Alcan Pipeline Company
Docket No. CP77-
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, ALASKA

REVIEW DRAFT

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

JUNE 18, 1976

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.

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1.0 DESCRIPTION OF THE PROPOSED ACTION

Northwest Pipeline Corporation proposes to design, construct, and operate an overland pipeline system transporting natural gas reserves from Prudhoe Bay in the Alaskan Arctic to consumers in Alaska and the western United States. The total system proposed will extend a large diameter pipeline across Alaska and Canada to points of tie-in with existing transmission facilities in British Columbia and Alberta; in turn, these existing pipelines will be expanded to transport the gas south to the existing Northwest Pipeline Corporation system in Washington and Oregon. The components of the proposed pipeline system that constitute this Application for a Certificate of Necessity and Convenience are as follows:

1. Prudhoe Bay, Alaska to the U.S.-Yukon border via a new Northwest Pipeline Corporation pipeline.

2. Alaska-Yukon border to Fort Nelson (British Columbia) and Zama (Alberta) via a new Northwest Pipeline Corporation pipeline.

3. Fort Nelson to Sumas, Washington (U.S.A.) via an augmented Westcoast Transmission Company Ltd. gas pipeline.

4. Zama to Kingsgate (British Columbia) via augmented Alberta Gas Trunk Line and Alberta Natural Gas Company pipelines.

5. Sumas to Kent, Oregon via a composite of new and augmented Northwest Pipeline Corporation gas pipelines.

The system will be herein referred to as the Alcan Pipeline due to the major portion of its alignment using a corridor common to the Alaska-Canada Highway. The segmentation employed is based on political boundaries as well as sponsorship and ultimate ownership of the component pipelines. Each of the four pipeline segments outside Alaska is described in detail in Volumes 2 through 5 of Exhibit Z1. In this volume, Northwest Pipeline Corporation requests the requisite authorizations to construct the Alaska segment of the Alcan natural gas transmission system.

This proposal is made feasible by the imminent production and transportation of crude oil resources from the North Slope. The gas fraction of the hydrocarbon complex will be produced jointly with the petroleum in which it is dissolved. As flaring or venting of this gas is unacceptable in the current context of national energy shortage, a collection and delivery system to provide this energy resource to waiting consumers is highly warranted.

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1.1 Purpose

The purpose of the Alaska segment 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. Gas delivered at this point will then be in sequence transported across Canada and into distribution networks in the lower 48 where it will become available directly or via exchange to customers in market areas of the western United States. This gas supply is intended to meet a portion of a projected widening gap between customer demand and available gas supply in these areas, a trend that has reached serious proportions in recent years. Applicant's proposal will provide 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, 1984, the Alcan pipeline will transport 2,250 million cubic feet of gas per day (MMSCFD). Buildup to this delivery level will occur in the following increments:

1,000 MMSCFD by January 1, 1981

1,500 MMSCFD by January 1, 1982

2,000 MMSCFD by January 1, 1983

2,250 MMSCFD by January 1, 1984

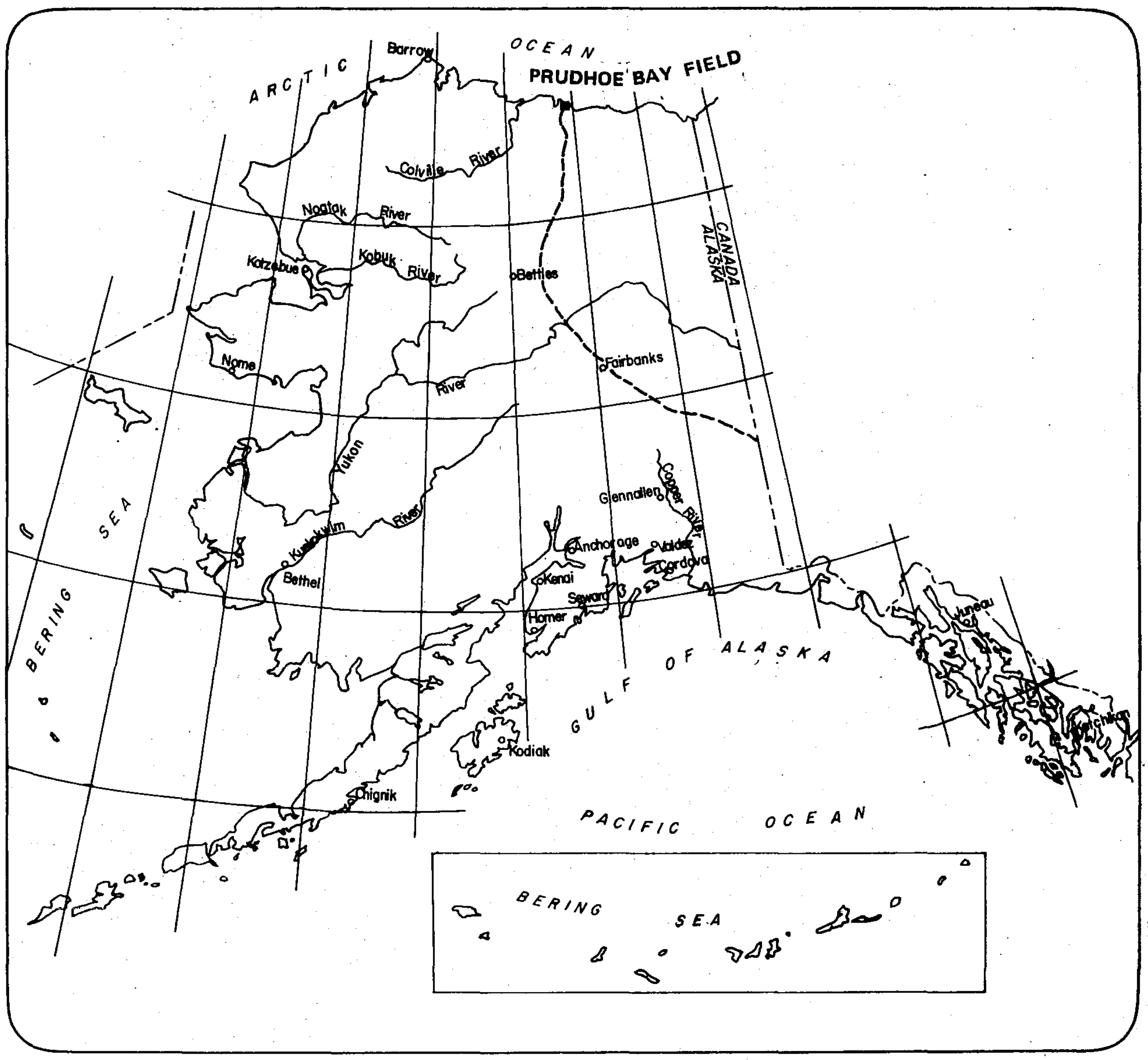
Fifteen percent of the Alaskan Royalty gas (12.5 percent of the average daily volume in the line) will be delivered to users in the Fairbanks area. Otherwise, no delivery points in Alaska are presently envisioned.

An assessment of the present and projected relationship between energy supply and demand in the Northwest Pipeline Corporation gas market is presented in Exhibit   of this application.

1.2 Location

1.2.1 Pipeline

The proposed Alaska segment of the Alcan pipeline shown in Figure 1.2-1 will consist of 790 miles of 42-inch outside diameter (O.D.) pipe. The pipeline route will closely follow two established transportation corridors. From Alyeska Pump Station No. 1 at Prudhoe Bay to Delta Junction 90 miles south of Fairbanks, the pipeline alignment will adjoin 540 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



Alcan Pipeline-Alaska

Figure 1.2-1

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 Creek, the alignment will follow the Alcan Highway. the route remains in the Tanana River throughout this traverse of the Tanana-Kuskokwim lowlands below the north face of the Alaska range. Besides following the Alcan Highway, this segment will adjoin the rights-of-way of a products pipeline used by the Air Force to transport gasoline between Fairbanks and Haines Junction and a microwave communications system operated by RCA, Inc. The products line is inactive between Tok and the border, and will be dismantled. The relative location of these and other transportation/communications facilities is shown in the land use map presented in Section 2.0.

1.2.2 Compressor Stations and Other Facilities

Operating at design capacity, the Alaska segment of the Alcan pipeline will utilize 16 compressor stations located at approximately 50-mile intervals along the line. Exact milepost locations for each station are presented in Table 1.2.1. Other major facilities include a gas flow control and monitoring center tentatively situated several miles south of Fairbanks, and gas flow metering stations at the producer's compressor station near Alyeska Pump Station No. 1, at the Fairbanks tap when and if implemented, and at the border point of delivery to the Canadian segment of the Alcan pipeline.

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 entire 730-mile Alaska segment of the Alcan pipeline. 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 product 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, however, due to local instances where terrain or other factors dictate a narrowed right-of-way.

Table 1.2.1

Location of Compressor Stations

Station No.	Alcan Pipeline Milepost (south from Alyeska Pump Station No. 1)
1	0
2	43.5
3	83.7
4	118.6
5	157.7
6	210.8
7	261.9
8	305.9
9	355.0
10	400.7
11	442.6
12	
13	543.6
14	590.3
15	639.4
16	684.1

Moreover, a significant portion of the construction zone will overlap existing rights-of-way in all but isolated cases where route deviations are appropriate. The extent of overlay varies. The new right-of-way north of Delta Junction will be located between the Alyeska haul road and the oil pipeline. In most instances the new work pad will directly adjoin either the existing haul road or the Alyeska work pad. Where the pads adjoin the minimum extension will be 40 feet. Overlap in such cases will be approximately 10 feet.

Greater overlap of existing rights-of-way is proposed for the Delta Junction to the Yukon border segment. East from Tok to the Canadian border, retired sections of the Haines products pipeline will be removed from the ground. The existing 50-foot right-of-way will then be extended to 120 feet in the direction of the Alcan Highway. Between Delta Junction and Tok the existing right-of-way will be paralleled but not overlapped.

1.3.2 River Crossings

In following the Alyeska oil pipeline alignment, the proposed natural gas pipeline will cross 37 natural water-courses. Between Delta Junction and the Yukon border, six principal crossings will be encountered.

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 from the shoreline a distance equal to the length of the crossing plus two 40-foot lengths of pipe, or no greater than 500 feet. Applying this concept to the 43 crossings suggests that construction areas at river banks would require less than 200 acres.

Major Alyeska crossings to be avoided in the Prudhoe-Delta Junction segment include the Sagavanirktok River and the Delta River. The Sagavanirktok, crossed five times by the oil pipeline, is a wide braided stream flowing on sand and gravel bed with an ill-defined channel. The gas line will adhere to its west bank where burial in the haul road will avoid long exposures in sections of high scour potential and reduce proximity to sensitive encironmental areas along Franklin Bluffs, east of the Sagavanirktok. Alyeska chose to bury the oil line in the Delta floodplain due to onshore space limitations. The gas line will be routed along hillsides east of the floodplain to avoid channelward scour enhanced by the Alyeska groin system protecting the oil line.

1.3.3 Compressor Stations

A total of approximately 300 acres will be required for the proposed compressor stations and their appurtenant facilities. Each of the compressor stations will be located on 20-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 seven-year construction period. Other facilities such as meter staging areas, stations, and the central control facility will require additional area, but those utilizations are inconsequential in comparison.

1.4 Proposed Facilities

1.4.1 Compressor Stations

Compression for moving the gas will be provided at each of the 16 stations by a 26,000 horsepower gas turbine driven centrifugal compressor unit. The general operating characteristics of such units are presented in Table 1.4.1. Each station will be automated and remotely operated from the Fairbanks control 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

Table 1.4.1

Characteristics of Typical Gas Turbine Power Unit
Operating at 59°F at Sea Level

Horsepower: 8750 (minimum ISO rating)*

Heat Input: 10,850 Btu/hph

Air Flow: 374,000 lb/hr

Emmissions from stack 37 feet high, 6 feet in diameter:

Parameter	lb/MMBtu	lb/hr	ppm
NO_x	0.25	20.18	54
particulates	negligible	--	--
CO	0.04	3.23	9

Exhaust Temperature: 585°F

Air Flow, Actual: 181,937 ft^3/min

Exhaust Velocity: 6436 ft/min

*The proposed compressor stations will require approximately 26,000 horsepower.

Source: A U.S. gas turbine manufacturer.

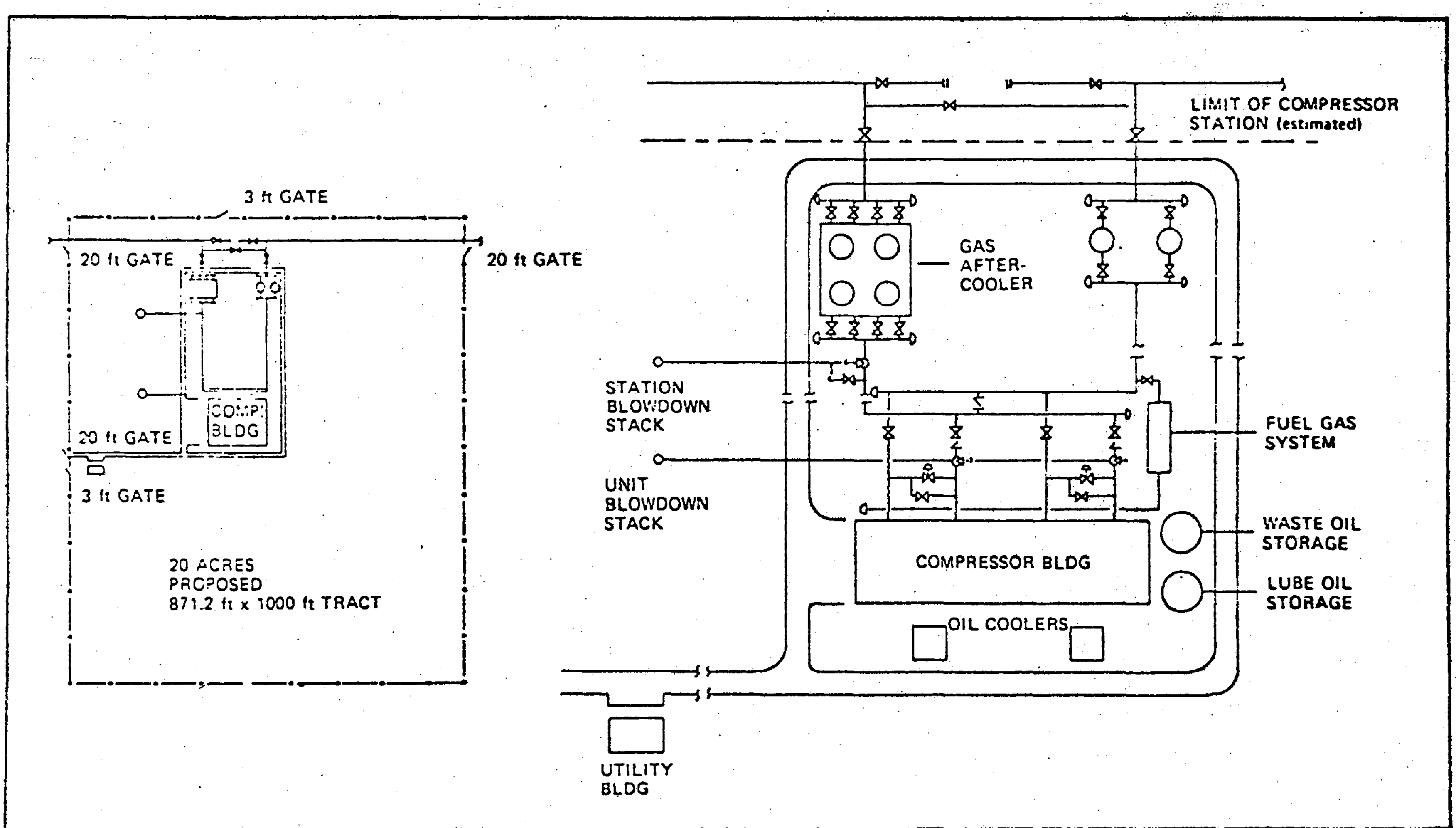


Figure 1.4-1 TYPICAL COMPRESSOR STATION, GENERAL PLAN

one 10,000 horsepower and one 5,000 horsepower turbine driven compressor, air-cooled condensers, and evaporators. Exit gas temperature from each station will be controlled to compensate for seasonal conditions and variability in downstream permafrost. It is anticipated that the normal range among the stations in exit gas temperatures will be between 10 and 25°F.

As previously indicated, the battery limits of each station will be approximately 20 acres, most of which will be open space, structures and related facilities occupying 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 main building at each station will be operating controls, instrumentation, automatic controls, gas measuring equipment, electric power generation equipment and an emergency generating system, a heating system, a small desk area, and a maintenance shop. Also enclosed will be tanks for storage of water, waste oils, lubrication oils, propane, and separator condensate drains, and a suitable wastewater handling and disposal system. An adequate water supply for utility and housekeeping purposes will be provided; if necessary, a well will be dug. 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. In addition, approximately 0.5 miles of 15-foot-wide all-weather road will be constructed within the grounds of each station to provide access to its facilities. 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

Compliance with Construction and Pipeline Regulations

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".

Northwest Pipeline Corporation 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. Alaska state and local construction codes and ordiances pertaining to pipeline construction and operation will be followed. In the design factor selection, consdieration 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 compilance 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, and will minimize the risk of damage.

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 coated in the field by the over-the-ditch pipe-coating method using a good quality protective coating. Field joints will be made using protection wrap flood coaters or their equivalent.

Pipe will be deliverfed by ship or barge to Prudhoe Bay, Seward, and possibly Valdez and will then be double-jointed in storage yards at these locations and later transported to the construction site by truck. 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 105 miles
Mile Post 125 to 230

Spread 3: Minnie Creek to Yukon River
Distance 127 miles
Mile Post 230 to 354

Spread 4: Yukon River to Moose Creek
Distance 117.5 miles
Mile Post 357 to 474.5

Spread 5: Moose Creek to M.P. 1366 Alcan Highway
Distance 130 miles
Mile Post 474.5 to 604.5

Spread 6: Mile Post 1366 Alcan to Yukon border
Distance 131.4 miles
Mile Post 604.5 to 735.9

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. In addition, special construction is scheduled to avoid ditching of ice-rich soils during flooding periods at maximum permafrost thaw depth and runoff. On a yearly basis, two time windows are available to accomplish this. These are starting at the cessation of the winter extremes to the onset of significant thaw and from the commencement of soil freeze back to the onset of winter extremes. The exact elapsed time for each window is variable along the route and in certain sections they may coincide.

In general the combined time for the two windows will average approximately 137 days of non-winter extremes over the construction year.

Clearing and grading operations will take place ahead of the mainline pipeline construction during these two windows. Major river crossings and transit of the Continental Divide at Atigun on the mainline spread operation. Scheduling will be directed at allowing minimum elapsed time between the trenching, pipelaying, and backfilling operations.

The total elapsed time for the pipeline construction over the six spreads will thus occupy two years, each with a two window season. Production will average approximately 2,400 feet per day over the two-year pipeline construction period.

Construction Sequence

The first step in the construction sequence will be right-of-way and acquisition. The proposed pipeline alignment paralleling the Alyeska pipeline and State 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 such as to retain the lands in public ownership.

Lands along the Alcan Highway are under Federal, State, Native Corporation, and private ownership. Existing rights-of-way along this route segment are those set aside by Public Land Order 1613, which allows a highway easement of 150 feet each side of the center-line of the Alcan Highway, a telephone line easement extending 25 feet to each side, and an easement for the abandoned 3" canal extending 10 feet to each side. In addition, the 8-inch Haines products pipeline has an easement for 25 feet each side of the line.

The proposed route alingment over these two segments is generally established at this time. Prior to construction, land required for the final alignmnet, compressor stations, and other ancillary facilities will be surveyed and identified. Once owenrship along the alignment has been established, permits will be secured from the necessary public bodies of jurisdiction and property owners. Agencies from whom permits may be required are outline in Section 9.0 of this volume.

Ditching operations will result in a ditch nominally seven feet deep by at least five and one half feet in width. The ditch will be cleaned of any material such as clods, rocks, or other debris which could damage the pipe or its protective coating. The operation will be carried out by excavation equipment such as backhoes where applicable. In regions of frozen soils, blasting will be used with subsequent clearing of the ditch by backhoe. 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 having been suitably cleaned and preheated according to 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 holidays by approved detection techniques, the pipe will be lowered in the ditch.

Backfill material will be such as to eliminate voids after placement and compaction. Ditch spoil may necessitate pulverization to control the particle size. Select backfill will be used where the detail design indicates it is required.

Once the backfilling is completed, the organic material previously removed from the ground surface and stockpiled will be spread over the filled ditch surface and compacted to specifications. Hydrostatic testing will then take place and the right-of-way will be cleaned up and the surface revegetated.

Typical stream crossings will have the pipeline buried at least five feet below the river bed or to a depth below which ice scour may be expected to take place. The pipe will be coated with concrete to afford protection during construction and possible scour abrasion should it ever become exposed while in operation. The concrete will also prevent floatation during installation at the crossing. Pipeline crossing limits will be taken as the distance of one 40-foot pipe joint beyond the concrete coating each side of the stream. At select locations river training and control works may be necessary.

1.5.2 Compressor Station Construction

Preliminary engineering studies indicate that 16 compressor stations will be required, spaced at 50-mile intervals along the route from Prudhoe Bay to the Alaska-Yukon border. These stations will be equipped with mechanical refrigeration equipment for chilling the gas after compression to keep it compatible with the local soil and permafrost temperatures.

Construction scheduling will be such that two stations will be operational and on line at the fourth year after the issue of the permit for the project. Construction of these compressor stations will start approximately 18 months after permit issuance. Prefabrication of buildings and equipment at the manufacturers' shops will commence six months before compressor station site work. Construction of the remaining stations will be started and brought on line tentatively as outlined below.

Construction Started	Operational	No. of Stations
(assumes permit effective January, 1978)		
mid-1979	Jan 1981	2
mid-1980	Jan 1982	4
mid-1981	Jan 1983	4 to 5
mid-1982	Jan 1984	4 to 5

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

Where piling in permafrost foundations is required and initial scheduling permits, the piles will be placed during the time of year when the permafrost temperatures are at or near their lowest values. The piles will be placed in pre-drilled holes and backfilled with a slurry. No loading of the piles will take place until the freeze-back of the slurry allows sufficient adfreeze strength.

In permafrost areas precautions will be used to insulate the compressor station structures from degrading the frozen subsoils. These precautions may include insulated floor decks either placed directly on the gravel pad or supported by piling allowing a three- to four-foot air gap between the deck and the pad. Exact detail will depend on both the site climate and permafrost soil conditions.

Non-permafrost sites may employ concrete footings or poured-in-place caissons where favorable soil conditions exist. Where bedrock is found beneath a site, the overburden may be stripped and concrete foundations keyed into the rock. Non-frost-susceptible material should be used for backfill.

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 Alaska segment of the Alcan pipeline will occur over the seven-year span beginning in January, 1978. However, the pipeline will be completed and become operative with the completion of two compressor stations in 1981. Full design capacity will be attained upon completion of fourteen additional compressor stations the construction of which will be staged over the ensuing three-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 and the work force decreased to 1,700 men per year involved in constructing the remaining compressor stations. Workers assigned to the initial compressor station sites will be reassigned to new sites upon their completion. There will be one construction camp for each pipeline spread. From Prudhoe Bay to Delta Junction, the labor force will be housed in the existing Alyeska construction camps. Two Alyeska construction camps south of Delta Junction will 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. A construction start-up in early 1978 should induce many newly layed-off Alyeska workers to postpone departures from Alaska, hence, reducing the effect of oil line completion on the State's labor pool. Alaskan residents, both native-American and Euro-American, will be given preference. Labor from the lower 48 will be recruited to complete the work force contingent.

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 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. All 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 from the air 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 qualified welding procedures will be employed. When welding is necessary in hazardous areas, special precautions will be taken. Gravel pads at heliports and stations in areas of permafrost will be examined regularly and repaired when necessary.

Corrosion

Periodic 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. Northwest Pipeline Corporation 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, to prevent an explosive mixture of air and gas.

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 unit. 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 disposed of by approved methods. Wastes will be processed on a physical-chemical cycle. Secondary treatment during thaw periods includes activated carbon filters and chlorination. Incineration or approved deposition methods will be used to dispose of dewatered sludge where necessary. Solid wastes will be burned in incinerators or buried in approved locations.

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

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. There are no existing noise level guidelines pertaining to the pipeline corridor; however, compressor station design will include noise suppression equipment.

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 or odors released from the new facilities will occur during emergency or infrequent scheduled blow-down 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, 1984, a staff of 190 will be required to operate and maintain the pipeline. Of these, 60 will be responsible for maintaining the line and 130 will be stationed at the compressor stations and 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 within established rights-of-way. 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 decades. If economically feasible, the pipeline will be abandoned and place and surface facilities removed or modified for other uses. All disturbed areas will be restored in compliance with current regulations.

