APPENDIX B

Environmental Implications of Natural Gas Transportation Options in the Northwest Territories

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1.0 Executive Summary

The following report is a summary of environmental implications for proposed pipelines in the Northwest Territories. This report summarizes existing studies on the environmental impacts of alternative pipeline routes for gas transportation from the North: the Alaska Natural Gas Transport System (ANGTS), Dempster Lateral, Mackenzie Valley and The Offshore Beaufort Sea route. This report addresses the potential environmental impacts of the proposed natural gas routes separately and does not attempt to delineate cumulative effects with co-existing activities or generate a comprehensive environmental impact assessment of each alternative. The information reviewed is summarized in tabular format for ease of presentation and comparison. As is typical for the environmental sensitivities related to any pipeline route, CERI organized the material for each pipeline into the following categories:

Additional sensitive issues will include:

- BACKGROUND
- GEOLOGY
- HYDROLOGY
- CLIMATE
- BIOLOGICAL
- UNIQUE AND SENSITIVE AREAS
- CULTURAL

The methodology for completing the "Natural Gas Transportation Options: Environmental Implications" report included review of relevant available literature, searching information available on the Internet, as well as discussions with key informants.

The potential impacts were ranked based on definitions provided by the Canadian Environmental Assessment Agency, Cumulative Effects Assessment Practitioners Guide It is important to note that the scope of this report covers only the potential impacts of the four proposed natural gas pipeline routes based on available literature and it does not address mitigation of these impacts, although some alternative suggestions are made. Mitigation of many of the potential impacts identified in this report have been addressed by additional studies for existing pipelines and projects in the Northwest Territories and Yukon.

Key Findings

Alaska Natural Gas Transportation System

The Alaska Natural Gas Transportation System (ANGTS) is a pipeline project intended to transport Alaskan and Northern Canadian natural gas to southern markets in Canada and the United States. One of the most significant issues was the potential environmental effect associated with a buried gas pipeline passing through areas containing permafrost.

The entire route proposed for Yukon lies in the zone of discontinuous permafrost. The potential effects of the proposed pipeline project on slope instability and erosion will depend if the slope is in areas of unfrozen ground or in areas of permafrost. Construction of the pipeline will involve considerable disturbance to vegetation and surface soil along the proposed right-of-way as well as on the access roads and at, or near, associated facilities. Concern was expressed with regards to the proposed pipeline route passing through known earthquake-prone areas.

In addition, the proposed route in the Yukon involves a variety of water crossings. Environmental concerns associated with river crossings were identified for both construction and operation phases of the project. The potential impacts include direct interference with fish spawning, migration and overwintering, and possible deleterious effects of siltation on fish and fish habitat. The construction and operation of the proposed pipeline may contribute to some air quality degradation, though not on a regional scale. Environmental impact on air quality may include fugitive dust, emissions from equipment during the construction phase and the formation of ice fog during operations.

A potential significant impact could be indirect habitat loss through the displacement of wildlife during the construction phase of the pipeline project. Certain wildlife species such as Dall Sheep, grizzly bears, and woodland caribou are particularly sensitive to human related disturbance. Critical winter range for Dall sheep is in close proximity to the proposed pipeline right-of-way.

Some important species of birds that might be impacted include Peregrine Falcon, Osprey, Gyrfalcon, Golden Eagle, Trumpeter and Whistling Swans, Bald Eagle, Sandhill Crane, and Canada Goose. Project activities that could affect bird populations are human presence, operation of construction equipment, aircraft overflights and noise from compressor stations. Possible impacts include direct mortality, displacement, disruption of migration-movement, destruction of habitat, degradation of habitat, disruption of feeding-resting activity and disruption of reproductive activity.

Construction of the proposed pipeline will mostly affect vegetation along the right-of-way. Project facilities such as compressor stations, stockpile sites and camps will occupy a relatively small area but could have a significant impact on vegetation depending on site location.

The pipeline right-of-way traverses the northern boundary of Kluane National Park and in close proximity to some International Biological Program (IBP) Sites. Unique or sensitive areas include: Sheep Mountain, Ibex Pass, Mt. Michie-Squanga Lake area and Pickhandle Lake.

It is unlikely that there will be significant conflict between pipeline construction activities and archaeological sites. The proposed route in most cases lies close to and parallels the Alaska Highway, and some of the archaeological sites likely to have been impacted during the construction phase are known and either already salvaged, protected or

impacted by previous construction activities. However, there is a potential concern at three major areas (i.e., along Kluane Lake, Dezadeash-Aishihik River confluence, and in the vicinity of Champagne).

Dempster Lateral

The Dempster Lateral is a pipeline proposal that approximately follows the Dempster Highway joining an existing mainline north of Whitehorse. The Dempster Route crosses three broad physiographic regions: the Arctic Coastal Plain, the Interior Plains, and the Cordillera.

A buried pipeline along the proposed Dempster Lateral route could encounter a wide variety of geotechnical problems. These problems relate to slope stability, river crossings, frost heave, thaw settlement and drainage and erosion control. Possible challenges with a buried pipeline along the proposed Dempster Route include mountainous terrain, intermontane valleys, other bedrock, and frost-susceptible soils. An alternative approach would be an above ground warm pipeline.

Continuous permafrost is present along the pipeline from Richards Island to the southern portion of the Ogilvie Mountains. From the Ogilvie Mountains to Whitehorse, the pipeline is located in the discontinuous permafrost zone. Possible impacts with a pipeline in areas of permafrost are frost heave and thaw settlement.

There are six to nine water crossings that may cause significant design and construction challenges due to the potential for frost heave. Other potential problems include ice scour, bed scour, and bank stability.

Construction machinery and routine road traffic would generate small amount of gaseous emissions to the atmosphere, but are not expected to have a significant impact on regional air quality.

One of the more significant biological concerns along the highway and proposed lateral pipeline is the potential implications on Porcupine caribou herd. The proposed Dempster lateral traverses winter range and spring and fall migration routes of the Porcupine caribou herd. Any pipeline along the Dempster Highway has the potential of dissecting the Porcupine caribou's winter range. Additional wildlife related concerns are related to critical sheep habitat near Rock River in the Ogilvie Mountains and furbearer habitat along most of the proposed route. Construction activities may disrupt life cycle activities of sensitive bird species.

There is a potential for increased siltation of fish spawning and nursery areas during pipeline construction and operation. Increased siltation would be caused by construction of access roads, and grading and ditching of the right-of-way. Construction of water crossings could physically interrupt spawning and migration, destroy eggs present in the stream beds, and alter existing spawning grounds and other fish habitat.

Vegetative zones along the route include tundra, grasslands, wetlands, riparian, and spruce and mixed wood forest. Construction of the proposed pipeline will mostly affect vegetation along the right-of-way.

Although most archaeological sites should have been identified with the construction of the Dempster Highway, any existing sites could be impacted by the proposed pipeline construction.

Mackenzie Valley

The Mackenzie Valley has seen increasing interest from oil industry since the moratorium was lifted in 1994. Recently, several factors combined to dramatically increase the interest expressed by producers and transporters in Mackenzie Valley. These include: concerns over future conventional natural gas supplies, recent gas price strength, and the potentially large future incremental gas demand due to environmental considerations and electricity restructuring.

Many parts of the Mackenzie Valley terrain are sensitive to disturbance. Potential impacts are primarily associated with the construction stage of the pipeline project.
The northern part of the proposed route lies within the zone of continuous permafrost. Pipeline construction and operation in these conditions could influence permafrost integrity and stability, which may increase erosion potential.

Pipeline construction activities can potentially impact hydrological features by disrupting natural drainage profiles, modifying and disturbing channel bank and bed habitats, promoting increased sediment loading and altering water quality. The potential effects on creeks that flow into Fisherman Lake is an area of concern.

Construction machinery and routine road traffic would generate small amounts of gaseous emissions to the atmosphere. There are no refineries or processing plants proposed over the length of the pipeline therefore operational gases would be from compressor stations.

The proposed pipeline route provides year-round habitat for numerous wildlife species and seasonal habitat for may other species during the summer months. Wildlife in the area can potentially be impacted directly by the project through habitat loss or modification, sensory disturbance from construction vehicles and equipment during sensitive overwintering periods, and increased access to the area for hunters. Moose wintering habitat has been noted near Fisherman Creek. A number of salt licks occur in the project area. During pipeline operations, regeneration of vegetation on the pipeline right of way may increase the presence of ungulates, and in particular, bison. Clearing operations on the right-of-way will alter some preferred habitat for these species, while creating new habitat for other species. Increased access could be an issue until vegetation regenerates on the pipeline right-of-way. Important areas for birds include staging and nesting sites for waterfowl in the valley habitats. Large numbers of ducks and Canada geese, loons and shorebirds nest in the Mackenzie Valley. The most important nesting,

moulting and staging areas for waterfowl are Ramparts River, Camkay Creek, Brackett Lake, Mills Lake and Beaver Lake. The birds are susceptible to disturbance during these stages.

Most fish in the Mackenzie Valley have specific migration routes and limited spawning, overwintering, nursery and feeding areas. The proposed pipeline involves the crossing of several watercourses that are varied in size. There is the potential for short-term impacts on fish habitat at the crossing sites and in the immediate downstream areas that will result from construction activities. The potential impacts related to fish and fish habitat include increased sediment loading in streams, loss or alteration of habitat, and effects from blasting.

The proposed route has been designed to avoid sensitive vegetation communities such as wetlands, major drainages, and steep topography. Pipeline construction activities will remove and alter vegetation along the right-of-way that may result in local destabilization of terrain and modification to natural habitats.

A number of archaeological and historical traditional use sites have been recorded along the shores and relic beaches of Fisherman Lake and at several sites on the northern fringes of the lake. In addition, archaeological sites are known to occur on Richards Island, at the mouth of Thunder River, Loon River, Fort Good Hope, Chick Lake, Nota Creek, Bear Rock, Bear Rock lakes, Great Bear River, Big Smith Creek, Little Canyon Creek, Saline River, Willowlake River, Cardinal Lake, and Peace River. The physical impacts of the pipeline are predicted to have negligible effect on the archaeological record of the region.

Beaufort Sea-Mackenzie Delta Offshore Route

The primary environmental constraint affecting offshore petroleum operations is sea ice. Floating ice in the Beaufort Sea scours the sea floor. The ice action potentially poses a threat for seabed installations such as pipelines or flow lines. There is permafrost in the ground below the Beaufort Sea. There is also the potential for buried pipelines to melt the permafrost and create frost heave.

The Delta is dominated by approximately 25 000 lakes and perched basins. These water bodies play a significant role in the ecology of the Delta. They affect the distribution of permafrost, support populations of fish, waterfowl and mammals, and provide storage for water, sediment and pollutants. Potential impacts to the Beaufort Sea-Mackenzie Delta during pipeline construction and operation could include discharges of sewage, heated cooling water, drilling muds, blowout preventer fluid, and produced water. Dredging activities may have short-term affects on water quality and may alter the Beaufort Sea Continental shelf.

Gaseous and particulate emissions from marine vessels, and equipment during construction and operation could impact air quality in the Beaufort Sea region. There is a possibility of ice fog formation around emissions sources, however, the wind conditions over the Beaufort should disperse emissions and ice fog if it occurs.

Within the Beaufort Sea region, the principal area of biological concern is the shear zone and the open leads at the edge of the land-fast ice. This area provides critical habitat for migrating birds, polar bears, arctic fox, beluga whales, bowhead whales, and several different species of seals.

