ALCAN PIPELINE PROJECT

SUPPLEMENTARY DATA

[redacted]

SUBMITTAL OF

ALCAN PIPELINE COMPANY
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BEFORE THE
UNITED STATES OF AMERICA
FEDERAL POWER COMMISSION

PROPOSAL FOR AN
ALASKA NATURAL GAS TRANSPORTATION SYSTEM

March 22, 1977

ALCAN PIPELINE COMPANY

SUPPLEMENTARY DATA

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ALCAN PIPELINE COMPANY

REPORT ON PROPOSED COMPRESSOR STATION LOCATIONS IN ALASKA

March 1977

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SECTION 1

SUMMARY DESCRIPTION OF THE ALCAN PROJECT 48" ALTERNATIVE PIPELINE SYSTEM

General

The alternative proposal provides a 48-inch high-pressure pipeline through Alaska and Canada to a point of bifurcation near James River, Alberta where gas destined for mid-west and eastern markets would be transported through a new high-pressure 42-inch pipeline to Monchy, Saskatchewan for delivery to Northern Border Pipeline Company ("Northern Border"). Gas destined for western markets would be transported from James River, Alberta through a new high-pressure 36-inch pipeline for delivery at Kingsgate, British Columbia to Pacific Gas Transmission Company ("PGT"). While in transit to the U.S. border, the Alaska gas would be kept separate and not commingled with any Canadian gas.

Service is expected to commence October 1, 1981, with an average day volume of 1600 MMCFD being received at Prudhoe Bay. After fifteen months of operation, this volume will increase on January 1, 1983 to 2400 MMCFD, average day receipt. Delivery split of the gas at James River will be 29% west to Kingsgate and 71% east to Monchy. Delivery pressure into the Pacific Gas Transmission system at Kingsgate will be 845 psig. At Monchy, delivery pressure to the proposed Northern Border system will be 1440 psig.

Location of the Route

The route of the proposed 48-inch alternative system in Alaska will be identical to that of the proposed 42-inch system as previously filed with the Federal Power Commission ("FPC") and the National Energy Board. The route originates at Prudhoe Bay on the Arctic Ocean and generally follows the existing Alyeska Pipeline corridor to Fairbanks and Delta Junction (about 539 miles), then veers eastward for about 192 miles following the Alaska Highway and the Haines products pipeline right-of-way to the U.S./Canadian border.

In the Yukon, the pipeline follows the Alaska Highway corridor to the B.C./Yukon border near Watson Lake.

The pipeline first deviates from the route of the 42-inch system in British Columbia at approximately mile post 1420 where it swings southeast in a direct line towards Gold Creek Junction on the AGTL system. It crosses the existing Westcoast system south of Fort Nelson and the Alberta/British Columbia border near Boundary Lake.

From Boundary Lake, the pipeline continues in a southeasterly direction to Gold Creek Junction, then follows the existing Alberta Gas Trunk Line Limited ("AGTL") right-of-way to a bifurcation point at James River. From this point, two smaller diameter legs follow existing AGTL rights-of-way; a 36-inch line south to Coleman on the Alberta/B.C. border, and a 42-inch line east to Empress on the Alberta/Saskatchewan border.

In British Columbia, the 36-inch western delivery leg follows the existing Alberta Natural Gas Company Ltd. right-of-way from Coleman to Kingsgate. At Kingsgate, the pipeline interconnects with proposed expanded PGT facilities for transmission to western markets. In Saskatchewan, the 42-inch eastern leg continues from Empress to the delivery point near Monchy where the system interconnects with Northern Border.

Pipeline Facilities

Pipeline facilities to the U.S./Canadian border consist of a total of 2753.7 miles of pipe. The main trunk from Prudhoe Bay to the bifurcation point at James River consists of 2077.6 miles of 48-inch O.D. (outside diameter), and the two delivery legs to Monchy and Kingsgate consists of 394.5 miles of 42-inch O.D. and 281.6 miles of 36-inch O.D., respectively. The total distance from Prudhoe Bay to Kingsgate is 2360 miles. From Prudhoe Bay to Monchy the distance is 2472 miles.

Compressor Stations

The overall pipeline system requires thirty (30) compressor stations in the final build-up year. Twenty-five (25) are located along the 48-inch main trunk line, and five (5) are located on the two delivery legs. A total of 975,000 HP (ISO) of mainline gas compression and 85,000 HP (ISO) of propane chilling compression are to be installed. Of the thirty stations, eight are to be located in Alaska, seven in the Yukon, five in British Columbia, eight in Alberta, and two in Saskatchewan.

All compressor stations in Alaska are single unit 26,500 HP (ISO) stations, each equipped with propane chilling facilities.

Meter Stations

Metering facilities for the measurement of flow and gas quality are required at the Prudhoe Bay receipt point, at the Fairbanks, Monchy, and Kingsgate delivery points, and at all interconnecting system transfer points. Thus, a total of nine (9) metering stations will be installed on the overall system.

SECTION 2

DESCRIPTION OF PROPOSED COMPRESSOR STATION SITES

General

Alcan's proposal for the 48" alternative system prepared and filed with the FPC in March, 1977, included a summary environmental assessment. As such, descriptions of the existing environment at the proposed compressor station locations along the pipeline alignment were included

The preliminary location of each site identified in the submittal was selected on the basis on engineering gas flow studies to optimize the efficiency of the overall system. These locations were included in the engineering sections of the 48-inch alternative proposal. Environmental and geotechnical data relating to each site was subsequently assembled and the locations subjected to detailed re-examination on the basis of environmental compatibility. Environmentally "preferred" locations were thus identified.

The "preferred" locations were inspected during a field reconnassance visit by helicopter and, in most cases, on the ground where ground or weather conditions did not preclude landing. Minor relocations of less than one mile resulted and additional flow studies were conducted which confirmed the feasibility of these locations. The team visiting the sites consisted of an environmental scientist, a hydrologic engineer, and a professional engineer. The descriptions of each site developed in the following subsections reflect available information concerning each site as supplemented by the observations of the reconnaissance team recorded during the field visit.

The sites are designated as AL-1 through AL-8 in consecutive order of occurrence by milepost from Prudhoe Bay to the Alaska/Yukon border. Proposed station locations are indicated on Figure 1. Milepost designations and elevations are listed in Table 1.

TABLE 1

PROPOSED COMPRESSOR STATION LOCATIONS[1/]

Station Number	Milepost	Elevation[2/]
AL-1	75.0	850
AL-2	133.0	2975
AL-3	242.3	1275
AL-4	331.8	700
AL-5	418.8	1650
AL-6	504.7	1275
AL-7	589.9	1425
AL-8	673.4	1900

1/ As determined on the basis of gas flow studies and field reconnaissance.

2/ Based on U.S. Geological Survey quadrangle maps, in feet above mean sea level.

Compressor Station AL-1, Milepost 75.0

Terrain in the vicinity of the proposed site of Compressor Station AL-1 is typical of the Arctic coastal plain and consists generally of flat-topped alluvial terraces separated by small scarps. The proposed station would be located on such a terrace (Figure 2) at a generally level site on the west side on the Alyeska haul road. The site is approximately 2000 feet west of the floodplain of the Sagavanirktok ("Sag") River. River training devices are currently under construction by Alyeska on the western edge of the Sag River floodplain in this area to protect the buried oil pipeline which is located within the river floodplain.

The flat to gently rolling topography in the area is unlikely to hamper dispersion of station emissions. The location is within 10 miles of Alyeska Pump Station No. 3 which will also contribute emissions. However, the proposed compressor station site avoids the lowest elevations in the area and thereby minimizes the possibility of channeling emissions such that the emissions from the two sources are additive.

A short access road of less than 1000 feet will be required to connect the proposed site to the haul road.

Surficial soils are thought to consist of poorly stratified, coarse, sandy gravels and sands of alluvial origin with minor amounts of silt; gravel clasts are usually sub-rounded to rounded and local beds and lenses of sand commonly occur. Except in close proximity to the main channel of the Sag River, permafrost will likely be encountered in the area within two feet of the surface. Ice wedges and ice masses may also be present in the on-site soils.

Bedrock outcrops consisting primarily of cretaceous sediments occur locally and may be found on-site close to the surface. Such outcrops, however, were not noted to protrude through the snow cover present at the time of the field reconnaissance.

Lacking bedrock, fill may be required to assure a stable foundation for the station. Sufficient material may be available in existing Alyeska material sites located within five miles of the proposed location.

The maximum probable earthquake for the site vicinity is one of magnitude 6.0 on the Richter scale. Faults were not apparent on or near the site, nor has fault movement occurred in the area during Holocene time.

The site is on Federally owned land which now supports Arctic tundra vegetation. The site may serve as year-around moose habitat of limited utilization. However, the only known moose wintering areas occur in the area at a distance of about 2-3 miles to the south along the Sag River floodplain. Caribou migrate past the site. They are present in greatest numbers while moving to calving habitat further northward from mid-April to early June. The site is not within the historical calving area of the species, nor is the vegetation sufficient to support over-wintering populations. Similarly, the site is not known to be used by other sensitive taxa. For example, raptors are thought to nest at Sagwon Bluffs, located approximately 2-3 miles south of the proposed site. Construction and operation of the station should not interfere with this activity. Grizzly bears, in addition, may occur in the area during the spring, summer, and fall seasons; but the site does not constitute critical habitat for the species.

Compressor Station Al-2, Milepost 133.0

The proposed site of Compressor Station AL-2 (Figure 3) occurs on a west-facing, gently sloping bench approximately one-half mile wide. The site is immediately adjacent to and on the west side of the Alyeska haul road, downslope of the Alyeska workpad. Terrain in the vicinity of the site consists of rolling to steeply sloping hills which rise to moderate to steep mountains to the west and south. This terrain is characteristic of foothill areas north of the Brooks Range. No major waterways are in close proximity to the site.

The topography of the area in combination with the presence of Alyeska Pump Station No. 4, which is located approximately 12 miles from the proposed site, presents a potential for channeling of the additive emissions of the two facilities. Emission trapping and impingement under inversion conditions may also occur. Additional site-specific study in combination with detailed dispersion modelling will be conducted to assess the probability of such occurrences.

Surficial soils consist of colluvium (a heterogeneous mixture of silt, sand, and rock fragments) and fine alluvial deposits. The colluvium is poorly sorted, gravelly, sandy silt. Sandy gravel with some silt, interbedded with gravel, sand, cobbles, and boulders of glacial origin may also be present. The alluvial deposits are generally silty sand with organics. Bedrock is known to occur throughout the area at variable depth.

Bedrock outcrops consist of Paleozoic sediments and metasediments. Outcrops were observed on-site and probably consist of cretaceous and jurassic sandstones, shales, or conglomerates. These on-site features likely result from the surface expression of a prominent north-south trending ridge which has been mined for aggregate by Alyeska at a location approximately five miles south of the proposed site.

Bedrock in the area is known to be faulted and folded along structural trends which are generally aligned in an east to west orientation. The maximum probable earthquake in the vicinity of the site, however, is one of Richter magnitude 6.0. Additionally, no fault movement during Holocene time has been noted.

Permafrost probably underlies the site and is likely to be ice-rich; the active layer in the area seldom exceeds two feet. Ice wedges and ice lenses are also common in these soils. As a result, the Alyeska system has been constructed in aboveground mode in the vicinity of the site. Suitable fill may be available from one or more of the seven material sites established by Alyeska which are located within five miles of the proposed location.

Lands in the vicinity of the site are Federally owned.

Generally sparse tundra vegetation is found on-site. Although located within the southern limits of the wintering area of the Central Arctic Caribou Herd and within the southern limit of the range of North Slope moose populations, the site does not constitute critical habitat for either of these species. No significant bird habitat exists in the vicinity. As noted earlier, the area is distant from all major waterways and thereby avoids encroaching on sensitive fishery habitats.

<u>Compressor Station AL-3, Milepost 242.3</u>

The proposed site for Compressor Station AL-3 is on Federally owned land within the broad valley of the Middle Fork of the Koyukuk River; the Koyukuk River floodplain occurs approximately 0.3 miles west of the site. The Alyeska pipeline has been constructed in the above-ground mode within the historic floodplain to the north of the proposed compressor station location and below-ground within the active floodplain to the south of the site.

As in the case of the proposed site for Station AL-1 described above, Alyeska has constructed river training structures along the edge of and within the active floodplain in order to protect the oil pipeline located there.

Insufficient space exists either between the Alyeska workpad and the river or between the workpad and the haul road in which to construct the proposed compressor station. Therefore, a south-facing slope shown in Figure 4 to the east of the haul road has been selected for the station site. Access to the site will require constructing a short lateral road.

Within the valley, the topography consists of gently rolling hills. To both the east and west, elevations rise to about 3200 to 3600 feet at Cathedral and Twelvemile Mountains, respectively. Emission trapping within the confines of the valley may, therefore, be possible. However, selection of the proposed site near the crest of a small hill avoids the lowest available elevations where the possibility of emission problems would otherwise be maximized.

Surficial soils consist of modern and older alluvium associated with the Koyukuk River. Silt, sand, and sub-angular to sub-rounded gravel with cobbles also occurs locally. Permafrost is generally found within two feet of the surface except in soils closely associated with the modern channel of the river. The presence of permafrost on-site is likely and is further suggested by the on-site vegetation which consists of scrubby black spruce over a poorly developed shrub layer (Figure 5). Such vegetation is often indicative of a high permafrost table. An Alyeska valve site on the upland in the vicinity of AL-3 has been equipped with thermal piles to preclude subsurface thaw. Fill, therefore, will likely be required to develop the site, but may be available in sufficient quantity from one or more of the seven material sources developed by Alyeska within five miles of the proposed location.

