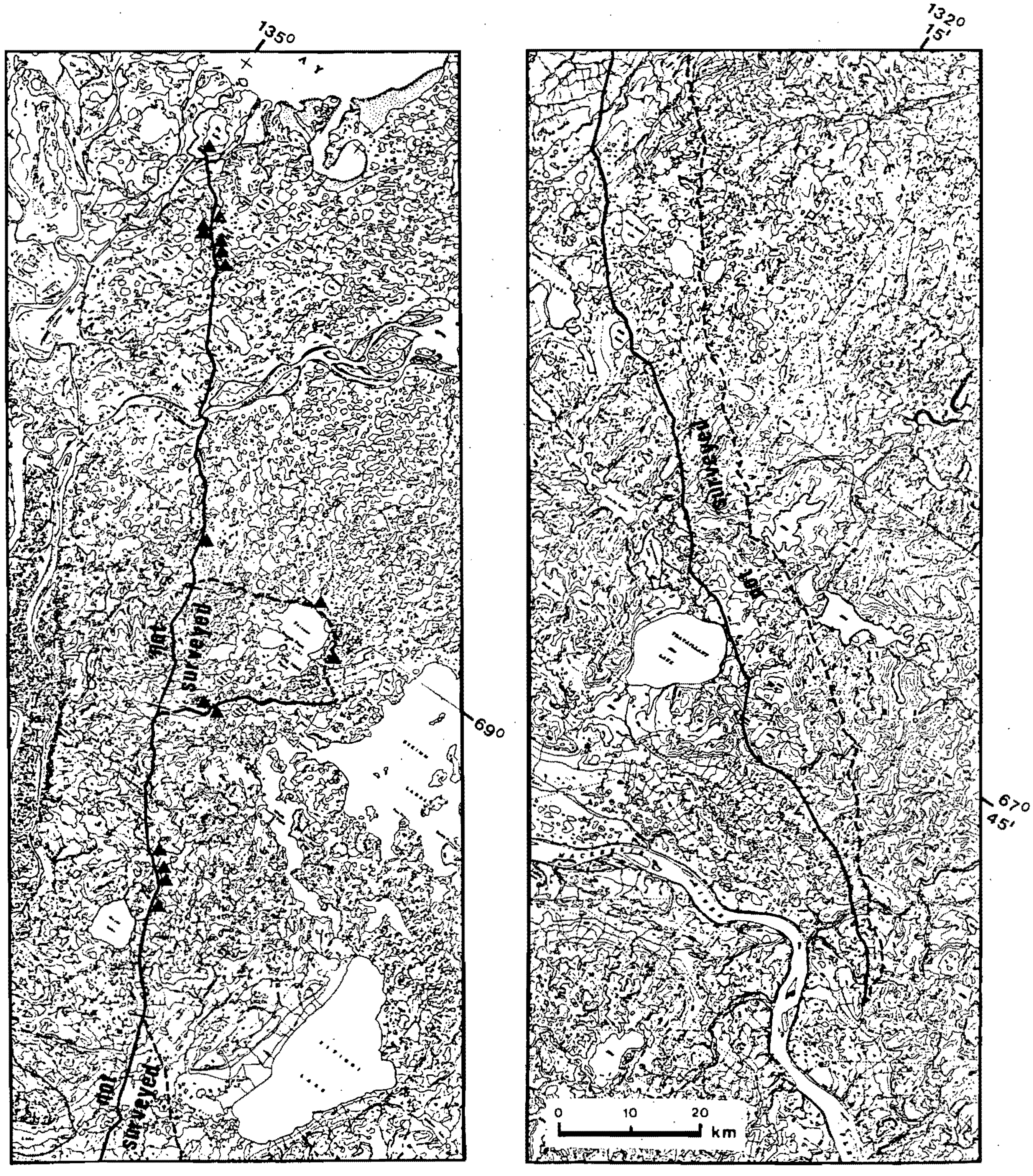


Figure 16. Locations of waterfowl observed during the August 26, 1985 aerial survey of the Polar Gas pipeline route.

areas traversed by the pipeline route (Barry 1967, Slaney 1974, Koski 1975, 1977).

In 1971, Barry and Spencer (1976) observed non-breeding greater white-fronted geese moving northward out of Denis Lagoon into channels leading to the coast to begin staging (Figure 17). Figure 17 also shows locations of tundra swans, snow and Canada geese observed during the same study period (July 6 - August 7). Slaney (1974) noted that, in the fall of 1973, white-fronted geese occurred most frequently on sedge and mudflats and willow-sedge habitat between Harry Channel and Ellice Island (see Figure 18 for locations of geographic features). Scattered flocks were also recorded along the Mackenzie River East Channel. Brant, tundra swans and snow geese similarly concentrate along coastal areas of the Mackenzie Delta. Koski (1975, 1977) observed flocks of brant along low-lying shorelines in Kittigazuit Bay, near Hansen Harbor, in Mallik Bay and in various locations between Kendall Island and Shallow Bay in 1973, 1974 and 1975 (Figures 18 and 19). Staging tundra swans were found to be most numerous around Mallik Bay, in the coastal section of the Kendall Island Bird Sanctuary and along the eastern shoreline of Shallow Bay in 1975 (Koski 1977) (Figure 19).

Many thousands of snow geese migrate early in the fall season to feeding areas on the Yukon and Alaska north slope. The coastal zones of Ellice, Olivier and Langley islands are also used extensively by thousands of snow geese as well as Shallow Bay and the Kendall Island area (Koski 1975, 1977) (Figure 20). In 1974, a small concentration of snow geese was also sighted near Fish Island (Koski 1975). Canada geese, in contrast, occur in low numbers in the

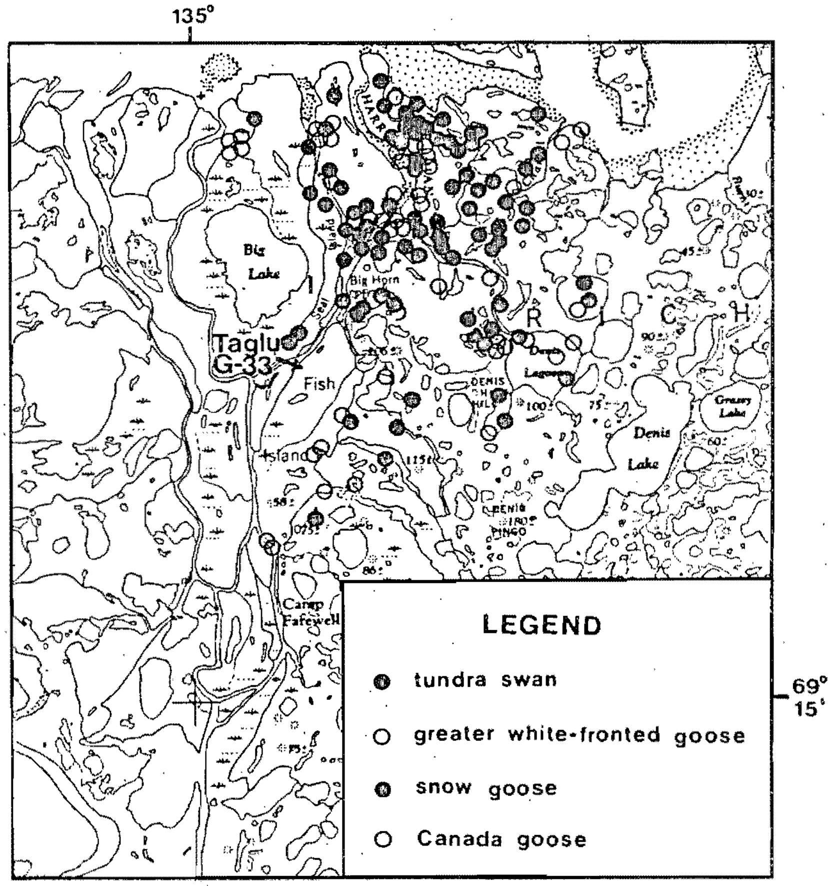


Figure 17. Locations of tundra swans, greater white-fronted geese, snow geese and Canada geese observed in the Taglu area beween July 6 and August 7, 1971.

Source: Barry and Spencer (1976)

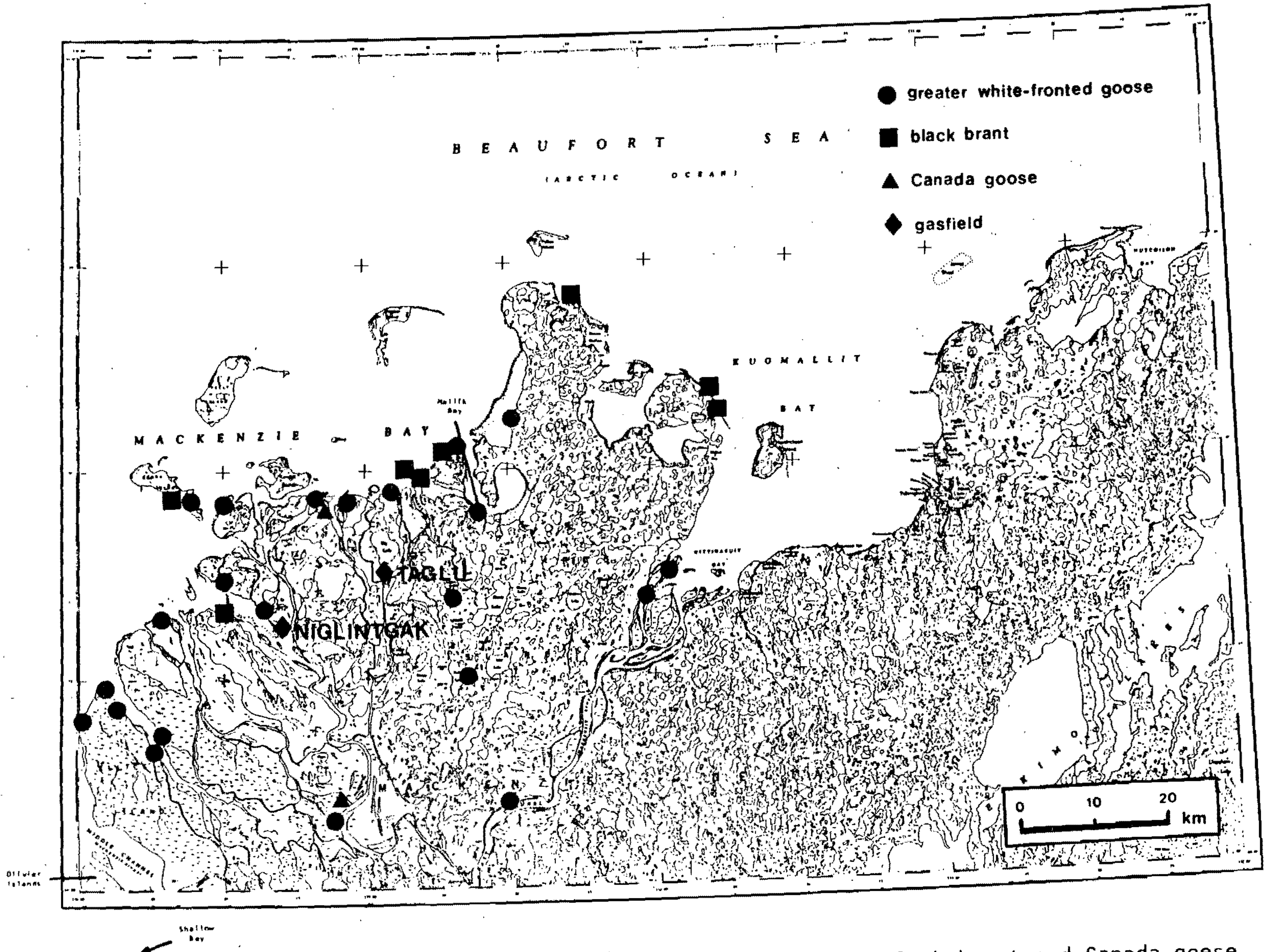


Figure 18. Distribution of staging greater white-fronted geese, black brant and Canada geese in the Mackenzie Delta - fall 1973,1974.

Sources: Koski (1975)

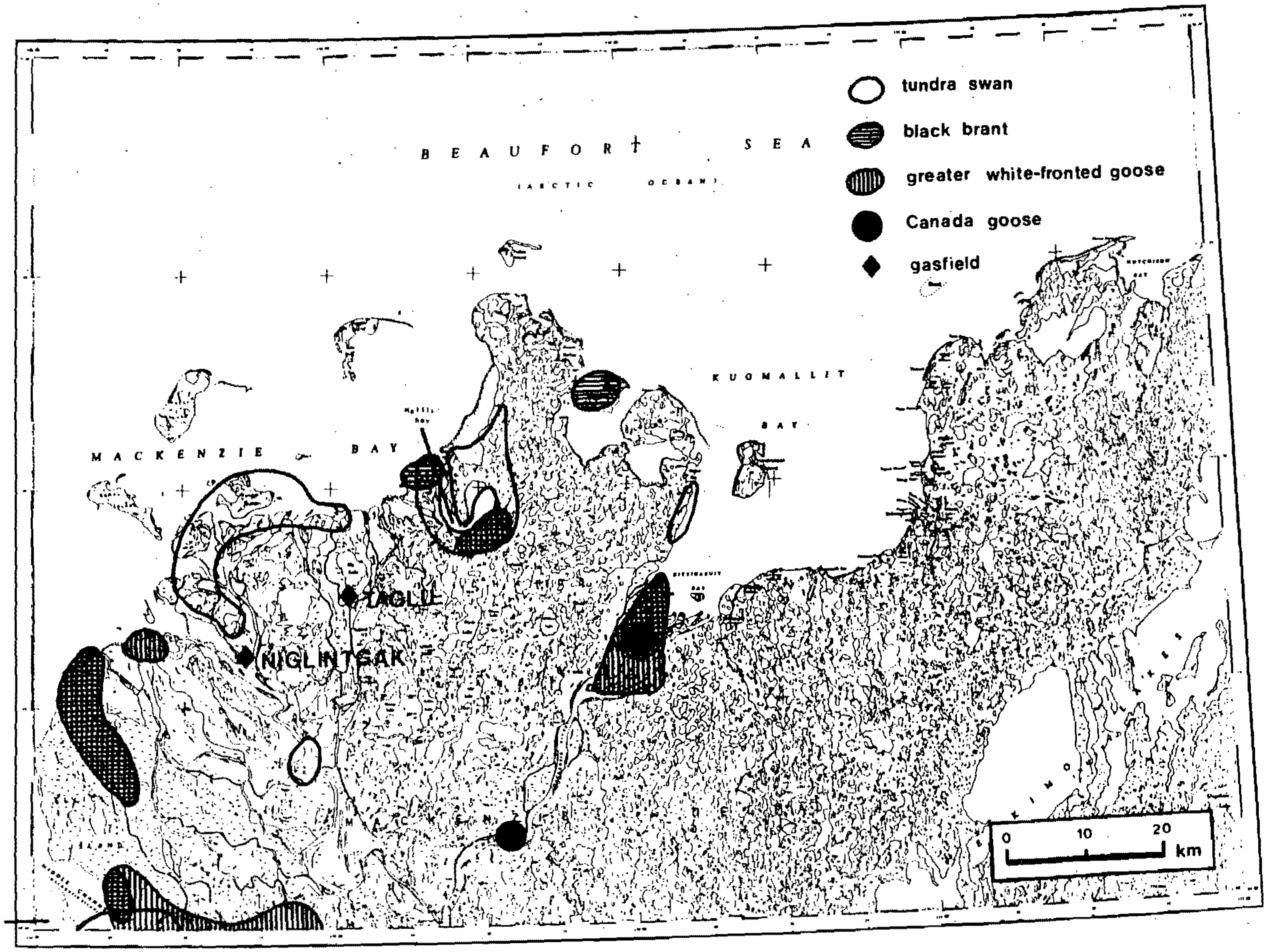


Figure 19. Areas used by staging tundra swans, greater white-fronted geese, black brant and Canada geese in the Mackenzie Delta - fall 1975.