2.0 DESCRIPTION OF THE EXISTING ENVIRONMENT

2.1 LAND FEATURES AND USES

Contents

2.1.1 Land Uses

Status of Land Tenure

Introduction

The most dramatic change 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 and into Native ownership pursuant to the Alaska Native Claims Settlement Act (ANCSA), but the lands remaining in federal ownership are undergoing change from public domain holdings to reserves for particular purposes, such as national parks and national wildlife refuges. These events and their effect are influencing the status of land tenure along several sections of the proposed Northwest Pipeline route. In order to comprehend the events taking place, some perspective is required on the Alaska Statehood Act and the Alaska Native Claims Settlement Act.

The Alaska Statehood Act departed from the traditional methods of providing lands to new states. Congress gave Alaska the right to select the following 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 for support of its government and the services it provides to its people. 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.

After gaining statehood in 1959, Alaska proceeded to select its share of the public lands. The 25-year period for completing land selections allows the State an opportunity to inventory and plan for choices that will yield maximum benefit. By 1969, less than 10 million acres had been transferred to the State, although considerably more land had been selected and some of it had been tentatively approved for transfer.

Interest in Alaska's lands was not limited to the State Government. Alaskan Natives--the Aleuts, Indians, and Eskimos--claimed title to lands they had historically used and their claims received official attention. Federal district offices in Alaska referred protests to Washington and issuing of land patents almost ceased. For several years, applications were challenged by Natives and, in 1969, the Department of the 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 the Alaska Native Claims Settlement Act (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 other cases 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.

Native Lands

Along or near the pipeline route several Native land tenure situations are being effected--and only a few of these have progressed very far in the adjudicatory process towards conveyance of title from the United States.

Village conveyances have proceeded further towards completion than have regional selections.

Within the Arctic Slope Regional Corporation (north of 68 degrees N latitude) area of interest, no Native lands are directly involved by the pipeline route although the subsistence resources of two villages, Nuiqsut and Anaktuvuk Pass could well be influenced 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 do contain both known and potential resources of fossil fuels. Existing ASRC-oil company agreements call for development, and if economical, production as well. Future arrangements for the transportation of these resources utilizing both the oil and the gas pipelines is a distinct possibility.

The ownership patterns of these lands is portrayed in the exhibit map for Land Status.

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 onwership, they will probably revert to village corporate ownership. It should be noted also that the village of Tetlin elected, under the terms of ANCSA, to retain the former Tetlin Indian Reserve acreage as its settlement under the Act.

Public Lands

Most of the lands along the pipeline routing are public lands, either federal or state. Some state selected lands have been transferred to the North Star Borough in the area around Fairbanks pursuant to state law. The location of state (including borough) lands is shown on the Land Status exhibit map, and represent part of the total 68,785,221 acres selected by the State throughout Alaska. State lands adjacent to the Trans-Alaska Pipeline, where 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 routing fall into three categories: withdrawals for specific federal purposes: military, power reservations, etc., and the pipeline's Transportation and Utility Corridor; public domain lands (incluing lands that will revert from Native Withdrawal status under Sec 17,d,1 of ANCSA); and lands withdrawn for future action by the Congress for possible additon to the four national conservation systems (under Sec 17,d,2 of ANCSA). These various categories of federal lands are shown on the Land Status exhibit map.

Federal lands within the Transportation and Utility Corridor for the Trans-Alaska pipeline have been classified for pipeline, road, and related transportation purposes.

Although not immediately adjacent to the pipeline routing itself, a Sec 17,d,2 withdrawal pursuant to ANCSA 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 routing are located primarily in the Fairbanks area and in communities and narrow bands along the major highways. A small exception exists at the old community of Wiseman in the canyon of the Dietrich River. These private ownerships came about through earlier federal applicatons for 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 due to legal situations or program reviews the scope of which are not germane to this text. 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 are prevalent along the proposed routing. These, however, do not effect the analysis of this report and will be subject to detail rights-of-way dealings at a later date.

Land Uses

General Comments

Land uses in the Arctic Region along the pipeline route are dominated by the exploration and development of petroleum reserves in the Prudhoe Bay area and by the construction of the Trans-Alaska Pipeline transportation system for these reserves together with its' ancillary facilities. Prior to the Prudhoe Bay oil discovery, subsequent events related to development, and the extinguishment of aboriginal rights by ANCSA the Inupiat (Eskimo) people exercised domain over all these lands and carried out a variety of pursuits in support of their livelihood. In the course of this dominion they left evidence of their uses including several graves of modern origin as well as the record derivable from historic and archaeological sites. (A summary of these latter situations is treated elsewhere in this report.) 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 Pipeline in diverse ways--some of a physical or biological nature and others by economics. Reference to these impacts in the context of this environmental assessment are made elsewhere in this report.

South of the Brooks Range crest the old mining community of Wiseman has been immediately impacted by present 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 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 pipeline project itself or brought to Alaska for peripheral reasons. This impact is presently wide-spread and the long-range effect of this growth of mass intrusion upon and competition for wildlife resources in this area is a present 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 lands along the highway system.

Major land uses along the proposed pipeline routing are further discussed by function.

Functional Uses of Lands

Communities

The following communities involve land uses along the routing.

Delta Junction is located on the right bank of the Delta River at the junction of the Alaska and Richardson Highways. Its 1970 population listed together with Big Delta (8.5 miles northwest on the Richardson Highway) was 703. 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, is compressed between the Clearwater Mountains to the northeast and the foothills of the Alaska Range to the southwest. Its 1970 population combined with that of Delta Junction was 703, of which 30 live in Big Delta. Lake Delta Junction, Big Delta is dependent upon highway commerce and upon commerce generated by Fort Greely for its economy.

The community of Dot Lake is on the Alaska Highway on Dot Lake, 40 miles northwest of Tok in the Tanana Lowland. Dot Lake is 1,500 feet long located on the east side of the highway. Forty-two persons lived in Dot Lake settlement in 1970 and depended on highway commerce supplemented by guiding, sport hunting, and firefighting as the basis of their economy.

Healy Lake is along the Healy River, southeast of Big Delta. No population is listed for the community in the 1970 census, but the Bureau of Indian Affairs lists an enrollment figure of 27 individuals for land claim purposes. No data exist concerning community facilities.

Northway is located on the east bank of the Nabesna Slough 5.5 miles southwest of North Junction. The 1970 population was 40 and the local economy was dependant upon seasonal employment in firefighting, guiding, and construction. These sources of income are heavily supplemented by subsistence hunting and fishing.

Tanacross on the Tanana River is 12 miles northwest of Tok. Its 1970 population was 84. Tanacross is supported by a mixed economy of subsistence hunting and fishing and seasonal employment in firefighting, trapping or construction.

Tanana is located near the junction of the Tanana and Yukon Rivers in the Kokrines-Hodzana Highlands. The 1970 population was 120 and its economy is based principally upon subsistence pursuits.

Tetlin is on the Tetlin River, 4.5 miles east of Tetlin Lake, 20 miles southeast of Tok. The 1970 population was 114 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.

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 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 1970 population of Fairbanks was 14,771, the second largest city in the State. It was incorporated in 1903, and its economy then was based supplying material and services for gold mining activity in the area. Its current economy is based principally on government agencies, service-oriented commercial establishments, transportation, and the University of Alaska.

Federal facilities and withdrawals

Three major federal military facilities exist along the general pipeline routing: 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 Alyeska Pipeline management purposes. Eielson is an active Air Force base. Ft. Greely is utilized for arctic military training and survival purposes. Acreages withdrawn for these installations are:

Ft. Wainwright, Eielson AFB and Test Range	1,518,800 acres
Ft. Greely	623,500 acres

A second major category of federal withdrawal is the Rampart Power Site reservation which extends down the Yukon River nearly to Tanana. The proposed pipeline routing will cross part of this withdrawal, as does the present oil pipeline under construction. The total area of the Rampart withdrawal is 8,959,000 acres.

Native lands

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

Stevens Village	69,120 acres
Healy Lake	69,120 acres
Dot Lake	69,120 acres
Tanacross	92,160 acres
Tetlin*	768,000 acres
Northway	115,200 acres

*Tetlin elected to receive the former 768,000 Tetlin Native Reserve.

Land uses include individual residences, stores, churches, material sites, hunting, fishing and trapping campsites, and use areas, cemetaries, and other community-related uses. No major commercial uses exist.

Transportation uses of land

Water transportation

In the Arctic Region the Prudhoe Bay field is served by an extension docking causeway. Here barge transport is unloaded and serviced after transit from "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.

Railroad transportation

Alaska's only railroad--the Alaska Railroad--provides service between Fairbanks and the ports 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 area with which this report is concerned.

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

Nenana: 279.4 acres; railroad and commercial business uses lease land from the railroad;

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.

At Nenana, the railroad has facilities to transfer freight to barges for operations on the Tanana and Yukon Rivers.

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 area covered by this report. 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 federal government; and consumer services are provided by private enterprise.

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.

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 4,000 4,000	Gravel Water Water
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	Private	3,340	Asph/Gravel
		H		50x50	Gravel
	Fairbanks International	T-A	State	10,300	Asph
				3,200	Treated Gravel
				100x100 (heliport)	Gravel
				2,000	Water
	Metro Field	T-C	Private	4,600	Gravel
	Ft. Wainwright	M	Federal	8,714	Asph/Concrete
				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/Gravel
				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
40	Riverside Lodge	S-B	Private	2,400	Dirt
41	Northway	T-C	State	7,500	Asph

Pipelines

Two pipeline rights-of-way exist along the proposed routing of the Northwest Gas pipeline.

The older of these is the Haines to Fairbanks Military Pipeline, No. 44LD513 or BLM F010143.

The 626-mile long Haines Pipeline was completed in 1955 to carry petroleum products from Lutak Inlet at Haines, Alaska, to military bases in the Fairbanks area. The 8-inch pipeline passes through sections of Alaska, British Columbia, and the Yukon Territory. This report is concerned only with that 283-mile long section of the pipeline paralleling the Alaska Highway between the Alaska-Yukon border and Fairbanks. Running right-of-way width is 50 feet; within the area of concern are a number of additonal stations:

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

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

Sears Creek Pumping Station, Milepost 1376, 11.24 acres

South Tank Farm, on Ft. Greely

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

Timber Pumping Station, Milepost 277, Richardson Highway, 7.49 acres

Birch Lake Tank Farm, Milepost 305, Richardson Highway, 38 acres

Fairbanks Terminal, Ft. Wainwright, 167 acres.

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

Since 1971, all but the 27-mile section of the pipeline between Eielson Air Force Base and Ft. Wainwright has been deactivated. Plans call for the General Services Administration to dispose of the remainder of the pipeline by lease or sale. No firm determination as to lease or sale or the time of offering the pipeline and related facilities has been decided. Reportedly, there is a non-transferrable clause in the easement provision for the pipeline. There are numerous land ownerships along the pipeline right-of-way and ownerships have changed considerably since the pipeline was designed and built.

The second of these is the Trans-Alaska Pipeline right-of-way wherein the Alyeska Pipeline is presently under construction between Prudhoe Bay and the ice-free part of Valdez in southcentral Alaska.

This 798-mile pipeline will make the estimated 9.6 billion barrel oil reserves at Prudhoe Bay available to industry and consumers.

Initially, 1.2 million barrels of oil a day will be transported through the line for shipment by tanker to West Coast ports. At capacity, the total will allegedly reach 2 million barrels a day.

The project, largest privately funded construction effort in history, is being built by the Alyeska Pipeline Service Company, formed by eight oil companies--The Amerada Hess Corporation, ARCO Pipe Line Company, SOHIO Pipe Line Company, Exxon Pipeline Company, Mobil Alaska Pipeline Company, Phillips Petroleum Company, Union Alaska Pipeline Company, and BP Pipelines, Inc.

The oil pipeline system is being developed in two phases. The first phase, scheduled for completion in mid-1977, includes completion of a new all-weather highway from the Yukon River to Prudhoe Bay, construction of a 48-inch steel pipeline from Prudhoe Bay to Valdez, building of eight pump stations along the route and development of oil storage and tanker loading facilities at Valdez.

Four additional pipeline pump stations along the route and more oil storage and tanker docking facilities at Valdez are planned in the final phase.

The right-of-way for this construction on federal lands during construction is 300 feet in flat terrain, 500 feet in other terrain; stream crossings--1,500 feet wide to 1,000 feet either side of the stream; final right-of-way 25 feet to either side of the structure.

The right-of-way on state lands during construction is 400 feet along the pipeline route; stream crossings--600 feet wide, 1,000 feet each side of stream; final right-of-way--25 feet either side of the structure.

Highways

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 and there is a highly developed, for Alaska, network of secondary roads branching off from the major arterials to serve outlying communities and settlements.

Major roads are shown on the Land Use exhibit map. 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	300
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 second 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 from the Elliott Highway just to the 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 on the haul road.

The Glenn, Taylor, and Richardson Highways connect with the Alaska Highway at various junctions south of Fairbanks. The Taylor Highway provides access to Eagle on the Yukon River and an alternate route 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, 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. Trucking companies are generally allowed relief by charging shippers on an hourly basis to compensate for decreased weights and speeds.

In addition to the spring breakup limitations imposed upon the rudimentary state highway system, normal maintenance efforts particularly during the summer construction months is more disruptive to the routine highway transport than would be the case were alternative routes available. The state cannot, or will not, stop highway construction programs for the benefit of private projects. Road closures or other limits to travel may be imposed. The Alaska Department of Highways has announced and described the following anticipated 5-year construction schedule for the major routes which might affect pipeline construction as follows:

Steese Highway: The Department of Highways plans to complete reconstruction of all sections of road between the Farmers Loop Road intersection and Central which have not been recently rebuilt. The section between the Farmers Loop Road intersection and Fox will be, for the most part, 4-lane to handle anticipated traffic. The latter portion will be by stage construction, and only two lanes will be constructed initially. Reconstruction between Mile 43 and Eagle Summit will be similar to those sections of the Steese already rebuilt.

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. The entire Elliott Highway has been severely impacted by pipeline related traffic, with resulting high maintenance costs and reconstruction is of utmost concern.

Alaska Highway: During the next five years the Interior District will continue its effort to reconstruct the entire Alaska Highway between the Border and Delta Junction. Because of limited funding, only the sections between Mile 1235 to Mile 1250 and ten miles south of Delta to Delta Junction will actually get under construction.

Parks Highway: There are only two sections of the Parks Highway within the Interior District which remain below par. These are the section between Ester Siding and Ester; and between Nenana and Rex. Both sections seriously detract from this route, and both are scheduled for reconstruction by 1980.

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

Yukon-Prudhoe Bay Highway: During 1976 this Department will continue its surveillance activities on the road between the Yukon River and Prudhoe Bay. This will help insure that at the completion of the pipeline the Alyeska Pipeline Service Company will turn over to the State a road which can be maintained by the State in a safe condition for the traveling public. This surveillance will be a continuation of the State's supervision of the construction of this road which began in 1974.

State of Alaska
Tentative Contract Award Schedule
Interior District
Federal and System Program

Project Location	Project Description	Estimated Total Cost (dollars)
	Calendar Year 1976	
Alaska Highway	Realignment, Mile 1376.5 to Mile 1377.7	$ 1,250,000
Taylor Highway	Construct six bridges between miles 43.3 and 81.9	3,600,000
Steese Highway	Reconstruct from Farmers Loop to Fox, 8.9 miles	13,000,000
Parks Highway	Pave Nenana to Rex, 29.1 miles	3,400,000
Peger Road	Replace Chena River Bridge	1,100,000
	Calendar Year 1977	
Steese Highway	Replace Albert Creek Bridge, Mile 132.1	130,000
Steese Highway	Reconstruct from Montana Creek to Eagle Summit, 27 miles	8,450,000
Elliott Highway	Reconstruct from Snowshoe Pass to Tolovana River, 29.1 miles including one bridge	8,460,000
Davis Road and University Ave.	Reconstruct Davis Road from Peger Road to University Ave., 1.0 miles, and construct four lane arterial on University Ave., from Davis Road to Airport Way, 0.7 miles	1,680,000

Calendar Year 1978

Steese Highway	Reconstruct from mile 43 to mile 66 (Sourdough Creek), 23 miles	7,020,000
Taylor Highway	Reconstruct from mile 23 to mile 43, 20 miles	5,800,000
Parks Highway	Reconstruct from Ester Siding to Ester 3.0 miles	1,880,000

Calendar Year 1979

Alaska Highway	Reconstruct from Delta Jct., SE, 10 miles including two bridges	4,890,000
Richardson Highway	Interchanges at both intersections of Badger Loop Rd.	2,900,000
Elliott Highway	Pave Olnes to Snowshoe Pass, 15.3 miles	1,770,000

Calendar Year 1980

Steese Highway	Reconstruct from mile 66 to mile 82 including one bridge, 16 miles	6,480,000
Alaska Highway	Reconstruct from mile 1235 to mile 1250, including one bridge, 15 miles	10,240,000
Elliott Highway	Reconstruct from Tolovana River to Prudhoe Bay Rd., 13.4 miles	5,550,000

Wooden Bridge Structures on the Highway System Affected by Construction are:

Location Milepost		Type Structure	Length	Width
		Elliott Highway		
44.9	Tataline River	Steel pony truss with timber plank deck	102'11"	19'
70.1	Livengood River	Treated timber stringer with treated timber plank deck	22'1 "	20'
130.2	Hutlinana Creek	Steel pony truss with timber plank deck with running plank	83'11"	12'8"
		Wales Highway		
40.0	Hess Creek	Timber stringer with timber plank deck TS/ TPR with running plank	141'2 "	24'
		Alaska Highway		
1372.3	Sears Creek	Treated timber stringer with treated laminated timber deck with asphalt surface	51'6 "	24'
1403.9	Sawmill Creek	Timber stringer with laminated timber deck with asphalt surface	52'	24'
1416.6	Small Stream	Treated timber stringer with treated laminated timber deck with asphalt surface	35'6 "	24'
		Tok Cutoff Highway		
64.1	Porcupine Creek	Timber stringer with laminated timber deck with asphalt surface	42'6 "	24'

67.8	Carlson Creek	Timber stringer with laminated timber deck	24'	24'
75.6	Slana Slough	Treated timber stringer with treated laminated timber deck with asphalt surface	51'3 "	24'
76.1	Mabel Creek	Treated timber stringer with treated laminated timber deck with asphalt surface	25'10"	24'
83.2	Bartell Creek	Treated timber stringer with treated laminated timber deck with asphalt surface	22'6 "	24'

The Alaska Department of Highways has also identified in its petition for federal relief, relating to pipeline damage impact on the state's road systems, the following projects to be carried out as early as possible in addition to its normal five-year continuous program:

Priority	Description	Cost
1	Richardson Highway 47 to 52 (Tiekel South) F-071-1(18). This project is a complete reconstruction for which P.E. and R/W are well advanced. The project has had to be moved up in our construction schedule from 1977 to 1976 due to damage done to the old road by heavy truck traffic.	$ 5,300,000
2	Richardson Highway 15 to 15.7 - Keystone Tunnel By-Pass RF-071-1(2). This project is made necessary by the operational and safety impact of	5,500,000

numerous large loads on the narrow tunnel, the substandard alignment of the tunnel approaches and the damage done to the tunnel cribbing itself by large load impacts.

3	Richardson Highway Mile 25 to 35 - Thompson Pass North. Slurry seal ten miles of 24' wide pavement laid in 1953. This job is intended as a band-aid type repair to hold this section of pavement together until we can rebuild it.	350,000
4	Richardson Highway New Dock to Mile 6, RF-071-1(32). This is a project to resurface some standard construction heavily impacted by pipeline and terminal cargo traffic and townsite expansion. Included are spurs to Valdez Airport.	2,300,000
5	Richardson Highway Mile 74 to 81 RF-071-1(33) Provides for repaving a standard template heavily impacted by pipeline construction traffic.	800,000
6	Richardson Highway Mile 110 to 115 RF-071-2(20). Provides for repaving a standard width project originally paved with BST and heavily impacted by pipeline traffic.	504,000
7	Richardson Highway Mile 125 to 129 RF-071-2(21). Provides for repaving a standard width project heavily impacted by pipeline construction traffic.	570,000

8	Richardson Highway Mile 185 to 191 Provides for repaving a standard width project heavily impacted by pipeline construction traffic.	700,000
9	Richardson Highway Mile 115 to 125 RF-071-2(18). Provides for complete reconstruction essentially on existing alignment. This area is substandard in width and has been heavily impacted by construction traffic and incidential traffic developed from pipeline camp service.	5,160,000
10	Richardson Highway Mile 35 to 40 Provides for spot base reconditioning and total paving overlay of an area of old narrow pavement broken up by heavy pipeline construction traffic.	600,000
11	Richardson Highway Mile 43 to 47 Provides for spot base reconditioning and total paving overlay of an area of old narrow pavement broken up by heavy pipeline construction traffic.	480,000
12	Richardson Highway Mile 100 to 106. This provides for slurry seal of an old narrow pavement that has been to date moderately damaged by pipeline traffic.	210,000
13	Richardson Highway Mile 6 to 15. This provides for slurry seal of an area heavily impacted by pipeline construction haul, but scheduled for	315,000

relocation and rebuilding in 1980. The seal is intended to hold most of the pavement surface until reconstruction can be accomplished.

14	Richardson Highway Mile 81 to 90. This provides for spot base reconditioning, shoulder work, and total paving overlay of an area heavily impacted by pipeline construction traffic. This work should give us a usable road for another ten years.	1,350,000
15	Richardson Highway Mile 15.5 to 19 This provides for slurry seal of an old narrow pavement that to date has been moderately damaged by pipeline construction traffic.	160,000
16	Richardson Highway mile 190 to 202. This provides for spot reconditioning and chip seal of an area where full construction impact has not yet been felt. Moderate damage had already taken place.	480,000
17	Richardson Highway Mile 98 to 100. This provides for leveling and repaving of an area of standard construction severely damaged in the last two years.	250,000
18**	Old Steese Highway, Fairbanks to Fox. The surface of this section of highway is an old BST which was not designed to withstand the tremendous increase of pipeline-related truck traffic. Increased maintenance has not been able to keep pace with the rate of deterioration of this surface. It will be necessary	800,000

for this roadway to continue to carry heavy North Slope truck traffic until the completion of the new Farmers Loop to Fox facility, probably sometime in 1979. After that the present roadway will serve primarily as a local access road. It is our opinion that a 2" asphalt overlay of the existing surface would get us through the remaining period of heavy truck use and then provide a relatively maintenance-free access facility for a number of years in the future.

19**	Elliott Highway, Fox to Snowshoe Pass	3,400,000

This section of roadway has been subjected to a tremendous increase in heavy truck traffic as a result of the pipeline-related truck traffic. The section from Fox to Olnes has a 1 1/2" asphalt mat. This surface has suffered a substantial amount of wear, and there are several sizeable areas where serious embankment deformation has occurred as a result of the continual pounding by heavy loads. Our proposal for this section would be to repair damaged embankment areas adn place a 2" hot asphalt pavement over the existing surface. On the portion of roadway from Olnes to Snowshoe the continual pounding by heavy truck loads has badly degraded the subgrade. Pumping and rutting are prevalent throughout this section. Recommendations for this section of the Elliott are to repain areas of major embankment damage and then place a 6" lift of alluvial gravel, 4 1/2" of crushed base course and a 1 1/2" asphalt map over the entire section.

20**	Elliott Highway, Snowshoe Pass to Tolovana River S-0680(10). This section of the Elliott has not been reconstructed. The existing road is extremely narrow, and what surface material there was prior to pipeline truck traffic has literally been worn out or pounded into mud. The road presently becomes impassable during breakup or periods of heavy rainfall. Restoration of the exising roadway to pre-pipeline condition is completely beyond the capability of our Maintenance Section.	12,000,000
21**	Richardson Highway Spot Improvement, Fairbanks to Delta Junction. A number of areas of embankment deformation have occurred within reconstruction sections of this roadway as a result of the extremely heavy volume of this pipeline-related truck traffic. Our proposal for this section would be to core out areas of extreme deformation and replace with alluvial gravel and resurface.	200,000
22	Richardson Highway, McCallum Creek to Delta Junction. The surface of this section of roadway has taken extremely heavy use since pipeline construction began and will continue to do so until it is completed. Last year's patching and sealing efforts were unable to keep up with the deterioration. It is our opinion that a seal coat the entire length could provide sufficient maintenance relief to allow current maintenance efforts to keep up.	2,000,000

23**	Alaska Highway, Mile 1250 to Delta Jct.	8,300,000

The Alaska Highway has borne the brunt of the increased Trans-Canadian traffic between this State and the lower 48. Our traffic records show a 28 percent increase over last year, 14 percent of which are trucks. As a consequence of this accelerated growth, the State must either accelerate its reconstruction program or provide a stop-gap measure to allow this highway to reach a normal life span. Because of fiscal, environmental and staffing restrictions, it is impossible for the State to appreciably accelerate its reconstruction program. The District feels that it can accelerate reconstruction of the first 15 miles (Mile 1235 to Mile 1250); therefore we have deleted this section as a stop-gap measure. The remainder of the highway (Mile 1250 to Delta Jct.) will require both spot repair and sections of seal coating.