Isolated normal and thrust faults occur in the area and generally trend in an east-west orientation. These faults subject the area to a maximum possible earthquake magnitude of about Richter 5.5 to 7.5.

The site of Station AL-3 was originally located within the floodplain of the Koyukuk at approximately milepost 243.0 on the basis of engineering gas flow studies. Field reconnaissance revealed the high potential for aufeis formation in the bottomlands of Rosie Creek, a tributary of the Middle Fork of the Koyukuk, at the above location. In addition, the site was relocated northward in order to avoid possible infringement on fisheries within the Koyukuk floodplain as well as to minimize the impact on known Dall sheep habitat associated with Cathedral Mountain, 2.5 - 3 miles to the south. The northward relocation also increased the distance between the site and a recognized caribou crossing area in the vicinity of milepost 248. No other sensitive species are known to occur within the area.

Compressor Station AL-4, Milepost 331.8

The terrain in the vicinity of the proposed site consists of rolling hills with gentle slopes. Steep slopes occur in the Fort Hamlin Hills area approximately 4.5 miles southeast of the site. Little potential for problems associated with emission dispersion likely exists at this location.

Compressor Station AL-4 would be located on generally level ground atop a small plateau (Figure 6) east of the Alyeska workpad and haul road, equidistant between two existing Alyeska material sites located about one mile to the north and south. Access is readily available to the site from the haul road. Significant waterbodies or waterways in proximity to the site include the Ray River, about 5-6 miles to the south and four small lakes or ponds which occur within about 2 miles of the site.

Local soils consist primarily of colluvium and wind blown silt (loess). High-level gravel which is clean, well-sorted, and up to two inches in diameter may also be present.

Local bedrock consists of metamorphic and igneous units, which may be faulted locally. No recent movement of these faults has been reported. The probable maximum earthquake is of magnitude 7.5 on the Richter scale. Bedrock outcrops may occur on-site or bedrock may be found at shallow depth.

Permafrost is generally found within two or three feet of the surface in the vicinity of the proposed site. However, the on-site vegetation consisting of a mixture of aspen and spruce with a moderately well developed shrub understory (Figure 7) probably indicates an active layer of greater depth than is likely to be present at some of the other sites visited. In addition, this cover type may also indicate drainage conditions superior to those of soils associated with scrub spruce or muskeg. The necessary fill required to provide an overlay for foundation purposes may be available from eight Alyeska material sites located within five miles of the proposed location.

The site is located on Federally owned land.

A high density black bear area is present some 2-3 miles south and southeast of the site in the bottomlands of the Ray River. In addition, the site would be located near the southern limit of the winter range of the Central Arctic Caribou Herd. Construction and operation of this station would not interfere with the life cycles of either of the above animal species.

Station AL-4 was originally located near milepost 331. The southward relocation was accomplished in order to avoid a south-facing slope where soil conditions were likely to be inferior and to take advantage of the favorable dispersion conditions offered by the hill-top location of the proposed site.

Compressor Station AL-5, Milepost 418.8

The proposed location of Station AL-5 is a site adjacent and on the west side of the Alyeska workpad atop a generally south-facing ridge (Figure 8). Slopes flanking the ridge are moderate to steep and the ridge is typical of the local topography which consists predominantly of gently rolling to steeply sloped hills. Due to its hill-top location, the site probably presents little or no potential for problems associated with atmospheric dispersion of station emissions.

Surficial soils in the area consist mainly of wind-deposited silt (loess) of undifferentiated origin and colluvium. Bedrock may outcrop or occur at shallow depth. Bedrock outcrops in the area typically consist of argillite, slate, limestone, quartzite, and schist. Other local rock types include chert, siltstone, dolomite, graywacke, and conglomerates. Valley deposits are generally of silt and sand from overbank deposition and are generally underlain by stream gravels. The floodplains of several small streams in the area contain placer mine dredge tailings which are largely reworked gravels.

Permafrost may be present at depths of two to four feet in valleys and floodplains. Some ice wedges and masses may also occur locally in these areas. However, permafrost is generally absent or occurs only at substantial depths of six feet or more on hill tops and well-drained south-facing slopes and, therefore, may not occur on site due to its predominantly southern orientation.

Subsurface strata may be faulted locally, including thrust faulting in bedrock units. Faults in the area generally trend southwesterly and may be concealed by overlying sediments of recent origin. The maximum probable earthquake in this area is of Richter 7.5 magnitude.

Access to the Federally owned site is provided via the Elliott Highway, approximately 2 miles to the east.

Station AL-5 has been originally located about 2 miles to the north in the bottomlands of the Globe Creek drainage. Available information, however, indicates that this drainage probably constitutes high density moose winter range and is also heavily utilized by black bear. Golden eagles are thought to nest in the vicinity of Globe Creek near this location. Additionally, the soils of Globe Creek bottomlands present a potential for aufeis formation due to the likely presence of permafrost at shallow depth. The oil pipeline is in buried mode adjacent to the site.

Relocation of the site to its proposed ridgetop location avoids the sensitive wildlife species noted above. The relocation also avoids the engineering costs associated with construction of the station in ice-rich permafrost soils.

Fill, however, will be required. Sufficient quantities may be available in one or more of the four existing Alyeska material source locations within five miles of the proposed site or at other suitable locations within the area.

With the exception of Globe Creek, there are no other waterbodies or waterways of importance in close proximity to the site; nor does the on-site vegetation (a moderately stocked interior forest of spruce, birch, and balsam) constitute sensitive habitat.

Compressor Station AL-6, Milepost 504.7

The proposed site for Station AL-6 is on state-owned land adjacent to an existing Alyeska material site. The site is east of the Alyeska right-of-way on the north-facing slope of a moderately steep hill (Figure 9). Local topography consists predominantly of such hills with more gentle slopes in the silt-covered lowlands.

Bedrock is usually present in the area of AL-6 at higher elevations. The lowland silts are usually frozen perennially. This permafrost is common throughout most of the area at depths of two to four feet, but may be lacking under the beds of the area's larger streams and creeks.

The site was originally located at lower elevation near the bottom of the Gold Run Creek drainage. Soils in the creek bottom probably consist of fine alluvium, and are likely to be ice-rich. Additionally, construction of the Alyeska workpad in the area stripped the organic layer from the creek bottom and resulted in blocking groundwater flow and surface icing adjacent to and over the Alyeska workpad (Figure 10). Similar phenomenon may occur along the lower spruce-covered slopes adjacent to the creek bottom. Relocating the station to the higher elevation shown in Figure 9 should avoid this problem.

Additionally, this location avoids the high density moose over-wintering area associated with bottomland habitat in the area. No other sensitive wildlife species are likely to be dependent on the mixed interior spruce-dominated forest which occurs on-site.

The probable maximum earthquake for this area is Richter magnitude 7.5. No fault activity has been noted. However, the Shaw Creek fault is located approximately 15 miles southeast of the site.

Four existing Alyeska material sites are located within five miles of the proposed site and may provide sufficient fill for construction of the station foundation at this location. Other suitable sites (including the borrow area immediately adjacent to the site) may contain additional material. No material site need be located within 100 yards of the vegetated bank of a stream or lake.

The site location is approximately 9-10 miles north of the Richardson Highway. Hence, access to the site may be gained via the workpad, by upgrading one of the existing low grade jeep trails which currently link the Alyeska workpad to the Richardson Highway, or by new access road construction.

Compressor Station AL-7, Milepost 589.9

The proposed location for Station AL-7 is on state-owned land on the south side of the Haines products pipeline right-of-way at a site approximately 0.1 mile south of the Alaska Highway and about eight miles west of the nearest community, Dot Lake. The highway would be used for access to the site. An old and apparently abandoned road which may be of military origin now connects to the highway both east and west of the site and could be upgraded for use during site construction or operation.

The proposed site is within the Tanana River Valley; the floodplain of the river is located approximately one-half mile north of the site. An extensive area of marshland exists along this floodplain to the east of the site and probably constitutes habitat used by moose for overwintering. The site was originally located further eastward but was relocated to the west in order to avoid infringing on this sensitive habitat or on the movements of moose as they enter and leave the area in spring and fall.

The river valley consists of flat to gently sloping terrain. Moderate to steep slopes are found to both the north and south side of the river valley where elevations reach about 2300 feet. Because of this topography, channeling of station emissions may be possible. However, the broadness of the valley suggests that trapping due to thermal inversions is probably not likely. Additional detailed dispersion studies to be conducted for each site based on site-specific meteorological data will resolve the current uncertainty concerning the importance of this potential.

The proposed site is on a gentle sloping, northeast facing bench about 30 feet above the elevation of the adjacent Haines right-of-way (Figure 11). Bedrock consists of igneous units, probably undifferentiated hornblende-biotite, granodiorite, and biotite quartz monzonite. Surficial soils are mainly clean gravels of glaciofluvial and alluvial fan origin. Surface and subsurface drainage through these soils is generally good. Peat bogs and muskeg may be found in low lying places near the site.

Permafrost is discontinuous throughout the area. Where present, the active layer is usually from eight to ten feet deep and generally supports a moderate to heavy mixed stand of birch, spruce, and balsam poplar. Vegetation on-site consists of a moderately stocked stand of black spruce with a decadent or dead birch component which may indicate a more shallow permafrost table. However, permafrost in this area is generally considered to be thaw-stable. Fill will be required to develop the site and will likely be obtained from new material sites to be located in the area or purchased from state or private sources.

The maximum probable earthquake is one of Richter magnitude 7.5. No recent fault activity has been noted, although a southwest trending fault has been inferred to exist approximately ten miles to the northeast of the proposed site.

The site does not constitute critical habitat for any wildlife species. However, four to five hundred caribou have been noted to range from the Macomb Plateau northward to the Robertson River and occasionally as far north as the Alaska Highway. These animals, however, usually stay at higher elevations in the summer and fall. Calving does not occur in the vicinity of the site. In addition, raptors have been noted to nest along the Tanana River between Johnson Slough and Robertson River. Construction and operation of the station is not anticipated to negatively influence this nesting activity. Additional studies, however, are planned prior to construction to more accurately define the critical areas.

<u>Compressor Station AL-8, Milepost 673.4</u>

The proposed site of Compressor Station AL-8 is located on the north side of the Haines products pipeline right-of-way. Access to the site is via the Alaska Highway, about 0.2 miles south of the Haines right-of-way. The site is located on the northwest facing slope of a gentle hill above a poorly drained muskeg area found between the highway and the Haines right-of-way (Figure 12) and in the bottom of a small drainage west of the site. The location is approximately 3/4 of a mile north of the floodplain of the Tanana River.

Terrain in this area consists of gently sloping to rolling hills within the river valley. Bedrock generally occurs at shallow depth and consists of igneous and metamorphic granodiorite, schist, and quartzite. Overlying the bedrock and forming the gentle hills are stabilized sand dunes consisting of medium to fine grained sands which are usually low in ice content and are thaw-stable. Permafrost is discontinuous throughout the area.

The bedrock is locally faulted. Three parallel southeasterly trending faults are reported for the area north of Midway Lake which is located about five miles northwest of the site immediately adjacent to the highway. Two small faults are roughly parallel to and north of the highway between Bitters Creek and Beaver Creek. Bitters Creek crosses the highway about 2 miles east of the site. No earthquakes of magnitude 6.0 or greater have been reported for this area, although a number of smaller shocks have been noted.

The site is on land selected by the Northway Village natives under provisions of the Alaska Native Claims Settlement Act. It is vegetated primarily by spruce and birch, although muskeg bogs occur in the lowlands, as noted previously. Spruce vegetation was observed to dominate on-site.

Sensitive wildlife species are unlikely to utilize the site as habitat. However, several hundred caribou typically move north and south across the highway in the Midway Lake area in March and November, respectively. The site is located on the eastern edge of this movement zone. In addition, the lowland marshes along the Tanana River floodplain probably provide habitat for waterfowl nesting and molting, which occurs in the area from about March through July.

An inhabited area occurs at Riverside Lodge, approximately 2.5 miles east of the site. However, the station has been located so that a ridge separates it from the above facility. Hence, noise will be attenuated by this topographic feature. Additionally, the compressor station will not be visible from the lodge.

Channeling of emissions is a potential problem associated with any location within the river valley. However, the broadness of the valley at this point in combination with the location of the site near the top of the small hill probably minimize the likelihood of emission concentration. Additional detailed modeling studies will be conducted to further investigate this potential.

Fill will probably be required for site development. However, foundation conditions on the side hill above the muskeg areas appear favorable. Such a location also avoids the potential for surface icing associated with flow disruption in muskeg lowlands illustrated in Figure 13. Aggregate materials for fill will be procured from sites to be located by Alcan along the Alaska Highway or by purchase from private or state sources.

SECTION 3

CONCLUSIONS

Eight preliminary compressor station locations for the Alaska segment of the proposed Alcan Pipeline Project 48-inch alternative were selected on the basis of engineering gas flow studies and subjected to re-examination with respect to their environmental compatability and construction feasibility. This detailed investigation was based on available information and supplemented by field reconnaissance. Several stations were relocated by 0.2 to 0.9 miles in order to minimize their impacts on the environment or to maximize ease of construction and/or operation. Flow studies using the new sites show that no change in installed horsepower is required and that the resulting design is feasible.

