Alcan Pipeline Company
Docket No. CP76-
Exhibit Z-1
Hearing Exhibit No. NW ____

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL POWER COMMISSION

APPLICATION OF ALCAN PIPELINE COMPANY FOR CERTIFICATE OF PUBLIC CONVENIENCE AND NECESSITY

EXHIBIT Z-1, VOLUME 1
ALASKA

PURSUANT TO SECTION 7 (C) OF THE

NATURAL GAS ACT

FOR AUTHORIZATION

TO CONSTRUCT AND OPERATE MAINLINE

FACILITIES AND FOR THE TRANSPORTATION

OF NATURAL GAS IN INTERSTATE COMMERCE

JULY 9, 1976

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PREFACE

This Environmental Report on the Alaskan segment of the Alcan pipeline system is the result of the cooperative effort of a number of organizations and individual consultants. The overall preparation of the report was coordinated by Land/Right-of-Way and Regulatory Affairs Department of Gulf Interstate Engineering Company ("GIEC"). The basic report describing the existing Alaskan environment and the impact of the proposed Alcan project on that environment (except the socio-economic portions thereof) was prepared by the staff of the Arctic Environmental Information and Data Center, of the University of Alaska, Anchorage ("AEIDC") under the direction of David M. Hickok. This input was reviewed, in cooperation with AEIDC, by independent consultants in a wide-range of environmental disciplines, as well as by GIEC. The portion of the Report which discusses socio-economic considerations (Sections 2.3 and 3.3) was prepared by staff from the Institute of Social, Economic and Government Research, University of Alaska, Fairbanks ("ISEGR"). The portion of the Report identifying mitigative measures which will be employed by Applicant in the construction and operation of the pipeline was prepared by GIEC after a review by engineering and construction personnel of information and recommendations provided by Applicant's independent consultants. In short, the Environmental Report is the product of an intensive effort by a broad range of individuals with considerable knowledge of and experience in the State of Alaska.

AEIDC was established in 1972 by the Alaska State Legislature to provide a center for arctic resource and science information services, and has grown rapidly in response to increasing demands for data that have been accelerated by resource development in the Arctic. AEIDC has three complementary groups: information services, resource and science services, and publication and communication services. Preparation of that portion of the Report for which AEIDC was responsible was accomplished by a team of interdisciplinary scientists and resource experts in both physical and biological disciplines. The AEIDC portion is similar to many others prepared by the Center for government agencies which summarize the extent and scope of current knowledge for particular geographic areas and resource and environmental situations in Alaska. It was prepared from available published and unpublished literature and data sources evaluated and supported by the AEIDC staff's cumulative Alaskan field experience totalling over 75 years, including many years of governmental, industrial and academic research and management service involving assessments of the trans-Alaska oil pipeline.

The professional vitae of Mr. Hickok and the staff personnel who participated in the preparation of the report are included in Section 10 of this Report. Substantial contributions to this Report have also been made by the Applicant's independent environmental and engineering consultants. These consultants reflect a broad range of disciplines and a wide variety of experience in Alaskan and Arctic environments. A list of these consultants and their professional vitae is contained in Section 10 of this Report.

Most of these consultants have initiated field studies in their respective area of expertise, as well as having conducted reconnaissance surveys of the entire pipeline route. A report on studies which have been completed are in progress or have been scheduled is set forth in Section F-IV of this Application.

1.0 DESCRIPTION OF THE PROPOSED ACTION

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1.0 DESCRIPTION OF THE PROPOSED ACTION

Alcan Pipeline Company proposes to construct, maintain and operate the Alaskan segment of an overland pipeline system designed to transport natural gas from Prudhoe Bay on the North Slope of Alaska to consumers in Alaska and the lower 48 states. The Alaskan segment will consist of a large-diameter pipeline extending from Prudhoe Bay southward to Delta Junction along the Alyeska oil pipeline corridor and then eastward to the Alaska-Yukon border along the Alcan Highway-Haines Pipeline corridor. At the Alaska-Yukon border, the Alcan pipeline segment will interconnect with facilities to be constructed by Foothills Pipe Lines, Ltd. and then will be further transported through new and existing pipeline systems in Canada to points of redelivery on the Canadian-United States border for lower 48 markets. The components of the applicant's proposed pipeline system that constitute this Application for a Certificate of Public Convenience and Necessity are as follows:

1. Prudhoe Bay, Alaska to the U.S.-Yukon border via a new Alcan Pipeline Company gas pipeline.

2. Fifteen compression stations.

3. Three meter stations.

4. Appurtenant Facilities

This proposal is made feasible by the imminent production and transportation of crude oil resources from the North Slope of Alaska. The gas fraction of the hydrocarbon complex will be produced jointly with the petroleum in which it is dissolved. In view of the national energy shortage, a collection and delivery system to transport this energy resource to waiting consumers is highly desirable.

1.1 PURPOSE

The purpose of the Alcan pipeline is to transport natural gas from the Prudhoe Bay reserve south and east across Alaska for delivery at the Yukon border into a receiving pipeline constructed concurrently by Foothills Pipe Lines, Ltd. Gas delivered at this point will then be transported across Canada and into distribution networks in the lower 48 States where it will become available directly or via exchange to customers in market areas of the United States. This gas supply is intended to meet a portion of the existing disparity between customer demand and available gas supply, a trend that has reached serious proportions in recent years. Applicant's proposal will deliver one of this nation's great untapped natural resources--the Prudhoe Bay gas fields--as a means of alleviating this energy shortage. At design flow, to be reached by January 1, 1983, the Alcan pipeline will transport 2,400 million cubic feet of gas per average day (MMCFD). Buildup to this delivery level will occur in the following increments:*

1,200 MMCFD by January 1, 1981

1,600 MMCFD by January 1, 1982

2,400 MMCFD by January 1, 1983

The actual rate of production from the Prudhoe Bay field will depend on the producer operating plan approved by the state of Alaska.

1.2 LOCATION

1.2.1 Pipeline

The proposed Alaska segment of the Alcan pipeline shown in Figure 1.2-1 will consist of 731.4 miles of 42-inch outside diameter (O.D.) pipe. The pipeline route will closely follow two established transportation corridors. The alignment of the proposed pipeline is shown on the Sensitivity maps DL through D25, as keyed in figure 1.2-2. From Alyeska Pump Station Number 1 at Prudhoe Bay to Delta Junction, 85 miles south of Fairbanks, the pipeline alignment will adjoin 538.8 miles of the Alyeska oil pipeline right-of-way. In this segment, the line will traverse the tundra of the North Slope of Alaska and enter the Brooks Range at Galbraith Lake. Crossing the Continental Divide at Atigun Pass, the route will follow the valleys of the North Fork Chandalar, Middle Fork Koyukuk, and the Dietrich Rivers. As the rivers trend to the west, the route will continue south across the drainage pattern to the Yukon River, and then southeast to Fairbanks and the Tanana River at Delta Junction.

From Delta Junction southeast to the Alaska-Canada border at Scottie's Creek, the alignment will follow the Alcan Highway. The route remains in the Tanana River Valley throughout this traverse of the Tanana-Kuskokwim lowlands below the east face of the Alaska range. Besides following the Alcan Highway, this segment will adjoin or utilize the rights-of-way of a products pipeline previously used to transport products between Fairbanks and Haines Junction

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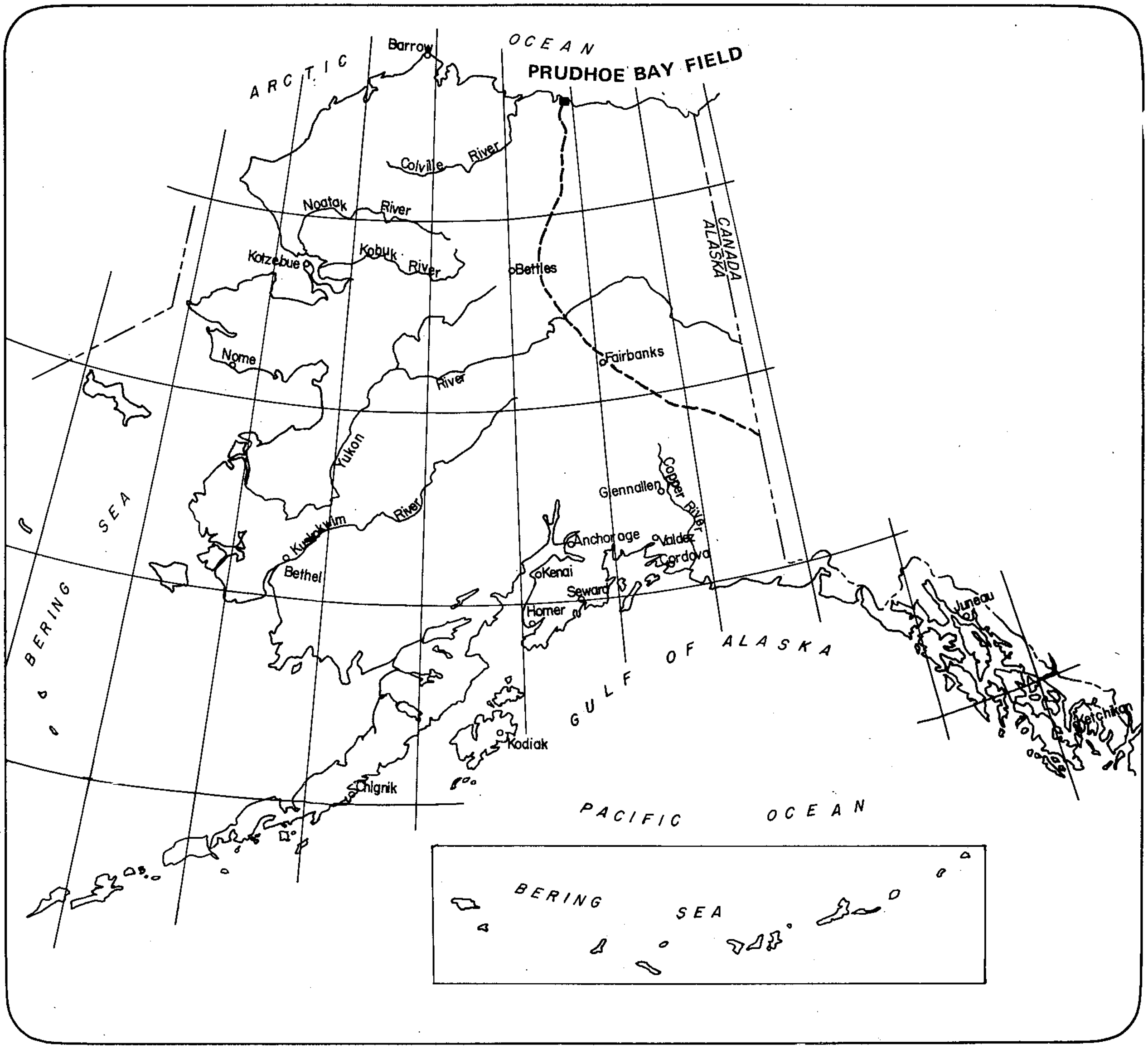
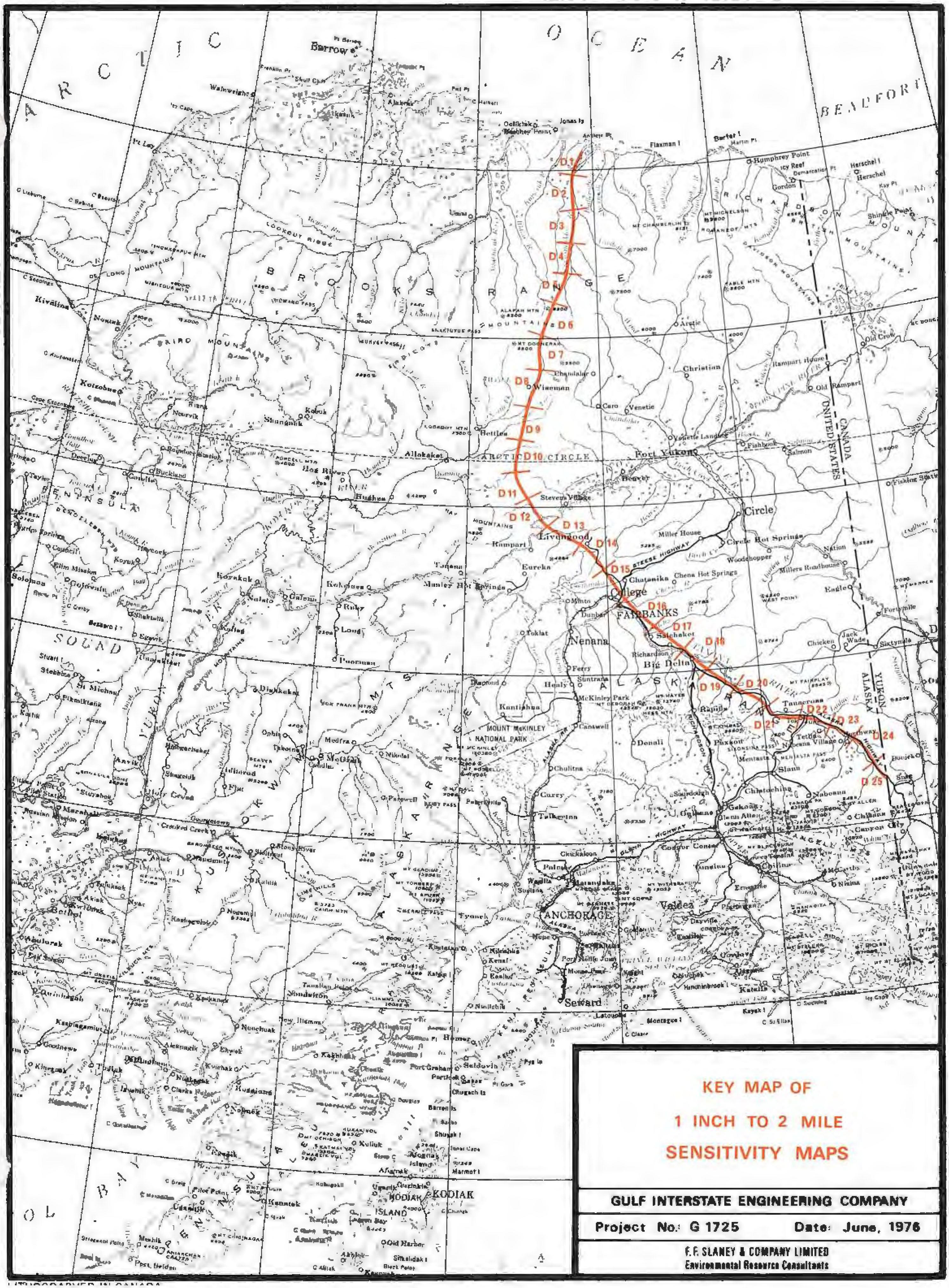
*This assumes receipt of all regulatory certificates by January 1, 1978.



Alcan Pipeline-Alaska

Figure 1.2-1



KEY MAP OF

1 INCH TO 2 MILE

SENSITIVITY MAPS

GULF INTERSTATE ENGINEERING COMPANY

Project No: G 1725 Date: June, 1976

F.F. SLANEY & COMPANY LIMITED
Environmental Resource Consultants

Wet tundra vegetation communities occur across uplands.

Moist tundra occurs along river slopes.

Only signigicant nesting colony of snow geese in Alaska occurs east of pipeline. Winter construction should cause no impact.

Important high density waterfowl habitat. Winter construction and restriction of activities to R/W should minimize impacts.

Muskox range is 25 miles east of pipeline. No impact is expected.

Caribou summer range.

Seabirds, mostly nesting colonies of black guillemots on offshore islands, use the corridor as a major migration route. Minimal impact is expected.

Moose are evenly distributed along the river, particularly in winter and spring. Concentrations should be avoided.

The entire delta region of the Sagavanirktok River is an important overwintering area for arctic char. The R/W is situated away the main channels so no effects are expected.

Pregnant female Polar bears will den up to 25 miles inland and are sensitive to disturbance during denning.

Important caribou wintering range. Concentrations of animals should be avoided.

Prudhoe Bay airport is private and state owned with a gravel runway.

Deadhorse airport is state owned with a gravel runway.

* State-Selected Lands.

* Transportation and Utility Corridor

A-5: Recent Eskimo site occupied in 1930's

The map-area lies within the zone of thick continuous permafrost. Pingos and thaw lakes are features of this region. These and other periglacial features may require special construction procedures when encountered along the pipeline.

The marine Gubik Formation of bedrock which underlies the map-area is often overlain by peat and loess. Segregated ice is prolific in the surficial deposits, though the Gubik Formation itself is not seriously frost susceptible.

Potential problems associated with freeze bulbs should be investigated through the wet tundra section.

MAP D1

GULF INTERSTATE ENGINEERING COMPANY

Alcan Pipeline Company

42" GAS LINE ROUTE

LEGEND: Sensitive Area | Water Quality Info. | Archaeological Site* | X Historic Site* | (* location approximate)

F. F. SLANEY & COMPANY LIMITED Environmental Resource Consultants

DRWN. a. W. B.	SCALE 1" = 2 Miles	DATE June 20/76
APPRVD. D. BL.	DRWG. NO.	REV. NO.

LITHOGRAPHED IN CANADA

brush vegetation communities occur throughout the sheet.

Fish species in Sagavanirktok River probably include Arctic char, Arctic grayling, whitefish and cisco, ninespine sticklebacks and to a lesser extent smelts, sculpins, burbot, chum and pink salmon in lower reaches. There are no commercial fisheries in this area. subsistence fisheries exist for Arctic char, tefish and smelts.

Moose concentrate along the river particularly during winter and spring. Concentrations of animals should be avoided.

Franklin Bluffs constitutes an important raptor nesting site. The Arctic peregrine falcon may nest here. Construction is 2 miles from the site so no disturbance is expected.

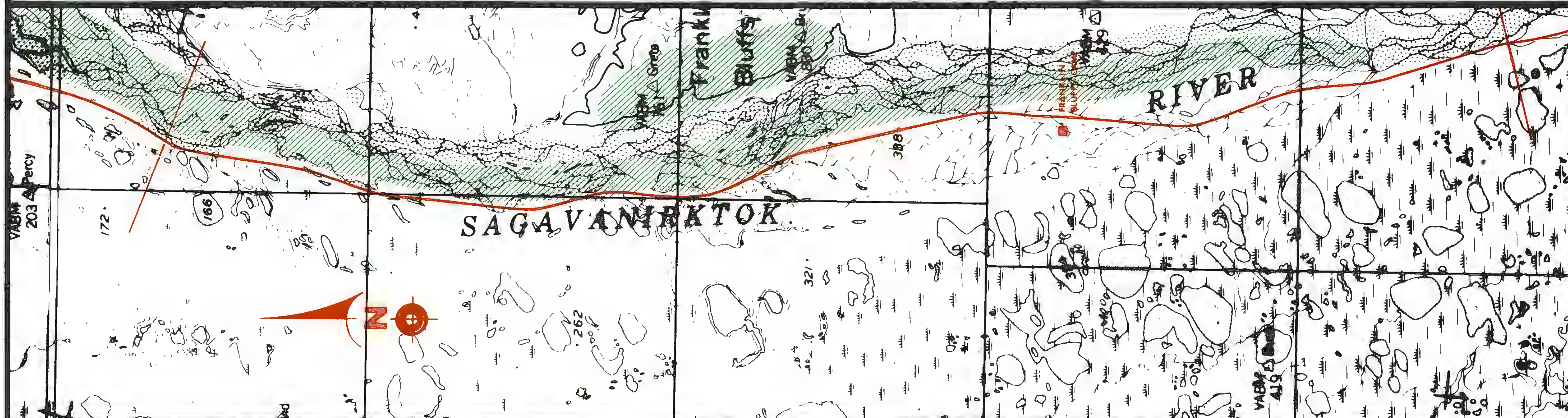
Waterfowl concentrations are sensitive to harassment during nesting and staging. Winter construction and restriction of activities to the R/W should minimize disturbance.

Caribou summer throughout this map.

Grizzly bear concentrations on the Sagavanirktok River are sensitive to disturbance during denning.

The Sagavanirktok River is a wide braided stream flowing on a sand and gravel bed with an ill defined channel. Flooding and channel alteration are common.

State-Selected Lands
Transportation and Utilit



The map-area lies within the zone of continuous permafrost.

Franklin Bluffs Camp has an infiltration gallery under the Sagavanirktok River.

Franklin Bluffs is an unusual geologic, botanical and zoological feature. It is a proposed ecological reserve and a natural landmark. The pipeline location along the west bank avoids this feature.

MAP D2

GULF INTERSTATE ENGINEERING COMPANY		
Alcan Pipeline Company		
42" GAS LINE ROUTE		
DRWN.	SCALE 1" = 2 Miles	DATE June 20/76
APPRVD.	DRWG. NO.	REV. NO.

LEGEND: Sensitive Area Water Quality Info. Archaeological Site* X Historic Site* (*location approximate)

F. F. SLANEY & COMPANY LIMITED
Environmental Resource Consultants

LITHOGRAPHED IN CANADA

High brush vegetation communities occur throughout the map.

High density waterfowl area. Winter construction and restriction of activities to the R/W should avoid disturbance.

Aquatic fur bearers are uncommon north of Brooks Range.

Raptors nest along river. Moderate capability waterfowl habitat.

Grizzly bear concentrations present on river should be avoided. Garbage disposal techniques should be designed to avoid attracting bears.

Territorial, individual caribou may be encountered in the coastal plain.

Year round moose concentrations on river.

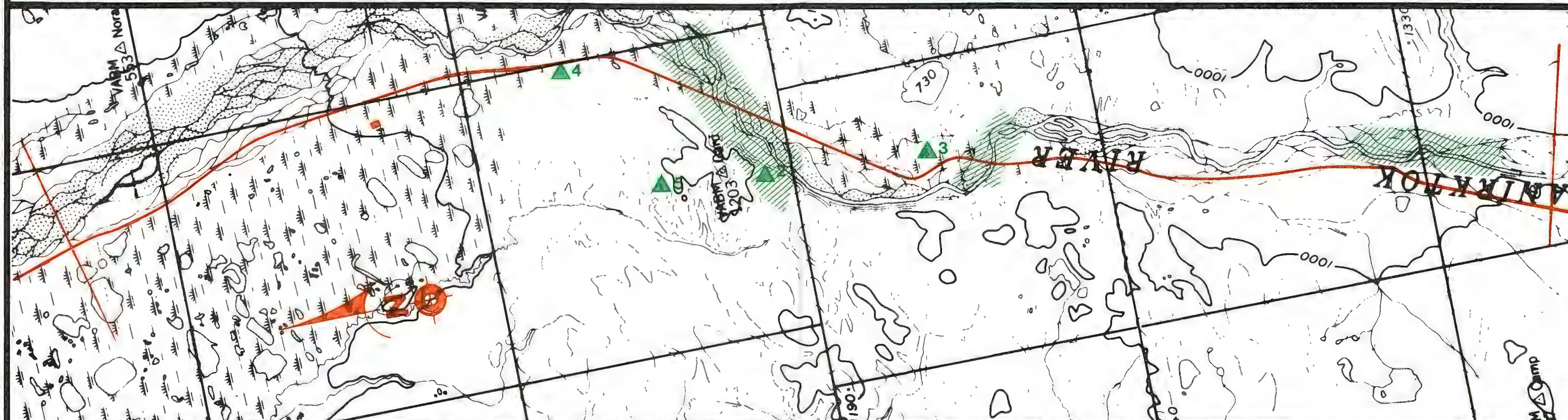
Caribou of Arctic and Porcupine herds summer throughout. Calving areas will be distant from pipeline.

Arctic char overwinter in deeper portions of river, particularly near springs and in the river delta, and spawn in upstream tributaries near Brooks Range, from August to October. Arctic grayling also overwinter in area and are sensitive to heavy sediment loads and fishing pressure. Restriction of activities away from river channels should avoid disturbance.

Sagwon Airport is private with a gravel runway.

* State-Selected Lands *

Transportation and Utility Corridor *



A-4: Site contains pre- and post-contact material.

A-2: Two tent rings of recent origin.

A-5: Site contains a hearth on a bluff above the river.

A-3: Site contains 60 pieces of wood.

Area contains up to six archaeological sites just east of the river.

The map-area lies within the zone of thick, continuous permafrost. Thermokarst and other permafrost related erosional hazards may be encountered. Extensive areas of aufeis will develop on the Sagavanirktok River flood plain during the winter. Bank erosion has been observed. The area is blanketed by silts and bogs. Subitiminous coal is found in the foothills.

MAP D3

GULF INTERSTATE ENGINEERING COMPANY		
Alcan Pipeline Company		
42" GAS LINE ROUTE		
DRWN. a.w.B	SCALE 1" = 2 Miles	DATE June 20/76
APPRVD. J.B.L.	DRWG. NO.	REV. NO.

LEGEND: Sensitive Area ■ Water Quality Info. ▲ Archaeological Site* X Historic Site* (*location approximate)

F. F. SLANEY & COMPANY LIMITED
Environmental Resource Consultants

LITHOGRAPHED IN CANADA

High brush vegetation community throughout the sheet.

Moderate capability for waterfowl. Concentrations of nesting birds should be avoided.

Arctic peregrine falcon may nest along the Sagavanirktok River.
Year round moose concentrations along the river.
Grizzly bear concentrations present along the river

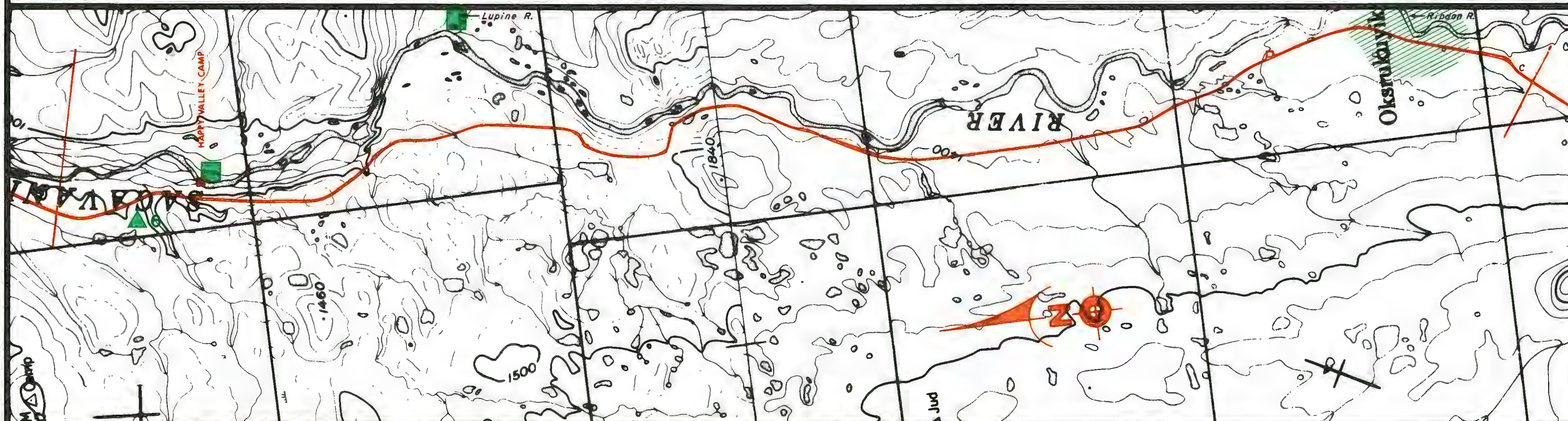
Low density waterfowl area.

Lupine River and other tributaries to Sagavanirktok River may provide areas for overwintering of Arctic char and Arctic grayling.

The Ribdon River joins the Sagavanirktok River at this point and is an important overwintering area for Arctic char. The proposed pipeline is not expected to have a significant effect on this resource.

Happy Valley Airport is private with a gravel runway.
Happy Valley has an infiltration gallery under the Sagavanirktok River.

Transportation and Utility Corridor



A-6: Surface site.

River plain can be seasonally inundated.

The map-area lies within a zone of thich continuous permafrost. Degradational erosional problems may occur especially on slopes. Silts, rich with ice, blanket much of the map-area. Mud flows and landslides are common in the region.

MAP D4

GULF INTERSTATE ENGINEERING COMPANY

Alcan Pipeline Company

42" GAS LINE ROUTE

DRWN.	SCALE 1" = 2 Miles	DATE June 20/76
APPRVD.	DRWG. NO.	REV. NO.

F. F. SLANEY & COMPANY LIMITED
Environmental Resource Consultants

LEGEND: Sensitive Area ■ Water Quality Info. ▲ Archaeological Site* X Historic Site* (*location approximate)

LITHOGRAPHED IN CANADA

High brush vegetation community occurs at elevations lower than about 2,000 feet.

Moist tundra vegetation community occurs throughout upland valleys.

Moose throughout this area.

Low capability for waterfowl.

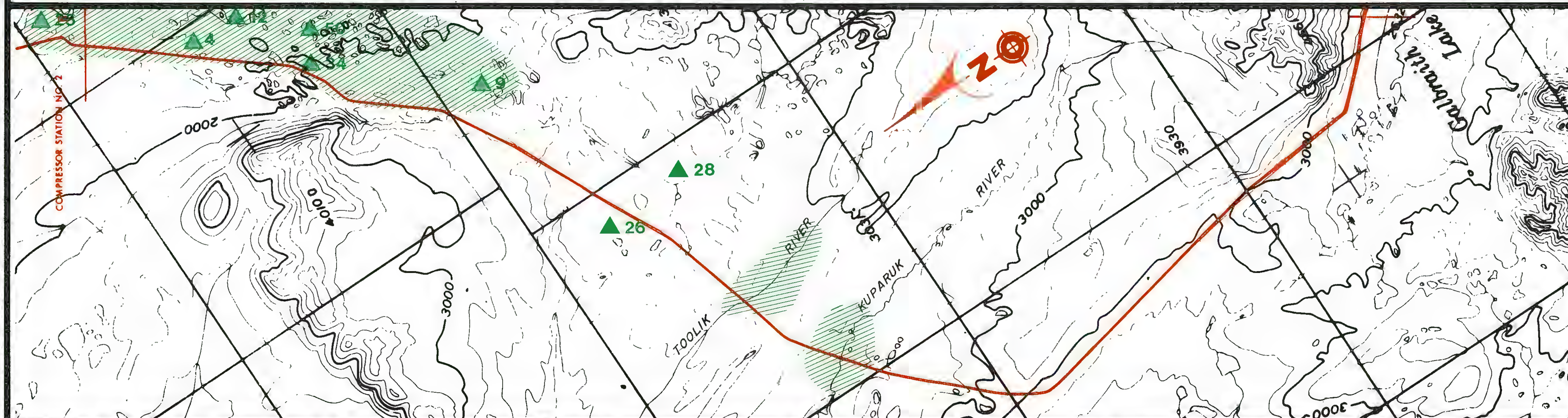
Toolick and Kuparuk River headwaters may contain Arctic grayling and Arctic char, spawning and over-wintering areas. Burbot and whitefish may also occur. These species are sensitive in fall and early winter (September to December).

Caribou may migrate through this pass from the south. Mineral licks occur east of line. Avoid caribou concentrations.

Galbraith Lake contains mainly grayling, char, whitefish and burbot. It may contain lake trout which in these northern latitudes has an extremely slow growth rate and is sensitive to depletion by overfishing.

Toolick Camp Airport is private with a gravel runway. Galbraith Lake Airport is private with a gravel runway.

Transportation and Utility Corridor



A-25: Tent rings.

A-12: Caches

A-4: Recent Nunamiut site.

A-9: Tent ring and soil houses.

A-26: Presumed lookout site.

A-28: Surface site.

Important archaeological sites around Murphy Lake, 2 miles west of line.

A-34: Material similar to Gallagher Flint Station (A-50).

A-50: Significant site containing material 8-12,000 years B.P. of Arctic Small Tool character. Excavated. (A National Register site).

The map-area is generally underlain by continuous permafrost but extreme variations in thickness can be expected due to topographic and related considerations. Ice-rich silts blanket much of the area. Mudflows are a common phenomena within the area.

MAP D5

GULF INTERSTATE ENGINEERING COMPANY

Alcan Pipeline Company

42" GAS LINE ROUTE

DRWN. a.a.B.	SCALE 1" = 2 Miles	DATE June 20/76
APPRVD. D.B.L.	DRWG. NO.	REV. NO.

LEGEND: Sensitive Area · Water Quality Info. · Archaeological Site* · X Historic Site* (*location approximate)

F. F. SLANEY & COMPANY LIMITED
Environmental Resource Consultants

LITHOGRAPHED IN CANADA

Moist tundra vegetation community occurs in the Atigun Valley floor.

Combination of moist tundra and alpine tundra vegetation communities occur in these mountain valleys.

Grizzly bear concentrations occur along river in greater numbers than on coastal plain. Complete disposal of garbage is important.

Moose are evenly distributed along valleys.

Tributaries in this area are important spawning and rearing grounds for Arctic char. July to September are sensitive months. Galbraith Lake is a potential overwintering area. Arctic grayling, burbot and whitefish are also abundant.

Grouse and ptarmigan migrate through Brooks Range in winter and will be sensitive to harassment.

Caribou migrating through Brooks Range will be sensitive to harassment. Concentrations should be avoided.

Dolly Varden may occur in the west fork of the Chandalar River. This species is tolerant of heavy silt loads as adults but is sensitive to migration blockages from August to September. Excessive silt loads in streams in December to February can inhibit the development of eggs.

Dall sheep may be encountered in Atigun Canyon occasionally. Valley bottom activities should have little effect.

Atigun Canyon is a recognized scenic and viewing area for Dall sheep.

ARCTIC DIVIDE

North Slope Borough Boundary. All drainage to Beaufort Sea.

All drainages to Yukon River.

Transportation and Utility Corridor

A-49: Site containing Arctic Small Tool material.

A-24: Tent rings.

A-30-33: Galbraith Lake sites of recent origin. Significant.

A-5: Surface site.

Atigun Camp has filtration gallery under Atigun River.

Atigun Canyon contains many archaeological sites, some are significant.

The route crosses a number of faults in the map-area. No recent movements have been noted though there has been some post glacial landslide activity near Galbraith Lake.

Galbraith Lake is a large lake important for winter water storage and flood flow regulation.

The map-area lies within a zone of continuous permafrost though topographic and related influences cause a variability in thickness. Valley floor silts have a high ice content. Ground ice problems are a special concern in the valleys. Talus slopes and frost heaving soils occur in the alpine pass.

High winds, generated through the mountain passes, can create severe wind chill conditions.

MAP D6

GULF INTERSTATE ENGINEERING COMPANY

Alcan Pipeline Company

42" GAS LINE ROUTE

LEGEND: Sensitive Area | Water Quality Info. | Archaeological Site* | X Historic Site* | (* location approximate)

F. F. SLANEY & COMPANY LIMITED
Environmental Resource Consultants

DRWN. QUB	SCALE 1" = 2 Miles	DATE June 20/76
APPRVD. D. B. L.	DRWG. NO.	REV. NO.

LITHOGRAPHED IN CANADA

Complexes of alpine tundra and upland spruce vegetation communities in valley conditions.

Moose distributed throughout the region.

Caribou wintering area in mountains east of line. Restriction of construction activities to valley bottoms should avoid conflicts.

Migrating caribou may use the pass and will be sensitive to harassment.

Dietrich Airport is state owned with water and gravel runways.

Table Mountain south of the Dietrich River Valley supports Dall Sheep and is a recognized viewing area. Mineral licks occur in the area. No conflict is expected from valley bottom construction activities.

Peregrine falcon may nest along the river.

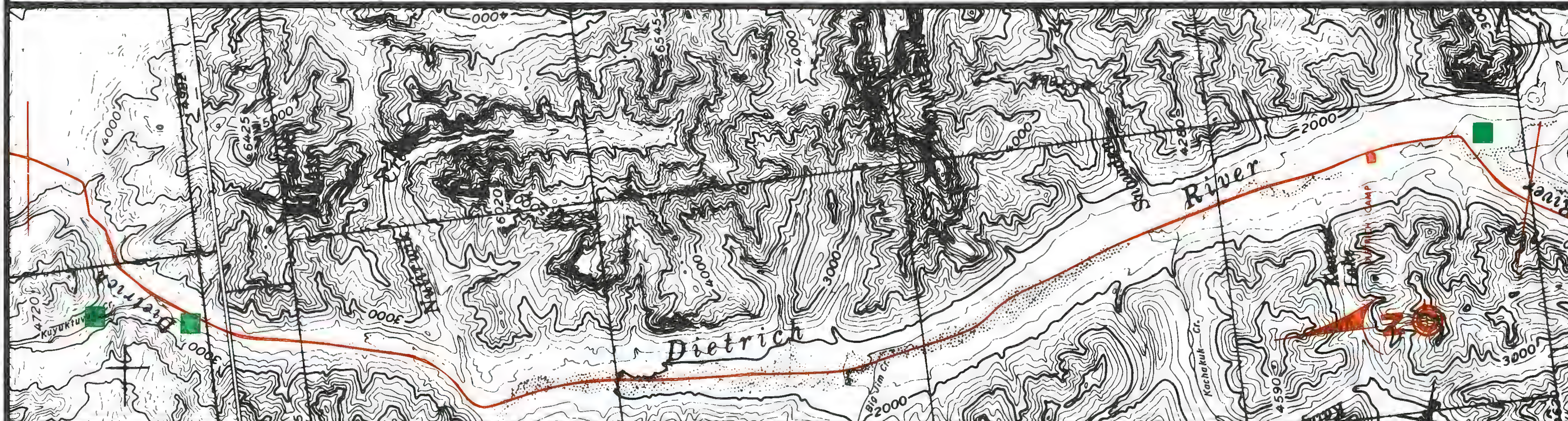
Grizzly bear along river are sensitive to harassment.

Migrating caribou may use the pass and may be sensitive to disturbance. Concentrations should be avoided.

Gravel bars of Dietrich used as access routes by hunters of grizzly bears and sheep.

Dietrich River is probably habitat for whitefish, Dolly Varden, grayling, longnose sucker and slimy sculpin. Arctic grayling is sensitive to excessive silt loads, migration barriers and overfishing from September to December.

* Transportation and Utility Corridor *



Pipeline Schematic

High wind speeds in mountain passes can create severe wind chill conditions.

Notes

This sheet lies within a zone of continuous permafrost with a variable thickness dependent on topographic and related influences. Solifluction processes are prevalent.

Ground ice problems may occur where silt moisture contents are high along the valley floors.

MAP D 7

GULF INTERSTATE ENGINEERING COMPANY

Alcan Pipeline Company

42" GAS LINE ROUTE

DRWN. TMA	SCALE 1" = 2 Miles	DATE June 20/76
APPRVD. D.B.L.	DRWG. NO.	REV. NO.

LEGEND: Sensitive Area ■ Water Quality Info. ▲ Archaeological Site* X Historic Site* (*location approximate)

F. F. SLANEY & COMPANY LIMITED Environmental Resource Consultants

LITHOGRAPHED IN CANADA

Upland spruce in river valley. Alpine tundra in mountains.

Gravel bars of upper middle fork of the Kayukuk River are used as access routes by hunters of grizzly bears and sheep.

Moose along the valleys.

Small tributaries in this region, including Linda Creek, Gold Creek, Sheep Creek, Nugget Creek, Rainbow Creek, and Bluff Gulch probably contain populations of Arctic grayling. Stream crossings in this area should avoid fall months when this species is sensitive to excessive sediment loads, migration barriers and overfishing.

Dall Sheep may be present along mountain slopes but should be little affected by valley bottom construction.

Whitefish, Arctic grayling, burbot and slimy sculpin may inhabit Minnie Creek; these fish are sensitive to construction from late August to November.

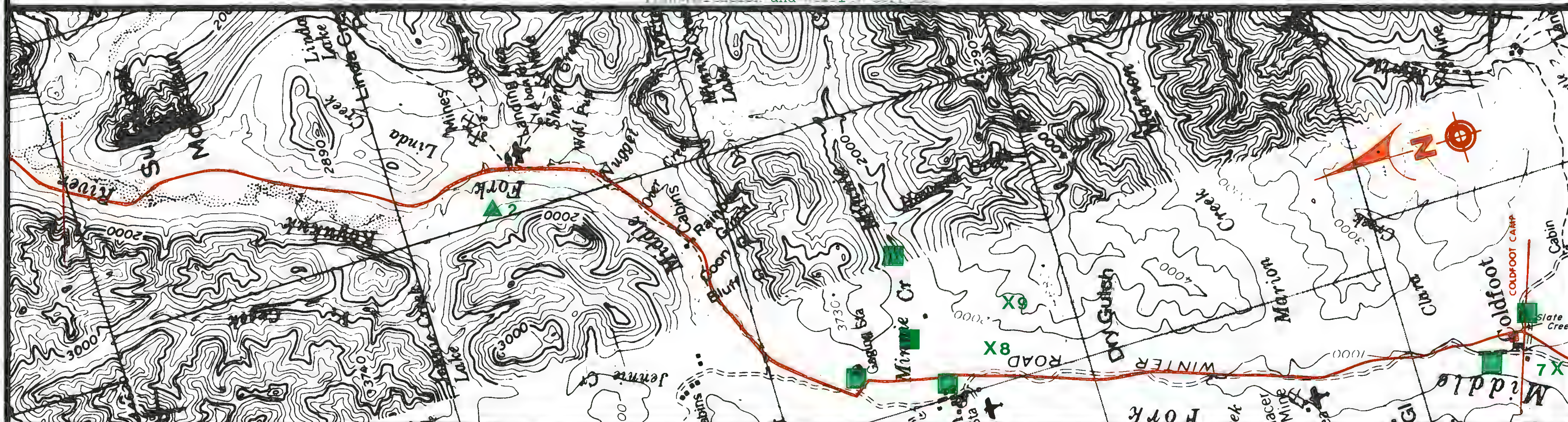
Caribou may migrate across the valley from the west. Concentrations should be avoided.

Grizzly bear are present along the river.

Emma Creek Airport is privately owned with a gravel/dirt strip.

Wiseman Airport is state owned with a gravel strip.

Transportation and Utility Corridor



Pipeline Schematic

A-2: Lookout site.

H-8: Mining town, active.

H-9: Log building.

Wiseman is an historic mining community with a few "old-timers" still resident.

H-7: Abandoned town, 1899.

MAP D8

Notes

The map-area lies in a zone of continuous permafrost with variable thickness. Ice content is high in valley bottom flats and ground ice phenomena may occur.

The mineral potential of the area includes lode antimony, gold, silver, lead, manganese and phosphate. Production is mainly placer gold near Linda Creek where a potential use conflict could occur.

High wind speeds which occur in mountain passes may cause severe wind chill conditions.

GULF INTERSTATE ENGINEERING COMPANY

Alcan Pipeline Company

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F. F. SLANEY & COMPANY LIMITED Environmental Resource Consultants

LITHOGRAPHED IN CANADA

Upland spruce vegetation communities occur in the valley bottom.

Moose wintering areas 5 to 10 miles east and west of pipeline. Otherwise moose uniformly distributed.

Slate Creek and the middle and south forks of the Kayukuk River are probable spawning areas for chinook salmon. Fish probably enter the area in June to August to spawn in early fall. Summer and early fall construction may interfere with fish passage and spawning activity.

Low capability for waterfowl.

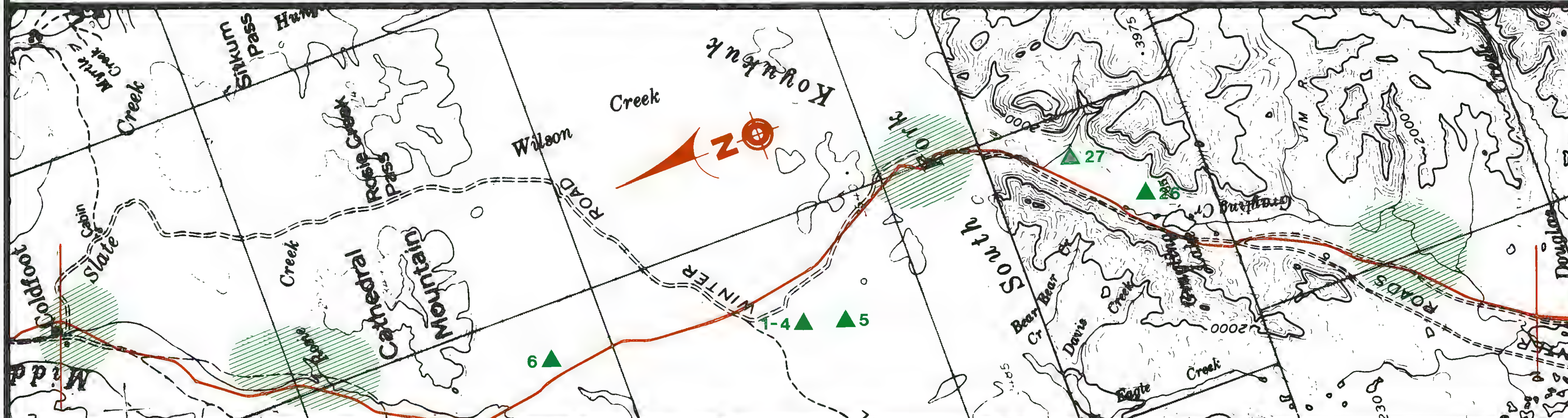
Tramway Bar Airport is privately owned with a dirt runway.

dfoot Airport is privately owned with a gravel runway.

Porcupine Creek Airport is state owned with a gravel/dirt runway.

Goldbench Airport is publicly owned with a dirt runway.

Transportation and Utility Corridor



A-1-4: Archaeological sites contain hearths, microblades, flakes. One is a presumed lookout site.

A-6: Unknown significance.

A-5: Blowout site.

A-26-27: Grayling Lake area. Significance unknown.

The Kayukuk Valley is prone to earthquake activity and resultant slumps can occur in sands and silts adjacent to river banks.

The map-area lies in a transition zone of continuous to discontinuous permafrost. Variable segregated ice content of the substrate is a concern as well as potential ground icing hazards. In the middle Kayukuk region high moisture silts are particularly prone to the development of ground ice.

Small placer gold operation on the Koyukuk River and tributaries.

MAP D9

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F. F. SLANEY & COMPANY LIMITED
Environmental Resource Consultants

LEGEND: Sensitive Area ■ Water Quality Info. ▲ Archaeological Site* X Historic Site* (*location approximate)

LITHOGRAPHED IN CANADA

Upland spruce vegetation community occurs throughout the map.

Moose evenly distributed throughout the area.

Low capability for waterfowl.

Jim River and Prospect Creek are probable spawning areas for chinook and chum salmon. Fish will be sensitive to late summer and autumn construction activity.

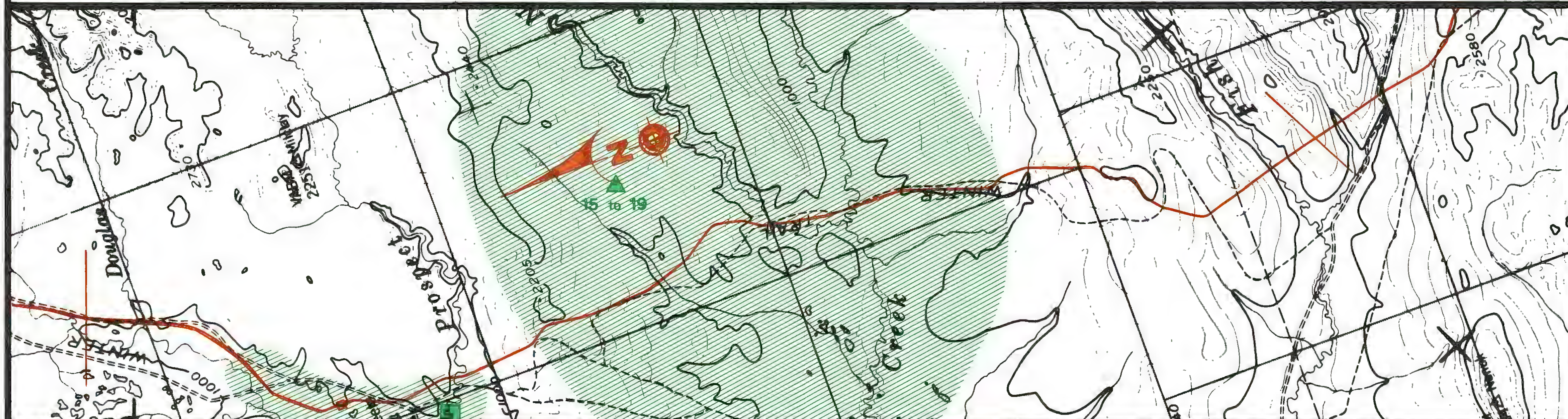
Caribou wintering area will be sensitive to harassment and habitat disturbance.

The community of Prospect Creek obtains domestic water from 2 wells on banks of Jim River.

Prospect Creek Airport is privately owned with a gravel runway.

Oldman Camp Airport is privately owned with a gravel runway.

Transportation and Utility Corridor



A-15-19: Bonanza Creek area. Sites include buried and surface artifacts and blowouts.

The map area lies within a zone of discontinuous permafrost. Winter ground icing may be a concern. A few thaw lakes may occur near the pipeline. Solifluction features will be more prevalent in this hilly terrain. Segregated or massive ice is rare. The depth to the permafrost table is variable. Saturated silts form the active layer. Special design of construction and operation procedures may be warranted.

MAP D 10

GULF INTERSTATE ENGINEERING COMPANY

Alcan Pipeline Company

42" GAS LINE ROUTE

DRWN. jgb	SCALE 1" = 2 Miles	DATE June 20/76
APPRVD. D.B.L.	DRWG. NO.	REV. NO.

LEGEND: Sensitive Area · Water Quality Info. · Archaeological Site* · X Historic Site* (* location approximate)

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Environmental Resource Consultants

Upland Spruce vegetation community occurs throughout much of the sheet.

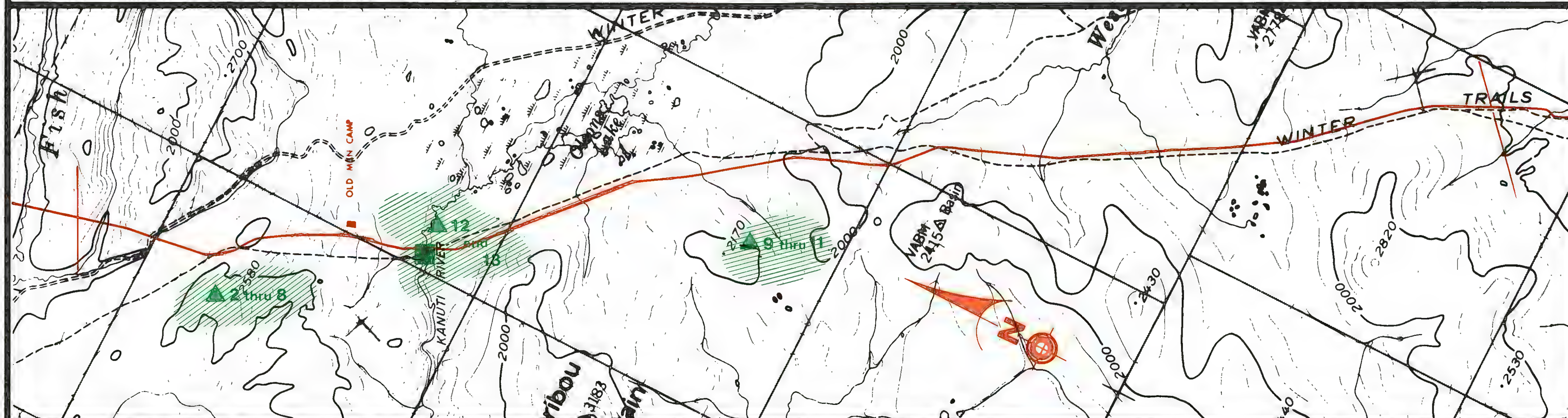
Caribou wintering area. Concentrations of animals should be avoided.

Moose throughout map area.

Low capability for waterfowl.

Major coho salmon spawning and rearing area. Migration starts in September and spawning occurs from October to November.

Transportation and Utility Corridor



A-2-8: Caribou Mt. North area.

A-9-11: Caribou Mt. South area. Surface sites.

A-12-13: Upper Kanuti River locality. Damaged microblades.

The map area lies in a zone of discontinuous permafrost. Winter ground icing hazards will be a concern. Solifluction deposits and activity will be encountered on some slopes.

MAP D II

GULF INTERSTATE ENGINEERING COMPANY

Alcan Pipeline Company

42" GAS LINE ROUTE

DRWN. jgb	SCALE 1" = 2 Miles	DATE June 20/76
APPRVD. D.B.L.	DRWG. NO.	REV. NO.

LEGEND: Sensitive Area ■ Water Quality Info. ▲ Archaeological Site* X Historic Site* (*location approximate)

F. F. SLANEY & COMPANY LIMITED
Environmental Resource Consultants

LITHOGRAPHED IN CANADA

Upland Spruce vegetation communities occur along the line.

Moose throughout the region.

High capability for waterfowl on Yukon flats east of the line. Restriction of activities to the R/W should avoid disturbance.

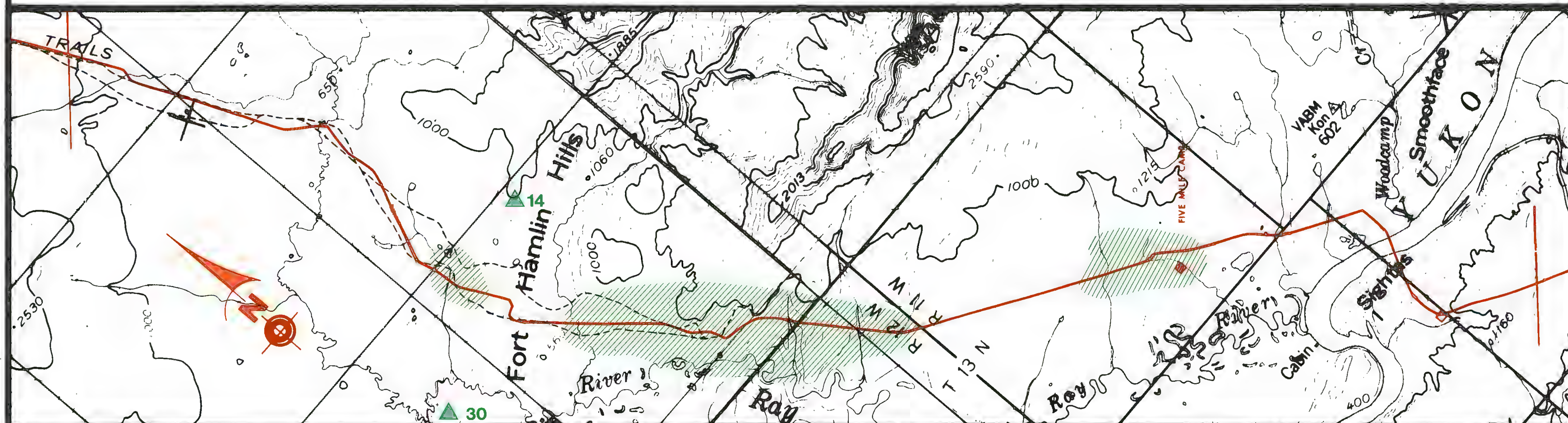
Ray River is a major spawning area for summer and fall run chum salmon. Fish will be sensitive to construction activities causing migration barriers or excessive sediment loads from August to December.

Lake trout inhabit headwaters of Yukon River. This species has a very slow growth rate and is sensitive to over-fishing.

Small commercial fishery for chum and chinook salmon in mainstem Yukon River. Total escapement up rivers approaches 10 million fish/year. Tributaries are closed to commercial fish harvest. Upstream sub-sistence fishery (Rampart) for salmon (3000-15,000 per annum). Minor subsistence fisheries for white-fish, inconnu, northern pike and burbot.

Five Mile Camp airport is privately owned with a gravel runway.

Transportation and Utility Corridor



A-14: Microblades found in this area.

A-30: Waste flakes found in this area.

With the possible exception of the Yukon River flood plain the entire map sheet lies within the zone of discontinuous permafrost. The flood plain is under-lain by coarse granular deposits but surficial cappings of loess are expected.

River plain can be seasonally inundated.

MAP D 12

GULF INTERSTATE ENGINEERING COMPANY

Alcan Pipeline Company

42" GAS LINE ROUTE

DRWN. jgb	SCALE 1" = 2 Miles	DATE June 20/76
APPRVD. DBL	DRWG. NO.	REV. NO.

F.F. SLANEY & COMPANY LIMITED Environmental Resource Consultants

LEGEND: Sensitive Area ■ Water Quality Info. ▲ Archaeological Site* X Historic Site* (*location approximate)

LITHOGRAPHED IN CANADA

Upland spruce vegetation community in better drained areas adjacent to the Yukon River.

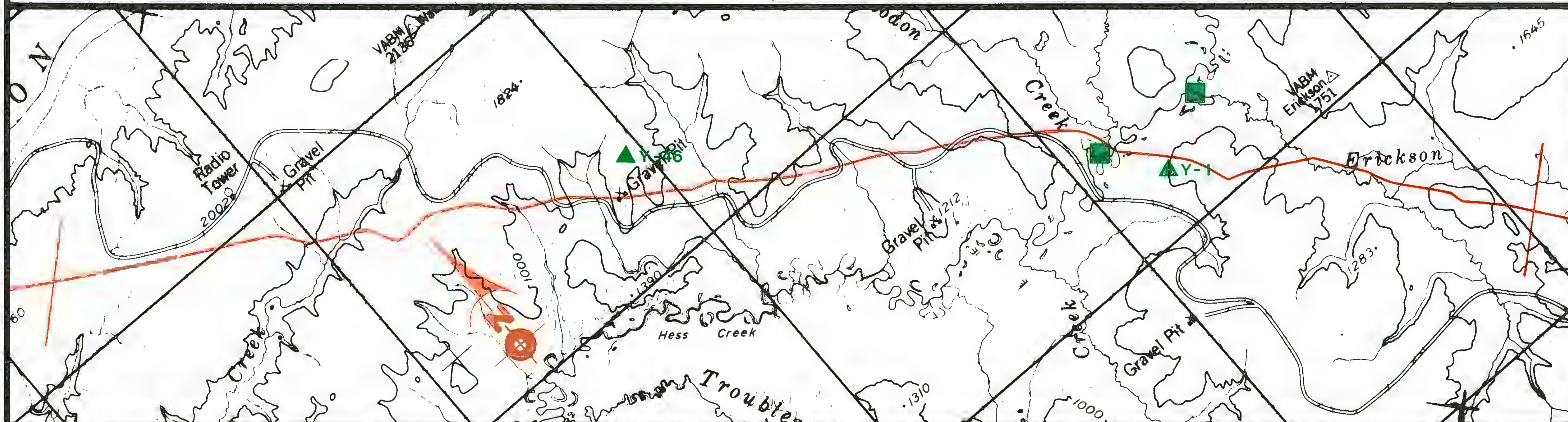
Low Brush, muskeg and bog occur in the bottom lands adjacent to the route.

Moose uniformly distributed and sensitive to harassment and habitat disturbance.
Moose wintering area.

Seasonal use limitations exist on highway due to spring breakup. Overuse and disruption of normal summer maintenance are concerns.

*

Transportation and Utility Corridor.



A-Y-46: One diagnostic artifact was retrieved by Alyeska archaeologists.

A-Y-1: Surface site.

This map sheet lies within the zone of discontinuous permafrost. Ground icings are a potential erosional hazard. Loess occurs near the Yukon River. The ice content of the silts is high. In the Hess Creek, permafrost conditions may require special attention during restablization.

The Rampart Trough at Hess Creek contains a belt of tightly folded "soft" rocks of Tertiary age. Some coal has been mined in this zone. Earthquakes of Richter Scale 6.5 are reported in this region accompanied by landslides and ground "breakage". The area lies parallel to a fault zone.

MAP D 13

GULF INTERSTATE ENGINEERING COMPANY

Alcan Pipeline Company

42" GAS LINE ROUTE

DRWN. TMA	SCALE 1" = 2 Miles	DATE June 20/76
APPRVD. D.B.L.	DRWG. NO.	REV. NO.

LEGEND: Sensitive Area ■ Water Quality Info. ▲ Archaeological Site* X Historic Site* (* location approximate)

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Environmental Resource Consultants

Upland spruce vegetation communities occupy better drained sites. Low brush, muskeg and bog occur in flat bottom and uplands.

Fall concentrations of moose 5 miles west of line. Restriction of activities to along pipeline should avoid disturbance.

Low capability for waterfowl.

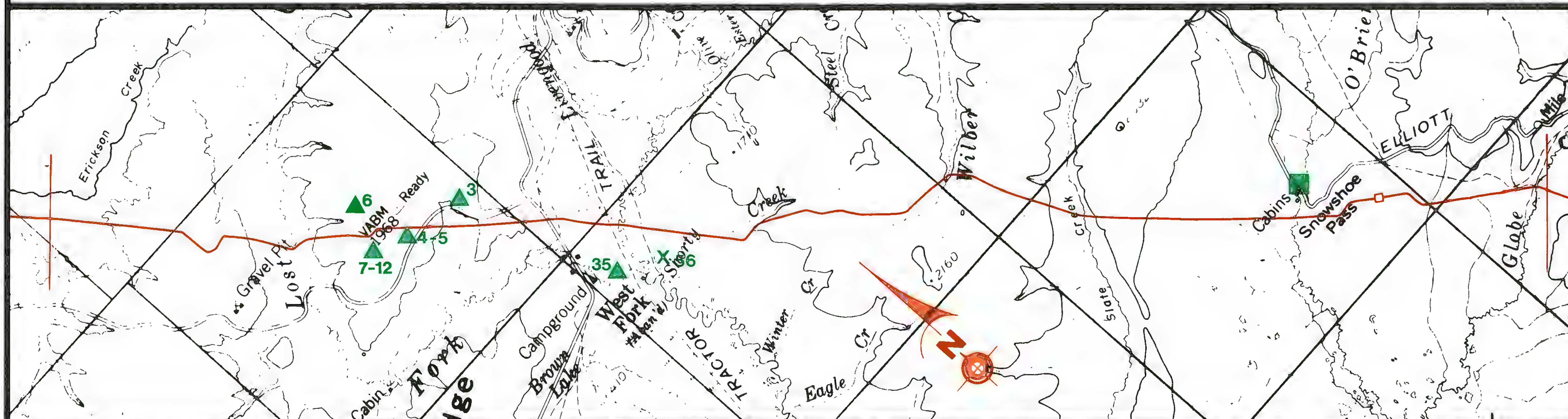
Caribou wintering area for the Forty-mile Herd along Tatalina River is mainly east of line.

Moose wintering area along Globe Creek. Concentrations of these animals should be avoided.

Whitefish and arctic grayling are abundant in tributaries throughout this region. Grayling are sensitive to migration barriers, heavy sediment loads and overfishing from late Aug. to Nov.

Campground near Brown Lake. Displacement of local users should be avoided.

Transportation and Utility Corridor



A-3 Rosebud Knob #1 and #3 - Surface sites.
A-4-5 Ready Ridge - surface sites.
A-6 Surface sites.
A-7-12 Look-out Ridge locality - surface sites.

A-35 Quarry site.
H-56 Roadhouse, sawmill and tram road, 1915.

Tatalina River wooden bridge has historic value.

The Livengood region contains lode gold, silver, antimony, mercury, chromium, nickel and iron but production to date has been limited. Placers in the region contain gold, monazite and uranium, rare earth minerals.

This sheet lies within the zone of discontinuous permafrost; ground icings may be an erosion hazard. Talik occurs in the ground profile.

MAP D 14

GULF INTERSTATE ENGINEERING COMPANY

Alcan Pipeline Company

42" GAS LINE ROUTE

DRWN. TMA	SCALE 1" = 2 Miles	DATE June 20/76
APPRVD. D.B.L	DRWG. NO.	REV. NO.

LEGEND: Sensitive Area · Water Quality Info. · Archaeological Site* · X Historic Site* (*location approximate)

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Upland spruce with some dense hardwoods vegetation community occurs in better drained regions.
Low brush-muskeg-bog occupies the lowland areas along the Chatanika River.

Agricultural land uses occur south of Dome.

Best commercial forest stands south of Chatanika River Basin to Tanana River.

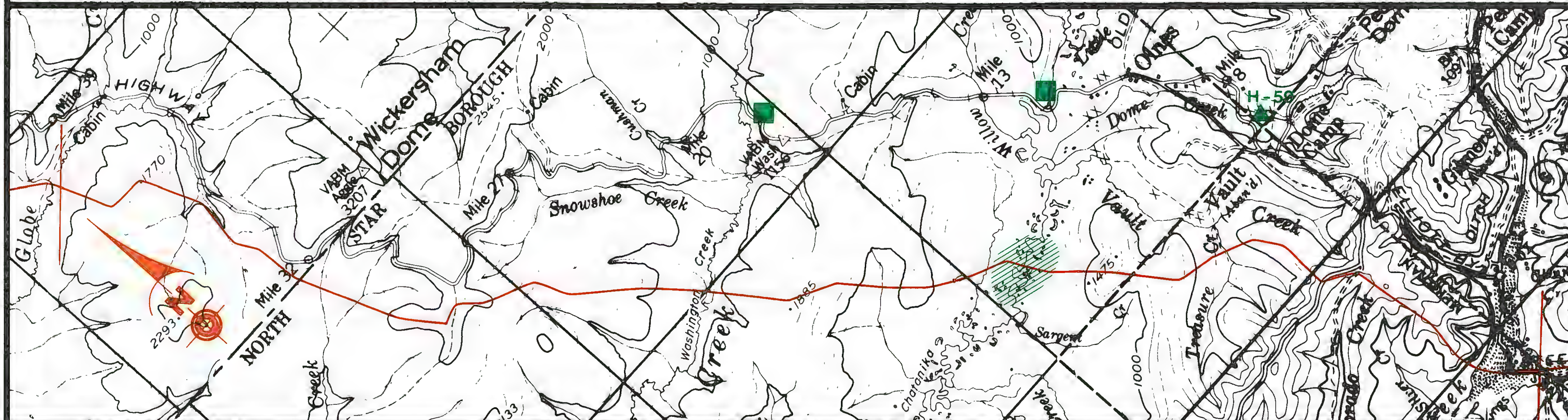
Chatanika River is a major salmon producing area. Chinook salmon spawn from July-August and silver (coho) salmon spawn from Oct.-Nov. Arctic grayling, inconnu, least cisco and humpback whitefish are also abundant. Avoid construction during spawning and rearing periods (July-Dec.); best construction period is spring. Avoid excessive sediment loads since juvenile salmon and arctic grayling require clear water.

Pipeline route interaction with furbearer and waterfowl populations.

Seasonal use limitations exist on highway due to spring break up. Overuse of public highways and disruption of normal summer maintenance are concerns.

Transportation and Utility Corridor *

State-Selected Lands.



Fairbanks North Star Borough Boundary

H-59 Mining Camp, 1907.

Goldstream.

Ridges and valley sides have a mantle of colluvial and wind-blown (loess) silts.
The Yukon-Tanana Upland is characterized by broad undulating divides and flat-topped (loess) silts.

Historic site Roadhouse circa 1906. Evidence of early mining communities in area.

In western edge of Yukon-Tanana Upland, a thick mantle of windborne silt lies on the lower slopes of hills and thick accumulations of muck overlie deep stream gravels in the valleys. Pingos are common in valleys and on lower hills slopes.

This map area is within the zone of discontinuous permafrost; talik is extensive and icings may be an erosion hazard. Thermokarst activity may occur on the flood plain of the Chatanika River. Frozen sediments are usually ice rich.

MAP D15

GULF INTERSTATE ENGINEERING COMPANY

Alcan Pipeline Company

42" GAS LINE ROUTE

DRWN. TMA	SCALE 1" = 2 Miles	DATE June 20/76
APPRVD. D.B.L.	DRWG. NO.	REV. NO.

LEGEND: Sensitive Area ■ Water Quality Info. ▲ Archaeological Site* X Historic Site* (* location approximate)

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LITHOGRAPHED IN CANADA

Chena River Basin low brush, muskeg-bog.

Lowland spruce-black spruce dominant

Small section north of French Creek - Bottomland Spruce

Subsistence fisheries in Fairbanks for chum salmon (2000-8000 per annum) and chinook salmon (< 300 per annum). Minor subsistence fisheries for whitefish & cisco, inconnu, northern pike and burbot.

Overwintering area for arctic grayling (> 1000 fish/mile in some areas); also area of heavy recreational fishery. This species has a tendency to remain in same location for years with minimal recruitment. Additional fishing pressure and excessive silt loads should be avoided. This river is also a major spawning area for chinook salmon between mid-July to September and a small run of chum salmon.

Primary agricultural land uses in this area.

Potential raptor nesting sites along bluffs of the Tanana River to the west may be sensitive to noise and aerial activity. Peregine falcons may nest in such bluff areas.

Seasonal distribution of moose in Fairbanks-Chena River area.

Fairbanks is Alaska's second largest city. It has a population of 55,817 (1975). It is a major government centre. Over 50% of the people employed work for the government. Trade and construction are important activities. Fairbanks acts as a service centre to the outlying areas. It has rail access.

Summer maintenance disruption and overuse of roads are concerns.

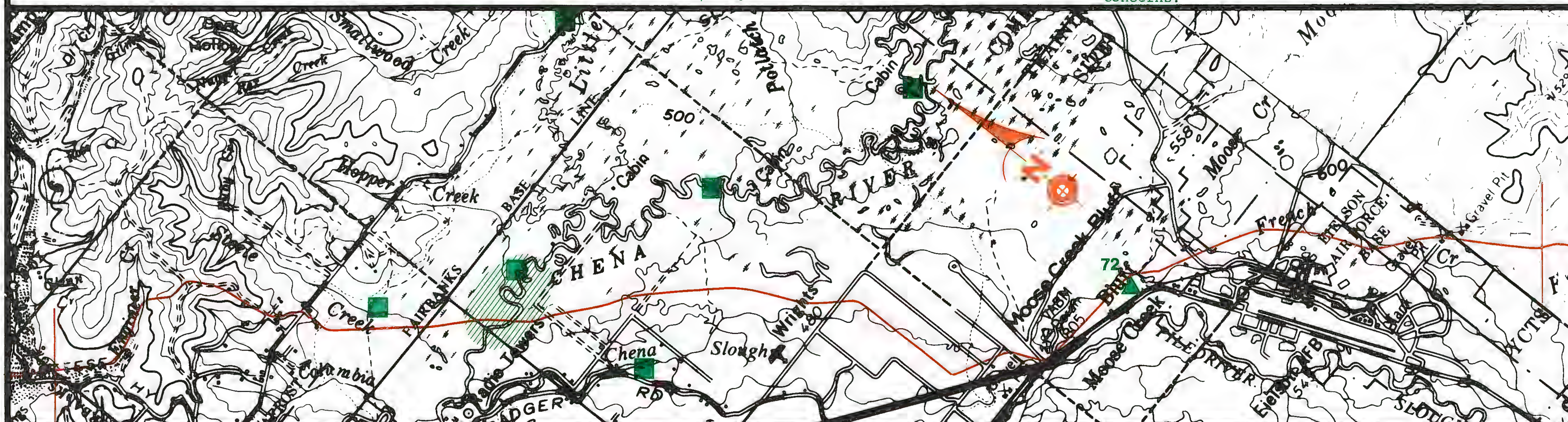
Only air quality stations are located in Fairbanks and North Pole.

Muskox experimental farm (University of Alaska) west of line.

Military lands north of highway.

State-selected lands south of pipeline.

Airport



Thick loess deposits in area which are a potental erosion problem.
Discontinuous permafrost present. North of Fairbanks the unconsolidated sediments are generally frozen and locally ice-rich. Ice forms include wedges, lenses and interstitial ice. The depth to the Pf table is as much as 40 feet. Lineaments that intersect pipeline are the Little Chena River, Badger Road and Chena River lineament. Area of moderate potential for earthquake damage as significant ground roll was observed during the 1964 event and various forms of landslide, mud boils etc. were developed during the July, 1937 event of Richter Magnitude 7.3. Several other strong quakes have also been recorded in the region.

Archaeological site containing campus material south of pipeline. Excavated.

Valleys are floored with alluvial sands and gravels which commonly have a thick covering of organic silts. Several unmined areas that may contain recoverable placer gold and extensive fields of old dredge trailings may be crossed.

The Fairbanks Mining District and adjacent Tolovana Mining District contain rich sources of metallic ores. Gold, silver, tungsten, antimony and minor amounts of many others are being extracted from the region. The pipeline corridor crosses several areas of potential placer gold.

Chena River
Freezeup
-early November
Breakup
-mid April.

Chena River basin provides 14% of Alaska's beaver harvest. It is important furbearer habitat and will be sensitive to habitat disruption and siltation. Also an important waterfowl nesting area.

MAP D16

GULF INTERSTATE ENGINEERING COMPANY

Alcan Pipeline Company

42" GAS LINE ROUTE

DRWN. TMA	SCALE 1" = 2 Miles	DATE June 20/76
APPRVD. D.B.C.	DRWG. NO.	REV. NO.

LEGEND: Sensitive Area, Water Quality Info., Archaeological Site*, X Historic Site* (* location approximate)

F. F. SLANEY & COMPANY LIMITED
Environmental Resource Consultants

LITHOGRAPHED IN CANADA

Agricultural area bordering south of pipeline.

The interior valley of the Tanana River (located to the southwest) is among the best nesting habitat for aquatic birds in Alaska. This habitat will be sensitive to downstream siltation.

Moose seasonally distributed on Little Salcha and Salcha Rivers.

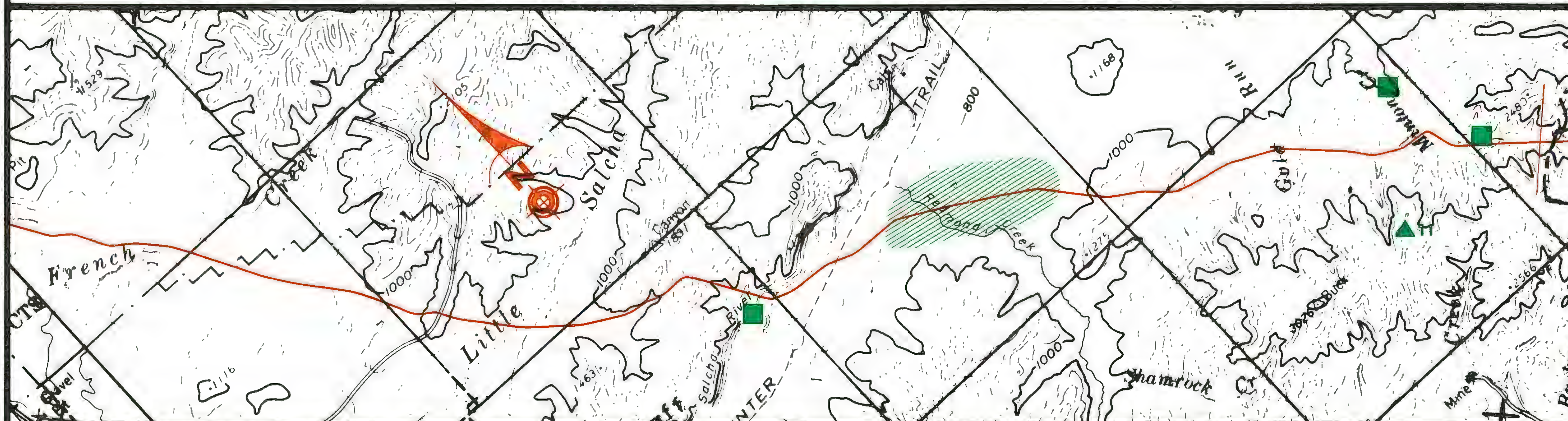
Migrating caribou may be encountered in these areas and will be sensitive to harassment and migration interruption. Prime moose habitat south of Tanana River.

Salcha River is a major chinook salmon producing river. Spawning occurs from July-August. Summer and fall run chum salmon as well as coho also spawn in this area; sensitive period from August to November. Mean annual chinook escapement to Salcha River is approximately 1000 fish; chum salmon escapement is over 2500 fish. Arctic grayling are also abundant (800/mile).

Salcha River provides good access to fishing, hunting and recreation areas.

Military Reserve *

State-Selected Lands



↑ Gravel Pit

Discontinuous permafrost present. South of Fairbanks, much of the area is thawed but there are large accumulations of ice in some of the sediments, especially the fine-grained reworked silt.
Potential for moderate erosion.
Lineaments intersected by pipeline are Little Salcha River and Salcha River lineaments.
Area of potential moderate earthquake damage.

The Salcha River valley is composed of dense alluvial sand and gravel.

MAP D17

GULF INTERSTATE ENGINEERING COMPANY		
Alcan Pipeline Company		
42" GAS LINE ROUTE		
DRWN. TMA	SCALE 1" = 2 Miles	DATE June 20/76
APPRVD. D.B.L.	DRWG. NO.	REV. NO.

LEGEND: ▨ Sensitive Area ■ Water Quality Info. ▲ Archaeological Site* X Historic Site* (*location approximate)

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Environmental Resource Consultants

Low brush, muskeg and bog vegetation communities occupy the poorly drained flatlands northeast of Big Delta.

Shaw Creek flats is recognized as a moose calving area.

High density aquatic fur bearer concentrations in Tanana River Valley. The R/W avoids the river channels so little direct impact is expected.

Spruce vegetation communities dominate southeast of Big Delta.

Some of highest snowshoe hare populations occur in Alaska along Tanana River Valley. Low density waterfowl area between Shaw Creek and Delta Junction.

Very important spawning and rearing area for arctic grayling; critical period from June to August. Arctic grayling are abundant throughout rivers and streams of this area, especially Delta River. Northern pike also moderately abundant in lowlying lakes of region.

Quartz Lake was stocked with rainbow trout and has resident population of Whitefish. Moderate recreational fishery during summer months.

Documented spawning and rearing area for coho, chum, and chinook. Sensitive to construction activities from Aug. to Dec. Also abundant populations of arctic grayling, inconnu, burbot, whitefish and northern pike.

Caribou wintering and calving area 15 miles west of line.

Spring and summer moose concentrations in Shaw Creek area sensitive to disturbance.

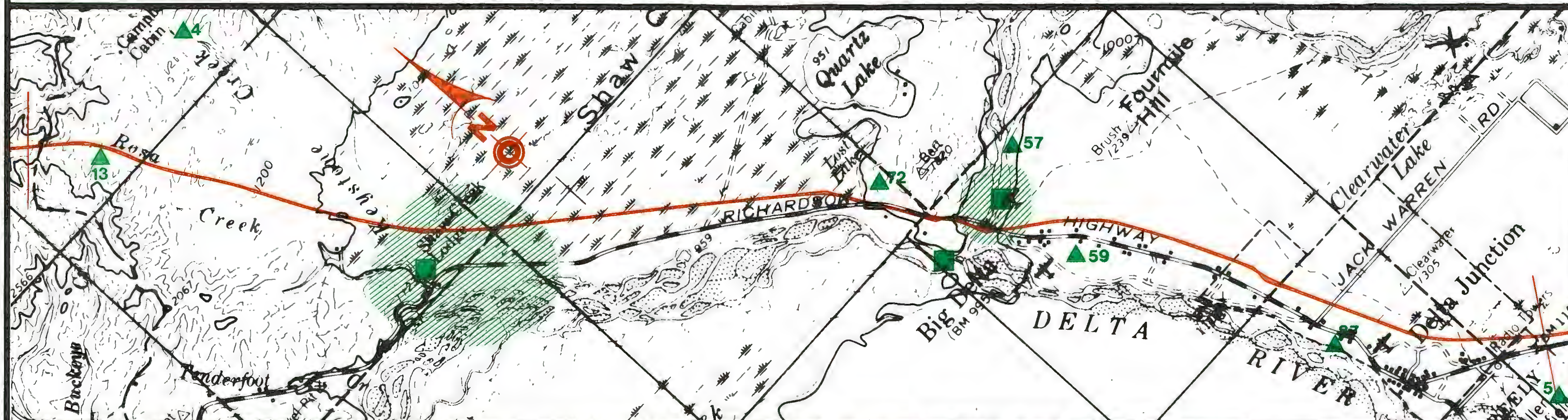
Delta Junction (including Big Delta) has a population of 703 (1970). Highway junction commerce provides the economic base.

Overuse and disruption of summer maintenance of highway are concerns.

Delta Junction Airport is federally owned with asphalt runway. U.S. Army arctic training and testing centre. Potential traffic congestion at Delta Junction.

Agricultural activities north, south and east of Delta Junction.

Summer maintenance disruption and cveruse of highway are concerns.



H-4 Roadhouse.

A-13 Archaeological site.

Gravel pit

A-72 An undisturbed site of possible significance.

H-57 Nigger Bill's Roadhouse, 1906.

H-59 Roadhouse, 1906.

A-87 Hearth.

H-5 Roadhouse, 1919

The sheet is within the zone of discontinuous permafrost. North of Quartz Lake the area is underlain by bog and fine grain sized sediments. Permafrost "islands" may occur on coarse flood plain deposits between Big Delta and Delta Junction. Thaw lakes, thaw sinks and open system pingos are characteristic of the region.

Flood plains and terraces of the Tanana and Delta Rivers contain dense alluvial sand and gravel.

Tanana River has headwaters in active glaciers and carries the highest sediment concentrations in the Yukon region.

MAP D18

LEGEND: Sensitive Area ■ Water Quality Info. ▲ Archaeological Site* X Historic Site* (*location approximate)

F. F. SLANEY & COMPANY LIMITED Environmental Resource Consultants

GULF INTERSTATE ENGINEERING COMPANY

Alcan Pipeline Company

42" GAS LINE ROUTE

DRWN. TMA	SCALE 1" = 2 Miles	DATE June 20/76
APPRVD. D.B.C.	DRWG. NO.	REV. NO.

LITHOGRAPHED IN CANADA

Lowland spruce communities occupy this sheet. Commercially productive forest lands may be crossed by the pipeline.

Fall and winter moose and winter bison concentrations between Delta Junction and Granite Creek. The R/W along the Alcan Highway should cause little additional stress.

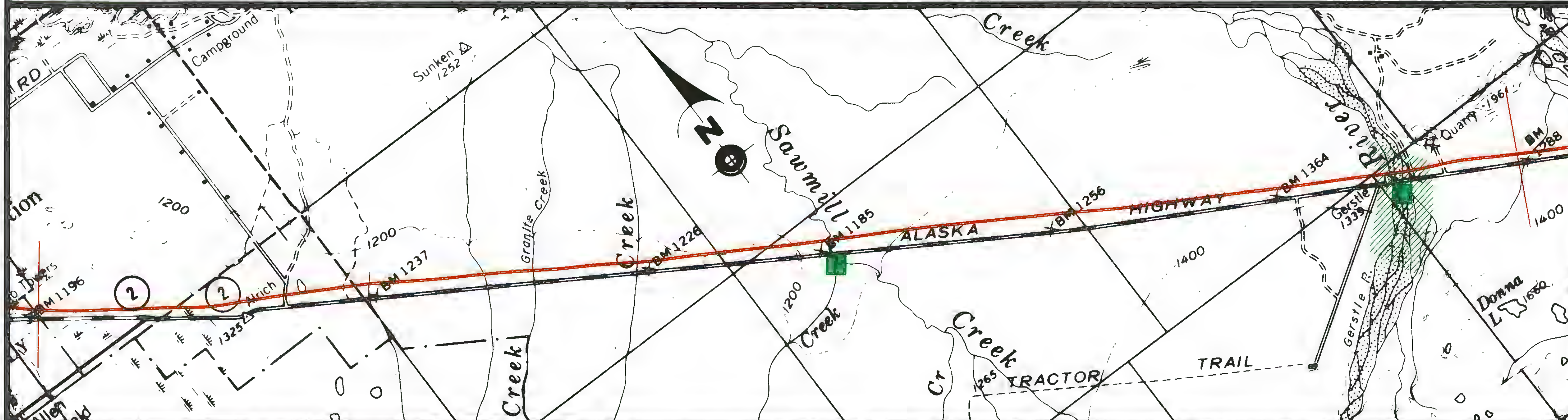
Bison calving area on Gerstle River. Location of the R/W adjacent to the Alcan Highway should cause little additional impact. Bison winter range 10 miles east of line, near Healy Lake.

Sporadic agricultural activities occur along the Alcan Highway.

Campground to north of pipeline. Avoid displacement of local users.

State-Selected Lands.

Overuse and disruption of summer maintenance of highway are concerns.



Healy Lake, 10 miles east of the line, contains many significant archaeological sites dating back to 12,000 years B.P.

Permafrost in this map area, despite a prevalence of coarse grain substrate, is reported as discontinuous to continuous. The depth to the permafrost table is variable and the temperatures are near the equilibrium point. Thaw lakes and thaw sinks are a characteristic of the region as are open-system pingos. Loess is prevalent over much of the area, and organic silts have a high moisture content.

Southeast of Delta Junction, the earthquake risk drops significantly until the Kluane area of the Yukon is reached.

MAP D 19

GULF INTERSTATE ENGINEERING COMPANY

Alcan Pipeline Company

42" GAS LINE ROUTE

DRWN. TMA	SCALE 1" = 2 Miles	DATE June 20/76
APPRVD. D.B.L.	DRWG. NO.	REV. NO.

LEGEND: Sensitive Area ■ Water Quality Info. ▲ Archaeological Site* X Historic Site* (*location approximate)

F. F. SLANEY & COMPANY LIMITED
Environmental Resource Consultants

LITHOGRAPHED IN CANADA

Spruce vegetation communities dominate along the R/W. Some areas of commercially productive forest may be crossed.

Important raptor nesting occur along Tanana River between Johnson Slough and Robertson River. Peregrine falcon may nest here. Restriction of activities to the R/W along the highway should minimize impacts.

Low capability for waterfowl.

Dolly Varden char occur in many creeks in this area including Sears Creek, Dry Creek, Berry Creek and Chief Creek. This species is sensitive to heavy fishing pressure particularly near the highway. Angling by construction crews should be restricted.

Sporadic cultivation and range use occurs along the highways.

Spring, summer and wintermoose concentrations along Tanana River.

Fall and winter moose concentrations west of line around Little Gerstle and Johnson Rivers. Bison calving area on Tanana River. Restriction of activities to the R/W should cause minimal impacts.

High capability for aquatic fur bearers along the river. Minimal impacts expected providing activities are restricted to the R/W.

Recreational fishery for stocked populations of rainbow trout in Craig Lake; rainbow trout and coho salmon (landlocked) in Lisa Lake.

Limited commercial fishery for chum and chinook salmon, only in mainstem Tanana River. Tributaries are closed.

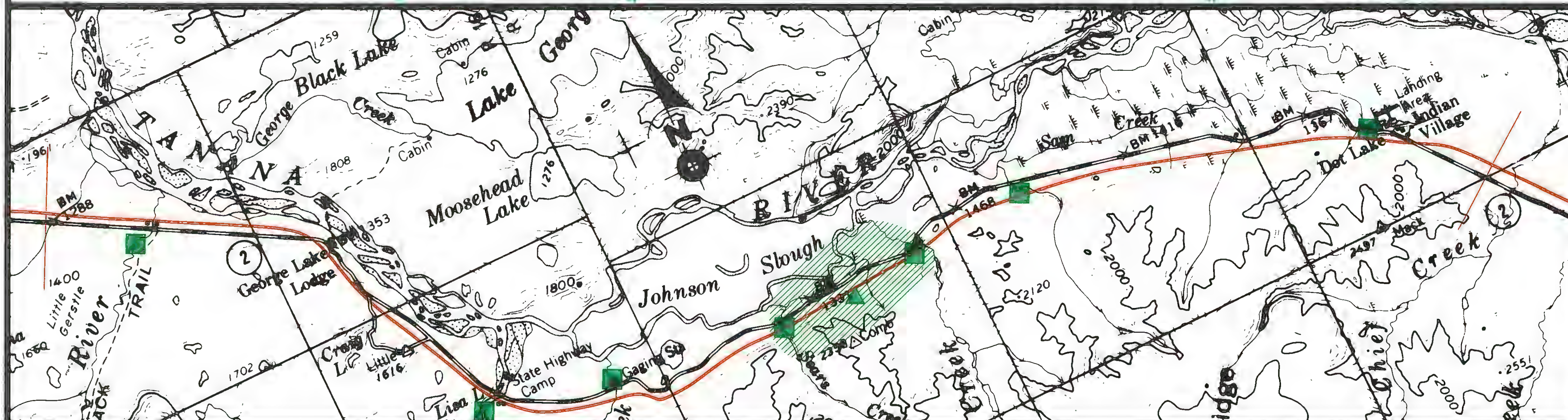
Lowland spruce.

Tanana River is a major salmon producing river with both summer (early - mid Aug.) and fall (mid - Sept. to Nov.) runs of chum salmon (mean annual escapement > 6000 fish) as well as an August run of chinook salmon. Arctic grayling, whitefish, northern pike, lake trout, inconnu and burbot are also found throughout the drainage. The proximity of the Alaska Highway and accompanying tourist traffic places heavy recreational fishing pressure on many areas of the river and adjacent lakes (many of which were stocked with rainbow trout).

Dot Lake is primarily a native community. The population is about 30 natives and 15 non-natives. Highway commerce, supported by guiding, sport hunting and fire fighting form the economic base.

* State-selected lands. *

* Native Corporation Lands.



A suspected archaeological site.

Lake George, 3 miles east of the line is an important archaeological area.

The map area lies within the zone of discontinuous permafrost. The route parallels the Tanana River flood plain which is underlain by coarse grained surficial deposits capped with some bogs. Thaw lakes and thaw sinks are potential erosional hazards.

MAP D 20

GULF INTERSTATE ENGINEERING COMPANY		
Alcan Pipeline Company		
42" GAS LINE ROUTE		
DRWN. TMA	SCALE 1" = 2 Miles	DATE June 20/76
APPRVD. D.G.L.	DRWG. NO.	REV. NO.

LEGEND: Sensitive Area ■ Water Quality Info. ▲ Archaeological Site* X Historic Site* (*location approximate)

F. F. SLANEY & COMPANY LIMITED Environmental Resource Consultants

Spruce vegetation communities dominate the route. Some commercially productive forest lands may be crossed.

Low capability for waterfowl.

High capability for snowshoe hare and aquatic fur bearers along the valley. Restriction of activities to the R/W along the highway should minimize additional impacts.

Winter moose concentrations occur along river beds.

Dall sheep are present on Alaska Range to the west of the R/W. No direct impacts are expected from construction activities along the Highway.

Jan Lake is stocked with land-locked coho salmon; and supports moderate recreational fishing pressure.

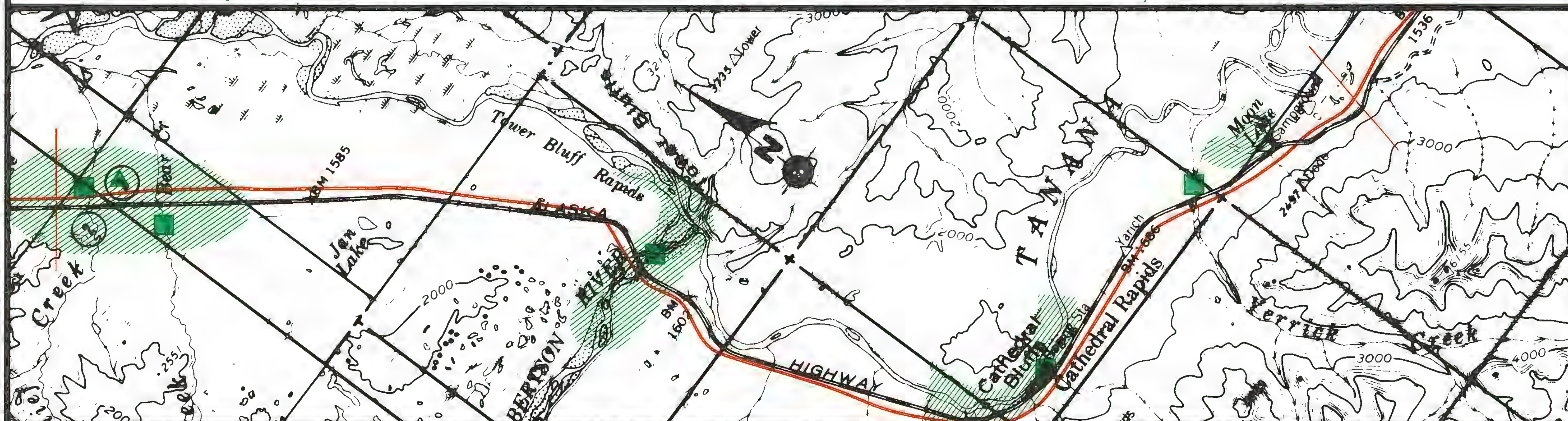
Dolly Varden, grayling and whitefish inhabit Bear Creek. These are sensitive to heavy fishing pressure and require relatively low sediment loads from Aug. - Nov.

Recreational fishery for northern pike in Moon Lake.

Overuse and disruption of summer maintenance of highways are concerns.

Cathedral Rapids Airport is private with a gravel runway.

* Native Corporation Lands. * State-Selected Lands. * Native Corporation Lands. *



This sheet lies within the zone of discontinuous permafrost. Fine grained sediments near the Robertson River crossing may contain permafrost. Other more coarse grained deposits should be frost free.

MAP D 21

GULF INTERSTATE ENGINEERING COMPANY

Alcan Pipeline Company

42" GAS LINE ROUTE

DRWN. TMA	SCALE 1" = 2 Miles	DATE June 20/76
APPRVD. D.B.L.	DRWG. NO.	REV. NO.

F. F. SLANEY & COMPANY LIMITED
Environmental Resource Consultants

LEGEND: Sensitive Area ■ Water Quality Info. ▲ Archaeological Site* X Historic Site* (* location approximate)

LITHOGRAPHED IN CANADA

spruce vegeta[illegible]ties predominate along the route. Some commercially productive forest lands may be crossed.

Winter moose concentrations between Tanacross and Tetlin Junction. These animals are habituated to the highway traffic.
High capability for hare and fur bearer concentrations along the valley.

[illegible] and disruption of summer maintenance of highway are concerns.

Tanacross Airport is state owned with an asphalt runway.

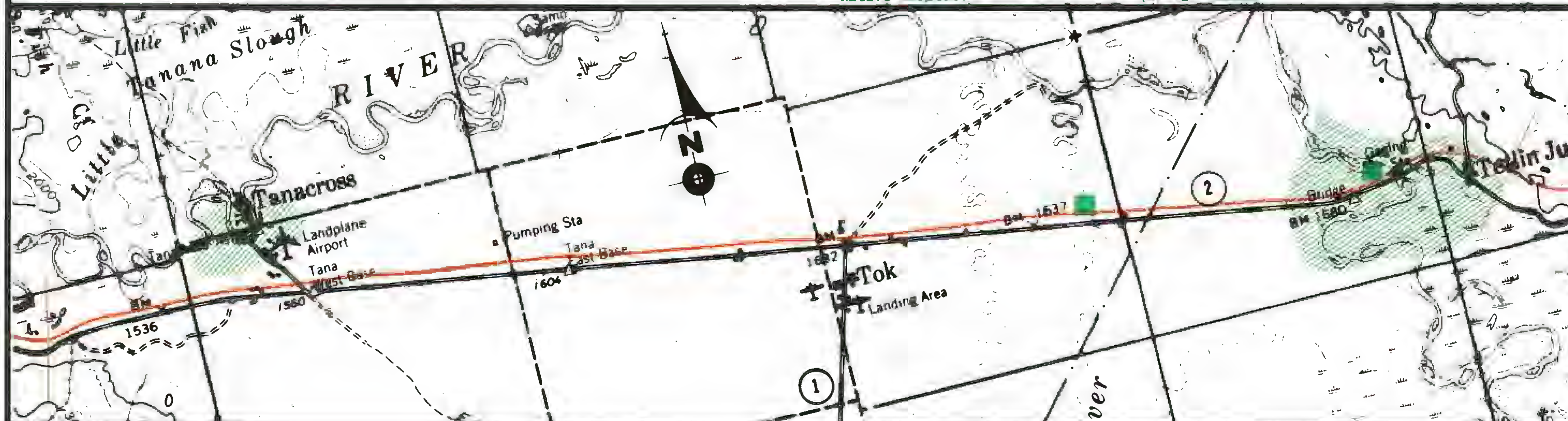
Tok Airport has a gravel runway.
Potential traffic congestion at Tok weigh station.

Tetlin Junction had a population of 114 in 1970. It has a subsistance economy with some gardening with the assistance of irrigation.

Tetlin Airport is state owned with a turf runway.

Tanacross' population in 1970 was 84. It has a mixed economy of subsistance hunting and fishing, and seasonal employment in fire fighting, trapping or construction.

Native Corporation Lands * * Native Corporation Lands *



No archaeological and historical sites are reported along the pipeline between Tanacross and Nebesna.
The Valdez - Eagle Trail, an old Klondike route, is crossed by the pipeline.
This sheet lies within the zone of discontinuous permafrost though testing on the coarse grain deposits of the flood plain has not revealed its presence. The area appears well drained except near Tetlin Junction.
Loess is present in the map area.

MAP D 22

GULF INTERSTATE ENGINEERING COMPANY

Alcan Pipeline Company

42" GAS LINE ROUTE

DRWN. TMA	SCALE 1" = 2 Miles	DATE June 20/76
APPRVD. D.G.L.	DRWG. NO.	REV. NO.

LEGEND: Sensitive Area ■ Water Quality Info. ▲ Archaeological Site* X Historic Site* (* location approximate)

F.F. SLANEY & COMPANY LIMITED
Environmental Resource Consultants

LITHOGRAPHED IN CANADA

Lowland spruce vegetation communities predominate. Commercially productive forests are confined to the banks of major drainages.

High capability for waterfowl along Tanana River. Restriction of activities to the R/W along the highway should avoid disturbance.

Spring and summer moose concentrations between Tetlin Junction and the Yukon border. The animals are habituated to the highway corridor.

High density hare and furbearer concentrations along the valley.

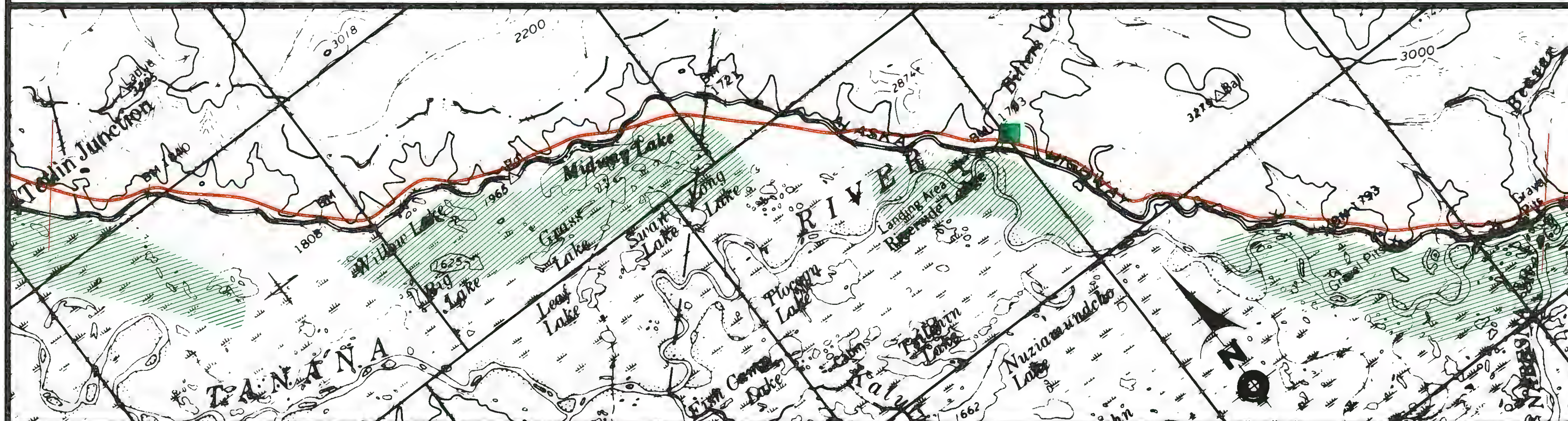
Caribou migration route from the southeast. These animals currently cross the highway so little additional impact is expected.

Genetically isolated populations of Dolly Varden char occur in the headwaters of the Tanana River. These populations are of scientific interest. Disturbance should be minimized.

Summer maintenance disruption and overuse of highway are concerns.

Riverside Lodge Airport is private with a dirt runway.

(d) (1) Lands * Native Corporation Lands. * (d) (1) Lands * Native Corporation Lands.



Fossil bones and ivory are found at Sand Canyon and Bitters Creek.

This map lies within the zone of discontinuous permafrost. Permafrost to be expected in bogs near the right-of-way but coarse deposits elsewhere may be ice-free. The region appears poorly drained. Frost susceptible loess present.

MAP D 23

GULF INTERSTATE ENGINEERING COMPANY

Alcan Pipeline Company

42" GAS LINE ROUTE

DRWN. TMA	SCALE 1" = 2 Miles	DATE June 20/76
APPRVD. D.B.L.	DRWG. NO.	REV. NO.

LEGEND: Sensitive Area ■ Water Quality Info. ▲ Archaeological Site* X Historic Site* (* location approximate)

F. F. SLANEY & COMPANY LIMITED
Environmental Resource Consultants

LITHOGRAPHED IN CANADA

Upland spruce and low brush, muskeg, bog – vegetation communities intermix along the route.

High density waterfowl area along Chisana River. The pipeline route along the existing highway should minimize potential disturbance.

Northway Airport is state owned with asphalt runway.

Northway Junction is primarily a native community of 40 (1970). The local economy is dependent on seasonal employment in fire fighting, guiding, construction and subsistance hunting and fishing.

High density furbearer concentrations along the valley.

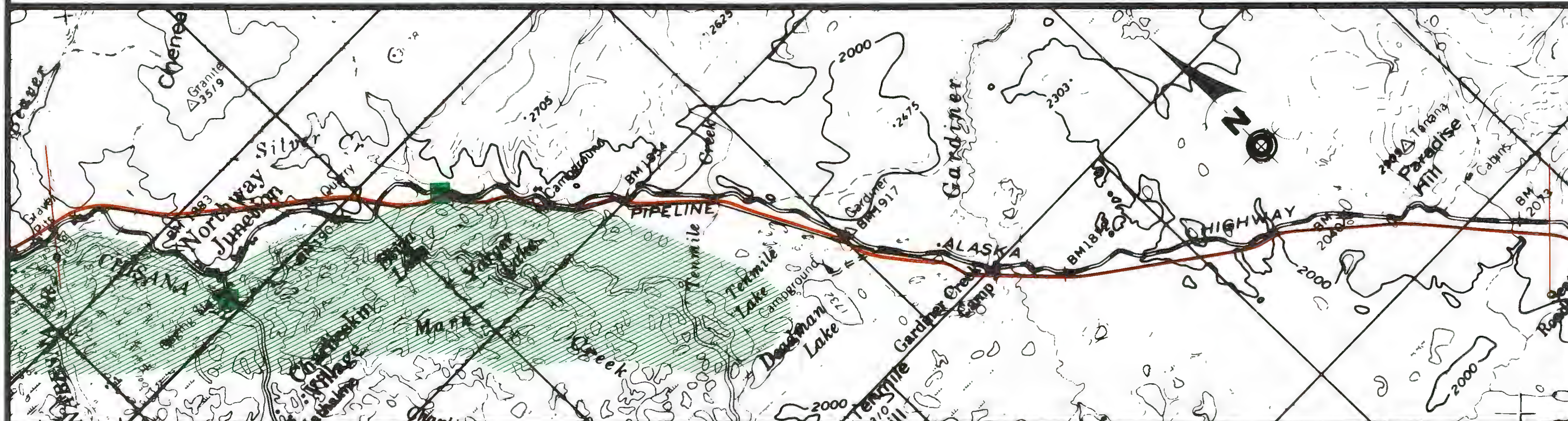
Moose are distributed year round between Tanacross and Yukon border.

Arctic grayling, northern pike, whitefish, burbot, inconnu and chum salmon all documented within Chisana River. Grayling and chum salmon sensitive to migration barriers and excessive sediment loads from Aug. - Nov.

Disturbance to campgrounds should be minimized.

Overuse and disruption of summer maintenance of highway are concerns.

Native Corporation Lands. * State-selected lands. * (d)(1) Lands.



This sheet lies within the zone of discontinuous permafrost. The area appears poorly drained with frost susceptible loess in the bottomlands. Ground ice is expected downslope from the highway, south to Ten Mile Lake.

MAP D 24

GULF INTERSTATE ENGINEERING COMPANY

Alcan Pipeline Company

42" GAS LINE ROUTE

DRWN. TMA	SCALE 1" = 2 Miles	DATE June 20/76
APPRVD. D. B. L.	DRWG. NO.	REV. NO.

LEGEND: Sensitive Area | Water Quality Info. | Archaeological Site* | X Historic Site* | (*location approximate)

F. F. SLANEY & COMPANY LIMITED
Environmental Resource Consultants

LITHOGRAPHED IN CANADA

Upland spruce and low brush, muskeg, bog are the major vegetation communities.

Scottie Creek and the lakes along the Chisana River are used by fly-in hunters of moose and waterfowl.

Summer maintenance disruption and overuse of highway are concerns.

Customs and Immigration Services has potential for traffic congestion crossing border.

* State-Selected Lands. *

This map lies within the zone of extensive though discontinuous permafrost. Ground icings are an erosion hazard. The area appears poorly drained; loess is present.

MAP D 25

GULF INTERSTATE ENGINEERING COMPANY

Alcan Pipeline Company

42" GAS LINE ROUTE

DRWN. TMA	SCALE 1" = 2 Miles	DATE June 20/76
APPRVD. D.B.L.	DRWG. NO.	REV. NO.

F. F. SLANEY & COMPANY LIMITED
Environmental Resource Consultants

LEGEND: Sensitive Area ■ Water Quality Info. ▲ Archaeological Site* X Historic Site* (* location approximate)

LITHOGRAPHED IN C...

and a microwave communications system operated by RCA, Inc.* The relative location of these and other transportation/communications facilities is shown in the land use map presented in Volume 1A, page 6.

1.2.2 Compressor Stations and Other Facilities

Operating at design capacity, the Alaska segment of the Alcan pipeline will utilize 15 compressor stations located at approximately 46-mile intervals along the line. Approximate milepost locations for each station are presented in Table 1.2-1. Other major facilities include a gas dispatching and control center located in Fairbanks, and gas flow metering stations at the producer's station near Alyeska Pump Station Number 1, at the Fairbanks city service tap and at the Alaskan/Yukon border point of delivery to the Canadian segment of the system.

1.3 LAND REQUIREMENTS

1.3.1 Right-Of-Way

The maximum width of the pipeline right-of-way will be 120 feet along the 731-mile segment of the Alcan pipeline in Alaska. This includes both the Prudhoe Bay to Delta Junction segment paralleling the Alyeska oil line, and the Delta Junction to Yukon border segment paralleling the Haines Products pipeline. Assuming that the full 120-foot right-of-way width were utilized for construction activities, the maximum concommitant land commitment will be approximately 10,600 acres (16.6 square miles). The actual land use will be somewhat less than this estimate due to local instances where terrain or other factors dictate a narrowed right of way.

Moreover, a significant portion of the construction zone will traverse existing rights-of-way in all but isolated cases where route deviations are appropriate. The extent of traverse varies. The new right-of-way north of Delta Junction will be located between the Alyeska haul road and the Alyeska oil pipeline. In most instances the new work pad will directly adjoin either the existing haul road or the Alyeska work pad. To the extent possible, the existing Alyeska work pad will be used.

Greater overlap of existing rights-of-way is proposed for the Delta Junction to the Yukon border segment. East from M.P. 538.8 to the Canadian border, retired

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*A small portion of the pipeline is still in service.

TABLE 1.2-1

LOCATION OF COMPRESSOR STATIONS

Station No.	Alcan Pipeline Milepost (south from Alyeska Pump Station No. 1)
1	43.5
2	83.7
3	118.6
4	157.7
5	210.8
6	261.9
7	305.9
8	355.0
9	400.7
10	442.6
11	497.4
12	543.6
13	590.3
14	639.4
15	684.1

sections of the Haines products pipeline might be removed from the right-of-way. The existing right-of-way will then be extended to 120 feet in the direction of the Alcan Highway where possible. Between Delta Junction and Tok the existing right-of-way will be paralleled.

1.3.2 River Crossings

In following the Alyeska oil pipeline alignment, the proposed natural gas pipeline will cross approximately 69 natural water-courses. Between Delta Junction and the Yukon border, seven principal crossings will be encountered; a total of approximately 87 streams will be crossed.

Each of these crossings will be made at right angles to the shore, wherever possible, in order to minimize the potential for localized scour along a channel above the pipe. It is conventional practice to utilize a double-width right-of-way in such instances to allow for pipe stringing, application of concrete anchors, and maneuvering of laying equipment. The widened corridor normally extends up the right-of-way a distance adequate to install the crossing. Application of this concept to the crossings suggests that construction areas at river banks would require less than 200 acres total.

1.3.3 Compressor Stations

A total of approximately 225 acres will be required for the proposed compressor stations and their appurtenant facilities. Each of the compressor stations will be located on 15 acre sites, of which five to seven acres will be dedicated to construction and operational purposes. An additional five acres at each site may be required for storage of pipe.

1.3.4 Roads

It is planned that existing public and private roads, including the Alyeska haul road, be used to the maximum possible extent as access to the construction right-of-way and permanent gas pipeline facilities. Wherever possible, valves will be located within proximity to existing roadways. Nevertheless, it is expected that in excess of 1,000 acres of additional roads will be required for access to borrow pits, quarries, and other sources of construction materials.

1.3.5 Total Requirements

A total land area of approximately 12,100 acres will be utilized for right-of-way, river crossings, compressor station sites and roads during the three-year construction period. Other facilities, such as stations, will require additional area, but those utilizations are inconsequential in comparison.

1.4 PROPOSED FACILITIES

Compressor Stations

Compression for moving the gas will be provided at each of the 15 stations by a 26,500 (ISO) horsepower gas turbine driven centrifugal compressor unit. Each station will be automated and remotely controlled from the Fairbanks center.

Discharge gas will be chilled to minimize degradation of permafrost adjacent to the buried line. The gas cooling will be accomplished by a propane refrigeration plant including two gas turbine-driven compressors, air-cooled condensers, and gas chillers. Exit gas temperature from each station will be controlled to compensate for seasonal conditions and variability in downstream permafrost. It is anticipated that exit gas temperatures will normally range between 10^{o} and $25^{o}F$ among the stations.

As previously indicated, the area occupied by each station will be approximately 15 acres, most of which will be open space; structures and realted facilities will occupy only five to seven acres at each site. Plans for a typical compressor station layout are shown in Figure 1.4-1. Among the systems housed in the buildings at each station will be operating controls, instrumentation, automatic controls, fuel gas measuring equipment, electric power generation equipment, a heating system, a small desk area, and a maintenance shop. Also enclosed will be tanks for storage of water, waste oils, lubrication oils and a suitable wastewater and sewage storage system. An adequate water supply for utility and housekeeping purposes will be provided. The building itself will be prefabricated, metal-clad, and erected upon a slab concrete foundation.

If necessary, an all-weather access road leading from the Alyeska haul road or the Alcan Highway will be provided. A chain-link security fence will surround each compressor station to prevent intrusion of wildlife and unauthorized personnel.

1.5 CONSTRUCTION PROCEDURES

1.5.1 Pipeline Construction

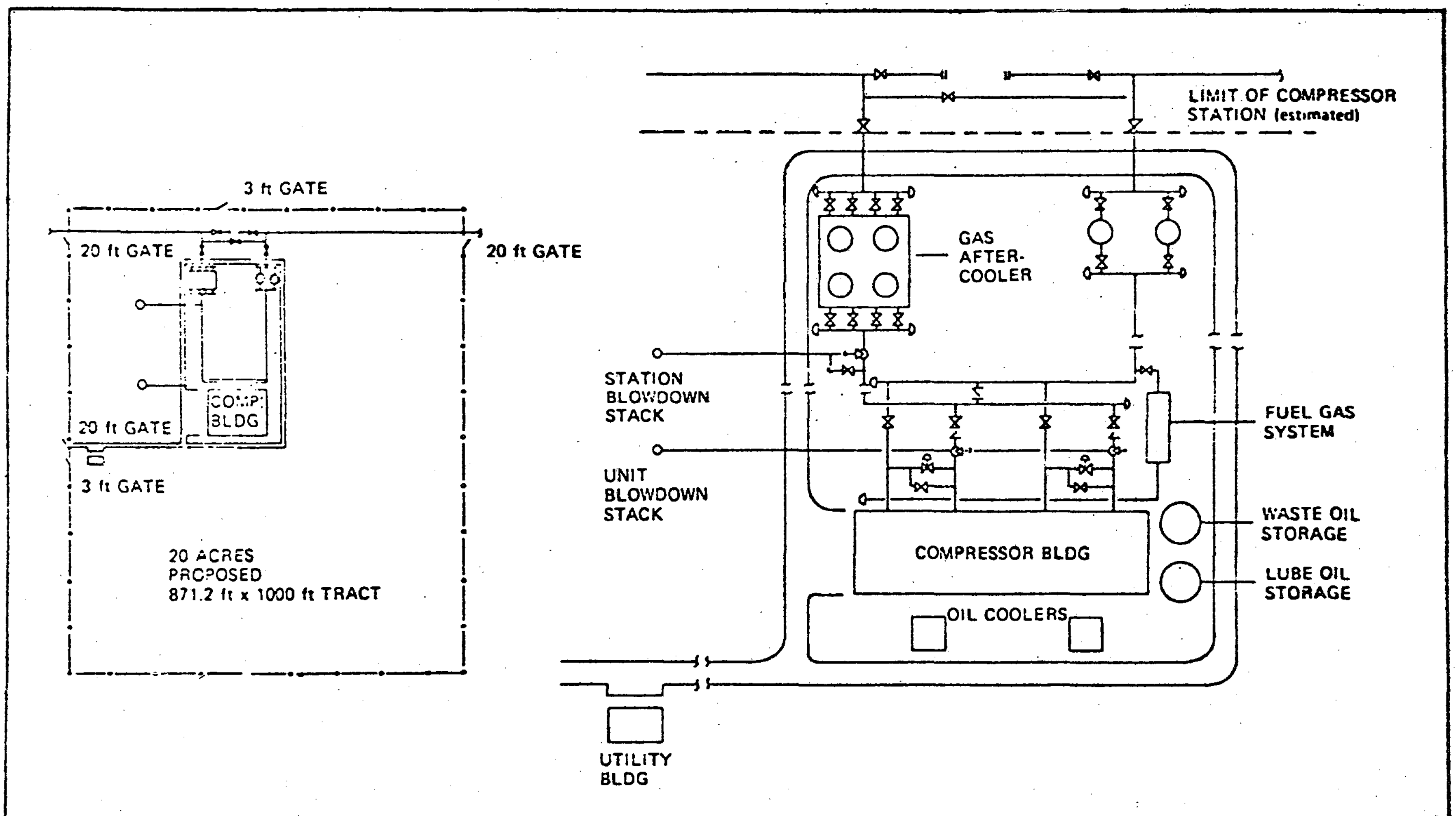


Figure 1.4-1 TYPICAL COMPRESSOR STATION, GENERAL PLAN

Compliance with Construction and Pipeline Regulation

All proposed facilities will be designed, constructed, and operated in accordance with requirements of Part 192, Title 49, Code of Federal Regulations, "Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards".

Applicant and its contractors will also comply with the pipeline construction guidelines published in Section 2.69, Part 2, General Policy and Interpretation, Subchapter A, Chapter 1, Title 18 of the Code of Federal Regulations (CFR), and with all Occupational Safety and Health Act (OSHA) regulations relevant to pipeline construction and operation. In the design factor selection, consideration will be given to the seismically active areas along the route as well as to the population density of all areas along the route. Modern construction methods, inspection to assure compliance with specifications, and the use of high quality steel pipe will provide a facility with integrity, capable of withstanding earthquakes of historical intensity in the area.

Prior to the construction of the pipeline across waterways, applicable permits will be obtained from agencies having jurisdiction. No aspects of pipeline work requiring a permit will be performed until all such permits have been obtained (Section 9.0).