24	Parks Highway, Nenana to Rex, RF-037-2(37).	4,800,000

This roadway experienced an accelerated traffic growth due to pipeline construction. As a result road wear has accelerated to the point it has been necessary to reconstruct this portion of roadway two years earlier than anticipated. This has been reflected in the State's Five-Year Program. This section of road is on the major highway between Anchorage and Fairbanks, Alaska's two largest population centers. Joining sections at both ends have been recently built or reconstructed and are in excellent shape. The section in question requires extensive maintenance efforts to keep the driving surface adequate for the traffic it must handle. Traffic volumes prohibit the option of letting the surface deteriorate. Thus this section must either be reconstructed immediately or the State must be prepared to increase its maintenance efforts even more than last year's extensive efforts. It is our opinion that reconstruction of this section will provide a relatively maintenance-free roadway for a number of years.

25	Parks Highway, Little Susitna to Willow. This 14.1 Mile of the Parks Highway is showing surface wear and should have a 2-inch overlay to protect the existing base.	1,200,000
26	Parks Highway, Willow to Rex. Seal at various locations, estimate 130 miles to protect existing surface.	400,000
27	Glen Highway, Palmer to Mile 133. This project consists of Spot improvement, paving and seal over 84 miles.	5,310,000
28	Seward Highway, M.P. 50-Ingram Creek.	2,100,000
29	Sterling Highway-Soldotna to Homer. This section is in need of a seal to protect the existing surface.	215,000
	Sub Total	$65,749,000
	15% Engineering	9,863,000
	Total	$75,612,000

**These projects parallel the proposed pipeline.

North of the Yukon River the use of the newly constructed haul road adjacent to the Trans-Alaska Pipeline was found to be the only possible way to mobilize men and equipment within the construction time frame for the pipeline construction project through the arctic north. Utilization of this road to provide highway transport for an additional utility will not affect any established communities with the exception of the pipeline construction camps and the industrial complex at Prudhoe Bay. The Governor of the State of Alaska has made a high priority issue, within the current administration, of the re-evaluation of the future use of the Pipeline Haul Road. The Governor's Alaska Growth Policy Council has recommended that for the new-term "...no public use be made of the North Slope haul road except by major industrial users, without state expense, pending final decision of land use and transportation in the corridor." The State of Alaska has furher requested the Alaska Federal-State Lane Use Planning Commission to examine and recommend new-term and long-range transport management options for use of the road. The F/SLUPC has asked the state to clarify, the legal issues relevant to management options for the haul road. Some of these are:

1. After the road has been transferred to the State, could the Commissioner of Highways or other appropriate State official close the road to certain segments of the public but not to others? For example, could the Commissioner close the road to tourist related traffic but leave it open for traffic related to mineral exploration and development?

2. In view of the fact that the road was built with free gravel extracted from Federal and State lands and that some Federal monies were used to monitor construction, could the Commissioner of

Highways or other appropriate State official close it immediately after transfer to all public use, or would such a closure, although generally permissible, be viewed in this case as an illegal measn by which public assets were used without charge in the construction of a road used for the sole benefit of a private party?

3. If the closure described in question 2 would not be legally permissable, could the deficiencies in such a procedure be cured by State reimbursement to the Federal government for Federal gravel and monies involved in road construction? If there are similar impediments in State law, or if the State's use of public monies to reimburse the Federal government would raise legal questions, what legislative or other action would be required to resolve such problems?

4. If the State were to affect a permanent closure of the road, would the right-of-way revert to Federal ownership? If so, could the Federal government maintain the road for public use or, in the alternative, for use by certain classes of the public, such as those engaged in resource exploration and development?

Implementation of the short-term management policy as recommended by the Growth Council would greatly facilitate construction activities north of the Yukon as amenities and rules at the road could be dispensed without the presence of the general public. It should be noted, however, that any serious construction program north of the Yukon should recognize that there exists the possibility of serious legal impediments which may not allow the State of Alaska to prohibit unrestricted public travel on the haul road.

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 the older troposcatter and microwave system intalled 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 link 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. They will provide one toll telephone circuit and one channel for emergency and medical use for 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 communications sites. By 1978 the earth station network in the state will have replaced most of the military system now in use.

Radio broadcast service is reasonably good in most urban areas. In such rural areas as Bristol Bay, the Aleutians, the western Interior, and the Brooks Range area, a poor selection of broadcast stations and bad reception are the rule. Educational radio programs are available in several major communities with additional community stations planned for operation before 1980.

Television programs from commercial, educational, or military stations are available to more than 80 percent of the state's people; about five percent of these receive only cable television. Except for special programs relayed by satellite to the Anchorage, Fairbanks, and Juneau areas, all network television is on film or tape. Delays range from a few hours to several weeks of the original broadcast. Some communities own low power "Mini TV" transmitters.

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. Single sideband (SSB) radios were used by some to fill the communications void but they were unreliable. Companies chartered aircraft to fly messages to Fairbanks and Anchorage, having no hope of getting information out over the few clogged DEW line circuits.

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 it was limited to use by the health aide and the school teacher. 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 pipeline.

There is a very high frequency (VHF) system which links the camps along the trans-Alaska pipeline and provides telephone service. Another VHF system enables exploration sites within 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 the repairs.

Broadcast stations in the Arctic are limited to the Air Force station at Barrow. There are long range stations which can be heard at night on the military bases via an audial distribution system and Anaktuvuk Pass sometimes receives a station out of Fairbanks. There is a closed circuit television station at Barrow.

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 ATS-6 Satellite is in use.

Public and commercial television coverage extends throughout the Fairbanks area as well as commercial radio. Four military radio broadcast facilities are also located in the surrounding areas.

Communication Services Available to Communities
in the Proposed Pipeline Area

	Radio	Television	Telephone
Prudhoe Bay	x	commercial mini	x
Deadhorse	x		x
Franklin Bluffs	x	commerical mini	x
Sagwon Camp	x	commercial mini	x
Happy Valley Camp	x	commercial mini	x
Toolik Camp	x	commercial mini	x
Galbraith Lake Campe	x	commercial mini	x
Pump Station 4		x	
Atigun Camp	x	commercial mini	x
Chandalar Camp	x		x
Dietrich Camp	x	commercial mini	x
Wiseman		commercial mini	bush phone
Coldfoot Camp	x		x
Prospect Camp	x		x
Old Man Camp	x		x

Five Mile Camp	x		x
Stevens Village			x
Livengood Camp	x	commercial mini	x
Fairbanks	x	commercial	x
Bettles	VHF-RCA	commercial mini	x
North Pole	x	commercial	x
Nenana	x	x	x
Rampart	x		bush phone
Delta Junction	x	mini PBS	bush phone
Dot Lake	x		
Tanacross	x		x
Tok	x		x
Tetlin	BIA Health Service		x
Northway	VHF to Tok		
Anaktuvuk Pass	x		bush phone
Nuiqsut	x		

A description of the communications system as it applies to Alyeska Pipeline Service Company prepared by Alyeska follows:

Construction of a final communications network for the operation of the pipeline will provide Alaska with its first cross-state, north-to-south public communications system.

A temporary system was installed for the construction phase of the project. A different system will be placed in operation once the line is completed and put into service.

The temporary system links construction camps with other facilities and includes a micro-wave system, mobile radio system, high frequency single side-band radios and aviation radios.

The temporary micro-wave system provides a maximum of 12 communication channels to each construction camp, including private line business communications, telephone channels for personal use by workers, teletypes, facsimile equipment and data processing terminals.

Leased private line telephone circuits also connect company offices in Anchorage, Fairbanks, and Valdez as well as all construction camps. High frequency single side-band radios on the Alaska public fixed frequency bands provide construction camps and the Fairbanks office with emergency communication facilities.

The final operational communication system is being developed around 41 permanent micro-wave stations between Prudhoe Bay and Valdez.

Owned by RCA-Alaska Communications, Inc., a communications common carrier, the system will provide 240 channels for public use and 60 channels for use by the Alyeska Pipeline Service Company. Aleyska is sharing the cost of construction.

The micro-wave system generally parallels the pipeline, linking all pump stations, remotely controlled gate valves and pipeline maintenance centers with the Valdez control center.

Twelve of the 41 stations are being built at pump stations. One will be installed at Valdez and 28 will be constructed at remote sites. Remote sites typically will include a self-supporting steel antenna tower, two prefabricated buildings and two to four fuel tanks. The stations are designed to operation at temperatures as low as minus 60 degrees F, in winds up to 150 miles per hour and with 3-inch coatings of ice. They will be powered by two small diesel generators--one in use and one on standby--with a battery backup system which can supply primary emergency power for operation of equipment for at least 48 hours under severe weather conditions. Helicopters will be used to service the remote stations.

The micro-wave system will be backed up by a satellite communications system. Four earth stations, one each at pump stations 1, 4, and 5 and the Valdez terminal, will be able to communicate with each other on dedicated channels via a space satellite in orbit 24,000 miles above the equator. The satellite system is designed to handle all pipeline control data in event of any break in communication along the chain of micro-wave stations.

The 62 remote valves on the pipeline will be linked to the main communication network by radio via two independent VHF channels. The radios will monitor and control all valve operations at each site.

In addition to the micro-wave and satellite systems, the permanent network will also include leased common carrier circuits, telephones, in-plant radios, a mobile radio system and the remote gate valve stations.

Agriculture

The following information is from the U.S. Department of Agriculture Soil Conservation Service which has surveyed through the cooperative soil survey program approximately 434,000 acres of capability class II and III lands within the Tanana Valley. These are considered prime Alaska agriculture lands in that they can totally be used for Alaska agriculture. There is approximately 160,000 acres of class IV lands that are somewhat limited for agriculture uses due to droughty or permafrost conditions. Approximately 40 percent of these lands could be utilized for agriculture.

Soil Conservation Service also through local experience potentially estimates there is approximately 60,000 plus acres of land that have not been surveyed, the bulk of which will be class I and III.

All crops that are adpated 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. With the waste heat from oil pipeline pumping plants, the Tanana Valley potentially in the near future could construct competitive processing facilities for locally produced agriculture products.

Agriculture is an important resource for the Tanana Valley. It has been an important enterprise from the time of the first settlement of the gold rush days to the present. Though it has varied in relative importance, the fluctuations have not been because of limitations of the land. With the many acres of potential farmland indentified in the Tanana Valley, and with the importance being placed on the oral food supply, this Alaska resource should be developed. Development can occur in a way to provide stable markets, meet population's needs, add an economic stability to the Tanana Valley, and put Alaska on a food supply foundation with many other nations.

Wild lands

Several areas along the proposed pipeline route are recognized as study areas, areas for viewing wildlife and scenery or for hunting and fishing.

Franklin Bluffs, about mile 30, although no large truly wild land has recognized unusual geologic, botanical, and zoological features and has been proposed as an ecological reserve and a Natural Landmark.

Atigun Canyon, mile 140, is a recognized scenic and viewing area for Dall sheep.

Toolik, Murphy, and Galbraith Lakes, miles 130 to 140, are recognized sport fisheries for lake trout and grayling.

Elusive Lake, 15 miles southeast of mile 110, is a sport fishing lake and a big game guide has a headquarters site there.

Table Mountain, mile 185, 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. Several grayling streams, particularly Prospect Creek, Bonanza Creek, and Jim River occur between mile 250 and 300.

Several rivers particularly Salcha and Goodpaster, provide access to fishing, hunting, and general recreation areas.

Scotty Creek and lakes along the Chisana, mile 700 to 730, 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 sawtimber 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 overage 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.

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        - Arctic Foothills
        - Brooks Range
        - Ambler-Chandalar Ridge and Lowland
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        - Frost creep and solifluction
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Geology

Unconsolidated deposits

Glacial deposits
Loess deposits

Regional geology

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 Northwest Gas Pipeline will pass. Exhibit maps 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. 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 deposition rather than bedrock geology. Bedrock and historic geology finally is briefly summarized under the heading of regional geology.

Interior Plains

Topography and Physiography

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 10 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 N15^{o}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 the 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 geomorhpic 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 the 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 10 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 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 the lake drains. Thaw extension continues 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 4 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.

Geology

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 the gently sloping plain. Consisting largely 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 Gubik 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 such a way that an exact boundary is 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 blanket 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 the wind or fine enough to hold sufficient moisture to maintain a vegetative 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 10 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 moved 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 stabilized 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 conditions 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 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.

East 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. Nonlocal currents are not very effective, 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 often results in coastline retreat and a threat to houses and usable land. 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 Schalk (1967) indicated that sediment transport near Barrow was 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 onto 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 some cases they persist by being pushed above the normal reach of waves, by growth of the beach, or because close pack ice retards wave

Figure 1 Generalized engineering characteristics of surficial deposits

Qa
Qf – **Sand and gravel—coarse-grained deposits**
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
Qe — **Sand—medium-grained deposits**
Fair to good foundation material
Relatively easy to excavate
Generally well-drained
Source of sand for construction
Not seriously frost susceptible

Qe
Ql — **Silt and Clay—fine-grained deposits**
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

— **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

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, although they also float singly. 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 Figure 1.

Regional Geology

The arctic coastal plain is nearly covered by 10 to more than 150 feet of Quaternary unconsolidated deposits which overlie gently south-dipping, late Mesozoic sandstone, conglomerate, and shale and Tertiary beds of conglomerate, sandstone, 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 old pre-Mississippian basement rocks, terminate against one or another of the unconformities 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 cu. ft. 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 cu. ft. 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 cu. ft.).

The proposed pipeline route in this segment begins just south of the Putuligayuk River close to Prudhoe Bay, and ends about 50 miles to the south near the confluence of the Sagavanirktok and Ivishak Rivers. From the origin station the route crosses, in a southeasterly direction, the flat coastal plain to a point just north of the Franklin Bluffs, where it extends southward along the west side of the Sagavanirktok River.

Deposits encountered 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.

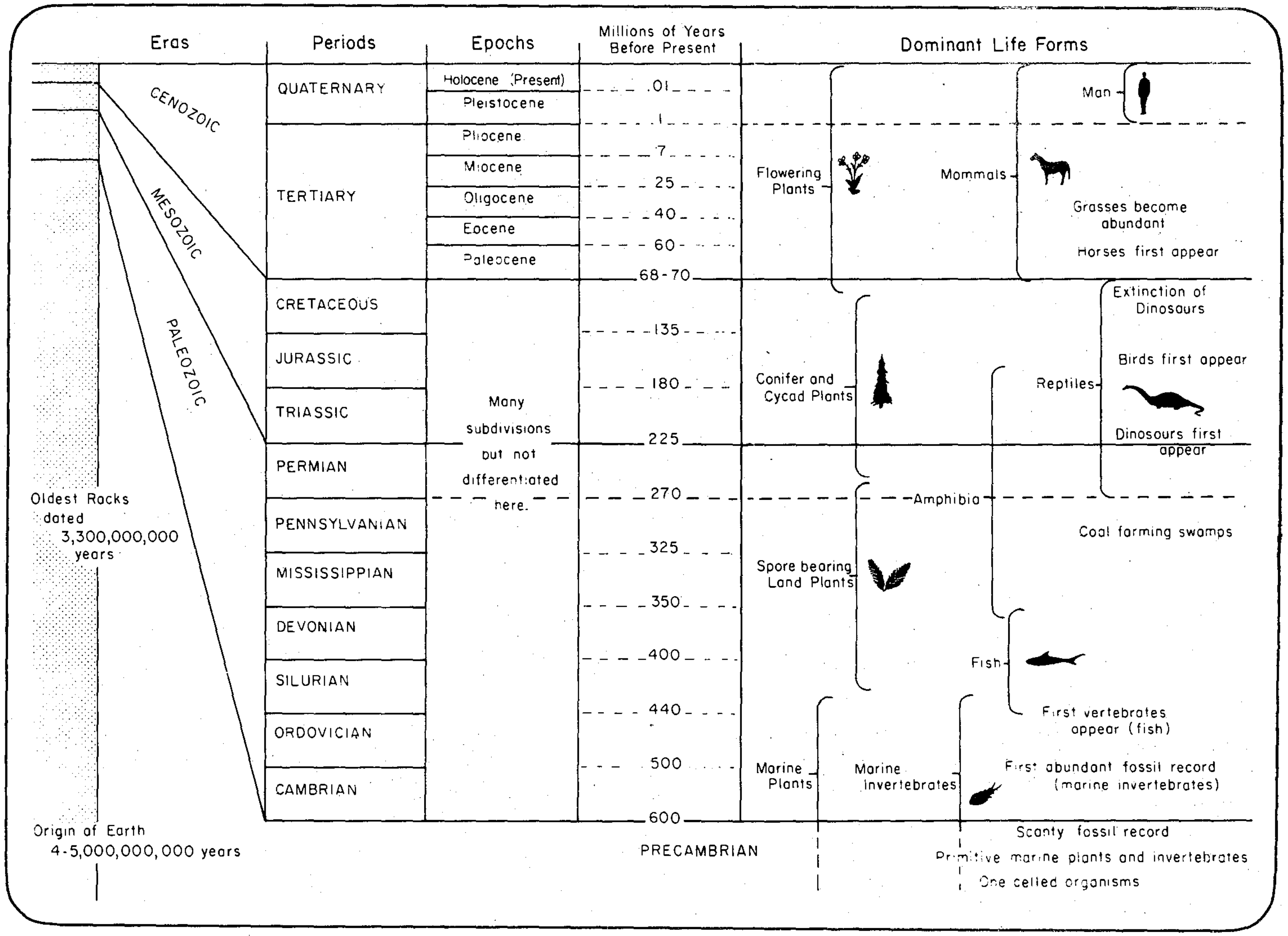


Figure 2 Geologic column

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.

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 route. The major rivers flow north to the Arctic Ocean and south to the Yukon, Koyukuk, 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 (1961) 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 northern 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 3 shows the area covering most

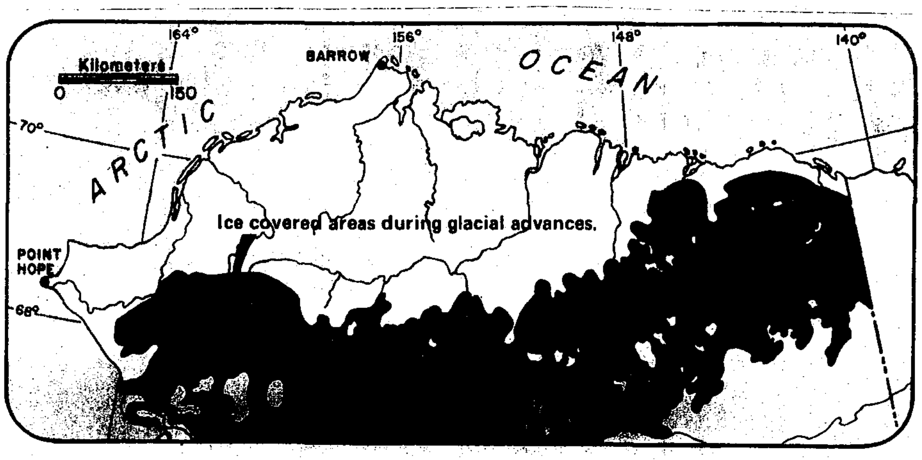


Figure 3 Extent of Pleistocene glaciation in northern Alaska

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 depoisted 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.

As the major glaciers retreated, several moraine-dammed lakes were found in the large U-shaped valleys. Some of these lakes still exist, such as Peters, Schrader, and Chandler Lakes. Many times, however, streams cut outlets through the morainal dams, and as the lakes drained, their sandy and silty floors were exposed to the winds. Clay-sized materials were winnowed out by the wind and carried great distances into adjacent areas; sand-sized deposits were formed into sand dunes on the old lakebeds. An outstanding example is in the Killik River valley, where the lakebed sands have been shaped into longitudinal sand dunes.

Sediment-laden meltwater streams flowing within, adjacent to, and in front of glaciers deposited stratified sand and gravel in floodplains and deltas. These alluvial deposits may be good sources of gravels and sands since they are sorted to varying degrees. Many of these alluvial materials are interfingered with marine sediments--sand, gravel, silt, and clay--deposited when seas intermittently covered the coastal plains and northern foothills during Pleistocene time.

Small valley and cirque glaciers now exist at only a few of the higher points in the Brooks Range, notably in the vicinity of Mt. Chamberlin and Mt. Michelson in the northeastern part of the range. Apparently, they are all retreating. The number and size of the glaciers decreases to the west, and glaciers are absent in the De Long Mountains.

Regional geology

The arctic foothills consist of rolling plateaus, asymmetrical ridges, and low mountains trending east-west and becoming higher to the south. The major structural feature of the southern foothills is characterized by open folds of Mesozoic beds that become steeper and deeper toward the south. Most of the region is underlain by east-trending belts of Cretaceous rocks that were deposited from source areas in the uplifted Brooks Range. Many of these, along with some earlier Paleozoic rocks to the south, were later displaced north by shallow thrust faults. Characteristic rocks in the area include Cretaceous sandstone, conglomerate, shale, siltstone, limestone, and chert. Less common rocks, exposed especially in the southern foothills, include Paleozoic and Mesozoic, dark intrusive rocks dominated by gabbro and basalt; Mississippian shale; Mississippian to Permian limestone; Permian to Triassic sandstone, siltstone, shale, and chert; Permian to Cretaceous shale, chert, and limestone; Jurassic to Cretaceous shale; and some Tertiary conglomerate and sandstone which crop out in the northern part of the foothills. A pre-glacial gravel-covered sediment surface is preserved on 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 (Patton and Matzko, 1959). Sub-bituminous coal and lignite occur in isolated outcrops close to the Sagavanirktok and Ivishak Rivers near the northern boundary of the Arctic Foothills (Barnes, 1967, p. B18, pl. 1). 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 (Gates, Grantz, and Patton, 1968, p. 35). Near the Colville River 70-90 miles west of the proposed pipeline route is the Umiat oil field (in Naval Petroleum Reserve No. 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 Atigun 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 coal beds; 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 the 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 Cretaceous 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 Mesozoic granitic igneous rocks; Triassic shale; Cretaceous shale; sandstone, and conglomerate; and scattered Mesozoic intrusions of dark igneous rocks. Rich oil shale outcrops in front of the range, and phosphate rocks occur between the Canning and Okpilak Rivers.

The only mineral resources 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 (Cobb, 19767b, e). Metalliferous lodes containing antimony, gold, silver, copper, lead, and manganese have been discovered, but the only production has been about 6 tons of antimony ore (Berg and Cobb, 1967, p. 234). 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 (Cobb, 1971). Phosphate rock deposits have been found about 50 miles west of the proposed pipeline route (Patton and Matzko, 1959).

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. Elsehwere, 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 latitute 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 Dietrich 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 (Brosge and Reiser, 1964). 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 (Cobb, 1971). 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 (Barnes, 1967, p. B19).

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.

Intermontane 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-Kuskokwim Lowland

The Tanana-Kuskokwim 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. The Yukon-Tanana Upland lies along the northern 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 a 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 Intermontane 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 on south- or southeast-facing slopes of alluvium-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 and none are probably older than about 7,000 years (Holmes, Hopkins and Foster, 1968). 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 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 use as semipermanent cold storage facilities, a technique employed in norhtwestern Alaska (Porsild 1938). To the engineer, presence of pingos would indicate very poor foundation conditions for buildings, roads, towers, or other permanent structures.