As a result, no site directly impacts on a sensitive environmental component. Specifically, sensitive wildlife populations, overwintering habitats, breeding areas, and migration or traditional movement zones have been predominantly avoided. Potential impact on fisheries has been precluded by selecting sites which are neither within floodplains nor immediately adjacent to the bottomlands of smaller drainages. The dispersion potential of station emissions has been enhanced by locating sites near the tops of hills or ridges and avoiding low elevations where drainage or channeling might constitute an air quality problem. Seven of the locations are remote from human habitation. The other is 2-3 miles from the nearest residence. Noise impact at this site, however, will be mitigated by local topography in combination with installation of standard noise attenuation devices.

Finally, construction feasibility has been enhanced by proposing sites which are accessible and which avoid muskeg bogs or other low-lying areas subject to thaw-instability or surface icing associated with physical disruption of groundwater flow. Foundation conditions at all sites appear acceptable, assuming the availability of sufficient aggregate fill.

It is concluded, therefore, that the sites proposed as compressor station locations in Alaska for Alcan's 48-inch alternative system are environmentally as well as technically sound; and that the incorporation of proper mitigating measures during final design will allow them to be constructed and operated in an economic manner and with little or no long-term environmental impact.

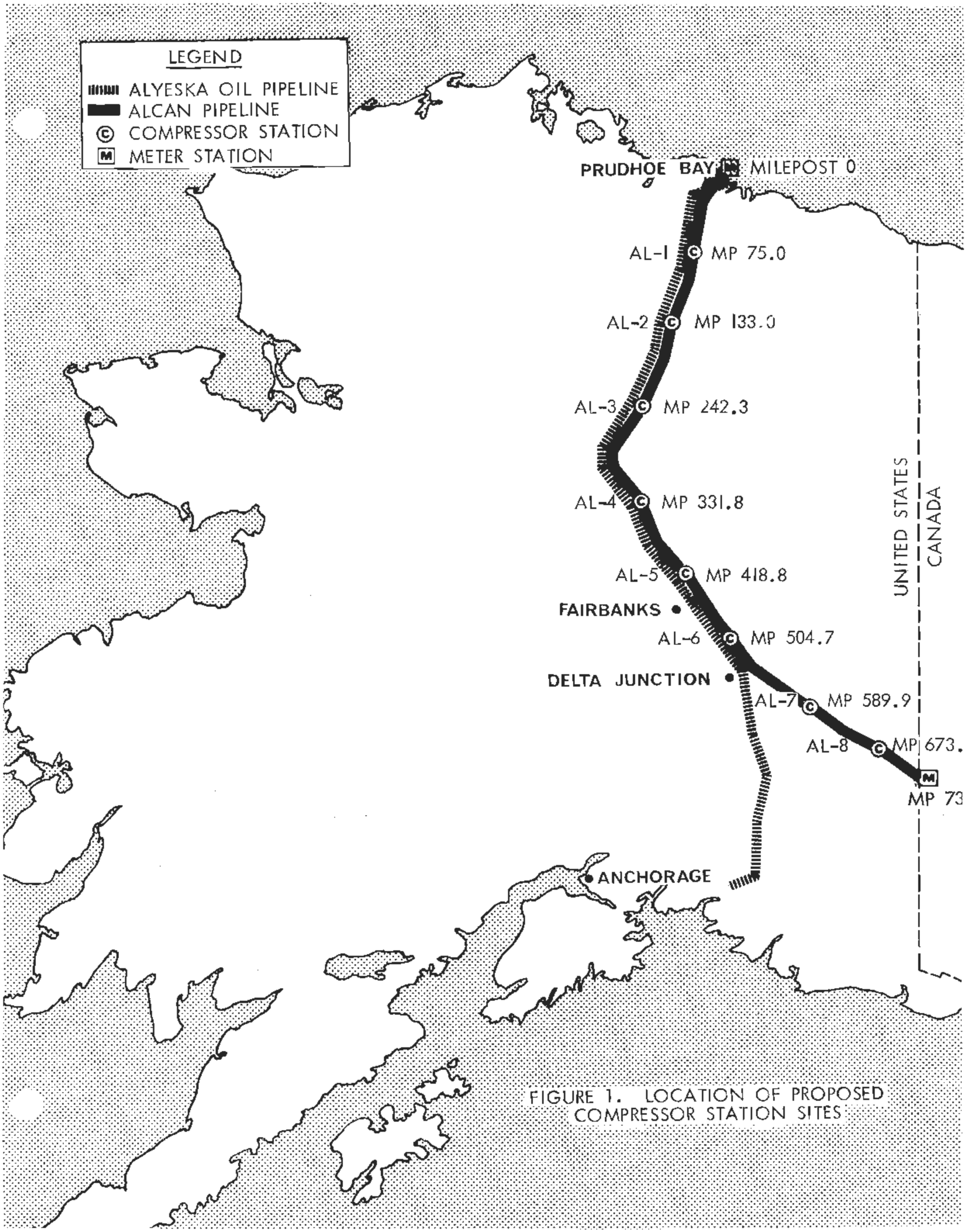

FIGURE 1. LOCATION OF PROPOSED COMPRESSOR STATION SITES

Figure No. 2 PROPOSED SITE OF COMPRESSOR STATION AL-I

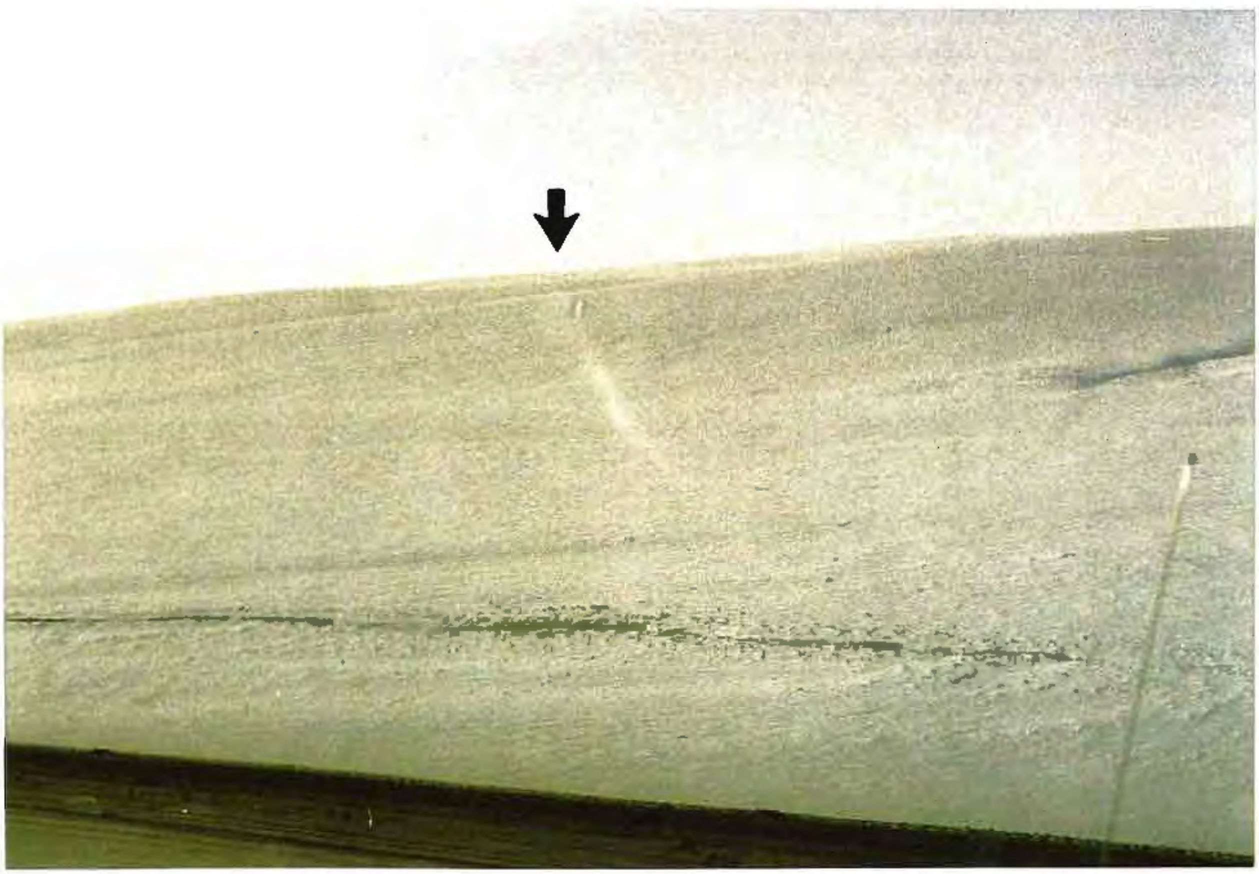

Figure No. 3 PROPOSED SITE OF COMPRESSOR STATION AL-2

Figure No. 4 PROPOSED SITE OF COMPRESSOR STATION AL-3

Figure No. 5 BLACK SPRUCE VEGETATION TYPE

Figure No. 6 PROPOSED SITE OF COMPRESSOR STATION AL-4

Figure No. 7 MIXED ASPEN-SPRUCE VEGETATION TYPE

Figure No. 8 PROPOSED SITE OF COMPRESSOR STATION AL-5

Figure No. 9 PROPOSED SITE OF COMPRESSOR STATION AL-6

Figure No. 6 PROPOSED SITE OF COMPRESSOR STATION AL-4

Figure No. 7 MIXED ASPEN-SPRUCE VEGETATION TYPE

Figure No. 10 AUFEIS ON ALYESKA WORKPAD

Figure No. 11 PROPOSED SITE OF COMPRESSOR STATION AL-7

Figure No. 12 PROPOSED SITE OF COMPRESSOR STATION AL-8

Figure No. 13 FLOODING OVER AUFEIS AT GOLD RUN CREEK

A LIST OF FISH STREAMS CROSSED BY THE PROPOSED ALCAN GAS PIPELINE IN ALASKA, INCLUDING FISH SPECIES PRESENT AND PERIODS OF SENSITIVITY

by

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INTRODUCTION

The following list delineates those streams crossed by the proposed Alcan Gas Pipeline in Alaska. The list is not complete but rather shows our state of the knowledge at this point. The streams along that portion of the route adjacent to the Alyeska line were taken directly from the Joint State/Federal Fish and Wildlife Advisory Team's (JFWAT) "A Partial List of Key Fish and Wildlife Areas Along the TransAlaska Pipeline Route with Critical Areas Identified." Therefore no field work was done for Alcan Pipeline Co. on the streams in Alignment Sheets 1-85. The JFWAT document is continually being updated, therefore additions and subtractions are probable. Streams listed between Delta Junction and the Yukon Border were determined by fishery surveys conducted by BIO/WEST, Inc. for Alcan Pipeline Co. in 1976.

Milepost locations were determined to the nearest tenth of a mile using Alcan Pipeline Co. alingment sheets (First Draft). Along the Alyeska portion of the route, streams from the JFWAT list were located on the maps and milepost locations determined. Several errors in the Alcan alignment sheets created many problems in accuracy. For example, the route in A.S. 24-26 does not follow the oil line as built, but rather an old, abandoned route. Hence streams in this area could not be taken directly from the JFWAT List. Also, Mile Post 470 is shown in both A.S. 74 and 75, almost a mile apart. Therefore milepost locations in many places are probably suspect.

Fish species in streams along the oil line were taken from the JFWAT list or from interviews with JFWAT personnel. A revised JFWAT list will be available shortly and will delineate species more clearly. Fish species along the Alaska Highway portion were determined by fishery surveys conducted by BIO/WEST, Inc. in 1976. Due to the restricted nature of the surveys, all species in many of these streams were not found. Question marks after species abbreviations refer to species reported by others or suspected, but not actually observed.

Critical periods follow those determined by the JFWAT. They generally eclosed migration, spawning and overwintering. Critical periods for streams along the Alyeska portion were taken directly from the JFWAT lists. Those along the Alaska Highway portion were determined from the fish species found during the 1976 survey. Critical periods shown on this list should not be taken as hard and fast rules but reflect the level of knowledge shown in the fish species present. Many of the critical periods were determined from fish presence rather than from actual knowledge of how and when the fish are using the system. More detailed and thorough studies of the streams, and ways fish use them, may alter these periods considerably.

Therefore this report should be considered as listing those streams where fish passage is required of any drainage structure, the species of fish present in those streams and critical periods during which instream construction should be limited, realizing that changes to this list will be made as more knowledge becomes available.