Pipe

Pipe will be furnished bare and will be coated in the field by the over-the-ditch pipe-coating method using a good quality protective coating.

Pipe will be delivered by ship or barge to Prudhoe Bay and Valdez and will then be double-jointed in storage yards at these locations and later transported to the construction site. Other materials required for construction, such as valves, fittings, and supporting equipment, will be supplied to the contractors by similar means.

Construction Spreads

Tentative pipeline construction involves six construction spreads, generally as follows:

Spread 1: Prudhoe Bay to Toolik
Distance 125 miles
Mile Post 0.0 to 125

Spread 2: Toolik to Minnie Creek
Distance 100.5 miles
Mile Post 125 to 225.5

Spread 3: Minnie Creek to Yukon River
Distance 127 miles
Mile Post 225.5 to 352.5

Spread 4: Yukon River to Moose Creek
Distance 117.5 miles
Mile Post 352.5 to 470.0

Spread 5: Moose Creek to MP. 1366 Alcan Highway
Distance 130 miles
Mile Post 470.0 to 600.0

Spread 6: Mile Post 1366 Alcan to Yukon border
Distance 131.4 miles
Mile Post 600.0 to 731.4

Construction Schedule

Pipeline construction has been scheduled for essentially those periods of the year which exclude the extreme winter climate and the associated lack of sufficient light for safe and efficient continuous spread operations.

Clearing and grading operations will take place ahead of the mainline pipeline construction.

Scheduling will be directed towards allowing minimum elapsed time between the trenching, pipelaying, and backfilling operations.

The total elapsed time for the pipeline construction over the six spreads will occupy two years. Production will average approximately 50 joints per day per spread over the two-year pipeline construction period.

Construction Sequence

The first step in the construction sequence will be right-of-way selection, and acquisition. The proposed pipeline alignment paralleling the Alyeska pipeline and the haul road between Prudhoe Bay and Delta Junction crosses Federal lands, State lands, and some parcels under private ownership. The Federal lands have been identified as part of a transportation and utility corridor. State lands, to facilitate pipeline construction, have been classified to retain the lands in public ownership.

The proposed route alignment is generally established at this time. Prior to construction, land required for the final alignment, compressor stations, and other ancillary facilities will be surveyed and identified.

Once ownership along the alignment has been established, permits will be secured from the necessary public bodies of jurisdiction and/or property owners. Agencies from whom permits may be required are outlined in Section 9.0 of this volume.

Ditching operations will result in a trench nominally seven feet deep by at least five feet wide. The ditch will be cleaned of any material such as clods, rocks, or other debris which could damage the pipe or its protective coating. Where blasting operations are carried out in close proximity to the pipe on the work pad or other construction equipment, protective mats to prevent damage by fragments will be used.

Line travel methods will be employed for coating and wrapping, with the pipe suitably cleaned in accordance with the primer and tape application specifications.

Where necessary, the bottom of the ditch will be covered with suitable bedding material to provide smooth continuous support of the pipe. After the coating has been checked for continuity by approved detection techniques, the pipe will be lowered in the ditch.

Backfill material will be utilized to eliminate voids after placement and compaction. Select backfill will be used where the detail design indicates it is required.

Once the backfilling is completed, hydrostatic testing will take place and the right-of-way will be restructured and the surface revegetated.

At typical stream crossings, the pipeline will be buried below the stream bed to a depth below which scour may be expected to take place. The pipe will be weighted with concrete to prevent floatation at the crossing. At select locations, river control works may be necessary.

1.5.2 Compressor Station Construction

Preliminary engineering studies indicate that 15 compressor stations will be required, spaced at approximately 46-mile intervals along the route from Prudhoe Bay to the Alaska-Yukon border. These stations will be equipped with refrigeration equipment for chilling the gas after compression to keep it compatible with the local soil and permafrost temperatures.

Construction scheduling will allow stations to be operational and on line as required. Construction of these compressor stations will start with the first construction season after permit issuance. Prefabrication of buildings and equipment at the manufacturers' shops will commence before compressor station site work.

Construction of the compressor stations will begin with the clearing, grading and preparation of the gravel base pad.

Compressor station foundations will be designed on a site specific basis to minimize degradation of the subsoils.

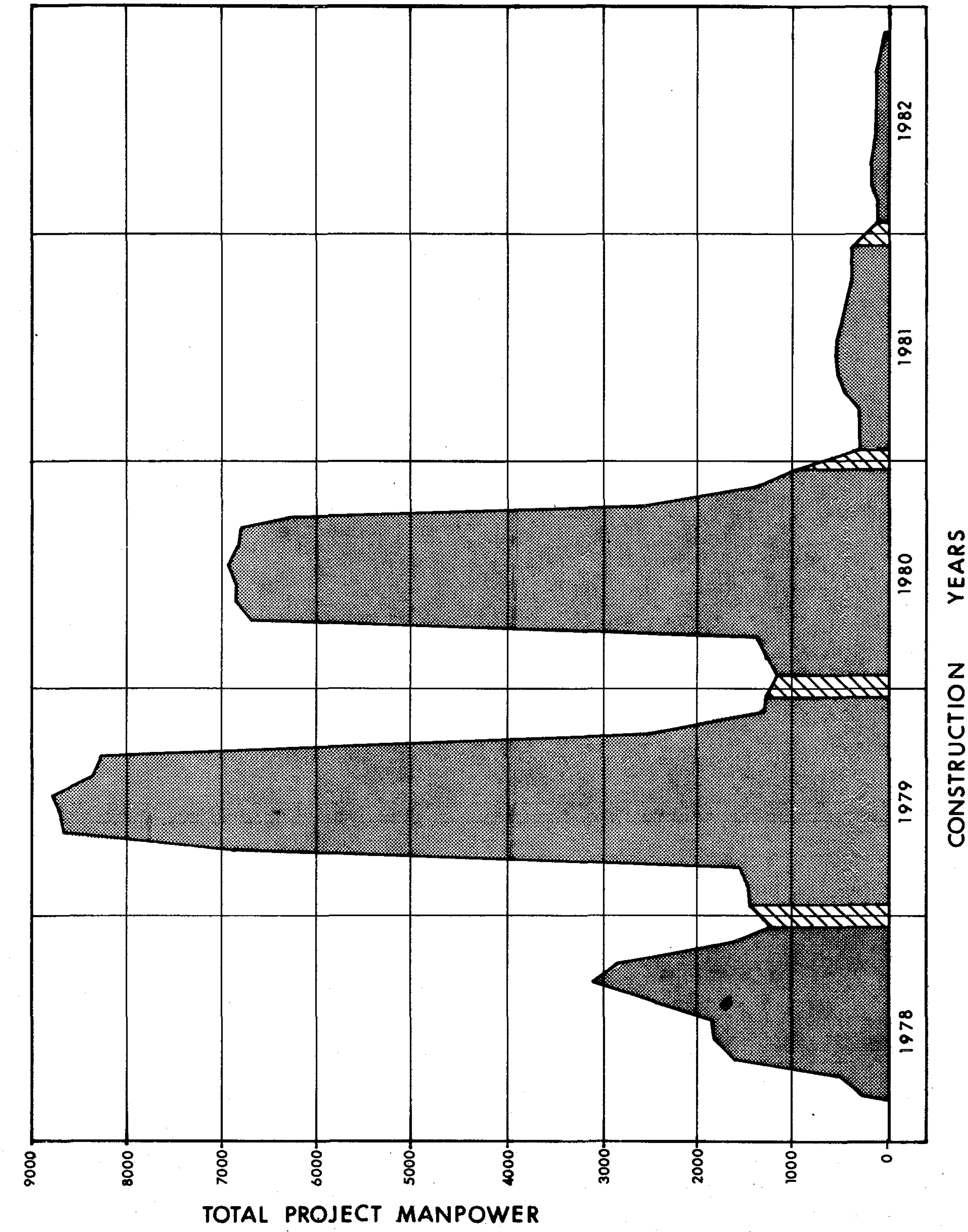
After the foundations have stabilized, erection of the prefabricated buildings will be started. Pipe support pieces will be installed, followed by the installation of equipment and piping. When in-station piping, pipe testing, and tie-ins have been completed, final construction detail such as painting and finish grading of access roads and station yard will complete the operation.

1.5.3 Construction Labor Requirements

Construction of the Alcan pipeline system will occur over the five-year span beginning in January, 1978. However, assuming all final regulatory approvals are received no later than January 1, 1978, the pipeline will be completed and become operative in 1981. Full design capacity will be attained upon completion of 15 compressor stations, the construction of which will be staged over the ensuing two-year period after 1981.

The estimated maximum work force required in each year of the project is shown in Figure 1.5-1. The labor force will peak in 1980, during the third project year. By 1982, pipeline and most ancillary construction will have terminated. Workers assigned to the initial compressor station sites will be reassigned to new sites upon their completion. There will be two construction camps for each pipeline spread. From Prudhoe Bay to Delta Junction, the labor force may be housed in the surplus Alyeska construction camps. Two Alyeska construction camps south of Delta Junction may be dismantled, and moved to new locations along the Alcan Highway; one near Tok and the other near Northway.

Experienced construction workers from the Alyeska project will be employed whenever possible. The construction of the gas pipeline would reduce the effect of oil line completion on the State's labor pool. Alaskan residents, both native and non-native, will be given preference. Labor from the lower 48 States will be recruited to complete the work force contingent.



GULF INTERSTATE ENGINEERING COMPANY

Alcan Pipeline Company

PROJECT MANPOWER
MAXIMUM

DRWN.	SCALE ———	DATE JUNE 1976
APPRVD.	FIG. 1.5-1	

1.6 OPERATING AND MAINTENANCE PROCEDURES

1.6.1 General Considerations

Operation and maintenance procedures for the new facility will be established in accordance with requirements of appropriate Federal, State, and local codes, regulations, and ordinances.

Operating and maintenance manuals will be made available to all operating personnel, who will be fully instructed as to their various duties and responsibilities. The manuals will be written to comply fully with the Department of Transportation regulation in CFR 49, Part 192, and all regulations of the Occupational Safety and Health Act. The manuals will describe all tests and inspections that are necessary to ensure that equipment and appurtenances are maintained in a safe and reliable condition. Adequate records and reports will be maintained so a history of the system will be available for study. All procedures in the manuals will be strictly observed by all pipeline personnel.

1.6.2 Procedures

Surveillance

Periodic inspections of the pipeline will be made to detect any condition which may require preventive maintenance or which could adversely affect the safety of the pipeline facilities or the public. Such surveillance will include inspections by land and air. The pipeline will be inspected to report any construction or encroachment activities, erosion or dead vegetation that may be indicative of a leak or hazardous condition, the condition of the cathodic protection system, or other circumstances that could affect the safety of the facilities and personnel. All valves will be periodically inspected and maintained in an operative condition. Increases in population density will necessitate increased surveillance in the affected area.

Repairs

Whenever leaks, imperfections, or damages occur, they will be repaired or cut out and replaced by pretested materials of equal or greater strength and toughness characteristics. In making repairs, all safety precautions will be observed. Only qualified welders and standard welding procedures will be employed. When welding is necessary in hazardous areas, special precautions will be taken. Gravel pads at stations in areas of permafrost will be examined regularly and repaired when necessary.

Corrosion

Records will be kept of all observed electrical potentials to indicate the status of all cathodic protection devices such as anodes, bonds, insulator joints, and the amount of electrical current required to provide protection by rectifiers. Applicant will cooperate fully with the owners of pipelines, electrical transmission lines, and other metallic substructures with regard to interference problems. Periodic inspections will be made of the pipeline's cathodic condition, and necessary adjustments to the electrical current will be applied by galvanic anodes and/or rectifiers. In all instances where the pipeline is exposed, inspections will be made, noting the surface condition of the coating and of the pipe where the coating has been removed. A report will be made recording conditions of the pipe and coating.

Purging

Operating and maintenance manuals will contain the detailed steps required to purge a line, a line segment, or a portion of a compressor station. These instructions will be strictly observed when any system or component is placed in service or removed from service.

Pipeline Pigging

Detailed instructions for the launching and receiving of pigs, together with appropriate drawings and diagrams to indicate valve locations and operation, will be available. Reports will be kept of all pigging operations as well as any observations made of unusual materials removed from the line.

Compressor Station

Comprehensive operating and maintenance manuals will be provided for the compressor station, including manufacturers' instructions for all equipment. The manual will include such items as start and shut-down instructions for both normal and emergency conditions, pressure relief devices, and any other applicable operational and emergency procedures.

Combustible materials and gas cylinders will be stored and handled in a safe manner. Only approved containers will be used for gasoline, lube oil, paint, turpentine, cleaning agents, and oily rags. Compressed-gas cylinders will be stored in fire-resistant, well-ventilated buildings.

An automatic control system is provided for each station. This electronic system operates automatic start-up and shut-down procedures. Monitoring will be maintained by auxiliary systems and problems will be indicated by annunciators.

Sanitary and industrial wastes will be hauled away and disposed of by approved methods.

Each compressor station will be equipped with safety devices. These include fire detection/alarm systems, automatic and portable fire extinguishing systems, and hazardous gas detection systems.

Refrigeration will be provided at all compressor stations to maintain optimum gas temperatures. The discharge temperature will be both remotely and locally adjustable, depending on conditions of soils surrounding the buried pipeline.

Multiple centrifugal multistage refrigeration compressors will have gas turbine drivers. These will be housed in the refrigeration buildings.

1.6.3 Emissions

Noise levels at the blow-down stacks and compressors will comply with OSHA guidelines for work crews. Existing noise level guidelines pertaining to the pipeline corridor and compressor station design, which include noise suppression equipment, will all be obeyed.

The emission of oxides of nitrogen from the operation of the turbines at the compressor station will consist primarily of NO_2. Such emissions will be controlled to the extent that the maximum ground level atmospheric concentration of NO_2 resulting from advective-diffusive processes will comply with Federal ambient air quality standards.

The only pipeline gas released from the new facilities will possibly occur during emergency or infrequently scheduled blow-downs of the pipeline compressor plant facility. Fluids and solid wastes from the facilities will be disposed of in a manner approved by local regulatory agencies. No discernible off-site odor is foreseen, nor is any fire hazard anticipated from venting of gas from either the pipeline or the compressor facility.

1.6.4 Operational Labor Requirements

It is estimated that after January 1, 1983, a staff of 108 will be required to operate and maintain the pipeline. Of these, 86 will be responsible for maintaining the pipeline and compressor station facilities and 22 will be stationed at the central control facility.

1.7 FUTURE PLANS AND ABANDONMENT

The system can be expanded if additional gas reserves are found. Although the expansion design has not been formulated, it will be dependent upon the location and magnitude of additional reserves as well as the costs of expansion.

Pipeline looping and increased compressor horsepower are the most feasible expansion procedures. Construction of lateral pipelines is not probable but the possibility should be considered. Unless technically impractical, looping pipelines will be placed parallel to existing lines with interconnections along the system. Increased compressor horsepower will be attained by installation of new compressor and refrigeration facilities as well as by modification of existing units. The design for lateral pipeline construction has not been determined but will be dependent upon the magnitude and location of additional reserves.

Specific abandonment procedures have not been established. The potential gas reserves in Alaska indicate that the proposed pipeline will be functional for years. If economically feasible, the pipeline will be abandoned in place and surface facilities removed or modified for other uses. All disturbed areas will be rehabilitated in compliance with current regulations.

CONTENTS

2.0 DESCRIPTION OF THE EXISTING ENVIRONMENT

Alaska is the largest state in the union. It features a variety of topography and climate. The proposed gas pipeline would traverse the state from north to south and be constructed in the areas of the state having the greatest variety of topography and climate.

Prudhoe Bay, in the Beaufort Sea, is a land of frozen tundra, icebergs and pan ice. Further south along the proposed route is the Brooks Mountain Range, an area of snow-capped peaks, narrow passes and frozen rivers. South of the Brooks range, the land is sparsely forested, but the sub-Arctic forest is established on the permafrost.

Fairbanks is further south. This is an area of urban and suburban expansion. Few industries exist here, but the climate does sustain small gardens and timberlands. South of Fairbanks to the Alaska-Canada border, is a true boreal forest with level topography and a climate more suited to human habitation.

The people and the biota of Alaska are as varied as the topography. A land of contrasts and extremes, Alaska supports a diverse wildlife and an equally unique people. Both native and immigrant alike are fiercely jealous of their land and their life-style. This last great frontier, with all its resources, is worthy of man's conscientious efforts to preserve its natural beauty and elegance.

2.1 LAND FEATURES AND USES

2.1.1 Land Uses

Introduction

Land uses in the Arctic Region along the pipeline route are presently dominated by the exploration and development of petroleum reserves in the Prudhoe Bay area and by the construction of the trans-Alaska oil pipeline, with its ancillary facilities. However, prior to the Prudhoe Bay oil discovery, the subsequent events related to development and the extinguishment of aboriginal rights by ANCSA, the Innuit (Eskimo) people exercised domain over all these lands and carried out a variety of pursuits in support of their livelihood. In the course of their dominion, they left evidence of their uses including several graves of modern origin as well as the record derivable from historic and archaeological sites. The people of two present-day Native villages in the Arctic Region-Nuiqsut and Anaktuvuk Pass continue to pursue subsistence livelihood land uses over a large geographical area. These pursuits are presently being affected by the construction of the trans-Alaska oil pipeline in a variety of ways, some of a physical or biological nature and others of a social or economic nature.

South of the Brooks Range crest the old mining community of Wiseman has been immediately impacted by the oil pipeline construction, and the few "old-timers" residing there have been disturbed. In a manner similar to the Arctic Region, the area south to the Yukon River has also been impacted by present pipeline construction. The subsistence livelihood pursuits of Native Athabaskan peoples from the regions of the Koyukuk and Chandalar River drainages have changed, as have the pursuits of individuals from Stevens Village on the Yukon River who previously hunted and trapped over much of this country. In essence, while these pursuits continue today, they have been diminished. Simultaneously with the lessening of Native reliance on and use of fish and wildlife resources north of the Yukon River, there has been an increase in sport or recreational hunting and fishing by non-Natives, including those working on the oil pipeline project itself or attached in related activities. This impact is presently wide-spread and the long-range effect of this growth or mass intrusion upon and competition for wildlife resources in this area is a source of concern for many biologists researching or managing these resources.

In the region from the Yukon River south and east to the Canadian border, land uses are more commonly of a nature associated with modern communities, transportation and the operation of federal facilities. Intermixed with these are subsistence and recreational uses of wild lands, some agriculture and the lineally oriented commercial uses of land along the highway system.

Status of Land Tenure

One of the most dramatic changes in land ownership and land status in the nation's history is taking place now in Alaska. Not only are lands changing from federal to state ownership as a consequence of the Alaska Statehood Act ("ASA"), and into Native ownership pursuant to the Alaska Native Claims Settlement Act ("ANCSA"), but also the lands remaining in federal ownership are undergoing change from public domain holdings to reserves for particular purposes, such as national parks or wildlife refuges. This change and its effects are influencing the status of land tenure along several sections of the proposed pipeline route.

ASA departed from the traditional methods of providing lands to new states. Congress gave Alaska the right to select within 25 years from the date of statehood: 400,000 acres of national forest lands for community purposes;400,000 acres of public domain for community purposes and 102,550,000 acres of public domain for general purposes. With statehood, Alaska also became eligible to select, within 10 years, 1,000,000 acres under the Mental Health Act of 1956. While still a territory, Alaska had been granted selection of 100,000 acres of land for a university. Therefore, a total of 104,450,000 acres was made available to the State. In addition to these land selections, the Submerged Lands Act of 1953 entitles Alaska to tidelands out to the Territorial Sea and land under the State's navigable lakes and streams.

ANCSA developed as a result of the claims of Alaskan Natives--the Aleuts, Indians and Eskimos--to lands they had historically used. Protests concerning the Native claims were referred by the Federal district offices in Alaska to Washington and issuing of land patents almost ceased. In 1969, the Department of Interior withdrew all public lands from state selection, homesteading, or other potential ownership changes. This land "freeze" continued until December 18, 1971 when Congress passed ANCSA. The Act provides for conveyance of 40 million acres to Alaska Natives statewide. Selections of Native lands were authorized to Regional and Village Corporations established by the Act. In addition, former Native Reserves under Interior Department trusteeship were also authorized for transfer to Native villages or groups of villages. Village selections were completed by December 18, 1974, and regional selections by December 18, 1975. Selection of cemeteries and historic sites under Section 14(h) of the Act are to be completed by June 30, 1976.

A land status map illustrating the ownership patterns along the proposed pipeline route (including Native, State and Federal lands) is found in Volume 1A, page 6.

Native Lands

Along or near the pipeline route, several Native land claims exist, only a few of which have progressed very far in the adjudicatory process towards conveyance of title from the United States. No village conveyances have proceeded further towards completion than have regional selections.

Within the Arctic Slope Regional Corporation (north of 68^{o} N latitude) area of interest, no Native lands are directly inpacted by the pipeline route, although the subsistence resources of two villages (Nuiqsut and Anaktuvuk Pass) could well be affected eventually. Several Arctic Slope Regional Corporation selections along the north flank of the Brooks range between the Arctic National Wildlife Range and the boundary of Naval Petroleum Reserve No. 4 may also be affected in the sense that these lands contain both known and potential resources of fossil fuels. Further arrangements for the transportation of these resources utilizing both the oil and the gas pipelines is a possibility.

Within the Doyon Regional Corporation land selection area, covering all of the pipeline route from Dietrich Pass to the Canadian border, the following village land selections are along or relatively close to the pipeline route: Stevens Village, Bettles, Alatna-Allakaket, Nanana, Rampart, Beaver, Healy Lake, Minto Mentasta, Manley Hot Springs, Dot Lake, Tanacross, Northway, and Tetlin. Of these, five have lands directly affected by the routing: Stevens Village, Healy Lake, Dot Lake, Tanacross, Tetlin, and Northway.

In addition to village lands, some small tracts (up to 160 acres) are in the process of transfer to individual Natives under the terms of the Alaska Native Allotment Act where such claims predate the passage of ANCSA. These allotments are primarily located along the Alaska Highway. If not adjudicated to individual Native ownership, they will probably revert to Village corporate ownership. The village of Tetlin elected, under the terms of ANCSA, to retain the former Tetlin Indian Reserve acreage as its settlement under ANCSA.

Public Lands

Most of the lands along the pipeline routing are public lands, either federal or state. A total of 68,785,221 acres have been selected by the State throughout Alaska. Some state-selected lands have been transferred to the North Star Borough in the area around Fairbanks pursuant to state law.

State lands adjacent to the trans-Alaska oil pipeline not previously disposed of have been classified for retention in public ownership to facilitate pipeline operations. The State also maintains four wayside campgrounds along the Alaska Highway between Delta Junction and the Canadian border. Public Land Order No. 1613 (April 7, 1958) grants an easement for operations and services for the Alaska Highway 150 feet each side of the center line.

Federal lands along or nearby the pipeline route fall into three categories: (1) withdrawals for specific federal purposes (military, power reservations, etc.) and for the Transportation and Utility Corridor; (2) public domain lands (including lands that will revert from Native Withdrawal status under Section 17(d) (1) of ANCSA); and (3) lands withdrawn from future action by the Congress for possible addition to the four national conservation systems (under Section 17(d) (2) of ANCSA). Federal lands within the Transportation and Utility Corridor have been classified for pipeline, road, and related transportation purposes.

Although not immediately adjacent to the pipeline route itself, an ANCSA Section 17(d) (2) withdrawal lies relatively nearby. It encompasses areas immediately to the north and west of the Transportation and Utility Corridor where it passes along the Middle Fork of the Koyukuk River and the Dietrich River.

Private Lands

Private lands along the proposed pipeline route are located primarily in the Fairbanks area and in communities and narrow bands along the major highways. An exception is the old community of Wiseman in the canyon of the Dietrich River. These private ownerships came about through earlier applications for federal lands under several public land laws and on lands classified by the State of Alaska as open-to-entry. Neither Federal nor State laws for the transfer of additional lands to private ownerships are presently operable. Existing State legal authority provides for condemnation of private lands for pipeline purposes.

Other land status matters--such as valid existing leases and specific rights-of-way for various purposes pursuant to Federal, State, and local law--also are prevalent along the proposed route.

2.1.1.2 Functional Uses of Lands

Communities

Fairbanks is the major urbanized area of the Fairbanks North Star Borough which lies in the interior of Alaska in the Tanana River basin. The Borough includes the Chena River from its headwaters to its junction with the Tanana and is bounded along the southwest by the Wood River, its west boundary and part of the south boundary follow township lines, and the north and east boundaries follow ridges between streams. The Borough which occupies 7,400 square miles, stretches 80 miles north and south, and 140 miles east and west. The city occupies only approximately five square miles and is surrounded by satellite urbanized areas such as North Pole, Fox, and Ester. The estimated 1976 population of the Borough was 63,744. In addition to the recent development resulting from the construction of the oil pipeline, its current economy is based principally on government agencies, service-oriented commercial establishments, transportation, and the University of Alaska.

Delta Junction is located on the east bank of the Delta River at the junction of the Alaska and Richardson Highways. Its estimated 1975 population (which is listed including Big Delta) was 892. Highway junction commerce provides the basis of the Delta Junction economy, which is also boosted by nearby Fort Greely.

Big Delta, located in the Tanana Valley, lies between the Clearwater Mountains to the northeast and the foothills of the Alaska Range to the southwest. Its estimated 1970 population was 30. Like Delta Junction, Big Delta is dependent upon highway commerce and upon commerce generated by Fort Greely for its economy.

Indian Village (Healy Lake) adjoins the Healy River and Healy Lake, southeast of Big Delta. No population is listed for the community in the 1970 census; the estimated October 1975 population is 11.

Dot Lake lies on the Alcan Highway about 40 miles northwest of Tok in the Tanana Lowland. An estimated 69 persons lived in Dot Lake in 1975 and depended on highway commerce supplemented by guiding, sport hunting, and firefighting as the basis of their economy.

Tanacross, on the Tanana River, is 12 miles northwest of Tok. Its estimated 1975 population was 104. Tanacross is supported by a mixed economy of subsistence hunting and fishing, and seasonal employment in firefighting, trapping, or construction.

Tetlin is on the Tetlin River, 4.5 miles east of Tetlin Lake, 20 miles southeast of Tok. The estimated 1975 population was 113 persons, supported principally by a subsistence economy, although some gardening is done with the assistance of irrigation. Tetlin is located on the former 768,000-acre Tetlin Native Reserve now corporately held by the Village of Tetlin.

Northway is located on the east bank of the Nabesna Slough, 5.5 miles southwest of North Junction. The estimated 1975 population was 175. The local economy was dependent upon seasonal employment in firefighting, guiding, and construction. These sources of income are heavily supplemented by subsistence hunting and fishing.

Applicant has initiated a survey of the communities along the proposed route from Delta Junction to the Canadian border. The above population estimates are a result of the initial phase of that survey. Extensive social and cultural information on Native villages and other communities in this area will be developed as a result of these ongoing studies.

Federal Facilities

Three major Federal military facilities exist in the area of the general pipeline route: Ft. Wainwright, Eielson Air Force Base, and Fort Greely. Ft. Wainwright has, in part, been deactivated and about half of its area is presently devoted to oil pipeline management activities. Eielson is an active Air Force base. Ft. Greely is utilized for arctic survival and other military training. Acreages withdrawn for Ft. Wainwright, Eielson Air Force Base and Test Range are 1,518,000 acres and for Ft. Greely, 623,500 acres. Another major Federal withdrawal, part of which will be crossed by the proposed pipeline route, is the Rampart Power Site reservation which extends down the Yukon River almost to Tanana. The total area of the Rampart withdrawal is 8,959,000 acres.

Native Lands

The Native villages of Stevens Village, Healy Lake, Dot Lake, Tanacross, Tetlin, and Northway have made selections for land entitlements under ANCSA. Part of these selections may be crossed by the proposed pipeline route. Village land selection entitlements are:

Stevens Village	69,120 acres
Healy Lake	69,120 acres
Dot Lake	69,120 acres
Tanacross	92,160 acres
Tetlin	768,000 acres (Tetlin Native Reserve)
Northway	115,200 acres

Land uses in the vicinity of these villages include residences; stores; churches and cemetaries; material sites; hunting, fishing and trapping campsites and use areas; and various community-related uses. No major commercial uses exist.

Transportation

1. Water Transportation

In the Arctic Region, the Prudhoe Bay field is served by an extensive docking causeway where barge transport is unloaded and serviced after transit from the lower 48 states and from MacKenzie River ports of origin.

The Tanana River is navigable by barge traffic to Nenana and by small craft upstream. Barge docks are located at Nenana.

2. Railroad Transportation

Alaska's only railroad--the Alaska Railroad--provides service between Fairbanks and the port of Anchorage, Seward, and Whittier. The railroad route generally parallels the George Parks Highway. This railroad, a federal facility, operates 483 miles of track as well as railroad-related facilities at locations along the railroad right-of-way. Track right-of-way is 200 feet wide; there is an additional 50-foot strip withdrawn for the railroad telegraph line which may or may not lie adjacent to the track. As of mid-1973, the following acreage made up the additional railroad land holdings within the general area of the pipeline route:

Clear: 2,780 acres proposed for station, terminal ground, and gravel pit now used for mining only;

Nenana: 279.4 acres; railroad and commercial business uses lease land from the railroad; the railroad also maintains facilities to transfer freight to barges for operations on the Tanana and Yukon Rivers;

Fairbanks: 461.5 acres; 200 acres being used for yards, trackage, buildings, freight depots, passenger depot and office buildings; 75 acres are in two industrial park developments; approximately 60 acres is being held for eventual development in industrial park.

The existing land uses map on page 3, volume 1A, indicates the railroads locale in relationship to the proposed pipeline route.

3. Air Transportation

Due to vast distances and few roads, air transport is the chief mode for moving people and goods in the northern part of the pipeline route area. South of the Yukon River, the air mode shares traffic with other modes but still is extremely important. Air transport is dependent upon the cooperation of a number of groups. Most trunk and secondary airports are owned and operated by the State of Alaska; most navigational assistance is provided by agencies of the Federal government; and consumer services are provided by private enterprise. Table 2.1.1-1 contains a list of airports in the area of the proposed pipeline route. The list is keyed to the Land Uses Map in Volume 1A, page 3.

Fairbanks is the air transportation center for the northern part of the state. Nearly every settled place in interior Alaska has its airstrip or landing place. Air service was developed to meet many particular needs. It presently consists of a system of jet, prop-jet, and bush aircraft services from a central distribution point to the consumer. Fairbanks is the heart of a system of jet and prop-jet service to Tanana, Galena, Bettles, and Fort Yukon. From the secondary trade centers of Galena, Bettles, and Fort Yukon, air carrier prop-jet service is extended to a number of bush airfields. From these, and from Tanana, bush air taxi operators serve still smaller localities.

4. Pipelines

There are two pipeline rights-of-way along the proposed Alcan pipeline route. The older of these is the Haines to Fairbanks Military Pipeline (No. 44LD513 or BLM F010143). The 626-mile long, eight inch Haines Pipeline was completed in 1955 to carry petroleum products from Lutak Inlet and Haines, Alaska, to military bases in the Fairbanks area. In its total traverse, the pipeline passes through sections of Alaska, British Columbia, and the Yukon Territory. The section of the pipeline paralleling the Alaska Highway between the Alaska-Yukon border and Fairbanks is 283 miles long and has a right-of-way width of 50 feet. Stations along this section of the Haines pipeline include:

Lakeview Pump Station, Mile Post 1256, Alaska Highway, 21.48 acres

Tok Terminal, 7 miles north of Tok Junction, 310 acres

Sears Creek Pump Station, Mile Post 1376, 11.24 acres

TABLE 2.1.1-1

A LIST OF AREA AIRPORTS FOLLOWS AND IS KEYED TO THE EXHIBIT MAP OF LAND USES

Map No.	Name	Class	Owner	Length (feet)	Surface
1	North Kuparuk	H	State	50	Gravel
		S-B	State	2,000	Gravel
2	West Kuparuk	T-C	State	5,033	Gravel
3	Kaparuk	S-B	State	1,956	Gravel
		H		50	Gravel
4	Hull	S-B	State	1,999	Gravel
5	Kavik River	T-C	Private	5,918	Gravel
6	West Kavik	T-C	State	5,200	Gravel
7	Kad River	T-C	State	5,460	Gravel
8	Pingo	T-C	State	6,000	Gravel
		H		50	Gravel
9	Kadler	S-B	State	2,398	Gravel
10	Coastal	S-B	State	2,360	Gravel
11	Prudhoe Bay	T-A	Private	5,500	Gravel
		H	State	100	Gravel
12	Deadhorse	T-A	State	5,000	Gravel
		H	State	100	Gravel
13	Sagwon	T-C	Private	4,250	Gravel
14	Happy Valley	CAB JET	Private	5,000	Gravel
		T-C De-activated	Private	6,000	Ice
		S-B	Private	1,500	Gravel
15	Toolik Camp	S-B	Private	2,500	Gravel
16	Galbraith Lake	S-B	Private	5,200	Gravel
17	Chandalar	T-C	State	4,500	Gravel
				4,000	Water
				4,000	Water

TABLE 2.1.1-1 (CONT'D)

Map No.	Name	Class	Owner	Length (feet)	Surface
18	Dietrich	T-C	State	5,200	Gravel
19	Wiseman	S-B S-B	State Private	3,000 1,550	Gravel Gravel/Dirt
20	Emma Creek	S-B	Private	2,000	Gravel/Dirt
21	Coldfoot	T-C	Private	5,000	Gravel
22	Porcupine Creek	S-B	State	1,500	Gravel/Dirt
23	Tramway Bar	S-B	Private	1,200	Dirt
24	Gold Bench	S-B	Public Domain	1,600	Dirt
25	Prospect Creek	T-B	Private	5,000	Gravel
26	Bettles Area:	SPA T-A	Public Domain State	2,000 1,500 5,199	Water Water Gravel
	Bettles River	S-B	Public Domain	1,500	Gravel/Dirt
27	Old Man Camp	T-C	Private	5,000	Gravel
28	Five Mile Camp	S-B	Private	2,500	Gravel
29	Livengood	S-B	Public Domain	1,250	Turf
30	Fairbanks Area:				
	Chena River	SPA	Public Domain	3,000 5,000	Water Water
	Bureau of Land Management	H	Federal	120x60 80x60	Gravel Gravel
	Merric, Inc.	H	Private	3/20x20	Gravel
	Phillips Field	S-A H	Private	3,340 50x50	Asph/Gravel Gravel

TABLE 2.1.1-1 (CONT'D)

Map No.	Name	Class	Owner	Length (feet)	Surface
	Fairbanks International	T-A	State	10,300	Asph
				3,200	Treated Gr
				100x100 (heliport)	Gravel
				2,000	Water
	Metro Field	T-C	Private	4,600	Gravel
	Ft. Wainwright	M	Federal	8,714	Asph/Concr
				7,364	Asphalt
	Mile 8, Richardson Highway	S-B	Private	1,580	Gravel
	Eielson AFB	M	Federal	14,520	Asphalt
31	North Pole Area	S-B	Private	2,550	Gravel
		S-B	Private	1,760	Dirt
		S-B	Private	2,400	Turf/Grave
				2,400	Turf
32	Big Horn	S-B	Private	1,200	Turf
33	Mile 46, Richardson Highway	S-B	Private	1,770	Turf
34	Delta Junction	M	Federal	7,500	Asph
				4,675	Asph
				6,100	Asph
35	Dot Lakes	H	Private	1,140	Turf/Dirt (into 3 heliports)
36	Cathedral Rapids	S-B	Private	1,055	Gravel
37	Tanacross	T-C	State	5,100	Asph
				5,000	Asph
38	Tok	S-B	Private	3,200	Gravel
		S-B	Private	2,035	Gravel
		S-B	State	2,300	Gravel
39	Tetlin	S-B	State	2,000	Turf

TABLE 2.1.1-1 (CONT'D)

Map No.	Name	Class	Owner	Length (feet)	Surface
40	Riverside Lodge	S-B	Private	2,400	Dirt
41	Northway	T-C	State	7,500	Asph

South Tank Farm, on Fort Greely

North Tank Farm and Take-off Station, Delta Junction, 2.04 acres

Timber Pump Station, Mile Post 227, Richardson Highway, 7.49 acres

Birch Lake Tank Farm, Mile Post 305, Richardson Highway, 38 acres

Fairbanks Terminal, Fort Wainwright, 167 acres

Between Big Delta and Fairbanks--a distance of 96 miles--the pipeline is buried; elsewhere, the line is predominately above ground. The pipe is not wrapped or coated; cathodic protection was provided where soil tests indicated a need.

All of the Haines pipeline, except the 27-mile westernmost section between Eielson Air Force Base and Fort Wainwright, has been deactivated. The General Services Administration plans to dispose of the deactivated section of the pipeline by lease or sale.

The second existing pipeline right-of-way is the 798 mile trans-Alaska oil pipeline between Prudhoe Bay and the ice-free port of Valdez in southcentral Alaska. The oil pipeline system is being developed in two phases. The first phase, scheduled for completion in mid-1977, includes a new all-weather highway from the Yukon River to Prudhoe Bay, a 48-inch steel pipeline from Prudhoe Bay to Valdez, eight pump stations along the route and oil storage and tanker loading facilities at Valdez. Four additional pump stations along the route and more oil storage and tanker docking facilities at Valdez are planned in the second phase. The construction right-of-way width varies with terrain and land ownership.

Note Land Uses map page 3, volume 1A.

5. <u>Highways</u>

Although there is only one road through and north of the Brooks Range, the situation to the south is different. Four major highways converge on Fairbanks. In addition, a relatively highly developed network of secondary roads branching off from the major arterials serves outlying communities and settlements. Major roads are shown on page 3, volume 1A. Right-of-way widths for these roads are as follows:

Highway	Width of Right-of-Way
Alaska Highway	600
Taylor Highway	200
Glenn Highway	300
Richardson Highway	300
Steese Highway	200
Elliott Highway	200
George Parks Highway	200
Pipeline Haul Road	200

The Alaska Highway extends from the Yukon border to Fairbanks. From the southwest, the recently completed George Parks Highway serves as a link between Anchorage and Fairbanks. The Steese Highway, northeast of Fairbanks, and the Elliott Highway, to the northwest, provide connecting links between Fairbanks and communities to the north. The pipeline haul road branches off the Elliott Highway just south and west of Livengood and continues to Prudhoe Bay. This road crosses the Yukon River on a 2,300-foot long two-lane bridge and there are 20 other major river crossings 90 feet or more in length of the haul road.

The Glenn, Taylor, and Richardson Highways intersect the Alaska Highway at various junctions south of Fairbanks. The Taylor Highway provides access to Eagle on the Yukon River and to Dawson City in the Yukon Territory. The Glenn Highway, from the Anchorage area, terminates in the Alaska Highway at Tok, and the Richardson Highway, the oldest road in the state, joins the Alaska Highway at Delta Junction.

Seasonal use limitations exist upon the all-weather road system in Alaska. They are most pronounced during the annual spring break-up period. Weight restrictions varying from 75 percent to 50 percent of legal axle weights are imposed by the Alaska Department of Highways for periods varying from two to seven weeks from March to June. The practical effect of the weight restrictions is to generally reduce the revenue cargo capacity and to increase delivery times. In addition to the spring break-up limitations imposed upon the state highway system, normal maintenance efforts, particularly during the summer construction months, are also disruptive to routine highway transport. During this period, road closures or other limits to travel may be imposed. The Alaska Department of Highways has announced a five-year construction schedule for the major routes. The following is a summary of the projects affecting highways along the proposed pipeline route:

Steese Highway: The Department of Highways Interior District plans to reconstruct all deteriorated roads along the 127-mile section between the Farmers Loop Road Intersection and Central. The section between the Farmers Loop Road Intersection and Fox will be mostly 4-lane to handle anticipated traffic, and will be constructed in stages; only two lanes will be built initially. Reconstruction between Mile 43 and Eagle Summit will be comparable to other recently rebuilt sections of the Steese Highway.

Elliott Highway: The Interior District anticipates bringing the entire Elliott Highway, from Snowshoe Pass to the North Slope Road Intersection, up to secondary standards within the next five years. The paved portion of the Elliott will be extended from Olnes to Snowshoe Pass. Elliott Highway has been severly impacted by pipeline related traffic.

Alaska Highway: During the next five years the Interior District will continue its effort to reconstruct the Alaska Highway between the Border and Delta Junction. Because of limited funding, construction is at present firmly committed only along the sections from Mile 1235 to Mile 1250 and from ten miles south of Delta to Delta Junction.

Parks Highway: Only two sections of the Parks Highway within the Interior District require attention. These are the 0.6 mile section between Ester Siding and Ester; and 28.6 mile section between Nenana and Rex. Both are scheduled for reconstruction by 1980.

Richardson Highway: Because of increased traffic on the Richardson Highway and numerous conflicts occurring at Mile 6 and the Badger Road intersection in North Pole, both locations have been scheduled for interchanges.

Yukon-Prudhoe Bay Highway: During 1976 the Department of Highways will continue its surveillance activities on the road between the Yukon River and Prudhoe Bay. This surveillance will be a continuation of the State's supervision of the construction of this road which began in 1974.

Communications

Alaska's basic civil communications still rely heavily on the military system developed for the North American Air Defense Command during the 1950s. This system supplies most of western, arctic, and southcentral Alaska. The portion of the military White Alice Communications System extending from Necklasson Lake near Anchorage through southeast Alaska is leased to RCA Alascom. Since it leased the system, RCA has constructed a new microwave system between Juneau and Annette Island which will replace older troposcatter and microwave systems installed by the military.

Almost all local telephone franchises in the state purchase long-distance service either in part or in total over circuits leased by RCA from the U. S. Air Force. Many smaller communities not served by franchised telephone companies have access to the statewide telephone system through single channel radio links called "bush-phones". Most of these are operated by RCA and consist of VHF radio links connecting the community telephone to the nearest facility or community on the White Alice System. Some communities must rely on state or privately owned HF radios that can connect with the telephone system through land-based radio facilities at major RCA stations.

Local telephone services range from very poor to good. Most urban areas have a shortage of lines and long-distance circuits between Alaskan urban areas, and many of the state's western communities cannot meet current demand. Communities served by radio-telephone sometimes find themselves without service for a week or more during periods of bad weather. When equipment fails, most communities must wait for a qualified radio technician to be flown in and make repairs.

In 1975 the State of Alaska and RCA embarked on a program of procuring and installing small satellite earth stations in remote communities. One hundred of these should be installed by 1978. Upon completion, they will provide one toll telephone circuit and one channel for emergency and medical use in each community. In addition to the small earth stations, RCA is engaged in a program of installing higher capacity earth stations in larger communities and communication sites. By 1978 the earth station network in the state will have replaced most of the military system now in use.

The communication systems of the Arctic Region rely primarily upon the military's Distant Early Warning (DEW) sites for their backbone circuits. This system, built in the late 1950s, provides telephone service to all permanent communities except Anaktuvuk Pass. Only Barrow has a local telephone exchange, the remaining communities may have telephones at the schoolhouse, the health clinic, and possibly one or two other locations. The onset of major oil exploration and development in the Arctic soon exhausted the limited capabilities of the DEW line circuits. Sincle sideband (SSB) radios were used by some to fill the communications void but they were unreliable. In desparation, companies often chartered aircraft to fly messages to Fairbanks and Anchorage.

An Applied Technology Satellite (ATS-1) radio was installed at Anaktuvuk Pass in 1971 on an experimental basis. This provided the community with its first reliable communications, but its access was limited to public service personnel only. In 1974 RCA Alascom installed major earth stations at Prudhoe Bay and Valdez which provided some 35 voice circuits via the Anik II satellite and relieved pressure on the DEW line circuits. This system will assist in monitoring the trans-Alaska oil pipeline.

RCA Alascom will also own the final operational communication system for the trans-Alaska oil pipeline. The system is being developed around 41 permanent microwave stations between Prudhoe Bay and Valdez and will provide 240 channels for public use and 60 channels for use by the Alyeska Pipeline Service Company.

A very high frequency (VHF) system now links the camps along the trans-Alaska pipeline and provides telephone service. Another VHF system enables exploration sites within a range of Prudhoe Bay to have telephone service via a patch-through arrangement. The only other systems are the National Guard (SSB) radios in the villages, which are unreliable and often have long delays during periods of repairs.

Fairbanks is the center of operations for most communication for the Arctic and the Yukon Regions. RCA open wire telephone system extends from there to the Canadian border and beyond; a local telephone exchange serves Fairbanks and Delta regions; the military microwave and troposcatter systems pass through as well as the RCA bush phone and microwave service; and an ATA-6 Satellite is in use. Communication corridors and stations are located on the map in Volume 1A, page 3.

Agriculture

There is substantial agricultural development in the Tanana Valley, mainly in the vicinity of Fairbanks. The Soil Conservation Service has classified 560,000 acres on the lower south-facing depositional slopes and better drained lowlands between Fairbanks and Delta Junction. The prime soil group is Subarctic Brown Forest Soil of the Fairbanks, Gilmore and Minto series. Approximately 380,000 acres are classified as potentially cultivable, mainly alluvial soils of the China and Salchaket series. Marginally cultivable lands consist of nearly 180,000 acres belonging to the Low-Hunil Gley soils series. Agriculture is an important resource for the Tanana Valley. All crops that are adapted to Alaska growing conditions can be grown in the Tanana Valley. The warm summers and long daylight hours produce high quality small grains, hay, and vegetables. Potentially, the Tanana Valley could serve Alaska's needs for adapted agriculture products and support a thriving export business. The Tanana Valley has many acres of potential farmland identified, and agricultural development could occur in response to both local and export markets. This would add an economic stability to the Tanana Valley.

Agriculture areas are indicated on the Land Uses map of volume 1A, page 3.

Other Land Uses

Several areas along the proposed pipeline route are recognized as study areas, areas for viewing wildlife and scenery, or areas for hunting and fishing. Franklin Bluffs has recognized unusual geologic, botanical, and zoological features and has beenproposed as an ecological reserve and a Natural Landmark. Atigun Canyon is a recognized scenic and viewing area for Dall sheep. Toolik, Murphy, and Galbraith Lakes are recognized sport fisheries for lake trout and grayling. Elusive Lake is a sport fishing lake; a big game guide is headquartered there. Table Mountain is recognized as a Dall sheep viewing area. Gravel bars of the Dietrich and Upper Middle Fork of the Koyukuk Rivers have been used as access routes for hunting grizzly bears and sheep. Also in this area, there are several grayling streams, particularly Prospect Creek, Bonanza Creek and Jim River. Several rivers, particularly Salcha and Goodpaster, provide access to fishing, hunting and general recreation areas. Scotty Creek and lakes along the Chisana are used by fly-in hunters for moose and waterfowl.

A moderate level of big game and small game hunting and fishing for both recreational and subsistence purposes occurs at numerous points along the route where access is available to habitat.

Forest resources along the proposed pipeline route are limited. Native tree species include white and black spruce, tamarack, Alaska paper birch, quaking aspen, and balsam poplar. Much of the forest type pattern is due to past wildfire history, topography, the presence or absence of permafrost and the relative availability of moisture. Forest inventory data are limited. Essentially all commercial forests, by present standards, are in the bottomland spruce-poplar type. Timber volumes in this general region average 1,500 BF per acre with sawmill stands averaging about 3,270 BF per acre. Good alluvial sites may yield 10,000 BF per acre of white spruce 100 to 200 years old, or 40,000 BF per acre of balsam poplar in rare instances. Very little of the volume is in trees larger than 30 inches (76 cm) in diameter (Hutchison 1967). Some of the best mature white spruce stands in Alaska occur near Fairbanks. The Bonanza Creek Experimental Forest of the U. S. Forest Service has been established to study such stands. In the Fairbanks Block of the Tanana Inventory Unit (forest inventory incomplete) sawtimber stands total about 120,000 acres (48,000 hec) or 16 percent of the commercial forest land. Volumes of 15,000 BF per acre are not uncommon, with an average volume of 7,500 BF per acre for all sawtimber stands (Hegg 1975). The best of these stands are located west of Fairbanks to Nenana and north of the Tanana River to the Chatauika drainage, and in the Dugan Hills west of Minto Flats. At present, limited harvesting of forest resources within the Tanana Valley is done for local building purposes and firewood. Some interest exists in pulp production, but markets are virtually non-existant. Note the Land Uses map on page 3, Volume 1A.

2.1.2 Topography, Physiography and Geology

Introduction

This section provides a description of the main physiographic and geologic features of the environment through which the proposed Alcan pipeline will pass. Maps in volume 1A, pages 4 and 8 show additional detail. The following descriptive treatment of this subject is broken down initially by the three major physiographic divisions traversed by the proposed pipeline: Interior Plains, Rocky Mountain System and Intermontane Plateaus. Under each of these, topography and physiography are discussed by physiographic province. The geomorphic features to be encountered by construction are then generally described. The geologic treatment initially emphasizes geologic description rather than bedrock geology. Bedrock and historic geology finally are briefly summarized under the heading of regional geology.

Interior Plains

Topography and Physiography of The Arctic Coastal Plain

The Arctic Coastal Plain is a smooth plain rising imperceptibly from the Arctic Ocean to a maximum altitude of 600 feet at its southern margin. The coastline makes a very small break in the profile of the coastal plain and shelf, and the shore is generally only one to ten feet above the ocean; the highest coastal cliffs are only 50 feet high. Locally, an abrupt scarp 50-200 feet high separates the coastal plain from the Arctic Foothills. In some places, pingos (ice-cored hills) are sufficiently abundant to give an undulatory skyline. The coastal plain just west of the delta of the Sagavanirktok River has scattered longitudinal sand dunes.

The Arctic Coastal Plain is very poorly drained and consequently, is very marshy in summer. It is crossed by rivers which head in highland to the south. The Sagavanirktok River crosses the plain in braided channels and is building a large delta into the Beaufort Sea. A large portion of the Arctic Coastal Plain is covered by elongated thaw lakes oriented approximately N 15° W; these lakes are generally oval or rectangular in shape. The lakes expand about one meter per year in places, and several generations of drained lake basins are present.

The entire land area is underlain by permafrost at least 1,000 feet thick, and in the Prudhoe Bay area it is as much as 2,000 feet thick (Howitt and Clegg, 1970). The permafrost table is 1/2 to four feet below the surface. The permafrost is reported to extend offshore beneath the waters of Beaufort Sea to at least the barrier islands near Prudhoe Bay. The salinity of the water and the history of shoreline movements during the past 10,000 years determine whether or not the supercooled interstitial water is frozen (Lachenbruch, 1957).

Geomorphic Features

Several types of geomorphic features are produced by permafrost and frost action.

Ice Wedge Polygons

Polygonal or patterned ground, characteristic of permafrost regions, results from ground contraction during extreme low winter temperatures. Water and snow collect in the contraction cracks, eventually turning to ice and producing ice wedges that surround each polygon. The addition of ice to the wedges is accompanied by upthrusting of material adjacent to them, both by the expansion of ice during freeze-up and of the ground during summer warm-up. This tends to form ridges of material on each side of the ice wedge.

If drainage conditions are sufficient, ice wedges thaw and form troughs that drainage tends to perpetuate. The ridge-forming material may slump back into troughs and develop high-centered polygons. In areas of poor drainage, ice wedges are not eroded, and ridges continue to develop. They stand in significant relief above polygon centers, producing low-centered polygons. Normally, polygon crack systems form at random in areas of uniform temperature stress. However, on receding shorelines, in drained lakes, and in abandoned stream channels, crack systems often form both parallel and perpendicular to the receding shorelines because of horizontal stresses caused by temperature gradients.

Beaded Streams

A beaded stream consists of a series of elliptical ponds approximately three to ten feet deep and a few yards in length and width, connected by short, usually straight water courses that generally follow ice wedges. The pools usually form at the intersections of ice wedges.

Thermokarst Topography

Thermokarst topography consists of mounds, sink holes, tunnels, caverns, short ravines, lake basins, and circular lowlands. Local melting of ground ice and the subsequent settling of the ground creates this uneven topography, so it is most common where massive ice formations such as ice wedges and thick segregated ice exist. Melting can result from the disturbance or removal of vegetation or by a warming trend in climate. Even small disturbances, such as a vehicle driven across the tundra, can create thermokarst features.

Thaw Lakes

Lakes are the most common thermokarst features of the Arctic Region. Perhaps the most outstanding of these are the oriented thaw lakes of the Arctic Coastal Plain which cover more than half the land surface. They commonly form in tundra regions underlain by continuous permafrost, range from a few yards to several miles in length, and are seldom deeper than 10 feet.

Slight ground surface depressions, such as low-centered polygons, cause pooling of standing water which begins to thaw the permafrost immediately beneath. Thaw continues along lake margins and the basin extends, often merging with other adjacent lakes and creating a large body of water. Teshekpuk Lake, the largest thaw lake in arctic Alaska, is over 25 miles long and was probably formed in this way. Some thaw lakes are connected by stream channels while others have neither an active inlet nor outlet stream. Since underlying permafrost prevents percolation into underground aquifers, water is trapped until intervening higher ground is breached, creating an outlet channel. The lake drains, leaving behind a low, marsh basin.

Most lakes on the coastal plain, especially the larger ones, have their long axes oriented 10-15 degrees west of north-perpendicular to prevailing winds. Apparently, these winds drive wave action that forms sublittoral shelves and bars. This protects the east and west shores from erosion and thaw, while the deeper central basin extends to the north and south.

Drained Basins and Initial Surface Residuals

The marshy basin left behind when thaw lakes drain is surrounded by the higher topography of the original tundra surface. Repeated formation and drainage of thaw lakes often creates an overlapping series of drained basins with only isolated ridges or platforms of the original surface remaining. These relief features, generally 10 to 15 feet above adjacent drained basins, are known as initial surface residuals and cover only about 25 percent of the land surface on the coastal plain.

Pingos - Closed System

When tundra thaw lakes drain, permafrost again encroaches from the sides. As sediments near the center slowly freeze, massive segregation of ice develops. Volume increases as freezing occurs and pushes the tundra and ice upward, forming a large ice-cored mound or pingo. Often, as the pingo expands upward, a summit crack or fissure opens, exposing the ice core and allowing part of it to melt and a small lake to form in the resulting crater. Pingos attain heights up to more than 100 feet and are well-scattered on the Arctic Coastal Plain.

Frost Mounds

The frost or ice-cored mound is smaller, but related in origin to the pingo. With a maximum relief of about four feet and diameters ranging from 10 to 15 feet, they may exist anywhere on the tundra but are most common in marshy, drained lake basins. These frost mounds consist of a core composed predominantly of ice, covered with soil or peat. Although some, especially the largest, have their cores rooted in permafrost, most probably are restricted to the active layer.

Unconsolidated Deposits

Coastal Plain Deposits

The Arctic Coastal Plain is mantled by unconsolidated deposits of the Gubik formation (named after the Eskimo word for Colville River). These Quaternary deposits (Qc), predominantly noncalcareous west of the Colville River and calcareous east of it, overlay older Cretaceous and Tertiary sediments. Though mainly of marine origin, the Gubik has also been modified by alluvial, lacustrine, eolian, and frost processes. The formation was laid down in a shallow sea, where frequent sea level changes alternately exposed and submerged large portions of gently sloping plain. Consisting largly of lenses and mixtures of gravel, sand, silt and clay, the area covered by the sediments is approximately 25,000 square miles. Though varying considerably in composition from place to place, O'Sullivan described a generalized section of the Gubic formation as:

> ...a basal gravelly sand, overlain by white laminated sand which may in some instances be missing (and replaced by a dark silt), overlain by orange sand or sand interlayered with a dark silt-sand which grades upward through a layered zone into the orange sand. The thin basal gravel may be absent, and the material under the main gravel may vary from reworked silty clay to sand with lenses of gravel and sand.

Sediment thickness varies from a few feet to about 150 feet. In the western and central parts of the region, the Gubik essentially extends to the base of the northern foothills. In the eastern part, however, a broad area of alluvial sediments occurs between the marine coastal plain sediments and the foothills. There, sediments are interfingered in a manner which makes an exact boundary difficult to locate.

A thin layer of surface peat mantles most of the area and supports a wide variety of tundra vegetation. Wind-blown silts often form a thin layer mixed with or underlying the peat layer.

Large boulders called glacial erratics (rocks carried from their place of origin by glacial action) occur near the mouth of the Kuparuk River, though rarely at other places along the coast. These boulders may be ice-rafted glacial debris carried to the sea by glaciers and floated by glacial or sea ice to their present positions on ancient shorelines.

Sand Dunes

Sand dunes cover about 5,000 square miles of the coastal plain west of the Colville River to the Meade River and from the latitude of the southern shore of Teshekpuk Lake to the foothills. The mantle consists of active sand dunes, principally along the western shores of larger streams and lakes, and old, stabilized dunes which cover most of the interjacent area.

The stabilized dunes are vegetated and include longitudinal, parabolic, and multicyclic dunes. Black (1951) believed that the stabilized dunes were formed in a climate slightly warmer than today when the thawed layer would have been thicker, allowing deeper wind penetration. Such a climate may have existed in the post-Pleistocene climatic optimum. The dune location may be due to lateral variation in grade of the coastal plain sediments from which they are derived. A slight change in grain size produces material either too coarse to be moved by wind or fine enough to hold sufficient moisture to maintain a vegatative cover. A decrease in size of surface material east and west of the Ikpikpuk River and a northward change to finer sediments in the vicinity of the Meade River seem to verify this theory. The stabilized dunes have an east-northeast orientation aligned with the present wind pattern.

The sand ridges are long and narrow and often attain lengths of more than a mile and widths exceeding a hundred yards. Longitudinal dunes are usually less than 3,000 feet long, but the longest are about 8,000 feet. Dune heights vary from a few feet to 30 or 40 feet. Most ice wedge polygons end on the outer and lower slopes of the sand ridges rather than crossing them. Eolian materials in interdunal areas are as much as ten feet thick.

Stabilized dunes are absent on river floodplains, on the beds of most drained lakes, and on steep slopes where soil movements are rapid. They are most abundant atop ridges or other topographic irregularities and are often associated with cut banks of large lakes and streams. Though often difficult to see on the ground, their improved drainage gives rise to a slightly different vegetative cover. They appear as darker bands against the general tundra from the air and on aerial photographs.

Present aeolian activity is restricted to blowouts in river and lake banks and to material removed from drained lake bottoms, river bars, floodplains, deltas, and coastal beaches. Most activity takes place in the same areas as past activity, where materials are easily moved if not stabilzed by vegetation. Major areas of active sand dune deposition include the lower Colville, Ikpikpuk, Topagoruk, Meade, and Sagavanirktok Rivers, though many dunes exist on smaller local streams as well. The area affected by modern aeolian activity is relatively small compared to the extent of stabilized dunes.

Throughout the coastal region active sand movement takes place during much of the summer because of the relatively deep thaw layer that develops in the dry material. Constant motion throughout the warm season retards the development of a stabilizing vegetative cover. Coarse material moved from the bars and blowouts on streams and lakes is rather quickly deposited, and sand dunes up to 20 feet high are known to accumulate on the west banks of rivers.

Dunes along the lower Colville River above the delta consist predominantly of fine sand with admixtures of considerable silt (Schrader 1904). Dunes in the delta are widely scattered between the numerous distributaries and along the west bank of the Nechelik Channel. Similar conditons prevail in the Sagavanirktok River delta, where numerous dunes exist between and along distributary channels.

Aside from riverbank dunes the largest concentration of active dunes is located on a dry lakebed about 15 miles south of Teshekpuk Lake at 70° 13' north latitude and 152° 10' west longitude, known as the Pik Dunes. There, a large lake has partially drained, exposing to the wind an unvegetated, sandy bottom. The lakebed sands, probably of aeolian origin, move easily with the prevailing winds and have formed into dunes on the lakebed and to the west of it.

Alluvial Deposits

As rivers leave the hills and enter the coastal plain, they often spread out from their initial narrow valleys onto extensive floodplains (Qf and Qw). Velocity decreases rapidly, and deposits on the plain are characteristically smaller than in the mountains and hills, the particles decreasing in size with distance from the mountain front. In any given stream all alluvial deposits will generally be coarser upstream and finer downstream. At any given location interfingered deposits of different grade reflect seasonal changes in flow velocity.

East of the Colville River, rivers have their sources high in the Brooks Range and have coarse gravel beds far into the coastal plain. Gravel reserves for construction are available.

Coastal Deposits

Winds on the Arctic Slope usually come from easterly or westerly directions. When sea ice is not present, the winds develop a longshore current that can transport fine sediments along the coast. Wave swash, in which waves strike the beach at an angle, causes longshore drift, the transport of coarse materials along the beach fronts in the same direction as longshore currents.

Offshore of Point Barrow waves tend to approach the Beaufort Sea coast from the east or north, setting up longshore currents flowing northwest or southeast respectively, and longshore transport may occur in either direction along the coast depending on prevailing local winds.

Materials for longshore transport come from stream mouth sediments and from erosion and slumping of bluff deposits along the coast. Fine materials (clay, silt, and fine sand) are usually carried in suspension in the longshore currents; coarser particles of sand and gravel are generally transported in the same direction by wave swash. Most fine materials are carried long distances, often being carried out to sea and deposited. Coarser materials are deposited along the coast as beaches, bars, spits, and barrier islands.

When used cautiously and moderately, beaches, spits, and barrier islands can provide fill materials for construction purposes. In populated areas, however, the effects of borrow of fill materials must be closely studied and controlled. Excessive removal may result in coastline retreat and compromise to houses and land use. Unlike more temperate regions, materials are not replaced by longshore transport as quickly or in as great quantities. The long nine-month period of winter freeze when coastal processes cease altogether, and the fact that summer pack ice often drifts to shore for days at a time, inhibit currents and transport processes. Studies by Hume and Schlak (1967) indicated that sediment transport near Barrow as approximately 10,000 cubic yards of material per year, with only half deposited on beaches and spits. This is far less than in more temperate regions.

Aside from normal wave and current deposition, several less significant processes also contribute to the sediment load on or near beaches. The most important of these is ice push. During times of onshore winds the ice approaches the shore and often rides up on it. Several observers have seen the ice move up onto the beach as much as 140 feet. The ice bulldozes sediments from the foreshore high up onto the beaches, and after melting, leaves behind irregular mounds or ridges of sediments extending along the beach as much as several miles. Some of those with ice cores may originally be up to six feet high but shrink to two feet when the core melts. Others have been observed up to five feet high with no ice cores.

Deposits are often destroyed by the first storm waves. In come cases they persist by being pushed above the normal reach of waves, by growth of the beach, or because close pack ice retards wave erosion. Deposition from ice push probably never amounts to more than 10 percent of the sediments above sea level, generally ranging between one and two percent. Ice carries sediments and drops them when it melts, possibly accounting for up to three percent of the deposition near shore.

Though not quantitatively significant, sand and pebbles up to 0.4 inches long have been observed floating freely in the sea. Only flat, tabular particles float; spherical particles sink. The floating particles commonly gather in patches or rafts. Surface tension has been described as the mechanism of floating. At most, only 20 to 25 pounds of material per hour has been observed passing any given point.

Generalized engineering comments on the characteristics of surficial deposits are made in Table 2.1.2-1.

Regional Geology

The arctic coastal plain is covered by ten to more than 150 feet of Quaternary unconsolidated deposits which overlie gently south-dipping, late Mesozoic sandstone, conglomerate, and siltstone. Extensive coal fields occur near the surface of the coastal plain and crop out at several points along the western coast.

Deeper in the subsurface, Paleozoic rocks that represent the buried extension of units seen in the Brooks Range and foothills, thin out and truncate against the Barrow Arch. Unconformities at the base of the Cretaceous sequence and other units, as well as many widespread fault systems, truncate progressively older rock units, northeastward. Each older unit, including the older pre-Mississippian basement rocks, terminate against one or another

TABLE 2.1.2-1

GENERALIZED ENGINEERING CHARACTERISTICS
OF SURFICIAL DEPOSITS

Qa - Sand and gravel - coarse-grained deposits
Qf   Good foundation material
Relatively easy to excavate
Generally well-drained
Source of sand and gravel for construction
Not frost susceptible

Qm - Mixed coarse- and fine-grained deposits - Till
Generally high in silt content, especially near surface
Generally poor foundation material, except where locally high in gravel and sand content
Poorly drained
High in ice content, especially in silts
Often becomes unstable if thawed; may cause differential settlement of foundations
Difficult to excavate
Frost susceptible

Qc - Sand - medium-grained deposits
Ae   Fair to good foundation material
Relatively easy to excavate
Generally well-drained
Source of sand for construction
Not seriously frost susceptible

Qe - Silt and Clay - fine-grained deposits
Ql   Generally poor foundation material
If thin, it can be removed or filled over prior to construction
Poorly drained
Unstable during earthquakes; may cause landslides along bluffs or differential settlement
High ice/water content
Will become unstable if thawed; may cause differential settlement of foundations
Generally poor fill material
Frost susceptible

\- Peat - organic surface material
Poor foundation material
Poorly drained
Commonly removed or filled over prior to construction
Contains high percentage of ice/water

TABLE 2.1.2-1 (Cont'd.)

GENERALIZED ENGINEERING CHARACTERISTICS
OF SURFICIAL DEPOSITS

- Bedrock
  Generally suitable for foundations
  Somewhat difficult to excavate
  Hard and resistant but commonly fractured
  Generally steep slopes in mountains make development difficult
  Can be quarried and crushed for construction material

of the conformities or faults. These conditions provide the impermeable stratigraphic traps atop the Barrow Arch where the oil and gas of the Prudhoe Bay field and other sites are found.

Large oil and gas resources in this section and in the Arctic Foothills section immediately to the south have not been fully evaluated, but estimates as high as 100 billion bbl. of oil for the entire North Slope have appeared. According to the American Petroleum Institute, recoverable reserves of the Prudhoe Bay field are 9.6 billion bbl. of oil and 26 trillion cubic feet of gas (summarized in The Alaska Scouting Service, March 31, 1971). Estimates of reserves made by Atlantic Richfield Company, BP Oil Corporation, and Humble Oil and Refining Company in annual reports and press releases since April 15, 1971, support these figures as field minima. Other estimates are higher. For example, T. R. Marshall, Jr., of the Alaska State Division of Oil and Gas (in Wilson, 1970, p. 115) placed the estimated reserves at 12-15 billion bbl. of oil and 10 trillion cubic feet of casing head gas (not including gas in caps over oil deposits), and Klemme (1971, p. 85) in a tabular summary of giant fields of the world estimated 20 billion bbl. of oil and 1.5 million bbl. of gas (equivalent to 9 trillion cubic feet).

Figure 2.1.2-1 illustrates the relationship of geologic events in time.

Deposits encountered along the proposed pipeline route between Prudhoe Bay and the Sagavanirktok River floodplain are extremely ice-rich silt and fine sand overlying frozen sand and gravel. The mantle of silt and fine sand generally ranges from five to 15 feet in thickness, and the underlying sand and gravel unit exceeds several hundred feet in thickness at the north end of this segment but thins to the south.

Rocky Mountain System

Topography and Physiography

Arctic Foothills

The Arctic Foothills consist of rolling plateaus and linear mountains; it is divided into two sections. The northern section rises from an altitude of 600 feet on the north to 1,200 feet on the south and has broad east-trending ridges, dominated locally by mesalike mountains. The southern section is 1,200-3,500 feet in altitude, has local relief of as much as 2,500 feet, and is characterized by irregular buttes, knobs, mesas, east-trending ridges, and intervening gently undulating tundra plains.

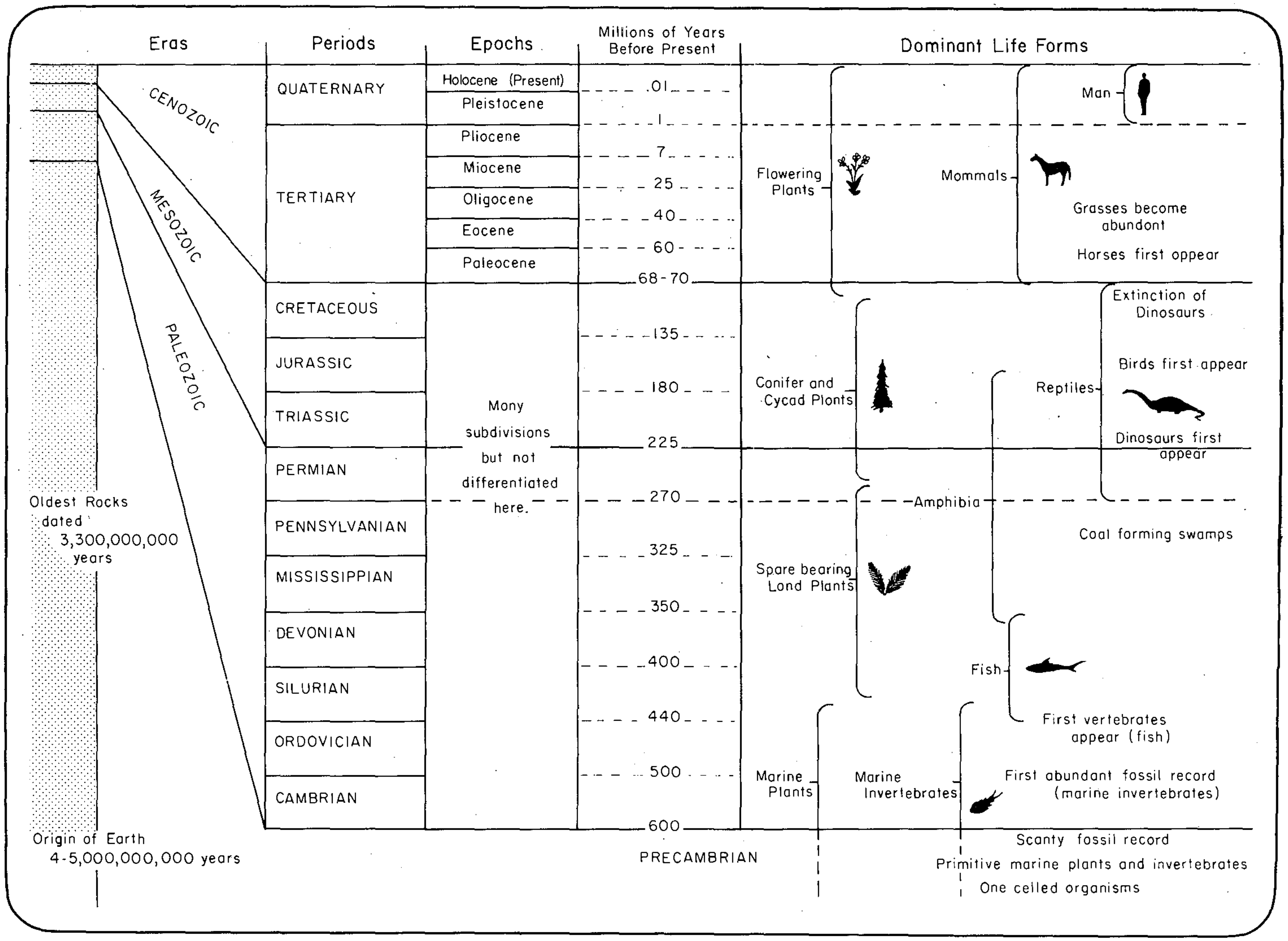


Figure 2.1.2-1 Geologic column

The Arctic Foothills are crossed by rivers flowing north from sources in the Brooks Range. Most streams have swift, braided courses across broad gravel flats that are locally covered in winter with extensive sheets of aufeis that freeze to the riverbeds; this filling of the channels causes the streams to flood their gravel flats. A few thaw lakes are present in the river valleys and on some divides. The upper valleys of major rivers from the Brooks Range contain many morainal lakes.

There are no glaciers. The entire province is underlain by continuous permafrost. Ice wedges, stone stripes, polygonal ground, and other features of a frost climate are common.

Brooks Range

The Brooks Range is a wilderness of rugged glaciated east-trending ridges that rise to generally accordant summits 7,000-8,000 feet in altitude in the northern part and 4,000-6,000 feet in altitude in the southern part. The easterly grain of the topography is due to belts of hard and soft sedimentary and volcanic rocks. The mountains have cliff-and-bench slopes characteristic of glacially eroded bedded rocks. Abrupt mountain fronts face foothills and lowlands on the north.

The drainage divide between the Bering Sea and Arctic Ocean drainages is near the north edge of the range west of the proposed pipeline route and in the center of the range east of the proposed pipeline route. The major rivers flow north to the Arctic Ocean and south to the Yukon, Loyukuk, and Kobuk Rivers in flat-floored, glaciated valleys 1/2 to two miles wide; they have a broad dendritic pattern. Minor tributaries flow east and west parallel to the structure, superposing a trellised pattern on the dendritic pattern of the major drainage. Large, rock basin lakes lie at the mouths of several large glaciated valleys on the north and south sides of the range. However, the Brooks Range in general is characterized by a paucity of lakes for a glaciated area.

Ambler-Chandalar Ridge and Lowland

The Ambler-Chandalar Ridge and Lowland consists of one or two east-trending lines of lowlands and low passes three to 10 miles wide and 200-2,000 feet above sea level, bordered on the north by the abrupt front of the Brooks Range. Along the south side is a discontinuous line of rolling to rugged ridges, 25-75 miles long and five to 10 miles wide rising to 3,000-4,500 feet in altitude. Some of these ridges were intensely glaciated. Within the lowlands are east-trending ridges five to 10 miles long.

The western part of the section is drained by tributaries of the Kobuk River; the central part, by the Koyukuk River and its tributaries; and the eastern part, near the proposed pipeline route, by the Chandalar River. Most streams flow south out of the Brooks Range across both the lowlands and the ridges to lowlands farther south. The drainage was probably superposed but may have been disoriented later by glaciers. The Chandalar River flows east along the eastern part of the trough. Several large lakes fill glacier-carved rock basins in deep, narrow canyons across the southern ridge. Areas of ground and end moraines contain many ponds. The floodplains of the major streams have thaw lakes and oxbow lakes.

Geomorphic Features

Geomorphic features produced by permafrost in the Brooks Range and its foothills include ice wedge polygons, which were described previously, and the following features.

Frost Creep and Solifluction

Frost creep and solifluction are probably the most common forms of mass wasting in permafrost environments. Frost creep is a downslope movement of soil particles caused by frost heaving of the ground perpendicular to the slope, followed by vertical settling upon thawing. Solifluction is the slow downslope flow of soil due to permafrost preventing the absorption of surface water into the subsurface, causing the surface sediments to be water-saturated.

Frost creep and solifluction can occur on slopes as gentle as three degrees and often creates such forms as lobes, sheets, and terrace-like features.

Stone Nets, Garlands, and Stripes

Found in some parts of the Brooks Range, stone nets are soil structures with centers of clay, silt, and gravel and roughly circular or polygonal borders of coarse stones. When isolated they are known as stone rings. Their net-like arrangement may extend downward as much as two feet, and they have diameters from a few to more than 30 feet. Stone nets are found on flat or nearly flat ground. On slopes of moderate inclination (about five to 15 degrees) they will be drawn out downslope by solifluction into tongue-like or elliptical shapes known as stone garlands. On steeper slopes (five to 30 degrees) garlands give way to stone stripes, parallel stony and earthy bands.

Geology

Unconsolidated Deposits

Unconsolidated deposits are extensive in the northern foothills and cover most valleys in the southern foothills and mountains. Most of these deposits were laid down during the Pleistocene Epoch, though much is of recent origin.

Foothills Silt

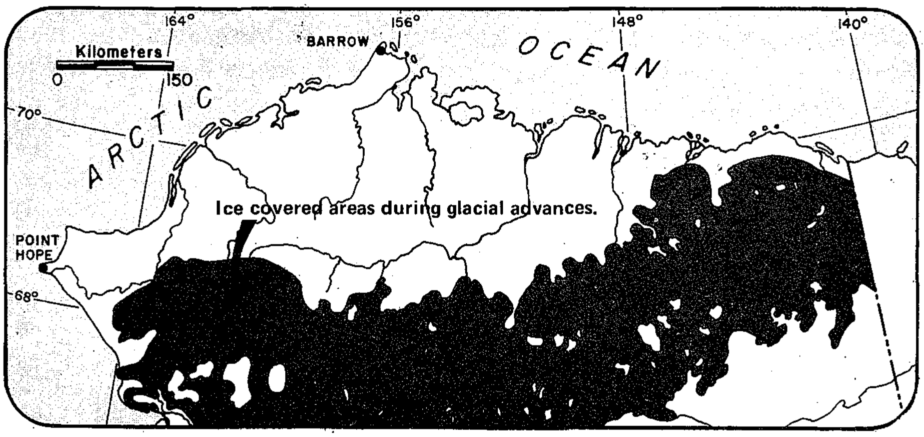
At the extreme northern edge of the foothills a silt belt forms a transitional zone between the rockier foothills to the south and the coastal plain to the north (Qe). O'Sullivan (1971) designated this gently north-sloping plain as the Foothills Silt Surface, which rises from an elevation of 100 to 200 feet at the northern boundary to about 400 to 600 feet in the south. The plain consists of a thick (50 to 170 feet) section of calcerous silts overlying alluvial deposits. O'Sullivan interpreted that the silt had been deposited during a Pleistocene marine transgression into part of the norther foothills. The advancing sea caused burial of the underlying alluvial sand and gravel.

Glacial Deposits

During the Pleistocene Epoch, when continental glaciers covered large parts of the North American continent, much of the Arctic Region remained ice-free. The Brooks Range, however, sustained a fairly extensive mountain glacier system. Figure 2.1.2-2 shows the area covering most of the Brooks Range and southern foothills that was glaciated at some time during the six major glacial advances. As the glaciers advanced and retreated, a complex interrelated series of deposits was produced by the interplay of three main agents--glacial ice, flowing water in streams or deltas, and still water in ponds and lakes (Qm).

The complex mixture of unsorted gravel, sand, silt, and clay transported and deposited by glaciers is called till. Till is usually deposited by glaciers as moraines, which are fairly regular, low, linear hills formed at the edges of glaciers. Ground moraine, a thin featureless blanket of till, may mantle extensive areas where melting glaciers have dropped debris in place. Today, morainal material may be found in most valleys and along the flanks of many mountains within the Brooks Range and southern foothills. In valley bottoms glacial material may often be mantled by more recent river-deposited gravels and sands.

Figure 2.1.2-2



Extent of Pleistocene glaciation in northern Alaska.

pre-glacial gravel-covered sediment surface is presernedon some divides between north-flowing rivers. Hummocky morainal ridges border most valleys issuing from the central Brooks Range.

Deposits of phosphate rock are known about 50 miles both east and west of the proposed pipeline. Subobituminous coal and lignite occur in isolated outcrops close to the Sagavanirktok and Ivishak Rivers near the northern boundary of the Arctic Foothills. Oil shale has been found in Mesozoic rocks in the southern part of the Arctic Foothills in deposits not known to be of sufficient size or thickness to be of current economic importance. Near the Colville River 70-90 miles west of the proposed pipeline route is the Umiat oil field (in Naval Petroleum Reserve Number 4) with an estimated reserve of 70 million bbls. of recoverable oil (Reed, 1958). Significant amounts of gas were discovered in one well at Umiat, but potential reserves have not been estimated. The field contains an estimated reserve of 22 billion cubic feet of recoverable gas (Reed, 1958). Gas has also been found about 50 miles east of the Sagavanirktok River, but the extent of the deposit has not been evaluated, and probably other unevaluated oil and gas resources also occur in this area.

The proposed pipeline route in this segment begins a few miles north of Sagwon near the confluence of the Sagavanirktok and Ivishak Rivers and ends about 70 miles to the south at the confluence of the Sagavanirktok and Atigum Rivers. Along most of this segment, the route is on either the active floodplain or low terraces of the Sagavanirktok River; however, at several places the route leaves the valley floor for short distances and crosses foothill terrain. The generally unvegetated, active floodplain is underlain by sand and gravel, and the bordering, vegetated low terraces are underlain by similar materials, but in addition are mantled by a few feet of silt and sand, which in many places is ice-rich. The foothills, bordering the valley floor, are generally mantled by thick silty soils over bedrock. These silty soils generally are extremely ice-rich.

The Brooks Range is comprised of high, rugged, east-trending ridges and mountains drained by numerous rivers. Intensive folding and thrust faulting have displaced the Paleozoic rocks many miles to the north over the Mesozoic sequences of the foothills.

The central range is underlain principally by a series of Paleozoic east-trending belts that include early Paleozoic rocks showing various degrees of metamorphism such as schist, quartzite, and limestone; Devonian sandstone, siltstone, shale, and slate; Silurian limestone and metamorphosed limestone and dolomite; Devonian to Mississippian sandstone and conglomerate; Mississippian shale and sandstone with small coal beds; Mississippian to Permian limestone, sandstone, shale, chert, and dark, igneous intrusive rocks; Permian shale, and shale, chert, and limestone that varies in age from Permian into Mesozoic. The major Mesozoic rocks are Jurassic to Cretaceous graywacke, chert, and dark, igneous intrusive rocks. Less important Mesozoic sequences include Cretaceous sandstone and conglomerate and several metamorphic units. Other intrusive bodies, composed of granite and diorite, are of uncertain age. Coal beds and oil shale are exposed along the northern mountain front and into the foothills. Phosphate rocks, interbedded with limestone, shale, and chert, also occur.

In the eastern Brooks Range many of the same rocks are represented, though the underlying basement metamorphic rocks have been exposed due to tertiary uplift and later erosion in the Romanzof Mountains. A large intrusive body of granite, emplaced in Cretacious or earlier time, is exposed near Mt. Michaelson. Exposed bedrock units in the eastern range include Devonian limestone, siltstone, sandstone, and metamorphic rocks including several types of schist, marble, and slate; Silurian limestone; Devonian to Mississippian sandstone and conglomerate; Mississippian shale, Mississippian to Permian limestone; Permian shale; Permian to Triassic shale and chert; late Paleozoic and Meszoic granitic igneous rocks; Triassic shale; Cretaceous shale; sandstone, and conglomerate; and scattered Mesozoic in front of the range, and phosphate rocks occur between the Canning and Okpilak Rivers.

The only mineral reources that have been developed near the proposed pipeline route through the Brooks Range are lode and placer mines of the Koyukuk mining district near Wiseman. Metalliferous lodes containing antimony, gold, silver, copper, lead, and manganese have been discovered, but the only production has been about five tons of antimony ore. Traces of sulfide minerals have been found in many parts of the mining district, but none have been investigated in more than a cursory fashion. Although gold-placer deposits have been mined in other parts of the Koyukuk mining district, more than 85 percent of the production has been from streams in a small area north of and within about 10 miles from Wiseman. Total probable production from the district has been 270,000-295,000 fine ounces of gold. Phosphate rock deposits have been found about 50 miles west of the proposed pipeline route.

Near the proposed pipeline route the bedrock is chiefly Paleozoic limestone, shale, quartzite, slate and schist. Northeast of the Sagavanirktok River the Paleozoic rocks are in faulted folds overturned to the north. Elsewhere, they are in giant plates or nappes thrust to the north. The deformation is of Late Mesozoic-Early Tertiary age. The north front of the range is made of light-colored cliff-forming Mississippian limestone. Rocks south of latitude 68°N. are metamorphosed and generally equivalent in age to those farther north.

The proposed pipeline route enters the Brooks Range at the confluence of the Atigun and Sagavanirktok Rivers. It follows the Atigun River upstream to the divide and is underlain by silt, sand, gravel, and locally, by bedrock. Some of the unconsolidated deposits are ice-rich, especially south of Galbraith Lake. Locally, the route skirts talus and landslide debris. In the divide, the route is underlain by talus and rubble mantling bedrock. Once through the divide, the route follows the upper reaches of the westernmost fork of the Chandalar River and is underlain by a veneer of generally frozen glacial silt, sand, and gravel over bedrock. Locally, these surficial deposits are ice-rich. The route leaves the Chandalar River valley about 10 miles south of the divide and enters the Deitrich River drainage and then the Middle Fork of the Koyukuk River drainage. It leaves the Brooks Range at Coldfoot.

The ridges of the Ambler-Chandalar ridge and lowland section are composed in part of resistant massive greenstone (metamorphosed basalt) of probably Mesozoic age. The lowlands are underlain largely by Cretaceous sedimentary rocks, folded into anticlines and synclines. Pleistocene glaciers from the Brooks Range extended across the lowland and through passes in the line of ridges.

The only lode mineral resources near the proposed pipeline route in the Ambler-Chandalar Ridge and Lowland are sparse copper mineral occurrences at two places in the drainage of the South Fork of Koyukuk River southeast of Coldfoot. A little nickel accompanies the copper at one of the localities. Placer gold has been recovered from bars and benches along the South and Middle Forks of the Koyukuk River and from deposits on a few tributaries of both streams. The total production has been probably less than 15,000 fine ounces of gold. Coal, probably bituminous in rank, has been reported from Tramway Bar on the Middle Fork of the Koyukuk River.

The proposed pipeline route enters the Ambler-Chandalar Ridge and Lowland at Coldfoot and leaves it at the South Fork of the Koyukuk River. This section of the route is underlain by unconsolidated deposits consisting of frozen glacial silt, sand, and gravel, colluvial silts, alluvium, and conglomeratic sandstone bedrock.

Intermontain Plateaus

Topography and Physiography

Kokrine-Hodzana Highlands

The Kokrine-Hodzana Highlands consist of even-topped rounded ridges rising to 2,000-4,000 feet in altitude surmounted by isolated areas of more rugged mountains. Valleys have alluviated floors to within a few miles of their heads.

The irregular drainage divide between the Yukon River and its large tributary, the Koyukuk River, passes through these highlands. Drainage to the Yukon is by way of the Hodzana, Tozitna, Melozitna, and Dall Rivers and by many shorter streams. Drainage to the Koyukuk is by the Kanuti River and the South Fork of the Koyukuk. There are a few thaw lakes in the lowland areas and a few lakes in north-facing cirques in the Kokrine Hills and the Ray Mountains.

Rampart Trough

The Rampart Trough is a structurally controlled depression having gently rolling topography 500-1,500 feet in altitude; it is incised 500-2,500 feet below highlands on either side.

The Yukon River enters the northeastern part of the trough through a narrow rocky gorge and swings in broad bends from one side of the trough to the other within a narrow floodplain. The Yukon and its tributaries appear to be superposed from a surface at least 1,500 feet in altitude. Scattered thaw lakes lie on the Yukon floodplain and elsewhere in the trough.

Yukon-Tanana Upland

The Yukon-Tanana Upland is the Alaskan equivalent of the Klondike Plateau in Yukon Territory. Rounded, even-topped ridges with gentle side slopes characterize this section of broad undulating divides and flat-topped spurs. In the western part, near the proposed pipeline route, these rounded ridges trend northeast to east; they have ridge-crest altitudes of 1,500-3,000 feet and rise 500-1,500 feet above adjacent valley floors. The ridges are surmounted by compact rugged mountains 4,000-5,000 feet in altitude. Valleys in the western part are generally flat, alluvium floored, and 1/4 to 1/2 mile wide to within a few miles of headwaters.

The entire section is in the Yukon drainage basin. Streams flow south to the Tanana River and north to the Yukon River. Most streams in the western part follow courses parallel to the structural trends of bedrock, and several streams have sharp bends involving reversal of direction around the ends of ridges of hard rock. Drainage divides are very irregular. Small streams tend to migrate laterally southward. The few lakes in this section are mainly thaw lakes in valley floors and low passes.

Tanana-Kuskokwin Lowland

The Tanana-Kuskokwin Lowland is a broad depression bordering the Alaska Range on the north; its surfaces are of diversified origin. Coalescing outwash fans from the Alaska Range slope 20-50 feet per mile northward to floodplains along the axial streams of the lowland. Rivers from the range flow for a few miles at the heads of the fans in broad terraced valleys 50-200 feet deep. Semi-circular belts of morainal topography lie on the upper ends of some fans. Thaw lakes abound in areas of fine alluvium, and thaw sinks are abundant in areas of thick loess cover.

The Tanana Valley decreases in width from about 50 miles near Fairbanks to 25 miles near Delta Junction to one mile at Cathedral Bluffs, and then increases to a maximum width of 30 miles near the confluence of the Nebesna River. Average width is about 10 miles. The valley floor is flat to rolling with steep scarps separating terraces of the Tanana River and its tributaries. Elevations increase from about 400 feet at Fairbanks to 1,200 feet at Delta Junction to slightly over 2,000 feet at the Canadian Border. Foothills of the Alaska Range which reach altitudes of 8,000 feet lie along the southern margin of the valley where its unglaciated rolling hills are generally less than 2,000 feet above the valley floor.

The land area of the Tanana Valley, which lies almost entirely south of the Tanana River, comprises mostly well-drained outwash fans up to Tetlin Junction. Eight large streams cross the valley, however, along the corridor between Fairbanks and Tetlin Junction where the Tanana River itself extends diagonally across the valley necessitating a river crossing. Southeast of Tetlin Junction to the Canadian border the valley is poorly drained lowland with numerous lakes and muskegs, crossed by four large streams. Here the better drained land is more restricted, being confined to a narrow swath between the Tanana River together with its headwater streams and the Yukon-Tanana Upland.

Geomorphic Features

Geomorphic features in the Intermontaine Plateaus caused by permafrost include thermokarst topography, thaw lakes, ice wedge polygons, beaded streams, frost mounds, and frost creep and solifluction features, all described earlier.

Solifluction Features

The elevation of well-developed solifluction features in central Alaska increases from west to east. Near Nulato they occur predominantly near 1,300 feet (400 m) elevation; near Fairbanks they are near 3,000 feet (900 m) elevation; and farther east near Eagle they occur at nearly 4,000 feet (1,200 m) elevation.

Pingos - Open System

Pingos, common to certain areas of Interior Alaska, exist as open-system pingos, which are characteristic of the discontinuous permafrost zone. Open system pingos form when subpermafrost or intrapermafrost water penetrates the permafrost layer under hydrostatic pressure. A large water-ice lens forms below the tundra that heaves up into a mound from a combination of freezing pressure and hydrostatic pressure. They generally lie near the base of slopes, where water is apparently able to enter the subsurface system from the nonpermanently frozen areas upslope. Almost all open-system pingos are filled valleys, and are composed of a variety of surficial materials, primarily silty colluvium and valley-fill material. None have been found on glacial drift. They nearly all lie in areas that have been unglaciated for at least 25,000 years.

Individual pingos vary widely in age, but all are more than 10 years old. Extinct pingos, or pingos that have collapsed and are marked today by a ring of sediment, are also found in central Alaska.

Open-system pingos may pass through several stages which include (1) low domes supporting vegetation and covered with soil similar to that of the surrounding area, (2) domes of low to medium height (10 to about 40 feet) covered with vegetation reflecting improved drainage conditions, (3) domes of moderate height having more mature forests, trenches, scarps, steps, craters, ponds, springs, and slightly developed forest soil profiles, (4) collapsed domes having large central depressions or ponds, disrupted vegetation, and low crater rims of tilted and disturbed surficial material, and (5) collapsed domes having second- or third-generation pingos forming on their flanks.

Nearly 300 pingos or pingo-like mounds have been located in central Alaska, between the Alaska and Brooks Ranges, in the forested discontinuous permafrost zone. In some cases they are as dense as 10 per 100 square miles.

Open-system pingos have definite, although limited, practical value. Crater ponds and springs, which flow even in very cold winters, are direct sources of water and should be good indicators of ground water at moderate depths. Some steep-sided pingos having ground ice at shallow depths could be tunneled and used as semipermanent cold storage facilities, a technique employed in northwestern Alaska (Porsild, 1938). To the engineer, presence of pingos would indicate very poor foundation conditions for buildings, roads, towers, or other permanent structures.

Figure 2.1.2-3 shows the distribution of open and closed system pingos in relation to permafrost systems and areas.

Geology

Unconsolidated Deposits

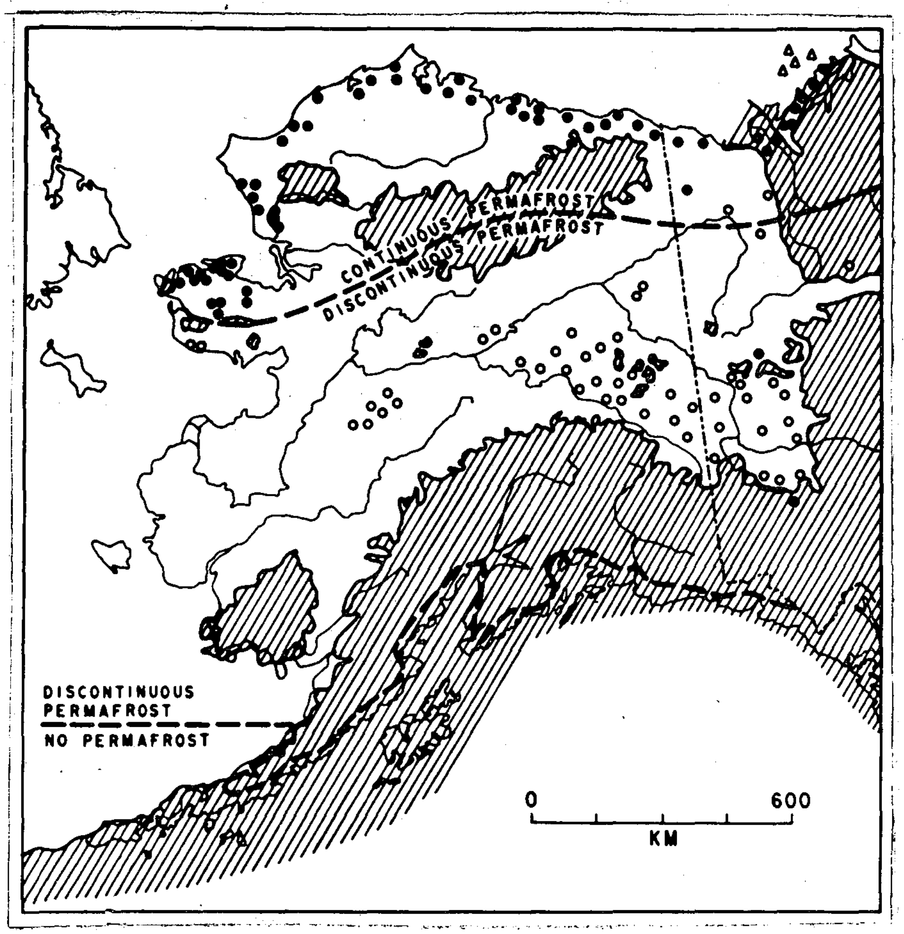
In the Intermontaine Plateaus unconsolidated deposits cover a major portion of the terrain, but are concentrated in the river valleys and lowlands. Most of these deposits are Pleistocene in age, but much is Recent.

Glacial Deposits

During the Pleistocene Epoch, mountain glaciers advanced several times in the Brooks Range and Alaska Range and their foothills, and existed at times in the Kokrines Hills, Ray Mountains, and Yukon-Tanana upland. Each period saw a different degree advance, but during the period of maximum extent, ice covered practially all of the Brooks and Alaska Ranges and their foothills (Figure 2.1.2-3). As the glaciers advanced and retreated, a complex series of deposits was produced (Qm).

The complex mixture of unsorted gravel, sand, silt, and clay transported and deposited by glaciers is called till. Till is usually deposited by glaciers as moraines, which are fairly regular, low, linear hills formed at the edges of glaciers. Ground moraine, a thin featureless blanket of till, often mantles extensive areas where melting glaciers have dropped debris in place.

Figure 2.1.2-3



Distribution of open and closed system pingos in relation to permafrost zones and areas covered by late Wisconsinan glacial ice in North America.

LEGEND

- Limit of Wisconsin glacial age
- ● Areas of closed system pingos
- o Areas of open system pingos
- △ Submarine pingos
- —— Permafrost zone boundaries

Today, morainal material may be found throughout the Brooks Range and its foothills as far south as the margin of Kanuti Flats, in the Kokrines Hills and Yukon-Tanana upland, and throughout the Alaska Range and its foothills as far north as the vicinity of Big Delta. In valley bottoms glacial material is often mantled or reworked by more recent river-deposited gravels and sands.

Alluvial Deposits

Sediment-laden meltwater streams that flowed within, adjacent to, and in front of glaciers during Pleistocene and Recent time deposited stratified sand and gravel in floodplains and deltas (Qw). These alluvial deposits, as well as modern deposits, may be good sources of gravel and sand for construction materials since they are sorted to varying degrees just like modern alluvial deposits.

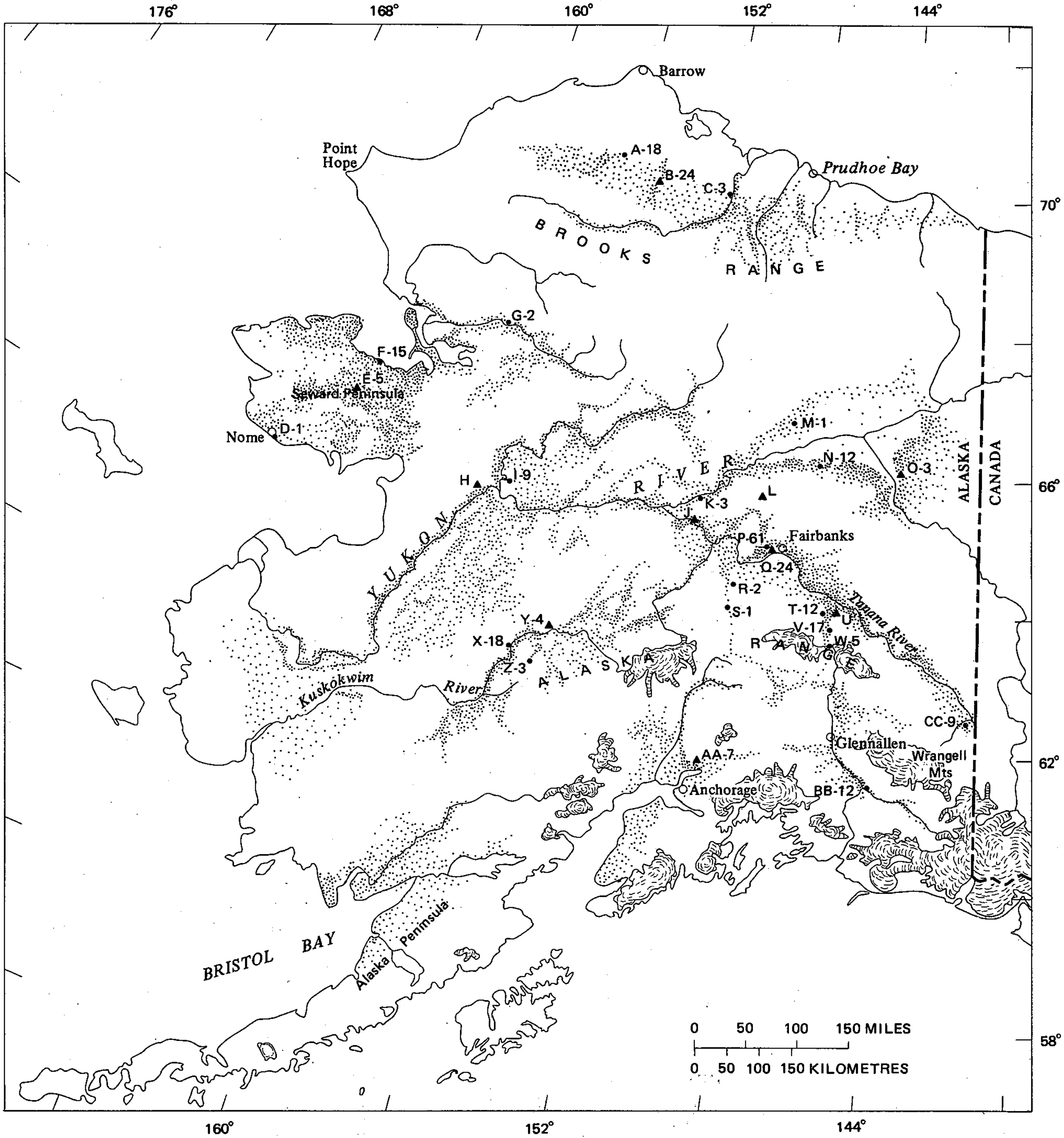
Principal areas of deposition include extensive alluvium and alluvial terraces in the valleys and surroundings of the Yukon River,Koyukuk River, and Tanana River (Qf). Important alluvial basins include the Yukon Flats, with as much as 100 feet (30 m) of alluvial deposits overlying 300 feet (90 m) of lacustrine sediments; the Koyukuk Flats, containing thicknesses of as much as 415 feet (125 m) of alluvium; and the Tanana River valley, with up to 590 feet (180 m) of deposits. Less extensive but still important areas occur in all significant tributaries of these rivers. Large alluvial fans occur in the upper Yukon Flats and along the northern margin of the Alaska Range, especially between the Kantishna and Gerstle Rivers, and at the Tok River.

Loess Deposits

Deposits of windblown sand and silt mantle portions of the low-lying areas of the Intermontain Plateaus, ranging in thickness from a few inches to several tens of feet (Qe). They are primarily of Pleistocene age, though a few deposits are Recent. The more widespread accumulations are of loess (Figure 2.1.2-4).

Loess was blown from the vegetation-free floodplains of braided glacial streams, and is thickest near streams that drained glaciated areas. Loess is now being deposited more rapidly near modern outwash streams. It has been deposited on ridges as high as 2,500 feet (760 m) above sea level, but most of it was apparently laid down at altitudes lower than 1,500 feet (450 m). Much loess that was deposited at higher elevations has been washed down into valley bottoms to form thick deposits of bedded to massive silt rich in organic debris (Pewe 1975).

Figure 2.1.2-4



Loess deposits of Alaska (Adapted from Pewe, 1975)

Alaska loess is generally massive and often forms cliffs containing swallow nesting tunnels. The thickest loess deposit known in Alaska is north of the Tanana River near Fairbanks, where a blanket 200 feet (61 m) covers the top of Gold Hill. Deposits as much as 10 to 40 feet (3 to 12 m) thick occur along the north side of the Tanana Valley and on both sides and the middle of the lower Yukon valley. Loess is thick adjacent to the Yukon Flats, and is extensive south of Hughes east of the Koyukuk River.

Stabilized, vegetated sand dunes of Pleistocene age are widespread in the Intermontane Plateaus. Most of the dunes occur on the northwest end of the Koyukuk Flats; north of the Yukon River in the Yukon Flats; along the south side of the Tanana River from west of Nenana to the Cosna River; south of the Yukon-Tanana confluence from the Chitianana River to the Nowitna River; and southeast of Northway Junction (Figure 2.1.2-5).

Regional Geology

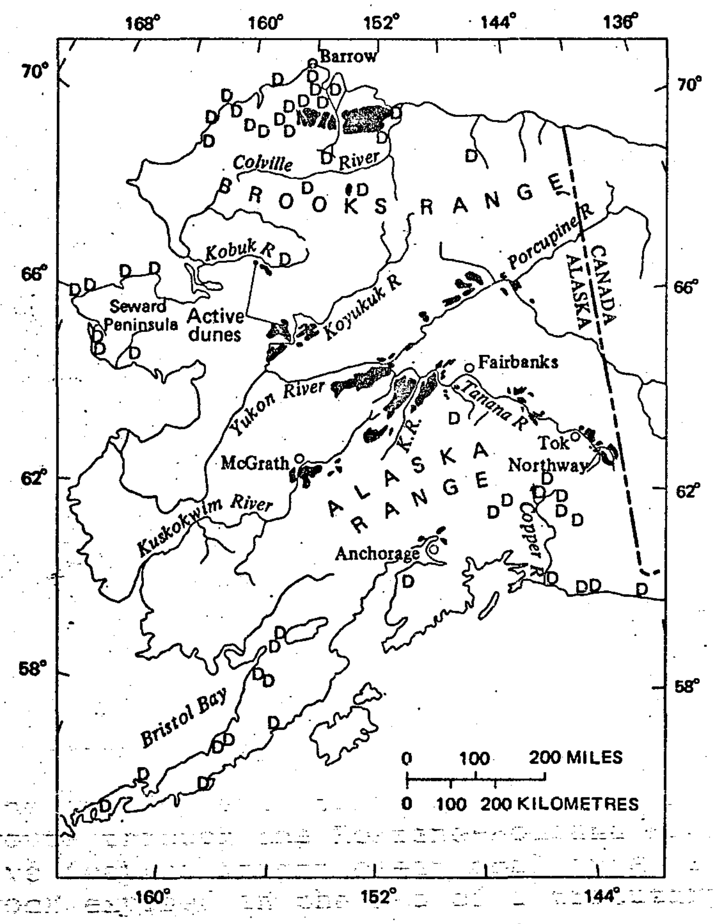
The Kokrine-Hodzana highlands are underlain chiefly by Paleozoic and Precambrian schist and gneiss having a northeast-trending structural grain, cut by several granitic intrusions, the largest of which is the granite batholith that upholds the Ray Mountains.

The only mineral resource known near the proposed pipeline route through the Kokrine-Hodzana Highlands is four to five feet of bright clean coal in an 11-foot-thick layer of rock exposed in the bed of a tributary of the Dall River.

This segment of the proposed pipeline route begins at the South Fork of the Koyukuk River and ends north of Hess Creek. The Yukon River, the largest stream that the proposed pipeline route will cross, is in the Kokrine-Hodzana Highlands physiographic unit. The route is underlain by unconsolidated deposits consisting of frozen colluvial silts, sands, and rock fragments, glacial sand and gravel, reworked windblown silts, lake sediments, and stream gabbro, diabase, basalt, chert, and schist.

The Rampart Trough was eroded along a tightly folded belt of soft continental coal-bearing rocks of Tertiary age. Hard rock hills and the surrounding uplands are partly metamorphosed sedimentary and volcanic rocks of the Mississippian age that strike about N60°E and are cut by granitic intrusions.

Figure 2.1.2-5



Major sand dune areas of Alaska (From Pewe, 1975)

The only mineral resource known in the Rampart Trough near the proposed pipeline route is bituminous coal in thin beds. Before 1902, at least 1,000 tons was mined from the Drew mine, across the Yukon River from the mouth of Hess Creek.

The proposed pipeline route enters the Rampart Trough unit north of Hess, crosses the creek north of its confluence with Erickson Creek, and leaves the Rampart Trough unit a few miles south of Hess Creek.

This segment of the pipeline is underlain by frozen colluvial silts, sand, and rock fragments, stream gravel, and ice-rick reworked windblown silt. The route crosses over a small bedrock area underlain by exrusive and intrusive volcanic and sedimentary rocks.

In the Yukon-Tanana upland, a belt of highly deformed Paleozoic sedimentary and volcanic rocks containing conspicuous limestone units, overthrust and overturned to the north, extends along the north side of the upland. The rest of the upland is chiefly Precambrian schist and gneiss but has scattered small elliptical granitic intrusions in the northwestern part; large irregular batholiths make up much of the southeastern part. In the western part a thick mantle of windborne silt lies on the lower slopes of hills, and thick accumulations of much overlie deep stream gravels in the valleys. Pingos are common in valleys and on lower hill slopes.

The proposed pipeline route in the Yukon-Tanana Upland passes through the economically most important part of the Fairbanks mining district and very close to Livengood, the major center of mining activity in the Tolovana mining district. About 150 lode mines and prospects in the Fairbanks district have been the source of more than 250,000 fine ounces of gold and silver, 2,500-3,000 tons of antimony ore, and several thousand units of tungsten ore. Minor amounts of copper, lead, zinc, bismuth, and chromium minerals are known in the district. The Fairbanks district has been the leading source of placer gold in Alaska; total production has been well over 7.5 million fine ounces, which is a little more than 37 percent of the total for the State. Deposits of limestone near Fox and clay near Harding Lake have been investigated. The proposed pipeline route crosses several unmined areas that may contain recoverable placer gold, and extensive fields of old dredge tailings.

Lodes near Livengood contain gold, silver, antimony, mercury, chromium, nickel, and iron, but the only production has been a little antimony ore and mercury. Placers in the same area have been the source of probably as much as 200,000 fine ounces of gold. Monazite and a uranium-rare earth mineral have been identified in placer concentrates.

The proposed pipeline route enters the Yukon-Tanana Uplands south of Hess Creek and leaves it at Shaw Creek Flats. The route is underlain by reworked windblown silt, colluvial silt, sand and rock fragments, alluvial silt, sand, and gravel, and dune sand. Locally, the unconsolidated deposits are absent or occur as a thin veneer over bedrock which consists chiefly of schist, dolomite, limestone, granite, and volcanic rocks.

In the Tanana-Kuskokwin Lowlands, the outwash fans grade from coarse gravel near the Alaska Range to sand and silt along the axial streams. Areas north of the axial streams are underlain by thick deposits of "muck," a mixture of frozen organic matter and silt. Parts of the southwestern part of the lowland have thick loess cover, but the central and eastern parts are free of loess south of the Tanana River. Scattered low hills of granite, ultramafic rocks, and Precambrian schist rise above the outwash. Tertiary conglomerate in the foothills of the Alaska Range plunges beneath the lowland in a monocline, and the heads of the outwash fans may rest on a pediment cut across the conglomerate. The base of the alluvial fill near Fairbanks is at or below sea level. No significant mineral resources, other than construction materials, have been reported from this area.

This segment of the proposed pipeline route begins at Shaw Creek and ends at the Canadian border. Geological units to be traversed include frozen ice-rich silts over alluvial gravels from Shaw Creek across the Shaw Creek Flats, frozen silt (loess) over bedrock (schist) from the southern end of Shaw Creek Flats to the Tanana River, and generally thawed gravels and sands of alluvial origin in the Tanana River Valley to the border.

The Tanana Valley is underlain primarily by unconsolidated sediments probably several hundred feet thick; the maximum recorded thickness is 200 feet adjacent to the Canadian Border. The most extensive unconsolidated materials are broad alluvial fans of sand and gravel. Overlying parts of these fans are moraines composed of coarse to fine-grained soils. Finer grained deposits, primarily poorly drained silt high in organic material and peat, occur adjacent to the floodplain, and in the lowlands southeast of Tetlin Junction. These materials are generally soft and wet during the summer and they are firmly frozen during the winter. Larger but discontinuous deposits of sand and gravel are available from the river bars, which are innundated during the spring. Most of the surficial materials are covered by loess.

2.1.3 Soils

General

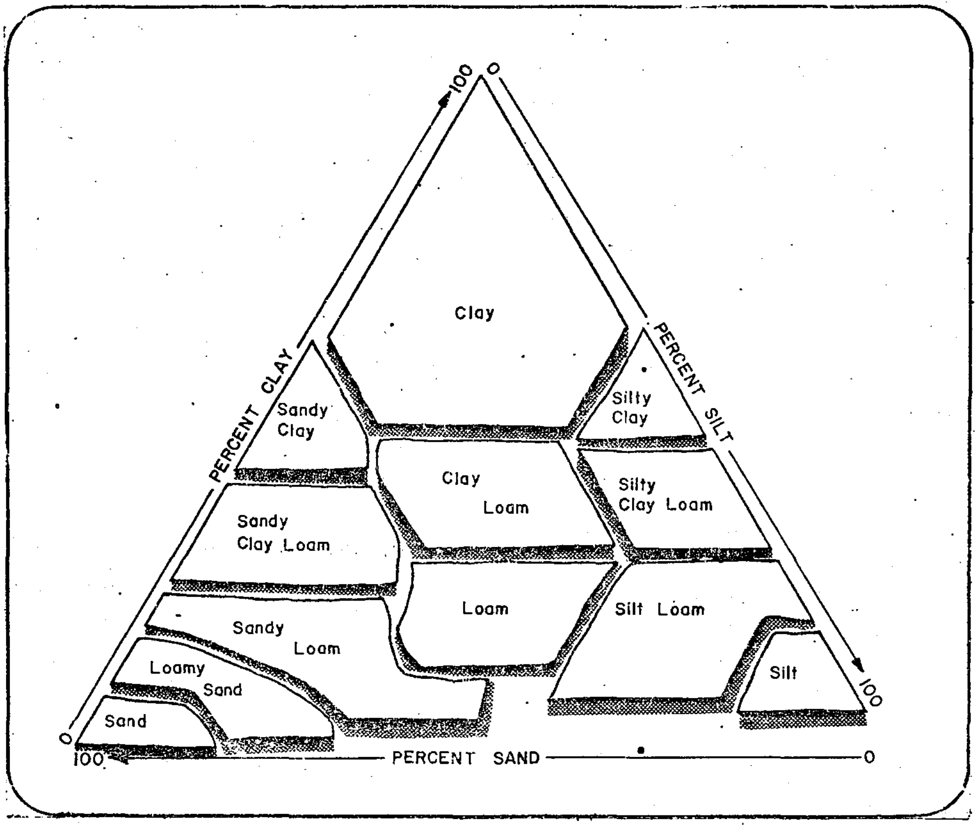
Soil is continuous over the land surface except for the steep, rugged mountain peaks and areas of perpetual ice and snow. Topography and drainage influence soil development by affecting soil moisture, soil temperature, and soil stability. Sheer, mountainous areas preclude any soil development due to excessive slope. Knolls, ridges, and steep slopes are the driest sites on the landscape since some rainfall runs off and less water is available for plant growth; hence, soils are shallow and low in organic matter. On the more gently sloping lands, more water enters the soil resulting in higher moisture and better plant growth. The lowlands frequently receive so much surface water that if the soils are poorly drained, muskeg and swamp areas form. Permafrost impedes internal drainage of the soil profile and arctic soils are considered immature. Tundra and bog soils are common and widespread. A detailed soils map is included on page 9 of volume 1A.

Soil texture refers to the relative proportions of different sized particles--sand, silt, and clay--in a mass of soil. Soil that contains 70 percent silt, 20 percent sand, and 10 percent clay is called silt loam, a textural class of soil materials containing relatively high proportions of silt-sized particles. The basic textural classes of soil materials and their content of sand, silt, and lay particles are given in Figure 2.1.3-1.

The terms soil structure describes the arrangement of soil particles into larger aggregates or clods. Soil structure is important since it affects soil permeability to water, water retention, aeration, soil tilth, the penetration of plant roots, the ability to supply nutrients to plants, and the resistance of the soil to erosion.

Undisturbed soils are generally protected from erosion by natural vegetation. When vegetation is disturbed or removed, wind and water may erode the soils. The frozen status of soil and the blanket of snow cover present during winter are effective in preventing erosion. During summer thaw, the vegetative mat acts as an effective barrier to erosion if undisturbed by animals or man.

Figure 2.1.3-1



Texture triangle showing the percentage of sand, silt, and clay in each of the textural classes.

Brown et al. (1969) described the results of research of the detrimental effects of disturbing the surface cover over ice-rich soils. He determined that such disturbances as removal, tearing, or compression of the surface mat cause melting and subsidence of the frozen soil, sometimes irreversibly. Any disturbance which eliminates or greatly reduces plant growth will result in increased thaw. If the vegetative cover is damaged and mineral soil exposed, erosion will follow.

Soil erosion in tractor trails for several areas in the Arctic has been well illustrated by Hok (1969). He observed that the use of heavy vehicles, particularly caterpillar-type tractors, often markedly disturbed the tundra surface. The nature and extent of these changes depended upon (1) the season (frozen versus thawed ground) during which the disturbance took place, (2) the degree to which surface material had been bladed aside, (3) substrate water content (ice-rich versus well-drained), and (4) the degree of slope. The season of occurrence proved the most critical in determining these changes. Tests to determine which vehicles caused a minimum of surface disturbance showed that track types frequently disturbed natural ground cover the most (Burt (1970 and Muskey Research Institute 1970).

Interior Plains

Arctic Coastal Plain

The Coastal Plain region of the Arctic includes low terraces and floodplains of streams draining the north slope of the mountains. Materials underlying the soils consist of water-deposited sands and silts from these streams, interstratified with marine sediments in the coastal area. Extensive windblown sand deposits and low dunes occur along streams between theMeade and Colville Rivers. In places, peaty materials have been buried by more recent deposits and can be observed with excavation. Generally, soils of the plain are poorly drained, thawing to not more than 18 inches in summer, with loamy textures common to terraces and floodplains and organic soils occurring in depressions. Overall susceptibility to erosion is moderate, although streambank and shoreline erosion on ponds, coastal lakes, and along coastal shorelines is extensive, particularly in early summer.