Figure 4 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 practically all of the Brooks and Alaska Ranges and their foothills (Figure 4). 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

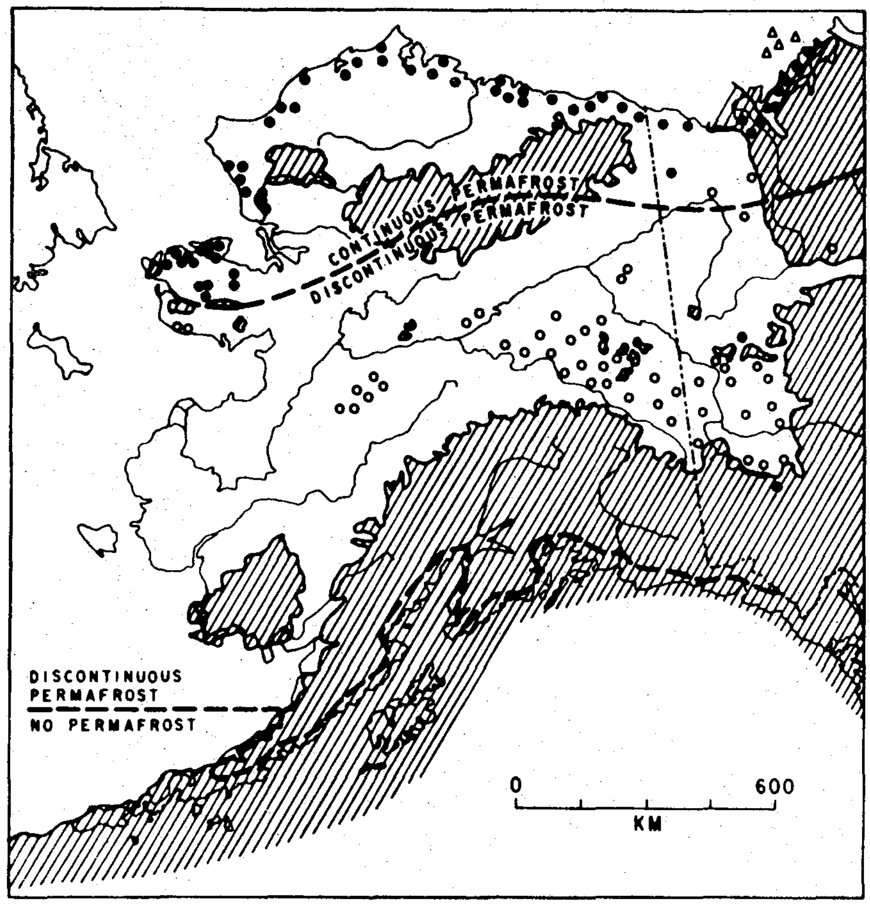


Figure 4 Distribution of open and closed system pingos in relation to permafrost zones and areas covered by late Wisconsinan glacial ice in North America.

LEGEND

(hatched area)	Limit of Wisconsin glacial age
●	Areas of closed system pingos
o	Areas of open system pingos
△	Submarine pingos
— —	Permafrost zone boundaries

mantles extensive areas where melting glaciers have dropped debris in place.

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

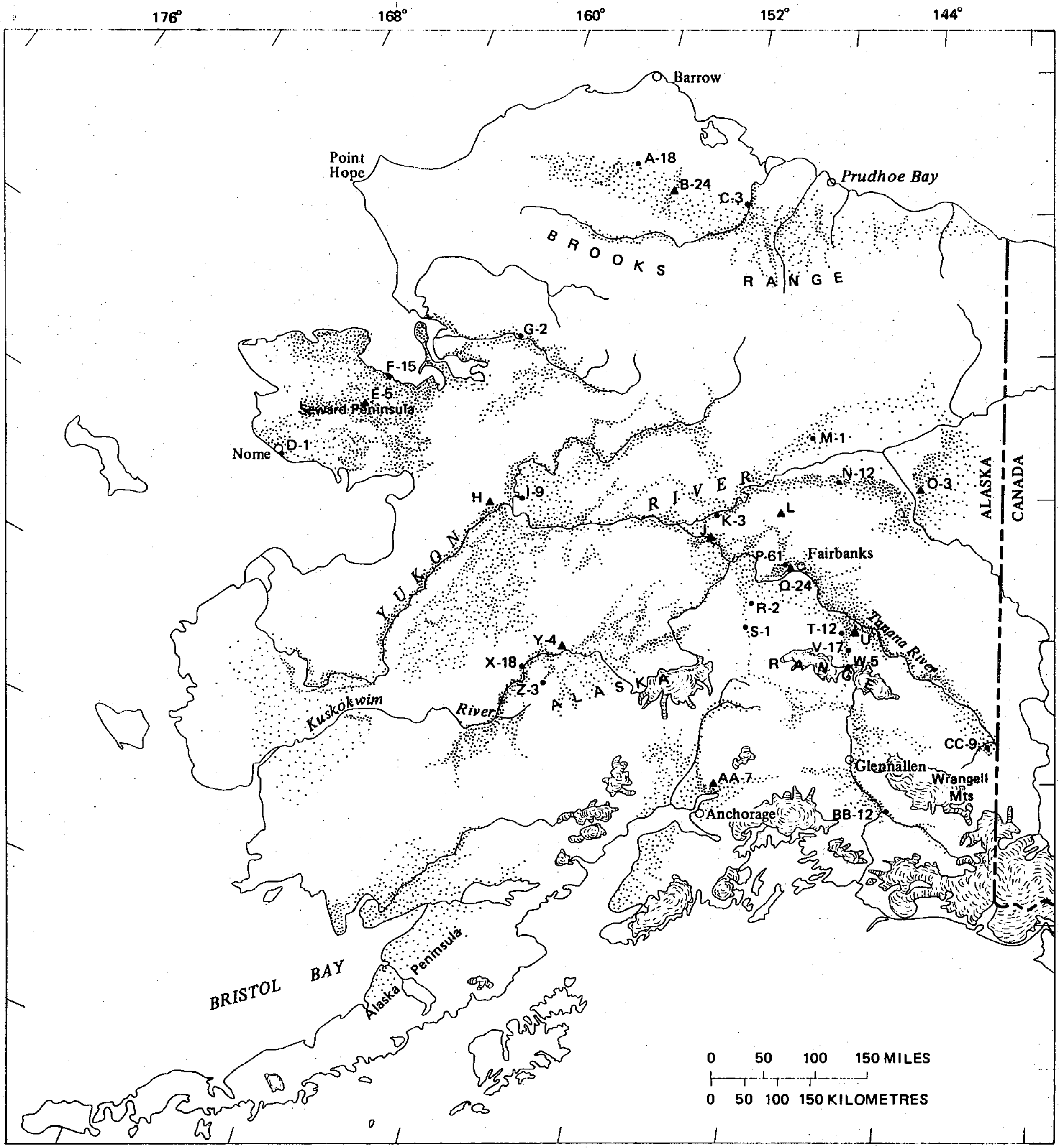
Sediment-laden meltwater streams that flowed within, adjacent to, and in front of glaciers during Pleistocene and Recent time deposited stratified sand and gravel in floodplains and deltas (Qw). These alluvial deposits, as well as modern deposits, may be good sources of gravel and sand for construction 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 (126 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 Intermontane 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 5).

Figure 5 Loess deposits of Alaska (Adapted from Péwé, 1975)



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 most 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).

Alaskan 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 (Pewe 1955). 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.

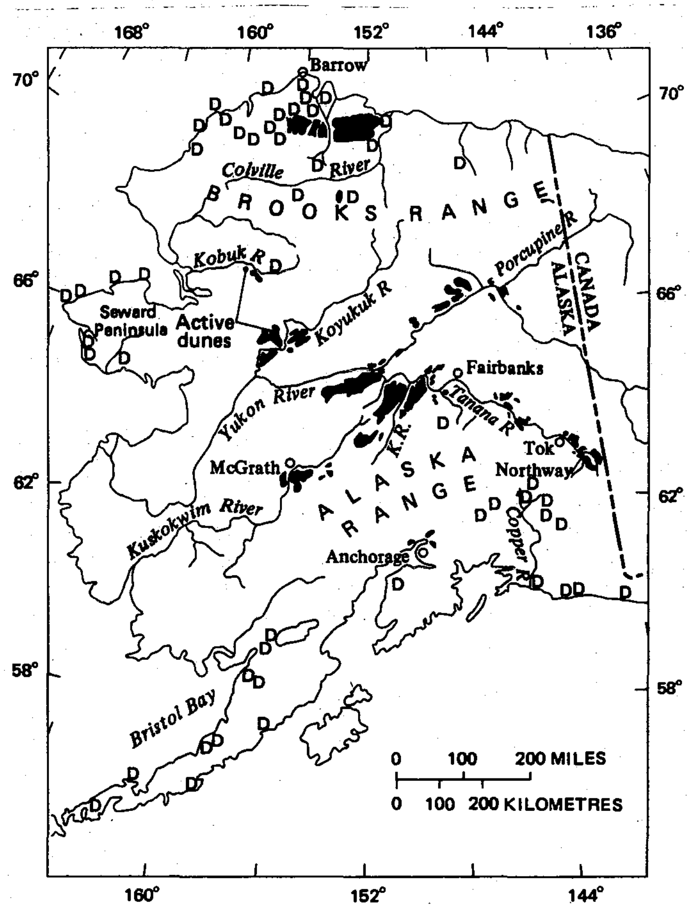


Figure 6 Major sand dune areas of Alaska
(From Péwé, 1975)

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 Chitinana River to the Nowitna River; and southeast of Northway Junction (Figure 6).

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 (Barnes, 1967, p. B22).

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 sand and gravel, and small areas of bedrock consisting of 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 Mississippian age that strike about N60^{O}E and are cut by granitic intrusions.

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 (Barnes, 1967, p. B21).

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-rich 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 over-turned 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 north-western 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 muck 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 propsects in the Fairbanks district (Cobb, 1967a, c, d; Chapman and Foster, 1969) 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 (Berg and Cobb, 1967, p. 218-221). 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 (Cobb, 1971). Deposits of limestone near Fox (Rutledge and others, 1953, p. 20-21) and clay near Harding Lake (Rutledge and others, 1953, p. 43-45) 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 (Cobb, 1967d) contain gold, silver, antimony, mercury, chromium, nickel, and iron, but the only production has been a little antimony ore and mercury (Berg and Cobb, 1967, p. 239). 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 (Cobb, 1971).

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-Kuskokwim 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. Geologic 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. Large but discontinuous deposits of sand and gravel are available from the river bars, which are inundated during the spring. Most of the surficial materials are covered by loess.

Contents

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 soils 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.

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 clay particles are given in Figure 1.

The term 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.

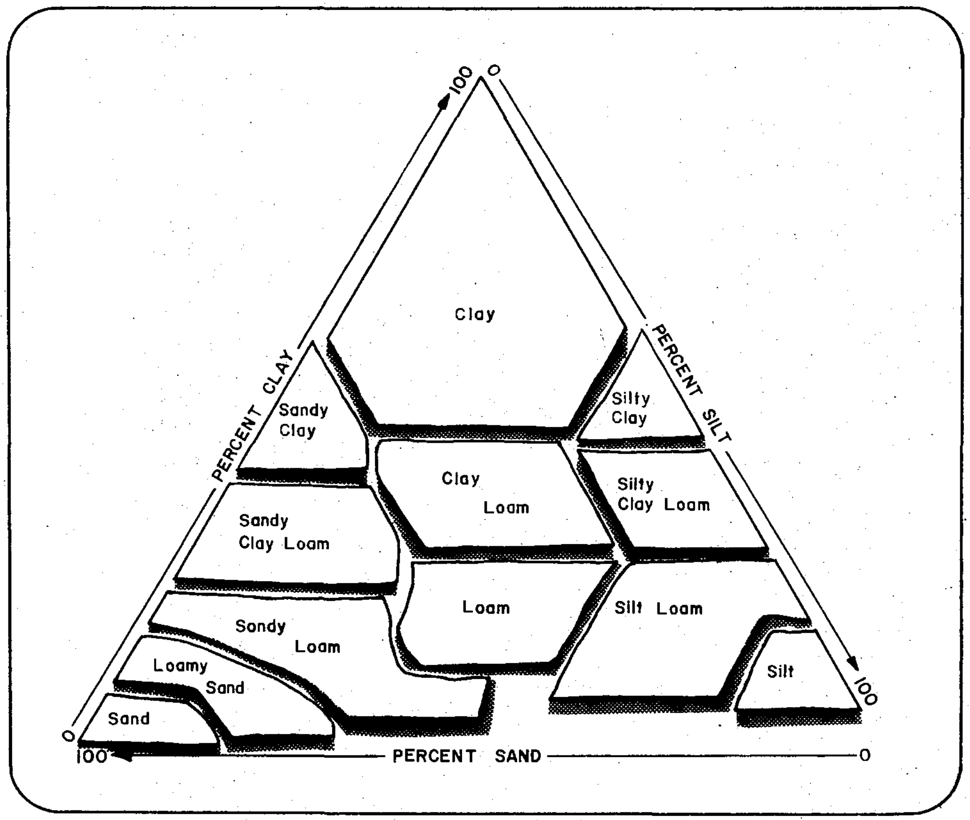


Figure 1 Texture triangle showing the percentage of sand, silt, and clay in each of the textural classes.

Brown et al. (1969) described the results of research on 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 Muskeg Research Institute 1970).

Regional Soils

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 (Karlstrom et al. 1964). Extensive, windblown sand deposits and low dunes occur along streams between the Meade and Colville Rivers (Rickert and Tedrow 1967). 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 (Lewellen 1972 and U.S. Army Corps of Engineers 1971).

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. Soils form 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 (Black 1951).

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. A few peat soils occur in valley bottoms (McNamara 1964) and a few sandy soils occur in isolated dunes bordering major streams (Rickert and Tedrow 1967).

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 (1969), and Lewellen and Brown (1970).

The major soil 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 essentially no vascular vegetation occurs above elevations of 3,000 feet (Tedrow and Brown 1967).

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 texture 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

Kokrine-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;

Organic-rich silts moderately dense of thickness to 14 feet 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:

Colluvial loose to dense, with wind-blown silts;

Wet organic silts predominant in low lying areas;

Alluvial, dense, sand and gravel (e.g. flood-plains 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 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 Northwest Gas 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 area. 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 soils along the proposed route 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 Tanana and Delta Rivers).

Problem Areas

Ground icing and differential jacking of a cold gas pipeline is liable to occur in soils with the following characteristics:

a. when there is considerable variation in the depth of the permafrost taken over short distances and in particular when the permafrost table does not meet with and is below the reaches of the active layer.

b. in regions where the permafrost is discontinuous and the soil is saturated and fine-textured.

c. in regions where there are rapid changes in soil textures.

d. where the permafrost is discontinuous and the soil is fine-textured and saturated.

Regional areas in which these conditions occur are:

Brooks Range

Kokrines-Hodzana Highlands

Rampart Trough

Yukon-Tanana Upland

Tanana-Kuskokwim Lowland

Areas with high moisture content silts would be susceptible to the formation of ground ice as a result of a chilled gas pipeline. The most critical areas are those with discontinuous permafrost that have temperatures close to the freezing temperature immediately below the level of seasonal degree variation. Areas which warrant careful study are:

the Middle Fork of the Koyukuk River

the valleys of the Brooks Range

the Yukon-Tanana Upland;

and

the Tanana-Kuskokwim Lowland northwest of Fairbanks.

Contents

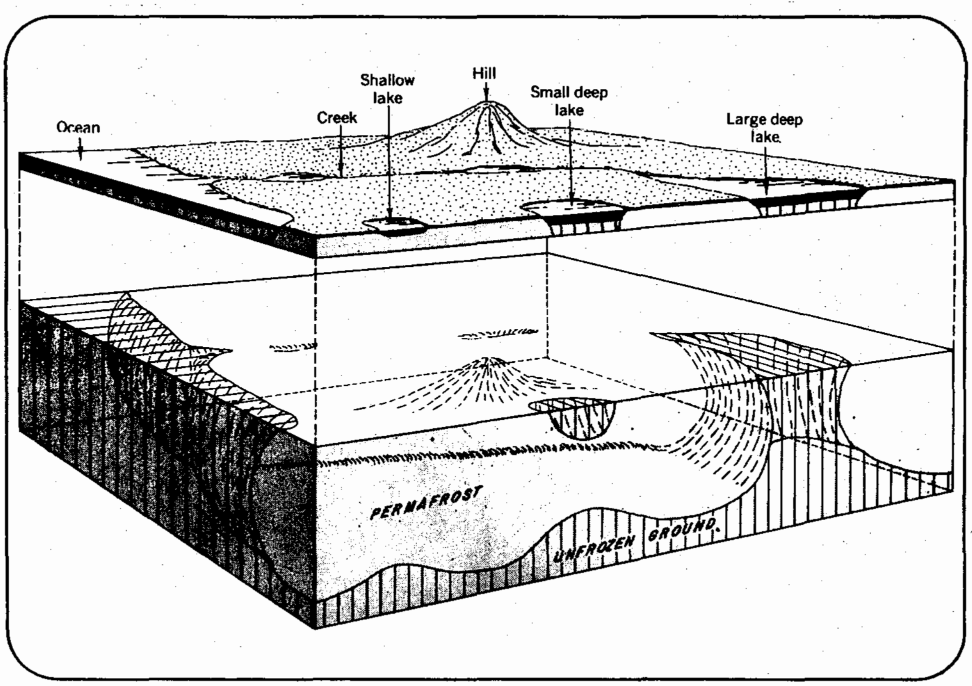
2.1.4 Geological Hazards

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.

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 large-scale surface topography (Figure 1).

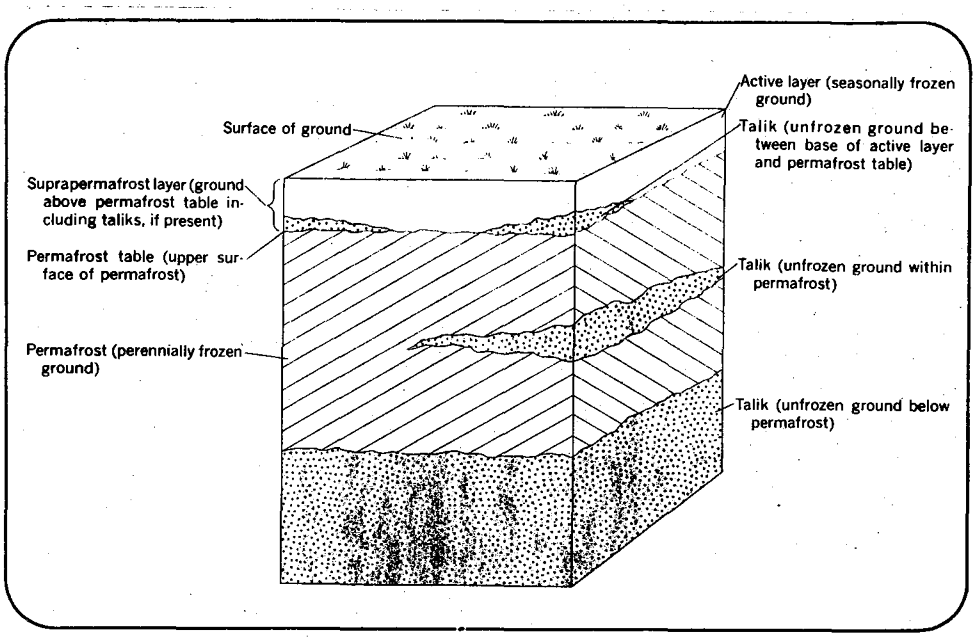


Source: O. J. Ferrians, Jr., R. Kachadoorian and G. W. Greene, 1969. **Permafrost and Related Engineering Problems in Alaska.** U. S. Geological Survey Professional Paper 678.

Figure 1 The effects of surface features on the distribution of permafrost

The permafrost table is the upper boundary of permanently frozen ground. The area above it is called suprapermafrost layer. The active layer is that part of the suprapermafrost zone that freezes in winter and thaws in summer. The thickness of the active 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 all the way 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). 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. 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.

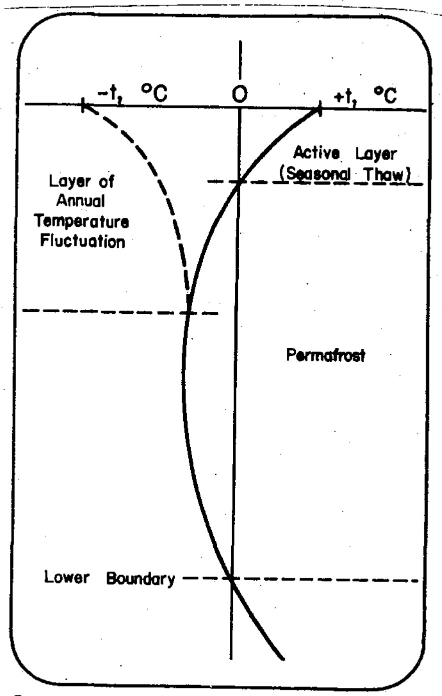


Source: O. J. Ferrians, Jr., R. Kachadoorian and G. W. Greene, 1969. **Permafrost and Related Engineering Problems in Alaska.** U. S. Geological Survey Professional Paper 678.

Figure 2 Occurrence of taliks in relation to the active layer, suprapermafrost zone, permafrost table, and permafrost

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 (Figure 3). 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 F (0 degrees C) 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 F (0 degrees C), indicating the subpermafrost boundary (Figure 3).

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



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

Figure 3 General temperature relationships of permafrost

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.

Various certain conditions have important effects on permafrost growth and thickness (Brown and Péwé 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 substantially 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 is up to nearly 80 percent of the volume of the upper 10 to 15 feet of the ground (Figure 4).

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

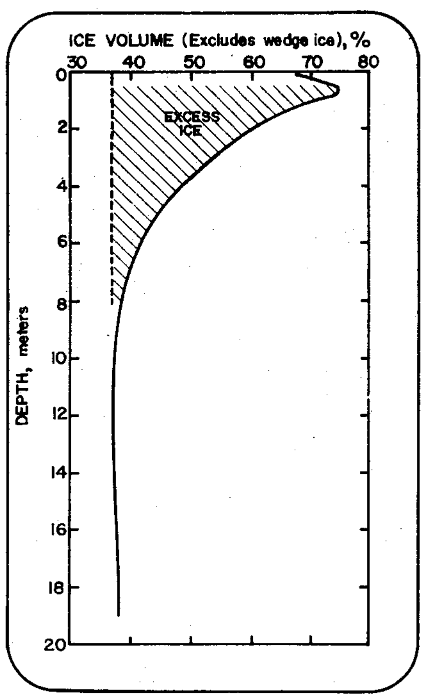
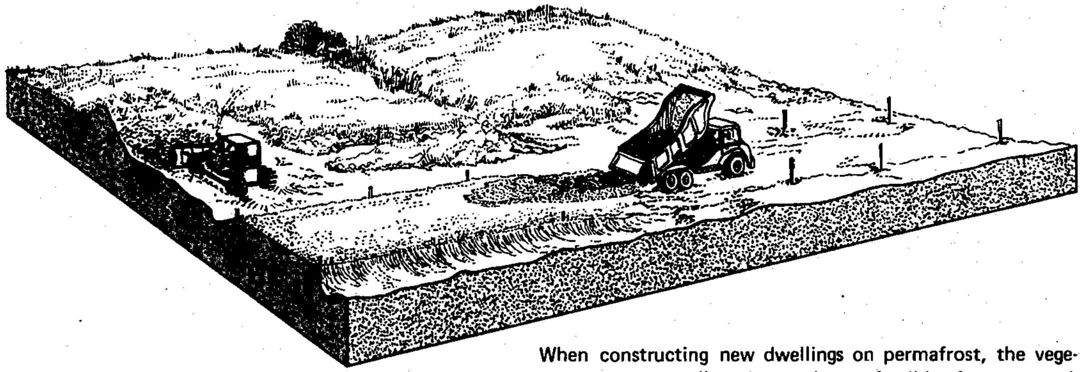
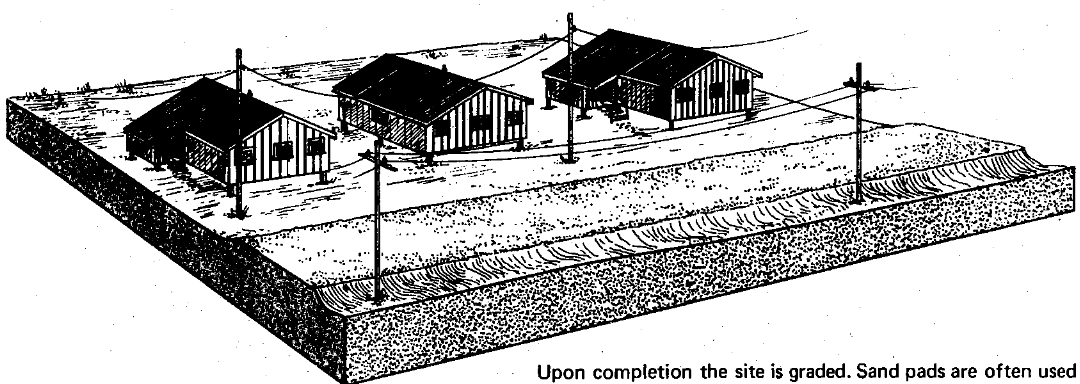


Figure 4 Average ice volume versus depth in permafrost

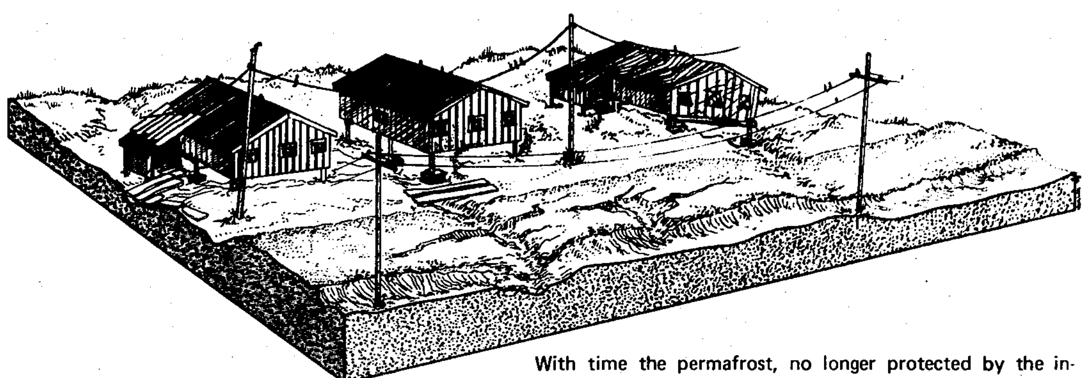
Figure 5 Engineering problems related to permafrost



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.