The Delta, the coast of the Delta region, the coastal waters and the offshore leads of the Beaufort Sea are of great importance for migratory birds. Two million migrating seabirds and waterfowl representing about 100 species frequent the Beaufort Sea and its coastal margins. The variety of habitat in the Delta-Beaufort supports critical life stage areas for several wildlife species. The nesting, staging and moulting areas of the outer Delta are important to various bird species. The offshore leads are critical for birds, seals and polar bears. The calving grounds in the shallow waters of the Delta are critical for the beluga whales. Impacts on birds will depend on facility location and timing of construction activities.

Fish are abundant in the Mackenzie Delta. Some populations of fish pass through the Delta on their way to the Beaufort Sea. The fish are at greatest risk from pipeline construction and operation during spawning, overwintering and migration. Potential impacts on fish could result from changes in the smaller food organisms and exclusion from important habitats. Offshore development in the Beaufort is expected to have minor impacts on fish. Closer to shore, the potential for impacts from pipeline construction and operation is greater, particularly during the summer months.

Two different habitat types are dominant in the vegetation communities of the Delta, tundra along the Beaufort Sea and taiga further inland. Successional changes in some plant communities are maintained by seasonal flooding and by fire. Potential impact of pipeline construction and operation on vegetation in the Delta will be negligible.

Sensitive habitats for certain fish species have been identified in several water bodies adjacent to the Beaufort Sea. Almost all water bodies within the Beaufort Sea-Mackenzie Delta area contain spawning habitat for anadromous species, such as arctic grayling or longnose sucker. Migratory routes for the Arctic cisco, Least cisco, whitefish species and Arctic char exist in the Mackenzie Delta. Spawning, migratory routes, and overwintering areas could be impacted by reduced stream flows, low water levels, heavy ice scour, contaminants, and reduced dissolved oxygen levels caused by pipeline construction and operation.

Although no documents were located that listed site specific information, it is expected that several historic and archaeological sites could exist in the Beaufort Sea-Mackenzie Delta Area.

Summary of Potential Impacts

The following two tables summarizes the potential impacts. The potential impacts are divided into construction and operational phases of pipeline development.

Table 1
Potential Impacts of Proposed Pipelines During Construction Phase

CONSTRUCTION	ANGTS				Dempster Lateral				Mackenzie Valley				Beaufort Sea Mackenzie Delta			
	Negligible	Minor	Moderate	Major	Negligible	Minor	Moderate	Major	Negligible	Minor	Moderate	Major	Negligible	Minor	Moderate	Major
Geology																
Permafrost																
Erosion																
Slope Instability																
Soil																
Seismic																
Hydrology																
Water Crossing																
Ground Water																
Surface Water																
Ice																
Climate																
Air Quality																
Biological																
Wildlife																
Fisheries																
Vegetation																
Sensitive Areas																
Species																
Archeolgical																
Cultural																

Negligible		**Moderate**	
Minor		**Major**	

Table 2
Potential Impacts of Proposed Pipelines During Operation

OPERATION	ANGTS				Dempster Lateral				Mackenzie Valley				Beaufort Sea Mackenzie Delta			
	Negligible	Low	Moderate	Major	Negligible	Low	Moderate	Major	Negligible	Low	Moderate	Major	Negligible	Low	Moderate	Major
Geology																
Permafrost																
Erosion																
Slope Instability																
Soil																
Seismic																
Hydrology																
Water Crossing																
Ground Water																
Surface Water																
Ice																
Climate																
Air Quality																
Biological																
Wildlife																
Fisheries																
Vegetation																
Sensitive Areas																
Species																
Archeolgical																
Cultural																

Negligible	
Minor	
Moderate	
Major	

2.0 Introduction

This report summarizes existing studies on the environmental impacts of alternative pipeline routes for gas transportation from the North: the Alaska Natural Gas Transport System (ANGTS), Dempster Lateral, Mackenzie Valley and The Offshore Beaufort Sea route (Figure 1). It is important to note that the intent of this report is to present a reasonably accurate understanding of the key environmental issues associated with each alternative, nor does it address cumulative effects of the development options. This report is not intended to generate a comprehensive environmental impact assessment of each alternative. For the purposes of this review, CERI conducted a literature review and compilation of existing materials.

The regulatory regime for Northern development has undergone significant changes in the past three decades. The available documents that detail the anticipated environmental impacts from pipeline development were prepared under the regulatory regime of the day. That regime has changed considerably and any new environmental studies would have to recognize the changes in jurisdiction, responsible authorities, screening and decision process, and information requirements of the new regulatory regime.

The information reviewed is summarized in tabular format for ease of presentation and comparison. See Tables 1 and 2 in the executive summary. As is typical for the environmental sensitivities related to any pipeline route, CERI organized the material for each pipeline into the following categories:

- **BACKGROUND**
- **GEOLOGY**
- **HYDROLOGY**
- **CLIMATE**
- **BIOLOGICAL**
- **UNIQUE AND SENSITIVE AREAS**
- **CULTURAL**

Additional sensitive issues will include:

- minimizing overall linear disturbance
- use of existing corridors
- nature and frequency of river crossings
- wetlands and other aquatic habitat
- culturally important locations, and activities
- protected areas
- rare or endangered species and/or habitats

Figure 1
Natural Gas Transportation Options

SOURCE: NAIS; Corporate Pipeline Maps; Enbridge; Nova; Westcoast; Ranger; Foothills Pipe Lines.

MAPPING PREPARED BY KOMEX INTERNATIONAL LTD.

3.0 Methodology

The methodology for completing this report included review of relevant available literature, searching information available on the Internet, as well as discussions with key informants. CERI utilized the sources listed below to complete this report.

Information Sources:

- Arctic Science and Technology Information System (ASTIS).
- Alaska Highway Pipeline Environmental Assessment Panel. *Alaska Highway Pipeline Interim Report of the Environmental Assessment Panel*, prepared for the Minister of Fisheries and the Environment Canada (Ottawa, Ontario; July 27, 1977) p. 9-14.
- Alaska Highway Pipeline Panel, *Initial impact assessment Dempster Corridor*, (Winnipeg, Manitoba. 1979.
- Arctic Gas Pipeline Ltd. *A Comparative Analysis of Arctic Gas VS. the Alaska Highway 48" Proposal, Maple Leaf, and the Dempster Highway Alternative*, prepared for the National Energy Board, (1978).
- Arctic Gas Ltd., *Arctic Gas Environmental Comments for the Alaska Highway Gas Pipeline Project*, presentation to the Environmental Assessment and Review Panel (Whitehorse, Yukon) June 13, 1977.
- AXYS Environmental Consulting Ltd. *Cumulative Effects Assessment Practitioners Guide*. Prepared for: Canadian Environmental Assessment Agency. http://www.ceaa.gc.ca/publications_e/cumull/3.0_e.htm.
- Banfield, Frank, *A comparison of the Total Environmental Impacts of the Coastal and Interior Routes*, prepared for the Mackenzie Valley Assessment Panel, (Inuvik, NWT., 1973).
- Berger, T.R. 1977. *Northern Frontier, Northern Homeland: The Report of the Mackenzie Valley Pipeline Inquiry*. Vol 1. Ottawa: Minister of Supply and Services Canada.
- Berger, T.R., *Northern Frontier, Northern Homeland: The Report of the Mackenzie Valley Pipeline Inquiry*, Vol. 2, prepared for the Minister of Supply and Services Canada, (Ottawa, Ontario 1977).
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- Chevron Canada Resources, *Environmental Assessment of the Fort Liard Gas Pipeline and facilities*, prepared for Mackenzie Valley Environmental Impact Review Board (Yellowknife, NWT., December 1999).
- Dome Petroleum Ltd., Esso Resources Canada ltd. and Gulf Canada Resources Inc., *Beaufort Sea-Mackenzie Delta Environmental Impact Statement*,(Vol. 1, 1982).
- Foothills Pipe Lines (Yukon) Ltd. *Public Interest, Environmental statement*, (Calgary, AB., 1976) Vol. 5A.

- Foothills Pipe Lines (Yukon) Ltd. *Winter Distribution of the Porcupine Caribou Herd in Relation to the Proposed Dempster Later Pipeline Route*, prepared by Renewable Resources Consulting Services Ltd., Edmonton Ab.
- Fedirchuk McCullough & Associates Ltd., *Mackenzie Valley "Phase I" Pipeline Environmental Effects*, prepared for Polar Gas, (Toronto, Ontario, 1984).
- Gulf Oil Canada Ltd., Imperial Oil Ltd., and Shell Canada Ltd., *The Environmental Impact of the Proposed Mackenzie Delta Gas Development System*, prepared for the Mackenzie Valley Pipeline Inquiry, (Inuvik, NWT, 1976).
- Interdisciplinary Systems Ltd. *Initial Environmental Evaluation of the Proposed Alaska Highway Gas Pipeline Yukon Territory*, prepared for Alaska Highway Pipeline Panel (Winnipeg, Manitoba, May 1977).
- Northern Pipeline Agency, *Performance Report For the Period Ending March 31,1999.* (www.tbs-sct.gc.ca/rma/dpr/98-99/npa98dpre.pdf).
- Pipeline Application Assessment Group, *Mackenzie Valley Pipeline Assessment: Environmental and Socio-Economic Effects of the Proposed Canadian Arctic Gas Pipeline on the Northwest Territories and Yukon*, (Ottawa, Ontario, 1974).
- Roland George, "ARCTIC EXPOSURE; Mackenzie Delta - Beaufort Sea Natural Gas - Is It Time?" *Oilweek*, November 1, 1999, (http://purvingertz.com/oilwk110199.html).
- Swystun, Heather, Mackenzie Delta EMAN (Ecological Monitoring and Assessment Network) Site Profile. (Inuvik, NWT., 1999). http://www.bmmda.nt.ca/mackenzie_delta.htm
- Walker, D.A., Webber, P.J., Binnian, E.F., Everett, K.R., Lederer, N.D., Nordstrand, E.A. and Walker, M.D. 1987. Cumulative impacts of oil fields on northern Alaskan landscapes. Science (Washington, DC) 238 (4828): p.757-761.
- Williams, K.C., *Mackenzie Delta Gas Opportunity*, notes for remarks, prepared for the National Association of Petroleum Investment & the Canadian Association of Petroleum Investment Analysts (Halifax Petroleum Investment Conference, Halifax, Nova Scotia, May 18, 2000). http://www.exxon.com/eaff/imperialoil/news/ speech000518 /sp000518.htm

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Owen, Rob. Manager of Environmental and Socio-Economic Affairs, Foothills Pipe Lines, Ltd.

Seale, Lorraine. Department of Indian Affairs and Northern Development, Northwest Territories Government.

Stewart, Gordon. Environmental Assessment Officer, Mackenzie Valley Environmental Impact Review Board.

Traynor, Janis. Consultant, GeoNorth ltd.

Potential Impact Ranking:
The information collected from the sources mentioned above was reviewed, compiled, and summarized in tabular form for ease of presentation and comparison (Table 1 and 2). These tables are included in the "Executive Summary", with more detail provided in the body of the report.

There are numerous acceptable ranking systems for assessing the potential impacts of a project (s). The definitions used for ranking the potential impacts in this report were determined based on the Canadian Environmental Assessment Agency, Cumulative Effects Assessment Practitioners Guide.[1] The definitions are as follows:

Negligible: Impact no greater than that of small random changes caused by natural environmental fluctuations.

Low: low probability of occurrence or magnitude of effect, probably acceptable.

Moderate: affects a portion of the population or species but does not endanger the integrity of the population as a whole, moderate or possibly significant effect.

Major: high probability of occurrence or magnitude of effect, probably unacceptable.

[1] AXYS Environmental Consulting Ltd. *Cumulative Effects Assessment Practitioners Guide*. Prepared for: Canadian Environmental Assessment Agency. http://www.ceaa.gc.ca/publications_e/cumull/3.0_e.htm.

