The North

Northern Frontier, Northern Homeland

This Inquiry was appointed to consider the social, environmental and economic impact of a gas pipeline and an energy corridor across our northern territories, across a land where four races of people – Indian, Inuit, Metis and white – live, and where seven languages are spoken. The Inquiry was also empowered to recommend terms and conditions that ought to be imposed to protect the people of the North, their environment, and their economy, if the pipeline were to be built.

Today, we realize more fully what was always implicit in the Inquiry's mandate: this is not simply a debate about a gas pipeline and an energy corridor, it is a debate about the future of the North and its peoples.

There are two distinct views of the North: one as frontier, the other as homeland.

We look upon the North as our last frontier. It is natural for us to think of developing it, of subduing the land and extracting its resources to fuel Canada's industry and heat our homes. Our whole inclination is to think of expanding our industrial machine to the limit of our country's frontiers. In this view, the construction of a gas pipeline is seen as the next advance in a series of frontier advances that have been intimately bound up with Canadian history. But the native people say the North is their homeland. They have lived there for thousands of years. They claim it is their land, and they believe they have a right to say what its future ought to be.

The question whether a pipeline shall be built has become the occasion for the joining of these issues.

In the past, Canada has been defined by its frontiers. In the words of Kenneth McNaught:

> From the time of the earliest records Canada has been part of a frontier, just as in her own growth she has fostered frontiers. The struggle of men and of metropolitan centres to extend and control those frontiers, as well as to improve life behind them, lies at the heart of Canadian history – and geography determined many of the conditions of that struggle. [*The Pelican History of Canada*, p. 7]

H.A. Innis insisted that it was Canadian geography and Canadian frontiers that made possible and defined the existence of the country. The nation's lines of transportation and communications were based on the St. Lawrence River, the Great Lakes and western waterways. French and British dependence on fish, fur, timber and wheat influenced the course of Canadian history, one staple after another drawing the nation from one frontier to the next. Innis refuted the notion that Canada's economy is simply a series of projections northward from the economic heartland of North America.

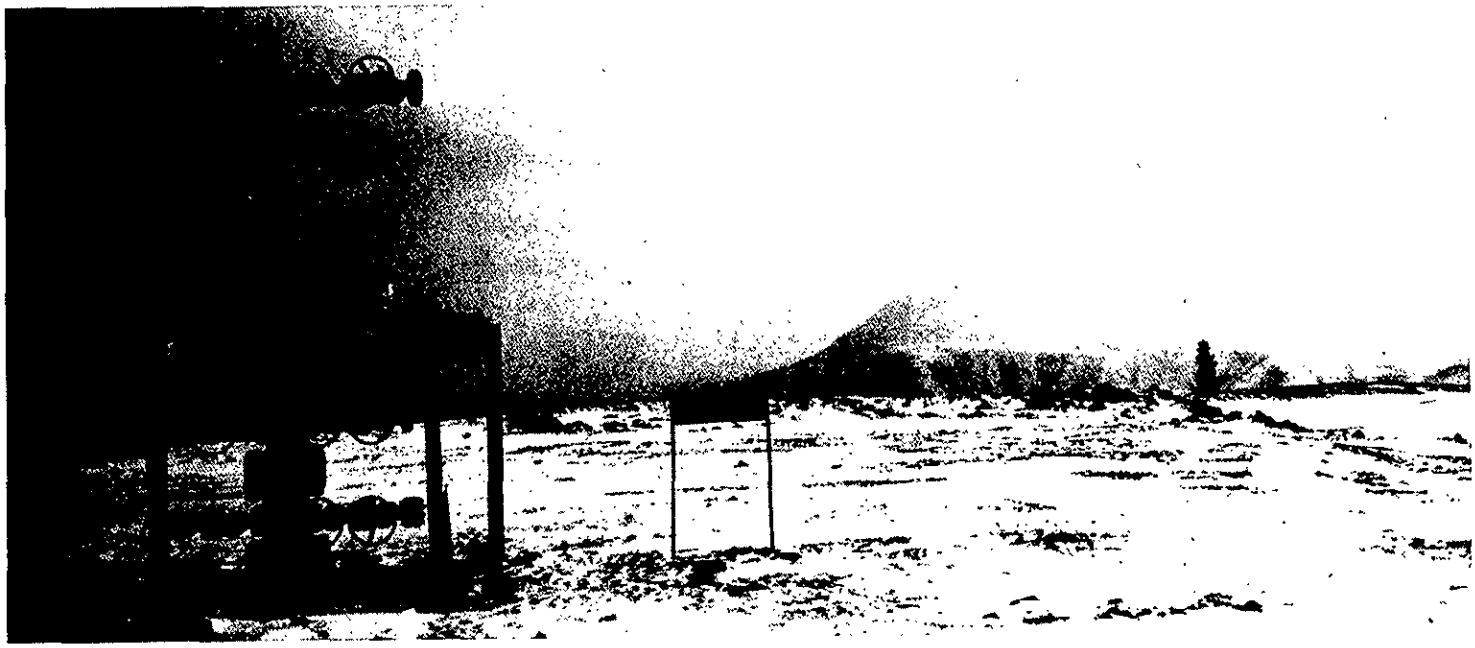
The French, the fur trade, British institutions – these have all played a part from the earliest times in the development of a separate community in the northern half of the continent. But it is a northern tradition that in large measure makes Canada distinct from the United States today. We share a mass culture with the United States, but it is Canada that has – and always has had – a distinct northern geography and a special concern with the North.

What happens in the North, moreover, will be of great importance to the future of our country; it will tell us what kind of a country Canada is; it will tell us what kind of a people we are. In the past, we have thought of the history of our country as a progression from one frontier to the next. Such, in the main, has been the story of white occupation and settlement of North America. But as the retreating frontier has been occupied and settled, the native people living there have become subservient, their lives moulded to the patterns of another culture.

We think of ourselves as a northern people. We may at last have begun to realize that we have something to learn from the people who for centuries have lived in the North, the people who never sought to alter their environment, but rather to live in harmony with it. This Inquiry has given all Canadians an opportunity to listen to the voices on the frontier.

In the past at each frontier we have encountered the native people. The St. Lawrence Valley was the homeland of the Huron and the Iroquois – they were overwhelmed; the West was the homeland of the Cree – they were displaced; the Pacific Coast was the homeland of the Salish – they were dispossessed. Now, we are told that the North is the homeland of the Dene, the Inuit and the Metis. Today in the North we confront the questions that have confronted Canadians before – questions from which we must not now turn away.

Should the future of the North be determined by the South? The question can, of course, be answered by saying that since 1867 the Government of Canada has had responsibility for the welfare of the native people, and that since 1870 it has had jurisdiction over the Northwest. This is to say that Ottawa is sovereign, and has the power to dispose of the North as it wills. But the Government of Canada has not been satisfied to make such an answer, and has established this Inquiry to make it plain that the goals, aspirations and preferences of the



northern peoples should be fully explored before any decision is taken.

The choice we make will decide whether the North is to be primarily a frontier for industry or a homeland for its peoples. We shall have the choice only once. Any attempt to beg the question that now faces us, to suggest that a choice has already been made or need never be made will be an inexcusable evasion of responsibility.

The issues we face are profound ones, going beyond the ideological conflicts that have occupied the world for so long, conflicts over who should run the industrial machine, and who should reap the benefits. Now we are being asked: How much energy does it take to run the industrial machine? Where must the energy come from? Where is the machine going? And what happens to the people who live in the path of the machine?

It may be that, in the national interest, the gas pipeline and the energy corridor should be built. It may be that they should not. But we owe to the peoples of the North, and to future generations, a careful consideration of the consequences before we go ahead with such projects. This report is an attempt to set out what those consequences will be.

The Northern Biome

To most Canadians, "the North" is the immense hinterland of Canada that lies beyond the narrow southern strip of our country in which we live and work. Throughout this report, my view of the North is confined largely to Canada's northern territories – the Yukon Territory and the Northwest Territories – and my attention is addressed principally to that part of Canada, including the adjoining sea and islands, that lies to the north of the provinces of British Columbia and Alberta.

In the course of this Inquiry, I have travelled throughout this region. I have learned how remarkably different the land is in winter and in summer. I have seen the great differences between the forest and the tundra. I have admired the vastness of the land, its variety, its beauty, and the abundance of its wildlife.

I have travelled throughout the Mackenzie Valley, and I have seen the great river in its varied moods. I have crossed the swampy and forested plains and the "great" lakes that extend eastward from the Valley to the edge of the Canadian Shield. I have seen the myriad lakes and ponds and the complex of river channels that form the Mackenzie Delta. I have flown over the Beaufort Sea – in winter covered by ice and snow, in summer by fields of ice floating in the blue water. I have seen the beaches, bars and islands of the Arctic coast, the pingos and lakes around Tuktoyaktuk, the rocky hills at Holman, and the clear rivers of the Yukon Coastal Plain.

On the Old Crow Flats, in the Mackenzie Delta, and along the Beaufort Sea coast I have seen the immense flocks of birds that migrate in their thousands to this arctic area each summer. I have seen the white whales swimming in the shallow coastal waters of the Beaufort Sea around the Mackenzie Delta. I have seen the Porcupine caribou herd in early summer at its calving grounds in the Northern Yukon, and the Bathurst herd at its wintering grounds north of Great Slave Lake. And in every native village I have seen the meat and fish, the fur and hides that the people have harvested from the land and water.

The Boreal Forest and the Tundra

Biologists divide the North into two great regions called "biomes": the boreal forest and the tundra. The boreal forest is characterized in the minds of most people by spruce trees and muskeg. It is the broad band of coniferous forest that extends right across Canada from Newfoundland to Alaska. The tundra, extending from the boreal forest northward to the Arctic Ocean, comprises one-fifth of the land mass of Canada, but most of us who have never seen it, and know of it simply as a land without trees, sometimes call it "the barrens." Yet the tundra biome includes landscapes as varied and as beautiful as any in Canada – plains and mountains, hills and valleys, rivers, lakes and sea coasts. In winter, land and water merge into a white and grey desert, but the summer brings running water, explosively rapid plant growth, and a remarkable influx of migratory birds.

The two northern biomes – the tundra and the boreal forest – meet along the tree line. The tree line is not really a line, but a transitional zone that is commonly many miles in width. This biologically important boundary, which separates forest and tundra, also separates the traditional lands of the Indians and the Inuit. The tree line may also be viewed as the southern limit of the Arctic, the boundary between the Arctic and the sub-Arctic; this is the distinction I shall adopt in this report. Thus, the entire Mackenzie Valley and most of the Mackenzie Delta lie south of the tree line and are described as sub-arctic. In contrast, the land along the coast of the Beaufort Sea and the islands to the north lie beyond the tree line and are described as arctic.

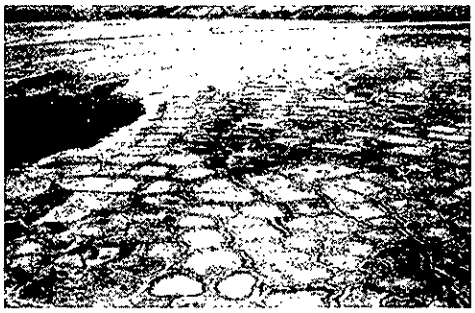
I have learned from experience that, arctic or sub-arctic, this region is one of great

Well head, Pointed Mountain pipeline, NWT. (GNWT)

Permafrost patterns on the Yukon tundra. (M. Church)

Landscape of the boreal forest. (C. & M. Hampson)

Hoar frost. (R. Fumoleau)



climatic contrasts. In mid-summer, it is never dark, but in mid-winter the only daylight is a combined sunset and sunrise. Summer weather can be pleasantly warm, and in the Mackenzie Valley temperatures in excess of 80°F are not uncommon. But summer weather can also be raw and damp, particularly near the coast where a switch from an offshore to an onshore wind will cause temperatures to drop rapidly almost to freezing, accompanied by fog and drizzle.

Both rainfall and snowfall are light. In the Mackenzie Valley, the amount of precipitation is similar to that at Saskatoon or Regina, but in the true Arctic, including the lands bordering the Beaufort Sea, precipitation is as low as that in the driest parts of the Canadian prairies. For this reason, the Arctic may be described as desert and semi-desert, and it is remarkable, therefore, that the land surface in summer is predominantly wet and swampy, and dotted with innumerable shallow ponds. This apparent anomaly is caused, in large part, by permafrost, perennially frozen ground, which prevents water from draining downward into the ground. The seasonally thawed active layer of the soil holds the water from rain and melting snow like a sponge.

Permafrost

In much of Southern Canada, the ground freezes downward from the surface every winter and thaws completely again in the spring. But in the northern half of our country, in the sub-arctic and arctic regions, frost has penetrated below the maximum depth of summer thaw, and a layer of frozen ground persists beneath the surface from year to year. This perennially frozen ground, called permafrost, modifies the character of the landscape in the North and profoundly affects the works of man on and beneath the surface of the land.

In the southern part of the permafrost region, the perennially frozen layer beneath the seasonally thawed "active" layer is only a few feet thick and occurs as patches or islands surrounded by unfrozen ground. Northward, permafrost is more extensive, the layer of frozen ground becomes thicker, and areas of unfrozen ground are smaller and fewer. Farther north still, the permafrost is relatively continuous and may be several hundred to more than a thousand feet thick; but there are areas without permafrost beneath rivers and lakes. To describe the main differences in its distribution, we speak of the continuous and the discontinuous permafrost zones. The proposed pipeline route north of Fort Good Hope lies within the continuous permafrost zone, whereas the route south of Fort Good Hope to around the Alberta border lies in the discontinuous permafrost zone.

Permafrost also occurs offshore beneath the Beaufort Sea, but little is yet known about it there. We believe most of the undersea permafrost was formed on land and has since been inundated by a rising sea level and shoreline erosion.

All of this, of course, is not obvious, but has been learned through a great deal of study. But what is obvious in travelling in the North is the presence of surface features that accompany permafrost. In the discontinuous permafrost zone, there are peat mounds or palsas, speckled and string bogs, and drunken forests with trees tilted in various directions. Farther north, there are pingos, frost-crack patterns, exposed masses of ice, thermokarst depressions caused by the melting of underground ice, as well as characteristic slump features and other signs of thawing soil along the sea coast and river banks, and around lakes and ponds. In summer, there is the all-pervading wetness of the ground surface. In a region that, under warmer conditions, would be desert or semi-desert, ponds, swamps, fens and water-filled frost cracks all bear witness to the inability of water to drain downward through the frozen ground. Permafrost keeps the ground in the North moist, and it profoundly affects the vegetation, insects, birds and other forms of life.

Tundra has been described as land floating on ice. This conception aptly emphasizes the fact that frozen water within the ground gives the terrain unique qualities and creates problems for engineers. Thus, in the permafrost region, rock (which contains little water) is normally no different from rock in temperate regions, but the unconsolidated earth material – the soil – changes radically when the water in it freezes to form ice. The frozen soil will not absorb more water nor can water pass through it: water must therefore remain on the ground surface. Soil cemented together by ice is not easy to dig or to use in construction projects, because it has taken on rock-like properties. True, so long as it is frozen, it provides a solid foundation. But, not uncommonly, when frozen soil thaws, particularly if it is a fine-grained soil, it loses its strength: the soil may flow under its own weight, and the ground surface may subside as water escapes. In ice-rich soils, the effect may be compared with the melting of ice cream. This drastic change in properties occurs whenever the melting of ice in the soil releases more water than the soil can absorb. Such soil is described as containing excess ice.

Thawing of permafrost is only one cause of frost-induced engineering problems in the Arctic and sub-Arctic. Seasonal frost action in the active layer above the perennially

frozen ground also causes problems. In winter, moisture in the active layer freezes, producing an upward displacement of the ground, called frost heave; in summer, there is a loss of bearing strength as the active layer thaws and the excess water is released. In some situations, engineering projects can lead to perennial freezing of areas where the ground is unfrozen or to the thickening of (existing) permafrost. When such changes take place in fine soil with abundant water, ice can build up and may cause frost heave. As we shall see later in this report, frost heave represents a serious problem for the proposed buried, chilled pipeline.

When roads, buildings or pipelines must be built where permafrost occurs, the engineers usually try to avoid disturbing the natural temperature regime in the ground. Disturbance of the ground surface is, therefore, kept to a minimum, particularly where peat or other organic material serves as a natural insulating blanket over the frozen ground. Frequently, where the thawing of permafrost would cause engineering or environmental difficulties, the structures are built above the ground on piles to permit air to circulate under them. The trans-Alaska oil pipeline is built on piles for this purpose. A common alternative is to place the structure on a pad of gravel, or of gravel plus insulation, thick enough to prevent heat from reaching the frozen ground. Compressor stations for the proposed Mackenzie Valley gas pipeline would be built on such pads. On the other hand, if a structure must disturb the ground or must be placed underground, then more complex techniques are required to avoid frost problems. The proposal to refrigerate the buried Mackenzie Valley gas pipeline is an example of such techniques.

The Northern Ecosystem

I have heard hundreds of hours of evidence from experts and laymen alike on the nature of the northern environment. Soil scientists and geotechnical engineers have explained the environmental problems associated with permafrost. Experts on vegetation have described the flora and the measures that can be taken to reestablish plant cover on disturbed areas. Biologists, hunters, trappers and fishermen have told me about the northern animals and fishes – their life cycles, habitat requirements and susceptibilities to disturbance. Throughout all this evidence, I have heard detailed expressions of concern for the northern ecosystem and of the measures that might be used to preserve it in the face of industrial development.

To understand the impact of industrial development on the northern ecosystem and the appropriateness of mitigative measures, it is essential first to understand its general nature and the features that set it apart from more familiar ecosystems in the South. Merely to characterize the North as sensitive, vulnerable or even fragile will not help. Granted, certain species are sensitive: falcons, for example, cannot tolerate disturbances near their nesting sites. The massing of some species such as caribou, white whales and snow geese in certain areas at certain times will make whole populations of them vulnerable. And the response of permafrost to disturbance suggests that its very existence is fragile. But anyone who has visited the North during the long winters and the short mosquito-infested summers will know that northern species must be hardy to survive.