Source: Koski (1977)

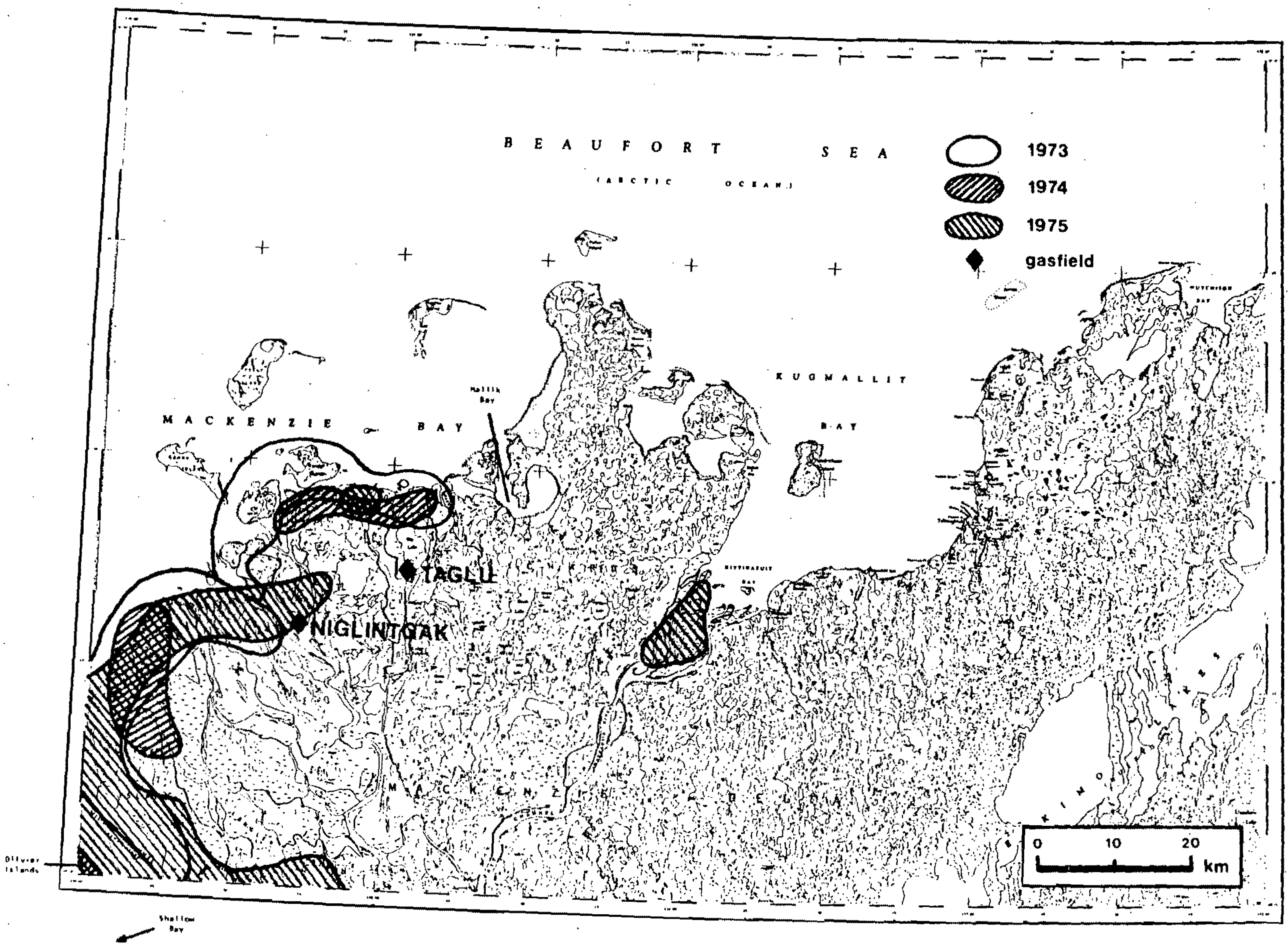


Figure 20. Areas used by staging snow geese in the Mackenzie Delta - fall 1973, 1974 and 1975. Source: Koski (1975, 1977)

Mackenzie Delta region. Koski (1977) noted a small flock of Canada geese concentrated at Swimming Point, Kittigazuit Bay and on Langley Island in 1975 (Figure 19).

# 6. POTENTIAL IMPACTS OF A MACKENZIE VALLEY PIPELINE AND RELATED FACILITIES

In this section, the potential impacts of the construction and operation of the proposed Polar Gas pipeline, and other possible pipelines, on waterfowl are assessed. Disturbance effects resulting from production and support facilities and activities, associated with pipeline projects, are also discussed. The reader should note that much of the discussion is focussed on the Mackenzie Delta area due to its importance to waterfowl as indicated in section 5.3. Also, no consideration is given to possible impacts in areas south of the Thunder River crossing since these are beyond the southerly limit of the study area.

## 6.1 Polar Gas Pipeline

Information on construction and operation of the Polar Gas pipeline was taken from Volume VI. Environmental Statement of the Polar Gas application to the National Energy Board (Polar Gas 1984).

### 6.1.1 Construction

In the Northwest Territories, all cleaning, grading, ditch excavation and pipe installation would be carried out in the winter months. An exception to this is the crossing of the Mackenzie River East Channel at Swimming Point (Figure 7) which is scheduled for the July - October period.

Winter construction will not, of course, result in any disturbance of waterfowl. At Swimming Point, aircraft would probably make use of the existing airstrip (upgraded for the project) for delivering supplies and materials and for crew changes. Vehicles would be required for transporting the pipe from the Swimming Point staging site to the river crossing location. On the river itself, there would of course be barge and dredge activity required for ditch excavation and pipeline installation. Some disturbance of local breeding and staging waterfowl likely would occur. However, the area is neither a major breeding or staging site and therefore only a few birds would be affected and the impact would be slight and short term.

Initially, no compressor stations would be needed over the 300-km pipeline segment considered in this report. Should further gas fields be developed in the Mackenzie Delta area, and the volume of gas to be pumped increases, additional compressor stations would be constructed near the Thunder River crossing (km 24.5), near North Caribou Lake (km 119.3) and near the interconnection with the Parsons lateral pipeline (km 225.9) (Figure 7). Since compressor stations require a 12-15 month period for construction, there would be activity at these sites during the summer months of two consecutive years (Polar Gas 1984). In addition, all-weather roads connecting the closest staging site to each compressor station site would be used by trucks as they hauled the materials required for compressor station construction. All-weather road requirements were discussed in section 4.1. An airstrip and a helipad would be included at each compressor station site. Therefore, aircraft activity in conjunction with compressor station construction could also be anticipated during the periods when waterfowl are present. As discussed in section 5, waterfowl densities are low in all three areas where compressor stations would be located. In addition, excluding the Richards Island segment, very few lake margins are traversed by the proposed pipeline route. Therefore, vehicle traffic along the right-of-way and local construction and aircraft activity at the compressor station sites would probably have little or no effect on waterfowl use.

### 6.1.2 Operation

During operation of the pipeline, Polar Gas plans call for helicopter surveillance of the pipeline route to be conducted "at weekly intervals during most of the year" (Polar Gas 1984). The flights would be conducted at an elevation of approximately 30 m a.g.l. and at speeds of about 160 kph. For most of the pipeline segment considered in this report, helicopter surveillance flights would cause little disturbance of waterfowl. Risk of disturbance would be much greater on Richards Island and greatest in the Taglu area during fall staging due to the proximity of the outer Mackenzie Delta coastline.

As discussed in section 5, the delta coastline is an important staging area for tundra swans, snow geese, brant and white-fronted geese in the fall. Figures 17 to 20 illustrate areas of waterfowl use documented by various researchers and underline the importance of northern Richards Island and adjacent islands in the Mackenzie Delta. In addition, the pipeline originates from within the boundaries of the Kendall Island Migratory Bird Sanctuary and also from within critical area boundaries identified by Dickson et al. (1983). Snow geese nest on four islands located south of Kendall Island, and a few kilometres west, still within the bird sanctuary boundaries, is an area considered critical for 40 breeding pairs of swans (CWS 1972). The pipeline would cross an area identified as "critical" by CWS (1972) for 200 breeding pairs of tundra swans, 400 pairs of white-fronted geese and 75 breeding pairs of sandhill cranes (Figure 21). Barry (1976) identified Harry and Swan channels, located 5 to 10 km northeast of the Taglu area (Figure 7), as critical for breeding tundra swans, white-fronted geese, sandhill cranes and shorebirds. Pre-moulting flocks of non-breeding swans have been reported to gather in Swan Channel and up to 2500 non-nesting sub-adult white-fronted geese have been observed preparing for the moult along Harry Channel and Denis Lagoon (Dickson et al. 1983). Slaney (1974) reported a colony of approximately 200 nesting brant at Denis Lagoon. Barry and Spencer (1976) also noted the importance of the Denis Lagoon/Harry Channel/Swan Channel area for waterfowl.

Most studies on disturbance have focussed on the effects of various human activities on snow geese. Because of the importance of the outer Mackenzie Delta to snow geese, and the availability of findings from other studies, the following discussion focusses on possible disturbance effects on this species as an indication of potential impacts on geese in general and swans. It should be stated at the outset that susceptibility of waterfowl to disturbances varies with the species, time of year and, in the case of aircraft disturbance, type of aircraft. For instance, recent studies have shown that different species of nesting waterfowl react differently to various types of helicopters and altitudes of overflight. Greater white-fronted geese appear to be the most sensitive to aircraft overflights whereas tundra swans seldom show any disturbance response (T. Barry, pers. comm.).

Non-breeding snow geese are the first to arrive at the north-western edge of the Mackenzie Delta from moulting areas on Banks

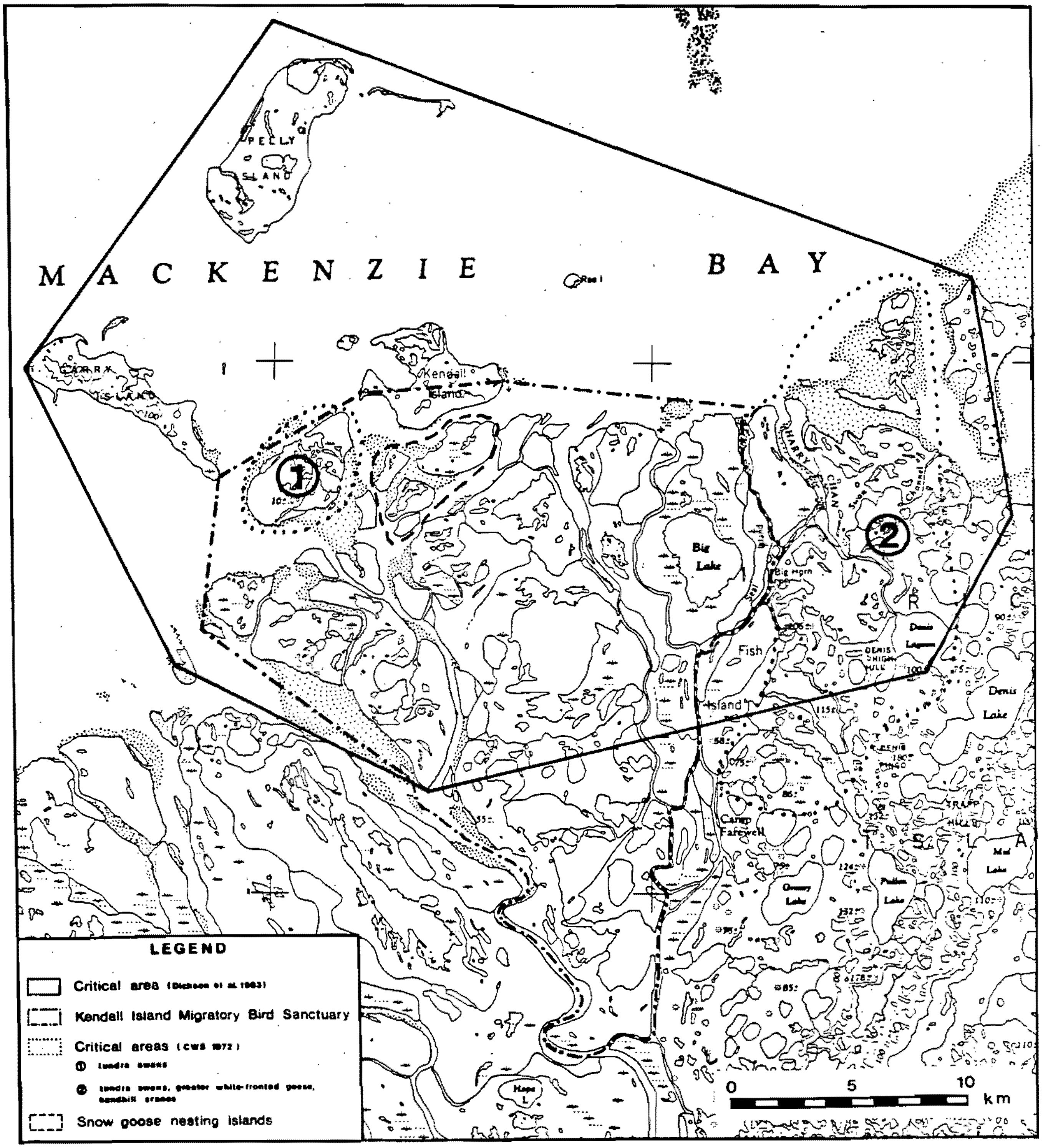


Figure 21. Boundaries of the Kendall Island Migratory Bird Sanctuary and the critical areas identified by Dickson et al. (1983) and CWS (1972).