Mitigation

A discussion of mitigation options and opportunities is not included in this report. The scope of this report covers only the key environmental issues and potential impacts of the four proposed natural gas pipeline routes (the Alaska Natural Gas Transport System, Dempster Lateral, Mackenzie Valley and The Offshore Beaufort Sea Route), based on available literature. Mitigation of many of the potential impacts identified in this report have been successfully addressed by additional studies for existing pipelines and projects in the Northwest Territories and the Yukon. Existing pipelines include Trans-Alaska Pipeline, Inuvik Gas Pipeline, Enbridge Norman Wells Oil Pipeline, Nova and WestCoast Energy pipelines. Monitoring reports are available for several of these systems.

4.0 Alaska Natural Gas Transportation System

4.1 Background

The Alaska Natural Gas Transportation System (ANGTS) is a pipeline project intended to transport Alaskan and Northern Canadian natural gas to southern markets in Canada and the United States. It is the largest proposed pipeline in North America, encompassing nearly 7,700 kilometres of mainline pipe. The proposed routing will generally follow the existing Alaska Highway. The pipeline will be buried except where aboveground pipe enters compressor and meter station buildings. Seven compressor stations were proposed to move the gas in the Yukon.[2]

In 1977, the Governments of Canada and the United States of America executed an "Agreement on Principles Applicable to Northern Natural Gas Pipeline". This agreement provided a framework for the construction and operation of the ANGTS. In this agreement, the project is also referred to as the Alaska Highway Gas Pipeline Project. Unfavourable economic conditions led to indefinite delays in the completion of the ANGTS, however in recent years, southern portions of the pipeline system have been constructed. These southern portions are referred to as the Prebuild. The Prebuild went into operation in 1981-82 for the initial purpose of transporting gas from western Canada. The second stage would link the prebuilt Western and Eastern Legs of the pipeline with the United States reserves at Prudhoe Bay and possibly also the Canadian reserves in the Mackenzie Delta region.

In response to growing export demands, the flow capacity of the Prebuild continues to approach the 102 million cubic metre (3.6 billion cubic feet) per day rate provided for in the agreement between Canada and the United States underpinning the ANGTS. The latest expansion of the Prebuild, which came into service in December 1998, has raised its current capacity to 94 million cubic metres (3.3 billion cubic feet) per day. Approximately one-third of all Canadian natural gas exports to the United States are transported through the Prebuild.[3]

Figures 2 and 3 show the proposed route of the ANGTS in Canada and the United States and details of the existing Prebuild in Canada.

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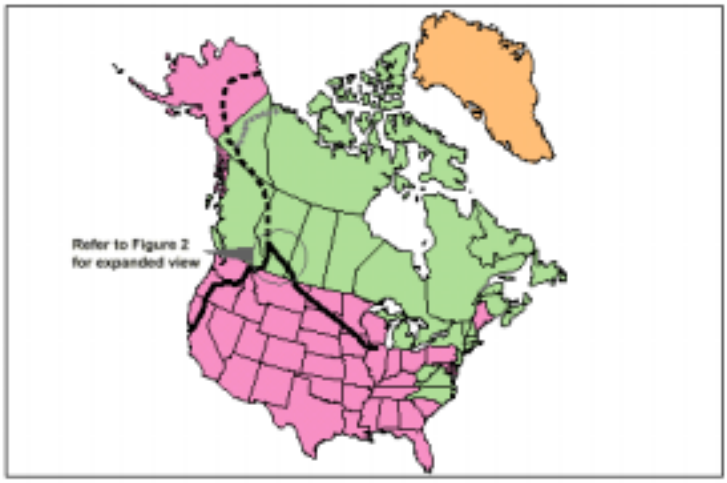
[2] Arctic Gas Ltd., *Arctic Gas Environmental Comments for the Alaska Highway Gas Pipeline Project*, presentation to the Environmental Assessment and Review Panel (Whitehorse, Yukon. June 13, 1977) p. 19-21.

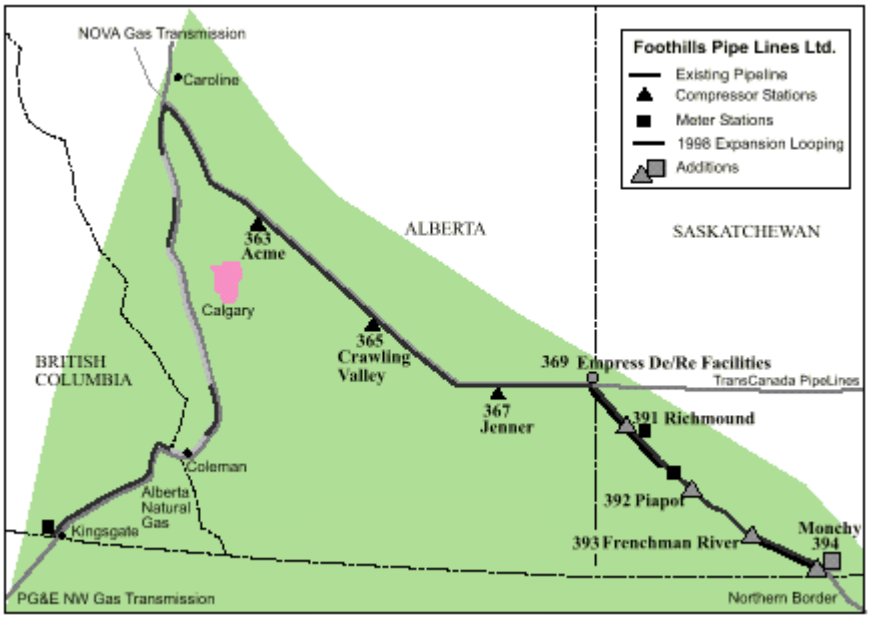
[3] Northern Pipeline Agency, *Performance Report For the Period Ending March 31,1999* (www.tbs-sct.gc.ca/rma/dpr/98-99/npa98dpre.pdf).

Figure 2
The Alaska Natural Gas Transportation System



Source: Northern Pipeline Agency Performance Report for the Period Ending March 31,1999 (www.tbs-sct.gc.ca/rma/dpr/98-99/npa98dpre.pdf)

Figure 3
The Foothills Prebuild



Source: Northern Pipeline Agency Performance Report For the Period Ending March 31,1999 (*www.tbs-sct.gc.ca/rma/dpr/98-99/npa98dpre.pdf*)

4.2 Geology

Permafrost:

One of the most significant issues was the potential environmental effect associated with a buried gas pipeline passing through areas containing permafrost. The entire route proposed for Yukon lies in the zone of discontinuous permafrost. The most serious problems would likely be encountered in the most westerly 100-mile section of the route. Drilling to delineate permafrost conditions along the proposed route was inconclusive. The Alaska Highway Pipeline Environmental Panel (AHPEP) agreed with the proponent that predictions of thaw settlement for the warm pipeline mode is more reliable than predictions of frost heave for the chilled mode. [Frost-heaving is when the active layer freezes and pushes the surface ground upward, and thaw settlement is when structures founded on "thaw-unstable" permafrost may settle if the large amounts of ice in the thaw-unstable permafrost are melted.] However, severe damage could occur with either method. Specifically, in the case of a warm pipeline, severe degradation could result in large areas of settlement causing ponding of water, erosion, siltation and aesthetic problems. In the case of a cold pipeline, extensive repairs to the pipeline may be necessary because of ruptures, interruption of ground water and sub-surface drainage due to the formation of a frost bulb which may cause extensive changes in drainage patterns with resultant erosion siltation. [4]

Erosion:

Soils stripped of vegetation will be subject to erosion by wind and water. Erosion will be greatly accelerated where vegetation has been removed and bare ground has been exposed. Construction activities for the pipeline, access roads, compressor stations, storage pads and other facilities have the potential to bare large areas making them susceptible to erosion. Increased erosion will increase sediment concentrations of streams and watersheds to be crossed by the pipeline. Increases in sediment concentration may have direct and indirect effects on fish and other aquatic fauna. [5]

Slope Instability:

The potential effects of the proposed pipeline project on slope instability will depend if the slope is in areas of unfrozen ground or in areas of permafrost. In areas of unfrozen ground, activities associated with construction of a pipeline and the operation of a warm pipeline will cause little, if any, change in slope instability except on locations where the slopes are modified by cut grading. In areas of permafrost, pipeline operation may lead to an increase in the depth of thaw that will change the stability of these slopes. Slope instability in permafrost regions can be caused if the rate of thaw is such that water in the thawed soil can

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[4] Alaska Highway Pipeline Environmental Assessment Panel. *Alaska Highway Pipeline Interim Report of the Environmental Assessment Panel*, prepared for the Minister of Fisheries and the Environment Canada (Ottawa, Ontario; July 27, 1977) p. 9-14.

[5] Interdisciplinary Systems Ltd. *Initial Environmental Evaluation of the Proposed Alaska Highway Gas Pipeline Yukon Territory*, prepared for Alaska Highway Pipeline Panel (Winnipeg, Manitoba, May 1977) p. 143.

not escape as fast it is generated and the soil could behave like a fluid. On sloping terrain, the soil could flow downhill. Movement of the thawed soil mass surrounding the pipe could cause large pipe deformation and ruptures. At river crossings, bank instabilities could also lead to increased sediment load in the adjacent waterway. Minimizing disturbance of surface vegetation and soils could reduce effects of construction activities. For operation, the lower the operating temperature, the adverse effects for slope stability will be less significant. [6]

Soil:

Agricultural soils make up from a few centimeters to as much as over a meter of the surficial material along the entire pipeline route.[7] Construction of the pipeline will involve considerable disturbance to vegetation and surface soil along the proposed right-of-way as will the access roads and at, or near, associated facilities. Environmental impact from vegetation and soil removal could include significant soil movements in steep terrain, wind and water erosion and erosion of riverbanks. All of these impacts could lead to siltation with resultant impacts on aquatic fauna.

Seismic:

Another concern identified by the AHPEP was the possibility of pipeline rupture due to seismic activity and resultant environmental impacts. The proposed pipeline route is to pass through known earthquake-prone areas, particularly the Shakwak Trench running Northwest from Haines Junction.[8] Ground motion generated by an earthquake may compress and wrinkle a pipeline that is placed below ground. Ground vibrations caused by earthquakes can lead to compaction and/or liquefaction of soils that may result in large settlement or cause a buried pipeline to float to the surface. [9]

4.3 Hydrology

Water Crossing:

The proposed route in the Yukon involves a variety of water crossings. The proponent has identified six of these as major river crossings on the basis of design discharge (20 000 cfs or greater), scour depth of the river bed (5ft. or greater), width of the river at proposed crossing (500 feet or wider) and the gradient of the river. Some of the rivers, particularly those that are glacier-fed, originate in the Kluane Mountain Range and flow across the proposed route, are

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[6] Interdisciplinary Systems Ltd. *Initial Environmental Evaluation of the Proposed Alaska Highway Gas Pipeline Yukon Territory*, prepared for Alaska Highway Pipeline Panel (Winnipeg, Manitoba, May 1977) p. 157-163.

[7] Bureau of Land Management. *Alaska Natural Gas Transportation System Final Environmental Impact Statement*, (Department of the Interior, Washington, D.C., March 1976) p. 58.

[8] Alaska Highway Pipeline Environmental Assessment Panel. *Alaska Highway Pipeline Interim Report of the Environmental Assessment Panel*, prepared for the Minister of Fisheries and the Environment Canada (Ottawa, Ontario; July 27, 1977) p. 10.