The major soil types along the proposed gas pipeline route are:

Saturated silts, with thicknesses to 10 feet covering sand and gravel;

Sand and gravel, covered by 2 feet of organic-rich, moist silt (e.g. river terraces of the Sagavanirktok River);

Saturated organic-rich silt, 5 to 10 feet thick, covering loose sand and gravel.

Rocky Mountain System

Arctic Foothills

The Foothills Province has a rolling topography with broad drainages in the uplands that levels out to a gentle plain extending across the region. The soils are formed from a variety of parent materials, ranging from very gravelly deposits on ridges and upper slopes to medium- and fine-grained materials in lower areas. In many places at lower elevations, these materials are mantled with windblown silts.

The dominant soils of the foothills are poorly drained and form in silty and clayey materials. These soils generally occur on long foot slopes and in broad valleys. A few well-drained, very gravelly soils have dark upper layers that are nonacid or only slightly acid. Peat soils occur in valley bottoms and sandy soils occur in isolated dunes bordering major streams.

Permafrost of the Foothills Province is generally shallow with many ice features on the surface. Many of the tractor trails across the tundra in the Colville River area are deeply gullied on low to moderate slopes, indicating a high degree of soil erodability when the vegetative cover is removed. Limitations on all uses of these soils are severe. The high erosion potential of the area is supported in reports by Brown et al. (1969), Furbush and Summerfield (1970), Hok (1960), and Lewellen and Brown (1970).

The major soils types along the proposed gas pipeline route are:

Loose, colluvial silts with some gravel and sand to a depth of 15 feet overlying bedrock;

Glacial moraine composed of loose, non-sorted silts; sands and gravels;

Loose to moderately compact alluvial sands and gravels of the Sagavanirktok River veneered with loose silts on low river terraces.

Brooks Range

The Brooks Range consists mainly of very steep, exposed bedrock and coarse rubble with small inclusions of shallow, very gravelly and stony soils in alpine valleys and less sloping areas. The eastern Brooks Range, particularly the Phillip Smith, Franklin, and Romanzoff Mountains, are more rugged and have fewer inclusions of soils than the western portion. Gravelly glacial till is found in the big valleys with outwash deposits extending down into the foothills along drainages. Vegetative cover is sparse and limited throughout this province, and essentialy no vascular vegetation occurs above elevations of 3,000 feet.

The proposed pipeline route follows the Atigun River valley to the continental divide and then descends to the Chandalar River valley via the valleys of the Dietrich River and the Middle Fork of the Koyukuk River. This portion of the route has soils which are of coarse textured alluvial and colluvial fan and mud flow deposits. The alluvial terraces of these rivers are mainly composed of sand and gravel with a veneer of silt. Locally the route traverses coarse textured glacial ice-contact deposits. Major soil types are:

Dense sand and gravel often silty in the form of colluvial and alluvial fans;

Dense sand and gravel with a veneer of loose, wet silt - alluvial terrace deposits;

Dense, coarse, sub-angular sand and gravel with some silt - glacial ice-contact deposits on valley sides.

Ambler-Chandalar Ridge and Lowland

The proposed pipeline route in this region crosses two east-west trending ridges via low passes separated by the lowland of the Wilson Creek and the South Fork of the Koyukuk River. Hill slopes have a mantle of colluvial silts with some gravel. The intervening lowland is underlain by glacial sands and gravel veneered with silts. Major soil types are:

Colluvial silts (ice-rich or wet) with angular gravel over bedrock;

Sands and gravels overlain by up to 10 feet of loose, wet silts which may be ice-rich.

Intermontane Plateaus

Kakrine-Hodzana Highlands

Soils in this region are predominantly colluvial silts deposited on an east-west trend over rounded ridges of metamorphic and granitic rocks. The colluvial cover seldom exceeds 20 feet, except in the major valleys. The cover becomes thinner at higher elevations where bedrock is exposed. Major valleys and the broader basins between ridges are in places underlain by alluvial sands and gravels which are often covered by organic-rich silts. Major soil types are:

Colluvial silts, ice-rich in places with some sand and gravel of variable thickness over bedrock;

Dense alluvial sands and gravel on floodplains and river terraces;

Moderately dense, organic-rich silts up to 14 feet thick over moderately dense gravel with some sand.

Rampart Trough

The Rampart Trough is a structurally controlled depression with gently rolling topography incised 500-2,500 feet below highlands on either side. The proposed route traverses this region at Hess Creek valley.

The floodplain of Hess Creek contains silt to a depth of approximately 17 feet over gravel and sand. The adjacent hill slopes are mantled with colluvial silts. Major soil types are:

Silt to a depth of 17 feet over gravel and sand;

Sandy silt with some gravel over weathered bedrock.

Yukon-Tanana Upland

The Yukon-Tanana Upland is characterized by broad undulating divides and flat-topped spurs; the ridges have crest altitudes of 1,500 to 3,000 feet and rise 500 to 1,500 feet above adjacent valley floors. The ridges and valley sides have a mantle of colluvial and wind-blown (loess) silts. The major valleys are floored with alluvial sands and gravels which commonly have a thick covering of organic silts. On the steepened hill slopes and ridge crests, the colluvium is shallow, generally less than 4 feet thick. Major soil types are:

Loose-to-dense colluvium with windblown silts;

Wet organic silts predominantly in low-lying areas;

Dense sand and gravel alluvium (e.g., floodplains of the Salcha River and in the vicinity of Ross Creek).

Tanana-Kuskokwim Lowland

The Tanana-Kuskokwim Lowland comprises a broad depression bordering the Alaska Range on the north. Wet loams with thick overlying peat and perma-frost occupy lowland areas along rivers. Other poorly drained soils occupy lower slopes adjacent to valley bottoms in the Tanana Valley. Their texture becomes more gravelly at higher elevations. Well-drained brown, loamy soils overlying gravelly-to-sandy materials occupy terraces, outwash plains, and low hills in the Tanana Valley near the Kantishna and Nenana Rivers, and occur in association with sandy soils of dune areas along the Kantishna. These brown loams also form in the upper valley from the Delta River to Tok in association with wet soils of lower slopes.

The erosion potential is high in many of these areas. A layer of volcanic ash two to six inches thick is found in profiles of the Northway Junction area--deposited about 14,000 years ago by an eruption within either the Wrangell Mountains or St. Elias Mountains.

Well-drained brown silty loams occupy a mantle of windblown loess on rolling-to-steep uplands bordering the Tanana lowlands from north of Cathedral Rapids to Minto Flats, and are associated with poorly drained silts as previously described. Loess deposits on low hills near the Tanana River may be 200 feet thick with an excess of 300 feet of accumulation at lower ends of some tributary valleys to the Tanana River (Rieger, Dement, Sanders 1963). Such deposits become thinner with increasing elevation and distance from floodplains. Erosion potential is considerable on these soils.

Along the proposed Alcan pipeline route, moderately deep and well-drained brown upland soils are most extensive. These are deep and loamy textured in the Fairbanks and Birch-Harding Lakes area, occupying moderate slopes of the highlands. Gravelly to sandy brown soils occupy moderate to steep slopes along the upper Tanana Valley from Big Delta to the boundary, and are shallow to moderately deep over gravelly parent material and bedrock.

Stratified sandy alluvial soils occupy river terraces along the Tanana River from Fairbanks to the Birch Lake areas. Wet, loamy soils with a thick overlying peat layer occupy low areas along drainages, extending to low gravelly slopes of the uplands along the upper Tanana. The major soil types are:

Moderately dense to dense silts over dense sand, locally overlain by thin (5 feet) organic-rich silt;

Loose, wet, organic-rich silt to 10 feet, over sand and gravel;

Dense alluvial sand and gravel (e.g. floodplains and terraces of the Tannana and Delta Rivers).

2.1.4 Geological Hazards

Permafrost and Erosion

Permafrost

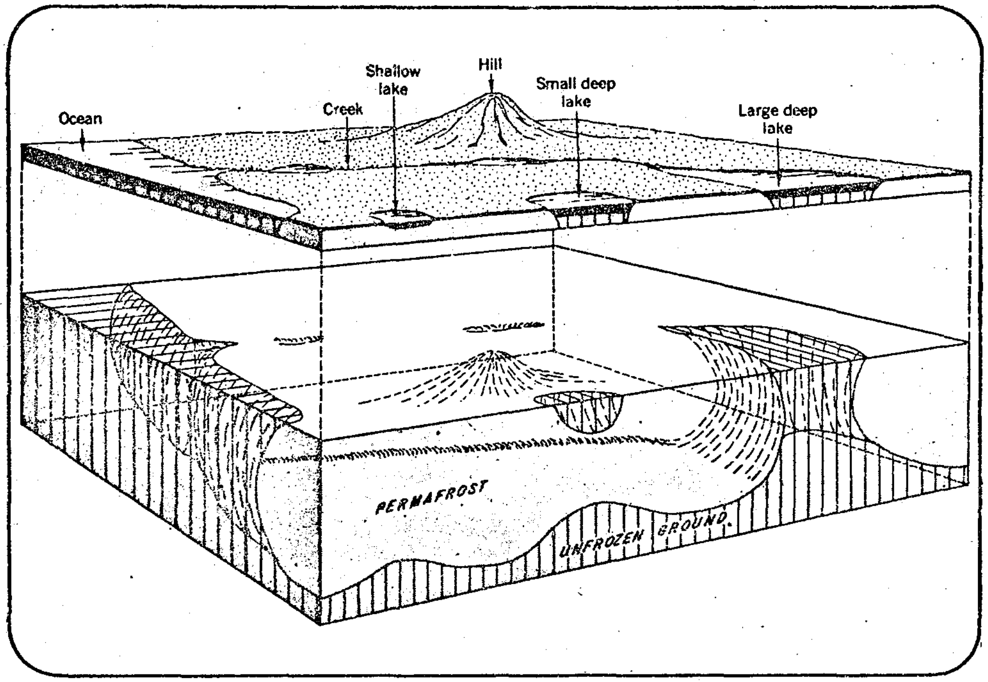
Permafrost is any earth material, such as soil or bedrock, that has remained below 32 degrees F (0 degrees C) at least from one winter through the next. This is the minimum duration of permafrost; much has been in existence for tens of thousands of years. A permafrost map is included on page 7, Volume 1A.

Permanently frozen ground prevails throughout most of Alaska, ranging from less than a foot in depth at the southern margin to 2,000 feet at Prudhoe Bay. Local variations in thickness, areal extent, and permafrost temperature depend on differing thermal properties of earth materials and on local differences in climate, topography, vegetation, geology, hydrology, glacial history, and rate of heat flow within the earth. In many places these local variations mask the regional southward decrease in areal extent and thickness and southward increase in permafrost temperatures. Areas around large water bodies and thermal springs are generally free of permafrost because of increased amounts of heat flow in the ground. The shape of the permafrost and subpermafrost tables reflect the presence of these features and largescale surface topography (Figure 2.1.4-1).

The permafrost table is the upper boundary of permanently frozen ground. The area above it is called the suprapermafrost layer. The active layer is that part of the suprapermafrost zone that freezes in winter and thaws in summer. The thickness of the action layer depends upon the capacity of the surface material to protect the underlying permafrost from summer heat. The thickness can vary locally from 1/2 foot to five or more feet and can change dramatically when the surface is disturbed.

When winter freezing does not extend down to the permafrost table, an unfrozen layer remains between the permafrost and the frozen active layer. Such unfrozen ground surrounded by frozen ground is known as talik (Figure 2.1.4-2). Groundwater trapped in taliks may be stored under great hydrostatic pressure. If disturbed, springs may burst to the ground surface and freeze, producing a thick and often widespread ice sheet or ice mound called aufeis.

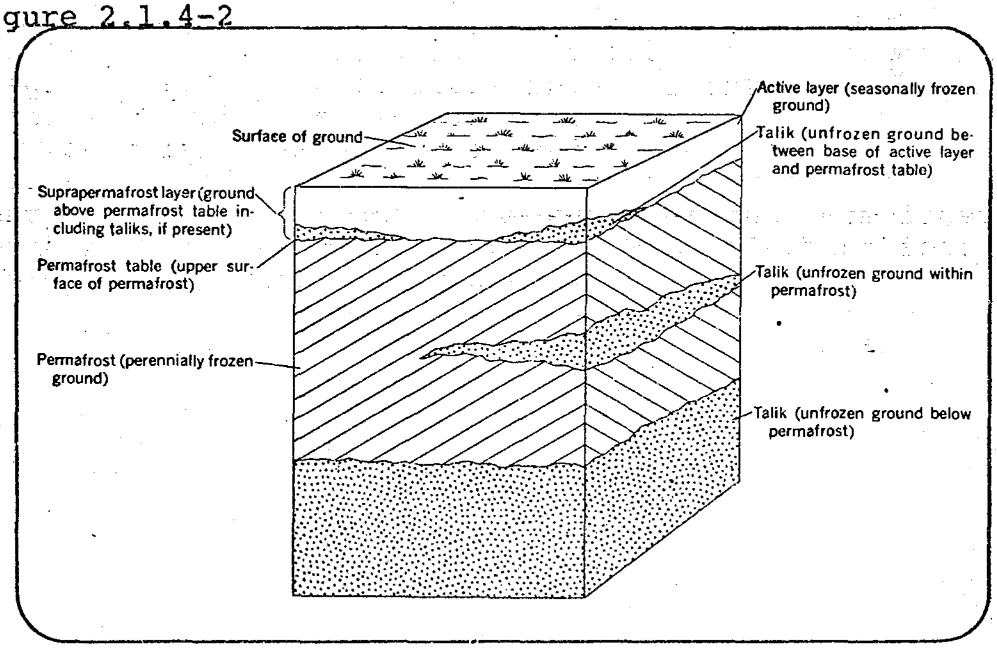
Figure 2.1.4-1



Source: O. J. Ferrians, Jr., R. Kachadoorian and G. W. Greene, 1969. **Permafrost and Related Engineering Problems in Alaska.** U. S. Geological Survey Professional Paper 678.

The effects of surface features on the distribution of permafrost

Figure 2.1.4-2



Source: O. J. Ferrians, Jr., R. Kachadoorian and G. W. Greene, 1969. **Permafrost and Related Engineering Problems in Alaska.** U. S. Geological Survey Professional Paper 678.

Occurrence of taliks in relation to the active layer, suprapermafrost zone, permafrost table, and permafrost.

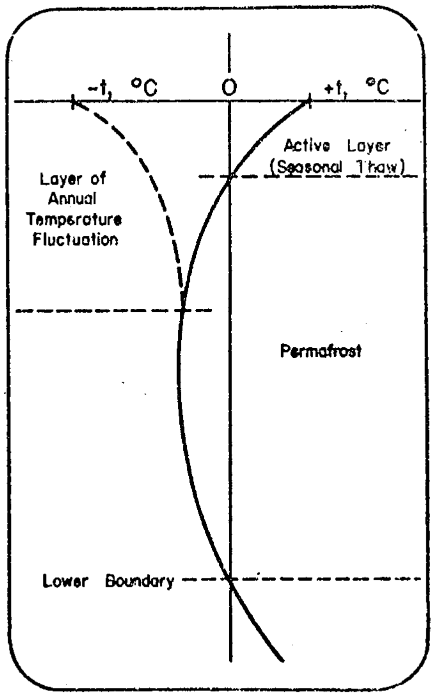
This process is known as icing. Since water tends to reduce temperature fluctuations from season to season, thawing usually reaches deeper in drier materials. Permafrost thickness is aggrading as it thickens and degrading as it thins.

The extent and thickness of permanently frozen ground along the proposed pipeline route varies from thick, continuous permafrost in the northern part of the region to moderately thin discontinuous permafrost in the northern part of the region to moderately thin discontinuous permafrost in the southern part of the region. Climate is a primary causitive factor in the formation of permafrost, which generally exists in areas where the mean annual air temperature is 32 degrees Fahrenheit (Zero degrees Centigrade) or below. However, in Alaska, this is complicated by complex relief characteristics. Seasonal temperature variations to a certain depth depends on a combination of climatic and terrain characteristics. In the lowland area north of the Brooks Range, permafrost temperatures reflect seasonal variations to a depth of approximately 70 to 100 feet. Below that depth permafrost is at its coldest, warming gradually thereafter with depth until it passes 32 degrees Fahrenheit (Zero degrees Centigrade), indicating the subpermafrost boundary (Figure 2.1.4-3).

The temperature of permafrost at a debth just below the zone of seasonal variation generally ranges from minus 11 degrees to minus five degrees Centigrade (about 12 degrees to 23 degrees Fahrenheit); in lowland areas south of the Brooks Range, the permafrost temperature generally is warmer than minus five degrees Centigrade (about 23 degrees Fahrenheit). Within mountainous areas (e.g., Brooks Range, Yukon-Tanana Upland, Alaska Range), the temperature is extremely variable.

The age of permafrost is also quite variable. Areas that were ice-covered during the Pleistocene were possibly free of permafrost until the glaciers melted (Hopkins, Karlstrom, et. al. 1955). The ice may have insulated the ground from low air temperatures at the same time that permafrost was aggrading in adjoining ice-free areas. It is believed that permafrost in areas that were never ice-covered during the Pleistocene may be much older. Some ice wedges in northern and central Alaska have been dated from 14,000 to 32,000 years old. After the ice disappeared, permafrost existing in areas of post-glacial flooding--such as proglacial lakes and marine transgressions--probably dissipated and was not able to reform until several thousand years later.

Figure 2.1.4-3

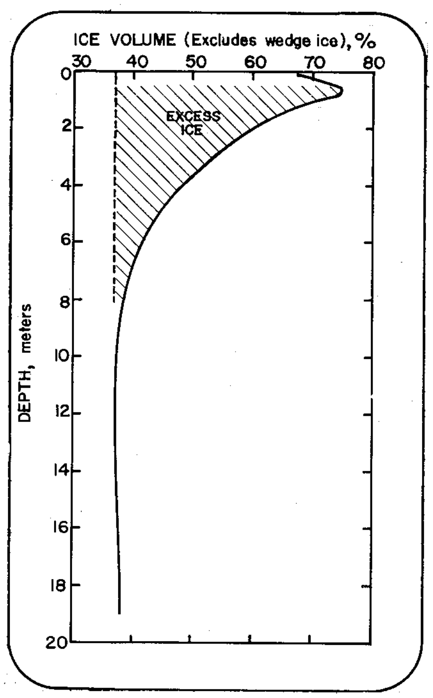


Source: Haugen, R.K. and J. Brown, 1971. Nature and man—indirect disturbances of permafrost terrain.

General temperature relationships of permafrost

Figure 2,1.4.-4

Source: Brown, J. and P.V. Sellmann, 1973. Permafrost and coastal plain history of arctic Alaska.



Average ice volume versus depth in permafrost

Various conditions have important effects on permafrost growth and thickness (Brown and Pewe 1973). Surface relief directly influences permafrost formation by controlling the amount of solar radiation received by the ground. In the discontinuous zone, permafrost may occur only on north-facing slopes, which receive less solar radiation. In the continuous zone, permafrost on north-facing slopes may be thicker, with a thinner active layer. Relief also affects snowfall accumulation and vegetative cover, which in turn affect permafrost thickness.

The type of ground surface is an important factor in determining permafrost conditions. The thermal conductivity of silt is about one-half that of coarse-grained sediments and several times less than that of bare rock, which has a high reflectivity value. The active layer is thinnest, and the permafrost layer generally thickest, in fine-grained soils such as silt and clay.

Vegetation affects permafrost in several ways. Its most apparent effect is in shading the ground from solar radiation, thereby protecting permafrost. Active layer thickness is directly affected by solar radiation, vegetation thickness, and tree shading. When vegetation is disturbed or removed, the permafrost table is lowered; in the discontinuous zone whole masses of permafrost may disappear.

Moss and peat are of special importance in insulating the ground and protecting permafrost. Little alteration of the permafrost may occur through removal of trees or brush, but severe damage occurs when the moss or peat cover is disturbed. It is this type of disturbance that results from vehicle traffic across tundra areas, resulting in permafrost thaw and subsidence, causing local flooding, drainage diversion, and soil erosion.

Though ground vegetation is of prime importance, trees also shade the ground and intercept some of the winter's snowfall, producing a significant effect on the underlying permafrost. Also, the density and height of trees influence the effects of ground level winds, lowering velocities where trees are dense. This affects the transfer of heat.

Permafrost considerably affects the rooting of plants. It inhibits the warming of the soil during summer, keeping the root zone temperature well below the optimum. This reduces water absorption by plant roots, leading to plant dryness. Root development is substantialy retarded, and roots are prevented from growing downward by the impenetrable permafrost layer. Roots are forced to grow out laterally, causing many large trees to be improperly supported and to lean over.

Because of the impermeability of the permafrost layer, water percolation downward is prevented, causing the active layer to be boggy and poorly aerated, as well as improperly nourished due to inhibited microorganic activity. Solifluction, a direct result of permafrost, disturbs vegetation stability by continually shifting the root zone.

Large water bodies create large thaw bulbs beneath themselves, the extent of which depends on the depth and temperature of the water body and the type of bottom sediments.

Snow cover influences permafrost distribution and thickness by controlling heat transfer to the ground from the atmosphere. Snowfall conditions and the length of time snow is on the ground are important. Early, heavy snowfall in winter effectively insulates the ground from the severe winter cold, preventing permafrost aggradation. Thick snow cover that lasts late into spring delays spring thaw, and can bring about aggradation of permafrost. The thickest and most extensive permafrost, and thinnest active layer, exist in areas of thin snow cover. Some investigators believe that variations in snow cover have more effect on permafrost than variations in vegetative cover.

The influence of fire on permafrost is dependent on vegetation moisture and the rate of burning. If a fire moves rapidly through an area, or the surface peat and moss layer is moist, the ground vegetation may be little affected and the permafrost little disturbed. If, however, the surface vegetation is very dry, it may be almost totally consumed by the fire, robbing the permafrost of its insulative cover. Under these conditions the permafrost layer will be appreciably affected. In the discontinuous zone, masses of thin permafrost below a fire of this type may disappear.

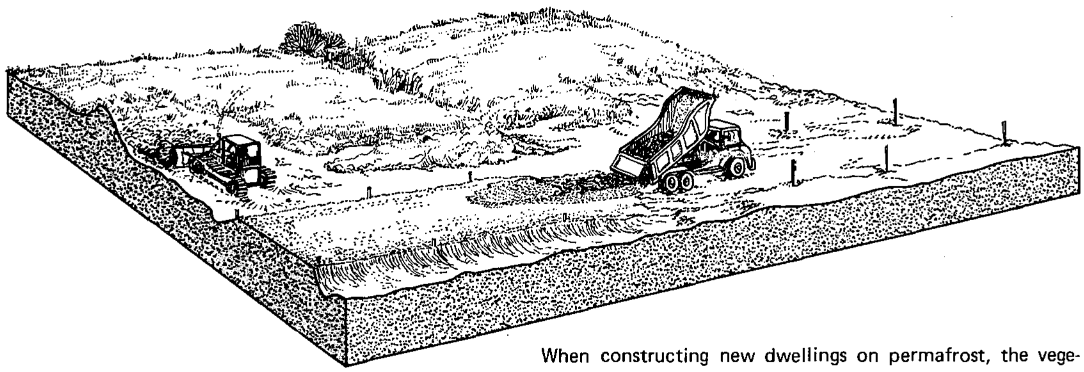
During the cold winter, thermal contraction of the ground surface in northern Alaska causes it to crack in a pattern resembling mud cracks, only much larger. Summer meltwater pours into these cracks in the permafrost and freezes, forming a vertical network of intersecting ice veins. As centuries pass, repeated cracking at these sites of weakness causes the veins to grow into a network of massive wedges of ice, often tens of feet deep, several feet wide at the top, and separated from one another by 100 feet or so. Ice wedges are sometimes indicated by polygonal ground surface markings, but more often they are not. Some ice wedges are the product of extinct climates, and they are preserved in permafrost today at considerable depth. Other forms of ice, including lenses of all sizes and interstitial forms, are also common in permafrost. On the Arctic Coastal Plain, ground ice can occupy nearly 80 percent of the volume of the upper 10 to 15 feet of the soil (Figure 2.1.4-4).

An unusual aspect of permafrost is that it can preserve fossil remains exceptionally well; even partial carcasses have been preserved. Numerous vertebrate fossils of Pleistocene age have been found in central Alaska near Fairbanks and a few finds have been reported in other areas along the proposed pipeline route all the way from the Arctic Coastal Plain in northern Alaska to the Copper River Basin in south-central Alaska. The most common fauna reported include bison, mammoth, horse, and ground squirrel. Other less common fauna include beaver, muskrat, hunting dog, wolf, fox, large cat, mastodon, elk, moose, caribou, musk ox, and mountain sheep.

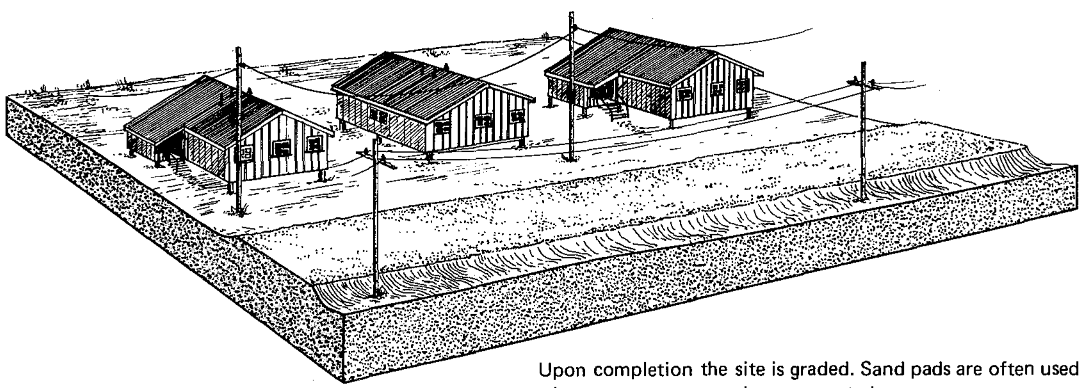
Engineering modifications of the environment can cause thawing of permafrost in two different ways. The first is by changing the seasonal thermal balance at the surface and causing the active layer to thicken from summer heating. Such effects can be caused by gravel pads, damage to the organic surface layer, or disrupted surface drainage. Such modifications can have a critical effect on roadways and on pile foundations for an elevated pipeline or for other structures, but it may take several years before the effects are fully manifest (Figure 2.1.4-5). The second type of modification results from heated buildings or buried hot pipelines which introduce a steady new supply of heat into the permafrost from artificial sources. The equilibrium thawing configuration for these modifications may not be approached for decades or centuries (Lachenbruch 1970).

The primary engineering problems (Figure 2.1.4-5). resulting from thawing of permafrost are related to its potential loss of strength and volume. In ice-rich material, this can cause severe differential settlement or loss of bearing strength in foundations. Such effects are often irreversible and under adverse conditions may be self-perpetuating and difficult to predict, particularly if undetectable massive ice is present. However, if all of

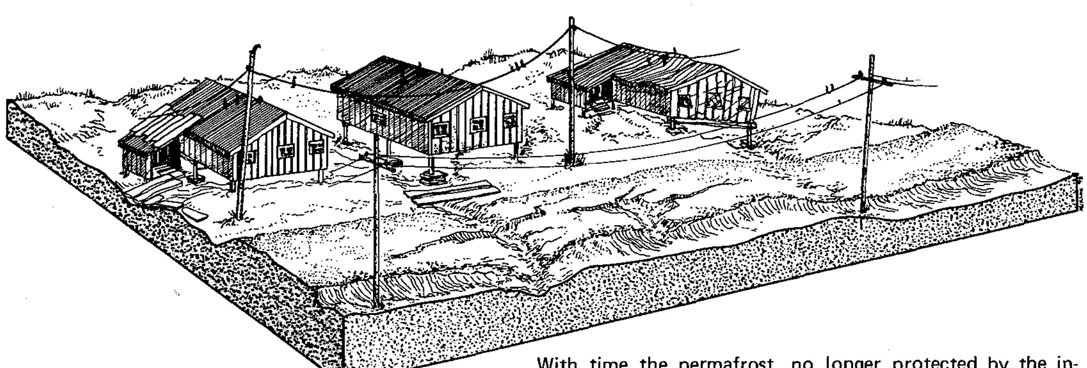
Figure 2.1.4-5 Engineering problems related to permafrost



When constructing new dwellings on permafrost, the vegetative cover as well as the top layer of soil is often removed, destroying the protective layer of insulation on the permafrost and disturbing surface runoff patterns.



Upon completion the site is graded. Sand pads are often used where structures are to be constructed.



With time the permafrost, no longer protected by the insulating layer, will thaw. This will result in subsidence of ground surface with damages to buildings, roads, and utilities. New runoff patterns established by regrading of the land and melting of the permafrost will cause severe erosion along road cuts and utility lines.

the ice in permafrost occurs only in the voids between mineral grains that are in firm contact, these engineering problems are minimal or absent.

Erosion

In the Arctic, normal wind and water erosion takes place very slowly on land because streams and ground surface are frozen for up to nine months of the year. Even during summer, erosion takes place very gradually. The frozen ground thaws slowly and only to shallow depths. Only during spring breakup, with extensive flooding and high velocity, do great quantities of sediments move downstream. Aided by the scouring and floatation action of large slabs of ice, even the coarsest deposits can be carried off. As streams thaw, their exposed bars and beaches and banks become sources of sand and silt for wind action. Wind deflation blowouts are common along stream and lake banks.

Thermal Erosion

Normal water erosion can only reach as deep as the thawed layer, but thermal erosion adds to the amount of thawed material. In permafrost areas where rivers or seas lap against banks or bluffs containing ground ice, undercutting of the banks commonly takes place. As water comes in contact with the ice-cemented sediments, heat transfer causes the ice to melt. The deposits are released and carried away by the water, creating a cavity or thermo-erosional niche below an overhanging tundra mat. Eventually, undercutting proceeds to the point that the overhanging portion collapses, breaks up in the water, and is carried away. This exposes a fresh ice surface, and the process begins again.

Coastal Erosion

Normal shoreline erosion and transport cease during the nine months each year when the seas bordering the Arctic Region are frozen. During the short summer the ice melts, breaks up, and drifts out to sea. Because of the proximity of the southern limit of the polar ice pack, the ice does not drift far and remains out of sight for only about a month, occasionally being blown back by onshore winds. As a result, the ice continues to act as a wave damper, retarding coastal erosion. Ice-push ridges along the coast also protect the beaches.

Seasonally frozen ground and permafrost cement particles together to a rocklike consistency, providing further erosion resistance along the beach. The beaches thaw to a depth of from five to ten feet in the summer months, which allows normal erosion.

During the summer, mechanical erosion of thawed beaches and thermal erosion of coastal banks and bluffs proceed at such a rate that coastal retreat is a continuing problem throughout the Arctic. Recession rates of as much as 33 feet (10 m.) per year have been reported along the coast from Barrow to the Mackenzie River. Most of the retreat in that area is due to thermal erosion and collapse of the coastal banks, as beaches are narrow or absent along much of that coast. Recession rates are greatest in banks containing fine--grained sediments, such as silt, which contain the greatest amount of ice; it is least in better drained banks of coarse sand and gravel.

Erosion and sedimentation on the beaches is a slow and steady process, but sudden large movement of material can take place during major storms. Storm surges, caused by onshore winds driving wind-generated tides and waves, can cause erosion and deposition equalling as much as 20 years at a normal rate. Also, removal of beach materials for construction purposes can accelerate coastal erosion and worsen the erosional effects of storms.

Riverbank Erosion

Erosion in central Alaska is of primary importance along river banks. Many villages were located along rivers before any knowledge or suspicion of erosion problems existed. Residents are now discovering that the land beneath buildings and other facilities is slowly disappearing. In some cases, erosion has progressed so far, or so rapidly, that community leaders are forced to give serious consideration to relocaton.

Riverbank erosion is a normal process that occurs as a river evolves and grades its course. Meandering rivers continually move back and forth across their floodplains over time, and occasionally extend their floodplains laterally. At any given time, the most rapid erosion takes place at the outside banks of river bends or curves. Here, the running water is directed toward the bank, undercutting and eroding away the bank sediments. If the bank contains permafrost, thermal erosion occurs, in which water laps against the frozen sediments in the banks and thaws them. The thawed sediments are carried away, leaving an overhanging mat of frozen sediments and vegetation. Eventually, undercutting proceeds to the point where the overhang collapses into the water. There it is thawed, broken up, and carried away. This exposes a fresh, frozen surface and the process begins again.

The rate of erosion depends on the type of sediments in the banks. Unconsolidated sandy sediments erode quickly, clays erode more slowly, and bedrock erodes very slowly, Permafrost-rich sediments erode more slowly than thawed sediments. Wind-generated waves striking a bank cause acceleration of erosion in all cases.

In braided streams gravel bars deflect channel waters toward the banks, accelerating erosion. As bars slowly migrate downstream bank erosion problems move with them. Erosion is usually greater in a river during times of high, rapid water, such as during breakup flooding in the spring. But, when floodwaters overtop the river bars and are no longer deflected toward the banks, erosion may decrease during flooding. Of course, if the river overtops its banks, erosion may occur some distance back from the river. Sometimes, after flooding subsides, river bars are substantially or completely altered in shape and position, changing erosion patterns. Also, old channels may be abandoned and new ones formed or reoccupied after flooding.

Differences in vegetative cover may also affect erosion rates. Deep-rooted plants help hold the sediments together, whereas shallow-rooted vegetation has little hold on the soil.

Regional Occurrences of Permafrost and Erosion

The proposed Alcan Gas Pipeline passes through the continuous and discontinuous permafrost zones. The boundary between the continuous and discontinuous permafrost zones intersects the 17.6 degrees Fahrenheit (minus eight degrees Centigrade) isotherm.

Interior Plains

Arctic Coastal Plain

The Arctic Coastal Plain is within the region of continuous, thick permafrost. The maximum recorded thickness is 2,000 feet at Prudhoe Bay; the active layer is generally less than two feet. Below the zone of seasonal temperature variation, the temperature of the permafrost ranges from minus 12 degrees Centigrade to minus seven degrees Centigrade. Considerable segregated ice is present in the soil in the form of crystals, coatings, inclusions, wedges, lenses and seams. Massive clear ice and dirty ice are common in the silts, and bore-hole logs reveal the presence of local ice lenses in gravel and gravel lenses in ice. Typical permafrost features include polygonal ground patterns and occasional pingos.

The presence of ice-rich permafrost throughout much of this physiographic region and shallow organic cover make this area particularly sensitive to surface disturbance. Permafrost is not generally present, at least near the surface, under the active floodplain of the Sagavanirktok River.

In addition to the obvious engineering problems posed by permafrost, flooding, erosion, and aufeis conditions occur along the Sagavanirktok River.

Rocky Mountain System

Arctic Foothills

The permafrost is continuous throughout this region with an active layer generally of less than two feet. Segregated ice is common and occurs in the form of crystals, coatings, inclusions, wedges and lenses. Massive ice is common in the silty soils. As a general rule, the sands and gravels only contain ice in the form of coatings on particles or filling of the voids; however, several bore-hole logs reveal layers of clear ice or gravel lenses in clear ice. Stone stripes, polygonal ground pattern and solifluction terraces are common.

Solifluction and mass wasting, in the form of mudflows and landslides, are common on the foothill slopes in this section. Flooding, erosion, and aufeis conditions occur along the Sagavanirktok River, which is crossed numerous times by the proposed pipeline alignment.

Brooks Range

Permafrost is continuous through the Brooks Range with an average active layer thickness of two feet, but, locally, five feet. Segregated ice-content is highly variable due to the wide variation in soil textures. In the central part of the Brooks Range (Dietrich River Valley) segregated ice is less common than in the southern and northern parts. Ice content in the gravel is low and occurs as ice coatings and void fillings. Silts contain segregated ice in form of lenses, wedges, and occasional massive ice. There are considerable variations in the thickness and temperature of permafrost in the Brooks Range due to differences in topography, altitude, soil type, soil moisture, insulation and vegetation cover.

There are landslides and active solifluction slopes along the proposed route.

Ambler-Chandalar Ridge and Lowland

Permafrost is continuous through this area except for small unfrozen portions of the floodplain of South Fork Koyukuk River. The active layer is less than two feet thick. Segregated ice content is variable and, where present, occurs in the form of lenses and seams, with massive ice locally.

Intermontane Plateaus

Kokrine-Hodzana Highlands

Permafrost is continuous throughout much of the region with an active layer of zero to two feet, increasing to five feet in the southern part of the region. The permafrost table is depressed locally below the active layer to depths greater than 20 feet in the vicinity of Hess Creek. Segregated ice throughout much of the region occurs occasionally, and then mainly in the form of lenses and seams. Massive ice is rare.

The variable depth of the permafrost table, which in places is well below the active layer, and the presence of unfrozen areas make this region a major problem area for the burial of a gas pipeline. Soils with a high ice content occur locally, but bore-hole data indicates that the moisture content of the colluvial silts (the major soils type) is near saturation, averaging 45 percent with extreme values of 34 percent and 116 percent (ice rich silts).

In local areas north of the Yukon River, ice-wedge polygons, solifluction lobes, and ice lenses occur. The fine-grained sediments are ice-rich and easily erodable, especially the reworked windblown silt and colluvium south of the Yukon River.

Rampart Trough

Permafrost is discontinuous and the floodplain of Hess Creek is unfrozen. The active layer varies from 1.5 to five feet, and the permafrost table is often depressed to depths greater than 20 feet. Segregated ice is encountered occasionally in the form of lenses and seams with massive ice locally. This zone of discontinuous permafrost is characterized by permafrost temperatures just below the zone of seasonal variation ranging from minus five degrees to minus one degree Centigrade and mean annual air temperatures from minus seven degrees Centigrade to zero degrees Centigrade.

The ice-rich fine-grained sediments and the colluvial debris are easily erodable.

Yukon-Tanana Upland

Permafrost is discontinuous, and the active layer varies from zero to three feet. The depth of the permafrost table is highly variable ranging from three to 25 feet, and locally as deep as 40 feet. Segregated ice occurs occasionally in the form of lenses and seams with massive ice locally. Bore-hole data reveals moisture contents ranging from 68 to 180 percent in silts (average 100 percent) and an average of 120 percent in organic silts.

North of Fairbanks the unconsolidated sediments are generally frozen and locally ice-rich. Ice forms include wedges, lenses, and interstitial ice. South of Fairbanks, much of the area is thawed; however, there are large accumulations of ice in some of the sediments, especially the fine-grained reworked silt.

Tanana-Kuskokwim Lowland

Permafrost is generally continuous from Shaw Creek to the Tanana River, and discontinuous in the Tanana River Valley. The permafrost table is highly variable ranging from two to 20 feet, locally depressed as much as 40 feet near the Chena River. The active layer varies from zero to two feet, but up to six feet in sand and gravel. Segregated ice is rare and where present (in silts) is in the form of crystals, coatings, seams and wedges (rare). Little or no visible ice is present in sand and gravel. Permafrost temperatures just below the zone of seasonal variation range from minus five degrees Centigrade to minus one degrees Centigrade. Current temperatures are often above minus one degree Centigrade in this region. Mean annual air temperatures range from minus seven degrees Centigrade to zero degrees Centigrade.

The fine-grained soils of this region appear to pose major problems to a chilled gas pipeline, since ground temperatures are close to zero degree Centigrade, the permafrost is discontinuous, and the silts, especially the organic silts, have a high moisture content.

The predominantly coarse-grained deposits of the Tanana Valley, which are the most extensive, are generally underlain by numerous isolated masses of permafrost more than 25 feet below the surface, and extending to recorded depths of from 90 to 209 feet. Scattered lenses of permafrost, in the hills composed of loess and sand, are 2.5 to 3.5 feet below the surface. In the finer-grained deposits containing silt, organic soils, and peat, the permafrost is usually one to three feet below the surface, except in the immediate vicinity of streams or ponds.

Earthquakes and Faults

Earthquakes

The proposed Alcan pipeline route lies at the northern edge of a vast continuous, seismically active belt that circumscribes the Pacific Ocean basin and parallels the Alaska and Coast Ranges and the Aleutian Islands. The route lies predominantly within Zones 2 and 3 (Figure 2.1.4-6)—areas of moderate to major earthquake damage. In Zone 3, the maximum expected intensities are above the potentially destructive level. In Zone 3, earthquakes that occur farther south or as small magnitude earthquakes within the gegion are commonly felt. About every decade, a shock of magnitude seven or greater occurs somewhere in Interior Alaska.

An earthquake is associated with faulting, which is rock fracturing and displacement. It is the shock that results when rock, distorted beyond its strength, finally ruptures and releases its stored up energy. Earthquakes can disrupt the equilibrium of surrounding rocks, triggering new faults and resultant shocks. The location at which a rupture within the earth occurs is known as the focus, or hypocenter; the point on the ground surface directly above the focus is the epicenter. Aftershocks commonly follow major earthquakes, occurring as rocks stabilize into new positions. Aftershocks generally have different epicenters from the primary shock. The major faults and fault systems of this region are shown on the geology maps and figures.

During the great Alaska earthquake of March, 1964, which had its epicenter in northern Prince William Sound and an intensity of 8.4 to 8.6, the city of Fairbanks experienced only minimal damage (Plafker et al. 1969). Seismic motion at Fairbanks lasted from four to five minutes and was of a rolling nature, chiefly northeast-southwest in direction. The intensity of seismic motion

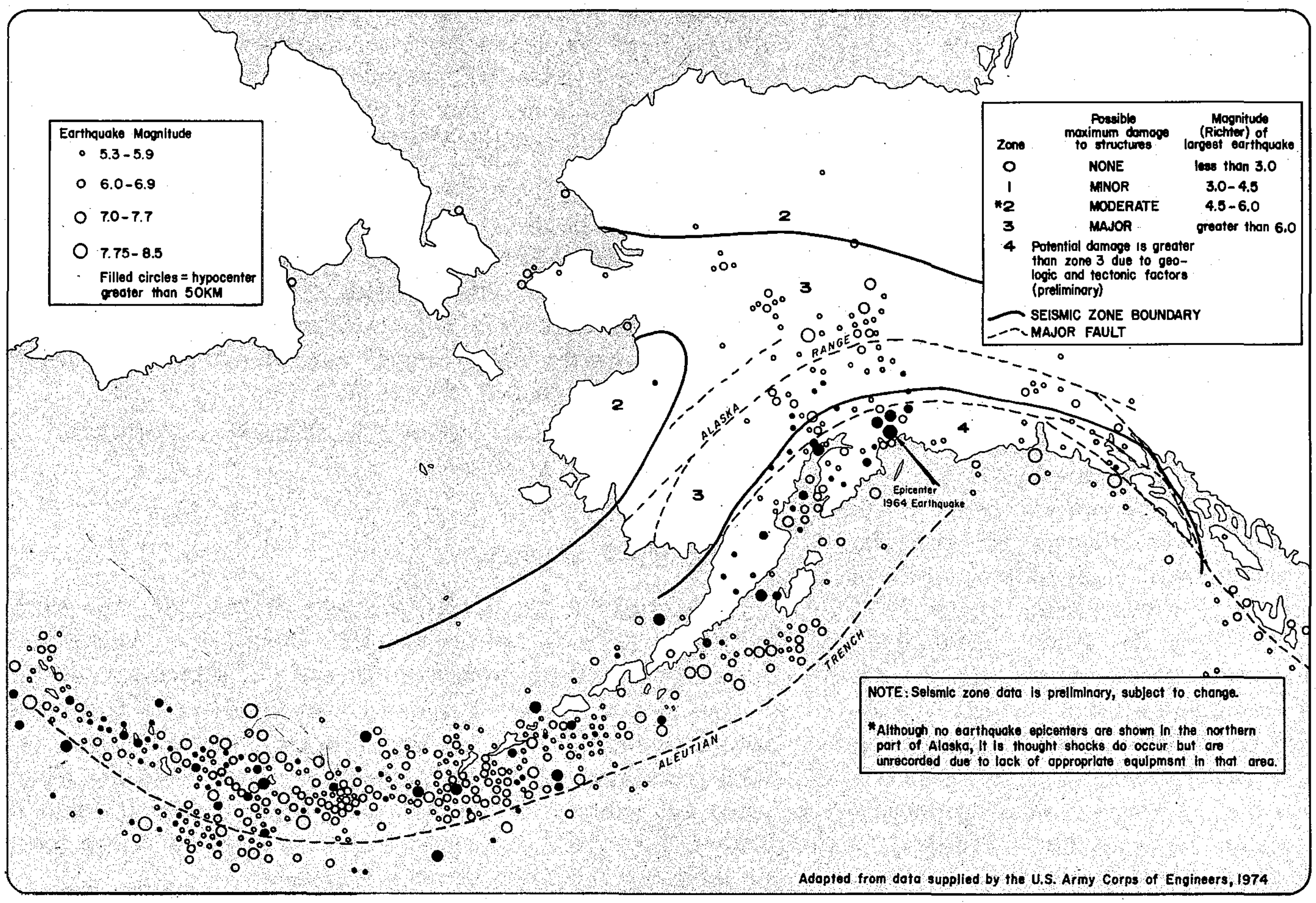


Figure 2.1.4-6 Seismic Zone Map of Alaska

increased gradually and, once at its maximum, did not vary much. The motion stopped abruptly. The very light damage experienced at Fairbanks is explained by the distance from the earthquake epicenter and by the fact that most of the city is underlain by permafrost, which responds to seismic vibrations much as solid rock does.

The amount of earthquake damage is dependent, to a large extent, on the subsurface conditions at the site of the damage (Wolff and Haring 1967). Most of the damage and destruction of the 1964 earthquake in the Southcentral Region was due to slumping, high water, and compaction and landsliding above and below water. The region around Huslie, on the Koyukuk River, is very sparsely populated; otherwise, severe damage would have resulted from the earthquake of April 7, 1958. At that location, underlying saturated silt and sand is overlain by stabilized dry sand dunes (Davis 1960). Apparently, spontaneous liquefaction of the underlying material allowed it to be forced from fissures in the sand dunes during the shaking. This resulted in sand flows and slumping. There was also slumping toward the river.

In October, 1968, a magnitude 6.5 earthquake caused extensive landsliding and ground breakage within 30 miles of the proposed pipeline route in the Rampart Trough area. Aftershock epicenters were located within 15 miles of the route (Gedney and others 1969).

In July 1937, a magnitude 7.3 earthquake occurred southeast of Fairbanks. Landslides, mud boils, and ground fissures were observed (Bramhall 1938) within ten miles of the proposed pipeline route. On June 21, 1967, a series of three magnitude 5.5 shocks occurred within a few miles of the route (Gedney and Berg 1969). Surface faulting was not observed in either earthquake episode. In this section of the route, the seismic risk is substantial, although it cannot be correlated with recognizable tectonic features.

The potential danger of earthquake damage to structures along the proposed route is very real, but difficult to assess. The largest magnitude earthquake that was recorded in Interior Alaska occurred in the Kantishna area, about 120 miles from Fairbanks. It had an intensity of 7.75. The most severe quake ever felt in Fairbanks was on January 29, 1929, which was caused by a quake near the head of the Tatlanika River, 60 miles away.

Southeast of Delta Junction lies within a region of relatively low seismicity. The closest recorded large earthquakes have occurred about 100 miles northwest of Delta Junction near Fairbanks. Although Gedney et al.

(1972) show a few Richter Magnitude two or greater epicenters of earthquakes near the corridor southeast of Delta Junction, their frequency is not great compared to those farther to the northwest near Fairbanks and farther to the south along the Denali fault.

Although Gedney et al. (1972) suggest that possibly three active faults cross the corridor between Johnson River and Tanacross, detailed field mapping by Foster (1970) does not support this inference. A fault was mapped by Pewe and Holmes (1964), and both these authors and Hamilton (1973) have mapped other faults that cut late Pleistocene deposits along the front of the Alaska Range. It is uncertain whether there is any modern activity along these faults.

The proposed route intersects several recognized major faults in the active seismic region south of 67 degrees N; however, risk of significant tectonic movement on these faults is essentially unknown at present. Many additional faults are also postulated, particularly in Zone 3 where this segment is characterized by the frequent occurrence of sizeable earthquakes that have yet to be identified with individual faults. The proposed route does not intersect the Zone 4 area (Figure 2.1.4-6).

The occurrence of large earthquakes is a potentially serious hazard to the integrity of the proposed pipeline. Seismic shaking or surface faulting accompanying a large shock could rupture the pipeline directly or cause failure in the foundation material that could lead to rupture. Furthermore, large earthquakes could trigger landslides that could jeopardize the integrity of the pipeline.

Fault Systems

In northern Alaska the principal fault systems are the east-trending thrust faults of the Brooks Range and Arctic Foothills. These are principally of Cretaceous age, and it is doubtful if any significant movement occurs on those faults today. All known lineaments adjacent to the proposed route are listed on Table 2.1.4-1.

The major faults of central Alaska are the thrust belts of the western Kukon-Koyukuk province and the Livengood area, mostly late Cretaceous and early Tertiary in age, and the series of extensive transcurrent faults of equivalent and younger age that cut obliquely across both young orographic and older tectonic elements. These transcurrent faults together with thrust belts that trend obliquely to them, seem to define a series of continental

TABLE 2.1.4-1

Known Lineaments Adjacent to the Proposed Route from Prudhoe Bay to Delta Junction:

1. Franklin Bluffs-Colville River lineament
2. North front of Brooks Range
3. North Wiseman lineament
4. Malamute trough-Chandalar River lineament
5. Kobuk-Alatna Hills fault
6. South Fork Koyukuk-Jack White Range
7. Koyukuk River magnetic anomaly
8. Kanuti fault
9. Dall Mountain fault
10. Sand Hills-Porcupine River lineaments
11. Kaltag fault
12. Iditarod-Nixon Fork fault
13. South edge of Yukon Flats
14. Tintina fault system
15. Isom Creek-Rogers Creek lineament
16. Hess Creek lineament
17. Victoria Creek fault
18. Minook Creek lineament
19. Tolovana escarpment
20. Bever Creek fault
21. Stevens Creek-North Fork Creek fault
22. Chatanika River lineament
23. Minto Flats
24. Champion Creek fault
25. Little Chena River lineament
26. Badger Road and related deformations
27. Chena River lineament
28. Little Salcha River lineament
29. Salcha River lineament
30. Shaw Creek fault
31. Blair Lakes-Tanana River escarpments
32. Clearwater Lake fault
33. Granite Mountain fault
34. Donnelly Dome Fault
35. Northern front of Alaska Range
36. Healy Creek fault
37. McGinnis Glacier fault
38. Hines Creek fault
39. Denali fault
40. Totschunda fault

blocks that have been translated large distances. Part of the lateral movement along the transcurrent faults may have been dissipated by foreshortening in the thrust belts. Along the Kaltag fault-Yukon-Porcupine lineament, the northern block seems to have been translated 60 to 80 miles to the northwest past the Yukon shelf buttress, possibly in response to eastward movement by the Siberian continental plate. This may have been accompanied by translation movement along the Kobuk fault zone.

On the Tintina fault, northwestward translation of the southwest block, postulated to be as much as 260 miles, may have been accompanied partially by northwestward thrusting on the Livengood belt.

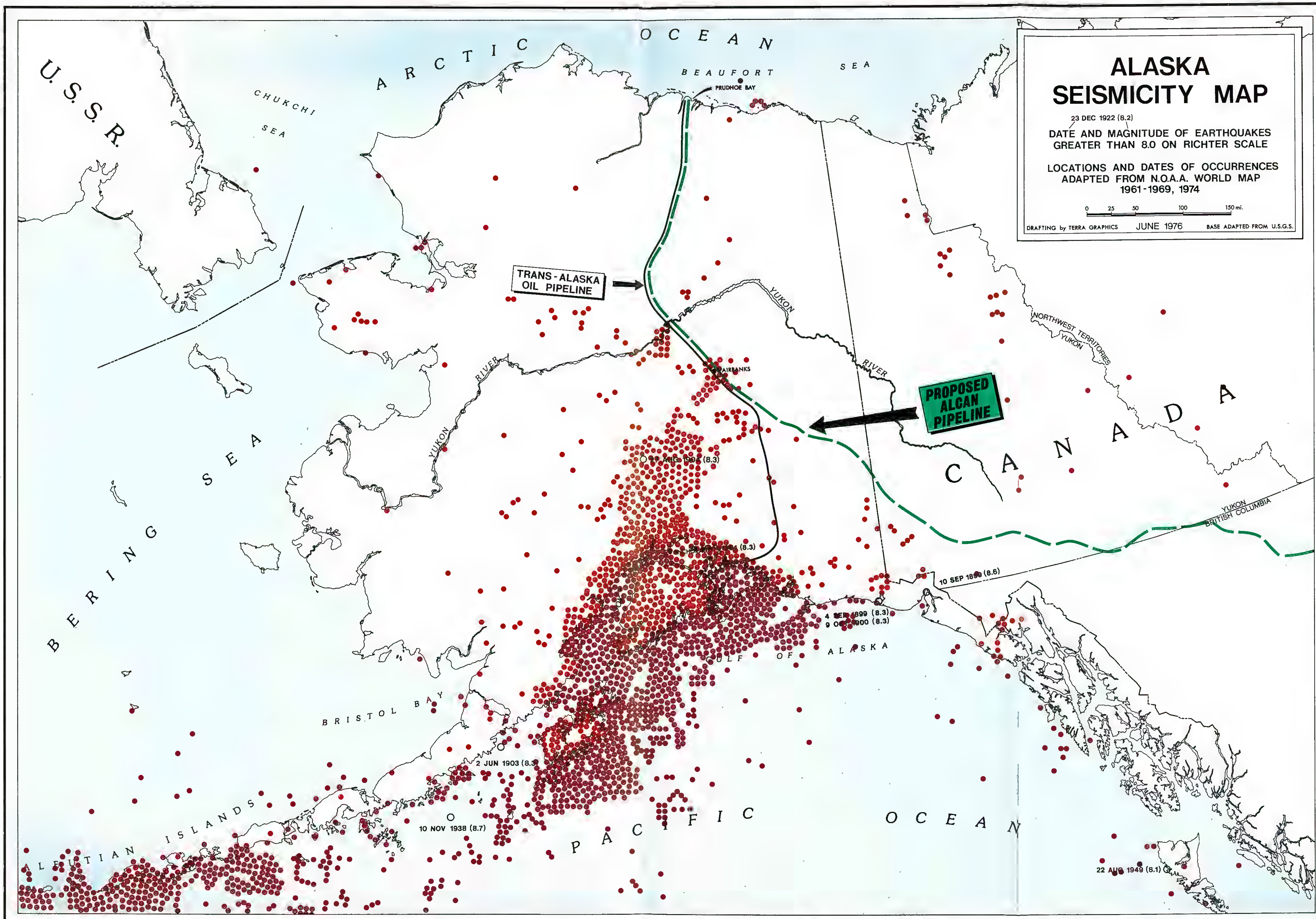
A major regional lineament, the Denali Fault, lies in a sweeping arc 30 miles south of and parallel to the lower part of the Tanana Valley section. The eastward continuation of this fault coincides with the southeast margin of the Tanana Valley from the Nebesna River to the Canadian Border. Although there are no recorded earthquakes of magnitude six or above in Tanana Valley section, there have been several smaller shocks in the vicinity of the junction of this section and the proposed pipeline.

Movement along the Denali fault seems varied, and vertical movement probably occurred at several places. The major movement throughout geologic time has been strike-slip. Generally, however, the fault seems to have offset the Tanana uplift and to have emplaced Permian and younger basinal rocks on the southern flank of the early Paleozoic and Precambrian Cordilleran geosyncline. This movement suggests crowding from the south, perhaps due to Pacific plate movements.

Alyeska Pipeline Service Company has identified approximately 8,000 lineaments along the Trans-Alaska Oil Pipeline route, many of which would also be crossed by the proposed Alcan pipeline route. Of the nearly 8,000 lineaments found in studies carried out for the Alyeska Pipeline Service Company, 55 were considered important enough for further study, because of length, degree of recent activity, geomorphic prominence, or orientation toward the pipeline. Of these, 40 are close enough to the proposed gas pipeline route to deserve mention (Table 2.1.4-1). Only a few are considered to be active faults in the corridor of the proposed gas pipeline route. One such fault extends 25 miles from Clearwater Lake, in the Big Delta quadrangle, southeast at least to the Gerstle River in the Mt. Hayes quadrangle. It consists of a series of parallel to sub-parallel, north-facing escarpments, with minor right slip and a normal-slip component of the south side up. The fault is crossed by the pipeline route north of Delta Junction and south of the Tanana River.

Southeast of Big Delta, there are no known surface evidence of active faults crossing the Tanana Valley. However, an epicenter map recently published by the Geophysical Institute at the University of Alaska indicates two linear zones of seismicity that may be related to subsurface faults.

The accompanying Alaska Seismicity Map has been taken from the map of world seismicity. The observational period was from 1961-1969. Each closed dot represents at least one earthquate epicenter and earthquakes greater than Richter scale magnitude 8.0 are indicated separately by an open circle.


ALASKA
SEISMICITY MAP
23 DEC 1922 (8.2)
DATE AND MAGNITUDE OF EARTHQUAKES GREATER THAN 8.0 ON RICHTER SCALE
LOCATIONS AND DATES OF OCCURRENCES ADAPTED FROM N.O.A.A. WORLD MAP 1961-1969, 1974
0 25 50 100 150 mi.
DRAFTING by TERRA GRAPHICS
JUNE 1976
BASE ADAPTED FROM U.S.G.S.
U.S.S.R.
ARCTIC OCEAN
CHUKCHI SEA
BEAUFORT SEA
PRUDHOE BAY
TRANS-ALASKA OIL PIPELINE
PROPOSED ALCAN PIPELINE
YUKON
YUKON RIVER
NORTHWEST TERRITORIES
YUKON
CANADA
YUKON
BRITISH COLUMBIA
BERING SEA
BRISTOL BAY
GULF OF ALASKA
2 JUN 1903 (8.3)
10 NOV 1938 (8.7)
ALEUTIAN ISLANDS
PACIFIC OCEAN

2.2 SPECIES AND ECOSYSTEMS

2.2.1 Species: Alaskan Flora and Fauna Species lists have been Incorporated into Section 2.2.2

2.2.2 Communities and Associations

Arctic Region, Terrestrial Communities

Plants

Wet Tundra Community

A mosaic of small lakes and wet tundra covers the arctic coastal plain. The peaty soil has a shallow, active layer and is saturated throughout the summer. The pattern of high and low center polygons occurs even under the lakes. Several species of sedges (especially *Carex aquatilis*) make up about 75 percent of the vegetation of the community (Spetzman 1959). Differences in the vegetation composition are related to the microrelief of the polygons. Many species of moss grow in the understory, but few lichens occur in the wet habitat. Secondary species include cottongrass, lousewort, and buttercup in the wetter sites and heather and purple mountain saxifrage in the raised drier habitats such as the ridges between the polygons.

Moist Tundra Community

Moist tundra is the dominant plant community of the foothills region. It is dissected locally by river drainages. Cottongrass tussocks 6 to 10 inches (15 to 25 cm) high, separated by narrow channels, cover large areas of rolling terrain. A tussock forms as a cottongrass clump grows and dies back each year, accumulating dead leaves which decompose slowly in the cold temperatures. Tussock meadows form on moderately drained, residual silt or peat accumulations modified by frost action. Mosses and lichens grow in the moist channels between the tussocks. Frost action creates small frost boils where small grasses and herbs occur. Other plants growing with the cottongrass include small shrubs such as dwarf birch, willows, Labrador tea, and a few herbs like bistort and cloudberry.

High Brush Community

The high brush plant community occurs along the floodplains of many large rivers of the Arctic Region, and in the mountains and foothills. Soils are usually well-drained gravel, sand, or silt, and the active layer is deeper than in the remainder of the Arctic. Spring floodwaters and floating ice may destroy some vegetation, so the community is constantly changing. Newly exposed gravel bars are invaded by a pioneer flora with such species as horsetail, alpine bluegrass, and dwarf fireweed. The high brush community, found in areas that have not been disturbed for several decades, includes willows, a few herbs, many mosses and lichens, and possibly alder.

Alpine Tundra Community

Alpine tundra communities occur in mountainous areas and along well-drained, rocky ridges. The coarse soil is rocky and dry. A fellfield community of low, mat-forming heather vegetation is characteristic of much of the area. Exposed outcrops and talus slopes sustain sparce islands of cushion plants and lichens among the rocks. The low growth form protects the vegetation from abrasion by blowing snow and sand in the exposed, windswept habitat. Important plants in the fellfield include dryas, willows, and heather. Lichens, especially reindeer mosses, are common. Grasses, sedges, and a few herbs are also evident. Cushion plants, such as moss campion and saxifrages as well as many lichens, occur in the dry talus communities.

Animals

Mammals

Wet tundra is inhospitable to burrowing mammals, which are restricted to well-drained sites such as pingos and stream banks. A few shrews feed on the prolific insects. The most common mammals are the Greenland collared and brown lemmings. These are the staple food for Arctic foxes and avian predators. Predatory birds can move from an area during periods of low lemming population, but the less mobile Arctic foxes may be forced to feed on bird eggs in the numerous shorebird and waterfowl nests during such periods. Caribou feed on grasses, sedges, and lichens where they occur. They also feed on cottongrass buds, which usually appear during caribou calving season.

The most obvious mammal of the moist tundra is the caribou. Two large herds, the Arctic in the west and the Porcupine in the east, travel over this community and feed on lichens and sedges. Each herd has its major calving areas distant from the proposed pipeline route. Evidence exists, however, that some individual caribou are territorially "resident" of the area--wintering, summering and calving along the coastal plain part of the pipeline route. These individuals do not constitute a major portion of these herds. In March the Arctic herd leaves its wintering grounds in the Kobuk and Koyukuk drainages and begins its northward movement through the passes of the Brooks Range. If the migration is not impeded, the animals calve from late May into late June in the moist tundra of the upper Utukok and Ketik River drainages. After calving, the animals wander widely throughout the western Arctic until fall when they begin migrating southward.

In winter the Porcupine herd disperses across the south slope of the Brooks Range in Alaska and the headwaters of the Porcupine River in Canada. In March they move north and approach their calving grounds south of Barter Island from the east. Calving is in late May and early June, predominantly in the cottongrass tussocks of the moist tundra. The animals then wander widely in their summer range and move south in early fall.

The abundance of caribou draws wolves to the moist tundra in search of food. Although wolves also prey on other available animals ranging from moose to voles, caribou are their principal quarry.

In moist tundra the ranges of the Arctic fox and the red fox overlap. Both occur in the region, especially during periods of high microtine populations. Lemmings and voles, both cyclical in abundance, feed on the grasses of the moist tundra and use them for insulating material in their nests.

Much of the year, moose in the Arctic depend on woody vegetation. They are mostly confined to high brush areas. Grizzly bears also concentrate in these watersheds, scavenging along the rivers for food ranging from grasses to fish. Although no taxonomic difference has been established between brown and grizzly bears, all the bears of the Arctic Region are most commonly designated as grizzly. Wolves, which range throughout the Arctic, occasionally prey on moose. They often make their dens along the dry riverbanks close to the high brush. Lynx are not common in the Arctic, but they do prey on the snowshoe hares which at times become abundant along stream valleys. Wolverines also hunt these hares and rodents. The red fox usually preys on smaller rodents such as voles and ground squirrels. River or land otters are rare in the Arctic, but they do occur along some of the more permanent streams associated with high brush.

Many mammals, including wolves, grizzly bears, red foxes, ground squirrels, and hoary marmots den in the dry soils of the alpine tundra. Grizzly bears often tear up large sections of sod looking for ground squirrels in their dens. Dall sheep occur in alpine tundra where they feed on bunchgrass, dryas, and lichens in terrain where their climbing ability gives them an advantage over potential predators. Dall sheep are intolerant of deep snow, and in winter they often head for the higher ridges that are blown clear.

Birds

Wet tundra is a foraging area for many birds, particularly shorebirds, which are numerous in summer and migrate south in winter. The red phalarope is especially abundant. Some observers believe that as a species it outweighs any other species of animal in the Arctic. Shorebirds found in wet tundra include the long-billed dowitcher, dunlin, common snipe, and pectoral, Baird's and semipalmated sandpiper. The semipalmated sandpiper is exclusively restricted to feeding on the muddy edges of ponds and lakes. Arctic terns, glaucous gulls, and all species of jaeger prey on small birds and mammals of the wet tundra. Waterbirds that nest and feed in wet tundra include yellow-billed, Arctic, and red-throated loons; whistling swans; pintails; oldsquaws; and Steller's, king, and spectacled eiders. Canada geese commonly nest on dry sites, such as well-drained streambank bluffs and pingos.

Shorebirds are common throughout the Arctic. Dunlins and pectoral and semipalmated sandpipers will be found nesting in the moist tundra. Arctic terns, Sabine's, and glaucous gulls nest on grassy islands in this community. The species composition of jaegers throughout the Arctic depends largely on the lemming cycle. Where lemmings are abundant, pomarine jaegers dominate. Long-tailed and parasitic jaegers are dominant where lemmings are not abundant.

Many waterbirds nest in the moist tundra, especially white-fronted geese, pintails, oldsquaws, and Steller's, king and spectacled eiders. Nearly all waterfowl migrate out of the Arctic in winter, some traveling as far as eastern coast of the United States. Passerines are most commonly represented by the Lapland longspur and the snow bunting. Snow buntings further south are found at high elevations, but on the arctic coastal plain they commonly nest in and around human habitations, garbage dumps, and under discarded barrels, lumber piles, and driftwood.

Marsh hawks are often seen in the moist tundra, but they are conspicuous and may appear more abundant than they really are. Snowy owls are a common predatory bird.

A number of birds are closely associated with the high brush community. Many are small and inhabit thick vegetation which provides cover and nesting sites. These include the fox, white-crowned, savannah, and tree sparrows; gray-cheeked thrushes and robins; redpolls; yellow wagtails; and Arctic warblers. For unknown reasons Arctic warblers appear to be increasing in number. Several predator species are found in the high brush, especially the northern shrike. The willow ptarmigan is also found here.

The alpine tundra and dry areas are used extensively by a wide variety of birds. Shorebirds are represented by the whimbrel, bar-tailed godwit, golden plover, black-bellied plover, ruddy turnstone, and the semipalmated and

Baird's sandpiper. Some, such as the golden plover, nest only in the alpine tundra.

Predatory birds include snowy owls, ravens, golden eagles, rough-legged hawks, gyrfalcons, and an endangered subspecies of peregrine falcon, the Arctic peregrine. The peregrine is relatively common in the Arctic, but when it migrates south in winter, it ingests some foods which contain large quantities of pesticides. These pesticides interfere with the physiology of the birds and cause them to lay thin-shelled eggs which seldom hatch. A June, 1976, survey of peregrines indicated only two nesting pairs, one at Franklin Bluffs and another at Sagwon (Reynolds). The gyrfalcon is not yet on the endangered list, but its population is also decreasing rapidly. All species of raptors habitually nest on rocky outcrops or high bluffs. The short-eared owl also occurs in alpine areas where lemmings are abundant.

Passerines, especially snow buntings, yellow wagtails, redpolls, and savannah sparrows, are common in alpine tundra.

Invertebrates

The tundra is especially noted for its production of flies and mosquitoes, although other invertebrates, both adult and larval forms, are equally important. The abundance of invertebrates in the mud along the edges of tundra ponds accounts for the tremendous numbers of shorebirds that nest in this habitat and characterize the arctic coastal plain in spring. Almost 60,000 collembolas (small, flightless insects) have been counted in one square meter of wet tundra habitat (Brown and West 1970).

The order Diptera is especially well represented in moist and wet tundra environments. The hordes of mosquitoes and flies are essential for the support of the seasonally abundant birdlife. Peak mosquito populations may occur from mid-June through July. Some parasites help keep populations of caribou from overgrazing the tundra and the wolf from overproducing. As many as 17,000 mites have been counted in one square meter of moist tundra habitat (Brown and West 1970).

Except for the numerous members of the order Diptera, these invertebrates are seldom noticed, but they are crucial to the continuation of the more visible forms of life. Much of the diversity of birdlife in the brief, arctic summers depends on the abundance of insects, spiders, and mites for food. Saw flies, one of the most numerous insects, feed on willows while other invertebrates, such as nematodes, are vital to the aeration and fertility of soil.

They digest and break down the accumulated plant detritus and recycle it into soil for other plants.

Aquatic Communities

Plants

Arctic freshwater vegetation includes three types of flora--phytoplankton, seed plants, and small bottom-dwelling (benthic) algae. Phytoplankton are food for many small zooplankton and fish larvae. More than 99 percent of arctic freshwater phytoplankton are extremely small and relatively unknown (Hobbie 1973). Golden algae usually dominate, although cryptomonads may dominate at certain times of the year. Diatoms are important in deeper lakes, while dinoflagellates reach sizable populations even under the ice cover. At times, green algae are common. Although phytoplankton are essential for many forms of micro-aquatic life, total production is relatively low in these waters and only the most sensitive radioisotopic techniques are able to measure its occurrence.

Both submerged and emergent forms of aquatic seed plants occur in shallow ponds and lakes.

Diatoms and green and blue-green algae commonly grow in the top few millimeters of soft bottom sediments in ponds and shallow lakes. These algae usually outproduce phytoplankton.

Animals

Tundra lakes, ponds, and marshes

Tundra lakes, ponds, and marshes, common on the arctic coastal plain, comprise shallow bodies of water less than 20 feet (6 m) deep with mud and organic sediment bottoms (McCart et al. 1972). Ponds less than 6 feet (1.8 m) deep may freeze completely to the bottom during most winters.

The zooplankton in these waters is composed primarily of copepods, rotifers, and cladocera. Though their productivity is low, they are quite efficient. Arctic ponds without fish may contain fairy and tadpole shrimp. Midge larvae dominate the benthic fauna in this habitat. Aquatic worms, stonefly larvae, and snails are also present (Hobbie 1973).

Most of the lakes in this permafrost zone are considered unproductive for fish, although fish are present in all arctic waters deeper than 10 to 15 feet (3.0 to 4.5 m). Whitefish and stickleback are most common and abundant.

These ponds are, however, important waterfowl habitat. Canada geese, white-fronted geese, and black brant nest on the tundra. In late August, white-fronted geese begin their autumn migration moving with favorable easterly winds.

Deep glacial lakes

Deep lakes are found in the Brooks Range and foothills close to the mountain front. These lakes originated during glacial times and are considerably deeper than tundra ponds and lakes.

Zooplankton are even less abundant than in the previous group of lakes and often are composed of only rotifers and copepods. Benthic fauna are similarly scant. Arctic char, lake trout, and Arctic grayling grow slowly in these waters, but may live to an advanced age and attain a large size.

Burbot and lake trout are lake dwellers, spawning and overwintering in the deeper lakes. Burbot spawn in late winter and lake trout spawn in the fall. Lake trout in the Arctic may spawn only once every three years.

Use of these lakes by birds is mainly by inland migrants as they proceed along migration pathways following major river valleys and mountain passes.

Rivers, streams, and springs

All but the large rivers and spring-fed pools of smaller streams may completely freeze during winter. Even in the larger rivers, flow may cease for several months during winter. Breakup severely erodes streambeds and further heightens the stress on organisms inhabiting this environment.

Zooplankton in flowing waters of the Arctic has not been extensively studied. Caddisfly, mayfly, stonefly, and midge larvae are the most common large invertebrates. Bottom fauna are particularly abundant in spring-fed streams (McCart et al, 1972).

Most fish must migrate seasonally to find suitable spawning sites and locations to support them over the winter. Char overwinter in spring areas, deeper portions of mountain streams, and river deltas. One such overwintering area in the Kavik River, estimated to be only 100 feet by 30 feet and 1.5 to 3 feet deep, contained nearly 1,500 adult Arctic char (Alaskan Arctic Gas Pipeline Company 1974). Whitefish, Arctic grayling, and Arctic char use freshwater streams as important summer rearing areas. These species migrate between the ocean and fresh water and between different areas within freshwater drainages throughout the summer months.

In the winter, arctic char tend to congregate in springs, deeper portions of mountain streams and river deltas, but they become more widely dispersed in the summer. Their spawning activities occur in the springs. Spawning grounds are usually located upstream from aufeis and at the canyon mouths of Brooks Range streams. These sections of stream are distinguished by open water in the winter and relatively constant winter water temperatures. Upstream migration begins in mid-July. Spawning starts in late August and may continue through early October. Char do not regularly spawn each year. Juvenile downstream migrations begin in early June and are continuous through early July.

The most important overwintering areas are spring-fed streams and the pools of mountain streams. Other important areas include the few deep lakes and ponds, the river deltas and offshore marine waters.

Arctic grayling tend to inhabit the streams, lakes and ponds in the summer and overwinter in the spring areas, larger rivers and lakes. As in other parts of their range, grayling are springtime spawners utilizing diverse locations in springs and foothill gravel shallows.

Birds from across the continental United States follow the Colville River and the arctic coastal migration route to their Alaskan and Canadian nesting grounds. A major spring migration route for land birds and waterfowl seems to leave the coast and river deltas near Norton Sound and move up the Yukon and Unalakleet Rivers to the Koyukuk, to the John River, then through Anaktuvuk Pass to the Colville and the Arctic coast. Local residents believe the north fork of the Koyukuk River is a more important migration route for waterfowl than Anaktuvuk Pass.

Populations

Table 2.2.2-1 summarizes the abundance and distribution of conspicuous terrestrial animals along the proposed pipeline route in the Arctic Slope region. Table 2.2.2-2 provides similar information for fish species in this region.

Yukon (Interior) Region, Terrestrial Communities

Plants

Boreal Forest Biome

Plants of the Yukon Region astride the Arctic Circle in interior Alaska have been described as subject to

TABLE 2.2.2-1

ABUNDANCE AND DISTRIBUTION OF CONSPICUOUS TERRESTRIAL ANIMALS ALONG THE PROPOSED PIPELINE ROUTE--ARCTIC SLOPE

Species	Abundance	Distribution
Mammals		
Snowshoe hare	Rare	Mostly absent north of Brooks Range
Beaver	Rare	Rare north of Brooks Range
Coyote	Rare	Rare north of Brooks Range
Wolf	Common	About one wolf per 105 square miles; more common in the mountains than on the coastal plain; abundance depends on abundance of prey
Arctic fox	Abundant	Abundant along coast; decrease inland and become rare in the mountains
Red fox	Common	Scarce along coast, populations high in the mountains
Grizzly bear	Common	About one per 65 square miles on coastal plain to one per 30 square miles in foothills and mountains
Polar bear	Uncommon	Occurs on sea ice and occasionally comes ashore to forage; some pregnant females den onshore within 25 miles of coast
Wolverine	Common	Distributed throughout
River otter	Rare	Associated with rivers or marine estuaries; occasionally some distance from water

TABLE 2.2.2-1 (Cont'd)

Lynx	Rare	Most of the Alaskan mainland, wherever the snowshoe hare occur
Moose	Uncommon	Occur along major river valleys where there is willow
Caribou	Abundant	Both Arctic and Porcupine herds (100,000 and 150,000 animals, respectively) occur throughout. Some individuals calve and winter in the vicinity. Major calving ground of Porcupine herd is to the east and that of the Arctic herd is to the west. Both herds winter mainly south of Brooks Range
Musk oxen	Uncommon	A few occur east of the pipeline route.
Dall sheep	Abundant	Occur in mountains of Brooks Range, particularly in Antigun Canyon
Birds		
:cks	Abundant	Most numerous in spring and summer on coastal plain (up to 50 per square mile); uncommon in foothills and mountains
Geese	Abundant	Most numerous in spring and summer on coastal plain (up to 40 per square mile); uncommon in foothills and mountains. Alaska's only snow goose nesting colony is on Howe Island.
Swans	Common	Most numerous in spring and summer on coastal plain (up to 2 per square mile); uncommon in foothills and mountains

TABLE 2.2.2-1 (Cont'd)

Other waterbirds	Abundant	Shorebirds, loons and others breed in high densities on coastal plain
Raptors	Common	Aeries along major streams in foothills, mountains and Franklin Bluffs
Grouse and Ptarmigan	Abundant	Migrate into and through Brooks Range in winter and spread throughout in summer
Other birds	Common	Numerous species occur along the route

TABLE 2.2.2-2

DISTRIBUTION AND ABUNDANCE OF FISH SPECIES IN ARCTIC ALASKA

Species	Form: Resident	Form: Anadromous	Abundance	Distribution
Lake trout	X		Low	Found only in deep lakes of the region. Generally of a smaller size than found in more southerly areas.
Arctic char	X	X	High	Major anadromous runs in larger rivers. Overwinter in deeper portions of rivers. Non-anadromous populations are found in small lakes near river streams.
Arctic grayling	X		High	Widely distributed in all clear water drainages. Found in lakes and streams. Overwinter in deeper pools of larger rivers and deeper lakes.
Whitefish	X	X	High	Most widespread group. Common in lakes, rivers, and streams. Found in all major drainages and in coastal lagoons.
Burbot	X		Moderate	Widely distributed in deep lakes and larger streams. Usually found in deep water and at the bottom. Spawn in shallows.
Smelt	X	X	Moderate	Anadromous population in lower sections of major drainages. Residents found in coastal ponds.

TABLE 2.2.2-2 (Cont'd)

Pink & chum salmon	X	Low	Scattered in larger rivers.

Adapted from a report prepared for the Joint Federal-State Lane Use Planning Commission for Alaska by the Alaska Dept. of Fish and Game, 1976.

some of the greatest climatic extremes occurring in North America. The principal trees that characterize the transcontinental boreal forest reach their northern limits in this region. Interactions of severe climate, repeated fires, discontinuous permafrost, and braided drainage systems have resulted in a complex pattern of vegetation.

Descriptions of plant communities are based on the map, "Major Ecosystems of Alaska," published by the Joint Federal-State Land Use Planning Commission for Alaska in 1973. This map was prepared from detailed studies made by Spetzman on 1:250,000 scale maps that are available from the Resource Library, Bureau of Land Management, Anchorage, Alaska. Scientific names follow Hultén (1968).

Bottomland Spruce-Poplar Forest Community

This tall, relatively dense, interior forest is primarily white spruce mixed in some locations with balsam poplar. In general, the best stands of white spruce are on level floodplains and low river terraces. Studies along the upper Yukon River indicate that stands usually contain trees of assorted diameters. The largest trees encountered were slightly less than 16 inches (41 cm) in diameter and the tallest trees were 90 feet (27 m) in height. Trees on favorable sites in this region have been reported with diameters of 24 inches (61 cm) and heights of 110 feet (34 m).

Balsam poplar usually occurs with white spruce as an early stage in succession and is an early invader of floodplains and deglaciated valleys. It grows rapidly and is replaced by white spruce as the forest matures. Mature balsam poplars average 70 to 80 feet (21 to 24 m) in height and 12 to 18 inches (30 to 46 cm) in diameter.

Undergrowth in this type is usually dense, consisting of such shrubs as American green alder, thinleaf alder, willows, rose, dogwood, Labrador tea and berry bushes. The forest floor is usually carpeted with ferns, bluejoint grass, fireweed, horsetails, lichens, herbs, and mosses.

Portions of floodplains adjacent to this type may be barren during periods of low water, and some periodically flooded backwater areas contain meadows of tall grass with clumps of willow. The bottomland spruce-poplar forest is confined to level broad floodplains, low river terraces, and more deeply thawed south-facing slopes of major rivers. It is found extensively along the Yukon, Koyukuk and Tanana Rivers and is somewhat less extensive along major tributaries of these rivers. It may occur at elevations of more than 2,000 feet (610 m) in higher valleys.

Upland Spruce-Hardwood Forest Community

This is a fairly dense forest of white spruce, paper birch, quaking aspen, and balsam poplar. Black spruce usually replaces white spruce on north-facing slopes and poorly drained flat areas. Trees of this type are shallow rooted and commonly fire-scarred.

White spruces 40 to 80 feet (12 to 24 m) in height and as much as 15 inches (38 cm) in diameter occur in mixed stands on south-facing slopes and well-drained soils and may form pure stands near streams.

Paper birch and quaking aspen stands, usually an early stage of succession following fire, tend to be even-aged and more uniform in size than spruce stands. The largest birches are about eight inches (20 cm) in diameter and 50 feet (15 m) tall. Quaking aspens may reach 10 inches (25 cm) in diameter and 50 feet (15 m) in height. Average diameters are four inches (10 cm) or less. Aspen and birch predominate on well-drained southern slopes.

Undergrowth in this type normally consists of mosses and grasses on drier sites and brush on moist slopes. Typical undergrowth species are willow, alder, ferns, rose, high bush cranberry, lingonberry, raspberry, currant, Labrador tea, and horsetail.

Annual production of plant material by the various species on the Yukon flats is white spruce--650 pounds per acre (729 kg per hectare), quaking aspen--635 pounds per acre (712 kg per hectare), and paper birch--900 pounds per acre (1,009 kg per hectare).

This is the most extensive single type in the Yukon Region. Treeline decreases from 2,000 to 3,500 feet (610 to 1,067 m) along the Alaska-Yukon border to 2,000 feet (610 m) on southern slopes of the central Brooks Range. White spruce becomes scattered among high brush, including dwarf and resin birch and willows, as treeline is approached.

Lowland Spruce-Hardwood Forest Community

This interior lowland forest of evergreen and deciduous trees is dominated by black spruce which sometimes forms extensive pure stands. It is a slow-growing species, and seldom exceeds eight inches (20 cm) in diameter or 50 feet (15 m) in height. Its cones open after a fire and spread abundant seed, enabling the species to invade newly burned areas quickly. The slow-growing stunted tamarack is associated with black spruce in wet lowlands. Like black spruce, it seldom reaches a diameter of more than six inches (15 cm).

Rolling basins and knolls in the lowlands support varied mixtures of white spruce, black spruce, paper birch, quaking aspen and balsam poplar. Bogs and muskegs occur on lower ground.

Undergrowth includes willows, dwarf birch, lingonberry, blueberry, rose, Labrador tea, crowberry, bearberry, cottongrass, ferns, horsetail, lichens, and sometimes a thick cover of sphagnum and other mosses. Large areas burned since 1900 are covered by willow brush and dense stands of small black spruce.

This type occurs extensively on shallow peat, glacial deposits, and outwash plains in intermontane basins and on lowlands and north-facing slopes throughout the Yukon Region. It occurs at elevations varying from sea level to 1,500 feet (457 m) in higher basins and lowlands to more than 2,500 feet (762 m) on north-facing slopes.

Low Brush, Muskeg-Bog Community

Extensive bogs occur where conditions are too wet for tree growth. Bog vegetation consists of sedges, sphagnum and other mosses, bog rosemary, rose, resin birch, dwarf birch, Labrador tea, willow, bog cranberry, and blueberry. Some low-lying saturated soils support cottongrass tussocks surrounded by zones of tall willow, and alder brush. Widely spaced dwarf spruce and tamarack may occur on higher ground. Bog surfaces in the region often have uneven, stringlike ridges (string bogs), usually too wet to support shrubs.

Muskegs and bogs occur primarily in unglaciated areas, old river terraces, outwash plains, filling ponds and sloughs, and occasionally on gentle, north-facing slopes.

Moist Tundra Community

Moist tundra may vary from stands of nearly continuous and uniformly developed cottongrass tussocks, sometimes interspersed with sparse growth of other sedges and dwarf shrubs, to stands where tussocks are scarce or absent and dwarf shrubs dominate. Associated species are polar grass, bluejoint grass, tufted hairgrass, sedges, mosses, alpine azalea, wood rush, dryas, bistort, horsetail, low-growing willows, dwarf birch, Labrador tea, American green alder, Lapland rosebay, blueberry, and lingonberry. This type is usually highly productive and forms a complete ground cover. It occurs sporadically in the foothills of the Brooks Range.

Alpine Tundra Community

This type occurs on ridges and rubble slopes, usually where bedrock is close to the surface, and on such porous soils as alluvial fans and the driest parts of river terraces. The soil is usually coarse and shallow and contains little humus. Alpine tundra is most common in mountains at elevations between 2,000 to 4,000 feet (610 to 1,219 m).

Vegetation is usually sparse and seldom more than a few inches high. Plant associations differ from one place to another, but dryas and lichens usually dominate along with low-growing herbs, grasses, and sedges. Associated species are resin birch, dwarf birch, cassiope, crowberry, alpine-azalea, Labrador tea, mountain heath, moss campion, black oxytrope, and Arctic sandwort.

Lowest production from these plant communities occurs on outcrops and talus, mainly in the higher parts of the foothills and in the mountains at elevations from about 2,000 to 4,500 feet (610 to 1,372 m). Above 4,500 feet (1,372 m), most of the mountains are bare except for rock lichens, but a few flowering plants grow at elevations approaching 6,000 feet (1,829 m). The vegetation at high altitudes consists of scattered plants, similar to those found at lower elevations, but not usually combined into any particular plant association.

Animals

Highly productive of wildlife are the "solar basins" of the Yukon and Tanana Rivers. The Yukon Flats, encompassing nearly 11,000 square miles, is the largest of the highly productive habitats in Alaska for bird life and supports an abundance of mammals of various species. The Minto Flats and the Tetlin Lake vicinity are also centers of high production of water-oriented animals. Interspersed scrubby timber, brush, marsh, and muskeg throughout these interior valleys also support upland species.

Less productive are the rolling hills and mountains that surround these broad valleys. Many are covered with unbroken spruce forest and support few animals. Red squirrel and pine marten, which can meet all their habitat requirements in this single type, are exceptions. The alpine tundra of the higher mountains of the Brooks Range, however, supports a normal complement of animal species.

Some animals thrive in a broad range of conditions at any season. The wolf, wolverine, and raven may be found almost anywhere in the region where they can find adequate food. Such others as the moose and many passerine birds during migration may be found in various habitats at various seasons. They may be confined to one type for nesting or winter feeding, but are able to make use of a broad range of habitats at other seasons. Other species are adapted to only a narrow range of habitats. Neither the red squirrel nor the ruby-crowned kinglet can be found far from coniferous forest. Some animals require a combination of habitats for certain functions. The beaver must have not only water, but also a supply of balsam poplar, birch, or willow for food. The common goldeneye, an aquatic bird, requires a hollow tree for a nest site and does not breed on treeless tundra. The close juxtaposition of many varied habitat types in the Yukon Region is a major cause of its high productivity for terrestrial animals. This variety and productivity are often increased by the numerous fires which frequently set the vegetation back to an earlier, usually more productive, stage of plant succession. The blackened ground following fire is also warmer. Lutz (1966) suggests that nitrogen, often bound up in cold, slowly decaying, dead plant materials, is released and made available following a fire for growth of new plants which provide food for animals.

Mammals

The broad valleys of the Koyukuk, upper Yukon, and Tanana River drainages, covered with mixed spruce-hardwood and muskeg-bog vegetation, in combination with river islands and bars covered with young willows, provide an intermixture of types favorable to numerous woodland mammals. Most species found in wooded habitats occur in reasonable abundance there. The abundance of various species in specific areas may vary in response to changes in habitat conditions resulting from fire or to hunting pressure. The effects of changing predator populations and climate are not well understood.

Caribou use a wide variety of habitats, but the best winter range is in sparse upland spruce timber where snow cover is not excessively wind packed and where lichens are available. Some wind blown alpine slopes also provide good forage. Other suitable winter range may consist mainly of sedges. Pruitt (1960) points out, however, that wherever it occurs, depth and hardness of snow must not be so great that the animals cannot paw through it to feed.

Several caribou herds range within the area. Much of the Porcupine herd estimated at about 150,000 animals, winters partly in the Porcupine and Chandalar River drainages of Alaska in an area extending from the Koyukuk River to the Canadian border. The smaller Fortymile herd, now estimated at 5,000 animals, ranges generally east of Livengood between the Yukon River and the Alaska Highway System and eastward into Canada. Both winter and summer ranges lie within this area. Calving grounds of the Fortymile herd are in the White Mountains and Tanana Hills. The small Delta, Chisana, Mentasta, and McKinley herds also range within the southern portions of the Tanana River drainage.

The grizzly bear of the Yukon Region, which does not attain the size of its counterpart on the coast, tends to favor open slopes and mountainous areas. Black bears occur generally throughout forested valleys, showing a preference for open mixed forests, but they may occur on alpine tundra as they search for roots and berries. Dall sheep occur in the mountains of the Brooks Range in the headwaters of the Koyukuk drainage, as they do in similar habitats of the Alaska Range farther to the south and east. Sheep occupy much of the alpine tundra in summer, but are restricted in winter to slopes blown clear of snow. Wolves and wolverines range throughout various habitats and may occur anywhere from the main river channels to high mountain ridges in either winter or summer, wherever hunting is favorable.

A herd of bison stabilized at 200 to 300 animals has become established near Big Delta from introductions made in 1928. A smaller herd of about 30 animals ranges near Healy Lake. Bison usually summer on the dry grass meadows on bars of the lower Delta and Gerstle Rivers. Winter range includes pastures that do not become wind-packed; the animals move to windswept alpine meadows east of the Delta River in late winter and spring.

Distribution of conspicuous species of mammals is shown on maps on pages 1, 10, and 11 in volume 1A. Other less conspicuous species are distributed throughout the region in suitable habitat.

Birds

Much of the Yukon Region provides excellent habitat for a diverse and abundant population of terrestrial birds. Millons of migratory birds transit the North American Continent and North Pacific Ocean in spring to breed and nest on the lands drained by the Yukon River and its tributaries. About 28 species of resident terrestrial birds remain in the region throughout the year. In recent years, a refuge has been proposed to encompass the extensive Yukon River flats.

The upper Yukon River basin upstream from Rampart is best known for the highly productive bird habitats in the streams, lakes, marshes, and varied woodlands of the Yukon Flats.

Twenty species of raptors occur in the Yukon basin, and 18 are known or suspected to breed there (Ritchie 1972).

Bald eagles nest in small numbers along or near the Yukon River in the lowlands, while a few golden eagles nest on ledges and other areas associated with alpine tundra (U.S. Department of the Interior, Alaska Planning Group 1973a). Ospreys, goshawks, red-tailed hawks, and great horned owls are considerably more abundant than other large raptors and are widely distributed throughout forested habitats (U.S. Department of the Interior, Alaska Planning Group 1973b). America's largest falcon, the gyrfalcon, is known to occur in the highlands in the southern part of the area and may nest there.

The peregrine falcon is of particular importance because of its status as an endangered species and its abundance along the Yukon River. It may also nest on tributaries of the Yukon. It appears to be diminishing in numbers, however. Peregrines are reported within the past few years to be having difficulty hatching eggs in interior Alaska aeries. Peregrines and their waterfowl prey are highly migratory and move during the spring, fall, and winter seasons to or through portions of the continent where these waterfowl consume significant quantities of pesticide residues with their food. These residues become concentrated in waterfowl tissues, then further concentrated in the bodies of their predators. Such metabolic toxins can reduce or even preclude reproductive success in birds. The long southward migration of Arctic peregrine (Falco peregrinus anatum) makes this race particularly vulnerable. Cade, et al. (1968) have found high pesticide levels in Arctic peregrines within the eastern Yukon River area and are gravely concerned about the future of this population.

Peregrine falcons nest on bluff faces too steep to support continuous vegetation or to provide access to the nest site by predators. A nest site may be used repeatedly, though it is common for a pair to utilize several sites over a period of years. Though the birds are very sensitive to human intrusion into the nesting area, it appears that river traffic on the Yukon does not lead to disruption of nesting activity.

Thirty-one species of shorebird, including plovers, sandpipers, and phalaropes, have also been recorded along river or lake shorelines in this area. The most common breeders are the semipalmated plover, golden plover, common snipe, spotted sandpiper, solitary sandpiper, lesser yellowlegs, and northern phalarope.

More than 70 species of passerine birds utilize the terrestrial habitats of the Yukon River region. The most abundant breeding species are the Swainson's thrush, alder flycatcher, and white-crowned sparrow. Yellow warbler, robin, fox sparrow, yellow-rumped myrtle warbler, northern waterthrush, orange-crowned warbler, junco, and varied thrush are also common species. Starling, yellowthroat, red-winged blackbird, and chipping sparrow also occur in small numbers in this part of Alaska, almost exclusively in the Tanana River drainage.

Despite long, cold winters, about 28 species regularly remain as winter residents. Included are two species of hawks, three of grouse, two of ptarmigan, four of woodpecker, and about a dozen passerines (corvids, chickadees, dipper, northern shrike, redpolls, and white-winged crossbill.)

Invertebrates

Of the million or more described species of animals in the world, approximately 95 percent are invertebrates. Bacteria, worms, and a host of other invertebrate species are responsible for the breakdown of natural organic matter which litters the tundra surface or the forest floor. Although seldom encountered, except by the more inquisitive, these animals are of great importance to the continuation of life and the recycling of nutrients important to other larger biota. Terrestrial invertebrate populations in Alaska are perhaps as diverse as they are numerous, ranging from disease-causing bacteria in caribou to the ubiquitous mosquito, which occurs in nearly every habitat of the Yukon Region. Much of the diversity of birdlife in summer depends upon the abundance of insects, spiders, and mites for food. Saw flies are one of the most numerous insects and feed on willows. Other invertebrates, such as nematodes, are vital to the aeration and fertility of soil. They digest and break down accumulated plant detritus and recycle it into the soil where it becomes available for new plants.

The order Diptera is especially well represented in the Interior. The hoards of mosquitoes and midges are essential, however, to the seasonally abundant bird populations, particularly the small passerine species. Peak mosquito populations usually occur from mid-June to early July.

In alpine tundra environments, a variety of insects is attracted to scattered patches of snow that persist through summer. The arthropod fauna of isolated snow surfaces consists primarily of Dipteran and Hymenopteran species followed by Coleoptera and Hemiptera, the latter largely represented by aphids. These insects may drift onto the snow or are attracted toward the highly reflective snow surfaces (Edwards 1972), and provide food for such birds as water pipits, swallows, finches, ptarmigan, and snow buntings.

Plants on the tundra provide a favorable habitat for terrestrial fauna which feed on fungi and other plant tissues. These organisms seek shelter under lichens and mosses and among the roots of higher plants. Collembola feed on fungi, and together with mites are important in converting vegetation to animal matter. Collembola and mites are preyed upon by beetles, spiders, and other arthropods which, in turn, are preyed upon by such vertebrate animals as birds and small insectivorous mammals.

Insects are important food for Arctic grayling, whitefish, and other fish. Although larvae of many aquatic insects are the principal diet of many fish, their adult winged forms commonly are eaten by fish as they are blown or tumbled into the water.

Parasites of big game and other mammals have gained increasing attention in recent years (Neiland 1965, 1970, 1975; Neiland et al. 1968). These organisms inhabit the internal organs and tissues of caribou, moose, wolves, sled dogs, and even man. They include many species of bacteria, protozoans, tapeworms, flukes, hookworms, and others. The botfly (Oedamagena tarandi) may heavily infest the hide of caribou (Weber 1950). It and the blowfly are regularly associated with the carcasses of mammals.

Aquatic Communities

Aquatic environments of the Yukon Region are characterized by large alluvial basins containing numerous marshes, lakes, slow-moving streams, and bogs. Such areas support various and abundant bird, mammal, and fish populations. Surrounding uplands usually contain deeper lakes, swifter streams, and few marshlands and usually support a different fish fauna and generally few mammals and birds.

The composition, diversity, and distribution of aquatic plants reflect the integrated effect of exposure to or protection from wave action, local and regional drainage patterns, associated sediment transport and discharge, topography and sedimentary character of the bottom, and freezing and ice conditions.

The Yukon Region contains abundant productive fresh waters along its major rivers and in its alluvial basins. Productive soils and warm growing seasons in the Interior often give rise to lush growth of macrophytes.

Like other plants, aquatic vegetation requires solar energy, atmospheric gases, and chemical nutrients for photosynthesis. Solar radiation is abundant at the high latitudes of the Yukon Region, but may be intercepted by cloud cover, snow on ice, ice, water, and suspended and dissolved materials in water; all of which can absorb and decrease the solar energy available to aquatic vegetation.

Sufficient quantities of major nutrient elements such as nitrates and phosphates and such minor nutrients as trace metals dissolved in water control aquatic plant growth. These nutrients vary in concentration with mixing of water masses, biological utilization, and augmentation in runoff. Dissolved carbon dioxide is also essential for plant growth.

Aquatic vegetation provides important habitat and food for various animals. Aquatic invertebrates and young fish find shelter from predators among the stems of aquatic plants. The decay of these plants provides organic detritus which microscopic zooplankton feed upon. Waterfowl rest during migrations, feed, and often breed and nest in these habitats.

Plants

Although the climate of this region is severe, summers in the Interior are warm, and primary productivity in lakes and streams is not necessarily low. Maximum productivity values in summer for Tangle Lake were greater than most values previously measured in other high latitude lakes (Barsdate and Alexander 1971). The depth of the euphotic zone, where plants receive sufficient light for growth, varies greatly in these lakes. Relatively deep lakes at high elevation, such as Tangle Lake, may have euphotic zones from 16 to more than 33 feet (five to more than 10 m) deep while shallow lakes along the Yukon River, such as Smith Lake, may have very shallow euphotic zones of less than 6.5 feet (two m) due to waters highly colored by dissolved organic (humic) acids.

Very little phytoplankton production occurs during the dark winters in these lakes. Within the ice which covers lakes in this region, Barsdate and Alexander (1970) have found photosynthetic bacteria and the flagellate Chlamydomonas. Major production does not begin in these lakes until late April or early May when the flagellates Chlamydomonas, Euglena, Chlorella, and Mallomonas increase to produce a large bloom under the ice and along the shallow mud bottom surface. This bloom declines before the ice melts and is replaced immediately after the ice cover has completely melted by a large bloom of the blue-green algae, Anabaena flos-aquae. This bloom declines rapidly toward the end of June. Throughout the remainder of the summer, low populations of Aphanizomenon, Anabaena and Selenastrum are produced. In fall, a brief bloom of Gymnodinium has been recorded (Billaud 1968). Even such normally turbid waters as the Yukon River, which are clear in winter and early spring, may support growths of filamentous algae in spring.

During winter, oxygen may become depleted in some lake waters. In the absence of oxygen, nutrients such as nitrates may be changed into nitrogen gas, therefore yielding a loss of nutrients. Phytoplankton in lakes of this region appear to utilize ammonia as a nitrogen source more than nitrate. Maximum productivities of 635 mg carbon/m^2/day have been measured, although mean values closer to 360 mg carbon/m^2/day are more representative. It is estimated that average annual production is approximately 30 g carbon/m^2/year (Barsdate and Alexander 1971).

Rooted aquatic vegetation is abundant in many lakes and attains its peak standing crop near the end of August each year. Pondweeds, water lily, bladderwort, and water milfoil are common. Also important, although their contribution to a lake's total productivity is unknown, are the epiphytes and benthic algae which grow upon the rooted aquatic plants and bottom muds.

Animals

Plankton and macroinvertebrates

Zooplankton of the freshwater lakes and streams in this region have never been studied in detail, and little recorded information is available concerning their abundance and distribution. Hooper (1947) reports the presence of two species of rotifers but no cladocera or copepods from the lower Yukon River. Nauman and Kernodle (1974) report small numbers of copepods, cladocera and ostracods from the streams and lakes along the route of the Trans-Alaska Pipeline.

Benthic macroinvertebrates are common. Nauman and Kernodle (1974) report midges, stoneflies, caddisflies, mayflies, blackflies and freshwater mites in streams flowing south from the Brooks Range into the Yukon River along the Trans-Alaska Pipeline route. In lakes of this region, a variety of clams, snails, aquatic worms, and flatworms are common inhabitants. In rivers flowing northward from the Alaska Range into the Yukon River, Nauman and Kernodle (1964) found midges, caddisflies, and mayflies to be the predominant benthic invertebrates. The major contrast between these tributaries and those entering the Yukon from the north was that stoneflies were much less abundant in the tributaries entering from the south. Morrow (1971b) found mayflies the dominant benthic invertebrates in the Chatanika River in the early part of the summer, whereas midges became dominant as the summer progressed. Caddisflies and stoneflies were present in the lower portions of this drainage.

In the headwaters, stoneflies were dominant and blackfly larvae abundant, while mayfiles and midge larvae were scarce.

Fish

The most widely distributed fish in the Yukon River basin are several species of whitefish, Arctic grayling, slimy sculpin, burbot, Arctic lamprey, longnose sucker, northern pike, and three species of Pacific salmon--chum, king and silver. In winter, Arctic grayling may inhabit such large rivers as the Tanana and usually spawn in mid-June in smaller tributaries (Wojcik 1955). Grayling are found in every stream in the area that has sufficient flow during the summer.

Small, sometimes seasonal, clear spring-fed streams such as the small tributaries to Shaw Creek and the Goodpaster River, are vital for grayling spawning and rearing activities and are easily disturbed because of their small size. Shaw Creek is noted as an important grayling spawning area.

Tagging and migration studies conducted in the Tanana River drainage have shown that grayling have a complex migration pattern. The Goodpaster River and Shaw Creek serve as rearing areas for several streams, thus providing a substantial portion of the adult grayling for the Delta Clearwater, the Richardson Clearwater, and other rivers. Other streams in the area may serve similar functions. Grayling are known to overwinter in the lower 60 miles of the Chena River. Tagging studies have also shown that grayling have a tendency to remain in the same location year after year; this fact could allow detrimental activities to decimate the local population of a specific area.

Large numbers of anadromous lampreys on spawning migrations may be conspicuous in some years in the Yukon River. In addition, lake trout and lake chub occur in headwater portions of the Yukon River basin, including the Koyukuk and Tanana River drainages. Northern pike are found in most low-lying lakes in the area that are deep enough to support fish.

Inconnu are widespread in the Yukon River drainage and studies suggest that three populations inhabit the central Yukon and Tanana Rivers. One population consists of anadromous and migratory inconnu that summer and winter in the lower and central Yukon and Koyukuk Rivers and spawn mainly in the Koyukuk River and the Yukon River above Rampart. Inconnu found at the mouths of central Yukon tributaries in the summer either belong to this population or are local sub-populations that overwinter in the mainstem Yukon. A second stock inhabits the Chatanika River-Minto Flats area. A third group, whose spawning area has not been discovered, occurs in the Porcupine River drainage. Some overlap of range between these groups may occur in the middle Yukon River. Inconnu spawn in early October.

Major salmon-producing streams include the Kanuti, Koyukuk, Tanana, Chatanika, Salcha, Chena, Delta, and Goodpaster Rivers. Numerous small tributaries are also important. The Yukon River is primarily a migration corridor for salmon moving upstream to distant spawning areas.

Silver salmon are found throughout the Yukon River drainage in Alaska; their late spawning run has thwarted attempts to define their distribution and abundance in detail. The silver salmon run is characteristically about one week behind the fall chum salmon run. Silver salmon usually spawn in October and often into early November.

King salmon inhabit the entire Yukon River in Alaska, and significant spawning populations occur as far upstream as the Yukon Territory. They usually reach Rampart in late June, Nenana in late June or early July, the Chena River in late July, and the Salcha River in late July. Middle river spawners (Salcha River, Tanana River) normally peak from early to mid-August.

Chum salmon occur throughout the Yukon River drainage in Alaska, and some of these fish accomplish the longest spawning runs known for their species.

Two distinct major runs of chum salmon enter the Yukon River: summer run chums and fall run chums. Summer chums are chiefly characterized by their early run, (early June-mid-July), rapid maturation in freshwater, small size (6-7 pounds) and large population. Fall chums are mainly distinguished by their later run (mid-July-mid September), more uniform robust body shape, bright silvery appearance, large size of individuals (7-8 pounds), and small population. Summer run chums generally spawn in the lower and middle portion of the Yukon River watershed; whereas fall chums spawn primarily in tributaries farther upstream.

Spawning of summer chums in the middle Yukon River system (Salcha River, lower Tanana River) generally peaks from early to mid-August.

Fall run chum salmon spawn much later in the year, from September to mid-November. Those utilizing the lower Tanana River generally spawn from early to mid-October. Peak of spawning in the upper Tanana River extends from early to mid-November.

In years of abundance, the total number of chum salmon in the Yukon River system may number several million, and in such peak years as 1975 even approach ten million fish. Distribution of salmon spawning areas in the Yukon River drainage is not completely understood due to the sparse human habitation of most of this region, the late arrival of certain runs in upstream areas each season, and the turbidity of many waters of the Yukon River drainage which precludes easy visual observation.

More than 30 lakes and ponds along the Alaska Highway have been either stocked or both rehabilitated and stocked in order to provide sport fishing. Most are stocked with rainbow trout or coho salmon every year and are utilized by sport fishermen both in summer and winter. Most of these waters are near the highway and receive heavy use.

Birds

The interior valleys of the Koyukuk-Yukon-Tanana River systems are among the best nesting habitat for aquatic birds in the state. A million or more ponds are scattered over these warm valleys and provide nesting grounds for millions of waterfowl, shorebirds, and other aquatic birds.

Water--lakes, rivers, sloughs, and small streams--is perhaps the most important habitat factor. The quality of inland bird habitats depends more on the number of lakes and ponds than on the total area of water, and the best production occurs in habitats having a large number of small lakes. Large lakes are important to molting birds in summer and as staging areas for fall migrants. Other important staging areas are located along sandbars and islands of larger river systems.

The Yukon Flats covering 10,800 square miles (27,980 sq km) is probably the largest and most productive warm basin anywhere in the Arctic and is one of the two most important habitats of the Yukon Region. Water is the dominant feature of this habitat unit which contains thousands of lakes or ponds and is traversed by more than 25,000 miles (40,000 km) of streams.

The most productive ponds are usually separated from active stream channels, are flooded infrequently, and do not normally drain off into streams. During flood periods, the streams inundate lakes, ponds, and sloughs on the Flats and provide their water supply. Prolonged periods of receding water levels increase the concentration of nutrients and productivity of these "closed basins" (King and Lensink 1971). Lakes that normally drain into active channels lose their nutrients into the streams and are usually less productive.

Lakes and ponds in burned areas appear to be more fertile and productive than those in mature or climax forests. The soil is darkened by fire, making it warmer, and nitrogen appears to be released from burned and decaying vegetation--most of it perhaps into the air, but apparently nitrogen and nitrates are leached into nearby waters (Lutz 1956, Heinselman 1971, and Lensink personal communication). Differences in plant cover and interspersion of various vegetation types caused by differences in soils, drainage, erosion by streams, permafrost, and forest fires contribute to the productivity of the area for various forms of wildlife.

Most lakes are shallow or have extensive shallow margins which support a luxuriant growth of aquatic plants. Migratory birds prefer lakes where submerged pondweeds, water milfoil, and coontail are abundant and where shoreline vegetation is broken or only moderately dense.

The Yukon Flats are most important to aquatic birds for nesting and for rearing young. Even in years when drought eliminates many breeding areas to the south and scatters the birds which might have nested there, the Flats remain productive (Hansen and MacKnight 1964).

Large productive lakes on the Flats are important molting habitats for ducks in late summer, not only for those that nest or are raised there, but also for molting birds that arrive from distant areas.

Southward migrants concentrating in this fertile area comprise a significiant portion of the population in the fall of the year. Both ducks and geese are found in great numbers on many lakes, and on islands and bars of the Yukon River where migrating geese graze extensively on horsetails growing on dewatered mudflats. Many thousands of snow geese pass through during migration, and occasional small flocks of black brant are also observed in spring.

Waterfowl arrive on the Flats shortly before breakup in April or May, when the first snowmelt forms small ponds, and may remain until freezeup in October. Small ponds become ice-free relatively early and some of the ducks and geese found there in the spring are migrants that will continue farther north and west.

Numerous species of birds nest on the Yukon Flats, but waterfowl--ducks and geese--are the most conspicuous. Ducks are most abundant in shallow, fertile lakes at low elevations. American wigeon and lesser scaup predominate, followed by pintail, green-winged teal, white-winged scoters, and northern shovelers. About 50,000 canvasbacks--10 to 15 percent of the average North American population--nest on the Flats. Other species nest in lesser numbers.

About 8,000 Canada geese nest near the larger lakes, a smaller number of white-fronted geese nest near the perimeter of the area, and a few trumpeter swans nest in the larger lakes, usually on the banks of small wooded streams. An average of about 2.1 million ducks and geese leave the Yukon Flats in fall. Ducks raised there are known to migrate to 43 states in all flyways (King and Lensink 1971).

About 10,000 lesser sandhill cranes, 15,000 Arctic loons, and smaller numbers of common and red-throated loons nest on the Yukon Flats, usually on large deep lakes.

Horned and red-necked grebes, like ducks, are most abundant in shallow, fertile lakes. Grebes are shy and escape observation by hiding in vegetation or by prolonged submergence making estimates of their numbers impossible, but they occur on nearly every lake or pond and their numbers may exceed 100,000.

Few species of seabirds occur on the Flats or other Yukon areas, but herring, mew, and Bonaparte's gulls, Arctic terns, and long-tailed jaegers occur there, as well as approximately 28 species of shorebirds, such as golden plovers, spotted sandpipers, and several species of yellow-legs and phalaropes.

The Minto Flats, a smaller habitat unit, is even more productive on a unit area basis in good years than the Yukon Flats. This unit is subject to frequent severe spring flooding, however, which may eliminate almost all nesting activity for a season and limits the area's average productivity. The series of lakes and marshes near Tetlin is also well-known as habitat for aquatic birds, and large lakes there are used heavily by moulting ducks in summer. Species using these areas are similar to those using the Yukon Flats.

The Upper Yukon-Tanana River area contains many other smaller habitats, usually in broad stream valleys or margins of lakes, which support waterbirds of various species.

Mammals

Several species of mammals inhabit freshwater habitats of the Yukon Region for all or part of their life cycles.

Muskrats, mink, and river otters occur throughout the region. Muskrats occur in water areas sustaining succulent vegetation and are most common on such productive areas as the Yukon Flats, Minto Flats, and Tetlin area. Both mink and river otters are carnivorous and are common where prey is abundant along flowing streams or still waters.

Beaver feed on the inner bark of trees, usually birch, aspen, balsam poplar, or willow. They occur wherever there are slow-flowing or still waters and sufficient food. Although they can subsist on small trees of these species, they do not commonly inhabit tundra areas.

Moose are not truly aquatic but, in summary, they may spend much of their time in lakes, feeding on tuberous lily roots in relative freedom from fly and mosquito attack.

Populations

Table 2.2.2-3, Terrestrial, summarizes the abundance and distribution of conspicuous terrestrial animals along the proposed pipeline route in the Yukon (Interior) Basin region.

Aquatic

Two major river systems in this area support significant populations of fish--the Yukon and Tanana Rivers.

Along most of the main Yukon River, there are comparatively few small streams and a limited number of lakes. The Yukon River is used by king, silver, and chum salmon that migrate upstream to distant spawning grounds. The Yukon Flats contain a number of lakes and streams that provide excellent habitat for whitefish and northern pike. Arctic grayling, northern pike, and whitefish are found throughout the main drainage of the Yukon River.

Chum salmon spawn in a number of tributaries of the Tanana River. Silver salmon spawn and rear in the Chatanika and Salcha Rivers and Clearwater Creek. King salmon also spawn and rear in these streams, as well as the Goodpaster, Delta, and Chena Rivers. Arctic grayling, whitefish and northern pike are present throughout the area. Lake trout, inconnu, and cisco are scattered in the various drainages.

The Yukon River area (330,000 square miles) is too extensive to be surveyed completely for salmon spawning escapement in any one year. Poor survey conditions and turbid waters also make escapement estimates difficult. Escapement surveys are now conducted primarily by aerial reconnaissance for king, silver, and chum salmon in selected key "index" streams. Large areas still remain unsurveyed and each year's survey effort is likely to reveal previously undocumented spawning areas.

Tables 2.2.2-4 to 12 provide information on the distribution and abundance of fish in the Yukon (Interior) Basin Region. It should be pointed out that the spawning season of salmon in these streams is prolonged and no single count can be relied upon to reveal all fish that spawn in a section of stream during the season.

TABLE 2.2.2-3

ABUNDANCE AND DISTRIBUTION OF CONSPICUOUS TERRESTRIAL ANIMALS ALONG THE PROPOSED PIPELINE ROUTE--YUKON (INTERIOR) BASIN

Species	Abundance	Distribution
Mammals		
Snowshow hare	Variable	Not abundant along Koyukuk. Increase south and eastward. Some of the highest populations in the state are in the Tanana River Valley.
Beaver	Abundant	Abundant in Koyukuk, Yukon, and Lower Tanana River drainages. Chena River basin provides 14 percent of the state's harvest. Population low in the upper Tanana River drainage.
Muskrat	Abundant	Highest abundance along floodplains of major streams, particularly the Tanana River Valley. Tetlin and adjacent lakes are among the 5 most important areas of the state.
Coyote	Uncommon	Rare in Brooks Range. Generally low numbers south of Brooks Range.
Wolf	Common	About one per 125 square miles in the Brooks Range, more abundant to the south in Koyukuk and Tanana River Valleys.
Red fox	Common	Most abundant along Koyukuk River. Abundance variable elsewhere.

TABLE 2.2.2-3 (Cont'd)

Black bear	Common	Abundance not well known. Relatively common throughout, particularly in woodlands.
Grizzly bear	Common	About one per 50 square miles in south slopes of Brooks Range, fewer southward, particularly near human settlement.
Pine marten	Common	Good populations in mature spruce timber. Occur at densities of 1.5 to 4.4 per square mile.
Mink	Common	Particularly abundant along floodplains of Koyukuk River
Wolverine	Common	Densities variable, good habitat throughout the interior, particularly along the Tanana and Koyukuk Rivers.
River otter	Uncommon	Highest densities on the floodplains of the Koyukuk River.
Lynx	Common	Most abundant along the Yukon and lower Tanana Rivers.
Moose	Abundant	High populations in Koyukuk River drainage, moderately low between the Koyukuk and Yukon Rivers. Prime habitat south of the Tanana River.
Caribou	Abundant	Parts of the Porcupine herd of 150,000 and the Arctic herd of 100,000 animals winter along the Koyukuk River valley. Part of the Fortymile herd of 5,000 animals

TABLE 2.2.2-3 (Cont'd)

		winter in the Tanana Hills. The Delta, Mentasta and Chisana herds of 2,000, 1,000, and 1,000 animals respectively, occupy uplands, adjacent to the route along the Tanana River Valley. Areas critical to the above herds are distant from the route.
Bison	Uncommon	About 300 animals resulting from a transplant spend the winter adjacent to the route near Delta Junction.
Dall sheep	Abundant	Abundant in the mountains along the Dietrich River and in the Alaska Range south of the Tanana River.
Birds		
Ducks	Abundant	Densest populations occur in Yukon Flats (about 45 nesting ducks per square mile), the Minto Flats, Tetlin Lake and lake areas south of the Tanana River east of Tetlin Lake.
Geese	Abundant	Geese, mainly Canada and white-fronted, are distributed much like ducks, but in lower densities.
Swans	Uncommon	A few trumpeter swans are known to nest in marshy lakes along the Koyukuk, Yukon, and Tanana River Valleys.
Cranes	Abundant	Widely distributed birds on the mainland of Alaska.

TABLE 2.2.2-3 (Cont'd)

Other waterbirds	Abundant	Shorebirds, loons, and others nest in high densities associated with concentrations of nesting ducks, especially on the Yukon Flats, Minto Lakes, Tetlin Lake vicinity and eastward to the Canadian border.
Raptors	Common	Raptors, including the endangered arctic peregrine falcon, are known to nest on bluffs of major streams along the route. Seven nest sites have been identified along the Tanana River.
Grouse and Ptarmigan	Common	Spruce grouse occur throughout the region in spruce forest and both willow and rock ptarmigan occur in alpine tundra. Ruffed grouse and sharptail grouse are abundant in some years in the upper Tanana River Valley.
Other birds	Abundant	The broad valleys of the Yukon, Koyukuk and Tanana Rivers support large numbers of songbirds and other species. Varied bird life is a characteristic of the Koyukuk-Yukon-Tanana River Valley.

Areas of Critical Environmental Concern

Areas of critical environmental concern are shown graphically in volume 1A, page 1.

TABLE 2.2.2-4

ESTIMATED KING SALMON ESCAPEMENT--SALCHA RIVER

(Data obtained from aerial surveys--main stem of river only--represents peak counts.)

	Salcha River
1960	1,660
1961	2,878
1962	937
1963	
1964	450
1965	408
1966	800
1967	
1968	735
1969	461*
1970	1,882
1971	159*
1972	1,193
1973	249
1974	1,857

Source: Alaska Dept. of Fish and Game Records.