Island, followed later by adults with young (Barry 1967). Birds also arrive from the Kendall Island sanctuary nesting grounds. The geese build up their weight feeding off sedges, grasses and *Equisetum* of the outer Mackenzie Delta. As these plants turn brown, the staging flocks move southwest to the foothills of the Richardson and British mountains in northern Yukon to feed on various berries, cottongrass tubers and other plants found in the small lakes and marshes among the hills (Barry 1967).

During their studies of the effects of aircraft disturbance on fall staging snow geese on the Yukon coast, Salter and Davis (1972) noted that the geese flushed when a Cessna 185 was as far away as 14 km. Overflights at an altitude of 3 100 m a.g.l. even caused disturbance of resting geese. This apparent extreme sensitivity of snow geese to aircraft is in contrast to recent observations made by other researchers. In the fall of 1985, the reactions of snow geese staging on the North Slope to a Bell 206 helicopter and two types of twin-engined aircraft were observed by T. Barry (pers. comm.). The flushing distance for these flocks ranged from 0.2 to 4.8 km with most of the geese taking flight at 1.2 km. In other words, at times aircraft were able to approach as close as 0.2 km to the flocks before they flushed. This is considerably different from the 14 km distance observed by Salter and Davis (1974).

During the spring of 1985, Boothroyd (1986) observed that a group of snow geese located on Goose Island in the Mackenzie River near Norman Wells did not flush until a Bell 212 helicopter, travelling at an elevation of less than 150 m a.g.l., was almost directly overhead. Ealey and Scott-Brown (1984) found that, in 1983 at Norman Wells, 70 percent of the aircraft flights occurring within 0.5 and 1.0 km of spring staging snow geese caused the geese to flush. At distances between 1.0 and 5.0 km from flocks, only 11 percent of the flights caused this response.

The effect of Bell 212 helicopter overflights on nesting snow geese in the Kendall Island Migratory Bird Sanctuary was studied in 1986 by T. Barry (pers. comm.). Analysis of the data is not yet complete. However, it appears that, in comparison with similar disturbance experiments conducted at the Anderson River colony, the Kendall Island geese were less disturbed than those at Anderson River even though a larger and louder aircraft was used. T. Barry (pers. comm.) believes that there are two reasons for this. The Kendall Island colony is only about 11 km from the Taglu drill rig which, in 1986, was located west of Big Lake. Because of the proximity of the colony to the Taglu rig operations, and to the flight path of many other aircraft servicing other rigs and vessels in Mackenzie Bay, the nesting geese accommodated to all aircraft that were flying direct and frequent routes. Secondly, at the time of the test flights, avian predators such as parasitic jaegers and glaucous gulls appeared to be more numerous and would have caused the geese to instinctively remain close to their nests. Accommodation of waterfowl and other birds to aircraft was also observed by Barry (1976) during monitoring studies at the original Taglu drilling site (G-33) located on Fish Island just south of Big Lake. Barry noted little, if any, reaction of local birds to the Bell 205 helicopter which arrived at the rig site every week or two for inspection of the diesel generator which operated continuously and provided power for the microwave tower located at the site. Little or no reaction was exhibited to the frequent overflights of Bell 205 helicopters travelling at high elevation from bases south of Taglu to project sites in Mackenzie Bay. Accommodation is probably the reason for the observed tolerance of snow geese to the helicopter flights in the Norman Wells area during construction and operation of Esso's oil production islands in the Mackenzie River (Boothroyd 1986).

On the basis of the preliminary findings of the disturbance studies ongoing in conjunction with the Taglu drilling operations, changes were made to the conditions of Esso's land use permit permitting lower aircraft flight elevation minimums and a direct flight path from their base at Tuktoyaktuk (T. Barry, pers. comm.). These changes saved Esso considerable time and money without an increase in the disturbance of the geese using the Kendall Island Migratory Bird Sanctuary.

The weekly helicopter flights envisaged by Polar Gas for monitoring the pipeline right-of-way would probably result in little incremental disturbance of waterfowl over levels experienced at present. Specific flight paths and elevations would, of course, have to be complied with and the cumulative effects of Polar Gas and non-Polar Gas flights on local waterfowl would have to be considered in the regulation of aircraft activity in the northern Mackenzie Delta area. Existing regulations require that aircraft maintain a minimum altitude of 150 m over sensitive waterfowl areas. This minimum altitude is considered to be adequate to prevent flushing of nesting geese in most cases (T. Barry, pers. comm.).

Levels of aircraft and other human disturbances, associated with the Polar Gas pipeline itself, would probably be low in comparison with the level of activities required to support oil and/or gas production drilling operations, hydrocarbon processing and the operation of airstrips and wharves. These activities were described in section 4 and the associated potential impacts on waterfowl are discussed in the following subsection.

## 6.2 Oil and Gas Production, Processing and Support Facilities

In section 4, a description was given of the array of facilities necessary to produce and process gas at the Taglu, Niglintgak and Parsons Lake fields prior to transport by the Polar Gas pipeline. Possible scenarios for onshore and offshore oilfield development were described and the layout of facilities associated with hydrocarbon development at Prudhoe Bay, Alaska (Figure 9) was given as an example of what could be expected (although Prudhoe Bay is the largest oilfield in North America). As mentioned in section 4, the Polar Gas National Energy Board application only covered construction and operation of pipeline-related facilities. No details were provided on proposed locations for airstrips, processing plants, roads, etc. Therefore, some assumptions have been necessary in assessing possible impacts of these development schemes on waterfowl.

### 6.2.1 Aircraft

One of the main sources of disruption of waterfowl populations in the Mackenzie Delta would probably be the use of airstrips and aircraft flights. Because of the distance between the Taglu and Niglintgak fields (20 km), an airstrip could be proposed for both sites. Due to its location, on the shoreline of one of the many delta channels, operation of an airstrip at Niglintgak could be more disruptive to waterfowl than at Taglu. Although nesting pairs of swans are widely distributed throughout the Mackenzie Delta along shores of tundra ponds, highest densities occur in the western portion of the Delta (T. Barry, pers. comm., cited in Allison and Nielsen 1978).

Aircraft could adversely affect birds in several ways. Effective loss of habitat could occur through exclusion of birds from areas where disturbance is too great. Disturbance could cause increased energy expenditure which could lead to decreased productivity and possibly increased mortality of adults and young. Mortality rates of young could be increased if disturbance caused a delay in the onset of nesting or abandonment of nests or if increased exposure of young to disturbance occurred. As was stated in the previous subsection (6.1), T. Barry (pers. comm.) noted that nesting snow geese in the Kendall Island Migratory Bird Sanctuary accommodated to Bell 212 helicopter overflights during studies conducted in 1985. The effects of twin-engined aircraft (Turbo Commander) overflights on flightless adult and young snow geese were also investigated at the Banks Island colony. T. Barry (pers. comm.) observed that the geese first reacted by stopping feeding and bunching close together when the aircraft was within 2.4 to 3.2 km. At low level overflights of 150 m, the flock would often panic and run away from the aircraft when it was 0.4 to 0.8 km away. As was stated in the previous subsection (6.1), most fall staging snow geese on the North Slope flushed at a distance of 1.2 km from a Bell 206 helicopter and twin-engined aircraft.

Fixed-wing aircraft take-offs from, and approaches to, an airstrip at Taglu, for example, may cause more disturbance of local birds than a low-altitude overflight because of the higher noise levels and lower altitudes involved. Data on the disturbance effects of take-offs and approaches on birds in the Mackenzie Delta area are not available. Therefore, any evaluation of bird impacts caused by these activities is speculative. Some studies have shown that the sight of overflying aircraft may cause as much disturbance to waterfowl as the sound of the aircraft. However, taking the distance observed by Barry at which most fall-staging snow geese flushed (1.2 km) and considering a runway length of 732 m (Dome et al. 1982), a possible "impact zone" of approximately 6 $km^2$ is obtained (Figures 22 and 23). This calculation considers only the effects of noise and visual disturbance originating from the 732 m-long runway. In actual fact, the impact zone would probably be larger because of the habitat crossed during take-offs and approaches while aircraft are at low altitudes. The impact zone as calculated represents about one percent of the 606 $km^2$ contained within the Kendall Island Migratory Bird Sanctuary.

It is unlikely that snow geese would use habitat contained in the impact zone for staging. Fall-staging use of the Mackenzie Delta by snow geese is predominantly coastal (Figure 20), as described in section 5.3. Therefore, aircraft activities in the Taglu impact zone, located several kilometres from the coast, would probably have little influence on staging snow geese. Similarly, the Taglu impact zone is too distant from the Kendall Island colony for aircraft activities in the zone to disturb nesting snow geese. Other species such as tundra swans or greater white-fronted geese, attempting to feed, moult or rest in this zone, would experience disturbance and likely vacate

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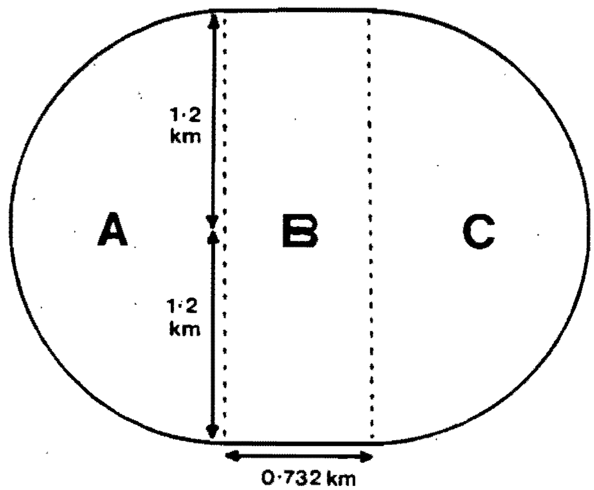
Length of S.T.O.L airstrip (Dome *et al.* 1982): 732 m

Distance at which most fall staging snow geese flushed on the North Slope (T. Barry, pers. comm.): 1.2 km

Using these two parameters, the possible impact zone can be diagrammed:




Area of impact zone = (A + B) + C

$$= \pi(1.2)^2 + (2.4 \times 0.732)$$

$$= 6.28 \text{ km}^2$$

Area of the Kendall Island Migratory Bird Sanctuary: 606 $km^2$

Impact zone expressed as a percentage of the sanctuary area: 1%

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Figure 22. Possible impact zone associated with use of an airstrip in the Mackenzie Delta.

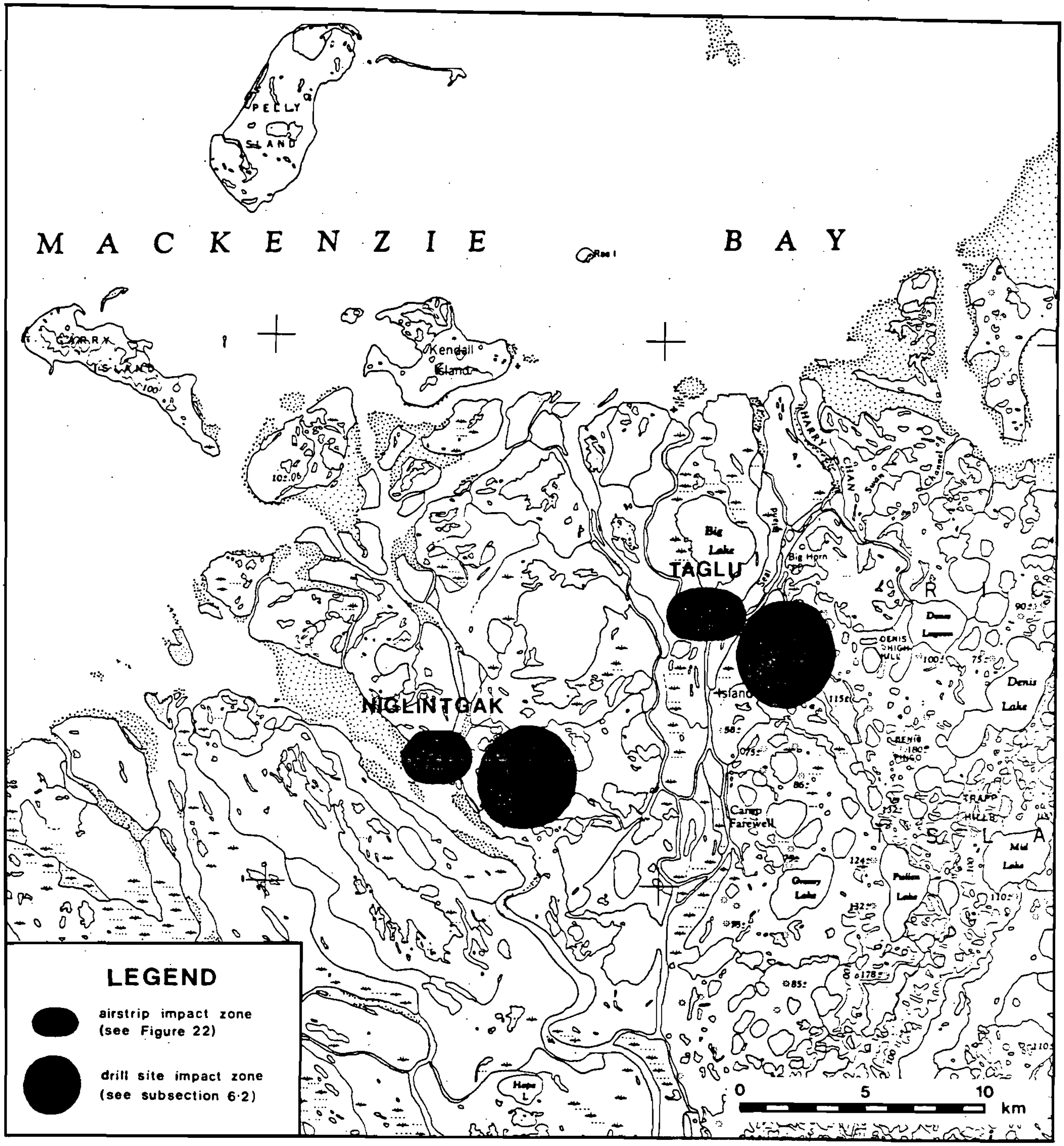


Figure 23. Hypothetical impact zones associated with airstrips located at Taglu and Niglintgak and two production drilling sites on the Mackenzie Delta.

habitat in the impact zone.

If a second airstrip was also required at Niglintgak, another 6 $km^2$ of habitat, or a total of two percent of the sanctuary area, could be avoided by waterfowl species (Figure 23). Due to its coastal location, greater numbers of waterfowl are more likely to be affected by the impact zone at Niglintgak than at Taglu. Snow geese were observed staging in the fall of 1975 (Koski 1977) within the impact zone boundaries (Figure 20). As mentioned earlier in the section, highest swan nesting density occurs in the western portion of the Delta. Swans would likely avoid using nest sites in the Niglintgak impact zone. Because of their sensitivity to aircraft overflights, greater white-fronted geese would probably avoid the impact zone area during fall staging.