[9] Interdisciplinary Systems Ltd. *Initial Environmental Evaluation of the Proposed Alaska Highway Gas Pipeline Yukon Territory*, prepared for Alaska Highway Pipeline Panel (Winnipeg, Manitoba, May 1977) p. 167-170.

high energy systems which have highly variable flow rates and are prone to flash flooding, constantly changing channels and deep scour depths.[10]

Environmental concerns associated with river crossings were identified for both construction and operation phases of the project. During the construction phase, the potential impacts include direct interference with fish spawning, migration and overwintering, and possible deleterious effects of siltation on fish and fish habitat. During operation, the possible impacts identified are siltation due to bank erosion or to emergency repairs and the possibility of gas leaks particularly under ice cover. The seasonal timing of construction, maintenance or repairs was also identified as an issue that would need to be addressed.

Ground Water:

Groundwater flow will be found intermittently along the pipeline route. It can occur in the active layer, in unfrozen areas of permafrost and as deep subsurface flow below the permafrost. Groundwater is used for domestic water supplies at several points along the pipeline route. The quantity and quality of available groundwater is of direct interest to local citizens. These include private or community wells at Beaver Creek, Burwash Landing, Destruction Bay, Silver Creek, Hianes Junction, Canon Creek, Champagne, Whitehorse, Teslin, and Watson Lake. [11]

The greatest hazard to groundwater during construction is from spills. Pollutants that enter the groundwater system are difficult to remove and can persist for long periods of time. In addition, operation of a gas pipeline could affect groundwater through alteration or interruption of subsurface drainage.[12]

Clearing of vegetation, cutting and filling of soil, excavation of rock and drainage provisions can also affect both ground and surface water regimes.

Surface Water:

The proposed pipeline traverses drainage basins whose waters ultimately flow to the Arctic Ocean, Hudson Bay, Pacific Ocean, and the Gulf of Mexico. Pipeline construction could change the local surface drainage patterns particularly in relatively flat terrain or initiate changes in channel regimes at pipeline crossings and within floodplains.

Three major river basins, the Yukon, Alsek and Liard, are crossed. In addition, seventeen lakes could potentially be affected because they are downstream from a

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[10] Alaska Highway Pipeline Environmental Assessment Panel. *Alaska Highway Pipeline Interim Report of the Environmental Assessment Panel*, prepared for the Minister of Fisheries and the Environment Canada (Ottawa, Ontario; July 27, 1977) p. 15.

[11] Foothills Pipe Lines (Yukon) Ltd. *Public Interest, Environmental statement*, (Calgary, AB., 1976) Vol. 5A, p. 15.

[12] Interdisciplinary Systems Ltd. *Initial Environmental Evaluation of the Proposed Alaska Highway Gas Pipeline Yukon Territory*, prepared for Alaska Highway Pipeline Panel (Winnipeg, Manitoba, May 1977) p. 99.

tributary that is crossed or closely paralleled by the proposed pipeline. Changes in lakes could be a result of increased sediments particularly at deltas of streams and rivers crossed by the pipeline. [13]

4.4 Climate

Air Quality:

The construction and operation of the proposed pipeline will contribute to some air quality degradation. Environmental impact on air quality will include fugitive dust, and emissions from equipment during the construction phase. Air pollution emissions from construction equipment could consist of nitrogen oxides, carbon monoxide and lesser amounts of sulfur oxides, particulates and unburned hydrocarbons.[14]

Longer-term effects are associated with the pipeline system operations. These effects will consist of emissions from compressor stations and the venting of gas into the atmosphere at blow-down points near compressor stations and pipeline block valves.

In addition, water vapor emissions from compressor stations in combination with particulates can cause the formation of ice fog. This could reduce visibility in the vicinity of the compressor station.

4.5 Biological:

Wildlife:

A potential significant impact could be indirect habitat loss through the displacement of wildlife during the construction phase of the pipeline project. Certain wildlife species such as Dall Sheep, grizzly bears, and woodland caribou are sensitive to human related disturbance. Construction activities and aircraft over-flights may influence their utilization of an area or they may permanently abandon it.[15]

Another potential impact is direct habitat loss. Critical range areas include winter and breeding ranges, lambing-calving-denning areas, mineral licks, and traditional travel routes. Habitat loss could be caused by disruption from equipment and human activity. Critical winter range for Dall sheep is in close proximity to the proposed pipeline right-of-way. [16]

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[13] Interdisciplinary Systems Ltd. *Initial Environmental Evaluation of the Proposed Alaska Highway Gas Pipeline Yukon Territory*, prepared for Alaska Highway Pipeline Panel (Winnipeg, Manitoba, May 1977) p. 105-116.

[14] Ibid., p. 185.

[15] Alaska Highway Pipeline Environmental Assessment Panel. *Alaska Highway Pipeline Interim Report of the Environmental Assessment Panel*, prepared for the Minister of Fisheries and the Environment Canada (Ottawa, Ontario; July 27, 1977) p. 28.

[16] Interdisciplinary Systems Ltd. *Initial Environmental Evaluation of the Proposed Alaska Highway Gas Pipeline Yukon Territory*, prepared for Alaska Highway Pipeline Panel (Winnipeg, Manitoba, May 1977) p. 122.

Direct and indirect mortality could also affect wildlife populations. Dall sheep and grizzly bears could experience increase in hunting demand and road traffic collisions. Other potential impacts could include indirect mortality related to increased man-wildlife encounters related to inadequately disposal of garbage and feeding of wildlife by pipeline personnel.

There is a potential to adversely affect bird populations along the route because certain species are highly sensitive to disturbance by humans and aircraft. Project activities that could affect bird populations are human presence, operation of construction equipment, aircraft overflights and noise from compressor stations. Possible impacts include direct mortality, displacement, disruption of migration-movement, destruction of habitat, degradation of habitat, disruption of feeding-resting activity and disruption of reproductive activity. Some important species of birds that might be impacted include Peregrine Falcon, Osprey, Gyrfalcon, Golden Eagle, Trumpeter and Whistling Swans, Bald Eagle, Sandhill Crane, and Canada Goose.

Fisheries:

As noted in Section 3.2, a potential impact could be increased siltation from erosion. Increased siltation could impact fish spawning and nursery areas. The primary causes of increased siltation would be construction of access roads, grading and ditching of the right-of-way. Siltation may decrease the survival rate of eggs and emergent fry and may also degrade spawning habitats. Construction of water crossings could physically interrupt spawning and migration, destroy eggs present in the stream beds, and alter existing spawning grounds and other fish habitat. Indirect impacts could also be realized through over exploitation of fish stocks by people during the construction phase of the pipeline.[17]

Vegetation:

Vegetation reduces erosion and in permafrost areas, helps insulate underlying permafrost. Vegetation along the proposed pipeline route consists of numerous plant communities, which vary in species composition, abundance, distribution, sensitivity to disturbance from construction activities and ability to recover following disturbance.

Construction of the proposed pipeline will mostly affect vegetation along the right-of-way. Project facilities such as compressor stations, stockpile sites and camps will occupy a relatively small area but could have a significant impact on vegetation depending on site location.[18]

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[17]Alaska Highway Pipeline Environmental Assessment Panel. *Alaska Highway Pipeline Interim Report of the Environmental Assessment Panel*, prepared for the Minister of Fisheries and the Environment Canada (Ottawa, Ontario; July 27, 1977) p. 27.

[18] Interdisciplinary Systems Ltd. *Initial Environmental Evaluation of the Proposed Alaska Highway Gas Pipeline Yukon Territory*, prepared for Alaska Highway Pipeline Panel (Winnipeg, Manitoba, May 1977) p.447.

Changes in drainage and soil compaction could also impact plant communities. These factors may change plant habitat as a result of a reduction in species and habitat diversity through the substitution and/or elimination of one species and community for others.[19]

4.6 Unique and Sensitive Areas:

The pipeline right-of-way traverses the northern boundary of Kluane National Park and in close proximity to some International Biological Program (IBP) Sites.[20] These include the following:

Sheep Mountain:

Sheep Mountain is located in Kluane National Park. It provides year round habitat and is the site of a mineral lick for about 200 Dall Sheep. As mentioned above, this species is known to be highly sensitive to disturbance. Several unique plant species also occur on Sheep Mountain and on the adjoining Slims River delta.

Ibex Pass:

The Ibex Pass supports populations of Dall Sheep, grizzly bears and raptors. Each of these species is noted for their sensitivity to human activity. In addition, there is a sport fishery in the area.

Mt. Michie-Squanga Lake:

Mt. Michie-Squanga Lake area is a woodland caribou wintering and calving area. This area is also highly sensitive to construction activity, and to hunting pressure resulting from increased access. Squanga Lake itself supports a unique species of whitefish. The pipeline construction and operation would influence the spawning grounds of this species. In addition, the area contains raptor nesting sites and valuable populations of aquatic fur-bearers.

Pickhandle Lake:

The Pickhandle wetland complex supports large populations aquatic fur-bearers and waterfowl. This wetland complex is also used as a staging and rearing area by waterfowl.

4.7 Cultural

Archaeological:

Prehistoric sites, relating to occupation by aboriginal peoples, and historic sites relating to exploration and occupation by Europeans, are known to exist in areas along the proposed pipeline. It is unlikely that there will be significant conflict

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[19] Bureau of Land Management. *Alaska Natural Gas Transportation System Final Environmental Impact Statement*, (Department of the Interior, Washington, D.C., March 1976) p. 202.

[20] Alaska Highway Pipeline Environmental Assessment Panel. *Alaska Highway Pipeline Interim Report of the Environmental Assessment Panel*, prepared for the Minister of Fisheries and the Environment Canada (Ottawa, Ontario; July 27, 1977) p. 31-33.

between pipeline construction activities and archaeological sites. [21] The proposed route in most cases lies close to and parallels the Alaska Highway, and some of the sites likely to have been impacted during the construction phase are known and either already salvaged, protected or impacted by previous construction activities. However, there is potential concern at three major areas (i.e., along Kluane Lake, Dezadeash-Aishihik River confluence, and in the vicinity of Champagne).

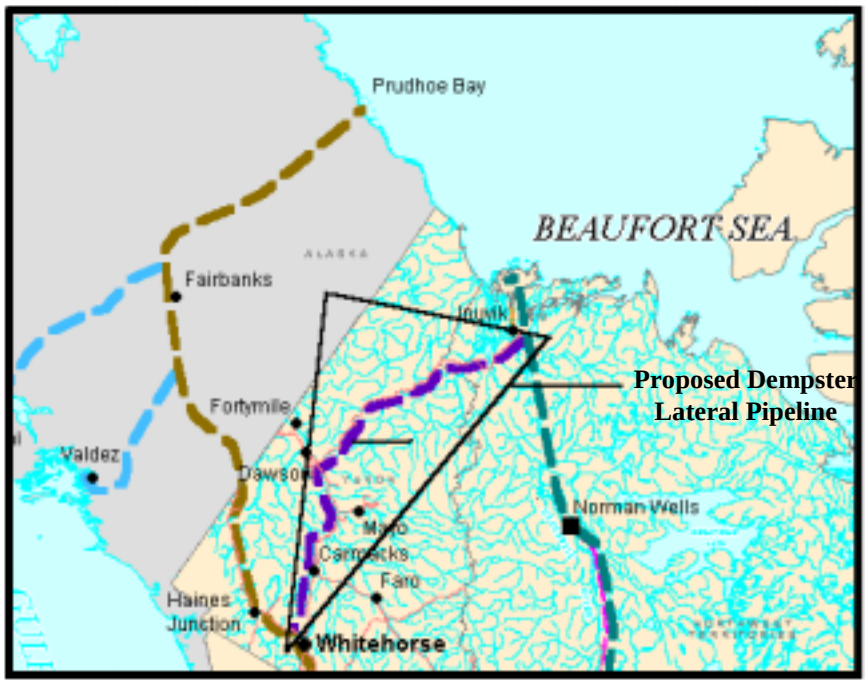
[21] Interdisciplinary Systems Ltd. *Initial Environmental Evaluation of the Proposed Alaska Highway Gas Pipeline Yukon Territory*, prepared for Alaska Highway Pipeline Panel (Winnipeg, Manitoba, May 1977) p. 639.