Key to Abbreviations of Fish Species used in Fish Stream Catalog

AB - Alaska Blackfish

AC - Arctic Char

AL - Arctic Lamprey

BB - Burbot

BL - Brook Lamprey

BW - Broad Whitefish

CA - Arctic Cisco

CD - Sculpin (general)

CI - Cisco (general)

CN - Slimy Sculpin

CS - Least Cisco

DS - Chum (Dog) Salmon

DV - Dolly Varden

GR - Arctic Grayling

HO - Pond Smelt

HW - Humpback Whitefish

IN - Inconnu (Sheefish)

KS - Chinook (King) Salmon

LC - Lake Chub

LS - Longnose Sucker

LT - Lake Trout

LW - Lake Whitefish

NP - Northern Pike

OM - Rainbow Smelt

PS - Pink (Humpback) Salmon

RB - Rainbow Trout

RS - Sockeye (Red) Salmon

RW - Round Whitefish

SS - Coho (Silver) Salmon

SB - Stickleback (general)

SK - Sucker (general)

S9 - Ninespine Stickleback

TP - Troutperch

WF - Whitefish (general)

FISH STREAM CATALOG - ALCAN PIPELINE ROUTE (ALASKA)

Period of Sensitivity
Highly Sensitive = ________
Critical = - - - - - - - -

lignment sheet	Stream Name and Milepost	Fish Species	J	F	M	A	M	J	J	A	S	O	N	D
2	Grayling Gulch 4.9	GR?												
6	32.8	GR, S9												
6	33.3	GR, S9												
7	37.8	GR												
7	38.4	GR												
8	40.1	GR												
8	40.4	GR												
8	41.0	GR												
8	41.1	GR												
8	41.6	GR												
8	42.5	GR												
8	42.7	GR												
9	48.0	GR												
9	48.6	GR												
9	48.8	GR												
9	49.7	GR												
9	50.0	GR												
9	50.4	GR												
10	51.8	GR												
10	52.7	GR												
11	Sag. R. 61.5-62.6	GR, AC, RW, CN, S9												
12	Sag. R. 66.6-67.2	GR, AC, RW, CN, S9												

FISH STREAM CATALOG - ALCAN PIPELINE ROUTE (ALASKA)

Alignment sheet	Stream Name and Milepost	Fish Species	Period of Sensitivity Highly Sensitive = ———— Critical = - - - - -											
			J	F	M	A	M	J	J	A	S	O	N	D
12	69.2-69.3	GR, AC, RW, CN												
12	70.1-70.2	GR												
12	70.3-70.4	GR												
13	72.6	GR												
13	73.2	GR												
13	76.5	GR?												
13	Channel Change Cr. 77.3	GR												
14	81.6	GR												
14	Happy Valley Cr. 82.4	GR, RW, AC, CN												
15	86.0	GR, AC												
15	88.0	GR												
16	93.9	GR, CN												
16	94.4	GR, CN												
16	96.8	GR, AC												
16	97.2	GR, AC												
17	99.0	GR												
17	99.9	GR												
17	100.2	GR												
17	100.7	GR?												
17	100.8	GR?												
17	102.4	GR												
18	Lower Oksrukuyik River 104.3	GR, RW, CN, AC												

FISH STREAM CATALOG - ALCAN PIPELINE ROUTE (ALASKA)

Period of Sensitivity: Highly Sensitive = ________ ; Critical = - - - - - - - -

Alignment sheet	Stream Name and Milepost	Fish Species	J	F	M	A	M	J	J	A	S	O	N	D
19	114.6	GR, AC												
20	Oksrukuyik R. 118.1	GR, AC												
21	Toolik R. 125.0	GR,												
21	E. Fork Kuparak R 125.9	GR												
21	Kuparak R. 127.6	GR												
21	128.2	GR												
21	128.3	GR												
22	129.9	GR												
22	133.8	GR, AC												
22	134.4	GR, AC												
22	134.9	GR, AC												
22	135.2	GR, AC												
22	135.6	GR, AC												
22	135.6	GR, AC												
24	Atigun River 143.2	GR, AC, LT, BB, CN, RW												
24	Tea Lake Outlet 144.4	GR, BB, LT, AC												
24	Tea Lake Outlet 144.5	GR, BB, LT, AC												
25, 26	Proposed Alcan Pipeline does not follow rerouted Alyeska Pipeline route in A.S. 25, and perhaps parts of A.S. 24 and 26, therefore stream crossings are not known without a field verification.													
27	Atigun R. 164.6-164.9	GR												
27	Atigun R. 164.9-165.4	GR												

FISH STREAM CATALOG - ALCAN PIPELINE ROUTE (ALASKA)

Period of Sensitivity: Highly Sensitive = ———— ; Critical = - - - - - -

Alignment sheet	Stream Name and Milepost	Fish Species	J	F	M	A	M	J	J	A	S	O	N	D
27	Atigun R. 165.4-165.7	GR					—	—	—	—	—	- -		
27	Atigun R. 166.1-166.3	GR					—	—	—	—	—	- -		
28	W. Fork N. Fork Chandalar River 172.0-172.2	GR, CN, DV, RW					—	—	- -	- -	—	—		
28	W. Fork N. Fork Chandalar River 174.8-175.1	GR, CN, RW, DV					—	—	- -	- -	—	—		
29	Dietrich R. 176.9-177.0	GR, DV					—	—	- -	- -	—	—		
29	Beaver Brook 178.1	GR, DV					—	—	- -	- -	—	—		
29	Dietrich R. 178.6-179.1	GR, DV, CN, BB, RW, LS					—	—	- -	- -	—	—		
29	Osker's Eddy 180.1	GR					—	—	- -					
29	Dietrich River 180.7-181.6	GR, DV, BB, RW, CN, LS					—	—	- -	- - —	—	—	- -	- -
29&30	Dietrich River 182.0-182.5	GR, DV, BB, RW, CN, LS					—	—	- -	- -	—	—	- -	- -
30	Dietrich River 182.7-182.8	GR, DV, CN, BB, RW, LS					—	—	- -	- -	—	—	- -	- -
30	M. Dietrich R. 183.7-185.2	GR, DV, BB, CN, RW, LS					—	—	- -	- -	—	—		
30	Nutirwik Cr. 185.4	GR					—	—	- -					
30	186.9	GR					—	—	- -					
30	Dietrich R. 187.3-187.9	GR, DV, BB, CN, RW, LS					—	—	- -	- -	—	—		

FISH STREAM CATALOG - ALCAN PIPELINE ROUTE (ALASKA)

Period of Sensitivity: Highly Sensitive = ———— ; Critical = - - - - - -

ignment heet	Stream Name and Milepost	Fish Species	J	F	M	A	M	J	J	A	S	O	N	D
31	Burger's Bayou 190.8	GR												
31	Dietrich R. 192.9-193.2	GR, DV, BB, CN, RW, LS												
32	Dietrich R. 194.4-196.1	GR, DV, BB, CN, RW, LS												
32	196.1	GR, CD												
32	197.3	GR, RW, LS												
32	Dunder's Dribble 197.4	GR, CD												
32	Number Lakes Cr. 197.5	GR, CD												
32	Snowden Pond [illegible] Outlet 198.0	GR												
32	Snowden Cr 198.8	GR, CD												
33	Sahr's Swamp 200.3	GR												
33	Dietrich R. 200.5-201.0	GR, RW, DV, LS, CN, BB												
33	Disaster Cr. 201.8	GR												
33	203.4	GR												
33	Wiehl Mt. Cr. 203.9-204.0	GR												
33	Lower Dietrich R. 205.2-205.3	GR, RW, DV, LS, CN, BB												
33	206.6	GR												
34	206.9	GR												
34	207.1	GR												

FISH STREAM CATALOG - ALCAN PIPELINE ROUTE (ALASKA)

Period of Sensitivity: Highly Sensitive = ———— ; Critical = - - - - -

Alignment sheet	Stream Name and Milepost	Fish Species	J	F	M	A	M	J	J	A	S	O	N	D
34	M.Fork Koyukuk River 207.5-208.3	GR, CD, RW, LS, NP, DV, BB												
34	208.5	GR												
34	Pamplin's Pot Holes 209.2-209.3	GR												
34	Sukakpak Cr. 209.9	GR												
34	209.9	GR												
34	210.3	GR												
34	210.6	GR												
34	Upper M. Fork Koyukuk R. 210.8-211.0	GR, LS, RW, CN, DV, NP, BB												
34	212.6	GR												
35	Linda Cr. 215.3	GR, CD												
35	Gold Cr. 215.7	GR, CD												
35	Cushing Cr. 216.3	GR												
35	Sheep Cr. 216.5	GR												
35	Wolf Pup Cr. 217.0	GR												
35	Nugget Cr. 217.4	GR												
35	Alignment Slough 217.8	GR												
35	Alignment Slough 217.9	GR												

FISH STREAM CATALOG - ALCAN PIPELINE ROUTE (ALASKA)

Period of Sensitivity: Highly Sensitive = ______ (solid line); Critical = - - - - - (dashed line)

ignment heet	Stream Name and Milepost	Fish Species	J	F	M	A	M	J	J	A	S	O	N	D
35	Alignment Slough 218.0	GR				___	___	___	- -					
35	Alignment Slough 218.1	GR				___	___	___	- -					
35	Alignment Slough 218.2	GR				___	___	___	- -					
35	Alignment Slough 218.2	GR				___	___	___	- -					
35	Alignment Slough 218.3	GR				___	___	___	- -					
35	Alignment Slough 218.9	GR				___	___	___	- -					
35	Alignment Slough 218.9	GR				___	___	___	- -					
35	Alignment Slough 219.0	GR				___	___	___	- -					
35	Rainbow (Over) Cr. 219.1	GR				___	___	___	- -					
[illegible]	[illegible]													
35	Richardson Slough 219.5	GR				___	___	___	- -					
36	One-O-One Cr. 222.3	GR				___	___	___	- -					
36	(Upper) M. Fork Koyukak River 222.5	GR, CD, DV, CS, RW, LS, CI	- -	- -	- -	___	___	___	___	___	___	___	- -	- -
36	Hammond River 222.8	GR, WF	- -	- -	- -	___	___	___	___	___	___	___	- -	- -
36	Union Cr. 224.0	GR				___	___	___	- -					

FISH STREAM CATALOG - ALCAN PIPELINE ROUTE (ALASKA)

Alignment sheet	Stream Name and Milepost	Fish Species	Period of Sensitivity Highly Sensitive = ——— Critical = - - - - -
36	Union Cr. 225.4	GR	
36	M. Fork Koyukuk River 225.3-225.4	GR, CD, RW, LS, DV, NP	
36	Minnie Cr. 226.3	GR, CD, BB	
37	Confusion Cr. 227.7	GR	
37	Confusion Cr. 228.2	GR	
38	Pence's Pond 233.2	GR	
38	Marion Cr. 233.6	GR, DV, CN	
38	Sharon Cr 233.7	GR?	
38	Sharon Cr. 233.9	GR?	
38	234.0	GR?	
38	Mary Angel Cr. 234.6	GR, CN, BB	
38	South Fork Mary Angel Cr. 234.7	GR, CN	
38	236.0	GR	
38	Organo Cr. 236.4	GR, CN, DV	
38	Equisetum Cr. 236.5	GR	
38	Clara Cr. 236.8	GR	

Months: J F M A M J J A S O N D

FISH STREAM CATALOG - ALCAN PIPELINE ROUTE (ALASKA)

ignment heet	Stream Name and Milepost	Fish Species	Period of Sensitivity Highly Sensitive = ——— Critical = - - - - J	F	M	A	M	J	J	A	S	O	N	D
38	Clara Cr. Overflow 237.1	GR												
38	South Fork Clara Cr. 237.2	GR												
38	Calf Cr. 237.4	GR, CD												
38	Slate Cr. 237.8	GR, DV												
38	239.4	GR												
39	239.6	GR												
39	Spring Cr. 240.6	GR, CN												
39	North Fork Spring Cr. 240.4	GR												
39	North Fork Spring Cr. 240.5	GR												
39	Spring Cr. 240.6	GR, CN												
39	South Fork Spring Cr. 240.9	GR												
39	Spring Cr. 241.0	GR, CN												

FISH STREAM CATALOG - ALCAN PIPELINE ROUTE (ALASKA)

Alignment sheet	Stream Name and Milepost	Fish Species	Period of Sensitivity Highly Sensitive = ______ Critical = ------											
			J	F	M	A	M	J	J	A	S	O	N	D
39	Rosie Cr. 243.2	GR, CN, RW												
39	Rosie Cr. 243.8	GR, CN												
39	Mud Cr. 244.3	GR												
39	Jackson Slough 244.7	GR												
40	Jackson Slough 245.1	GR												
40	Jackson Slough 245.4	GR												
40	Trents Trickle 246.1	GR												
40	North Fork Windy Arm 248.0	GR												
40	Chapman Cr 250.1	GR, CD, NP												
41	South Fork Koyukuk River 256.7-256.8	GR, CD, SK, KS, DS, HW												
42	Aba-Dabba Cr. 258.5	GR, CD												
43	Jim River 268.3	GR, CD, KS, RW, DS												
43	Dee Cr. 269.2	GR, CD												
44	Douglas Cr. 270.5	GR, CD												

FISH STREAM CATALOG - ALCAN PIPELINE ROUTE (ALASKA)

Period of Sensitivity: Highly Sensitive = ———— ; Critical = - - - - -

lignment sheet	Stream Name and Milepost	Fish Species	J	F	M	A	M	J	J	A	S	O	N	D
44	Jim River (side Channel) 271.9	GR, CD, DS, KS, RW												
44	Jim River (side Channel) 271.9	GR, KS, KS, CD, RW												
44	272.3	GR												
45	Prospect Cr. 278.3	GR, RW, CN, KS												
45	Little Nasty Cr. 283.1	GR												
45	S.F. Little Nasty Cr. 283.3	GR												
46	North Fork Bonanza Cr. 285.5	GR, CD, RW, LS												
47	South Fork Bonanza Cr 287.0	GR, RW, NP, LS CN												
47	Pung's Crossing Cr. 290.6	GR												
47	Pung's Crossing Cr. 290.6	GR												
47	Alder Mt. Cr. 294.4	GR												
47	Fish Cr. 296.0	GR, CD, RW, LS												
47	Middle Fork Fish Cr. 297.5	GR												
48	South Fork Fish Cr. 298.7	GR, CD												
49	Kanuti River 304.2	GR, CD, NP, BB, DS, RW												

FISH STREAM CATALOG - ALCAN PIPELINE ROUTE (ALASKA)

Period of Sensitivity: Highly Sensitive = ——— ; Critical = - - - - -

Alignment sheet	Stream Name and Milepost	Fish Species	J	F	M	A	M	J	J	A	S	O	N	D
49	Caribou Mt. Cr. 307.4	GR												
49	Olson Lake Cr. 310.0	GR												
50	Finger Mt. Cr. 313.1	GR												
51	M.Fork of W.Fork Dall River 316.0	GR, IN, WF												
51	S.Fork of W.Fork Dall River 318.2	GR, BW, CS, LC, IN, ND, HW												
52	Fred Cr. 325.7	GR												
53	N.Fork Ray River (No Name Cr.) 329.5	GR, CD, LS, LC, IN, NP, RW, BB												
54	Hamlin Hills Cr. 335.7	GR, RW												
55	Phelps Cr. 344.4	GR												
56	Wood Chopper Cr. 349.9	GR												
56	Burbot Cr. 351.0	BB												
56	Yukon River 352.6-353.0	PS, RS, HO, OM, AL, BL, LS, CN, CA, HW, RW, BB, NP, TP, LC, BW, CS, IN, WF, GR, KS, DS, SS												
58	Isom Cr. 362.2 -362.4	GR												
59	Hot Cat Cr 370.5	GR?												