A third 6 $km^2$-impact zone would be located in the Parsons Lake area in conjunction with recovery of gas from the Parsons Lake field. Swans are likely to be the species most affected and any nest sites located within the impact zone would probably not be used.

## 6.2.2 Facilities

Another source of disturbance would be operation of gas production and processing facilities and the necessary support activities. Barry and Spencer (1976) noted that geese and swans, particularly moulting birds and family groups, consistently avoided the area within 2.4 km of an exploratory drilling rig at Taglu in 1971. Whether or not gas production and processing operations would be more disruptive than exploratory drilling activities is open to speculation. If it is assumed that the level of impact from the two operations would be equivalent, an impact zone zone having a radius of 2.4 km, or an area of 18 $km^2$, could be expected. If production and processing facilities were located at both Taglu and Niglintgak, approximately 36 $km^2$ of habitat could be avoided by waterfowl. An additional 18 $km^2$ impact zone would exist in the Parsons Lake area due to the requirement for similar facilities.

Initially, the majority or all of the impact zone, associated with production drilling and processing, would likely be contained within the airstrip impact zone, assuming all facilities are located adjacent to each other. As the gasfields are developed further, new drilling locations would result in the existence of impact zones, separate from the airstrip impact zones, each having a 2.4 km radius (Figure 23). Each new production drilling facility could, therefore, result in 18 $km^2$ of habitat (3% of the Kendall Island Sanctuary area) being avoided by various waterfowl species. As an example, the impact zones associated with two airstrips and two separate drilling sites would, in total, occupy 48 $km^2$ or eight percent of the Kendall Island sanctuary area. Thus, in this hypothetical example, almost one-tenth of the sanctuary area could be effectively removed from use by various waterfowl species such as snow geese, swans and other geese. In other words, the incremental effects of hydrocarbon development activities could accumulate to produce a significant impact on waterfowl populations.

Dome et al. (1982) state that dock facilities would be built close to central processing facilities. Virtually all the material required for construction of the processing plants would arrive at these docks on barges. Staging areas would be built alongside the docks for storage of unloaded materials prior to use. In the Mackenzie Delta, the barge navigation season extends from mid-June to mid-September. Figure 24 shows dock, storage and other facilities at Esso's Taglu-Big Lake exploratory drilling site located on the banks of one of the delta channels. Presence of the facilities would probably have only a slight impact on waterfowl. A few swan nest sites might be abandoned either through direct removal of habitat required for the facilities or from noise and human activity. Nesting of other waterfowl species would be similarly affected. At Prudhoe Bay, Gavin (1980) found that some swans continued to nest within sight of drilling rigs, camp sites and other facilities. During staging, birds would tend to avoid the immediate area of the Mackenzie Delta where the facilities were located. However, the impact zone associated with these facilities would probably be much less in area than the airstrip impact zones. More disturbance of waterfowl is likely to occur in the Niglintgak area than at Taglu, particularly during the fall staging period.

### 6.2.3 Oilfield Development

As was stated in section 4, it is possible that an oil pipeline originating from oilfields in the Mackenzie Delta, Tuktoyaktuk Peninsula, and possibly offshore in the Beaufort Sea, could be in place prior to or following the installation of the Polar Gas pipeline.

The mid-size pipeline option would be selected if off-shore oil was to be recovered. As described in section 4, the oil would be brought to shore at North Point (Figure 7). At North Point, an array

Figure 24. Esso's Taglu - Big Lake drilling operation under-
way on June 26, 1985.

of facilities would be required, including: a production well cluster to incorporate oil from the Ivik field; a central processing facility for extraction of gas and preparation of the crude oil; dock, material stockpile, camp and oil storage facilities; and an airstrip and helipad. If the Polar Gas pipeline was already in place, a lateral pipeline could be constructed to convey the gas to the Taglu facilities.

As was discussed earlier, aircraft arrival at and departure from the airstrip would constitute one of the greatest sources of disturbance to local waterfowl populations. A 6 $km^2$ impact zone could be expected to exist in the North Point area reducing its use by waterfowl. Considering available waterfowl use data, fewer birds would probably be affected than at Taglu or Niglintgak. Low-altitude pipeline monitoring flights could disrupt staging birds in Mallik Bay. Koski (1977) noted the importance of this bay particularly for staging swans (Figure 19).

Development of the Adgo field (Figure 11) would pose a greater risk to waterfowl of the outer Mackenzie Delta than at the Taglu and Niglintgak fields. There is the obvious potential hazard of an oil spill occurring from a break in the pipeline which would convey the oil to the main onshore pipeline system. Such a spill could of course be disastrous to waterfowl if the oil entered Mackenzie Bay during fall staging. The oil spill hazard situation has been the focus of many other scientific investigations and, therefore, it is not addressed here. Not as significant as oil spills, but still a sizeable threat to waterfowl would be the disturbance associated with low-altitude surveillance flights required for periodic monitoring of pipeline and terrain integrity. In addition to the monitoring flights required once the pipeline was in operation, helicopters would be used during construction of the Adgo production island, installation of the pipeline and for transporting materials, equipment and work crews.

Should the Adgo field be connected by the most direct route to the Taglu facilities, as indicated in Figure 11, the pipeline right-of-way would cross the Kendall Island Migratory Bird Sanctuary and pass extremely close to the islands used by nesting snow geese and swans. A decline in the size of the Kendall Island snow goose colony has been noted since the 1960s (Kerbes 1983) and oil and gas exploration activities, along with spring hunting, storm tides, grizzly bear depredation and barge traffic, have been suspected as the cause (T. Barry, pers. comm.). The importance of the northwestern portion of the Mackenzie Delta for thousands of fall staging snow gese, swans and other waterfowl was noted in section 5. It would probably be preferable, from a waterfowl standpoint, to connect the Adgo field to the Niglintgak site rather than Taglu, thus bypassing the snow goose colony and important swan breeding habitat. However, site specific studies would have to be conducted before a specific route could be selected.

Connection of the Garry oil well to the onshore pipeline system would also pose a challenge in avoiding serious disruption of waterfowl. Possibly, a pipeline could be installed between Garry and Adgo and the oil brought on shore at Niglintgak. Further studies would be required to evaluate this and other options from an environmental standpoint.

In developing offshore oilfields, a source of waterfowl disturbance which may be more significant than aircraft overflights is barge traffic. Barges originating from points on the Mackenzie River would gain access to Mackenzie Bay via the route shown in Figure 25. As the figure shows, the route passes immediately adjacent to the islands used by nesting snow geese near Kendall Island. One summer, a barge was beached on one of the nesting islands. Considerable nest abandonment occurred the same year the barge was moored at the island (T. Barry, pers. comm.) The potential impacts of increased vessel traffic on waterfowl, resulting from hydrocarbon development in the Mackenzie Delta/Beaufort Sea region, was one of the issues addressed by the Mackenzie Environmental Monitoring Project (MEMP) (Indian and Northern Affairs Canada *et al*. 1986). It was concluded that these potential impacts would probably not be significant. However, this conclusion resulted from an evaluation of the effects of vessel traffic on spring staging waterfowl use of the Mackenzie River *upstream* from the Mackenzie Delta. The possible effects of vessel traffic on nesting waterfowl in the Mackenzie Delta are not referred to in the MEMP report.

On the Tuktoyaktuk Peninsula, either a small or mid-sized pipeline could tap oil reserves at Kamik, near Parsons Lake, Mayogiak and Tuk/Tuktuk, near Tuktoyaktuk, and Atkinson further east (Figure 11). Central processing facilities, production well clusters, an airstrip and helipad, camp facilities and stockpile sites could be installed at each of these three locations. The associated habitat impact zones would exist at each location. The area of these zones would be enlarged should oil and gas development at one or more sites become more extensive as illustrated hypothetically in Figure 10 at

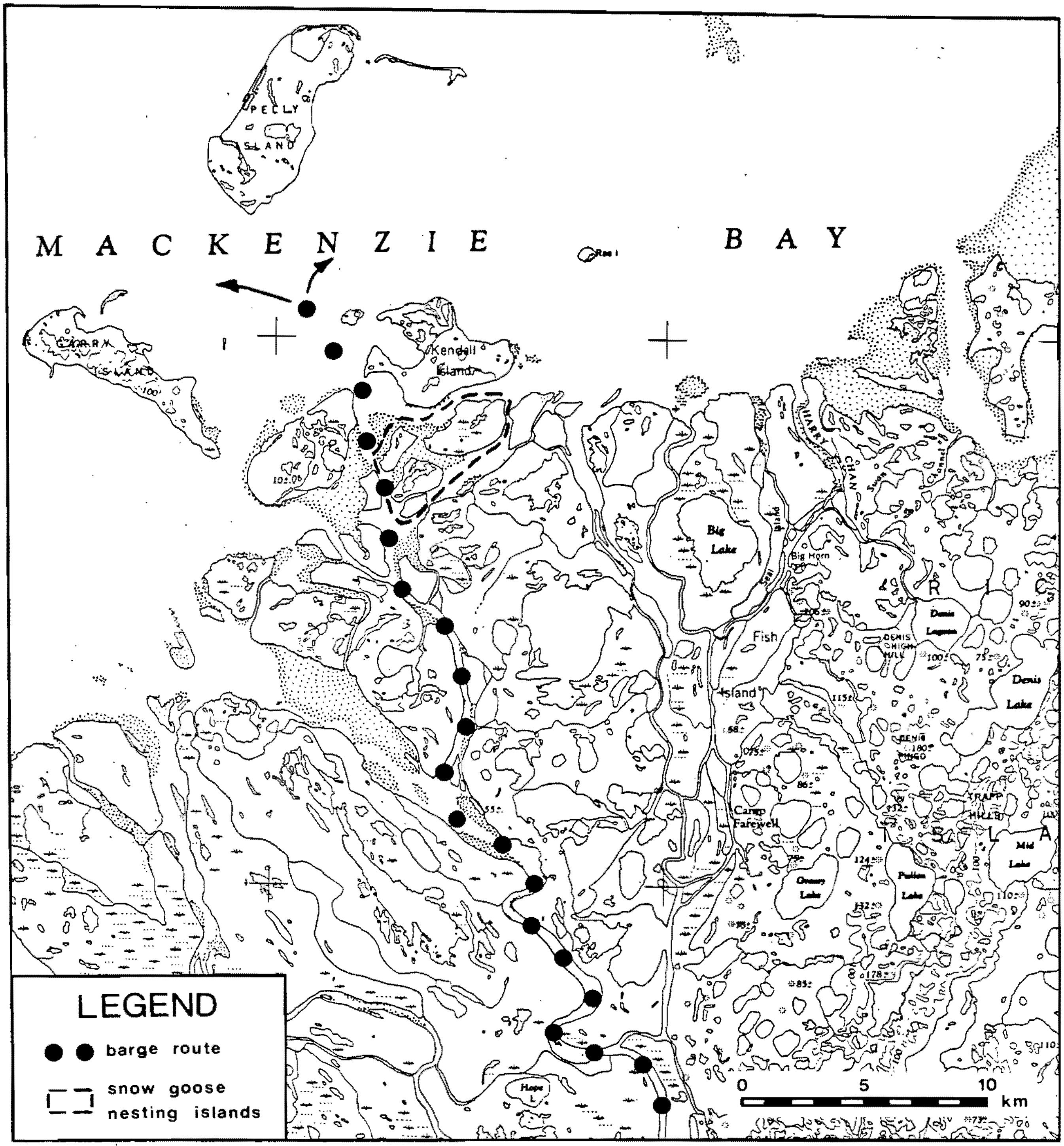


Figure 25. Barge access route to offshore hydrocarbon development sites in the Beaufort Sea.

the Parsons Lake field.

### 6.2.4 Human Access

The development of gasfields in the Mackenzie Delta and Parsons Lake areas will result in an increased number of roads in the lower Mackenzie region. Additional roads would be constructed if onshore or offshore oilfields were also developed. If an all-weather road between Inuvik and Tuktoyaktuk was not already in place prior to hydrocarbon development, construction of the road would certainly be encouraged by such development. The existence of roads would provide access to previously inaccessible areas.

One of the working groups of MEMP considered increased access to waterfowl and their nesting habitat to be one of the greatest potential impacts of hydrocarbon development in the area (Indian and Northern Affairs Canada et al. 1986). While access of petroleum and support industry personnel to waterfowl nesting, brood rearing and moulting areas could be regulated, the intrusion of tourists would be much more difficult to control.

Researchers have observed that the appearance of humans on foot seems to disturb waterfowl more than aircraft overflights or landings. In the MEMP report, T. Barry (pers. comm.) noted that helicopters have landed, on occasion, near flocks of birds without causing any apparent disturbance while the subsequent emergence of passengers has caused birds to flush. Johnson (1984) studied the effects of human activity on nesting and moulting waterfowl at Thetis Island in the Alaskan Beaufort Sea. No common eiders were observed to flush from their nests during 18 low-level (30 m altitude) surveys using a Cessna 206. However, at least three and possibly as many as eight common eider nests were abandoned early during egg-laying, apparently as a result of disturbance by biologists on foot. A workman, wandering from the construction site on Thetis Island, flushed at least three incubating eiders from their nests. One of the three nests was abandoned as a result of this disturbance.

Tourists visiting waterfowl nesting areas, as a result of improved access, would similarly cause nest abandonment and, therefore, reduced nest success. However, most of the impact would result from increased predation of eggs and young birds by gulls, jaegers and foxes when the presence of humans forces adults to vacate their nests (MacInnes 1980, Strang 1980). It is expected that separation of broods and subsequent loss of young may also occur as a result of human presence (Indian and Northern Affairs Canada et al. 1986).

Another likely consequence of increased access considered by MEMP, was increased harvest of waterfowl. Of particular concern is the increased access provided to hunters by a road from Inuvik to Tuktoyaktuk should it be built (Indian and Northern Affairs Canada et al. 1986). Large numbers of snow geese are present along the proposed road corridor in the spring, constantly moving between areas around the Eskimo Lakes (east of Parsons Lake) and the Mackenzie Delta. Also, large numbers of snow geese pass through the Eskimo Lakes/ Parsons Lake area in late summer en route to staging areas in and west of the Mackenzie Delta (A. Aviugana, pers. comm.). Presence of an all-weather road into this relatively inaccessible region would likely result in an increased harvest of geese from the area.

Troy (1986) describes and documents waterfowl use of impoundments associated with roads constructed in conjunction with the Prudhoe Bay oilfield in Alaska. The impoundments resulted from major changes in drainage patterns caused by the roads. While most species appear to avoid impoundments during the breeding season, northern pintails seemed to prefer this habitat. Greater white-fronted geese have not been observed to use impoundments during the breeding season but were frequently found in this habitat during the post-breeding season.

It is possible that impoundments could be formed as a result of roads constructed in the Mackenzie Delta, on the Tuktoyaktuk Peninsula and in the Parsons Lake area. Should impoundments exist, it is also possible that this habitat would be attractive to some waterfowl species such as the northern pintail and greater white-fronted goose. However, this potential benefit would be out-weighed by the potential risk of the increased human access to important waterfowl habitat made possible by these roads.