Every ecosystem is built on both living and non-living elements. The two are inextricably linked, and the characteristics of the one are reflected in those of the other. It is not surprising that the combinations of climate and topography in the northern biomes have produced plant and animal populations unique to the North. The relations within the northern ecosystems are not well understood, but at least three characteristics appear to distinguish them: the simplicity of the food chains, the wide oscillations in populations, and the slow growth rates. Dr. Max Dunbar, a marine biologist of international repute, provides an overview of these features in his book *Environment and Good Sense*:

> Arctic ecosystems are simple compared with those in temperate and tropical regions: that is to say, they consist of a comparatively small number of species. There are about 8,600 species of birds in the world; of these only some 56 breed in Greenland, and perhaps a little over 80 in Labrador-Ungava. Colombia, on the other hand, has 1,395, Venezuela 1,150. Of the 3,200 species of mammals known in the world, only 9 are found in the high Arctic, on land, and only 23 in the Cape Thompson area of Alaska. The world is full of fish; well over 23,000 are known. But only about 25 live in arctic waters. The same proportions, approximately, are shown in other groups of animals and plants.
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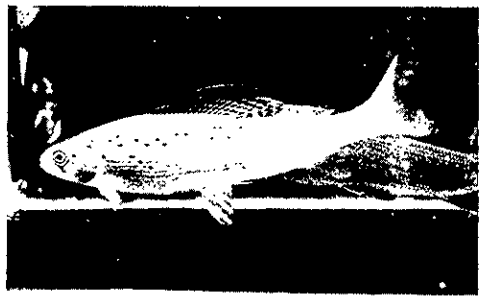
> As an example of such simple systems: the lemmings (there are two species in the North, but with fairly separate distributions, so that they are seldom found together) form the herbivore link between the mosses and grasses (the primary producers) and the foxes, snowy owls, and weasels. Here we have only one dominant herbivore, three common predators, and a few species of plants: so far only four species of mammals and birds in any one region. In certain areas, add two more predators: the rough-legged hawk and the gyrfalcon; elsewhere, add caribou and ground squirrels, two other herbivores; here and there, a wolf. In more southerly regions of the North another fox, the red fox, is also found; and a few herbivorous and insectivorous birds,

The Mackenzie Delta. (CAGPL)

Caribou on the move. (G. Calef)

Arctic ground squirrel. (C. & M. Hampson)

Arctic grayling. (R. Read)



perhaps five species. This gives only 15 species of homotherms or warm-blooded animals, and it is rare to find all of them in one "system" or restricted region. To these must be added the invertebrates and the plants, but this is enough to show how simple the pattern is when compared with the variety of birds and mammals found together in temperate parklands, or, even more so, in the tropical rain forest. In arctic lakes the number of species is very small indeed, and in the sea the same general proportion of species numbers is maintained in comparison with lower latitudes. Other similar examples could be given for coastal communities and for islands.

The cause of this simplicity is not the low temperatures themselves, contrary to common belief. Living organisms can adapt very easily to low temperature as such: this is true not only of the warm-blooded forms but of the poikilotherms ("cold-blooded" species) as well. The limiting factor is the ability of the system to produce life in abundance. In the sea, at least, and in lakes, this means that the limiting factor is the supply of inorganic nutrients.... On land the limiting factors may be both this lack of nutrients and the long frozen winter when the food supply is very greatly, though not entirely, reduced. In either instance it is food supply rather than low temperature....

One important result of the simplicity of arctic systems is that the component species oscillate in abundance over periods of time. In the example given above, the period of oscillation is controlled by the length of life and reproductive capacity of the lemming, and is maintained at from three to five years with quite remarkable regularity. These oscillations are severe in amplitude, so that they give rise frequently to what amounts to local extinction of species; the populations then have to be built up again by immigration from adjacent areas. The upsetting of this already rather shaky equilibrium by man's activity is probably very easy to do, and hence one must suppose that the North is more, rather than less, sensitive to pollutants and other environmental dislocations. This is the sort of thing upon which we need more precise information than we have at present, and which we need time to obtain.

One important ecological factor that may well be dependent both upon food supply and temperature is growth, the rate at which animals reach maturity. This is especially true of the poikilothermal animals and of plants. This means that damage done to populations of animals and plants takes a long time to repair. One may, for instance, come upon a remote lake full of arctic char, or lake trout, and thrill at the prospect of such excellent fishing. This has happened not infrequently in the North. After two years of fishing by Eskimos, or by visitors, the lake appears to be devoid of fish: the reproductive rate and the growth rate of the fish have not come near to making up for the fishing take, and it may in fact require a rest of many decades before the fish population is restored. The arctic char of the Sylvia Grinnell River, at Frobisher Bay in Baffin Island, take twelve years' growth in the female before ripe eggs are produced, and even then each female spawns only every second or third year. Small wonder that such resources are soon fished out and destroyed....

The factors of population oscillation, then, and of slow growth rates, appear to give the northern ecosystems a quality of sensitivity, a knife-edge balance. A third factor is the simplicity of the system itself, for where so few species are involved the extinction of just one must be a serious matter. Yet one cannot at the moment be dogmatic on this point, because the situation has not been experimentally tested: we do not know how much stress the systems will bear and still survive. [p. 56ff.]

In the North, a certain number of species thrive. They are tough – they have to be to survive – but at the same time they are vulnerable. And in the North, man has the capability to cause irreparable injury to the environment.

Francis Bacon wrote, "Nature to be commanded must be obeyed." The northern environment requires us to obey its rules. Where necessary, we must establish and follow new approaches. That is why we must on this, our last frontier, proceed only with the most complete knowledge of and concern for the flora and fauna of the North, for the biomes of the forest and the tundra.

Northern Peoples

The North is the homeland of a complex of indigenous cultures. We in the South may speak airily of "native people," and thereby convey the impression that there is a single culture, a single social system that occupies the vast arctic and sub-arctic terrain. But the term "native" is an inheritance from the European colonists, who usually regarded the original inhabitants of the lands they sought to subdue and settle, as a single group unified by "primitive" customs, and by their political relationship to the colonial powers themselves. In this way, the term "native" obscures essential differences between the cultures encountered in the course of European expansion.

The landscapes of the North have been shaped only marginally by the activities of man. The northern peoples have always been hunters and gatherers, and most have lived with a high degree of mobility. Small groups travelled over large areas, hunting and gathering what they needed, but without altering the environment itself. It is not always easy to remember, as one flies over the unbroken boreal forest, the tundra, or the sea ice, that the Canadian North has been inhabited for many thousands of years. The populations that have used this great area were never large by European standards, but their skills as travellers and hunters made it

possible for them to occupy virtually all of the land. Extremely slow rates of northern plant growth and of decay mean that it is possible to see almost everywhere in the North signs of ancient occupation – old house remains, tent rings, fire-cracked rocks – and for archaeologists to find, on or close to the surface, a wealth of artifacts and other evidence to show the richness, diversity and wide extent of northern aboriginal society.

In the North, there are not just "native peoples," but a network of social systems. The Indians of the Mackenzie Valley and Western Arctic are part of the Athabascan language and culture group. They are separated into the Kutchin (or Loucheux), Hare, Slavey, Dogrib and Chipewyan. The Athabascan people are one of the most widely dispersed groups of Indians in North America. In addition to the Indians of the Northwest Territories and the Northern Yukon, they include the Koyukon and Tanana of Alaska, the Tutchone of the Southern Yukon, the Beaver and Carrier of British Columbia, the Navaho and Apache of the Southwest United States, and still others in California and Oregon. All these Indians, with whatever dialectical variation in their languages, regard themselves as *the people*. To the Slavey they are the *Dene*, to the Navaho *Dine;* in Kutchin the word is *Dindjie;* in Apache it is *Nde*. Today, in the North, the Indian people collectively call themselves the *Dene*.

The native peoples of the Western Arctic also include the Eskimos or, as they are now widely known, the Inuit; they occupy part of the Mackenzie Delta and the shores of the Beaufort Sea. Although all of the Inuit, from Siberia to eastern Greenland, speak closely related dialects of the same language, regionally there are differences in technology and social organization that even today complicate anthropological generalizations about them. Certainly the Inuit themselves perceive major differences between their various groups: the Inuvialuit of the Delta see themselves as distinct from the Copper Eskimos, who are their neighbours to the east; and the Copper Eskimos – or Qurdlurturmiut – emphasize that they are unlike the Netsilik, the Aivilik or the Igloolik people, who live still farther east. And, within each of these broad groups, there are yet finer divisions and distinctions that reflect different patterns of land use and are represented by changes in dialect and in hunting techniques.

This brief elaboration of social systems may seem to lie at the periphery of this Inquiry, but it indicates that the Dene and the Inuit – as well as the Metis, to whom I shall return – are distinct peoples in history. They have common interests in relation to the proposed Mackenzie Valley pipeline, and they therefore share many concerns. But the intensity of their feelings, no less than the vigour with which they are now expressing their hopes and fears, reflect historical and cultural depths that cannot be comprehended by the term "native." The North has become our frontier during the past few decades; it has been a homeland of the Dene and Inuit peoples for many thousands of years.

Earliest Known Migrations

The last glaciation affected occupation of the arctic regions of North America in two ways. Covered by a vast ice-sheet, much of the area was uninhabitable, but the lowered sea level exposed the continental shelf and provided a land-bridge for migrants across what is now the Bering Strait, and the interior of Alaska and parts of the Yukon remained free of ice. The earliest of these migrations occurred probably between 25,000 and 30,000 years ago. Some of the people who crossed the land-bridge at that time seem to have continued south, giving rise to many early Indian cultures. A later migration from eastern Asia, perhaps 10,000 to 14,000 years ago, is believed to have taken place just before the final melting of the ice-sheets. These were the ancestors of the Athabascan Indians, and their later arrival is evidenced by their occupation of large blocks of land in northwestern North America. Yet a third migration, around 5,000 years ago, is thought to have brought the predecessors of the Eskimo peoples to the New World.

The people of the Thule culture, famous for their skills as whale hunters, are probably the descendants of these earlier Palaeo-Eskimo people. About a thousand years ago, they spread throughout the Arctic, displacing the Dorset culture, which had developed in Northern Canada in about 1,000 B.C. Superbly equipped for life on the barrens and on the sea ice, the range of the Thule people in what is now Canada eventually included all the coastal areas, practically all of the islands of the Arctic Archipelago, and reached as far east as the Gulf of St. Lawrence and Newfoundland. The Inuit of today are their direct descendants.

It must, of course, be recognized that all models of early Arctic occupation remain speculative, and that the full historical extent of occupation of Northern Canada is only beginning to be documented. As archaeological work advances, however, so we will more and more realize the cultural heritage of which the Inuit and Dene are a part. But it is already evident that Indians were established in the forestlands of Western and Northern Canada, and Palaeo-Eskimos inhabited the northern rim of the "New

Dogrib Indians at Great Slave Lake, unloading canoes, 19th century. (Alberta Archives)

Eskimos, 1893. (Public Archives)

"Before they lived in houses." (Alberta Archives)

Joseph (King) Beaulieu, 1836-1916, son of Old Man Beaulieu who built the first trading post at Fort Smith. Ancestor of one of the largest NWT Metis families. (NWT Metis Association)

World" some 5,000 years before Alexander Mackenzie reached the Arctic coast.

Distinctive Material and Intellectual Cultures

The specialized skills and knowledge of the Dene and Inuit corresponded, of course, to the different terrains that each people has so long inhabited. The dog team, for example, was the principal means of travel, although the sledge styles and hitches varied regionally. The relationship between these variations and the kinds of terrain in which they were used can be illustrated by a comparison between the fan-hitch of the Inuit of the Central and Eastern Arctic and the tandem- or line-hitch used by the Dene and the Inuit of the Western Arctic. The former was ideal for travel on rough ice and the barrens; the latter was suited for travel over snowy lakes and through trees. The range of each broadly corresponds to the two kinds of landscape.

Both Inuit and Dene societies used caribou skin for clothing. The density of the fur and the fact that the hairs are hollow make the skin both light and extremely effective insulation, so it is ideal for arctic garments. Despite many conventions of style and varieties of sewing, differences that have given each group or society its distinctive clothing, both the Dene and Inuit regarded the caribou as their most important source of winter clothing.

Inuit and Dene cultures are not merely a response to environmental conditions. Each society, armed with its own skills and perceptions, found and used the North in its own distinctive way. One example of a distinctive and essential element of material culture is the Inuit harpoon. This brilliantly successful device, with its detachable head and turning blade, is found throughout Inuit territory, and it evidently came with them from Asia.

The Inuit and Dene also speak different languages. Some thousands of years separate their ancestors' departures from Asia, and it is not surprising, therefore, that the Eskimoan and Athabascan languages have no more in commmon than do English and Hungarian. Indeed, the linguistic contact between them even today is so limited that virtually no words have been borrowed from one by the other, despite the fact that the hunting grounds of some Athabascan groups overlapped with those of some Inuit. Because there are no longer any Asiatic peoples (with the exception of some 1,500 Siberian Inuit, who represent a back-migration across the Bering Strait), who speak versions of either of the two language families, it is not possible to establish a link between the two even in ancient times.

The various Athabascan languages spoken in Northern Canada bear the same kind of relation to one another that exists among the Romance languages of Europe. The structure of Athabascan grammar is noted for its use of prefixes, and its vocabulary is finely tuned to descriptions of the environment. Moreover, the nature of its word-forming system equips it well for the task of inventing new terms.

The Inuit language is agglutinative and very regular. Each word-like expression is composed of several items, and a word can be as intricate as a whole sentence in English. This agglutination is found in all of the Inuit dialects and, although the dialects most remote from one another are not readily mutually intelligible, the single language, with comparatively minor variations, reaches from Siberia to eastern Greenland – a spread of some 5,000 miles.

The specialized material and intellectual culture of the Inuit and Dene obviously cannot be elaborated in this report, but I wish to emphasize that each of these peoples had its own way of hunting, of making clothes, of raising children, of dealing with one another, and of regarding the environment and the spiritual powers they saw as integral to their world. Their knowledge of the land and its life constitute distinctive ethno-scientific traditions.

The Metis

During the past 150 years, the Metis have joined the Dene and Inuit of the Mackenzie Valley as one of the groups now included in the category of "northern native people." The first Metis who moved into the North in the early 19th century settled around Great Slave Lake, and they trace their ancestry to the unions between coureurs de bois and Indian women in the early days of the fur trade. Richard Slobodin, in *Metis of the Mackenzie District*, has described their heritage:

> The Metis nationality or ethnic group ... evolved in Quebec and Ontario during a period from the late 17th to the early 19th centuries, through the activities of *coureurs de bois* and other fur trade functionaries who, with their offspring by Indian women, developed a way of life partly Indian, partly marginal European, but in time distinct from both. ... On the prairies and the high plains, the Metis way of life underwent a further ecological adaptation. It was here, among Metis centering on the Red and Saskatchewan River Valleys, that consciousness of kind was heightened to the level of incipient nationality, a tendency culminating in the declaration of Metis nationhood and the consequent insurrections of 1870 and 1885. [p. 12]

In the aftermath of the Northwest Rebellion of 1885, many Metis moved North and settled in what is now the Northwest Territories.

Indians and whites in Fort Resolution. (National Museums)

Other Metis are the descendants of unions between Hudson's Bay Company men – mainly of Scottish origin – and Dene women. The children of these unions usually intermarried with the original Dene inhabitants, so that in most native communities in the North there are close family ties between the Metis and the Dene.

The Metis culture has been patterned after that of the Dene. In *Our Metis Heritage . . . A Portrayal*, produced by the Metis Association of the Northwest Territories, we are given this account of the location of the Metis between the Dene and white worlds:

> For most Metis families in the present Northwest Territories, it would appear that the woman passed on to her children all that she knew of her own culture, which was the Indian culture, and the man's influence though significant, played a secondary role in the emergent Metis way of life. This may account in part for the fact that the Metis lifestyle was very closely patterned after the Indian.
>
> The Metis were equipped with survival mechanisms to operate in both worlds; they could hunt, trap and live off the land like their Indian ancestors, or they could take advantage of their white ancestors' technology through education.
>
> Although the N.W.T. Metis seem to have chosen to maintain the traditional relationship with the Indian, they have creatively succeeded in building and sustaining a unique way of life. [p. 95]

Discussion of the Metis brings us to changes that have occurred in recent times. These are matters to which I shall return, and they need not be more than adumbrated here. I have tried to indicate the depth and richness of aboriginal cultures; I urge that we not lose sight of their historical reality, their values, and their right to command our respect. The North has been a homeland to the native people for thousands of years; it has been a frontier only since the fur trade, and a major oil and gas frontier only since the 1960s.

The Corridor Concept

The Corridor Concept and Cumulative Impact

The concept of a pipeline corridor from the North was first enunciated by the Government of Canada in the 1970 Pipeline Guidelines. In 1972, these Guidelines were expanded. The Expanded Guidelines for Northern Pipelines (to which I shall refer as the "Pipeline Guidelines") were tabled in the House of Commons in June 1972, and they form the cornerstone of Canadian policy with regard to the construction of northern pipelines. The Inquiry is bound by Order-in-Council, P.C. 1974-641 March 21, 1974, under which it was established, to consider the proposals made by the pipeline companies to meet the specific environmental and social concerns set out in the Pipeline Guidelines.

The significance of the corridor concept to this Inquiry relates to the consideration of impact and cumulative impact. The Pipeline Guidelines assume that, if a gas pipeline is built, an oil pipeline will probably follow it, and they call for examination of the proposed gas pipeline from the point of view of cumulative impact. We must consider then, not only the impact of a gas pipeline, but also the impact of an oil pipeline – in sum, the impact of a transportation corridor for two energy systems.