FISH STREAM CATALOG - ALCAN PIPELINE ROUTE (ALASKA)

lignment sheet	Stream Name and Milepost	Fish Species	Period of Sensitivity (Highly Sensitive = ———; Critical = - - - -) J F M A M J J A S O N D
61	Fish Cr. 378.7	NP, GR, RW	
61	Hess Cr. 378.8-378.9	NP, GR, RW	
61	Erickson Cr. 382.6	GR	
61	Erickson Cr. 384.3	GR	
63	Lost Cr. 391.3	GR	
64	Tolovana River 397.7	GR, RW, NP	
65	Wilber Cr. 404.9	GR	
65	Slate Cr. 407.6	GR	
66	412.1	GR	
66	Tatalina R. 412.2	GR, RW, LS	
66	412.8	GR	
66	413.2	GR	
66-67	Globe Cr 416.9	GR	
67	N. Aggie Cr. 422.8	GR	
68	S. Aggie Cr. 423.6	GR	
69	Washington Cr. 430.7	GR, RW	

FISH STREAM CATALOG - ALCAN PIPELINE ROUTE (ALASKA)

Period of Sensitivity: Highly Sensitive = ———— ; Critical = - - - - - -

Alignment sheet	Stream Name and Milepost	Fish Species	J	F	M	A	M	J	J	A	S	O	N	D
69	Shocker Cr. 436.0	GR, RW, CD					—	—	- -					
70	Chatanika R. 436.8	GR, RW, KS, DS	- -	- -	- -	- -	—	—	—	—	—	—	- -	- -
70	Treasure Cr. 440.9	GR, KS					—	—	- -					
71	Gold Stream Cr. 446.8	GR, AB					—	—	- -					
73	Chena R. 457.6	GR, BB, KS, DS	- -	- -	- -	- -	—	—	—	—	—	—	—	- -
73	Chena R. Slough 459.8	GR, LS					—	—	- -					
73	Chena R. Slough 460.0	GR, LS					—	—	- -					
74	Moose Cr. 469.9	GR, NP, CS, HW, RW, LC, CN, LS, BB	- -	- -	- -	- -	—	—	- -		—	—	- -	- -
75	Moose Cr. 470.3	GR, NP, CS, HW, RW, LC, CN, LS, BB	- -	- -	- -	- -	—	—	- -		—	—	- -	- -
75	Moose Cr. 471.5	GR, NP, CS, HW, RW, LC, CN, LS, BB	- -	- -	- -	- -	—	—	- -		—	—	- -	- -
75	French Cr. 472.7	GR, NP, CS, HW, RW, LC, CN, LS, BB	- -	- -	- -	- -	—	—	- -		—	—	- -	- -
75	French Cr. 474.4	GR, NP, CS, HW, RW, LC, CN, LS BB	- -	- -	- -	- -	—	—	- -		—	—	- -	- -
75	French Cr. 474.7	GR, NP, CS, HW, RW, LC, CN, LS, BB	- -	- -	- -	- -	—	—	- -		—	—	- -	- -
75	French Cr. 475.2	GR, NP, CS, HW, RW, LC, CN, LS, BB	- -	- -	- -	- -	—	—	- -		—	—	- -	- -
75	French Cr. 476.1	CR, NP, CS, HW, RW, LC, CN, LS, BB	- -	- -	- -	- -	—	—	- -		—	—	- -	- -

FISH STREAM CATALOG - ALCAN PIPELINE ROUTE (ALASKA)

Period of Sensitivity: Highly Sensitive = ——— ; Critical = - - - - -

Alignment sheet	Stream Name and Milepost	Fish Species	J	F	M	A	M	J	J	A	S	O	N	D
76	478.5	GR, NP, CS, HW, RW, LC, CN, LS, BB	- -	- -	- -	- -	—	—	- -		—	—	- -	- -
76	French Cr. 481.7	GR, NP, CS, HW, RW, LC, CN, LS, BB	- -	- -	- -	- -	—	—	- -		—	—	- -	- -
77	Million Dollar Cr. 482.6	GR, RW	- -	- -	- -	- -	—	—	- -		—	—	- -	- -
77	Million Dollar Cr. 483.0	GR, RW	- -	- -	- -	- -	—	—	- -		—	—	- -	- -
77	Million Dollar Cr 483.2	GR, RW	- -	- -	- -	- -	—	—	- -		—	—	- -	- -
77	Million Dollar Cr. 483.5	GR, RW	- -	- -	- -	- -	—	—	- -		—	—	- -	- -
78	Little Salcha R. 488.4	GR, RW	- -	- -	- -	- -	—	—	—	—	—	—	—	- -
78	489.5	GR					—	—	- -					
78	Salcha River 493.1	GR, KS, SS, DS, BB, NP, CN, DV, HW, IN, LC, LS	- -	- -	- -	- -	—	—	—	—	—	—	—	- -
78	Salcha R.Slough 493.4	KS, DS, BB ?									—	—	- -	- -
79	Redmond Cr. 497.2	GR, RW, KS, DS, BB	- -	- -	- -	- -	—	—	—	—	—	—	- -	- -
80	Gold Run Cr. 503.8	GR, KS, DS, RW, BB	- -	- -	- -	- -	—	—	—	—	—	—	- -	- -
80	Minton Cr. 505.6	GR	- -	- -	- -	- -	—	—	—	—	—	—	- -	- -
80	Minton Cr. 506.3	GR	- -	- -	- -	- -	—	—	—	—	—	—	- -	- -
80	Minton Cr. 506.6	GR	- -	- -	- -	- -	—	—	—	—	—	—	- -	- -

FISH STREAM CATALOG - ALCAN PIPELINE ROUTE (ALASKA)

Alignment sheet	Stream Name and Milepost	Fish Species	Period of Sensitivity Highly Sensitive = ——— Critical = - - - - J	F	M	A	M	J	J	A	S	O	N	D
81	Minton Cr. 507.6	GR	- -	- -	- -	- -	—	—	—	—	—	—	- -	- -
81	Minton Cr. 507.8	GR	- -	- -	- -	- -	—	—	—	—	—	—	- -	- -
81	Minton Cr. 508.5	GR	- -	- -	- -	- -	—	—	—	—	—	—	- -	- -
81	Minton Cr. 508.7	GR.	- -	- -	- -	- -	—	—	—	—	—	—	- -	- -
81	Minton Cr. 509.1	GR	- -	- -	- -	- -	—	—	—	—	—	—	- -	- -
81	Minton Cr. 509.3	GR	- -	- -	- -	- -	—	—	—	—	—	—	- -	- -
82	Keystone Cr. 515.8-515.9	GR					—	—	- -		—	—		
82	Rosa Cr. 517.1	GR					—	—	- -		—	—		
82	Shaw Cr. 517.3	GR, NP, RW	- -	- -	- -	- -	—	—	- -		—	—	- -	- -
83	Tanana R. 528.0-528.2	GR, BB, CN, DS, DV, HW, IN, KS, LS, NP, RW, SS	- -	- -	- -	- -	—	—	—	—	—	—	—	—
86	Unnamed 540.8	GR(?), DV(?), SS(?)					—	—	- -			—	—	- -
87	Granite Cr. 547.3	GR(?), DV(?), SS(?)					—	—	- -			—	—	- -
87	Rhodes (Rhoads) Cr. 548.2	GR(?), DV(?), SS(?)					—	—	- -			—	—	- -
88	Sawmill Cr. 555.3	GR(?), DV(?)					—	—	- -			—	—	- -
90	Gerstle River 565.7-566.1	GR(?), RW(?), DV(?), SS(?)	- -	- -	- -	- -	—	—	- -		- -	—	—	- -

FISH STREAM CATALOG - ALCAN PIPELINE ROUTE (ALASKA)

Period of Sensitivity: Highly Sensitive = ———— ; Critical = - - - - -

lignment sheet	Stream Name and Milepost	Fish Species	J	F	M	A	M	J	J	A	S	O	N	D
91	Little Gerstle R. 570.2	GR, RW, LS, DV(?)												
92	Johnson River 578.0-578.2	GR, LC, BB, DV, NP(?)												
92	Dry Cr. 580.5	GR, RW, DV, LS(?)												
93	Sears Cr. 584.1	GR, DV(?)												
94	Berry Cr. 587.3	GR, RW, LS, BB, DV												
94	Unnamed Cr. 589.3	GR, RW, LS												
94	Sam Cr 592.5	GR, RW, LS, NP												
95	Unnamed Cr. (Dot Lake) 595.7	GR, NP												
95	Unnamed Cr. (Dot Lake) 595.9	GR, NP												
96	Chief Cr. 599.1	GR												
96	Bear Cr. 600.6	GR. LS. DV												
97	Robertson River 610.2	GR, RW, DV												
98	Sheep Cr. 615.4	GR(?), RW(?)												
99	Unnamed Cr. 617.7	GR, LX, NP, LC												
100	Yerrick Cr. 623.4	GR, RW, LS(?)												
104	Tok River 648.6	GR, RW, LS, NP, LC, BB, CS(?)												

FISH STREAM CATALOG - ALCAN PIPELINE ROUTE (ALASKA)

Period of Sensitivity: Highly Sensitive = ———— ; Critical = - - - - - - -

Alignment sheet	Stream Name and Milepost	Fish Species	J	F	M	A	M	J	J	A	S	O	N	D
105	Tanana River 653.8-654.0	GR, RW, HW, LS, NP, BB, DV(?), CS	- -	- -	- -	- -	—	—	—	—	—	—	—	
108	Bitters Cr. 675.6	GR, LS					—	—	- -					
110	Beaver Cr. 686.9	GR, RW, LS	- -	- -			—	—	- -			—	—	- -
111	Silver Cr. 694.8	RW, HW, NP	- -	- -	- -							—	—	- -
112	Tenmile Cr. 700.4	NP(?)					—	—						
113	Gardiner Cr. 706.5	GR, RW, HW(?), NP, LS	- -	- -	- -	- -	—	—	- -		- -	—	—	- -
116	Desper Cr. 725.9	GR(?), RW(?), HW(?), NP	- -	- -	- -	- -	—	—	- -		- -	—	—	- -
117	Scottie Cr. 727.7	GR, RW(?), HW, SK, LS, NP, BB	- -	- -	- -	- -	—	—	- -		- -	—	—	- -

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SALMON SURVEYS OF THE UPPER TANANA RIVER, 1976

by

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Prepared for the Gulf Interstate Engineering Company

Houston, Texas

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INTRODUCTION

Next to oil and gas, salmon is Alaska's most valuable natural resource. In the development of the non-renewable petroleum resources it is essential that the renewable resources, such as fisheries, not be damaged or reduced in productivity. To avoid damage, it is important to have an understanding of the distribution and abundance in time and space of the various salmonid species, their life history and general environmental relationships and to identify sensitive spawning and rearing areas so that maximum protection can be afforded.