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. 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 resulting from thawing of permafrost are related to its potential loss of strength and volume (Ferrians, Kachadoorian, and Greene 1969). 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 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 flotation 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 10 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 movements 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 amounting to as much as 20 years normal rate. Also, removal of beach materials for construction materials 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, and are now discovering that the land is slowly disappearing beneath buildings and other facilities. In some cases erosion has progressed so far, or so rapidly, that community leaders are forced to give serious consideration to relocation.

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 or river bends or curves, where 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, where 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 at river bars, where floodwaters overtop the 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 even some distance back from the river. Sometimes, after flooding subsides, river bars are substantially or completely altered in shape and position, altering erosion patterns. Also, old channels may be abandoned and new ones formed or reoccupied after flooding. Meanders are often cut off, straightening the river's course but leaving behind ox-bow lakes and islands.

Differences in vegetative cover probably 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 Northwest Gas Pipeline passes through the continuous and discontinuous permafrost zones. The boundary between the continuous and discontinuous permafrost zones intersects the 17.6 degrees F (minus 8 degrees C) isotherm.

Interior Plains

Arctic Coastal Plain

The Arctic Coastal Plain is within the region of continuous, thick permafrost with a maximum recorded thickness of 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 C to minus seven degrees C. 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 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, although 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 masses wasting in form of mudflows and landslides are common on the foothill slopes in this section, and 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 from 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 only occurs occasionally and 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. However, soils with a high ice content only 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 only 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 C and mean annual air temperatures from minus seven degrees C to zero degrees C.

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 C to minus one degrees C. Current temperatures are often above minus one degree C in this region. Mean annual air temperatures range from minus seven degrees C to zero degree C.

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 C, 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 Northwest Gas 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 6)--areas of moderate to major earthquake damage. In Zone 3, maximum expected earthquakes are below the potentially destructive level. In zone three, earthquakes are commonly felt that occur farther south or as small magnitude earthquakes within the region. About every decade, a shock of magnitude 7 or greater occurs somewhere in Interior Alaska.

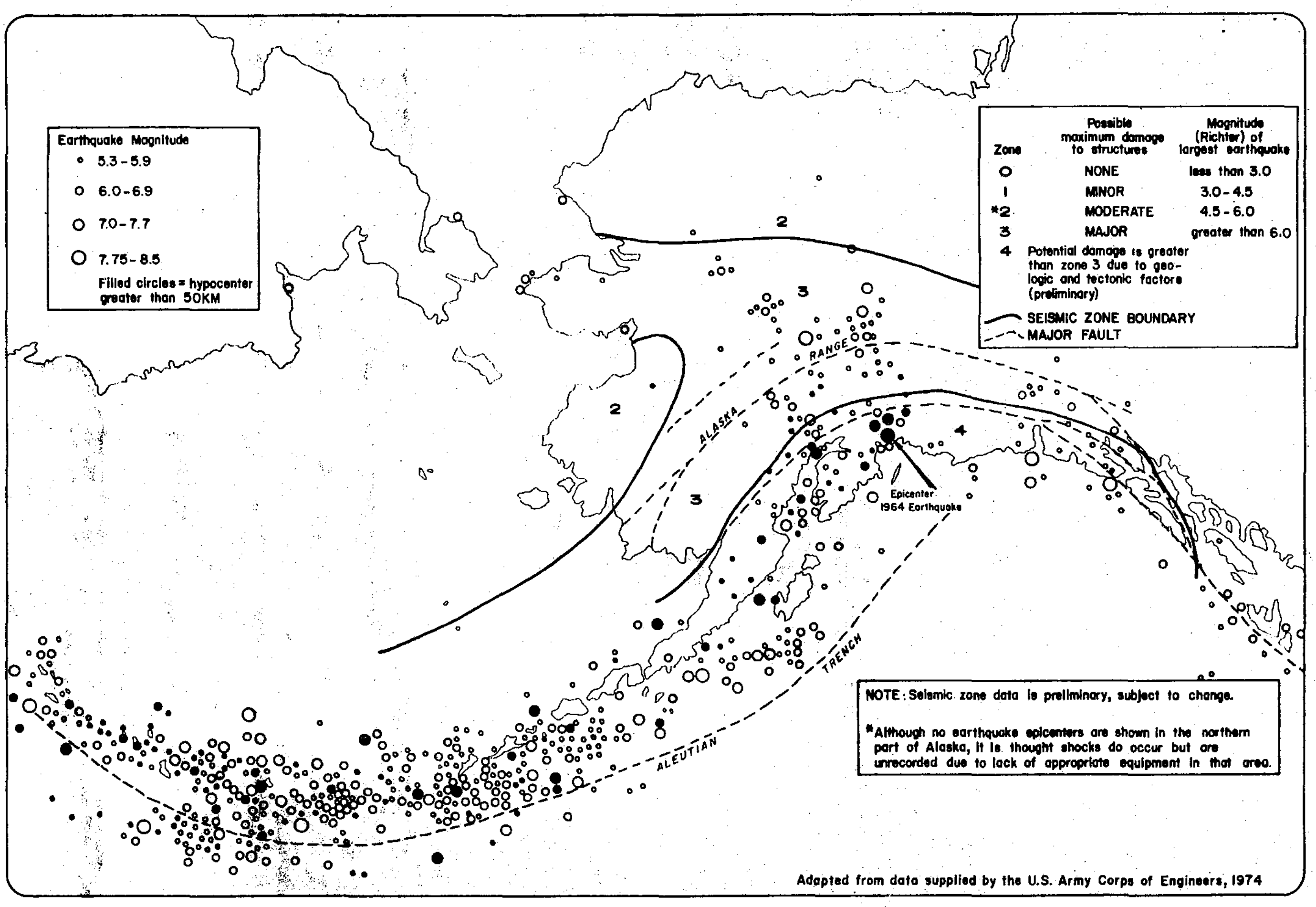


Figure 6 Seismic zone map of Alaska

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 rupture occurs within the earth is known as the focus, or hypocenter, and 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 than 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 increased gradually and once at its maximum did not vary much. The motion stopped abruptly.

One observer reported seeing ground waves, four to six inches high, traveling about 10 miles an hour in a northeast direction. He also reported that a parked automobile rolled back and forth one to 1.5 feet in the same direction.

Relatively little damage was reported at Fairbanks. Shelf goods were shaken but not toppled. There were some fissures in the ground. At the Alaska Motel, fissures two inches wide and 40 feet long developed during the earthquake. One edge of the structure sank about four inches, and some slumping occurred in the excavation beneath the motel. Some damage to utilities and a few concrete structures at Fort Wainwright were reported. The water in one 23-foot deep well in Fairbanks was muddy for about two days after the quake.

The very light damage experienced at Fairbanks is accounted for 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 surface 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 Huslia, 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 10 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 low seismicity (Krinsley et al. 1971). 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 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.

Figure 7
Severity of Seismic Activity Along Route of Trans-Alaska Pipeline
(Adapted from Alyeska Pipeline Service Co., 1973)

Zone	Richter Magnitude Maximum Credible	Acceleration	Duration 0.05g.	(secs) 0.10g
Canadian border to Campbell's Cabin	6.0	0.35g	13-18	3-7
Campbell's Cabin to 66^{o} N	7.0-7.5	0.40g	18-28	5-10
66^{o} N to 67^{o} N	5.5	0.15g	2-5	1-1.5
67^{o} N to Prudhoe Bay	4.5-5.0	0.10g	0.5-1.0	0.25-0.5

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.

The major faults of central Alaska are the thrust belts of the western Yukon-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 have resulted in gross offset of trends in rocks of all ages. The most extensive of the transcurrent faults together with thrust belts that trend obliquely to them, seem to define a series of continental 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 Trans-Alaska Pipeline.

Movement along the Denali fault seems varied, and vertical movement probably occurred at several places. 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 Northwest Gas Pipeline route. Of these, only one fault--the Clearwater Lake Fault--is considered to be an active fault in the corridor of the proposed gas pipeline route. The 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. An active fault crossing of approximately 20,000 feet occurs along the pipeline corridor.

Recent studies by the U.S. Geological Survey have failed to locate the fault in the vicinity of the pipeline route. It is presently uncertain whether the active fault actually crosses the pipeline route.

Southeast of Big Delta, there are no known active faults crossing the Tanana Valley.

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 (Figure 8). It is considered, however, that none of these is important for Northwest Gas Pipeline development consideration, with the exception of Clearwater Lake Fault.

Figure 8

Known Lineaments that Intersect the Proposed Northwest Gas Pipeline 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. Beaver 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

2.2 SPECIES AND ECOSYSTEMS

2.2. SPECIES AND ECOSYSTEMS

2.2.1. Species

Arctic Region

Important Species of Terrestrial Communities

Wet Tundra Plants

Wet Tundra Animals

Moist Tundra Plants

Moist Tundra Animals

High Brush Plants

High Brush Animals

Alpine Tundra Plants

Alpine Tundra Animals

Important Species of Aquatic Communities

Freshwater Plants

Freshwater Animals

Species of Commercial Subsistence and Recreational Importance

Commercial

Subsistence

Recreational/Sport

Yukon (Interior) Region

Important Species of Terrestrial Communities

Alpine Tundra Plants

Alpine Tundra Animals

Lowland Spruce-Hardwood Forest Plants

Lowland Spruce-Hardwood Forest Animals

Upland Spruce-Hardwood Forest Plants

Upland Spruce-Hardwood Forest Animals

Low Brush, Muskeg Bog Plants

Low Brush, Muskeg Bog Animals

Moist Tundra Plants

Moist Tundra Animals

Bottomland Spruce-Poplar Forest Plants

Bottomland Spruce-Poplar Forest Animals

Important Species of Aquatic Communities

Freshwater Plants

Freshwater Animals

Species of Commercial, Subsistence and Recreational Importance

Commercial

Subsistence

Recreational/Sport

2.2.2. Communities and Associations

Arctic Region

Terrestrial Communities

Plants

            - Wet Tundra Community
            - Moist Tundra Community
            - High Brush Community
            - Alpine Tundra Community
        - Animals
            - Mammals
            - Birds
            - Invertebrates
    - Aquatic Communities
        - Plants
        - Animals
            - Tundra lakes, ponds and marshes
            - Deep glacial lakes
            - Rivers, streams, and springs
    - Populations
        - Terrestrial
        - Aquatic
- Yukon (Interior) Region
    - Terrestrial Communities
        - Plants
            - Bottomland Spruce-Poplar Forest Community
            - Upland Spruce-Hardwood Forest Community

Lowland Spruce-Hardwood Community

Low Brush, Muskeg-Bog Community

Moist Tundra Community

Alpine Tundra Community

Animals

Mammals

Birds

Invertebrates

Aquatic Communities

Plants

Animals

Plankton and macroinvertebrates

Fish

Mammals

Populations

Terrestrial

Aquatic

2.2.3. Unique and Other Biotic Resources

Arctic Region

Unique Ecosystems

Rare or Endangered Species

Biotic Resources of Special Importance to the Proposed Action

2.2 SPECIES AND ECOSYSTEMS

This section identifies those species and ecosystems along the proposed pipeline route which might be affected by the construction, operation, and management of the pipeline. Species lists and the discussion of ecological communities is regionally divided between the Arctic (north of the Brooks Range Crest) and the Yukon (or Interior) basin.

2.2.1 Species

The following species lists are shown in groupings of natural community association.

Arctic Region

Important Species of Terrestrial Communities

Wet Tundra Plants

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

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	C. bairdii
Dunlin	C. alpina
Semipalmated sandpiper	C. 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

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

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	Insects (Class)
Flatworms	Platyhelminthes (Phylum)
Roundworms	Nematoda (Class)
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

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
Northern shrike	Lanius excubitor
Redpoll	Acanthis hornemanni
Savannah sparrow	Passerculus iliaca
Tree sparrow	Spizella arborea
White-crowned sparrow	Zonotrichia leucophrys
Fox sparrow	Passerella iliaca

Invertebrates	
Spiders and mites	Arachnida (Class)
Insects	Insecta (Class)
Flatworms	Platyhelminthes (Phylum)
Roundworms	Nematoda (Class)

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

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
Black-bellied plover	Squatarola squatarola
Ruddy turnstone	Arenaria interpres
Whimbrel	Numenius phaeopus
Baird's sandpiper	Calidris bairdii
Semipalmated sandpiper	C. pusillus
Bar-tailed godwit	Limosa lapponica
Snowy owl	Nyctea scandiaca
Short-eared owl	Asio flammeus
Yellow wagtail	Motacilla flava
Redpoll	Acanthis hornemanni
Savannah sparrow	Passerculus sandwichensis
Snow bunting	Plectrophenax nivalis
Invertebrates	
Spiders and mites	Arachnida (Class)
Insects	Insecta (Class)
Flatworms	Platyhelminthes (Phylum)
Roundworms	Nematoda (Class)

Important Species of Aquatic Communities

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

Freshwater Animals

Invertebrates	
Bacteria	Schizomycetes (Phylum)
Rotifers	Rotifera (Class)
Flagellates	Mastigophora (Phylum)
Ciliates	Ciliophora (Phylum)
Aquatic worms	Plesiopora (Order)
Crustaceans	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
Whistling 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

Species of Commercial, Subsistence, and Recreational Importance

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

Yukon (Interior) Region

Important Species of Terrestrial Communities

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.

Alpine Tundra Animals

Mammals	
Tundra shrew	Sorex tundrensis
Pika	Ochotona collaris
Hoary marmot	Marmota monax
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
American golden plover	Pluvialis dominica
Wandering tattler	Heteroscelus incanus
Horned lark	Eremophila alpestris
Barn swallow	Hirundo rustica
Cliff swallow	Petrochelidon pyrrhonota
Bank swallow	Riparia riparia
Common raven	Corvus corax
Water pipit	Anthus spinolettus
Gray-crowned rosy finch	Leucosticte tephrocotis
Savannah sparrow	Passerculus sandwichensis
Golden-crowned sparrow	Zonotrichia atricapilla
Lapland longspur	Calcarius lapponicus
Snow bunting	Plectrophenax nivalis
McKay's bunting	P. hyperboreus

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)
Bettles	Coleoptera (Order)
Butterflies and moths	Lepidoptera (Order)
True flies (mosquitoes)	Diptera (Order)
Ants, bees, and wasps	Hymenoptera (Order)

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

Lowland Spruce-Hardwood Forest Animals

Mammals	
Masked shrew	Sorex cinereus
Dusky 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 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
Oldsquaw	Clangula hyemalis
White-winted scoter	Melanitta deglandi
Surf scoter	M. perspicillata
Goshawk	Accipiter gentilis
Sharpshinned hawk	A. striatus
Peregrine falcon	Falco peregrinus
Spruce grouse	Canachites canadensis
Lesser sandhill crane	Crus canadensis
Spotted sandpiper	Actitis macularia
Greater yellowlegs	Tringa malanoleuca
Lesser yellowlegs	T. flavipes
Northern phalarope	Lobipes lobatus
Common snipe	Capella gallinago
Mew gull	Larus canus
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 calendulus
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

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)

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

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 xanthognathus
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
Great horned owl	Bubo virginianus
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
Bank swallow	Riparia riparia
Gray jay	Perisoreus canadensis
Common raven	Corvus corax
Black-capped chickadee	Parus atricapillus
Boreal chickadee	P. hudsonicus
Gray-headed chickadee	P. cinctus
Robin	Turdus migratorius
Varied thrush	Ixoreus naevius
Hermit thrush	Catharus guttatus
Swainson's thrush	C. ustulatus
Gray-cheeked thrush	C. minimus
Mountain bluebird	Sialia currucoides
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	Cestoa (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)

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

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 candensis
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
Greater yellowlegs	Tringa malanoleuca
Lesser yellowlegs	T. flavipes
Northern phalarope	Lobipes lobatus
Common snipe	Capella gallinago
Mew gull	Larus canus
Bonarparte's gull	L. philadelphia
Arctic tern	Sterna paradisaea
Hawk-owl	Surnia ulula
Tree swallow	Iridoproche bicolor
Gray jay	Perisoreus canadensis
Common raven	Corvus corax
Bohemian waxwing	Bombycilla garrulus
Rusty blackbird	Euphagus cyanocephalus

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)
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

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	Lagopus lagopus
Rock ptarmigan	L. mutus
Lesser sandhill crane	Grus canadensis
Black-bellied plover	Pluvialis squatarola
Rock sandpiper	Calidris ptilocnemis
Dunlin	C. alpina
Western sandpiper	C. mauri

Red phalarope	Phalaropus fulicularius
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
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)

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 spruce	P. glauca
Balsam poplar	Populus balsamifera
Quaking aspen	P. tremuloides
Paper birch	Betula papyrifera

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	Tamiasciurus 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	Mustela 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 macularis
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
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)

Important Species of 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	Mallomonas 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
Crowfoot	Ranunculus aquatilis
Bladderworts	Utricularia intermedia
	U. vulgaris

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)
Dragonfly larvae	Odonata (Order)
Stonefly larvae	Plecoptera (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)
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 caerulescens
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
Bristle-thighed curlew	Numenius tahitiensis
Bar-tailed godwit	Limosa lapponica
Dunlin	Calidris alpina
Western sandpiper	C. mauri
Sanderling	C. alba
Lesser yellowlegs	Tringa flavipes
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
Dipper	Cinclus mexicanus

Mammals

Beaver	Castor canadensis
Muskrat	Ondatra zibethicus
Mink	Mustela vison
River otter	Lutra canadensis
Moose	Alces alces

Species of Commercial, Subsistence, and Recreational Importance

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 and lower Tanana 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.

Blueberry	Vaccinium spp.
Lingonberry	V. vitis-idaea
Crowberry	Empetrum nigrum
Sourdock	Rumex arcticus
Cottongrasses	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
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

2.2.2. 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, particularly 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 sparse 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 moss and other 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, predominantely 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 they 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 do prey on the snowshoe hares which at times beome abundant along stream valleys. Wolverines also hunt these hares and other 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 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 also 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, while 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 travelling as far as the eastern coast of the United States. Passerines are most commonly represented by the Lapland longspur and snow buntings. 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, lumberpiles, 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 the most 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 and the short-eared owl. 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 nowhere else in the Arctic.

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. 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.

a June 1976 survey of peregrines indicated one nesting pair at both Frankli Bluffs and Sagwon (Reynolds, 1976)

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 family Diptera is especially well represented in moist and wet tundra environments. The hordes of mosquitoes and flies are esential for the support of the seasonally abundant birdlife. Peak mosquito populations may occur from mid-June on into July. Some parasites help limit populations of such grazers as caribou, preventing the tundra from being overgrazed 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 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 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 only under the ice cover. At times, green algae are common. Phytoplankton production is so low in these waters that 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 easterly, favorable 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 is generally less abundant than in the previous group of lakes and often is 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 advanced age and attain 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 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 to the bottom 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 is 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.

Arctic char tend to congregate in springs, deeper portions of mountain streams and river deltas, but they become more widely dispersed in the summer. The focus of their spawning activities occurs 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 small streams, lakes, and ponds in the summer and overwinter in the spring areas, ~~and~~ 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

Terrestrial

Abundance and Distribution of Conspicuous Terrestrial Animals Along the Route of the Proposed Gas Pipeline--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	
Lynx	Rare	
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 Atigun Canyon
Birds		
Ducks	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
Other waterbirds	Abundant	Shorebirds, loons and others breed in high densities on coastal plain
Raptors	Common	Aeries along major streams in foothills, mountains and at 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

Aquatic

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. ~~Landlocked~~ Non-anadromous populations found in small lakes near river systems.
Arctic grayling	X		High	Widely distributed in all clear water drainages. Found in lakes and streams. Overwinter in deeper pools of larger rivers and ~~larger~~ 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.
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.

Yukon (Interior) Region

Terrestrial Communities

Plants

Plants of the Yukon Region astride the Arctic Circle in interior Alaska have been described as subject to 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 the severe climate with 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 and 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 and 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 and 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 lies 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 eithr winter or either 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, but 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 the 1:1 million scale exhibit map. 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. Dozens of 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) make 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.

Twenty-eight species of shorebirds including killdeer, plovers, surf birds, common snipe, sandpipers, and phalaropes have also been recorded along river or lake shorelines in this area.

More than 60 species of passerine birds utilize the terrestrial habitats of the upper Yukon and adjacent lands. Common breeding birds are yellow-shafted flickers, Traill's flycatchers, cliff swallows, robins, water pipits, Bohemian waxwings, and several species of thrushes and sparrows. Some of the less common but regular breeders are belted kingfishers, western wood peewees, horned larks, dippers, wheatears, northern shrikes, and chipping sparrows.

Despite long, cold winters, 14 species remain in the area as year-round residents. Among these are several species of woodpeckers and chickadees, gray jays, black-billed magpies, common ravens, brown creepers, and common redpolls. Migratory or resident passerines which are relatively uncommon or rare are rufous hummingbirds, yellow-bellied flycatchers, barn swallows, starlings, pine siskins, and Oregon juncos (U.S.

Department of the Interior, Alaska Planning Group 1973a).

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 tumble 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 and 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.

Such small, sometimes even seasonal, clear spring-fed streams as several very 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 that could allow detrimental activities to decimate a 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 upstreams to distant spawning areas.

Silver salmon are found throughout the Yukon River drainage in Alaska, although 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 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 some of 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 father 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 some is 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 signifcant 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 and 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 twenty-eight species of shorebirds, such as golden plovers, spotted sandpipers, dunlins, and several species of yellowlegs and phalaropes.

The Minto Flats, a smaller habitat unit, are 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 summer, they may spend much of their time in lakes, feeding on tuberous lily roots in relative freedom from fly and mosquito attack.

Populations

Terrestrial

Abundance and Distribution of Conspicuous Animals Along the Route of the Proposed Gas Pipeline--Yukon (Interior) Basin

Species	Abundance	Distribution
Mammals		
Snowshow hares	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.
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 winters 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. None ~~immediately adjacent to the route~~.
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.
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.

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 in 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 sq 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.

The following tables provide information on the distribution and abundance of fish in the Yukon (Interior) Region. It should be pointed out that the spawning season of salmon in these streams is ~~protected~~ prolonged and no single count can be relied upon to reveal all fish that spawn in a section of stream during the season.

Figure 1

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.

Figure 2

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

Figure 3

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.

Figure 4

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.

Figure 5

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.

Figure 6

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	1,000+ LCi
(-) 2.61	LCi, HWF	800	2,000 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

(-) 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.

Figure 7

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

Figure 8

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

2.2.3. Unique and Other 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 gas 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 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 to the Proposed Action

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 includes denning habitat for polar 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 on 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 spectacular 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 on a map exhibit. Illustrated are: spawning, rearing, and overwintering areas for fish and important denning and nesting areas for mammals and birds.

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 to the Proposed Action

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 Dept. of Fish and Game, in press).

The Chena River sustains noted concentrations of beaver--three to four lodge 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.

The following are known critical areas for Arctic char. 1/

System	Spawning		Overwintering	
	No. of Sites	No. of Fish	No. of Sites	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

1/ 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 is 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 also used for rearing.

The entire delta region of the Sagavanirktok River is used for overwintering.

Birds

Minto Flats--A major nesting, molting, 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.

Areas of Critical Environmental Concern

Areas of critical environmental concern are shown on the exhibit map pertaining to this section.

2.3 SOCIO-ECONOMIC CONSIDERATIONS

2.3.1 Alaskan Overview: The State

Population

Alaska is at once the largest state in land area and the smallest in population. 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.

Recent growth in population has been extremely rapid due to the enormous manpower and capital requirements of Alyeska's trans-Alaska oil pipeline (TAPS) 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.