The government's corridor policy is plainly spelled out in the Pipeline Guidelines:

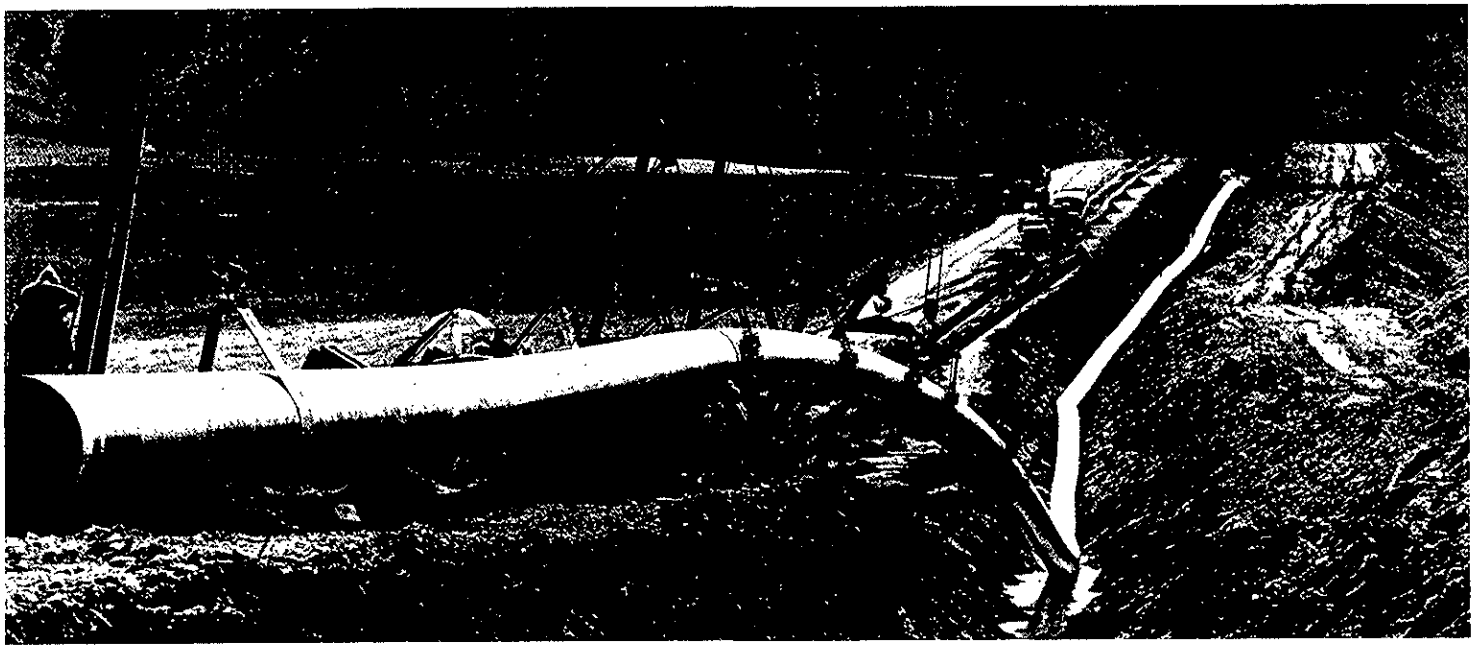
> In view of the influence of the *first* trunk pipeline in shaping the transportation corridor system and in moulding the environmental and social future of the region, any applicant to build a first trunk pipeline within any segment of the corridor system outlined in 1. above must provide with [its] application:
>
> i) assessment of the suitability of the applicant's route for nearby routing of the other pipeline, in terms of the environmental-social and terrain-engineering consequences of the other pipeline and the combined effect of the two pipelines;...
>
> ii) assessment of the environmental-social impact of both pipelines on nearby settlements or nearby existing or proposed transportation systems....[p. 10]

The assumption in 1970 was that an oil pipeline would be built first, and a gas pipeline would be likely to follow it; ever since the Pipeline Guidelines were issued in 1972, the assumption has been that a gas pipeline would come first and that an oil pipeline would be likely to follow it. Now we have before us proposals by Arctic Gas and Foothills to build a gas pipeline. The influence of a gas pipeline on the development of an energy corridor and in moulding the social, economic and environmental future of the North will be enormous. The Pipeline Guidelines call for a consideration of the environmental and social impact of a gas pipeline and an oil pipeline, as well as of the combined impact of the construction of both pipelines along the corridor. That policy ramifies throughout the Inquiry's consideration of the environmental and social issues that arise along the whole route. However, the corridor will not be simply a corridor for gas and oil pipelines. The Pipeline Guidelines envisage that the corridor may eventually include roads, a railroad, hydro-electric transmission lines and telecommunications facilities.

There are real limits to our capacity to forecast the impact of such a corridor. The Pipeline Guidelines are principally concerned with the impact that gas and oil pipelines will have in the North. The Inquiry has, therefore, largely limited itself to a consideration of the impact of these energy transportation systems. But sometimes it has been necessary to consider the impact of pipelines in relation to other transportation systems. For instance, what if a haul road had to be built along the Arctic Coastal Plain of the Northern Yukon? Or to what extent will the capacity of the existing fleet of tugs and barges on the Mackenzie River have to be augmented? Or to what extent will hunting from the Dempster Highway have to be restricted to enable the recommendations of this Inquiry to be carried out? We cannot make an intelligent assessment of the impact of a gas pipeline unless we do so in the light of the cumulative impact of the corridor.

Of course, the gas pipeline itself will be a multi-stage project involving considerations of cumulative impact. The gas pipelines proposed by Arctic Gas and by Foothills can be expected to be looped. Looping is the process of progressively increasing the amount of gas that can be transported by the pipeline system; a second (or third) pipeline is built beside the first in sections or loops from one compressor station to the next. This means that construction along the gas pipeline right-of-way can be an ongoing or repetitive process and can involve cumulative impacts over and above those resulting from the project that was originally proposed.

The importance of considering the impact of a gas pipeline in the light of cumulative impact along the corridor is obvious. This importance can be illustrated by reference to gravel, which is in short supply in the North. Arctic Gas estimate that the gas pipeline will require 30 million cubic yards of gravel and other borrow materials within Canada and North of 60. Mackenzie Valley Pipeline Research Limited estimated the gravel requirements for an oil pipeline at 42 million



cubic yards. It would be foolish to consider the impact of the borrow requirements of a gas pipeline without taking into account the gravel requirements of an oil pipeline, as well as those of other regional and local projects. Substantial amounts of borrow materials will be required for gas plants and gas-gathering systems in the Mackenzie Delta, for the completion of the Mackenzie Highway and the Dempster Highway, and for airports, not to mention the needs of communities along the route. Gravel provides a quite straightforward example of cumulative impact. There are many other examples, some of them by no means as straightforward, that I shall be dealing with in this report.

The Northern Yukon Corridor and the Mackenzie Valley Corridor

It should be borne in mind that there are two proposed corridors: one across the Northern Yukon and another along the Mackenzie Valley. The following passage from the Pipeline Guidelines makes this plain:

> The Government of Canada is prepared to receive and review applications to construct one trunk oil pipeline and/or one trunk gas pipeline within the following broad "corridors":
>
> i) Along the Mackenzie Valley region (in a broad sense) from the Arctic coast to the provincial [Alberta] boundary;
>
> ii) Across the northern part of the Yukon Territory either adjacent to the Arctic coast or through the northern interior region from the boundary of Alaska to the general vicinity of Fort McPherson, and thus to join the Mackenzie "corridor"; . . . [p. 9]

Arctic Gas propose to build a pipeline from Alaska that would use the corridor across the Northern Yukon as well as the corridor along the Mackenzie Valley. Foothills propose to build a pipeline that would use only the corridor along the Mackenzie Valley.

Arctic Gas propose to transport only Alaskan gas in the corridor across the Northern Yukon, and to transport both Alaskan and Canadian gas in the Mackenzie Valley corridor. Under the Foothills proposal, the Mackenzie Valley corridor would be used to carry only Canadian gas.

Since 1972, as mentioned above, the Government of Canada has assumed that a gas pipeline along either of these corridors would probably be followed by an oil pipeline. That assumption is a sound one: once a gas pipeline is built across the Northern Yukon, there will be every reason for an oil pipeline carrying American oil to follow the same route. You may ask, is not the trans-Alaska pipeline to carry American oil to the Lower 48? The Alyeska pipeline was built to deliver oil to the western states, but the United States still has severe shortages of oil in the midwest and the east. And there are great petroleum reserves in northern Alaska, especially in Naval Petroleum Reserve No. 4 lying to the west of Prudhoe Bay. The urgency of bringing oil from northern Alaska to the markets in the Lower 48 that need it most is obvious. If a gas pipeline and energy corridor were already in place across the Northern Yukon and along the Mackenzie Valley, it is quite likely this corridor would be the route of choice.

Once a gas pipeline is built along the Mackenzie Valley, it is likely that in the future an oil pipeline will follow. Oil has in fact been found in the Mackenzie Delta region. It is said that discoveries of oil in the Mackenzie Delta and the Beaufort Sea do not justify an oil pipeline today. Nonetheless, while the proven reserves of oil in the Mackenzie Delta region have not yet reached threshold levels, they may do so in time. In any event, it is obvious that if present or future exploration programs reveal large reserves of oil under the Beaufort Sea, the call for an oil pipeline from the Delta to the mid-continent will be made once again.

I think all of this demonstrates the wisdom of the Pipeline Guidelines, which insist that there should be an examination of the impact of an oil pipeline along with the gas pipeline. Any attempt to dismember the policy and to assess the impacts piecemeal, along either the Northern Yukon corridor or the Mackenzie Valley corridor, should be resisted.

The United States' Interest in the Corridor

The Arctic Gas pipeline, if it is built, would provide a land bridge for the delivery of Alaskan gas across Canada to the Lower 48. The implications of this prospect, from the point of view of Canadian policy in the North, should be borne in mind.

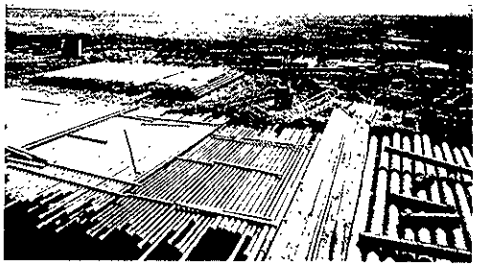
The corridor across the Northern Yukon will be an exclusively American energy corridor. The Mackenzie Valley corridor, under the Arctic Gas proposal, will be an American energy corridor as much as it is a Canadian energy corridor. The United States will have an interest in the scheduling of pipeline construction in Canada and, when the pipeline is built, in seeing that it remains safe and secure, because it will be carrying Alaskan gas in bond to the Lower 48. It will be an energy lifeline for the United States,

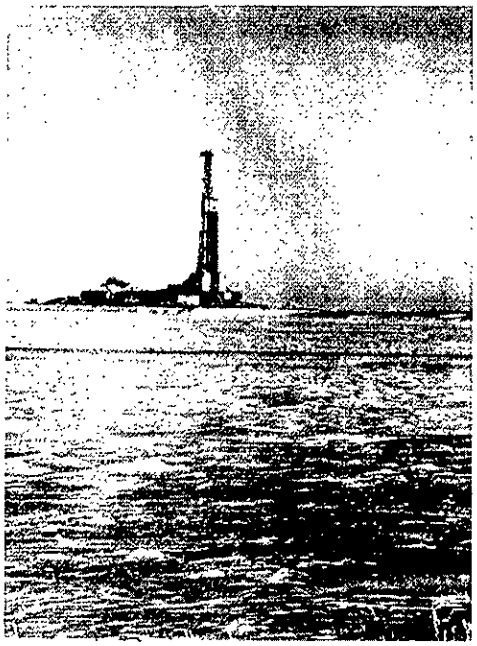
Trans-Alaska pipeline and gravel haul road. Sideboom tractors lower pipe into ditch. (Alyeska)

Stockpile of drill pipe. (NFB—McNeill)

Drill rig in the Delta. (Arctic Gas)

Mackenzie Highway right-of-way beside Mackenzie River. (J. Inglis)





extending across the Northern Yukon, across the Mackenzie Delta, along the Mackenzie Valley, and then through Alberta, Saskatchewan and British Columbia to the Lower 48. It will supply gas to a complex of industries and urban centres in the United States. The Americans will be dependent on the continuous supply of gas, and the gas being transported from Alaska will be their own gas. Moreover, the United States wants the pipeline to begin to deliver that gas as soon as possible.

There are, of course, pipelines that cross United States territory and carry oil and gas to Canadian markets: the Interprovincial pipeline, which delivers western oil to Ontario; the Portland-Montreal pipeline, which delivers offshore oil to Quebec; and the Great Lakes Transmission Company pipeline, which delivers gas to Ontario. All of them pass through the United States. But these connections cannot be compared in magnitude or impact to the Arctic Gas proposal. They are not pipelines reaching some 2,000 miles from a distant frontier.

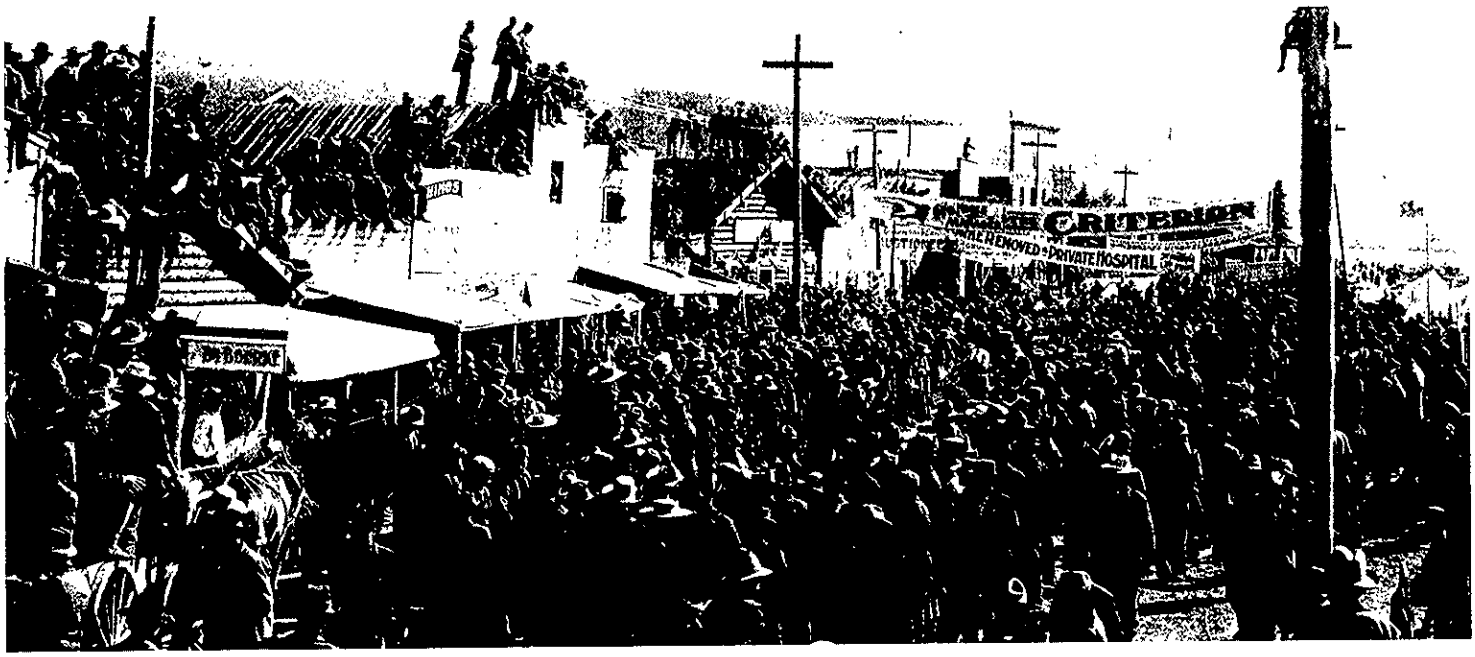
The consequences of such American interest in the pipeline are of special concern to the Inquiry. The impact of the pipeline, so far as northern peoples and the northern environment is concerned, will be largely within Canada (the line from Prudhoe Bay to the Alaska-Yukon border is only 200 miles long, whereas the line from the Alaska-Yukon boundary to the Northwest Territories-Alberta border is 1,000 miles long). The native people's concern over when a pipeline is built, the environmental concern over where it should be built, and the stipulations for protecting the people and the environment apply largely in Canada. The United States cannot be expected to be as concerned as Canada with the seriousness of the social and environmental impact of the pipeline along its route. This difference, coupled with the Americans' rather more urgent need of gas, might result in pressure to complete the pipeline without due regard to the social and environmental concerns in Canada. The risk is in Canada. The urgency is in the United States.

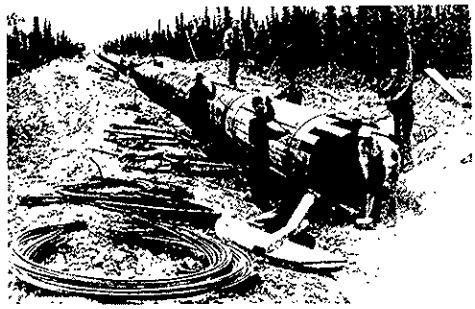
A pipeline 2,200 miles long (in Canada) is a highly vulnerable artery. What measures might have to be taken to forestall an interruption of delivery — an interruption that would affect vital Canadian interests, but even more tellingly, vital American interests? There may be real possibilities for misunderstanding and tension between our two countries, notwithstanding our long history of good relations. These considerations deserve the attention of the Government of the United States as well as of the Government of Canada. It may be that they are not at all daunting. But they should still not be overlooked.

A treaty between Canada and the United States will not cover all possibilities. It will, of course, define the rights of our two governments with regard to the pipeline and to the gas being transported in that pipeline. And it will establish the ground rules for the transportation of Alaskan gas across Canada to the United States. It cannot do more. I say this because a treaty, although it will regulate the conduct of our two governments, will not necessarily regulate the conduct of the two countries' citizens.