*Incomplete survey or poor survey, resulting in a minimum estimate.

TABLE 2.2.2-5

ESTIMATED CHUM SALMON ESCAPEMENT IN THREE YUKON (INTERIOR) STREAMS

(Counts obtained from aerial surveys and represent peak counts)

	Chena River	Salcha River	Tanana River
1960		670	
1961		1,152	
1962	402	1,161	862
1963	898		
1964		250	
1965		2,375	
1966		2,200	
1967			
1968		3,790	
1969		424*	
1970		7,879	800
1971		306*	
1972	670	947	19,657
1973		290	5,635**
1974		8,040	4,567**

Source: Alaska Dept. of Fish and Game Records.

*Poor survey conditions
**Survey from Richardson Highway Bridge to Blue Creek

TABLE 2.2.2-6

GRAYLING POPULATION ESTIMATES FOR CHENA RIVER,
SECTIONS 2a, 2b and 6*, 1968-1972. 1/

River Section	Year	Dates	Number of Arctic Grayling/km	Number of Arctic Grayling/mile
2a	1971	8/30-9/3	684	(1,095)
	1972	6/22-6/26	416	(666)
	1973		293	(469)
	1974		65	(104)
2b	1968		684	(1,095)
	1969		1,181	(1,890)
	1970	7/2-7/10	1,540	(2,465)
	1971a	6/2-6/7	2,036	(3,257)
	1971b	8/30-9/3	2,338	(3,741)
	1972	6/22-6/26	919	(1,471)
	1973		424	(679)
	1974		488	(780)
6	1968		282	(452)
	1969		571	(913)
	1970	5/26-5/30	481	(769)
	1971	6/21-6/24	368	(589)
	1972	6/19-6/20	207	(331)
	1973		243	(389)
	1974		100	(159)

* Section Locations
2a University Ave. to Peger Rd. (Fairbanks)
2b Peger Rd. to Wendel St. (Fairbanks)
6 Badger Slough to Little Chena

1) Source: Tack, S.L. 1973-1975. Distribution, Abundance, and Natural History of the Arctic Grayling in the Tanana River Drainage, Alaska Dept. of Fish and Game, Federal Aid in Fish Restoration, Volumes 14-16.

TABLE 2.2.2-7

GRAYLING POPULATION ESTIMATES (SCHNABEL METHOD)
FOR THE CHATANIKA, SALCHA AND GOODPASTER RIVERS, 1972. 1/

River	Inclusive Dates of Sampling	Number of Arctic Grayling/km	Number of Arctic Grayling/mile
Chatanika, Vicinity of Elliot Hwy Bridge	8/10-8/17	305	(488)
Salcha, Vicinity of Redmond Creek	8/2-8/4	503	(805)
Goodpaster, Vicinity of Jolly's Cabins	7/12-7/14	189	(303)

1) Source: Tack, S.L. 1973. Distribution, Abundance, and Natural History of the Arctic Grayling in the Tanana Drainage. Alaska Dept. of Fish and Game, Federal Aid in Fish Restoration, Annual Progress Reports, Volume 13.

TABLE 2.2.2-8

CALCULATED ARCTIC GRAYLING POPULATION ESTIMATES FOR 185 km OF THE GOODPASTER RIVER, 1974. 1/

Area	km	Petersen Total Population Estimate (Number of fish)	Number of Arctic Grayling/km
1*	53	10,648	201
2**	45	13,412	298
3***	87	3,381	39
Combined Areas	185	27,441	148

* Between mouth and confluence of North and South forks.
** North Fork between confluence and Central Creek.
*** North Fork between Central Creek and Lower Eisenmenger Fork.

1/ Source: Tack, S.L. 1974. Distribution, Abundance, and Natural History of the Arctic Grayling in the Tanana Drainage. Alaska Dept. of Fish and Game, Federal Aid in Fish Restoration, Annual Progress Reports, Volume 16.

TABLE 2.2.2-9

CONCENTRATIONS OF SPAWNING FISH
ON THE UPPER CHATANIKA RIVER, 1972

(Numbers refer to kilometers above and below Olnes Bridge. Plus (+) = upstream from Olnes Bridge, Minus (-) downstream distance. 1/

Location (km)	Species Present	Length of Spawning Area in m	Estimates of Abundance
(+) 2.62	LCi, HWF	100	1,000 LCi, 500 HWF
(+) 2.82	LCi, HWF	100	500 LCi, 500+ HWF
(+) 3.38	LCi, HWF	200	1,000 LCi, 500+ HWF
(+) 3.86	LCi, HWF, SF	300	mainly HWF, 20 SF
(+) 4.43	LCi, HWF	300	1,000 LCi, 500 HWF
(+) 7.24	LCi, HWF	200	1,000+ LCi
(+) 11.47	HWF, SF	500	= *2,000 HWF, 30 SF
(+) 11.64	LCi, HWF	200	500 LCi, 300 HWF
(-) 1.01	LCi, HWF	100	500 LCi, 400 HWF
(-) 1.61	LCi, HWF, SF	400	= *1,500 LCi, 500 HWF
(-) 2.01	LCi, HWF	200	1000+ LCi
(-) 2.61	LCi, HWF	800	2,0000 LCi, 500 HWF
(-) 5.54	LCi, HWF	300	500+ LCi
(-) 7.34	LCi, HWF	200	1,000 LCi
(-) 7.74	LCi, HWF	200	1,000 LCi, 500 HWF

TABLE 2.2.2-9 (Cont'd)

(-)	9.56	LCi, HWF	200	1,000 LCi
(-)	11.37	LCi, HWF	100	500 LCi
(-)	13.78	LCi	200	1,500 LCi, 500 + HWF
(-)	15.91	LCi	200	1,000 LCi
			TOTALS	LCi - 16,500 HWF - 6,700 SF - 50

*Estimated by Schnabel tag-recovery method; other estimates by visual counts.

**LCi - Least Cisco; HWF - humpback; SF - sheefish whitefish

1/ Source: Kepler, P., 1973. Population Studies of Northern Pike and Whitefish in the Minto Flats Complex with Emphasis on the Chatanika River, Federal Aid in Fish Restoration, Annual Progress Reports, Volume 14.

TABLE 2.2.2-10

DISTRIBUTION AND ABUNDANCE OF FISH SPECIES IN THE CENTRAL YUKON BASIN

Species	Form	Abundance	Distribution
Lake trout	R	Moderate	Found in most of the larger foothill lakes and many of the smaller lakes in the Yukon Flats.
Char	R	Low	Found in isolated populations in several tributary streams. Confusion in this area between Arctic char and Dolly varden.
Arctic grayling	R	High	Universally distributed in clear water systems and tributaries.
Whitefish	R	High	Universally distributed in most drainages.
Inconnu	R,A	Moderate	Found in most major systems and at the mouths of smaller tributary streams.
Northern pike	R	High	Universally distributed in lowland lakes and streams. Also found in lakes and sloughs throughout area.
Burbot	R	Moderate	Distributed throughout area. Koyukuk River system noted for proportionately greater populations than other areas.
Sturgeon	A	Unknown-low	Distribution and range unknown. Reported in several systems.

A = Anadromous
R = Resident

TABLE 2.2.2-11

DISTRIBUTION AND ABUNDANCE OF FISH SPECIES IN THE TANANA DRAINAGE

Species	Form	Abundance	Distribution
Rainbow trout	R	Moderate-high	Occurs in the Interior only in stocked lakes.
Lake trout	R	Moderate-low	Found in deeper lakes mostly inaccessible.
Dolly varden char	R	Low	Isolated populations in tributary streams.
Landlocked silver salmon	R	Moderate	Found in a few stocked lakes.
Arctic grayling	R	High-very high	Found in all streams and tributaries.
Whitefish	R	High-very high	Found in all systems and tributaries.
Inconnu	R	Low	Found in some major systems.
Northern pike	R	High-very high	In majority of lakes and ponds at low elevations, as well as in sloughs and back-waters of larger rivers.
Burbot	R	High	In most deep lakes and sloughs of large rivers and streams.

R = Resident

TABLE 2.2.2-12

KNOWN CRITICAL AREAS FOR ARCTIC CHAR

System	Spawning No. of Sites	Spawning No. of Fish	Overwintering No. of Sites	Overwintering No. of Fish
Accomplishment Creek	1	2000-3000	1*	100-1000
Ribdon River			2	100-1000
Lupine River			1	100-1000
Saviukviayak River			1	less than 100
Flood Creek	1	100-1000	1*	100-1000
Ivishak River	5	unknown	5	one major w/ 71,000
Echooka River	1	100-1000		
Sagavanirktok River			1	unknown
Shaviovik River	1	more than 1000	1*	more than 1000

(Source: McCart, P.J. Classification of streams in Beaufort Sea drainages and distribution of fish in Arctic and Sub-Arctic drainages. Canadian Arctic Gas Study. Ltd. Biol. Rep. Ser. Vol. 15.)

*Single site serves as both spawning and overwintering area.

The Ivishak River, one of the most important streams in the region, may be used by populations from other tributaries as overwinter site.

The Echooka River is a spring fed region and is also used for rearing.

The entire delta region of the Sagavanirktok River is used for overwintering.

Species and Ecosystems Summary

The following tables identify those species and ecosystems along the proposed pipeline route which might be affected by the construction, operation, and maintenance of the pipeline. Tables 2.2.2-13a through 2.2.2-26 list the species in groupings of natural community associations, regionally divided between the Arctic (north of the Brooks Range Crest) and the Yukon (or Interior) Basin. Tables 2.2.2-18 and 2.2.2-26 cite species of commercial, subsistence, and recreational importance to their respective regions. Maps on pages 10 and 11 in volume 1A illustrate the range of significant Alaskan mammals in relation to the proposed pipeline route. The map on page 13, volume 1A, illustrates critical waterfowl and fish habitat. Plant communities and a general species distribution map is included on page 12 of volume 1A.

IMPORTANT SPECIES OF TERRESTRIAL COMMUNITIES
IN THE ARCTIC REGION
TABLE 2.2.2-13,a THROUGH TABLE 2.2.2-18

TABLE 2.2.2-13,a

<u>Wet Tundra</u> - <u>Plants</u>

Lichens and mosses	
Mosses	Sphagnum spp.
Grasses and sedges	
Cottongrass	Eriophorum angustifolium
Sedges	Carex spp.
Juncus	Juncus biglumis
Rush	Luzula arctica
Herbs	
Marsh marigold	Caltha palustris arctica
Snow buttercup	Rannunculus nivalis
Purple mountain saxifrage	Saxifraga oppositifolia
Bog rosemary	Andromeda polifolia
Cloudberry	Rubus chamaemorus
Lousewort	Pedicularis parviflora pennellii
Shrubs	
Four-angled heather	Cassiope tetragona
Willows	Salix spp.
Lingonberry	Vaccinium vitis-idaea

TABLE 2.2.2-13,b

Wet Tundra - Animals

Mammals	
Shrews	Soricidae (Family)
Lemmings and voles	Cricetidae (Family)
Wolf	Canis lupus
Arctic fox	Alopex lagopus
Grizzly bear	Ursus arctos
Polar bear	Thalarctos maritimus
Weasels	Mustelidae (Family)
Wolverine	Gulo gulo
Caribou	Rangifer tarandus
Birds	
Loons	Gavia spp.
Whistling swan	Olor columbianus
Pintail	Anas acuta
Oldsquaw	Clangula hyemalis
Steller's eider	Polysticta stelleri
King eider	Somateria spectabilis
Spectacled eider	Lampronetta fishcheri
Marsh hawk	Circus cyaneus
Snipe	Capella gallinago
Pectoral sandpiper	Calidris melanotos
Baird's sandpiper	Erolia bairdii
Dunlin	E. alpina
Semipalmated sandpiper	Ereunetes pusillus
Long-billed dowitcher	Limnodromus scolopaceus
Red phalarope	Phalaropus fulicarius
Jaegers	Stercorarius spp.
Glaucous gull	Larus hyperboreus
Arctic tern	Sterna paradisaea
Snowy owl	Nyctea scandiaca
Invertebrates	
Spiders and mites	Arachnida
Insects	Insecta
Flatworms	Platyhelminthes
Roundworms	Nematoda

TABLE 2.2.2-14,a

Moist Tundra - Plants

Lichens and mosses	
Mosses	Sphagnum spp.
Grasses and sedges	
Sedge	Carex bigelowii
Cottongrass	Eriophorum vaginatum
Herbs	
Dryas	Dryas spp.
Cloudberry	Rubus chamaemorus
Bistort	Polygonum bistorta
Stiff stemmed saxifrage	Saxifraga hieracifolia
Shrubs	
Dwarf birch	Betula nana
Willows	Salix spp.
Labrador tea	Ledum palustre
Crowberry	Empetrum nigrum

TABLE 2.2.2-14,b

Moist Tundra - Animals

Mammals	
Shrews	Soricidae (Family)
Arctic ground squirrel	Citellus parryi
Lemmings and voles	Cricetidae (Family)
Wolf	Canis lupus
Arctic fox	Alopex lagopus
Red fox	Vulpes fulva
Grizzly bear	Ursus arctos
Weasels	Mustelidae (Family)
Wolverine	Gulo gulo
Caribou	Rangifer tarandus
Muskox	Ovibos moschatus
Birds	
White-fronted goose	Anser albifrons
Pintail	Anas acuta
Oldsquaw	Clangula hyemalis
Steller's eider	Polysticta stelleri
King eider	Somateria spectabilis
Spectacled eider	Lampronetta fischeri
Marsh hawk	Circus cyaneus
Pectoral sandpiper	Calidris melanotos
Dunlin	C. alpina
Semipalmated sandpiper	C. pusillus
Jaegers	Stercorarius spp.
Glaucous gull	Larus hyperboreus
Sabine's gull	Xema sabini
Snowy owl	Nyctea scandiaca
Raven	Corvus corax
Lapland longspur	Calcarius lapponicus
Snow bunting	Plectrophenax nivalis
Invertebrates	
Spiders and mites	Arachnida (Class)
Insects	Insecta (Class)
Flatworms	Platyhelminthes (Phylum)
Roundworms	Nematoda (Class)

TABLE 2.2.2-15,a

High Brush - Plants

Lichens and mosses	
Lichens	Cladonia spp.
	Sterocaulon spp.
Mosses	Sphagnum spp.
Ferns and fern allies	
Horsetail	Equisetum arvense
Grasses and sedges	
Alpine bluegrass	Poa alpina
Grass	Agropyron macrourum
Sedge	Carex aquatilis
Herbs	
Dwarf fireweed	Epilobium latifolium
Monkshood	Aconitum delphinifolium
Milkvetch	Astragalus eucosmus
Shooting star	Dodecatheon frigidum
Lupine	Lupinus arcticus
Shrubs	
Alder	Alnus crispa
Willows	Salix spp.
Buffaloberry	Shepherdia canadensis
Rose	Rosa acicularis
Trees	
Cottonwood	Populus balsamifera

TABLE 2.2.2-15,b

High Brush - Animals

Mammals	
Shrews	Soricidae (Family)
Ground squirrel	Citellus parryi
Lemmings and voles	Cricetidae (Family)
Porcupine	Erethizon dorsatum
Wolf	Canis lupus
Red fox	Vulpes fulva
Grizzly bear	Ursus arctos
Weasels	Mustelidae (Family)
Wolverine	Gulo gulo
Otter	Lutra canadensis
Lynx	Lynx canadensis
Moose	Alces alces
Birds	
Willow ptarmigan	Lagopus lagopus
Short-eared owl	Asio flammeus
Common raven	Corvus corax
Robin	Turdus migratorius
Gray-cheeked thrush	Hylocichla minima
Arctic warbler	Phylloscopus borealis
Yellow wagtail	Motacilla flava tschutschensis
Northern shrike	Lanius excubitor
Redpoll	Acanthis hornemanni
Savannah sparrow	Passerculus sandwichensis
Tree sparrow	Spizella ochracea
White-crowned sparrow	Zonotrichia leucophrys
Fox sparrow	Passerella iliaca
Invertebrates	
Spiders and mites	Arachnida (Class)
Insects	Insecta (Class)
Flatworms	Platyhelminthes (Phylum)
Roundworms	Nematoda (Class)

TABLE 2.2.2-16,a

Alpine Tundra - Plants

Lichens and mosses	
Lichens (reindeer moss)	Cladonia spp.
	Cetraria spp.
Mosses	Sphagnum spp.
Ferns and fern allies	
Club moss	Lycopodium spp.
Ferns	Cystopteris fragilis
Grasses and sedges	
Grasses	Festuca brachyphylla
	Poa arctica
Sedges	Carex spp.
Herbs	
Bistort	Polygonum viviparum
Moss campion	Silene acaulis
Purple mountain saxifrage	Saxifraga oppositifolia
Spider plant	S. flagellaris
Dryas	Dryas spp.
Wooly lousewort	Pedicularis kanei
Shrubs	
Willows	Salix spp.
Dwarf birch	Beutla nana
Crowberry	Empetrum nigrum
Labrador tea	Ledum palustre
Lapland rosebay	Rhododendron lapponicum
Four-angled heather	Cassiope tetragona
Cranberry	Vaccinium vitis-idaea
Blueberry	Vaccinium uliginosum
Alpine bearberry	Arctostaphylos alpina

TABLE 2.2.2-16,b

Alpine Tundra - Animals

Mammals	
Shrews	Soricidae (Family)
Hoary marmot	Marmota caligata
Lemmings and voles	Cricetidae (Family)
Wolf	Canis lupus
Red fox	Vulpes fulva
Brown grizzly bear	Ursus arctos
Wolverine	Gulo gulo
Dall sheep	Ovis dalli
Birds	
Canada goose	Branta canadensis
Rough-legged hawk	Buteo lagopus
Golden eagle	Aquila chrysaetos
Gyrfalcon	Falco rusticolus
Peregrine falcon	F. peregrinus
Rock ptarmigan	Lagopus mutus
Golden plover	Pluvialis dominica
Whimbrel	Numenius phaeopus
Baird's sandpiper	Erolia bairdii
Semipalmated sandpiper	Ereunetes pusillus
Redpoll	Acanthis hornemanni
Savannah sparrow	Passerculus sandwichensis
Snow bunting	Plectrophenax nivalis
Tree sparrow	Spizella arborea
Lapland longspur	Calcarius lapponicus
Invertebrates	
Spiders and mites	Arachnida (Class)
Insects	Insecta (Class)
Flatworms	Platyhelminthes (Phylum)
Roundworms	Nematoda (Class)

TABLE 2.2.2-17,a

Freshwater Plants

Diatoms	Bacillariophyceae (Class)
Golden algae	Chrysophyceae (Class)
Cryptomonads	Cryptomonas sp.
	Rhodomonas minuta
Dinoflagellates	Dinoflagellata (Class)
Green algae	Chlamydomonas sp.
	Pyramidomonas sp.
	Ankistrodesmus sp.
Blue-green algae	Cyanophyta (Phylum)
Mare's tail	Hippuris vulgaris
Pendent grass	Arctophila fulva
Pondweeds	Potamogeton spp.
Crow foot	Ranunculus pallasii
Burreed	Sparganium sp.
Sedge	Carex aquatilis
Cottongrass	Eriophorum scheutzeri
Marigold	Caltha sp.
Foxtail	Alopecurus sp.
Tundra grass	Dupontia fischeri

TABLE 2.2.2-17,b

Freshwater Animals

Invertebrates	
Bacteria	Schizomycetes (Phylum)
Rotifers	Rotifera (Class)
Flagellates	Mastigophora (Phylum)
Ciliates	Ciliophora (Phylum)
Aquatic worms	Plesiopora (Order)
Crusteceans	Copepoda (Class)
	Cladocera (Order)
	Ostracoda (Class)
	Anostraca (Order)
	Notostraca (Order)
Midge larvae	Chironomidae (Family)
Cranefly larvae	Tipulidae (Family)
Mosquito larvae	Culicidae (Family)
Dragonfly larvae	Odonata (Order)
Stonefly larvae	Plecoptera (Order)
Mayfly larvae	Ephemeroptera (Order)
Caddisfly larvae	Trichoptera (Order)
Beetles	Coleoptera (Order)
Water mites	Hydracarina (Family)
Snails	Gastropoda (Class)
Fish	
Arctic char	Salvelinus alpinus
Lake trout	S. namaycush
Arctic grayling	Thymallus arcticus
Scuplin	Cottidae (Family)
Whitefish and cisco	Coregonus spp.
Burbot	Lota lota
Ninespine stickleback	Pungitius pungitius
Waterfowl	
Oldsquaw	Clangula hyemalis
King eider	Somateria spectabilis
Whisting swan	Olor columbianus
Pintail	Anas acuta
American green-winged teal	A. crecca
White-fronted goose	Anser albifrons
Canada goose	Branta canadensis
Black brant	B. nigricans

TABLE 2.2.2-18

SPECIES OF COMMERCIAL, SUBSISTENCE, AND RECREATIONAL IMPORTANCE IN THE ARCTIC REGION

Commercial	
Arctic fox	Alopex lagopus
Subsistence	
Leaves and young shoots of spring plants	
Medicinal herbs	
Starchy roots	
Crowberry	Empetrum nigrum
Blueberry	Vaccinium uliginosum
Grasses	
Willows	Salix spp.
Caribou	Rangifer tarandus
Wolf	Canis lupus
Wolverine	Gulo gulo
Arctic fox	Alopex lagopus
Red fox	Vulpes fulva
Ptarmigan	Lagopus spp.
Owls	Strigidae (Family)
Waterfowl	Anatidae (Family)
Bird eggs	
Whitefish and cisco	Coregonus spp.
Arctic char	Salvelinus alpinus
Smelt	Osmerus mordax
Recreational/Sport	
Caribou	Rangifer tarandus
Grizzly bear	Ursus arctos
Dall sheep	Ovis dalli
Moose	Alces alces
Wolf	Canis lupus
Waterfowl	Anatidae (Family)
Lake trout	Salvelinus namaycush
Arctic char	S. alpinus
Arctic grayling	Thymallus arcticus

IMPORTANT SPECIES OF TERRESTRIAL COMMUNITIES IN THE YUKON REGION

TABLES 2.2.2-19,a THROUGH 2.2.2-26

TABLE 2.2.2-19,a

Alpine Tundra

Plants

Mosses and lichens	
Lichens	
Mosses	
Grasses and sedges	
Sedges	Carex spp.
Grasses	
Herbs	
Dryas	Dryas spp.
Moss campion	Silene acaulis
Oxytropes	Oxytropis spp.
Minuartia	Minuartia arctica
Shrubs	
Resin birch	Betula glandulosa
Dwarf birch	B. nana
Crowberry	Empetrum nigrum
Alpine azalea	Loiseleuria procumbens
Labrador tea	Ledum palustre
Mountain heather	Phyllodoce spp.
Willows	Salix spp.
Blueberry	Vaccinium uliginosum
Bearberry	Arctostaphylos alpina
Cassiopes	Cassiope spp.

TABLE 2.2.2-19,[b]

<u>Alpine Tundra</u> - <u>Animals</u>

Mammals	
Tundra shrew	Sorex tundrensis
Pika	Ochotona collaris
Hoary marmot	Marmota caligata
Arctic ground squirrel	Citellus parryi
Greenland collared lemming	Dicrostonyx groenlandicus
Alaska vole	Microtus miurus
Gray wolf	C. lupus
Black bear	Ursus americanus
Grizzly bear	U. arctos
Ermine	Mustela erminea
Wolverine	Gulo gulo
Moose	Alces alces
Caribou	Rangifer tarandus
Dall sheep	Ovis dalli
Birds	
Marsh hawk	Circus cyaneus
Rough-legged hawk	Buteo lagopus
Gyrfalcon	Falco rusticolus
Rock ptarmigan	Lagopus mutus
Golden eagle	Aquila chrysaetos
American golden plover	Pluvialis dominica
Wandering tattler	Heteroscelus incanus
Horned lark	Eremophila alpestris
Cliff swallow	Petrochelidon pyrrhonota
Common raven	Corvus corax
Water pipit	Anthus spinolettus
Gray-crowned rosy finch	Leucosticte tephrocotis
Savannah sparrow	Passerculus sandwichensis
Tree sparrow	Spizella arborea
Golden-crowned sparrow	Zonotrichia atricapilla
Lapland longspur	Calcarius lapponicus
Snow bunting	Plectrophenax nivalis
Invertebrates	
Bacteria	Schizomycetes (Phylum)
Protozoans	Protozoa (Phylum)
Flukes	Trematoda (Class)
Tapeworms	Cestoda (Class)
Roundworms	Nematoda (Phylum)
Earthworms	Oligochaeta (Class)

TABLE 2.2.2-19,b

Alpine Tundra - Animals (Cont'd.)

Invertebrates (cont'd)	
Spiders and mites	Arachnida (Class)
Dragonflies	Odonata (Order)
True bugs	Hemiptera (Order)
Beetles	Coleoptera (Order)
Butterflies and moths	Lepidoptera (Order)
True flies (mosquitoes)	Diptera (Order)
Ants, bees, and wasps	Hymenoptera (Order)

TABLE 2.2.2-20,a

Lowland Spruce-Hardwood Forest - Plants

Mosses and lichens	
Mosses	Sphagnum spp.
Lichens	
Ferns and fern allies	
Ferns	
Horsetails	Equisetum spp.
Grasses and sedges	
Cottongrass	Eriophorum spp.
Herbs	
Fireweed	Epilobium angustifolium
Shrubs	
Willows	Salix spp.
Dwarf birch	Betula nana
Blueberries	Vaccinium spp.
Lingonberry	V. vitis-idaea
Labrador tea	Ledum palustre
Crowberry	Empetrum nigrum
Bearberries	Arctostaphylos spp.
Trees	
Black spruce	Picea mariana
White spruce	P. glauca
Tamarack	Larix laricina
Paper birch	Betula papyrifera
Quaking aspen	Populus tremuloides
Balsam poplar	P. balsamifera

TABLE 2.2.2-20,b

Lowland Spruce-Hardwood Forest - Animals

Mammals	
Masked shrew	Sorex cinereus
Dusty shrew	S. obscurus
Snowshoe hare	Lepus americanus
Red squirrel	Tamiasciurus hudsonicus
Red-backed vole	Clethrionomys rutilus
Porcupine	Erethizon dorsatum
Coyote	Canis latrans
Gray wolf	C. lupus
Red fox	Vulpes fulva
Black bear	Ursus americanus
Grizzly bear	U. arctos
Pine marten	Martes americana
Ermine	Mustela erminea
Wolverine	Gulo gulo
Lynx	Lynx canadensis
Moose	Alces alces
Birds	
Common loon	Gavia immer
Arctic loon	G. arctica
Red-necked grebe	Podiceps grisegena
Horned grebe	P. auritus
Whistling swan	Olor columbianus
Trumpeter swan	O. buccinator
Canada goose	Branta canadensis
Mallard	Anas platyrhyncos
Pintail	A. acuta
American wigeon	A. americana
Northern shoveler	A. clypeata
American green-winged teal	A. crecca
Canvasback	Aythya valisineria
Lesser scaup	A. affinis
Common goldeneye	Bucephala clangula
Oldsquaw	Clangula hyemalis
White-winged scoter	Melanitta deglandi
Surf scoter	M. perspicillata
Goshawk	Accipiter gentilis
Sharpshinned hawk	A. striatus
Peregrine falcon	Falco peregrinus
Boreal owl	Aegolius funereus
Spruce grouse	Canachites canadensis
Downy woodpecker	Dendrocopus pubescens
Lesser sandhill crane	Crus canadensis
Spotted sandpiper	Actitis macularia
Lesser yellowlegs	Totanus flavipes
Northern phalarope	Lobipes lobatus
Common snipe	Capella gallinago

TABLE 2.2.2-20,b (Cont'd)

Lowland Spruce-Hardwood Forest - Animals

Bonaparte's gull	L. philadelphia
Arctic tern	Sterna paradisaea
Great horned owl	Bubo virginianus
Hawk-owl	Surnia ulula
Belted kingfisher	Megaceryle alcyon
Yellow-shafted flicker	Colaptes auratus
Hairy woodpecker	Dendrocopos villosus
Northern three-toed woodpecker	Picoides tridactylus
Tree swallow	Iridoprocne bicolor
Gray jay	Perisoreus canadensis
Common raven	Corvus corax
Black-capped chickadee	Parus atricapillus
Robin	Turdus migratorius
Varied thrush	Ixoreus naevius
Hermit thrush	Catharus guttatus
Swainson's thrush	C. ustulatus
Ruby-crowned kinglet	Regulus calendula
Orange-crowned warbler	Vermivora celata
Myrtle warbler	Dendroica coronata
Blackpoll warbler	D. striata
Northern waterthrush	Seiurus noveboracensis
Pine grosbeak	Pinicola enucleator
White-winged crossbill	Loxia leucoptera
Slate-colored junco	Junco hyemalis
White-crowned sparrow	Zonotrichia leucophrys
Mull gull	Larus canus
Invertebrates	
Bacteria	Schizomycetes (Phylum)
Protozoans	Protozoa (Phylum)
Flukes	Trematoda (Class)
Tapeworms	Cestoda (Class)
Roundworms	Nematoda (Phylum)
Earthworms	Oligochaeta (Class)
Spiders and mites	Arachnida (Class)
Dragon flies	Odonata (Order)
True bugs	Hemiptera (Order)
Beetles	Coleoptera (Order)
Butterflies and moths	Lepidoptera (Order)
True flies (mosquitoes)	Diptera (Order)
Ants, bees, and wasps	Hymenoptera (Order)

TABLE 2.2.2-21,a

Upland Spruce-Hardwood Forest - Plants

Mosses and lichens	
Mosses	
Ferns and fern allies	
Ferns	
Horsetails	Equisetum spp.
Grasses and sedges	
Bluejoint grasses	Calamagrostis spp.
Herbs	
Fireweed	Epilobium angustifolium
Shrubs	
Willows	Salix spp.
Alders	Alnus spp.
Roses	Rosa spp.
High bush cranberry	Viburnum edule
Currants	Ribes spp.
Labrador tea	Ledum palustre
Raspberry	Rubus idaeus
Lingonberry	Vaccinium vitis-idaea
Trees	
White spruce	Picea glauca
Black spruce	P. mariana
Paper birch	Betula papyrifera
Quaking aspen	Populus tremuloides
Balsam poplar	P. balsamifera

TABLE 2.2.2-21,b

Upland Spruce-Hardwood Forest - Animals

Mammals	
Masked shrew	Sorex cinereus
Dusky shrew	S. obscurus
Little brown bat	Myotis lucifugus
Snowshoe hare	Lepus americanus
Red squirrel	Tamiasciurus hudsonicus
Northern flying squirrel	Glaucomys sabrinus
Red-backed vole	Clethrionomys rutilus
Yellow-cheeked vole	Microtus zanthognathus
Meadow jumping mouse	Zapus hudsonius
Porcupine	Erethizon dorsatum
Coyote	Canis latrans
Gray wolf	C. lupus
Red fox	Vulpes fulva
Black bear	Ursus americanus
Grizzly bear	U. arctos
Pine marten	Martes erminea
Least weasel	M. rixosa
Wolverine	Gulo gulo
Lynx	Lynx canadensis
Moose	Alces alces
Caribou	Rangifer tarandus
Bison	Bison bison
Birds	
Common goldeneye	Bucephala clangula
Barrow's goldeneye	B. islandica
Bufflehead	B. albeola
Harlequin duck	Histrionicus histrionicus
Goshawk	Accipiter gentilis
Sharpshinned hawk	A. striatus
Rough-legged hawk	Buteo lagopus
Osprey	Pandion haliaetus
Peregrine falcon	Falco peregrinus
Spruce grouse	Canachites canadensis
Willow ptarmigan	Lagopus lagopus
Boreal owl	Aegolius funereus
Great horned owl	Bubo virginianus
Downy woodpecker	Dendrocopus pubescens
Hawk-owl	Surnia ulula
Yellow-shafted flicker	Colaptes auratus
Hairy woodpecker	Dendrocopos villosus
Northern three-toed woodpecker	Picoides tridactylus
Barn swallow	Hirundo rustica
Cliff swallow	Petrochelidon pyrrhonota
Tree swallow	Iridoprocne bicolor

TABLE 2.2.2-21,b (Cont'd)

Upland Spruce-Hardwood Forest - Animals

Barn swallow	Riparia riparia
Gray jay	Perisoreus canadensis
Common raven	Corvus corax
Black-capped chickadee	Parus atricapillus
Boreal chickadee	P. hudsonicus
Robin	Turdus migratorius
Varied thrush	Ixoreus naevius
Hermit thrush	Cathrus guttatus
Swainson's thrush	C. ustulatus
Ruby-crowned kinglet	Regulus calendulus
Northern shrike	Lanius excubitor
Myrtle warbler	Dendroica coronata
Blackpoll warbler	D. striata
Northern waterthrush	Seiurus noveboracensis
Pine grosbeak	Pinicola enucleator
Hoary redpoll	Acanthis hornemanni
Common redpoll	A. flammea
White-winged crossbill	Loxia leucoptera
Slate-colored junco	Junco hyemalis
White-crowned sparrow	Zonotrichia leucophrys
Invertebrates	
Bacteria	Schizomycetes (Phylum)
Protozoans	Protozoa (Phylum)
Flukes	Trematoda (Class)
Tapeworms	Cestoda (Class)
Roundworms	Nematoda (Phylum)
Earthworms	Oligochaeta (Class)
Spiders and mites	Arachnida (Class)
Dragonflies	Odonata (Order)
True bugs	Hemiptera (Order)
Beetles	Coleoptera (Order)
Butterflies and moths	Lepidoptera (Order)
True flies (mosquitoes)	Diptera (Order)
Ants, bees, and wasps	Hymenoptera (Order)

TABLE 2.2.2-22,a

Low Brush-Muskeg Bog - Plants

Mosses and lichens	
Mosses	Sphagnum spp.
Lichens	
Grasses and sedges	
Sedges	Carex spp.
Rushes	Juncus spp.
Cottongrasses	Eriophorum spp.
Shrubs	
Labrador tea	Ledum palustre
Crowberry	Empetrum nigrum
Willows	Salix spp.
Bog cranberry	Oxycoccus microcarpus
Blueberries	Vaccinium spp.
Roses	Rosa spp.
Resin birch	Betula glandulosa
Dwarf birch	B. nana
Bog rosemary	Andromeda polifolia
Alders	Alnus app.
Soapberry	Shepherdia canadensis
Cassandra	Chamaedaphne calyculata
Trees	
Black spruce	Picea mariana
Tamarack	Larix laricina

TABLE 2.2.2-22,b

Low Brush-Muskeg Bog - Animals

Mammals	
Masked shrew	Sorex cinereus
Snowshoe hare	Lepus americanus
Northern bog lemming	Synaptomys borealis
Meadow vole	Microtus pennsylvanicus
Tundra vole	M. oeconomus
Coyote	Canis latrans
Gray wolf	C. lupus
Black bear	Ursus americanus
Grizzly bear	U. arctos
Ermine	Mustela erminea
Wolverine	Gulo gulo
Lynx	Lynx canadensis
Caribou	Rangifer tarandus
Birds	
Common loon	Gavia immer
Arctic loon	G. arctica
Red-necked grebe	Podiceps grisegena
Horned grebe	P. auritus
Whistling swan	Olor columbianus
Trumpeter swan	O. buccinator
Canada goose	Branta canadensis
Mallard	Anas platyrhynchos
Pintail	A. acuta
American wigeon	A. americana
Northern shoveler	A. clypeata
American green-winged teal	A. crecca
Canvasback	Aythya valisineria
Lesser scaup	A. affinis
Oldsquaw	Clangula hyemalis
White-winged scoter	Melanitta deglandi
Surf scoter	M. perspicillata
Peregrine falcon	Falco peregrinus
Lesser sandhill crane	Grus canadensis
Solitary sandpiper	Tringa solitaria
Gray-cheeked thrush	Hylocichla minima
Lesser yellowlegs	Totanus flavipes
Northern phalarope	Lobipes lobatus
Common snipe	Capella gallinago
Orange-crowned warbler	Vermivora celata
Mew gull	Larus canus
Bonaparte's gull	L. philadelphia
Arctic tern	Sterna paradisaea
Hawk-owl	Surnia ulula
Tree swallow	Iridoproche bicolor

TABLE 2.2.2-22,b (Cont'd.)

Low Brush-Muskeg Bog - Animals

Gray jay	Perisoreus canadensis
Common raven	Corvus corax
White-crowned sparrow	Zonotrichia leucophrys
Lincoln sparrow	Melospiza lincolni
Tree sparrow	Spizella arborea
Bohemian waxwing	Bombycilla garrulus
Rusty blackbird	Euphagus carolinus
Invertebrates	
Bacteria	Schizomycetes (Phylum)
Protozoans	Protozoa (Phylum)
Flukes	Trematoda (Class)
Tapeworms	Cestoda (Class)
Roundworms	Nematoda (Phylum)
Earthworms	Oligochaeta (Class)
Spiders and mites	Arachnida (Class)
Dragonflies	Odonata (Order)
True bugs	Hemiptera (Order)
Beetles	Coleoptera (Order)
Butterflies and moths	Lepidoptera (Order)
True flies (mosquitoes)	Diptera (Order)
Ants, bees, and wasps	Hymenoptera (Order)

TABLE 2.2.2-23, a

Moist Tundra - Plants

Mosses and lichens	
Mosses	Sphagnum spp.
Ferns and fern allies	
Horsetails	Equisetum spp.
Grasses and sedges	
Cottongrasses	Eriophorum spp.
Sedges	Carex spp.
Polar grass	Arctagrostis latifolia
Bluejoint grasses	Calamagrostis spp.
Hairgrass	Deschampsia caespitosa
Fescue grasses	Festuca spp.
Herbs	
Fireweed	Epilobium angustifolium
Wood rushes	Luzula spp.
Dryas	Dryas spp.
Bistort	Polygonum bistorta
Yarrows	Achillea spp.
Shrubs	
Willows	Salix spp.
Dwarf birch	Betula nana
Resin birch	B. glandulosa
Labrador tea	Ledum palustre
American green alder	Alnus crispa
Lapland rosebay	Rhododendron lapponicum
Bearberries	Arctostaphylos spp.
Blueberries	Vaccinium spp.
Lingonberry	V. vitis-idaea
Bog cranberry	Oxycoccus microcarpus
Alpine azalea	Loiseluria procumbens
Crowberry	Empetrum nigrum

TABLE 2.2.2-23,b

Moist Tundra - Animals

Mammals	
Masked shrew	Sorex cinereus
Tundra shrew	S. tundrensis
Arctic ground squirrel	Citellus parryi
Greenland collared lemming	Dicrostonyx groenlandicus
Brown lemming	Lemmus trimucronatus
Tundra vole	Microtus oeconomus
Meadow jumping mouse	Zapus hudsonius
Gray wolf	Canis lupus
Red fox	Vulpes fulva
Grizzly bear	Ursus arctos
Ermine	Mustela erminea
Least weasel	M. rixosa
Wolverine	Gulo gulo
Moose	Alces alces
Caribou	Rangifer tarandus
Birds	
Whistling swan	Olor columbianus
Canada goose	Branta canadensis
White-fronted goose	Anser albifrons
Mallard	Anas platyrhynchos
Pintail	A. acuta
American wigeon	A. americana
Northern shoveler	A. clypeata
American green-winged teal	A. crecca
Lesser scaup	Aythya affinis
Oldsquaw	Clangula hyemalis
Red-breasted merganser	Mergus serrator
Willow ptarmigan	Logopus lagopus
Rock ptarmigan	L. mutus
Lesser sandhill crane	Grus canadensis
Black-bellied plover	Squatarola squatarola
Rock sandpiper	Erolia ptilocnemis
Dunlin	Calidris alpina
Western sandpiper	Ereunetes mauri
Red phalarope	Phalaropus fulicarius
Northern phalarope	Lobipes lobatus
Common snipe	Capella gallinago
Long-tailed jaeger	Stercorarius longicaudus
Herring gull	Larus argentatus
Mew gull	L. canus
Bonaparte's gull	L. philadelphia
Arctic tern	Sterna paradisaea

TABLE 2.2.2-24,b (Cont'd.)

Moist Tundra - Animals (Cont'd)

Short-eared owl	Asio flammeus
Snowy owl	Nyctea scandiaca
Common raven	Corvus corax
Savannah sparrow	Passerculus sandwichensis
Lapland longspur	Calcarius lapponicus
Snow bunting	Plectrophenax nivalis
Invertebrates	
Bacteria	Schizomycetes (Phylum)
Protozoans	Protozoa (Phylum)
Flukes	Trematoda (Class)
Tapeworms	Cestoda (Class)
Roundworms	Nematoda (Phylum)
Earthworms	Oligochaeta (Class)
Spiders and mites	Arachnida (Class)
Dragonflies	Odonata (Order)
True bugs	Hemiptera (Order)
Beetles	Coleoptera (Order)
Butterflies and moths	Lepidoptera (Order)
True flies (mosquitoes)	Diptera (Order)
Ants, bees, and Wasps	Hymenoptera (Order)

TABLE 2.2.2-24,a

Bottomland Spruce-Poplar Forest - Plants

Mosses and lichens	
Mosses	
Lichens	
Ferns and fern allies	
Ferns	
Horsetails	Equisetum spp.
Grasses and sedges	
Bluejoint grasses	Calamagrostis spp.
Herbs	
Fireweed	Epilobium angustifolium
Wintergreens	Pyrola spp.
Shrubs	
American green alder	Alnus crispa
Thinleaf alder	A. incana
Willows	Salix spp.
Roses	Rosa spp.
Dogwoods	Cornus spp.
Labrador tea	Ledum palustre
Blueberries	Vaccinium spp.
Bearberries	Arctostaphylos spp.
Amelanchier	Amelanchier alnifolia
Raspberry	Rubus idaeus
High bush cranberry	Viburnum edule
Trees	
Black spruce	Picea mariana
White spurce	P. glauca
Balsam poplar	Populus balsamifera
Quaking aspen	P. tremuloides
Paper birch	Betula papyrifera

TABLE 2.2.2-24,b

Bottomland Spruce-Poplar Forest - Animals

Mammals	
Masked shrew	Sorex cinereus
Dusky shrew	S. obscurus
Little brown bat	Myotis lucifugus
Snowshoe hare	Lepus americanus
Red squirrel	Tamiasciuris hudsonicus
Northern flying squirrel	Glaucomys sabrinus
Red-backed vole	Clethrionomys rutilus
Porcupine	Erethizon dorsatum
Coyote	Canis latrans
Gray wolf	C. lupus
Red Fox	Vulpes fulva
Black bear	Ursus americanus
Grizzly bear	U. arctos
Pine marten	Martes americana
Ermine	Mutela erminea
Wolverine	Gulo gulo
Lynx	Lynx canadensis
Moose	Alces alces
Birds	
Common goldeneye	Bucephala clangula
Barrow's goldeneye	B. islandica
Bufflehead	B. albeola
Goshawk	Accipiter gentilis
Sharpshinned hawk	A. striatus
Bald eagle	Haliaeetus leucocephalus
Osprey	Pandion haliaetus
Spruce grouse	Canachites canadensis
Ruffed grouse	Bonasa umbellus
Spotted sandpiper	Actitis macularia
Great horned owl	Bubo virginianus
Belted kingfisher	Megaceryle alcyon
Yellow-shafted flicker	Colaptes auratus
Hairy woodpecker	Dendrocopos villosus
Northern three-toed woodpecker	Picoides tridactylus
Gray jay	Perisoreus canadensis
Common raven	Corvus corax
Black-capped chickadee	Parus atricapillus
Boreal chickadee	P. hudsonicus
Robin	Turdus migratorius
Varied thrush	Ixoreus naevius
Hermit thrush	Catharus guttatus
Swainson's thrush	C. ustulatus
Ruby-crowned kinglet	Regulus calendulus

TABLE 2.2.2-25,b (Cont'd.)

Bottomland Spruce-Popular Forest - Animals

Orange-crowned warbler	Vermivora celata
Myrtle warbler	Dendroica coronata
Pine grosbeak	Pinicola enucleator
White-winged crossbill	Loxia leucoptera
Slate-colored junco	Junco hyemalis
White-crowned sparrow	Zonotrichia leucophrys
Invertebrates	
Bacteria	Schizomycetes (Phylum)
Protozoans	Protozoa (Phylum)
Flukes	Trematoda (Class)
Tapeworms	Cestoda (Class)
Roundworms	Nematoda (Phylum)
Earthworms	Oligochaeta (Class)
Spiders and mites	Arachnida (Class)
Dragonflies	Odonata (Order)
True bugs	Hemiptera (Order)
Beetles	Coleoptera (Order)
Butterflies and moths	Lepidoptera (Order)
True flies (mosquitoes)	Diptera (Order)
Ants, bees, and wasps	Hymenoptera (Order)

TABLE 2.2.2-25,a

AQUATIC COMMUNITIES

Freshwater Plants

Algae	
Green algae	Ankistrodesmus sp.
	Chara globularis
	Chlamydomonas sp.
	Chlorella sp.
	Nitella flexilis
	Planktosphaeria sp.
	Scenedesmus sp.
	Selenastrum sp.
Desmids	Cosmarium sp.
Golden algae	Mallomanas sp.
Diatoms	Fragilaria sp.
Euglenoid algae	Euglena sp.
Blue-green algae	Anabaena flos-aquae
	Aphanizomenon sp.
	Ricciocarpus natans
	Spirulina sp.
Dinoflagellates	Glenodinium sp.
	Gymnodinium sp.
Macrophytes	
Wild calla	Calla palustris
Sedges	Carex aquatilis
	C. lasiocarpa
	C. rostrata
	C. rotundata
Hornwort	Ceratophyllum demersum
Water hemlock	Cicuta maculata
Grass	Colpodium fulvum
Spike rush	Eleocharis palustris
Horsetail	Equisetum fluviatile
Manna grass	Glyceria borealis
Mare's tail	Hippuris vulgaris
Quillwort	Isoetes sp.
Water milfoil	Myriophyllum spicatum
Yellow pond lily	Nuphar sp.
Dwarf water lily	Nymphaea sp.
Water smartweed	Polygonum amphibium
Pondweeds	Potamogeton filiformis
	P. gramineus
	P. perfoliatus
	P. praelongus
	P. richardsonii
Marsh fivefinger	Potentilla palustris

TABLE 2.2.-25,a (Cont'd.)

Freshwater Plants

Crowfoot	Ranunculus aquatilis
Bladderworts	Utricularia intermedia
	U. vulgaris

TABLE 2.2.2-25,b

Freshwater Animals

Invertebrates	
Bacteria	Schizomycetes (Phylum)
Rotifers	Rotifera (Class)
Flagellates	Mastigophora (Phylum)
Ciliates	Ciliophora (Phylum)
Flatworms	Turbellaria (Class)
Aquatic worms	Plesiopora (Order)
Leeches	Hirudinea (Class)
Crustaceans	Copepoda (Class)
	Cladocera (Order)
	Anostraca (Order)
	Amphipoda (Order)
	Notostraca (Order)
	Ostracoda (Class)
Midge larvae	Chironomidae (Family)
Biting midge larvae	Ceratopogonidae (Family)
Mosquito larvae	Culicidae (Family)
Cranefly larvae	Tipulidae (Family)
Blackfly larvae	Simulidae (Family)
Stonefly larvae	Plecoptera (Order)
Dragonfly larvae	Odonata (Order)
Mayfly larvae	Ephemeroptera (Order)
Caddisfly larvae	Trichoptera (Order)
Beetles	Coleoptera (Order)
Water mites	Hydracarina (Family)
Clams	Pisidium sp.
Snails	Lymnea sp.
	Gyraulus sp.
	Physa sp.
Fish	
Chum (dog) salmon	Oncorhynchus keta
Silver (coho) salmon	O. kisutch
King (chinook) salmon	O. tshawytscha
Dolly varden	Salvelinus malma
Lake trout	S. namaycush
Arctic grayling	Thymallus arcticus
Whitefish and cisco	Coregonus spp.
Inconnu	Stenodus leucichthys
Northern pike	Esox lucius
Sculpin	Cottidae (Family)

TABLE 2.2.2-25,b (Cont'd.)

Freshwater Animals (Cont'd.)

Burbot	Lota lota
Longnose sucker	Catostomus catostomus
Lake chub	Couesius plumbeus
Birds	
Common loon	Gavia immer
Arctic loon	G. arctica
Red-throated loon	G. stellata
Red-necked grebe	Podiceps grisegena
Horned grebe	P. auritus
Whistling swan	Olor columbianus
Trumpeter swan	O. buccinator
Canada goose	Branta canadensis
White-fronted goose	Anser albifrons
Snow goose	Chen hyperborea
Mallard	Anas platyrhynchos
Pintail	A. acuta
American wigeon	A. americana
Northern shoveler	A. clypeata
American green-winged teal	A. crecca
Canvasback	Aythya valisineria
Lesser scaup	A. affinis
Common goldeneye	Bucephala clangula
Bufflehead	B. albeola
Harlequin duck	Histrionicus histrionicus
Oldsquaw	Clangula hyemalis
White-winged scoter	Melanitta deglandi
Surf scoter	M. perspicillata
Lesser sandhill crane	Grus canadensis
Semipalmated plover	Charadrius semipalmatus
Lesser yellowlegs	Tringa flavipes
Northern phalarope	Lobipes lobatus
Common snipe	Capella gallinago
Long-tailed jaeger	Stercorarius longicaudus
Herring gull	Larus argentatus
Mew gull	L. canus
Bonaparte's gull	L. phildelphia
Arctic tern	Sterna pardisaea
Dipper	Cinclus mexicanus
Mammals	
Beaver	Castor canadensis
Muskrat	Ondatra zibethicus
Mink	Mustela vison
River otter	Lutra canadensis
Moose	Alces alces

TABLE 2.2.2-26

SPECIES OF COMMERCIAL, SUBSISTENCE, AND RECREATIONAL IMPORTANCE IN THE YUKON REGION

Commercial

White spruce	Picea glauca
Paper birch	Betula papyrifera
Balsam poplar	Populus balsamifera
Quaking aspen	P. tremuloides
Grasses	
Roots	
River otter	Lutra canadensis
Mink	Mustela vison
Muskrat	Ondatra zibethicus
Pine marten	Martes americana
Lynx	Lynx canadensis
Red fox	Vulpes fulva
Beaver	Castor canadensis
Wolf	Canis lupus
Wolverine	Gulo gulo
King salmon	Oncorhynchus tshawytscha
Chum salmon	O. keta
Silver salmon	O. kisutch

Limited commercial fishing is widely dispersed over 1,200 river miles of the upper Yukon Rivers. Tributary streams of the Yukon and Tanana Rivers are closed to commercial fishing.

Subsistence

Subsistence harvest of salmon has been statistically recorded since early in this century along the Yukon River. Only since 1970 are similar data available for the Fairbanks vicinity.

For normal years the subsistence harvest of chum salmon at Rampart and Stevens Village on the Yukon River is 3,000 to 15,000 fish and 2,000 to 7,000 fish respectively. Total harvest has declined in recent years. The Fairbanks area catch has varied from 2,000 to 8,000 fish.

King salmon harvests have been more stable with Rampart and Stevens Village recording 300 to 1,500 fish and 300 to 1,000 fish respectively. Fairbanks area harvests have remained under 300 fish annually.

TABLE 2.2.2-26 (Cont'd.)

Subsistence (Cont'd.)

Blueberry	Vaccinium spp.
Lingonberry	V. vitis-idaea
Crowberry	Empetrum nigrum
Sourdock	Rumex arcticus
Cotton grasses	Eriophorum spp.
Logs/timber (fuel)	
Moose	Alces alces
Caribou	Rangifer tarandus
Black bear	Ursus americanus
Snowshoe hare	Lepus americanus
Mink	Mustela vison
Muskrat	Ondatra zibethicus
Beaver	Castor canadensis
River otter	Lutra canadensis
Lynx	Lynx canadensis
Red fox	Vulpes fulva
Pine marten	Martes americana
Arctic ground squirrel	Citellus parryi
Ptarmigans	Lagopus spp.
Grouse	Tetraonidae (Family)
Geese and ducks	Anatidae (Family)
Lesser sandhill crane	Grus canadensis
Whitefish	Coregonus spp.
Chum salmon	Oncorhynchus keta
Chinook salmon	O. tshawytscha
Northern pike	Esox lucius
Burbot	Lota lota
Inconnu	Stenodus leucichthys

Recreational/Sport

Crowberries	Empetrum nigrum
Blueberries	Vaccinium spp.
Raspberries	Rubus idaeus
Willow	Salix spp.
Moose	Alces alces
Caribou	Rangifer tarandus
Black bear	Ursus americanus
Grizzly bear	U. arctos
Dall sheep	Ovis dalli
Snowshoe hare	Lepus americanus

TABLE 2.2.2-26 (Cont'd.)

Recreational/Sport (Cont'd.)

Ptarmigans	Lagopus spp.
Spruce grouse	Canachites canadensis
Waterfowl	Anatidae (Family)
Ruffed grouse	Bonasa umbellus
Sharptailed grouse	Pedioecetes phasianellus
Inconnu	Stenodus leucichthys
Northern pike	Esox lucius
Arctic grayling	Thymallus arcticus
Lake trout	Salvelinus namaycush
Chinook salmon	Oncorhynchus tshawytscha
Chum salmon	O. keta
Coho salmon	O. kisutch
Whitefish	Coregonus spp.
Burbot	Lota lota

2.2.3 Unique and Other Special Biotic Resources

Arctic Region

Unique Ecosystems

Most ecosystems in this region are not unique; however, within the foothills of the eastern Brooks Range, two large freshwater springs provide a unique environment for aquatic life. These springs provide a rare, year-round supply of flowing water and support aquatic communities otherwise unable to survive this far north. These ecosystems also support critical life stages and activities of such migrant fish as Arctic char and Arctic grayling. These fish can spawn and overwinter adjacent to these spring areas where they are protected from freezing, even during the coldest months.

Rare or Endangered Species

The only rare or endangered fish in arctic Alaskan waters reported by Miller (1972) was the Angayukaksurak char. Walters (1955) stated that this fish, also known as old man fish, had been reported in the headwaters of the Anaktuvuk, Hulahula and John Rivers in the Brooks Range. Populations of this fish may exist in streams along the pipeline route, but none have yet been adequately documented. This fish is either a dwarf form of Arctic char or a distinct species. It is stocky in appearance and almost black in color.

The status of the polar bear is listed by the U.S. Department of the Interior (1973) as "undetermined," but research is presently being conducted by governmental agencies and others to further evaluate this classification.

The threatened Arctic peregrine falcon (Falco peregrinus anatum) nests along major waterways of the region, including the Sagavanirktok and Atigun Rivers.

Biotic Resources of Special Importance

Mammals

Atigun Canyon is habitat for a herd of Dall sheep that is of special value because it is easily visible from the proposed route.

The first 25 miles (42 km) of the route south from the Beaufort Sea coast may pass through denning area used by bears. Pregnant females den in drifted snow in late November or early December, bear their young in the den and emerge in

April. Some den of sea ice, but dens have also been found as far as 26 miles inland in the Prudhoe Bay area.

Birds

The coastal plain within 70 miles (115 km) of the sea coast is nesting habitat for numbers of shorebirds and other arctic waterbirds.

Franklin Bluffs is recognized as an important nesting site for nesting raptors, including the endangered arctic peregrine falcon. It has been the site for studies by several agencies including the University of Alaska, U.S. Fish and Wildlife Service and the Alaska Department of Fish and Game. It has also been proposed as an ecological reserve and as a national landmark.

Areas of Critical Environmental Concern

Areas of critical environmental concern are shown graphically in volume 1A, page 1. Illustrated are spawning, rearing and overwintering areas for fish and important denning and nesting areas for mammals and birds.

Table 2.2.2-12 lists additional information concerning known spawning and overwintering areas for Arctic char.

Yukon (Interior) Region

Unique Ecosystems

No ecosystems of substantial uniqueness exist within this region.

Rare or Endangered Species

The threatened arctic peregrine falcon (status uncertain) (*Falco peregrinus anatum*) and the osprey both nest along major waterways of the region.

Biotic Resources of Special Importance

Fish

Isolated non-migratory populations of Dolly varden char occur in the headwaters of the Tanana River drainage. They are important because of their genetic isolation from other populations of the species occurring south of the Alaska Range.

Mammals

Table Mountain in the Dietrich River Valley is recognized as an area with potential for observing Dall sheep (Alaska Department of Fish and Game, in press).

The Chena River sustains noted concentrations of beaver--three to four lodges per mile of river--and supplies about 14 percent of the state harvest of that species.

About 300 bison range in the lower Delta River and the farming area to the east. An additional 30 animals range between Healy Lake and Gerstle River.

Shaw Creek Flats is recognized as a calving area for moose.

Birds

Minto Flats, which is a nesting, moulting and hunting area for waterfowl and other waterbirds, lies downstream from the proposed route.

Tetlin Lake and adjacent lakes east to the Canadian border are also breeding and summering areas for waterfowl and other waterbirds.

The North American peregrine survey (Cade and Fyfe 1970) designated bluffs along the Tanana River as nesting habitat for peregrine falcons.

2.3 SOCIO-ECONOMIC CONSIDERATIONS

2.3.1 Alaska Overview: The State

Population

Alaska is at once the largest state in land area and the smallest in population. Nineteen seventy-five (1975) estimates by the Alaska Department of Labor put the state population at around 404,000, of which roughly one-half (177,817) live in the Anchorage area or within commuting distance of that community. Alaska's second largest city, Fairbanks, had an estimated population of 55,517 in 1975. The coastal communities of Southeast Alaska constitute the other major region of population concentration in the state, including Juneau--17,714 and Ketchikan--11,311. Figure 2.3-1 shows areas of population concentration in Alaska.

Recent growth in population has been extremely rapid due to the enormous manpower and capital requirements of the Trans-Alaska oil pipeline construction project. This project has at peak levels of activity directly employed over 22,000 people on the line, plus additional support staff. Economic activity spawned by the construction project has created new business opportunities in virtually every sector, as the tremendous capital inflow has filtered through the economy, attracting more immigrants. The growth rate has been all the more spectacular, given Alaska's initially small population base.

Economic Trends

The history of the Alaskan economy is one of boom and bust resource extractive activity. Initially, the attraction of fur-bearing animals drew traders of Russian, British, and American origin. It was not until the discovery of gold in the Juneau area and the subsequent discoveries in the Klondike and Nome areas during the later 1800's and early 1900's that any substantial numbers of people came to Alaska. By this time, the salmon fisheries had also begun to develop.

The mining activity--not only gold, but the extraordinarily rich copper deposits in the Kennicott area--generated the initial development thrust in Alaska as the Alaska railroad was constructed to connect the interior of Alaska at Fairbanks with Seward on the coast and a military trail built from Valdez to Eagle.

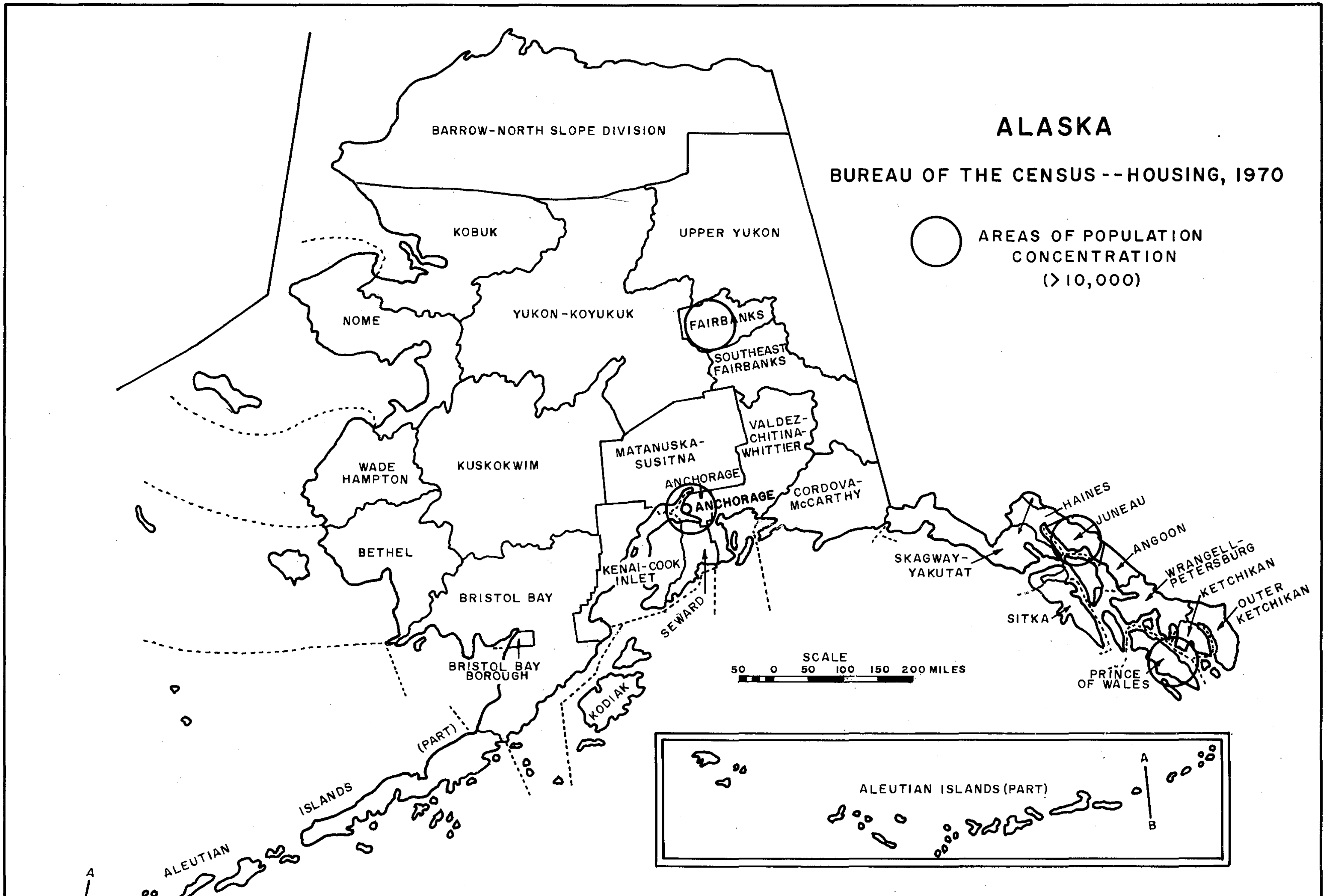


FIGURE NO. 2.3-1

By the 1920's, mining activity had slowed and Alaska entered a stagnant economic phase. Although the fisheries enjoyed immense prosperity, virtually all employment was seasonal and highly transient.

World War II brought renewed national interest in Alaska as its strategic location became evident. A massive influx of military personnel followed (over 100,000) and continued into the early 1950's, when virtually all currently existing roads in the state were constructed. (The Alaska Highway connecting Alaska with the southern states was constructed during the war.) The 1950's was the decade of the military in Alaska and its presence continues to be a considerable force in the Alaskan economy.

Discovery of oil on the Kenai Peninsula in the late 1950's ushered in a new phase in the economy as exploration and development activities in the oil and gas sector provided another "big boom" impetus to Alaskan economic growth.

Alaska Economic Growth 1961-1972

Several indicators exist which can be used to measure economic activity. Gross state product and employment are convenient measures which are readily available and illustrate quite clearly the dynamics of the Alaskan economy.

As shown in Table 2.3-1, all industries in the state grew between 1961 and 1972. The mining sector, which includes oil and gas, was the most rapidly expanding sector due to development of the Kenai fields and the exploration on the North Slope. Oil development was a major driving force underlying the growth of the economy, especially in the support sectors like transportation, communications, public utilities, trade, finance, and services, which thrived on the incomes generated by the oil activity. State and local government was also a rapidly expanding sector; Alaska began to assume the responsibilities which came with statehood, not the least of which was the management of funds accruing from the enlarged tax base provided by oil production and development, including the $900 million bonus lease sale at Prudhoe Bay in 1969. The enlargement of local government and land selections falling out of the Statehood Act were other early responsibilities. Contract construction received a major push during and after the earthquake in 1964 (due partly to reconstruction) and grew as a direct result of both government and mining sector activities. Construction of roads, residential construction, and commercial construction were all represented. There was slow and relatively insignificant growth in the renewable resource

Table 2.3.-1

GROSS PRODUCT IN SELECTED INDUSTRIAL SECTORS
Average Annual Growth Rate 1961-1972
(Percent)

	Current Price Gross Product	Real Gross Product
All Industries	9.8	5.7
All Industries except mining	9.3	4.2
Commodity Producing Industries	10.5	7.8
Mining	17.8	17.6
Commodity Producing Industries Except Mining	8.3	2.4
Contract Construction	11.5	5.6
Fisheries and Forest Products	4.5	0.4
Other Manufacturing	11.2	7.3
Support Sector	10.0	7.4
Transportation, Communications, and Public Utilities	7.4	6.3
Trade, Finance, and Services	11.3	8.2
Government	9.1	1.4
Federal	6.4	0.5
State and Local	16.6	9.7

Source: David T. Kresge, "Alaska Economic Growth, 1961-1972", Alaska Review of Business and Economic Conditions 11(2), Aug. 1974.

industries--agriculture, forestry, and fisheries--as fluctuating world market conditions and productivity problems tended to prevent large gains in this sector.

Employment growth shows a slightly different picture, mainly due to the capital intensity of oil and gas production (Table 2.3-2). The major source of employment growth was the support sector. State and local government was the other leading sector in employment growth as more people became employed in the young state's burgeoning public sector. The fisheries and forest products sector showed a greater increase in employment than in real output which would indicate that the output per worker declined and the income generated was spread among a larger number of employees.

Table 2.3-3 lists Alaskan personal income by major sources per industry and illustrates dramatically that most personal income in Alaska came from wages and salaries with the government sector the largest contributor, followed by the support sectors and contract construction. Such a finding is not surprising in a sparsely populated capital-deficient region relying on seasonal resource extraction and government as its economic base.

A more recent comparison of economic growth between 1970 and 1974 shows initial stages of the impact on the economy of the construction of the Trans-Alaska oil pipeline (Table 2.3-4). Growth came primarily in construction and the support industries while government, a previously leading growth sector, grew more slowly than before.

Alaska per capita income has historically been the highest in the nation. In 1974, it was $5,947 compared to a U. S. average of $4,640 (Table 2.3-5). Offsetting this is the fact that it costs more to live in Alaska. Although there is no one statistic upon which to rely, the cost of living generally runs 20 to 50 percent higher in Alaska than for the United States as a whole.

In order to account for both cost of living differences and the change in relative price levels in Alaska with respect to the rest of the United States, the University of Alaska's Institute of Social, Economic, and Government Research (ISEGR) has created a hybrid index based upon the Anchorage consumer price index, urban family budget, and United States Department of Agriculture food price surveys. This price index, known as RPI, though subject to some rather severe limitations, illustrates changes in the cost of living differential in Alaska versus the U.S.A. caused by price movements (Table 2.3-6).

<u>Table 2.3.-2</u>

EMPLOYMENT BY INDUSTRY GROUP
Annual Average Employment

	1961	1964	1967	1970	1972
Total Employment	100.2	109.0	121.7	136.4	144.0
Nonwage and Salary Employment	10.9	11.3[a]	11.2[a]	12.5[a]	13.4[a]
Total Wage and Salary Employment	89.3[a]	97.8	110.5	123.9	130.6
Wage and Salary Employment					
All Industries	89.3[a]	97.8	110.5	123.9	130.6
COMMODITY PRODUCING INDUSTRIES	10.6	12.6	14.8	17.9	18.9
Mining	1.2	1.1	2.0	3.0	2.1
Commodity Producing Industries Except Mining	9.4	11.5	12.8	14.9	16.8
Contract Construction	4.1	5.8	6.0	6.9	7.9
Fisheries and Forest Products	4.5	4.8	5.8	6.7	7.4
Other Manufacturing	.8[a]	.9	1.0	1.3	1.5
SUPPORT SECTOR	21.9	24.6	30.3	39.0	44.8
Transportation, Communications, and Public Utilities	7.1	6.9	7.5	9.1	10.0
Trade, Finance, and Services	14.8	17.7	22.8	29.9	34.8
GOVERNMENT	56.3	60.5	65.5	66.9	66.9
Federal	48.1	49.7	51.1	48.5	43.6
State and Local	8.2[a]	10.8	14.4	18.4	23.3

[a]Taken from Alaska Department of Economic Development, Division of Economic Enterprise, Statistical Review, December, 1972.
[b]Taken from National Bank of Alaska, A Performance Report of the Alaskan Economy, 1973

Source (except as otherwise indicated): Alaska Department of Labor, Statistical Quarterly various issues. Reprinted from Kresge, "Alaska Economic Growth".

Table 2.3.-3

ALASKA PERSONAL INCOME BY MAJOR SOURCES
1961-1972
(Millions of Dollars)

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
Personal Income	651.3	679.1	710.3	797.4	864.1	934.3	1042.2	1126.3	1265.9	1442.7	1573.2	1728.1
Wage and Salary Disbursements	538.3	557.1	589.3	670.4	722.1	777.3	867.2	947.3	1080.9	1217.7	1315.2	1447.1
Mining	11.5	12.5	12.5	12.5	13.1	17.5	28.4	38.0	56.3	52.0	43.7	39.1
Metal Mining	2.8	2.6	2.1	1.4	1.8	2.0	1.6	1.5	1.6	2.7	2.1	1.5
Oil and Gas	6.2	7.3	8.1	8.5	8.3	12.5	24.2	34.3	52.7	47.1	38.9	34.6
Other	2.4	2.6	2.4	2.6	3.0	3.0	2.6	2.3	2.1	2.1	2.8	3.0
Contract Construction	47.1	47.6	51.1	77.8	88.0	88.8	95.2	100.1	117.9	125.8	143.0	153.4
Manufacturing	40.1	41.6	44.0	46.0	54.7	56.2	56.4	63.3	69.3	83.9	86.5	89.8
Food and Kindred Products	20.1	18.6	18.5	18.2	24.0	24.2	20.1	23.2	23.7	31.3	31.1	30.0
Lumber, Wood, Paper & Allied Prod.	14.1	16.2	18.4	19.8	21.8	23.2	27.6	29.2	31.6	36.7	37.8	40.9
Other	5.8	6.8	7.1	8.0	8.9	8.8	8.7	10.8	13.9	15.9	17.6	18.9
Transportation	30.9	32.2	33.5	35.3	37.8	39.2	46.2	49.2	65.1	70.9	67.2	74.2
Trucking and Warehousing	6.1	6.6	7.0	8.4	10.1	8.0	11.0	11.7	17.1	19.2	17.5	18.7
Water Transportation	7.1	7.9	7.8	7.5	6.9	9.0	9.3	8.4	8.2	8.5	8.1	9.9
Air Transportation	14.9	14.9	15.8	16.8	17.8	18.9	22.1	24.7	35.0	37.4	34.9	39.2
Other Transportation	2.8	2.8	2.8	2.7	3.0	3.2	3.9	4.3	4.9	5.8	6.6	6.4
Communications and Public Utilities	31.4	29.4	29.0	29.2	30.9	33.4	32.7	34.9	37.1	40.6	52.8	57.2
Trade	54.2	53.5	56.7	61.3	71.4	79.1	89.6	99.0	116.6	132.0	142.2	157.5
Wholesale Trade	16.6	14.8	15.3	17.3	19.5	22.9	26.0	28.4	35.6	40.8	41.8	46.0
Retail Trade	37.6	38.7	41.5	44.0	52.0	56.2	63.6	70.6	81.0	91.2	100.4	111.5
Finance, Insurance, and Real Estate	9.3	10.5	12.0	13.6	15.8	17.3	17.5	19.7	22.4	27.6	31.1	37.7
Services	33.5	36.5	36.4	40.7	45.7	49.2	57.0	66.3	77.8	88.9	99.4	117.8
Hotels, Motels, and Lodges	NA	NA	3.6	4.1	5.3	6.1	6.8	6.8	7.8	8.5	9.7	11.0

Table 2.3.-3 (Cont.)

ALASKA PERSONAL INCOME BY MAJOR SOURCES
1961-1972
(Millions of Dollars)

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
Personal Services	NA	NA	3.3	3.4	3.7	3.9	4.1	4.7	4.9	5.3	5.7	5.9
Business Services	NA	NA	8.0	10.0	11.1	11.6	14.1	18.9	22.1	18.8	18.2	17.4
Medical Services	NA	NA	5.8	6.6	6.9	7.8	8.5	9.3	11.9	15.8	20.4	28.5
Other Services	NA	NA	15.7	16.5	18.7	19.8	23.4	26.6	31.1	40.4	45.3	55.1
Government	279.6	292.5	331.3	353.0	363.5	395.0	442.9	475.0	516.3	593.6	646.6	708.6
Federal Government	228.5	231.9	241.2	274.9	271.6	291.1	324.6	339.1	359.7	404.7	416.6	438.0
State and Local Government	51.1	60.6	72.2	78.2	91.9	103.9	118.3	135.9	156.6	188.9	230.0	270.6
Other Industries (Agriculture Forestry, and Fisheries)	0.8	1.0	0.8	0.9	1.1	1.5	1.2	1.9	2.0	2.5	2.8	11.8
Other Labor Income	15.0	16.0	18.0	20.0	23.0	26.0	29.0	33.0	33.0	38.0	44.0	40.0
Proprietors' Income	47.0	51.0	53.0	50.0	56.0	66.0	71.0	67.0	68.0	74.0	86.0	90.0
Property Income	39.0	44.0	38.0	47.0	52.0	53.0	61.0	62.0	70.0	82.0	89.0	95.0
Transfer Payments	28.0	28.0	30.0	32.0	34.0	38.0	42.0	52.0	58.0	79.0	100.0	114.0
Less Personal Contribution to Social Ins.	16.0	17.0	18.0	22.0	23.0	26.0	28.0	35.0	44.0	48.0	61.0	67.0

Sources: Alaska Department of Labor, Statistical Quarterly, various issues; U.S. Department of Commerce, Survey of Current Business, various issues, as reported by Kresge, "Alaska Economic Growth"

Table 2.3.-4
COMPARISON OF THE ECONOMY OF ALASKA, 1970 and 1974

	TOTAL PAYROLL[1]		AVERAGE YEARLY[2] EMPLOYMENT	
	1970	1974	1970	1974
Ag, Fish, Forest	(2,489,507)	18,415,474	(193)	1,031
Mining	52,002,943	67,365,820	2,995	2,976
Construction	125,775,092	385,403,484	6,894	14,066
Manufacturing	83,927,202	130,838,528	7,839	9,611
Food	31,314,331	42,184,229	3,741	4,292
Lumber	22,642,507	40,887,902	1,743	2,395
Paper	14,068,618	22,380,440	1,016	1,244
Other	15,901,746	25,385,957	1,339	1,680
Transportation	70,892,498	130,425,740	6,428	8,534
Air	37,408,974	62,497,693	3,071	3,977
Other	33,483,524	67,928,047	3,356	4,557
Communications	29,665,699	53,042,840	1,857	2,808
Public Utilities	10,883,728	20,016,601	819	1,039
Trade	132,011,981	220,738,153	15,365	21,135
Finance	27,604,099	56,148,018	3,098	4,895
Services	88,927,726	193,399,663	11,435	18,313
Government	593,559,162	830,217,409	66,978	72,376
Federal	404,667,366	491,955,940	48,537	46,616
State & Local	188,891,796	338,261,469	18,441	25,760
Total	1,217,739,637	2,106,011730	123,901	156,784

Table 2.3.-4 (Cont.)

COMPARISON OF THE ECONOMY OF ALASKA, 1970 and 1974

	NUMBER OF[3] ESTABLISHMENTS		GROSS STATE PRODUCT[4] (MILLION 1958 DOLLARS)	
	1970	1974	1970	1974
Ag, Fish, Forest			35.9	23.6
Mining	214	182	403.9	425.9*
Construction	1062	1478	54.4	107.6
Manufacturing	350	426	98.9	118.8
Food	145	175	46.5	46.0
Lumber	85	91	16.0	23.1
Paper	4	4	23.3	32.2
Other	116	156	13.1	17.4
Transportation	510	564	89.3	167.0*
Air	187	199	55.8	89.7*
Other	323	365	33.5	77.3*
Communications	53	126	63.8	113.7
Public Utilities	35	38.	31.8	55.0
Trade	1946	2281	137.4	197.8
Finance	402	581	85.0	137.7
Services	1798	2253	67.3	108.1
Government			303.2	320.0
Federal			234.5	224.8
State & Local			68.7	95.2
Total	7230	8919	1370.9	1775.2

Table 2.3.-4 (Cont.)
COMPARISON OF THE ECONOMY OF ALASKA, 1970 and 1974

	1970-1974 RATE OF GROWTH EMPLOYMENT (%)	1970-1974 AVG. RATE OF GROWTH GROSS STATE PRODUCT (%)
Ag, Fish, Forest	NA	
Mining	-0.1	1.1
Construction	7.8	19.6
Manufacturing	4.5	4.0
Food	2.9	-0.2
Lumber	7.5	8.9
Paper	4.5	7.6
Other	5.1	6.6
Transportation	6.6	17.4
Air	5.9	12.2
Other	7.2	26.1
Communications	10.2	15.6
Public Utilities	5.4	14.6
Trade	7.5	8.8
Finance	11.6	12.4
Services	12.0	12.1
Government	1.6	1.1
Federal	-0.8	-0.8
State & Local	7.9	7.7
Total	5.3%	5.9%

Source: 1. Alaska Department of Labor, Statistical Quarterly, various issues.
2. Ibid.
3. Ibid.
4. ISEGR

* 1973 deflators used.

Table 2.3.-5
U. S. and Alaska Personal Income
and
Per Capita Income, 1970-74

PERSONAL INCOME

	1970	1971	1972	1973	1974
U.S.	3,966	21,195	4,537	5,023	5,448
Alaska	4,644	4,916	5,192	5,930	7,062

PER CAPITA PERSONAL INCOME

	1970	1971	1972	1973	1974
U.S.	3,397	3,627	3,856	4,305	4,640
Alaska	3,882	4,129	4,281	4,967	5,947

Source: U.S. Department of Commerce, Bureau of Economic Analysis, Survey of Current Business, various issues.

Table 2.3.-6

ALASKAN RELATIVE PRICE INDEX COMPARED TO CONSUMER PRICE INDEX

	Alaska RPI	% Difference	U.S. CPI
1967	142.5	42.5	100.0
1968	150.6	44.5	104.2
1969	156.2	42.3	109.8
1970	164.3	41.3	116.3
1971	168.4	38.8	121.3
1972	169.9	35.6	125.3
1973	175.6	31.9	133.1
1974	193.7	31.1	147.7

Source: Kresge, "Alaska Economic Growth"

The declining difference between Alaska's RPI and the U.S. CPI shows that changing price levels through 1974 have somewhat mitigated the cost of living differential between Alaska and the rest of the United States although that difference is still substantial. The surge of economic activity associated with the construction of the trans-Alaska oil pipeline has caused recent price increases in Alaska to exceed those in the contiguous United States, but this may or may not be an aberration in the longer trend.

Government Sector

Historically, the government sector has been very important to the Alaskan economy and will continue to be in the future, but in a different form. In 1961, average annual wage and salary employment in the state was 89.3 thousand, of which 48.1 thousand were Federal government employees, both military and civilian. An additional 8.2 thousand were state and local government employees, so that 63 percent of wage and salary earners were within the government sector. By 1973, the composition of the government sector had changed considerably and its relative importance in terms of direct employment declined. Of a wage and salary labor force of 137.3 thousand, 44.6 thousand were Federal employees and 24.3 thousand state and local for a total of 68.9 thousand, or 50 percent of wage and salary earners. Federal government employment declined slightly due to a reduction in military employment to 27.5 thousand by 1973. Over the same period, civilian Federal employment remained fairly constant at approximately 17 thousand. State and local government employment grew at a 9.5 percent annual rate between 1961 and 1973 to account for the absolute increase in government sector employment. This growth reflects the increase in demand for services associated with the coming of statehood in 1959 and the growth in population during this period.

The fiscal capacity of the economy also has been transformed over this historic period. In 1961, state government revenues of $46 million came primarily from income taxes, selective sales and gross receipt taxes, and miscellaneous revenues. Federal government transfers were 12 percent of revenues. By the 1970's, revenues from petroleum-related activities began to contribute the largest share to state funds and Federal government transfers had increased to approximately 30 percent of state revenues. The most important single event accounting for this shift was the bonus lease sale of state lands at Prudhoe Bay in 1969. The revenue from this sale allowed substantial expansion of state government operations during the early 1970's but will have dissipated before production taxes and royalties on Prudhoe Bay oil begin providing the state with an income source commensurate with the lease bonus revenues. Over the period since statehood, state government revenues have grown at the annual rate of approximately 20 percent.

Local government fiscal capacity has not expanded to the same extent as the state because much of the oil and gas development-related activity is in rural areas of the state and, thus, not subject to municipal property taxes. Between 1962 and 1972, total local revenues increased from $41 million to $195 million for an annual growth rate of 17 percent. Local revenues from traditional sources such as the property tax and the sales tax have increased with the formation and growth of communities, but transfers from the state government have been the most important local revenue source and have grown faster than any other. In the early 1970's, they have accounted for nearly 50 percent of local revenues.

The pattern of government expenditures since statehood has changed most markedly at the Federal level as direct expenditures in Alaska grew at a moderate 6 percent annually. Intergovernmental transfers, primarily to the state, grew at a 35 percent annual rate. Direct Federal government expenditures in the state remain an important economic component but their relative position is declining. State government expenditures have been growing at an annual rate of 18 percent with expenditures for education and transportation consistently accounting for 60 percent of the total. Local government expenditures have also been growing at approximately 18 percent annually, with education alone accounting for approximately 50 percent of the total.

2.3.2 Alaska Overview: Potential Impact Areas

Population

The latest complete population data for Alaska compiled on a native - non-native basis were gathered during the 1970 Census. The oil pipeline activity within the state has attracted numerous non-native (temporary) residents into affected areas. Table 2.3-7 lists 1975 population estimates for selected Census Divisions. For analysis purposes, the Census Division listed in Table 2.3-7 have been aggregated into economic regions for the impact simulation using the ISEGR econometric (MAP) model. Table 2.3-8 contains the 1970 distribution of population between natives and non-natives for selected areas of Alaska and also sets forth the most current population estimates (as well as native - non-native distribution where available).

Table 2.3.-7

Alaska 1975 Estimated Population, Selected Census Divisions

Census Division	1975 Population	MAP Region
Anchorage	177,817	Anchorage
Fairbanks	55,517	Fairbanks
S. E. Fairbanks	5,894	Fairbanks
North Slope	6,454	Northwest
Upper Yukon	8,780	Interior
Yukon-Koyukuk	8,423	Interior

Source: Alaska Department of Labor, Research and Analysis Section, Current Population Estimates by Census Division, July 1, 1975.

TABLE 2.3-8
DISTRIBUTION OF POPULATION IN COMMUNITIES
WITH MAJOR POTENTIAL FOR GAS PIPELINE IMPACT

	1970 Population			Current Population Through October, 1975*		
WITHIN 5 MILES OF ROUTE	Native	Non-Native	Total	Native	Non-Native	Total
Prudhoe Bay	4	45	49	-	-	-
Deadhorse	15	148	163	-	-	-
Fairbanks	-	-	14,771	-	-	-
North Star Borough	1,818	44,046	45,864	-	-	63,744**
Delta	10	693	703	-	-	892
Dot Lake	29	13	42	45	24	69
Healy Lake	0	0	0	10	1	11
Tanacross	77	7	84	100	4	104
Tetlin	108	6	114	109	4	113
Tok	26	118	214	40	410	450
Northway	10	30	40	-	-	175
FROM 6 to 50 MILES						
Evansville	14	43	57	-	-	-
Stevens Village	72	2	74	75	2	77
Rampart	35	1	36	-	-	-
Minto	159	9	168	-	-	-
BEYOND 50 MILES						
Anaktuvik Pass	97	2	99	-	-	-
Allakakett	170	4	174	-	-	-
Barrow	1,904	200	2,104	-	-	-
Anchorage	5,286	121,047	127,333	-	-	-
Haines	108	355	463	-	-	-

* Population figures not tabulated were unavailable on press date.
** Estimate, prorated through June 30, 1976.

TABLE 2.3-8 (Cont'd.)
DISTRIBUTION OF POPULATION IN COMMUNITIES
WITH MAJOR POTENTIAL FOR GAS PIPELINE IMPACT

SOURCES: "1970 Census of Population: Number of Inhabitants--Alaska," PC(1)-A3. Bureau of the Census.

"Indian Population, 1970 Census--Census County Divisions and Places: Alaska." Bureau of Indian Affairs, U. S. Department of Interior, March 1970 (Unpublished).

"Community Inventory--Alaska," Federal Field Committee for Development Planning in Alaska. Anchorage: June, 1971.

Demographic Studies of Fairbanks Town and Village Association for Development, Inc. in association with Tanana Chiefs Conference.

Economic Activity

In order to more closely examine current economic activity and to set the stage for the impact simulations in a following section, economic data for Fairbanks, Anchorage, and the North Slope have been compiled.

Table 2.3-9 illustrates the relative distribution of wages and salaries and employment for these three regions. As expected, mining (in this case, oil and gas) accounts for over one-third of the payroll on the North Slope. On the other hand, the mining payroll is of far less direct importance to the economies of Anchorage and Fairbanks. Owing to the relatively high wages paid by the mining sector, the percentage of people hired in each region by mining is far less than the percentage of total wages and salaries paid. This holds true in all three of the regions. Government is the most important employer in all three regions, especially in Fairbanks and the North Slope where over half of the people employed work for a government. Not only is government the major employer, but it also has the largest payroll.

Pipeline construction in 1974 can be seen to impact Fairbanks more than the other two regions by reference to the quarterly figures, which illustrates what happened to Anchorage, Barrow, and Fairbanks in 1974 when the construction of the trans-Alaska oil pipeline got underway. Barrow exhibits very little construction impact with a major upswing in government employment (Table 2.3-10). Fairbanks shows a substantial growth in construction from 2,000 employed in second quarter to 5,700, in the fourth. In fact, this construction boom was enough to counteract the historic seasonal downturn in fourth quarter employment in all sectors.

Anchorage, owing to its larger size, does not exhibit such a marked boom although there is noticeable growth throughout the year. Interestingly, the construction boom effectively counteracted the seasonal downturn in economic activity in Anchorage too.

Personal Incomes and Per Capita Incomes

The existing distribution of personal income is shown in Table 2.3-11 for the parts of Alaska which are expected to be most heavily impacted by gas pipeline development. The five-year history demonstrates very rapid growth in all but the Barrow-North Slope Census Division. As can be seen from the table, there has been a tremendous burst in wage and salary payments in each of the census divisions

Table 2.3.-9

DISTRIBUTION OF PAYROLL AND EMPLOYMENT BY INDUSTRY FOR MAJOR IMPACT REGIONS 1974

INDUSTRY	FAIRBANKS		NORTH SLOPE		ANCHORAGE	
	Percent of* Payroll	Percent of Employment	Percent of Payroll	Percent of Employment	Percent of Payroll	Percent of Employment
Ag., Fish, Forest	0.06	0.01	0	0	0.1	0.2
Mining	1.5	1.4	38.3	20.0	8.9	1.8
Const.	29.1	15.9	14.9	8.2	16.4	10.0
Mfg.	1.4	1.6	0	0	2.4	2.3
Trans., Commun. Pub. Fac.	11.9	10.0	11.3	10.0	11.3	9.5
Trade	11.2	16.5	2.0	6.3	16.4	20.9
Finance, Insurance, Real Estate	2.1	3.2	3.5	4.7	4.6	5.4
Services	12.4	16.7	0.3	6.6	13.7	17.2
Government	30.3	34.6	29.8	44.2	26.2	32.7

Source: Alaska Department of Labor, Statistical Quarterly

*Totals my not equal 100% due to rounding

Table 2.3.-10
ALCAN PIPELINE DIRECT
EMPLOYMENT ASSUMPTIONS USED*
IN MAP MODEL
(Average Annual Project Workforce)

Year	Direct Construction Employment**			Direct Mining Employment**			Total Direct
	Interior	Fairbanks	Subtotal	Interior	Fairbanks	Subtotal	Employment
1978	1120	1120	2240	0	0	0	2240
1979	2645	2645	5290	0	0	0	5290
1980	2957	2958	5915	0	0	0	5915
1981	890	890	1780	15	15	30	1810
1982	935	935	1870	35	35	70	1940
1983	1215	1215	2430	65	65	130	2560
1984	0	0	0	95	95	190	190
1985	0	0	0	95	95	190	190
1986	0	0	0	95	95	190	190
1987	0	0	0	95	95	190	190
1988	0	0	0	95	95	190	190
1989	0	0	0	95	95	190	190
1990	0	0	0	95	95	190	190

* Employment data source: Gulf Interstate, Houston, Texas.

** Average annual employment assumed to be divided evenly between Fairbanks and Interior regions.

Table 2.3.-11

PERSONAL INCOME BY SOURCE AND
PER CAPITA INCOME, PIPELINE IMPACT AREA
(Millions of Dollars)

CENSUS DIVISION	Wages and Salaries**	Transfer Payments***	Personal Income***	Per Capita Income (Dollars)	Real Per Capita Income (1967 U.S. Dollars)
1970					
Barrow-North Slope	38.0	1.0	38.4	14,420	8,767
Upper Yukon	2.5	1.2	3.4	2,019	1,229
Yukon Koyokuk	21.2	2.2	19.0	3,998	2,433
Fairbanks*	158.6	9.1	187.8	3,753	2,284
Anchorage	556.1	24.1	548.4	4,341	2,642
State Total	1217.7	79.0	1442.7	4,771	2,904
1971					
Barrow-North Slope	26.9	1.3	27.2	9,481	5,715
Upper Yukon	6.4	1.6	6.5	3,689	2,224
Yukon-Koyokuk	20.3	2.8	18.3	3,828	2,307
Fairbanks*	214.9	12.1	193.2	3,989	2,404
Anchorage	627.1	31.6	623.0	4,588	2,766
State Total	1315.2	100.0	1573.2	5,027	3,030
1972					
Barrow-North Slope	21.9	1.4	22.9	9,019	5,308
Upper Yukon	6.7	1.6	21.5	11,832	6,964
Yukon-Koyokuk	20.5	3.1	24.3	5,053	2,974
Fairbanks*	237.9	14.2	273.6	5,453	3,210
Anchorage	704.2	39.6	823.9	5,713	3,363
State Total	1447.1	114.0	1728.1	5,321	3,131

Table 2.3.-11 (Cont.)

PERSONAL INCOME BY SOURCE AND
PER CAPITA INCOME, PIPELINE IMPACT AREA
(Millions of Dollars)

1973

DIVISION	Wages and Salaries**	Transfer Payments***	Personal Income***	Per Capita Income (Dollars)	Real Per Capita Income (1967 U.S. Dollars)
Barrow-North Slope	19.6	7.1	26.4	10,221	5,821
Upper Yukon	9.4	4.3	13.8	8,338	4,748
Yukon-Koyokuk	24.3	8.8	34.1	6,710	3,821
Fairbanks*	248.8	21.4	292.1	5,859	3,337
Anchorage	745.6	58.7	888.4	5,945	3,386
State Total	1564.0	260.3	2002.8	6,058	3,450
1974					
Barrow-North Slope	26.0	4.5	29.4	9,091	4,710
Upper Yukon	76.2	3.0	77.0	29,145	15,101
Yukon-Koyokuk	62.9	8.4	72.1	13,752	7,125
Fairbanks*	373.8	21.5	412.4	7,462	3,866
Anchorage	945.4	64.1	1098.7	7,176	3,718
State Total	2106.0	222.7	2509.4	7,146	3,703

Notes:
* Fairbanks estimates include the Southeast Fairbanks Census Division.

** Civilian wages and salaries are as reported in Alaska Dept. of Labor Statistical Quarterly. Federal military wage and salary payments in Alaska were allocated to the census divisions, based on estimated military population in the Alaska Department of Labor Current Population Estimates.

*** Transfer payments and other components of personal income (see Table 23.1.3 were taken from U. S. Department of Commerce, Bureau of Economic Analysis, Personal Income by Major Sources 1970-74. State totals for Personal Income were taken from Kresge, "Alaska Economic Growth, 1961-1972" for 1970-72, and estimated in the same way for 1973-74.

except Barrow-North Slope. In addition, most of these divisions show large increases in transfer payments to natives of Federal monies under the terms of the Alaska Native Claims Settlement Act. These were accumulated for 1972, 1973, and 1974 fiscal years pending certification of the native rolls and paid in January 1974. In spite of the actual date of the payment, it appears that the Department of Commerce included the payment in their 1973 figures. In 1974, payments were made only in October, which accounts for most of the decline in transfers.

On a per capita basis, the Upper Yukon Census Division currently has incomes approximately four times the statewide average. This demonstrates the impressive power of an influx of unattached, highly paid workers to alter the incomes of a small population. Per capita wages in salaries went from $5,679 per person in 1973 to $28,842 in 1974, while the population of this census division increased by 60 percent in the same period. The Fairbanks and Anchorage areas also show impressive increases in wages and salaries paid, yet the wider population base and the lower average wage of workers hired outside the petroleum and construction sectors in these areas make the change in real per capita incomes much smaller. The Barrow-North Slope Division shows an uneven decline in real per capita incomes with the boom in transfer payments in 1973 offsetting a three-year decline in wages and salaries in this area. Renewed employment opportunities in 1974 partly offset the decline in Native Claims payments and Barrow per capita incomes remain above the state average. Upper Yukon and Yukon-Koyukuk have both been improving their per capita positions relative to the state.

There are at least three reasons why these statistics should be viewed with caution. Wages and salaries and other forms of cash income are the principal forms of income measured, yet it is known that unmeasured subsistence hunting and gathering activities are important contributors to the incomes of residents of the Barrow, Upper Yukon, and Yukon-Koyukuk Divisions (and possibly to some residents of the Fairbanks area). Thus, incomes in these areas do not accurately reflect actual standards of living. Secondly, the Alaska RPI is a statewide index, yet it is known that cost of purchased items such as food, fuel, and housing is much higher in the "bush" than in Anchorage or even Fairbanks. Thus, the same per capita income in the three rural census divisions most likely represents a lower standard of living. Third, much of the increase in wages and salaries reported in the census divisions imported by the trans-Alaska pipeline are earned by transitory oil and gas industry workers, many of whom will likely leave the state at the conclusion of that pipeline project. Therefore, the per capita measure of income does not address the question of what the real incomes of the "permanent" residents in the region are now or how they have been influenced by pipeline construction and payments from the Alaska Native Fund.

Local Government

Local government in the areas which would be directly affected by construction under this proposal includes four basic jurisdictions--Municipality of Anchorage, Fairbanks-North Star Borough, North Slope Borough, and miscellaneous small communities. As noted previously, local government, in general, receives a large portion of its revenues from the state, the bulk of which supports education. The growth in estimated full value of real and personal property in the first three communities is shown in Table 2.3-12. These values include, after 1973, the value of oil and gas exploration, production, and transmission facilities in each community which is separately assessed by the state since it is subject to a state property tax. Assessment of property values is not presently carried out in the other communities directly adjacent to the proposed pipeline route, although the value of oil and gas production and transmission equipment is assessed in rural parts of the state, known as the Unorganized Borough. The bulk of this capital in the Unorganized Borough is associated with the trans-Alaska oil pipeline and would be taxable by the state but not local communities as they are presently organized.

The value of property in each community is composed of elements in different proportion. Growth of the estimated full value of property in Anchorage has been strong and steady over the period reflecting the most diverse growth of the three communities. Of a total estimated full value of property of $2.935 billion in 1975, less than $6 million was directly attributed to the special category of oil and gas production and pipeline property assessed by the state. Much of the growth in values is related to petroleum activity, but growth in other economic sectors has also been significant.

In Fairbanks, the 40 percent increase in estimated full value of property between 1974 and 1975 indicates a greater sensitivity of the tax base to petroleum activity. This is a result of both Fairbanks' role as a staging area for North Slope development and the oil pipeline and also the fact that the pipeline passes within the boundary of the community.

TABLE 2.3.-12

ESTIMATED FULL VALUE OF PROPERTY, REAL AND PERSONAL
FOR SELECTED ALASKAN COMMUNITIES

(million of $)

	Municipality of Anchorage	Fairbanks City & North Star Borough	North Slope Borough	Unorganized Borough	Total State
1965	624,769	201,719			1,262,452
66	719,562	213,694			1,415,743
67	808,885	217,174			1,628,759
68	882,564	200,319			1,855,089
69	959,652	250,464			1,959,413
70	1,105,577	304,481			2,280,441
71	1,399,335	340,566			2,687,913
72	1,660,977	390,583	250,000		3,343,872
73	2,010,036	475,802	202,667		4,090,134
74	2,301,939	567,232	256,121		4,831,877
75	2,935,159	795,156	560,969	220,861	6,674,575

Source: Department of Community and Regional Affairs, State of Alaska ALASKA TAXABLE, MUNICIPAL PROPERTY ASSESSMENTS AND FULL VALUE DETERMINATIONS, Juneau, annual

The North Slope Borough has seen the most rapid increase in its estimated full value of property as a result of petroleum development within its borders. Of a total estimated value in 1975 of $560 million, $430 million of that was in the oil and gas production and transmission category of property.

The property tax base for potentially impacted communities along the route of the pipeline outside of Anchorage, Fairbanks, and the North Slope Borough is not known, as no other community has established a property tax. However, there are no significant concentrations of industrial property in the area except for oil pipeline related property taxed by the state.

The sales tax is the other traditional source of revenue at the local government level. Anchorage Borough did not rely upon the sales tax as a revenue source (nor does the since-formed Municipality). Fairbanks city and Borough employ sales tax which varies among service areas within the Borough proper and from year to year. In 1975, the rate in Fairbanks city was 5 percent and 2 percent in most outlying service areas of the Borough. In calendar year 1975, of total revenues to the general and special funds of $14.8 million for the city, $6.3 million came from the sales tax and $3.1 million from property taxes. Inter-governmental revenues amounted to $18.5 million.

The North Slope Borough employs a sales tax in addition to the property tax, which was between 2 percent and 3 percent in 1975, depending upon community within the Borough.

Second-class cities are empowered to use a sales tax and all other organized local communities adjacent to the pipeline route are second-class cities. Reliable information on these communities is sparse but some have a sales tax of 1 or 2 percent which may vary from year to year. Second-class cities include North Pole, in the Fairbanks Borough; Nuiqiut, Anaktuvik Pass, and Kaktovik, in the North Slope Borough; and Allakaket, Fort Yukon, and Delta Junction in the Unorganized Borough.

As with Alaska in general, the local communities along the route of the proposed pipeline receive a large portion of their revenues from the state government. The principal programs through which the transfers presently occur are the education foundation program and the local revenue-sharing program. In fiscal year 1975, approximately $85 million was distributed statewide for the foundation program. Preliminary 1975 fiscal year state revenue-sharing with local governments is approximately $15 million. In extradordinary circumstances, impact grants are also provided to local communities by the state.

2.3.3 Economic Growth Without the Gas Pipeline

Methodology

The ISEGR Man-in-the-Arctic Program (MAP) has developed a series of computer simulation models which are designed specifically to analyze the long-range implication of changes in the major factors affecting the path of Alaskan economic and population growth. These models are built on a series of economic and population studies for the time period since statehood. The economic models proceed sequentially to estimate gross product, employment, wages and salaries, personal income, and disposable personal income. The output of certain industries, designated the "support sector" (trade, public utilities, transportation, communications, finance, and services, plus a portion of the construction industry), is dependent upon the growth of Alaskan personal incomes, and since income is both a function of output and contributes to further output, output and income are simultaneously determined in the models. The population model computes additions in the state at any point and adds net immigration, which has been found to be well predicted by increases and decreases in employment and real per capita income in Alaska relative to the Lower 48.[1]. These models are used to project economic growth in Alaska in the following sections.

Even without the gas pipeline, Alaska's economy and population are expected to grow vigorously over the next 15 years. However, many of the factors contributing to this growth are either determined by forces beyond the control of Alaskans (such as the national policies pertaining to energy independence and oil and gas leasing in OCS areas) or while under the control of Alaskans, cannot be predicted with any confidence (for example, future production tax rates on oil). Consequently, the MAP researchers have projected several possible future patterns of hydrocarbon development in Alaska of varying intensity and probability. These cases are designed to explore the range of outcomes under different assumptions concerning factors exogenous to Alaska's growth.

The most conservative scenario, Limited Development, would limit future petroleum production to the existing areas being developed in Cook Inlet and in the vicinity of Prudhoe Bay while restricting Federal lands development to the Gulf of Alaska and Lower Cook Inlet. With new oil being priced at $7 per barrel at the wellhead (about $11 per barrel delivered on the West Coast contiguous United States), state petroleum revenues would reach $1.3 billion in 1980 and $2.2 billion by 1985, and this could rise to 3.6 billion in 1990.

The next most conservation scenario, Accelerated Development, features all the development in the Limited Scenario plus National Petroleum Reserve 4 (NPR4) and adjacent areas. Federal offshore development moves into St. George's Basin and either the Beaufort or Chukchi Sea. The primary factor in this scenario is that NPR4 turns out to be as productive as Prudhoe Bay, draws additional exploration on state and native lands, and justifies the building of a second trans-Alaska oil pipeline. In this scenario, the state receives $1.4 billion per year in 1980 from petroleum taxes, royalties, and property taxes, and $3.1 billion per year by 1990. Production is about 4.9 billion barrels per day in 1985 and 7.3 billion per day in 1990.

The Maximum Development scenario is by far the least likely since several technical problems would have to be solved for the offshore environments in the North Bering Sea and Chukchi Sea. It is by no means certain that $7 per barrel would permit these developments which would go far beyond those in the Accelerated Development Case. In this scenario, several major lease sales are held on Federal OCS lands in the Bering and Chukchi Seas and Bristol Bay. These are productive enough to justify western Alaska oil pipeline and gas pipelines from Kotzebue to the west side of Cook Inlet. State oil and gas revenues stay at $1.4 billion per year in 1980, the same as the Accelerated case, but rise to $3.9 billion in 1990. Some additional leasing occurs in the lower Kuskokwim and onshore Bering and Chukchi Sea areas but most developments are on Federal OCS lands.

Economic Growth

From these scenarios, none of which include the assumption of a gas line from Prudhoe Bay, simulations were carried out to give a range of possible future growth rates in the absence of a gas pipeline. The results were produced with the latest version of the MAP Regional Model and are reported below.

Gross Product

Gross Product measures the value of all goods and services produced for final demand in Alaska and each of its regions and industries. Changes in this variable indicate the degree to which real output is expected to grow in Alaska in the absence of a gas pipeline. In addition to a statewide summary of results in Table 2.3-13, by region, an industry breakdown is provided for the two economic regions[2] of the state through which the pipeline will pass, Interior and Fairbanks, and for the Anchorage metropolitan area, which is heavily impacted by all economic development in the state.

Table 2.3.-13

GROSS STATE PRODUCT BY REGION
(Millions of 1958 Dollars)

LIMITED DEVELOPMENT

	Anchorage	Interior	Fairbanks	State
1978	902.991	365.265	232.159	2817.94
1979	950.11	374.737	238.331	3028.03
1980	1034.86	393.846	248.608	3522.34
1981	1083.31	339.069	257.444	3549.14
1982	1159.41	294.996	271.857	3569.56
1983	1233.03	243.86	283.788	3691.66
1984	1294.12	232.311	293.404	3743.07
1985	1346.57	233.024	301.496	3816.72
1986	1395.22	220.961	308.287	3855.42
1987	1454.02	218.769	315.536	3960.43
1988	1525.47	210.447	324.209	4101.96
1989	1601.62	208.547	334.214	4172.22
1990	1688.56	209.943	345.689	4228.62

ACCELERATED DEVELOPMENT

	Anchorage	Interior	Fairbanks	State
1978	947.025	424.651	234.457	3464.86
1980	1142.18	527.393	256.677	4654.04
1981	1222.26	522.066	271.751	4937.84
1982	1346.96	511.391	299.08	4993.37
1983	1476.32	457.842	319.94	5191.42
1984	1547.09	388.078	328.88	4927.8
1985	1602.55	391.435	336.3	4972.65
1986	1682.46	413.745	348.673	5104.44
1987	1777.45	415.76	360.325	5271.84
1988	1896.94	432.802	373.911	5564.98
1989	2009.06	425.191	388.939	5632.39
1990	2128.2	415.824	404.428	5687.82

MAXIMUM DEVELOPMENT

	Anchorage	Interior	Fairbanks	State
1978	947.025	424.651	234.457	3464.86
1979	1022.2	436.271	244.809	3749.91
1980	1163.83	529.287	259.435	4701.96
1981	1272.11	525.327	278.457	5102.93
1982	1429.75	516.203	307.902	5333.82
1983	1610.49	459.697	328.707	6017.41
1984	1729.52	390.358	344.266	5868.07
1985	1817.01	394.237	356.658	5987.88
1986	1977.74	416.964	371.829	6582.59
1987	2191.3	420.572	394.91	7209.43
1988	2441.35	439.569	422.494	7986.83
1989	2661.06	433.463	449.07	8350.46
1990	2921.44	425.538	475.872	8969.41

Growth in economic output comes from two sources. In the exploration and development phases of oil development, there is a sharp increase in the level of employment in mining and construction. This increase in employment leads to increases in personal incomes in Alaska, and to increased demand for the services and goods produced in the support sector. In addition, the state and local governments begin to receive additional income, first from oil bonuses and income taxes, gross receipts taxes, and property taxes; and later, from oil production taxes and royalties. The picture is similar in each of the three scenarios in the major impacted regions, although the levels are much different. In the middle case, Accelerated Development, Gross State Product rises to $4.7 billion in 1980, $5.0 billion in 1985, and $5.7 billion in 1990. 1980 and 1985 are within the period of construction of the second oil pipeline, and growth is substantial in all three areas. However, by 1990, most growth in output is centered in Anchorage. The Limited case does not include development of NPR4 or the second oil pipeline, so the level of development is much lower in each of the three regions. The Interior and Fairbanks regions are much more heavily dependent on the development of the North Slope than is Anchorage, even though much of the induced development under either scenario occurs in Anchorage. There is relatively little difference in real output from the middle case in Interior Fairbanks, when compared to the Maximum Development scenario, since most additional petroleum development takes place in southwest Alaska. However, Anchorage would grow anyway, because it is a statewise general support, distribution, government, and financial center.

The distribution of economic growth which would occur without the gas pipeline differs between the three regions, no matter which scenario is adopted. (Tables 2.3-14, 2.3-15, 2.3-16, 2.3-17). Interior (basically, the northern half of the pipeline corridor) generates over three-fourths of its real output in mining, with government providing the only stable pattern of growth. Anchorage, on the other hand, accounts for only 14 percent of its total output in mining in 1980, and this declines to about seven percent in 1990 in the Accelerated case, accounting for three percent of the total growth. Government output accounts for only about five percent of the growth in values of output in Anchorage in this case, the support sector being most important. Fairbanks growth is more heavily dependent on government than Anchorage, if the gas pipeline is not built and government spending follows past regional patterns. About 13 percent of Fairbanks' growth in gross product occurs in state and local government. In the Limited Development case, total output in the Interior region is only about 50 percent of either the Accelerated or Maximum case, but it is again heavily concentrated in mining. Anchorage 1978-1990 Maximum growth is about 1.4 times the Accelerated case with about nine percent of the growth occuring in mining, and three percent in state

Table 2.3.-14

ACCELERATED DEVELOPMENT:
GROSS PRODUCT BY INDUSTRY,
Interior Region

(Millions of 1958 Dollars)

	Ag. Fish. Forest	Mining	Construction	Manufacturin
1978	0.	366.315	4.202	0.
1979	0.	380.158	2.067	0.
1980	0.	468.275	1.	0.
1981	0.	436.052	10.131	0.
1982	0.	385.894	20.645	0.
1983	0.	339.419	18.985	0.
1984	0.	313.231	5.98	0.
1985	0.	322.481	3.49	0.
1986	0.	347.945	1.	0.
1987	0.	347.945	1.	0.
1988	0.	361.664	1.	0.
1989	0.	352.222	1.	0.
1990	0.	341.121	1.	0.

	Transportation Communications Public Utilities	Finance	Services
1978	26.218	0.1	13.631
1979	26.671	0.1	12.808
1980	27.569	0.1	14.946
1981	29.694	0.1	27.579
1982	32.356	0.1	48.984
1983	32.751	0.1	43.376
1984	30.823	0.1	19.075
1985	30.866	0.1	16.114
1986	31.263	0.1	15.152
1987	32.027	0.1	16.055
1988	32.984	0.1	17.834
1989	33.774	0.1	18.506
1990	34.575	0.1	19.109

		Government			Region
	Trade	Total	Federal	State	Total
1978	4.443	9.743	6.202	3.541	424.651
1979	4.239	10.228	6.202	4.026	436.271
1980	4.761	10.742	6.202	4.54	527.393
1981	7.547	10.964	6.202	4.763	522.066
1982	11.625	11.788	6.202	5.586	511.391
1983	10.609	12.602	6.202	6.401	457.842
1984	5.72	13.149	6.202	6.947	388.078
1985	5.03	13.346	6.202	7.144	391.435
1986	4.811	13.476	6.202	7.274	413.745
1987	5.024	13.611	6.202	7.409	415.76
1988	5.438	13.783	6.202	7.581	432.802
1989	5.591	13.998	6.202	7.797	425.191
1990	5.728	14.192	6.202	7.99	415.824

Table 2.3.-15

ACCELERATED DEVELOPMENT:
GROSS PRODUCT BY INDUSTRY,
Anchorage Region

(Millions of 1958 Dollars)

	Ag. Fish Forest	Mining	Construction	Manufacturin
1978	0.1	131.444	45.774	21.
1979	0.1	135.677	48.708	22.6
1980	0.1	169.694	51.812	24.5
1981	0.1	174.232	54.479	26.4
1982	0.1	169.142	59.077	28.8
1983	0.1	170.246	63.711	31.1
1984	0.1	162.981	67.093	33.7
1985	0.1	163.639	69.304	36.4
1986	0.1	165.837	72.169	39.7
1987	0.1	169.031	75.371	43.
1988	0.1	175.898	79.117	46.9
1989	0.1	172.68	83.002	51.
1990	0.1	168.039	87.1	55.5

	Transporation Communications Public Utilities	Finance	Services
1978	182.888	125.107	85.523
1979	199.2	139.314	95.6
1980	221.007	155.023	106.787
1981	241.265	169.065	116.821
1982	272.651	194.436	135.024
1983	302.365	221.469	154.513
1984	316.224	242.098	169.444
1985	327.401	255.992	179.525
1986	345.476	274.471	192.964
1987	367.773	295.736	208.469
1988	395.662	321.448	227.27
1989	423.03	349.034	247.5
1990	452.398	379.14	269.644

		Government			Region
	Trade	Total	Federal	State	Total
1978	190.106	165.084	114.167	50.917	947.025
1979	209.637	171.367	114.167	57.2	1022.2
1980	235.206	178.057	114.167	63.89	1142.18
1981	259.05	180.846	114.167	66.679	1222.26
1982	296.007	191.727	114.167	77.56	1346.96
1983	330.319	202.497	114.167	88.33	1476.32
1984	345.767	209.685	114.167	95.518	1547.09
1985	358.001	212.185	114.167	98.018	1602.55
1986	377.954	213.792	114.167	99.625	1682.46
1987	402.489	215.481	114.167	101.314	1777.45
1988	432.877	217.667	114.167	103.5	1896.94
1989	462.258	220.455	114.167	106.288	2009.06
1990	493.325	222.952	114.167	108.785	2128.2

Table 2.3.-16

ACCELERATED DEVELOPMENT:
GROSS PRODUCT BY INDUSTRY,
Fairbanks Region

(Millions of 1958 Dollars)

	Ag. Fish. Forest	Mining	Construction	Manufacturin
1978	0.1	28.802	14.646	3.9
1979	0.1	28.802	13.984	4.2
1980	0.1	28.802	14.665	4.5
1981	0.1	28.802	17.557	5.
1982	0.1	28.802	20.888	5.3
1983	0.1	28.802	20.737	5.8
1984	0.1	28.802	17.07	6.3
1985	0.1	28.802	16.409	6.9
1986	0.1	31.911	15.853	7.4
1987	0.1	31.911	16.056	8.
1988	0.1	31.911	16.354	8.7
1989	0.1	31.911	16.476	9.5
1990	0.1	31.911	16.601	10.3

	Transportation Communication Public Utilities	Finance	Services
1978	43.807	20.99	16.463
1979	46.923	22.229	17.436
1980	50.062	23.441	18.389
1981	54.137	24.979	19.597
1982	61.593	27.705	21.739
1983	67.864	29.902	23.466
1984	71.434	31.12	24.424
1985	73.957	31.962	25.085
1986	77.352	33.077	25.962
1987	81.34	34.364	26.974
1988	85.936	35.821	28.119
1989	91.032	37.406	29.365
1990	96.359	39.028	30.641

	Trade	Government Total	Government Federal	Government State	Region Total
1978	36.642	69.108	45.927	23.181	234.457
1979	39.567	71.569	45.927	25.642	244.809
1980	42.516	74.202	45.927	28.275	256.677
1981	46.338	75.241	45.927	29.314	271.751
1982	53.354	79.598	45.927	33.671	299.08
1983	59.359	83.91	45.927	37.983	319.94
1984	62.87	86.76	45.927	40.833	328.88
1985	65.383	87.701	45.927	41.774	336.3
1986	68.736	88.283	45.927	42.356	348.673
1987	72.678	88.902	45.927	42.975	360.325
1988	77.243	89.728	45.927	43.801	373.911
1989	82.345	90.804	45.927	44.877	388.939
1990	87.723	91.765	45.927	45.838	404.428

Table 2.3.-17

ACCELERATED DEVELOPMENT:
GROSS PRODUCT BY INDUSTRY,
State

(Millions of 1958 Dollars)

	Ag. Fish Forest	Mining	Construction	Manufacturing
1978	32.9	1809.65	101.89	152.8
1979	33.3	1983.76	103.233	159.4
1980	33.7	2765.87	108.691	166.3
1981	34.	2862.88	144.088	171.9
1982	34.2	2606.06	187.119	178.1
1983	34.6	2611.38	199.203	184.4
1984	35.	2344.8	167.612	191.3
1985	35.3	2349.78	157.217	198.5
1986	35.6	2391.95	152.032	206.4
1987	36.	2431.09	156.817	214.7
1988	36.4	2570.38	160.777	223.9
1989	36.8	2476.81	168.018	233.3
1990	37.2	2362.21	175.461	243.7

	Transportation Communication Public Utilities	Finance	Services
1978	378.731	178.058	150.429
1979	406.438	195.426	162.889
1980	431.373	212.795	178.57
1981	489.598	230.227	205.823
1982	587.333	261.349	252.815
1983	630.801	293.385	272.953
1984	601.01	317.37	266.079
1985	600.261	331.661	273.264
1986	620.403	352.758	287.849
1987	653.84	377.31	307.316
1988	694.948	406.79	331.129
1989	735.894	437.979	355.728
1990	779.396	471.514	382.152

		Government			Region
	Trade	Total	Federal	State	Total
1978	294.668	365.741	216.441	149.3	3464.86
1979	321.651	383.82	216.441	167.379	3749.91
1980	353.668	403.077	216.441	186.636	4654.04
1981	338.271	411.059	216.441	194.618	4937.84
1982	443.972	442.428	216.441	225.987	4993.37
1983	491.238	473.471	216.441	257.03	5191.42
1984	510.477	494.166	216.441	277.725	4927.8
1985	525.356	501.324	216.441	284.883	4972.65
1986	551.552	505.907	216.441	289.466	5104.44
1987	584.051	510.73	216.441	294.29	5271.84
1988	623.67	516.989	216.441	300.548	5564.98
1989	662.882	524.991	216.441	308.551	5632.39
1990	704.039	532.157	216.441	315.717	5687.82

and local government. In the Limited case, Anchorage output grows 67 percent as much as in the Accelerated case but mining actually declines slightly between 1978 and 1990, while state and local government accounts for six percent of the total increase in gross product. In all three cases the support sector is of major importance, demonstrating Anchorange's role as a support base for the entire state. The Fairbanks region also has total output rising about 1.4 times as much as the Maximum as in the Accelerated case, and about 67 percent of the Accelerated, in the Limited case. Construction provides part of the difference of the two higher cases from the Limited; while much of the rest of the difference is in the level of state government output and the consequent different levels of output in the support sectors.