# 7. SUMMARY AND CONCLUSIONS

## 7.1 Waterfowl Use

Aerial surveys of portions of the proposed and alternative Polar gas pipeline routes were conducted on June 26, July 22 and August 26. In both June and July, the highest density of waterfowl, especially tundra swans, occurred in the northernmost segment of the main pipeline route, particularly Richards Island in the Mackenzie Delta. Swan density in this segment in July was almost twice that recorded in June. Waterfowl were much reduced in number in August, consisting mostly of small flocks of swans and dark geese.

In June, waterfowl density was lower along the proposed Parsons lateral route (south of Parsons Lake) than along a route selected to the north of Parsons Lake. In July and August, however, the situation was reversed.

Results of the June survey of the Lost Reindeer Lakes alternative to the main pipeline route indicated that, probably, there would probably be no advantage in selecting this alternative route over the proposed route from a waterfowl standpoint.

A review of the literature indicated the importance of the outer Mackenzie Delta to fall staging waterfowl. The northwestern portion of the Delta from Harry Channel to Shallow Bay is consistently used by large flocks of swans, snow geese, greater white-fronted geese and smaller concentrations of brant and Canada geese. Other staging locations include Kittigazuit Bay, Hansen Harbour, Mallik Bay and the Mackenzie River East Channel.

## 7.2 Impact of Hydrocarbon Development

Since the Polar Gas pipeline would be installed almost entirely during the winter months, impacts of pipeline construction on waterfowl would be minor. Some local disturbance of breeding and staging waterfowl could occur during summer pipeline installation at Swimming Point on the Mackenzie River East Channel.

No compressor stations would be required along the 300-km segment of the Polar Gas pipeline to transport gas from the Taglu, Niglintgak and Parsons Lake fields for the volumes proposed. Additional compressor stations would be required should gas field development expand and the volume of gas produced increase. All stations would be located in low waterfowl density areas (outside of the Mackenzie Delta). Therefore, operation of the stations and use of airstrips and helipads would have a negligible effect on waterfowl.

Weekly helicopter surveillance of the pipeline route would cause some disturbance of local waterfowl. Greatest disturbance would occur on the Mackenzie Delta segment of the route. Because of the importance of the outer Mackenzie Delta coastline to fall staging waterfowl, substantial numbers of birds potentially could be disturbed by aircraft activity in the Taglu and Niglintgak areas in the fall.

One of the main sources of disruption of waterfowl populations in the Mackenzie Delta would be the use of airstrips located near oil and gas production wells and processing facilities at Taglu, Niglintgak and Parsons Lake. Should oil reserves be developed and a pipeline network be constructed, there would be additional airstrips on the Delta and Tuktoyaktuk Peninsula. Takeoffs from airstrips may be the most disruptive because of the sound levels produced and the lower altitudes involved. A possible "impact zone" area of approximately 6 $km^2$ was calculated for each airstrip. It is considered that geese and swans, and possibly other waterfowl, would likely avoid using habitat contained within each impact zone. Impact zones of approximately 18 $km^2$ could result from the existence of oil and gas production and processing facilities and support activities. Impact zones associated with two production/processing sites located remote from two airstrips, therefore, could occupy as much as 48 $km^2$ or eight percent of the area of the Kendall Island Migratory Bird Sanctuary. These calculations are, of course, speculative and their validity is subject to confirmation or amendment on the basis of actual on-site experience.

Use of dock facilities and staging sites located on the Mackenzie Delta near production and processing facilities could cause some local disturbance of waterfowl during the fall staging period. Barge traffic and dredging, if required, could be particularly disruptive if they occurred in documented important waterfowl areas, such as the channel immediately west of the Kendall Island snow goose nesting islands, during the nesting period.

Should recovery of oil and gas from onshore reserves become extensive in the Mackenzie Delta, at Parsons Lake or other locations, a network of roads could be expected to be built in these areas. Hydrocarbon development could encourage the construction of an all-weather road from Inuvik to Tuktoyaktuk. Some waterfowl habitat would be removed by the roads and some adjacent habitat could be avoided as a result of disturbance from vehicle traffic. It is possible that new habitat in the form of impoundments could be created if drainage patterns were altered by the roads. One of the greatest concerns about roads is the increased access to important waterfowl habitat they would provide. Increased access would lead to tourists and hunters in previously inaccessible areas and could result in increased nest desertion, predation and harvest.

If and when decisions are made for oil and gas development in the Mackenzie Delta area to begin, careful planning will be necessary, before pipelines and other facilities are constructed, to ensure that important migratory bird habitat and populations are protected. To this end, recommendations are presented in section 9 as a guide to those directly involved in decision-making with respect to the orderly development of hydrocarbon resources in the Delta and adjacent areas.

## 8. PREAMBLE TO RECOMMENDATIONS

In its July 1984 report, the Beaufort Sea Environmental Assessment Panel made the following statements on the subject of oil and gas pipelines originating from the Beaufort Sea/Mackenzie Delta region:

> ".... the Panel is satisfied that enough information is known to develop effective terms and conditions to ensure that a gas pipeline could be constructed and operated in an environmentally acceptable manner."
>
> "There is also a wide consensus among federal and territorial government departments that a small-diameter (400 mm oil) pipeline could be built in an environmentally acceptable manner, given appropriate regulations, regulatory enforcement and monitoring procedures."
>
> (Federal Environmental Assessment Review Office 1984)

Much of the discussion on potential impacts of hydrocarbon development on waterfowl has focussed on disturbance of birds and avoidance of habitat in the vicinity of oil and gas production/processing and support facilities. Impacts could arise directly from industry-related activities or indirectly as a result of the increased access provided to tourists and hunters. Of most concern is the northwestern portion of the Mackenzie Delta including the Kendall Island Migratory Bird Sanctuary.

It is likely that a hydrocarbon development plan for the Mackenzie Delta would ultimately include a number of sites within the Kendall Island Sanctuary in addition to the Taglu and Niglintgak gas production sites. This scenario raises a series of important policy questions for CWS which were not addressed in the Beaufort Sea Panel report:

1) what level of industrial activity should be permitted in the Sanctuary?

2) should hydrocarbon production and processing facilities be permitted in the Sanctuary at both Taglu and Niglintgak?

3) should airstrips, construction camps and other facilities be permitted in the Sanctuary at both Taglu and Niglintgak or should they be located outside the Sanctuary boundaries?

4) to what extent should further drilling operations, stimulated by the presence of facilities at Taglu and Niglintgak, be permitted in the Sanctuary?

5) which areas within the Sanctuary should be declared off-limits to industrial operations and activities?

These and other related policy questions must be answered as soon as possible before site-specific development proposals for the Mackenzie Delta are submitted by industry for government approval. Whatever policy is established concerning the regulation of industrial development activities in the Kendall Island Sanctuary will, of course, set a precedent for the control of industrial activities in other bird sanctuaries.

Before gas could be produced at Taglu or Niglintgak, a production license would be required under the Oil and Gas Production and Conservation Act. Prior to issuance of the license, the Canada Oil and Gas Administration (COGLA) requires a development plan to be filed. A statement of environmental impact and mitigation is required as part of the development plan. In addition, the Territorial Land Use Regulations, under the Territorial Lands Act, require land use permits to be obtained for developments such as roads, construction camps, airstrips, fuel storage facilities, etc. which would be included as part of the hydrocarbon development plan. Terms and conditions may be applied to land use permits for the purpose of protecting wildlife and fisheries habitat. Terms and conditions would also be prescribed by the National Energy Board which would govern construction and operation of the pipeline system for transporting the gas to southern markets.

It is imperative that CWS, the agency responsible for protection of migratory birds and their habitat, is fully involved in the setting of various environmental terms and conditions governing hydrocarbon development in the lower Mackenzie/Beaufort Sea region. It is especially important that CWS policy, concerning the level and types of industrial activity to be permitted within the Kendall Island Sanctuary, is reflected in these terms and conditions.

## 9. RECOMMENDATIONS

1) As soon as possible, CWS (Western & Northern Region) must develop policy which clearly spells out the level and types of industrial activity that will be permitted to occur within the Kendall Island Migratory Bird Sanctuary.

2) As soon as the policy in 1) has been developed, it should be conveyed to appropriate officials in COGLA and INAC for their information.

3) CWS must ensure that it is involved in the setting of terms and conditions for construction of pipelines, oil and gas production/processing facilities and all other land use activities such as roads, airstrips, docks, fuel storage facilities, construction camps, etc. associated with hydrocarbon development in the lower Mackenzie/Beaufort Sea region.

4) Once hydrocarbon development begins, CWS should engage in monitoring studies to determine <u>actual</u> impacts on migratory birds. This monitoring work would be additional to, and independent of, industry-sponsored monitoring for the purpose of determining whether terms and conditions are adequate for protecting migratory birds, and their habitat, or whether they need to be more or less stringent.

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# LEGEND FOR APPENDICES I, II & III

## SPECIES

| | | | |
|---|---|---|---|
| **TS** | tundra swan | **WIG** | American wigeon |
| **WF** | greater white-fronted goose | **DAB** | unidentified dabblers |
| **SG** | snow goose | **S** | scaup spp. |
| **B** | brant | **E** | eider spp. |
| **CG** | Canada goose | **OLD** | oldsquaw |
| **DG** | dark goose spp. | **SC** | scoter spp. |
| **GWT** | green-winged teal | **MER** | red-breasted merganser |
| **M** | mallard | **DIV** | unidentified divers[a/] |
| **P** | northern pintail | **D** | unidentified ducks |
| **SHO** | northern shoveler | | |

a/ for the purpose of this study, divers were considered to include scaup spp., oldsquaw, eider spp., scoter spp. and red-breasted merganser

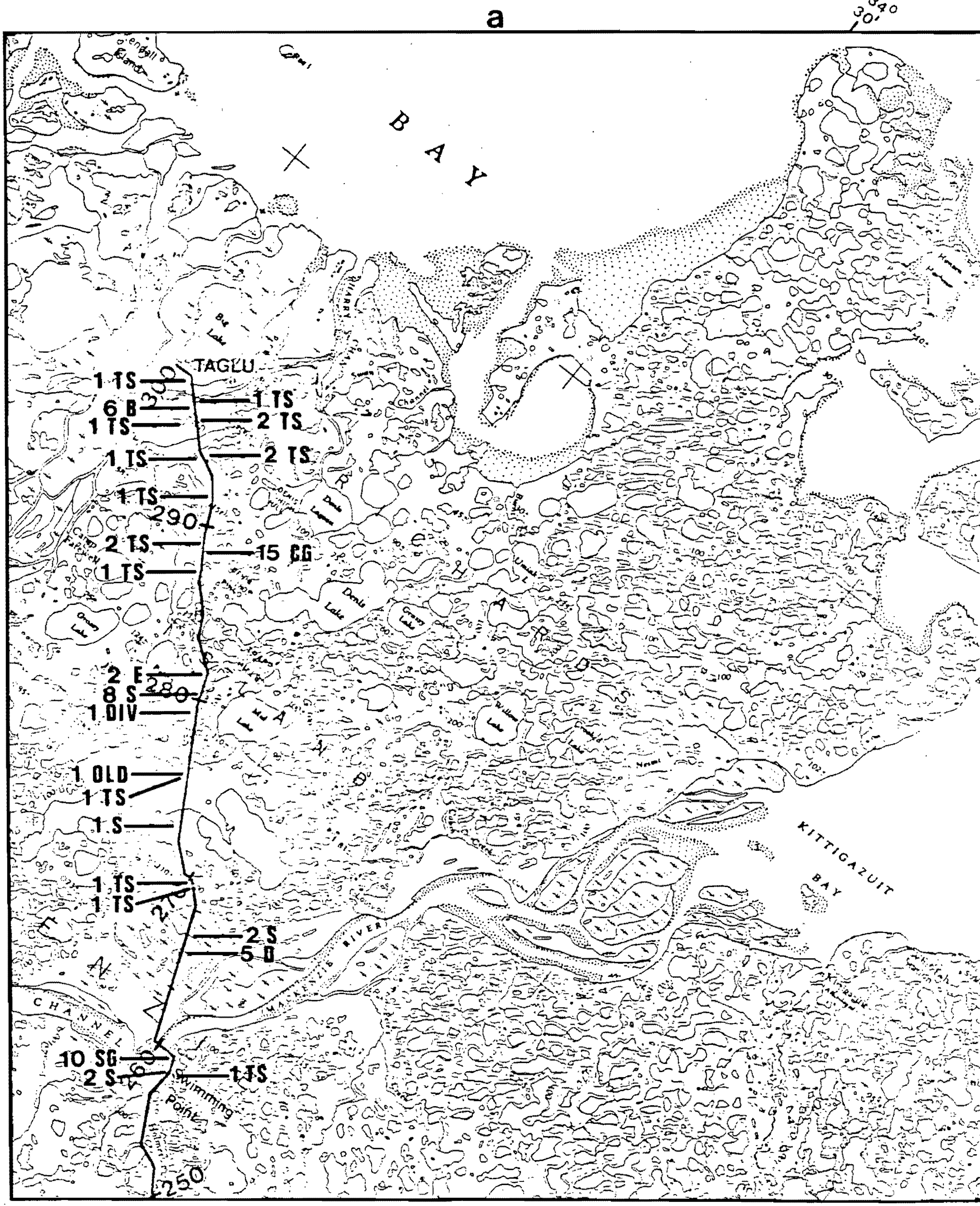
## NOTES

**2 TS+3y** indicates 2 adult tundra swans with 3 young of the year

all surveys - portion of pipeline route between north and south Parsons Lake laterals (North Storm Hills area) not surveyed to minimize survey costs