The implications for our relations with the United States of the building and maintenance of the proposed gas transmission system deserve careful consideration by all Canadians. We are not simply considering a proposal to build a pipeline on an isolated frontier. We are considering, in the Arctic Gas proposal, the establishment of an international energy corridor that will cross some 2,200 miles of Canadian territory, opening up wilderness areas that are among the most important wildlife habitat in North America. It will cross lands that are claimed by Canada's native people, a region where the struggle for a new social and economic order and political responsibility is taking place.

It seems to me the question of whether or not there should be a corridor to carry vital energy supplies from Alaska through the heartland of Canada to the Lower 48, is at the threshold of the decision-making process. If Canadians decide that there is to be such a corridor, then we must also consider when it should be established and what route it should follow. These are questions Canadians must decide for themselves.





Early northern development: clockwise from top:

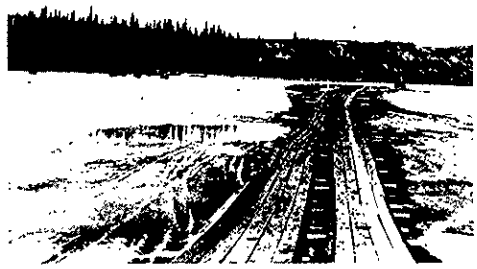
Dawson City at the height of the Klondike Gold Rush, July 4, 1899.

A wood-stave pipe used to carry water to Klondike placer mines.

Plank road on the ice across the Peace River, part of the Alaska Highway, 1942.

US soldiers lay logs for corduroy road, Alaska Highway, 1941.

Inspector checks weld in Canol pipeline, Mackenzie Mountains, 1944.
(Public Archives of Canada)



Engineering and Construction

Transportation and Construction in the Northwest

THE EARLY YEARS

Fur-traders of the Montreal-based North West Company followed the water routes explored by the French to the western plains, then extended them north to Lake Athabasca, where they built Fort Chipewyan in 1788. A year later, Alexander Mackenzie set out across Great Slave Lake and down the long northern river that now bears his name. It proved to extend just over a thousand miles through rich new fur territory, and soon the North West Company had established trading posts along its banks at Trout River in 1796, and at sites near the present settlements of Fort Simpson, Fort Norman and Fort Good Hope in the following decade.

In the last century, the traders travelled by York boat from Methy Portage to the 16-mile stretch of rapids on Slave River above present-day Fort Smith, around which they had to portage. (This river route was shortened by the extension of rail from Edmonton to Waterways early in this century, and York boats were replaced by steamboats.) They then continued down the Slave River to Fort Resolution, across Great Slave Lake to the head of the Mackenzie, and down the Mackenzie as far as the Delta. Today, the Mackenzie River is still the principal means of transporting supplies to settlements along the Mackenzie Valley and in the Western Arctic. And it is this fleet of tugs and barges on the Mackenzie River that will have to be expanded to carry the equipment, material and supplies for the proposed pipeline.

In 1888, a Select Committee of the Senate was appointed "to inquire into the resources of the Great Mackenzie Basin and the country eastward to Hudson's Bay," but Northern Canada first came to international notice in the late 1890s, when gold was discovered in the Yukon Territory. An estimated 100,000 men and women sought the gold fields, and almost overnight Dawson City became the largest city in Canada west of Winnipeg, with a population of over 30,000.

The city was built on difficult permafrost soils. Most of its early foundations were simple mud sills of local timbers laid in gravel or sand and levelled with the same material. Wood was the primary building material for the banks, post office, hotels and dance halls and the many homes that were built. The city acquired such urban services as running water, electric lighting and telephones. On the gold fields themselves, the Yukon Gold Company built a 70-mile ditch system to provide water for a large-scale dredging operation on the Klondike River and its tributaries. This project, which included 13 miles of 42- to 54-inch-diameter wood-stave and steel pipe, was a remarkable engineering feat on an isolated frontier.

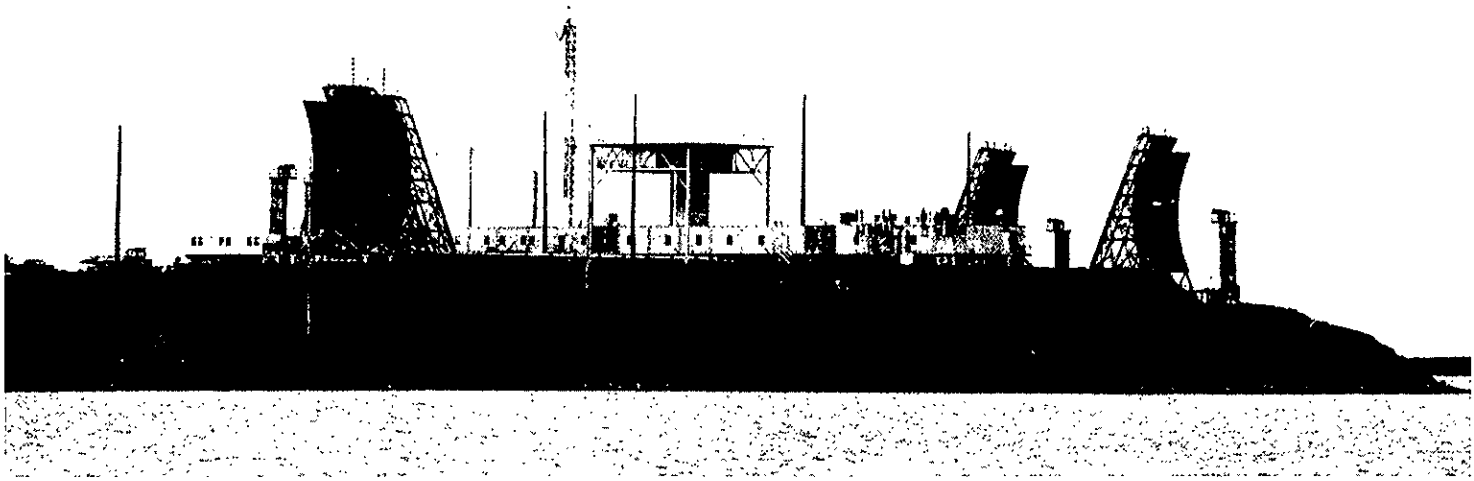
The 1920s witnessed the development of the petroleum reserves at Norman Wells. Mackenzie himself had reported oil seepages on the river bank, but it was only in 1914 that a geologist, T.O. Bosworth, staked three claims near these seepages. Imperial Oil acquired these claims in 1919, and by 1924 six wells had been drilled, three of which were producers. A small refinery was built, but the market was so small that in the same year the wells were capped and the refinery shut down. During the development of the petroleum reserves at Norman Wells, the detrimental results of thawing perennially frozen water-bearing silts and clays soon made themselves evident, and experimentation began with the installation of foundations on gravel pads.

In the early 1930s, after rich mineral deposits had been discovered at Yellowknife and at Port Radium on Great Bear Lake, the refinery at Norman Wells was reopened to supply gasoline and fuel oil for riverboats and mine machinery. Between 1937 and 1972, heavy fuel oil was barged from Norman Wells to the rapids on Great Bear River, transported by a 2-inch 8.5-mile pipeline around the rapids, then barged the remainder of the way to the Eldorado uranium mine on Great Bear Lake.

DEFENCE PROJECTS DURING AND AFTER THE SECOND WORLD WAR

During the Second World War the United States Army undertook two major construction projects in the Canadian North: the Northwest Staging Route and an associated highway, now called the Alaska Highway; and the Canol Project to transport men, materials, equipment and oil to defend Alaska against the Japanese.

The Alaska Highway connected Dawson Creek, B.C., to Fairbanks, Alaska, following the Northwest Staging Route airports at Fort St. John and Fort Nelson, B.C., Watson Lake and Whitehorse, Y.T., and Big Delta, Alaska. The construction began in March 1942, and it involved a force that totalled some 11,000 officers and men over the construction period. By the end of October 1942, a passable pioneer road, 1,428 miles long and 26 feet wide, linked Dawson Creek to Big Delta. Permafrost conditions were ignored during construction, which resulted in road failures and severe icings at many locations. During most of 1943, 81 contractors under the United States Public Roads Administration worked on an all-weather gravel road with a civilian



force that totalled some 15,950 men over the construction period. The total cost of the project was $147 million. When the war ended, the United States handed over the Canadian section of the Alaska Highway to Canada.

In 1942, also, the United States Army undertook the Canol project to transport oil from Norman Wells across the Mackenzie Mountains to Whitehorse. The oil was to be refined there, then delivered to Alaska to aid the war effort. The labour force over the construction period of the pipeline involved 2,500 military personnel and approximately 22,550 civilians. A pioneer road preceded pipelaying and the building of pumping stations. Except at its southern end, the road was laid entirely over permafrost. The road performed satisfactorily during its short period of use, April 1944 to May 1945, except for icings on some stretches. The pipeline, consisting of 100 miles of 6-inch pipe and 500 miles of 4-inch pipe, was laid on the ground beside the road, and pumping stations were spaced about 50 miles apart. This project was completed in 1944 and cost $134 million. Very little oil reached Whitehorse by the pipeline, and when the war ended, the Canol road was closed and the pipeline dismantled.

Between 1955 and 1957, Canada and the United States built the Distant Early Warning Line (DEW Line), a chain of radar stations intended to detect foreign aircraft in polar regions and to relay the warning to North American Air Defence Command units. The line stretches 5,000 miles along the Arctic coast from Point Barrow, Alaska, to Cape Dyer, Baffin Island. The construction of the DEW Line involved airlifting a total of about 25,000 men and one-half million tons of equipment by commercial aircraft. Approximately 45,000 flights averaging 720 miles each were made.

POST-WAR PERIOD

In 1954, construction began on Inuvik, a new regional administrative centre for the Western Arctic at a site on the east side of the Mackenzie Delta. All major buildings, including serviced housing, are elevated on piles. The air space between the buildings and the ground dissipates heat losses from the buildings, thus reducing the possibility of permafrost degradation and associated shifting of foundations. These buildings have performed satisfactorily; only a few of the 14,000 piles installed have shown any significant movement owing to thaw settlement.

Other new towns have been built farther south, but they did not encounter the same formidable permafrost problems. In the 1960s, Cominco's development of the rich lead-zinc deposits on the south shore of Great Slave Lake led to the construction of a large mill and the associated mining town of Pine Point. Edzo, another new town, was built at the head of the North Arm of Great Slave Lake in 1971. At Yellowknife and Hay River, there are suburbs and high-rises that would have been difficult to imagine in such settings only a few years ago. The development of the Northern Transportation Company Limited (NTCL) dry-dock and transshipment facilities at Hay River is representative of the recent growth in transportation.

TRANSPORTATION

Barge and boat transporation on the Athabasca, Slave and Mackenzie Rivers has served the transportation needs of the Northwest for more than a century. Today, water transport northward from Hay River continues to be important, particularly for construction materials, heavy equipment and fuels. Although freight traffic on the Mackenzie River has had intermittent periods of rapid growth, its long-term annual growth rate is about nine percent. This growth peaked in 1972 at 477,000 tons; since then annual traffic has averaged around 400,000 tons.

Northern Transportation Company Limited, a crown corporation, is the largest common carrier in the Mackenzie River system, and it also serves the Arctic coast from Alaska to Spence Bay. KAPS Transport Limited, the second largest operator, is licensed to transport goods to and from exploration and drilling sites, and building and construction sites in the Mackenzie watershed.

In recent years, there have also been major air, rail and road developments in the Western Arctic. Northern air services began in the region in 1920, with float-equipped aircraft. During and shortly after the Second World War, airfields were built at several settlements on Great Slave Lake and along the Mackenzie River, including Hay River, Yellowknife, Fort Resolution, Fort Providence, Fort Simpson and Norman Wells, and both scheduled and charter flights in the Western Arctic increased steadily.

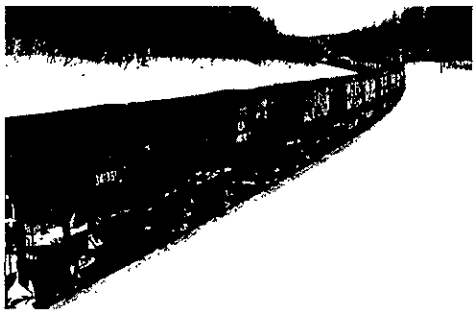
Today, there is air service to all of the Mackenzie River settlements, although its frequency varies. Pacific Western Airlines, the largest carrier operating in the Northwest Territories, has the most extensive network of routes; and chartered aircraft serve the smaller and remoter settlements. These carriers, commercial and private, are essential to the communities in the Mackenzie Valley and the Western Arctic, the territorial and federal governments, tourist

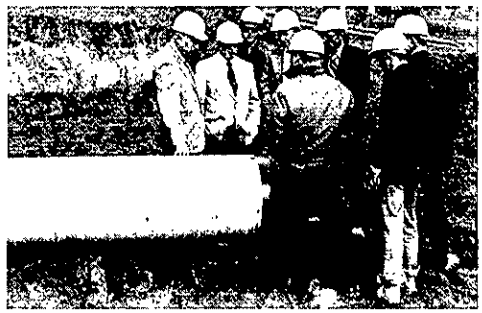
Distant Early Warning (DEW) Line site, Tuktoyaktuk. (GNWT)

Great Slave Lake Railway near Pine Point. (Canadian National)

Judge Berger at pipe stockpile in Alaska. (I. Waddell)

Inquiry staff viewing TransCanada pipeline under construction in Ontario. (G. Milne)





lodges, and construction companies, and they play a vital role in the activities related to oil and gas exploration.

The Great Slave Lake Railway, built in the early 1960s, extends from Grimshaw, Alberta, to Hay River, Northwest Territories. The railway, which closely parallels the Mackenzie Highway, was constructed primarily to ship concentrates from Cominco's mine at Pine Point, to which it is connected by a branch line. Heavy goods are shipped by rail to Hay River, then trans-shipped to barges for the voyage down the Mackenzie River.

The Mackenzie Highway between Grimshaw and Hay River was built between 1946 and 1948. In 1960, as part of the federal Roads to Resources program, it was extended 280 miles around the north end of Great Slave Lake to Yellowknife; in 1970, the highway reached Fort Simpson, and it is planned to reach Wrigley by 1979. There has been road construction between Arctic Red River and Inuvik, but it is not complete.

A second major highway project, the Dempster Highway, was begun in 1959 and is scheduled for completion in the late 1970s. It will link Dawson City to Inuvik and will connect with the Mackenzie Highway.

Recent gas and oil exploration activity in the Mackenzie Valley and Western Arctic used existing transportation systems in the region, which has helped these systems to expand to their present capacities. The nature and level of future petroleum development will clearly have an important influence on the future development of these transportation systems. Implementation of either pipeline proposal will involve major expansion in existing transportation capabilities.

The Pipeline Project: Its Scope and Scale

Two companies, Canadian Arctic Gas Pipeline Limited and Foothills Pipe Lines Ltd., are competing for the right to build a pipeline to bring natural gas through the Mackenzie Valley to markets in the South. Arctic Gas propose to build a pipeline from the Prudhoe Bay field in Alaska across the Northern Yukon to the Mackenzie Delta, to join with their pipeline extending south from the Mackenzie Delta gas fields. The Foothills proposal is for a pipeline southward from the Mackenzie Delta only.

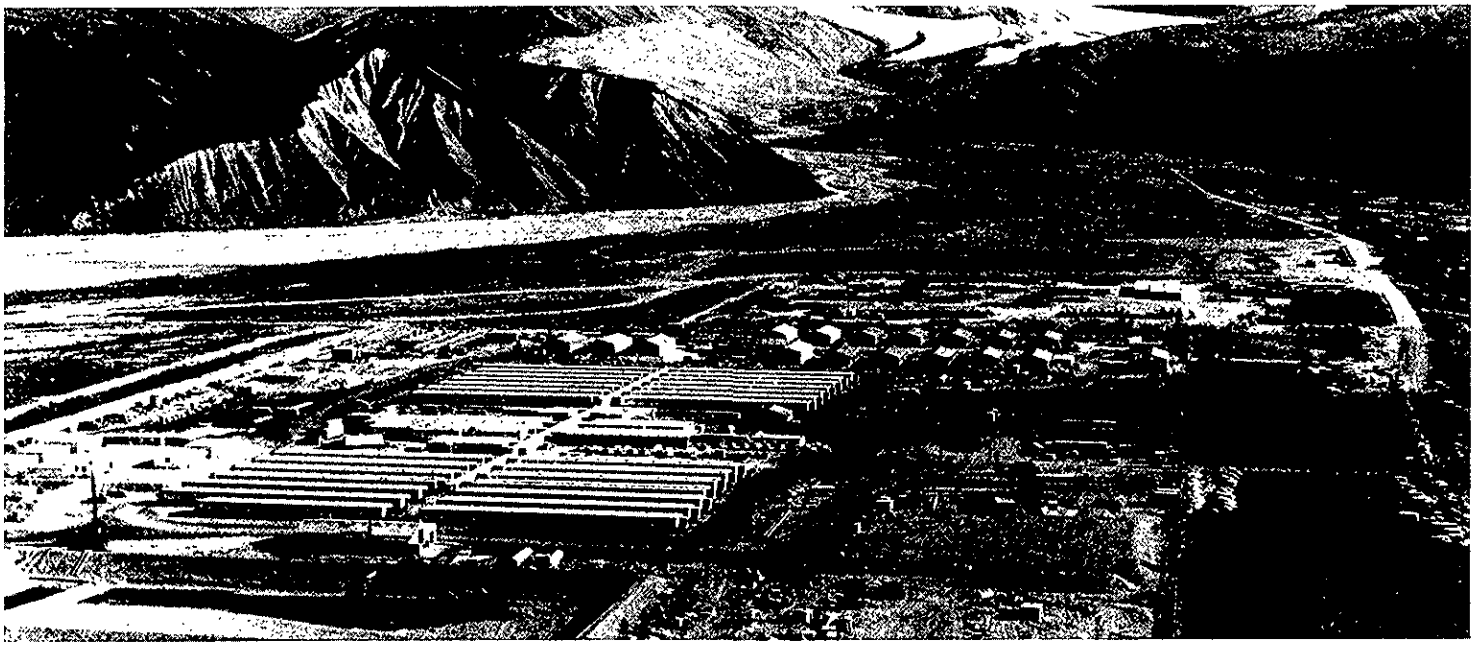
The Arctic Gas group is a consortium of Canadian and American producers and gas transmission and distribution companies. Imperial, Gulf and Shell, the three principal gas producers in the Mackenzie Delta, are members of the consortium, as well as TransCanada Pipe Lines, Canada's largest gas transmission company. The Foothills Pipe Lines group is made up of two companies, Alberta Gas Trunk Line and West Coast Transmission, the largest gas transmission companies in Alberta and British Columbia.