In each case, Anchorage grows significantly faster than the state as a whole in the absence of gas pipeline development. Fairbanks also grows faster than the state in the Accelerated case, but slower than the state in the Maximum and Limited scenarios. This reflects Fairbank's importance as a regional supply center which has relatively low growth rates when development is somewhere other than the regions served by Fairbanks. Interior has a very small unstable economy which is strongly influenced by major construction and development within its boundaries, but which grows much slower over the long term than the state as a whole.

Employment

Statewide employment by 1990 varies from 336,096 for the Limited Development scenario to 525,404 for the Maximum Development case, while the middle case projects statewide employment to be 408,913 by 1990 (Table 2.3-18). For each case, the Anchorage region will account for roughly 55 percent of total statewide employment by 1990, whereas roughly 45 percent of statewide employment occurs in this region now. Owing to the nature of the development scenarios, neither Fairbanks nor the Interior employment is as responsive as Anchorage employment, over the long run, to the different envisioned development patterns. As with gross product, this is because of Anchorage's importance as a control center for development activities in all state regions. For example, the Interior region employment peaks coincidentally with the Prudhoe Bay and NPR4 field development in 1983 and remains stable throughout the remainder of the forecast period, showing no additional impact from development along Alaska's west coast as envisioned in the Accelerated and Maximum cases.

Employment by industry (Tables 2.3-19, 2.3-20, 2.3-21) in the three regions considered shows that, in Anchorage, the service industry, in particular, and the support industries, in general, experience the greatest growth in employment. The Interior region shows a relatively constant level of employment concentration in mining, some

Table 2.3.-18

EMPLOYMENT BY REGION
(Thousands of Wage Earners)

LIMITED DEVELOPMENT

	Anchorage	Interior	Fairbanks	State
1978	99.071	7.271	29.567	210.781
1979	104.407	6.98	30.462	219.48
1980	112.439	7.103	31.669	234.322
1981	118.111	6.708	32.605	243.869
1982	127.362	6.495	34.327	260.103
1983	135.574	6.141	35.628	274.709
1984	142.051	6.111	36.522	284.659
1985	147.52	6.153	37.234	291.512
1986	152.576	6.047	37.748	297.538
1987	158.23	6.048	38.232	304.749
1988	165.166	6.003	38.862	313.557
1989	172.858	6.034	39.618	323.949
1990	181.776	6.116	40.508	336.096

ACCELERATED DEVELOPMENT

	Anchorage	Interior	Fairbanks	State
1978	101.736	7.867	29.887	216.69
1979	109.716	7.721	31.188	230.724
1980	119.086	8.445	32.722	249.439
1981	126.293	10.663	34.245	267.188
1982	140.309	13.665	37.406	298.641
1983	154.627	12.982	39.849	323.586
1984	164.377	9.258	40.89	331.487
1985	170.526	8.757	41.581	337.716
1986	178.431	8.528	42.337	347.247
1987	187.562	8.653	43.274	360.179
1988	198.711	8.954	44.384	375.867
1989	210.447	9.022	45.623	392.096
1990	222.993	9.068	46.85	408.913

MAXIMUM DEVELOPMENT

	Anchorage	Interior	Fairbanks	State
1978	101.736	7.867	29.887	216.69
1979	109.716	7.721	31.188	230.724
1980	120.908	8.578	32.924	253.069
1981	130.76	10.912	34.984	276.28
1982	147.113	14.003	38.395	315.247
1983	164.193	13.156	40.954	353.58
1984	178.604	9.529	42.815	369.133
1985	187.733	9.111	44.095	376.06
1986	200.93	8.919	45.136	401.514
1987	220.487	9.239	47.377	434.813
1988	243.331	9.777	50.018	465.456
1989	265.184	10.019	52.419	493.995
1990	289.789	10.221	54.709	525.404

Table 2.3.-19

ACCELERATED DEVELOPMENT:
EMPLOYMENT BY INDUSTRY, ANCHORAGE REGION
(Thousands of Wage Earners)

	Ag, Fish, Forest	Mining	Construction	Manufacturing
1978	0.086	1.514	6.603	1.82
1979	0.087	1.554	6.493	1.96
1980	0.088	1.868	6.951	2.118
1981	0.089	1.909	7.347	2.281
1982	0.09	1.863	8.034	2.473
1983	0.091	1.873	8.733	2.666
1984	0.091	1.807	9.245	2.876
1985	0.092	1.813	9.582	3.099
1986	0.093	1.833	10.02	3.363
1987	0.094	1.862	10.511	3.631
1988	0.095	1.924	11.089	3.938
1989	0.096	1.895	11.691	4.264
1990	0.097	1.853	12.329	4.612

	Transportation Communications Public Utilities	Finance	Services	Trade
1978	7.532	4.632	15.616	18.113
1979	8.11	5.192	17.634	19.873
1980	8.901	5.815	19.897	21.95
1981	9.626	6.375	21.945	23.827
1982	10.689	7.394	25.701	26.924
1983	11.637	8.489	29.773	29.992
1984	11.965	9.33	32.925	31.926
1985	12.257	9.899	35.068	33.296
1986	12.774	10.659	37.941	35.234
1987	13.421	11.536	41.279	37.501
1988	14.229	12.603	45.356	40.243
1989	14.968	13.753	49.778	43.047
1990	15.736	15.015	54.656	46.048

	Government Total	Federal	State and Local	Self Employed	Region Total
1978	37.556	23.6	13.956	8.803	101.736
1979	39.319	23.6	15.719	9.494	109.716
1980	41.2	23.6	17.6	10.297	119.086
1981	41.986	23.6	18.386	10.908	126.293
1982	45.059	23.6	21.459	12.082	140.309
1983	48.11	23.6	24.51	13.264	154.627
1984	50.151	23.6	26.551	14.06	164.377
1985	50.861	23.6	27.261	14.559	170.526
1986	51.318	23.6	27.718	15.196	178.431
1987	51.799	23.6	28.199	15.928	187.562
1988	52.421	23.6	28.821	16.814	198.711
1989	53.215	23.6	29.615	17.739	210.447
1990	53.926	23.6	30.326	18.721	222.993

Table 2.3.-20

ACCELERATED DEVELOPMENT:
EMPLOYMENT BY INDUSTRY, INTERIOR REGION
(Thousands of Wage Earners)

	Ag, Fish, Forest	Mining	Construction	Manufacturing
1978	0.	2.582	0.531	0.
1979	0.	2.662	0.261	0.
1980	0.	3.16	0.126	0.
1981	0.	2.98	1.281	0.
1982	0.	2.695	2.611	0.
1983	0.	2.425	2.401	0.
1984	0.	2.27	0.756	0.
1985	0.	2.325	0.441	0.
1986	0.	2.475	0.126	0.
1987	0.	2.475	0.126	0.
1988	0.	2.555	0.126	0.
1989	0.	2.5	0.126	0.
1990	0.	2.435	0.126	0.

	Transportation Communications Public Utilities	Finance	Services	Trade
1978	0.517	0.002	1.08	0.78
1979	0.51	0.002	1.032	0.743
1980	0.508	0.002	1.154	0.839
1981	0.519	0.002	1.802	1.358
1982	0.534	0.002	2.737	2.133
1983	0.526	0.002	2.506	1.938
1984	0.494	0.002	1.378	1.016
1985	0.483	0.002	1.219	0.89
1986	0.476	0.002	1.166	0.848
1987	0.473	0.002	1.216	0.887
1988	0.471	0.002	1.313	0.964
1989	0.468	0.002	1.348	0.992
1990	0.466	0.002	1.38	1.017

	Government Total	Federal	State and Local	Self Employed	Region Total
1978	2.265	1.3	0.965	0.11	7.867
1979	2.401	1.3	1.101	0.111	7.721
1980	2.545	1.3	1.245	0.111	8.445
1981	2.608	1.3	1.308	0.112	10.663
1982	2.84	1.3	1.54	0.112	13.665
1983	3.071	1.3	1.771	0.113	12.982
1984	3.226	1.3	1.926	0.114	9.258
1985	3.282	1.3	1.982	0.114	8.757
1986	3.319	1.3	2.019	0.115	8.528
1987	3.358	1.3	2.058	0.115	8.653
1988	3.407	1.3	2.107	0.116	8.954
1989	3.468	1.3	2.168	0.116	9.022
1990	3.524	1.3	2.224	0.117	9.068

Table 2.3.-21

ACCELERATED DEVELOPMENT, EMPLOYMENT BY INDUSTRY, FAIRBANKS REGION (Thousands of Wage Earners)

	Ag, Fish, Forest	Mining	Construction	Manufacturing
1978	0.013	0.341	1.883	0.375
1979	0.013	0.341	1.8	0.402
1980	0.013	0.341	1.896	0.429
1981	0.013	0.341	2.274	0.471
1982	0.013	0.341	2.709	0.497
1983	0.013	0.341	2.693	0.541
1984	0.013	0.341	2.216	0.588
1985	0.014	0.341	2.131	0.64
1986	0.014	0.371	2.06	0.683
1987	0.014	0.371	2.088	0.733
1988	0.014	0.371	2.129	0.792
1989	0.014	0.371	2.146	0.859
1990	0.014	0.371	2.163	0.925

	Transportation Communications Public Utilities	Finance	Services	Trade
1978	1.876	0.809	2.88	3.841
1979	1.994	0.862	3.064	4.068
1980	2.111	0.915	3.245	4.29
1981	2.262	0.981	3.475	4.567
1982	2.535	1.101	3.887	5.044
1983	2.761	1.199	4.221	5.434
1984	2.889	1.253	4.407	5.659
1985	2.978	1.291	4.536	5.82
1986	3.098	1.341	4.707	6.028
1987	3.238	1.399	4.905	6.265
1988	3.398	1.466	5.13	6.532
1989	3.575	1.538	5.375	6.821
1990	3.758	1.612	5.628	7.118

	Government Total	Federal	State and Local	Self Employed	Region Total
1978	15.759	9.4	6.359	2.111	29.887
1979	16.46	9.4	7.06	2.184	31.188
1980	17.212	9.4	7.812	2.268	32.722
1981	17.51	9.4	8.11	2.35	34.245
1982	18.763	9.4	9.363	2.515	37.406
1983	20.008	9.4	10.608	2.638	39.849
1984	20.834	9.4	11.434	2.689	40.89
1985	21.108	9.4	11.708	2.722	41.581
1986	21.277	9.4	11.877	2.759	42.337
1987	21.457	9.4	12.057	2.804	43.274
1988	21.697	9.4	12.297	2.856	44.384
1989	22.01	9.4	12.61	2.914	45.623
1990	22.29	9.4	12.89	2.971	46.85

minor growth in government, and a brief upsurge in construction employment during NPR4 development (1982-1983). Impacted sectors in the Fairbanks region are concentrated in the support sectors, specifically service and trade, and in government employment. This result is rather obvious, as Fairbanks is the logical support center for development North of the Yukon River.

Statewide, with the exception of the renewable resource industries, employment grows substantially for all industries by 1990 (Table 2.3-22). Major growth industries are forecasted to include mining, construction, transportation, finance, services, trade, and government.

Payroll (Wages and Salaries)

Payroll is related to employment by wage rate. Wage rate differences between economic sectors will help determine the differences of payrolls in the projections. Employment growth in the support sectors will tend to have less impact than growth in mining or construction on payroll.

Statewide real (corrected for inflation) wages and salaries are projected to range from $2698.5 million for the Limited Development case, to $3306.6 million for the Accelerated case, to $4266.1 million for the Maximum Development case by 1990 (Table 2.3-23). In 1974, total statewide payroll was just over $1 billion (See Table 2.3-24).

As in the case of GSP and employment, payrolls in the Interior region are projected to experience slow growth (actually declining in the Limited Development case) to 1990, with a major short-term increase in 1982 and 1983. In contrast, both Fairbanks and Anchorage experience substantial growth for all three cases, with Anchorage growing fastest. By 1980, well over half the payroll in the state will be paid in the Anchorage area.

Results of this payroll forecast by industry and region show that, statewide, the support sectors and state and local government will account for the largest share of growth in wages and salaries (Table 2.3-24). Construction and the Federal government will also continue to be important contributors of wage and salary income. Interestingly, by 1990 manufacturing is forecast to have a larger payroll than mining, a direct result of the capital intensive nature of the latter.

On a regional basis, Anchorage payroll growth behaves much the same as the state, with the support and government sectors accounting for a sizeable amount of overall growth in the payroll bill. Here, manufacturing wages and salaries are

Table 2.3-22

ACCELERATED DEVELOPMENT:
EMPLOYMENT BY INDUSTRY, STATE
(Thousands of Wage Earners)

	Ag, Fish, Forest	Mining	Construction	Manufacturing
1978	1.093	8.238	13.433	11.228
1979	1.105	8.676	13.71	11.708
1980	1.116	12.17	14.491	12.204
1981	1.126	12.617	19.13	12.645
1982	1.137	12.109	24.86	13.132
1983	1.148	12.217	26.556	13.634
1984	1.16	11.491	22.596	14.183
1985	1.172	11.561	21.321	14.76
1986	1.183	11.779	20.768	15.384
1987	1.196	12.102	21.516	16.046
1988	1.207	12.78	22.196	16.776
1989	1.219	12.463	23.285	17.527
1990	1.231	12.005	24.407	18.347

	Transportation Communications Public Utilities	Finance	Services	Trade
1978	15.18	6.666	26.154	30.286
1979	16.045	8.051	31.745	32.745
1980	16.949	8.051	31.745	35.457
1981	18.462	8.753	35.423	38.557
1982	20.705	10.018	41.752	43.728
1983	21.997	11.331	47.03	47.84
1984	21.698	12.323	49.589	49.667
1985	21.782	12.912	51.621	51.177
1986	22.37	13.788	54.872	53.624
1987	23.268	14.811	58.902	57.579
1988	24.375	16.043	63.744	60.12
1989	25.415	17.354	69.029	63.729
1990	26.493	18.769	74.783	67.538

	Government Total	Federal	State and Local	Self Employed	State Total
1978	85.559	44.7	40.859	18.853	216.69
1979	90.64	44.7	45.94	19.93	230.724
1980	96.967	44.7	51.367	21.19	249.439
1981	98.32	44.7	53.62	22.154	267.188
1982	107.2	44.7	62.5	24.001	298.641
1983	116.018	44.7	71.318	25.815	323.586
1984	121.912	22.7	77.212	26.87	331.487
1985	123.953	44.7	79.253	27.457	337.716
1986	125.26	44.7	80.56	28.219	347.247
1987	126.636	44.7	81.936	29.122	360.179
1988	128.423	44.7	83.723	30.203	375.867
1989	130.709	44.7	86.009	31.365	392.096
1990	132.758	44.7	88.058	32.582	408.913

Table 2.3-23

REAL WAGES AND SALARIES PAID BY REGION
(Millions of 1967 Dollars)

LIMITED DEVELOPMENT

	Anchorage	Interior	Fairbanks	State
1978	667.045	65.523	203.098	1467.57
1979	708.29	60.6	210.472	1510.33
1980	775.668	61.655	223.728	1644.06
1981	827.333	58.174	235.126	1736.83
1982	904.776	55.732	252.774	1874.12
1983	976.632	52.124	267.627	2006.08
1984	1038.58	52.197	280.099	2110.95
1985	1092.25	52.521	290.366	2180.46
1986	1144.33	51.569	299.456	2248.15
1987	1203.5	52.281	309.307	2338.68
1988	1273.63	52.457	320.723	2443.51
1989	1350.71	53.406	333.505	2562.53
1990	1439.1	54.864	347.955	2698.52

ACCELERATED DEVELOPMENT

	Anchorage	Interior	Fairbanks	State
1978	685.406	70.808	205.519	1513.49
1979	751.137	68.905	218.948	1634.74
1980	822.657	73.721	232.164	1768.29
1981	885.692	96.389	249.023	1943.07
1982	997.656	123.94	279.175	2213.66
1983	1114.59	117.518	303.701	2423.79
1984	1202.4	82.026	317.382	2492.45
1985	1260.89	76.189	326.868	2540.86
1986	1337.97	74.163	339.475	2647.23
1987	1425.73	76.065	354.082	2788.14
1988	1530.62	79.646	370.678	2954.84
1989	1641	80.947	388.814	3126.25
1990	1761.58	82.09	407.464	3306.56

MAXIMUM DEVELOPMENT

	Anchorage	Interior	Fairbanks	State
1978	685.406	70.808	205.519	1513.49
1979	751.137	68.905	218.948	1634.74
1980	841.051	76.465	236.511	1832.3
1981	922.694	99.721	257.57	2047.26
1982	1051.38	127.663	289.768	2386.13
1983	1183.42	118.539	312.841	2702.
1984	1305.77	83.617	333.478	2825.78
1985	1387.88	78.398	348.395	2860.2
1986	1505.7	76.664	363.904	3109.89
1987	1673.64	79.873	390.572	3417.95
1988	1870.26	85.063	421.777	3695.29
1989	2062.58	87.625	451.683	3964.65
1990	2280.03	89.947	481.609	4266.08

Table 2.3-24

ACCELERATED DEVELOPMENT:
WAGES AND SALARIES BY INDUSTRY,
State

(Millions of Dollars)

	Ag. Fish, Forest	Mining	Construction	Manufacturing
1978	24.777	219.252	344.303	182.475
1979	25.651	242.709	361.977	201.023
1980	26.545	359.328	393.986	221.306
1981	27.438	390.582	566.488	241.531
1982	28.389	392.943	787.856	264.311
1983	29.371	415.017	864.725	289.05
1984	30.425	407.021	731.389	316.887
1985	31.485	427.531	707.675	347.728
1986	32.565	455.245	707.538	382.085
1987	33.737	488.615	761.772	420.354
1988	34.887	539.877	816.72	463.548
1989	36.078	552.554	889.685	510.738
1990	37.326	560.654	968.2	564.202

	Transportation Communications Public Utilities	Finance	Services
1978	293.804	106.848	341.497
1979	328.625	125.713	397.167
1980	368.836	146.946	463.27
1981	423.398	170.122	545.74
1982	500.708	207.427	678.825
1983	565.368	249.983	807.615
1984	595.519	289.456	899.686
1985	635.551	323.437	990.29
1986	693.011	367.707	1112.41
1987	764.759	420.494	1261.99
1988	850.375	484.915	1443.36
1989	941.093	558.554	1651.7
1990	1041.59	643.579	1890.62

Table 2.3-24 (Cont'd)

		GOVERNMENT			
	Trade	Total	Federal	State & Local	Region Total
1978	375.663	1446.34	714.99	731.352	3334.96
1979	424.741	1643.26	766.914	876.347	3750.87
1980	481.491	1866.71	822.478	1044.23	4328.41
1981	545.344	2044.07	882.146	1161.93	4954.71
1982	642.593	2389.22	945.986	1443.23	5892.27
1983	735.761	2769.65	1014.48	1755.17	6726.53
1984	800.333	3113.82	1088.12	2025.7	7184.53
1985	860.62	3383.5	1166.99	2216.51	7707.8
1986	940.963	3653.5	1251.6	2401.9	8345.02
1987	1035.94	3947.03	1342.48	2604.55	9134.68
1988	1148.65	4276.76	1439.74	2837.02	1.01F+04
1989	1269.89	4650.54	1543.91	3106.64	1.11F+04
1990	1403.64	5047.01	1655.98	3391.03	1.22F+04

forecast to increase dramatically from around $10 million in 1974 to $149.1 million in 1990 (Table 2.3-25).

Mining is forecast to dominate payroll in the Interior region, with the support sectors and state and local government accounting for most growth in 1990 (increased by 500 percent for state and local government over the forecast period). The construction payroll is forecast to rise in 1982 and 1983 and fall dramatically by 1990 (Table 2.3-26).

In Fairbanks, the support sectors and government are forecasted to continue as the major contributors to payroll and also to experience the most rapid growth (Table 2.3-27). As in the case of Anchorage, the forecast for manufacturing shows a very large growth, as could be expected from growth in local demand for bakeries, dairies, and the like, which make up most of this sector.

(Editor's note: Real wages and salaries by region, Table 2.3-23, include payments to Natives under the Native Claims Settlement Act through a clerical error. This is never larger than 5 percent of the total in the largest case, and the amount of payments falls to zero by 1985. The impact section results are not influenced by the reporting error, nor is the regional distribution of any other variable in the three base cases.)

Personal Income, Population, Per Capita Income

As would be expected from the data on wages and salaries, Alaskan aggregate personal income grows substantially over the period of 1978 to 1990. While it is demonstrated in Table 2.3-28 that personal income for the state as a whole rises between 190 and 340 percent, in real terms, the growth rate is only 80 to 180 percent, and in real per capita terms 15 to 20 percent. Despite the fact that the projected increases in the Alaskan cost of living for 1978 to 1990 are below such projections for the United States as a whole, the Alaska Relative Price Index for the same period shows an increase of 59 percent. This figure is equivalent to 63 percent decline in purchasing power.

Furthermore, as was mentioned in connection with state and local spending, the MAP population model assumes that increases in real personal income will induce additional migration to Alaska; therefore, additions to personal income will be "averaged" over a much larger population base than was present before incomes began to rise.

The projected regional distribution of population between 1978 and 1990 which the MAP models project in the absence of a gas pipeline is shown in Table 2.3-29. Except

Table 2.3-25

ACCELERATED DEVELOPMENT:
WAGES AND SALARIES BY INDUSTRY
ANCHORAGE REGION
(Millions of Dollars)

	Agriculture, Forestry, Fisheries	Mining	Construction	Manufacturing
1978	0.971	40.376	139.17	31.372
1979	1.006	43.58	154.817	35.537
1980	1.043	55.082	172.143	40.429
1981	1.081	59.192	188.983	45.838
1982	1.119	60.735	214.629	52.386
1983	1.16	64.202	242.283	59.501
1984	1.188	65.133	266.434	67.638
1985	1.231	68.714	286.805	76.814
1986	1.275	73.05	311.507	87.905
1987	1.32	78.033	339.43	100.063
1988	1.367	84.78	371.917	114.48
1989	1.415	87.794	407.233	130.726
1990	1.465	90.274	446.083	149.148

	Transportation, Communications, Public Utilities	Finance	Services	Trade
1978	153.402	78.418	214.82	240.927
1979	174.987	93.525	255.947	275.485
1980	203.669	111.443	304.769	318.093
1981	233.542	129.999	354.773	361.031
1982	275.213	160.409	438.496	425.47
1983	317.896	195.924	536.267	493.106
1984	346.481	229.123	625.596	543.96
1985	376.204	258.639	703.247	589.696
1986	415.865	296.298	802.981	649.927
1987	463.662	341.248	922.149	720.691
1988	521.795	396.625	1,069.18	805.87
1989	582.626	460.448	1,238.57	897.252
1990	650.328	534.873	1,435.19	998.993

Table 2.3-25 (Cont.)

	Total Federal, State & Local Government	Federal Government	State & Local Government	Region Total
1978	660.049	389.321	270.728	1,559.5
1979	742.718	417.594	325.124	1,777.6
1980	835.956	447.85	388.106	2,042.63
1981	912.601	480.339	432.262	2,287.04
1982	1,052.9	515.101	537.797	2,681.36
1983	1,207.22	552.396	654.822	3,117.56
1984	1,348.81	592.493	756.316	3,494.36
1985	1,463.34	635.44	827.890	3,824.96
1986	1,578.96	681.513	897.45	4,217.77
1987	1,704.47	730.998	973.476	4,671.77
1988	1,844.64	783.954	1,060.69	5,210.66
1989	2,002.52	840.677	1,161.84	5,808.58
1990	2,170.23	901.702	1,268.53	6,476.58

Table 2.3-26

ACCELERATED DEVELOPMENT:
WAGES AND SALARIES BY INDUSTRY, INTERIOR,
Interior Region

(Millions of Dollars)

	Ag. Fish, Forest	Mining	Construction	Manufacturing
1978	0.	73.042	19.275	0.
1979	0.	79.189	9.851	0.
1980	0.	98.842	4.949	0.
1981	0.	98.015	52.078	0.
1982	0.	93.198	110.222	0.
1983	0.	88.174	105.271	0.
1984	0.	86.793	34.445	0.
1985	0.	93.473	20.879	0.
1986	0.	104.629	6.213	0.
1987	0.	110.025	6.454	0.
1988	0.	119.426	6.703	0.
1989	0.	122.861	6.962	0.
1990	0.	125.837	7.231	0.

	Transportation Communications Public Utilities	Finance	Services
1978	13.457	0.029	13.722
1979	13.822	0.031	13.837
1980	14.349	0.033	16.339
1981	15.291	0.035	26.925
1982	16.403	0.037	43.155
1983	16.893	0.039	41.702
1984	16.617	0.042	24.202
1985	16.987	0.045.	22.594
1986	17.509	0.047	22.8
1987	18.215	0.051	25.101
1988	19.044	0.054	28.592
1989	19.846	0.057	31.003
1990	20.706	0.061	33.49

Table 2.3-26 (Cont'd)

	Trade	GOVERNMENT			Region Total
		Total	Federal	State & Local	
1978	5.579	29.659	17.086	12.574	154.944
1979	5.719	33.622	18.327	15.295	156.071
1980	6.733	38.101	19.654	18.446	179.346
1981	11.366	41.736	21.08	20.655	245.446
1982	18.618	48.542	22.606	25.936	330.175
1983	17.644	56.033	24.243	31.791	325.756
1984	9.644	62.871	26.002	36.868	234.615
1985	8.808	68.337	27.887	40.45	231.124
1986	8.751	73.839	29.909	43.93	233.788
1987	9.55	79.814	32.081	47.734	249.21
1988	10.817	86.502	34.405	52.097	271.137
1989	11.612	94.052	36.894	57.158	286.393
1990	12.419	102.068	39.572	62.496	301.812

Table 2.3-27

ACCELERATED DEVELOPMENT:
WAGES AND SALARIES BY INDUSTRY
Fairbanks Region

(Millions of Dollars)

	Ag. Fish, Forest	Mining	Construction	Manufacturing
1978	0.141	7.94	49.08	6.502
1979	0.145	8.35	48.733	7.365
1980	0.148	8.779	53.342	8.299
1981	0.152	9.232	66.424	9.589
1982	0.156	9.706	82.209	10.693
1983	0.16	10.205	84.868	12.301
1984	0.164	10.732	72.549	14.095
1985	0.181	11.284	72.447	16.217
1986	0.185	12.909	72.732	18.279
1987	0.189	13.575	76.573	20.76
1988	0.194	14.274	81.096	23.705
1989	0.199	15.007	84.891	27.166
1990	0.204	15.781	88.89	30.921

	Transportation Communications Public Utilities	Finance	Services
1978	37.368	11.415	38.305
1979	42.112	12.947	42.999
1980	47.284	14.612	48.059
1981	53.766	16.686	54.325
1982	64.056	19.919	64.12
1983	74.115	23.068	73.506
1984	82.278	25.66	80.959
1985	89.963	28.124	87.946
1986	99.287	31.086	96.316
1987	110.135	34.512	105.947
1988	122.687	38.453	116.923
1989	137.004	42.925	129.323
1990	152.927	47.883	142.882

Table 2.3-27 (Cont'd)

	Trade	GOVERNMENT Total	Federal	State & Local	Region Total
1978	47.143	265.369	142.569	122.8	463.263
1979	52.265	298.29	152.923	145.367	513.205
1980	57.687	335.498	164.002	171.496	573.709
1981	64.321	365.714	175.9	189.814	640.209
1982	74.625	422.227	186.63	233.597	747.71
1983	84.318	484.434	202.287	282.146	846.975
1984	91.875	541.223	216.971	324.253	919.534
1985	98.762	586.647	323.698	353.949	991.57
1986	106.979	632.374	249.57	382.804	1070.15
1987	116.343	682.035	267.691	414.344	1160.07
1988	126.95	737.61	287.084	450.526	1261.89
1989	138.784	800.344	307.856	492.489	1375.64
1990	151.628	866.954	330.203	536.752	1498.07

Table 2.3-28

ALASKA PERSONAL INCOME AND PER CAPITA INCOME

	Personal Income (10^6 Dollars)	RIP	Real Personal Income (10^6 1967 Dollars)	Real Personal Income Per Capita (1967 Dollars)
LIMITED DEVELOPMENT				
1978	3,953.4	231.8	1,705.2	3,885.2
79	4,237.9	240.9	1,759.3	3,849.1
80	4,784.4	250.3	1,911.3	3,965.7
81	5,245.6	260.1	2,016.5	4,020.4
82	5,874.7	270.3	2,173.1	4,103.3
83	6,527.7	281.0	2,323.1	4,174.3
84	7,126.4	291.9	2,441.3	4,221.2
85	7,647.4	303.4	2,521.0	4,226.9
86	8,189.6	315.2	2,597.9	4,239.2
87	8,842.9	327.6	2,699.1	4,283.2
88	9,587.3	340.4	2,816.3	4,337.4
89	10,434.6	353.8	2,949.3	4,399.1
90	11,401.6	367.7	3,101.2	4,468.8
ACCELERATED DEVELOPMENT				
1978	4,076.0	231.8	1,758.1	3,927.3
79	4,567.1	240.9	1,896.0	4,006.0
80	5,140.7	250.3	2,053.6	4,062.7
81	5,859.5	260.1	2,252.4	4,192.1
82	6,921.8	270.3	2,560.5	4,357.7
83	7,863.8	281.0	2,798.6	4,424.6
84	8,391.5	291.9	2,874.8	4,371.7
85	8,894.8	303.4	2,932.1	4,316.4
86	9,617.5	315.2	3,050.9	4,335.6
87	10,512.0	327.6	3,208.5	4,384.1
88	11,557.3	340.4	3,394.9	4,446.6
89	12,688.5	353.8	3,586.3	4,504.3
90	13,924.0	367.7	3,787.2	4,562.8

Table 2.3-28 (Cont'd)

ALASKA PERSONAL INCOME AND PER CAPITA INCOME

	Personal Income (10^6 Dollars)	RIP	Real Personal Income (10^6 1967 Dollars)	Real Personal Income Per Capita (1967 Dollars)
MAXIMUM DEVELOPMENT				
1978	4,076.0	231.8	1,758.1	3,927.3
79	4,567.1	240.9	1,896.0	4,006.0
80	5,309.6	250.3	2,121.1	4,159.3
81	6,154.6	260.1	2,365.9	4,302.5
82	7,438.8	270.3	2,751.7	4,501.4
83	8,752.3	281.1	3,114.8	4,611.2
84	9,496.5	291.9	3,253.3	4,556.6
85	9,993.2	303.4	3,294.2	4,445.9
86	11,268.4	315.2	3,574.6	4,531.7
87	12,843.3	327.6	3,920.1	4,625.5
88	14,400.4	340.4	4,230.1	4,676.2
89	16,028.5	353.8	4,530.3	4,718.3
90	17,889.4	367.7	4,865.8	4,770.2

Table 2.3-29

POPULATION BY REGION
(Thousands of Persons)

LIMITED DEVELOPMENT

	Anchorage	Interior	Fairbanks	Statewide
1978	198.962	14.469	61.678	438.899
1979	210.093	13.937	63.959	457.069
1980	223.839	14.163	65.996	481.957
1981	235.107	13.56	68.008	501.552
1982	250.732	13.263	71.05	529.598
1983	265.861	12.744	73.579	556.537
1984	279.377	12.8	75.69	578.353
1985	292.135	12.968	77.718	956.402
1986	304.283	12.861	79.318	612.838
1987	316.941	12.925	80.642	630.162
1988	331.382	12.893	82.092	649.29
1989	346.721	12.989	83.681	670.422
1990	363.809	13.166	85.412	693.949

ACCELERATED DEVELOPMENT

	Anchorage	Interior	Fairbanks	Statewide
1978	203.377	15.541	62.11	447.653
1979	217.562	15.293	64.625	473.272
1980	234.92	16.6	67.814	505.487
1981	248.012	21.097	70.38	537.302
1982	269.163	27.165	75.133	587.569
1983	294.544	25.813	79.912	632.522
1984	316.595	18.732	83.564	657.574
1985	333.025	17.97	86.274	679.299
1986	350.821	17.678	88.498	703.69
1987	369.858	18.038	90.737	731.844
1988	391.877	18.706	93.116	763.486
1989	414.784	18.942	95.714	796.198
1990	439.247	19.13	98.271	830.02

MAXIMUM DEVELOPMENT

	Anchorage	Interior	Fairbanks	Statewide
1978	203.377	15.541	62.11	447.653
1979	217.377	15.293	64.625	473.272
1980	236.653	16.864	67.706	509.973
1981	253.56	21.556	71.126	549.886
1982	277.83	27.682	76.088	611.295
1983	306.096	25.742	80.542	675.488
1984	336.094	19.038	85.773	713.975
1985	360.206	18.622	90.286	740.954
1986	385.136	18.304	92.393	788.795
1987	419.28	18.989	96.406	847.494
1988	460.595	20.175	101.575	904.608
1989	501.265	20.839	106.575	960.158
1990	546.818	21.398	111.09	1020.03

for the construction period, the model predicts much of the growth will occur in the Anchorage region. This follows from the relative growth in employment in Anchorage.

The MAP models do not give regional personal income estimates at this time; however, if it is assumed that the statewide non-wage personal income growth rate is applied to the regions as well, the resulting increases in regional total personal income would be shown in Table 2.3.30. No claim is made that this would be the income which would actually prevail. As a matter of fact, the component of personal income, wages and salaries, grows at a rate faster than the state average in Anchorage, while the growth rate in this component is far below the state average in Fairbanks and the Interior, but it is unknown whether non-wage income grows at these or some other rates in each region. Under the assumptions given, Interior would see a decrease in real income during the period of 1978 through 1990 relative to 1974, in the most restricted case. However, in all other cases personal income in each region tends to rise. On a per capita basis, real personal income declines slightly in the Interior region while rising between 14 and 24 percent in the other regions, if the gas pipeline is not built. This compares with a statewide increase in real per capita income of between 15 and 21 percent between 1978 and 1990, in the absence of a gas pipeline (Table 2.3-31).

State and Local Revenues and Expenditures

State and local revenues and expenditures are expected to grow quite rapidly, even without a gas pipeline. From 1978 level of about $1.5 billion, state annual revenues are conservatively estimated to rise to between $4.6 and $7.5 billion in 1990 with $7 billion in oil, depending upon the exact path of oil and gas development and the applicable features of the future tax structure. This is between 9 and 15 times the 1974 level of receipts. Local revenues are projected to rise from $530-550 million level in 1978 to between $2.3 and $4.3 billion in 1990. This is between 10 and 18 times 1974 levels. Part of local revenues would be shared revenues from the state, but even local revenues from local sources can be expected to grow to between $1.7 to $3.4 billion from 1990, compared with $330 to $340 million in 1974 (See Table 2.3-32).

Due to large population increases accompanying development, backlogs of demand for services created by relatively low real per capita expenditures in the past and numerous other factors, Alaska's state and local governments are expected to increase expenditures rapidly, in spite of the existence of a permanent fund to save a substantial (25 percent) portion of the state's petroleum revenues. Expenditures by the state government, including revenue sharing, would rise from around $1.3 billion annually in

Table 2.3-30

ESTIMATED REAL PERSONAL INCOMES RECEIVED, BY REGION
(Millions of 1967 Dollars)

Year	Anchorage	Interior	Fairbanks	State
1974 Civilian	975.5	140.1	351.4	2,261.3
Military	123.2	9.0	61.0	250.0
TOTAL	1,098.7	149.1	412.4	2,511.3
1974 Real Income (1967 $)[1,2]	569.3	77.3	213.7	1,301.2
LIMITED DEVELOPMENT[3]				
1978	757.3	71.4	225.8	1,705.2
1980	877.2	68.3	249.2	1,911.3
1985	1,221.6	60.9	322.8	2,521.0
1990	1,592.0	64.8	386.3	3,101.2
ACCELERATED DEVELOPMENT[3]				
1978	778.3	76.9	228.9	1,758.1
1980	931.1	80.8	259.5	2,053.6
1985	1,409.5	85.9	364.3	2,932.1
1990	1,944.2	94.0	453.4	3,787.2
MAXIMUM DEVELOPMENT[3]				
1978	778.3	76.9	228.9	1,758.1
1980	950.8	83.7	264.1	2,121.1
1985	1,552.7	89.2	389.9	3,294.2
1990	2,507.7	104.8	538.9	4,865.8

1 Military payroll estimate of $250 million was divided among regions in the same proportions as 1974 military population, as estimated by the Alaska Dept. of Labor.

2 "Actual" Civilian incomes were computed using Alaska Dept. of Labor, STATISTICAL QUARTERLY, payrolls for 1974, and adding the other components of personal incomes as estimated by the U.S. Dept. of Commerce, Bureau of Economic Analysis. No residence adjustment was made.

3 Real wages and salaries were added to an estimate of non-wage income implied by statewide growth rates.

Table 2.3-31

ESTIMATED REAL PER CAPITA INCOME, BY REGION
(1967 Dollars)

	Anchorage	Interior	Fairbanks	State
LIMITED DEVELOPMENT				
1978	3,806	4,935	3,661	3885.2
1980	3,919	4,822	3,776	3965.7
1985	4,182	4,696	4,153	4226.9
1990	4,376	4,922	4,523	4468.8
ACCELERATED DEVELOPMENT				
1978	3,827	4,948	3,685	3927.3
1980	3,963	4,867	3,827	4062.7
1985	4,232	4,780	4,223	4316.4
1990	4,426	4,914	4,614	4562.8
MAXIMUM DEVELOPMENT				
1978	3,827	4,948	3,685	3927.3
1980	4,018	4,963	3,901	4159.3
1985	4,311	4,790	4,318	4445.9
1990	4,586	4,898	4,851	4770.2

Table 2.3-32

STATE AND LOCAL GOVERNMENT REVENUES AND EXPENDITURES
No Gas Pipeline (Millions of Dollars)

LIMITED DEVELOPMENT

	Individual Income Tax	Corporate Income Tax	Sales and Gross Receipts Taxes	Miscellaneous Taxes and Charges
1978	112.6	21.4	60.1	106.8
1979	132.0	25.5	67.0	124.5
1980	144.5	28.2	71.2	135.8
1981	169.1	33.7	79.3	158.1
1982	190.6	38.4	86.1	177.4
1983	220.8	45.3	95.1	204.5
1984	253.3	52.7	104.4	233.4
1985	283.8	59.9	112.9	260.5
1986	311.1	66.3	120.1	284.6
1987	340.0	73.2	127.6	310.1
1988	375.7	81.8	136.6	341.5
1989	417.3	91.9	146.7	377.9
1990	465.8	103.9	158.2	420.2
ACCELERATED DEVELOPMENT				
1978	119.8	22.9	62.7	113.3
1979	137.4	26.7	68.8	129.3
1980	159.2	31.5	76.1	149.1
1981	185.7	37.3	84.5	173.0
1982	220.1	45.1	94.9	203.8
1983	273.3	57.4	110.0	251.2
1984	322.6	69.0	123.1	294.7
1985	351.0	75.8	130.4	319.8
1986	378.5	82.5	137.3	344.0
1987	419.0	92.4	147.2	379.4
1988	470.3	105.0	159.2	424.1
1989	531.9	120.5	173.1	477.6
1990	600.5	137.9	188.1	536.9
MAXIMUM DEVELOPMENT				
1978	119.8	22.9	62.7	113.3
1979	137.4	26.7	68.8	129.3
1980	159.2	31.5	76.1	149.1
1981	193.7	39.1	87.0	180.1
1982	234.6	48.4	99.1	216.8
1983	300.1	63.7	117.2	274.9
1984	370.7	80.6	135.4	337.1
1985	412.1	90.7	145.5	373.4
1986	440.4	97.6	152.2	398.0
1987	514.7	116.1	169.3	462.7
1988	610.1	140.3	190.1	545.2
1989	707.8	165.6	210.4	629.3
1990	813.5	193.3	231.3	719.7

Table 2.3-32 (Cont'd)

LIMITED DEVELOPMENT

	Petroleum Revenues	Total State Revenues	Total State Expenditures
1978	798.9	1,481.0	1,281.3
1979	996.6	1,764.8	1,515.7
1980	1,276.8	2,113.6	1,794.4
1981	1,375.8	2,325.4	1,981.5
1982	1,763.8	2,818.0	2,377.1
1983	1,979.8	3,175.1	2,680.2
1984	2,051.8	3,400.6	2,887.7
1985	2,116.8	3,614.9	3,085.7
1986	2,172.8	3,811.9	3,268.7
1987	2,180.8	3,968.7	3,423.5
1988	2,186.8	4,147.5	3,600.8
1989	2,192.8	4,346.7	3,798.6
1990	2,196.8	4,569.3	4,020.1
ACCELERATED DEVELOPMENT			
1978	798.9	1,503.8	1,304.1
1979	1,094.6	1,880.0	1,581.8
1980	1,374.8	2,262.5	1,894.3
1981	1,404.8	2,414.8	2,063.6
1982	1,877.8	3,035.2	2,565.7
1983	2,238.8	3,615.1	3,055.4
1984	2,490.8	4,081.8	3,459.1
1985	2,695.8	4,437.5	3,763.6
1986	2,883.8	4,778.5	4,057.6
1987	2,981.8	5,077.2	4,331.7
1988	3,044.8	5,380.9	4,619.7
1989	3,097.8	5,711.9	4,937.4
1990	3,102.8	6,021.9	5,246.2
MAXIMUM DEVELOPMENT			
1978	798.9	1,503.8	1,304.1
1979	1,094.6	1,880.0	1,581.8
1980	1,374.8	2,262.5	1,894.3
1981	1,502.8	2,538.6	2,138.4
1982	1,979.8	3,188.0	2,668.5
1983	2,263.8	3,735.3	3,169.3
1984	2,563.8	4,321.9	3,681.0
1985	2,845.8	4,800.3	4,088.8
1986	3,148.8	5,261.8	4,474.6
1987	3,393.8	5,827.9	4,979.5
1988	3,611.8	6,446.2	5,543.3
1989	3,786.8	7,036.9	6,090.2
1990	3,878.8	7,579.3	6,609.6

Table 2.3-32 (Cont'd)

LIMITED DEVELOPMENT

	Total Local Revenues	Total Local Expenditures	State and Local Expenditures (Adjusted for Revenue Sharing)
1978	530.3	566.2	1,638.2
1979	634.4	660.1	1,927.9
1980	721.1	736.1	2,238.5
1981	836.8	850.6	2,511.6
1982	973.6	985.4	2,982.7
1983	1,130.5	1,139.3	3,395.9
1984	1,283.6	1,289.0	3,724.1
1985	1,432.1	1,433.6	4,039.7
1986	1,566.6	1,564.2	4,328.5
1987	1,707.2	1,700.5	4,599.2
1988	1,881.5	1,868.9	4,921.5
1989	2,086.7	2,066.6	5,291.1
1990	2,330.9	2,301.2	5,718.6
ACCELERATED DEVELOPMENT			
1978	557.7	593.5	1,684.5
1979	663.4	688.9	2,012.0
1980	788.2	802.6	2,389.0
1981	909.0	921.8	2,652.2
1982	1,110.9	1,120.2	3,278.1
1983	1,387.1	1,389.8	3,967.7
1984	1,641.2	1,636.6	4,562.6
1985	1,800.6	1,790.8	4,980.7
1986	1,955.7	1,940.4	5,385.9
1987	2,166.5	2,143.3	5,827.7
1988	2,431.4	2,397.5	6,333.2
1989	2,752.4	2,704.4	6,917.8
1990	3,113.8	3,048.7	7,532.8
MAXIMUM DEVELOPMENT			
1978	557.7	593.5	1,684.5
1979	663.4	688.9	2,012.0
1980	788.2	802.6	2,389.0
1981	949.5	961.8	2,755.5
1982	1,181.0	1,188.8	3,434.4
1983	1,510.3	1,509.7	4,185.4
1984	1,872.7	1,860.3	4,977.8
1985	2,105.7	2,084.8	5,556.3
1986	2,279.3	2,251.6	6,059.0
1987	2,679.5	2,634.8	6,882.9
1988	3,197.8	3,128.5	7,870.2
1989	3,741.2	3,643.8	8,865.8
1990	4,338.3	4,207.6	9,886.9

1978 (compared to $700-800 million in the current budget) to between $4.0 and $6.6 billion in 1990. Local government also expands rapidly, from $520-560 million in 1978 ($310 million in 1974) to between $2.3 and $4.2 billion in 1990.

In current dollar terms, state and local combined expenditures increase from three to seven times. In per capita terms, this growth in combined expenditures is much slower, ranging from 121 percent growth in the Limited case to 157 percent in the Maximum case. In real per capita terms, it is lower still. Total growth in real combined state and local expenditures ranges from $1610 to $1623 per capita in 1978, to $2241 to $2636 per capita in 1990. This reflects the state's inability to prevent migration in response to Alaska's increased real incomes and employment opportunities created by development and by state spending, and represents an increase of 1.4 to 1.6 times the 1978 level during the period 1978-1990, in the absence of a gas pipeline.

The distribution of future government revenue sources is also of interest. Without the pipeline, petroleum revenues provide about 53 percent of state revenues in 1978 and from 48 to 51 percent by 1990. The next largest source of state revenues is expected to be the individual income tax, which would provide about 7 percent of state revenues in 1978, and about 10 to 11 percent by 1990. Miscellaneous charges, revenues from miscellaneous taxes, etc. make up the next largest category, with about 9 percent of the total in 1990. The largest source of local revenue is the state government, with the property tax second. The property tax could become a larger source if local governments were to take maximum advantage of the state tax law which permits them to tax oil and gas production and transmission facilities at a maximum rate of 20 mills, replacing a state tax at the same maximum rate, which is included in Table 2.3-32 as part of petroleum revenues. In such a case, the state might be expected to equivalently reduce revenue sharing, resulting in the same total level of local income.

Government operations in the areas most likely to be affected by construction and operation of a gas pipeline will show varied patterns of development in future years. At present the MAP model is unable to project specific local revenue and exptenditure patterns, but it is clear that there will be significant departures from the statewide pattern in particular communities.

In Fairbanks, activities related to petroleum development will have a substantial direct effect on the tax base particularly as more development occurs in the northern portion of the state. For example, in 1975, 8 percent of the estimated full value of property within the borough was petroleum exploration, production and pipeline transportation property. In addition, property values in related industries and the residential and commercial sector will rise in response to development in the petroleum sector. The large-est taxpayers in the borough and city are shown in Table 2.3-33.

Revenue available for the expansion of government services will expand most rapidly at the state level and will undoubtedly continue to be a major source of revenue to both Fairbanks City and the North Star Borough. General revenue sharing from the state to local governments is presently relatively small, but large increases in state revenues could lead to substantial increased in this program. The rationale is that a significant portion of the wealth producing property of the state is outside the taxing jurisdiction of the local communities and that the state should act as a tax collector who then would allocate the revenues to local governments.

The growth in local government services in the Fairbanks-North Star Borough will probably not be able to smoothly accommodate population increase resulting from economic growth. This is a result of the high degree of uncertainty involved in petroleum exploration and development activities. Thus, not only will increases in required expenditures probably not correspond to increases in revenues, but the time constraints necessary to provide the services as needed will increase costs substantially. Here again, the state may be called upon to provide assistance to smooth out the cycle at the local level.

The North Slope Borough is in a slightly different position. Economic development, and thus growth in the tax base, is more highly dependent upon development of the petroleum industry within its regions than is Fairbanks. Presently, it has a tax base consisting of 77 percent of petroleum exploration, development and pipeline transmission property. This property is taxable by the state but the borough can recoup the revenues using its own property tax. It can do so only up to limits established by the legislature to prevent both discriminatory taxation of this property within the borough, and also a grossly inequitable statewide distribution of the revenues generated by the state property tax on the petroleum property. Principal taxpayers in the borough are listed in Table 2.3-34. Questions regarding the taxing jurisdiction of the borough in relation to the state and the formula for the sharing of revenues will undoubtedly continue to be a significant issue as petroleum development proceeds in Northern Alaska. The borough is presently in a strong financial position with a very low ratio of debt to values as shown in Table 2.3-35.

One other feature of importance to the future of local government in the North Slope Borough is the newly established Arctic Slope Regional Corporation which is nearly

Table 2.3-33

LARGEST TAXPAYERS WITHIN FAIRBANKS NORTH STAR BOROUGH

J. C. Penny	Retail Sales
Northward Operating Corporation	Apartment, Hotels, Commercial Buildings
Travelers Inn of Fairbanks	Hotel
The Lathrop Company	Commercial Rental
Bently Trust	Land
Fairview Development, Inc.	Apartments
Gavora, Inc.	Shopping Center
USSR&M	Mining Corporation
Safeway Stores, Inc.	Retail Grocery
Arthur J. Schaible, et al	Medical Clinic building
Second & Lacy Street Apartments, Inc.	Apartments
North Star, Inc.	Industrial Building Area
Nerland Corporation	Commercial Rental
Fairbanks Medical Center	Medical Clinic Building
Tanana Clinic	Medical Clinic Building
Medical & Dental Arts Building	Medical Clinic Building
Northern Commercial Company	Retail Sales
Nordstrom's	Retail Sales
Fairbanks Development Corporation	Apartment Rental
Polaris Investment Company	Hotel, Apartment Rental
King 8	Hotel
Chena View	Hotel

Source: Fairbanks North Star Borough, ANNUAL FINANCIAL REPORT 1974-75, City of Fairbanks, ANNUAL FINANCIAL REPORT 1975

Table 2.3-34

PRINCIPAL TAXPAYERS IN NORTH SLOPE BOROUGH

Alyeska Pipeline Service Company

SOHIO Petroleum Company

Atlantic Richfield Company

Mobil Oil Corporation

Alaska General Construction Company

Parker Drilling Company

Bechtel, Inc.

Rowan Drilling Company, U.S.

Kodiak Oil Field Haulers

Geophysical Services, Inc.

Western Geophysical Company

Atwood Enterprises, Inc.

Nabors Alaska Drilling

Puget Sound Tug & Barge Company

Source: North Slope Borough, ANNUAL FINANCIAL REPORT

<u>Table 2.3-35</u>

GENERAL OBLIGATION BOND STATUS OF SELECTED ALASKA COMMUNITIES

	General Obligation Bonded Debt (million $)	Per Capita Debt $	Per Capita Valuation $	Rate of Debt to $
MUNICIPALITY OF ANCHORAGE				
1966	41.917	345	5,709	6.04%
67	44.853	369	6,434	5.75%
68	58.719	483	6,961	6.94%
69	64.046	527	7,574	6.96%
70	66.734	536	8,724	6.14%
71	116.572	884	10,273	8.61%
72	171.441	1,189	11,099	10.71%
73	182.298	1,179	12,437	9.48%
74	210.371	1,295	13,468	9.61%
75	211.781	1,205	15,856	7.60%
FAIRBANKS CITY AND NORTH STAR BOROUGH				
1966	15.939	514	5,178	9.93%
67	15.058	471	5,460	8.62%
68	15.613	488	5,697	8.56%
69	14.482	526	6,625	7.94%
70	13.233	432	6,594	6.55%
71	11.812	378	7,345	5.15%
72	12.470	382	8,159	4.67%
73	13.629	358	7,912	4.52%
74	14.828	354	8,246	4.30%
75	27.274	431	7,117	6.05%

Table 2.3-35 (Cont'd)

NORTH SLOPE BOROUGH

	General Obligation Bonded Debt (million $)	Per Capita Debt $	Per Capita Valuation $	Rate of Debt to $
1973	------	---	N/A	------
74	------	---	56,203	------
75	9.000	1,337	38,539	3.47%

Source: ANNUAL FINANCIAL REPORTS, City of Anchorage, Greater Anchorage Area Borough, City of Fairbanks, Fairbanks North Star Borough, City of Barrow, North Slope Borough, and ALASKA TAXABLE coterminous with the North Slope Borough. If the Corporation invests its assets in economic activity within the region, it could have a significant impact on the tax base of the Borough. The Corporation has followed that line of development thus far, by placing emphasis on the selection of lands which show the largest potential for mineral development within its territory. In addition, through subsidiaries, it has moved into petroleum exploration and development service related operations. This will have an impact on traditional local sources of revenues.

Expenditures for services will not need to expand as rapidly as the tax base grows because the increase in value of property will not be connected with a large influx of permanent residents. However, the Borough has a large capital development program under way which is designed to meet the public needs of the community. Some of these services represent a backlog of unmet demands within the community to bring its public facilities up to the level of other communities within Alaska. This activity will mean an increase in government expenditures in the Borough in the future years.

Other communities directly along the route of the pipeline are small and have only rudimentary levels of local government. Such communities do not impose a property tax and sales taxes are rare. The impact of growth on the finances and services of these communities will, in general, come through the extension of these state services provided by the state revenues.

Expansion of the tax base in the Municipality of Anchorage will proceed more regularly than either Fairbanks or the North Slope because the growth of the economy there is not as dependent upon petroleum development as these other communities. The estimated full value of property in the Anchorage Borough has grown at an annual 17 percent rate over the past decade. This strong growth should continue over the MAP projection period, although the rate of growth will be dependent upon petroleum development elsewhere in the state. The value of property classified by the state as petroleum exploration, production, and transmission forms an insignificant portion of the value of property in the Borough, since the majority of the land is either urban or state park. The largest taxpayers in the Borough according to recent annual reports are shown in Table 2.3-36. As with other local governments within the state, a significant portion of future revenues will continue to come from the state government, because the Borough forms such a large portion of the population of the state.

Local expenditure growth in Anchorage will follow the state pattern more than other communities and will be rapid and steady as population growth continues in Anchorage. The requirement for increased public services for human needs

Table 2.3-36

LARGEST TAXPAYERS WITHIN THE ANCHORAGE MUNICIPALITY

Anchorage Natural Gas Company

Anchorage Westward Hotel

Carr's/Gottstein (Wholesale/Retail Trade)

Hickel Investment Company

J. C. Penney Company

Lathrop Corporation (Building and Theater Owner)

R.C.A. Alaska Communication, Inc.

Standard Oil Company of California

Union Oil Company

Wein Air Alaska

Source: Greater Anchorage Area Borough, ANNUAL FINANCIAL REPORT 1974-1975 in Anchorage will also be affected by the large number of dependents of petroleum workers who will reside in Anchorage while the family wage earners work in the camps located at the development sites.

Summary of Growth Without the Pipeline

On the whole, in the absence of a gas pipeline project, the economy of the state grows quite rapidly. Gross output goes up between 50 to 160 percent between 1978 and 1990; employment between 60 and 140 percent, real personal income between 80 and 180 percent; and population between 60 and 130 percent. The results are different in the areas to be directly impacted by pipeline construction than they are in areas which will only receive the indirect benefits in the form of additional state spending. The areas directly impacted are not "typical" when the expected growth pattern in the absence of the pipeline is compared to that of the state. Anchorage grows much faster. Gross output increases between 90 and 180 percent, and population between 80 and 170 percent. Interior shows either slight growth or some decline from 1978 to 1990 in the absence of a gas pipeline project. Gross output falls by nearly 40 percent in the lowest case, and does not show growth with Maximum Development. While employment booms to as much as 77 percent above 1978 projections, in the absence of a gas pipeline during the early 1980's, employment changes are expected to range anywhere from a 15 percent decrease to a thirty percent increase--far below the statewide rate. Population also will virtually stagnate in comparison to the state and to the faster growing regions. Fairbanks will not grow as slowly as Interior in absence of a gas pipeline, but it will generally grow at a rate slightly below the statewide average and at a far slower rate than that of Anchorage. Gross output will rise between 50 and 100 percent, while employment increases from 40 to 80 percent during the period, and population increases between 40 and 80 percent.

FOOTNOTES

[1] For a more thorough explanation of the MAP models, see David T. Kresge, "Alaska's Growth to 1990," ALASKA REVIEW OF BUSINESS AND ECONOMIC CONDITIONS, University of Alaska Institute of Social, Edonomic, and Government Research, 13(1): January, 1976

[2] The MPA regions are combined groups of census divisions from the 1970 Census of Population. The regions are:

Northwest (Barrow, Kobuk, Nome)

Southwest (Aleutian Islands, Bethel, Bristol Bay, Kuskokwim, Wade Hampton)

Southeast (Juneau, Ketchikan, Haines, Skagway-Yakutat, Prince of Wales, Sitka, Wrangell-Petersburg, Outer Ketchikan Angoon)

Southcentral (Cordova-McCarthy, Kenai-Cook Inlet, Kodiak, Matanuska-Susitna, Seward, Valdez-Chitina-Whitter)

Anchorage (Anchorage)

Interior (Upper Yukon, Yukon-Koyukuk)

Fairbanks (Fairbanks, Southeast Fairbanks)

2.4 AIR AND WATER ENVIRONMENTS

2.4.1 Climate

Introduction

There are 24 locations from which climatic data are available which are pertinent to the proposed gas pipeline route within Alaska. Twenty of these are along or close to the route. Some data locations are at camps for the construction of the Trans-Alaskan pipeline, and have short periods of records which may not be representative of long-term averages for temperature, precipitation and winds. The climate along the proposed route, however, is also influenced by regional climatic regimes throughout the state which may not be totally reflected in the existing stations of record.

Alaska contains four major climatic zones (Searby 1968): Arctic, Continental, Maritime, and Transition. Weather conditions vary within each zone, but certain conditions predominate. The route of the proposed pipeline lies entirely in the Arctic and Continental zones.

The Arctic Zone extends from the central ridgeline of the Brooks Range north to the ocean. No Maritime or Transition Zones have been designated along the Arctic coast, primarily because of the nearly continuous frozen condition of the Arctic Ocean. However, minor marine influences moderate temperatures along the coast. Precipitation levels do not increase in the coastal area because of proximity to the Arctic Ocean. Surface winds are strong along the coast but decrease further inland.

South of the Central Brooks Range and inland from the Coastal Maritime Zone lies the Continental Zone of Interior Alaska. Generally, both summer and winter temperatures are extreme, and precipitation is light. Except for a few isolated locations, surface winds are light.

State Wide Perspective

Precipitation

Precipitation patterns for Alaska are shown in Figures 2.4-1 and 2.4-2. A strong marine influence, accentuated by the presence of coastal mountain ranges, exists in Southeast Alaska and along the gulf coast. This combination results in the extremely high precipitation centers depicted on the maps, not only in coastal areas but also in the Interior. The overall range of annual precipitation across the state varies from less than five inches in the Arctic to more than 300 inches in Southeast Alaska.

FIGURE 2.4-1

MEAN ANNUAL PRECIPITATION — INCHES

BASED ON ALL AVAILABLE DATA THROUGH 1972

IN CO-OPERATION WITH THE U.S. GEOLOGICAL SURVEY

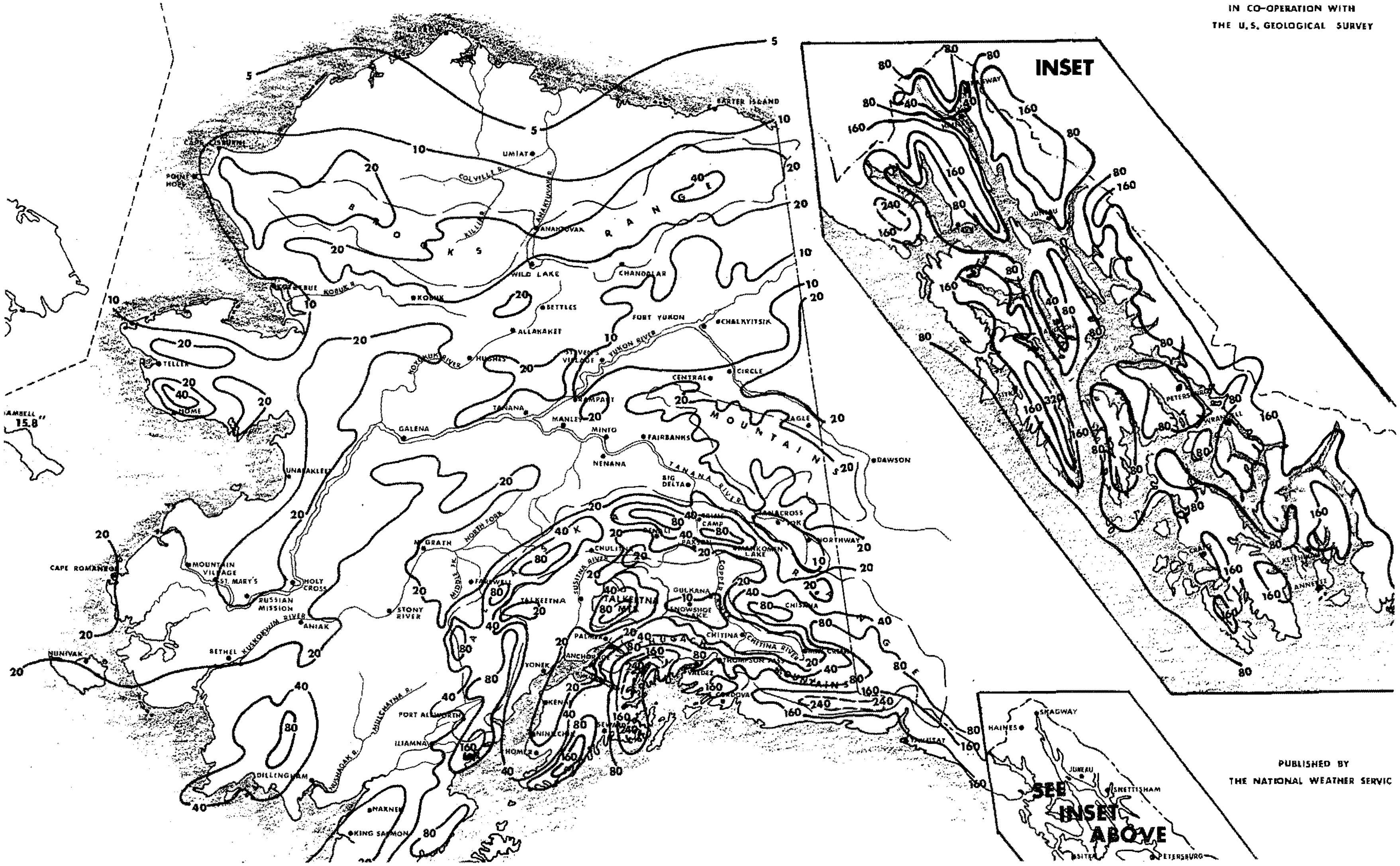
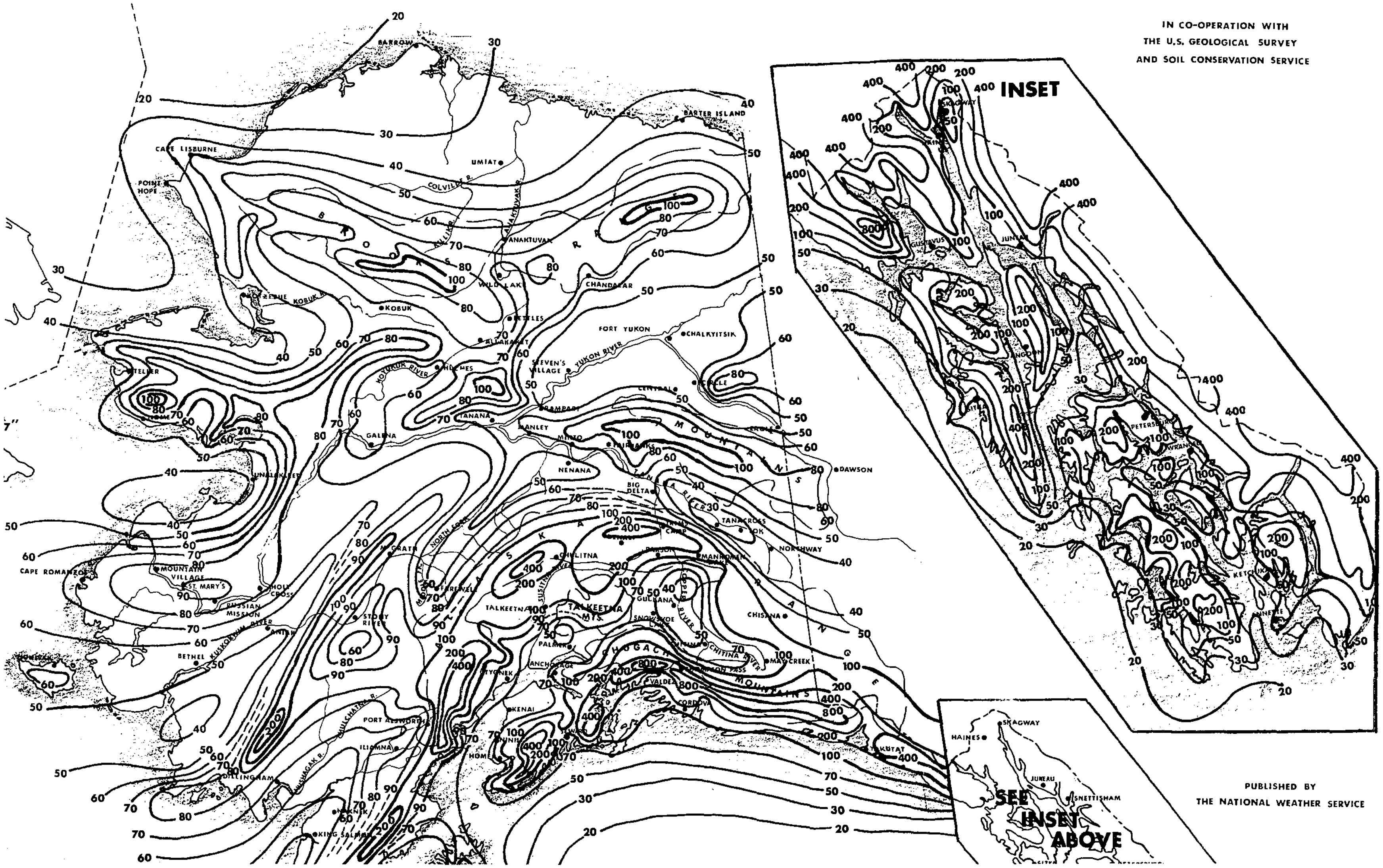


FIGURE 2.4-2

MEAN ANNUAL SNOWFALL - INCHES



Throughout the state, except in the Arctic, snow provides less of the total precipitation than does rain. Snow, however is the more important of the two. As a water resource, snow exerts both positive and adverse influences. On the positive side, the gradual melt of snow at high elevations maintains a continual runoff into streams and reservoirs for home, industrial, and agricultural use. Adversely, sudden and prolonged warming at a time when ground and streams are still frozen causes fast melting that can lead to serious flooding. Heavy rains can and do cause flooding, but the frequency is much less than that of flooding caused by rapid snow melt.

Temperature

Temperature patterns appear in Figures 2.4-3 through 2.4-6. The range of more than 100 degrees F between summer high and winter low temperatures in the Interior is characteristic of the Continental Zone, just as a range of only about 40 degrees F is typical of the Maritime Zone to the south. The National Weather Service, the official weather reporting and recording agency of the Federal government, reported 100 degrees F at Fort Yukon on June 27, 1915, as the highest recorded temperature in the state. The lowest recorded temperature was minus 80 degrees F at Prospect Creek, about 25 miles southeast of Bettles, on January 23, 1971.

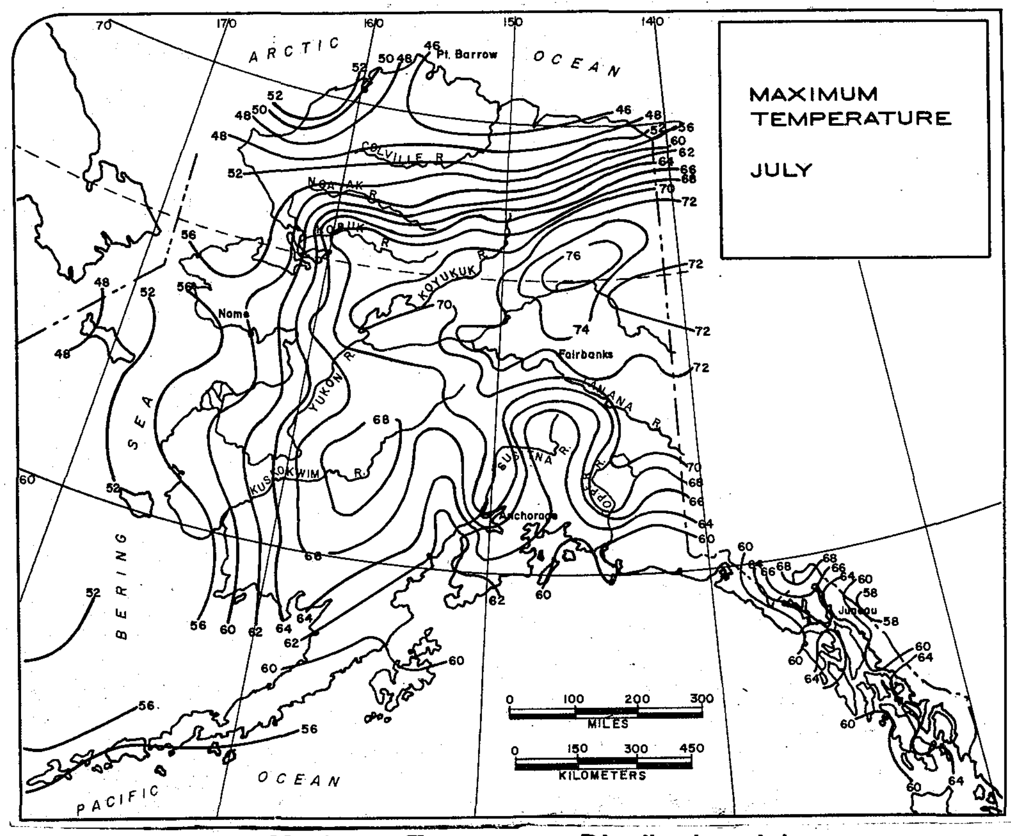
In general, the temperature patterns shown are representative since the map scale makes it impossible to show them individually. The variety of terrain in Alaska creates microclimates or small areas where temperature, precipitation, or both will vary from that of the surrounding area. For example, summer frost in interior Alaska varies in frequency from one location to another but correlates most closely with elevation, as sites at higher elevations have greater frost frequency.

Chill Factor

The temperature of the air is not always a reliable indication of how cold a person will feel outdoors. Other weather elements such as wind speed, relative humidity, and sunshine (solar radiation) also exert an influence. Generally, coldness is related to the loss of heat from exposed flesh: one can therefore assume this coldness to be propo. tional to the measured rate of heat loss from an object. The term "wind chill" was first used to describe the relative discomfort resulting from combinations of wind and temperature.

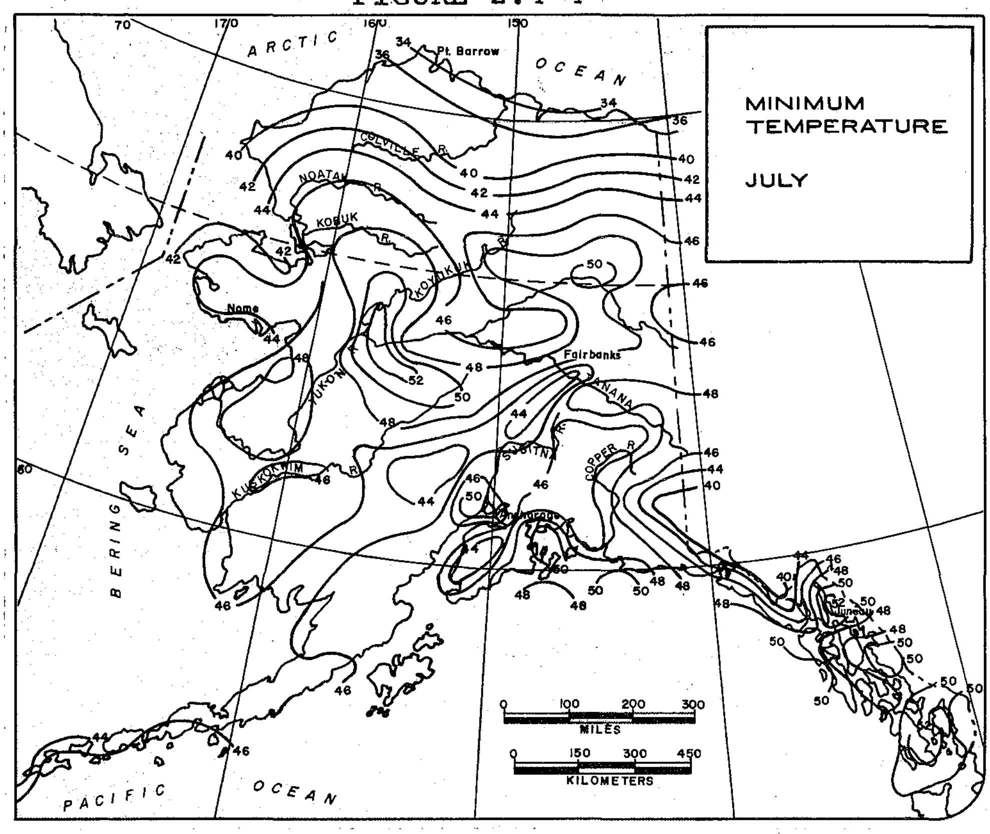
The relationship between body heat loss and the cooling power of different wind and temperature combinations is shown in Table 2.4-1. Equivalent wind chill temperature relates a particular wind and temperature combination to whatever

FIGURE 2.4-3



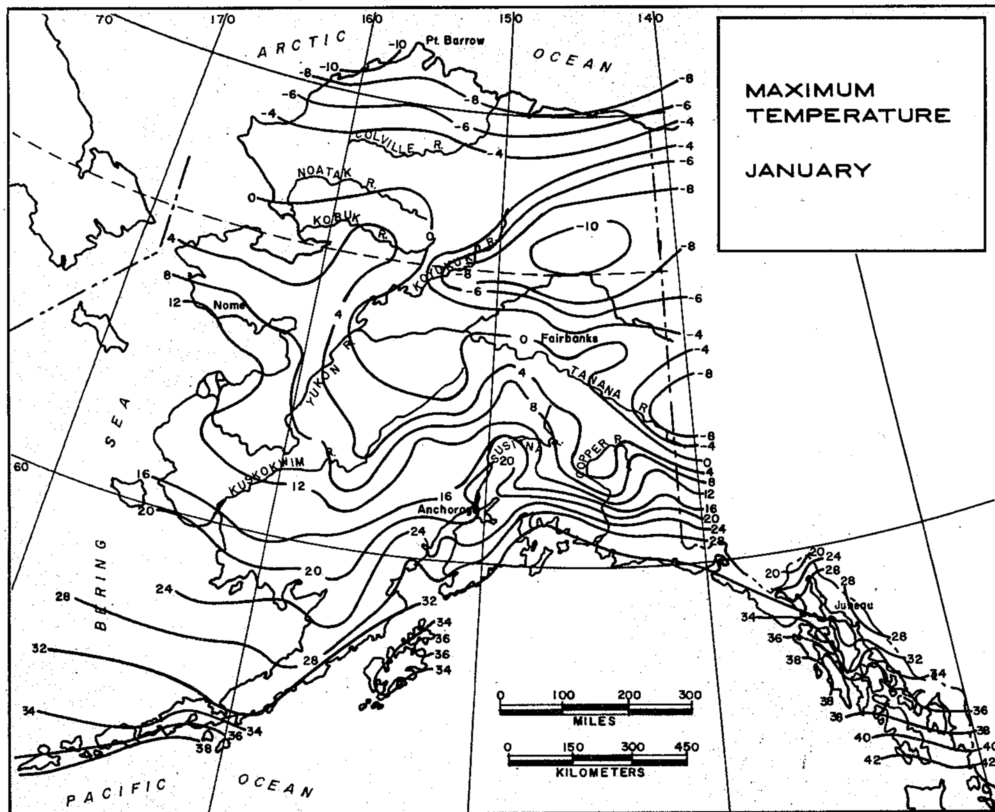
Mean Maximum Temperature Distribution, July

FIGURE 2.4-4



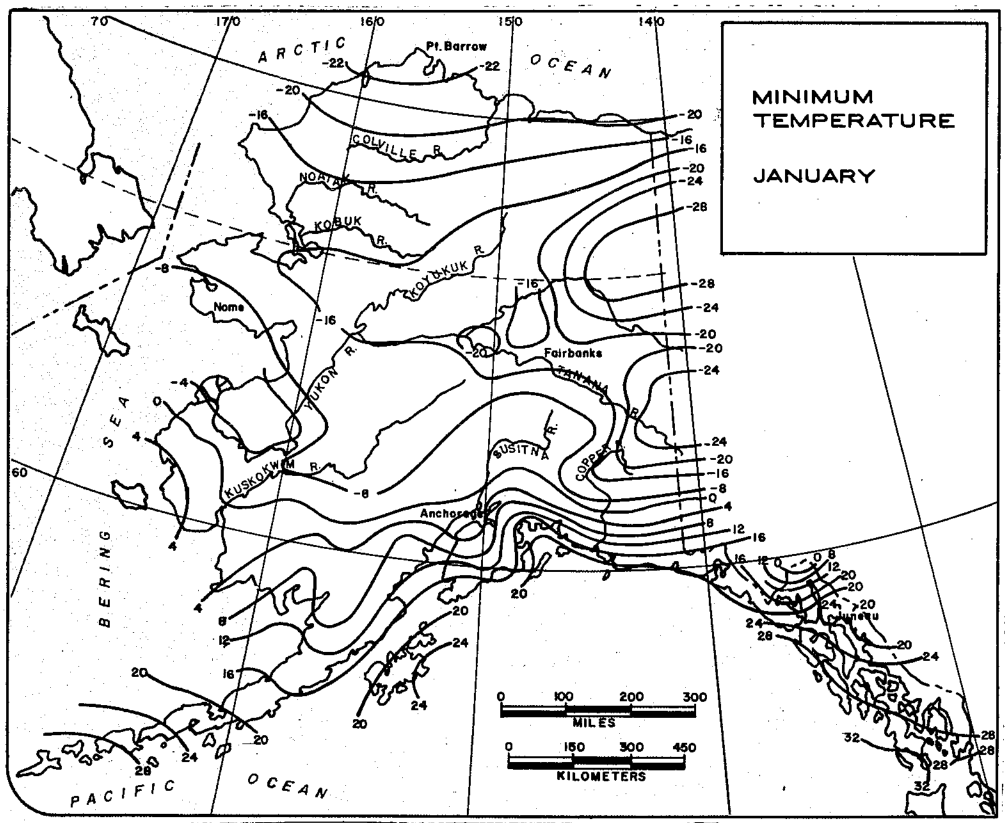
Mean Minimum Temperature Distribution, July

FIGURE 2.4-5



Mean Maximum Temperature Distribution, January

FIGURE 2.4-6



Mean Minimum Temperature Distribution, January

TABLE 2.4-1

WIND SPEED	COOLING POWER OF WIND EXPRESSED AS "EQUIVALENT CHILL TEMPERATURE"																				
MILES PER HOUR	TEMPERATURE (°F)																				
CALM	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45	-50	-55	-60
	EQUIVALENT CHILL TEMPERATURE																				
5	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45	-50	-55	-65	-70
10	30	20	15	10	5	0	-10	-15	-20	-25	-35	-40	-45	-50	-60	-65	-70	-75	-80	-90	-95
15	25	15	10	0	-5	-10	-20	-25	-30	-40	-45	-50	-60	-65	-70	-80	-85	-90	-100	-105	-110
20	20	10	5	0	-10	-15	-25	-30	-35	-45	-50	-60	-65	-75	-80	-85	-95	-100	-110	-115	-120
25	15	10	0	-5	-15	-20	-30	-35	-45	-50	-60	-65	-75	-80	-90	-95	-105	-110	-120	-125	-135
30	10	5	0	-10	-20	-25	-30	-40	-50	-55	-65	-70	-80	-85	-95	-100	-110	-115	-125	-130	-140
35	10	5	-5	-10	-20	-30	-35	-40	-50	-60	-65	-75	-80	-90	-100	-105	-115	-120	-130	-135	-145
40	10	0	-5	-15	-20	-30	-35	-45	-55	-60	-70	-75	-85	-95	-100	-110	-115	-125	-130	-140	-150
WINDS ABOVE 40 HAVE LITTLE ADDITIONAL EFFECT.	LITTLE DANGER					INCREASING DANGER (Flesh may freeze within 1 min.)						GREAT DANGER (Flesh may freeze within 30 seconds)									
	DANGER OF FREEZING EXPOSED FLESH FOR PROPERLY CLOTHED PERSONS																				

Equivalent Wind Chill Temperatures

temperature would produce the same loss of heat at four miles an hour or less.

The reduction of human efficiency in an "equivalent chill temperature" (ECT) of -75°F., is more than theory. Human hypothermia is a real danger, often fatal, to men in such climates. Neither man nor machine can function reliably below -75°F. ECT.

Storms

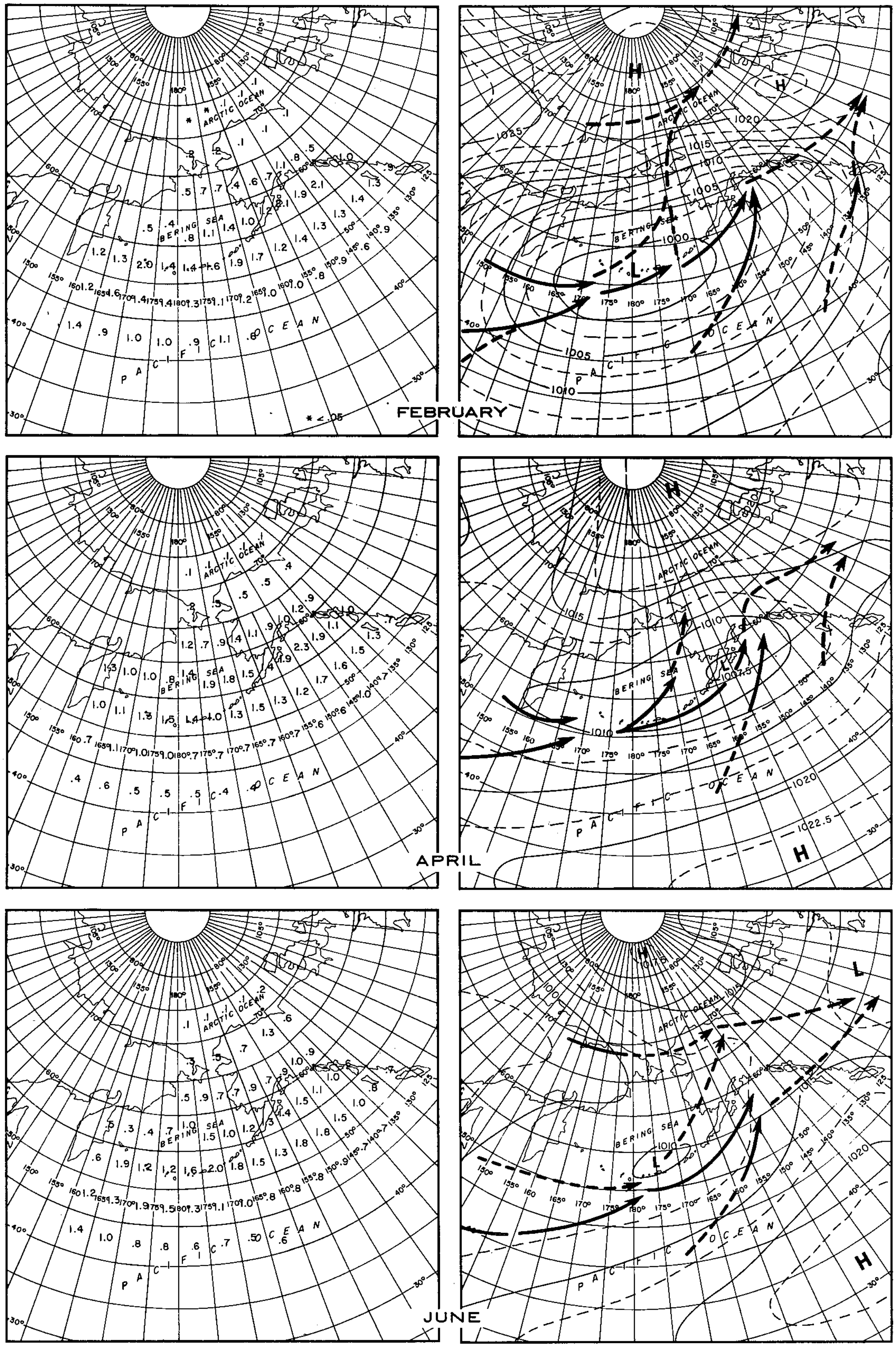
Storms affecting Alaska are extra tropical cyclones, low pressure areas associated with cold, warm, or occluded fronts and air mass showers and thunderstorms in the Interior in summer. Hurricanes (typhoons) and tornadoes seldom if ever occur in Alaska. Figure 2.4-7 shows storm tracks and storm frequencies which affect Alaska. The numbers represent the number of storms and not the number of days with storms. A primary storm track is the path along which the most significant storms travel; a secondary track is a path traveled by fewer and weaker storms.

All months have at least one primary storm track into the Gulf of Alaska. There is a secondary track north through the Bering Sea during all months of the year except May, June, and August. During May and June the secondary track moves east farther into the Interior, and in August the storm track in the Bering Sea becomes a primary track. Near the Arctic coast a secondary storm track is nearly always present on shore in summer and offshore in winter. Storm tracks only penetrate the Interior during summer months. The rest of the year a mass of cold air over the Interior diverts storms around the edges of the state.

Seasonality

Latitude and season of the year determine the length of each day at a particular location (Figure 2.4-8). In the north, days are longer in summer and shorter in winter than at more southerly latitudes. Sunrise, or the time of sunrise, is that instant when the upper limb of the sun appears on the sea-level horizon. For the purposes of many computations, the sunrise occurs when the center of the sun's disc is 50 minutes below the horizon allowing 16 minutes for the sun's radius and 34 minutes for astronomical refraction. Similarly, the time of sunset is that instant when the upper limb of the sun's disc just disappears below the sea-level horizon (American Meteorological Society 1959). Therefore the period of time with the sun below the horizon is much shorter in winter than the period of time with continuous sunshine in summer. Twilight marks the beginning of darkness or sunlight. The three twilight terms in use are civil, nautical, and astronomical. Civil twilight, the term most frequently used, is

FIGURE 2.4-7



Average Number of Storms per Month

Primary Storm Track

Secondary Storm Track

—1015— Sea Level Pressure in Millibars (mb)

FIGURE 2.4-7 (Cont'd)

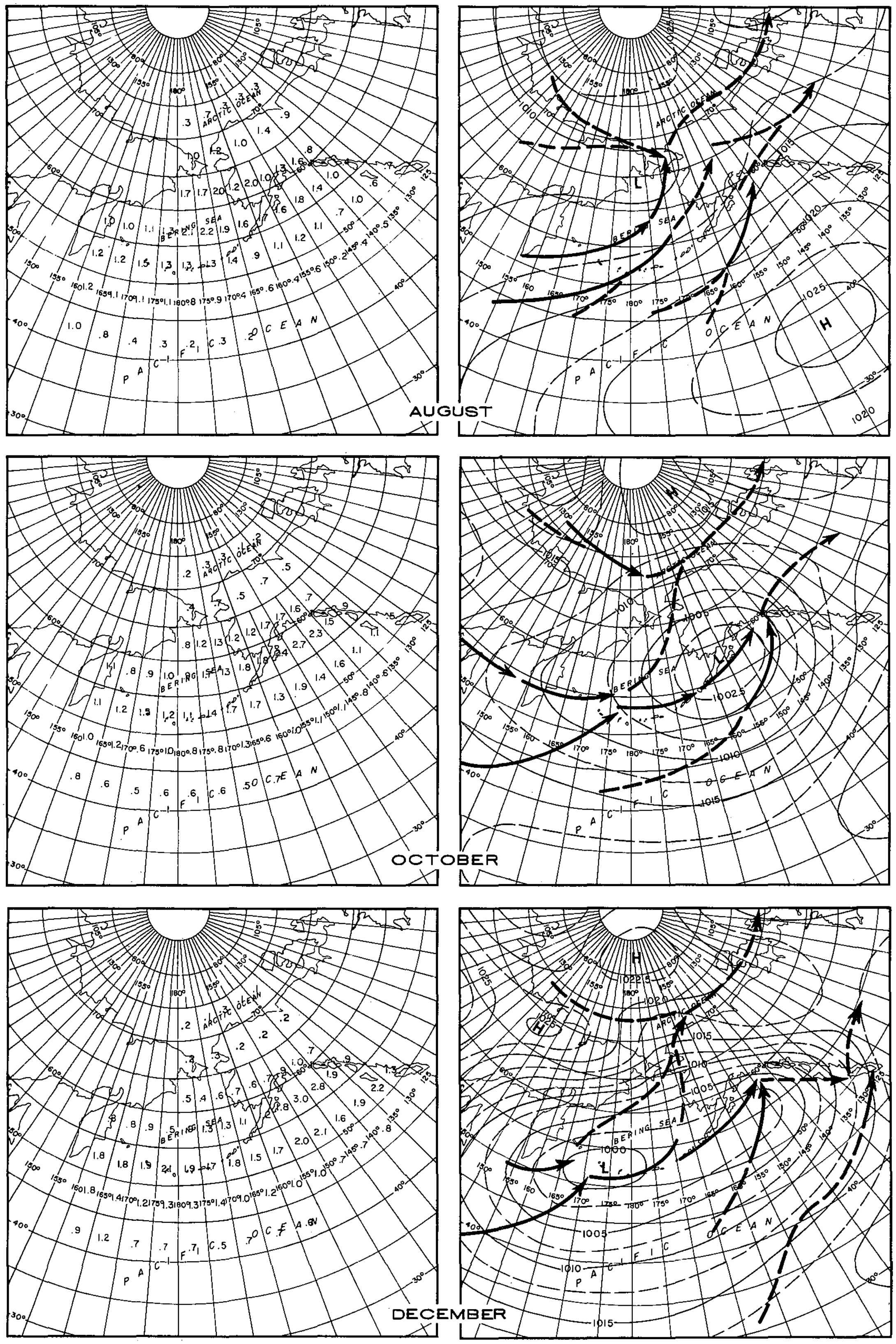
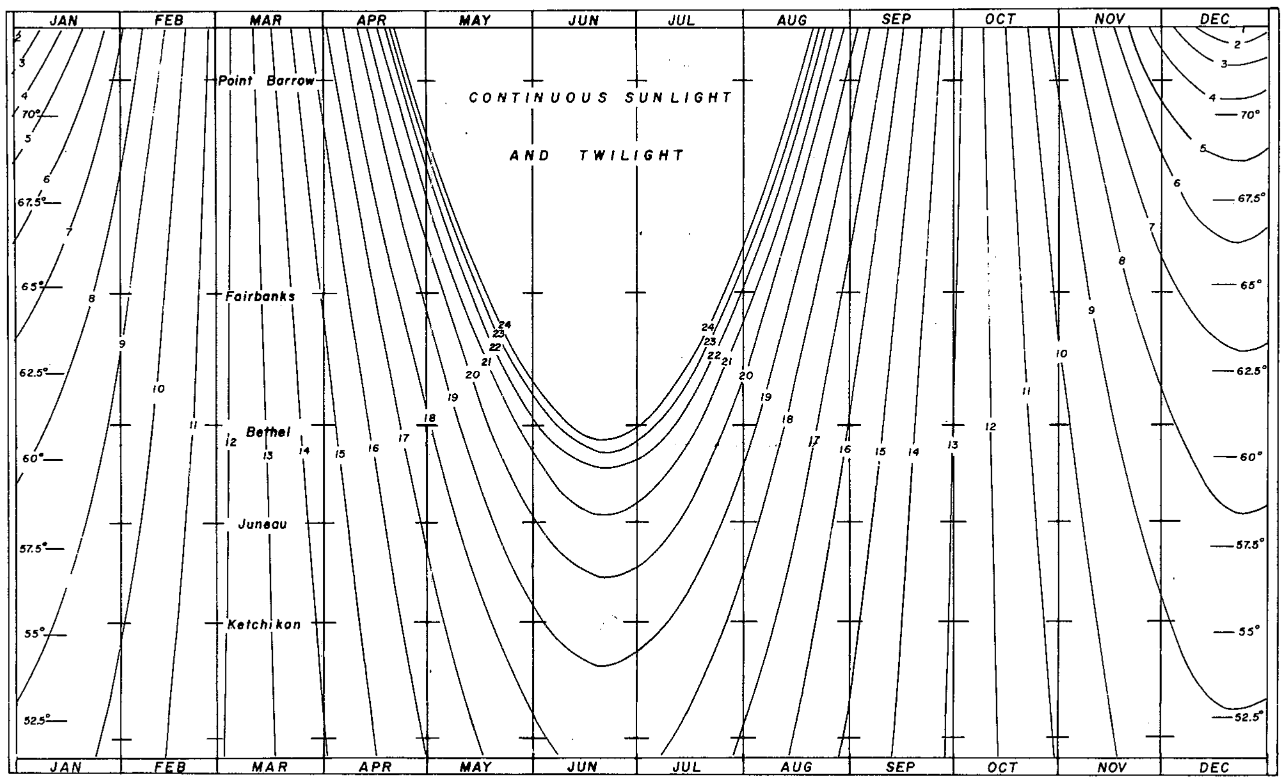


FIGURE 2.4-8



The curved lines are labeled in hours and represent the combined hours of sunlight and civil twilight for different latitudes and months of the year. Hours of darkness can be estimated by computing the difference between the value of the line and the total of 24 hours.

Source: **Environmental Atlas of the Greater Anchorage Area Borough, Alaska.** L. Selkregg et al. 1972.

the time of day when the sun is below the horizon by six degrees or less. Nautical twilight represents the range between six and twelve degrees below the horizon, and astronomical twilight is between 12 and 18 degrees below the horizon (American Meteorological Society 1959). Beyond 18 degrees, sunlight no longer results from bending the sun's rays, but is reflected light such as from the moon. At the end of civil twilight visibility is drastically reduced, affecting most outdoor activities.

In summer, at the farthest north portion of the route, the sun rises on the 10th of May and does not set again until August 2. This is an elapsed time of nearly 85 days with at least part of the sun above the horizon. Actually, darkness ceases with the beginning of civil twilight on April 23rd and does not return until August 19. Total elapsed time without complete darkness is nearly 119 days. In the most southerly portion of the pipeline route, there are 19 hours and 20 minutes between sunrise and sunset on the longest day and darkness does not occur between June 7 and July 5.

In winter at the most northerly portion of the route, the sun sets on November 18th and does not rise again until January 24, with an elapsed time of 67 days. However, a short period of twilight or indirect sunlight occurs during each of these days, ranging from three hours in December to slightly more than six hours in November and January. At the most southerly portion of the route, on the shortest day in winter, there are five hours and 28 minutes between sunrise and sunset, and seven hours and 31 minutes between the beginning and the end of civil twilight.

Climate Along the Route

Precipitation

Along the gas pipeline route from the Arctic Coast through the foothills, annual precipitation amounts range from five to seven inches. Most precipitation occurs during the summer as rain, with July and August being the wettest months. Precipitation amounts increase slightly with altitude. Snowfall averages nearly 20 inches near the beginning of the pipeline and increases to between 20 and 30 inches from the immediate coastal area to the foothills. Snowfall increases with elevation, reaching nearly 60 inches annually at the continental divide near Atigun Pass.

Snow depth data must be applied with caution. Even though these data are compiled and presented in Table 2.4-2, their value is greatly reduced since wind continuously moves the snow from one area to another. Also, there are areas where the snow is packing and developing a hard crust.

TABLE 2.4-2

Depth of Snow on Ground

Month	Trace or less	1- 6 inches	7-12 inches	13-24 inches	25-36 inches	37-48 inches	49-60 inches	Trace or less	1- 6 inches	7-12 inches	13-24 inches	25-36 inches	37-48 inches	49-60 inches
J		12	16	48	22	1		1	12	18	50	16	3	
F			15	45	34	5	1	1	10	13	44	27	5	*
M		3	26	45	25	1		1	9	19	41	24	6	
A	21	29	19	26	5	*		29	21	19	25	5	1	
M	96	4	*					96	3	1				
J	100							100						
J	100							100						
A	100							100						
S	99	1						98	2					
O	46	49	5					38	57	5				
N	3	55	30	10	2			4	47	37	11	1		
D		22	37	39	2			*	25	39	30	5	1	
YR	47	15	13	18	7	1	*	47	15	13	17	7	1	*
	Fairbanks Airport							Eielson AFB						

Month	Trace or less	1- 6 inches	7-12 inches	13-24 inches	25-36 inches	37-48 inches	49-60 inches	Trace or less	1- 6 inches	7-12 inches	13-24 inches	25-36 inches	37-48 inches	49-60 inches
J	5	34	44	11	1		5			38	48	11	2	1
F	4	34	36	13	6	2	5			24	52	17	5	2
M	2	31	36	22	5	3	1		1	20	63	13	4	0
A	20	48	19	8	5			8	35	28	25	4		
M	92	7	1	*				74	19	5	2			
J	100							100						
J	100							100						
A	100							100						
S	96	4						97	3					
O	44	50	6					42	53	1	4			
N	16	63	19	2				1	52	41	5	1		
D	3	66	25	5	1		*		12	58	25	5		
YR	47	24	18	7	2	1	1	44	13	18	19	4	1	*
	Big Delta							Northway						

Month	Trace or less	1- 3 inches	4- 6 inches	7-12 inches	13-24 inches	25-36 inches	37-48 inches	Trace or less	1- 3 inches	4- 6 inches	7-12 inches	13-24 inches	25-36 inches	37-48 inches
J			9	31	37	21	2				49	51		
F			2	17	56	18	7				18	82		
M			1	19	47	20	13				50	50		
A			6	29	29	26	10			7	49	32	12	
M		8	14	25	38	13	2	13	4	32	38	13		
J	49	26	7	10	6	2		79	18	3				
J	99	1						100						
A	98	2						100						
S	78	15	2	2	3			86	14					
O	18	20	34	20	8			12	42	44	2			
N		4	26	46	24				13	30	57	8		
D			16	40	35	9				11	49	40		
YR	29	6	10	20	23	9	3	32	7	11	26	23	1	
	Barter Island							Umiat						

*Less than .5

Data are percentage frequency of occurrence for categories as shown.

Measurements made at a single or even several locations, will not necessarily give an accurate picture of general conditions.

Nearly all the snowfall that occurs in a season accumulates on the ground, and there is very little snowmelt until breakup in spring. Snow depth data for Umiat, (Table 2.4-2), is probably the most representative of locations along the route to the foothills. Snow depths are greatest in April and decrease rapidly thereafter. In a single season, an accumulation of snow on the ground can be expected from late September to early May.

Along the pipeline route south of the Brooks Range to Fairbanks, annual precipitation averages from 10 to 15 inches, with August and September generally the wettest months. Snowfall is generally greatest in this area, averaging 83 inches per year at Wiseman, 76 inches at Bettles, and 50 to 70 inches elsewhere along the route. Snow survey data (U.S. Department of Agriculture, Soil Conservation Service) indicate the snow depths near 30 inches are quite common along the pipeline route in the Prospect Creek area and higher elevations such as the Dietrich area. Maximum snow depths reported are considerably higher, with 80 to 90 inches recorded at Wiseman and Bettles.

Along the route from Fairbanks to the south and east, precipitation amounts are 10 to 14 inches annually. The wettest months are July, and in some cases, June. Snowfall amounts average 33 to 54 inches annually. Snow depths on the ground can be expected from October through April at most locations, with the higher elevations having a snow accumulation well into May and June. The average snow depth in the winter months is normally less than 24 inches; however, maximum snow depths of 50 to 60 inches have been recorded at Big Delta and Northway. Precipitation averages and extremes for the 24 locations along or near the proposed gas pipeline route are shown on the map for climate (See Climatic Data Map, Volume 1-A, Page 2).

Surface Winds

Inadequate amounts of wind data along the proposed gas pipeline make it difficult to accurately depict the variety of wind conditions that exist. This is particularly true from the Brooks Range northward. For this reason, conditions at Barrow, Barter Island, and Umiat are described, and these conditions should apply to the area of the pipeline.

Surface wind speeds along the coast are persistent and strong compared to the northern foothills of the Brooks Range and to the interior sections farther south. Calm conditions are recorded at Barrow only one percent of the time, compared to 17 percent and 45 percent of the time at Umiat and Eielson AFB respectively. Applying this knowledge to the pipeline route, the northern terminus will experience near continuous wind with relatively strong speeds. With increased distance from the coast, wind speeds will be lighter with greater periods of calm. Wind direction is predominately easterly at Barrow; Barter Island varies seasonally, is easterly in summer, and divided between easterly and westerly in winter. Along the pipeline, the coastal portion will be similar to Barter Island, with winds becoming lighter and more variable in direction toward the mountains. In the mountains themselves, the wind will be channeled by the valleys. The direction will be either up or down the valley, toward the lower pressure. The speed of the air flow through the valleys will vary considerably, ranging from an occasional calm to general averages of 10 to 15 knots. Extreme winds in the mountain valleys and passes, as well as along the coast, may exceed 50 knots during all months, but primarily in winter months.

South of the Brooks Range, wind recording stations near or along the pipeline are Bettles, Fairbanks, Eielson, Big Delta, and Northway. Average and extreme wind speeds shown by these stations are generally representative of the section of the pipeline in which they are located. This is not necessarily true of wind direction. Terrain exerts a strong influence on direction by channeling through valleys, making the direction at a station applicable only to its immediate vicinity. However, direction is not difficult to determine. A study of a contour map and the average pressure pattern will determine wind direction at most locations.

Wind patterns for all available stations along or near the proposed gas pipeline are shown on the proposed gas pipeline route map for climate.

For examples of how channeling determines wind direction, note a prevailing air flow from the south at Eielson, while just a few miles to the northwest, at Fairbanks International Airport, the prevailing direction is north. For only two of the twelve months do both locations share the same general wind direction. An example of the affect of channeling on speed is Big Delta (Federal Aviation Administration). Greatest speeds come from four directions; two of the four are either up or down the Tanana River valley, while the other two are along the orientation of the Delta River. Average speeds are also increased by channeling at Big Delta.

Temperature

Monthly and annual averages of maximum and minimum temperatures, and extremes of temperature along or near the proposed gas pipeline route, are shown on the proposed gas pipeline route map for climate. The accuracy of these 24 locations varies. A minimum of 10 years of record is desirable for temperature averages to be considered representative of a particular area. Eight of these 24 stations have five years or less and some have only one year of record. These eight stations are probably only representative of the brief period in which the observations were made. However, used with this knowledge, the data can still be quite useful.

The varied terrain found along the pipeline route is an important factor in determining the temperature regime of any one section of the route. In crossing the Brooks Range, the pipeline will reach elevations in excess of 2,500 feet. Temperature inversions, the condition of warming with altitude for a finite distance, then cooling with a continued increase in elevation, have a high frequency all along the pipeline route. Most of the time, the top of the inversion (warmest portion) lies between 1,000 and 2,000 feet above mean sea level (MSL) with the base at ground level (a lower MSL value). A good percentage of the time, particularly during the winter, the higher elevation portions of the route will have warmer air temperatures than those portions at lower elevations. At other times, when there is no inversion, temperatures will decrease with altitude and be colder at the higher elevations.

Surface winds exert an influence on temperature patterns. Within an inversion layer, they can cause vertical mixing of the air, making it more homogenous. The result is a weakening of the inversion with surface temperatures warming and the air at the top of the inversion becoming colder. The horizontal movement of air can make extensive changes in temperatures. Statistically, an annual period of strong warming occurs over most of the state about mid-winter. This mid-winter warming often raises sub-zero temperatures to at the low 40s over all of the area along the proposed pipeline route.

The combination of free air temperature and surface wind produces an "equivalent chill temperature" (ECT), or a temperature value that under a no wind condition would produce the same rate of heat loss from a human body as does the temperature/wind combination. Although the coldest actual temperatures occur south of the Brooks Range under calm wind conditions, the surface winds along the arctic coast produce an ECT much colder than the actual extremes to the south. The climatic effects on outdoor operations are much greater. The ECT statistics for six locations along the proposed gas pipeline are shown in Table 2.4-3. These six were originally prepared to show the distribution of ECT for specific geographical sections along the Alyeska transportation corridor. They cover the route from Prudhoe Bay southward to Big Delta (Federal Aviation Administration). A seventh ECT Data Summary was also compiled for Gulkana, not on the proposed gas pipeline route. To provide ECT data for

TABLE 2.4-3
Annual Equivalent Chill Temperature

Min. Temp.	Pct.	Percent Freq.
-110	100.00	0.02
-105	99.97	0.03
-100	99.94	0.09
-95	99.86	0.19
-90	99.66	0.42
-85	99.21	0.66
-80	98.56	1.14
-75	97.48	1.40
-70	96.12	2.12
-65	94.10	2.74
-60	91.48	3.47
-55	88.12	3.41
-50	84.85	3.82
-45	81.29	3.57
-40	78.02	4.14
-35	74.24	4.15
-30	70.44	4.33
-25	66.46	4.09
-20	62.64	4.32
-15	58.60	4.14
-10	54.72	3.67
-5	51.06	4.01
0	46.97	4.54
5	42.13	4.67
10	36.88	5.62
15	30.43	6.51
20	23.27	6.56
25	16.07	5.71
30	9.99	4.53
35	5.05	3.21
40	2.11	1.75
45	0.60	0.6[illegible]
50	0.11	0.[illegible]
55	-0.01	0.02

Mean -10.92
Std. 33.472
Min. -106.6
Max. 56.0

Barter Island

Min. Temp.	Pct.	Percent Freq.
-100	100.00	0.07
-95	99.89	0.00
-90	99.89	0.07
-85	99.83	0.14
-80	99.69	0.64
-75	98.94	0.68
-70	98.15	1.07
-65	97.02	1.97
-60	94.86	2.04
-55	92.77	2.47
-50	90.03	3.26
-45	86.60	2.62
-40	84.05	4.23
-35	79.94	3.94
-30	76.02	3.51
-25	72.61	4.48
-20	68.15	4.91
-15	63.38	4.30
-10	58.98	4.98
-5	54.22	4.98
0	49.38	4.84
5	44.58	3.87
10	40.49	4.45
15	35.92	3.91
20	31.69	4.16
25	27.14	3.91
30	22.96	4.55
35	18.23	4.98
40	13.45	4.73
45	8.96	3.44
50	5.80	3.37
55	2.83	2.04
60	1.00	1.11
65	0.07	0.10

Mean -0.75
Std. 34.877
Min.-98.4
Max. 66.2

Umiat

"Pct" column is cumulative frequency of the hours of occurrence. "Percent Freq" column is frequency of occurrence of total days per year for each temperature category.

TABLE 2.4-3 (Cont'd)

Annual Equivalent Chill Temperature

Min. Temp.	Pct.	Percent Freq.
-90	100.00	0.03
-85	99.95	0.01
-80	99.93	0.03
-75	99.89	0.21
-70	99.65	0.29
-65	99.33	0.51
-60	98.76	0.53
-55	98.23	0.84
-50	97.33	1.22
-45	96.00	1.67
-40	94.23	2.10
-35	92.14	2.08
-30	90.10	2.48
-25	87.46	3.05
-20	84.33	3.58
-15	80.83	4.17
-10	76.74	4.04
-5	72.62	4.47
0	68.18	5.10
5	62.90	4.69
10	58.04	4.90
15	53.03	4.59
20	48.35	3.80
25	44.39	4.17
30	40.05	5.04
35	34.85	4.92
40	29.88	5.71
45	24.23	7.07
50	17.24	7.68
55	9.92	6.91
60	3.49	3.17
65	0.64	0.65
70	0.07	0.09
75	-0.00	0.01

Mean 16.35
Std. 32.292
Min. -89.9
Max. 75.5

Wiseman

Min. Temp.	Pct.	Percent Freq.
-80	100.00	0.07
-75	99.93	0.18
-70	99.71	0.03
-65	99.68	0.29
-60	99.33	0.26
-55	99.07	0.63
-50	98.43	0.67
-45	97.65	1.68
-40	95.85	1.53
-35	94.03	2.24
-30	91.57	2.54
-25	89.00	3.03
-20	85.89	3.44
-15	82.39	4.56
-10	77.55	4.52
-5	72.57	5.46
0	66.96	5.65
5	60.98	4.75
10	56.15	5.05
15	51.09	4.30
20	46.66	3.03
25	43.66	3.40
30	40.20	3.63
35	36.66	4.67
40	32.05	5.38
45	26.81	6.62
50	20.33	8.00
55	12.74	7.74
60	5.74	4.97
65	1.34	1.27
70	0.22	0.18
75	0.07	0.07

Mean 18.21
Std. 31.955
Min. -79.4
Max. 78.0

Livengood

TABLE 2.4-3 (Cont'd)

Annual Equivalent Chill Temperature

Min. Temp.	Pct.	Percent Freq.
-65	100.00	0.00
-60	99.98	0.04
-55	99.92	0.21
-50	99.60	0.70
-45	98.78	0.70
-40	97.98	1.26
-35	96.64	1.98
-30	94.63	2.23
-25	92.40	3.07
-20	89.37	3.30
-15	86.11	3.72
-10	82.39	4.38
-5	78.10	4.47
0	73.62	5.25
5	68.35	5.01
10	63.37	5.02
15	58.24	5.20
20	52.86	4.54
25	47.95	4.33
30	43.42	5.08
35	38.16	4.95
40	33.28	6.61
45	26.69	7.21
50	19.50	6.98
55	12.62	7.06
60	5.91	4.45
65	1.84	1.69
70	0.34	0.42
75	-0.02	0.01

Mean 21.20
Std. 29.384
Min. -64.1
Max. 77.8

Fairbanks

Min. Temp.	Pct.	Percent Freq.
-100	100.00	0.01
-95	99.98	0.04
-90	99.94	0.04
-85	99.90	0.16
-80	99.72	0.25
-75	99.46	0.39
-70	98.97	0.39
-65	98.56	0.48
-60	98.00	0.72
-55	97.23	0.79
-50	96.42	1.27
-45	94.97	1.70
-40	93.19	2.20
-35	90.96	2.66
-30	88.11	2.83
-25	85.24	3.25
-20	81.89	3.63
-15	78.17	3.78
-10	74.32	4.19
-5	70.09	4.54
0	65.56	4.13
5	61.49	4.53
10	56.78	4.34
15	52.36	4.41
20	47.80	4.15
25	43.33	4.56
30	38.71	4.90
35	33.92	5.02
40	28.93	6.47
45	22.48	7.34
50	15.24	7.00
55	8.67	5.88
60	3.30	2.81
65	0.81	0.88
70	0.05	0.09
75	-0.02	0.01

Mean 14.91
Std. 33.401
Min. -96.4
Max. 75.2

Big Delta

TABLE 2.4-3 (Cont'd.)
Annual Equivalent Chill Temperature

Min. Temp.	Pct.	Percent Freq.
-80	100.00	0.03
-75	99.96	0.03
-70	99.92	0.01
-65	99.91	0.00
-60	99.91	0.15
-55	99.76	0.22
-50	99.53	0.51
-45	99.00	0.50
-40	98.48	0.91
-35	97.54	1.26
-30	96.30	1.85
-25	94.45	2.59
-20	91.83	3.14
-15	88.67	3.73
-10	84.90	4.02
-5	80.85	4.70
0	76.10	5.86
5	70.15	6.23
10	63.73	6.46
15	56.96	5.44
20	51.45	5.84
25	45.39	6.03
30	39.31	6.84
35	32.32	6.97
40	25.27	8.07
45	17.34	7.82
50	9.81	5.41
55	4.72	3.33
60	1.66	1.53
65	0.30	0.38

Mean 19.22
Std. 25.910
Min. -78.0
Max. 69.5

Gulkana

the Northway area, both temperature and wind conditions for Big Delta, Gulkana and Northway were compared. Conclusions were that Big Delta ECT's were colder than Northway's, and that Gulkana should be similar to Northway. Therefore, the Gulkana data are offered as a substitute for Northway, also in Table 2.4-3.

February is the coldest month for that portion of the route northward from the Brooks Range, and January is the coldest month south of the range. Without exception, July is the warmest month for all locations.

Aviation Weather

Flying is extremely important for the construction and operation of the proposed pipeline, for it can serve as a limiting factor. Using the statistics for percentage frequence of occurrence of ceilings and visibilities (Table 2.4-4), an estimate of the usable time for an airfield can be determined. For comparison purposes, the occurrence of a 1,000-foot ceiling and three miles visibility or better are discussed. These values of ceiling and visibility are the lowest conditions allowed for a terminal when landing or taking off under Visual Flight Rules (VFR). On the average, flying conditions improve with distance from the coast. Near the Arctic coast, Barter Island, which is representative of the area from the coast to 25 miles inland along the proposed gas pipeline route, conditions of a 1,000-foot ceiling and visibility of three miles or better occur approximately 70 percent of the time. Generally, flying weather is better during winter than it is during summer. In summer, the Arctic Ocean loses much of the ice close to the shore, allowing the development of low stratus clouds and resulting in poorer flying weather. The occurrence of fog is also greatest in summer. Inland from the coast, to elevations of approximately 1,000 feet, conditions in Umiat are representative of conditions found along the proposed route. Umiat shows that this specific ceiling/visibility combination occurs 85 percent of the time on an annual basis. In the case of Umiat, fog occurs more often in winter, and low clouds are more prevalent in summer and fall. Data on obstructions to vision, cloud cover, and heavy fog (visibility one quarter mile or less) are shown in Table 2.4-5. Poorest flying weather is in the months of September through November. For the higher elevations of the Brooks range along the proposed route, no summarized data are available on ceilings and visibilities. In summer, the coastal fog and low stratus clouds dissipate by the time the higher elevations of the Brooks Range are reached. Summertime showers and thunderstorms at the higher elevations account for some deterioration in flying weather. The more persistent cloud masses, such as with weak frontal systems, will usually have lower ceilings at the higher elevations. South of the range where elevations are less than

TABLE 2.4-4

Visibility (in miles) ≥3	≥1½	≥1	≥¾	≥½	≥¼	≥0	Station	Ceiling (in feet)	Station	Visibility (in miles) ≥3	≥1½	≥1	≥¾	≥½	≥¼	≥0
74	75	76	76	76	76	76	Umiat	≥ 1,800	Barter Island	61	63	64	65	66	68	68
77	79	79	80	80	80	80		≥ 1,500		64	66	68	68	70	71	72
81	83	84	84	84	84	84		≥ 1,200		67	69	71	72	73	74	75
85	87	88	88	89	89	89		≥ 1,000		70	73	75	76	78	79	80
86	88	90	90	90	90	90		≥ 900		71	74	76	77	79	80	81
87	90	91	91	91	92	92		≥ 800		73	76	79	80	81	83	84
88	91	93	93	93	94	94		≥ 700		74	78	80	82	83	85	86
89	93	94	94	95	95	95		≥ 600		76	80	82	84	85	87	88
90	93	95	95	96	96	97		≥ 500		77	81	84	86	88	89	91
90	94	96	96	97	97	98		≥ 400		78	82	86	87	89	91	92
91	94	96	97	98	98	98		≥ 300		78	83	87	88	91	93	95
91	94	97	97	98	99	99		≥ 200		78	83	87	89	92	95	97
91	95	97	97	98	99	100		≥ 100		78	83	87	89	92	96	98
91	95	97	97	98	99	100		≥ 0		78	83	87	89	92	96	103
90	91	92	92	92	93	93	Fairbanks Airport	≥ 1,800	Eielson AFB	88	89	90	91	91	92	92
91	93	93	94	94	95	95		≥ 1,500		89	91	92	92	93	94	94
93	94	95	95	96	96	97		≥ 1,200		90	92	93	93	94	95	95
93	95	96	96	97	97	98		≥ 1,000		91	93	94	95	95	96	97
94	95	96	96	97	98	98		≥ 900		91	93	94	95	96	97	97
94	96	96	97	97	98	98		≥ 800		91	94	95	96	96	97	98
94	96	97	97	98	98	99		≥ 700		92	94	95	96	97	98	98
94	96	97	98	98	99	99		≥ 600		92	95	96	96	97	98	98
94	96	97	98	99	99	99		≥ 500		92	95	96	97	98	99	99
95	97	97	98	99	99	100		≥ 400		93	95	97	97	98	99	99
95	97	98	98	99	99	100		≥ 300		93	96	97	98	99	99	100
95	97	98	98	99	99	100		≥ 200		93	96	97	98	99	99	100
95	97	98	98	99	100	100		≥ 100		93	96	97	98	99	100	100
95	97	98	98	99	100	100		≥ 0		93	96	97	98	99	100	100
90	90	91	91	91	91	91	Northway	≥ 1,800	Big Delta	90	91	91	91	91	92	92
91	92	92	92	93	93	93		≥ 1,500		92	93	93	93	93	94	94
92	93	93	94	94	94	94		≥ 1,200		93	94	95	95	95	96	96
93	94	95	95	96	96	96		≥ 1,000		94	96	97	97	97	97	97
93	94	95	96	96	96	96		≥ 900		94	96	97	97	97	98	98
94	95	96	96	97	97	97		≥ 800		95	97	98	98	98	98	99
94	95	96	97	97	97	97		≥ 700		95	97	98	98	99	99	99
94	96	97	97	98	98	98		≥ 600		95	97	98	99	99	99	99
94	96	97	98	98	98	98		≥ 500		95	97	98	99	99	100	100
94	96	98	98	99	99	99		≥ 400		95	97	99	99	99	100	100
95	96	98	98	99	100	99		≥ 300		95	97	99	99	99	100	100
95	96	98	98	99	100	99		≥ 200		95	97	99	99	99	100	100
95	96	98	99	99	100	100		≥ 100		95	97	99	99	99	100	100
95	96	98	99	99	100	100		≥ 0		95	97	99	99	99	100	100

Note: Data are presented for all months and all hours. A ceiling exists when the sky is more than half covered with clouds. Due to the cumulative nature of this presentation, it is possible to determine the percentage frequency of occurrence for any given limit of ceiling or visibility separately or combined. The totals progress to the right and downward. The frequency of occurrence of a particular ceiling height may be determined independently by referring to totals in the far right hand column for each station. The frequency of occurrence of a particular visibility range may be determined independently by referring to the horizontal row of totals at the bottom of each station grid. The percentage frequency for which the station was meeting or exceeding any given set of minima may be determined from the figure at the intersection of the appropriate ceiling column and visibility row. Period of record 19 to 30 years.