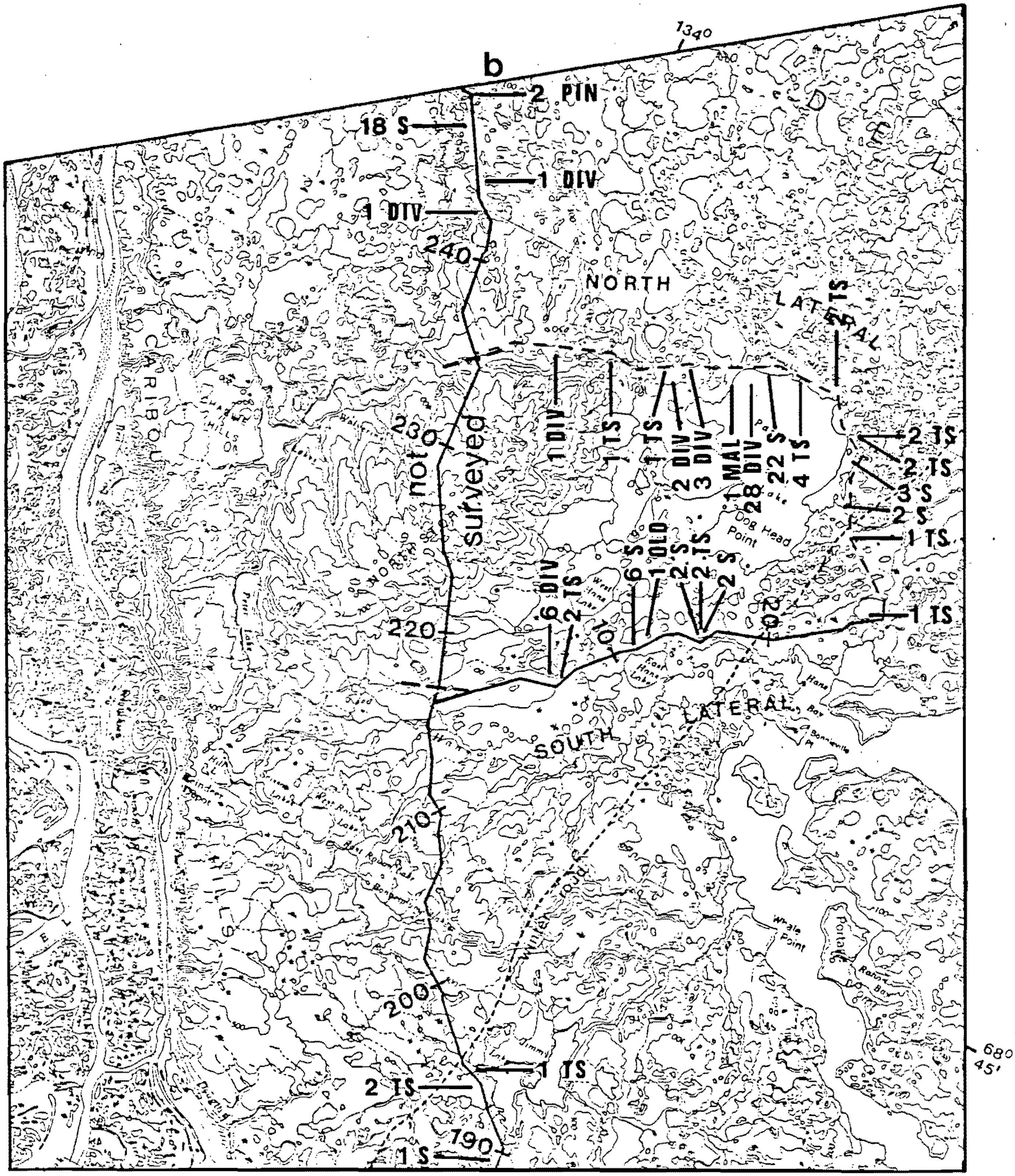
June 26 survey - portion of pipeline route near Campbell Lake (Appendix Ic) not surveyed due to forest fire

July 22 and August 26 surveys - portions of pipeline routes south of km 170 not surveyed to minimize survey costs




Appendix I: Locations of waterfowl observed during the June 26, 1985 aerial survey of the proposed Polar Gas pipeline route and the Lost Reindeer Lakes alternative route.

(a)

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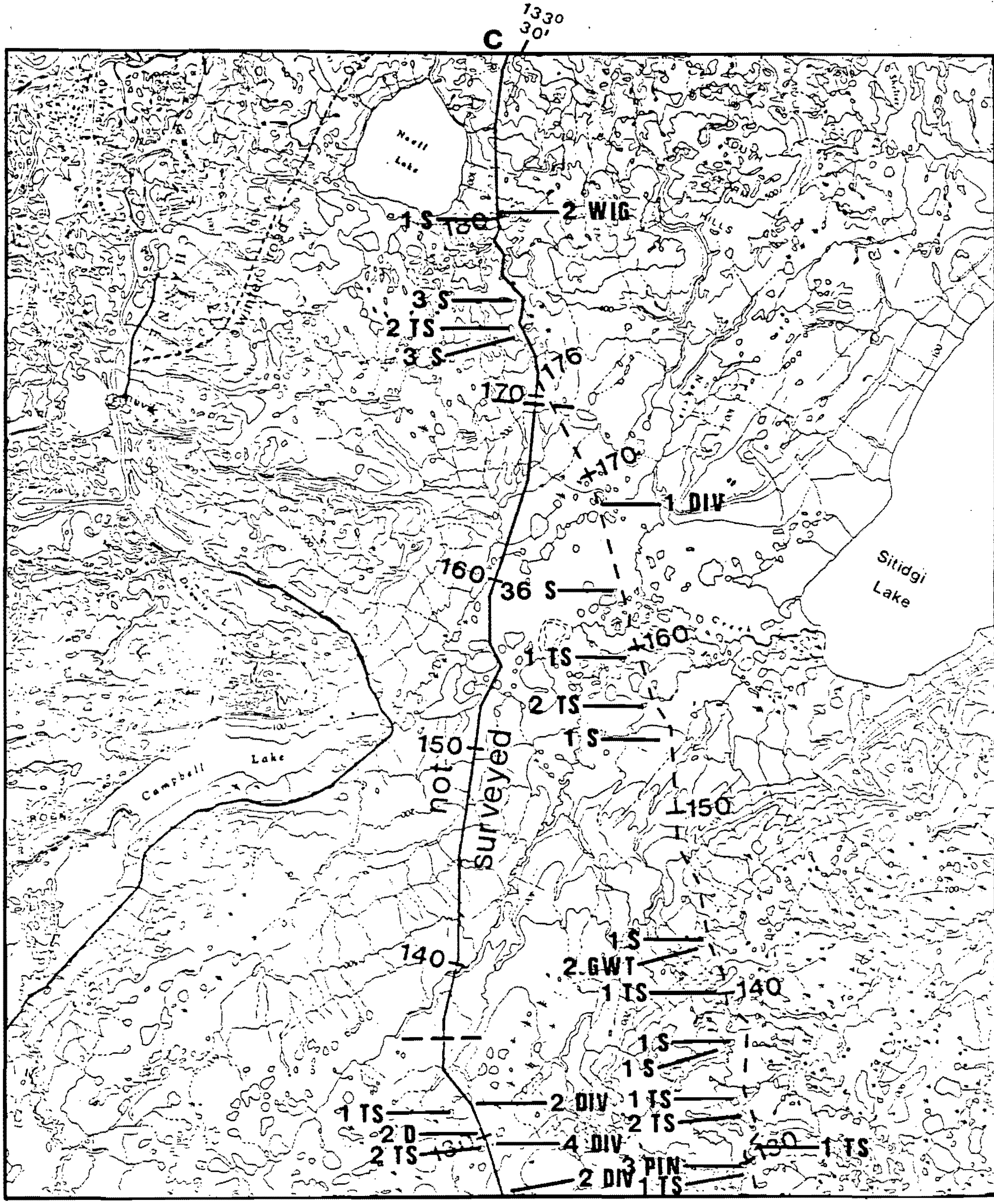


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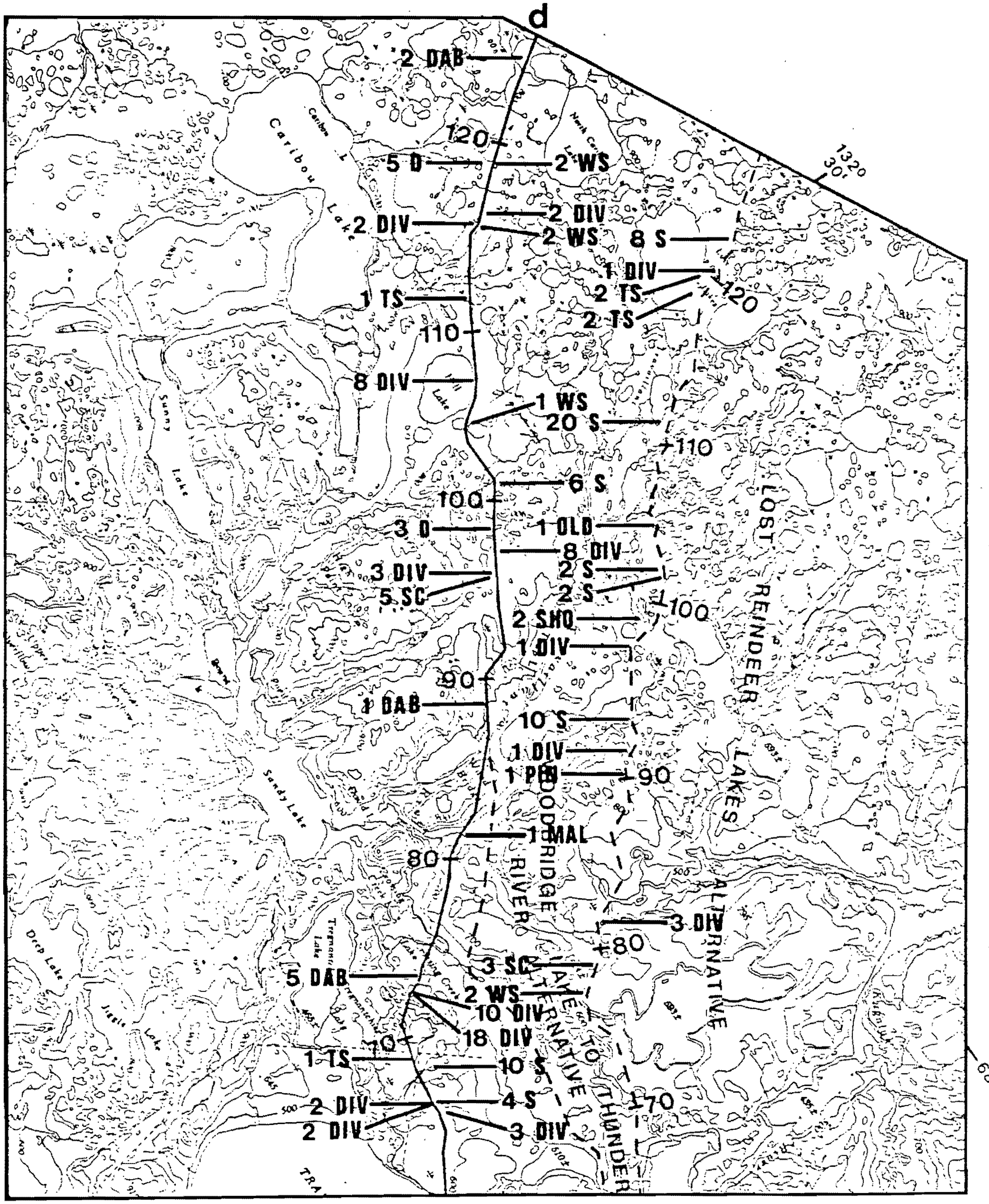


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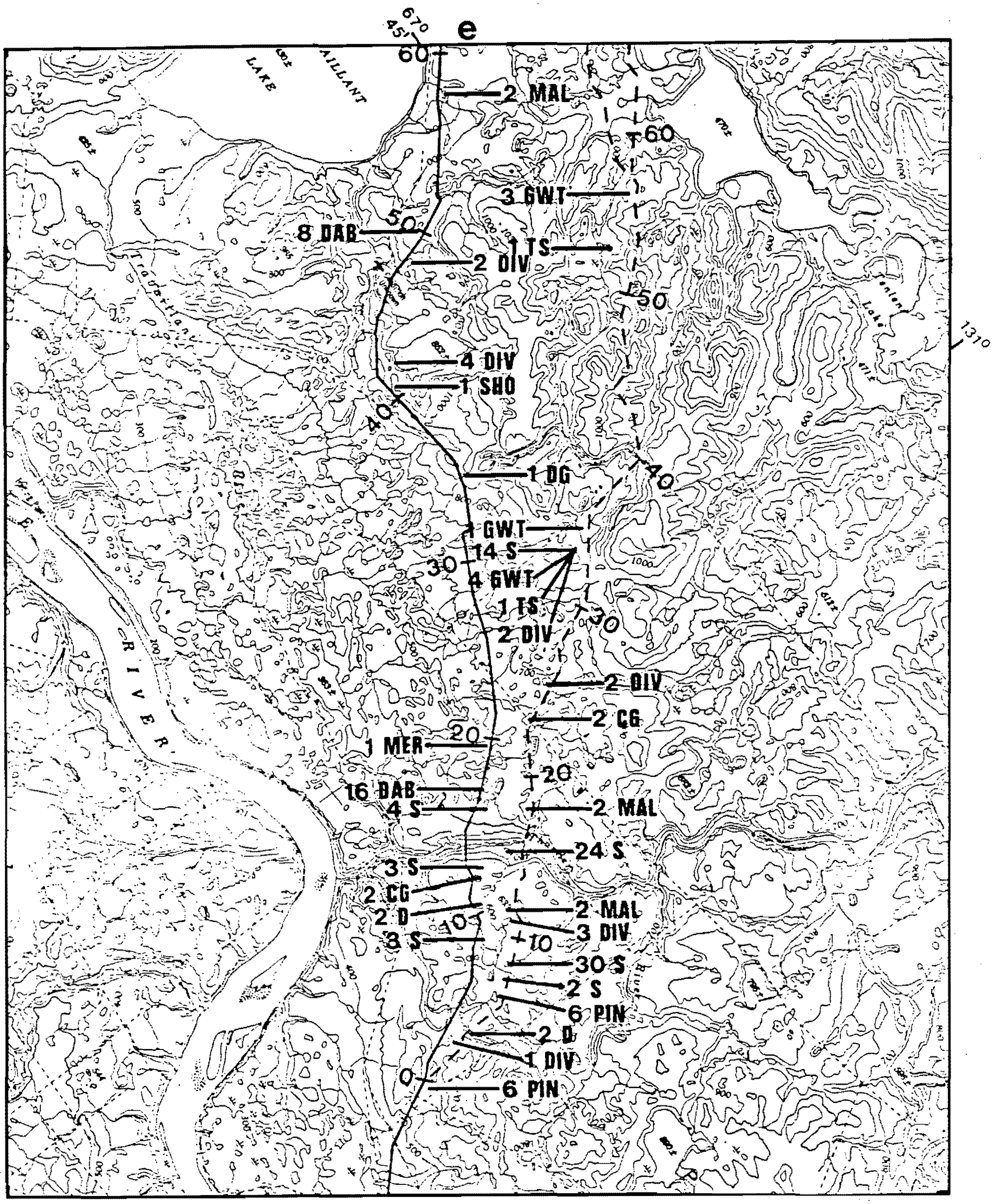