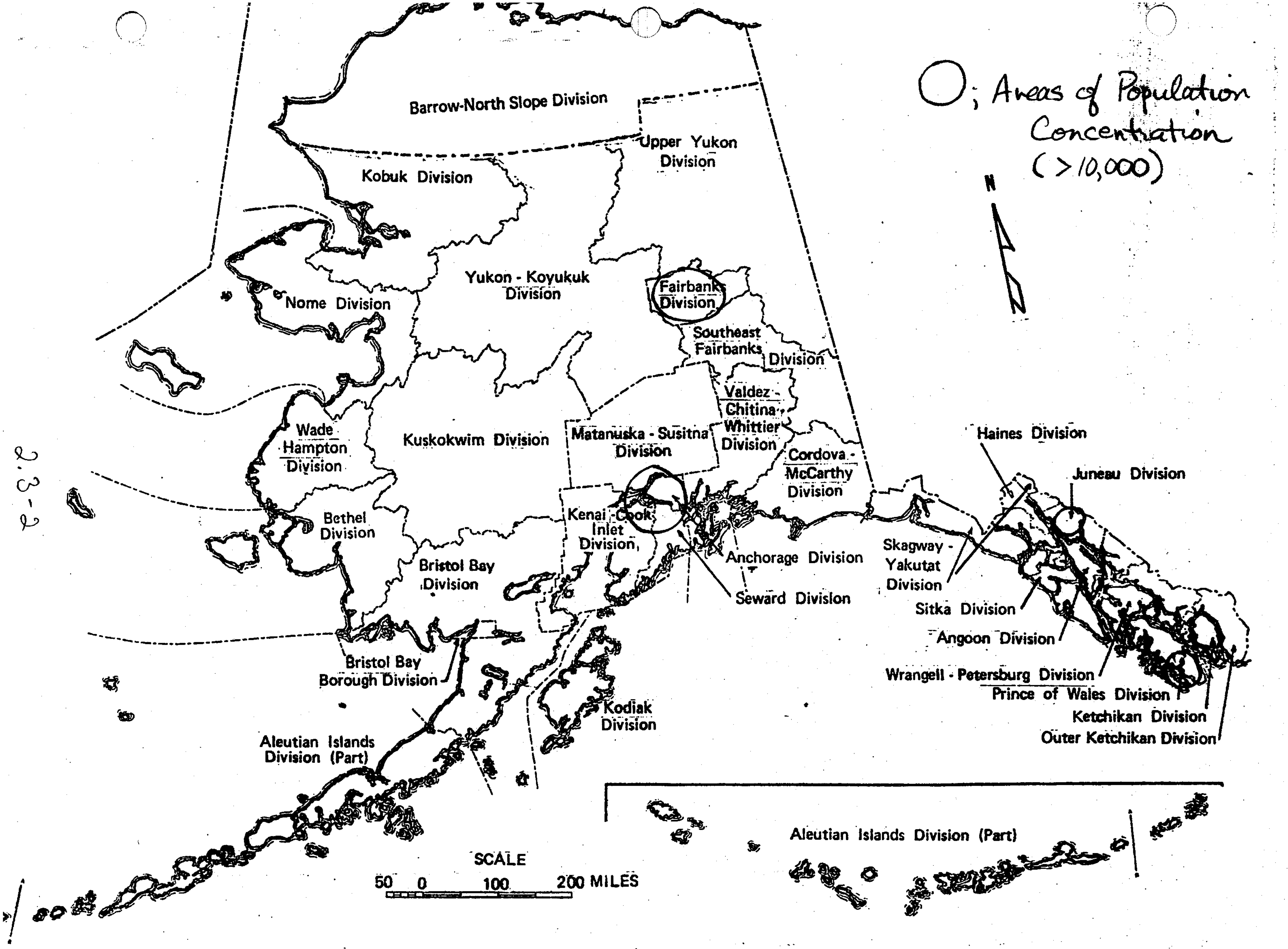
Economic Trends

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 white men 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.

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


O; Areas of Population Concentration (>10,000)
N
Barrow-North Slope Division
Upper Yukon Division
Kobuk Division
Yukon - Koyukuk Division
Nome Division
Fairbanks Division
Southeast Fairbanks Division
Valdez - Chitina - Whittier Division
Wade Hampton Division
Kuskokwim Division
Matanuska - Susitna Division
Cordova - McCarthy Division
Haines Division
Juneau Division
Bethel Division
Kenai - Cook Inlet Division
Anchorage Division
Skagway - Yakutat Division
Bristol Bay Division
Seward Division
Sitka Division
Angoon Division
Bristol Bay Borough Division
Wrangell - Petersburg Division
Prince of Wales Division
Kodiak Division
Ketchikan Division
Outer Ketchikan Division
Aleutian Islands Division (Part)
Aleutian Islands Division (Part)
SCALE
50 0 100 200 MILES

2.3-2

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 2.3.1.1, 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, as 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 growth. Construction of roads, residential construction, and commercial construction were all represented.

There was slow and relatively insignificant growth in the renewable resource 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. 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.

Table 2.3.1.1
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.

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 2.3.1.2)

Table 2.3.1.3 lists Alaska personal income by major sources by 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 2.3.1.4) 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 2.3.1.5) 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 vs. the U.S.A. caused by price movements. (Table 2.3.1.6)

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 Alyeska TAPS 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

Table 2.3.1.2

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 2.3.1.3

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 2.3.1.3

ALASKA PERSONAL INCOME BY MAJOR SOURCES
1961-1972
(Millions of Dollars)

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
Personal 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 2.3.14
COMPARISON OF THE ECONOMY OF ALASKA, 1970 and 1974

	TOTAL PAYROLL[1]		AVERAGE YEARLY EMPLOYMENT[2]	
	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 2.3.14
COMPARISON OF THE ECONOMY OF ALASKA, 1970 and 1974
(Cont'd)

	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 2.3.14
COMPARISON OF THE ECONOMY OF ALASKA, 1970 and 1974
(Cont'd)

	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

NUMBER OF[3] ESTABLISHMENTS		GROSS STATE PRODUCT[4] (MILLION 1958 DOLLARS)	
1970	1974	1970	1974

Table 2.3.1.5
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 2.3.1.6

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" 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, 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 receipts 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%.

Local goverment 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%. 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

Baseline data for those regions which would be directly affected by the gas line along the Alcan route follows. Unfortunately, the latest reliable data available on a native-non-native basis is from the 1970 Census. Undoubtedly, the current pipeline activity in these regions has brought many non-native temporary residents into the areas. For analysis purposes, the Census Divisions listed in Table 2.3.2.1 will be aggregated into economic regions for the impact simulation using the ISEGR econometric model (MAP model) section.

Table 2.3.2.1
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.

In order to construct the TAPS pipeline, numerous construction camps have been established along the pipeline corridor. Camps and pump stations along the corridor north of Delta Junction are as follows, going south from Prudhoe Bay.

1. Prudhoe - (Pump 1)
2. Franklin Bluffs
3. Pump 2
4. Happy Valley
5. Pump 3
6. Atigun
7. Galbraith (Pump 4)
8. Chandalar
9. Dietrich
10. Coldfoot
11. Prospect (Pump 5)
12. Old Man
13. 5 Mile (Pump 6)
14. Livengood
15. Fort Wainwright
16. Delta Junction (Pump 8)*

* Pump 7 is presently only a proposed site with development dependent upon future capacity requirements of the line. Since personnel shifts occur frequently, no attempt has been made to estimate camp populations although, in general, roughly 5,000-8,000 people are accomodated.

Future use of these camps by gas pipeline construction crews would result in population concentrations in the same geographic vicinities and would require similar economic services. In addition, the two planned construction camps between Delta Junction and the Canadian border would also require economic support services.

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 2.3.2.3 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 TAPS got under way. Barrow exhibits very little construction impact, with a major upswing in government employment (Table 2.3.2.4). 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 incomes is shown in Table 2.3.2.5 for the parts of Alaska which are expected to be most heavily impacted by gas pipeline development. The five-year history demonstrates

Table 2.3.2.3

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 2.3.2.4
Northwest Gas 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 2.3.2.5

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 2.3.2.5

PERSONAL INCOME BY SOURCE AND
PER CAPITA INCOME, PIPELINE IMPACT AREA
(Millions of Dollars)
(Cont'd)

DIVISION	Wages and Salaries**	Transfer Payments***	Personal Income***	Per Capita Income (Dollars)	Real Per Capita Income (1967 U.S. Dollars)
1973					
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.

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 except Barrow-North Slope. In addition, most of these divisions show large increases in transfer payments from 1972 to 1973 because of 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-Koyokuk 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-Koyokuk 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 TAPS 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. Thus 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 2.3.2.6. 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 diversity of growth of the three communities. Of a total estimated full value of property of $2.935 billion in 1975, less than six 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 TAPS line, and also the fact that the pipeline passes within the boundary of the community.

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.

Table 2.3.2.6

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 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 Alyeska 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 one or two 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 state-wide for the foundation program. Preliminary 1975 fiscal year state revenue sharing with local governments is approximately $15 million. In extraordinary circumstances, impact grants are also provided to local communities by the state.

2.3.3 Economic Growth Without the Gas Pipeline

2.3.3.1 Methodology

The ISEGR Man-in-the-Arctic program 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 populaiton 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 fifteen 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 in 1990. Production would be about 3.0 billion barrels per day in 1985, and rise to 3.6 billion in 1990.

The most conservative scenario, Accelerated Development, features all the development in the Limited Scenario, plus National Petroleum Reserve 4 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 certian 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 th $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.

2.3.3.2 Economic Growth

From these scenarios, none of which include the assumption of a gas line from Prudhoe Bay, simulations are 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 in this section. The results are as follows:

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, and 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 2.3.3.1, 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.

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 royalities. The picutre 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. Nineteen eighty and 1985 are within the period of construction of the second oil pipeline, and growth is substatial 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 statewide general support, distribution, government, and financial center.

Table 2.3.3.1

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
1979	1022.2	436.271	244.809	3749.91
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

The distribution of economic growth which would occur without the gas pipeline differs between the three regions, no matter which scenario is adopted. (Tables 2.3.3.2, 2.3.3.3, 2.3.3.4, 2.3.3.5). Interior (basically, the northern half of the pipeline corridor) generates over three-fourths of its real output in mining, with only government providing any 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 and local government. In the Limited case, Anchroage output grows 67 percent as much as in the Accelerated case but mining actually delcines 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 Anchorage'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 Fairbanks' 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

Table 2.3.3.2

ACCELERATED DEVELOPMENT: GROSS PRODUCT BY INDUSTRY, Interior Region

(Millions of 1958 Dollars)

	Ag. Fish. Forest	Mining	Construction	Manufacturing
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	5.039	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 2.3.3.3

ACCELERATED DEVELOPMENT: GROSS PRODUCT BY INDUSTRY, Anchorage Region

(Millions of 1958 Dollars)

	Ag. Fish Forest	Mining	Construction	Manufacturing
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

	Transportation 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 2.3.3.4

ACCELERATED DEVELOPMENT: GROSS PRODUCT BY INDUSTRY, Fairbanks Region

(Millions of 1958 Dollars)

	Ag. Fish. Forest	Mining	Construction	Manufacturing
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

		Government			Region
	Trade	Total	Federal	State	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 2.3.3.5

ACCELERATED DEVELOPMENT: GROSS PRODUCT BY INSUSTRY, 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	388.271	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

case, while the middle case projects statewide employment to be 408,913 by 1990. (Table 2.3.3.6) 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 2.3.3.7, 2.3.3.8, 2.3.3.9) 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 concentrated in mining, some 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 2.3.3.10) 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 a re 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 2.3.3.11) In 1974, total statewide payroll was just over $1 billion. (See Table 2.3.1.4.)

Table 2.3.3.6

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 2.3.3.7

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 2.3.3.8

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 2.3.3.9

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

Table 2.3.3.10

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

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Table 2.3.3.11

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	1641.75	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

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 2.3.3.12) 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 forecast to increase dramatically from around $10 million in 1974 to $149.1 million in 1990. (See Table 2.3.3.13)

Mining is forecast to dominate payroll in the Interior region, with the support sectors and state and local government accounting for most growth to 1990 (increasing 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 2.3.3.14)

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 2.3.3.15) 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 2.3.3.11, 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.)

Table 2.3.3.12

ACCELERATED DEVELOPMENT: WAGES AND SALARIES BY INDUSTRY

STATE

(In preparation)

Table 2.3.3.13
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 2.3.3.13 (con't)

	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 2.3.3.14
ACCELERATED DEVELOPMENT: WAGES AND SALARIES BY INDUSTRY
INTERIOR REGION

(In preparation)

Table 2.3.3.15
ACCELERATED DEVELOPMENT: WAGES AND SALARIES BY INDUSTRY
FAIRBANKS REGION

(In preparation)

Personal Income, Population, Per Capita Income

As would be expected from the data on wages and salaries, Alaskan aggregate personal incomes grow substantially over the period of 1978 to 1990. While it is demonstrated in Table 2.3.3.16 that personal incomes for the state as a whole rise 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. This reflects the fact that even at growth rates in Alaska cost of living between 1978 and 1990, which are somewhat below those of the United States as a whole, the Alaska Relative Price Index shows an increase of 59 percent, equivalent to a 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; and 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 2.3.3.17. Except 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 2.3.3.18. No claim is made that these would be the incomes which would actually prevail. As a matter of fact, the the component of personal incomes, 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 2.3.3.19)

Table 2.3.3.16

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 2.3.3.16 (Con't)

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

Element: ...

Table 2.3.3.17
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	501.264	20.839	106.575	960.158
1990	546.818	21.398	111.09	1020.03

Table 2.3.3.18

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 2.3.3.19

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

State and Local Revenues and Expenditures

State and local revenues and expenditures are expected to grow quite rapidly, even without a gas pipeline. From a 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 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 2.3.3.20)

Due to large populaiton 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 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 revenue 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

Table 2.3.3.20
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 2.3.3.20 (con't)

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 2.3.3.20 (cOn't)

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

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 2.3.3.20 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 expenditure patterns but it is clear that there will be significant departures from the statewide pattern in particular communities.

In Fairbanks, petroleum development--related activities 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 largest taxpayers in the borough and city are shown in Table 2.3.3.21.

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 in state revenues could lead to substantial increases 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 accomodate 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 somewhat 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. It has presently a tax base consisting

Table 2.3.3.21

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 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, however, only up to limits established by the legislature so as 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 2.3.3.22. Questions regarding the taxing jurisdicition 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 2.3.3.23.

One other feature of importance to the futrue of local government in the North Slope Borough is the newly established Arctic Slope Regional Corporation which is nearly 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. None imposes 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

Table 2.3.3.22

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

Table 2.3.3.23

GENERAL OBLIGATION BOND STATUS OF
SELECTED ALASKA COMMUNITIES

MUNICIPALITY OF ANCHORAGE

	General Obligation Bonded Debt (million $)	Per Capita Debt $	Per Capita Valuation $	Rate of Debt to $
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

	General Obligation Bonded Debt (million $)	Per Capita Debt $	Per Capita Valuation $	Rate of Debt to $
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 2.3.3.23 (Con't)

GENERAL OBLIGATION BOND STATUS OF SELECTED ALASKAN COMMUNITIES

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 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 2.3.3.24. 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 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 and 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. None of the directly impacted areas is "typical" when its 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 shows no growth with Maximum Development. While employment booms to as much as 77 percent above 1978 employment in the absence of a gas pipeline during the early 1980's, over the whole period 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.

Table 2.3.3.24

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

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, Economic, 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-Koyokuk)

Fairbanks (Fairbanks, Southeast Fairbanks)

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2.4 AIR AND WATER ENVIRONMENTS

Contents

2.4.1. Climate

Introduction

There are 24 locations from which climatic data are available and pertinent to the proposed Northwest Pipeline Corporation gas pipeline route within Alaska. Twenty of these are along or close to the route. Some data locations are at the camps for the construction of the Trans-Alaska Pipeline System (TAPS) and have short periods of record and therefore may not be representative of long term averages of 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 1968b); 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.

Statewide Perspective

Precipitation

Precipitation patterns for Alaska are shown in Figures 1 and 2. A strong marine influence, accentuated by the presence of coastal mountain ranges, exists in southeast

MEAN ANNUAL PRECIPITATION — INCHES

BASED ON ALL AVAILABLE DATA THROUGH 1972

IN CO-OPERATION WITH THE U.S. GEOLOGICAL SURVEY

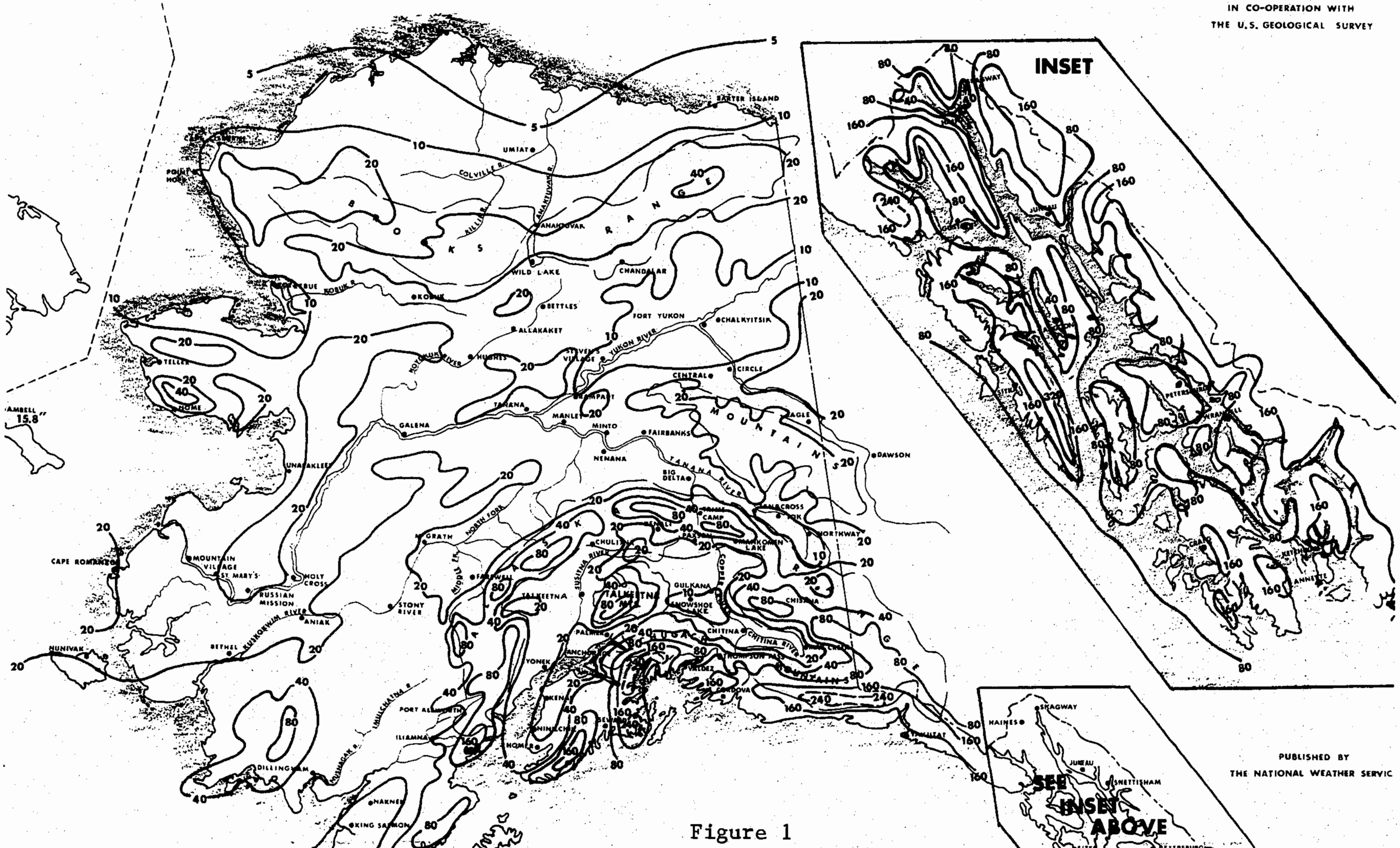


Figure 1

PUBLISHED BY THE NATIONAL WEATHER SERVIC

MEAN ANNUAL SNOWFALL — INCHES

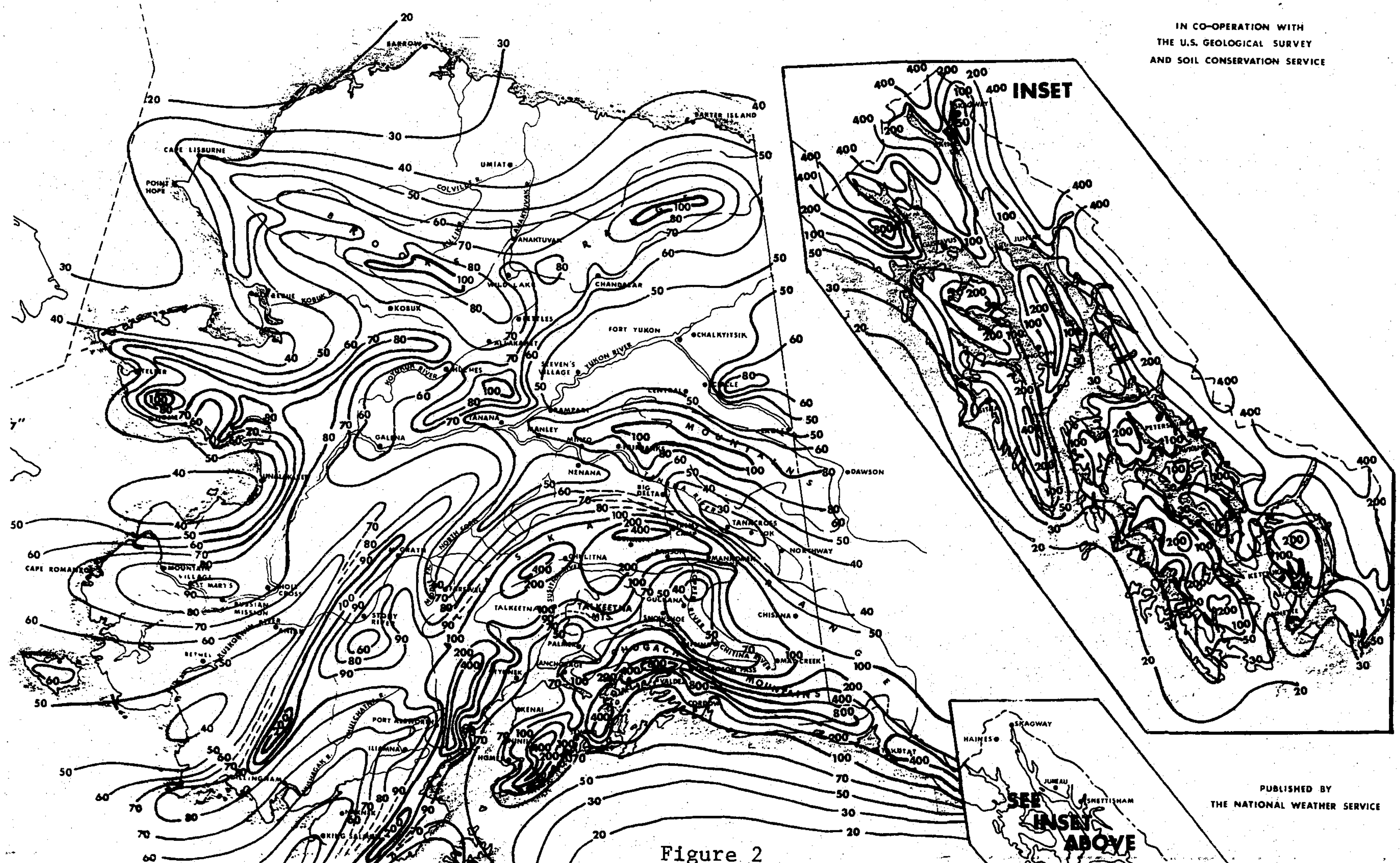


Figure 2

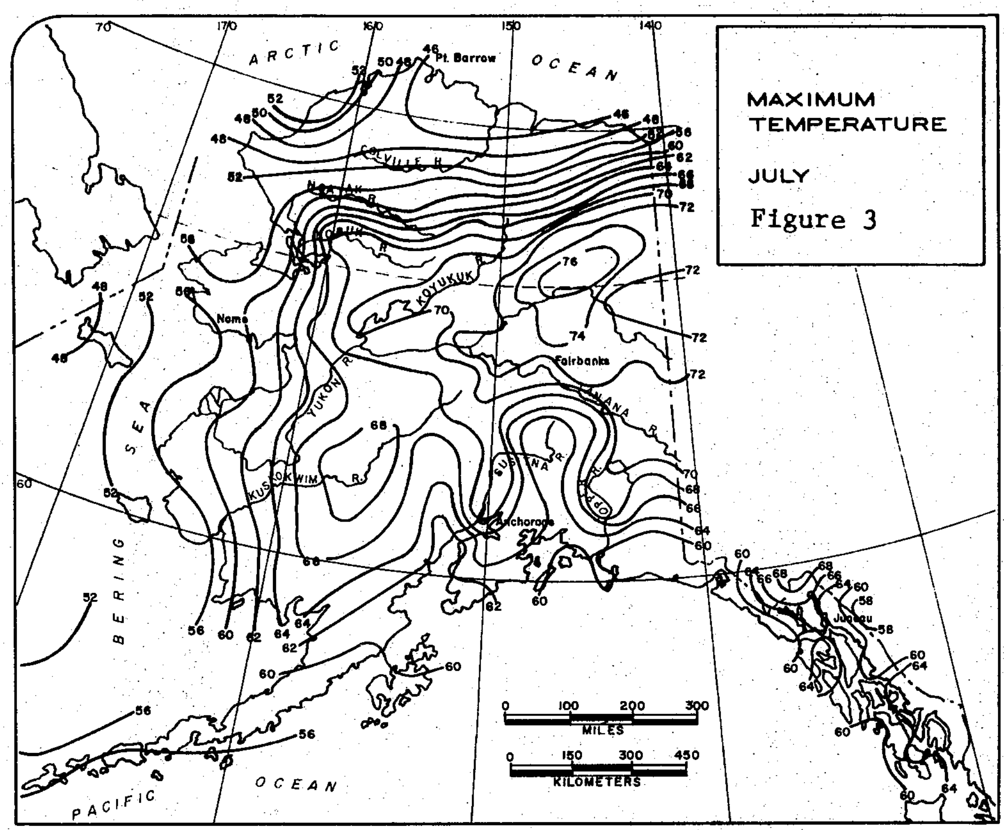
Alaska and along the gulf coast. This combination results in the extremely high precipitation centers depicted on the maps, not only in coastal areas but also in the Interior. The overall range of precipitation across the state is from less than five inches in the Arctic to more than 300 inches in southeast Alaska.