Prepared by AEIDC from Air Weather Service data.

TABLE 2.4-5

Barter Island

Month	Obstructions to Vision: Fog	Smoke or Haze	Blowing Snow	Observations with Obstructions to Vision	Sky Cover Data: Tenths of Sky Cover 0-3	4-5	6-7	8-9	10	Fog Data: Days with Heavy Fog
Jan	7	.1	20.0	27	42	5	7	8	38	2
Feb	8	.1	22.0	29	44	6	6	7	37	1
Mar	10	.1	17.0	25	42	6	7	10	35	1
Apr	12	.2	12.0	23	35	5	7	10	43	3
May	25	.0	3.0	28	14	3	4	8	71	7
Jun	27	.1	.1	27	15	5	6	13	61	12
Jul	25	.0		25	16	6	7	15	56	15
Aug	32	.1		32	10	4	6	14	66	16
Sep	27	.0	1.9	28	12	4	5	10	69	10
Oct	14	.2	10.0	23	15	4	4	8	69	4
Nov	10	.1	18.0	25	27	4	5	8	56	2
Dec	8	.1	17.0	24	39	5	6	7	43	1
Ann	17	.1	10.0	26	25	5	6	10	54	75

Umiat

Month	Obstructions to Vision: Fog	Smoke or Haze	Blowing Snow	Observations with Obstructions to Vision	Sky Cover Data: Tenths of Sky Cover 0-3	4-5	6-7	8-9	10	Fog Data: Days with Heavy Fog
Jan	15	.8	6.0	20	43	5	5	6	41	1
Feb	16	.7	9.0	23	46	5	6	7	36	*
Mar	12	.0	2.0	14	40	6	7	10	37	*
Apr	14		.4	17	31	5	8	10	46	1
May	14		.4	14	19	3	5	8	65	4
Jun	8	.0		8	15	6	9	15	55	4
Jul	7	1		8	19	6	10	17	48	2
Aug	10			10	11	4	7	13	65	2
Sep	13	.0	.3	14	11	3	5	9	72	4
Oct	16		2.0	18	18	3	6	7	66	4
Nov	15	.0	5.0	20	20	5	5	7	63	3
Dec	13	.5	6.0	18	36	5	5	6	48	1
Ann	13	.3	3.0	15	26	5	6	9	54	26

* means less than .5
NA means not available

.0 means less than .05
Blank space means no occurrence

Data are percentage frequency of occurrence for categories as shown.

Fairbanks International Airport

Month	Obstructions to Vision: Fog	Smoke or Haze	Blowing Snow	% Observations with Obstruction to Vision	Sky Cover Data: Tenths of Sky Cover 0-3	4-5	6-7	8-9	10	Fog Data: Days with Heavy Fog
Jan	18	.8	.2	18	36	6	6	10	42	5
Feb	12	3.0	.3	12	34	5	7	11	43	2
Mar	3	.2	.2	3	40	5	7	11	37	1
Apr	1			1	30	6	8	15	41	*
May	1	.0		1	25	7	10	19	39	*
Jun	1	1.0		2	17	9	12	22	40	*
Jul	3	3.0		6	17	7	10	19	47	1
Aug	4	2.0		6	15	7	9	20	49	2
Sep	4	.3		4	20	5	7	15	53	2
Oct	5	.0		5	22	4	6	11	57	2
Nov	10	2.0	.1	10	37	6	6	10	46	1
Dec	21	3.0	.2	21	30	8	8	10	44	4
Ann	7	1.0	.1	8	27	6	8	14	45	20

TABLE 2.4-5 (Cont'd)

Eielson AFB

Month	Obstructions to Vision: Fog	Smoke or Haze	Blowing Snow	% Observations with Obstruction to Vision	Sky Cover Data: Tenths of Sky Cover 0-3	4-5	6-7	8-9	10	Fog Data: Days with Heavy Fog
Jan	54	6.0	2.0	56	39	7	7	10	37	N/A
Feb	38	5.0	2.0	40	36	6	7	10	40	"
Mar	20	2.0	2.0	23	39	6	8	11	36	"
Apr	9		1.0	10	27	7	9	15	42	"
May	7	.1	.2	7	21	8	11	21	39	"
Jun	9	4.0		13	15	9	11	23	42	"
Jul	19	8.0		24	15	9	10	20	46	"
Aug	29	7.0		32	14	7	10	20	49	"
Sep	27	4.0		29	20	6	8	16	50	"
Oct	34	2.0	.6	34	21	6	6	12	55	"
Nov	37	3.0	2.0	39	32	6	7	10	45	"
Dec	45	4.0	2.0	47	31	8	9	10	42	"
Ann	27	4.0	1.0	29	26	7	9	15	43	"

Big Delta

Month	Obstructions to Vision: Fog	Smoke or Haze	Blowing Snow	% Observations with Obstruction to Vision	Sky Cover Data: Tenths of Sky Cover 0-3	4-5	6-7	8-9	10	Fog Data: Days with Heavy Fog
Jan	8	.1	1.0	9	38	6	6	11	39	5
Feb	6	.1	.5	7	36	7	7	12	38	1
Mar	3		.1	3	41	6	6	13	34	0
Apr	2		.1	2	29	8	9	18	36	0
May	1		.0	1	22	10	12	22	34	0
Jun	1	.3		1	16	10	11	26	37	0
Jul	1	2.0		3	18	10	10	22	40	*
Aug	2	.5		2	18	9	9	21	43	1
Sep	4	.0		5	19	7	7	16	51	2
Oct	6	.0		6	22	6	7	12	53	1
Nov	5	.0	.1	6	33	7	7	12	41	1
Dec	8	.2	.6	9	45	8	7	13	37	1
Ann	4	.2	.7	4	27	8	8	17	40	12

Northway

Month	Obstructions to Vision: Fog	Smoke or Haze	Blowing Snow	% Observations with Obstruction to Vision	Sky Cover Data: Tenths of Sky Cover 0-3	4-5	6-7	8-9	10	Fog Data: Days with Heavy Fog
Jan	10	.1	1.0	11	29	6	6	10	49	1
Feb	6	.1	1.0	7	29	6	7	11	48	1
Mar	2	.0	.8	3	34	6	8	14	38	0
Apr	1		.5	2	26	8	9	16	41	0
May	1			1	18	8	10	21	42	0
Jun	1	.4		1	14	9	11	24	43	0
Jul	1	1.0		2	13	9	11	23	45	0
Aug	2	.3		2	16	8	11	20	45	1
Sep	4	.1	.0	4	16	6	7	16	55	3
Oct	9		.2	9	18	6	6	12	58	3
Nov	14		.9	15	22	6	6	10	57	1
Dec	10	.1	.6	11	25	6	6	11	52	2
Ann	5	.2	.5	6	22	7	8	16	48	12

1,000 feet, (Fairbanks for example) ceiling and visibility of three miles or better occur 93 percent of the time. Wintertime fog is considerably less frequent at the higher elevations of Big Delta and Northway, due to more winds, low level mixing of the air, and fewer sources of condensation nuclei for the formation of fog. Fog and ice fog primarily affect the terminal weather, while clouds and precipitation affect the enroute weather, and can severely restrict VFR flying.

Atmospheric Dispersion

Atmospheric stability or instability is the culmination of a vast interplay of both chemical and physical forces. Wind, water, and the sun's direct energy as heat are the primary determinants of meteorological phenomena. Mocro-climate is the description of an area that is usually geographically or topographically isolated from other locations in the same latitudes. This situation of climatic isolation or uniqueness often lends unusual meteorlogical and geological aspects to the isolated area.

An area surrounded by mountains is protected from the global or prevailing winds. Such protection may provide a great deal of stability to the local atmosphere even though that atmosphere itself may be uncommon. Fairbanks is such an area.

Fairbanks is mostly surrounded by mountains and protected from the prevailing winds. Fairbanks has a uncommonly low mean temperature for its latitude. These two micro-climate parameters combine to form a very stable and layered atmosphere in the Fairbanks/Tanana Valley area. The winter air is generally colder near the ground in the Fairbanks area; the lack of winds prevents mixing and any emissions from ground sources tend to remain trapped in this cold, still air.

These phenomena and thermal inversions, barometric highs and lows, and "Chinook" type winds, all occur in various Alaska districts. Such meteorological occurrences result in ice fogs or "white outs", bizarre wind storms, and extremely low temperatures in the Alaskan interior.

Certain meteorological conditions are required before a pollutant in the air will increase its concentration. Vertical mixing of the air must be stopped by a temperature inversion. Horizontal mixing must also be stopped or at least greatly reduced. This can happen if winds are calm, and with a temperature inversion they often are. In instances when they are not, the horizontal spreading of a pollutant will be restricted if it is blown into an area ringed by hills or mountain ranges. River valleys make a good trap for a pollutant.

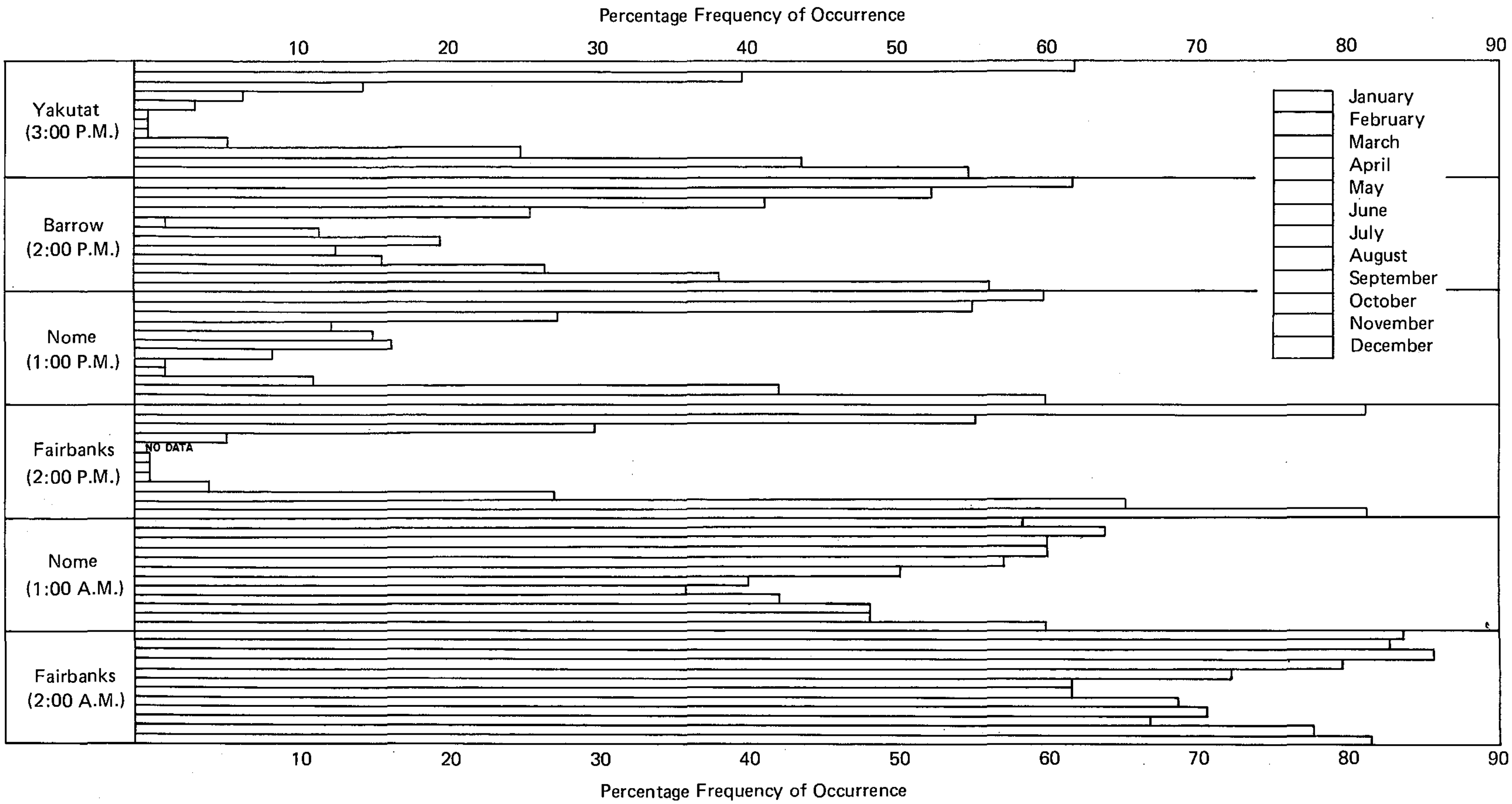
Statistical data along the proposed pipeline route show the average annual frequency of inversions to the north and the south of the Brooks Range is very close to being the same. Seasonally, however, there are differences. Both areas have a maximum in winter and a minimum in summer, but the winter occurrence of inversions to the south of the Brooks Range is considerably greater than to the north, and from late spring through the fall months the opposite is true. A comparison of inversion conditions in various portions of the state is shown in Figure 2.4-9. Observational time of these comparative figures is 0000 Grenwich Meridian time or 2 P.M. Alaska Standard Time. Time of day affects the inversion frequency, particularly in summer when the cooler nighttime temperatures cause a greater frequency during afternoon hours. This variation is shown for Fairbanks in Figure 2.4-10. The greater surface heating in summer accounts for the seasonal variation mentioned above, and also accounts for the variation in frequency between night and day in summer. Heating on a summer afternoon is usually sufficient to eliminate a temperature inversion at or near ground level, and create enough vertical mixing of the air to prevent a pollutant from concentrating near the ground.

The percentage frequency of calm winds along the route varies with the season of the year. For example, the annual calm wind average for Fairbanks is 21 percent. February is much higher with 44 percent; May is the lowest month with nine percent. There can be considerable variation in the percentage of calm of 21, that seasonally varies from 55 in January to 21 percent in June. Percentage of calm on an annual basis can be found in the wind data presentation shown on the proposed gas pipeline route map for climate.

Sources of a pollutant along the proposed pipeline route at present are the oil pipeline camps and existing villages and towns. Industrial sources are power generation facilities, and by far the major sources are automobiles and residential and commercial heating. In summer an intermittent source is lightning and man-caused fires. This source, on occassion, will also substantially reduce both horizontal and vertical visibility. Obviously the winter months, when the potential for concentration of a pollutant is greatest, are also when the greatest amount of pollutants are available.

The growth that has occurred in the city of Fairbanks in recent years has produced a pollution problem in winter that at times becomes critical to the welfare of the residents of the city. To deal with such a problem, corrective action is necessary. The likelihood of modifying meteorological conditions is extremely unlikely. All that is left is to change the way of life of the community. To lower the pollutant concentration level point, sources are going to have to be modified or eliminated, at least during critical high concentration periods.

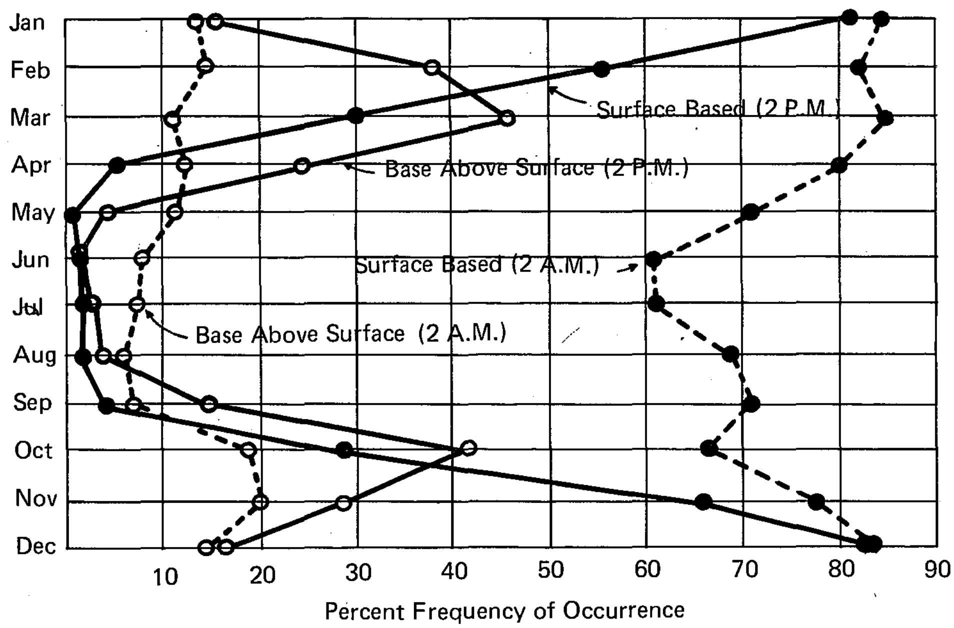
FIGURE 2.4-9



Note: Fairbanks, representing interior Alaska, has by far the greatest frequency and number of inversions during the months of November through February. Data shown are for ground-based inversions only. The daytime upper air reading was used for this comparison. Only data for Nome and Fairbanks are available for the nighttime reading. Period of record is nine years.

Prepared by AEIDC from U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory data.

FIGURE 2.4-10



Period of record is nine years.

Note: The graphs compare observation times with the percentage frequency of occurrence of both surface-based and above-surface inversions. Inversion frequencies differ with the time of day and whether based above the surface or at the surface. The time variation includes both time of day and season of the year.

Prepared by AEIDC from U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory data

Relating the temperature inversion, wind conditions, and pollutant sources to the proposed pipeline route, the relatively strong surface winds and flat terrain of the coastal region make concentration of a pollutant highly unlikely. This changes with increasing distance southward. In the Brooks Range, including the foothills, are valleys that will restrict the horizontal movement of a pollutant, and a temperature inversion that will limit its vertical movement. If a north to south component to the wind blows a pollutant into these valleys, they will become increasingly more concentrated with time. On the south side of the range where the percentage of occurrence and the persistence of calm winds is high, there is good potential for the concentration of a pollutant. Fairbanks is a good example of this (Table 2.4-6). The portion of the pipeline route south of the Brooks Range also provides many locations where valleys can trap pollutants without the need of calm winds.

In addition to noxious pollutants produced by internal combustion engines there is produced water vapor which can produce ice fog, primarily of the type occurring in the interior of Alaska (an example is the Fairbanks area). The occurrence of ice fog is related to organic fuel combustions, which provide both moisture and nuclei for the formation of the ice fog. The final necessary condition is a cold temperature of about -30 degrees C or colder. Under these conditions the combustion by-products can adversely affect the human body. Ice fog also reduces visibility which is a hazard to transportation.

TABLE 2.4-6

Frequency of inversion occurrence, in terms of thickness and temperature gradient, for two 6-month periods.

Fairbanks, Alaska*

November through April:

3188 soundings (approximately 9 years of record).
2862 inversions observed (frequency = 89.8%) of which 2186 were with base at the surface, and 676 were with base above the surface.

	Temperature gradient (°C/100 m) 0.1 to <1.0*		1.0 to <3.0*		≥3:0*	
Thickness (m)	Number of inversions observed	Frequency of occurrence (%)	Number of inversions observed	Frequency of occurrence (%)	Number of inversions observed	Frequency of occurrence (%)
001-199	164	5.1	274	8.6	335	10.5
200-399	219	6.9	267	8.4	227	7.1
400-599	133	4.2	222	7.0	82	2.6
600-799	99	3.1	191	6.0	8	0.2
800-999	83	2.6	131	4.1	0	—
≥1000	174	5.5	253	7.9	0	—

*Computations based on 1200 and 2400 Z observations.

May through October:

3187 soundings (approximately 9 years of record).
1510 inversions observed (frequency = 47.4%) of which 1171 were with base at the surface, and 339 were with base above the surface.

	Temperature gradient (°C/100 m) 0.1 to <1.0*		1.0 to <3.0*		≥3.0*	
Thickness (m)	Number of inversions observed	Frequency of occurrence (%)	Number of inversions observed	Frequency of occurrence (%)	Number of inversions observed	Frequency of occurrence (%)
001-199	180	5.6	248	7.8	125	3.9
200-399	295	9.2	282	8.8	19	0.6
400-599	158	5.0	88	2.8	0	—
600-799	56	1.8	24	0.8	0	—
800-999	17	0.5	5	0.2	0	—
≥1000	13	0.4	0	—	0	—

2.4.2 Hydrology

Surface Water

The proposed Alcan gas pipeline crosses two major hydrologic regions of Alaska--the Arctic region and the Yukon region. In the Arctic region, the proposed line lies within the Sagavanirktok drainage basin. It crosses the Brooks Range into the Koyukuk subregion, the Upper Yukon subregion, and the Tanana subregion. The Yukon region, with a drainage area of 334,500 square miles, of which 130,500 square miles are in Canada, discharges more than 200,000 cubic feet/second annually. The drainage of the Upper Yukon subregion is approximately 85,000 square miles above the pipeline crossing. Principal streams are listed in Table 2.4.2-1. Detailed lists of streams crossed by the existing trans-Alaska oil pipeline are available (U. S. Bureau of Land Management 1973). Note: Water Resources maps, volume 1A, page 14 (a supportive overview of water resources along the proposed pipeline corridor).

Although few large lakes are present adjacent to the proposed gas line, numerous small tundra lakes are located in the Sagavanirktok drainage basin. Most of these are less than 10 square miles in area, seldom more than six to eight feet deep, and most freeze to the bottom in winter. Larger, glacier-formed lakes in the Yukon region are listed in Table 2.4.2-2. These lakes are important in winter water storage and in regulating flood waters of streams draining into them. Most water storage is provided by the winter snowpack. The U. S. Soil Conservation Service has established snow survey sites to aid in predicting water runoff when the snow melts. The snow course stations listed in Table 2.4.2-3 include index snow stations on selected glaciers operated by U. S. Geological Survey. While the proposed line does not lie near the termini of any glaciers, there are active glaciers at the headwaters of rivers tributary to the Tanana. These glaciers store tremendous amounts of water and many of the streams draining into the Tanana are glacier-fed.

Distribution of Runoff

Surface water runoff is recorded by the U. S. Geological Survey in cubic feet per second (cfs). Areal runoff rates are computed from stream gaging records in cubic feet per second per square mile and are used to compare runoff of the larger rivers and hydrologic regions of Alaska. Mean annual runoff is the average areal runoff occurring over a period of years. However, actual runoff varies from instantaneous peak rates to periods of low flow reflecting temperature, elevation and size of drainage basin, vegetation

TABLE 2.4.2-1

PRINCIPAL STREAMS CROSSED BY PROPOSED ROUTE

Sagavanirktok River	Tolovana River
Toolik River	Tatalina River
Kuparuk River	Washington Creek
Atigun River	Chatanika River
Dietrich River	Goldstream Creek
Bettles River	Chena River
Middle Fork Koyukuk River	Salcha River
South Fork Koyukuk River	Shaw Creek
Jim River	Tanana River
Prospect Creek	Gerstle River
Bonanza Creek	Johnson River
Fish Creek	Robertson River
Kanuti River	Tok River
West Fork Dall River	Tanana River
Ray River Tributary	Desper Creek
Yukon River	Scottie Creek
Hess Creek	Oksrukuyik River

TABLE 2.4.2-2

LARGER LAKES ADJACENT TO PROPOSED ROUTE

	Latitude		Longitude	
	Degrees	Minutes	Degrees	Minutes
Glacier Lake	67	31	149	33
Big Lake	67	30	149	24
Twin Lakes	67	30	149	04
Chandalar Lake	67	30	148	30
Minnie Creek Lake	67	27	149	52
Grayling Lake	66	57	150	23
Olsons Lake	66	24	150	28
Harding Lake	64	25	146	50
Birch Lake	64	20	146	40
Quartz Lake	64	13	145	49
Volkmar Lake	64	07	145	11
Healy Lake	64	00	144	45
Twelvemile Lake	63	51	144	40
Black Lake	63	48	144	41
Lake George	63	47	144	32
Moosehead Lake	63	45	144	32
Sand Lake	63	45	144	15
Glaman Lake	63	26	143	29
Lake Mansfield	63	30	143	25
Fish Lake	63	29	143	15
Wolf Lake	63	27	143	10
Tetlin Lake	63	05	142	45
Midway Lake	63	13	142	17
Fish Lake	62	57	141	50
Deadman Lake	62	53	141	33
Island Lake	62	42	141	07

TABLE 2.4.2-3

SNOW SURVEY SITES

Course Name	Course No.*	Elev.	Latitude Degrees	Latitude Minutes	Longitude Degrees	Longitude Minutes	Yrs. of Record
Anaktuvuk Pass	51TT1A	2100	68	09	151	41	10
Bettles Field	51RR1A	640	66	35	151	32	10
Chandalar Lake	48SS1A	2040	67	30	148	30	13
Squaw Lake	48SS2a	2150	67	33	148	15	10
Venetie	46SS1A	610	67	03	146	25	13
Arctic Village	45TT1A	2300	68	05	145	35	13
Koness Lake	44SS1A	1790	67	55	144	08	10
Coleen River	42SS1A	1100	67	44	142	28	12
Vundik Lake	43SS1a	950	67	23	143	45	10
Fort Yukon	45RR1AM	430	66	35	145	15	13
Black River	42RR1A	650	66	36	142	45	12
Circle City	44QQ3A	600	65	50	144	05	12
Bull Lake	41RR1A	810	66	12	141	59	10
Eagle Village	41PP1A	900	64	08	141	08	12
Boundary	41PP3A	3300	64	05	141	27	10
Chicken Airstrip	41PP2A	1650	64	05	141	45	12
Yak Pasture	47PP1	540	64	52	147	55	17
Cleary Summit	47QQ1A	2230	63	03	147	24	17
Little Chena	46QO2AP	2200	65	08	146	32	15
Mt. Ryan	46QQ1AP	2950	65	16	146	07	15
Chena Hot Springs	45QQ1	1250	65	03	145	03	13
Big Windy	44QQ2AP	3850	65	07	144	52	14
Munson Ridge	46PP1AP	3100	64	52	146	13	15
French Creek	46PP2MP	2010	64	43	146	40	15
Little Salcha	46PP3	1500	64	38	146	44	15
Glenn Creek	47PP2	930	64	54	147	34	11
Colorado Creek	46PP4	750	64	52	146	39	11

TABLE 2.4.2-3 (Cont'd.)

SNOW SURVEY SITES

Course Name	Course No.*	Elev.	Latitude Degrees	Latitude Minutes	Longitude Degrees	Longitude Minutes	Yrs. of Record
Caribou Mine	45PP2A	1115	64	40	145	40	12
Big Delta	45PP1	980	64	14	145	58	17
Tok Junction	43001	1650	63	18	143	00	17
Mentasta Pass	43NN1	2430	62	51	143	30	15
Upper Chena	44QQ1AP	3000	65	07	144	55	10
Wolf Creek	44QQ4a	3850	65	08	144	57	9
Ft. Greely	45005	1420	63	57	145	45	10
Meadows Road	45002	1570	63	52	145	50	10
Donnelly Dome	45003	2200	63	47	145	43	10
Granite Creek	45004	1240	63	57	145	24	9
Bonanza Creek	48PP1	1150	64	05	141	27	10
Dempsey Creek	41RR2a	950	66	06	141	48	8
Gulkana Glacier (A)	45006	4590	63	15	145	29	9
Gulkana Glacier (B)	45007	5480	63	17	145	26	9
Gulkana Glacier (C)	45008	6360	63	19	145	29	9
Mt. Fairplay	42001a	3100	63	42	142	17	7
Nation River	41QQ1a	3050	65	25	141	40	7
Haystack Mountain	47QQ2	1950	65	08	147	38	7
Caribou Creek	47QQ3	1440	65	09	147	35	6
Poker Creek	47QQ4	1025	65	08	147	32	7
Dietrich Camp	49SS1A	1550	67	42	149	45	3
Cold Foot Camp	50SS1	1000	67	16	150	10	3
Prospect Creek	50RR1	980	66	47	150	45	3
Five Mile Camp	49RR1	400	65	55	149	48	3
Table Mountain	49SS3a	2200	67	58	149	45	2
Snowden Mountain	49SS4a	1900	67	50	149	41	2
Kupuk Creek	50SS2a	2300	67	48	150	08	5

TABLE 2.4.2-3 (Cont'd.)

SNOW SURVEY SITES

Course Name	Course No.*	Elev.	Latitude Degrees	Latitude Minutes	Longitude Degrees	Longitude Minutes	Yrs. of Record
Glacier Creek	49SS2a	2000	67	28	149	31	4
West Buttons	49SS5a	1600	67	17	149	34	4
Jim River	49RR1a	1900	66	51	149	50	1
Thirty Mile	50RR2a	1300	66	13	150	15	2
Teuchet Creek	45PP3	1640	64	57	145	31	4
Monument Creek	45QQ2	1900	65	03	145	55	4

*Letters following the snow course number refer to:

- A. Snow course and aerial marker
- a. Aerial stadia marker only
- M. Soil Moisture Station
- P. Precipitation Storage Gage
- S. Snow Pillow

Source: U.S. Soil Conservation Service. 1970. SUMMARY OF SNOW SURVEY MEASUREMENTS FOR ALASKA, 1951-70, and U.S. Soil Conservation Service. Annual. SNOW SURVEYS AND WATER SUPPLY OUTLOOK FOR ALASKA.

and permafrost. These extremes are average for a period of years and are expressed as mean annual peak runoff and mean annual low monthly runoff.

In the Arctic region the severe climate, characterized by below freezing temperatures throughout most of the year and the continuous presence of permafrost, leads to wide fluctuations in stream discharge. There is little or no groundwater storage to reduce these fluctuations because unfrozen subsurface material occurs only locally near larger lakes and streams. During the long arctic winter, there is little snowmelt or rain. In contrast, considerable rain and snowmelt occur during the short, wet arctic summer with long periods of daylight and above freezing temperatures. Mean annual runoff in the Arctic region is lowest near the coast at 0.5 cfs per square mile; runoff increases somewhat in the foothills and mountains to the south to two cfs per square mile. Drainage from the Colville River accounts for almost half the runoff from the region each year. Mean annual peak runoff of 50 cfs per square mile in the mountains and 25 cfs per square mile in the lowlands occurs from late May to early July during and after breakup. Freezeup and breakup dates are shown in Table 2.4.2-4. Mean annual low monthly runoff has not been calculated for the Arctic region. Even in areas where fluid water exists in river channels below ice, streamflow is so slow that it cannot be measured during the late winter months. The region is classed as having a mean annual low monthly runoff of zero.

Runoff in the Yukon region reflects climatic influences with a decrease in seasonal variation and an increase in the annual runoff rate from north to south. More detailed information is available for the Tanana subregion (Feulner, Childers, and Norman 1971). Mean annual runoff is 0.5 cfs per square mile in the Upper Yukon subregion lowlands and ranges from one cfs per square mile in the Tanana subregion lowland to four cfs per square mile in the Alaska Range.

Annual runoff varies from year to year--annual runoff from the Chena River at Fairbanks was 0.36 cfs per square mile in 1958 and 1.32 cfs per square mile in 1962. Mean annual peak runoff ranges from about 10 cfs per square mile in the lowlands to 50 cfs per square mile in the uplands of the Brooks Range, the Alaska Range, and the Upper Yukon-Tanana boundary. Most annual peaks occur in summer from rainfall, although spring snowmelt can also cause annual peaks. Low flow is usually in late winter or early

TABLE 2.4.2-4

FREEZEUP AND BREAKUP DATA FOR MAJOR RIVERS

Station	River	Approximate Freezeup	Approximate Breakup
BEAVER	Yukon River	November 5-12	April 30-May 10
BETTLES	Johns River	October 20-30	May 5-12
	Koyukuk River	October 20-27	May 5-10
	Wild River	October 18-28	May 5-7
FAIRBANKS	Chena River	October 30-November 20	April 7-14
FORT YUKON	Yukon River	October 22-November 5	April 24-May 2
NORTHWAY	Chisana River	November 7-8	April 2-17
	Nabesna River	November 2-18	April 7-20
RAMPART	Yukon River	November 10-15	May 10-15

spring following the winter streamflow recession. Mean annual low monthly runoff ranges from between 0 and 0.1 cfs per square mile in the Upper Yukon and Koyukuk subregions and from 0.2 cfs per square mile in the Tanana subregion lowlands to 0.3 cfs per square mile in the Alaska Range. Streams in many small basins probably freeze completely during most winters. During winter when there is little or no snowmelt or rain, the only large contribution to streamflow is from groundwater discharge in the channels of the larger rivers.

Surface Water Quality

The types of U. S. Geological Survey water quality data available along the proposed route are detailed in Table 2.4.2-5. To determine existing water quality conditions, U. S. Geological Survey field studies are conducted at regular intervals at selected sites; water samples are collected periodically for both field and laboratory analysis. Field analyses include dissolved oxygen, pH, alkalinity, turbidity, and specific conductance. Laboratory analyses include concentration of suspended sediment, chemical quality of water, and assessments of benthic biology. In addition, continuous records of water temperature and stream biota are obtained by thermographs and by artificial culturing. U. S. Environmental Protection Agency has also conducted bacteriological and other studies through their Arctic Environmental Research Laboratory in Fairbanks.

As shown in Table 2.4.2-5, the streams that have been sampled in the Arctic region generally have dissolved solids concentrations less than 120 mg/l. The data suggest that both the dissolved solids content and mineral composition vary considerably between winter and summer. A July sample from the Colville River near Umiat had a dissolved solids content of 60 mg/l and hardness of 54 mg/l; an April sample (representing late winter) had a dissolved solids content of 356 mg/l and hardness of 318 mg/l. Except for high salinities of lakes and rivers near the Arctic Ocean, the mineral content of the surface water is probably acceptable for domestic and public supply throughout this subregion. Temperature measurements from eight lakes and streams in the region indicate an annual range of $0^{o}C$ (Celsius) to $3^{o}C$.

In the Yukon region all surface water sampled has been of the calcium bicarbonate type and of acceptable quality. A few of the streams carry excessive iron content during parts of the year. Surface water sampled in the Tanana subregion has acceptable quality for public supply. Although concentrations of dissolved solids range from 60 to 484 mg/l, most samples are less than

TABLE 2.4.2-5

STREAMFLOW STATIONS AND WATER QUALITY OBSERVATION SITE

Map No.	Station Name	Latitude	Longitude	Drainage area (sq.mi.)	Streamflow stations: Classification	Streamflow stations: Type of data	Streamflow stations: Years of record	Water-Quality Sites (years of record): Continuous water temp.	Water-Quality Sites (years of record): Suspended sediment 1/	Water-Quality Sites (years of record): Std. water analysis	Water-Quality Sites (years of record): Nutrient	Water-Quality Sites (years of record): Benthos
1	Kuparuk R near Deadhorse	70°16'54"	148°57'35"	3,130	H	D	1	1	1	3	1	2,S
2	Putuligayuk R near Deadhorse	70°16'08"	148°37'11"	176	H	D	2		2	2	1	2,S
5	Sagavanirktok R near Sagwon	69°05'20"	148°45'10"	2,208	P.	D	2	1	2	2		2,S
6	Lupine River	69°05'15"	148°45'10"	325						1		
7	Happy Valley C at Happy Valley Camp	69°09'05"	148°51'00"	29						1	1	1
8	Atigun R study area below Galbraith Lake	68°21'45"	149°20'00"	279					1	1	1	2

1/ - Intermittent collection unless noted, D - Daily, F - Flood peak only, H - Hydrologic, P - Principal, S - Seasonal

Map number	Station number	Station name	Location: Latitude	Location: Longitude	Data available: Chemical: Period of record	Chemical: Frequency	Temperature A/: Period of record	Temperature A/: Frequency	Sediment: Period of record	Sediment: Frequency	Biological: Period of rocord	Biological: Frequency	Remarks
30	15453500	Yukon River near Stevens Village	65°52'28"	149°38'33"	1970-72	I					1970-71	I	
31		Hess Creek above Fish Creek near Livengood	65°40'22"	149°03'59"	1971	I					1971	I	
32		Unnamed Pond at Hess Creek near Livengood	65°40'05"	149°05'25"	1970	I							
33	15457800	Hess Creek near Livengood	65°39'55"	149°05'47"	1970-72	I	1971-72	C	1970-72	I	1970-72	I	
34	15468000	Yukon River at Rampart	65°30'25"	150°10'15"	1954-56, 1957-59, 1960-64, 1965, 1967	D I D I I	1954-56, 1961-64	D D	1954-55, 1962-67	I I			R, M

TABLE 2.4.2-5 (Cont'd.)

35		Scotty Creek near Northway Junction	62°38'20"	141°01'40"	1971	I							
36	15469900	Silver Creek near Northway Junction	62°59'01"	141°40'07"	1971-72	I							
37	15470000	Chisana River at Northway Junction	63°00'23"	141°48'17"	1950-51, 1953-59, 1965, 1967, 1971-72	I I I I I			1953-67	I			
38	15471000	Bitters Creek near Northway Junction	63°09'38"	142°05'20"	1971	I							
39	15472000	Tanana River near Tok Junction	63°19'00"	142°38'30"	1949-50, 1951-53	I D	1951-53	D	1953-54	I			
40	15473000	Bartell Creek near Mentasta	62°55'45"	143°34'30"	1949, 1955, 1961	I I I							
41	15473500	Little Tok River near Tok Junction	62°57'50"	143°20'00"	1949, 1951-58	I I							
42		Trail Creek near Tok	62°58'10"	143°18'50"	1949	I							
43	15473900	Tok River on Slana-Tok Highway near Tok Junction	63°06'35"	143°17'40"	1949, 1951-58	I I							
44		Question Mark Creek near Tok Junction	63°08'25"	143°15'10"	1952-53	I							
45	15473950	Clearwater Creek near Tok	63°10'19"	143°12'03"	1949, 1951-52, 1955-56, 1972	I I I I							
46	15474000	Tok River near Tok Junction	63°19'30"	142°50'05"	1949-54, 1956, 1958	I I I							
47		Yerrick Creek near Tok Junction	63°22'57"	143°35'35"	1949, 1951-53, 1955-56	I I I							
48	15476000	Tanana River near Tanacross	63°23'18"	143°44'47"	1953, 1954, 1955-56, 1957-66, 1967-69	I D I D I	1954, 1957-66	D D	1953-54, 1955-56, 1957-66, 1967-69	D I D I			R
49	15476100	Robertson River near Tanacross	63°29'55"	143°49'50"	1949, 1951-58, 1966	I I I							
50		Chief Creek near Dot Lake	63°37'50"	144°00'30"	1952, 1955-56	I I							

TABLE 2.4.2-5 (Cont'd.)

Map number	Station number	Station name	Location		Data available								Remarks
					Chemical		Temperature Δ		Sediment		Biological		
			Latitude	Longitude	Period of record	Frequency	Period of record	Frequency	Period of record	Frequency	Period of record	Frequency	
51		Bear Creek near Dot Lake	63°36'55"	143°59'00"	1949, 1952-53, 1955	I I I							
52		Dot Lake at Dot Lake	63°39'45"	144°04'00"	1971	I							
53	15476200	Tanana River Tributary near Dot Lake	63°41'40"	144°17'40"	1970-72	I			1970	I			
54	15476300	Berry Creek near Dot Lake	63°41'23"	144°21'47"	1949, 1951-53, 1955-56, 1971-72	I I I I							
55		Sears Creek near Dot Lake	63°41'15"	144°27'30"	1951-52	I							
56	15476400	Dry Creek near Dot Lake	63°41'32"	144°34'16"	1952, 1955	I I							
57	15476500	Johnson River near Dot Lake	63°42'13"	144°38'34"	1949, 1951-58, 1966	I I I							
58	15476600	Little Gerstle River near Big Delta	63°47'15"	144°47'30"	1949, 1951-53, 1955-58	I I I							
59	15476700	Gerstle River near Big Delta	63°49'00"	144°55'00"	1949, 1951-58, 1966	I I I							
60		Sawmill Creek near Big Delta	63°53'55"	145°13'45"	1949	I							
61	15478000	Tanana River at Big Delta	64°09'20"	145°51'00"	1948, 1949-52, 1953, 1955-58	I D I I	1949-51	D	1953, 1971	I I			
62	15478010	Rock Creek near Paxson	63°04'16"	146°06'17"	1971-72	I							
63		Moss Creek near Paxson	63°04'00"	145°58'30"	1952	I							
64		Wildhorse Creek near Paxson	63°10'50"	145°56'25"	1952	I							
65		Delta River below Eureka Creek near Paxson	63°15'20"	145°48'30"	1952	I							
66		Rainy Creek near Paxson	63°17'05"	145°47'45"	1952	I							
67		Phelan Creek at Richardson Highway near Paxson	63°12'44"	145°38'13"	1951-55, 1971	I I							

TABLE 2.4.2-5 (Cont'd.)

Map number	Station number	Station name	Location		Data available								Remarks
					Chemical		Temperature		Sediment		Biological		
			Latitude	Longitude	Period of record	Frequency	Period of record	Frequency	Period of record	Frequency	Period of record	Frequency	
68		Fielding Lake near Paxson	63°11'03"	145°38'42"	1952	I							
69	15478050	McCallum Creek near Paxson	63°13'27"	145°38'56"	1956, 1971-72	I I							
70		Phelan Creek below McCallum Creek near Paxson	63°14'04"	145°39'48"	1972	I							
71		Miller Creek near Black Rapids	63°22'25"	145°43'45"	1951-56	I							
72		Lower Miller Creek near Black Rapids	63°23'52"	145°44'00"	1952-53	I							
73		Castner Creek near Black Rapids	63°24'12"	145°43'55"	1951-56	I							
74		Falls Creek near Black Rapids	63°31'03"	145°51'15"	1951-53	I							
75		Gunnysack Creek near Black Rapids	63°31'30"	145°51'05"	1953	I							
76	15478100	Delta River at Black Rapids	63°31'45"	145°51'30"	1949, 1951-53, 1955-58	I I I							
77	15478500	Ruby Creek near Donnelly	63°37'52"	145°53'03"	1971-72	I							
78		Bolio Lake near Delta Junction	63°53°42"	145°50'30"	1951, 1957	I I							
79		Jarvis Creek near Big Delta	64°01'25"	145°43'25"	1949, 1951, 1953-56	I I I			1955	I			
80		Delta River near Big Delta	64°07'35"	145°50'00"	1955-58, 1966	I T							
81	15479500	Shaw Creek near Delta Junction	64°15'37"	146°06'24"	1951-53, 1955-58, 1971-72	I I I					1971-72	I	
82	15480000	Banner Creek at Richardson	64°17'24"	146°20'56"	1951-52, 1955, 1971-72	I I I							
83	15481000	Tanana River near Harding Lake	64°24'04"	146°56'56"									R(1971)
84		North Fork Minton Creek near Salchaket	64°23'43"	146°16'29"	1971	I					1971	I	
85		South Fork Minton Creek near Salchaket	64°23'41"	146°16'01"	1971	I					1971	I	
86		Salcha River 8 miles above gage near Salchaket	64°29'10"	146°39'00"	1971	I					1970-71	I	

TABLE 2.4.2-5 (Cont'd.)

Map number	Station number	Station name	Location		Data available								Remarks
					Chemical		Temperature A/		Sediment		Biological		
			Latitude	Longitude	Period of record	Frequency	Period of record	Frequency	Period of record	Frequency	Period of record	Frequency	
87	15484000	Salcha River near Salchaket	64°28'22"	146°55'26"	1948-58, 1967-68, 1970-72	I I I			1953, 1967-68, 1970-	I I I			
88		Little Salcha River near Salchaket	64°30'57"	146°58'15"	1951-53, 1955-56	I I							
89	15490000	Monument Creek at Chena Hot Springs	65°03'17"	146°03'05"	1971	I							
90	15493000	Chena River near Two Rivers	64°53'55"	146°24'42"	1968, 1971-72	I I			1968, 1971	I I			
91		Chena River Site 12 near North Pole	64°49'45"	147°01'35"	1973	I					1973	I	
92		Chena River Site 11 near North Pole	64°50'05"	147°02'55"	1973	I					1973	I	
93		Chena River Site 10 near North Pole	64°49'58"	147°03'50"	1973	I					1973	I	
94		Chena River below Mullen Slough near Eielson Air Force Base	64°49'35"	147°04'50"	1973	I					1973	I	
95		Chena River Site 9 near North Pole	64°49'25"	147°06'55"	1973	I					1973	I	
96		Chena River Site 8 near North Pole	64°48'55"	147°07'10"	1973	I					1973	I	
97		Chena River Site 7 near North Pole	64°48'35"	147°07'55"	1972-73	I					1973	I	
98		Chena River Site 6 near North Pole	64°47'35"	147°09'45"	1973	I					1973	I	
99.		Chena River Site 5 near North Pole	64°47'10"	147°10'15"	1973	I					1973	I	
100		Chena River Site 4 near North Pole	64°47'40"	147°11'30"	1973	I					1973	I	
101	15493500	Chena River near North Pole	64°47'47"	147°11'56"	1972-	I	1972-	C	1972-	I	1973	I	M
102		Chena River Site 3 near North Pole	64°47'55"	147°12'00"	1973	I					1973	I	
103		Chena River Site 2 near North Pole	64°48'16"	147°12'35"	1973	I					1973	I	
104		Chena River Site 1 near North Pole	64°48'00"	147°13'40"	1973	I					1973	I	
105	15494000	Chena River near Fairbanks	64°50'32"	147°20'29"	1970-71	I					1970-71	I	
106	15511000	Little Chena River near Fairbanks	64°53'10"	147°14'50"	1961-62, 1967-68, 1971-	I I I	1972-	C	1962, 1967-68, 1972-	I I I	1973	I	M

TABLE 2.4.2-5 (Cont'd.)

Map number	Station number	Station name	Location: Latitude	Location: Longitude	Data available: Chemical: Period of record	Chemical: Frequency	Temperature A/: Period of record	Temperature: Frequency	Sediment: Period of record	Sediment: Frequency	Biological: Period of record	Biological: Frequency	Remarks
107		Chena River above Chena Slough near Fairbanks	64°50'47"	147°27'02"	1971-72	I					1971	I	
108	15511500	Steele Creek near Fairbanks	64°53'36"	147°29'12"	1971	I							
109	15512000	Chena Slough near Fairbanks	64°49'15"	147°26'15"	1949-51, 1961	I I							
110		Chena River at Fort Wainwright	64°50'00"	147°34'30"	1959-60	I							
111	15514000	Chena River at Fairbanks	64°50'45"	147°42'04"	1948-52, 1953, 1954-58, 1963-64, 1967-71	I D I D I	1953, 1962-66, 1969-71	D D C	1954-56, 1962-71, 1972-	I D I			M
112		Noyes Slough at Fairbanks	64°51'18"	147°42'51"	1950, 1952, 1961	I I I							
135	15518900	Tolovana River near Livengood	65°28'16"	148°15'59"	1956, 1970, 1972	I I I					1970	I	
136	15519000	Bridge Creek near Livengood	65°27'52"	148°15'13"	1970-71	I			1970-71	I			
137		Tolovana River 13 miles below Elliott Highway near Livengood	65°27'53"	148°37'49"	1972	I							
138	15519200	Brooks Creek Tributary near Livengood	65°23'02"	148°56'12"	1971-72	I							
139	15520000	Idaho Creek near Miller House	65°21'13"	146°09'33"	1972	I							
140	15530000	Faith Creek near Chena Hot Springs	65°17'32"	146°22'48"	1949, 1956, 1972	I I I							
141	15534900	Poker Creek near Chatanika	65°09'32"	147°28'49"	1971-72	I			1971-73	I			
142	15535000	Caribou Creek near Chatanika	65°09'00"	147°33'D5"	1969-72	I	1972-	C	1970-73	I	1970-71	I	
143	15538000	Chatanika River near Chatanika	65°08'00"	147°30'00"	1949, 1956	I I							
144		Chatanika River near Fairbanks	65°05'05"	147°43'25"	1949, 1956-57	I I							
145		Chatanika River near Olnes	65°03'43"	147°48'27"	1971-72	I					1971	I	M
146		Tatalina River near Livengood	65°19'45"	148°18'30"	1949, 1956	I I							
147	15541800	Washington Creek near Fox	65°09'04"	147°51'22"	1956, 1972	I I							M

TABLE 2.4.2-5 (Cont'd.)

Map number	Station number	Station name	Location		Data available								Remarks
					Chemical		Temperature Δ		Sediment		Biological		
			Latitude	Longitude	Period of record	Frequency	Period of record	Frequency	Period of record	Frequency	Period of record	Frequency	
163		Kuyuktuvuk Creek 14 miles above Dietrich River near Wiseman	68°04'00"	149°59'37"	1971	I					1971	I	
164		Kuyuktuvuk Creek 10 miles above Dietrich River near Wiseman	68°03'08"	149°50'44"	1971	I					1971	I	
165		Kuyuktuvuk Creek 5 miles above Dietrich River near Wiseman	68°00'00"	149°54'37"	1971	I					1971-72	I	
166		Kuyuktuvuk Creek 1 mile above Dietrich River near Wiseman	67°55'38"	149°51'11"	1971-72	I					1971	I	
167		Dietrich River below Kuyuktuvuk Creek near Wiseman	67°54'10"	149°49'14"	1971-72	I					1971	I	
168		Unnamed Pond near mouth of Dietrich River near Wiseman	67°39'09"	149°43'18"	1970, 1972	I I					1970-71	I	
169		Unnamed Lake near mouth of Dietrich River near Wiseman	67°38'52"	149°43'11"	1970, 1972	I I					1970-71	I	
170	15564875	Middle Fork Koyukuk River near Wiseman	67°25'54"	150°04'55"	1970-72	I	1971-72	C	1970-73	I	1970	I	
171		Minnie Creek near Wiseman	67°25'00"	150°02'22"	1971	I					1971	I	
172		Minnie Creek at Wiseman	67°25'20"	150°05'28"	1971	I					1971	I	
173	15564877	Wiseman Creek at Wiseman	67°24'38"	150°06'21"	1970-72	I	1973-	C	1971	I	1970-71	I	
174		Middle Fork Koyukuk River above Slate Creek near Wiseman	67°15'46"	150°12'16"	1972	I							
175		Slate Creek near Wiseman	67°15'29"	150°11'05"	1971-72	I					1971-72	I	
176		Unnamed Lake at Anaktuvuk Pass	68°08'28"	151°44'26"	1971	I							
177		Unnamed Spring at Anaktuvuk Pass	68°08'11"	151°44'12"	1972	I							M
178		Prospect Creek at mouth near Prospect Camp	66°47'37"	150°42'36"	1970-72	I					1970-71	I	
179	15564885	Jim River near Bettles	66°47'10"	150°52'23"	1970-72	I	1971-	C	1970-72	I			
180		Koyukuk River at Allakaket	66°34'00"	152°38'30"	1972	I							M
181		Kanuti River near Bettles	66°26'03"	150°38'07"	1971-72	I							

TABLE 2.4.2-5 (Cont'd.)

A/ Only continuous or once-daily temperature records shown (at most sites where intermittent chemical or sediment data have been collected, temperature measurements were made at time of collection), D - Daily, C - Continuous recorder, I - Intermittent, R - Radiochemical, M - Minor elements

Still, P.J. 1975. INDEX OF SURFACE WATER QUALITY RECORDS TO SEPTEMBER 30, 1973, YUKON BASIN, ALASKA. U.S. Geological Survey. Open-file report.

U.S. Geological Survey. Water Resources Division. 1972. WATER RESOURCES INVESTIGATIONS ALONG PORPOSED TRANS-ALASKA PIPELINE ROUTE. Anchorage.

200 mg/l. The dissolved solids content is highest in water from areas adjacent to the mountains and decreases toward the center of the basin. Water sampled near the center of the basin has the highest concentration of dissolved solids during periods of low flow, when groundwater recharge is probably greatest. The streams flowing from the Alaska Range are generally higher in sulfate and magnesium content than are the other streams, but none contain excessive amounts of these constituents. Iron is the only constituent that is present in excessive amounts in any of the surface water sampled. Two analyses from swampy areas near the Canadian boundary have iron contents of 0.60 and 0.73 mg/l. The iron may be complexed with organic material. Lakes may be either higher or lower in iron content and color than streams, but the hardness of lake water sampled is generally less than that of the streams. The normal summer surface water temperatures in the Yukon region range between 7°C and 10°C, and of winter temperatures from 0°C to 2°C. The maximum recorded summer water temperature is 19°C on the Chena River near Fairbanks in June. The rivers in this subregion cool uniformly to about 0°C by October and usually remain at this temperature until about late April. Temperature data taken during periodic summer streamflow measurements of the Yukon River range from 6°C to 18°C.

Suspended sediment data for Alaska streams are scanty and consist only of scattered analyses. This information is available for 20 sites in the vicinity of the proposed gas line, but the period of record is generally less than five years. In general, nonglacial streams transport less than 100 mg/l of suspended sediment during the summer in contrast to as much as 2,000 mg/l for glacial streams. The summer period refers to May through October. Nonglacial streams often transport their highest concentration during the spring melt from May through June, and other highs occur in August through September. Glacial streams transport their highest concentration during heavy glacial melt, usually in middle or late summer but also carry high concentrations during the spring snowmelt period. During fall and winter, glacial and nonglacial streams both carry less sediment than in summer. The normal suspended sediment concentration between January and April is about 20 mg/l or less for all streams. Less than 15 percent of the annual sediment load is carried during this period. The percentage of material finer than 0.062 mm (the silt-clay fraction as generally defined) transported by nonglacial streams is less than 50 percent in contrast to more than 50 percent for glacial streams. However, the percentage of fine material increases appreciably if a glacial stream flows through a lake. Many large rivers result from a combination of glacial and nonglacial tributaries and accordingly transport suspended sediment that in its particle-size distribution and concentration reflects its dual origin.

The only data available regarding the Arctic Slope subregions indicate that the instantaneous suspended sediment concentration has been measured as high as 1,650 mg/l on the Colville River and is in excess of 3,000 mg/l on Chamberlain Creek (Table 2.4.2-6).

In the Yukon region, the Yukon River is the most heavily sediment-laden stream in terms of concentration except for those streams in the Tanana Basin. During the summer the Yukon transports a normal concentration ranging from 200 to 400 mg/l suspended sediment, 70 to 80 percent of which is finer than 0.062 mm. In contrast, samples taken during the winter indicate that most streams in the region transport less than 15 mg/l suspended sediment between January and April. Of streams in the Yukon region, the Tanana River transports the highest concentration of sediment. It receives both its principal flow and its largest quantity of sediment from streams draining the glacier fields on the north slope of the Alaska Range and the Wrangell Mountains. Samples collected from these streams indicate that their normal summer concentration generally ranges from 500 to 2,000 mg/l. In contrast, the nonglacial streams draining into the Tanana River transport only about 10 to 300 mg/l. Normal summer concentrations of the Nenana River range from 10 mg/l in the headwaters to more than 1,000 mg/l downstream, 50 to 70 percent of which is finer than 0.062 mm. Concentrations during all winter are generally less than 20 mg/l for all streams measured in this basin from January to April. The average annual sediment yield of the basin ranges from less than 100 tons per square mile in the mountains north of the Tanana River to perhaps 5,000 tons per square mile in the Alaska Range.

Floods

Extensive severe flooding, especially in the larger stream channels, occurs in the Arctic and Yukon regions during spring breakup between May and early July. Ice jams increase the height of the floodwater, especially in downstream reaches. When spring flow begins, it overflows the massive ice that is still frozen to the channel bed. Flooding extends for considerable distances, often up to several miles on each side of the stream. The extent of known or inferred river flooding is shown on the map.

TABLE 2.4.2-6

ESTIMATED SUSPENDED SEDIMENT LOADS AND YIELDS
AT SELECTED POINTS ON ALASKAN RIVERS

Station Name	Drainage Area (sq. mi.)	Glaciers % of Area	Yrs. of Record	Millions of Tons Per Yr.	Tons Per Sq. Mile
Chamberlain Creek	1.46	64%	1	.0015	1,000
Chena River near Fairbanks	1,980	0%	8	.406	200
Colville River	19,300	?	1	6.4	300
Copper River near Chitina	20,600	13%	3	72.2	3,500
Koyukuk River at Hughes	18,700	0%	5	1.0	50
Nenana River near Healy	1,910	4%	15	3.29	1,700
Susitna River near Gold Creek	6,160	5%	1	10.6	1,700
Tanana River near Tanacross	8,550	1%	11	9.39	1,100
Yukon River at Eagle	113,500	3%	5	30.7	270
Yukon River at Ruby	259,000	1%	3	70	300

Source: Feulner, A. J. 1973. SUMMARY OF WATER SUPPLIES AT ALASKA COMMUNITIES. YUKON REGION, TANANA SUBREGION. Resource Planning Team, Joint Federal-State Land Use Planning Commission, p. 27.

Flooding subsides as the ice is released from the streambed and carried downstream and out to sea. Often, large blocks of ice are left stranded on beaches and bars where they quickly melt and disappear.

Tundra flooding is common during the snowmelt season in the Arctic. Because of the extremely flat terrain, drainage is slow and sluggish. Melting snow often pools temporarily behind unmelted snow berms, hard-packed winter snow roads, and other minor obstructions. Local flooding, especially bothersome in populated areas, occurs until snowmelt is complete and the waters can drain away. Intense, long periods of rainfall can cause general flooding and swollen streams. This is not a normal yearly occurrence because of low precipitation in the Arctic; however, floods from August rains have been extensive, perhaps once every 15 to 20 years. In winter, flooding is locally caused by the growth of large icings that cover some river floodplains to heights that often exceed open channel flood states. During late fall, storm surges often cause significant flooding and damage along coastal areas. At that time, ice may be far enough offshore to allow northwest winds a long fetch of open sea. The winds can develop high waves and a storm surge tide that inundates coastal areas. A storm of this type occurred in October 1963; the worst in Eskimo memory and considered a once in two hundred years occurrence. Extensive flooding and damage were sustained at the village of Barrow and the Naval Arctic Research Laboratory. Beach erosion, most extensive during storms, but known to be a continual process, often is responsible for local flooding of coastal communities and installations. Studies have shown this process can be accelerated by removal of beach gravel for local constructon.

Floods resulting from rainfall can be disastrous in the Yukon region. Floods of August 1967 in east-central Alaska caused almost 100 million dollars in damages even though the area is very sparsely inhabited (Childers and Meckel 1967 and Childers et al. 1972). Low flow occurs in late winter as a result of cold winter temperatures when precipitation is stored as snow. Streams draining basins without glaciers or perennial snow can also have low discharge during dry summers. Permafrost affects streamflow characteristics by reducing basin infiltration, which increases peak runoff rates but reduces base flow rates. Peak discharges can result from snowmelt, usually in the spring or from rainfall usually in late summer. The spring peaks often occur when channels are partially blocked with ice. This can cause spectacular icejam floods, especially along the Yukon River and the Koyukuk and its tributaries. The U. S. Army, Corps of Engineers, has experimented with methods to alleviate icejam flooding (Cook and Wade 1968, Moor and Watson 1971). Maximum discharge for selected sites is shown in Table 2.4.2-7. Flood surveys are being conducted along the existing pipeline corridor by the U. S. Geological Survey (Childers 1973, Childers and Lamke 1973).

Glacial-outburst flooding is a potential problem in the Tanana subregion. Known and inferred glacier flooding is shown on the map (Post and Mayo 1971). Glaciers are sensitive and responsive to even minor changes in climate. If Alaska's regional climate became slightly cooler and wetter than at present, glaciers of the Delta River valley could reverse their apparent present trend of retreat. In addition to climatically induced advances, certain glaciers may surge (advance suddently at very high speeds) for reasons not related to climatic variations. Black Rapids Glacier has surged in the past.

Glaciers are an integral part of the hydrologic regime. Streams that originate at glaciers or within heavily glaciated terrain display peculiar characteristics of runoff (peak flow in mid-summer, diurnal fluctuation in runoff, runoff much greater or much less than derived from local, short-term precipitation, high silt content, and outburst floods) that are not shown by nonglacial streams (Meier 1969).

The proposed pipeline route crosses at the mouth of the Delta River drainage basin, of which about 225 square miles or 15 percent is presently glaciated (Dingman et al. 1971). The terminus of Black Rapids Glacier lies at 2,200 feet altitude and the termini of Castner and Canwell Glaciers at approximately 2,500 and 2,700 feet, respectively. Thses three large glaciers now have extensive, moraine-covered and stagnant terminal areas. The Fels Glacier terminus lies at approximately 3,000 feet altitude. Several smaller glaciers within the Delta River basin terminate at altitudes between 4,000 and 5,500 feet.

Several small glacier-dammed lakes have been identified in the Alaska Range (Post and Mayo 1971). Glacier-dammed lakes are water bodies at least partially contained by glacier ice. The lakes usually form when a depression either on or adjacent to a glacier, a pocket beneath it, or a valley blocked by a glacier is filled by rain and runoff from melting snow and ice. At some critical point during the lake's filling, the ice dam becomes unstable, or is overtopped by the rising water. The water then erodes a channel through or beneath the ice and the lake drains

TABLE 2.4.2-7

MAXIMUM FLOODS ALONG THE PROPOSED CORRIDOR

Station no.	Stream	Location: Latitude	Location: Longitude	Drainage area (sq mi)	Period of record (years/dates)	Maximum known flood: Date	Gage height (ft)	Discharge (cfs)	Discharge (cfs per sq mi)
				ARCTIC SLOPE					
15896000	Kuparuk R nr Deadhorse	70°16'54"	148°57'35"	3,130	1(1971)	June 5, 1971	36.40	77,000	24.6
15896700	Putuligayuk R nr Deadhorse	70°16'08"	148°37'11"	176	2(1970-71)	June 6, 1971	24.50	4,980	28.3
15910000	Sagavanirktok R nr Sagwon	69°05'20"	147°45'10"	2,208	2(1970-71)	June 8, 1970	15.27	19,300	8.74
15910200	Happy C nr Happy Valley	69°08'50"	148°49'50"	34.5	1(1972)	1972	15.54	527	15.3
				YUKON					
15457800	Hess C nr Livengood	65°39'55"	149°05'47"	662	2(1970-71)	July 1, 1970	65.76	5,910	8.93
15468000	Yukon R at Rampart	65°30'25"	150°10'15"	199,400	13(1955-67)	June 15, 1964	49.98	950,000	4.75
15469900	Silver C nr Northway Jct	62°59'01"	141°40'07"	11.7	10(1963-72)	July 11, 1964	16.25	355	30.3
15470000	Chisana R at Northway Jct	63°00'23"	141°48'17"	3,280	24(1949-72)	June 28, 1964	13.18	12,000	3.66
15471000	Bitters C nr Northway Jct	63°09'38"	142°05'20"	15.4	8(1964-72)	June 1964	17.54	1,010	65.6
15471500	Tanana R Tr nr Tetlin Jct	63°16'45"	142°30'27"	2.43	8(1965-72)	May 1972	12.45	28	11.5
15472000	Tanana R nr Tok Jct	63°19'00"	142°38'30"	6,800	4(1950-53)	Aug. 7, 1953	9.00	35,700	5.25
15473000	Bartell C nr Mentasta	62°55'45"	143°34'30"	12.0	2(1964-69)	June 1966	-	88	7.33
15473600	Log Cabin C nr Log Cabin Inn	63°01'48"	143°20'36"	10.7	7(1965-72)	July 27, 1972	11.41	330	30.8
15473950	Clearwater C nr Tok	63°10'19"	143°12'03"	36.4	10(1963-72)	June 27, 1968	18.39	1,040	28.6
15474000	Tok R nr Tok Jct	63°19'30"	142°50'05"	930	3(1951-54)	June 16, 1952	6.83	3,830	4.12
15476000	Tanana R nr Tanacross	63°23'18"	143°44'47"	8,550	20(1953-71)	June 19, 1962	11.65	39,100	4.57
15476050	Tanana R Tr nr Tanacross	63°24'44"	143°48'38"	3.32	8(1963-72)	July 27, 1972	16.17	172	51.8
15476200	Tanana R Tr nr Dot Lake	63°41'40"	144°17'40"	11.0	9(1964-72)	July 1964	12.70	146	13.3
15476300	Berry C nr Dot Lake	63°41'25"	144°21'50"	65.1	10(1963-72)	July 19, 1964	15.25	2,800	43.0
15476400	Dry C nr Dot Lake	63°41'32"	144°34'16"	57.6	10(1963-72)	July 10, 1964	16.20	2,200	38.2
15478000	Tanana R at Big Delta	64°09'25"	145°51'00"	13,500	8(1948-57)	July 29, 1949	23.57	62,800	4.65
15478010	Rock C nr Paxson	63°04'16"	146°06'17"	50.3	10(1963-72)	June 1971	12.16	1,440	28.6
15478040	Phelan C nr Paxson	63°14'27"	145°28'03"	12.2	6(1966-72)	Aug. 13, 1967	11.51	2,320	190
15478050	McCallum C nr Paxson	63°13'27"	145°38'56"	15.5	6(1966-72)	Aug. 13, 1967	12.12	1,010	65.2
15478500	Ruby C nr Donnelly	63°37'52"	145°53'03"	5.32	10(1963-72)	June 1969	12.62	190	35.7
15480000	Banner C at Richardson	64°17'24"	146°20'56"	20.2	9(1963-72)	Aug. 14, 1966	13.55	732	36.2
15484000	Salcha R nr Salchaket	64°28'22"	146°55'26"	2,170	22(1909-10, 1948-72)	Aug. 14, 1967	21.78	97,000	44.7
-	L Salcha R nr Salchaket	64°30'50"	146°58'10"	67.4	Miscellaneous	Aug. 13, 1967	-	1,900	28.2
15485000	Moose C at Eielson AFB	64°42'50"	147°06'45"	136	2(1964-65)	June 14, 1965	7.88	370	2.72
15485200	Garrison Slough at Eielson AFB	64°42'15"	147°70'05"	6.24	2(1964-65)	Apr. 18, 1965	4.45	51	8.17
15490000	Monument C at Chena Hot Springs	65°03'17"	146°03'05"	26.7	3(1970-72)	June 7, 1972	28.06	1,700	63.7
15493000	Chena R nr Two Rivers	64°53'55"	146°24'42"	941	4(1967-72)	Aug. 5, 1969	19.99	10,800	11.5
-	Potlatch C nr Two Rivers	64°52'14"	147°03'00"	3.49	Miscellaneous	Aug. 12, 1967	-	40	11.5
-	Chena R ab L Chena R nr Eielson AFB	64°50'45"	146°57'55"	1,370	Miscellaneous	Aug. 13,14,1967	-	105,000	76.6
15511000	L Chena R nr Fairbanks	64°53'10"	147°14'50"	372	6(1966-72)	Aug. 13, 1967	31.95	17,000	45.7
15511500	Steele C nr Fairbanks	64°53'36"	147°29'12"	10.7	4(1967, 1970-72)	Aug. 12, 1967	11.23	340	31.8
15514000	Chena R at Fairbanks	64°50'45"	147°42'04"	1,980	26(1947-72)	Aug. 15, 1967	18.82	74,400	37.6
-	Isabella C nr Fairbanks	64°53'10"	147°40'30"	4.56	Miscellaneous	Aug. 12, 1967	-	160	35.1

TABLE 2.4.2-7 (Cont'd.)

Station no.	Stream	Location: Latitude	Location: Longitude	Drainage area (sq mi)	Period of record (years/dates)	Maximum known flood: Date	Gage height (ft)	Discharge (cfs)	Discharge (cfs per sq mi)
-	Tolovana R nr Livengood	65°28'20"	148°15'50"	140	Miscellaneous	Aug.12,13,1967	-	12,000	85.7
15519000	Bridge C nr Livengood	65°27'52"	148°15'13"	12.6	10(1963-72)	Aug. 1964	17.60	1,070	85.0
-	W F Tolovana R nr Livengood	65°28'05"	148°38'35"	291	Miscellaneous	Aug. 13, 1967	-	2,290	7.86
15519200	Brooks C Tr nr Livengood	65°23'02"	148°56'12"	7.81	9(1964-72)	Aug. 1964	12.58	137	17.5
15520000	Idaho C nr Miller House	65°21'13"	146°09'33"	5.31	10(1963-72)	July 1964	16.00	813	15.3
15530000	Faith C nr Chena Hot Springs	65°17'32"	146°22'48"	61.1	10(1911-12, 1963-72)	Aug. 14, 1967	15.15	4,950	81.0
-	Chatanika R nr Chatanika	65°14'00"	146°52'00"	244	Miscellaneous	Aug. 13, 1967	-	19,600	80.3
15535000	Caribou C nr Chatanika	65°04'00"	147°33'05"	9.19	2(1969-71)	June 30, 1970	3.36	89	9.68
-	Chatanika R nr Olnes	65°05'20"	147°43'00"	528	Miscellaneous	Aug.13,14,1967	-	25,000	47.3
-	Rose C nr Fox	64°58'23"	147°30'50"	2.00	Miscellaneous	Aug. 13, 1967	-	104	52.0
-	L Goldstream C nr Nenana	64°40'00"	148°56'40"	40.8	Miscellaneous	Aug.12-14,1967	-	1,490	36.5
-	Tatalina R nr Livengood	65°19'45"	148°18'25"	80.8	Miscellaneous	Aug.12-14,1967	-	3,560	44.1
15541600	Globe C nr Livengood	65°17'07"	148°08'00"	23.0	9(1964-72)	Aug. 12, 1967	17.05	1,240	53.9
15541650	Globe C Tr nr Livengood	65°16'31"	148°06'58"	9.01	10(1963-72)	Aug. 12, 1967	15.35	490	54.4
15541800	Washington C nr Fox	65°09'03"	147°51'22"	46.7	10(1963-72)	Aug. 12, 1967	18.29	2,500	53.5
15564875	M F Koyukuk R nr Wiseman	67°26'35"	150°03'40"	1,426	1(1970-71)	June 24, 1971	10.34	6,860	4.81
15564877	Wiseman C at Wiseman	67°24'40"	150°06'00"	49.2	1(1970-71)	June 6, 1971	4.82	590	12.0
15564885	Jim R nr Bettles	66°47'05"	150°52'10"	465	1(1970-71)	May 30, 1971	16.84	8,520	18.3

Jones, S.H. 1973. SMALL-STREAM FLOOD INVESTIGATIONS IN ALASKA. U.S. Geological Survey. Basic-data report. pp. 54-55.

rapidly. The resulting floods have sharp, sudden peaks that may cause extensive damage to man-made structures. Glacier-dammed lakes may form initially, breakout, and never refill, or the filling-draining cycle may be repeated many times.

Another naturally occurring phenomenon related to flooding is channel erosion. Streams along the proposed pipeline route cause channel erosion by bank cutting, streambed scouring and rechannelizing. The depth of vertical scour and the extent of lateral scour of streams to be crossed by the pipeline under both natural conditions and conditions as changed by construction are critical to the design of the pipeline. They are also important in the protection of the pipeline after construction. Studies have been conducted by U. S. Geological Survey along the existing pipeline (Brice 1971; Childers 1975; Childers and Jones 1975; Norman 1975).

Ground Water

Groundwater conditions in Alaska along the proposed pipeline route are highly variable. Unfrozen recent alluvial deposits in river valleys, including the floodplains, terraces and alluvial fans, are the principal aquifers (Williams 1970a). Alluvium, consisting largely of permeable sand and gravel, ranges in thickness from a few feet in small mountain valleys to about 2,000 feet in the Tanana Valley (Anderson 1970). Glacial and glaciolacustrine deposits in the interior valleys are a much smaller source of groundwater near the proposed pipeline, but the older consolidated bedrock is capable of small yields from fractures and is used locally for water supply in the Yukon-Tanana Uplands (Cederstrom 1963). Groundwater also occurs in cavernous carbonate rocks that support large springs near the proposed pipeline route. Some of these are shown on the map, and more information is available (Waring 1917 and 1965; Stearns and Waring 1937; Biggar 1971; Millar 1973 a, b).

The extent and thickness of permafrost along the pipeline route limits the availability of groundwater. Because it is virtually impermeable, permafrost restricts recharge, discharge, and movement of groundwater, confines water under artesian pressure, and limits storage capacity. The volume of frozen ground decreases southward along the pipeline consistent with the regional zonation of permafrost and there is a corresponding increase in the quantity of groundwater available. Within the zone of continuous permafrost, unfrozen alluvium is found only under the major streams and beneath lakes deeper than about seven feet (Williams 1970a).

Recharge of the principal alluvial groundwater reservoirs along the proposed pipeline route occurs largely through the unfrozen zones underlying streams. According to Anderson (1970), the most important source of groundwater in the Tanana Basin is seepage from streams. He found that seepage losses from streamflow in Jarvis Creek near Big Delta average ten cfs or 6.5 mgd (million gallons per day) per linear mile of channel. Dingman et al. (1971) found that the groundwater outflow from the basin of the Delta River averaged 1,105 cfs or 717 mgd over the entire year, and that most of the recharge occurred by seepage from the Delta River and Jarvis Creek between the front of the Alaska Range and the mouth of the streams. Recharge to other alluvial, glacial, and bedrock aquifers is from precipitation.

The direction of movement of water in the alluvial floodplain deposits of the river valleys is generally parallel to the direction of streamflow, whereas direction of movement in the adjacent terrace, alluvial fan deposits and upland deposits is, in general, parallel to the surface slope as indicated by topographic expression of these land forms. The direction of movement in confined zones within the alluvium or bedrock aquifers and within fracture or joint systems within bedrock is independent of surface features.

Discharge of groundwater from principal alluvial aquifers along the proposed pipeline route occurs largely as base flow discharge to streams. Groundwater is also discharged at springs, lakes and wetlands and directly by evapotranspiration from shallow groundwater reservoirs. Although pumpage from wells is, in general, a minor source of groundwater discharge, withdrawal of groundwater in the Tanana Valley near Fairbanks is estimated to be 2.8 mgd.

In the Arctic region, groundwater availability within the Sagavanirktok basin has been limited to unfrozen aquifers beneath the river (Sherman 1973). Yield is generally less than ten gpm (gallons per minute). As shown on the map, most well holes drilled in the Arctic encountered permafrost.

In the Yukon region, the alluvial deposits of the Tanana subregion have the highest potential for groundwater yields in Alaska, exceeding 1,000 gpm in the floodplains. Upland deposits yield less than 100 gpm. A detailed study for the entire basin was completed by Anderson in 1970. However, many wells drilled in the basin have passed through permafrost before reaching water.

Groundwater Quality

In the Arctic region groundwater quality data are scarce. Periodic water samples from an infiltration gallery at Cape Lisburne increase annually in dissolved solids content from about 94 mg/l in summer to about 225 mg/l in winter. The water is of the calcium bicarbonate type. The temperature of groundwater from the gallery ranges from $1^{o}C$ to $2^{o}C$. Wells drilled at Umiat beneath thick permafrost contained more than 500 mg/l dissolved solids and were saline, as shown in the pie diagrams on the map (Williams 1970b).

In the Yukon region wells generally yield calcium bicarbonate type water. Groundwater normally ranges from 200 to 300 mg/l dissolved solids content and, except for high iron content, is acceptable for most uses. Water from several wells exceeds suggested limits in single constituents. Wells drilled near the headwaters of smaller streams contain calcium bicarbonate type water of acceptable quality. Shallow wells drilled near the larger rivers, such as the one at Fort Yukon near the Yukon River, receive water by infiltration from the river and generally yield water of low dissolved solids content (dissolved solids 174 mg/l; calcium bicarbonate type water). Groundwater from the deeper zones beneath and adjacent to the Yukon River, however, is high in iron content and contains objectionable amounts of organic matter.

In the Yukon Region, wells along the boundaries of the area are drilled to bedrock; some yield groundwater high in magnesium bicarbonate or magnesium sulphate. Water of this type is represented by a sample from a well at the customs station near the Alaska-Canada boundary that has a dissolved solids content of 1,800 mg/l, a magnesium content of 335 mg/l, and a sulfate content of 1,120 mg/l. Groundwater from the lowlands, even in the permafrost regions, is generally of acceptable quality, although many samples are high in iron content. Such water is unstable so that it is extremely corrosive to iron pipe. This is demonstrated by a water analysis for a well at Galena having a dissolved solids content of 258 mg/l and an iron content of 6.7 mg/l. Analyses of water from three representative springs in the Tanana Basin showed: Manley Hot Springs, a dissolved solids content of 322 mg/l (sodium chloride type water); a mineral spring near Kantishna, a dissolved solids content of 2,900 mg/l (calcium magnesium bicarbonate type water); and a spring near Fox, a dissolved solids content of 224 mg/l (calcium bicarbonate type water). Wells containing high concentrations of nitrate have been reported by the Arctic Environmental Research Laboratory (McFadden in press). Wells containing extremely high concentrations of arsenic have been recently discovered in the Pedro Dome-Cleary Summit areas (Wilson 1975) and in the Ester area (Wilcox in press), both in the mining districts near Fairbanks. Investigations are underway by the University of Alaska's Institute of Water Resources, the Alaska Department of Environmental Conservation, and the U.S. Geological Survey. Bacteriological contamination has also occurred in wells drilled in shallow aquifers near Fairbanks. Temperatures of groundwater from wells in this area range from 0°C to 4°C, and from springs, from 2°C to 65°C.

Aufeis

Aufeis, or icings, are masses of ice formed by the overflow and subsequent freezing of sheets of emerging groundwater and springs. Icings have caused problems including flooding and erosion along Alaska highways. Improper construction of drainage ditches and culverts can induce or augment the formation of aufeis.

As described by Carey (1970), no one factor alone, but the complex interaction of several factors, controls the incidence of icing. At any site, topographic, geologic, hydrologic, and meterorologic factors determine the dynamics, regime, and magnitude of the icing process. Icings occur on streams when channel ice thickens until the channel is completely frozen or flow is restricted beneath the ice. Hydrostatic pressure increases so that water breaks through the ice cover or flows out at the edge of the ice sheet. The water then spreads out and freezes. Icings thicken throughout the winter season as successive ice sheets accumulate on the surface. Thick floodplain icings commonly form on braided rivers because the channels are shallow. Icings are less common on large rivers where the flow is confined to a narrow or single channel because of the greater channel depth. Icings also form along small, shallow channels in those areas where winter streamflow is sustained by groundwater. Large springs are the source of major icings in some river valleys. Small springs and seeps of groundwater form small upland or hillside icings.

Icings occur throughout the proposed corridor and are being observed by the U.S. Geological Survey (Sloan et al. 1975). The Institute of Water Resources has conducted several studies on the formation and growth of aufeis (Kane 1975).

Water Use

The river basins and their glaciers, streams, lakes, and wetlands, constitute, in general, a large undeveloped wilderness area where present use of water is unregulated and is largely for hunting, fishing, trapping, or for recreation or navigation use. There is a very limited use of water at scattered small communities in the proposed corridor for water supply, waste disposal, cooling, agriculture, and placer mining.

The largest development and use of groundwater along the proposed pipeline route occurs at Fairbanks, Eielson Air Force Base, Big Delta, and Fort Greeley in the Tanana Basin. Other development and use of groundwater is limited to the scattered communities, homesteads, roadhouses, and the existing construction camps for the pipeline haul road. Community water supplies, liquid and solid waste disposal, and power supplies are shown in Table 2.4.2-8. Solid waste disposal has been a major problem since permafrost limits the construction of sanitary landfill sites, and low temperatures inhibit bacterial decomposition of organic wastes.

Hydroelectric Power Facilities

Within the proposed corridor there are no existing hydroelectric power facilities, but there are four potential sites that the U.S. Alaska Power Administration (1974) has identified on the Tanana River, and several others in the vicinity of the corridor. Potential sites in the Yukon region are summarized in Table 2.4.2-9.

TABLE 2.4.2-8

INVENTORY OF WATER SUPPLY, WASTEWATER TREATMENT, AND POWER SOURCES

Community	Water Supply	Wastewater Treatment	Power Source
Pump Station 1	Surface water hauled from Kuparuk River to 30,000 gal. storage tank; coagulation, filtration, chlorination; distribution system*	Physical/chemical treatment plant and FCMR**	Diesel generators (four 250 kw)
Slope Camp	Surface water hauled from Sagavanirktok River to 10,000 gal. storage tank; filtration, chlorination; distribution system	Extended aeration activated sludge treatment plant and FCMR	Diesel generators
Franklin Bluffs	Infiltration gallery under Sagavanirktok River pumped to 80,000 gal. storage tank; filtration, chlorination; distribution system	Physical/chemical treatment plant and FCMR	Diesel generators (ten 300 kw)
Pump Station 2	Site in preparation		
Sagwon	Currently inactive; surface water source		
Lupine	Currently inactive; surface water sources		
Happy Valley	Infiltration gallery under Sagavanirktok River pumped to 60,000 gal. storage tank; filtration, chlorination; distribution system	Physical/chemical treatment plant and FCMR	Diesel generators (four 300 kw; four 250 kw)

TABLE 2.4.2-8 (Cont'd)

Community	Water Supply	Wastewater Treatment	Power Source
Pump Station 3	Well pumped to 30,000 gal. storage tank; coagulation, filtration, chlorination; distribution system	Physical/chemical treatment plant and FCMR	Diesel generators (three 250 kw)
Toolik	Surface water from Toolik Lake pumped to 45,000 gal. storage tank; filtration, chlorination; distribution system	Physical/chemical treatment plant and FCMR	Diesel generators (two 500 kw; one 300 kw)
Galbraith Lake	Well next to creek pumped to 80,000 gal. storage tank; filtration, chlorination; distribution system	Physical/chemical treatment plant and fcmr	Diesel generators (one 600 kw; one 500 kw; two 300 kw; two 200 kw)
Pump Station 4	Formerly hauled from Galbraith Lake Camp, well next to Tea Lake (June 1, 1976) pumped to 30,000 gal. storage tank; filtration, chlorination; distribution system	Physical/chemical treatment plant and FCMR	Diesel gen-ators (three 250 kw)

TABLE 2.4.2-8 (Cont'd)

Community	Water Supply	Wastewater Treatment	Power Source
Atigun	Infiltration gallery under Atigun River pumped to 40,000 gal. storage tank; filtration, chlorination; distribution system	Extended aeration activated sludge treatment plant and FCMR	Diesel gen- erators (three 250 kw; one 350 kw)
Chandalar	Well pumped to 40,000 gal. storage tank; filtration, chlorination; distribution system	Extended aeration activated sludge treatment plant and FCMR	Diesel gen- erators (three 250 kw)
Dietrich	Well pumped to 80,000 gal. storage tank; filtration, chlorination; distribution system	Physical/chemical treatment plant and FCMR	Diesel gen- erators (one 335 kw; four 300 kw; two 250 kw; two 90 kw; six 50 kw)
Coldfoot	Well pumped to 80,000 gal. storage tank filtration, chlorination; distribution system	Physical/chemical treatment plant and FCMR	Diesel gen- erators (three 300 kw; one 250 kw; one 200 kw; two 90 kw)

TABLE 2.4.2-8 (Cont'd)

Community	Water Supply	Wastewater Treatment	Power Source
Pump Station 5	Well pumped to 30,000 gal. storage tank; coagulation, filtration, chlorination; distribution system	Physical/chemical treatment plant and infiltration pad	Diesel generators (three 250 kw)
Prospect Creek	Formerly hauled from Pump Station 5 and from Jim River upstream of camp, three wells--two on banks of Jim River pumped to 60,000 gal. storage tank; filtration, chlorination; distribution system	Physical/chemical treatment plant and FCMR	Diesel generators (four 335 kw; three 300 kw; two 90kw)
Old Man	Four wells pumped to 80,000 gal. storage tank; filtration, chlorination; distribution system	Physical/chemical treatment plant and two FCMR which are pumped out annually into spray irrigation system	Diesel generators (eight 300 kw)
Five Mile Camp	Well pumped into 60,000 gal. storage tank; filtration, chlorination; distribution system	Physical/chemical treatment plant and FCMR	Diesel generators (one 350 kw; three 300 kw; two 250 kw)
Bridge Camp	Currently inactive; well		

TABLE 2.4.2-8 (Cont'd)

Community	Water Supply	Wastewater Treatment	Power Source
Pump Station 6	Hauled from well at Bridge Camp to 30,000 gal. storage tank; filtration, chlorination; distribution system	Physical/chemical treatment plant and infiltration pad	Diesel generators (three 250 kw)
Livengood	Well pumped to 60,000 gal. storage tank; filtration, chlorination; distribution system	Physical/chemical treatment plant and FCMR	Diesel generators (five 500 kw)
Pump Station 7	Site in preparation		
Fort Wainwright	Well; storage facilities; distribution system	Primary treatment plant, to hook up with new Fairbanks treatment plant	Diesel gen-power plant
Pump Station 8	Well pumped to 30,000 gal. storage tank; filtration, chlorination; distribution system	Physical/chemical treatment pland and FCMR	Diesel generators (three 250 kw)
Delta Camp	Well pumped to 80,000 gal. storage tank; filtration, chlorination; distribution system activated sludge	Physical/chemical and extended aeration	Diesel generators (five 500 kw)

TABLE 2.4.2-8 (Cont'd)

Community	Water Supply	Wastewater Treatment	Power Source
Dot Lake	Well pumped to storage tank; chlorination and flouridation; community distribution system	Privies, septic tanks	Generator at lodge
Tanacross	Wells	Individual septic tanks	Generators
Tok	Individual wells	Priview, septic tanks	Alaska Power & Electric Company

No data available on other communities. Individual systems generally used.

* All pump station camps are supplied with a water treatment unit, but coagulation is only used when necessary.

** FCMR = flow control management reservoir for treated effluent. All camps have five-day holding ponds for untreated effluent in case of treatment plant or other failure.

Source: Feulner, A.J. 1973. SUMMARY OF WATER SUPPLIES AT ALASKAN COMMUNITIES, YUKON REGION, TANANA SUBREGION. Resource Planning Team, Joint Federal-State Land Use Planning Commission. p. 27.

U.S. Public Health Service. Office of Environmental Health, Anchorage. (personal communication)

Alaska Department of Environmental Conservation, Fairbanks. (personal communication)

TABLE 2.4.2-9

INVENTORY OF HYDROELECTRIC POWER SITES

No.*	Project Name	Stream	Drainage Area (sq. mi.)	Maximum Regulated Water Surface Elevation (ft.)	Active Storage (1,000 A/F)	Percent Stream Regulation
6.	Holy Cross	Yukon River	320,000	137	**	-
7.	Dulbi	Koyukuk River	25,700	225	22,200	100
8.	Hughes	Koyukuk River	18,700	320	**	-
9.	Kanuti	Koyukuk River	18,000	500	13,800	100
10.	Melozitna	Melozitna River	2,659	550	1,800	91
11.	Ruby	Yukon River	256,000	210	**	-
12.	Junction Island	Tanana River	42,500	400	29,000	100
13.	Bruskasna	Nenana River	650	2,330	840	-
14.	Carlo	Nenana River	1,190	1,900	53	83
15.	Healy (Slagle)	Nanana River	1,900	1,700	310	-
16.	Big Delta	Tanana River	15,300	1,100	6,450	98
17.	Gerstle	Tanana River	10,700	1,290	**	-
18.	Johnson	Tanana River	10,450	1,470	5,300	97
19.	Cathedral Bluffs	Tanana River	8,550	1,650	4,900	100
20.	Rampart	Yukon River	200,000	665	142,000	100
21.	Porcupine (Campbell River)	Porcupine River	23,400	975	9,000	100
22.	Woodchopper	Yukon River	122,000	1,020	39,000	100***
23.	Fortymile	Fortymile River	6,060	1,550	1,610	84
24.	Yukon-Taiya	Yukon River	25,700	2,200	21,000	100

* Numbers used in the statewide inventory.
** Reservoir held essentially full for operation with upstream plants.
*** Operated in conjunction with downstream storage.
Source: U.S. Alaska Power Administration. 1974. 1974 ALASKA POWER SURVEY. v. 3, p.112.

2.4.3 Air, Noise and Water Quality Monitoring

Air Quality

Air quality is evaluated by measuring the ambient levels of various pollutants and comparing them to the applicable ambient air quality standards. There are two levels of ambient air standards. The primary standards have been set at a level required for the protection of public health. Secondary standards are set at levels to protect the public welfare. The current National Air Quality Standards (NAAQS) are summarized below.

Pollutant	Primary	Secondary
Particulate Matter		
Annual geometric matter	75 $\mu g/m^3$	60 $\mu g/m^3$
Maximum 24 hour concentration*	260 $\mu g/m^3$	150 $\mu g/m^3$
Sulfur Oxides		
Annual arithmetic mean	80 $\mu g/m^3$ (0.03 ppm)	
Maximum 24 hour concentration*	365 $\mu g/m^3$ (0.14 ppm)	
Maximum 3 hour concentration* (SO_2)		1300 $\mu g/m^3$ (0.5 ppm)
Carbon Monoxide		
Maximum 8 hour concentration*	10 mg/m^3 (9ppm)	same as primary
Maximum 1 hour concentration*	40 mg/m^3 (35 ppm)	same as primary
Photochemical Oxidants		
Maximum 1 hour concentration*	160 $\mu g/m^3$ (0.08 ppm)	same as primary
Hydrocarbons		
Maximum 3 hour (6-9A.M.) concentration*	160 $\mu g/m^3$ (0.24 ppm)	same as primary
Nitrogen Oxides		

Annual arithmetic mean	100 μg/m^3 (0.05 ppm)	same as primary

*Not to be exceeded more than once per year.

In the uninhabited or sparsely populated regions of Alaska it is generally conceded that the quality of the air in those regions is high because of the absence of inhabitants, communities, and industries. Locally, however, the air quality may be temporarily degraded during the summer months by forest fires and wind-generated dust particles.

Air quality monitoring has been done in the Fairbanks area for the past six years. The particulate concentrations measured at the National Air Surveillance Network (NASN) site in downtown Fairbanks, and similar data for North Pole are shown below.

Fairbanks

Year	Annual Geometric Mean	24-Hour Concentrations Greater Than 150 μg/m^3	24-Hour Concentrations Greater Than 260 μg/m^3
1969	175	16	8
1970	152	11	6
1971	100	2	0
1972	137	12	5
1973	102	6	2
1974	74	1	0

North Pole

Year	Annual Geometric Mean	150 μg/m^3	260 μg/m^3
1972*	13 μg/m^3	0	0
1973	55 μg/m^3	5	1
1974	33 μg/m^3	2	0

*Data not for entire year.

The State of Alaska has developed its own Air Quality Standards that are equal to or more stringent than the NAAQS published requirements. Alaska State Air Quality Standards are summarized below:

Pollutant	Primary	Secondary
Particulates		
Annual Geometric mean	75 $\mu g/m^3$	60 $\mu g/m^3$
Maximum 24 hour concentration*	260 $\mu g/m^3$	150 $\mu g/m^3$
Sulfur Oxides (as SO_2)		
Annual Arithmetic mean	60 $\mu g/m^3$	
Maximum 24 hour concentration*	260 $\mu g/m^3$	
Maximum 3 hour concentration*	1300 $\mu g/m^3$	
Carbon Monoxide**		
Maximum 8 hour concentration*	10 mg/m^3	
Maximum one hour concentration*	40 mg/m^3	
Photo-Oxidants		
Maximum one hour concentration	160 $\mu g/m^3$	
Hydrocarbons		
Maximum 3 hours concentration (6-9 A.M.)	160 $\mu g/m^3$	
Nitrogen Oxides		
Annual Arithmetic mean	100 $\mu g/m^3$	

* Not to be exceeded more than once per year.
** Carbon Monoxide emissions have special limitation.

The State of Alaska has air quality regulations, governing open burning, incinerators, and industrial process or fuel burning equipment, all of which may be applied to this proposed pipeline project. Pertinent examples of these special regulations are: no open burning except by permit and no open burning during "Air Quality Advisory" days, i.e. days of heavy pollution or adverse weather which are announced by radio and television. Industrial and Fuel Burning Processes may not exceed 0.05 grains/cubic foot of particulate matter emitted; not more than 500 ppm measured as SO_2 but occurring as any sulfur compound may be emitted. If Carbon Monoxide levels in any one locale exceed 10 mg/m^3, all motor vehicle traffic (except emergency vehicles) shall be routed out of that locale. The Alaskan Air Pollution Control Regulations (Chapter 50, amended November 9, 1972, authority AS46.03.1501 and others) may require any industrial process which generates pollutants and/or water vapor to obtain a special permit and to reduce water emissions, if that process will occur in areas of potential ice fog.

Other Alaskan Air Quality Regulations may apply episodically or generally to the proposed construction or operation of this proposed pipeline. The levels of carbon monoxide and other noxious or toxic gases, can be alarming in certain areas of ice fog or white out. The State of Alaska recognizes these special problems and is continually modifying their codes and guidelines in an effort to resolve these problems.

Noise Quality

No noise data are known to be available for the parts of Alaska that would be crossed by the proposed pipeline system. It is generally conceded, however, that objectionable noises are rare and transient along existing highway systems and at communities.

Water Quality

Existing U.S. Geological Survey surface water sites are shown on the map exhibit with 2.4-2 and details on location, period of record, and data available are listed in Figure 5 of Section 2.4-2. The period of record for stations north of the Tanana subregion is five years or less. Pie diagrams are shown on the exhibit map for hydrology for representative U.S. Geological Survey observation wells. Site specific studies have been conducted by the Alaska Department of Environmental Conservation, University of Alaska Institute of Water Resources, U.S. Army Cold Regions Research and Engineering Laboratory, and U.S. Environmental Protection Agency's Arctic Environmental Research Laboratory.

Water quality information relating to flood waters, available from U.S. Army Corps of Engineers, has also been previously summarized in 2.4-2. Throughout the region the quality of surface and groundwater is generally good, although problems are encountered with brackish or saline waters from deep wells, and with suspended sediment in surface water supplies. Site specific problems with surface and groundwater in the Fairbanks area are also detailed in Section 2.4-2.

2.5 UNIQUE FEATURES

Historic Sketch

A hunting, trapping and trading economy prevailed throughout the area of pipeline interest prior to the coming of Europeans. Trade routes followed the Arctic coastline into Canada and entered the Interior along major river valleys. Marine mammals and birds were the primary food source for coastal inhabitants who settled in permanent villages; those persons living in the Interior, who followed the caribou migrations and fished the streams, tended to gather into smaller and more nomadic groups. The entire area was sparsely populated from earliest days in accordance with relative abundances of food and other necessities for livelihood.

Four factors brought major change: The whaling and fur trade industries of the 19th century, the Klondike and subsequent gold rushes, construction of the Alaska Highway in World War II and discovery of oil and natural gas on the North Slope.

Because the area crossed by the proposed natural gas pipeline was remote in earlier days, outside pressures came relatively late. The first whalers arrived off the Arctic coast in 1838 and their impact was felt almost immediately. The Hudson Bay Company established a trading post at Ft. Yukon in 1847 and other traders first entered the Tanana region in 1860 but it was not until the late 1890's that hordes of Klondike gold seekers reduced the game supply to the degree that Native inhabitants were forced to change their food gathering patterns. Contact with the newcomers brought epidemic diseases as well as a reduced food supply and Native populations declined drastically.

Whalers, trappers and traders, and gold seekers came, took what they sought and departed. The Alaska Highway, 1,523 miles of gravel road built in 1942-43, changed the face and the future of the North. With easier access, more people began moving into the territory and, in 1958, Alaska became a state. The Alaska Statehood Act provided that the state could select approximately 104 million acres of federal land and the process of selection soon was begun. Since Congress, despite the Statehood Act, had reserved to itself the right to settle the Alaska Native land claims and had not acted in this matter, state land selection almost immediately came into conflict with Native claims to lands they used and occupied. Congress was asked to settle this ownership question. Discovery of oil and natural gas in commercial quantities on the North Slope in the mid-1960's brought a sense of urgency to resolving this conflict and, in late 1971, Congress extinguished aboriginal claims with the passing the Alaska Native Claims Settlement Act. This Act established Native village and regional corporations and provided approximately 44 million acres of Alaska lands and nearly $1 billion as compensation for lands taken by the federal government.

Following passage of the Alaska Native Claims Settlement Act, Congress authorized the construction of a pipeline haul road from Livengood north to Prudhoe Bay and a 48-inch petroleum pipeline from the North Slope to a shipping port at Valdez, Alaska.

The proposed natural gas pipeline dealt with in this report will follow the pipeline-haul road corridor from Prudhoe Bay to Delta Junction south of Fairbanks and the Alaska Highway from Delta Junction to the Alaska-Canada border near Northway.

Archeology

Archeological resources along most of the existing trans-Alaska oil pipeline (and all of that paralleled by the Alcan route) have been surveyed intensively by the University of Alaska. The final report for this contract, covering Prudhoe Bay to Hogan's Hill, is to be submitted by mid-summer, 1976, by Dr. John P. Cook, Institute of Arctic Biology, University of Alaska, Fairbanks.

Site information for many of these has been filed with the Alaska Division of Parks as a part of its Heritage Resource Inventory Survey. The Survey also maintains public records on many other sites, including historic buildings, trails, and communities. The following annotated list is from the Survey files and is not complete since not all of the Alyeska data are incorporated into the system yet. A complete inventory will be available within the next month. However, certain conclusions can be stated with regard to the presence of archeological resources. Archeological resources that are presently known primarily include those that were discovered by the Alyeska project. From Prudhoe Bay south to approximately 68 degrees 45 minutes north latitude (where the pipeline veers west from the Sagavanirktok River), there will be a minimal impact. Only 22 sites have been found along the Alyeska pipeline. From the Sagavanirktok River to the Galbraith Lake area, however, there are nearly 120 sites that may be affected by the proposed pipeline. Further up the Atigun River to the Continental Divide, there are very few sites. The sites in the region north of the Brooks Range vary considerably in size and topographic location, but almost all gravel knolls have some cultural features on them. This will have to be taken into account when planning gravel requirements.

South of the Divide, to the Wiseman area, there are relatively few (6) sites along the Alyeska route. However, between Wiseman and Caribou Mountain, a rather high density of resources may be affected by construction. These occur in clusters; eg., Bonanza Creek, Jim River, and Caribou Mountain. Over 100 sites are known from this section of the route, most of which are on bedrock knobs or ridges which afforded lookout stations for caribou hunting. The majority of them are fairly small and can be excavated, if necessary, rather quickly.

Between the Yukon crossing and Delta Junction, approximately 20 sites are known to be in the close vicinity of the Alyeska pipeline. Some of these may require excavation, depending upon the exact placement of the proposed line. Most of them, and the largest in extent, are near Livengood.

Inasmuch as no archeological survey has been conducted along the pipeline route east of Delta Junction to the U.S.-Canadian border, there is a marked paucity of information for this section. A recent survey in the Delta Land Management Area shows some 78 sites in that region. Moreover, some of these (Healy Lake, Dixthada) are among the more significant sites in Alaskan history. Ethnographic studies indicate that the upper Tanana and Nabesna Rivers were important centers of Athapaskan subsistence. Sporadic findings of artifacts along the Taylor Highway north of Tok, as well as the Healy Lake data, attest to the antiquity of this occupation.

The segment east and south of Delta Junction is the least known but surveys by Alcan and the State Division of Parks should reduce the uncertainty of resources along this part of the pipeline.

Table 2.5-1 lists the "Cultural Resources Enumerated on The U.S. Biological Survey Quadrangle Maps" and contains a brief discription of the sites. Note: Historic and Archaeological Sites map on page 5, volume 1A.

TABLE 2.5-1

Beechey Point

A-5	Recent Eskimo site, presumed to have been occupied in the 1930s.

Sagavanirktok

A-2	Two tent rings of recent origin.
A-3	Site contains 60 pieces of wood.
A-4	Site contains pre- and post-contact material.
A-5	Site contains a hearth on a bluff above the river.
A-6	Surface site.
	Approximately nine miles north of the confluence of the Ivishak and Sag Rivers is an area containing six sites.

Philip Smith Mountains

A-4	Recent Nunamiut site.
A-5	Surface site.
A-9	Tent ring and sod houses.
A-10	Site containing core and blade technology.
A-11	Surface site.
A-12	Caches.
A-14	Historic Eskimo site.
A-22	Surface site.
A-24	Tent rings.
A-25	Tent rings.
A-26	Presumed lookout site.
A-28	Surface site.
A-30-33	Galbraith Lake sites of recent origin. Significant.
A-34	Material similar to Gallagher Flint Station (A-50).

TABLE 2.5-1 (Cont'd.)

A-36	Nunamiut site. 3 tent rings.
A-38	Site has been excavated.
A-40-48	Murphy Lake sites; some are significant.
A-49	Site containing Arctic Small Tool material.
A-50	Highly significant site containing material of several Eskimo and earlier cultural phases from 1,500 - 10,000 B.C. Only partially excavated.
	The Atigun Canyon contains many sites; some are significant.
Chandalar	
A-2	Lookout site.
Wiseman	
A-1-4	Sites contain hearths, microblades, flakes. One is a presumed lookout site.
A-5	Blowout site.
H-7	Abandoned town, 1899.
H-8	Mining town, active.
H-9	Log building.
Bettles	
A-2-8	Caribou Mt. North area.
A-9-11	Caribou Mt. South area. Surface sites.
A-12-13	Upper Kanuti River locality. Damaged microblades.
A-14	Microblades.
A-15-19	Bonanza Creek area. Sites include buried, surface and blowouts.
A-26-27	Grayling Lake area.
A-30	Waste flakes.

TABLE 2.5-1 (Cont'd.)

Livengood

A-(Y-1)	Surface site.
A-(Y-46)	One diagnostic artifact was retrieved by Alyeska archaeologists.
A-3	Rosebud Knob #1 and #3. Surface sites.
A-4-5	Ready Ridge. Surface sites.
A-6	Surface sites.
A-7-12	Lookout Ridge locality. Surface sites. Tuktu material.
A-35	Quarry site.
H-56	Roadhouse, sawmill, tram road, 1915.
H-59	Mining camp, 1907.

Fairbanks

A-72	Site contained campus material. Excavated.

Big Delta

A-11,13	Archaeological sites.
A-72	An undisturbed site of possible significance.
A-87	Hearth.
H-4	Roadhouse.
H-5	Roadhouse, 1919.
H-57	Nigger Bill's Roadhouse, 1906.
H-59	Roadhouse, 1906.
	Healy Lake contains many sites of significance; some date to 12,000 years B.C.

Mt. Hayes

The Healy Lake area contains numerous sites of significance (A-204-212 on the Heritage Resource Inventory), along with several important sites near George Lake (A-213-217).

TABLE 2.5-1 (Cont'd.)

It is assumed more sites will be discovered along the highway during the summer, when the Alaska Division of Parks conducts an archaeological survey. The survey will verify several roadside areas reported to contain sites; these are circled on the map.

Tanacross-Nebesna

No sites have been reported as yet along the pipeline route for this area.

Information on the above sites was obtained from the State of Alaska, Division of Parks, Office of History and Archaeology, Heritage Resource Inventory Survey File.

Scenic Sites

The route of the proposed pipeline passes through several different areas, ranging from the birch and spruce forests along the Alaska Highway to the tundra reaches of the North Slope. The route parallels one major mountain range and traverses a second. North of Fairbanks, the Yukon River crossing offers a magnificant view of this river as well as an example of an interesting engineering project. Some additional points of interest are shown on the map in Volume 14, page 5.

CONTENTS

3.0 ENVIRONMENTAL IMPACT OF THE PROPOSED ACTION

The proposed gas pipeline described in Section 1 will have certain impacts on the existing resources and uses of the environment delineated in Section 2. These anticipated impacts are identified in this section, with a distinction being made between impacts resulting from construction, and impacts resulting from operation and maintenance. Because the socio-economic impacts of the proposed action are essentially a continuing process, the discussion of these impacts was not divided into construction and operation and maintenance periods; instead, these impacts have been treated chronologically, in a separate subsection (3.3).

The environmental effects of the proposed gas pipeline along that portion of the route generally paralleling the trans-Alaska oil pipeline, will impact an area which has been and will continue to be impacted by the construction and operation of that extant pipeline. Similarly, the environmental effects along that portion of the route paralleling the Alcan Highway will also impact an established transportation and utility corridor. Thus, many of the impacts identified in this section can be considered incremental in nature and, as a result, have relatively less effect on the existing environment. Moreover, the implementation of proper mitigating measures can reduce or avoid the adverse environmental impacts of the proposed action.

3.1 CONSTRUCTION

3.1.1 Land Uses

The major impacts upon existing land uses during the construction phase of the proposed pipeline include those upon: (1) the physical condition of the Alaska highway and road system, as well as the use of that road system for usual commercial and recreation purposes; (2) the port facilities at Prudhoe Bay, Valdez, and other potential shipping points such as Seward, Whittier, or Skagway; (3) the railroad facilities of the Alaska Railroad; (4) airports and airfields; (5) gravel material sites; and (6) the general utilization of lands for hunting, fishing and trapping purposes, both for recreational and subsistence reasons. These various impacts are discussed, in turn, in this section. First, however, it can be generally stated that little impact is to be expected upon aesthetic values--except of a temporary nature--, particularly since construction activities will occur in areas already impacted by oil pipeline construction on the existing Alaska Highway-Haines Pipeline corridor. Although appropriate measures will be taken to minimize any adverse effects, some noise and dust disturbance to residences and communities is anticipated; this will be localized and of short duration. Moreover, the impact upon agriculture or forest products will be negligible.

In describing the impact of the proposed gas pipeline on Alaskan roads, it must first be recognized that while there are many advantages to locating the proposed pipeline along a principal all-weather highway, the present road system in Alaska is not comparable to the major highway systems in the lower 48 states. The impact of the proposed pipeline upon the highways south of the Yukon River are primarily the result of activities directly related to the construction effort, or to traffic necessary to meet the logistical requirements of construction. These impacts will be felt, not only on the Alaska Highway, but also on the major intersecting highways, particularly the Parks, Glenn and Richardson Highways. Traffic congestion to users of the highway system along the rural routes is not seen as a significant problem for a major shipper. Prudent traffic practices, such as defined lead time intervals for trucks and buses, must be utilized. Congestion problems will probably occur to a larger extent in the urban area of Fairbanks. This will result from the centralization of associated support services there, and the general increase in the economic vitality of the community derived from this project. To a lesser degree, other areas of congestion would occur in the vicinity of Delta Junction, Tok and, to a much lesser degree, at the customs station on the border. The Tok area also has a weigh station, operated by the Alaska Department of Revenue in conjunction with other state services designed to meet the requirements of travelers.

Constraints on logistical support stations are primarily created by bridge restrictions for oversize loads, permit requirements for overwidth and overweight loads, and seasonal difficulties affecting logistical flow. An inventory of the most restrictive bridges, in terms of physical dimensions, is listed in Table 3.1-1.

Permit requirements for movements of oversize and overweight loads are handled on an individual basis, by the Alaska Department of Highways and the Department of Public Safety. On occasion, the Department of Highways has allowed loads as wide as 19 ft. to be transported from Valdez to north of the Yukon River, but only after a thorough review of the traffic management plans of the shipper. The Department has issued permits allowing loads in the range of 60,000 to 70,000 pounds over timber structures, and up to 90,000 pounds over steel bridges. A few of the Department's considerations in the permit review include whether or not the load can be managed piecemeal, traffic conditions, speed, number of weight-bearing axles, stopping distances, and the width of travelled road.

TABLE 3.1-1

BRIDGE DIMENSIONS ON SELECTED ALASKAN HIGHWAYS

Mileposts	Crossing	Length	Width	Height
Alcan Highway				
1303.2	Tanana River	946'	24'	15'
1309.3	Tok River	253'	24'	16'
1333.6	Yerrick River	204' 10"	24'	16'
1381.3	Johnson River	969' 8"	24'	15' 8"
1392.6	Gerstle River	183' 2"	24'	16'
Richardson Highway				
15.4	Keystone Tunnel	636'	24'	(Various)
275.3	Tanana River	783' 6"	30'	17' 11"
Parks Highway				
275.8	Nenana River	509' 10"	30'	17' 10"
Glenn Highway				
5.0	Muldoon Road Overcrossing	260' 4"	73'	16' 3"
6.7	Gate 2 Over-crossing	238'	40'	16' 6" proposed
11.9	Hiland Road Overcrossing	208'	28'	16' 6" proposed
13.8	Artillery Road Overcrossing	216'	40'	16' 6" proposed
Tok Cutoff Highway				
1.75	Gakona River	229' 2"	24'	15'

An area of major highway impact will be that segment of the Alcan Highway from the Tanana River east of Tok to the Canadian Border. This section of road was built with marginal materials, and was designed for low-volume traffic. It is composed of bedrock and sands, with an oil and rock-chip bituminous surface treatment overlay. The 1975 Sufficiency Rating System indicates this section of road is showing signs of considerable wear. Significant potholing and loss of pavement exists in approximately 5 to 10 percent of the route. Drainage structures are shallow, and the road has narrow shoulders. In general, surface characteristics, as a whole combine to reduce the average speed 10 miles per hour below the speed limit, for comfortable operation of vehicles.

Both railroad and port facilities can expect to be affected during the construction phase of the project. However, experience, and the improvement of facilities made during the trans-Alaska oil pipeline construction, should keep impact within present operational capacities. The many strategically-placed airports along the proposed pipeline route generally have been able to absorb the impact of Alyeska's pipeline construction. The impact of the proposed gas pipeline construction can be expected to be handled as well.

Gravel will be required for two primary purposes during the construction phase of the project. It will be required to construct the extension of existing work pads adjacent to the haul road, and to add separate work pads where needed. Separate pads will be needed where the alignment diverts from the Alyeska route or from the haul roads. The second use will be for maintenance of the construction haul road when necessary. Estimates for gravel and fill for both work pad construction and haul road maintenance are in the range of seven million cubic yards. Although existing Alyeska material sites will be used to the maximum extent practicable, the need for borrow pits, for both gravel and fill, will result in short-term impact to the environment over the construction period. In some cases, revegetation after construction can be used to prevent potential long-term impacts. Selected gravel and fill sites will have to be left open. These will supply gravel for the maintenance of the work pads and other requirements over the lifetime of the project. The impact on the environment, caused by the need for these pits, may be minimized by judicious selection. In certain areas along the Alaska Highway, some long-range impact upon gravel uses by the Alaska Department of Highways and local communities can be expected.

Both short and relatively long-range impacts are to be expected upon subsistence and recreational activities involving fish and wildlife resources along the proposed route. In some areas, present harvest levels are already taxing the wildlife carrying capacity. The continued presence of a relatively large population of hunters and fishermen can be expected to further diminish both the quality and quantity of fish and wildlife stocks. Additionally, the mass intrusion of activity along the gas pipeline route will tend to drive some species of big game away from the work area. This is especially true of caribou, bear, and certain other sensitive species.

3.1.2 Impact on Species and Ecosystems

Much has been written, by both governmental and private sources, describing the various ways biotic resources may be affected by pipeline construction. Authors have described in detail the reactions of species to specific activities, such as effects of culverts on graylings (McPhee and Watts 1975), effects of sediments on fish (Cardone and Kelley 1961, Gammon 1970), effects of barriers on caribou movements (Child 1973), and effects of noise on birds (Gunn and Livingston 1972). For the most part, construction of a chilled gas pipeline along a route where industrial activities have already occurred will be a continuation of existing stresses or an increment to them. Movements of people, trucks, heavy equipment, aircraft, and similar activities will already have had their effect; animals intolerant of such disturbances may already have moved away or otherwise adapted. A haul road has been constructed for the oil pipeline, from the Fairbanks area north of Prudhoe Bay, and, whether or not the haul road is opened to the public, physical access to former wilderness lands has already been created. The heavy silt loads resulting from construction in regions with poorly-known hydrologic regimes should not occur now that experience has been gained in the construction of oil pipelines. Neither should contamination from untested sewage treatment systems occur. In other words, adverse circumstances in regions where little or no construction activity previously has occurred, should be relatively small. In addition, the impacts from normally anticipated construction activities can be minimized, with proper planning and adequate mitigation techniques. A culvert can usually be placed in a stream with only a moderate amount of sediment disposition; however, the washing out and replacement of a poorly manufactured or planned structure is much more of a problem. Disturbances such as blasting can disrupt nesting of birds or cause damage to fish life, but such damage can be reduced by the use of care in timing activities.

Specific impacts considered to be significant to species and ecosystems, occurring as a result of construction of the proposed gas pipeline, are identified and discussed separately for the Arctic and Interior regions.

Arctic

Terrestrial

1. If explosives are used during certain periods, nesting birds could be disturbed and nests deserted in an area within about one mile of the activity.

2. Sightseeing excursions by aircraft, surface vehicle, or humans afoot could cause nesting failure in birds or reduce productivity in mammals; survival of young mammals could also be affected. Calving caribou along the arctic coast, and nesting peregrine falcons at Franklin Bluffs and at Sagwon are the most significant animals that would be affected.

3. Although restrictions will be in effect, a large work force would increase the number of hunters. If not in the immediate area, numbers would certainly increase in the region and the state, with consequent greater demand on game resources.

4. Mammals, particularly bears, wolves, and foxes, would be attracted to food around camps, possibly resulting in the need to destroy the animals for the safety of personnel and property.

5. General construction activities and noise may disturb peregrine falcons and dall sheep during nesting or lambing season.

Aquatic

1. Construction activities would introduce added sediment into water bodies. Most sediment discharges would be temporary, and directly related to the time of the year and type of stream. Sediments resulting from erosion of slopes, particularly from thermal erosion, may be difficult to stabilize and could cause problems lasting for several years. Sediment can smother and reduce survival of fish eggs in spawning gravels, and can reduce the productivity of stream or lake habitats by smothering benthic organisms. It may also result in increased oxygen demand, reduction of light for photosynthesis, interference with feeding of filter-feeders, and physical burial of the habitat. These factors can all result in reduction of

growth rates, survival, and reproduction of fish. Lakes and streams that are not flushed by periodic flooding can be most seriously affected. A few small clearwater beaded streams along the arctic coastal plain would be most affected.

2. Even temporary impediments to migrating fish during spawning runs, or to out-migrant fry, can reduce productivity and survival. Impediments could be caused by poor design or placement of culverts, temporary dams, channel alterations, or in-stream construction during migrations.