5.0 Dempster Lateral

5.1 Background

The Dempster Lateral is a pipeline proposal that approximately follows the Dempster Highway joining an existing mainline north of Whitehorse (Figure 4).[22] During full volume operation, eight compressor stations would be required for the entire Dempster Line.

Figure 4
Proposed Dempster Lateral Pipeline



Source: Corporate Pipeline Maps; Enbridge; Nova; Westcoast; Ranger; Foothills Pipe Lines Mapping Prepared by Komex International Ltd.

5.2 Geology:

Most of the Dempster Lateral route lies in either continuous permafrost terrain or in non-frost susceptible terrain such as bedrock, coarse tills and outwash gravels.[23] The Dempster Route crosses three broad physiographic regions: the Arctic Coastal Plain, the

[22] Foothills Pipe Lines (Yukon) Ltd. *Winter Distribution of the Porcupine Caribou Herd in Relation to the Proposed Dempster Later Pipeline Route*, prepared by Renewable Resources Consulting Services Ltd., Edmonton Ab., p. 2.
[23] Arctic Gas Pipeline Ltd. *A Comparative Analysis of Arctic Gas VS. the Alaska Highway 48" Proposal, Maple Leaf, and the Dempster Highway Alternative*, prepared for the National Energy Board, (1978) p. III-35.

Interior Plains, and the Cordillera (Figure 5). Unconsolidated surficial materials and bedrock are present within each of the physiographic regions.[24]

A buried pipeline crossing different terrain materials and topographic settings can be affected by a wide variety of geotechnical problems. These problems relate to slope stability, river crossings, frost heave, thaw settlement and drainage and erosion control.[25]

Possible challenges with a buried pipeline along the proposed Dempster Route include mountainous terrain, intermontane valleys, other bedrock, and frost-susceptible soils. An alternative approach would be an above ground warm pipeline. This approach could pose serious conflict with wildlife movement.[26]

Figure 5
Dempster Highway

Source: //canadafarnorth.about.com/citiestowns/canada/canadafarnorth/gi/dynamic/offsite.htm

Permafrost:

Continuous permafrost is present along the pipeline from Richards Island to the southern portion of the Ogilvie Mountains. From the Ogilvie Mountains to Whitehorse, the pipeline is located in the discontinuous permafrost zone.[27] As described in section 4.2, possible impacts with a pipeline in areas of permafrost are frost heave and thaw settlement.

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[24] Arctic Gas Ltd., *Environmental Comments for the Alaska Highway Gas Pipeline Project*, prepared for the Environmental Assessment and Review Panel. (Whitehorse, Yukon. June 13, 1977), p. 34.
[25] Ibid., p. 37.
[26] Alaska Highway Pipeline Panel, *Initial impact assessment Dempster Corridor*, (Winnipeg, Manitoba. 1979) p. 15.
[27] Arctic Gas Ltd. *Environmental Comments for the Alaska Highway Gas Pipeline Project*, prepared for the Environmental Assessment and Review Panel. (Whitehorse, Yukon. June 13, 1977), p 38.

Erosion and Slope Instability:

Slopes that have high potential for instability are steep slopes or cross slopes. There is significant potential for erosion along the proposed pipeline right-of-way where it will cross steep slopes, cross-slopes or flat wet areas.

Soil:

There is the potential for frost heave in the areas where a chilled pipeline would cross fine-grained soils that have shallow permafrost or are unfrozen. This is most likely to occur where the route passes through several areas of discontinuous permafrost, especially in the Yukon-Tannana Uplands.

5.3 Hydrology:

Water Crossing:

Water crossings may cause significant design and construction challenges particularly at locations upstream of the last point of cold flow where the potential for frost heave in the unfrozen riverbed may exist. This potential could be realized at six of the nine river crossings along this route. Other potential problems include ice scour, bed scour, bank stability, and other environmental disruption.[28]

5.4 Climate:

Air Quality:

Construction machinery and routine road traffic would generate small amounts of gaseous emissions to the atmosphere. Direct effects would only be local and would not have a significant effect upon regional air quality. An additional effect will be noise pollution caused by equipment during the construction.

5.5 Biological:

Wildlife:

One of the more significant environmental concerns along the highway and proposed lateral pipeline is the potential implications on Porcupine caribou herd. This herd is the largest herd in Alaska. Any pipeline along the Dempster Highway has the potential of dissecting the Porcupine caribou's winter range.[29] The proposed Dempster lateral traverses winter range and spring and fall migration routes of the Porcupine caribou herd.

Additional concerns are related to critical sheep habitat near Rock River in the Ogilvie Mountains and furbearer habitat along most of the proposed route. [30]

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[28] Arctic Gas Ltd., *Environmental Comments for the Alaska Highway Gas Pipeline Project*, prepared for the Environmental Assessment and Review Panel. (Whitehorse, Yukon. June 13, 1977), p. 37.

[29] Berger, T.R. 1977. *Northern Frontier, Northern Homeland: The Report of the Mackenzie Valley Pipeline Inquiry*. Vol 1. Ottawa: Minister of Supply and Services Canada. Pg. 96.

[30] Arctic Gas Pipeline Ltd. *A Comparative Analysis of Arctic Gas vs the Alaska Highway 48" Proposal, Maple Leaf, and the Dempster Highway Alternative*, prepared for the National Energy Board, (1978) p. III-38.

Waterfowl are abundant in the Eagle River valley and between Fort McPherson and Arctic Red River. There are a significant amount of birds nesting and rearing their young in these areas. A nesting peregrine falcon was observed along the Ogilvie River and other peregrines are known to nest near the Peel River crossing of the Dempster Highway. Many other raptors inhabit the area along most of the route.[31] Construction activities may disrupt life cycle activities of sensitive bird species.

Fisheries:

There is a potential for increased siltation of fish spawning and nursery areas during pipeline construction and operation. Causes of increased siltation would be construction of access roads, and grading and ditching of the right-of-way. Siltation may decrease the survival rate of eggs and emergent fry and may also degrade spawning habitats.

Construction of water crossings could physically interrupt spawning and migration, destroy eggs present in the stream beds, and alter existing spawning grounds and other fish habitat. Additionally, the over-exploitation of fish stocks as a result of the anticipated major influx of people during the construction phase could be a concern.

Vegetation:

Vegetation along the proposed pipeline route consists of numerous plant communities, which vary in species composition, abundance, distribution, sensitivity to disturbance from construction activities and ability to recover following disturbance. Vegetative zones along the route include tundra, grasslands, wetlands, riparian, and spruce and mixed wood forest. Vegetation reduces erosion and in permafrost areas, helps insulate underlying permafrost.

Construction of the proposed pipeline will mostly affect vegetation along the right-of-way. Project facilities such as compressor stations, stockpile sites and camps will occupy a relatively small area but could have high potential for affecting vegetation depending on site location.[32]

5.6 Unique and Sensitive Areas:

As mentioned above, one of the main concerns of this proposed pipeline is the Porcupine caribou. Any area that is utilized by the herd should be considered unique and sensitive.

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[31] Arctic Gas Ltd., *Environmental Comments for the Alaska Highway Gas Pipeline Project*, prepared for the Environmental Assessment and Review Panel. (Whitehorse, Yukon. June 13, 1977), p. 32.

[32] Alaska Highway Pipeline Panel, *Initial impact assessment Dempster Corridor*, (Winnipeg, Manitoba. 1979) p. 3.

5.7 Cultural

Before the arrival of European fur traders and explorers, Kutchin people inhabited the Dempster Highway region north of Dawson City. There were about 1500 Kutchin, spread throughout the Porcupine, Arctic Red, and Peel River valleys. Europeans came to this area with the fur trade and established Fort McPherson as a Hudson's Bay Company outpost.[33] Although most archaeological sites should have been identified with the construction of the Dempster Highway, any existing sites could be impacted by the proposed pipeline construction.

[33]http://canadafarnorth.about.com/citiestowns/canada/canadafarnorth/gi/dynamic/offsite.htm?site=http://www.onroute.com/destinations/yukon/demps.html (June, 00)

6.0 Mackenzie Valley

6.1 Background

The Mackenzie Valley has seen increasing interest from the oil industry since lifting the moratorium in 1994.[34] Recently, several factors combined to dramatically increase the interest expressed by producers and transporters in Mackenzie Valley. These include: concerns over future conventional natural gas supplies, recent gas price strength, and the potentially large future incremental gas demand due to environmental considerations and electricity restructuring. Other reasons motivating the interest in Mackenzie Delta-Beaufort Sea gas include the potential for huge reserves, new pipeline infrastructure pushing northward, technological innovations that are reducing finding and development costs, a more clear land claim situation, and a renewed interest by governments and aboriginal peoples in economic development in the region.

It has been estimated that the region has 64 trillion cubic feet of discovered and undiscovered resource potential. The three largest on-shore discoveries are Taglu, Parsons Lake and Niglintgak. Taglu is the largest and was discovered by Imperial in 1971. Gulf's discovery at Parsons Lake and Shell's discovery at Niglintgak were made in 1972 and 1973, respectively.

Several pipelines were proposed during the 1970s to transport gas from Alaska and the Mackenzie Delta to southern markets. The federal government initiated a three-year inquiry headed by Justice Thomas Berger to assess these proposals. In 1977, Justice Berger recommended that a 10-year moratorium be placed on pipeline development in the Mackenzie Valley, to allow for the settlement of Aboriginal land claims in the region. Exploration interest in the North remained high during the 1980s. However, following de-regulation of the gas industry and large discoveries further south, gas prices fell and so did the interest in developing Northern gas reserves due to poor economics. [35]

Currently, there is a renewed interest by Governments and Aboriginal peoples to use hydrocarbon exploration and development to contribute to the diversification of economic activity in northern communities. An improved clarity of the land claim situation and the promise of significant resource potential have renewed activity on the part of the oil and gas industry. New gas discoveries have occurred in the southern NWT and the necessary infrastructure is being pushed northward to meet the demands of these discoveries. Additionally, there are concerns that natural gas supplies south of the 60th parallel may be inadequate to meet future demand which has resulted in climbing natural gas forecasts. The Kyoto Protocol could substantially increase natural gas consumption in North America and could put additional upward pressure on gas prices. Most recently, the strength of Western Canadian gas prices is also seen as a positive factor for