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 a positive and adverse influence. 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 with rapid snow melt.

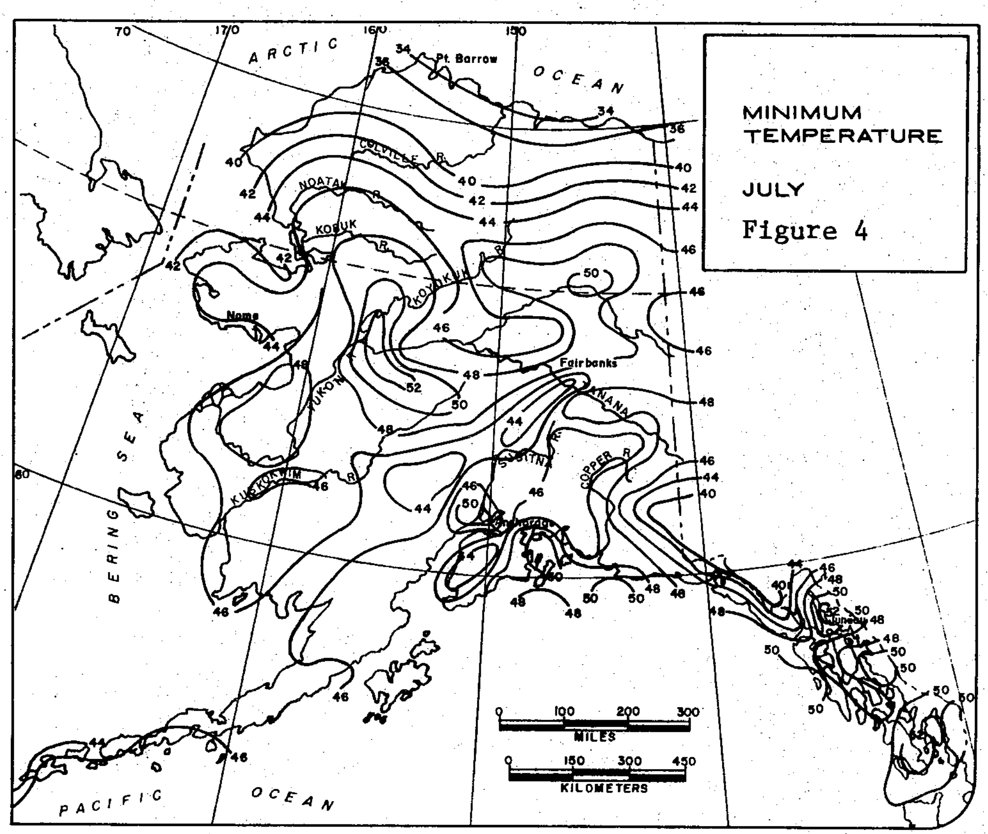
Temperature

Temperature patterns appear in Figures 3 through 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.

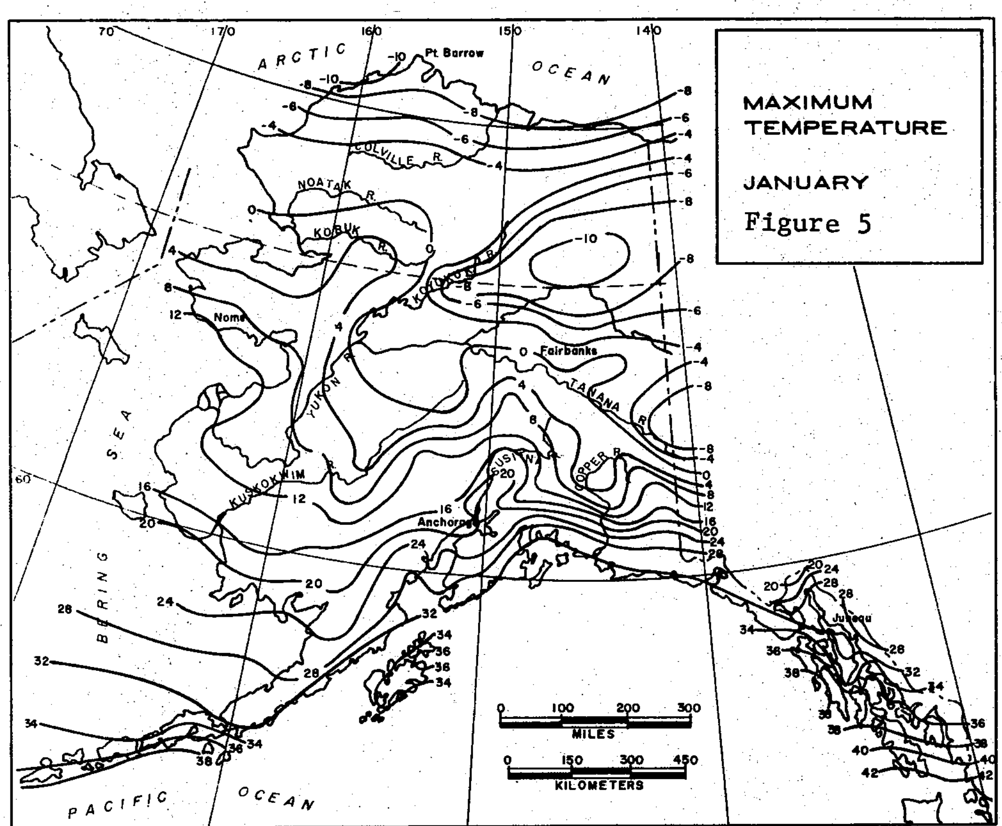
In general, temperature patterns shown are representative since the map scale makes it impossible to show them individually. The variety of terrain in Alaska creates microclimates or small areas where temperature, precipitation, or both will vary from that of the surrounding area. For example, summer frost in interior Alaska varies in frequency from one location to another but correlates most closely with elevation. Sites at higher elevations have greater frost frequency.



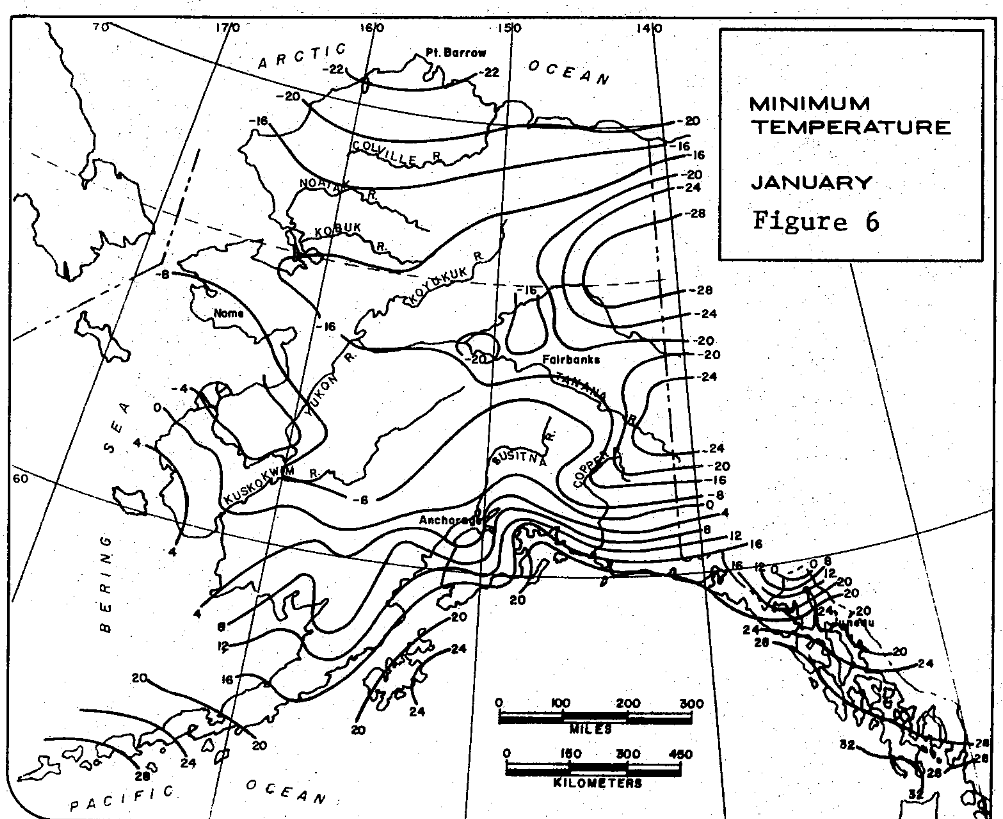
Mean Maximum Temperature Distribution, July



Mean Minimum Temperature Distribution, July



Mean Maximum Temperature Distribution, January



Mean Minimum Temperature Distribution, January

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, and one can assume this coldness to be proportional 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 Figure 7. Equivalent wind chill temperature relates a particular wind and temperature combination to whatever temperature would produce the same loss of heat at four miles an hour, the normal speed of a person walking vigorously. Notice that a temperature of minus five degrees F and a wind of 20 miles an hour has the same cooling power as a temperature of minus 45 degrees F with wind of four miles an hour or less.

Further relationships of reduction in efficiency of men and machinery due to climate amd more specific Equivalent Wind Chill information for locations along the proposed pipeline route are included in Section 3.

Storms

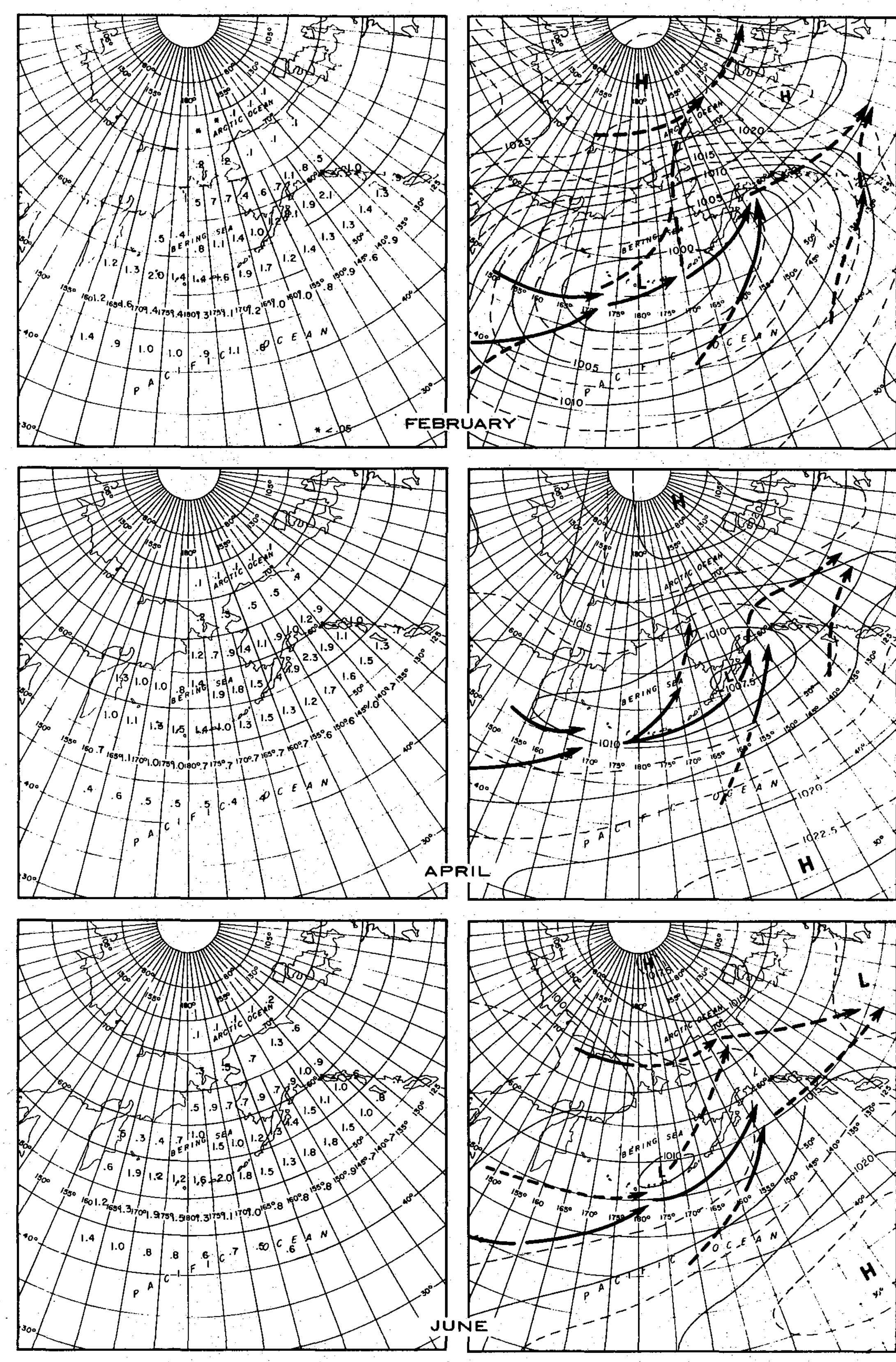
Storms affecting Alaska are extra tropical cyclones, low pressure areas associated with cold, warm, or occluded fronts and air mass showers and thunderstorms in the Interior in summer. Hurricanes (typhoons) and tornadoes seldom if ever occur in Alaska. Figure 8 shows storm tracks and storm frequencies 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 storm track

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	[illegible]	[illegible]	[illegible]	-95
15	25	15	10	0	-5	-10	-20	-25	-30	-40	-45	-50	-60	-65	-70	[illegible]	[illegible]	[illegible]	-100	-105	-110
20	20	10	5	0	-10	-15	-25	-30	-35	-45	-50	-60	-65	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-120
25	15	10	0	-5	-15	-20	-30	-35	-45	-50	-60	-65	[illegible]	[illegible]	[illegible]	[illegible]	-100	-110	-120	-125	-135
30	10	5	0	-10	-20	-25	-30	-40	-50	-55	-65	-70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
35	10	5	-5	-10	-20	-30	-35	-40	-50	-60	-65	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
40	10	0	-5	-15	-20	-30	-35	-45	-55	-60	-70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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

Figure 7



Average Number of Storms per Month

Figure 8

→ Primary Storm Track
- - -→ Secondary Storm Track
—1015— Sea Level Pressure in Millibars (mb)

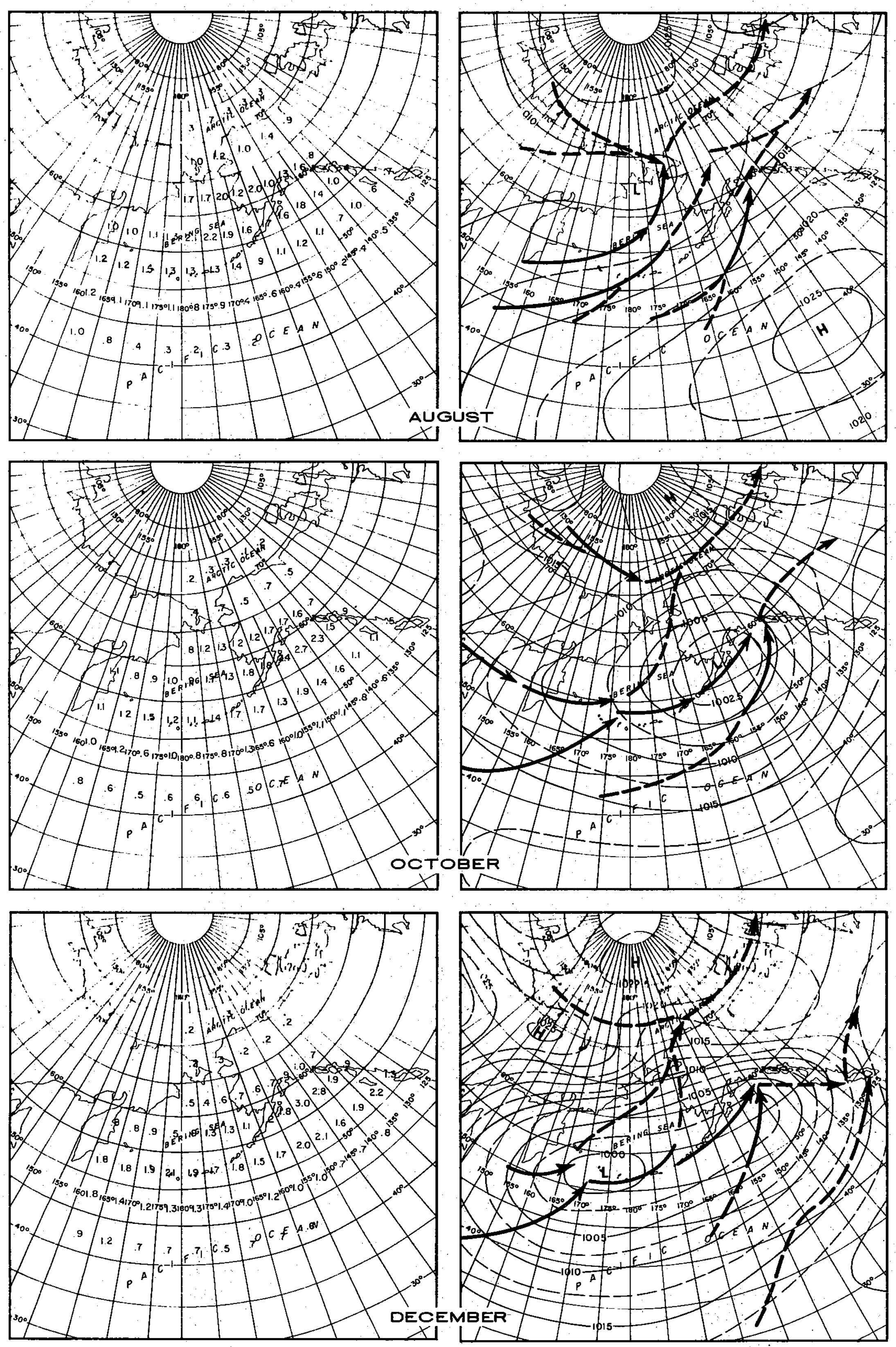


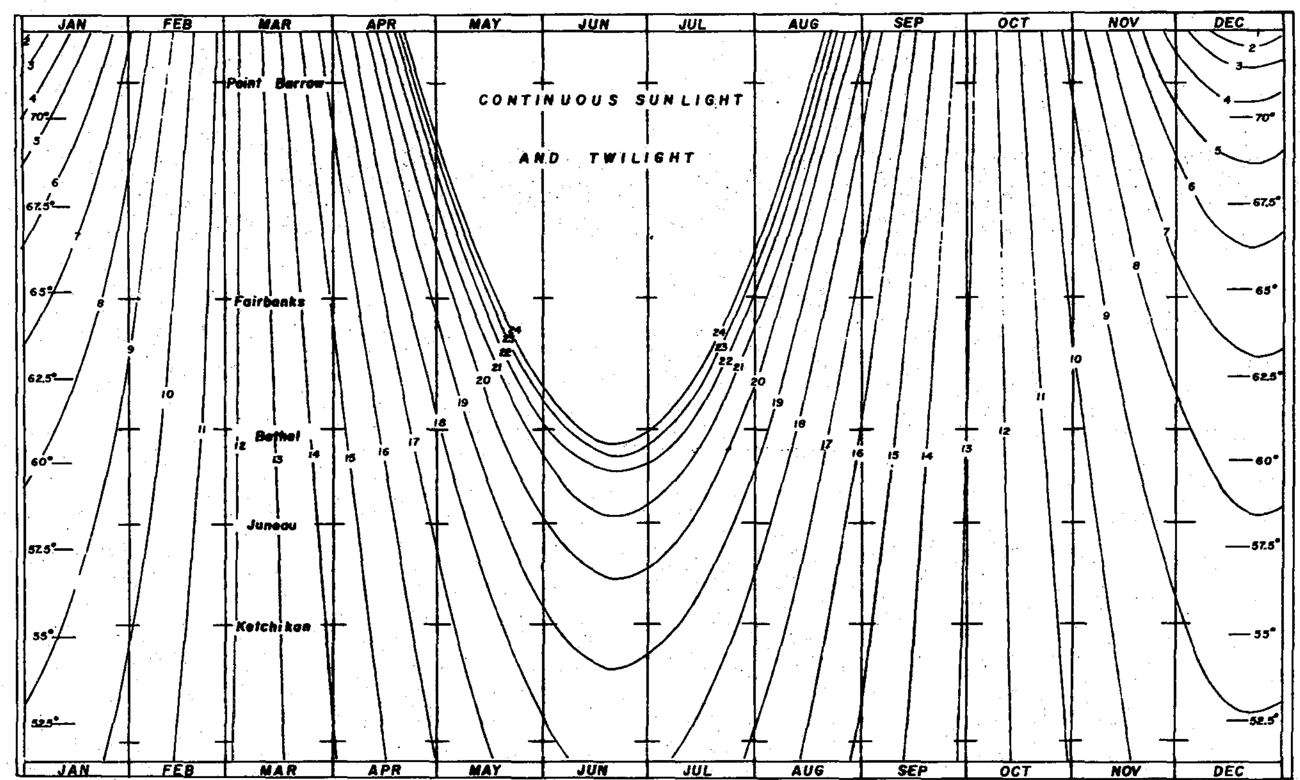
Figure 8 continued

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.

Storm frequencies are highest year-round along the Aleutian Chain and into the northern Gulf of Alaska. Highest frequencies in the Interior and along the Arctic coast occur in summer when the storm tracks move inland. However, storm frequencies are still considerably less than along the Aleutian Chain and in the Gulf of Alaska.

Seasonality

Latitude and season of the year determine the length of each day at a particular location (Figure 9). 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 is assumed to be 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 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



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.

Figure 9

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 with an elapsed time of nearly 85 days with the sun or part of it above the horizon. Actually darkness ceases with the beginning of civil twilight on April 23rd and does not begin again until August 19. Total elapsed time without complete darkness is nearly 119 days. In the farthest south 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 farthest north 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 farthest south 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 beginning and end of civil twilight.

Climate Along the Route

Precipitation

Along the gas pipeline route from the Arctic Coast through the foothills, annual precipitation amounts are 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 near 20 inches near the beginning of the pipeline and increases to 20 to 30 inches from the immediate coastal area to the foothills. Snowfall increases with elevation to near 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 Figure 10, their value is greatly reduced since wind continuously moves the snow from one area to another. Also, there are areas where snow is packing and developing a hard crust. 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, (Figure 10), is probably the most representative of locations along the route to the foothills. Snow depths are the 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 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 that snow depths near 30 inches are quite common along the pipeline route in the Prospect Creek area and higher elevations and are near 20 inches in 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 and 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.

Month	Fairbanks Airport: Trace or less	1- 6 inches	7-12 inches	13-24 inches	25-36 inches	37-48 inches	49-60 inches	Eielson AFB: 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	*

Big Delta: Trace or less	1- 6 inches	7-12 inches	13-24 inches	25-36 inches	37-48 inches	49-60 inches	Northway: Trace or less	1- 6 inches	7-12 inches	13-24 inches	25-36 inches	37-48 inches	49-60 inches	Month
5	34	44	11	1		5			38	48	11	2	1	J
4	34	36	13	6	2	5			24	52	17	5	2	F
2	31	36	22	5	3	1		1	20	63	13	4	0	M
20	48	19	8	5			8	35	28	25	4			A
92	7	1	*				74	19	5	2				M
100							100							J
100							100							J
100							100							A
96	4						97	3						S
44	50	6					42	53	1	4				O
16	63	19	2				1	52	41	5	1			N
3	66	25	5	1		*		12	58	25	5			D
47	24	18	7	2	1	1	44	13	18	19	4	1	*	YR

Month	Barter Island: Trace or less	1- 3 inches	4- 6 inches	7-12 inches	13-24 inches	25-36 inches	37-48 inches	Umiat: 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	

*Less than .5

Depth of Snow on Ground

Data are percentage frequency of occurrence for categories as shown.