3. Alteration of stream hydraulics by channelization or impoundment could affect the productivity of the stream permanently. Even temporary channel shifts would destroy the benthic biota, with consequent short-term effects on productivity of the stream section shifted.

4. Blasting, particularly close to spawning areas, could decrease survival of eggs, fry, or adults.

5. Removal of gravel from stream sections would cause at least short-term damage to benthic biota and any eggs or fry that might be present.

6. Removal of water from the limited unfrozen winter habitat of the Arctic would affect fish survival, as would blockage of inter-gravel flows.

7. Although restrictions would be in effect, construction personnel would increase the fishing burden on local, regional or state stocks.

8. Toxic materials (including excessive sewage, spilled oil, insecticides, or fertilizers) spilled into streams could damage aquatic habitats and fish by increasing oxygen demand, or by direct toxic effects on organisms. While domestic sewage and petroleum products have variable biological effects, depending on the amount, composition, and duration of a spill, excessive amounts of either can be damaging to vegetation, benthic organisms, and fish.

<u>Interior</u>

<u>Terrestrial</u>

1. The effects of using explosives during certain periods would be the same as in the Arctic. Raptors nesting on bluffs over the Tanana River and concentrations of nesting birds on lakes east of Northway would be the items of major concern. Effects on mammals should not be significant.

2. Sightseeing intrusions by vehicles, aircraft or pedestrians would have the same effects as in the Arctic. The most critical area would be to the raptor-nesting habitat along the Tanana River.

3. As in the Arctic, there would probably be an increase in hunting pressure in the vicinity of construction activity between Livengood and the Canadian border. Here, the pipeline would not be in a corridor subject to special controls. The major impact, however, would be in other areas of the state resulting from the increase in human population.

4. South of Livengood, problems arising from mammals attracted to camps would be reduced because the area is already so developed that little opportunity for scavenging presently exists.

5. The effects of general construction activities and noise may disturb peregrine falcons and dall sheep during nesting or lambing periods.

Aquatic

1. Sediment deposition would have the same effects as in the Arctic, except that most streams are adapted to carrying seasonal sediment loads. Productivity of some lakes, particularly in the Minto Flats, could be reduced for extended periods of excessive siltation. This could damage marginal and shallow benthic fish and water bird habitats.

2. Impediments to fish migration would be the same as in the Arctic, except that carelessly handled trees and logs could be present, which could also create barriers.

3. Alteration of stream hydraulics, blasting, and the removal of gravel would have the same effects as in the Arctic, except that salmon would be among the species affected.

4. South of the crest of the Brooks Range, except in the Upper Dietrich Valley, water supplies are generally not severely limited; effects of the removal of water from winter habitats should not be significant.

5. The effects of increased fishing activity, and release of toxic materials would be essentially the same in the Interior as in the Arctic. Effects of toxic material could be long-lasting; however, if they were introduced into such areas as the Minto Flats, the Oxbow Lake complex of the lower Chena River, or lakes east of Northway.

3.1.3 Air, Noise and Water Environments

Air Quality

Existing air quality is discussed in Section 2.4.3. This section discusses the impacts of the proposed gas pipeline on existing air quality.

The construction impacts on air quality generally will be temporary in nature, and will vary depending on the season and the time of day. The approximate period for construction activities is May through September, with the possible (and probable) addition of March-April and October-November, depending on weather conditions at the time. During this season, dust will undoubtedly be the primary particulate matter added to the air environment. Historically, air quality measurements have been made only at Fairbanks. Air quality statistics there show that serious problems do exist, from dust in summer and from construction by-products in winter. Construction camps on the haul road cannot be considered similar to Fairbanks but, given a particular set of conditions, it is possible that critical concentrations can be reached in the camps and along the road. Because surface winds are stronger during the warmest part of the day, (also the least likely time for a temperature inversion), dust particle concentrations would tend to be greatest during the light wind, inversion-prone night hours.

Construction activities prior to March and after November will probably be conducted with a snow cover, usually hard packed on the roads. Dust will then be eliminated, except where traffic removes the snow, and even then the ground will be frozen and much less likely to produce dust. Combustion products, assuming comparable amounts of vehicular activity, should develop higher concentrations than during summer months. Surface winds are much lighter, and temperature inversions stronger and occur more frequently.

Construction camps or activity centers are potential producers of air pollutants. During the construction period of March through November combustion by-products may briefly build minor local concentrations, but should pose no serious problem. If extensive construction work were done during winter months, temperature inversion and "no wind" conditions for an extended period could cause pollutants to reach critical concentrations in the immediate vicinity of the pollutant source.

Construction Noise

The equipment used in the construction phase of the project is noisy by nature, and during the time and at the location of its use, will greatly increase the noise level. Where entrenching for the pipe is done with explosives, additional temporary noise will be generated. All Federal and state regulations designed to protect workers from excessive noise levels will be complied with during construction. With respect to the potential impact on wildlife, some of these have been identified above, in Section 3.1.2. Any adverse impacts will be temporary in nature, and can be minimized by proper construction scheduling in areas of critical concern.

Water Quality

The environmental impacts of construction of the proposed pipeline and its associated facilities would have some minor effects on the general chemical and physical quality of surface and ground water. Sediment concentration in surface waters would be increased by the accelerated erosion caused by construction activities, but water temperatures would be little affected. Organic pollutants derived from human wastes would affect the biological quality over a wide area if good sanitation practices were not followed. Environmental impact would accrue locally from small accidental spills or release of oil or other wastes into surface or ground water. The effects of small spills on fishfood organisms, primary productivity, and other biotic resources, would generally be in proportion to the amount and characteristics of the material spilled; but this would also depend on the character of the receiving waters and the vulnerability of the life cycle stages of affected organisms. Large or moderately large spills of construction fuels, directly into lakes or streams that support significant biotic resources, would obviously cause a significant adverse effect.

The natural quality of stream or lake habitats would be impaired where construction activities, such as removal of vegetation, gravel excavation, spoil removal, and road or camp building, added or put particulate matter (generally silt, organic detritus, bacteria, or plankton) into water suspension.

Drainage patterns have been altered by the present oil pipeline construction activity, and have reached new equilibrium situations. The effects of a second line on drainage patterns would depend on local conditions and on the proximity of the line. Effects of the proposed gas pipeline on drainage will vary, depending on whether it is constructed on the downstream or upstream side of the existing line, and whether it is buried or elevated. Drainage patterns would also be altered where gravel is removed for fill.

Snowmelt, glacial outwash, and rain-induced flooding occur throughout the project area. During periods of construction, spoil materials are excavated and subject to inundation by floods. Should flooding occur at this time, additional siltation above "natural" levels will enter main water courses.

The oil pipeline and the highway will already have stabilized overland flow. Drainages downstream of these structures will also have been stabilized, so that additional erosion should not result. However, depending on local conditions, erosion could be augmented by the proximity of the proposed gas line to the oil line. In some locations, construction activities would increase the freezing and thawing action in soils, reducing resistence to stream velocity and shear; this would increase the effect of flowing water. Coffer dams, and other structures temporarily located in streams, could also increase erosion and siltation.

Construction will also affect the thermal equilibrium of the permafrost terrain, by reducing the insulating properties of the surface soil. Road cuts or pipe excavations will intercept shallow ground water flows in some locations. The effect of these activities will induce a greater than normal flow of ground water to the surface, cause above normal runoff of surface waters, and possibly induce temporary erosion.

During spring months, soils are in the process of thawing. If excessive amounts of water are allowed to accumulate on any surface heavily traveled by vehicles, such surfaces will become muddy and even impassable to most vehicles. Proper drainage of soils is necessary.

During May and early June, heavy showers are rare; rainfall is usually low in intensity and seldom wets the soils sufficiently to permit erosion. During the June-to-September period, precipitation amounts increase drastically to a maximum in August and early September. Although showers are the most frequent form of precipitation, heavy continuous rains do occur periodically. Where ground cover has been removed or grading done in a manner that permits a concentrated flow and accumulation of water, flooding and siltation will occur. During late April and May, surface runoff of snowmelt will produce the same flooding if slopes have been improperly graded or ground cover removed.

3.1.4 Waste Disposal

Waste materials consist of spoils, vegetation (including trees), construction materials, camp wastes, and hydrostatic test water. Each presents its own disposal problems. Disposal of solid waste is a particular problem in the Arctic, where burial is not a simple matter of digging a hole and covering it over. Sites must be selected where each burial will not cause thermal degradation of soils, or contamination of ground water sources.

a. Spoil materials can erode into water bodies, possibly damaging spawning beds of fish and other habitats. They often create an unproductive environment where establishment of vegetation is difficult; they can create a long-lasting source of eroding sediments, and can also be an eyesore.

b. Waste vegetation, particularly trees, can cause jams and obstructions in streams. If not properly disposed of, they can also create a fire hazard and exert a negative aesthetic effect.

c. Construction materials may contain various toxic or flammable materials. Unless properly disposed of, they can be fire hazards, possible sources of water or air pollution, and eyesores.

d. Camp wastes, particularly if they contain food materials, can be attractive to bears, wolves, foxes and other animals which usually become a health or safety hazard. These animals are eventually destroyed or transported to another location.

e. Hydrostatic test water will be disposed of after the pipe sections have been subjected to the test pressures for the prescribed time periods.

The proposed route traverses areas in which freezing temperatures may be anticipated over the entire year, as well as areas where freezing temperatures may exist for only a portion of the year. Thus, depending on location and test schedule, the water may have to be heated for testing certain sections.

Three types of environmental concerns involving test water may be anticipated: (1) those concerned with the availability of the aqueous test fluids, (2) those concerned with leakage from the pipe section under test; and (3) those concerned with the disposal of the test fluid.

Water requirements: Water requirements will be variable, depending upon the length of individual sections under test, and whether sections are tested successively. Approximately 0.36 million gallons will be required for each mile of the section under test. Impact on the local water supply in certain areas may result. The impact would depend on the season of year and the volume requirements. Water requirements will generally be lower if the sections are tested successively. Where the alignment is in close proximity to large rivers and lakes, no serious impact is anticipated.

Leakage during testing: Quality assurance programs during the welding of the joints and the pipe laying and backfilling operations should reduce the possibility of leakage during hydrostatic testing. Leaks could occur, but their probable quantities are virtually impossible to estimate. A variety of environmental impacts could result from leakage as a result of pipe failure during hydrostatic testing. Vegetation could be affected, and permafrost thaw initiated by local ponding. Seepage through the backfill soil could change its properties and alter the thermal regime in the immediate vicinity of the pipe. Seepage from the leak could find its way into local streams or water courses, thus introducing into them any material or soluble compounds which may have been picked up by the water while it was in the pipe.

Test fluid disposal: Proper test fluid discharge practices will be utilized to minimize potential harmful impacts. Thermal pollution as a result of discharging the test fluid into large bodies of water, or on the thin ice covering these bodies, would probably not cause large impact. However, warm waste water introduced into or onto ice covered small streams in large quantities could adversely affect spring ice breakup characteristics. This might, in turn, affect fish migration patterns. Impacts on water quality and aquatic habitat may also result from materials cleansed from the pipe and not removed from the fluid prior to introduction into the receiving watercourse. Should the hydrostatic testing be carried out by successive sections, then impact could result from dissolved materials being introduced into waters with different compositions from the source.

3.1.5 Historic and Prehistoric Cultural Values

Cultural resources will be affected in two ways: 1) direct and immediate impact, and 2) indirect impact through curio seeking and vandalism. The major direct impact will occur during acquisition of materials, eg., gravel and rip-rap. Many of the sites described above (Section

2.5) are associated with developed and/or potential gravel sources. In addition, access roads, camp areas, storage yards, etc., may disturb some sites. The work pad and the pipeline itself will possibly intersect with some sites. Whereas a building associated with Gold Rush days, for example, may be moved, an archeological site will be either partially or totally destroyed.

Direct impact of this nature will be greatest in the region between the Sagavanirktok River and Atigun Pass, particularly in the Galbraith Lake area (the Philip Smith Mountain quad), and in the region south of the Continental Divide along the Jim River and near Caribou Mountain (Wiseman and Bettles quads). Other regions, such as those near Livengood or Hess Creek, have a high probability for impact, as does part of the line east of Delta Junction. The latter has not been inspected sufficiently to make an accurate assessment.

Indirect impact can be immediate or long-range. This pipeline, since it is routed through previously affected areas, will have little or no long-range secondary impact other than a slight incremental effect. However, it may be expected that some of the construction workers will attempt to collect curios and souvenirs along and near the route. Such indirect impact is an important but hard-to-assess factor.

The amount and intensity of impact is directly related to the location of the pipeline, and associated construction efforts. Potential impact can, and will, be minimized by an appropriate mitigation program (see Section 4).

3.2 OPERATION AND MAINTENANCE

In many cases, impacts from operation and maintenance will be similar to those from construction, but on a smaller scale as activity and the work force decrease. A few impacts, particularly those that relate to the freeze-bulb on the pipe and the action of compressors, will be new.

3.2.1 Land Uses

Upon completion of construction, impacts on the physical condition of the Alaska Highway and road system, existing recreational and commercial uses of the system, port facilities, railroads, airport and airfields, water supplies, material sites, and utilization of wildlife should be for the most part eliminated. Effects on the physical condition of the Alaska Highway should be minor except for problems resulting from interception of subsurface water flows by the pipe or its freeze bulb. This could cause glaciering and ice lenses under or across highways. High volume heavy traffic should no longer be a problem, nor should competitions with existing uses. There should no longer be a load on port facilities, railroads, or airports. Certain material sites would be required for operation and maintenance of access roads, operating stations, airstrips and other appurtenances of the line. At these material sites, revegetation and rehabitation would be delayed as long as materials were needed. Where work pads have not been revegetated, and where haul road spurs to the work pad exist, some long-term subsidence of soils may occur. In addition, pad and spur road side slopes may degrade. To mitigate against further degradation as a result of possible water ponding, it is anticipated that remedial maintenance will be required from time to time. Gravel will be required for this work. No estimates of the gravel required are possible; however, the amount required will represent a very small fraction of that used during construction. Use of this gravel may, in some cases, cause siltation of water bodies and destruction of a small amount of wildlife habitat. Such effects should be small. Utilization of lands would be reduced when large numbers of construction personnel are no longer required.

3.2.2 Species and Ecosystems

Arctic

Terrestrial

1. Operation and maintenance will produce some effects similar to those resulting from construction, but probably with less frequency or intensity. Procedures that result in such unusual disturbances as explosious or sightseeing, would have the same effects on both birds and mammals during operation as during construction. If fewer personnel are required to operate the line, effects of hunting and attraction to camps should also be reduced.

2. Any above-ground sections of the line could be a barrier to movements of large mammals, particularly caribou, which range both sides of it. Effects would be most significant where the line is crossed most frequently.

3. The noise from compressors could, depending on the type of equipment used, be sufficient to cause some species to remain at a distance, denying them the use of a certain area of habitat. In critical areas, this loss could be significant. Raptor nesting sites at Franklin

Bluffs and Sagwon, the Dall sheep viewing area in Atigun Canyon, and polar bear denning habitat along the Arctic coast would be most sensitive to noise disturbance.

4. The freeze bulb surrounding the chilled pipe could affect ground water flows and hydraulic regimes over broad areas, creating conditions unfavorable for existing vegetation, but favorable to new species and communities. There would probably be some disruption of vegetative cover during the adjustment period.

Aquatic

1. Operation and maintenance of the line should create few channel alterations or sediment problems, except where pipeline modifications or repairs (including repairs of line ruptures) are necessary. As activity and personnel are reduced following construction, water withdrawals and wastewater discharges should be less frequent; fishing activity resulting directly from project personnel would be reduced.

2. Although the operation and maintenance phase would result in reduction of impediments to fish migration resulting from construction activities, the freeze bulb surrounding the chilled pipe could affect subsurface water flows, cause formation of aufeis, and perhaps even create localized ice dams. The dams could reduce water supplied to fish spawning, rearing, or overwintering areas during critical low water winter months, as well as inhibit migrations.

Interior

Terrestrial

1. In general, the same reduction of impacts from unusual disturbances, explosions, sightseeing, hunting, and attraction of scavenger species to camps would occur in the Interior as would occur in the Arctic.

2. Any above-ground sections of the line could be barriers to movement of large mammals, particularly caribou from the Porcupine herd. A few animals from the Fortymile, Mentasta, Chisana and Delta herds also cross the route and could be affected.

3. Effects of compressor noise would be the same as in the Arctic. A critical area of concern would be raptor nesting habitat along the Tanana River heights.

4. Adjustment of Interior vegetation to new hydrologic regimes would be similar to the Arctic, but would probably be more obvious and long-lasting, where mature trees and woody species are affected.

Aquatic

1. After construction has been completed and the line put into operation, effects of channel change, sediment deposition, explosion, wastewater discharge, and fishing activity should be reduced as they would be in the Arctic.

2. Effects of the freeze bulb surrounding the chilled pipe would be similar to those occurring in the Arctic. Interruptions of subsurface flows might be more frequent, especially in areas of intermittent permafrost where subsurface flows are more important. This would be particularly significant if ground water flows to critical chum salmon spawning areas were reduced or interrupted, resulting in eggs being frozen.

3.2.3 Air and Water Environment

Air Quality

Operation and maintenance activities will be continuous and fairly constant throughout the year. The production of pollutants should also be relatively constant. However, the impact of emitting these pollutants will vary with climatic conditions. In contrast to the construction phase, dust will be minor problem, and combustion by-products will be the more important consideration. As a result, the time of possible critical pollution concentrations shifts from summer to winter.

Wintertime light winds and stronger more persistent temperature inversions create the most favorable conditions for buildup of pollutant concentrations. Add this to the "bowl" effect of terrain that serves to retard horizontal movement of air, and the potential will exist for concentrations in the vicinity of compressor stations to reach critical levels.

Winter ice fog will occur more frequently during operation than during construction, but will be primarily restricted to areas around stationary sources. High contaminant concentrations due to unfavorable stability conditions can occur without ice fog being evidenced. However, the presence of ice fog will probably be indicative of poor air quality. It will not always develop during critical concentrations of noxious fumes, but when it does occur, noxious fumes will also be present. Ice fog density increases as temperatures lower and water vapor and condensation nuclei increase.

Use of fuels to run motor vehicles and the machinery at pump stations will result in emissions of the standard of combustion (water vapor, carbon dioxide, small quantities of carbon monoxide, and the oxides of nitrogen and sulfur). The quantities of carbon monoxide and the oxides of nitrogen and sulfur are not expected to exceed existing state standards. In winter, under calm conditions with ambient air temperatures of less than minus 25 degrees F. resulting in strong low level inversions, ice fog will form in the immediate vicinity of pump stations. Pollutant concentrations are not expected to be serious; however, ice fog may cause short delays in surface and air transportation in certain locales.

Ice fogs, which are site specific phenomena, pose the only important environmental threat during the operation of the pipeline. Even these meteorological entities are limited in areal extent, and are of a transient nature. Operations of the pipeline which might compromise potential ice fog areas will be resolved on a site specific basis.

Water Quality

As the line is put into operation and becomes chilled, a freeze bulb will develop surrounding the pipe. Both the line and the freeze bulb would have considerable effect on subsurface water supplies and movement. The most obvious is that either the pipe or freeze bulb could create a dam intercepting subsurface flows. This could lead to waterlogging of soils, ponding on the upslope side of the pipe, and glaciering in winter. The freeze bulb would also attract moisture from surrounding soils and would cause ridging over the pipe itself. Ridging could, in turn, act as a dam to the flow of surface water. On the nearly level Arctic coastal plain, this could inundate a broad area. Surrounding soils, from which water is drawn to create the freeze bulb, will become drier as the bulb progresses.

These changes in subsurface and surface water will create local changes in vegetation, inundating some plant communities and decreasing water supplies for others. The result will be an alteration of species composition of plant communities and some elimination of vegetation cover until species adapted to the new situation become established. Animal species will also change their distribution in response to habitat changes.

The most significant effects will be in areas used by chum salmon for spawning. These areas occur where ground water percolates through gravel in winter. Some of these areas could be eliminated by changes in subsurface flow.

The only significant demands on water supplies would be to meet the needs of the small crews at compressor and maintenance stations. An exception would occur in case of pipe failure and repair requiring hydrostatic test. If this occurred in winter, particularly in the Arctic, it could cause severe impact on water supplies and fish habitats.

Water will be required in less quantity than during the construction phase once construction camps are demobilized and hydrostatic testing has been completed. Even small amounts of water taken from unfrozen stream segments and lakes north of the Brooks Range could diminish critical supplies for overwintering fish. Localized unfrozen stream segments may be the only winter habitat available for the fish population of an entire drainage. Even in some areas south of the Brooks Range, sites where large volumes of water can be obtained in winter without damage to fish may be limited.

3.2.4 Solid Waste

Solid wastes should accumulate during operation and maintenance in much smaller quantities than during the construction period. Disposal of wastes requires care in site selection to avoid thermal degradation of soil or contamination of ground water supplies. The problem of avoiding attraction to scavenging animals is a continuing one and requires immediate disposal, usually by incineration, of all wastes that could be attractive.

3.2.5 Accidents and Natural Catastrophes

Fire and pipeline ruptures are the two types of potential accidents which would result in the most impact on the environment. In the unlikely event of a pipeline rupture, there could be certain adverse impacts of a temporary nature; however, it is anticipated that there would be little long-range impact on species and ecosystems from such an occurrence. The most significant impact of such an accident would be repair operations which could release sediments or debris to water bodies, create water demands for hydrostatic testing, possibly create a need for blasting, and other construction operations. Impacts may be increased because of the difficulty in scheduling repairs to meet the needs of fish or other wildlife species.

3.2.6 Impact of Use of Resources During Operation and Maintenance

Use of resources during operation will, in general, be considerably reduced from requirements during the construction.

Water will be required in less quantity than during the construction phase once construction camps are demobilized and hydrostatic testing has been completed. Even small amounts of water taken from unfrozen stream segments and lakes north of the Brooks Range could diminish critical supplies for overwintering fish. Localized unfrozen stream segments may be the only winter habitat available for the fish population of an entire drainage. Even in some areas south of the Brooks Range, sites where large volumes of water can be obtained in winter without damage to fish may be limited. As during construction, site specific permits for water acquisition and discharge may be required before large volumes of water are withdrawn from specific sources.

Gravel Use During Operation

Where work pads have not been revegetated and where haul road spurs to the work pad exist, some long-term subsidence of soils may occur. In addition, pad and spur road side slopes may degrade. To mitigate against further degradation as a result of possible water ponding, it is anticipated that remedial maintenance will be required from time to time. Gravel will be required for this work. No estimates of the amounts required are possible; however, the amount required will represent a very small fraction of that used during construction.

Use of this gravel may, in some cases, cause siltation of water bodies and compromise a small amount of wildlife habitat. Such effects should be small, localized, and transient.

Use of Resources

Use of fuels for motor vehicles and to run the machinery at pump stations will result in emissions of the standard products of combustion which are water vapor, carbon dioxide, small quantities of carbon monoxide, and the oxides of nitrogen and sulfur. The quantities of carbon monoxide and the oxides of nitrogen and sulfur are expected to be so minute as to not be significant. In winter, under calm conditions with ambient air temperatures of less than minus 25^{o} F. resulting in strong low level inversions, ice fogs could form in the immediate vicinity of pump stations. Pollutant concentrations are not expected to be serious, nor to exceed Alaskan State of National Air Quality Standards.

Breakdown and Shutdown

Breakdown of the various components of the pipeline system, other than major pipe rupture, could cause environmental impacts of several types. A component of the system could fail and cause shutdown of the system or a compressor station might be shut down for maintenance. In case of a line failure, gas may have to be vented to relieve excess pressure in other sections as well as to clear the section in which the failure has occurred. Gas venting may impact the local atmosphere, particularly during a winter inversion period. Should the component failure result in leakage which permeates through the soil to the surface, "methane" damage would alter the vegetation. Change of albedo at the surface as a result of the chemically-burned vegetation could affect the soil thermal regime.

Repair of components requires access to the location of the damage. Should access not be available along the work pad, damage to vegetation could result from vehicular traffic using emergency roadways.

3.2.7 Cultural Resources

It is expected that there will be no direct impact on cultural, archeological or other unique features during the operations and maintenance of the proposed pipeline. If new material sources are required for maintenance, there is a possibility of opening new gravel sources (by permit) and possibly uncovering new historic or archeological sites. Erosion of previous construction areas may uncover some sites.

Immediate indirect or secondary impact will come, if at all, from souvenir collecting and/or vandalism, which could remove scattered or trail side artifacts of archeological value. Operations personnel will need to be aware of cultural resources and their value as well as the regulations concerning them. Since there will be no new areas of the state opened up by this pipeline route as it parallels existing routes, there will be little or no long-range secondary public intrusion upon wild lands due to available access. Access will be severely restricted.

3.2.8 Termination and Abandonment

It is assumed that abandonment would not include removing the pipe from buried sections and would not include excavation or disturbance of permafrost soil. The major effect will be the gradual elimination of the freeze bulb in some areas and a cessation of freeze bulb accretion in others.

Some alteration of surface flows will also occur as drainage facilities are no longer maintained. The major effect on biotic resources would result from stabilization of ground temperatures as the pipe returns to the temperature of surrounding soils. As the freeze bulb thaws, channels for subterranean water flows would be reopened, perhaps diverting water from fish spawning or overwintering areas established during the operation of the project. Vegetation types developed during the operation of the project could also be altered and require time to re-stabilize under the new hydraulic and thermal regime.

Except for temporary instabilities in surface drainage, water quality should be unaffected by abandonment.

Impacts on air quality during all phases of the gas pipeline project would be localized, and termination and abandonment of the line will return the air quality to the pre-pipeline level.

3.3 SOCIO-ECONOMIC IMPACT

3.3.1 Assumption and Methodology Used for Economic Impact Study

The MAP models show rapid economic growth in Alaska between 1978 (the first year of gas pipeline construction) and 1990. Therefore, the impact of the gas pipeline on the Alaskan economy will be to increase this growth rate somewhat, while changing the regional distribution of growth toward the three major impacted regions--Interior, Fairbanks, and Anchorage. In order to test the difference the gas pipeline makes in the MAP model results, the middle development scenario was selected and modified to reflect the higher level of petroleum sector (mining) and construction sector employment directly created by the pipeline project, and to show the greater level of petroleum revenues which would accrue to the state at current property tax rates, production tax rates, and royalty rates. The effect of these additions was traced through the model, and the impact of the changes, measured as differences from the case in which no gas pipeline is built, including changes in gross product, employment (direct and indirect), wages and salaries, personal income, and state and local revenues and expenditures was determined. These impacts were determined using the middle (Accelerated Development) case, but the absolute size of the impacts would be approximately the same regardless of the base used. The only difference would be the relative importance of the impact, which increases as the economic baseline against which it is applied decreases. This abstracts somewhat from reality, since the absolute size of the baseline economy may matter because of economies of scale. However, the differences are probably of second order importance when compared to factors which cannot be accurately predicted, such as the price of natural gas.

The following analysis is based on the assumptions that construction would begin in 1978 and that the pipeline would be operational in January, 1981, with two pump stations, at a level of one billion cubic feet per day. In addition, it is assumed that twelve more pump stations would be completed over the following three years, bringing average daily production to an assumed level of 2.25 billion cubic feet of gas per day by January, 1984. Long-term direct operations and maintenance employment was assumed to be 190 persons. Employment in construction is assumed to be at the levels projected in Table 3.3-1.

Since the wellhead price of natural gas is uncertain, three alternative prices were selected, for different runs of the MAP model, to indicate the range of effects which could be expected. A minimum wellhead price of 50 cents

TABLE 3.3-1

ALCAN PIPELINE DIRECT EMPLOYMENT ASSUMPTIONS USED[1] IN MAP MODEL

(Average Annual Project Workforce)

Year	Direct Construction Employment[2]			Direct Mining Employment[2]			Total Direct Employment
	Interior	Fairbanks	Subtotal	Interior	Fairbanks	Subtotal	
1978	1120	1120	2240	0	0	0	2240
1979	2645	2645	5290	0	0	0	5290
1980	2957	2958	5915	0	0	0	5915
1981	890	890	1780	15	15	30	1810
1982	935	935	1870	35	35	70	1940
1983	1215	1215	2430	65	65	130	2560
1984	0	0	0	95	95	190	190
1985	0	0	0	95	95	190	190
1986	0	0	0	95	95	190	190
1987	0	0	0	95	95	190	190
1988	0	0	0	95	95	190	190
1989	0	0	0	95	95	190	190
1990	0	0	0	95	95	190	190

[1] Employment data source: Gulf Interstate, Houston, Texas

[2] Average annual employment assumed to be divided evenly between Fairbanks and Interior regions

is often used to suggest the approximate lower bound for a price of gas in Prudhoe Bay, since it would require about that much per thousand cubic feet to convert and/or install the necessary collection lines and stations to make 2.25 bcf available to any pipeline. If delivery costs to Lower 48 markets average about one dollar per mcf, then the wellhead price cannot rise much above $1.50 per mcf. This is because FEA predicts that markets for gas in the Lower 48 will disappear at prices above about $2.40 per mcf.

While the exact construction costs and taxable value of the pipe and pumping stations in place is not known, initial estimates of direct committed capital cost in Alaska are available, and these were used as a proxy for the eventual taxable property value in pipeline equipment. The direct revenues injected into Alaska's economy by the Alcan pipeline are shown for the three different prices assumed above in Table 3.3.1-2.

The structure of the MAP models does not permit division of impacts into a construction period and an operations and maintenance period. This is partly because the construction activity directly gives rise to general economic growth, which continues beyond the construct-tion period. In addition, some state revenues are collected in the construction period, and the spending of these revenues also extends past the construction period of 1978-1983. Finally, the construction and operations and maintenance periods overlap (1981-1983), further confusing the effects. Consequently, the impacts are reported by year only. While the reader may wish to divide the projection period in his own mind at January 1, 1981 or at January 1, 1984, one should recognize that the growth impacts of a gas pipeline are essentally a continuing process.

This analysis was prepared from preliminary data on costs, employment, volumes of gas to be transported, and other factors. The results are as accurate as can be forecast at the present time. A further analysis based on updated information may produce different conclusions.

Table 3.3-2

ANNUAL PROPERTY TAXES, PRODUCTION TAXES, AND ROYALTY RECEIPTS: ALCAN PIPELINE

Alaska Portion
(Millions of Dollars)

Year	Cumulative Capital Cost	Property Tax	Gas Production (106 Mcf per day)	Gas Production Taxes, Plus Royalties:		
				$.50 Per Mcf	$1.00 per Mcf	$1.50 per Mcf
1978	$ 546.395	$ 10.9	0	0	0	0
1979	1,531.663	30.6	0	0	0	0
1980	2,015.310	40.3	0	0	0	0
1981	2,211,135	44.2	1.00	$30.1	$60.2	$90.3
1982	2,277.990	45.6	1.50	45.2	90.3	135.5
1983	2,277.990	45.6	2.00	60.2	120.4	180.7
1984	2,277.990	45.6	2.25	67.8	135.5	203.3
1985	2,277.990	45.6	2.25	67.8	135.5	203.3
1986	2,277.990	45.6	2.25	67.8	135.5	203.3
1987	2,277.990	45.6	2.25	67.8	135.5	203.3
1989	2,277.990	45.6	2.25	67.8	135.5	203.3
1990	2,277.990	45.6	2.25	67.8	135.5	203.3

3.3.2 Economic Impacts

Gross Product

The impact of the gas pipeline on gross product reaches its peak during the construction phase in 1980, generating an additional $210 million (in 1958 dollars) statewide. Owing to the specification of the development scenarios, roughly three-quarters of this construction period impact occurs in the Fairbanks and Interior regions. (Table 3.3-3). Following completion of the project in 1983, the level of impact falls sharply in these two regions, and by 1990, the total impacts for these regions range from 40 percent of the total statewide impact, given $0.50 gas, to 28 percent for the $1.50 case.

Impacts on the Anchorage region peak at a somewhat lower level in 1983, but also fall off much more slowly, so that by 1990 this region accounts for 45.6 percent of the total statewide impact for $0.50 gas and 54.2 percent for $1.50 gas. Interestingly, the impact analysis shows that the distribution of gross product impact between the three regions (and most particularly between Anchorage and the other two regions) is very sensitive to the price of natural gas. At higher gas prices, more of the gross product impact goes to the Anchorage region. This is undoubtedly a function of increased state revenues for higher priced gas, which are more likely to enter the state economy in the Anchorage region than in Fairbanks or in the Interior. It should also be pointed out that at all three prices of natural gas, these three regions accounted for a fairly constant share of the total gross product impact (roughly 84 percent in 1990).

An industry-by-industry impact simulation was performed for $1.00/mcf gas. (Tables 3.3-4, 3.3-5, 3.3-6, 3.3-7). In the Interior, gross product impact peaks in the early 1980's, then falls to zero. Additional gross product in mining reaches $16 million by 1984 and remains constant throughout the forecast period. Impacts in the support sectors (service, trade, transportation, etc.) tend to follow the construction boom and bust, leveling out in 1984 and remaining essentially constant through 1990. The additional impacts in the Fairbanks region follow the same pattern as those in the Interior. In fact, a strong case can be made showing much of the support sector output and employment allocated to Interior actually occurs to the Fairbanks Region. For all sectors except mining and construction, it is probably useful to think of these regions as a combined total, though reported separately here. By 1990, roughly half the impact is experienced by the mining sector, and half by the support sectors, state and local government, and construction for both Interior and Fairbanks regions.

Table 3.3-3

IMPACT ON GROSS PRODUCT BY REGION
(Millions of 1958 Dollars)

PRICE = 50¢/mcf

	Anchorage	Interior	Fairbanks	Statewide
1978	10.663	25.221	19.913	56.788
1979	33.825	69.526	49.344	158.643
1980	53.408	85.636	58.49	210.082
1981	47.211	30.066	25.418	121.359
1982	42.006	43.611	27.454	128.742
1983	49.221	59.066	37.062	161.852
1984	43.418	18.394	19.018	98.758
1985	34.976	18.082	17.359	83.902
1986	32.798	18.182	17.018	80.004
1987	33.217	18.233	16.969	80.121
1988	35.097	18.471	17.135	82.562
1989	37.802	18.484	17.448	86.02
1990	41.365	18.492	17.863	90.605

PRICE = $1.00/mcf

	Anchorage	Interior	Fairbanks	Statewide
1978	10.663	25.221	19.913	56.788
1979	33.825	69.526	49.344	158.643
1980	53.408	85.636	58.49	210.082
1981	51.256	30.233	26.222	128.328
1982	49.433	43.988	28.905	141.648
1983	60.182	59.604	39.157	130.578
1984	56.956	18.772	21.54	120.992
1985	49.739	18.463	20.06	107.719
1986	48.476	18.565	19.822	104.93
1987	49.869	18.631	19.87	106.289
1988	53.002	18.893	20.158	110.32
1989	57.16	18.926	20.625	115.656
1990	62.603	18.959	21.229	122.66

PRICE = $1.50/mcf

	Anchorage	Interior	Fairbanks	Statewide
1978	10.663	25.221	19.913	56.788
1979	33.825	69.526	49.344	158.643
1980	53.408	85.636	58.49	210.082
1981	55.305	30.4	27.026	135.297
1982	56.891	44.366	30.361	154.59
1983	71.201	60.144	41.261	199.391
1984	70.579	19.152	24.075	143.352
1985	64.627	18.846	22.782	131.723
1986	64.297	18.951	22.647	130.062
1987	66.682	19.032	22.796	132.684
1988	71.093	19.32	23.207	138.352
1989	76.736	19.373	23.832	145.605
1990	84.024	19.432	24.63	155.004

TABLE 3.3-4

$1.00/Mcf: IMPACT ON GROSS PRODUCT, BY INDUSTRY: INTERIOR
(Millions of 1958 Dollars)

	Ag, Fish, Forest	Mining	Construction	Manufacturing
1978	0.	0.	8.854	0.
1979	0.	0.	20.91	0.
1980	0.	0.	23.377	0.
1981	0.	2.67	7.036	0.
1982	0.	6.1	7.392	0.
1983	0.	11.091	9.605	0.
1984	0.	16.006	0.	0.
1985	0.	16.087	0.	0.
1986	0.	16.302	0.	0.
1987	0.	16.302	0.	0.
1988	0.	16.411	0.	0.
1989	0.	16.336	0.	0.
1990	0.	16.245	0.	0.

	Transportation Communications Public Utilities	Finance	Services	Trade
1978	1.414	0.	12.193	2.741
1979	3.56	0.	37.335	7.592
1980	4.24	0.	48.396	9.343
1981	1.501	0.	15.561	3.019
1982	1.69	0.	24.305	4.114
1983	2.262	0.	30.928	5.293
1984	0.348	0.	1.577	0.352
1985	0.324	0.	1.336	0.311
1986	0.322	0.	1.27	0.3
1987	0.331	0.	1.23	0.31
1988	0.345	0.	1.452	0.33
1989	0.363	0.	1.525	0.343
1990	0.385	0.	1.605	0.358

	Government Total	Federal	State and Local	Region Total
1978	0.019	0.	0.019	25.221
1979	0.128	0.	0.128	69.526
1980	0.28	0.	0.28	85.636
1981	0.447	0.	0.447	30.233
1982	0.387	0.	0.387	43.988
1983	0.424	0.	0.424	59.604
1984	0.488	0.	0.488	18.772
1985	0.404	0.	0.404	18.463
1986	0.371	0.	0.371	18.565
1987	0.359	0.	0.359	18.631
1988	0.356	0.	0.356	18.893
1989	0.359	0.	0.359	18.926
1990	0.366	0.	0.366	18.959

TABLE 3.3-5

$1.00/Mcf: IMPACT ON GROSS PRODUCT, BY INDUSTRY: FAIRBANKS
(Millions of 1958 Dollars)

	Ag, Fish, Forest	Mining	Construction	Manufacturing
1978	0.	0.	8.994	0.
1979	0.	0.	21.16	0.
1980	0.	0.	23.605	0.
1981	0.	1.547	7.228	0.
1982	0.	3.632	7.548	0.
1983	0.	6.805	9.77	0.
1984	0.	10.028	0.232	0.
1985	0.	10.028	0.213	0.
1986	0.	10.191	0.207	0.
1987	0.	10.191	0.204	0.
1988	0.	10.191	0.201	0.
1989	0.	10.191	0.204	0.
1990	0.	10.191	0.209	0.

	Transportation Communications Public Utilities	Finance	Services	Trade
1978	4.092	1.668	1.311	3.746
1979	10.498	4.066	3.195	9.724
1980	12.801	4.805	3.776	11.96
1981	5.766	2.15	1.689	5.385
1982	6.039	2.146	1.687	5.73
1983	7.872	2.689	2.114	7.581
1984	3.354	1.132	0.89	3.225
1985	2.967	0.99	0.778	2.868
1986	2.887	0.948	0.745	2.81
1987	2.937	0.946	0.744	2.882
1988	3.059	0.966	0.76	3.03
1989	3.237	1.001	0.787	3.237
1990	3.46	1.047	0.824	3.493

	Government Total	Federal	State and Local	Region Totel
1978	0.102	0.	0.102	19.913
1979	0.703	0.	0.703	49.344
1980	1.542	0.	1.542	58.49
1981	2.456	0.	2.456	26.222
1982	2.123	0.	2.123	28.905
1983	2.326	0.	2.326	39.157
1984	2.679	0.	2.679	21.54
1985	2.216	0.	2.216	20.06
1986	2.035	0.	2.035	19.822
1987	1.967	0.	1.967	19.87
1988	1.951	0.	1.951	20.158
1989	1.967	0.	1.967	20.625
1990	2.003	0.	2.003	21.229

TABLE 3.3-6

$1.00/Mcf: IMPACT ON GROSS PRODUCT, BY INDUSTRY: ANCHORAGE
(Millions of 1958 Dollars)

	Ag, Fish, Forest	Mining	Construction	Manufacturing
1978	0.	0.	0.241	0.
1979	0.	0.	0.857	0.
1980	0.	0.	1.456	0.
1981	0.	0.	1.673	0.
1982	0.	0.	1.529	0.
1983	0.	0.	1.773	0.
1984	0.	0.	1.828	0.
1985	0.	0.	1.579	0.
1986	0.	0.	1.514	0.
1987	0.	0.	1.529	0.
1988	0.	0.	1.591	0.
1989	0.	0.	1.682	0.
1990	0.	0.	1.808	0.

	Transportation Communications Public Utilities	Finance	Services	Trade
1978	3.763	1.143	0.809	4.457
1979	10.944	4.268	8.035	13.008
1980	16.08	7.607	5.432	19.069
1981	12.842	9.065	6.494	15.183
1982	12.725	8.758	6.304	14.924
1983	15.842	10.719	7.752	18.397
1984	13.457	11.464	8.316	15.324
1985	11.853	10.116	7.353	13.407
1986	11.658	9.974	7.267	13.074
1987	12.098	10.388	7.589	13.439
1988	12.987	11.181	8.193	14.265
1989	14.108	12.235	8.992	15.315
1990	15.558	13.607	10.029	16.677

	Government Total	Federal	State and Local	Region Total
1978	0.249	0.	0.249	10.663
1979	1.714	0.	1.714	33.825
1980	3.763	0.	3.763	53.408
1981	5.998	0.	5.998	51.256
1982	5.192	0.	5.192	49.433
1983	5.698	0.	5.698	60.182
1984	6.568	0.	6.568	56.956
1985	5.433	0.	5.433	49.739
1986	4.99	0.	4.99	48.476
1987	4.824	0.	4.824	49.869
1988	4.786	0.	4.786	53.002
1989	4.828	0.	4.828	57.16
1990	4.923	0.	4.923	62.603

TABLE 3.3-7

$1.00/Mcf: IMPACT ON GROSS PRODUCT, BY INDUSTRY: STATE
(Millions of 1958 Dollars)

	Ag, Fish, Forest	Mining	Construction	Manufacturing
1978	0.	0.	18.164	0.
1979	0.	0.	43.438	0.
1980	0.	0.	49.587	0.
1981	0.	4.217	17.818	0.
1982	0.	9.733	18.164	0.
1983	0.	17.896	23.081	0.
1984	0.	26.034	4.364	0.
1985	0.	26.115	3.75	0.
1986	0.	26.492	3.578	0.
1987	0.	26.492	3.586	0.
1988	0.	26.602	3.69	0.
1989	0.	26.527	3.866	0.
1990	0.	26.436	4.103	0.

	Transportation Communications Public Utilities	Finance	Services	Trade
1978	9.616	2.855	14.373	11.059
1979	26.533	8.63	48.972	31.114
1980	35.931	13.045	58.504	42.14
1981	25.053	12.238	25.201	26.461
1982	26.04	11.807	33.585	27.316
1983	32.338	14.425	42.243	34.136
1984	23.021	13.823	12.504	22.283
1985	19.649	12.128	10.927	19.461
1986	18.985	11.906	10.665	18.896
1987	19.583	12.333	11.04	19.325
1988	20.847	13.188	11.811	20.369
1989	22.493	14.33	12.763	21.739
1990	24.606	15.811	13.989	23.507

	Government Total	Federal	State and Local	State Total
1978	0.72	0.	0.721	56.788
1979	4.955	0.	4.955	158.643
1980	10.879	0.	10.879	210.082
1981	17.335	0.	17.335	128.328
1982	15.001	0.	15.001	141.648
1983	16.457	0.	16.457	180.578
1984	18.966	0.	18.966	120.992
1985	15.687	0.	15.687	107.719
1986	14.408	0.	14.408	104.93
1987	13.927	0.	13.927	106.289
1988	13.818	0.	13.818	110.32
1989	13.937	0.	13.937	115.656
1990	14.211	0.	14.211	122.66

In Anchorage, with the exception of small short-run bursts in 1980 and 1983, gross product impacts increase steadily for all industries except agriculture, fisheries, forestry, and manufacturing, throughout the forecast period. The support sectors (transportation, finance, services, and trade) account for the major portion of the additional gross product impact.

Employment

Employment yields a slightly different view of the impacts caused by the gas pipeline, a result of the differences in capital intensity between economic sectors. That is, the labor requirement for a given level of gross product is far lower for the mining sector than for the support sectors. (Table 3.2-8).

Statewide, the impact on employment peaks in 1980, when an additional 20,278 jobs are created with the envisioned scenario, indicating 13,000 jobs in the Fairbanks and Interior regions. With the completion of the project in 1983, employment impact falls dramatically and then grows slowly for the remainder of the forecast period. In the Anchorage region, additional impact grows slowly throughout the period, with a minor boom and decline during the construction period.

In contrast to the impact on gross product, the regional distribution of impact on employment is far less sensitive to changes in the price of gas. Comparison of 1990 forecasts suggests that the Anchorage share of total employment impact remains roughly constant at about 58 percent.

As a result of the Interior region's reliance on employment in the mining sector (a sector with a low labor output ration), the total employment impact here was half of the gross product impact. Construction employment impacted during the development phase of the pipeline shows no additional impacts following completion of the project in the Interior region. Following initial impact, additonal employment in the support sectors and government (whether actually in Interior or Fairbanks) falls dramatically and grows very slowly to 1990. (Table 3.2-9). The discussion of employment impact on Interior in general holds true for the Fairbanks region, although the impacts on the support and government sectors do not decrease as dramatically following the completion of the project. (Table 3.2-10).

The employment impact in the Anchorage region is far more stable than in the other two, and ranges between 5,000 in 1980 and 6,880 in 1990, with general growth through the forecast period. The support and government sectors once again account for the major portion of the employment impact. (Tables 3.3-11, 3.2-12).

Table 3.3-8
IMPACT ON EMPLOYMENT BY REGION
(Thousands of Wage Earners)

PRICE = 5¢/mcf

	Anchorage	Interior	Fairbanks	State
1978	0.79	2.29	2.055	5.289
1979	2.866	5.903	5.062	14.87
1980	4.964	6.999	6.036	20.278
1981	5.263	2.293	2.687	13.548
1982	4.491	2.785	2.579	12.449
1983	5.088	3.591	3.18	14.562
1984	5.047	0.335	1.191	9.684
1985	4.014	0.292	0.961	7.645
1986	3.719	0.278	0.88	6.991
1987	3.726	0.278	0.856	6.89
1988	3.894	0.284	0.857	7.06
1989	4.159	0.289	0.874	7.384
1990	4.516	0.295	0.901	7.84

PRICE = $1.00/mcf

	Anchorage	Interior	Fairbanks	State
1978	0.79	2.29	2.055	5.289
1979	2.866	5.903	5.062	14.87
1980	4.964	6.999	6.036	20.278
1981	5.757	2.312	2.798	14.519
1982	5.385	2.822	2.773	14.183
1983	6.39	3.643	3.452	17.035
1984	6.645	0.385	1.516	12.661
1985	5.744	0.344	1.302	10.82
1986	5.538	0.33	1.227	10.275
1987	5.637	0.33	1.208	10.282
1988	5.926	0.338	1.215	10.596
1989	6.336	0.344	1.241	11.101
1990	6.883	0.353	1.281	11.795

PRICE = $1.50/mcf

	Anchorage	Interior	Fairbanks	State
1978	0.79	2.29	2.055	5.289
1979	2.866	5.903	5.062	14.87
1980	4.4.964	6.999	6.036	20.278
1981	6.251	2.331	2.91	15.491
1982	6.283	2.859	2.968	15.922
1983	7.698	3.695	3.724	19.517
1984	8.253	0.435	1.841	15.652
1985	7.487	0.395	1.646	14.015
1986	7.372	0.382	1.576	13.582
1987	7.566	0.383	1.562	13.701
1988	7.977	0.392	1.576	14.162
1989	8.536	0.4	1.612	14.851
1990	9.269	0.411	1.664	15.782

TABLE 3.3-9

$1.00/Mcf: IMPACT ON EMPLOYMENT, BY INDUSTRY: INTERIOR
(Thousands of Wage Earners)

	Ag, Fish, Forest	Mining	Construction	Manufacturing
1978	0.	0.	1.12	0.
1979	0.	0.	2.645	0.
1980	0.	0.	2.957	0.
1981	0.	0.015	0.89	0.
1982	0.	0.035	0.935	0.
1983	0.	0.065	1.215	0.
1984	0.	0.095	0.	0.
1985	0.	0.095	0.	0.
1986	0.	0.095	0.	0.
1987	0.	0.095	0.	0.
1988	0.	0.095	0.	0.
1989	0.	0.095	0.	0.
1990	0.	0.095	0.	0.

	Transportation Communications Public Utilities	Finance	Services	Trade
1978	0.017	0.	0.639	0.509
1979	0.04	0.	1.753	1.43
1980	0.045	0.	2.146	1.772
1981	0.015	0.	0.693	0.572
1982	0.015	0.	0.932	0.795
1983	0.02	0.	1.201	1.021
1984	0.003	0.	0.082	0.065
1985	0.003	0.	0.073	0.058
1986	0.003	0.	0.07	0.055
1987	0.003	0.	0.072	0.057
1988	0.003	0.	0.077	0.061
1989	0.003	0.	0.08	0.064
1990	0.003	0.	0.083	0.067

	Government Total	Federal	State and Local	Self Employed	Region Total
1978	0.005	0.	0.005	0.	2.29
1979	0.036	0.	0.036	0.	5.903
1980	0.079	0.	0.079	0.	6.999
1981	0.126	0.	0.126	0.	2.312
1982	0.109	0.	0.109	0.	2.822
1983	0.12	0.	0.12	0.	3.643
1984	0.139	0.	0.139	0.	0.385
1985	0.115	0.	0.115	0.	0.344
1986	0.106	0.	0.106	0.	0.33
1987	0.102	0.	0.102	0.	0.33
1988	0.102	0.	0.102	0.	0.332
1989	0.102	0.	0.102	0.	0.344
1990	0.105	0.	0.105	0.	0.353

TABLE 3.3-10

$1.00/Mcf: IMPACT ON EMPLOYMENT, BY INDUSTRY: FAIRBANKS
(Thousands of Wage Earners)

	Ag, Fish, Forest	Mining	Construction	Manufacturing
1978	0.	0.	1.16	0.
1979	0.	0.	2.736	0.
1980	0.	0.	3.069	0.
1981	0.	0.015	0.941	0.
1982	0.	0.035	0.984	0.
1983	0.	0.065	1.275	0.
1984	0.	0.095	0.032	0.
1985	0.	0.095	0.029	0.
1986	0.	0.095	0.029	0.
1987	0.	0.095	0.028	0.
1988	0.	0.095	0.028	0.
1989	0.	0.095	0.028	0.
1990	0.	0.095	0.029	0.

	Transportation Communications Public Utilities	Finance	Services	Trade
1978	0.156	0.072	0.248	0.275
1979	0.393	0.177	0.609	0.675
1980	0.474	0.211	0.724	0.802
1981	0.213	0.094	0.324	0.36
1982	0.219	0.095	0.326	0.362
1983	0.282	0.12	0.411	0.457
1984	0.119	0.051	0.173	0.193
1985	0.105	0.045	0.152	0.169
1986	0.102	0.043	0.146	0.163
1987	0.103	0.043	0.146	0.163
1988	0.107	0.044	0.15	0.167
1989	0.112	0.046	0.155	0.174
1990	0.119	0.048	0.163	0.183

	Government Total	Federal	State and Local	Self Employed	Region Total
1978	0.029	0.	0.029	0.115	2.055
1979	0.201	0.	0.201	0.272	5.062
1980	0.442	0.	0.442	0.315	6.036
1981	0.705	0.	0.705	0.146	2.798
1982	0.612	0.	0.612	0.139	2.773
1983	0.674	0.	0.674	0.167	3.452
1984	0.778	0.	0.778	0.073	1.516
1985	0.644	0.	0.644	0.063	1.302
1986	0.592	0.	0.592	0.059	1.227
1987	0.572	0.	0.572	0.057	1.208
1988	0.568	0.	0.568	0.057	1.215
1989	0.573	0.	0.573	0.057	1.241
1990	0.585	0.	0.585	0.058	1.281

TABLE 3.3-11

$1.00/Mcf: IMPACT ON EMPLOYMENT, BY INDUSTRY: ANCHORAGE
(Thousands of Wage Earners)

	Ag, Fish, Forest	Mining	Construction	Manufacturing
1978	0.	0.	0.035	0.
1979	0.	0.	0.126	0.
1980	0.	0.	0.216	0.
1981	0.	0.	0.249	0.
1982	0.	0.	0.23	0.
1983	0.	0.	0.268	0.
1984	0.	0.	0.278	0.
1985	0.	0.	0.241	0.
1986	0.	0.	0.232	0.
1987	0.	0.	0.235	0.
1988	0.	0.	0.246	0.
1989	0.	0.	0.262	0.
1990	0.	0.	0.283	0.

	Transportation Communications Public Utilities	Finance	Services	Trade
1978	0.153	0.045	0.161	0.256
1979	0.433	0.169	0.612	0.799
1980	0.615	0.303	1.107	1.241
1981	0.455	0.363	1.334	1.178
1982	0.444	0.354	1.317	1.13
1983	0.543	0.436	1.633	1.369
1984	0.425	0.469	1.767	1.299
1985	0.37	0.415	1.57	1.138
1986	0.359	0.411	1.562	1.11
1987	0.366	0.43	1.642	1.142
1988	0.385	0.465	1.787	1.211
1989	0.408	0.512	1.976	1.305
1990	0.44	0.572	2.221	1.428

	Government Total	Federal	State and Local	Self Employed	Region Total
1978	0.07	0.	0.07	0.069	0.79
1979	0.482	0.	0.482	0.247	2.866
1980	1.061	0	1.061	0.421	4.964
1981	1.692	0.	1.692	0.484	5.757
1982	1.47	0.	1.47	0.447	5.385
1983	1.618	0.	1.618	0.523	6.39
1984	1.868	0.	1.868	0.539	6.645
1985	1.546	0.	1.546	0.464	5.744
1986	1.42	0.	1.42	0.444	5.538
1987	1.373	0.	1.373	0.449	5.637
1988	1.363	0.	1.363	0.468	5.926
1989	1.376	0.	1.376	0.497	6.336
1990	1.404	0.	1.404	0.535	6.883

TABLE 3.3-12

$1.00/Mcf: IMPACT ON EMPLOYMENT, BY INDUSTRY: STATE
(Thousands of Wage Earners)

	Ag, Fish, Forest	Mining	Construction	Manufacturing
1978	0.	0.	2.326	0.
1979	0.	0.	5.579	0.
1980	0.	0.	6.403	0.
1981	0.	0.03	2.347	0.
1982	0.	0.07	2.39	0.
1983	0.	0.13	3.035	0.
1984	0.	0.19	0.641	0.
1985	0.	0.19	0.551	0.
1986	0.	0.19	0.528	0.
1987	0.	0.19	0.531	0.
1988	0.	0.19	0.549	0.
1989	0.	0.19	0.577	0.
1990	0.	0.19	0.615	0.

	Transportation Communications Public Utilities	Finance	Services	Trade
1978	0.334	0.119	1.062	1.054
1979	0.899	0.358	3.066	2.99
1980	1.195	0.541	4.185	4.01
1981	0.776	0.501	2.695	2.425
1982	0.769	0.488	2.88	2.564
1983	0.946	0.601	3.6	3.155
1984	0.651	0.573	2.443	1.919
1985	0.562	0.504	2.152	1.672
1986	0.541	0.497	2.116	1.617
1987	0.549	0.516	2.198	1.648
1988	0.574	0.555	2.358	1.73
1989	0.607	0.605	2.572	1.843
1990	0.65	0.671	2.848	1.99

	Government Total	Federal	State and Local	Self Employed	State Total
1978	0.202	0.	0.202	0.193	5.289
1979	1.395	0.	1.395	0.582	14.87
1980	3.073	0.	3.073	0.872	20.278
1981	4.903	0.	4.903	0.842	14.519
1982	4.258	0.	4.258	0.765	14.183
1983	4.686	0.	4.686	0.882	17.035
1984	5.412	0.	5.412	0.834	12.661
1985	4.478	0.	4.478	0.711	10.82
1986	4.114	0.	4.114	0.674	10.275
1987	3.979	0.	3.979	0.672	10.282
1988	3.949	0.	3.949	0.69	10.596
1989	3.986	0.	3.986	0.72	11.101
1990	4.067	0.	4.067	0.743	11.795

Impact on Real Wages and Salaries

Wages and salaries impact in general follows the same pattern as employment impact. (Table 3.3-13). Statewide, payroll impact peaks in 1980, creating an additional $167 million in real wage and salary income in that year. Payroll impact in the Fairbanks and Interior regions peaks in 1980, falls dramatically in 1984, and then grows slowly through 1990. By 1990, the Anchorage region contains 55 percent of total statewide impact for all three gas prices.

As was the case for employment and gross product, mining and construction payroll are most directly affected in the Interior and Fairbanks, with construction falling off dramatically upon project completion and mining payroll impact remaining relatively constant. (Tables 3.3-14, 3.3-15). Fairbanks, in addition, has significant impacts in the support sectors and government. Anchorage experiences favorable impact in all sectors with the exception of agriculture, fisheries, forestry, and manufacturing. (Tables 3.3-16, 3.3-17). Here again, the support sectors and government absorb the largest portion of the wage and salary income impact. As was the case in employment, the price of natural gas appeared to have little effect on regional impact distribution.

Population

The impact of the gas pipeline, as demonstrated in the previous discussion, increases payroll and gross product. This, in turn, has effects on personal income which the simulation model uses to estimate statewide immigration. The results (Table3.3-18) of the gas line simulation indicate a statewide population impact in 1990 of 19,456 for $0.50 gas, 26,479 for $1.00 gas, and 33,547 for $1.50 gas. Scenario construction estimates a statewide peak population impact of 28,692 in 1980 for all cases. Thus by 1990, only in the $1.50 gas case is the impact greater than the construction boom peak.

Regional population impacts are related to regional employment; hence, the magnitude of impact will tend to follow the employment impacts. For Anchorage, this implies a peak population impact, during the pipeline development phase, of around 10,000 for all three cases, and a 1990 population impact of 10,692 for $0.50 gas, 14,742 for $1.00 gas, and 18,783 for $1.50 gas. The Interior impact amounts to a peak of 14,354 during the construction phase for all cases, and a 1990 population impact of 715 for $0.50 gas, 845 for $1.00 gas, and 978 for $1.50 gas. The Fairbanks impact amounts to a peak of 8,413 for the construction phase in all cases and a 1990 impact of 2,279 for $0.50 gas, 2,991 for $1.00 gas, and 3,707 for $1.50 gas.

Table 3.3-13

IMPACT ON REAL WAGES AND SALARIES PAID, BY REGION
(Millions of 1967 Dollars)

PRICE = 50¢/mcf

	Anchorage	Interior	Fairbanks	State
1978	5.332	22.847	18.097	47.3
1979	19.542	56.311	44.583	127.44
1980	34.248	64.978	53.042	167.958
1981	36.816	20.742	22.879	103.654
1982	31.791	23.695	22.401	96.529
1983	36.43	30.921	28.044	115.241
1984	36.683	2.599	10.053	72.656
1985	29.558	2.384	8.277	58.39
1986	27.723	2.331	7.725	54.254
1987	28.103	2.357	7.654	54.25
1988	29.707	2.42	7.805	56.339
1989	32.074	2.483	8.102	59.694
1990	35.202	2.558	8.5	64.182

PRICE = $1.00/mcf

	Anchorage	Interior	Fairbanks	State
1978	5.332	22.847	18.097	47.3
1979	19.542	56.311	44.583	127.44
1980	34.248	64.978	53.042	167.958
1981	40.272	20.848	23.749	110.529
1982	38.133	23.902	23.958	109.
1983	45.771	31.216	30.27	133.325
1984	48.302	2.902	12.762	94.817
1985	42.294	2.703	11.187	82.399
1986	41.285	2.659	10.746	79.477
1987	42.53	2.696	10.776	80.698
1988	45.215	2.775	11.047	84.298
1989	48.874	2.855	11.495	89.49
1990	53.658	2.949	12.081	96.307

PRICE = $1.50/mcf

	Anchorage	Interior	Fairbanks	State
1978	5.332	22.847	18.097	47.3
1979	19.542	56.311	44.583	127.44
1980	34.248	64.978	53.042	167.958
1981	43.73	20.955	24.62	117.408
1982	44.497	24.108	25.519	121.511
1983	55.154	31.513	32.502	151.477
1984	59.985	3.207	15.481	117.081
1985	55.127	3.024	14.114	106.568
1986	54.955	2.99	13.785	104.878
1987	57.081	3.038	13.917	107.345
1988	60.869	3.132	14.312	112.487
1989	65.846	3.229	14.914	119.554
1990	72.268	3.344	15.69	128.696

TABLE 3.3-14

$1.00/Mcf: IMPACT ON REAL WAGES AND SALARIES PAID, BY REGION: INTERIOR
(Millions of 1967 Dollars)

	Ag, Fish, Forest	Mining	Construction	Manufacturing
1978	0.	0.	40.618	0.
1979	0.	0.	99.638	0.
1980	0.	0.	115.693	0.
1981	0.	0.493	36.168	0.
1982	0.	1.21	39.463	9.
1983	0.	2.363	53.26	0.
1984	0.	3.632	0.	0.
1985	0.	3.819	0.	0.
1986	0.	4.016	0.	0.
1987	0.	4.223	0.	0.
1988	0.	4.44	0.	0.
1989	0.	4.669	0.	0.
1990	0.	4.909	0.	0.

	Transporation Communications Public Utilities	Finance	Services	Trade
1978	0.406	0.	8.119	3.759
1979	1.	0.	23.505	11.006
1980	1.195	0.	30.371	14.225
1981	0.434	0.	10.356	4.792
1982	0.461	0.	14.697	6.94
1983	0.647	0.	19.985	9.297
1984	0.116	0.	1.44	0.622
1985	0.115	0.	1.348	0.569
1986	0.119	0.	1.375	0.572
1987	0.126	0.	1.496	0.617
1988	0.135	0.	1.675	0.686
1989	0.146	0.	1.838	0.746
1990	0.16	0.	2.024	0.813

	Government Total	Federal	State and Local	Region Total
1978	0.068	0.	0.068	52.969
1979	0.498	0.	0.498	135.647
1980	1.17	0.	1.17	162.655
1981	1.991	0.	1.991	54.235
1982	1.843	0.	1.843	64.614
1983	2.162	0.	2.162	87.714
1984	2.662	0.	2.662	8.472
1985	2.349	0.	2.349	8.2
1986	2.301	0.	2.301	8.382
1987	2.372	0.	2.372	8.834
1988	2.51	0.	2.51	9.446
1989	2.701	0.	2.701	10.1
1990	2.938	0.	2.938	10.844

TABLE 3.3-15

$1.00/Mcf: IMPACT ON REAL WAGES AND SALARIES PAID, BY INDUSTRY: FAIRBANKS
(Millions of 1967 Dollars)

	Ag, Fish, Forest	Mining	Construction	Manufacturing
1978	0.	0.	30.244	0.
1979	0.	0.	74.097	0.
1980	0.	0.	86.311	0.
1981	0.	0.406	27.483	0.
1982	0.	0.996	29.861	0.
1983	0.	1.945	40.191	0.
1984	0.	2.99	1.053	0.
1985	0.	3.144	1.001	0.
1986	0.	3.306	1.007	0.
1987	0.	3.476	1.03	0.
1988	0.	3.655	1.057	0.
1989	0.	3.843	1.116	0.
1990	0.	4.041	1.187	0.

	Transportation Communications Public Utilities	Finance	Services	Trade
1978	3.213	1.014	3.299	3.626
1979	8.597	2.659	8.553	9.357
1980	11.007	3.368	10.723	11.665
1981	5.246	1.605	5.066	5.469
1982	5.74	1.724	5.381	5.785
1983	7.839	2.318	7.164	7.667
1984	3.526	1.04	3.185	3.384
1985	3.297	0.97	2.945	3.106
1986	3.386	0.992	2.984	3.125
1987	3.634	1.059	3.155	3.283
1988	3.991	1.155	3.41	3.526
1989	4.451	1.279	3.741	3.846
1990	5.014	1.431	4.145	4.237

	Government Total	Federal	State and Local	Region Total
1978	0.562	0.	0.562	41.957
1979	4.133	0.	4.133	107.396
1980	9.702	0.	9.702	132.776
1981	16.507	0.	16.507	61.782
1982	15.281	0.	15.281	64.766
1983	17.928	0.	17.928	85.053
1984	22.074	0.	22.074	37.252
1985	19.474	0.	19.474	33.937
1986	19.076	0.	19.076	33.875
1987	19.668	0.	19.668	35.304
1988	20.814	0.	20.814	37.608
1989	27.394	0.	27.394	40.67
1990	24.361	0.	24.361	44.417

TABLE 3.3-16

$1.00/Mcf: IMPACT ON REAL WAGES AND SALARIES PAID, BY INDUSTRY: ANCHORAGE (Millions of 1967 Dollars)

	Ag, Fish, Forest	Mining	Construction	Manufacturing
1978	0.	0.	0.809	0.
1979	0.	0.	3.009	0.
1980	0.	0.	5.348	0.
1981	0.	0.	6.415	0.
1982	0.	0.	6.137	0.
1983	0.	0.	7.447	0.
1984	0.	0.	8.018	0.
1985	0.	0.	7.216	0.
1986	0.	0.	7.214	0.
1987	0.	0.	7.604	0.
1988	0.	0.	8.254	0.
1989	0.	0.	9.113	0.
1990	0.	0.	10.223	0.

	Transportation Communications Public Utilities	Finance	Services	Trade
1978	3.2	0.76	2.219	4.02
1979	9.578	3.042	8.877	12.605
1980	14.437	5.809	16.95	19.8
1981	11.326	7.406	21.567	18.26
1982	11.713	7.674	22.381	18.349
1983	15.208	10.073	29.419	23.248
1984	12.662	11.524	33.572	22.012
1985	11.706	10.854	31.481	20.104
1986	12.034	11.434	33.048	20.435
1987	13.024	12.728	36.684	21.892
1988	14.543	14.649	42.116	24.194
1989	16.401	17.138	49.167	27.121
1990	18.753	20.383	58.33	30.867

	Government Total	Federal	State and Local	Region Total
1978	1.354	0.	1.354	12.362
1979	9.961	0.	9.961	47.072
1980	23.387	0.	23.387	85.731
1981	39.79	0.	39.79	104.764
1982	36.833	0.	39.833	103.086
1983	43.215	0.	43.215	128.61
1984	53.209	0.	53.209	140.997
1985	46.942	0.	46.942	128.302
1986	45.981	0.	45.981	130.145
1987	47.408	0.	47.408	139.34
1988	50.171	0.	50.171	153.926
1989	53.979	0.	53.979	172.918
1990	58.72	0.	58.72	197.277

TABLE 3.3-17

$1.00/Mcf: IMPACT ON REAL WAGES AND SALARIES PAID, BY INDUSTRY: STATES
(Millions of 1967 Dollars)

	Ag, Fish, Forest	Mining	Construction	Manufacturing
1978	0.	0.	71.956	0.
1979	0.	0.	178.796	0.
1980	0.	0.	212.138	0.
1981	0.	0.899	78.263	0.
1982	0.	2.207	83.184	0.
1983	0.	4.309	110.095	0.
1984	0.	6.622	20.492	0.
1985	0.	6.963	18.289	0.
1986	0.	7.321	18.166	0.
1987	0.	7.699	18.987	0.
1988	0.	8.095	20.386	0.
1989	0.	8.511	22.259	0.
1990	0.	8.95	24.618	0.

	Transportation Communications Public Utilities	Finance	Services	Trade
1978	6.968	1.799	13.784	11.544
1979	19.797	5.881	42.005	33.955
1980	27.814	9.587	60.575	47.984
1981	18.828	9.714	41.376	32.288
1982	19.779	10.057	46.636	34.621
1983	25.903	13.179	61.609	44.636
1984	18.68	13.57	44.518	31.068
1985	17.17	12.718	41.445	28.253
1986	17.556	13.337	43.076	28.522
1987	18.929	14.765	47.307	30.325
1988	21.019	16.885	53.649	33.21
1989	23.612	19.622	61.848	36.882
1990	26.873	23.165	72.406	41.547

	Government Total	Federal	State and Local	State Total
1978	3.61	0.	3.61	109.662
1979	26.552	0.	26.552	306.987
1980	62.338	0.	62.338	420.437
1981	106.06	0.	106.06	287.527
1982	98.179	0.	98.179	294.664
1983	115.192	0.	115.192	374.625
1984	141.83	0.	141.83	276.781
1985	125.125	0.	125.125	249.961
1986	122.565	0.	122.565	250.539
1987	126.368	0.	126.368	264.387
1988	133.73	0.	133.73	286.973
1989	143.883	0.	143.883	316.821
1990	156.52	0.	156.519	354.078

Table 3.3-18

IMPACT ON POPULATION BY REGION
(Thousands of Persons)

PRICE = 50¢/mcf

	Anchorage	Interior	Fairbanks	State
1978	0.115	4.567	2.815	6.537
1979	1.705	11.976	6.893	19.458
1980	4.92	14.354	8.413	28.692
1981	8.449	4.76	4.355	23.28
1982	7.945	5.997	4.279	23.191
1983	8.886	7.617	5.154	26.708
1984	10.736	0.792	2.751	21.721
1985	9.734	0.723	2.486	19.473
1986	9.485	0.694	2.373	18.69
1987	9.545	0.693	2.316	18.497
1988	9.799	0.704	2.283	18.616
1989	10.175	0.709	2.273	18.936
1990	10.692	0.715	2.279	19.456

PRICE $1.00/mcf

	Anchorage	Interior	Fairbanks	State
1978	0.15	4.567	2.815	6.537
1979	1.705	11.976	6.893	19.458
1980	4.92	14.354	8.413	28.692
1981	9.03	4.778	4.496	24.48
1982	9.065	6.031	4.542	25.45
1983	10.586	7.676	5.536	30.064
1984	12.903	0.878	3.23	25.944
1985	12.207	0.819	3.018	24.225
1986	12.222	0.797	2.945	23.864
1987	12.552	0.803	2.922	24.079
1988	13.107	0.821	2.924	24.634
1989	13.815	0.832	2.95	25.424
1990	14.724	0.846	2.991	26.479

PRICE = $1.50/mcf

	Anchorage	Interior	Fairbanks	State
1978	0.115	4.567	2.815	6.537
1979	1.705	11.976	6.893	19.458
1980	4.92	14.354	8.413	28.692
1981	9.612	4.796	4.637	25.682
1982	10.188	6.065	4.805	27.714
1983	12.292	7.736	5.919	33.433
1984	15.082	0.965	3.71	30.183
1985	14.697	0.915	3.552	29.001
1986	14.98	0.901	3.519	29.066
1987	15.581	0.914	3.532	29.694
1988	16.441	0.939	3.568	30.69
1989	17.486	0.957	3.629	31.958
1990	18.783	0.978	3.707	33.547

Personal Income

Table 3.3-19 contains the results of the gas pipeline simulation statewide impact on personal income, real personal income, and real personal per capita income for each of the three postulated gas prices. The trend in both personal income and real personal income impacts is essentially the same for each of the three assumed gas prices. That is, the impact is highest during the construction phase, peaking in 1980 and again in 1983, when additional impact ranges between $368.2 million and $483.9 million for personal income and $131 million and $172.2 million for real personal income, depending on the assumed gas price. The size of impact then declines slightly, after which it increases through 1990, when the impact ranges between $265.8 million and $532.9 million for personal income, and $72.3 million to $145.0 million for real personal income.

The model projects a negative impact on real personal per capita income following the construction phase, which is more pronounced for $0.50 gas than for $1.50 gas. This curious impact is undoubtedly the result of several factors. First, high paying construction employment attracts in-migrants. Second, once the construction is completed, continued economic impacts are in the relatively lower paying support and government sectors. Hence, even though wages and salaries grow over the simulated time period (see Table 3.3-13), population increases caused by the gas pipeline causes wages and salaries per capita for the impact simulation to fall below the level in the base case following project completion, as more people compete for jobs in the growing support and government sectors.

It should be noted, however, that there are favorable impacts on per capita personal income during the construction phase. This impact peaks in 1980, when for all three assumed gas prices there is an increase of $141.80 per capita.

State and Local Government Revenues and Expenditures

The construction and operation of the proposed pipeline would have a substantial impact on state and local revenues and expenditures, no matter which assumption is made, concerning the price of gas at the wellhead (Table 3.3-20). Under each assumption, the additions to annual state revenues rise to $93 million in 1980, of which $40.3 million, or about 43 percent, are provided directly by petroleum sector taxes and charges. The next largest component, at 17 percent, is the individual income tax; a fairly substantial portion of the revenues collected under this and the corporate income tax will be paid by workers and businesses directly employed on the pipeline. Additional local revenues ($13 million of which are projected by the MAP model to be shared

Table 3.3-19

IMPACT ON PERSONAL INCOME AND PER CAPITA INCOME

	Personal Income (mil$)	Real Personal Income (mil$)	Real Personal Per Capita Income (mil$)
PRICE=50¢/MCF			
1978	126.2	54.4	63.3
	352.4	146.3	138.7
	481.4	192.3	141.8
	308.2	118.5	37.2
	297.4	110.0	14.7
	368.2	131.0	19.5
	240.9	82.5	-18.3
	201.0	66.3	-25.5
	193.8	61.5	-27.1
	201.1	61.4	-26.2
	216.7	63.7	-24.4
	238.3	67.3	-22.0
1990	265.8	72.3	-19.4
PRICE=$1.00/MCF			
1978	126.2	54.4	63.3
	352.4	146.3	138.7
	481.4	192.3	141.8
	349.0	134.2	47.1
	374.3	138.5	28.7
	483.9	172.2	36.5
	388.2	133.0	1.5
	366.8	120.9	-6.0
	374.6	118.8	-9.8
	397.9	121.5	-11.5
	432.6	127.1	-11.8
	477.1	134.8	-11.0
1990	532.9	145.0	-9.4

TABLE 3.3-20

IMPACT ON STATE AND LOCAL GOVERNMENT REVENUES AND EXPENDITURES
(Million of Dollars)

	Individual Income Tax	Corporate Income Tax	Sales and Gross Rec. Tax	Misc. Taxes & Crgs.	Petroleum Revenues	Total State Rev.	Total State Exp.	Total Local Rev.	Total Local Exp.	State & Local Expenditures (adj. for Rev. Sharing)
Price-50¢/Mcf										
1978	0.0	0.0	0.0	0.0	10.9	10.9	8.2	1.4	1.4	8.2
1979	5.5	1.2	1.9	5.0	30.6	48.6	41.0	25.7	25.5	59.8
1980	16.1	3.6	5.2	14.6	40.3	93.2	83.1	70.3	69.4	139.5
1981	22.9	5.2	7.0	20.5	74.3	150.1	131.5	104.4	102.7	214.0
1982	15.2	3.5	4.4	13.5	90.8	143.0	120.3	75.1	73.5	176.2
1983	15.4	3.6	4.2	13.6	105.8	160.6	134.2	80.0	77.8	193.0
1984	19.8	4.7	5.1	17.4	113.4	185.0	156.7	103.2	99.9	235.1
1985	13.1	3.2	3.3	11.6	113.4	165.3	136.9	73.8	71.3	189.7
1986	11.2	2.7	2.7	9.8	113.4	160.8	132.4	65.3	62.9	177.7
1987	11.0	2.7	2.6	9.6	113.4	162.4	134.1	65.8	63.2	179.7
1988	11.7	2.9	2.7	10.2	113.4	167.1	138.7	70.8	67.8	188.5
1989	13.0	3.3	2.9	11.3	113.4	173.7	145.3	78.8	75.2	202.0
1990	14.7	3.8	3.1	12.7	113.4	181.8	153.4	89.6	85.2	219.2
Price-$1.00/Mcf										
1978	0.0	0.0	0.0	0.0	10.9	10.9	8.2	1.4	1.4	8.2
1979	5.5	1.2	1.9	5.0	30.6	48.6	41.0	25.7	25.5	59.8
1980	16.1	3.6	5.2	14.6	40.3	93.2	83.1	70.3	69.4	139.5
1981	22.9	5.2	7.0	20.5	104.4	180.2	154.1	107.8	106.0	236.5
1982	16.2	3.7	4.7	14.4	135.9	191.9	157.9	84.5	82.7	217.5
1983	17.3	4.1	4.7	15.4	166.0	228.7	187.2	95.5	92.8	253.7
1984	22.9	5.5	5.9	20.2	181.1	265.5	220.2	124.9	120.9	310.9
1985	17.2	4.1	4.3	15.1	181.1	250.0	204.7	100.0	96.5	273.6
1986	15.8	3.8	3.9	13.8	181.1	248.6	203.3	94.5	91.0	267.3
1987	16.1	4.0	3.8	14.1	181.1	253.3	208.0	98.1	94.2	274.9
1988	17.5	4.3	4.0	15.2	181.1	261.1	216.0	106.7	102.1	290.2
1989	19.5	4.9	4.3	16.9	181.1	271.7	226.4	119.3	113.8	311.3
1990	22.0	5.6	4.7	19.0	181.1	284.2	238.9	135.6	128.9	337.8

TABLE 3.3-20 (cont'd)

IMPACT ON STATE AND LOCAL GOVERNMENT REVENUES AND EXPENDITURES
(Millions of Dollars)

	Individual Income Tax	Corporate Income Tax	Sales and Gross Rec. Tax	Misc. Taxes & Crgs.	Petroleum Revenues	Total State Rev.	Total State Exp.	Total Local Rev.	Total Local Exp.	State & Local Expenditures (adj. for Rev. Sharing)
Price-$1.50/Mcf										
1978	0.0	0.0	0.0	0.0	10.9	10.9	8.2	1.4	1.4	8.2
1979	5.5	1.2	1.9	5.0	30.6	48.6	41.0	25.7	25.5	59.8
1980	16.1	3.6	5.2	14.6	40.3	93.2	83.1	70.3	69.4	139.5
1981	22.9	5.2	7.0	20.5	134.5	210.3	176.6	111.2	109.4	259.0
1982	17.2	3.9	5.0	15.3	181.1	240.9	195.7	93.9	91.8	258.9
1983	19.4	4.5	5.2	17.1	226.3	296.9	240.4	110.9	107.9	314.4
1984	26.0	6.2	6.7	22.9	248.9	346.1	283.9	146.7	141.9	386.9
1985	21.2	5.1	5.3	18.7	248.9	334.9	272.7	126.3	121.9	357.9
1986	20.4	5.0	5.0	17.9	248.9	336.7	274.4	123.9	119.3	357.4
1987	21.3	5.2	5.1	18.6	248.9	344.5	282.2	130.6	125.4	370.7
1988	23.3	5.8	5.3	20.2	248.9	355.8	293.6	142.9	136.8	392.5
1989	26.0	6.6	5.7	22.5	248.9	370.1	309.8	160.2	152.8	421.4
1990	29.5	7.6	6.2	25.4	248.9	387.0	324.8	182.2	173.2	457.2

revenue from the state) will amount to $70.3 million in each case. Additional state and local expenditures, adjusted for revenue sharing, amount to almost $140 million per year by 1980.

In 1981, the gas begins to flow, and the three cases diverge. State revenues peak twice -- once in 1984 and once in 1990. Total impact in 1984 ranges from $185 million with 50 cent gas to $346 million with $1.50 gas. Thereafter, total state revenues impacts decline briefly because construction activity ends, but then the growth of the state economy in response to government spending takes over, and steady growth in revenues continues to 1990, with revenues impacts ranging from $182 million in the $0.50 case to $387 million in the $1.50 case. Total local revenues impacts follow a similar pattern, but peak three times -- 1981, 1984, and 1990.

The additional state revenues in the first peak year of 1984 are mainly from direct taxes and royalties on the gas industry. These range from 61 percent of the total (contrasted with 43 percent in the construction year 1980) for the price of $0.50/Mcf, to 72 percent (contrasted with 43 percent) in the case of $1.50/Mcf. The next largest component is again the individual income tax, with impacts ranging from 11 percent with 50 cent gas to 7.5 percent with $1.50 gas, and miscellaneous taxes and charges are a close third. By 1990, petroleum sector (gas) revenues have declined in relative importance in the $1.00 and $1.50/Mcf cases, but in all cases this direct source still provides well over half of all state revenue additions.

Impacts on expenditures tend to follow the pattern established by revenues in both the case of the state government and in the case of the local government. There is a peak in combined additional spending during the first production year (made possible by production revenues) of between $214 and $259 million. When the line is fully operational and up to maximum capacity in 1984, the additional revenues make possible additional combined expenditures of between $235 and $386 million. With the end of the construction boom, spending tails off, but the impact by 1990 in response to longer term growth still ranges from $219 million to $457 million.

In per capita terms, the impacts on state and local revenues and expenditures are not nearly as impressive. Referring to the key turning point years of 1981, 1984, and 1990 in Table 3.3-20, another table has been constructed (Table 3.3-21) which shows state revenues and state and local expenditures in per capita and real (1967 dollar) per capita terms for these years. After the initial construction period, which shows reduced per capita revenues and expenditures because of rapid increases in State population associated with pipeline construction impact, the impact on both state

TABLE 3.3-21

IMPACT ON PER CAPITA AND REAL PER CAPITA REVENUES AND EXPENDITURES OF STATE AND LOCAL GOVERNMENT

	Per Capita State Revenues (DOLLARS)	Real Per Capita State Revenues (1967 DOLLARS)	Per Capita State Expenditures (DOLLARS)	Real Per Capita State Expenditures (1967 DOLLARS)	Per Capita State and Local Expenditures (DOLLARS)	Real Per Capita State and Local Expenditures (1967 DOLLARS)
PRICE=50¢/Mcf						
1978	-24.4	-10.4	-23.9	-10.3	-36.2	-15.6
1981	81.0	31.1	75.1	28.9	176.7	67.9
1984	73.9	25.3	62.5	21.4	124.2	42.5
1990	47.8	13.0	35.9	9.8	50.2	13.7
PRICE=50¢/Mcf						
1978	-24.4	-10.4	-23.9	-10.3	-36.2	-15.6
1981	124.9	48.0	106.9	41.1	205.8	79.1
1984	152.8	52.3	122.5	42.0	191.5	65.6
1990	107.5	29.2	83.5	22.7	113.8	30.9
PRICE=50¢/Mcf						
1978	-24.4	-10.4	-23.9	-10.3	-36.2	-15.6
1981	168.5	64.8	138.5	53.2	234.8	90.3
1984	230.8	79.1	181.9	62.3	258.1	88.4
1990	166.3	45.2	130.6	35.5	176.8	48.1

revenues and expenditures is positive, but minimal. In real terms, the largest measured impact on state revenue is only 79 dollars per person in 1984. Population increases, in response to increased personal incomes in Alaska and increases in employment opportunities, reduce even this impact to 45 dollars in real terms by 1990. Much the same story can be told for the state expenditures and for state and local combined expenditures. The direct construction period impact actually reduces the level of spending per capita; and while the state enjoys a brief increase in potential spending when gas begins to flow, the impact per capita is both small and short-lived.

Within those local communities directly impacted by the construction and operation of the pipeline, the revenue effect of pipeline construction would show considerable variation. The major staging area for construction would be Fairbanks, as it is for the trans-Alaska oil pipeline. Drawing on the recent experience of that community, one would project a significant increase in the value of property in the community as a result of both an increase in the stock of capital resources in the community and a demand generated increase in property values. For example, between 1974 and 1975, the estimated full value of property in Fairbanks City and the North Star Borough increased 40 percent. Receipts from the property and sales taxes increased sharply between 1974 and 1975. In both the city and the Borough, property tax revenues were up 33 percent and general sales tax revenues 53 percent. Expenditures in the city were up 13 percent and in the Borough 69 percent over the previous year. The large population influx associated with trans-Alaska pipeline-related activities has had a significant impact on the ability of the community to provide both private and public services. Ability to respond is a function of the position of the community at the time of impact. One would not expect the same relative impact on either revenues or expenditures from the proposed gas pipeline as the trans-Alaska oil pipeline, because of an increase in the supply of services now available,which was a response to the construction of that pipeline.

In the North Slope Borough, the revenue impact of the construction of the gas line is more problematical. The line would pass within the boundary of the Borough for a significant distance and thus would come within its taxing jurisdiction. Since petroleum transportation facilities are presently taxed by the State government with transfers to local communities based upon a formula, the Borough could receive additional property taxes according to the guidelines of the formula at the time of pipeline installation. At present, the ceiling within which the local community must stay in collecting property tax from petroleum production and pipeline property,can be calculated in two ways. It can be figured so that the yield per capita from the total property tax does not exceed $1,000, or so that the yield is derived from a tax base which does not exceed the product of 225 percent of average per capita assessed value of property in the state and the number of residents in the taxing municipality. The fomulae are generous to the local community and allow growth in the yield as the tax base grows. The stipulations of the formulae at any time are essentially a political concern.

Requirements for services provided by local communities in the Borough would not increase commensurate with the potential increase in revenues. This is essentially the result of the nature of the work camps associated with the line and, in all likelihood, the operations and maintenance thereafter. The camps are self-contained, with services provided from Fairbanks and Anchorage. Construction and operation support facilities would, to a certain extent, be in place as a result of the trans-Alaska pipeline, and additional infrastructure would be provided by a combination of private, state, and local interests.

The rural regions of the state along the proposed pipeline route would experience little direct revenue impact because of a thin tax base and little local government structure. The presence of the line within a region might serve as an incentive for a region to incorporate to take advantage of the tax base created by the pipeline itself. Requirements for the provision of human services would increase only slightly in the region north of Fairbanks, because of its sparse population. Since population density is higher along the portion of the route southeast of Fairbanks, the requirements for services would increase there somewhat more. Primarily these services would be provided by the state, because of a lack of local government structure. A major uncertainty at this time is the status of the haul road constructed for the trans-Alaska oil pipeline to supply construction operations in the northern part of the state. Upon completion of the line, the state will take over the road. There is debate whether to open it to private vehicles for recreational and other uses. If this were done, demand on the road created by construction would add to demand created by recreational use. In the section southeast of Fairbanks, the existing road system would be employed during construction, greatly adding to required expenditures on maintenance.

Impacts on revenues and expenditures in Anchorage would be more generalized. The property tax base would rise not only as a direct result of pipeline construction support activities, but also as a result of increased state incomes generated by government spending at the state level. Requirements for the services provided by local government and the private sector would rise but against the background of general rapid growth of the Anchorage economy, the impact would be less than that created by the trans-Alaska oil pipeline.

Special Economic Impacts

There are three special topics in economic impacts which the preceding consideration does not address. These are the impact of gas pipeline development on the Native regional and village corporations, the impact of the pipeline on in-state gas use in Alaska, and the impact of the construction of the Canadian section of the line on the Alaskan economy. There is not a formal model or analysis to guide these comments, so the most that can be done is to identify the effects and give some notion as to their direction.

By the terms of the Alaska Native Claims Settlement Act, there were 12 regional corporations and one corporation for Alaska Natives living outside of Alaska. A specific system of payments was included in the Act by which the Federal and State governments agreed to buy the Native aboriginal land claims. These payments are made to the corporations, which in turn are required to redistribute part of the received funds to their individual stockholders and to the village corporations formed in their regions. Only about 10 percent goes directly to the Natives as individuals. The rest, about $63 million in each of the 1974, 1975 and 1976 fiscal years, becomes the contributed capital of either the village or regional corporations.

Several of the corporations have been inclined to invest at least part of their money in pipeline or construction service-related businesses. For example, Cook Inlet Regional Corporation has participated in two joint venture contracts on the trans-Alaska oil pipeline. Ahtna supplies gravel to Alyeska Pipeline Service Company and has acquired a joint venture agreement with Rogers and Babler, a construction firm which has done work previously for Alyeska. NANA Regional Corporation has four companies involved in the trans-Alaska oil pipeline: its Security Systems Division provided guards for the northern pipeline camps, NANA Oilfield Services provides lodging and food at Deadhorse along with electricity and catering services, NANA Environmental Systems builds waste disposal facilities in the Arctic,and NANA Commercial Catering operates at the Ship Creek and Deadhorse Camps. Bering Straits Native Corporation owns an airline (Pacific Alaska), a trucking firm (Alaska Truck Transport), and Coastal Barge Lines, all capable of serving new development in Alaska. In addition, this corporation now owns Central Construction of Seattle, having previously worked with this firm to build a $14 million dollar highway from Skagway to the Canadian border. Doyon's joint venture with Alaska International Construction maintains the pipeline haul road north of the Yukon, and this corporation has expressed interest in other construction and mineral-related businesses. Finally, Arctic Slope Regional Corporation has been involved with National Mechanical on pipeline wrapping at Valdez and maintenance at Prudhoe Bay. Arctic Slope also wants to bid on school construction in its region. Several corporations have thus demonstrated interest and capability to do pipeline-related or construction work.

If these corporations were to displace potential contracting firms from the Lower 48 in the proposed project, reduction of the leakage of profits and some other non-wage payments to the Lower 48, to the extent that the regional corporations reinvest a greater proportion of pipeline after-tax profits in Alaska, could result. This would reduce the cost and enhance the availability of venture capital in Alaska, possibly increasing the growth rate above what the MAP model would predict. Also, to the extent the village and regional corporations are successful bidders and their ventures profitable, they would increase the wealth position of their Native stockholders, who as a group have the lowest per capita incomes in Alaska.

The MAP model computer runs were based on the assumption that the entire assumed final production level of 2.25 Bcf/day of gas would be exported from Alaska, and no consideration was given to in-state gas use in the Fairbanks area or elsewhere along the pipeline. There is potential for such gas use in Fairbanks in at least two ways. Space heating is an obvious use of gas in the Fairbanks vicinity, since most homes are currently heated with oil, wood, or electricity. Since 1973, the price of this shipped-in oil has increased dramatically, as has the cost of electricity, a large part of which has been generated with oil-fired gas turbines. With the completion of the trans-Alaska oil pipeline and a small (30,000 b/d) refinery at North Pole, it is expected that the cost of heating fuels to the utilities and consumers will drop; however, gas could be made available as a substitute fuel. The impact on the Fairbanks economy and state economy of such a substitution in heating and electricity would have to be the subject of a separate study.

Finally, the impacts shown on the Alaskan economy by the MAP model are those produced only by construction and maintenance of the Alaskan portion of the line, using the same basic staging areas as were used for the trans-Alaska oil pipeline. However, it may be possible for other Alaskan ports to be used as staging areas for Canadian section construction, e.g. Haines and Skagway. To the extent that different ports and staging areas such as Haines and Skagway are used to support the pipeline in Alaska, there will be some regional re-distribution of effects within Alaska during construction, but the long-term statewide regional impacts ought to be about the same as shown in the MAP model simulations.

3.3.3 Impact on the Human Environment (Social Effects)

The social effects of the Alcan pipeline would include changes at the individual, family, and community levels. The following discussion of these effects is based on a breakdown of communities into five categories:

A. Major support centers (Anchorage, Fairbanks)

B. Major staging areas (Fairbanks)

C. Construction camp locations (Tok, Northway, Delta, and camps located north of Fairbanks)

D. Communities along the pipeline corridor and major supply corridors (approximately 11 small Native communities, 5 small non-Native communities)

E. Communities exporting labor (throughout Alaska)

Within each of the above categories the projected social effects would differ by community according to at least the following factors:

1. Extent of experience with the construction phase of the trans-Alaska oil pipeline and other major projects (e.g., OCS exploration, highways, defense).

2. Degree and success of community integration with a regional cash economy.

3. Presence of critical limitations to community growth, such as a lack of private land, potable water, employable local manpower, or highway links with the rest of the state.

4. Conflicts with other sectors at the community resource base, such as the tourist industry and subsistence activities.

5. The timing and occupational characteristics of the manpower required for the sector of the gas pipeline in which a given community is located.

6. The extent to which construction activities are based within camps as opposed to nearby towns.

7. Community attitudes toward social change, including alterations in community size, the social characteristics of its resident population, and alteration in the social characteristics of a community's transient population.

8. Community attitudes towards planning.

The social impact of the Alcan pipeline proposal is discussed in the context of the five community categories and eight key factors listed above.[1]

Major Support Centers

The Anchorage region clearly would provide the bulk of the required support services in Alaska. MAP projections indicate a continued high growth rate for the area, and one can expect continued bottlenecks in the expansion of community services. In addition, the scarcity of large lot, single family housing sites would result in an escalation of land prices, an expansion into the agricultural and rural recreational areas in the Matanuska and Susitna Valleys, and a shift to higher density housing.

The incidence of social impacts on the Anchorage population is difficult to project in view of its high turnover rate. Available data for Fairbanks, discussed below, suggest that long-term Anchorage residents are more likely to bear the brunt of social costs, not receive as many of the social and economic benefits, and to prefer the city as it was at an earlier time.

The relatively smooth growth pattern projected for Anchorage is not likely to be observed in Fairbanks due to its heavy dependence on construction employment. Although much of the employment generated by the oil pipeline construction activities is isolated within the construction camps, a substantial portion of the Fairbanks population (22 percent of the households) is currently employed by Alyeska or a subcontractor (see Table 3.3-22).[2] The high proportion of construction manpower among Fairbanks households can be seen in Table 3.3-23. Most of those working on the pipeline have been residing in the Fairbanks area three years or less (see Table 3.3-24). Not surprisingly, it is the newcomers that are primarily deriving the benefits of pipeline impact and the long-term residents who are bearing the costs (see Table 3.3-25).

In part, the negative impacts caused by rapid community growth would not be repeated during the construction of a gas pipeline. The construction boom recently experienced has resulted in significant capital investments in schools, telephone systems, utilities, and private housing stocks. Some support services, however, were transferred from local to absentee ownership, thus increasing the flow of money out of the community.

A further rise in the cost of living, accompanied by shortages of manpower and supplies directed to pipeline construction activities, can be expected during another construction boom. While incomes of Fairbanks households have risen

Table 3.3-22

FAIRBANKS COMMUNITY SURVEY

PIPELINE COMPANY EMPLOYMENT
(percentage distribution)

	Percent
Presently working for pipeline company	22
Trying, interested, or possibly interested in becoming employed by pipeline company	24
Not employed by pipeline company and not interested	54
TOTAL	100
Number of respondents	265

Table 3.3-23

FAIRBANKS COMMUNITY SURVEY

OCCUPATION OF HEAD OF HOUSEHOLD
(percentage distribution)

	Percent
Professional-Technical	24
Managerial-Administrative	15
Sales	4
Clerical	6
Craftsman	23
Operatives	11
Transport	8
Laborers	3
Farm	0
Service	6
TOTAL	100
Number of respondents	257

Table 3.3-24

FAIRBANKS COMMUNITY SURVEY

LENGTH OF RESIDENCE BY PIPELINE COMPANY EMPLOYMENT
(percentage distribution)

Length of Residence	Working for Pipeline Co. Percent	Trying, Interested or Possibly Interested Percent	Not Employed or Interested Percent
Three years or less	69	45	35
Over three to ten years	12	33	16
Over ten years	19	22	49
TOTAL	100	100	100
Number of respondents	59	64	142

Table 3.3-25

FAIRBANKS COMMUNITY SURVEY

LENGTH OF RESIDENCE BY RECEIVING OF BENEFITS OR BEARING COSTS (percentage of distribution)

Length of Residence	Receiving Benefits Percent	Bearing Costs Percent	Neither or Both Percent
Three years or less	61	32	49
Over three to ten years	13	21	22
Over ten years	26	47	29
TOTAL	100	100	100
Number of respondents	67	121	77

over the period of pipeline construction (see Table 3.3-26), pipeline employees earn considerably higher salaries (see Table 3.3-27) with a resultant drain on manpower and loss in status of professional positions.

Since Fairbanks employment will follow a boom-bust pattern with regard to pipeline construction, post-construction social effects of the oil pipeline will, in large part, depend on the speed at which outmigration will occur. Table 3.3-28 indicates that a serious discrepancy may exist between occupational supply and demand. While a substantial 37 percent of those heads of households who are engaged in a professional-technical occupation plan to leave in the next two years, only 21 percent of the blue-collar heads of households have similar plans. A comparison with the occupational distribution of Fairbanks residents presently holding pipeline jobs suggests a surplus of blue-collar workers (see Table 3.3-29) . Furthermore, 40 percent of those residents here three years or less have no plans to move from Fairbanks (see Table 3.3-30) . A trans-Alaska gas pipeline route may mitigate a manpower surplus, at least temporarily, smoothing the changes in economic activity. A delay in gas pipeline construction might, however, aggravate the negative social impacts by delaying outmigration.

A gas pipeline route near Fairbanks is currently favored by 70 percent of the adult population surveyed (see Table 3.3-31) . This percentage varies by employment status with respect to the pipeline (see Table 3.3-32) . Many local residents explain their support by saying that the negative impacts of construction have already occurred and it is now important to prevent a serious decline in economic activity.

The long-range social effects of the Alcan pipeline construction on the Fairbanks region are likely to include an economic downturn during the post-construction phase,which will range in degree from somewhat less to much less than that projected for the period following the oil pipeline, depending on oil and gas activities in the Interior, North Slope and Outer Continental Shelf.

Major Staging Areas (Fairbanks)

A brief overview of the social effects of a gas pipeline on Fairbanks in its role as a support center has been given above. Fairbanks may also be a major staging area. The distinction between support and staging activities is somewhat arbitrary since the support activites will primarily involve the management of construction. For the purposes of this analysis, it was assumed that operations management would primarily occur in Anchorage.

Table 3.3-26

FAIRBANKS COMMUNITY SURVEY

INCOMES OF HOUSHOLDS
(percentage distribution)

Income (thousands of $)	Percent 1973	Percent 1974	Percent 1975	Percent 1976
Under 12,000	33	20	15	10
12,000-24,999	43	40	23	21
25,000-39,999	19	30	34	29
Over 39,999	5	10	28	40
TOTAL	100	100	100	100
Number of Respondents	246	253	260	238

Table 3.3-27

FAIRBANKS COMMUNITY SURVEY

HOUSEHOLD INCOME BY PIPELINE COMPANY EMPLOYMENT
(percentage distribution)

Income (thousands of $)	Working for Pipeline Co. Percent	Trying, Interested or Possibly Interested Percent	Not Employed or Interested Percent
Under 12,000	3	19	17
12,000-24,999	3	22	31
25,000-39,999	35	38	32
Over 39,999	59	21	20
TOTAL	100	100	100
Number of respondents	58	63	136

Table 3.3-28

FAIRBANKS COMMUNITY SURVEY

OCCUPATION OF HEAD BY PLANS TO MOVE FROM FAIRBANKS
(percentage distribution)

Plans to Move Within	Prof-Tech Percent	Mgr-Sales-Cler-Serv Percent	Crafts-Operat-Trans-Laborers-Farm Percent
Next 6 mos.	21	9	12
Next 2 yrs.	16	16	9
In the future	21	19	22
No plans to move	42	56	57
TOTAL	100	100	100
Number of respondents	62	78	117

Table 3.3-29

FAIRBANKS COMMUNITY SURVEY

OCCUPATION OF HEAD BY PIPELINE EMPLOYMENT
(percentage distribution)

	Prof-Tech Percent	Mgr-Sales-Cler-Serv Percent	Crafts-Operat-Trans-Laborers-Farm Percent
Presently working for pipeline company	13	17	28
Trying, interested, or possibly interested in becoming employed by pipeline company	28	24	24
Not employed by pipeline company and not interested	59	59	48
TOTAL	100	100	100
Number of respondents	61	76	117

Table 3.3-30

FAIRBANKS COMMUNITY SURVEY

LENGTH OF RESIDENCE BY PLANS TO MOVE FROM FAIRBANKS
(percentage distribution)

	Length of Residence		
Plans to Move	3 Years or Less Percent	Over 3-10 Years Percent	Over 10 Years Percent
Within next 6 months	22	8	4
Within next 2 years	20	8	5
In the future	18	23	24
No plans to move	40	61	67
TOTAL	100	100	100
Number of respondents	120	52	96

Table 3.3-31

FAIRBANKS COMMUNITY SURVEY

ATTITUDE TOWARD A GAS PIPELINE PASSING NEAR FAIRBANKS
(percentage distribution)

	Percent
Strongly favor	36
Mildly favor	34
No opinion	8
Mildly oppose	12
Strongly oppose	10
TOTAL	100
Number of respondents	267

Table 3.3-32

FAIRBANKS COMMUNITY SURVEY

ATTITUDE TOWARD A GAS PIPELINE PASSING NEAR FAIRBANKS

BY PIPELINE COMPANY EMPLOYMENT
(percentage distribution)

	Working for Pipeline Co. Percent	Trying, Interested or Possibly Interested Percent	Not Employed or Interested Percent
Strongly favor	52	33	29
Mildly favor	36	33	35
No opinion	7	11	7
Mildly oppose	3	9	18
Strongly oppose	2	14	11
TOTAL	100	100	100
Number of respondents	59	64	141

The demands created by oil pipeline construction activities have resulted in heavy capital investments in warehousing, equipment, and service facilities. The high local construction employment generated overlapped with employment demands for the pipeline construction activities and may have resulted in an overdependence on the construction sector. Since these facilities would be used for the construction phase of the gas pipeline, it is possible construction employment will not peak (and later fall) to the degree observed for the oil pipeline. Alternatively, a shift in construction may occur whereby the management and service potential of the Fairbanks area may be realized. The latter would be risky not only because it would involve another local construction boom but also because it is less certain that a large management operation can continue to be supported in Fairbanks.

The employment picture is critical to an evaluation of the social effects of the proposed gas pipeline on the Fairbanks area. Dramatic shifts in employment opportunities have set in motion a chain of effects ranging from the arrival of new families possessing no money, few skills, and little chance of obtaining housing on the one hand to the departure of long-term residents in the face of rising costs and a changing town where a stranger is more frequently seen than a friend. Other residents appear to have personally experienced few of these social effects. Research is now underway to assess the scope and distribution of social effects on the Fairbanks population.[3]

<u>Major Camp Locations (Tok, Delta, Northway)</u>

Construction camps north of Fairbanks are relatively isolated and will not directly affect existing communities. For this reason, our discussion is directed to the existing camp at Delta and the proposed camps at Tok and Northway. Two Alyeska construction camps from south of Delta are to be moved to locations at Tok and Northway. Peak employment at each camp might reach 1,000 in the summer. The planned construction season would occur between March and late November. Civil work is planned to commence in 1978.

The communities of Tok, Delta, and Northway possess widely divergent social characteristics.[4] Tok is a small, primarily non-Native highway community which serves as a tourist stop and subregional commercial and service center. The Tok community has already experienced the effects of pipeline construction in the form of increased truck traffic, increased volume of transient job seekers, a lack of available local manpower, decreased tourist activity, and housing shortages, as well as rising family incomes. The population of Tok has increased from 214 in 1970 to an estimated 450 in 1975.[5] In part, this population increase is due to construction and transportation workers who have decided to use Tok as a home base.

A construction camp located near Tok is likely to draw on the skills of residents in the blue-collar trades. Continued growth in permanent and transient populations may further erode the community potential for tourist trade and strain local services.

The community of Glennallen provides a useful comparative case in view of the oil pipeline construction camp located there and its similar size and highway orientation. Glennallen has experienced significant personal income gains, improvement of housing stock, and a growth in community infrastructure.[6] The ability of Glennallen to respond to growth pressures has been limited by a severe lack of private land and high construction costs. While private land holdings are plentiful in the Tok area (although much is owned by non-residents), high construction costs may continue to result in a deficit in low to moderate cost housing.

Both Tok and Glennallen residents share a strong antipathy to government interference. Tok residents, however, appear more willing to provide community services for themselves and may be able to respond to growth pressures in that sector. Non-residents control of the local power utility, a scarcity of good water supplies, and a lack of solid waste disposal sites may become problems in the Tok area.

A recent opinion poll of Tok residents indicates a level of support among adult residents for a gas pipeline corridor nearby that is similar to the support found in Fairbanks (70 percent).[7] There is some evidence, however, that there is less support among high school age youth in the Tok area. Both age groups rank a pipeline construction center as the least preferable alternative on which to establish a community economic base (the other alternatives being: tourism, Federal and state programs, resource development, regional supply and service center, transportation).

The construction camp at Delta would continue to be used under the pipeline proposal. Delta has experienced similar effects to those outlined for Tok (truck, traffic, transients, local manpower deficit, drop in tourist activity, housing shortages) due to its highway orientation. The effect of the construction camp itself has been not only to magnify the actual extent of change but also to generate local fears concerning the occurrence of problems. Such expectations have led to decreased use of local commercial facilities and an increase in confrontations between pipeline workers and local residents. The location of the camp at Delta has also led to an influx of families of pipeline workers.

In contrast to Tok, where many residents are engaged in construction trades, Delta residents are primarily oriented toward nearby Fort Greely. A large contingency of retired military personnel live in Delta and the community's economy has traditionally been dependent on the military base. Delta also has a comparatively successful farming community, by Alaska standards, and caters to the summer tourist trade, The farming community has benefited from a demand for hay in connection with oil spills, but has been hurt, as well, by an escalation of land prices and resultant subdivision of agricultural land. Land speculation, in general, is more salient in Delta than in Tok.

The community of Delta has not been able to successfully respond to a need to expand community services. An unstable political situation has resulted in deterioration of community services which would be intensified by continued use of the Delta construction camp.

The community of Northway, located on a side road about seven miles off the Alaska Highway, is populated by both Natives and non-Natives, the later being primarily employed by the FAA and the local lodge and gas facilities.

The Native community suffers from a poor adjustment to high levels of western contact and is reported to have relatively high rates of alcoholism, broken homes, and welfare cases. The location of a large construction camp nearby is not likely to result in the relatively successful community response projected for Tok. Labor participation rates would be low and contacts between construction workers and village residents would probably aggravate existing social problems. Physical disruption and contact with transients in the village itself should be less than for those communities located on the Alaska Highway itself. The residents of Northway engage in subsistence activities, but it is not known to what extent these activities would be disrupted by the construction of a gas pipeline.

Communities Along the Proposed Pipeline Corridor

The communities along the pipeline corridor north of Fairbanks have already experienced some of the social effects of the oil pipeline. Only Wiseman and Livengood are located near the pipeline and these communities would probably not be additionally changed by a gas pipeline. The major social effects for the remainder of the communities north of Fairbanks have been related to changes in employment opportunities for persons willing to leave their community. These communities can be thus more appropriately considered under the heading of communities which export labor.

The Alcan pipeline will closely follow the highway between Delta and the border. Communities located close to the road (including Dot Lake and, to a lesser extent, Tanacross) are vulnerable to severe physical disruption. The extent of the social impacts ranges from the need to physically remove existing structures to the temporary inconveniences incurred by the movement of materials and equipment. A more precise estimate can only be made after the engineering plans for the route have been finalized.

The communities of May Creek, Dot Lake, Tanacross, and Tetlin are located along the proposed corridor and have not been previously discussed. Proceeding southeast from Delta along the Alaska Highway, the first community is May Creek, a religious settlement of about 200 people located somewhat off the main highway. Community residents wish to remain isolated and as self-sufficient as possible, growing their own food and fiber. The youth of the settlement have, at times, obtained employment outside the community and may take advantage of local employment opportunities provided by pipeline construction, or fill jobs vacated by others. In view of the purpose for which May Creek was established, a major construction effort would require careful planning to avoid a serious disruption of the community.

Dot Lake is the next community to the southeast. It is reported to have a current population of 24 non-Natives, an increase of 60 percent over the 1970 population.[8] The Dot Lake Native community is active in the regional Native corporation, Doyon, and its non-profit counterpart, the Tanana Chiefs Conference. The community has been relatively successful in adapting to western cultural influences. Residents of Dot Lake work for the government, on road or other construction, and recently have been employed on the oil pipeline. Hunting and trapping activities occur in winter. Residents are likely to participate in employment opportunities provided by the gas pipeline.

The community of Tanacross is primarily Native, has shared in the exposure to western culture experienced by other highway communities, and has adjusted to such influences with a level of success intermediate to Dot Lake and Northway. Tanacross, as with other Native communities in the area, faces the challenge of mixing subsistence pursuits with rising material expectations. Seasonal trapping and carpentry, highway construction, and fire fighting work have, in part, met the increasing need and/or desire for a cash income. The construction of a gas pipeline near the community would be likely to create a salient alternative source of seasonal employment. Acting against this incentive is the possible necessity of having to travel to Fairbanks to participate in the union call, or worse, being transferred to a construction camp away from home. In any case, Native participation in pipeline employment opportunities will largely depend on the existence of a policy to hire Natives coupled with a means to disseminate employment information and actively recruit Native manpower. The long-range effects of the pipeline should not be expected to include a stable economic base and in most cases, it appears that job opportunities are correctly perceived as a temporary source of seasonal employment.

The final community to be discussed under the catagory of communities located along the proposed pipeline corridor is Tetlin. Presently unconnected by road to the state highway system. the residents of Tetlin have enjoyed the ability to better control the degree of contact with other cultures. This is not to say Tetlin residents have not sought employment outside the community. The lack of easy access not only limits unsolicited outside contact, but also makes it expensive to leave the community to seek employment or to obtain food and fuel.[9]

Under optimum circumstances, a gas pipeline constructed along the Alaska Highway will provide employment opportunities for Tetlin residents without imposing unwelcome outside pressures on the community. Even under these conditions, the dependence on locally available subsistence resources may be jeopardized by construction activities, or more likely, increased use of the area by non-resident hunters. The latter pressure has already been reported.[10]

Communities Exporting Labor

The pattern of village participation in pipeline employment opportunities is at this point unclear. Residents of villages throughout Alaska have been employed on the pipeline but some villages have exported a substantially higher percentage of their manpower than others. Some of the factors which probably influence village participation are:

1. A village orientation toward seasonal jobs, particularly in construction.

2. Inexpensive, convenient transportation connections to hiring centers.

3. A village age/sex distribution weighted toward young males.

4. Saliency of the employment opportunities either by proximity to construction sites and/or an active dissemination of employment information.

5. An effective recruitment program by government agencies and Native organizations.

6. A lack of time conflicts between traditional local job and subsistence activities.

One prevalent hypothesis is that villages which have successfully adapted to non-Native contacts in the past are more likely to contribute manpower. This statement is, of course, nearly a tautology in the absence of a detailed discussion of the factors related to successful adaptation. Such an integrated perspective has yet to be prepared. It is significant to note that villages currently suffering from a deterioration of traditional lifestyles and an inability to incorporate successful new lifestyles may not be helped by pipeline employment opportunities. These communities may continue to have high rates of alcoholism and accidental death and a heavy dependence on welfare, while more successful communities take advantage of the additional employment opportunities.

Village Natives who do take pipeline jobs do not necessarily achieve a net gain in total well-being, either for themselves or for their village. The necessity of coming through Fairbanks or Anchorage on their way to and from a pipeline job poses a problem for those not acquainted with city life. If temporary housing cannot be found, the streets must be used, and some spend their earnings before they ever reach home. Meanwhile, the village may experience a scarcity of local manpower and leadership, forcing women to take on heavy work and community projects to be postponed. There have been some reports that the discrepancy between pipeline and local wage rates has deterred village youth from working at all.

Since distance to the construction site is only one factor influencing village manpower participation, the projected social impacts for this category of communities should be proportional to the projected manpower demand and Native hire policies.

3.3.4 Summary of Social Impacts

The above consideration of social impacts has focused on the community level. Such a perspective is necessary, given variations in community functions and characteristics. Whichever gas route becomes a reality, social impacts will be felt in a wide range of Alaskan communities. Employment opportunities and the redistribution of state revenues from gas production and transportation are two forces operating to diffuse impacts.

The social impact of changes in subsistence resource availability have not been extensively considered. While many communities have noted decreases in the availability of game, it is not clear whether natural migration changes, over-hunting, mismanagement, lack of time spent hunting, or actual effects of the pipeline are primary limiting factors. It is possible that the development incentives provided by the pipeline would cause major long-term disruptions to subsistence. Recreation hunting access, for example, has resulted in competition for subsistence resources in the Copper River region.

Also of major concern are changes in the social desirability of subsistence activities, particularly among young people. Evidence of numerous changing attitudes are present in the remarks of many village elders. Village activities which depend on volunteer or low salary labor are rejected by teenagers who are well aware of the high paying jobs available. The construction of a gas pipeline will aggravate the conflict between self-interest and village welfare.

The proposed pipeline route will become a salient force against traditional lifestyles in an expanded number of communities. While some communities may currently desire wage incomes, such attitudes may shift back and forth over time. The process of cultural change cannot be documented by an undimensional change in attitudes; rather, it is an interplay between adaptation and consolidation. The use of small villages as major supply depots would prevent the community from maintaining elements of its traditional lifestyle.

The optimum employment opportunity for a village resident with strong family ties and who depends on subsistence opportunities is one which is near home and is temporary. Adverse social impacts increase when employment is only available far away from home or is so near home that it is related to a decrease in subsistence opportunities and provides the only source of income. Obviously, no route can take such an alignment with respect to every Alaskan village.

Incoming population groups may not share the same cultural background of long-term residents, White or Native. Should the original village population become the minority, it is possible that new interest and activities will supplant old ones. In some cases this process may threaten efforts to preserve Native cultures. The unique lifestyles and perspectives held in small Alaskan communities represent a reservoir of diversity that massive population increases could overwhelm.

FOOTNOTES FOR SECTION 3.3

1. The author of this portion of the Environmental Report, John A. Kruse, has prepared a report on the social effects of alternative gas pipeline routes which was submitted to the Bureau of Land Management. All qualifications contained in that report are applicable to the analysis of the Alcan route as well. See Kruse, John A.. A Cursory Comparison of Social Impacts Alternative Gas Pipeline Routes from Prudhoe Bay, Alaska, Institute of Social, Economic and Government Research, University of Alaska, December 23, 1975.

2. The tables in Section 3.3 are based on a preliminary analysis of 268 interviews presently completed in a probability sample of 500 Fairbanks households. The results are subject to modification as the study is not yet complete. Kruse, J. A., Institute of Social, Economic, and Government Research, Spring, 1976.

3. Kruse, J. A. and Kleinfeld, J.K., Institute of Social, Economic, and Government Research. A household survey based on a probability sample of 500 Fairbanks householed was 60% complete as of June 6, 1976. Results will be reported in the fall of 1976.

4. Alan Epps, University of Alaska Cooperative Extension Service provided much of the background information on the communities between Fairbanks and the Canadian border.

5. Fairbanks Town and Village Association for Development, Inc., COMMUNITY FACILITIES SUMMARY, October, 1975.

6. Institute of Social, Economic and Government Research, COPPER RIVER-WRANGELL MOUNTAINS REGION SOCIO-ECONOMIC PROFILE (working draft), March 30, 1976.

7. Morgan, Ray and Epps, Alan, Cooperative Extension Service, University of Alaska, TOK, ALASKA OPINION POLL, May, 1976, mail questionnaire of 107 residents.

8. Fairbanks Town and Village Association, Op Cit.

9. Fairbanks Town and Village Association for Development, Inc., Rural Pipeline Impact Information Program, REPORT ON QUESTIONNAIRE SURVEYS, JUNE, 1975.

10. Ibid.

Contents

4.0 MEASURES TO ENHANCE THE ENVIRONMENT OR TO AVOID OR MITIGATE ADVERSE ENVIRONMENTAL IMPACTS

4.1 PREVENTATIVE MEASURES AND MONITORING

Construction caused environmental disturbance can usually be averted or substantially reduced if there is sufficient knowledge of the impacted resource, and appropriate preventative measures have been formulated. This section provides an initial enumeration of the techniques that Applicant plans to implement to limit environmental disturbances during construction and operation of the Alcan pipeline. Each of these techniques has its basis in the experience of other pipeline projects in arctic environments, particularly the trans-Alaska oil pipeline. The list of techniques is not static or all inclusive. Rather, it will be continually updated as field studies now underway channel additional site specific environmental information to the design engineers. These studies, described more fully later in this section, are being planned and conducted by environmentalists with experience in Alaska and a working familiarity with the Alyeska oil pipeline project. In addition, State and Federal agencies regulating environmental matters are being contacted to determine the information that they will need to review the project on a site specific basis. Although it may not be possible to obtain all the necessary information to totally avoid disturbances caused by a major construction project, environmental disturbances will be minimized. If there is a concerted effort by qualified researchers at obtaining key environmental information, and this information is used to develop appropriate construction practices, Applicant intends to provide a flexibility in pipeline design that allows for this ongoing environmental input.