The Northwest Pipeline Corporation proposes to build a natural gas pipeline from the Prudhoe Bay fields adjacent to the Alyeska crude oil pipeline until near the community of Delta Junction. There it will diverge and follow the Alcan Highway, utilizing the old Haines to Fairbanks military pipeline right-of-way. This route essentially parallels the Tanana River, and its major tributary, the Chisana River, to the headwaters before crossing into Canada (Figure 1). The fisheries problems of the pipeline north of Delta Junction have been addressed by the Alyeska Pipeline Corporation in contract research and monitoring activities by the various state and federal agencies. In particular, the important salmon spawning areas in the Salcha and Delta Rivers, Delta-Clearwater Creek and the Tanana River near Big Delta have been studied by the Alaska Department of Fish and Game(ADFG). Little is known, however, of fish populations above Delta Junction, in particular, if significant salmon populations do or do not exist in the upper Tanana River and its tributaries. Most observers familiar with the area feel that there are probably few salmon spawning above Delta Junction

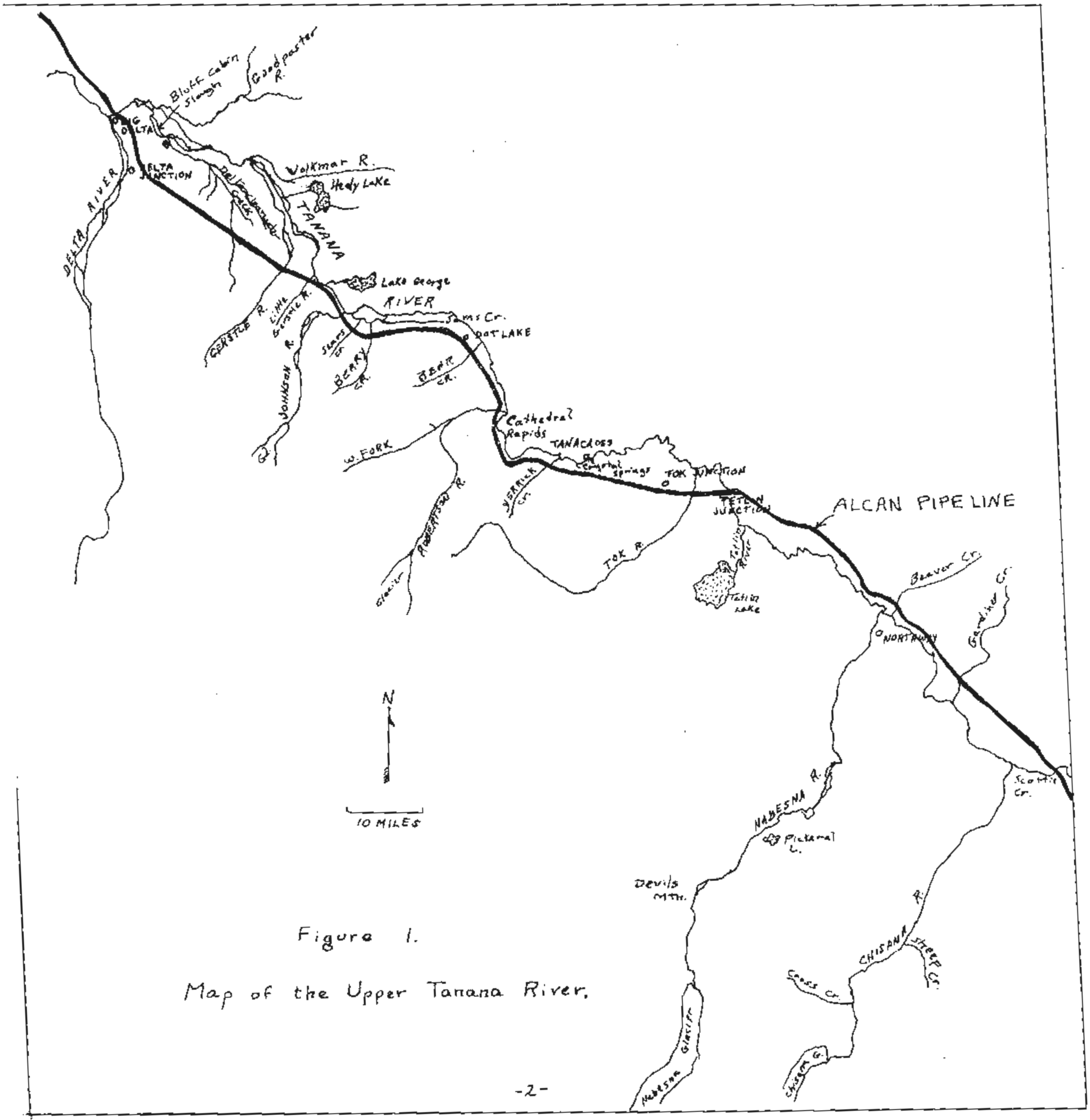

Figure 1.

Map of the Upper Tanana River.

-2-

but this assumption needs confirmation as it is suspected that we may be unaware of important concentrations.

The purpose of this study is to review available information regarding salmon stocks in the upper Tanana River and to conduct a field survey to determine the extent of salmon spawning in the area during the fall of 1976.

BACKGROUND

All five species of Pacific salmon are indigenous to the Yukon River drainage, but the pink salmon (Oncorhynchus gorbuscha) is confined to the lower areas and the sockeye salmon (O.nerka) is rare. In order of abundance are found chum salmon (O.keta), chinook salmon (O. tschawytscha), and coho salmon (O. kisutch). Chum salmon are found throughout the Yukon River drainage and consist of two distinct runs - summer and fall.

The Yukon River basin encompasses 330,000 square miles, is the largest river in Alaska and the fifth largest in North America flowing over 2,300 miles from its origin in Canada to the Bering Sea. The Tanana River, its largest Alaskan tributary, is formed by the confluence of the Chisana and Nabesna Rivers near Northway and then flows 440 miles northwest to the Yukon River. During the summer, the Tanana, and many of its tributaries, is heavily laden with glacial silt, but in the fall, as glacial activity ceases, the water clears and remains low and clear until spring break up. The flow during the winter is from springs and groundwater upwelling.

The Yukon system is an important producer of salmon to Alaska's commercial and subsistence fishermen. The commercial catch in 1975 totaled over a million salmon (63,000 chinook, 2,000 coho, 993,000 chum) producing wages to fishermen and cannery workers of $2.4 million and with a first wholesale value of nearly $5 million. Since the vast majority of the people in the industry are Natives this is particularly important and in many cases may be their only source of cash income. Some 10,000 to 15,000 Eskimo and Indian people in 45 villages are dependent upon Yukon salmon to a considerable degree for their food needs and 17,600 chinook and 277,000 chums were harvested in the 1975 subsistence fishery - an average of some 600 salmon per fishing family.

A large, but unknown, portion of the commercial and subsistence harvest from the lower Yukon consists of fish originating in the Tanana River. In the Tanana River itself in 1975, 460 chinook, 14,650 summer chum, 18,680 fall chum and 50 coho were taken commercially, while subsistence users took 630 chinook and 31,000 of other mixed species, mostly chums (Geiger and Andersen, 1976). Considering the total Yukon system, summer chums are more abundant and important than fall chums; the commercial catch in 1975 was 728,000 summer chums compared to 265,000 of the fall run. In the upper areas, however, fall chums are more numerous.

Summer chums enter the Yukon River from early June to mid-July and spawn primarily in the run-off streams in the lower 500 miles of the drainage during August. Important summer chum streams are the Andreafsky, Anvik, Nulato and Koyukuk Rivers. Summer chums have not been observed in Tanana River tributaries above the Salcha River, except for a few in the Good-Daster River. Fall chums enter the Yukon from mid-July through early September and spawn in the upper portion of the drainage in spring-fed streams from September through November. In the Tanana and its tributaries peak spawning is from mid-October through mid-November, while in the upper tributaries of the Porcupine and Chandalar Rivers, they spawn during September and October. Major fall chum spawning areas so far located include the Sheenjek and Fishing Branch Rivers, tributary to the Porcupine River; the Kluane and Yukon rivers in the Yukon Territory, Canada; and the Tanana River near Big Delta and its tributaries the Delta and Toklat Rivers.

Chinook salmon enter the mouth of the Yukon after breakup in early June, arrive in the Tanana in early July and spawn basically during the month of August, peaking during the second week. They spawn widely over the drainage in permanent, clear-water streams from the Andreafsky River, 100 miles from the mouth, to near the headwaters in the Yukon Territory, Canada, some 2,000 miles distant. The Salcha River population is the major component of the Tanana River run with spawning ground counts generally on the order of 1,000 fish. The Goodpaster River, which enters the Tanana just above Big Delta, has a small run of chinooks, and they were observed in Delta-Clearwater Creek in the early 1960's (Shallock, Environmental Protection Agency, pers. comm. to Francisco, ADFG, 1975).

Very recently, however, workers in Canada have reportedly found chinook and summer chum salmon spawning in the turbid main stem of the upper Yukon River during the summer months. These observations were made during the course of extensive netting programs and the fish were not detectable by ordinary visual survey methods. The localities where they were captured are not unlike many areas in the upper Tanana and the possibility of salmon spawning in the main stem of the Tanana River cannot be discounted. Francisco (pers. comm., 1976) found chinook smolts in the lower Delta River; the only known spawning occuring upstream is the small population in the Goodpaster River. The origin of these smolts is unknown; but they could have entered the Delta River from the Tanana during their migration downstream from the Goodpaster or upper Tanana or could have been migrating down the Delta River from unknown spawning grounds upstream. An unconfirmed report persists that chinook salmon have been observed spawning at the mouth of George Creek and Natives have reported an occasional chinook captured in the Tetlin River (Mauney, 1975).

The farthest upstream spawning recorded for chum salmon on the main Tanana is Volkmar River Slough, and for the tributaries, the upper Chisana near Sheep Creek (Geiger and Andersen, 1976).

Coho salmon enter the Yukon River during late July through mid-September and spawn discontinuously throughout the drainage from the middle of September to the end of December with peak spawning varying with the river system. The major coho spawning concentrations on the Yukon documented to date occur in tributaries of the Tanana River such as Delta-Clearwater Creek. Coho salmon primarily utilize spring-fed streams, such as Delta-Clearwater Creek, which originate from large springs near their source and have a steady, year-around flow of clear, relatively warm water. A few coho have been noted spawning also in glacial streams such as the Delta River. Coho fry remain in fresh water for one or two years before migrating to sea.

Due to the vastness of the Yukon area, its wilderness character, the turbidity of many of the streams and the often inclement weather during the spawning season, estimates of the size of salmon spawning runs are difficult to obtain. Most counts are obtained from aerial surveys, but a few weirs and towers have been maintained for obtaining more accurate estimates of spawning escapements. A few estimates for 1975 illustrate the magnitude of some of the salmon populations in the Yukon basin (from Geiger and Andersen, 1976):

Anvik River	720	chinook
	467	coho
	845,485	summer chum
Tanana River		
Toklat River	78,285	fall chum
Chena River	316	chinook
	2,380	summer chum
Salcha River	1,055	chinook
	7,573	summer chum
Delta River	3,946	fall chum
Delta-Clearwater Creek, Lake & Slough	6,575	coho
	745	fall chum
Porcupine River		
Sheenjek River	78,060	fall chum
Fishing Branch River(Canada)	353,282	fall chum
Yukon River (Canada)	913	chinook
	7,000	fall chum

The ecology of fall chum salmon of the Delta and Tanana Rivers near the Alyeska Pipeline Crossing and Delta-Clearwater Creek has been studied (Francisco, 1976; Van Hyning, 1973) and will be summarized here since the information has pertinence to possible spawning sites farther upstream on the Tanana.

Fall spawning chum salmon appear to primarily utilize the subpermafrost springs which surface along the south bank of the Tanana River. Spring water visibly upwells along the bank of the Tanana and throughout the lower Delta River and Delta-Clearwater Creek as well as in several side sloughs. Groundwater is the only water flow between freeze-up in late October and the spring thaw and these areas remain open and flowing throughout the winter. The water temperature in the upwelling areas remains between 34^{0} and 40^{0}F during the winter.

Adult chum salmon appear in the Tanana River at Big Delta and enter the Delta River in early October and spawning reaches its peak during the last week of October. Redd excavation and spawning occurs in a gravel substrate which appears to contain an unusually high percentage of silt compared to most other salmon spawning areas. Spawning is completed by mid-November to early December after which the adults die. The eggs hatch between the second week of February and the last week of March. The alevins or yolk sac fry remain in the gravel until early April to late May, with the peak of emergence during the last week of April. Outmigration occurs throughout April and May with the peak varying with high flows through the spawning area. Chum salmon fry do not reside in fresh water, but drift down to the sea shortly after emergence from the gravel.

Mauney (1975) interviewed residents of Northway, Tok Junction, Tanacross and Dot Lake as to their knowledge of salmon spawning in those areas: "The general consensus of opinion of the elder native fishermen of this area was that salmon occur above the Delta-Clearwater, Goodpaster areas only rarely." In the early days a large native salmon fishing camp existed at Big Delta, but above that point most subsistence fishing was for whitefish. At some upstream locations a few salmon were caught or observed by Indian fishermen: the mouth of Scotty Creek produced chum salmon in the 1940's and some were observed in this area in August 1975 (these were probably of the same group that Geiger and Andersen (1976) observed spawning in the upper Chisana near Sheep Creek in October 1975); perhaps one chinook a year has been taken in the Tetlin River (whitefish gear would not be very efficient for capturing chinook salmon); chums were reported to spawn in the main Tanana River above the mouth of the Tetlin River (an area of springs and clear sloughs there was noted during this survey); fish wheels near Tanacross used during the summer produced only whitefish; many years ago salmon were observed spawning under the ice in a channel of the Tanana near Dot Lake and some were captured. Francisco (pers. comm., 1976) reports that Mr. Bud Coiley of the George Lake Lodge has caught chums in the Tanana River near George Lake and an occasional chum salmon has been reportedly caught in Healy Lake. Additionally, Francisco did some experimental gill netting in the Tanana in an attempt to determine if any numbers of salmon were migrating above Delta-Clearwater Creek (pers. comm., 1976). On July 19-20, about 15 fathoms of 5½-inch salmon gillnet was fished 2 miles downstream from the mouth of the Volkmar River. No fish were caught. From September 22-24, the net was fished between Healy and George Lakes. Four humpback whitefish, but no salmon were caught. On October 6-8, 1 4-inch mesh sheefish net was fished in the same area and four humpback whitefish and one coho salmon was caught.