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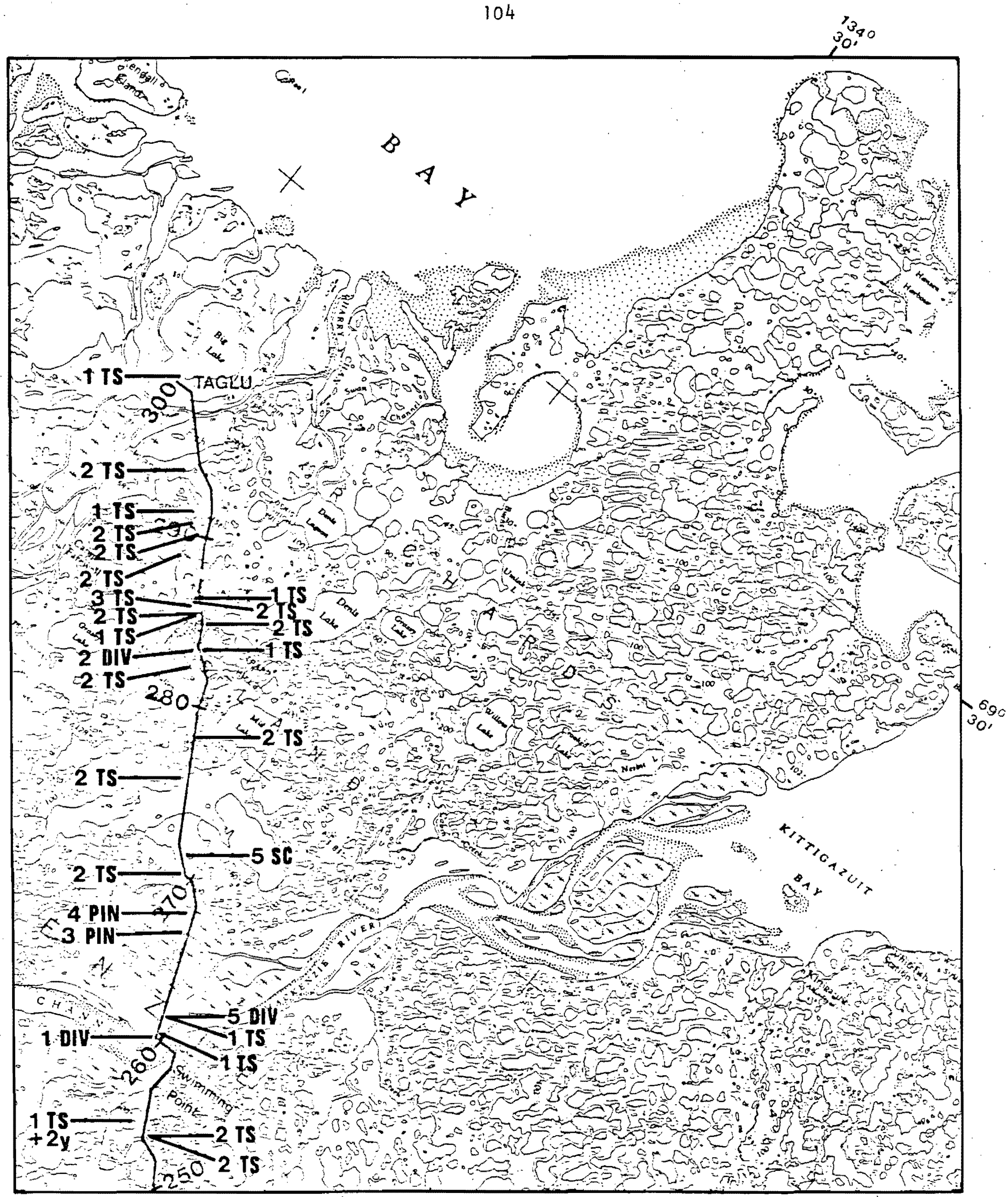
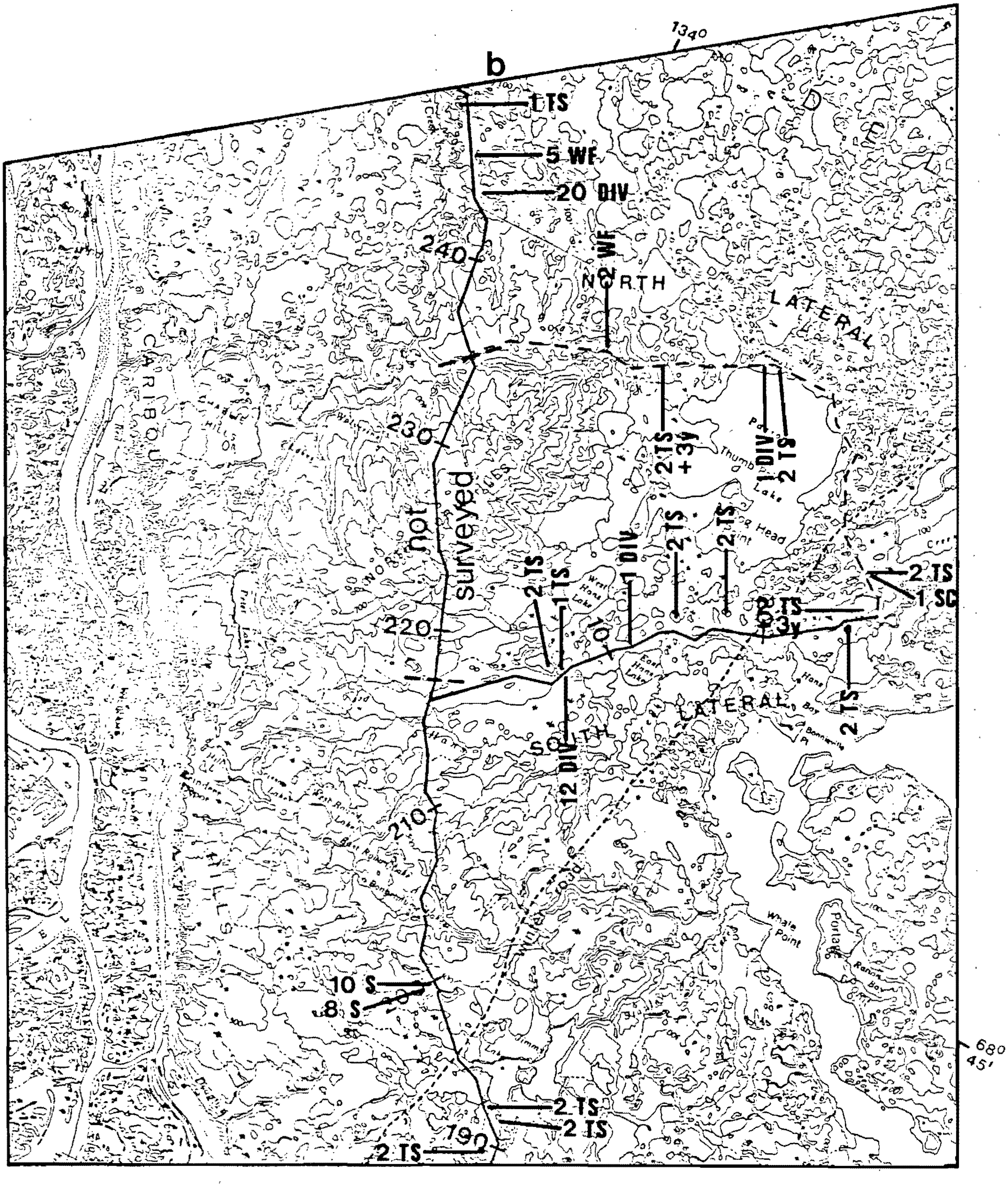



Appendix II. Locations of waterfowl observed during the July 22, 1985 aerial survey of the proposed Polar Gas pipeline route.

(a)

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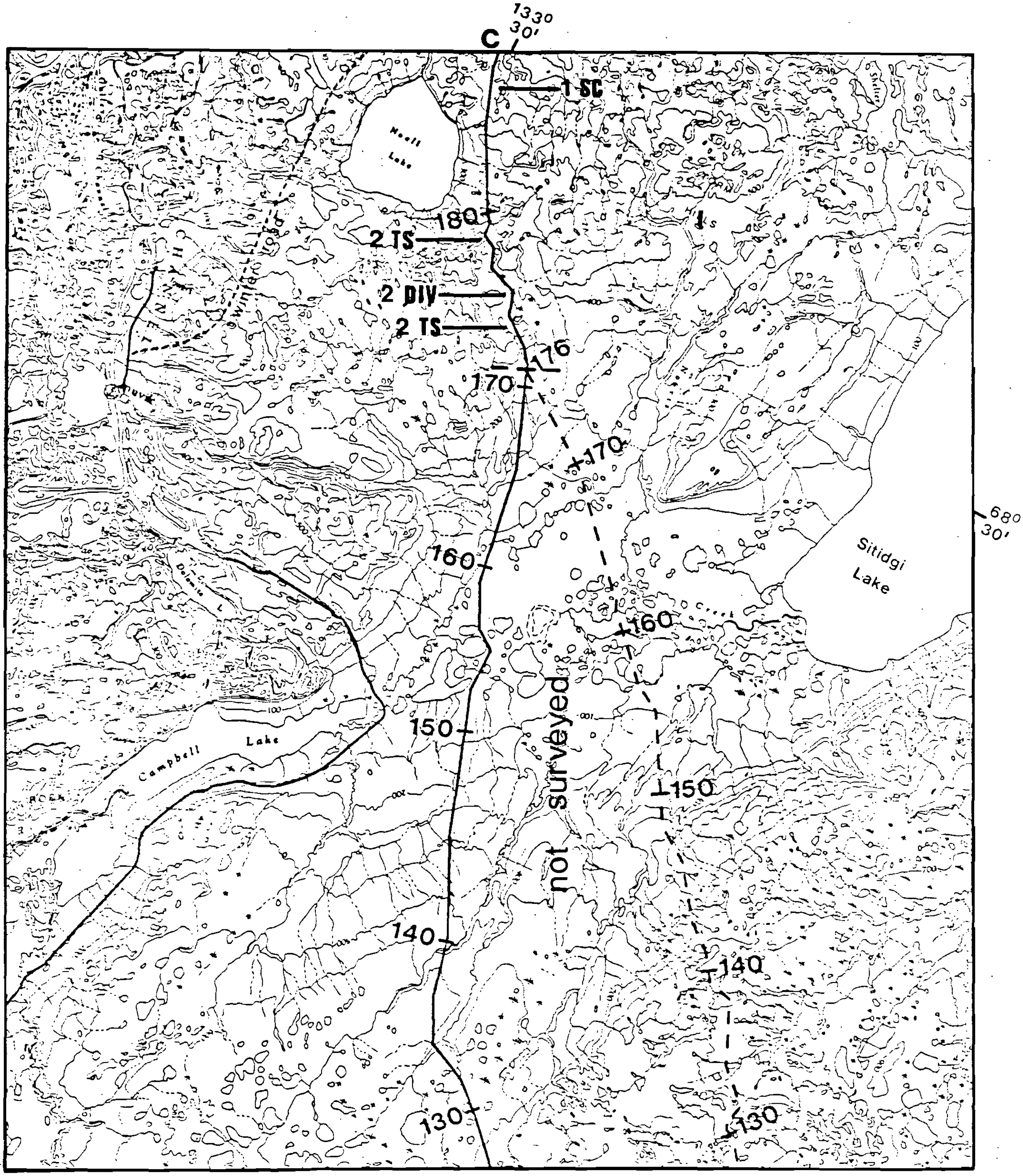
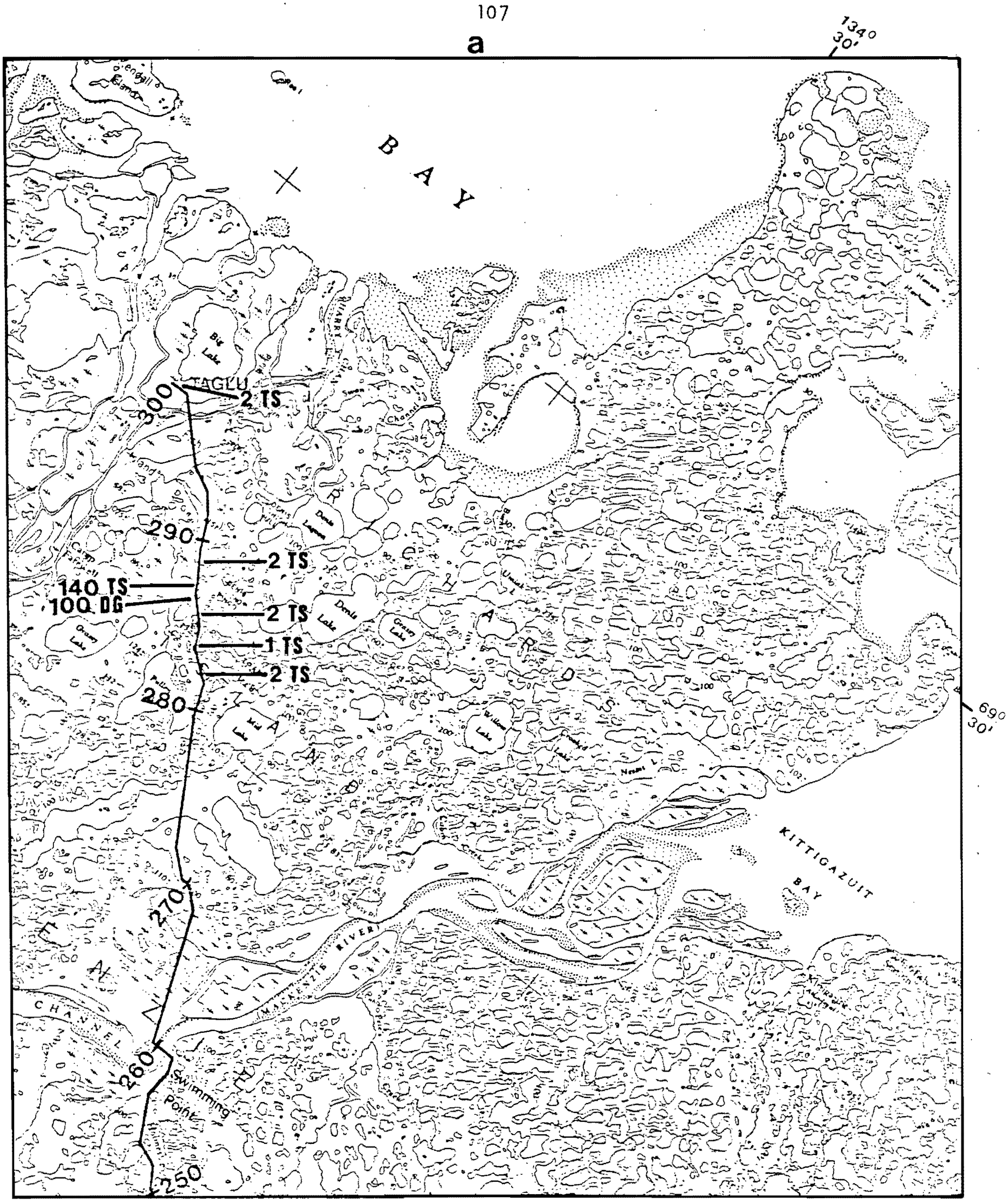