The methods for impact avoidance or mitigation presented in this section generally follow the order in which the impacts were described in Section 3.0. While the mitigation techniques identified below are generic in many instances, the studies now underway, committed to or planned, will provide the information necessary for the localized application of these techniques. In addition, Applicant will initiate a training program for all construction and operation personnel which will provide the necessary instruction and supervision throughout the project to insure that environmental stipulations and safeguards are followed. The program will be developed in cooperation with the appropriate Federal and State Agencies. Examples of the types of training that will be undertaken are included in the following sections.

4.1.1.1 Land Features and Uses

To mitigate the impact on land use the Alcan pipeline will follow existing transportation and utility corridors along its entire alignment through Alaska. By so doing the project will be able to utilize to the extent practicable existing material sites, access roads, support facilities, and communications and logistic networks, thereby minimizing new disturbances of land areas. Moreover, use of this alignment provides a prior inventory of potential land use conflicts and expedites the determination of means to alleviate them based upon prior experience.

4.1.1.2 Transportation Systems

The potential impacts on Alaskan highways due to movement of pipeline related materials will be mitigated by several techniques proven effective during construction of the oil pipeline.

A central control system will be established to determine and implement a traffic management plan along major logistical routes. The primary objective of this system will be to minimize delays and safety hazards to the general public. Also considered in establishing the system will be a means of minimizing wear of recently improved highway surfaces. The system will be developed in close concert with the Alaska Department of Public Safety and the Alaska Department of Highways.

It will be the policy of Applicant to review all of its highway use plans with the Department of Highways in order that potential conflicts with the State's road reconstruction program can be identified and resolved. With this information and subject to funding priorities, the State will be better able to time its construction projects to complement activities along the utility corridor associated with gas pipeline construction.

Looking beyond the construction period, Applicant will continue to coordinate with the State to the extent necessary to remedy any long-term maintenance problems relating to snow removal, drainage flow, and glaciering of the highway system that may be induced by pipeline construction.

4.1.1.3 Geology

Geologic factors that must be accounted for in pipeline construction may be viewed from two perspectives: those that pipeline construction may cause, such as erosion; and those that may later affect the pipeline once constructed and made operable, such as seismicity. The frames of reference are not so mutually exclusive that geologic factors can be considered exclusively to be in one category or the other. In fact, most fall in both. Slope stability -- where a fragile soil embankment may be erosion prone and thus where there may be the risk of soil loss and a risk to pipeline integrity from landslides as well -- is one example. Permafrost is another. Both perspectives must be taken into account in geotechnical design. Applicant is and will continue to explore the various implications of these geotechnical considerations and incorporate adequate mitigative measures in its design, construction plans and operating procedures. The following briefly discusses general means of avoiding or mitigating the geotechnical problems which will be encountered. Field studies are now in progress to provide the information necessary to implement these measures.

Erosion

Erosion by water will be a problem on steep slopes that have fine grained soils. A field investigation of soil and slope conditions along the Alcan Highway segment of the route is presently in progress. Representative soil samples now being laboratory tested will be used to determine the distribution and erosion susceptibility of soils along the route in order that appropriate mitigation techniques such as deviation or soil stabilization practices can be employed. In addition, hydrologic controls will be used to minimize erosion. The types of drainage control facilities to be employed will include temporary culverts, check dams, sandbags, gabions, cross-drains, channel lining, and energy dissipators at structure outlets.

The actual selection of facilities and their placement will be determined by localized conditions. Stream flow analyses has been conducted for the oil pipeline route. Using generalized rainfall data and basin areas, an analysis predicts basin runoffs for given recurrence intervals and risk factors necessary to design drainage control facilities. Applicant is presently conducting an intensive hydrologic investigation of the Delta Junction to Yukon border segment of the proposed pipeline route. When completed, the study will provide a set of design discharge values compatible with data generated for the oil pipeline, including sized and stationed control structures. Also integrated into the program will be extensive field verification of the hydrologic design characteristics predicted for this segment of the route. This aspect of the hydrologic field studies now underway should almost entirely obviate the need for revising drainage control plans in the field after construction has commenced. Hence, undersizing and/or misplacement of control structures should not occur.

Slope Stability

Slope stability will be handled through aerial photo and field studies of potential and existing landslide areas in order that they may be located and avoided. In the more level areas of the project, the problem is essentially nonexistent so long as the pipeline remains in relatively level ground. South of the Brooks Range, where the line enters the rolling hills of the Yukon-Tanana uplands, and continuing southward to the Tanana River crossing north of Delta Junction is the principal area in which slope stability problems could develop if proper design and construction procedures were not followed. In this area, an effort will be made to avoid sidehill cuts and fills which, in permafrost areas, tend to become unstable after construction disturbance and during the thawing process. From the Tanana River crossing to Tanacross, the route is generally on either level or gently sloping terrain, such that major landslide or slope stability problems should be insignificant. From Tanacross to the crossing of the Tanana River east of Tok Junction, the ground is reasonably flat, and slope stability is not a major problem. From the Tanana River crossing east of Tok Junction to the Alaska-Canada border, the route will pass through a hilly area. Studies are now underway to determine potential landslide hazards in this area.

Seismic Considerations

As a minimum, the pipeline will be designed to withstand the maximum historic seismic intensity experienced along any segment of the route. Seismic risk estimates have been previously developed for the route segment that follows the oil pipeline alignment between Prudhoe Bay and Delta Junction. Applicant is expanding the data base for seismic risk between Delta Junction and the border by conducting a survey of the relationship between seismicity and prehistoric and historic movement along the Denali Fault. Computer modeling of ground accelerations along this pipeline segment from various magnitude earthquakes along the fault is now underway. The resulting data will be used to determine the method of burial for pipe in the zone which might be influenced by fault movement.

Permafrost

Both continuous and discontinuous permafrost occurs over the entire pipeline route from Prudhoe Bay to the Alaska-Yukon border. To minimize degradation of frozen soils, gas moving through the pipeline will be chilled as required by refrigeration plants located at each of the 15 compressor stations. This will avoid radical alteration of natural freeze-thaw regimes. The extent of temperature control employed at each station will depend upon seasonal conditions and the various properties of soils along the downstream pipeline segment. To the extent possible, localized areas of discontinuous permafrost will be avoided. Where they cannot be avoided, the mitigating measures employed will depend on the nature of the surficial material, the depth of permafrost, and the slope of the terrain.

4.1.2 Species and Ecosystems

Protection of important plant and animal species along the pipeline route will be a primary objective throughout the construction, operation and maintenance of the Alcan Project. Applicant recognizes the need to minimize the detriment to sensitive arctic ecosystems. This consideration is one of the single-most important assets of the route selected for the Alcan pipeline. While sensitive areas exist at discrete locations along the route, these areas have already been subjected to prolonged disturbance and inventory surveys, the latter having occurred primarily along the oil pipeline corridor. Hence, the proximate ecosystems characteristics and extent are fairly well documented, as is their tolerance to pipeline construction and/or highway traffic. Applicant intends to make optimum use of the experience gained from the oil pipeline construction by adopting ecological impact programs similar to those shown to be most effective for the earlier project and by designing those programs using environmental personnel familiar with pipeline construction in Alaska and working in close cooperation with State and Federal regulatory agencies. Applicant will initiate a thorough program for mitigating ecological impacts by which relevant data is obtained, effective mitigative techniques are developed, and strong management guidance is provided to insure that the techniques are properly implemented. Communication with governmental agencies is seen as a key particularly with respect to the first two items. Both ongoing and future survey programs will use advice from State and Federal agencies as a principal input to determining study objectives. With respect to implementation, Applicant will condition its relationships with construction contractors in a manner that will ensure full compliance with environmental stipulations imposed by appropriate regulatory agencies and will educate all personnel to the consequences of failing to satisfy these requirements. As the first step in its mitigation program, Applicant will make commitments to protect ecological communities as discussed below.

Vegetation

The proposed pipeline route passes through two major vegetation types in Alaska, the tundra and the tiaga. Disturbed areas of both vegetative types will be fertilized, artificially stabilized as needed, and seeded at the outset of the first appropriate season following construction.

Mitigation measures will be employed to reduce the extent of impact and to expedite rehabilitation and to contain disturbances within the bounds of the right-of-way.

Studies now underway or to be initiated prior to construction include the following: preparation of a detailed natural vegetation map of the entire alignment; deployment of permanently marked photo plots and photopoints to document changes and/or stability of representative habitats and plant communities; chemical analyses of surface and subsurface soils to predict special fertilizer needs relative to revegetation of soils along the route; testing of revegetation techniques to stabilize sand dunes to be encountered in the upper Tanana Valley; route surveys to locate discrete important plant communities and/or species; and evaluation of vegetation recovery along the Haines products pipeline and the oil pipeline corridor to estimate revegetation needs for the Alcan Project.

Other procedural measures will be taken to minimize impact on plant communities during the construction period. Road surfaces will be watered during dry seasons to minimize the extent of fugitive dust coating aerial plant parts. Personnel training and supervision programs developed during oil pipeline construction will be continued. Artificial revegetation will be used to assist rate of natural succession following construction. Off-road vehicle travel will be minimized and confined to specific time-frames when least damaging to plants. Litter will be picked up by maintenance crews. Fertilizer application will be confined to the right-of-way and disturbed areas only, and not randomly broadcast.

Fish

The first step toward mitigating impacts on important fish species will be to conduct certain detailed preconstruction baseline studies appropriate for developing adequate stream crossing techniques on a site-by-site basis. Cataloging streams along the route as to fish presence by species and abundance, coupled with a knowledge of sensitive times of fish life history (such as spawning or overwintering periods), is essential to determining crossing techniques. This is also essential to determining drainage structures necessary to meet fish-specified passage criteria. A catalog of fish presence in and utilization of streams is complete for the section of the pipeline route from Prudhoe Bay to Delta Junction, and was compiled by the Joint Federal-State Fish and Wildlife Advisory Team during oil pipeline monitoring efforts. Comparable studies have been initiated by Applicant to extend the list through the Delta Junction-Yukon border pipeline segment.

Spawning areas for anadromous fish must be identified so that these important species are not significantly impacted. Arctic char spawning areas are well-known on the Arctic Slope as are spawning areas in the interior, excluding the upper Tanana basin. Studies suggested by Alaska Department of Fish and Game personnel to determine salmonid use of this basin have been adopted by Applicant and are presently underway.

Overwintering is probably the most critical time in the life history of Alaskan fishes. Hence, the importance of determining overwintering areas prior to construction cannot be overemphasized. While overwintering areas have been located over most of the route, additional areas probably exist. Studies have been designed for initiation this coming 1976-77 winter to locate these additional areas so they and their supplying aquifers can be avoided. In addition, winter flow characteristics of streams will be determined.

As the above studies are completed, their results will be applied to the problem of determining crossing techniques on a site-by-site basis. Most fishery problems at stream crossings can be overcome by proper timing of construction. Streams which freeze solid are best crossed at that time, avoiding flowing water. These include most Arctic Slope streams. Crossing of other streams which are dry in late summer produces little erosion. However, the majority of Interior streams must be crossed wet for they flow continually. Timing of these crossings will be planned so as to avoid spawning seasons, especially for salmon, and overwintering periods. Settling basins, diversions, flumes and a variety of other techniques will be used to minimize sediment problems in streams that must be crossed while flowing. Often use of several methods simultaneously will produce the best results. Plans for stabilization of all stream banks immediately after construction will be firmed prior to beginning the crossing. Another major source of sediment occurs when pumping a wet ditch to reduce the water level before lowering the pipe. Pump outfalls will be selected to avoid direct discharge to fish streams or lakes. Effluent high in suspended solids will be discharged to settling basins or onto vegetated areas to filter out fine particles.

Stream crossing structures must pass fish. Culverts will be sized adequately to allow fish passage. Spans are much preferred at pipeline stream crossings due to the minimal resulting disturbance of the natural streambed. Hence, the most sensitive streams will be spanned if no other crossing technique will adequately protect fish populations. Where culverts are used in fish streams, the constricted flow will meet Q10 velocities of four feet per second. In addition, bedding requirements of at least six inches below the streambed will be maintained. Some high gradient streams need special fish passage structures when culverts are not used if velocity and bedding requirements cannot be met simultaneously. Damming and channel alteration in fish streams will be minimized. Where such activities are necessary, they will be undertaken during non-critical times.

Hydraulic changes when crossing sensitive fish streams will be minimized. Streams will be crossed at right angles to the shore wherever possible. In areas where hydraulic changes cannot be avoided, natural hydraulics will be re-established to the maximum practicable extent.

Material sites in rivers will be located to minimize hydraulic disturbance. Mining will be limited to one foot above flowing channels and follow the natural hydraulic contours of the site. Materials may be stockpiled during winter months when over-ice traffic is feasible.

Blasting within one-quarter mile of fish streams requires an Alaska Department of Fish and Game permit, which will be obtained for each such action. Blasting in streambeds will be timed to avoid spawning or overwintering periods or other vulnerable concentrations of fish and eggs.

During late winter, water will not be pumped from surface flows in overwintering streams north of the Yukon River or in other systems near overwintering areas. Intragravel flows can be blocked by the resulting enhancement of freezedown. Freezedown can also be increased when an insulating layer is removed or when traffic compacts an area. Material sites in rivers are prime examples, as are winter roads that cross streams without sufficient bridging. To counter these problems, mining near overwintering areas will be limited and crossings will be sufficiently bridged with snow, ice or artificial materials.

Restrictions on fishing near the pipeline route will be established in conjunction with the Alaska Department of Fish and Game.

Programs will be initiated to reduce accidental spillage of toxic materials. Cleanup teams and facilities will be trained and stationed at each camp. A handbook describing cleanup techniques will be prepared.

Thermal studies will be undertaken to predict the likelihood of ice dams or intragravel flow reductions being created by a freeze bulb at smaller crossings. Where such effects seem probable and significant numbers of eggs and fry would be impacted, the streams will be spanned as necessary. Larger rivers may not be as affected as small streams and reduction of the freeze bulb by other means may be effective. In most cases minor route deviations will successfully avoid critical areas or reaches in streams.

Mammals

Experience with pipeline construction has shown that disturbances to mammals can be primarily attributed to general presence of human activity and concommitant noise, interferences, barriers to migration paths, and the availability of scavengeable foods from refuse, rather than to massive habitat loss. Because these problems become most pronounced at critical times and areas, construction scheduling can be designed to alleviate greatly any disturbances.

The measures to minimize mammal interference that are described below will be adhered to during construction of the Alcan pipeline. The measures cover both Arctic and Interior large mammals.

The pipeline will be designed and constructed in a manner that will minimize the possibility of it being a physical or psychological barrier to animals traversing the pipeline corridor. In those areas where animal movements or migrations are significant, sections of the pipe will be constructed to allow unimpeded passage. Caribou migration zones along the proposed Alcan pipeline route are well documented. Construction scheduling will be arranged so disturbances during spring and fall migrations are minimized. No caribou calving areas occur along the corridor. Buffalo movement near Delta will be monitored to minimize construction disturbances, such as an open ditch across the route.

Effective minimum aircraft altitude regulations will be enforced in areas determined to be critical wildlife habitats. Furthermore, minimum altitude regulations will be instituted during those times when the pipeline corridor is being used by large mammals for migration, denning, breeding or calving. These stipulations will help to avoid physiological stress and energy deficits which can result when animals are harrassed. Prior disturbance along the oil pipeline will appreciably lessen the effect of additional disturbance to denning animals during construction of the Alcan pipeline. The area from Delta to the Yukon border is heavily used by man and present denning probably will not be further disturbed. Summer construction will avoid bear denning. Use of explosives will be limited or curtailed in areas where mammals are known to be denning, calving or lambing. Employee feeding of animals and intrusion outside the corridor area will not be permitted in order to avoid unnecessary impacts on mammals. Wolves, bears and foxes are attracted to construction sites due to the availability of food. Major problems will be avoided by proper disposal of garbage and strictly enforcing regulations prohibiting the feeding of wild animals. Control programs will be planned and made available on an as-needed basis. Harrassment is not considered a viable method of removing nuisance animals. Trapping and physical removal will be employed as necessary in severe cases.

A contingency plan will be developed to deal with gas explosions and fires, particularly in the Yukon Basin area where vegetation during summer months is extremely dry. A contingency plan for toxic material spills will also be developed. The plan will cover spills of engine fuels, both gasoline and diesel, hydraulic oil, natural gas (leaks), herbicides if they are to be utilized, pesticides, and any other chemicals known to be toxic. The use of persistent chemicals including herbicides and pesticides which could have long-term deleterious effects on large mammals foraging in the corridor area will be avoided. Carnivores such as the wolf and, to a lesser degree, the bear, could be most affected because of their position in the food chain.

Machinery noise levels along the pipeline corridor will be minimized. Minimizing noise levels during construction could be especially important in preventing herd scattering of caribou, sheep, and bison.

The use of all-terrain vehicles will, except for emergency purposes, be prohibited. Employee intrusion outside the pipeline corridor area will not be allowed in order to avoid unnecessary impacts on large mammals, particularly in those areas or at those times determined to be critical to animals. An example would be to prohibit intrusion into known sheep lambing areas during lambing season.

Operational noise generated by the compressor stations will be minimized to the greatest extent practicable. Abatement procedures including stack silencers, vegetative screening and/or earthen barriers will be site specific depending upon location, topography or sensitivity of large mammal species inhabiting the area.

Hunting restrictions will be determined in conjunction with the Alaska Department of Fish and Game. Monitoring studies of wildlife populations, especially in critical areas will continue throughout the project to avoid unanticipated problems.

<u>Birds</u>

As in the case with mammals, disturbances of critical bird habitats can be avoided if necessary by minor route deviations, scheduling construction to avoid critical time periods, and minimizing intrusions into critical areas by humans, vehicles and aircraft. Data from earlier work along the oil pipeline has delineated critical areas for raptors and waterfowl. Recent studies conducted for Applicant along the Tanana River have similarly identified sensitive areas along the Delta Junction-Yukon border segment.

Scheduling will avoid construction around staging areas for fall migration of waterfowl, nests of swans, loons, geese, ducks and cranes and within an acceptable radius of active peregrine falcon nests. Studies of nesting falcons and waterfowl will be conducted ahead of construction to determine appropriate scheduling.

Human disturbance of critical areas during critical times will be minimized by prohibiting foot-traffic and vehicular intrusion as well as restricting aircraft activities over and adjacent to these areas. Permanent and temporary facilities will be selected so as to avoid critical areas.

4.1.3 Socio-Economic Considerations

Local

Local involvement in the developmental process and provisions for continual interaction between Applicant's project managers and local communities will minimize potential adverse impacts of the construction effort on socio-economic considerations at the local level. Information concerning workforce and facilities requirements, staging areas, time schedules and related information will be given to local officials so that they may plan ahead.

An effort will be made, if desired, to minimize direct physical impact on a native or predominantly native community. Storage areas, staging areas, work pads, transportation links and other related activities will avoid such communities to the extent construction constraints allow.

An effort will be made to come to grips with the work pattern of natives who, unlike his non-native fellow workers, leaves his job to respond to traditional subsistence pursuits from time to time. Flexibility to accommodate this need on the part of the native will be incorporated into employment practices. Scheduling of work will be arranged to consider traditional land use areas and subsistence activities where possible. Many lakes along the route have great attachment to the native community and are used for fishing and hunting activity. Activities that threaten existing subsistence areas or resources will be minimized. Appropriate restrictions on hunting and fishing as well as restrictions on intrusions into certain areas that might be sought out for recreational purposes will be established. Many recreational areas not directly related to native activity already exist and can be utilized.

An in-depth analysis of the native hire situation associated with the oil pipeline project will be used to maximize native hire for the gas pipeline. The training programs and retention records of the oil pipeline project will be reviewed in developing job training programs for natives. While maximum use of local available hire will be made, some manpower losses may be caused in local communities. Maximization of local hire also minimizes any potentially disruptive effects of non-resident workers in the local areas.

Accurate and up-to-date information on the communities to be impacted and continual monitoring of these communities will be undertaken throughout the project to provide ongoing flexibility in determining ways to mitigate any adverse effects of the construction effort.

Additional and case specific measures to mitigate socio-economic impacts of the proposed construction will be determined through the course of field studies presently initiated or to be undertaken by Applicant. Principal among these ongoing studies are: (1) a demographic survey and census of the communities contiguous to the Delta Junction to Yukon border route segment; (2) an attitudinal survey of these same communities, with specific reference to an Alcan pipeline; (3) a survey of the level of subsistence activity along the Alcan route segment from Delta Junction to the Yukon border and the relationship of this activity to local geographic features; and (4) an analysis of the intergroup relations between different cultural groups along the pipeline route.

<u>Regional</u>

Potential adverse effects on the general Alaskan economy and society of the construction of the pipeline will be minimized considerably by the timing of the construction of the line shortly after the completion of the Alyeska oil pipeline. The public and private sectors in the State have had time and have developed the capability to react to the type of construction activity associated with large pipeline projects and the same infrastructure can be readily transferable to this project. The construction of the gas pipeline will provide a continuity for the economic and social growth the State is currently undergoing. The significant variable in this equation will be the timing of the construction phase of the Alcan project. If the transition period is short and current capabilities are carried over, this construction will give impetus to the long-term growth of employment, income and social development. In this respect, workforce utilization will be a crucial element in the transition. If the Alyeska workforce is correctly utilized, particularly with respect to native hire and the use of Alaska hire, negative effects of construction will be minimal.

Because adverse socio-economic effects are mainly indirect in nature and to some extent relate to taxing structures and legislative responses as well as to the timing of construction, specific measures to mitigate broad-range impacts of the construction of the pipeline cannot be formulated precisely at this time. However, continued communication with the State and local communities is necessary for the development of mitigating measures over the period of the project.

4.1.4 Air, Noise and Water Environments

Air

During construction the principal impacts of the project would be fugitive dust stirred up by operation of earth moving equipment, primarily in the dry summer months, and the emissions of nitrogen oxide, water vapor, and carbon monoxide from space heating systems and incinerators at construction camps and from vehicle exhaust. All of these are short-term impacts. Dust problems will be controlled by periodic spraying of water during construction. Stationary sources at the camps will be controlled to the extent that their emissions do not cause ground-level concentrations of primary contaminants to exceed applicable standards.

Oxides of nitrogen, hydrocarbons, water vapor, and carbon dioxide will be emitted from space heating systems and compressor and refrigeration turbines at each compressor station. Emission rates will comply with all applicable standards of the Environmental Protection Agency and the State of Alaska. To the maximum extent possible, compressor stations will be located in well-ventilated areas and away from other pollution sources at each site where the possibility exists that the turbine plume may become impinged on surrounding higher terrain and trapping might occur. Baseline air quality and meteorological data (including atmospheric dispersion characteristics) will be documented and quantitative estimates of the air quality impact will be made, based on onsite meteorology, engineering design factors (stack diameter, stack height, exit velocity and temperatures, emission inventory, etc.), and appropriate dispersion formulae. Once the stations become operable, monitoring and inspection programs will be conducted on a regular basis to ensure that all equipment is functioning properly and that procedures relating to safety and operational integrity are being followed.

Noise

As indicated previously in Section 4.1.2, operational noise at compressor stations will be attenuated to the extent necessary to avoid any significant intrusion upon ambient off-site noise levels. Intrusion will be considered from the standpoint of impact to important wildlife species and humans, emphasizing wildlife impacts due to the remote location of most compressor station sites. The specific techniques utilized will vary from station to station depending upon the above factors, the sound absorption or propagation characteristics of the site and surrounding areas, and present noise levels. Illustration of the significance of the latter is found at each of the sites along the Alcan Highway where even though the locations are remote, noise levels are intermittently high due to traffic passage.

Certain mitigation measures will be enacted at each station. First, inherent sound characteristics will be a consideration in selection of turbine accessory equipment. Turbine units with inordinately high noise emissions will not be utilized. All turbines will be equipped with silencers at their air inlet and exhaust. Compressor station buildings will be insulated with materials that have high sound absorptive properties. Blowdown silencers will be installed at all sites considered sound sensitive. Determination of these sites will be by an ambient noise monitoring program conducted during seasons of sensitive conditions, that is when wildlife are least tolerant to noise intrusion, and/or when background levels are lowest.

The above methods are intended as a minimum to reduce compressor related noise within the facility to levels compliant with OSHA standards for work crews. Perceptible offsite noise will be further diminished by completely fencing the periphery of each site, thereby presenting a surrounding buffer to noise receptors.

Water Quality

Prior to construction of the oil pipeline, Alaska waters along the proposed alignment had generally not been influenced to a significant degree by human activity. To date, only infrequent and generally transient impacts have occurred along this corridor. Most problems have been associated with accidental spillage of contaminants, overload of treatment facilities, or unforeseen siltation. To insure that no unacceptable alterations of existing water quality are incurred by activities related to the gas pipeline, Applicant will comply with all Federal and State water quality regulations and standards during the periods of pipeline construction and operation.

A detailed description of waste water character and proposed methods of treatment will be submitted for approval of all applicable regulatory agencies before any point discharge of liquid material is released to Alaskan waters. The primary source of wastewater generation will be at construction camps situated at regular intervals along the route. Wastewater flows from these facilities will be adequately treated in accordance with permit requirements specified by State and Federal agencies. In all likelihood, package secondary treatment plants now in operation for the oil pipeline construction camps will be used to serve gas pipeline crews housed in the same or comparable facilities. New camps along the Alcan Highway segment of the route will be provided with secondary treatment systems with demonstrated performance capabilities sufficient to satisfy all requirements. All treatment plans will be run by competent operators experienced in the handling of wastewater systems in cold climates. Treated effluent will be stored during winter months and discharged at breakup and months of sufficiently high stream flow as specified by regulatory agencies. Backup equipment and emergency flow storage facilities will be provided at each camp.

Hydrostatic test waters will be another point source discharge. Water withdrawn for hydrostatic testing of the pipeline will be taken from sources selected specifically to avoid excessive drawdown or flow interruption. The test water will be discharged at points determined by the acceptability of receiving waters in accordance with applicable permits. Any discharge water with observed excessive suspended solids will be clarified in holding basins constructed on high ground adjacent to the point of discharge. All discharge rates will be controlled to preclude erosion of the banks or beds of receiving waters. Wherever possible, test water will be reused.

Control of erosion will be an important aspect of Applicant's plans to protect the quality of adjacent waterways during the construction period. As discussed above, techniques have been identified to minimize soil loss and disturbance of streambeds.

To retain silt transported by surface runoff from upland cuts, several important measures will be undertaken. Cleared areas will not exceed the construction right-of-way width and brush and soil cover will be left intact wherever possible. Excavating operations will be conducted in a manner to avoid undercutting or disturbing areas outside of the work limits. Erosion control will be carried out on all disturbed areas immediately following construction or at a later time determined by site and field conditions. Structural or surface controls will be used singly or in combination, depending on the character and condition of each site. To minimize induced and accelerated erosion on slopes, flow velocity controls or diversion structures will be implemented according to soil and hydraulic criteria.

To limit sediment suspension during the course of activities within stream beds, operation of mobile ground equipment in natural waters will be avoided wherever possible. To retain silt from material sites, approved sites in or near lakes, rivers, or streams will be provided with suitable structures to minimize siltation. To prevent siltation from log skidding or landing, logs will not be skidded or yarded across streams unless no other action is feasible. Of course, some localized silt release is unavoidable during the course of construction activities in and near watercourses. Actions described here are intended to reduce these releases to acceptable levels.

Where possible, non-toxic materials will be utilized to perform pipeline supportive functions. Use of other materials near natural waters will be rigorously controlled. Persistent pesticides will not be used in any quantity without express approval of the requisite regulatory agencies.

4.1.5 Archeological Values

Adequate mitigation of impact on archeological values cannot be accomplished if the specific relationships between the cultural resources and the pipeline project are not known. Therefore, a detailed archeological survey of the right-of-way and proposed facilities will be conducted prior to final selection and staking of any construction areas to identify sites that may be impacted. The route east of Delta Junction is presently being surveyed to identify sections needing excavation or perhaps minor routing deviation. Concurrently, a study of previously known sites and their relation and/or potential for impact is now being conducted.

Basically, there are two possibilities to conserve the data inherent in an archeological site. One is to avoid the site entirely; the other is to salvage the information through excavation. The former is preferable, but will not always be feasible due to construction requirements. Both require early recognition of site areas and sufficient planning to reduce the adverse effect to acceptable levels. With this advance work now underway, there will be sufficient lead time to make appropriate decisions regarding excavation or route alignment.

At this point in the mitigation process, there must be an interface between on-ground field operations of the Applicant and the requirements of Federal and State law, regulation and policy. The overriding concern is that resources eligible for the National Register of Historic Places be found, evaluated, and protected by following procedures established by the Advisory Council on Historic Preservation (see Code of Federal Regulations, Title 36, Chapter VIII, Part 800). Accordingly, Applicant will:

1. locate resources, assess their significance, and determine the effect of construction impact;

2. in consultation with the Alaska State Historic Preservation Officer, Federal agency archeologists, and the Department of the Interior, provide sufficient information to the Secretary of the Interior (or his designee) to determine the eligibility of the site for the National Register of Historic Places;

3. recommend mitigation measures;

4. allow the Advisory Council on Historic Preservation to comment on adverse effects on the site if it is eligible for the national register, and prepare a memorandum of agreement under 36 CFR, VIII, 800; and

5. execute an appropriate or approved mitigation by avoidance, excavation, or planned destruction.

Because some of these procedures may require some time, the lead time provided by the prior surveys will be of great advantage.

If excavation is required, a qualified archeologist will be available to do the work in a fully professional manner. Since there will be time for adequate planning in most cases (see below), a competent methodology can be explicitly formulated, with a set of questions and goals, for each site or set of sites.

Once the project has begun, construction will be continually monitored to insure that unforeseen impacts do not result from construction on sites not found during the prior surveys. This is necessary because the vagaries of sampling inherent in any archeological survey do not insure identification of all significant sites which do exist. Additionally, construction needs are often changed in the field (unexpected permafrost or bedrock, a gravel source running short), and new construction areas will require archeological investigation as quickly as possible. Inasmuch as there will not be time to formulate a specific plan for such contingencies, a general methodology will be explicitly outlined before construction begins.

At the same time, construction personnel will be advised of locations of potential archeological resources and will be made aware of the laws and regulations governing these. Specific guidelines will be established for reporting unexpected finds to the monitoring archeologists and to other appropriate agencies, e.g., the State Historic Preservation Officer.

These mitigation procedures will continue until construction and rehabilitation work is complete.

4.2 ENVIRONMENTAL RESTORATION AND ENHANCEMENT

Applicant will revegetate all cleared areas, such as excavation sites for the pipeline, borrow pits, spoil deposits, and other sites where vegetation is removed during construction phases. A detailed revegetation plan and associated maps will be prepared.

It is recognized that revegetation requirements vary greatly among sites, necessitating site specific guidelines along the route. Detailed vegetation and soils maps will be developed for the area along the proposed Alcan route from air photos and field reconnaissance data. These maps will provide the basic framework for developing detailed revegetation and vegetation management guides.

Map overlays will be constructed to locate problem areas resulting from various environmental constraints such as droughty and highly erosive soils, steep slopes, ice-rich permafrost, probable regions subjected to high intensity rain storms and wind erosion, as well as sites where construction activities will likely create unusual revegetation situations such as artificial slopes, unfavorable soil (seedbed) conditions, and soil pollution problems. Where special erosion problems and heavy animal grazing pressures coincide, the planting of relatively less palatable species and other techniques will be explored as a means of protecting new seedings from overgrazing. An overlay map will be constructed to detail soil fertility status along the route in terms of revegetation requirements. This data will be updated continually during the construction and operational phases to reflect previously unanticipated nutrient status and moisture holding capacity limitations in the trench backfill and wherever it is unfeasible to replace top soil on the cleared sites.

Information pertinent to seeding rates and techniques and seedbed preparation will be shown on the map overlay and used to prepare written revegetation guidelines.

Anticipated problem areas such as droughty soils and locations where seed losses from bird feeding and erosion, as well as other factors that could likely hinder revegetation efforts, will also be shown on the map overlays to alert planners and field personnel.

Key sources of information on revegetation potential will be acquired from success patterns apparent within the rights-of-way of the oil pipeline, the Haines Products Pipeline and Alcan Highway, each of which parallel portions of the proposed gas pipeline route.

A program for acquiring adequate supplies of seed, fertilizer, mulches, etc., will be initiated according to the needs as determined from the revegetation plan and overlay maps.

In addition to guidelines for revegetation, provisions for post-seeding management, such as additional fertilization, watering, or protective structures will be developed from current published information and experience and will be implemented as required. Personnel responsible for revegetation will continue updating plans during preconstruction through operational phases of the pipeline by personally inspecting comparable revegetation projects in Alaska and adjacent Canadian areas, researching the literature, and conducting pertinent field studies.

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5.0 UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS

5.1 HUMAN RESOURCES IMPACTED

The proposed gas pipeline will cause no unavoidable adverse environmental effects in the scattered human population within its general or immediate vicinity. No dwelling units will be displaced by the right-of-way or by compressor facilities. No adverse impacts upon the productivity of human labor will be imposed by the construction and/or operation of the pipeline. With the exception of small agricultural losses where the proposed pipeline crosses gardens, small farms, pastures or timber stands, the actual and potential effects on human resources will be unchanged. No schools, hospitals, public buildings or dwellings are within the immediate right-of-way of this proposed pipeline route.

5.2 USES PREEMPTED AND UNAVOIDABLE CHANGES

Unavoidable environmental impacts on land and present land use will be minimal since the same haul road, gravel pits, work camps, airfields, and most other existing facilities used by Alyeska for the oil pipeline will be used by the gasline construction. Along the Alaska Highway portion of the route, natural environmental impacts will also be minimal. However, considerable impact upon the highway road bed and upon normal transportation can be expected. The only new impact will be the isolated instances where additional facilities are required.

Historical, archaeological and aesthetic values or scenic areas will not be altered; early identification assures their integrity.

Environmental impact on fish, wildlife, forests, and other vegetation will be small if proper and planned engineering design is followed and activities take place at seasons when fish and wildlife species are not at vulnerable stages. Recreational demands on wildlife will be temporarily impacted during construction. Some wildlife productivity will be restructured in favor of smaller herbivores.

The important unavoidable change will result from the number of people working on the line, presumably with large expendable incomes, who will use their free time to hunt, fish, or engage in other backcountry activities throughout the state. They will compete for these resources with both rural and urban residents. The former not only depend on fish and wildlife for all or part of their livelihood, but are also at an economic disadvantage when it comes to transportation. Their competition with urban residents will be just as real, but less critical.

This situation will not be new, but will be a prolongation of effects that began several years ago, when the Alyeska project was initiated.

Implementation of the proposed project will result in the following unavoidable compromises:

1. Permanent utilization of approximately 10,600 acres of soil, vegetation, and wildlife habitat in the immediate vicinity of the proposed gas transmission pipeline, compressor station, and appurtenant facilities.

2. Temporary periodic increase in noise, dust, vehicular traffic, and human presence during pipeline and station construction. Permanent impacts due to vehicular and pedestrian traffic are statistically inconsequential.

3. Unauthorized off-road vehicle use of the right-of-way for access to relatively undisturbed wild lands; in spite of various controls to limit access, various "sportsmen" often manage to use the pipeline corridor for a roadway.

4. Temporary disruption of normal activities of wildlife from increased human presence and noise during pipeline construction. Permanent effects on wildlife may provide a net gain in energy, territory, fecundity and diversification.

5. Temporary downstream increases in suspended sediments and turbidity at river and stream crossings. Permanent stabilization of stream banks and flood plains.

6. Temporary physical chemical changes in the micro-climate of some river crossing sites.

7. Enlargement of the existing Alyeska and Haines corridors. This is a permanent increment of land use, but in lands presently committed to a "utility corridor."

5.3 LOSS OF ENVIRONMENTAL QUALITY

Implementation of the proposed project will result in the following unavoidable adverse changes in environmental quality during its construction and operational phases:

1. Temporary increase in dust and noise levels in the construction vicinity.

2. Increase of NO_x, CO, CO_2, and H_2O concentrations in the atmosphere in the immediate vicinity of the proposed compressor station. Fog/inversion phenomena may occur.

3. Increase in ambient noise levels in the vicinity of the compressor station during the operable life of the project.

4. Temporary downstream increases in suspended solids and turbidity, coupled with microclimatic physical chemical changes in the areas of river and stream crossings.

5. Large amounts of water may be required for hydrostatic testing, which, if obtained during low flow periods or from critical overwintering fish areas, would deplete the water source irreversibly or eliminate the fish. Subsurface aquifers would be displaced, altered or depleted.

During construction and heavy vehicular traffic on unpaved roads, much dust will be generated during dry times of the year. This dust will cause a temporary deterioration of air quality by increasing the quantity of particulate matter in the air. Dust should not be significant during operation of the pipeline.

During operation of the pipeline local microclimate changes in the vicinity of compressor locations include local ice fog in winter in the immediate area. The arial extent of the ice fog and duration will depend on the meteorological conditions at the time.

The gaseous pollutants from compressor stations along the route consist of combustion products, mainly nitrogen oxides and hydrocarbons. There may be intermittent emmissions of hydrocarbons, particularly methane, as a result of leaks, accidental emissions and venting. Sulfur dioxide and particulate emissions from compressor stations are very small. Typical emissions from gas fired turbines are shown below.

SO_2	0.01 lbs/MMBTU
NO_x	0.69 lbs/MMBTU
CO	0.04 lbs/MMBTU
Particulates	Trace

Where the pipeline passes near towns and farms, construction equipment noise may be quite loud and annoying. Noise generated by the operation of compressors will increase the noise level in the immediate vicinity of each compressor station.

Compressors may be audible for a considerable distance and the degree to which their noise annoys people would depend on their location with respect to human habitation. Periodic venting of high-pressure gas from the pipeline and compressor stations would cause temporary increases in sound levels. Emergency blowdowns, episodic events, would also cause temporary noise impacts in the area.

A typical noise level from a gas blowdown was estimated at a maximum of 140 dB(A) at a distance of 100 feet from the stack. Gas blowdown occurs infrequently, and with a stack silencer noise levels could be reduced to 80 dB(A).

No adverse effect on the environment is expected from the disposal of solid wastes as their disposition is expected to be accomplished using tested and approved procedures with no long-term adverse effects.

As maintenance operations proceed during the operational phase of the pipeline, there may be restructuring or repair work performed on or near river crossings or aquifers. Such activities, similar to the original construction, could prompt stream siltation, temporary erosion and/or rechanneling. Extensive repair procedures would be the same as the original construction operations, in their environmental effects.

5.4 CHANGES IN BIOTA

There are a few significant, unavoidable impacts on the environment as it affects the biota of Alaska. In both areas, the Interior and the Arctic these effects are limited to the micro environment of and immediate associations of the proposed pipeline. These effects are enumerated in their order of importance.

1. A corridor of cleared land will remain through various areas of tundra, mountain, river plain and forests. This corridor will be restructured and restored as much as is practicable, but will probably be reclaimed by fireweed, and the hardier species of grasses which typify secondary succession of cutover forest lands. Tundra areas may support lichens and mosses; other areas will succeed to controlled low bush or grassy vegetation.

2. Restructuring of various ponds and/or swamplands may increase their rate of succession. To provide stabilization and protection of the pipe, various construction materials (rip rap, slag, rock, sand bags) may be used in certain areas. The introduction of such "construction material" can only increase the rate of pond or swamp primary succession and shorten the seral stages. Generally the stabilization of the various erosion/slump sites is a positive change in the areas.

3. The actual dimensional changes imposed on a stream bank or bottom by the presence of a pipeline is of no consequence. The restructuring of a stream bank, designed to inhibit erosion, will change the rate of succession and probably the seral stage of the river during flood flow periods. The stabilization of the banks will reduce the addition of soil (from erosion) to the river; bottom contours, food and mineral supplies, and emerging bankside vegetation will be altered. These are mostly positive changes in the flood plain system.

4. There are no predicted impacts upon the environment resulting from the interaction of the proposed chilled pipeline and the areas of continuous or discontinuous permafrost. The application of experienced engineering techniques; selection of soil and water regimes, extensive pipe insulation and careful maintenance will assure that frost bulb formation and all its concomitant impacts will be minimized.

5. There are no predicted unavoidable impacts on arboreal, aerial and terrestrial species, as imposed by the presence of a buried pipeline. The corridor provides some secondary sere which represents a net gain in energy flow to the biological food chain. Cover and habitat are still available nearby. In a sense, the corridor is similar to some highly productive "wildlife openings" established in various national forests.

6. The subterranean species, both vertebrate and invertebrate, may find it impossible to live near a buried pipe due to the presence of a small electromagnetic flux which surrounds the pipe. Such physical and chemical changes attendant to the pipe are strictly microclimatic and would not affect more than a few inches of the soil surrounding the pipe.

7. The various large mammalian species ranging on or near the proposed pipeline route, will suffer temporary harassment from the noise of the construction. Anecdotally, it has been reported that caribou, moose, and other large

mammals adapt well to the presence of man and machine. The operations and maintenance procedures may harass some birds, but these mobile species readily adopt new ranges. Unavoidable impacts are relegated to displacement of some animal species and transient relocation of others.

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6.0 RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

6.1 SHORT-TERM PRODUCTIVITY

The most important and obvious benefit resulting from the construction and operation of the proposed Alcan pipeline system will be to transport the projected 1983 receipt volume of 2.4 billion cubic feet per day of natural gas to connecting pipelines at the Canadian border for ultimate delivery to customers in the lower 48 states. Natural gas is, of course, a premium fuel--particularly from an environmental point of view--which is in increasingly short supply. The immediate availability of natural gas from Prudhoe Bay will reduce to some extent the need to develop and utilize other, environmentally inferior sources of energy.

Another significant benefit of the proposed pipeline project will be to continue the economic development in Alaska initiated by the trans-Alaska oil pipeline. While the primary benefit in terms of employment will be concentrated in the construction phase of the project, continuing employment opportunities will also be provided in the operation phase, as a result of both the need for operation and maintenance personnel and other economic activity stimulated by the pipeline's construction. The employment benefits will include those not only directly related to pipeline construction and operation but also, those indirectly generated by the need for related support services. In addition, the Alcan pipeline project will provide increased revenues, in the form of taxes and royalties, to the State of Alaska and local governments throughout the life of the project. The magnitude of these increased revenues, based on certain assumed levels of production and prices, are discussed in Section 3.3. Other indirect economic and social benefits and the impacts of the proposed project, particularly on communities along the pipeline route, are also presented in Section 3.3. These additional impacts generated by the Alcan project will range from the immediate effect of stimulating economic development along the Alcan Highway from Delta Junction to the Canadian border to the longer-range effect of stimulating other resource development in the State of Alaska.

The short-term impacts on biotic resources have been described previously in Sections 2.0 and 3.0, and, as discussed therein, will be limited in extent and will occur primarily in the construction phase of the project. In addition, the mitigation techniques outlined in Section 4.0 will be utilized to minimize any adverse short-term impacts and to avoid any long-term problems.

It is a significant benefit that the Alcan pipeline will follow an existing transportation and utility corridor throughout the entire 731 miles in Alaska, thereby limiting adverse environmental disturbances. The impact will be, in most instances, incremental in nature to existing disturbances created by the trans-Alaska oil pipeline and prior development along the Alaska Highway. In addition, because roads, pads, construction camps, material sites and other facilities developed by Alyeska will be utilized to the extent practicable in the construction of a substantial portion of the Alcan pipeline, the land use requirements of the project will be minimized. Utilization of the Alaska Highway and Haines Pipeline right-of-way will further reduce the land use requirements.

6.2 LONG-TERM PRODUCTIVITY

The long-term commitment of resources, including land use requirements, is described in Section 7.0. While certain dedication of land will be required for the duration of the project and while there will be surface and subsurface alterations, future uses of this land after the termination of the project will not be precluded or prevented. In addition, it is obvious that the production and consumption of the natural gas to be transported through the Alcan pipeline system will reduce the reserves at Prudhoe Bay available in the long-term. However, this is not to be considered an adverse consequence in light of the demonstrated immediate-term need and market for the natural gas supplies from this area. Finally, it is expected that there will be no long-term adverse consequences on biological productivity within the corridor impacted by the proposed Alcan project.

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7.0 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

7.1 LAND FEATURES AND USE

A significant amount of land in the State of Alaska will be permanently committed to the Alcan pipeline project including the land necessary for the pipeline right-of-way, work pad, access roads, and compressor stations. In addition, there will be an irretrievable commitment of building materials such as gravel, sand and select rock necessary for work pad construction and haul road maintenance. Other land may be used temporarily, such as for material sites, but with proper reclamation measures may be returned to a near-natural state. Right-of-way maintenance does preclude natural succession by trees and other woody plant species, and, thus, the permanent loss of select vegatative canopy.

7.2 ENDANGERED SPECIES AND ECOSYSTEMS

Two threatened species exist in areas along the proposed pipeline route: The Angayukaksurak char and the Arctic peregrine falcon. The range of the char is little known, but it has been reported from only a few headwater streams in the Brooks Range. Activities that affected a major portion of the streams in its range could affect this species as a whole.

The peregrine falcon has a rather wide nesting distribution. While the destruction of a major nesting site would have an appreciable impact on its population, the species' endangered status results from toxic pesticide residues rather than habitat losses. While it is doubtful that the proposed project would have a determining effect on the species, the Applicant will take necessary measures to limit the potential impact of construction on the peregrine falcon.

Another unique (but not listed as endangered) fish species which may be impacted is a genetically isolated population of Dolly Varden Char. They occur near the headwaters of the Tanana River drainage and occupy a unique niche as well as having a unique appearance. Any river crossings which might affect these fish will be carefully monitored to assure their survival.

Franklin Bluffs, with its scientifically important biotic resources, lies near the proposed pipeline route. This area has already been impacted by the construction of the Alyeska oil pipeline, and Applicant's proposed project could continue the intrusion upon this area. This and other potential critical habitat areas will be identified and the necessary accommodations in route alignment or construction scheduling will be made to avoid disturbance of these areas.

With the exceptions cited above, there are no projected impacts of the proposed project on threatened Alaskan species or ecosystems. It is the Applicant's belief that the proposed project will not result in the loss of any of the species discussed above.

7.3 SOCIO-ECONOMIC CONSIDERATIONS

There would, of course, be a substantial irreversible and irretrievable commitment of labor and financial resources to the construction, operation and maintenance of Applicant's proposed pipeline in Alaska. This irrevocable commitment would make these resources unavailable for other purposes. In addition, there would be significant commitment of resources to support or related development, facilities and services. These indirect commitments would probably include such improvements as the upgrading of the Alaska Highway from Delta Junction to the Canadian border.

The labor and financial resource commitments, both direct and indirect, will have an irrevocable, but not adverse, impact on the economy of the State of Alaska. These impacts on such items as employment in Alaska and tax and royalty revenues to the State and the local governments have been described in Section 3.3 of this Report. In addition, there will be some irreversible social or human impact, particularly on certain Native communities located along the Alaska Highway, and these are also considered in Section 3.3. The contemporary social and economic impacts of the Alyeska oil pipeline have established certain commitments of human resources; the proposed gas pipeline is a prolongation of these effects. Moreover, the resource investment required by construction of the gas pipeline will provide continuity to the State of Alaska's economic development following the construction of the Alyeska pipeline.

The proposed gas pipeline requires approximately 108 permanent operation and maintenance jobs.

7.4 FINITE RESOURCES LOST OR USES PREEMPTED

There are certain materials which are an integral part of the construction, operation, and maintenance of the proposed pipeline. The pipeline project must utilize vast quantities of steel, as well as other metals and materials, such as brass, iron welding material, flux, and installation materials. In addition, gravel and other borrow materials will be irretrievably committed to the installation of the proposed line. Substantial quantities of materials such as cement in the form of concrete saddles or weights used at river crossings or cement casings used in bored road crossings will also be used. Various fossil fuels (including natural gas and fuel oils) will be consumed in the construction and operation of the proposed pipeline. Housing and other related facilities indirectly associated with the project will require wood, glass, fabric and other materials.

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8.1 OBJECTIVES

The United States has substantial energy resources, but full realization of their potential is being delayed because of technological, economic, and environmental problems. The major finite energy resources in the United States are natural gas, coal, petroleum, and uranium. Most of the nation's energy is supplied by fossil fuels, (coal, petroleum, and natural gas). The supply of this energy has increased at an average rate of 5% per year while the demand for energy has doubled every ten years. Domestic usage of natural gas has reflected this trend in rising to 22.6 TCF in 1972, an increase of about 70% over 1962 consumption. However, since 1972 natural gas production has decreased. In 1975, gas production was 20.1 TCF.

In addition to the heavily used fossil fuels, there are viable alternatives for future energy needs, including oil shale, nuclear, solar, and geothermal. However, the Federal Energy Administration, in 1976, projects that the major contributions from solar, geothermal, and synthetic fuels will not be felt until after 1990.

8.2 ENERGY ALTERNATIVES

Energy deficits encountered in the immediate future (to 1985) must, in all likelihood, be met by simultaneous efforts to conserve energy and develop conventional hydrocarbon sources. The following evaluation of supplements to the proposed project is considered in this context.

8.2.1 Energy Conservation

An energy conservation program is essential not only as a means of preserving the nation's limited resources, but also to reduce the continued environmental degradation accompanying production of energy from some sources. The Office of Emergency Preparedness estimated in 1972 that energy growth could be reduced 16% by 1980 and 25% by 1990 without materially affecting the quality of life in the United States. For example, the home consumption of gas for heating could be reduced substantially by proper insulation of both old and new homes. Energy could be further conserved by improved transportation systems and more efficient industrial processes and equipment. Energy savings are possible also if recycling of products and waste is accomplished, particularly in industries which are energy intensive. Such energy practices are presently being encouraged by both individual companies and the Federal government. However, the potential energy savings from conservation will not be sufficient to eliminate the need for development of new energy sources.

Inefficient use of various fuels as a source of energy is also a problem. Natural gas is the most efficient of the heating fuels available. If natural gas continues to be available for space and water heating, other fuels could be utilized more efficiently for energy or feedstock sources.

8.2.2 Supplemental Sources of Natural Gas Supply

Natural gas is by far the most environmentally acceptable of fossil fuels. Air pollution from combustion of natural gas is less than from a coal-burning system and is significantly less than from a high-sulfur oil system. Although land is required for gas transmission, the environmental effects are relatively slight when compared to other alternatives. Gas requires only small amounts of land for production (CEQ, 1972).

Increased Natural Gas Supplies

From a national standpoint it is clear that the domestic natural gas supply is increasingly unable to match the evergrowing demand for this environmentally superior fuel. This problem is evidenced by the continuing decline in the ratio of reserves to production (R/P) since 1946, resulting from increased production rates without corresponding additions of proven reserves. To meet the anticipated demands for natural gas, a substantial reversal of this trend would have to occur. Such a reversal seems unlikely and, indeed, even matching historical levels of reserve additions will be quite difficult. Moreover, the R/P ratio is calculated without considering the physical and economic limitations which govern gas withdrawal or reflecting increased environmental concerns with respect to the techniques necessary to develop certain potential reserves. For these reasons, the availability of domestic natural gas sufficient to offset projected supply deficiencies seems unlikely.

Liquefied Natural Gas and Methanol

Natural gas in remote areas can be liquefied and transported by ocean-going liquefied natural gas (LNG) tankers. In addition to the construction of LNG vessels, use of LNG involves the construction of port facilities, liquefaction plants, vaporization plants, and pipelines. The environmental impact of the operations and facilities associated with LNG transportation are similar to those for ocean transport of other liquids but include the intake and discharge of ocean water for supplying the vaporization heat.

As yet, no deliveries of LNG have been made to the United States under long-term contracts. While several proposals have been filed with the Commission, estimates of when LNG would actually be delivered are uncertain in view of the time required for government authorizations and construction of complex transportation and handling equipment.

Conversion of foreign source natural gas to methanol (methyl alcohol) offers a transportation alternative to LNG. Methanol can be burned directly as fuel and does not require specialized tankers, storage, and handling facilities. The liquid is clean-burning with combustion products free of sulphur and particulate matter. It could displace natural gas and fuel oil in large industrial applications, but it must be converted to synthetic methane in order to substitute directly for pipeline gas. Methanol is not considered a substitute for the natural gas supply developed by this project, but could offer an alternate transportation mode for future projects which propose to ship LNG.

8.2.3 Synthetic Gas Supplies (SNG)

Synthetic gas (SNG) of pipeline quality can be produced from liquid hydrocarbons, coal, and such other sources as sanitary landfills. None of these projects or potential sources of SNG are deemed to be an alternative to this pipeline project.

SNG from Oil and Naphtha

Synthetic gas can be produced from certain liquid petroleum products (such as naphtha). In the past, a number of proposals have been made to produce synthetic gas as an alternative to dwindling supplies of natural gas. However, because of very limited domestic supplies of such products, the feedstock for gasification processes would have to be imported. There is also a worldwide shortage of such products and numerous competitive uses for them in petrochemical applications.

The high demand for liquid petroleum in transportation, petrochemical, industrial, and power generation uses is expected to keep feedstock prices so high that the manufacture of SNG from this source will remain uneconomic.

SNG from Waste

Small plants for the production of methane gas from organic wastes can be constructed in a relatively short time. However, this process is limited in scale and, to date, incapable of efficiently producing gas in marketable quanitites. The production of gas from a sanitary landfill in southern California is actively being studied. The potential volumes of SNG to be produced from this source are so small as to disqualify it as an alternative to this proposed project.

SNG from Coal

A variety of new processes are being developed in addition to older technologies for the production of low-BTU gas from coal. This gas can be used locally for fuel or can be converted to high-BTU, pipeline-quality gas for transportation to more distant markets. The National Petroleum Council estimates that utilization of coal for synthetic pipeline-quality gas could reach 2.48 TCF per year by 1985 under optimum conditions. Even this volume is relatively small when compared with growing nationwide demand, and legal and economic barriers may prove substantial. Production in this amount is dependent on obtaining necessary water for minemouth plants in the water-deficient western states as well as coordinated action by governmental bodies to ensure legal availability of this water. Also, continued authority to strip mine the western coal fields is necessary if any synthetic gas is to be produced. Federal leasing policies will also influence production in the west since a large percentage of coal-bearing lands are owned by the government. Of course, each of these aspects carries with it important environmental impacts which must be dealt with, including the control of emissions from SNG plants of fine particulate matter, gases, liquid wastes, and waste ash.

8.2.4 Alternate Primary Sources of Energy

Other practical primary sources of energy, under some circumstances, could be considered as alternatives to the proposed natural gas pipeline project. These primary energy alternatives do not provide the important advantages of gas in serving particular market needs. Supplies of such products are not adequate to meet their own current market requirements, let alone to satisfy gas market requirements.

Oil

Although oil comprises about 46 percent of the nation's current primary energy consumption, domestic production is insufficient to satisfy the present demand. Current production of crude oil and gas liquids is about 12 million bbl/day. The balance of the nation's needs (approximately 6 million bbls/day) must be imported.

The U.S. is and will be competing for foreign supplies of oil with Japan, Europe, and other rapidly developing areas. Though domestic reserves remain to be discovered, they will be expensive to develop and there are technological and environmental problems which must be solved. For most industrial, commercial, and domestic uses of petroleum, crude oil first must be refined. Shortages of crude oil are compounded by insufficient domestic refining capacity.

Among refined products, No. 2 distillate is used generally for domestic heating in the eastern United States, where supplies are far from people. In the western United States use of this fuel by residential consumers would require costly conversion of heating equipment.

Residual fuel oil is burned in large industrial installations and central station power plants; it, too, is environmentally undesirable because of its high sulfur content, as high as 4 percent. Though some of the sulfur in fuel oil can be removed, present sulfur removal capacity is limited and costly. Even in the absence of desulfurization, however, burning residual fuel oil generates fewer emissions than burning of coal.

Without additional oil discoveries, domestic oil reserves would be depleted in less than ten years. Even with additional discoveries, assuming no increase in demand the time period for oil depletion could be extended to perhaps 30 years. However, the national oil consumption in 1975 was about 18 million bbl/day and the deficit between the demand and domestic production had to be made up by oil imports totaling 6 million bbl/day.

Environmental Impact

Increased domestic production of petroleum does not appear to be a realistic substitute for energy deficiencies which will be made up by this proposed project and no environmental impacts are deemed necessary here. However, it is clear that the impact of increased production will be mostly in offshore areas and this will be different in nature from the impact of onshore drilling.

Coal

There are abundant reserves of coal in the United States. The most likely source area for coal would be the Rocky Mountain states because of this coal's low sulfur content and its shorter transportation distance.

Direct coal burning cannot economically replace natural gas in high priority residential and commercial applications in the northwestern regional market. Although environmentally acceptable electrical energy might be provided by coal burning power plants, the cost of converting present high-priority gas users to the use of electricity would be very high. Estimates, for example, of converting a household from natural gas to electricity range from 2,000 to 5,000 dollars.

Environmental Impact

Coal extraction to meet western market demands would probably occur in the Rocky Mountain states. The coal in this area would more than likely be produced by surface mining techniques (Atwood, 1975; FEA, 1976).

Area stripping and contour stripping are generally the two types of surface coal mining used. The following is a consideration of the environmental impacts of these mining techniques.

Area stripping for coal is usually employed when the topography is relatively flat. The overburden, which is often as deep as 100 feet or more, is removed by power shovels, draglines, or other types of excavators, leaving a trench or "box cut". After the overburden is removed, the coal is extracted, usually by similar equipment. Sometimes blasting may be necessary. When the coal has been removed from the first excavation, an adjacent cut is made, and the overburden or "spoil" removed from this cut is dumped into the previous cut. The final cut, which may be a mile or more from the original excavation, leaves an open trench as deep as the combined thickness of the overburden and the recovered mineral. Without postmining grading or leveling, area stripping leaves a landscape of roughly parallel ridges of unvegetated spoil, as well as the open trench.

The second kind of strip mining, contour mining, is the method used to extract mineral deposits from seams lying in hilly or mountainous areas. The contour miner begins by removing the overburden at the outcrop of the coal seam and deposits the spoil at the outer edge of the cut or on the slope below the cut. As the miner digs into the hill, the amount of overburden he must remove becomes greater with the increasing height of the hill. Eventually the height of the overburden makes further extraction uneconomical. This method leaves a bench along the hill or mountain and is characterized by a steep cliff or "highwall" which is the exposed face of the cut.

Both area and contour stripping entail removal of the vegetative cover. The topsoil, subsoil, broken rock, and other strata are then usually mixed together in the spoil, with the topsoil at the bottom. The spoil will usually not support vegetation, and the loose and unstable soil readily washes downhill. In addition, strip mining uncovers sulfurbearing minerals, such as pyrite and marcasite, which are normally present with coal. Water vapor and atmospheric oxygen react with these oxidizable sulfide minerals, whether they occur in rock strata or in the coal, to form sulfuric acid and acid-forming salts such as iron, magnesium, manganese, sodium, potassium, aluminum, and calcium sulfates. These stripping by-products inhibit plant growth on the soil banks and cause contamination of surface and subsurface waters. Often this acid, called "yellowboy", destroys virtually the entire aquatic ecosystem of the streams of a mining district, and this pollution can continue for many years.

The environmental costs of coat strip mining are potentially greater than the impacts associated with Applicant's proposed pipeline. Coal as an energy alternative to this project is environmentally unrealistic.

Hydro-Power

Conventional hydroelectric projects utilize controlled river flow through a system of dams to spin turbines and thereby generate electricity. Though their capital costs are high, operating costs are low. Dam projects, however, greatly alter the character of both the river being controlled and its drainage basin. As a result, their real impact can be far more widespread than the impact of obtaining subsurface fossil fuel.

Another form of water power is the pumped-storage system where water is pumped to an elevated storage reservoir at periods of low consumer demand for electricity, and drawn through the turbines during peak demand. More electricity is required for the pumping process than is generated when the water flows down. Approximately 15% of the electricity produced in the United States in 1970 was generated with water power. In the mountainous areas of the West, where more than half of the nation's hydroelectric capacity is located, water power supplied nearly 60% of the total output of electricity.

By 1985, even with concentrated development, electricity produced by hydro-power will represent no more than 8% of the total amount of electricity generated, and will supply less than 3% of the nation's primary energy demand. Because of the limited number of suitable sites, hydro-power is not a reasonable alternative to the natural gas to be provided by this project. Even if significant additional energy could be supplied by water-power, the same necessity of expensive end-user facilities conversion to electricity exists as already discussed.

Environmental Impact

Due to the limited number of available sites for hydro-power and the inability of this alternative to produce the energy equivalent of this proposed project, no environmental impact analysis has been made.

Nuclear Energy

The use of nuclear power as an energy source is traditionally limited to generation of electricity by electric utilities. Approximately 25 nuclear power plants are now in operation in the U.S., 50 more are under construction and another 60 have been proposed to the AEC. In 1974, nuclear power comprised 2% of the nation's total energy supply. Although nuclear power has experienced significant delays, it could furnish about 26% of electricity generation by 1985.

Nuclear-generated electricity is not a direct substitute for high-priority uses of natural gas since the cost of converting present gas users to this energy system would be very high. Other barriers to utilization of nuclear power as an alternative to the proposed project are environmental restraints on siting, construction, and operation. In addition to thermal releases to adjacent waters and the atmosphere, nuclear plants require substantial attention to operational safety. The disposal of long-lived radioactive wastes also constitutes a difficult long-term operational problem. These problems combine to result in very long lead times for nuclear power plants.

8.2.5 Future Energy Sources

A number of energy sources not now available in quantity are being investigated for future use. None of these is considered to provide an alternative to the Northwest Pipeline Corporation project.

Geothermal Energy

Geothermal steam or superheated water is produced when the earth's heat energy is transferred to subsurface water from rocks in the earth's crust. Where the pressure and temperature are adequate, the steam output may be used in turbines for conversion to electricity (CEQ, 1973).

Development of geothermal energy on a large scale will not be possible until certain economic, technical, and environmental difficulties are overcome. Geothermal wells may release gaseous pollutants and can contaminate surface and groundwater systems with dissolved salts. It has been estimated that a 1000 megawatt power plant in the Geysers geothermal field of northern California annually emits 18,000 tons of hydrogen sulfide. Sulfur emissions at similar potential geothermal plant sites in California could exceed those from comparable coal-fired power plants (CEQ, 1973).

Oil Shale

Oil Shale deposits in the Green River Formation of Colorado, Utah, and Wyoming are estimated to contain 600 billion barrels of extractable oil in seams yielding 25 or more gallons per ton of shale. By comparison, the nation's proven domestic reserves of liquid petroleum total only 39 billion barrels.

Oil from shale can be extracted by either in place underground retorting or by mining followed by retorting. In the former method, the shale is heated in place and the oil piped to the surface.

The retort process produces significant amounts of hydrogen sulfide and extensive solid waste by-products, whose volume even after compaction would be 15 percent more than the inplace shale. Because the residual solids are far less dense than the parent shale and cannot be readily compacted, only 60 to 80 percent of the wastes could be returned to the mine. Surface disposal of the spent shale could lead to the leaching of salts which could enter surface waters. Retorting, spent shale disposal, and shale oil upgrading would use large amounts of water in a region where water is in short supply. The sulfur content of the residual oil that could be produced from shale crude would be significantly below present levels in residual fuel. This sulfur oxide air pollution at the power plant would be reduced. The development of oil shale may dramatically increase domestic oil resources, but associated environmental impacts will depend to a large extent on the technologies used to extract and process the shale, to dispose of the spent shale, and to reclaim mined lands (CEQ, 1973). This energy source is not expected to contribute to available supplies in the near future and does not pose a viable alternative to the proposed project.

Tar Sands

It has been estimated that the development of tar sands, particularly the Athabasca tar sands in northern Alberta, Canada, would provide large supplies of oil in the future (Senate Committee, 93rd Congress). Thus the energy potential of the tar sands is not a substitute for the natural gas available from this project.

Nuclear Fusion and Breeder Reactors

Controlled thermonuclear fusion would use light-element fuels that occur in abundance to supply energy needs almost indefinitely. However, since the technology does not exist to produce controlled nuclear fusion for extended periods, thermonuclear power will probably not be available as an energy source for several decades.

The development of breeder reactors has not progressed to the point where they can provide economical energy supplies. Their potential offers lower thermal pollution, cheaper electric energy, and more efficient use of uranium reserves than conventional nuclear power plants.

Solar Energy

Significant results from solar energy research in the areas of direct conversion to electricity, indirect conversion to electricity, and photochemical conversion (including photosynthesis) are not expected before the year 2000 (Senate Committee, 93rd Congress). Nevertheless, solar energy may prove useful in meeting some space and water heating needs in the interim (CEQ, 1973).

It has been estimated that less than one percent of the nation's land surface area would be needed for the development of enough solar energy to supply all of its energy requirements. Disadvantages exist, however, and include the high temporal variability in energy (because of daily and seasonal changes and because of variable cloudiness) and the low energy density of solar radiation as compared to combustion (about 1/500 of that available from combustion).

The use of solar energy for space and water heating is currently technically feasible but costs are about double that for heating with natural gas. Again, daily and seasonal variability require some energy storage and a back-up fuel supply.

8.3 ALTERNATIVE PROJECTS

8.3.1 Alternative Routes

General Routes

The applications previously filed with the FPC by the Alaska Arctic Gas consortium and El Paso Company both constitute alternative systems to that proposed by this application. However, there are substantial disadvantages to each route that are not inherent in the Alcan pipeline.

The proposed Alaska Arctic Gas route extends east from Prudhoe Bay, south through Canada, and into the Lower 48 through an area previously unimpacted by pipeline construction. Specific detriments of this route are:

1. The alignment traverses only a short distance in Alaska through undeveloped areas. The line is principally a Canadian route. Consequently, economic benefits to Alaska from construction will be less than the two other alternatives. Moreover, the route precludes delivery of gas to the urban centers and citizens of Alaska.

2. Approximately 700 miles of the proposed Arctic Gas line route is inaccessible by existing roads.

3. Construction of the proposed pipeline route would involve use of unproven technology, such as snow roads, in an area where adequate snow accumulation would be questionable.

4. There are few towns, roads, hospitals, airfields, or other support facilities along the route. Construction would provoke urbanization and development of adjacent lands. Many residents of isolated subarctic communities see nearby construction as a threat to long-standing life styles.

5. The route encroaches upon the Arctic National Wildlife Range, an area set aside because of its ecological sensitivity. Intrusions would result in unavoidable degradation of the range.

6. The route would impact previously undisturbed caribou, and traverse caribou calving grounds.

The proposed El Paso Gas pipeline roughly follows the Alyeska oil pipeline to a proposed LNG terminal site at Gravina Point. LNG would be transported by tankers to proposed vaporization facilities on the West Coast of the Lower 48. Apparent detriments of this system are:

1. The liquification plant, storage faility, marine terminal, and portions of the pipeline would be situated in an area of high seismic risk.

2. Liquification and vaporization processes are not as efficient as natural gas transportation by pipeline. Thus, a significant amount of fuel energy would be consumed resulting in increased cost and diminished yield from the project.

3. An LNG terminal of the magnitude proposed extends beyond proven technology.

4. Construction of the southern portion of proposed El Paso System would impact relatively undisturbed wilderness areas; specifically Gravina Point, Prince William Sound, and the Chugach National Forest.

5. Carrier transport of LNG along the Canadian and United States shorelines presents both environmental and safety hazards.

6. Vaporization facilities would have to be constructed on the west coast of the Lower 48, extending the horizons of environmental impact.

In conclusion, both the Alaska Arctic Gas System and the El Paso System alternatives present problems and new environmental impacts to areas previously unaffected. Conversely, the alternative proposed by this application traverses areas where other pipelines (Alyeska, Haines products) or roads (Alcan) exist. Environmental impacts along this line are incremental rather than primary, the technology is established, and access is available with only a minimum of new road construction. Reaching these same conclusions, Federal Power Commission staff in the FPC Final Environmental Impact Statement on Alaska Natural Gas Transportation Systems, recommended the route proposed in this application over either the Alaska Arctic Gas System or the El Paso System (1976,IAI-IA3).

Localized Routes

The present route alignment will follow corridors established by the Trans-Alaska Pipeline (Alyeska) from Prudhoe Bay to Delta Junction and the Haines product pipeline from Delta Junction to the Alaska-Yukon border. Studies are in progress to determine instances where deviation from the alignments would be advantageous from engineering and environmental standpoints.

8.3.2 Alternative Transportation Modes

Alternative transportation modes for the pipeline system include LNG, dense-phase and methanol pipelines, railway and monorail systems, ice-breaking tankers, submarines, and aircraft.

LNG Pipeline

The longest operational cryogenic pipeline used to transport LNG is the 2.5 mile-long cryogenic pipeline at Brunei in Borneo. LNG is maintained at a temperature of minus 161 degrees C to minimize vaporization . The system is elevated and provides for expansion and contraction through the use of bellows. Its prime purpose is for the loading of LNG tankers. The feasibility of a very long cryogenic pipeline has yet to be demonstrated. It is doubtful that cooling and insulation techniques currently being employed could be used for a pipeline hundreds of miles in length. An operational LNG pipeline could not be developed within the time frame of the proposed project.

Dense-Phase Pipeline

Natural gas could be converted to its dense-phase, where it exhibits properties between a liquid and a gas. This corresponds to a temperature of minus 115 degrees F to minus 150 degrees F and pressures from approximately 400 to 1,000 pounds per square inch. The gas could then be transported by pipeline and regasified for distribution by conventional pipeline systems. Dense-phase pipelines have yet to be used commercially over great distances. Anticipated costs are greater and the efficiency less than for a natural gas pipeline. Environmental impacts are those due to the pipeline itself, plus the additional impact of the refrigeration and regasification plants.

Methanol Pipeline

Natural gas could be converted to methanol in plants at the producing areas and transported as a liquid through pipelines. At its destination it could be converted to synthetic natural gas or used directly as methanol. A methanol pipeline system, though technically feasible, would have a lower efficiency and higher overall cost than a natural gas pipeline. Impacts on the environment would result from the methanol and conversion plants as well as the pipeline itself.

Railway

Natural gas liquefied at the producing area and transported as LNG by railroad could be regasified for distribution by conventional gas pipelines. A railway from Prudhoe Bay and special railway equipment would be required. Ignoring the severe terrain between Prudhoe Bay and areas to the south, efficiencies would be lower and costs higher for a railway and the special equipment than for a natural gas pipeline. Impacts on the environment due to railway construction, the liquification and regasification plants would be greater than those due to the equivalent natural gas pipeline.

LNG Monorail

A system in which the LNG is contained in railway-type vehicles, moving on a single elevated guideway is within the scope of current technology. Recent emphasis has been placed on such systems for mass transit rather than cargo system use. Small systems supported on wheels are presently in use and advanced systems employing magnetic levitation are under construction. Costs of an LNG monorail system would likely exceed those of a railway system. Environmental impacts would be similar to those for the railway system but would probably require less construction material.

Ice Breaking Tanker

Ice breaking tankers could be used to transport LNG or methanol through ice covered waters to terminals on the east of west coast ports. Natural gas would be liquefied or converted at the producing area and regasified or reconverted for introduction into conventional natural gas distribution lines. Ice breaking tankers for both methanol and LNG are within the present technology; however, costs would be prohibitive, particularly for an LNG tanker. Design and construction of the tankers would require a longer time than that needed for a conventional natural gas pipeline. Impact on the environment would result from the conversion plants as well as that resulting from tanker accidents.

Submarine

A system similar to the ice breaking tanker but using submarines could be used. Development of the system would require considerable lead time and would take longer to implement than a natural gas pipeline system. Impacts would be similar to the ice breaking tanker.

Air Transportation

An airplane capable of transporting LNG has been proposed by Boeing. It would be four times the size of a 747 and capable of carrying 1,000 tons of LNG. Transportation of LNG by very large airships would be an alternative to the LNG airplane. Designs for such an airship have yet to be seriously considered.

A form of aircraft, the helifloat, is presently being developed. It combines the characteristics of a helicopter, a bouyancy craft and an airplane. Such a craft could carry an LNG cargo.

The above forms of possible air transportation are all in the early stages of study or development. Lead times associated with prototype construction would far exceed the time frame for constructing a natural gas line. Environmental impacts associated with the above craft would be those of the craft construction, the conversion plants, and auxillary facilities such as runways and morring pads. Risk of aerial transport would be substantial.

8.4 NO ACTION OR POSTPONEMENT

If no action is taken the results will have negative consequences for both the Lower 48 states and Alaska. In the Lower 48, gas will not be available in the quantity needed to meet existing and projected energy demands. Although alternate energy sources are available to meet a portion of the demand, a energy shortage might well be anticiated in both the short and long term. In addition, alternate energy sources are either economically or technologically unfeasible or environmentally prohibitive.

The Alaskan economy is closely tied to the development of its energy resources. This project will alleviate an employment and commercial slump to follow completion of the Alyeska project. It will provide state revenues and expanded public services for Alaskan citizens. Overall, greater economic stability and regulated expansion of the Alaskan economy is anticipated.

If the project is delayed, energy needs within the Lower 48 might be curtailed. Negative environmental impacts and prohibitive energy costs might result from development of inferior energy resources. In Alaska, delay of the project would create a gap between the termination of the Alyeska project and initial construction on the gas pipeline, affecting state, local, and individual economies.

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9.0 PERMITS AND COMPLIANCE WITH OTHER REGULATIONS AND CODES

9.1 PERMITS

The following list outlines permits and other known requirements for the proposed project within the State of Alaska. Prior to undertaking any construction phase, each applicable permit will be secured. (In itemizing these requirements, Applicant does not necessarily concede the jurisdiction of any agency or governmental unit, or the validity or applicability of any of the statutes, codes or regulations herein.)

Agency or Authority	Requirement
Federal:	
Bureau of Indian Affairs	Coordination
Department of the Interior, National Parks Service	Survey, Test and Excavation Permit
Federal Communications Commission	Approval
Federal Energy Administration	Approval
Federal Power Commission	Certificate of Public Convenience and Necessity
Federal Power Commission	Presidential Permit
General Services Administration	Approval
Land Use Planning Commission of Alaska	Coordination
U. S. Department of Agriculture	Approval
U. S. Department of the Air Force	Approval
U. S. Department of the Army	Approval
U. S. Department of Commerce	Approval
U. S. Department of Health, Education and Welfare	Coordination
U. S. Department of the Interior	Right-of-Way Permit
U. S. Department of the Navy	Approval
U. S. Department of Transportation	Approval
U. S. Environmental Protection Agency	Permit for discharge of hydrostatic test waters

Agency or Authority	Requirement
State - Alaska:	
Department of Commerce	Approval
Department of Economic Development	Approval
Department of Environmental Conservation	Approval
Department of Fish and Game	Approval
Department of Highways	Approval
Department of Health and Social Services	Approval
Department of Labor	Approval
Department of Natural Resources	Approval
Department of Natural Resources, Division of Parks	Survey, Test and Excavation Permit
Department of Public Safety	Approval
Department of Public Works	Approval
Office of the Governor	Notification

Agency or Authority	Requirement
Borough-Municipal:	
Fairbanks-North Star Borough	Approval
North Slope Borough	Approval
City of Fairbanks	Approval
Town of Delta Junction	Approval
Town of North Pole	Approval

9.2 HEALTH AND SAFETY MEASURES

Federal Regulations

The minimum Federal safety standards for transportation of natrual and other gas by pipeline were issued by the Department of Transportation, Office of Pipeline Safety, and by the Occupational Safety and Health Administration (OSHA).

These are the minimum standards for health and safety which must be utilized in the construction of a natural gas pipeline.

To these basic criteria, the following Federal laws and regulations apply:

a. The Williams Steiger Occupational Safety and Health Act of 1970, Public Law 91-596, Title 29, Chapter 17, Part 1910 of the Act. This concerns itself with the safety of employees. Title 29, Chapter 17, Part 1926 of the Act is concerned with the health and safety regulations for construction.

b. Motor Carrier and Safety Regulations, Department of Transportation, Federal Highway Administration, Title 49 CFR, Part 390-397; this pertains to company vehicles involved in interstate travel.

c. The Natural Gas Pipeline Safety Act of 1968, Public Law 90-481, Minimum Federal Safety Standards for the Transportation of Natural Gas and Other Gases by Pipeline, Title 49, CFR, Part 192; the Act and standards are concerned with the safe construction, operation, and maintenance of pipelines and with the safety of the public.

d. Aesthetic Guidelines for Interstate Gas Pipeline Construction, Part 2, Subchapter A, Chapter 1, Title 18, of the Code of Federal Regulations, Section 2.69.

e. Title 26 CFR, Part 181. This deals with the transportation of explosives.

State Regulations

Alaska Statutes Title 18, Chapter 60 contains the Alaska General Safety Code. This body of law has been amended to conform to the pertinent provisions of OSHA.

Section 18.60.030, as amended in 1973, requires the State Department of Labor to establish and enforce occupational safety and health standards which prescribe requirements for safe and healthful working conditions for all employment within Alaska. These requirements are as effective as federal OSHA regulations. Alaska has entered into a Section 5 (b) agreement under the Natural Gas Pipeline Safety Act with the Department of Transportation, which allows the state to act as an agent for pipeline safety for interstate pipelines.

Local Requirements

To the extent that they are not overriden by Federal and state requirements, all health and safety laws, regulations, and codes in force on the local level will be complied with. All pertinent local requirements will have been promulgated by the Fairbanks-North Star Borough, the North Slope Borough, or by the affected municipalities of Fairbanks, North Pole, or Delta Junction.

Industry and Underwriter Codes

In the design and construction of the facilities, the latest revisions of applicable industry and underwriter codes pertaining to safety matters will be used.

Pertinent codes include, but are not limited to, those of the following associations and boards:

American Concrete Institute	ACI
American Gas Association	AGA
American Institute of Steel Construction Standards Specifications and Codes	AISC
American Iron and Steel Institute	AISI
American Petroleum Institute	API
American Society of Mechanical Engineers	ASME
American National Standards Institute - Code for Gas Transmission and Distribution Pipeline System	ANSI
American Water Works Association Standards - Department of Transportation - Federal Gas Pipeline Safety Standards	AWWA
American Welding Society	AWS
National Electric Code	NEC
National Electrical Manufacturer's Association	NEMA
National Fire Protection Association	NFPA
National Board of Fire Underwriters	NBFU

9.2.1 Authorities Consulted

Pertinent regulations and codes were determined from prior experience of the Applicant in the construction, operation, and maintenance of natrual gas pipeline systems.

9.2.2 Procedures To Be Followed

To assure compliance with Federal, state, local and industry codes and regulations, the following procedures will be observed

1. Inclusion of or reference to applicable codes and regulations in contract specifications for construction of pipelines and appurtenances.

2. Personnel will be provided with current editions of the pertinent codes, and will be required to become familiar with code requirements.

3. As needed, current construction procedures will be modified and updated.

Contents

10.0 SOURCE OF INFORMATION

10.1 PUBLIC HEARINGS

No public hearings have been held in regard to the proposed project. Prior to construction, public meetings will be held to adequately inform the public of the pipeline project. The comments and concerns of the public will be considered in the final planning and design of the pipeline system.

10.2 OTHER SOURCES

10.2.1 Meetings with Governmental and Other Entities

There have been no meetings held with governmental entities.

10.2.2 Studies Conducted

Supportive studies of the environmental effects of the proposed pipeline are in progress. By discipline and author, these are:

Archaeology, John P. Cook
Fisheries, Jack M. Van Hyning; Paul B. Holden
Geotechnical, Ralph R. Migliaccio
Hydrogoly, Robert F. Carlson
Land Ownership and Land Use Patterns, Dale P. Tubbs
Large Mammals, Dennis D. Bromley
Meteorology, Alan W. Bowman
Ornithology, Brina Kessel
Seismic, Robert B. Forbes
Sociological Anthropology, Larry L. Nayor and Lawrence Gooding
Vegetation, Jay D. McKendrick.

10.2.3 The names, addresses, and professional vitae of the consultants contributing to this report are included in this section. These are as follows:

BROMLEY, DENNIS D.

Education
Michigan State University, B.S., 1965

University of Michigan, M.S., 1967

Experience
High School Teacher, Anchorage School District, 1968 - present.

Participated in population structure study of Arctic Caribou Herd, 1970.

Principal investigator and author of environmental impact assessments of maintenance and expansion of five small boat harbors in Southeast Alaska, 1973.

Selected Publications
Bromley, Dennis, D., 1967. Some observations on Spreading of Aquatic Flowering Plants in Deep Water of Douglas Lake, Michigan. The Michigan Botanist. Vol. 6: pp. 75-80.

Thomas, Paul M. and Bromley, D., 1968. The Establishment of Aquatic Vegetation in and Around Artificial Fish Shelters in Douglas Lake, Michigan. The American Midland Naturalist. Vol. 80: No. 2, Oct., 1968. pp. 550-554.

Bromley, Dennis D., 1972. The Porcupine. Part of the Wildlife Notebook Series. Alaska Department of Fish and Game.

Bromley, et. al., 1975. A Fish and Wildlife Resource Inventory of the Northeast Gulf of Alaska. Compiled by the Alaska Department of Fish and Game under contract to the Alaska Department of Environmental Conservation for Coastal Zone Data Development. Vol. I: 411 p.

BROMMELSIEK, PATRICIA H., Librarian

Born
July 29, 1946

Soc. Sec. No.
562-68-1883

Education
Chapman College, Orange, CA., B.A. cum laude, 1968

University of Southern California, M.S.L.S., magna cum laude, 1971

Experience
Research Assistant in Library Science, Arctic Environmental Information and Data Center, University of Alaska, Anchorage, Alaska, 1974 - Present.

Librarian, Reference and Community Services, Palos Verdes Library District, Rolling Hills Estates, CA., 1972 to 1974.

Librarian, Reference, Santa Barbara Public Library, Santa Barbara, CA., 1971 to 1972.

Library Assistant II, Black Gold Information Center, Santa Barbara, CA., 1968 to 1970.

BUCK, EUGENE H., Research Analyst in Fisheries

Born
December 13, 1943

Soc. Sec. No.
380-44-1413

Education
Michigan State University, B.S., Fisheries, 1965

Michigan State University, M.S., Limnology, 1968

Experience
Research Analyst, University of Alaska, Arctic Environmental Information and Data Center, Anchorage, Alaska, 1972 - Present.

Program Co-ordinator, University of Alaska, Arctic Environmental Information and Data Center, Anchorage Alaska, 1974-1975.

Professor of Fisheries and Biology, Sheldon Jackson College, 1968 to 1972.

Acting Academic Dean, Sheldon Jackson College, 1969 to 1970.

Chemical Analyst, Institute of Water Research, Michigan State University, 1968.

Research Project Director, Dept. of Fisheries and Wildlife, Michigan State University, 1964.

Research Assistant, Dept. of Fisheries and Wildlife, Michigan State University, summers of 1962 and 1963.

Selected Publications
Buck, E. H. et al. 1975. Kadyak--A Background for Living. Arctic Environmental Information and Data Center, University of Alaska, Anchorage. Sea Grant Report no. 75-9. 324 p.

Buck, E. H. et al. 1974. The Briston Bay Environment--A Background Study of Available Knowledge. Report for U.S. Army. Corps of Engineers.

Buck, E. H. 1973. Alaska and the Law of the Sea--National Patterns and Trends of Fishery Development in the North Pacific. Arctic Environmental Information and Data Center, University of Alaska, Anchorage. Sea Grant Report no. 73-4.

Selected Publications (Cont'd.)

Evans, C., E.H. Buck, et al. 1972. The Cook Inlet Environment--A Background Study of Available Knowledge. Report for U.S. Army. Corps of Engineers.

Selkregg, L., E.H. Buck, et al. 1972, Environmental Atlas of the Greater Anchorage Area Borough. Arctic Environmental Information and Data Center, University of Alaska, Anchorage.

CARLSON, ROBERT F.

Education
B.S.

M.S.

Ph.D. Civil Engineering (Hydrology), University of Wisconsin.

Experience

Director of the Institute of Water Resources; Professor of Hydrology, Department of Civil Engineering, University of Alaska, Fairbanks. Dr. Carlson is also a consultant to R & M in the field of hydrology and water resources.

He has extensive research experience in many areas of arctic and subarctic hydraulic and hydrological problems. This research includes computer models of runoff, streamflow, flood frequency and offshore hydraulics. He is currently working in the areas of applied statistical analysis, air and water pollution transport modeling, lake and reservoir modeling and thermal pollution. Dr. Carlson has a long list of publications on these topics as well as many other aspects of hydrology and water pollution.

Dr. Carlson has fifteen years experience in engineering, teaching and research at both the University of Wisconsin and the University of Alaska. Dr. Carlson also has done consulting work for Alaskan construction and engineering companies and governmental agencies.

Activities
Registered Professional Engineer in Alaska and Wisconsin, Registered Land Surveyor in Alaska.

COOK, JOHN P.

Birthdate
January 17, 1938

Education
B.A. Dartmouth College, 1959

M.A. Brown University, 1964

Ph.D. University of Wisconsin, 1969

Experience
Research Associate in Archaeology, Institue of Arctic Biology, University of Alaska 1975 - Present

Assistant Professor of Anthropology, Department of Anthropology, University of Alaska 1974 - 1975.

Chairman and Assistant Professor of Anthropology, Department of Anthropology, University of Alaska 1971 - 1974.

Publications
"An Analysis of Some Northern Microblade Cores." Abstracts, Society for American Archaeology, Ann Arbor. p. 10, 1967.

(with R.A. McKennan) "Prehistory of Healy Lake, Alaska." Paper presented to the Society for American Archeology, Santa Fe; and to the VIIIth International Congress of Anthropological and Ethnological Sciences, Japan, 1968.

Report of Archeological Survey and Excavations along the Alyeska Pipeline Service Company Haulroad and Pipeline Alignments. 216 pp. Department of Anthropology, University of Alaska, College, 1970.

DOOLEY, DENNIS M.

Birthdate
July 9, 1942

Education
University of Alaska, B.B.A., 1972

Northwestern University, M.S., 1973

Experience
Special Assistant to the Commissioner, Alaska Department of Highways, 1975-1976

Assistant General Manager, Valdez, Alaska Terminals, 1974

Department of Budget and Management, State of Alaska, 1973-1974

DREYER, LINDA DWIGHT, Research Analyst in Water Resources

Born
August 24, 1949

Soc. Sec. No.
214-48-9866

Education
Colgate University, Marine Biology and Environmental Science, 1971

Cornell University, M.S., Natural Resources, In progress

Experience
Research Analyst in Water Resources, University of Alaska, Arctic Environmental Information and Data Center, Anchorage, Alaska, September 15, 1973 - Present. Joint appointment with Institute of Water Resources, July 1, 1975 - Present.

Geologic Field Assistant, U.S. Geological Survey Office of Marine Geology, Woods Hole, Massachusetts, June-September 1972 and June-July, 1973.

Head Teaching Assistant, Department of Natural Resources, Cornell University, September 1972 to May 1973.

Associate Editor in Water Resources, Environment Information Center, New York, New York, November 1971 to May 1972.

Selected Publications
Bason, R. and A. Harrison, eds. 1971. Environmental Study Group, Final Report, Spring 1971. Colgate University, Hamilton.

AHTNA, Inc. 1973. The AHTNA Region. Background for Regional and Community Planning. Prepared for AHTNA, Inc. by the Arctic Environmental Information and Data Center.

Selkregg, L. et al. 1975. The Alaska Regional Profiles: Arctic Region. Arctic Environmental Information and Data Center. University of Alaska, Anchorage.

Selkregg, L. et al. 1974. The Alaska Regional Profiles: Southcentral Region. Arctic Environmental Information and Data Center. University of Alaska, Anchorage.

EVANS, CHARLES D., Associate Resource Biologist

Born
July 1, 1920

Soc. Sec. No.
062-14-9071

Education
University of Minnesota, B.S., 1949

University of Minnesota, M.S., 1951

Experience
Associate Resource Biologist, University of Alaska, Arctic Environmental Information and Data Center and Sea Grant Program, Anchorage, Alaska, 1972 - Present.

Twenty-two years experience in fish and wildlife studies with the U. S. Fish and Wildlife Service:

3 years as Waterfowl Biologist, Division of River Basin Studies, Minneapolis, Minnesota.

2 years Flyway Biologist (waterfowl), Mississippi Flyway.

7 years Flyway Biologist in Atlantic Flyway.

9 years in Alaska as Field Office Supervisor with Division of River Basin Studies.

1 year as Biologist, Special Trans-Alaska Pipeline Studies.

Selected Publications
Evans, C.D. 1969. Environmental effects of petroleum development in the Cook Inlet area in Proceedings of the 20th Alaskan Science Conference.

Evans, C.D. et al. 1972. The Cook Inlet Environment--A Background Study of Available Knowledge. U.S. Army. Corps of Engineers Report. Alaska District. Anchorage.

Selkregg, L. et al. 1972. Environmental Atlas of the Greater Anchorage Area Borough. Arctic Environmental Information and Data Center, University of Alaska, Anchorage.

FORBES, ROBERT B.

Birthdate
March 14, 1924

Education
University of Washington, B. S., 1950
University of Washington, Ph. D., 1959

Experience
Professor of Geology, Geophysical Institute and Department of Geology, University of Alaska, 1970 - Present.

Visiting Research Geologist, Alaskan Geology Branch, U.S.G.S., Menlo Park, California. 1965 - 1969.

Selected Publications

Forbes, R. B., D. K. Ray, T. Katsura, H. Matsumoto, H. Haramura, and M. J. Furst, The comparative composition of continental versus island arc andesites in Alaska, International Upper Mantle Project Scientific Report #16, State of Oregon Dept. of Geology and Min. Indus. Bull., 65. 111-120, 1969.

Forbes, R. B. and M. J. Lanphere, Tectonic significance of mineral ages of blueschists near Seldovia, Alaska, J. Geophys. Res., 75, 1383 - 1386, 1973.

Bunder, C. M., C. A. Bush and R. B. Forbes, Radioelement distribution in the Birch Creek basement complex, Eielson Deep Test Hole, Alaska, J. Res. U.S. Geol. Survey, 1, No. 6, 659-663, 1973.

Forbes, R. B., D. L. Turner and J. R. Carden, Age of trachyte from Ross Island, Antarctica Geology, pp. 297-298, June 1974.

Swainbank, R. and R. B. Forbes, Petrology of eclogitic rocks from the Fairbanks district, Alaska, Geol. Soc. Am. Special Paper, 1975.

GOLDSMITH, OLIVER S.

Born
July 17, 1945

Education
Princeton University, B.A., 1967

University of Wisconsin, M.S., 1972

Experience
Assistant Professor of Economics, Institute of Social, Economic, and Government Research, University of Alaska, Present.

Economic consultant, Dane County Airport Commission, 1975.

Project Assistant, Department of Revenue, State of Wisconsin, 1974.

Selected Publications
Goldsmith, Oliver S., "Market Allocation of Exhaustive Resources," Journal of Political Economy, Vol. 82, No. 5 (Sept. - Oct., 1974).

Cicchetti, Charles J., and Oliver S. Goldsmith, "Oil and Gas: A Case Study of Institutional Irrationality", presented at National Science Foundation RANN Energy Conference, M.I.T., February 14, 1973.

Foell, W.K., D.B. Shaver, M.S. Caruso and Oliver S. Goldsmith, "1973 Survey of Energy Use in Wisconsin", Institute for Environmental Studies, Report #10, University of Wisconsin, Madison, Wisconsin, September, 1973.

Foell, W.K., Oliver S. Goldsmith, and Paul Hayes, "Energy Shortages: The States Respond", presented at National Workshop on State and Local Decision Making on Energy Policy, Washington, D.C., sponsored by the Energy Policy Project of the Ford Foundation, September, 1973.

GOODING, LAWRENCE A.

Birthdate
April 27, 1939

Current Address
Department of Psychology/Sociology
209-A Gruening Building
University of Alaska, Fairbanks

Specialization
Family, Religion, Social Change, Rural Sociology, Community and Methodology

Experience
Research Director for the "Study of Shrine Shinto" under the auspices of the Ford Foundation, 1969.

Consultant, Environmental Inventory of Indianola, Iowa, under the auspices of National Science Foundation, 1974.

Preliminary study of Alaskan Native involvement in the construction phase of the Trans-Alaska Pipeline, 1975.

Assistant Professor of Sociology, University of Alaska, Fairbanks, 1974 - Present.

Selected Publications
"Attitudes Toward Rural Zoning" Bureau of Governmental Research, University of Oregon, 1968.

"Community Resources of Crested Butte" Mimeo, 1971

Papers Read at Professional Meetings
"Rural Social Work Education in Iowa" Presented at the CSWE Conference on Rural Social Work, Denver, Colorado, 1973.

HICKOK, DAVID M., Director, Arctic Environmental Information and Data Center, University of Alaska

Born
October 7, 1924

Soc. Sec. No.
534-26-5730

Education
New York State College of Forestry, Syracuse University, (summa cum laude), B.S., 1947

Experience
Director, Arctic Environmental Information and Data Center, University of Alaska, Anchorage, Alaska, 1972 - Present.

Director, Sea Grant Program, University of Alaska, 1970 to January, 1975.

Planning Officer for Natural Resources, Federal Field Committee for Development Planning in Alaska, Anchorage, Alaska, 1967 to 1970.

Natural Resources Officer and Regional Planning Coordinator, U.S. Department of Commerce, Washington, D.C., 1966 to 1967.

Director of Alaska Centennial Projects, U.S. Department of Commerce, Washington, D.C., 1966 to 1967.

Analyst in Science and Technology, Library of Congress, Washington, D.C., 1956 and 1966.

Congressional Fellow, with Senator Muskie of Maine and Congressman Ullman of Oregon, Washington, D.C., 1964 and 1965.

Chief, Branch of Refuge Operations and Branch of Planning for Wildlife Refuges, and Assistant Chief, Branch of Resource Management, Bureau of Sport Fisheries and Wildlife, U.S. Department of the Interior, Washington, D.C., 1959 to 1964.

Refuge Manager, National Wildlife Refuges, Bureau of Sport Fisheries and Wildlife, U.S. Department of the Interior, Vermont, Delaware, Maine, and Montana, 1950 to 1963.

Experience (Cont'd.)

Game Research Investigator, Conservation Department, State of New York, 1948 to 1950.

Natural resource and engineering assignments for various private resource-related industries, 1943 to 1948.

Selected Publications

Hickok, D. "Alaska Natives and the Land", Federal Field Committee for Development Planning in Alaska, Anchorage, Alaska, 1969; responsible for over-all supervision of publication and graphics and author of Chapter III, "Land and Ethnic Relationships", and Chapter IV, "Natural Resources".

Hickok, D. "An Approach to Marine Resources Development in Alaska", a report to the Institute of Marine Science, University of Alaska, Fairbanks, Alaska, 1969, by an Ad-Hoc Sea Grant Committee.

Hickok, D. and E.C. Wunnicke. "Observations on Marine Affairs in Alaska", Ibid., 1970.

HOLDEN, PAUL B.

Birthdate
February 11, 1944

Education
B.S. Wisconsin State University, 1966

M.S. Utah State University, 1968

Ph.D. Utah State University, 1974

Experience
Consultant, Colorado Squawfish Recovery Team, 1976.

Fish and Wildlife Biologist, U.S. Fish and Wildlife Service, Anchorage, 1974 - 1975.

Instructor, Department of Wildlife Science, Utah State University, 1972 - 1974.

Publications
Systematic studies of the cyprinid genus Gila, in the upper Colorado River basin. Copeia 3:409-420. (with C. B. Stalnaker), 1970.

Threatened fishes of Utah. Proc. Utah Acad. Sci., Arts and Letters 51(2):46-65. (with Utah Fishes Committee, Bonneville Chapter, American Fisheries Society), 1974.

Distribution of fishes in the Dolores and Yampa River systems of the upper Colorado basin. Southwestern Naturalist 19(4):403-412. (with C. B. Stalnaker), 1975.

Distribution and abundance of mainstream fishes of the middle and upper Colorado River basins, 1967-1973. Trans. Am. Fish Soc., 104(2):217-231. (with C. B. Stalnaker), 1975.

KESSEL, BRINA

Education

B. S. Cornell University, 1974

M.S. University of Wisconsin, 1949

Ph. D. Cornell University, 1951

Experience

Administrative Assistant for Academic Programs, Office of the Provost, Northern Region, University of Alaska, 1973 - present.

Curator of Terrestrial Vertebrate Collections, University Museum, University of Alaska, 1972 - Present.

Professor of Zoology, University of Alaska, 1959 - Present.

Dean, College of Biological Sciences and Renewable Resources, University of Alaska, 1961 - 1972.

Selected Publications

Kessel, Brina, H. K. Springer, and C. M. White. June Birds of the Kolomak River, Yukon-Kuskowim Delta, Alaska. Murrelet 45:37-47. 1965.

Kessel, Brina, and H.K. Springer. Recent Data on Status of Some Interior Alaska Birds. Condor 68:185-195. 1966.

Isleib, M. E., and Brina Kessel. Birds of the North Gulf Coast-Prince William Sound Region, Alaska. Biol. Papers, University of Alaska No. 14. 149 p. 1973.

Winter Activity Patterns of Black-capped Chickadees in Interior Alaska. Wilson Bull. 88:36-61. 1976.

Birds of Interior Alaska. (A volume covering 25 years of original data.) In Preparation.

KRUSE, JOHN A.

Education
Williams College, B.A., 1972

University of Michigan, M.R.P., 1975

University of Michigan, Ph.D., 1975

Experience
Assistant Professor of Survey Research, Institute of Social, Economic, and Government Research, University of Alaska, 1975 - Present.

Assistant Study Director, Institute for Social Research, 1973-1974.

LABELLE, JOSEPH C., Research Analyst in Geomorphology

Born
July 29, 1937

Soc. Sec. No.
026-28-7843

Education
University of Massachusetts, B.S., Geology, 1969

University of Michigan, M.S., Physical Geography, In progress

Experience
Research Analyst in Geomorphology, University of Alaska, Arctic Environmental Information and Data Center, Anchorage, Alaska, January 1, 1974 - Present.

Project Manager and Environmental Investigator, Mt. Logan High Altitude Research Project, Arctic Institute of North America, 1968 to 1973.

Glaciological Investigator, North Slope Ice Investigation Project of Polar Expeditions, Inc., Arctic Institute of North America, 1970.

Investigator in glaciological-oceanographic winter voyage of the ice-breaker CCGS Louis S. St. Laurent, Arctic Institute of North America, 1972.

Project Leader, Mountaineering Equipment Research Program, Arctic Institute of North America, 1972.

Project Leader, investigation of fill materials and aggregate resources, under contract of U.S. Navy, Office of Naval Petroleum and Oil Shale Reserves, Arctic Institute of North America, 1972 to 1973.

Selected Publications
LaBelle, J.C. 1968. Environmental Studies on Mt. Logan, Yukon Territory. Arctic Institute of North America. High Mountain Environment Project. Technical report 4.

LaBelle, J.C. Studies at High Elevation, Mt. Logan, Yukon. Ice-field Ranges Research Project Scientific Results, volume 4.

Selected Publications (Cont'd)

LaBelle, J.C. January 1973. Fill Materials and Aggregate Near Barrow, Naval Petroleum Reserve No. 4, Alaska. Arctic Institute of North America. Final Report to Office of Naval Petroleum and Oil Shale Reserves. Contract NOd-9915 (72-2). Vol.1.

December 1973. Fill Materials and Aggregate in the Cape Halkett Region, Naval Petroleum Reserve No. 4, Alaska. Vol. 2.

LOGSDON, CHARLES L.

Born
June 23, 1949

Education
Washington State University, B.A., 1971

Washington State University, M.A., 1975

Experience
Research Associate, Institute for Social, Economic, and Government Research, University of Alaska, Anchorage, Present.

Selected Publications
Logsdon, Charles L., Ken L. Casavant, and Wayne Thomas, "Boom or Bust Economy--Past History for Alaska?", presented at the American Agricultural Economics Association, College Station, Texas, 1974.

Logsdon, Charles L., David W. Holland, and Jacqueline M. Baritell, "On the Importance of the Small Town as a Population Aggregate: The Experience of Washington State," submitted for publication Fall, 1974.

Logsdon, Charles L., Ken L. Casavant, "Impact of Alaska Trade on the Washington Economy," to appear in an upcoming issue of the Annals of Regional Science.

Logsdon, Charles L., Ken L. Casavant, and Wayne Thomas, "Input-Output Tables for Alaska--A First Look," pending Experiment Station Bulletin.

MCKAY, A. RONALD

Birthdate
May 8, 1929

Education
B. Eng. McGill University, Montreal

M. Eng. McGill University, Montreal

Experience
Manager Special Programs - Arctic Engineering Division, Mechanics Research Inc., 1975 - Present.

Associate with Dames and Moore, Consultants in the Environmental and Applied Earth Sciences. 1973 - 1975.

Selected Publications and Reports
"Possible Uses and Construction Methods for Arctic Coastal Platforms Fabricated from Frozen Sea Water", Invited paper presented Aug., 1975 at the "Third International Conference on Port and Ocean Engineering under Arctic Conditions" (POAC), Fairbanks, Alaska, with R. C. Miller & R. N. Ragle.

"Power Generation using Arctic Sea Water as a Heat Source", Second Annual Thermal Power Conference, Pullman, Washington, October, 1971.

"Evaluation of the Effect of Air Velocity on the Heat Transfer Rate of the Two-Phase Thermal Pile", Contract #DACA89-70-C-0022.
U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, February, 1971.

"Sea Ice Activity and Pressure Ridge Growth in Vicinity of Surcharged Grounded Ice Islands UNAK 1 and UNAK 2", for Humble Oil, classified to December, 1971. Institute of Arctic Environmental Engineering, University of Alaska, November, 1969.

MCKENDRICK, JAY D.

Education
University of Idaho, Moscow, B.S., 1963

University of Idaho, Moscow, M.S., 1966

Kansas State University, Manhattan, Ph.D., 1971

Experience
Assistant Professor of Agronomy, University of Alaska, 1971 - Present.

Research Experience
Range Research, Alaska, 1972 - Present.

Reclamation of land damaged by oil spills, 1972 - Present.

Tundra Rehabilitation Research, 1972 - Present.

Selected Publications
Mitchell, Wm. W., J.D. McKendrick, F.J. Wooding, and M.A. Barzee. Agronomists on the banks of the Sagavanirktok. Agroborealis 6(1):33-35. 1974.

Mitchell, George A., and Jay D. McKendrick. Volcanic-ash-affected soils of southcentral Alaska: some chemical and mineralogical properties. Agroborealis 7(1):21-23. 1975.

McKendrick, J.D. Soil nutrients. In: J. Brown (ed.) Ecological and limnological reconnaissances from Prudhoe Bay into the Brooks Range, Alaska. U.S. Army CRREL, Hanover, N.H. p. 21-23. Summer 1975.

Mitchell, William W., and Jay D. McKendrick. Responses of Arctic, boreal and alpine biotypes in reciprocal transplants. In: Jerry Brown (ed.) Ecological investigations of the tundra biome in the Prudhoe Bay Region, Alaska. Biological papers of the University of Alaska, Special Report No. 2. p. 92-111. 1975.

MIGLIACCIO, RALPH R.

Education

B.S. in Geology, Brigham Young University, 1958; Engineering Management (currently enrolled in M.S. Program), University of Alaska.

Honors and Professional Activities

Member, Association of Engineering Geologists; Affiliate Member, American Society of Civil Engineers; Member Civil Air Patrol; Mayor (Pro Tem) and City Councilman, Valdez, Alaska.

Experience

Partner, R & M Engineering-Geological Consultants, 1969.

Ralph R. Migliaccio, Consulting Engineering Geologist, 1968.

Research Engineering Geologist, Arctic Environmental Engineering Laboratory, College, Alaska, 1968 - Present.

State Foundation Geologist, Materials Section, 1966 - 1968.

Engineering Geologist, Juneau District, 1965, Alaska State Highway Department.

Engineering Geologist, Pacific Materials Laboratory, Bloomington, California, 1965.

Valdez District Geologist and Materials Engineer, 1963 - 1964.

Engineering Geologist, Utah State Department of Highways, 1960 - 1963.

Photo Interpretation and Map Construction, Western Aerial Photo Lab., Salt Lake City, Utah, 1960.

Photo Interp. and Map Construction, Aeronautical Chart Center, St. Louis, Mo., 1958 - 1960.

MORRIS, KRISTI JOAN, Research Assistant in Geology

Born
May 20, 1950

Soc. Sec. No.
519-56-6627

Education
Augustana College, Illinois, B.A., Geology, 1972

Experience
Research Assistant in Geology, University of Alaska, Arctic Environmental Information and Data Center, Anchorage, Alaska, September 15, 1973 - Present.

Clerk Typist, Rock Island Arsnenal, Illinois, June 1972 to May 1973.

NAYLOR, LARRY L.

Birthdate
March 15, 1940

Address
Anthropology Program
211 B Gruening Building
University of Alaska
Fairbanks, Alaska

Education
State University of New York, Geneseo, B.S., 1962

State University of New York, Geneseo, M.S., 1968

Southern Illinois University, Ph.D., 1974

Experience
Research Anthropologist, United Nations Fund for the Development of West Irian, Indonesia (FUNOWI/8) 1971-1973

Assistant Professor, Department of Anthropology, University of Alaska, Fairbanks, 1974-Present

Selected Publications
Culture change and development in the Balim Valley, Irian: bulletin of West Irian Development, Vol. I. no. 3: 101-103, 1972

Culture Change and Development in the Balim Valley, Irian Jaya, Indonesia: A final report on Central Highlands Research, FUNDWI/8, November 1971 - March 1973. United Nations Mimeo., 75 pages, 1973

Applied Anthropology: Approach to using anthropology, Human Organization, Journal for Applied Anthropology, Winter Issue, Vol. 32, no. 4: 363-369, 1973

SCOTT, MICHAEL J.

Education

Washington State University, B.A., 1970

University of Washington, M.A., 1971

University of Washington, Ph.D., 1975

Experience

Institute of Social, Economic, and Government Research, University of Alaska, 1975 - Present

Selected Publications

Crutchfield, James A., and Michael J. Scott, "Economic Criteria for Low Flow Standards," State of Washington Water Research Center, June, 1973, as Washington Water Research.

Scott, Michael J., "Some Implications of Petroleum Conservation Regulation," Ph.D. dissertation in economics, University of Washington, University Microfilms, Ann Arbor, Michigan, 1975.

Crutchfield, James A., et. al., "The Washington Baseline Study--Marine Economic Component," Institute for Marine Studies, University of Washington, forthcoming.

Scott, Michael J., "Analysis of Economic and Social Impact of Alternative Routes to the Alaska Arctic Gas Pipeline: An Economic Analysis," prepared for U.S. Department of the Interior Bureau of Land Management, Alaska Natural Gas Transportation System Task Force, Contract YA-512-CT6-68, December, 1975.

SEARBY, HAROLD W., Associate in Climatology

Born
June 15, 1918

Soc. Sec. No.
559-38-3579

Education

Nebraska State Teachers College, Chadron, B.S., Physics-Math, 1941

Penn State University, University Park, M.S., Meteorology, 1961

Experience

Associate in Climatology, University of Alaska, Arctic Environmental Information and Data Center, Anchorage, Alaska, July 1, 1973 - Present.

Regional Climatologist, NOAA, National Weather Service, Anchorage, Alaska, 1966 - Present.

Aviation Forecaster, E.S.S.A., Weather Bureau, Anchorage, Alaska, 1961 to 1966.

Forecaster, U.S. Weather Bureau, Colorado Springs, Colorado, 1955 to 1961.

Meteorologist-Forecaster, U.S. Weather Bureau, Oklahoma City, Oklahoma, 1954 to 1955; Brownsville, Texas, 1952 to 1954.

Observer-Briefer, U.S. Weather Bureau, Tulsa, Oklahoma, 1949 to 1952.

SEIVER, DANIEL A.

Born
November 1, 1947

Education
Yale University, B.A., 1969

Yale University, M. Phil., 1971

Yale University, Ph.D., 1974

Experience
Assistant Professor of Economics, Institute for Social, Economic, and Government Research, University of Alaska, 1974 - Present.

Associate in Research and Post-Doctoral Fellow, Economic Growth Center, Yale University 1973-1974.

Selected Publications
Seiver, Daniel A., "Comment on W. Whitney Hicks' 'Economic Development and Fertility Change in Mexico, 1950-1970'", Demography, February, 1976.

Seiver, Daniel A., "Recent Fertility in Mexico: Measurement and Interpretation", Population Studies, November, 1975.

Rosenzweig, M.R., and Seiver, Daniel A., "Comment on N.K. Namboodiri's 'Which Couples at Given Parities Expect to Have Additional Births? An Exercise in Discriminant Analysis'", Demography, November, 1975.

Seiver, Daniel A., "Alaska Population Growth and Movements, 1960-1973", Institute for Social Economic, and Government Research Research Note, April, 1975.

Seiver, Daniel A., "Fetal Mortality and Population Density in the United States, 1960", Working Paper of the Institute for Social and Policy Studies, Yale, 1971.

SKELKREGG, LIDIA LIPPI, Professor of Regional Planning

Born
July 24, 1920

Soc. Sec. No.
574-16-3966

Education
University of Florence Italy, Doctor of Natural Sciences (equiv. Ph.D.), 1943.

Experience
Professor of Regional Planning, University of Akaska, Arctic Environmental Information and Data Center, Anchorage, Alaska, 1971 - Present.

Planning Consultant, Alaska Planning and Management, 1971 to 1972.

Planning Officer, Federal Field Committee for Development Planning in Alaska, 1970 to 1971.

Planning Specialist, Alaska Training and Planning Center, 1969 to 1970.

Capital Improvement Coordinator, City of Anchorage, 1968 to 1969.

Technical Director, Staff Geologist-Planner, Planning Associate, Assistant Planner, Alaska State Housing Authority, 1961 to 1968.

Geologist-Engineer, U.S. Army. Corps of Engineers, 1958 to 1959.

Geologist, Illinois State Geological Survey, Champaign, Illinois, 1951 to 1958.

Assistant Professor, Geology Department, University of Florence, Italy.

Selected Publications
Selkregg, L.L. et al. 1975. Akaska Regional Profiles: Arctic Region. Arctic Environmental Information and Data Center. University of Alaska. Anchorage. Office of the Governor.

Selkregg, L.L. et al. 1974. Alaska Regional Profiles: Southcentral Region. Arctic Environmental Information and Data Center. University of Alaska, Anchorage. Office of the Governor.

Selected Publications (Cont'd)

Selkregg, L. L. et al. 1972. Environmental Atlas of the Greater Anchorage Area Borough. Arctic Environmental Information and Data Center, University of Alaska, Anchorage. Office of the Governor.

Selkregg, L. L. and other staff members of the Federal Field Committee for Development Planning in Alaska. 1970. Economic Outlook for Alaska.

Selkregg, L. L., E. Crittenden, and N. Williams. 1970. Urban planning in the reconstruction in Human Ecology Volume, The Great Alaska Earthquake of 1964. National Academy of Science.

TUBBS, DALE P.

Birthdate
July 8, 1931

Education
Michigan Technological University, B.S.

Experience
Consultant, Moening-Grey and Associates, Geotechnical Consultants, Anchorage, Alaska, 1976-Present

Fourteen years, State of Alaska, Division of Lands, 1962-1976 in the following capacities:

2 years Deputy Director, Anchorage, Alaska

1 year Acting Chief of Lands Section

6 years South Central District Land Manager

VAN HYNING, JACK M.

Born
May 10, 1922

Education
University of Washington, B.S., 1948

University of Miami, M.S., 1951

Oregon State University, Ph. D., 1965

Experience
Privately employed consultant: Living Marine Resources, Inc., F. F. Slaney and Co., Ltd., 1973 - Present.

Associate Professor of Fisheries Biology, University of Alaska, 1968-1973.

Acting Director of Research, Division of Research and Management, Clackamas, Oregon Fish Commission, 1959-1968.

Selected Publications
Keim, Charles J., and Van Hyning, Jack M., The Caribou, An Unendangered Species. Elements Magazine. 3(2): 14-25, 1975.

Van Hyning, Jack M., Fisherman Plan Salmon Hatcheries. Alaska Magazine. June 1975, 41(6):29-30.

Van Hyning, Jack M., Aquaculture in Alaska's future. The Commercial Fish Farmer and Aquaculture News, 1975.

Cooney, R. T., and Van Hyning, Jack M., The developing fishery for snow crabs in Prince William Sound, Alaska, with observations on biology, size composition, and abundance. Proceedings 23rd. Alaskan Science Conference, 1972.

Van Hyning, Jack M., University of Alaska Sea Grant program. In: Minutes of the Third Alaskan Shellfish Conference. Alaska Department of Fish and Game, Informational Leaflet, 1972.

Scarborough, A.M., and Van Hyning, Jack M., Identification of fungal encrustation of the shell of the snow crab (*Chionoecetes bairdi*). Journal Fisheries Research Board of Canada 30(11):1738-1739, 1973.

Cooney, R. T., and Van Hyning, Jack M., Association of juvenile walleye pollock (*Theragra chalcogramma*) with the jellyfish *Cyanea*. Copeia 1974, No. 3:791.

WILSON, WILLIAM J., Research Analyst in Fisheries and Wildlife Biology

Born
October 3, 1947

Soc. Sec. No.
540-58-4966

Education
Gonzaga University, Spokane, Washington, B.S., Biology, 1969

Oregon State University, Corvallis, Oregon, M.S., Fisheries and Wildlife, 1973

Experience
Research Analyst in Fisheries and Wildlife Biology, University of Alaska, Arctic Environmental Information and Data Center, Anchorage, Alaska, August 1, 1975 - Present.

Research Assistant in Biology, University of Alaska, Arctic Environmental Information and Data Center, Anchorage, Alaska, August 1, 1974 to July 31, 1975.

Independent Consultant, Water Quality Biologist, Puget Sound Oil Baseline Studies, Daniel, Mann, Johnson, Mendenhall/Hilton, Portland, Oregon, May 1 to July 1, 1974.

General Science Instructor, Lincoln County School District, Newport, Oregon, February to June, 1974.

Aquatic Biologist, Research Assistant, Pesticide Toxicity to Dungeness Crab, Thermal Tolerance of Estuarine Organisms, Oregon State University, Marine Science Center, Newport, Oregon, 1973-1974.

Environmental Protection Agency Trainee in Water Quality, Suspended Sediments Study, Oregon State University, Marine Science Center, Newport, Oregon, 1970-1973.

Fisheries Laboratory Assistant, Freshwater Stream Productivity Studies, Oregon State University, Oak Creek Fisheries Research Laboratory, Corvallis, Oregon, 1970.

Selected Publications
Wilson, W. J. 1974. "Effects of concentration and particle size of suspended materials on growth and condition of the Pacific oyster (*Crossostrea gigas*)." Oregon State University, Corvallis. M.S. thesis. 65 p.

WISE, JAMES L.

Born
May 22, 1931

Soc. Sec. No.
278-28-2411

Education
Kent State University, B.S., Education, 1953

Florida State University, M.S., Meteorology, 1968

Experience
Research Analyst in Climatology/Meteorology, University of Alaska, Arctic Environmental Information and Data Center, Anchorage, Alaska, 1975 - Present.

Major, U.S. Air Force, 1953 to 1975. Assignments included:
- Aerospace Science Officer, 11th Weather Squadron (Climatologist and Technical Services).
- Chief NH MACRO Section at Air Force Global Weather Central.
- Commander of Forecasting and Observing Unit.
- Commander of Forecasting Unit, Vietnam, 1966.
- Chief Forecaster and Duty Forecaster.

ZENAN, JOAN S., Librarian

Born
March 9, 1940

Soc. Sec. No.
568-48-8563

Education
U.C.L.A., B.A., 1965

U.C.L.A., M.L.S., 1967

Experience
Research Assistant in Library Science, University of Alaska, Arctic Environmental Information and Data Center, Anchorage, Alaska, 1974 - Present.

School Librarian, Greater Anchorage Area Borough School District, 1974.

Elementary School Teacher (substitute), Tehama County School District, Mineral, CA., 1973.

Librarian II, U.C.L.A., 1971.

Departmental Libraries Cataloger, Welch Medical Library, Johns Hopkins University, Baltimore, MD., 1969.

Librarian I, Cataloger, U.C.L.A. Biomedical Library, 1968 to 1969.

Intern in Medical Librarianship, U.C.L.A. Biomedical Library, 1967 to 1968.

Circulation Clerk, Palo Alto Public Library, 1965 to 1966.

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