The pipeline that Arctic Gas and Foothills propose to build presents quite novel problems of science, engineering and logistics. Either pipeline will be very long, and will carry enormous volumes of gas. But these are not unique characteristics: what makes either pipeline unique from an engineering point of view is that it will be buried in ice-rich, permanently frozen soil – permafrost – and the gas transported in the pipe will be refrigerated. The pipeline is to be built across our northern territories, a land that is cold and dark throughout the long winter, a land that is at present largely inaccessible by road or rail, and through which a large infrastructure of roads, wharves, airstrips and other work sites must be built. The pipeline's impact will not, therefore, be confined to its right-of-way.

Unique Aspects of the Project

The pipeline that Arctic Gas propose to build would be longer than any pipeline in the world: it is 2,400 miles from Prudhoe Bay to the Lower 48. Pipelines have, of course, been built over great distances in the past. The 31-inch trans-Arabian pipeline (now abandoned) from Abaiq Field in Arabia to Sidon in Lebanon is 1,047 miles long; the 36-inch Colonial pipeline from Houston to New Jersey is 1,531 miles long. And pipelines have been built and are being built today across difficult terrain and in northern latitudes. The trans-Andean pipeline crosses one of the most rugged mountain ranges in the world, and the trans-Alaska pipeline crosses three mountain ranges. Some of the biggest pipelines in the world have been built in Siberia, and both these and the trans-Alpine pipelines were constructed in severe climatic conditions. But, as we shall see, there is not a great deal we can learn from the experience of the Soviet Union, the United States and other nations that is directly relevant to the design and operation of a buried refrigerated pipeline.

Normally, gas flows through a pipeline at temperatures above freezing. Compressors drive the gas through the pipe, and the process of compressing gas makes it hot. If the pipeline is buried in permafrost, heat from the gas will thaw the ground around the pipe. Such thawing could lead to severe and costly engineering and environmental problems where the soil contains any appreciable quantity of ice. Problems arising from



progressive sinking of the ground, blocking of drainage, erosion or slope failure could damage or rupture the pipe. To avoid these problems, both Arctic Gas and Foothills propose to chill the gas passing through the pipeline so there will be no heat loss to melt the permafrost. Chillers will, therefore, be needed to extract the heat generated by compression before the gas goes into the pipeline and through the permafrost.

A pipeline running south from the Mackenzie Delta along the Mackenzie Valley must cross about 250 miles of continuous and about 550 miles of discontinuous permafrost. It cannot avoid long stretches of ice-rich soil in both zones of permafrost. A pipeline across the Northern Yukon would lie entirely within the zone of continuous permafrost. Thus, neither the Arctic Gas nor the Foothills proposal can avoid the problem. They must either refrigerate a pipeline through the permafrost or, at much greater cost, lay a pipeline on the ground or elevated above it. Now, if a chilled and buried pipeline passes through ground that is not frozen, it will freeze the ground around it. This change may lead to a build-up of ice in the ground around the pipe and may cause the pipe to move upward. This is known as frost heave.

Magnitude of the Project

A pipeline through the Canadian North has been likened to a string across a football field. This simile is misleading and is indicative of a utopian view of pipeline construction. Of course, the area required for the right-of-way, compressor stations, and ancillary facilities is miniscule when measured against the great mass of the Canadian North. Although Arctic Gas propose to lay 1,100 miles of pipeline across the Yukon and Northwest Territories, their total land requirement for the right-of-way and related facilities is only about 40 square miles. Such a figure gives a mistaken impression of the magnitude of the construction project. It is not just a 120-foot right-of-way.

The estimated cost of the Arctic Gas project within Canada now stands at about $8 billion. A network of roads largely of snow and ice must be built. The capacity of the fleet of tugs and barges on the Mackenzie River must be greatly increased. Nine construction spreads and 6,000 construction workers will be required North of 60 to build the pipeline. Imperial, Gulf and Shell will need 1,200 more workers to build the gas plants and gas gathering systems in the Mackenzie Delta. There will be about 130 gravel mining and borrow operations, and about 600 water crossings. There will be about 700 crawler tractors, 400 earth movers, 350 tractor trucks, 350 trailers and 1,500 trucks. There will be almost one million tons of pipe. There will be aircraft, helicopters, and airstrips. Arctic Gas propose to use about 20 wharf sites; and plan to build about 15 STOL airstrips of 2,900 feet each and five airstrips of 6,000 feet each. Carson Templeton, Chairman of the Environment Protection Board, has likened the building of a pipeline in the North in winter to the logistics of landing the Allied forces on the beaches of Normandy. The pipeline's effects will be felt far beyond the area of land across which it is built.

I have visited the trans-Alaska pipeline project, and it has given me some idea of the scale of activity that construction of a pipeline in Northern Canada would entail. Construction of the trans-Alaska oil pipeline began officially in April 1974. To transport oil from Prudhoe Bay on the northern coast of Alaska to the southern Alaskan port of Valdez has required, in addition to the construction of an 800-mile-long, 48-inch diameter pipe, the construction of a 360-mile-long gravel road, bridges over 20 major streams, a 2,300-foot bridge over the Yukon River, three permanent airfields, eight temporary airfields, 15 permanent access roads, numerous temporary access roads, 19 construction camps, 12 pump stations, and oil-storage and tanker-loading facilities. The project is expected to cost approximately $8 billion, and the estimated completion date is mid-1977.

Flying low along the route of the trans-Alaska pipeline, south from Prudhoe Bay, you can see the extent of activity: construction spreads, pump station sites, hovercraft on the Yukon River, trucks on the haul road, the right-of-way itself. At Prudhoe Bay, the oil wells and gathering facilities stretch outward for miles, and they give you some idea of how similar facilities would alter the landscape of the Mackenzie Delta.

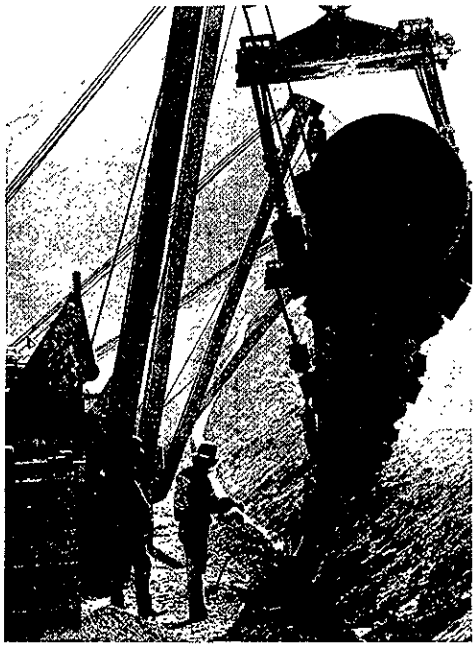
The Mackenzie Valley pipeline, according to the proposal of Arctic Gas, would be the greatest construction project, in terms of capital expenditure, that private enterprise has ever undertaken, anywhere. We have been told by Vern Horte, President of Arctic Gas, that if the pipeline is built, it is likely that it will be fully looped over time – that is, by building loops between compressor stations, a second gas pipeline would ultimately parallel the original one. But looping would not begin until the original system is fully loaded, and that, we were told, will not happen until its fifth year of operation.

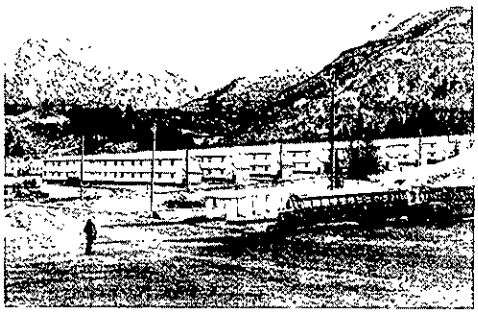
Twelve-hundred man construction camp on the trans-Alaska pipeline. (Alyeska)

Welding pipe on the trans-Alaska pipeline. (E. Weick)

Pipe being laid in ditch, trans-Alaska pipeline. (Alyeska)

Bunkhouses for workers at the Valdez terminal of trans-Alaska pipeline. (E. Weick)





Pipe Size and Pressure

The Arctic Gas pipeline, by tapping both the Prudhoe Bay and Mackenzie Delta gas fields, would carry much more gas than the Foothills pipeline. The Arctic Gas proposal is, therefore, for a larger pipe than that proposed by Foothills, and it will be operated at a higher pressure.

To carry very large quantities of gas, Arctic Gas propose to use 48-inch diameter pipe made of steel 0.720 inches thick and operated at a maximum pressure of 1,680 pounds per square inch. At this pressure, the pipe can carry 4.5 billion cubic feet of gas per day, which is more gas than Canada at present consumes each day. This pipe is bigger in diameter than any existing gas pipeline in North America, although there are 48-inch and 56-inch gas pipelines in the Soviet Union. There are oil pipelines of this size in North America: both the Alyeska oil pipeline and loops on the Interprovincial oil pipeline are 48 inches in diameter. The pressure of 1,680 pounds per square inch is substantially higher than that of ordinary gas pipelines in Canada, and even the 48-inch and 56-inch gas pipelines in the Soviet Arctic reach pressures of only about 1,000 pounds per square inch. Of course, the pipe to be used by Arctic Gas is designed to withstand this high pressure, and the pressure complies with Canadian standards for the maximum operating pressure in such pipe. Nonetheless, Arctic Gas are sufficiently concerned by the possibility that the pipe might crack under pressure, that they plan to surround the pipe with steel reinforcing bands or "crack arrestors" at intervals of about 300 feet.

Foothills say that the system proposed by Arctic Gas is novel and untried, whereas the system they propose will use conventional techniques. Foothills propose to use 42-inch diameter pipe made of steel 0.520 inches thick and operated at a pressure of 1,220 pounds per square inch, although that pressure can (and might) be raised to 1,440 pounds per square inch. The higher pressure is the maximum operating pressure for this 42-inch pipe, according to Canadian standards, and Foothills say they will use the lower pressure for safety. Pipe of the size chosen by Foothills is already used by TransCanada Pipe Lines and Alberta Gas Trunk Line in sections of their gas pipelines, but at pressures lower than that proposed by Foothills.

Existing Pipelines in Permafrost Areas

Pipelines have been built across permafrost areas of Alaska and the Soviet Union, and short sections of the Pointed Mountain pipeline on the British Columbia-Yukon-Northwest Territories boundary cross permafrost. Although we can learn about permafrost and northern construction from these projects, they are of little help in assessing the proposals before this Inquiry to bury a refrigerated gas pipeline in ice-rich permafrost soils.

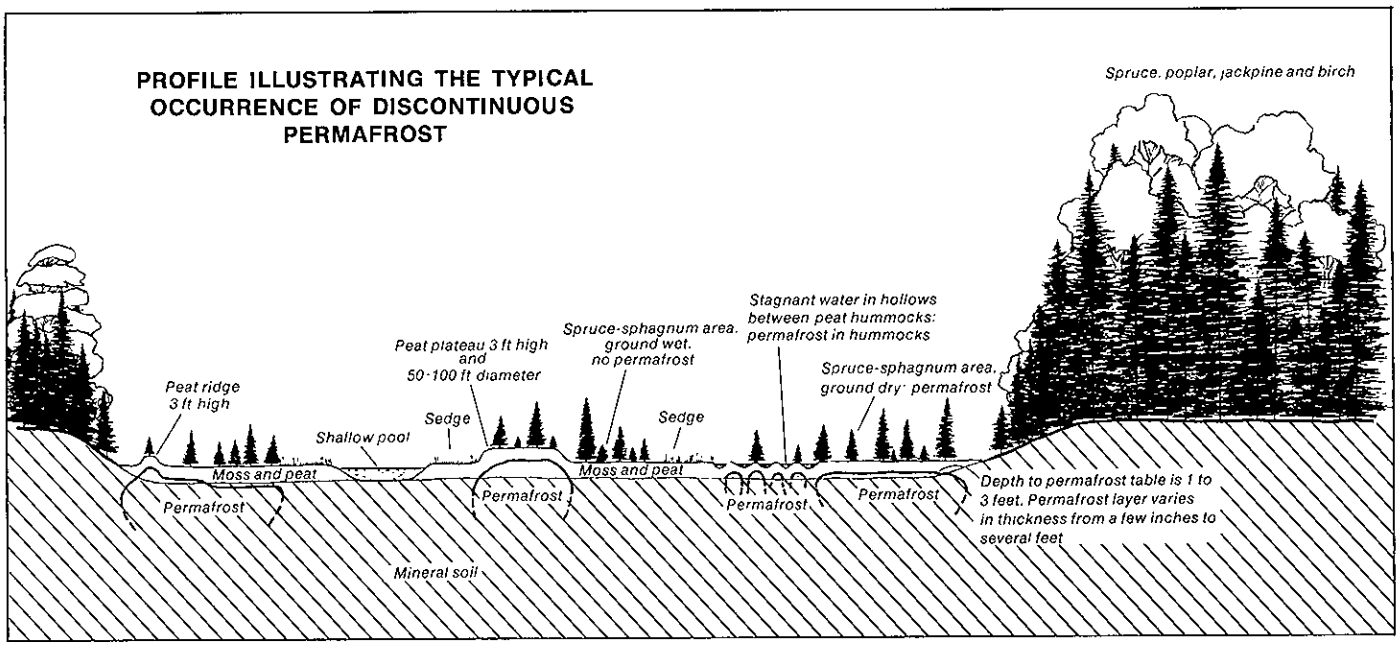
Let us look first at the Soviet experience. Gas pipelines in the Soviet Union are usually buried, but in permafrost regions they may also be elevated on piles or placed on the ground surface in a sand mound or berm. Elevated-pile construction is used across ice-rich permafrost terrain, berm construction is used where the permafrost terrain has moderate-to-low ice content, and burial is used only where the soil is sandy and dry or unfrozen.

There are three pipeline systems in the Soviet sub-Arctic, but none has yet been built north of the tree line. The oldest of these pipelines was built between 1966 and 1968 from Tas Tumus to Yakutsk in Eastern Siberia; it is 300 km (190 miles) long and 500 mm (20 inches) in diameter. The northern half of it crosses what appears to be ice-rich permafrost terrain and is built on piles; the southern half is buried. The line was later extended about 100 km south to Bestyakh and Pokrovsk; this section is apparently almost entirely elevated.

The Messoyakha-Norilsk system in the north part of West Siberia comprises two 730-mm (29 inches) lines, each 265 km (165 miles) long. The first was built between 1968 and 1970, the second between 1971 and 1973. The system crosses an area of discontinuous permafrost and is elevated on piles. In 1972, a 730-mm (29-inch), 35-km (22-mile) extension was built on piles from the Soleninskoye to Messoyakha gas fields.

The most recently built trunk pipeline system in the Soviet Union – the line between Medvezhye and Punga in northwestern West Siberia – is the largest in the Soviet Union in terms of pipe size. It comprises 670 km (420 miles) of 1,420-mm (56-inch) and 1,220-mm (48-inch) diameter pipe. The northern part of this pipeline passes through a region of discontinuous permafrost, where it is partly on the ground in a berm and partly buried. In many places the route of this pipeline avoids potentially troublesome areas of ice-rich permafrost by crossing dry sand plains, where the pipeline is buried. The Medvezhye pipeline, like the others, is operated at temperatures above freezing, but it is planned to refrigerate a short section of it as an experiment.

There is not a great deal that we can learn from the Russian experience. The Yakutsk and the Messoyakha-Norilsk systems are



built on piles above ground, and they are not large-diameter pipelines. Where the Medvezhye pipeline has been buried, it has been routed to avoid permafrost. The Soviet Union, so far, has been able to avoid the vital questions that we must consider in Northern Canada: How can the permafrost be kept from melting? And how can we overcome the problem of frost heave?

What about the trans-Alaska oil pipeline? Alaska, after all, has a permafrost distribution very similar to Canada's, and the problems to be overcome would seem to be similar. But, once again, the experience is of limited usefulness for us. The Alyeska pipeline will carry oil, and oil can be transported in a pipeline only when it is hot. Obviously, such a pipe cannot be buried in permafrost without melting the ice in it, and therefore the trans-Alaska pipeline is elevated wherever it crosses ice-rich permafrost terrain. Elsewhere it is either bermed or buried, depending upon the ground conditions.

The proposed Mackenzie Valley pipeline is a new kind of pipelining venture that will entail innovations in engineering design, construction and operation. Canadian engineers and pipeline contractors have as much northern experience and expertise as their counterparts in any country. Nevertheless, the proposed pipeline will confront engineers and builders with major challenges of engineering and logistics.

Buried Refrigerated Pipeline: Frost Heave

Where the pipeline crosses permafrost, both Arctic Gas and Foothills propose to refrigerate their buried pipeline by chilling the gas to a temperature below freezing. Unfortunately, because permafrost is discontinuous along parts of the route, this ingenious solution to the problem of thawing of frozen ground would create other problems in previously unfrozen ground. The creation of artificial permafrost around the refrigerated pipe could cause upward movement of the ground by a process called frost heave. This movement, if it exceeded certain limits, would damage the pipe.