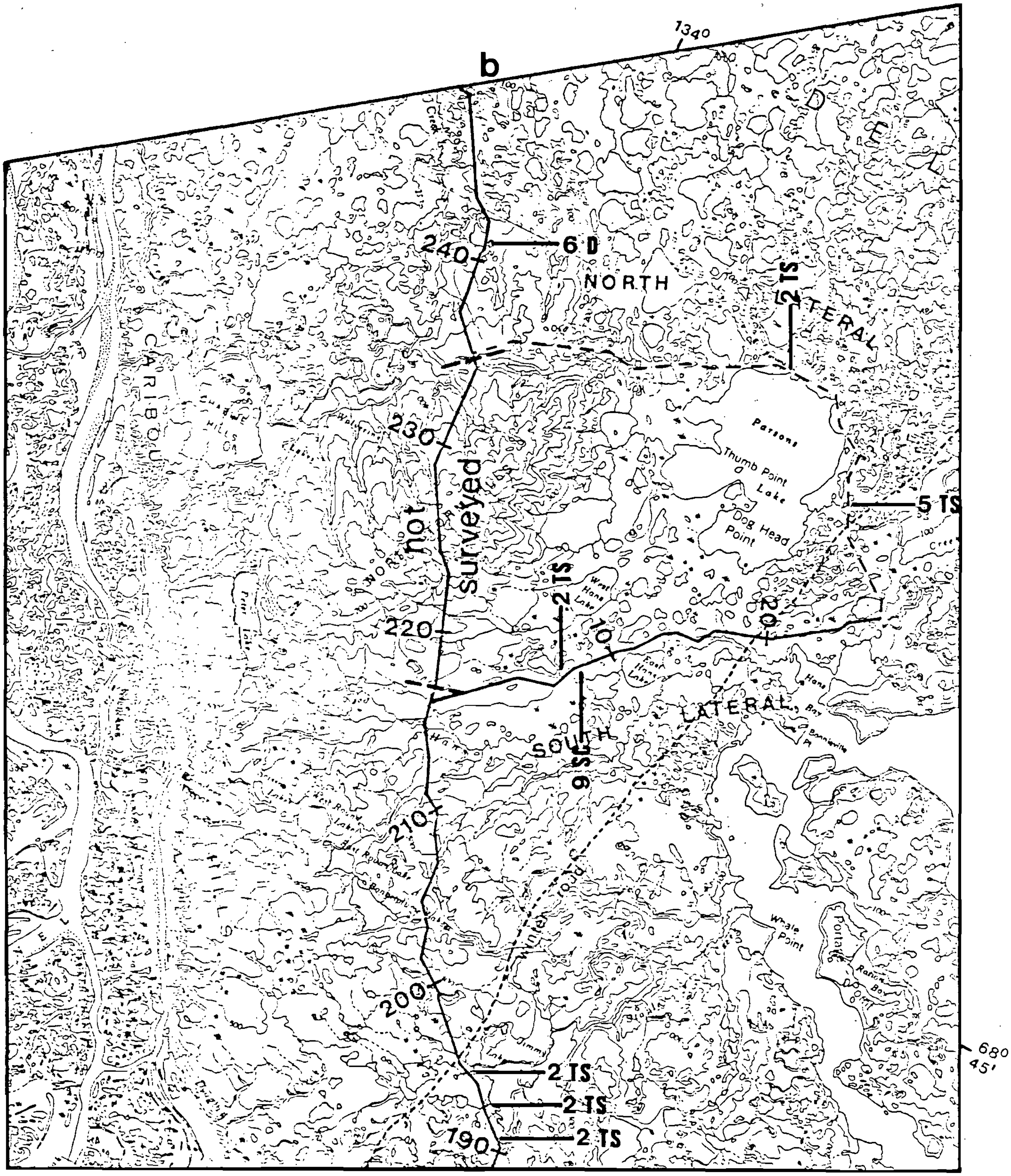

Appendix II (cont'd)(c)

**a**




Appendix III. Locations of waterfowl observed during the August 26, 1985 aerial survey of the proposed Polar Gas pipeline route.

(a)

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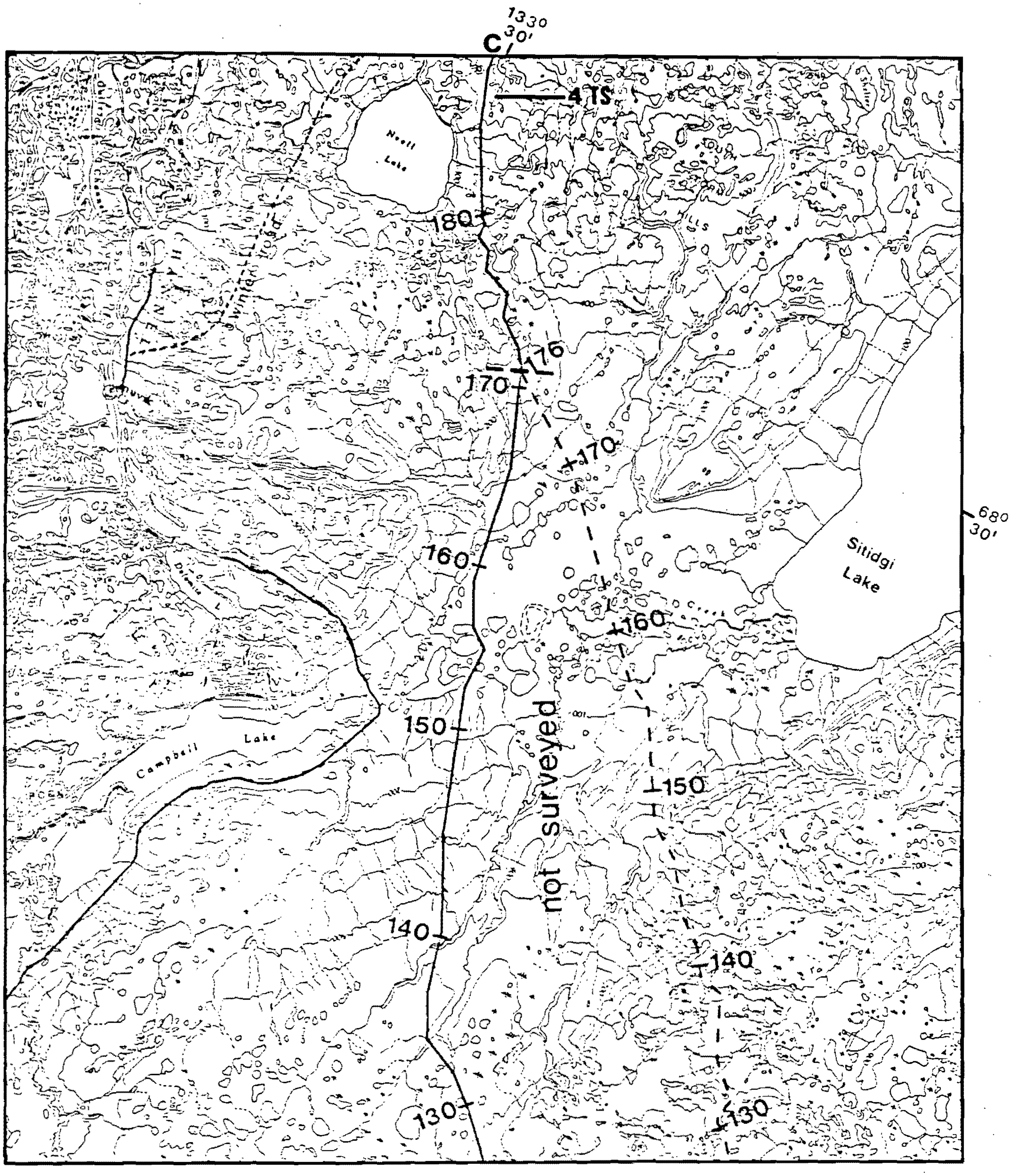


Appendix III (cont'd)(c)

Appendix IV: Numbers and distribution of waterfowl observed by Poston (1977) in June 1973 within various physiographic regions of the Mackenzie Valley.[a/]

| | Hyndman Lake Hills 0 - 130 km | Campbell Lake Hills 130 - 150 km | Campbell-Sitidgi Lake Lowland 150 - 170 km | Noell Lake 170 - 220 km | North Storm Hills 220 - 240 km | Tununuk Low Hills/Delta 240 - 300 km | TOTAL ROUTE |
|---|---|---|---|---|---|---|---|
| Area surveyed ($km^2$) | 3.4 | - | - | 19.1 | 1.0 | 10.6 | 34.0 |
| Tundra swan | -[b/] | •[c/] | • | 17 (0.89)[d/] | 8 (8.00) | 89 (8.40) | 114 (3.35) |
| Greater white-fronted goose | • | • | • | • | • | • | • |
| Snow goose | • | • | • | • | • | • | • |
| Brant | • | • | • | • | • | • | • |
| Canada goose | • | • | • | • | • | • | • |
| Dark goose spp. | - | • | • | - | - | - | - |
| Green-winged teal | • | • | • | • | • | • | • |
| Mallard | • | • | • | • | • | • | • |
| Northern pintail | • | • | • | • | • | • | • |
| Northern shoveler | • | • | • | • | • | • | • |
| American wigeon | • | • | • | • | • | • | • |
| Unidentified dabblers | 9 (2.65) | • | • | 148 (7.75) | - | 141 (13.30) | 298 (8.76) |
| Scaup spp. | • | • | • | • | • | • | • |
| Eider spp. | • | • | • | • | • | • | • |
| Oldsquaw | • | • | • | • | • | • | • |
| Scoter spp. | • | • | • | • | • | • | • |
| Red-breasted merganser | • | • | • | • | • | • | • |
| Unidentified divers | 248 (72.94) | • | • | 501 (26.23) | - | 139 (13.11) | 888 (26.12) |
| Unidentified ducks | • | • | • | • | • | • | • |
| TOTAL WATERFOWL | 257 (75.59) | • | • | 666 (34.87) | 8 (8.00) | 369 (34.81) | 1300 (38.24) |

a/ survey period: June 22-27

b/ no birds observed

c/ species not recorded

d/ birds/$km^2$

Appendix V. Numbers and distribution of waterfowl observed by Poston (1977) in July 1973 within various physiographic regions of the Mackenzie Valley.[a/]

| | Hyndman Lake Hills 0 - 130 km | Campbell Lake Hills 130 - 150 km | Campbell-Sitidgi Lake Lowland 150 - 170 km | Noell Lake 170 - 220 km | North Storm Hills 220 - 240 km | Tununuk Low Hills/Delta 240 - 300 km | TOTAL ROUTE |
|---|---|---|---|---|---|---|---|
| Area surveyed ($km^2$) | 1.6 | - | - | 4.3 | 0.5 | 3.6 | 10.0 |
| Tundra swan | -[b/] | •[c/] | • | 6 (1.40)[d/] | - | 14 + 5[e/] (3.89)[f/] | 20 + 5 (2.00) |
| Greater white-fronted goose | • | • | • | • | • | • | • |
| Snow goose | • | • | • | • | • | • | • |
| Brant | • | • | • | • | • | • | • |
| Canada goose | • | • | • | • | • | • | • |
| Dark goose spp. | - | • | • | - | - | 2 (0.56) | 2 (0.20) |
| Green-winged teal | • | • | • | • | • | • | • |
| Mallard | • | • | • | • | • | • | • |
| Northern pintail | • | • | • | • | • | • | • |
| Northern shoveler | • | • | • | • | • | • | • |
| American wigeon | • | • | • | • | • | • | • |
| Unidentified dabblers | 5 (3.13) | • | • | 15 (3.49) | 2 (4.00) | 103 + 15 (28.61) | 125 + 15 (12.50) |
| Scaup spp. | • | • | • | • | • | • | • |
| Eider spp. | • | • | • | • | • | • | • |
| Oldsquaw | • | • | • | • | • | • | • |
| Scoter spp. | • | • | • | • | • | • | • |
| Red-breasted merganser | • | • | • | • | • | • | • |
| Unidentified divers | 40 (25.00) | • | • | 26 (6.05) | 2 (4.00) | 68 + 3 (18.89) | 136 + 3 (13.60) |
| Unidentified ducks | • | • | • | • | • | • | • |
| TOTAL WATERFOWL | 45 (28.13) | • | • | 47 (10.43) | 4 (8.00) | 187 + 23 (51.94) | 283 + 23 (28.30) |

a/ survey period: July 21-27
b/ no birds observed
c/ species not surveyed
d/ birds/$km^2$
e/ 14 + 5 = 14 adults and 5 young
f/ adult birds/$km^2$ only

Appendix VI: Numbers and distribution of waterfowl observed by Salter (1974) in June and August 1973 within various physiographic regions of the Mackenzie Valley.

| | June 30 | | | August 1 | | |
|---|---|---|---|---|---|---|
| | Campbell-Sitidgi Lake Lowland/ Noell Lake 150 - 230 km | North Storm Hills/Tununuk Low Hills 230 - 270 km | TOTAL ROUTE | Campbell-Sitidgi Lake Lowland/ Noell Lake 150 - 230 km | North Storm Hills/Tununuk Low Hills 230 - 270 km | TOTAL ROUTE |
| Area surveyed ($km^2$) | 32.4 | 13.0 | 43.4 | 32.4 | 13.0 | 43.4 |
| Tundra swan | -[a] | 8 (0.62)[b] | 8 (0.18) | 2 (0.06) | 2 (0.15) | 4 (0.09) |
| Greater white-fronted goose | - | - | - | 6 (0.19) | - | 6 (0.14) |
| Snow goose | - | - | - | - | - | - |
| Brant | - | - | - | - | - | - |
| Canada goose | - | - | - | - | - | - |
| Dark goose spp. | - | - | - | - | - | - |
| Green-winged teal | - | - | - | - | - | - |
| Mallard | - | - | - | - | - | - |
| Northern pintail | - | - | - | - | - | - |
| Northern shoveler | - | - | - | - | - | - |
| American wigeon | - | - | - | - | - | - |
| Unidentified dabblers | .[c] | . | . | . | . | . |
| Scaup spp. | 12 (0.37) | 2 (0.15) | 14 (0.32) | - | - | - |
| Eider spp. | - | - | - | - | - | - |
| Oldsquaw | 7 (0.22) | 3 (0.23) | 10 (0.23) | 17 (0.52) | 8 (0.62) | 25 (0.58) |
| Scoter spp. | - | - | - | - | - | - |
| Red-breasted merganser | - | - | - | - | - | - |
| Unidentified divers | . | . | . | . | . | . |
| Unidentified ducks | - | - | - | 71 (2.19) | - | 71 (1.64) |
| TOTAL WATERFOWL | 19 (0.59) | 13 (1.00) | 32 (0.74) | 96 (2.96) | 10 (0.77) | 106 (2.44) |

[a] no birds recorded

[b] birds/$km^2$

[c] species not recorded