These historical and recent observations, although sketchy in nature, suggest that a few salmon spawn throughout the upper Tanana River, but there are no major concentrations.

Fall chum and coho salmon would be the species most likely to be encountered in the upper areas since there are no large, clear, run-off streams similar to the Salcha or Chena Rivers which are typically utilized by chinook and summer chums. It should be recognized, however, that chinook and summer chums may be present in the main-stem Tanana, but it would require a netting program to ascertain their distribution and abundance.

In terms of previous fisheries research in the upper Tanana Basin, there has been relatively little. The Sport Fish Division of ADFG has done inventory and cataloging of lakes and streams (Pearse, 1975 and 1976), and a considerable amount of grayling biology. The ADFG Division of Commercial

Fisheries conducts annual surveys of known salmon spawning areas for fisheries management purposes (Geiger and Andersen, 1976) and ecological studies on the Salcha and Delta Rivers and Delta-Clearwater Creek in connection with pipeline monitoring (Francisco, 1976). Van Hyning (1976) conducted a reconnaisance of the fishery resources of the Alcan pipeline corridor and Bio/West, Inc. (1976) sampled the summer resident fish populations. Canadian biologists are doing considerable research on the upper Yukon (Elson, 1973, for example), which has application to interior Alaskan problems.

MATERIALS AND METHODS

Available evidence indicated that fall chum and coho would be the only salmon encountered in any abundance in the upper Tanana River and the timing of the present survey (early October - early November) was designed to bracket their peak of spawning. Since ADFG was also engaged in spawning ground surveys, our work was coordinated to avoid overlap.

A fixed-wing aircraft, the Heliocourier, (Figure 2), was the primary mode of transportation and observation. This aircraft has a slow cruising speed (60 knots) and is extremely maneuverable so that the river courses could be closely followed. It was planned to utilize a helicopter for follow-up, detailed surveys of observed spawning activity and to reach inaccessable areas, but there was insufficient evidence of salmon presence to justify its use and the fixed-wing aircraft was able to cover all areas adequately.

The plane was piloted by Mr. Ron Warbelow of Tok Junction for a total of 14.3 hours. ADFG biologists made a survey of the upper Chisana River in addition to their standard surveys of the Delta River, Delta-Clearwater Creek and the lower Tanana River. On all flights, visibility and flying conditions could be rated good to excellent, with one exception being the main Tanana River which remained somewhat murky throughout October. Polaroid glasses were used when conditions warranted.

Where the Alcan Highway and Haines Pipeline crossed tributaries, visual observations and photographs from the ground were taken. In some cases, water temperatures were taken and flows estimated. The flows are order of-magnitude estimates only. In some cases, part or most of the stream was flowing under ice cover which would entail boring through the ice to obtain accurate flow estimates.

No fish collection was attempted. No attempt was made to enumerate spawning salmon below Bluff Cabin slough or in Delta-Clearwater Creek, as that area was covered by ADFG.

The information obtained on the streams during October and November 1976 is presented in sequence as one travels from the Canadian border towards Delta Junction. General observations on ice and snow cover and flow are recorded, as little is known of fall and winter hydrology in this area.

OBSERVATIONS

Scottie Creek.

5 November. A tributary of the Chisana River.
Completely ice covered with no evidence of flowing water; probably some water flowing under the ice (Figure 3).

Gardiner Creek.

5 November. Another tributary of the Chisana River. Mostly covered with 1-inch thick ice, but some open areas. A flow of 4-5 cfs, humic water, 32 F. Walked from bridge downstream 1/4 mile past pipeline crossing. No evidence of fish usage.

Beaver Creek.

5 November. Another tributary of the Chisana River. Stream largely covered with brown, slushy ice suggesting some spring flow. Remainder of stream covered with "normal" white ice and snow. No flow visible.

Chisana River.

The Alcan Highway and the Haines Pipeline border the Chisana for about five miles downstream from Northway (Figure 4), but for most of its length the river lies from one to five miles to the south of the highway until it turns south near the border, heading up into the Wrangell Mountains. The Chisana River valley is 110 miles in length from the mouth near Northway to its origin at Chisana Glacier; following the meanderings would probably double the actual stream length. In its lower reaches it traverses marshyflats, but in the middle and upper areas it becomes a fast-flowing, braided stream flowing over rock and gravel substrate occupying a broad flood plain (Figure 5). Flows have been estimated by ADFG (Pearse, 1976) as from 1,500 to 6,500 cfs. In summer the river is heavily laden with glacial silt, but becomes clear in the fall. Geiger and Anderson (1976) observed 29 fall chum salmon in the Chisana River near the mouth of Sheep Creek on October 27, 1975. All were dead and heavily fungused so had probably spawned 10 days or 2 weeks earlier. Andersen (ADFG pers. comm. 1976) compares the Chisana with the Toklat River, an important chum salmon producer, in terms of physical appearance, spring flow, and extensive gravel beds.

24 September. ADFG biologist Francisco surveyed the upper Chisana to Sheep Creek by air (pers. comm.). No salmon or their predators orscavengers were observed.

15 October. Flew from mouth to Sheep Creek. In lower areas water was deep and could not see bottom of pools. Water low and clear in upper areas and visibility excellent. Very little ice on the river although most of the lakes and ponds were frozen over. Three possible fish observed, but circled back and could not

Figure 2. The Heliocourier aircraft at Tanacross Field

Figure 3. Scotty Creek, 5 November, 1976.

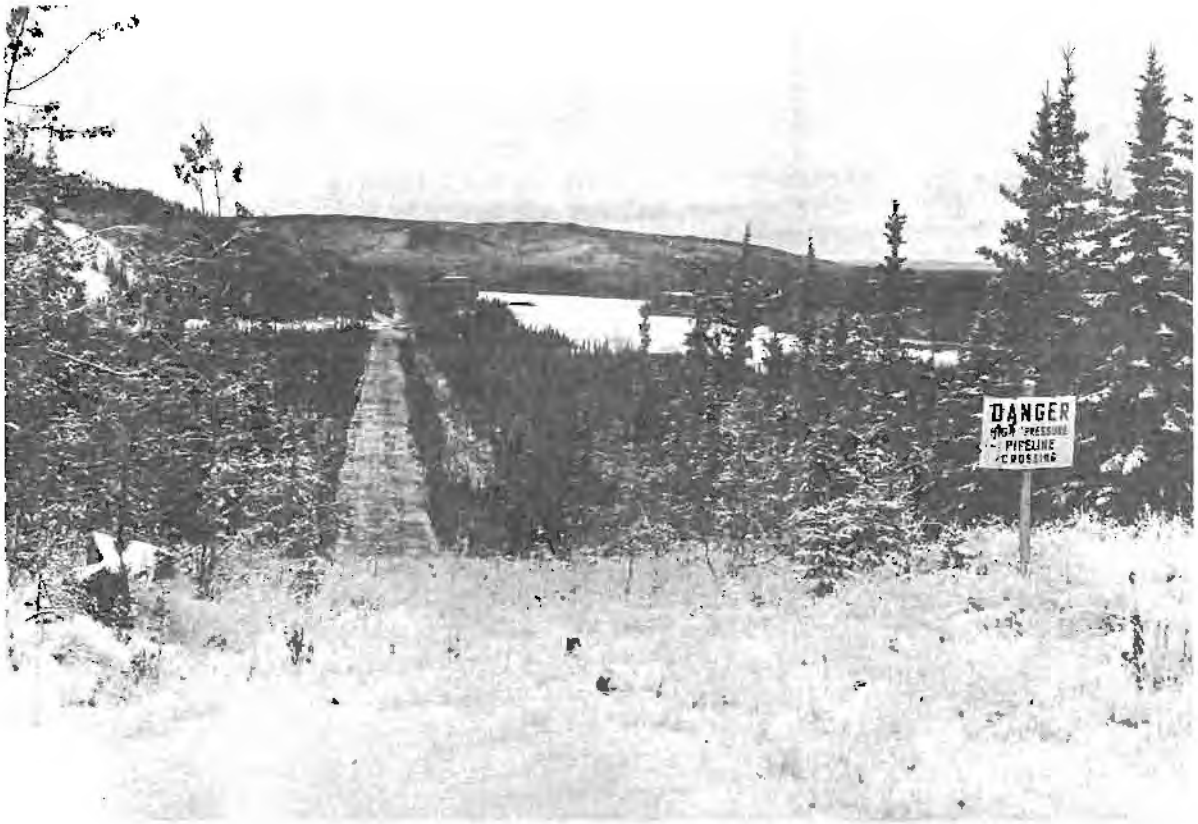

Figure 4. Haines Pipeline Right-Of-Way and the Chisana River, 5 November, 1976.

Figure 5. Upper Chisana River, 4 November, 1976.

verify. About a dozen bald eagles scattered along middle and upper areas. Numerous mergansers, a few goldeneye and mallard ducks in lower sections; one beaver. The eagles gave the impression that they were waiting for something - possibly the salmon run - but checked carefully those that were sitting on gravel bars and no evidence of salmon carcasses.

4 November. Flew from mouth to Cross Creek. At Northway the river was completely frozen over. In some of the lower areas open channels and shallow waters were present in the middle of the river, but the banks were completely iced over. In the middle areas there were some sections clear of ice, but mostly mud and sand bottom visible. Considerable turbidity from a couple of tributaries was noted. In the foot hills the river was mostly open and clear, very little snow and the gravel beds appeared ideal. No fish observed and the eagles and waterfowl had left. One hawk observed; probably a goshawk. Very little visible flow above Cross Creek and much evidence of overflow icing. Chum salmon carcass availability should have been at peak; salmon predators and scavengers presumably left because of lack of salmon. Later checked Northway Bridge from shore. Ice appeared to be about a foot thick; four holes cut by fishermen had refrozen to a depth of 4-6 inches.

Nabesna River.

A stream very similar to the Chisana. The lower part meanders through marshes; the upper part through a braided, glacial flood plain and originates at a large glacier. From the mouth to Nabesna Glacier is approximately 75 miles.

15 October. Flew from Pickerel Lake to mouth. Some floating ice, and river more turbid than Chisana, but visibility still good on gravel riffle areas. Many mergansers, some goldeneyes, and a few mallards. As on the Chisana, ten or a dozen bald eagles were scattered along the river and again appeared to be waiting for something. One, on a gravel bar, appeared to be feeding, but we circled back and could not see anything. Eagles are generally a good indicator of salmon presence, but no fish were observed.

4 November. Flew from Devil's Mountain to mouth. Little ice or snow in upper areas, but much anchor and shore ice in middle portions and completely frozen over approaching Northway. More flow and poorer visibility than Chisana, but could see clearly on gravel riffles and shallow pools. No indication of fish; eagles and waterfowl had left except for two unidentified ducks.

Tok River.

15 October. Flew from mouth upstream about 10 miles. Completely frozen over at all points.

4 November. Flew from mouth to highway bridge - completely frozen over. There is undoubtedly some flow under the ice at this time,

although Pearse (ADFG, pers. comm. 1976) states that the river goes dry at the bridge during winter.

Yerrick Creek.

3 October. Ice along edges, but a small flow of clear water, about 2 cfs. No fish observed near highway.

14 October. Almost completely frozen over, but some open areas and flow visible in the middle of the stream.

7 November. Completely ice and snow covered, no indication of flowing water, but some fresh icing below the bridge.

Robertson River.

3 October. Surveyed from mouth upstream 15 miles to junction with West Fork. Water crystal clear, ± 25 cfs, flowing over extensive gravel beds. A spring area 10 miles up from the mouth flows all winter and contains grayling and Dolly Varden char according to the pilot. No fish observed even though conditions were perfect.

15 October. Walked downstream from bridge to mouth, (Figure 6). Heavily iced along edges and more flow and turbidity than on 3 October. Most of flow along west bank; east side channels apparently frozen; no sign of spring discharge areas; water temperature 32 F. No fish observed.

6 November. Surveyed by air from mouth upstream to forks. From mouth to bridge largely frozen over with large areas of overflow ice, but no evidence of spring flow, (Figure 7). River open above bridge, flowing clear over gravel riffles; 5-10 cfs in visible channels. Springs 10 miles upstream flowing clear, no fish visible. At forks the flow was down to about 1 cfs; the stream bed appeared mostly frozen with large areas of overflow ice. The Robertson River has a year-round flow from springs according to Pearse (1976).

Sheep Creek.

3 October. Dry.

7 November. Ice and snow covered. No flow.

Bear Creek.

3 October. Considerable marginal ice, but flowing 1 or 2 cfs of 32 F water.

7 November. Completely dry and frozen.

Chief Creek.

7 November. Dry and snow covered.

Figure 6. Robertson River, from near mouth looking upstream towards Alcan Highway bridge, 15 October, 1976.

Figure 7. Robertson River showing overflow ice, 6 November, 1976.

Sam Creek.