A great deal was said at the Inquiry about the plans of Arctic Gas and Foothills to prevent, avoid, reduce or control frost heave and its effects, and the two companies were not in agreement on the problem nor on its treatment. I have, as well, heard a great deal of criticism of their plans to control frost heave and I have heard many expressions of concern about the environmental consequences likely to result from inadequate control of this problem. Moreover, in the last weeks that the Inquiry heard evidence, Arctic Gas revealed that, through a laboratory error, they had underestimated the magnitude of the forces causing frost heave, and I learned that they will have to modify the procedures proposed for controlling frost heave.

How important is this specific problem of engineering, a problem that involves concepts of physics about which the experts do not agree? From the beginning, refrigeration of the gas has been regarded as the key to design of the Mackenzie Valley pipeline. This technique, it was claimed, would solve the problems created by the thawing of permafrost and the settling of ground that had forced Alyeska to adopt the expensive elevated construction mode. But the refrigerated buried gas pipeline is an innovation that lacks engineering precedent. Arctic Gas and their engineering consultants have discussed their plan to refrigerate and bury the pipeline with optimism and assurance. I think, however, my own approach should be conservative. I must consider the impacts that can be expected to arise from the construction, operation, maintenance and repair of a buried refrigerated pipeline that must be protected from frost heave.

In my view, the controversy and uncertainty that surround the subject of frost heave and its control reflect adversely on the proposals brought before this Inquiry by both companies. I recognize, of course, that these proposals were in a preliminary, conceptual stage, not in their final design stage. I recognize, too, that important improvements will appear in the final design. Arctic Gas filed their application for a right-of-way in March 1974. They insisted then, that it was essential that the right-of-way be granted within the year. Yet now, three years later, we are still faced with basic uncertainty about this fundamental aspect of their design.

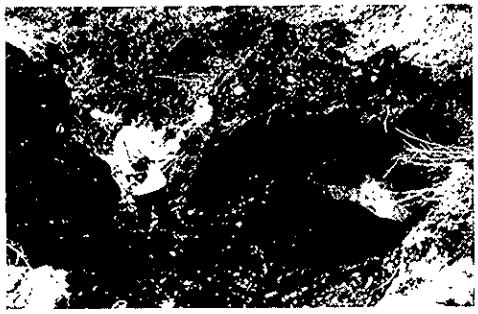
Frost Heave and the Frost Bulb

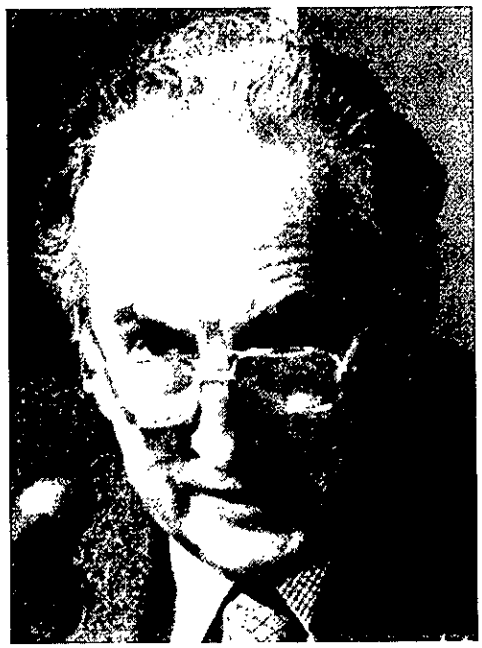
A refrigerated pipeline will experience frost heave and related effects principally in the zone of discontinuous permafrost, which extends southward from Fort Good Hope to the general vicinity of the Alberta border, a distance of about 550 miles. In this zone, the pipeline will repeatedly pass through sections of unfrozen ground that alternate with

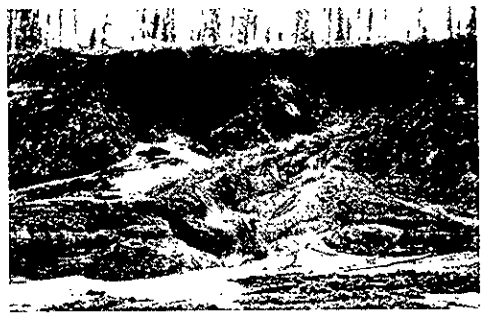
Ice in soil in permafrost area, Inuvik. (R. Read)

Carson Templeton. (Native Press)

Thawing of permafrost caused the soil to liquify and flow, Dempster Highway near Fort McPherson. (GSC–A. Heginbottom)







sections of permafrost. Heave may occur wherever the pipe passes through unfrozen wet ground and the gas in it is kept at a temperature below the freezing point of water. Foothills argued at the Inquiry that the "southern limit of chilling" should be in the neighbourhood of Fort Simpson, but Arctic Gas argued that it should be near the Alberta border. North of Fort Good Hope, in the zone of continuous permafrost, the pipeline would pass through unfrozen ground in relatively few places, principally beneath river channels. The problem of frost heave is not, therefore, widespread in this zone, but it may be serious at river crossings: Arctic Gas say that their present proposed route passes through 17 miles of unfrozen ground beneath the channels of the Mackenzie Delta.

Where the refrigerated pipe passes through unfrozen ground, it will surround itself with a frost bulb, a zone of frozen soil, that will grow outward at first rapidly, then more slowly, over a period of years. It could extend 20 feet or more below the pipe. The frost bulb will cause frost heave in varying degrees, depending on local conditions in the ground, including the nature of the soil, temperature, pressure and availability of water. When soil freezes, two things happen that cause it to expand and the ground to heave. First, water in the soil expands by about ten percent in changing to ice. Second and more important, water in fine and fairly fine soils such as silt or clay may move progressively to the freezing soil, so that the amount of water, as ice, increases in the frozen soil generally in layers. The expanding soil would heave the pipe upward by a distance approximately equal to the sum of all the ice layers that have grown beneath it. If this heave should be uniform all along the pipe, it would raise both the pipe and the ground surface, but it would not buckle the pipe. However, where the amount of heave varies within a short distance, the pipe could buckle or even rupture.

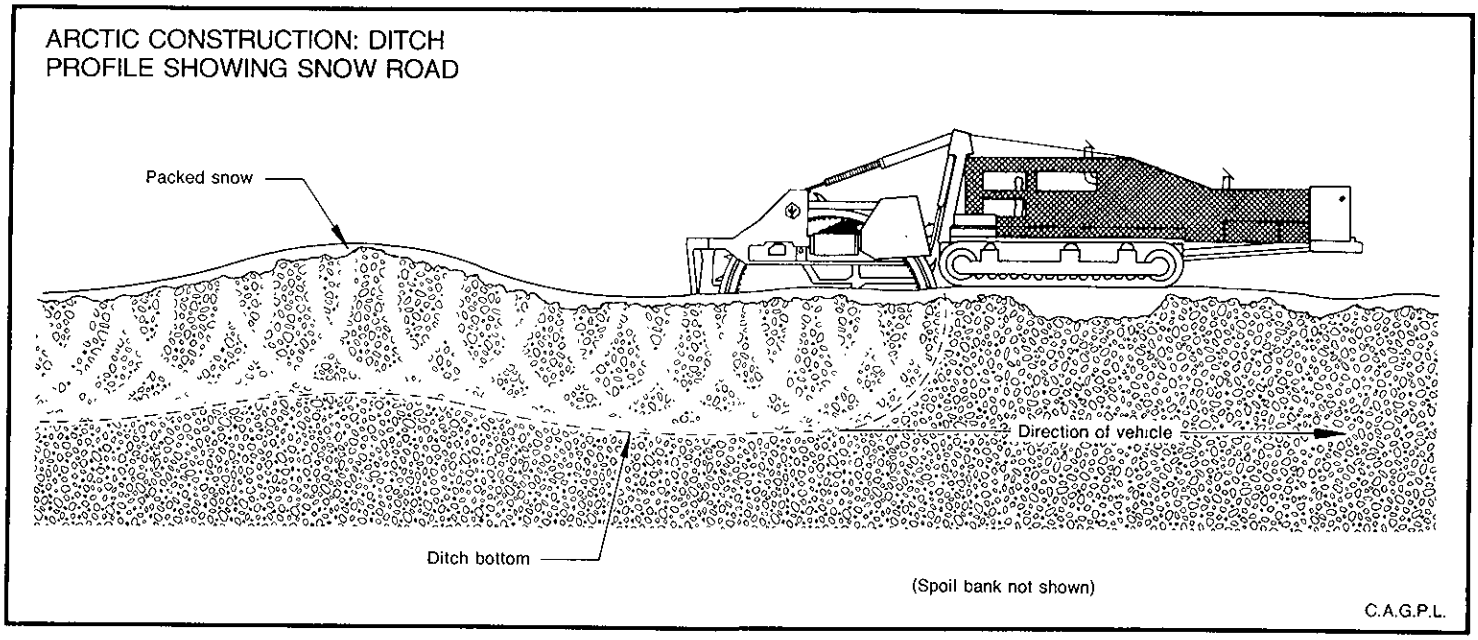
The effects of the growing frost bulb are not limited to frost heave. Carson Templeton of the Environment Protection Board referred to the frost bulb as a wall. It would be a continuous frozen underground barrier that would be created along the length of each section of refrigerated pipe that passes through unfrozen ground. This barrier would block movement of groundwater across the pipeline's route. Ponds or surface icings might be created, or water might begin to move along the pipe or parallel to it. This movement of groundwater on sloping terrain could lead to erosion or slope instability. Also, many river and stream beds are not frozen in winter: when a buried chilled pipeline crosses under a stream that has only a little water flowing in it, the frost bulb could block or divert that flow or create icings.

Controversy over Heave Forces and Control

The processes that cause frost heave are understood in general terms, and so are the soil types, temperature, pressure, and water availability that are conducive to frost heave. Moreover, highway engineers and others have had practical experience in reducing the amount and rate of frost heave by putting a load – gravel perhaps – on the surface to counteract the upward heaving force. Experience in controlling frost heave, however, is limited to situations in which frost builds up during the winter months and then melts in spring and summer. This experience is no precedent for a situation in which frost will build up continuously from year to year. Moreover, there is no unanimity about details of the frost heave process, the magnitude of the forces that are generated, the range of situations in which the problem may be encountered, and – especially – the magnitude of the differential forces to which the pipe might be subjected. Finally, the engineering procedures to reduce or avoid the heaving of a buried refrigerated pipeline over the years are still in a conceptual stage. There has been no practical demonstration of these procedures under the conditions that will prevail in this project.

Arctic Gas have given much attention to frost heave and its related effects on a buried refrigerated pipeline. More than $1 million has been spent on their Calgary test site and on associated experiments. The impressive panel of geotechnical experts brought before the Inquiry in the spring of 1975 by Arctic Gas indicated that they fully understood the frost heave phenomenon and its effect on the pipeline, and that they had complete confidence in the methods they proposed for its control. They gave assurances that frost heave could be reduced to an acceptable level by loading – either by deep burial or by a built-up berm or by both – without substantial environmental impact. Dr. Ken Adam, on behalf of the Environment Protection Board, and Dr. Peter Williams, of Carleton University, who was called by Commission Counsel, disagreed with the opinion of the Arctic Gas panel. Williams in particular disputed the theoretical and experimental basis of the analysis made by the Arctic Gas experts, and he indicated that the magnitude of the heave forces had been underestimated:

> In my opinion, the maximum shut-off pressures that would be required to prevent deleterious heaving during the life of the pipe are greater than those that have been stated. Correspondingly, at problem sites, such as



> transitions between different types of materials where the possibilities of differential heave damaging the pipe are greatest, conditions will be more difficult than that described by the Applicant's witnesses. Particularly in the region of discontinuous permafrost, it appears that freezing induced by the cold pipeline could give rise to pipe deformations greater than the Applicant's maximum permissible curvature of the pipe. [Summary of evidence, filed July 8, 1975, p. 2]

Arctic Gas disagreed fundamentally with the position taken by Williams, which their counsel summarized as follows:

> Dr. Williams' thesis is that a chilled pipeline, such as that proposed by Arctic Gas, is going to produce many times more heave than our evidence predicts, and that we will not be able to suppress this heave with types of burial or surcharging that we propose. [F10825]

Arctic Gas then brought forward another panel that strongly challenged Williams' thesis and emphasized that the position of Arctic Gas remained unchanged. Williams in turn maintained his position.

About a year later, in October 1976, Arctic Gas informed the Inquiry that there had been a continuing malfunction in the test apparatus they were using to determine frost heave. This discovery, which had been made by the Division of Building Research of the National Research Council, indicated that the measurements of frost heave pressures upon which Arctic Gas had relied were erroneous: the pressures that had been measured were, in fact, less than the correct pressures. At that date, Arctic Gas did not know the magnitude of the heave forces that the refrigerated pipeline would encounter under severe conditions, and they admitted that, in some situations, burial or surcharge would not be able to suppress heave. Counsel for the company stated:

> Arctic Gas believe that there are some soils in which the heave pressure is larger than can be controlled by deep burial and/or surcharge. [F31491]

Counsel went on to list five other methods that are available to control the problem: insulation of the pipe, insulation of the pipe with heat trace (heating cable), operation of the pipe at temperatures close to 32° Farenheit, replacement of frost-susceptible soil, and placement of the pipe with insulation in a berm on the ground surface.

Thus, at the end of the hearings, Arctic Gas had withdrawn from the position they had held so strongly regarding frost heave and its control. The surcharge method they had relied on as the principal means of controlling frost heave was admitted to be inadequate in severe conditions. The five alternative methods of frost heave control were not described in any detail.

The evolution of the plans of Arctic Gas to control frost heave of the refrigerated twin pipes they propose to bury beneath Shallow Bay, a four-mile crossing in the Mackenzie Delta, provides a graphic illustration of the uncertainties in frost heave control. At Shallow Bay, and at river crossings in general, it is obvious that a berm cannot be used to control heave. In March 1976, the design proposed for the Shallow Bay crossing indicated that burial of the pipeline 10 feet below the bottom would satisfy frost heave requirements. But further studies led to an increase in the depth of burial: 35 feet was then thought to be required to achieve the necessary overburden pressure. Arctic Gas presented this information to the National Energy Board in June 1976. After the fault in the test equipment was discovered, Arctic Gas told this Inquiry in November 1976 of yet further changes to their plans for Shallow Bay:

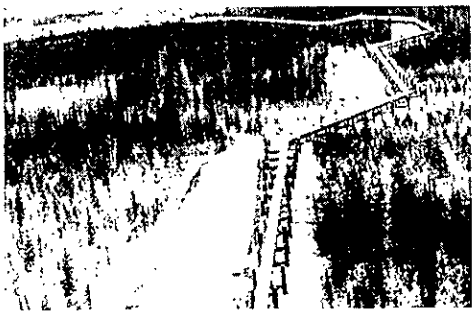
> This [fault] indicated a need for even greater burial depths and gravel borrow if the surcharge method were employed. Further assessment of the data is required to determine the feasibility of this technique. If the surcharge method of design proves to be not feasible, alternative designs as put before the Berger Commission on October 15, 1976, will be applied. Two alternatives are feasible: one involving the use of insulation and replacement of frost-susceptible soil . . . and the other . . . insulation of the pipe with heat trace. [Exhibit F891, p. B-13]

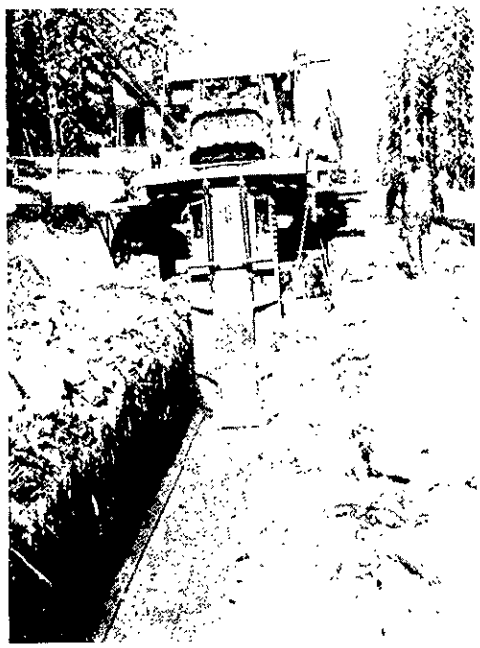
In view of these uncertainties, it is not surprising that counsel for Arctic Gas said that this Inquiry is not in a position to offer any specific findings in this regard.

In February 1977, Arctic Gas filed with the National Energy Board further evidence regarding their plans for controlling frost heave in which they conceded that, for virtually all soils to be crossed by the refrigerated buried pipe, the depth of burial and the height of the berm required to control frost heave would exceed practical limits. They had found that they could not, as a practical matter, bury the pipe deep enough nor build a berm high enough to control frost heave. Moreover, Arctic Gas indicated, for the first time, that frost heave would be a problem wherever the refrigerated pipe passes through shallow permafrost. According to their new plans, presented with this evidence, insulated pipe with heat trace would be used in all of the overland sections where the ground is unfrozen or where permafrost is less than 15 feet deep. Heat probes would be used to prevent the build-up of ice lenses where permafrost is 15 feet or more thick. At river crossings, in frost-susceptible soils, a heavy casing would be placed around the insulated pipe and heating cables would also be used.

To reduce the length of pipe requiring frost heave control, the southern limit of

Above-ground section of trans-Alaska pipeline. (Alyeska)
Pipeline ditching machine. (E. Owen)
Pipe in ditch with saddle weights to prevent it from floating, Pointed Mountain. (E. Owen)





refrigeration of the pipe would, according to this modified plan, be moved northward about 160 miles to a point north of Fort Simpson. This 160-mile section would be kept above rather than below freezing, and it would thaw any permafrost that it encounters. To maintain pipe stability when such a thaw occurs, Arctic Gas now propose deep burial of the pipe and, in critical locations, support of the buried pipe on piles fixed in stable material beneath the thawed zone.