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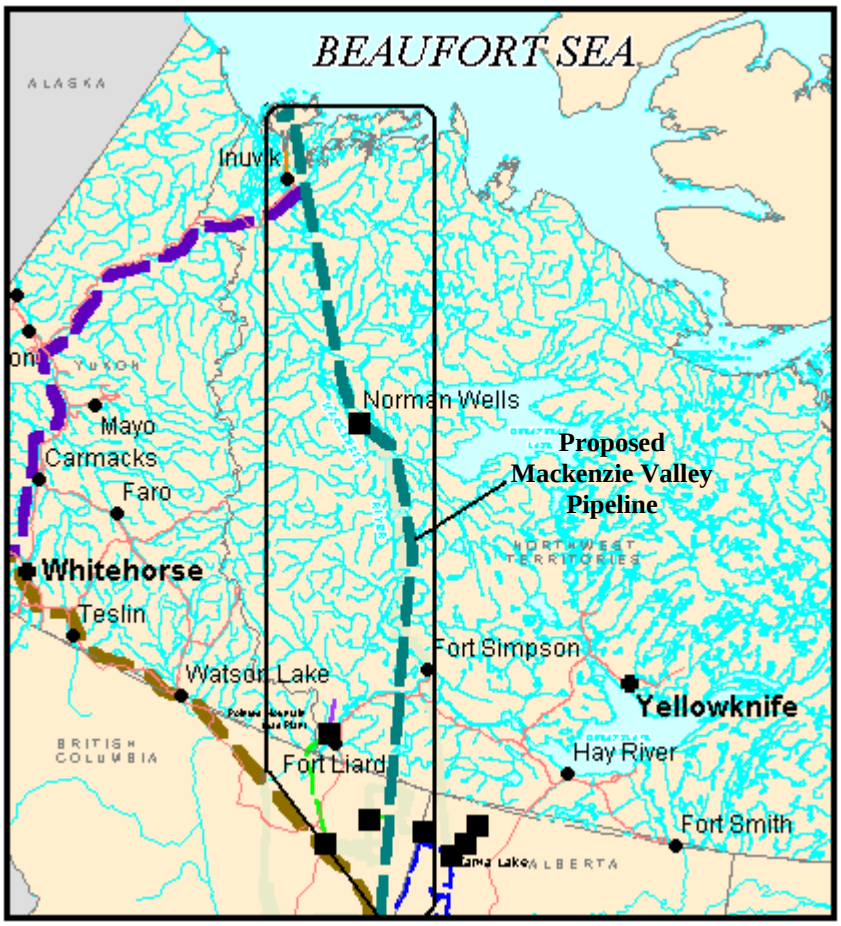
[34] Brackman, Cal. "The Northwest Territories Petroleum Industry". RWED Minerals, Oil and Gas Division. June 1999. Pg. 7.

[35] Williams, K.C., *Mackenzie Delta Gas Opportunity, n*otes for remarks, prepared for the National Association of Petroleum Investment & the Canadian Association of Petroleum Investment Analysts (Halifax Petroleum Investment Conference, Halifax, Nova Scotia, May 18, 2000). http://www.exxon.com/eaff/imperialoil/news/speech000518/sp000518.htm

developing new sources of supply. These and other related factors warrant this new strategic and commercial review of Mackenzie Valley natural gas development. [36] the proposed route for the Mackenzie Valley option is presented in figure 6.

Figure 6
Proposed Mackenzie Valley Pipeline



Source: Corporate Pipeline Maps; Enbridge; Nova; Westcoast; Ranger; Foothills Pipe Lines
Mapping Prepared by Komex International Ltd.

[36] Roland George, "ARTIC EXPOSURE; Mackenzie Delta - Beaufort Sea Natural Gas - Is It Time?" *Oilweek*, November 1, 1999, (http://purvingertz.com/oilwk110199.html).

6.2 Geology

Many parts of the Mackenzie Valley terrain are sensitive to disturbance. Potential impacts are primarily associated with the construction stage of the pipeline project.[37]

Permafrost:

The northern part of the proposed route lies within the zone of continuous permafrost. Within this zone, permafrost is well below freezing. However, beneath lakes and major streams, the ground is unfrozen to a depth far in excess of the proposed depth of pipeline burial. Farther south, permafrost becomes warmer and discontinuous. In the southern portions of the route, permafrost is found only in isolated patches.[38] Pipeline construction and operation in these conditions could influence permafrost integrity and stability.

Erosion:

Soils along the proposed route vary greatly in their capacity to resist erosion from running water.[39] Loss of aesthetic and environmental values could result from slope failures and increased erosion by channeling water associated with pipeline development. Removal of vegetation and downslope movement of sediment could lead to increased siltation of lakes and streams.

Slope Instability:

In areas of unfrozen ground, activities associated with construction of a pipeline and the operation of a warm pipeline will cause little, if any, change in slope instability except on locations where the slopes are modified by cut grading.[40]

Instability of slopes in permafrost regions is predicted as a result of increased depth of thaw brought by construction activities and operation of a warm pipeline.[41]

Soil:

The Mackenzie valley consists of silty, clayey permafrost soils that are vulnerable to thermal degradation, especially along the river valleys and slopes of the region.[42]

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[37] Chevron Canada Resources, *Environmental Assessment of the Fort Liard Gas Pipeline and facilities*, prepared for Mackenzie Valley Environmental Impact Review Board (Yellowknife, NWT., December 1999), p. 51.

[38] Pipeline Application Assessment Group, *Mackenzie Valley Pipeline Assessment: Environmental and Socio-Economic Effects of the Proposed Canadian Arctic Gas Pipeline on the Northwest Territories and Yukon*, (Ottawa, Ontario, 1974), p. 169.

[39] Ibid., p. 192.

[40] Interdisciplinary Systems Ltd. *Initial Environmental Evaluation of the Proposed Alaska Highway Gas Pipeline Yukon Territory*, prepared for Alaska Highway Pipeline Panel (Winnipeg, Manitoba, May 1977) p.157.

[41] Ibid., p. 127.

[42] Berger, T.R., *Northern Frontier, Northern Homeland: The Report of the Mackenzie Valley Pipeline Inquiry*,Vol. 1, prepared for the Minister of Supply and Services Canada, (Ottawa, Ontario 1977) p. 78.

The potential impacts to soil resources include:

- disturbance to the soil profile (i.e., soil loss, admixing, compaction, etc.);
- disturbance to permafrost integrity;
- increased erosion potential; and
- soil contamination from spills and wastes.

No residual effects to soils are predicted from pipeline construction or operations, with the exception of some soil compaction and some localized erosion. No significant adverse effects are predicted.[43]

6.3 Hydrology

Pipeline construction activities can potentially impact hydrological features by disrupting natural drainage profiles, modifying and disturbing channel bank and bed habitats, promoting increased sediment loading and altering water quality. Fuel spills or leaks constitute a potential hazard to surface water, ground water, wetlands and aquatic organisms. The potential effects on creeks that flow into Fisherman Lake is a specific localized area of concern.[44]

Water Crossing:

Potential impacts include increased in-stream sediment loading during construction and increased erosion rates at disturbed sites. Potential exposure of the pipeline due to scour during floods could cause pipeline rupture and subsequent negative impacts. There is a potential risk of bank erosion at pipeline stream crossings.

Ground Water:

The greatest hazards to groundwater during construction of the pipeline are spills. Pollutants that enter the groundwater system are difficult to remove and can persist for long periods of time. In addition, operation of a gas pipeline could affect groundwater through alteration or interruption of subsurface drainage. Pipeline construction activities such as clearing of vegetation, cutting and filling of soil, excavation of rock and drainage provisions can affect both ground and surface water regimes.

6.4 Climate

Air Quality:

Construction machinery and routine road traffic would generate small amounts of gaseous emissions to the atmosphere. Direct effects would be local only and would not have a significant effect upon regional air quality. There are no

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[43] Chevron Canada Resources, *Environmental Assessment of the Fort Liard Gas Pipeline and facilities*, prepared for Mackenzie Valley Environmental Impact Review Board (Yellowknife, NWT., December 1999), p. 72.

[44] Ibid., p. 67.

refineries or processing plants proposed over the length of the pipeline, therefore, operational gases would come from compressor stations. The four types of emissions that will mostly occur during operation and construction of the pipeline is dust, the unintended release of unburned natural gas, exhaust gases, and steam.[45]

In the event that gas-processing plants are constructed, they could act to produce a heat island effect. Water vapour emitted from the plants could locally form fog, reduce net radiation to the ground, and increase relative humidity. Under certain winter conditions, ice fog could build up near the plants. These atmospheric effects should not have a significant effect on the environment.[46]

6.5 Biological

The Mackenzie Valley is characterized by a variety of vegetation communities and is an area of concentrated land use by fish and mammals. In addition, valleys have been the preferred areas for many native people.[47]

Wildlife:

The proposed pipeline route provides year-round habitat for numerous wildlife species and seasonal habitat for many other species during the summer months. Wildlife in the area can potentially be impacted directly by the project through habitat loss or modification, sensory disturbance from construction vehicles, and equipment during sensitive overwintering periods, and increased access to the area for hunters. Impacts related to wildlife and wildlife habitat can include:

- loss or alteration of habitat;
- increased predation;
- creation of a long line-of-sight opportunities for hunters and predators;
- sensory disturbance from noise and light;
- habitat fragmentation;
- increased access to remote areas;
- physical barriers to wildlife movements; and
- wildlife harassment and/or habituation.[48]

Ungulates in the project area include moose, Woodland caribou, Dall sheep, elk and wood bison. Moose wintering habitat has been noted near Fisherman Creek. Alternative grazing areas could likely be created along portions of the right-of-

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[45] Pipeline Application Assessment Group, *Mackenzie Valley Pipeline Assessment: Environmental and Socio-Economic Effects of the Proposed Canadian Arctic Gas Pipeline on the Northwest Territories and Yukon*, (Ottawa, Ontario, 1974), p. 335.

[46] Gulf Oil Canada Ltd., Imperial Oil Ltd., and Shell Canada Ltd., *The Environmental Impact of the Proposed Mackenzie Delta Gas Development System*, prepared for the Mackenzie Valley Pipeline Inquiry, (Inuvik, NWT, 1976) p.4.

[47] Berger, T.R., *Northern Frontier, Northern Homeland: The Report of the Mackenzie Valley Pipeline Inquiry*, Vol. 1, prepared for the Minister of Supply and Services Canada, (Ottawa, Ontario 1977) p. 79.

[48] Chevron Canada Resources, *Environmental Assessment of the Fort Liard Gas Pipeline and facilities*, prepared for Mackenzie Valley Environmental Impact Review Board (Yellowknife, NWT., December 1999), p. 79.

way. A number of salt licks occur in the project area.[49] During pipeline operations, vegetation regeneration on the pipeline may increase the presence of ungulates, and in particular, bison.

Several mammals such as rabbits, lynx, fox, wolf and beaver could experience a temporary displacement during the construction activities. Clearing operations on the right-of-way will alter some preferred habitat for these species, while creating new habitat for other species. Increased access could be an issue until vegetation regenerates on the pipeline right-of-way.

Important areas for birds include staging and nesting sites for waterfowl in the valley habitats. Large numbers of ducks and Canada geese, loons and shorebirds nest in the Mackenzie Valley. The most important nesting, moulting and staging areas for waterfowl are Ramparts River, Camkay Creek, Brackett Lake, Mills Lake and Beaver Lake. The birds are susceptible to disturbance during these stages. [50]

Falcons, eagles, and hawks also inhabit the Mackenzie Valley. There are nesting sites for the peregrine falcon and other raptors all along the proposed pipeline and in particular, in Campbell Hills and the Franklin Mountains.

Fisheries:

The Mackenzie River is more productive and has more fish species than either the Porcupine River or the North Slope drainage of the Yukon. Most fish in the Mackenzie Valley have specific migration routes and limited spawning, overwintering, nursery and feeding areas. The proposed pipeline involves the crossing of several watercourses that are varied in size. There is the potential for short-term impacts on fish habitat at the crossing and in the immediate downstream areas that will result from construction activities. The potential impacts related to fish and fish habitat include:

- increased sediment loading in streams;
- loss or alteration of habitat;
- alteration to top of bank; and
- effects from blasting.[51]

Vegetation:

The proposed route has been designed to avoid sensitive vegetation communities such as wetlands, major drainages, and steep topography. Pipeline construction activities will remove and alter vegetation along the right-of-way that may result in local destabilization of terrain and modification to natural habitats. The

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[49] Ibid., p. 181.