Figure 10

Surface Winds

Inadequate amounts of wind data along the proposed gas pipeline make it difficult to accurately depict the variety of wind conditions that exists. This is particularly true from the Brooks Range northward. For this reason conditions at Barrow, Barter Island, and Umiat are described, with applicability 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 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. Applying this knowledge to the pipeline route, the northern terminus will experience near continuous wind with relatively strong speeds. With distance from the coast wind speeds will be lighter with greater periods of calm. Direction is predominatly easterly at Barrow; Barter Island varies seasonally, is easterly in summer, and divided between east and west in winter; Umiat is easterly in summer and westerly in winter. Along the pipeline the coastal portion will be similar to Barter Island, 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, whichever is toward 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.

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 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 channeling determining 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. Only for two out of the twelve months do both locations share the same 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, 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 proposed gas pipeline route map for climate. The representativeness 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, some with 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 mean sea level (MSL) with the base at ground level (a lower MSL value). A good percent of the time, particularly in winter, the higher elevation portions of the route will have warmer air temperatures than those portions at low 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, a period of strong warming occurs over most of the state about mid-winter every year. This mid-winter warming often raises sub-zero temperatures to 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 effect on outdoor operations is much greater. ECT statistics for six locations along the proposed gas pipeline are shown in Figure 11. 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 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, and that Gulkana should be similar to Northway. Therefore the Gulkana data are offered as a substitute for Northway also in Figure 11.

Annual Equivalent Chill Temperature

Barter Island

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	0.63
50	0.11	0.17
55	-0.01	0.02

Mean -10.92
Std. 33.472
Min. -106.6
Max. 56.0

Barter Island

Umiat

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.

Figure 11

Annual Equivalent Chill Temperature

Wiseman

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

Livengood

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

Figure 11 continued

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

Figure 11 continued

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

Figure 11 continued

February is the coldest month for the portion of the route northward from the Brooks Range, and January is the coldest 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. Aviation weather can be a limiting factor. Using the statistics for percent frequency of occurrence of ceilings and visibilities (Figure 12), an estimate of the useable time for an airfield can be determined. For comparison purposes the occurrence of 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 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 in winter than in summer. In summer, the Arctic Ocean loses much of the ice close to the shore allowing the development of low stratus clouds and therefore poorer flying weather. The occurrence of fog is also greatest in summer. Inland from the coast, to elevations of approximately 1,000 feet, Umiat is very 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 Figure 13. 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

Umiat

Ceiling (in feet)	≥3	≥1½	≥1	≥¾	≥½	≥¼	≥0
≥1,800	74	76	76	76	76	76	76
≥1,500	77	79	79	80	80	80	80
≥1,200	81	83	84	84	84	84	84
≥1,000	85	87	88	88	89	89	89
≥900	86	88	90	90	90	90	90
≥800	87	90	91	91	91	92	92
≥700	88	91	93	93	93	94	94
≥600	89	93	94	94	95	95	95
≥500	90	93	95	95	96	96	97
≥400	90	94	96	96	97	97	98
≥300	91	94	96	97	98	98	98
≥200	91	94	97	97	98	99	99
≥100	91	95	97	97	98	99	100
≥0	91	95	97	97	98	99	100

Barter Island

Ceiling (in feet)	≥3	≥1½	≥1	≥¾	≥½	≥¼	≥0
≥1,800	61	63	64	65	66	68	68
≥1,500	64	66	68	68	70	71	72
≥1,200	67	69	71	72	73	74	75
≥1,000	70	73	75	76	78	79	80
≥900	71	74	76	77	79	80	81
≥800	73	76	79	80	81	83	84
≥700	74	78	80	82	83	85	86
≥600	76	80	82	84	85	87	88
≥500	77	81	84	86	88	89	91
≥400	78	82	86	87	89	91	92
≥300	78	83	87	88	91	93	95
≥200	78	83	87	89	92	95	97
≥100	78	83	87	89	92	96	98
≥0	78	83	87	89	92	96	103

Fairbanks Airport

Ceiling (in feet)	≥3	≥1½	≥1	≥¾	≥½	≥¼	≥0
≥1,800	90	91	92	92	92	93	93
≥1,500	91	93	93	94	94	95	95
≥1,200	93	94	95	95	96	96	97
≥1,000	93	95	96	96	97	97	98
≥900	94	95	96	96	97	98	98
≥800	94	96	96	97	97	98	98
≥700	94	96	97	97	98	98	99
≥600	94	96	97	98	98	99	99
≥500	94	96	97	98	99	99	99
≥400	95	97	97	98	99	99	100
≥300	95	97	98	98	99	99	100
≥200	95	97	98	98	99	99	100
≥100	95	97	98	98	99	100	100
≥0	95	97	98	98	99	100	100

Eielson AFB

Ceiling (in feet)	≥3	≥1½	≥1	≥¾	≥½	≥¼	≥0
≥1,800	88	89	90	91	91	92	92
≥1,500	89	91	92	92	93	94	94
≥1,200	90	92	93	93	94	95	95
≥1,000	91	93	94	95	95	96	97
≥900	91	93	94	95	96	97	97
≥800	91	94	95	96	96	97	98
≥700	92	94	95	96	97	98	98
≥600	92	95	96	96	97	98	98
≥500	92	95	96	97	98	99	99
≥400	93	95	97	97	98	99	99
≥300	93	96	97	98	99	99	100
≥200	93	96	97	98	99	99	100
≥100	93	96	97	98	99	100	100
≥0	93	96	97	98	99	100	100

Northway

Ceiling (in feet)	≥3	≥1½	≥1	≥¾	≥½	≥¼	≥0
≥1,800	90	90	91	91	91	91	91
≥1,500	91	92	92	92	93	93	93
≥1,200	92	93	93	94	94	94	94
≥1,000	93	94	95	95	96	96	96
≥900	93	94	95	96	96	96	96
≥800	94	95	96	96	97	97	97
≥700	94	95	96	97	97	97	97
≥600	94	96	97	97	98	98	98
≥500	94	96	97	98	98	98	98
≥400	94	96	98	98	99	99	99
≥300	95	96	98	98	99	100	99
≥200	95	96	98	98	99	100	99
≥100	95	96	98	99	99	100	100
≥0	95	96	98	99	99	100	100

Big Delta

Ceiling (in feet)	≥3	≥1½	≥1	≥¾	≥½	≥¼	≥0
≥1,800	90	91	91	91	91	92	92
≥1,500	92	93	93	93	93	94	94
≥1,200	93	94	95	95	95	96	96
≥1,000	94	96	97	97	97	97	97
≥900	94	96	97	97	97	98	98
≥800	95	97	98	98	98	98	99
≥700	95	97	98	98	99	99	99
≥600	95	97	98	99	99	99	99
≥500	95	97	98	99	99	100	100
≥400	95	97	99	99	99	100	100
≥300	95	97	99	99	99	100	100
≥200	95	97	99	99	99	100	100
≥100	95	97	99	99	99	100	100
≥0	95	97	99	99	99	100	100

Visibility (in miles)

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.

Figure 12

Month	Fog	Smoke or Haze	Blowing Snow	Observations with Obstructions to Vision	0-3	4-5	6-7	8-9	10	Days with Heavy Fog
	Obstructions to Vision				Sky Cover Data: Tenths of Sky Cover					Fog Data
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

Barter Island

Month	Fog	Smoke or Haze	Blowing Snow	Observations with Obstructions to Vision	0-3	4-5	6-7	8-9	10	Days with Heavy Fog
	Obstructions to Vision				Sky Cover Data: Tenths of Sky Cover					Fog Data
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

Umiat

* 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.

Month	Fog	Smoke or Haze	Blowing Snow	% Observations with Obstruction to Vision	0-3	4-5	6-7	8-9	10	Days with Heavy Fog
	Obstructions to Vision				Sky Cover Data: Tenths of Sky Cover					Fog Data
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

Fairbanks International Airport

Figure 13

Month	Obstructions to Vision				Sky Cover Data: Tenths of Sky Cover					Fog Data
	Fog	Smoke or Haze	Blowing Snow	% Observations with Obstruction to Vision	0-3	4-5	6-7	8-9	10	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	"

Eielson AFB

Month	Obstructions to Vision				Sky Cover Data: Tenths of Sky Cover					Fog Data
	Fog	Smoke or Haze	Blowing Snow	% Observations with Obstruction to Vision	0-3	4-5	6-7	8-9	10	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

Big Delta

Month	Obstructions to Vision				Sky Cover Data: Tenths of Sky Cover					Fog Data
	Fog	Smoke or Haze	Blowing Snow	% Observations with Obstruction to Vision	0-3	4-5	6-7	8-9	10	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
Mey	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

Northway

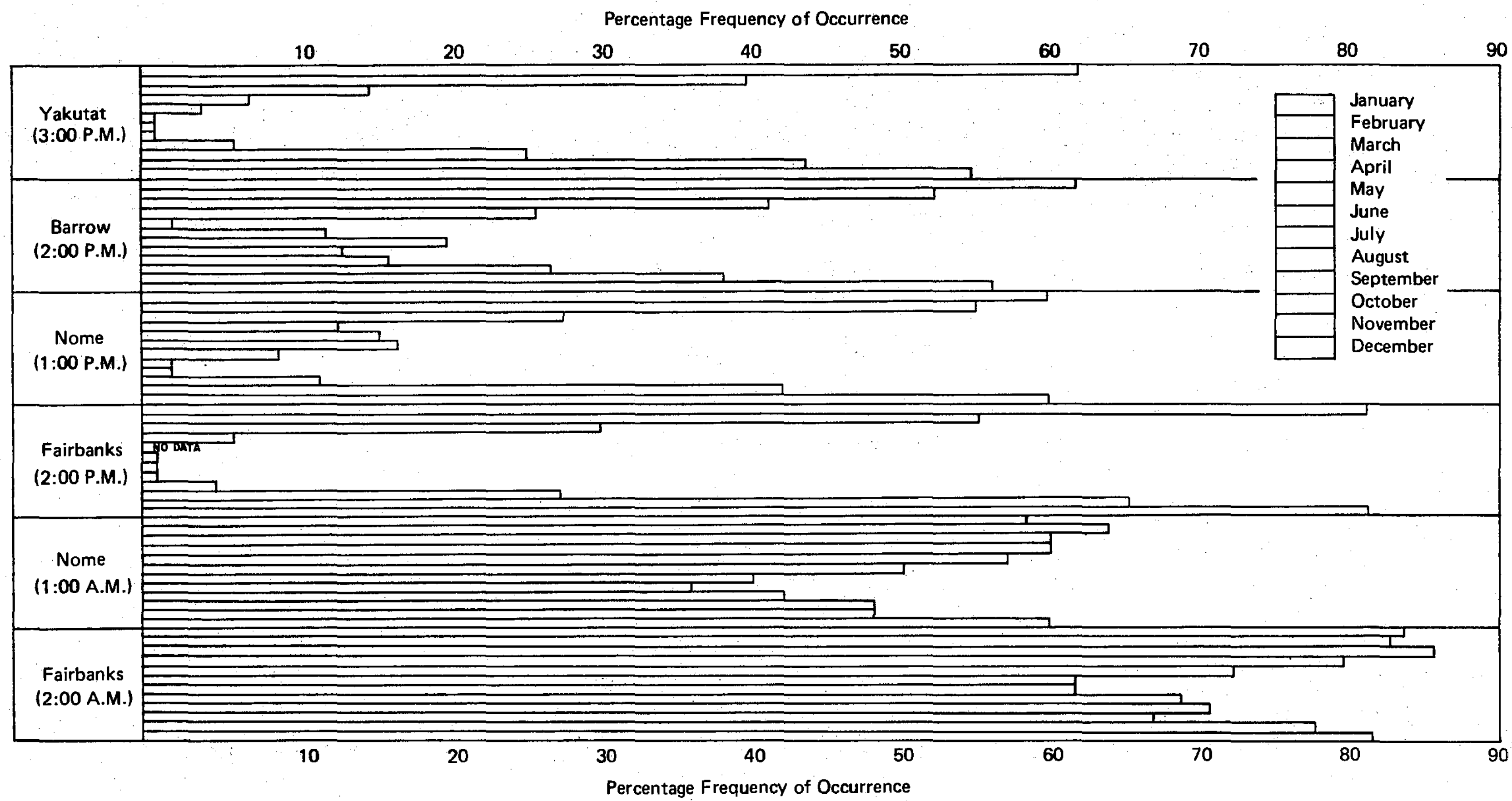
Figure 13 continued

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 1,000 feet, Fairbanks ceiling and visibility data are representative. Conditions of a 1,000-foot ceiling and visibility of three miles or better occur 93 percent of the time at Fairbanks. The poorest flying weather occurs in the late summer and fall from clouds and precipitation and during the winter due to fog and ice fog. Along the gas pipeline route to the south and west of Fairbanks, favorable flying conditions occur over 93 percent of the time. Wintertime fog is considerably less at the higher elevations at 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.

Air Pollution

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 14. Observational time of these comparative figures is 0000 Greenwich Meridian time or 2 P.M.



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.

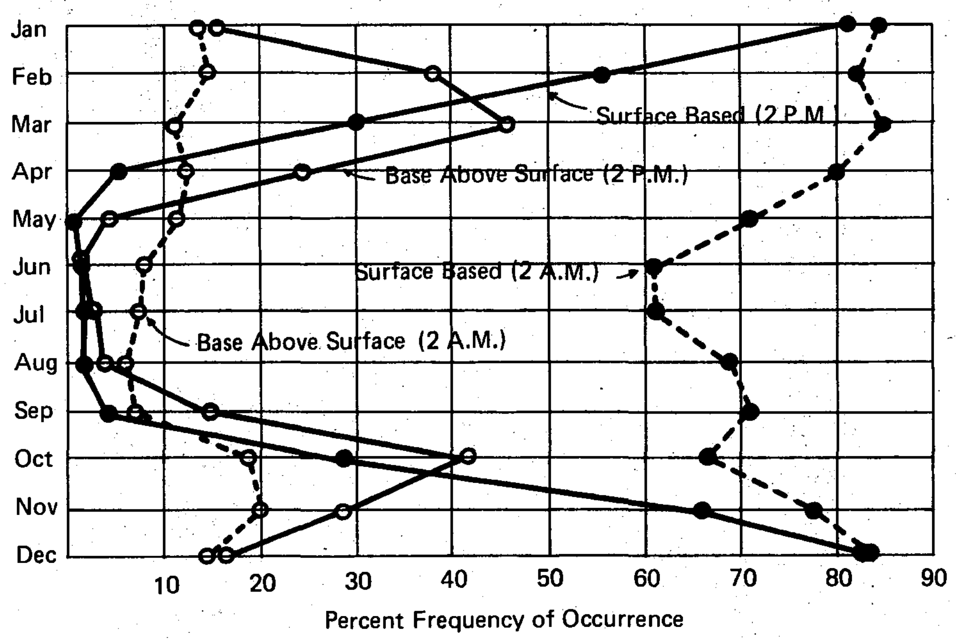
Figure 14

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 15. 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 in relatively short distances. Eielson, less than 40 miles from Fairbanks, has an annual percent calm of 41, and 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 occasion, 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



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

Figure 15

unlikely. All that is left is to change the way of life of the community. To lower the pollutant concentration level, sources are going to have to be modified or eliminated, at least during critical high concentration periods.

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. 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 pollutants produced by combustion is 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 combustions, which provides 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. Where the combustion by-products can adversely affect the human body. Ice fog reduces visibility which is a hazard to transportation.

Contents

2.4.2 Hydrology

Surface Water

The proposed gas line 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 Figure 1. Detailed lists of streams crossed by the existing trans-Alaska oil pipeline are available (U.S. Bureau of Land Management 1973).

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 6 to 8 feet deep, and most freeze to the bottom in winter. Larger, glacier-formed lakes in the Yukon region are listed in Figure 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 runoff. The snow course stations listed in Figure 3 include index snow stations on selected glaciers operated by U.S. Geological Survey. While the proposed line does not lie near the terminus 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

Figure 1

Principal Streams Crossed by Proposed Route

Sagavanirktok River

Oksrukuyik River ~~Toolik River~~

Kuparuk River

Atigun River

Dietrich River

Bettles River

Middle Fork Koyukuk River

South Fork Koyukuk River

Jim River

Prospect Creek

Bonanza Creek

Fish Creek

Kanuti River

West Fork Dall River

Ray River Tributary

Yukon River

Hess Creek

Tolovana River

Tatalina River

Washington Creek

Chatanika River

Goldstream Creek

Chena River

Salcha River

Shaw Creek

Tanana River

Gerstle River

Johnson River

Robertson River

Tok River

Tanana River

Desper Creek

Scottie Creek

Figure 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

Figure 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	46Q02AP	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

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
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

Course Name	Course No.*	Elev.	Latitude Degrees	Latitude Minutes	Longitude Degrees	Longitude Minutes	Yrs. of Record
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 stadia 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.

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, and permafrost. These extremes are averaged 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/sq mi and increases somewhat in the foothills and mountains to the south to 2 cfs/sq mi. Drainage from the Colville River accounts for almost half the runoff from the region each year. Mean annual peak runoff of 50 cfs/sq mi in the mountains and 25 cfs/sq mi in the lowlands occurs from late May to early July during and after breakup. Freezeup and breakup dates are shown in Figure 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/sq mi in the Upper Yukon subregion lowlands and ranges from 1 cfs/sq mi in the Tanana subregion lowland to 4 cfs/sq mi in the Alaska Range.

Figure 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 7-18	April 2-17
	Nabesna River	November 2-18	April 7-20
RAMPART	Yukon River	November 10-15	May 10-15

Annual runoff varies from year to year--annual runoff from the Chena River at Fairbanks was 0.36 cfs/sq mi in 1958 and 1.32 cfs/sq mi in 1962. Mean annual peak runoff ranges from about 10 cfs/sq mi in the lowlands to 50 cfs/sq mi 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 spring following the winter streamflow recession. Mean annual low monthly runoff ranges from between 0 and 0.1 cfs/sq mi in the Upper Yukon and Koyukuk subregions and from 0.2 cfs/sq mi in the Tanana subregion lowlands to 0.3 cfs/sq mi 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 shown on the map and detailed in Figure 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 determination of benthic biology. In addition, continuous records of water temperature and stream biota are obtained by thermographs and by artificial substrates. U.S. Environmental Protection Agency has also conducted bacteriological and other studies through their Arctic Environmental Research Laboratory in Fairbanks.

As shown by the pie diagrams on the map, 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

Figure 5

Streamflow Stations and Water Quality Observation Sites

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°16'09"	148°37'11"	176	H	D	2		2	2	1	2,S
5	Sagavanirktok R near Sagwon	[illegible]°05'20"	148°[illegible]'10"	2,[illegible]	P	D	2	1	2	2		2,S
6	Lupine River	[illegible]'16"	148°46'10"	325						1		
7	Happy Valley C at Happy Valley Camp	[illegible]	148°51'00"	20						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 record	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

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							

Map number	Station number	Station name	Location		Data available								Remarks
					Chemical		Temperature 4/		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							

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	
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 I							
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	

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

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	
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°33'05"	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

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	
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 Wisemen	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							

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.

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°C (Celsius) to 3°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 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. As shown on the map, 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 subregion 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 (Figure 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

Figure 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. Mi.
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.

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. 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 inundate 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 construction.

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 Figure 7. Flood surveys are

Figure 7

Maximum Known 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 Fivers	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

Station no.	Stream	Location: Latitude	Location: Longitude	Drainage area (sq mi)	Period of record (years/dates)	Maximum known flood: Date	Maximum known flood: Gage height (ft)	Maximum known flood: Discharge (cfs)	Maximum known flood: 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
[illegible]	Washington C nr Fox	65°09'03"	147°51'22"	44.7	10(1963-72)	Aug. 12, 1967	18.29	[illegible]	[illegible]
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.

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 suddenly 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 regimen. 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. These 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 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, 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 10 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 10 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°C to 2°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 $0^{o}C$ to $4^{o}C$, and from springs, from $2^{o}C$ to $65^{o}C$.

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 meteorologic 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 proproposed 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 Figure 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 Figure 9.

Figure 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)
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)

Community	Water Supply	Wastewater Treatment	Power Source
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 generators (three 250 kw)
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 generators (three 250 kw; one 300 kw)
Chandalar	Well pumped to 40,000 gal. storage tank; filtration, chlorination; distribution system	Extended aeration activated sludge treatment plant and FCMR	Diesel generators (three 250 kw)
Dietrich	Well pumped to 80,000 gal. storage tank; filtration, chlorination; distribution system	Physical/chemical treatment plant and FCMR	Diesel generators (one 335 kw; four 300 kw; two 250 kw; two 90 kw; six 50 kw)

Community	Water Supply	Wastewater Treatment	Power Source
Coldfoot	Well pumped to 80,000 gal. storage tank; filtration, chlorination; distribution system	Physical/chemical treatment plant and FCMR	Diesel generators (three 300 kw; one 250 kw; one 200 kw; two 90 kw)
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 90 kw)
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		
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)

Community	Water Supply	Wastewater Treatment	Power Source
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 generator power plant
Pump Station 8	Well pumped to 30,000 gal. storage tank; filtration, chlorination; distribution system	Physical/chemical treatment plant 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 treatment plants and FCMR	Diesel generators (five 500 kw)
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	Privies, 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)

Figure 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)	Nenana 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.

Contents

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. Units are micrograms per cubic meter.

Pollutant	Primary	Secondary
Particulate Matter		
Annual geometric matter	75 ug/m^3	60 ug/m^3
Maximum 24 hour concentration*	260 ug/m^3	150 ug/m^3
Sulfur Oxides		
Annual arithmetic mean	80 ug/m^3 (0.03 ppm)	
Maximum 24 hour concentration*	365 ug/m^3 (0.14 ppm)	
Maximum 3 hour concentration*		1300 ug/m^3 (0.5 ppm)
Carbon Monoxide		
Maximum 8 hour concentration	10,000 ~~10~~ ug/m^3 (9 ppm)	
Maximum 1 hour concentration*	40,000 ~~40~~ ug/m^3 (35 ppm)	same as primary
Photochemical Oxidants		
Maximum 1 hour concentration*	160 ug/m^3 (0.08)	same as primary

Hydrocarbons

Maximum 3 hour (6-9 am) concentration*	160 ug/m^3 (0.24 ppm)	same as primary

Nitrogen Oxides

Annual arithmetic mean	100 ug/m^3 (0105 ppm)	same as primary

*Not to be exceeded more than once per year.

No air quality data are yet available for the generally uninhabited parts of Alaska that would be crossed by the proposed gas pipeline. 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 ug/m^3	260 ug/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

1972*	13 ug/m^3	0	0
1973	55 ug/m^3	5	1
1974	33 ug/m^3	2	0

*Data not for entire year.

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, an 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

Contents

2.5 Unique Features

2.5.1 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 1890s 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-1960s 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.

2.5.2 Archaeology

Cultural resources along the proposed pipeline route are categorized by an "H" for historic sites or an "A" for prehistoric archaeological sites on the exhibit maps. The numbers after each letter refer to the Alaska Division of Parks, Heritage Resource Inventory Survey designation. Archaeological and historic sites which qualify for or are presently on the National Register of historic places are outlined for special attention. An inventory of cultural sites is cataloged by the Division of Parks on U.S. Geological Survey quadrangle maps, 1:250,000 scale, and the numbers repeat with each succeeding map.

Cultural resources along the existing TransAlaska pipeline have been surveyed extensively by the University of Alaska. The final report for this contract, covering Prudhoe Bay to Valdez, is to be published by mid-summer, 1976, by Dr. John P. Cook, University of Alaska, Fairbanks, Institute of Arctic Biology.

The vicinity of George and Healy Lakes, southeast of Delta Junction, is highly significant archaeologically. However, there is sparsity of information for the proposed pipeline route south of Delta Junction. This gap should be reduced by the end of the summer, as the State of Alaska, Division of Parks, is conducting an archaeological survey from Delta Junction to Tok during June-July, 1976. The area from Tok to the Canadian Border is not well known archaeologically.

The following list refers to the cultural resources enumerated on the U.S. Geological Survey quadrangle maps, and contains a brief description of the sites.

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).
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	Significant site containing material 8-12,000 years B.P., of Arctic Small Tool character. 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.

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.P.

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).

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.

2.5.3 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 exhibit map.