Throughout the uncertainties and changes associated with frost heave, Arctic Gas have strongly opposed the use of above-ground pipeline construction. In 1975, Dr. Hoyt Purcell, a witness for Arctic Gas, summarized the company's position as follows:

> After reviewing the pros and cons of above-ground versus buried construction, the Arctic Gas engineers continued to use the buried mode as their prime design technique, and put the above-ground mode on the shelf to be used only in the event insuperable problems with the buried mode emerged. [F3764]

Purcell also said that the cost of a section of pipeline would be increased by 60 percent if two-thirds of its length were built above ground on piles instead of being buried. Arctic Gas told the Inquiry in November 1976 that they do not consider above-ground construction a viable alternative. In February 1977, they still maintained that above-ground construction is greatly inferior to an insulated, heat-traced pipeline buried in frost-susceptible terrain.

Despite the strength of their statements against above-ground construction of the pipeline, Arctic Gas have admitted the possibility of placing short sections of insulated pipe on the ground within a berm to avoid frost heave. Counsel for Arctic Gas referred to this possibility in October 1976; it was raised again before the Inquiry in November 1976, and again before the National Energy Board in February 1977.

Implications

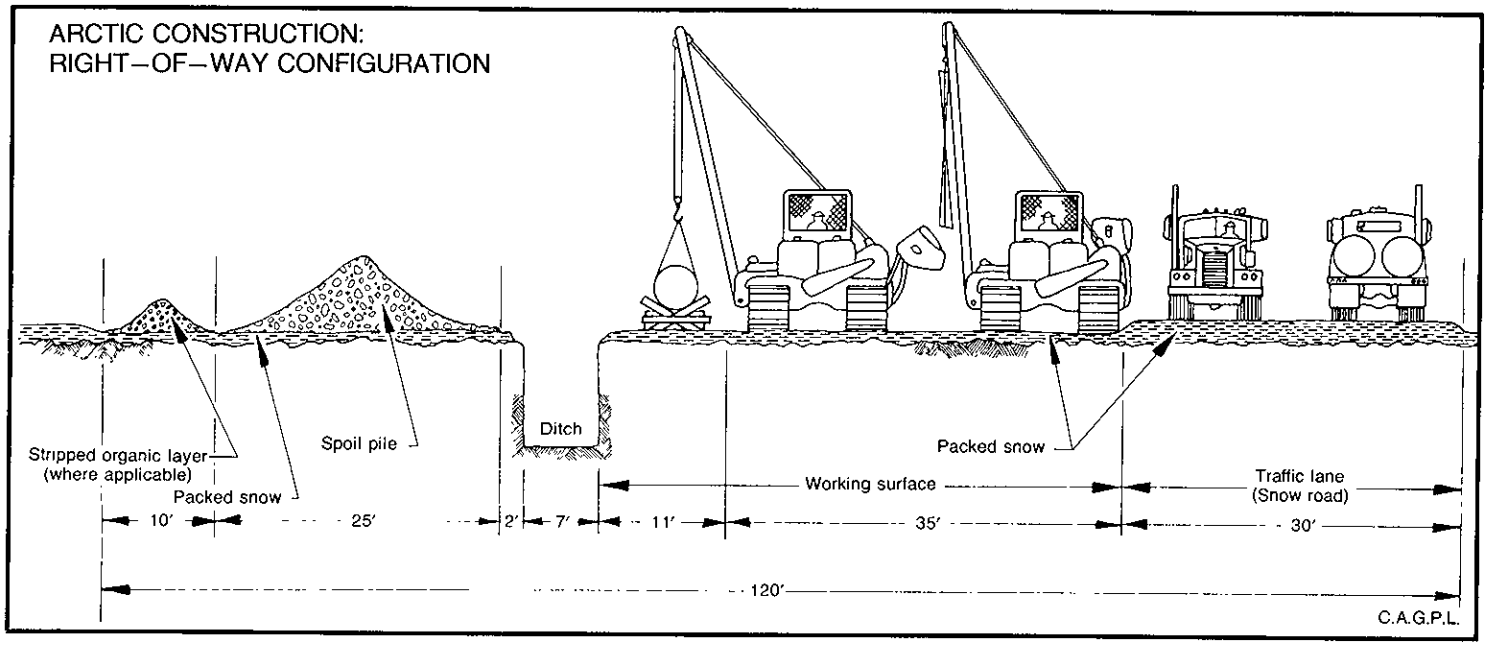
I have reviewed the problem of frost heave in some detail to illustrate two problems: first, the inadequacies in some aspects of the pipeline proposals; and second, inadequacies in the knowledge that is available to the Inquiry and to the government on which an assessment of precedent-setting or innovative aspects of the pipeline engineering must be based.

In considering the original pipeline proposal made by Arctic Gas, the Pipeline Application Assessment Group stated in their report, published in November, 1974:

> The application provides principles and theory but in many respects lacks specifics of the *modus operandi*; it contains frequent assurances that the subject being considered is adequately understood, that designs will be developed to cope with the situations of concern, or that additional studies already planned will remove any uncertainties. [*Mackenzie Valley Pipeline Assessment*, p. 5]

Now, more than two years later, this comment is still applicable. Critical questions remain unanswered. Company officials and consultants continue to express confidence in proposed engineering designs and construction plans and to give assurances that major and precedent-setting aspects of the project are well in hand. The question of frost heave illustrates these unsatisfactory aspects of the present design proposals. The section of this chapter on construction scheduling will provide a comparable illustration. I recognize that the project proposals are still in a conceptual, and not a final, design stage. I also recognize that improvements in them will continue to be made. My concern about the engineering and scheduling aspects of construction relates to my duty to assess and judge the proposals as they now stand. Arctic Gas, at the close of the hearings, argued that the Inquiry was not in a position to make any specific finding with regard to frost heave. I agree. I am not, therefore, in a position to say that the proposals made by Arctic Gas to control frost heave are sound. But I can say something about the reasons why the Inquiry is in this position.

In dealing with frost heave and with other questions of innovative design or construction planning, it has become apparent that much of the specialized knowledge and expertise that is relevant to these matters is tied up with industry and its consultants. This situation is untenable when faced with the need to make an objective assessment of the project. Government cannot rely solely on industry's ability to judge its own case; rather, with respect to questions of fundamental design, government must have the knowledge to make an independent judgment. A contrast has been clearly apparent at the Inquiry between biological issues, where the Environmental-Social Program, the Beaufort Sea Project and related ongoing federal research have provided knowledge and expertise, and engineering issues, where the knowledge and expertise is largely confined to the industry itself. This is in no way a criticism of the advice and information that the Inquiry has received on technical matters. Indeed, it is this advice that has enabled the Inquiry to assess the magnitude and the implications of the frost heave question. But I urge the government to make itself more knowledgeable in matters involving major innovative technology, such as frost heave and other questions related to the burial of pipelines in permafrost, which are and will be involved in northern oil and



gas exploration and development proposals for years to come. Acquisition of this knowledge will necessitate ongoing research and expert scientific staff. Industry proposes, the government disposes. Without such a body of knowledge, the government will not be able to make an intelligent disposition of industry's proposals now or in the future.

The question of frost heave is basic to the theory and design of the pipeline project. If the pipe is to be buried, the gas must be chilled. If the gas is chilled, the result – frost heave – has to be overcome. The pipeline companies are obviously having trouble in designing their proposal to deal with frost heave, and they are making fundamental changes in the methods proposed for heave control. Their methods seem to be getting more complex, and the conditions for success more restrictive. There is every likelihood that the companies will make yet further changes in their proposals, changes that are likely to increase costs further and to alter substantially the environmental impacts that we have been trying to assess. The possibility that for some sections of the pipe, the buried refrigerated mode will be replaced by above-ground berm construction or above-ground pile construction brings with it a host of attendant problems. It seems to me unreasonable that the Government of Canada should give unqualified approval to a right-of-way or provide financial guarantees to the project without a convincing resolution of these concerns.

The Construction Plan and Schedule

Large-scale engineering projects are not unprecedented in the arctic and sub-arctic regions of North America. I have mentioned the large defence-oriented projects that have already been constructed in these regions, such as the Alaska Highway, the Canol Pipeline and the DEW Line. More recently, we have seen the Churchill Falls hydro-electric project in Labrador, the James Bay hydro-electric project in Quebec and, of course, the Alyeska oil pipeline in Alaska. These are all huge multimillion dollar projects in frontier settings. Now we have before us the Mackenzie Valley pipeline proposals of Arctic Gas and Foothills. Why are we so concerned by these proposals?

At the outset, we must bear in mind that the pipeline as proposed is not a simple extension of past defence- and energy-oriented frontier construction projects, nor simply an extension of tested technology to a far northern setting. In my discussion of frost heave, I have already sought to demonstrate the novel engineering aspects of the project. But the innovations – and problems – are not confined to design: the construction plans and proposed schedules for building the pipeline also involve techniques that lack precedent. Even now, before the project is underway, a number of scheduling problems can be discerned that may well compound one another in ways that have not yet been adequately considered by either Arctic Gas or Foothills. The natural and logistical constraints that the project will encounter could make the present approach to its construction optimistic and, in some respects perhaps, unrealistic.

The environmental, social and economic assessments made by the pipeline companies were carefully predicated on the assumption that the project would, in fact, be built as proposed. However, it should be plain to anyone that every substantial modification in the schedule or in the methods of construction will alter these impacts.

Let me outline some of the features of the construction plan that are novel and that may pose problems. Each of them could lead to difficulties in adhering to the construction schedule. Each of them could force changes in the project. When taken together, these changes could present us with a project that has become so different from the one originally proposed that we should question the basis of the present assessments of impact. This concern is greatest along the Arctic Gas route across the Northern Yukon where the schedule is likely to be most susceptible to upset and where the environment is highly sensitive to impact.

Snow Roads

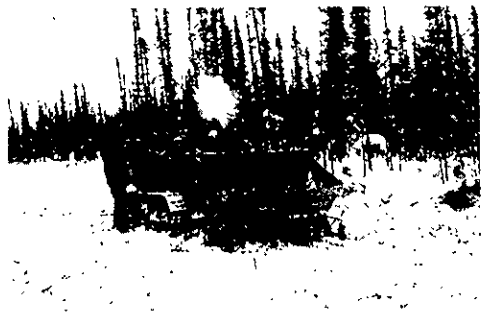
Except for pre-construction activity, and for construction of major water crossings and compressor stations, the companies intend to build the pipeline in winter. Winter pipeline construction is not new: it is now almost standard Canadian practice because it allows heavy equipment to be moved along a right-of-way when the ground is frozen, making the construction of all-weather roads unnecessary. Such roads are expensive and could result in greater environmental and social impact than the pipeline itself.

This pipeline project is different because the continuous or discontinuous permafrost that underlies its entire route North of 60 precludes the standard approach to winter

Arctic Gas snow road test loop. (W. Sol)

Les Williams, Northern Engineering Services. (Arctic Gas)

Snow road construction at test site. (K. Adam)



grading and right-of-way preparation. Measures must be taken to protect the ground surface from damage that would lead to thermal degradation of the permafrost. To protect the ground surface, both companies propose to use snow roads and snow working surfaces, which are subtle but important variations on winter road construction practices that are common in Northern Canada. Winter roads are of snow pack or ice construction or are cleared rights-of-way along frozen waterbodies. The Denison Ice Road, which runs from the Mackenzie Highway near Rae north to Great Bear Lake, the winter road that used to run northward along the Mackenzie Valley from Fort Simpson in the early 1970s, and the roads the oil companies and their contractors have recently been using in their Delta exploration programs are examples of conventional winter roads.

The snow roads proposed for the pipeline project are a more sophisticated version of these common winter roads, and are designed to protect the vegetation, and hence the permafrost, from heavy traffic. Access roads from stockpile sites, water sources, borrow pits and camps to the pipeline right-of-way are expected to have as many as 45,000 vehicle passes in one season, and haul roads along the right-of-way will have about 29,000 passes. This volume of traffic requires a higher standard of construction than is necessary on conventional winter roads. Thus the proposed snow roads will consist of a densely compacted snow pavement over the naturally frozen but undisturbed ground surface. Adjacent to the snow road on the right-of-way there will be a snow working surface along the ditch line; it will be similar to the snow road but its pavement will be less densely packed because it will need to sustain only a few passes of slow-moving equipment.

Both Arctic Gas and Foothills propose to build hundreds of miles of snow roads, and the whole pipeline construction schedule will depend on their availability. Yet lack of experience with them has led to a number of criticisms about their potential usefulness, particularly in tundra areas.

Arctic Gas undertook at an early stage to verify the practicability of the snow road concept. Preliminary tests at the Sans Sault Rapids and Norman Wells test sites were, as Les Williams, Director of Field Services for Northern Engineering Services Company Ltd., said, "not too successful" and were "not completely valid." [F4306] In 1973, Northern Engineering Services built an experimental snow road at Inuvik to verify the viability of the scheme in the more northern latitudes where the problems would be greater. A test section about three-quarters of a mile long was prepared but, because of low snowfall, snow had to be harvested from a nearby lake and hauled to the site. Snow manufacturing also was tried with some success. Once in place, the snow was compacted to achieve the necessary pavement density, and trafficability tests were conducted in winter and spring by making successive passes with a loaded truck. Follow-up observations made on the vegtation beneath the road revealed that the ground surface was relatively undisturbed.

Arctic Gas concluded that densely packed snow roads will be able to withstand heavy traffic and to protect sensitive terrain from disturbance. But not everyone shared their view. Walter Parker, Commissioner of Highways for the State of Alaska, and Dr. Robert Weeden of the State Governor's Office told the Inquiry that, despite the results of the test at Inuvik, they did not think the feasibility of snow roads had been demonstrated, particularly for use on the Arctic Coastal Plain. In their opinion, snow roads should be regarded as operationally unproven. Others, such as Dr. Ken Adam of the Environment Protection Board, and Paul Jarvis, a witness for Foothills, also expressed reservations, although they did not criticize the concept as severely.

In my view, the issue is not whether snow roads, once in place, will work. Canadian engineers have had ample experience with winter roads, airstrips and snow-surfaced work areas. Rather the dispute hinges on two questions. The first relates to timing, and the second to the sufficiency of snow.

The timing question is this: can the snow roads be ready early enough and can they be used long enough to enable the construction to be completed on schedule? After all, they must be prepared before pipeline construction can begin, and construction cannot continue after the roads begin to melt. There is a definite "window" for winter construction, limited on each side by freezing and thawing temperatures. The construction season cannot be extended beyond it: additional men and equipment would be of no help once the season has ended.

If the pipeline company tries to adhere to a fixed schedule in preparing snow roads, there could be considerable unnecessary damage to terrain and disruption of construction plans. Schedules must take into account regional and annual variations in climate, snowfall and frost penetration. Before snow roads can be prepared in the fall, the ground must be frozen deep enough to support heavy vehicles and there must be sufficient snow to protect the surface vegetation. Frost penetration varies from place to place and from year to year. Streams, drainage channels and wet areas will delay road

preparation because they freeze more slowly than intervening areas. If it is impossible to wait until the frost has gone deep enough in wet areas to support the movement of vehicles, temporary crossings will have to be built.

Construction activity in the spring will also be of great environmental concern. There will be compelling reasons to try to extend the use of snow roads as long as possible, particularly if the work is running behind schedule. But the shut-down date of a snow road is completely dependent on the spring weather, which varies substantially from year to year. Construction activity must be able to stop at short notice without harm to the environment.

If scheduled work cannot be accomplished in the period prescribed by nature, it will either have to be postponed until the next season or, as in Alaska, a permanent gravel road-and-working surface will have to be built to permit summer construction. Either way, the schedules and costs of construction would be changed, and the impact of the project would be increased. Arctic Gas maintain that such alterations will not be necessary. Foothills dispute that claim; late in the Inquiry, they told us they propose to build 50 miles of gravel road along the northern end of their right-of-way, to enable them to proceed whether or not temperature and snowfall allow construction of snow roads early in the season.

The second question about snow roads is this: will the snowfall early in the season be adequate for building the roads, and, if not, can sufficient snow be gathered or manufactured in an environmentally acceptable manner? The farther north you go along the proposed pipeline route, the less snow there is. The average annual snowfall of the Arctic Coastal Plain of the Yukon is less than half that of Northern Alberta. So, at the northern end of the pipeline route, the longer winter construction season is offset by lack of snow.

Thus, construction of snow roads will be most difficult in the tundra regions, mainly because of the light snowfall there. The proposed Arctic Gas Coastal Route across the Northern Yukon is the principal area of concern in this regard. Arctic Gas say that, in such regions, they will supplement natural snowfall by using snow fences to catch snow, by harvesting snow from lakes and hauling it to the road bed, and by mechanically manufacturing snow and blowing it onto the roads and work surfaces. But the winter winds sweeping across the treeless landscape will further complicate the harvesting and accumulation of snow for roads.

Along the Coastal Route snow will have to be harvested from a multitude of lakes and then hauled to where it will be used – an activity that will require extensive movements of equipment and networks of secondary snow roads (and thus even more snow). Vehicles and equipment will have to be kept in the area over summer to be available on site in the fall, and snow fences will have to be strung in the fall. Snow fences have not yet been tested on a scale and in locations similar to those proposed, nor has there been any field research on their potential effects on wildlife.

The plans for manufacturing snow also involve uncertainties. Snow making is common practice on ski slopes, and it has been used to a limited extent to make snow surfaces on airstrips, but it has never been used on the scale proposed by Arctic Gas. The experimental snow road in Inuvik used what Les Williams described as a "gerry rigged apparatus." The snow-making equipment to be used on the Arctic Gas Coastal Route does not yet exist – we were simply shown an artist's conception of a large vehicle, with a big compressor and up to six snow-making nozzles. This machine will be fed by fleets of tanker vehicles, which will in turn require an extensive network of snow roads to acceptable water sources. The snow-making machine will require up to 1,000 Imperial gallons of water per minute. Williams said that if the snow road and working surface had to be fully manufactured, about 1.75 million Imperial gallons (50,000 barrels) of water per mile of right-of-way would be needed.