[50] Berger, T.R., *Northern Frontier, Northern Homeland: The Report of the Mackenzie Valley Pipeline Inquiry*, Vol. 1, prepared for the Minister of Supply and Services Canada, (Ottawa, Ontario 1977) p. 80.

[51] Chevron Canada Resources, *Environmental Assessment of the Fort Liard Gas Pipeline and facilities*, prepared for Mackenzie Valley Environmental Impact Review Board (Yellowknife, NWT., December 1999), p. 88-94.

potential disturbances to vegetation from pipeline construction and operation include changes to distribution and abundance of certain vegetative communities, loss and /or disturbance to rare and traditional plants, loss of timber resources, and increased fire hazard from machinery operations.[52]

Construction of the roads connecting well clusters and gas plants could alter drainage and flood patterns on some adjacent acreage. This will result in changes in the distribution of certain vegetation types. Vegetation that occupies future airstrips, permanent pad facilities and road development would be destroyed. [53]

6.6 Unique and Sensitive Areas

Northern Canada is recognized as one of the last refuges for many species of North American raptors including the Gyrfalcon, Golden Eagle, Peregrine Falcon, and the Bald Eagle. These birds are protected under the Game Ordinances of the Territories and Provinces. The proposed pipeline route passes through wilderness areas that provide important nesting sites and breeding habitat for these birds. Areas used by these birds should be considered unique and sensitive.

6.7 Cultural

Archaeological

The Yukon interior and portions of the Northwest Territories are the only substantial regions of Canada that were not overrun by glaciers during the Pleistocene Epoch. Many records of human occupation may exist in these areas.[54]

Initial direct impacts will come from planned construction activities and have predictable outcomes. Direct impacts will be in areas of the pipeline right-of-way and the locations of the ancillary facilities (borrow areas, construction camps, compressor stations, access roads, shoo-flys, airstrips, and staging facilities), bank stabilization, and land reclamation programs.[55]

The potential impacts in these zones that could affect archaeological resources include compaction and displacement of sites occurring on or near the surface as a result of vehicular activity.

A number of archaeological and historical traditional use sites have been recorded along the shores and relic beaches of Fisherman Lake and several sites on the northern fringes of the lake. In addition, archaeological sites are known to occur on Richards Island, at the mouth of Thunder River, Loon River, Fort Good Hope, Chick Lake, Nota Creek, Bear Rock, Bear Rock lakes, Great Bear River, Big

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[52] Ibid., p. 77.

[53] Gulf Oil Canada Ltd., Imperial Oil Ltd., and Shell Canada Ltd., *The Environmental Impact of the Proposed Mackenzie Delta Gas Development System*, prepared for the Mackenzie Valley Pipeline Inquiry, (Inuvik, NWT, 1976) p. 5.

[54] Berger, T.R., *Northern Frontier, Northern Homeland: The Report of the Mackenzie Valley Pipeline Inquiry*, Vol. 1, prepared for the Minister of Supply and Services Canada, (Ottawa, Ontario 1977) p. 33.

[55] Fedirchuk McCullough & Associates Ltd., *Mackenzie Valley "Phase I" Pipeline Environmental Effects*, prepared for Polar Gas, (Toronto, Ontario, 1984) p. 6.

Smith Creek, Little Canyon Creek, Saline River, Willowlake River, Cardinal Lake, and Peace River.[56] The physical impacts of the pipeline are predicted to have negligible effect on the archaeological record of the region.[57]

[56] Ibid., p. 17-27.
[57] Chevron Canada Resources, *Environmental Assessment of the Fort Liard Gas Pipeline and facilities*, prepared for Mackenzie Valley Environmental Impact Review Board (Yellowknife, NWT., December 1999), p. 95.

7.0 Beaufort Sea-Mackenzie Delta Offshore Route

7.1 Background

The Mackenzie Delta-Beaufort Sea frontier region is potentially a new source of supply for the ever-increasing North American natural gas market. In the 1970s, the Canadian federal government initiated a moratorium on the issuance of land rights in the Northwest Territories to the oil and gas industry. This was put in place to allow time for settling land claims in the North. The 1977 Berger Commission report – entitled Northern Frontier, Northern Homeland – effectively reduced interest in northern oil and gas for a number of years when it stated, "If the native people are to achieve their goals, no pipeline can be built now." Subsequently, hydrocarbon exploration and development slowed down considerably despite the large northern resource potential.

Renewed interest resulted in the Mackenzie Delta gas export hearings at the National Energy Board for Gulf Canada Resources Ltd., Shell Canada Ltd. in 1988 and Esso Resources Canada Ltd. in 1989. However, costs of exploration, development, production and transportation to market were seen as too high to justify proceeding, particularly, given the outlook for the North American gas industry. Development of these resources for the North American continental gas grid was considered beyond any reasonable planning horizon.[58]

There are a variety of gas compositions in the Mackenzie Delta-Beaufort Sea area. Some wells are oil and gas wells that will produce rich associated gas containing substantial volumes of recoverable liquids. Other wells are non-associated gas wells that combine lean and rich gas, and include condensate. Gas processing will be required to meet hydrocarbon dew point pipeline requirements. [59]

The Mackenzie Delta-Beaufort Sea basin has an excellent discovery record with 53 discoveries, including two major oilfields, three major gas and one major oil and gas field. A 1994 resource assessment by the Geological Survey of Canada (GSC) suggested that the prospects for doubling the number of discoveries in this size range are good, in both onshore and offshore exploration plays.[60] It has been speculated that coastal routes have less environmental impacts than interior routes.[61] The proposed route for the Beaufort Sea-Mackenzie Delta is presented in figure 7.

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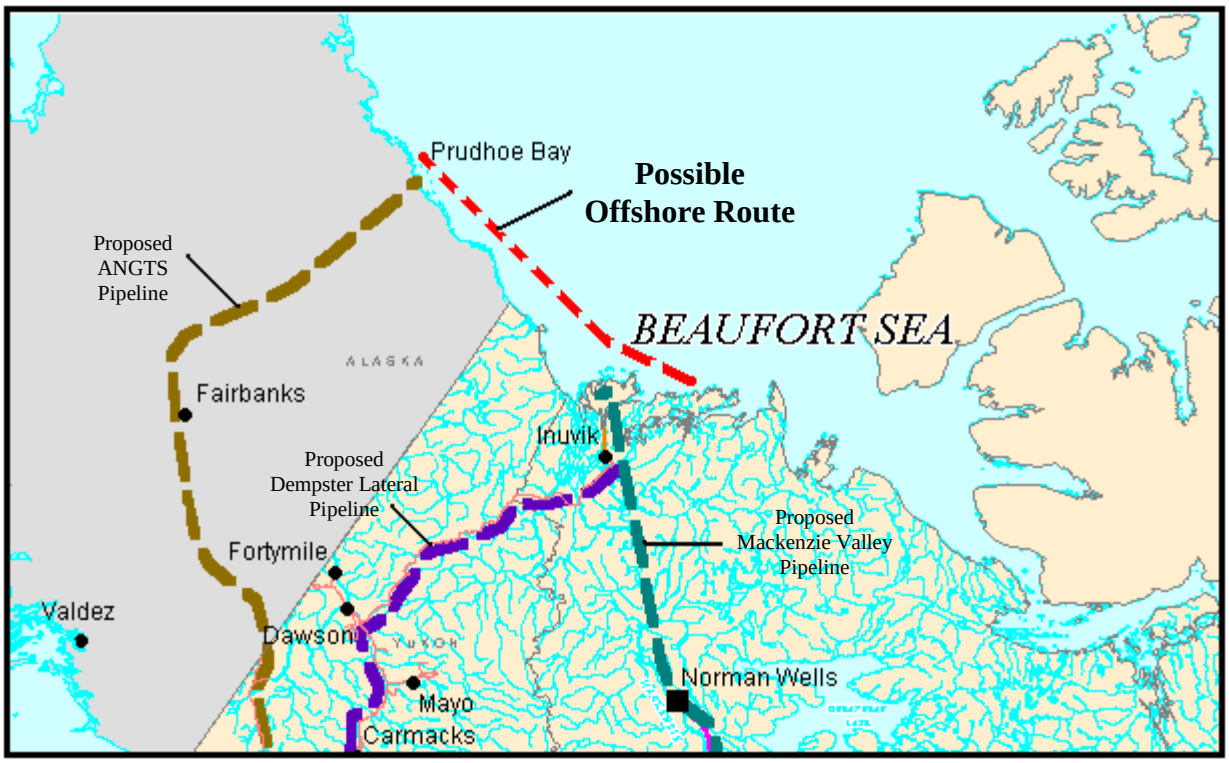
[58] Williams, K.C., *Mackenzie Delta Gas Opportunity, n*otes for remarks, prepared for the National Association of Petroleum Investment & the Canadian Association of Petroleum Investment Analysts (Halifax Petroleum Investment Conference, Halifax, Nova Scotia, May 18, 2000).http://www.exxon.com/eaff/imperialoil/news/speech000518/sp000518.htm

[59] Roland George, "ARTIC EXPOSURE; Mackenzie Delta - Beaufort Sea Natural Gas - Is It Time?" *Oilweek*, November 1, 1999, (http://purvingertz.com/oilwk110199.html).

[60] Beaufort Sea and Mackenzie Delta Open for Posting. Northern Oil and Gas Bulletin. Volume 5, Number 1. January 1998. http://www.inac.gc.ca/oil/bulletin/vol5_1.html

[61] Banfield, Frank, *A comparison of the Total Environmental Impacts of the Coastal and Interior Routes*, prepared for the Mackenzie Valley Assessment Panel, (Inuvik, NWT., 1973) p. 4.

Figure 7
Possible Beaufort Sea-Mackenzie Delta Offshore Route



Source: Corporate Pipeline Maps; Enbridge; Nova; Westcoast; Ranger; Foothills Pipe Lines
Mapping Prepared by Komex International Ltd

7.2 Geology

The Delta-Beaufort region can be divided into three areas: the Mackenzie Delta, The Delta region, and the Beaufort Sea. Mackenzie Delta is a maze of islands, channels, perched basins, lakes and swamps. It is forested except for tundra areas along the coast. Permafrost plays a dominant role in the formation of the delta. Situated above 67.5 degrees N., the majority of the delta still remains in the discontinuous permafrost zone. This is due to the warming of the landscape caused by the Mackenzie River. The unfrozen, nutrient rich soil allows the treeline to reach farther north in the Western Arctic than elsewhere in the NWT. In the northern part of the delta, near Tuktoyaktuk where the permafrost is continuous, the world's largest concentration of pingos (cone-shaped hills with a core of ice) are found dotting the landscape. [62] The Delta region is largely a treeless low land that extends eastward from the Mackenzie Delta. The Beaufort Sea is covered with ice for many months of the year.

[62] Fedirchuk McCullough & Associates Ltd., *Mackenzie Valley "Phase I" Pipeline Environmental Effects*, prepared for Polar Gas, (Toronto, Ontario, 1984) p. 16.

Seabed Permafrost and Ice Scour:
Floating ice in the Beaufort Sea scours the sea floor. The depth of scour penetration into the sea floor varies between 10-25 ft. The ice action potentially poses a threat for seabed installations such as pipelines or flow lines.[63] There is permafrost in the ground below the Beaufort Sea. There is also the potential for buried pipelines to melt the permafrost and create frost heave.

Erosion and Slope Instability:
Instability of slopes in permafrost regions is predicted as a result of increased depth of thaw that could result from construction activities and operation of a warm pipeline. [64]

7.3 Hydrology

Ice:
The primary environmental constraint affecting offshore petroleum operations is sea ice. For eight to nine months each year (October through July), ice covers most of the region. An ice-free corridor develops along the coast during the summer months.[65] The maximum extent of open water is usually attained in early September.

Ice islands and hummock fields may also be encountered in the Beaufort Sea. Ice islands are a potential threat to offshore structures in water depths greater that 20 m.[66]

The Beaufort Sea is completely ice covered for most of the year. A zone of land fast ice extends outward from the shore tens of miles, and is separated from the moving polar pack ice by a narrow shear zone characterized by rapidly deforming, irregular ice. In summer, the land fast ice melts and the polar pack retreats farther offshore. Within the Beaufort Sea region, the principal area of environmental concern is the shear zone and the open leads at the edge of the land fast ice. This area provides critical habitat for migrating birds in the spring and for polar bears and seals in both winter and spring.[67]

Surface Water*:*
The Delta is dominated by approximately 25 000 lakes and perched basins. These water bodies play a significant role in the ecology of the Delta. They affect the

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[63] Berger, T.R., *Northern Frontier, Northern Homeland: The Report of the Mackenzie Valley Pipeline Inquiry*, Vol. 1, prepared for the Minister of Supply and Services Canada, (Ottawa, Ontario 1977) p.68.
[64] Interdisciplinary Systems Ltd. *Initial Environmental Evaluation of the Proposed Alaska Highway Gas Pipeline Yukon Territory*, prepared for Alaska Highway Pipeline Panel (Winnipeg, Manitoba, May 1977) p. 127.
[65] Dome Petroleum Ltd., Esso Resources Canada ltd. and Gulf Canada Resources Inc., *Beaufort Sea-Mackenzie Delta Environmental Impact Statement*,(Vol. 1, 1982) p. 1.1.
[66] Ibid., p. 1.8.
[67] Berger, T.R., *Northern Frontier, Northern Homeland: The Report of the Mackenzie Valley Pipeline Inquiry*, Vol. 1, prepared for the Minister of Supply and Services Canada, (Ottawa, Ontario 1977) p.54.

distribution of permafrost, support populations of fish, waterfowl and mammals, and provide storage for water, sediment and pollutants. [68]

Potential impacts to the Beaufort Sea-Mackenzie Delta during pipeline construction and operation could include discharges of sewage, heated cooling water, drilling muds, blowout preventer fluid, and produced water. Dredging activities may have short-term affects on water quality and may alter the Beaufort Sea Continental shelf.[69]

7.4 Climate

Air:

Gaseous and particulate emissions from marine vessels, and equipment during construction and operation could impact air quality in the Beaufort Sea region. There is a possibility of ice fog formation around emissions sources, however, the wind conditions over the Beaufort should disperse emissions and ice fog if it occurs.[70]

7.5 Biological

Wildlife:

Within the Beaufort Sea region, the principal area of environmental concern is the shear zone and the open leads at the edge of the land-fast ice. This area provides critical habitat for migrating birds, polar bears, arctic fox, beluga whales, bowhead whales, and several different species of seals.[71]

The Delta, the coast of the Delta region, the coastal waters and the offshore leads of the Beaufort Sea are of great importance for migratory birds. Every spring, millions of birds converge on the Delta-Beaufort region from wintering grounds in Southern Canada, the United States, South America and the Antarctic. Two million migrating seabirds and waterfowl representing about 100 species frequent the Beaufort Sea and its coastal margins. Birds migrate east and west along the coast of the Beaufort Sea. The Mackenzie Delta also functions as a principal fall staging area for the migrating snow geese.[72]

The variety of habitat in the Delta-Beaufort region supports a wide range of mammals including beluga whales, muskrat, grizzly and polar bears. Many of these wildlife species are migratory and also play an important role in the traditional lives of people living in and around the delta. Approximately fifty-four species of mammals, one hundred and thirty-seven species of birds, and one

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[68] Swystun, Heather, Mackenzie Delta EMAN (Ecological Monitoring and Assessment Network) Site Profile. (Inuvik, NWT., 1999). http://www.bmmda.nt.ca/mackenzie_delta.htm

[69] Dome Petroleum Ltd., Esso Resources Canada ltd. and Gulf Canada Resources Inc., *Beaufort Sea-Mackenzie Delta Environmental Impact Statement*,(Vol. 1, 1982) p. 2.16.

[70] Ibid. 2.16.

[71] Berger, T.R., *Northern Frontier, Northern Homeland: The Report of the Mackenzie Valley Pipeline Inquiry*, Vol. 1, prepared for the Minister of Supply and Services Canada, (Ottawa, Ontario 1977) p.54

[72] Berger, T.R., *Northern Frontier, Northern Homeland: The Report of the Mackenzie Valley Pipeline Inquiry*, Vol. 1, prepared for the Minister of Supply and Services Canada, (Ottawa, Ontario 1977) p.55.

amphibian are known to occur in the Delta-Beaufort region. [73] This region also supports critical life stage areas that are essential to the survival of other populations. The nesting, staging and moulting areas of the outer Delta are important to various bird species. The offshore leads are critical for birds, seals and polar bears. The calving grounds in the shallow waters of the Delta are critical for the beluga whales.[74] With proper wildlife management, overall impacts to mammals are expected to be minor. Impacts on birds will depend on facility location and timing of construction activities.[75]

Fisheries:

Fish are abundant in the Mackenzie Delta. There are approximately fifty-five species of fish including humpback whitefish, pike, sucker, lake trout, arctic grayling and arctic char. Some populations of fish pass through the Delta on their way to the Beaufort Sea. The fish are at greatest risk from pipeline construction and operation during spawning, overwintering and migration.

Potential impacts on fish could result from changes in the smaller food organisms and exclusion from important habitats. There may also be changes in the habitats related to oxygen depletion, and sedimentation of spawning and overwintering areas.[76]

Offshore development in the Beaufort is expected to have minor impacts on fish. As mentioned earlier, water quality could be impacted from waste and other discharges. Closer to shore, the potential for impacts from pipeline construction and operation is greater, particularly during the summer months.[77]

Vegetation:

Two different habitat types are dominant in the vegetation communities of the delta, tundra along the Beaufort Sea and taiga further inland. Successional changes in some plant communities are maintained by seasonal flooding and by fire. This transitional zone provides a home for a variety of wildlife not normally seen at these latitudes. [78]

Potential impact of pipeline construction and operation on vegetation in the Delta will be negligible because of the relatively flat topography of the region and the

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[73] Swystun, Heather, Mackenzie Delta EMAN (Ecological Monitoring and Assessment Network) Site Profile. (Inuvik, NWT., 1999). http://www.bmmda.nt.ca/mackenzie_delta.htm

[74] Berger, T.R., *Northern Frontier, Northern Homeland: The Report of the Mackenzie Valley Pipeline Inquiry*, Vol. 1, prepared for the Minister of Supply and Services Canada, (Ottawa, Ontario 1977) p. 56-57.

[75] Dome Petroleum Ltd., Esso Resources Canada ltd. and Gulf Canada Resources Inc., *Beaufort Sea-Mackenzie Delta Environmental Impact Statement*,(Vol. 1, 1982) p.2.23.

[76] Berger, T.R., *Northern Frontier, Northern Homeland: The Report of the Mackenzie Valley Pipeline Inquiry*, Vol. 1, prepared for the Minister of Supply and Services Canada, (Ottawa, Ontario 1977) p. 62.

[77] Dome Petroleum Ltd., Esso Resources Canada ltd. and Gulf Canada Resources Inc., *Beaufort Sea-Mackenzie Delta Environmental Impact Statement*,(Vol. 1, 1982) p. 2.18.

[78] Swystun, Heather, Mackenzie Delta EMAN (Ecological Monitoring and Assessment Network) Site Profile. (Inuvik, NWT., 1999). http://www.bmmda.nt.ca/mackenzie_delta.htm

fact that the plant communities in the Delta are already adapted to severe environmental stress in the form of annual flooding and high sediment deposition.[79] However, impacts to tundra may be more substantive. Historical mapping of the Prudhoe Bay Oil field indicates that impacts to tundra have exceeded initial estimates, both in terms of area and time an area is affected. [80]

7.6 Unique and Sensitive Areas

Four terrestrial and one marine setting have been identified by Parks Canada as natural regions in the Beaufort Sea area. These areas include the calving grounds of the Porcupine caribou herd coastal zones that support migrant and staging waterfowl in the northern Yukon. In addition, the International Biological Programme (IBP) has identified several coastal and tundra areas in the Beaufort Sea region as IBP sites. These IBP sites include: Hershel Island, Firth River, Garry and Pelly Islands, Caribou Hills, Kugaluk River, Toker Point, Anderson River, and Minto Inlet.[81]

Other significant areas include Polynyas (areas of open water bounded by fast ice or by fast ice and land). In the Beaufort Sea, polynyas are used in winter by marine mammals and during spring by migrant beluga whales, bowhead whales and birds. [82]

Sensitive habitats for certain fish species have been identified in several water bodies adjacent to the Beaufort Sea. Almost all water bodies within the Beaufort Sea-Mackenzie Delta area contain spawning habitat for anadromous species, such as arctic grayling or longnose sucker. Migratory routes for the Arctic cisco, Least cisco, whitefish species and Arctic char exist in the Mackenzie Delta. There are also potential overwintering habitats for several fish species.[83] Spawning, migratory routes, and overwintering areas could be impacted by reduced stream flows, low water levels, heavy ice scour, contaminants, and reduced dissolved oxygen levels caused by pipeline construction and operation.

The Beaufort Sea-Mackenzie Delta is also a migratory route for many bird populations. Sensitive areas were also identified in the west Mackenzie Bay, where the beluga whales use several areas for calving and where the main mass of beluga whales gather in the summer.[84]

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[79] Arctic Gas Ltd., *Statement of the Arctic Gas Project on Environmental Impacts of Alaska Natural Gas Transportation System Alternatives*, prepared for the Council in Environmental Quality of the United States of America, (May 24, 1977) p. 10.

[80] Walker, D.A., Webber, P.J., Binnian, E.F., Everett, K.R., Lederer, N.D., Nordstrand, E.A. and Walker, M.D. 1987. Cumulative impacts of oil fields on northern Alaskan landscapes. Science (Washington, DC) 238 (4828): p.757-761.

[81] Dome Petroleum Ltd., Esso Resources Canada ltd. and Gulf Canada Resources Inc., *Beaufort Sea-Mackenzie Delta Environmental Impact Statement*,(Vol. 3A, 1982) p.3.77-3.80.

[82] Ibid.

[83] Dome Petroleum Ltd., Esso Resources Canada ltd. and Gulf Canada Resources Inc., *Beaufort Sea-Mackenzie Delta Environmental Impact Statement*,(Vol. 3A, 1982) p. 4.74-4.76.

[84] Berger, T.R., *Northern Frontier, Northern Homeland: The Report of the Mackenzie Valley Pipeline Inquiry*, Vol. 1, prepared for the Minister of Supply and Services Canada, (Ottawa, Ontario 1977) p. 65.

7.7 Cultural

Several historic and archaeological sites could exist in the Beaufort Sea-Mackenzie Delta Area. The earliest human migration to this area is believed to have occurred 25 000 to 30 000 years ago, a second migration from eastern Asia 10 000 years ago, and around 5 000 years ago the early ancestors to the Eskimo migrated.[85] No additional information on known or suspected archaeological sites was located.

[85] Berger, T.R., *Northern Frontier, Northern Homeland: The Report of the Mackenzie Valley Pipeline Inquiry*, Vol. 1, prepared for the Minister of Supply and Services Canada, (Ottawa, Ontario 1977) p. 6.