This program of harvesting and manufacturing snow for roads and work surfaces is obviously a very extensive operation and Arctic Gas have tended to understate the problems involved. Quite understandably, they hope for an early and abundant snowfall during the winter they build the pipeline from Prudhoe Bay to the Mackenzie Delta. Although they have outlined techniques for harvesting and manufacturing snow, they have not presented a comprehensive plan for the whole range of activities that will be required if conditions are less than favourable.

Our greatest concern about the snow roads centres on the Northern Yukon. There the project faces the greatest environmental sensitivity; there adherence to schedules is most critical. If the snow roads across the Northern Yukon cannot be built according to plan, there could be massive disturbance that would have far-reaching geotechnical and environmental consequences.

Productivity

I began this discussion of the planning and scheduling of construction with snow roads because they determine the length of the winter construction season. Productivity

Machines in darkness of arctic winter day. (DIAND)

Alan Hollingworth and Reginald Gibbs, Q.C., counsel for Foothills. (Native Press)

Vern Horte, President of Arctic Gas. (Arctic Gas)

Pierre Genest, Q.C. and Jack Marshall, counsel for Arctic Gas. (Native Press)

within that season will dictate the success of the schedule. The duration of the construction season lengthens from south to north because of earlier freeze-up and later break-up. But other factors such as cold and dark that affect productivity are more severe farther north. Assuming that the snow roads can be built and used in the time proposed, can the amount of work that each construction spread must accomplish be done during the winter construction season?

The schedule that Arctic Gas propose is based on a winter construction season substantially longer than that proposed by Foothills. According to Arctic Gas, the preparation of snow roads and snow working surfaces across the Northern Yukon can begin in October, and pipelaying can start in early November. Foothills disagree; they say that December is the earliest starting date, but because of the cold and darkness and because the construction crews will insist on a Christmas break, it would be impractical to start work on that segment before the end of January. Arctic Gas say that darkness can be overcome by floodlighting the construction spread. In addition, they will shorten the Christmas break and pay people to stay on the job. Cold and adverse weather such as ice fog, blowing snow and whiteouts will, they agree, pose problems, but they have allowed for some delays in their schedule. They maintain, and so do the union representatives who testified, that the workers can and will work throughout the northern winter.

I heard a great deal of evidence about start-up dates, productivity, shut-down dates, downtime, the effects of cold and darkness, the practicability of lighting an entire construction spread, the working conditions the unions would insist upon, and so on. Out of it all, several main themes emerge that underline the uncertainties in planning and scheduling the pipeline project.

Winter conditions, of course, will affect productivity. Arctic Gas estimate that, along the Yukon Coastal Plain, winter productivity will be only 60 percent of what it is for summer pipeline construction on the prairies, although in the southern part of the Northwest Territories, productivity will reach about 90 percent. In preparing their construction schedules, they allowed for break-up, freeze-up, holidays, bad weather, darkness, low temperatures and downtime for environmental reasons. But, as Williams pointed out, their downtime evaluations did not include allowances for wind chill and limited visibility.

The unions and the workers will also have something to say about productivity. The labour representatives who appeared at the Inquiry said that there will be a no-strike no-lockout agreement. They said that work in severe weather can be undertaken, and specific conditions will be on a business-like basis with the contractor on the job – but unresolved and unquantified is the whole issue of downtime caused by labour disputes. Despite assurances from the company and the unions, it seems obvious that there are limits beyond which the workers will not go.

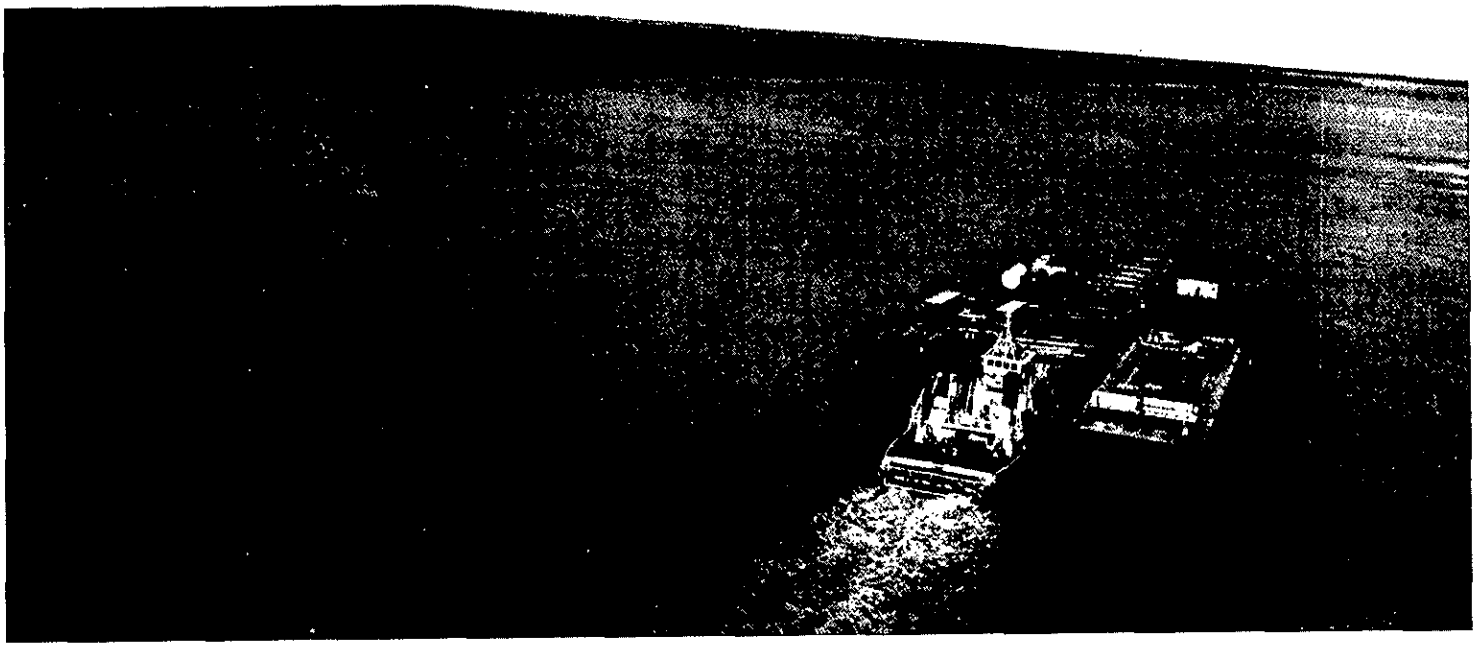
Innovations in equipment will also be required. The ditching machine, for example, is still being developed and so are some of its components such as the ditcher teeth. There is only one large ditcher in existence, the 710. Arctic Gas say that this ditcher can do 60 percent of the ditching. But this machine has not been used in permafrost, and its teeth appear to be unsuitable for permafrost work. A new ditcher, the 812, is therefore being developed, and new teeth for it are being tested to meet Arctic Gas' requirements. No prototype has yet been built.

Changes in the design of the project could also have an adverse effect on productivity. For instance, the uncertainties about frost heave referred to in the preceding section and the requirements for installing crack arrestors around the pipe have both arisen since Arctic Gas prepared their schedule.

Foothills criticized Arctic Gas' proposal to illuminate artificially a winter construction spread that will involve up to 500 men and 50 pieces of equipment deployed over a two-or-three mile stretch of confined right-of-way. They maintain that work under these conditions would be hazardous to workers – even if it were feasible. The lighting of a moving pipeline spread of this magnitude is in itself novel and quite different from the lighting of fixed and confined operations such as drilling rigs.

Although Foothills have raised important questions about the Arctic Gas proposal, they have not vindicated their own construction plan. As Arctic Gas pointed out, the most significant difference between the two plans lies in the start-up dates of fall construction, not in the productivity per spread. Recently, Foothills have modified their plans for the northern end of their pipeline to include the construction of an all-weather gravel road so that pipelaying can be carried out in the fall, too. This change in itself is of great environmental concern, and it is perhaps an indication of the way in which we might expect the construction plans of either company to evolve.

The schedules of both companies are unproven. There are no precedents by which to judge the winter construction schedule for the northern part of the line. Even if there were, the many unique elements of design would make any comparison doubtful. It has



been said that the trans-Alaska pipeline is a precedent – but that pipeline is a hot oil pipeline built in summer and is fundamentally different in design from the buried chilled gas pipeline that is proposed for the Mackenzie Valley. In fact, Arctic Gas told the Inquiry that the trans-Alaska project is so different from their proposal that any comparison between the two is meaningless.

The Schedule in the Northern Yukon

The problems of snow roads and of productivity will be especially acute on the north slope of the Yukon, and it is right to ask whether Arctic Gas can build a pipeline from Alaska across the Northern Yukon in one season. Arctic Gas have said that, if experience during the first two years of pipelaying in the Mackenzie Valley indicates that they will encounter greater difficulty on the north slope than they now envisage, and if they think the pipeline from Alaska could not be built on schedule, they will establish two additional construction spreads, one in Canada and one in Alaska. But this approach – overcoming the forces of nature with more money, more men, and more equipment – clearly has limits. The extreme environmental sensitivity of the Northern Yukon that I will describe in a subsequent chapter will impose severe limits on any *ad hoc* response to construction problems.

If the pipeline across the Northern Yukon cannot be built in one winter season, there will be great pressure to extend the work into summer and to build a gravel road rather than to postpone further construction until the following winter. Only by this means will a heavy financial penalty be avoided. But once a permanent road is in place, the likelihood is that it will be used for maintenance and repairs and will form an integral part of corridor development. This will open up the wilderness of the Northern Yukon, exposing caribou, snow geese and other species to impacts that will go well beyond the impact of pipeline construction itself.

Logistics

The Arctic Gas project will require approximately two million tons of materials to be transported from southern supply points to northern stockpile sites scattered along the pipeline route. Summer barging on the Mackenzie River and, to a lesser degree, along the Arctic coast will be relied upon to deliver the material. The deluge of construction materials – pipe, fuel, camps and equipment – will require a doubling of the capacity of the river barging system. Virtually a whole infrastructure of wharves, stockpile sites, staging areas, haul roads, camps and communication systems must be installed by the company before the pipeline can be built.

Winter construction will depend, therefore, on a short summer shipping season. If there are delays in summer transportation, the winter construction program may well be disrupted, forcing the companies to ship goods by the Dempster Highway, or by winter road from Fort Simpson to Inuvik, or by aircraft. These alternatives would be of only limited value in major freight movements, and they could involve substantial social and environmental impacts.

The vulnerability of the construction schedule goes right back to the suppliers involved. Delays in delivery caused by strikes or slowdowns by southern transportation facilities, such as railways, ports and trucking operations, could seriously impede the construction program. This dependence on suppliers and on logistics is common to all construction projects – so why the great concern here? The answer is that the construction plan and schedule of this particular project are based on a "winter-only" construction program. And its success depends on the shipment of supplies from the South during a short, inflexible "summer-only" transportation season.

All large construction projects operate according to definite schedules, and there is every reason to believe that this project would use the most sophisticated techniques of planning and management to assure success. But there are limits to what any one company or union – or even government – can do. A series of relatively small, unforeseen, and uncontrollable logistical problems could cause the break-down of the whole supply program.

The logistics plans of both companies include the use of many non-company facilities. For example, they have made various assumptions about the Mackenzie Highway, the Dempster Highway, the Fort Simpson-to-Inuvik winter road, the use of wharf sites and airstrips near communities, and the use of trans-shipment facilities at Hay River. Also, they say that a proposal they both have made to establish a new major trans-shipment facility at Axe Point, near Mills Lake on the Mackenzie River, will extend the barging season and will relieve the pressure on the existing facilities at Hay River. Over the course of the Inquiry, there has been a steady modification of all these plans, partly in reaction to the attitudes of local people, and partly in response to specific requirements as the designs and plans have evolved. It should not be assumed that the approval of a right-of-way would

Barge on the Mackenzie River. (NTCL)

Building materials being loaded into aircraft. (N. Cooper)

Forty-eight-inch diameter pipe at Sans Sault Test Site. (Canadian Press)

Trucks passing on northern highway. (Native Press)

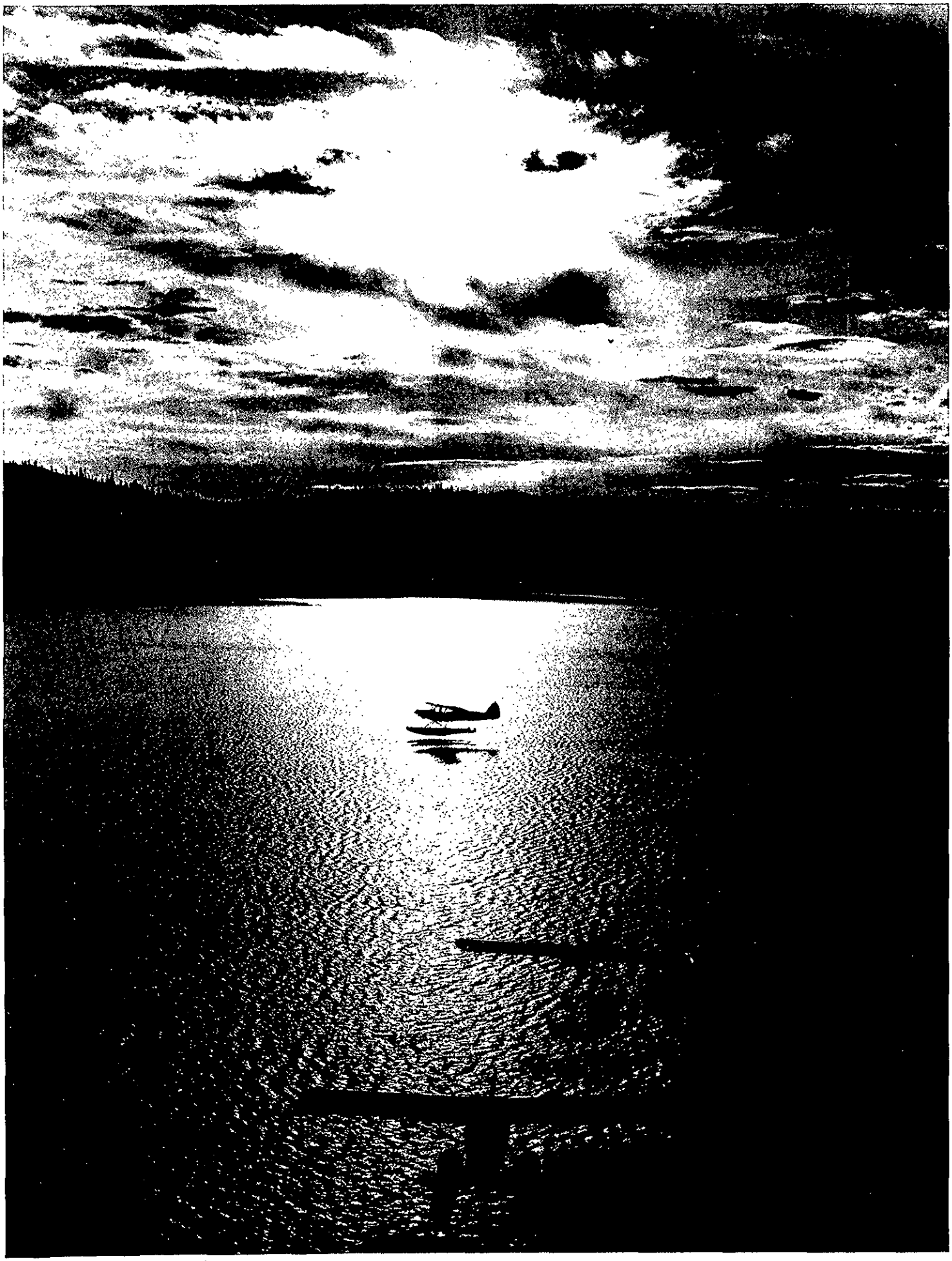
automatically carry approvals of all the logistical details advanced by the companies. For example, it will be necessary to decide if the proposed new facility at Axe Point will serve the immediate and long-term needs of the region. If the Axe Point facility is not approved, how will the limited summer shipping schedule be affected?

Implications

Throughout this Inquiry, we have heard a great deal about the ways the construction schedules could go wrong. In this section, I have reviewed at some length some criticisms of the proposals because of the consequences that a break-down in the construction plans and schedules would have. Scheduling failures will have serious financial implications for the company, its contractors, sub-contractors and workmen; for suppliers, shippers and the whole logistics infrastructure; and for local people and local communities. If the government has guaranteed cost overruns, then the government too will have an important financial stake in ensuring that the project adheres to the planned schedule. If there were a schedule failure and plans had to be changed, all of the parties concerned would react in a way dictated by their own interest. Such reaction could lead to *ad hoc* solutions, loss of quality control, an increase in accidents, and it might become impossible to protect the environment, the local people, and the local economy as originally planned.

I am not confident that the pipeline can be built in accordance with the present plans and schedules. Particularly, I am concerned that scheduling problems in the Northern Yukon could lead to a need for summer construction and a gravel road along the Coastal Route. The environmental impact of this change would be very severe. The project would then have to be completely reassessed, because the premises that were basic to all planning, environmental, social and economic assessments would have changed.

I recognize that the present stage of the companies' planning is preliminary and that, by the time final design and final plans are ready, there may be answers to the scheduling problems that concern us now. But my task is directed to assessment of the proposals in their present form and to the decision that government must make about them now. In this context, it seems unreasonable to me that Canada should give unqualified approval of the pipeline right-of-way or financial guarantees to the project without a convincing resolution of the fundamental concerns over the schedules.



(DIAND Yellowknife—B. Braden)