6 November. Examined carefully from the air. A short, spring-fed stream. Good flow of clear water, 2-3 cfs, and good gravel. Appears similar to streams used in the lower areas by spawning salmon, but no salmon or associated animals observed, although many tracks were visible in the snow (probably mostly foxes).

Berry Creek.

3 October. From the highway bridge some ice could be seen along the bank, but the stream was flowing at near summer levels. Water temperature 32 F. No fish observed.

14 October. Much ice along the edge, but still good flow.

7 November. Completely ice covered; no indication of flowing water. Pearse (1976) reports very little winter flow.

Sears Creek.

3 October. Normal flow for this small stream.

7 November. Upstream from the bridge and over the buried pipeline, the stream was covered with about 6 inches of slush ice; presumably from some spring source. Downstream from bridge, there was hard ice and snow over the stream bed. Flowing water was not visible.

Dry Creek.

3 October. Dry.

Johnson River.

3 October. Walked from bridge downstream to mouth and up the Tanana about 1/2 mile. Very little ice present; good flow of somewhat murky water; 35 F. The Tanana was muddy and 34 F. No evidence of spring upwell areas or fish utilization.

14 October. From the highway bridge. The west channel next to bank contained a good flow; east channels frozen over with much ice and snow.

6 November. Surveyed by air from mouth upstream about 5 miles. Mouth completely ice covered (Figure 8). Some open water near the bridge along the west bank. Above the bridge there was more open water - clear and flowing over gravel beds. Some 4-5 cfs just above the bridge tapering down to perhaps 1 cfs at upper limit of survey. The river bed appeared to be mostly frozen at this point with much overflow ice; little visible water and no indication of fish. Pearse (1976) reports that numerous springs feed streams fed into the upper Johnson River.

George Creek.

6 November. An unconfirmed report exists that chinook salmon have been observed spawning at the mouth of George Creek which drains George Lake. Surveyed from the air. George Creek was completely frozen over with slush ice in lower part and overflow ice out into Tanana. Creek flowing some 5 cfs into Tanana and open water present, but no obvious "typical" spawning areas.

Little Gerstle River.

3 October. At the highway bridge. A good flow of murky, 32 F. water. Some ice along the edge.

14 October. Almost completely frozen over; a little flow visible.

3 November. Completely frozen over and dry; no flow.

Gerstle River.

14 October. From the highway bridge. Much ice present, especially on stream bottom. Water flowing over the top of the ice.

6 November. From air. Wide channel at the bridge narrows down to a single channel winding for miles through the forest to the mouth. Completely frozen over, no flow visible. At the bridge and for 5 miles above, there were a few patches of open water, but little flow and much ice and snow.

Sawmill Creek.

3 October. Dry at the highway bridge.

Delta River.

3 October. From shore, 3 chum salmon observed on a riffle and (Figure 9) several more finning in deep pools and at the mouth. Water too turbid to estimate how many actually present. Water temperatures 36 F.

14 October. From shore, observation of channel closest to the highway. Water lower and clearer, but still discolored; temperature 38 F. About 100 chums in channel and a large school just inside the mouth. Mostly in good condition and had not yet spawned.

19 October. ADFG biologists counted 4,719 chums in the Delta River.

6 - 7 November. From air and shore. Full of chum salmon and a large school just off the mouth. Abundant throughout the 3/4 mile of stream and in all the channels. No open water above 3/4 mile (Figures 10 and 11).

Figure 8. Johnson River, from mouth looking upstream towards Alcan Highway bridge, 6 November, 1976.

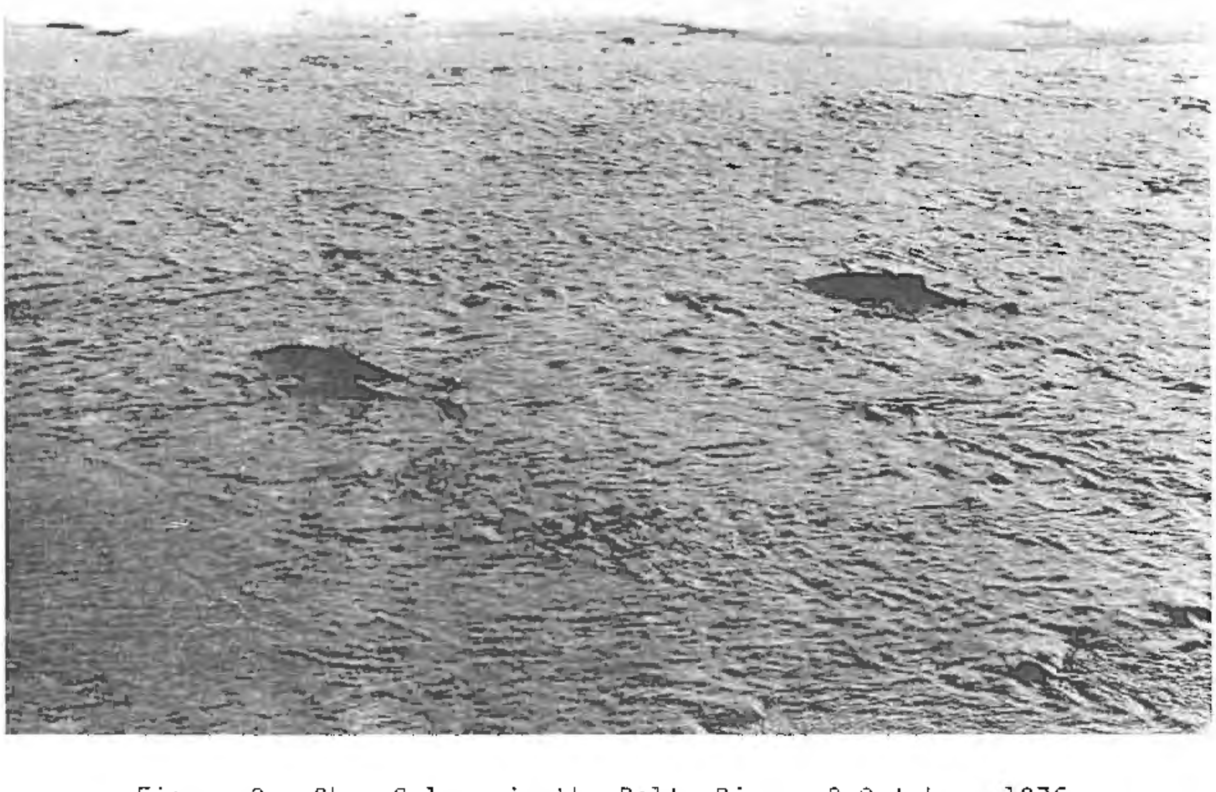

Figure 9. Chum Salmon in the Delta River, 3 October, 1976.

Figure 10. Chum salmon spawning in the Delta River with the Alyeska pipeline crossing the Tanana River in the background, 7 November, 1976.

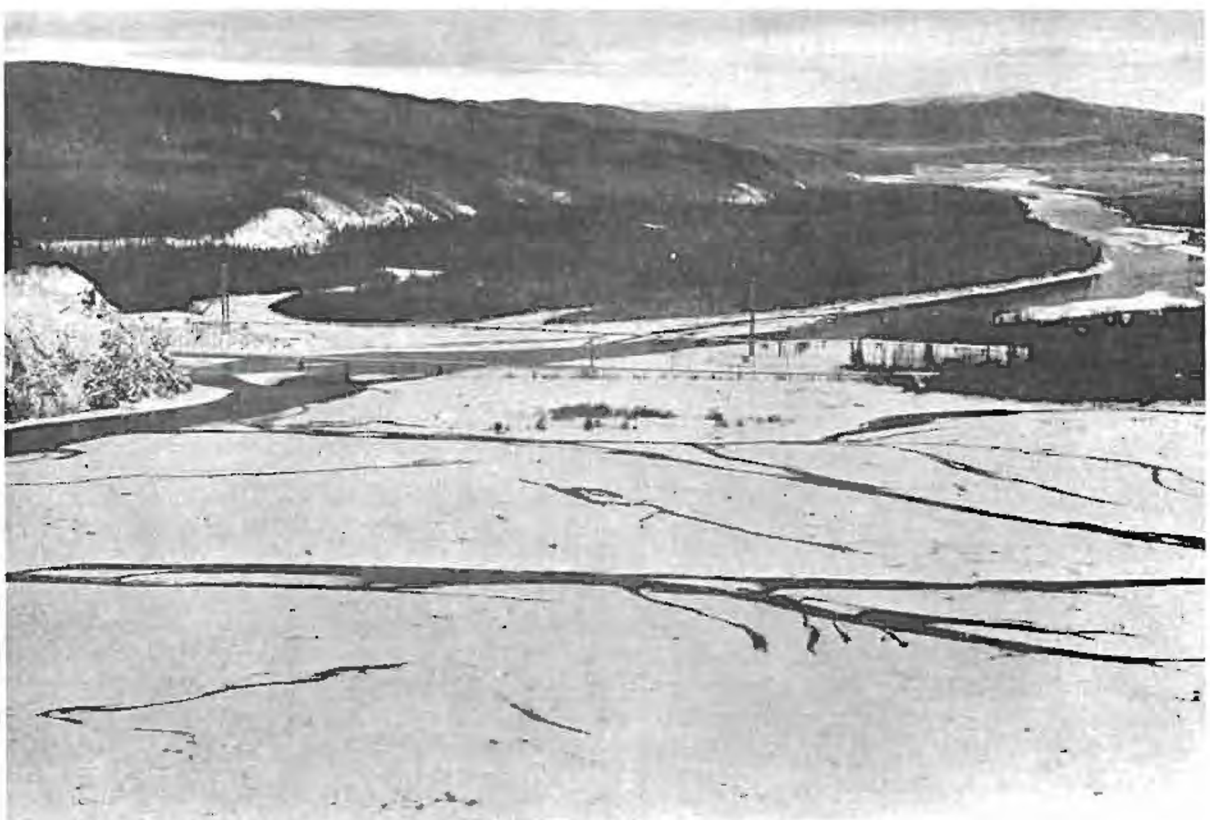

Figure 11. Mouth of Delta River, Tanana River at Alcan Highway and pipeline crossing. Springs and open water clearly visible, 6 November, 1976.

Tanana River.

Tanacross to confluence with Nabesna and Chisana Rivers.

15 October. Aircraft survey. This area mostly mud and silt banks and bottom; little gravel and potential spawning area appears negligible. Some areas ice covered, but mostly open. Much ice floating down along with globs of mud. One good area of springs and clear sloughs appeared opposite Midway Lake, mouth of the Tetlin River; one bald eagle there.

4 November. Much of river completely ice covered and a great deal of anchor ice. Some areas had open leads and channels in middle, but thick ice along the banks (Figure 12). Near Tanana River bridge at Tetlin completely ice covered except for one small open spot. Spring area at mouth of Tetlin River open, but no fish observed.

At Tanacross. From shore and aircraft.

3 October. Several small springs and gravel areas checked at end of airstrip. Spring water clear and 36-37 F. Tanana muddy and 32 F. No fish.

15 October. Spring areas and gravel bars look good, but no fish present. Spring temperature 38 F. A great amount of ice coming down Tanana and still somewhat discolored; temperature 33 F.

4 November. Tanana clear and largely free of ice although some ice along edge (Figure 13); Tanana River temperature 32 F; spring water temperature 36 F. No fish.

Tanacross to Dot Lake.

3 October. From air. Tanana River itself still too muddy to see fish at any depth, but several spring areas and side sloughs were clear and appeared to present suitable spawning habitat. Several shallow gravel riffles were also observed in the main river. Crystal Springs, 3 miles west of Tanacross, flows all winter, according to the pilot. No fish observed; 2 bald eagles and numbers of mergansers along the river.

15 October. Crystal Springs and vicinity, from air. Good flow and clear, but no fish.

6 November. From air. Some parts of river clear, but much of it ice covered; some floating ice. In vicinity of Cathedral Rapids to Robertson River mostly ice covered, but with open spots and leads. Below Robertson River mostly open, but with much anchor ice and mud clods in the water. Crystal Springs was crystal clear, flowing 2 cfs over good gravel beds. No fish observed.

Figure 12. Tanana River above Tok Junction showing ice cover and open leads, 4 November, 1976.

Figure 13. Tanana River at Tanacross, 4 November, 1976.

Dot Lake to Alyeska Pipeline Crossing.

19 October. ADFG biologist counted 3,197 chums in Bluff Cabin Slough.

6 November. Considerable open water in vicinity of Johnson River, but mostly in middle of channel with the banks still ice covered. At Healy Lake river mostly frozen over, but with some open leads. East of Delta Junction, some open areas with good gravel, but much of river covered with ice. NE of Delta Junction, just above Bluff Cabin Slough, side channels and sloughs containing many chum salmon; 2 eagles and many ravens feeding on carcasses. Bluff Cabin Slough - hundreds of chum salmon; one eagle, several gulls and ravens, 4 mallards. At the mouth of the Goodpaster River, a large flow entering under the ice. No fish visible, 15 mergansers.

At Alyeska Pipeline crossing, Big Delta.

3 October. Water very murky, but no salmon visible in shallow, gravel areas of spring upwelling.

14 October. Running much cake ice and water still discolored; spring area water temperature 36 F. Chum salmon spawning actively all along shore, but difficult to see. One carcass.

19 October. ADFG biologists counted 4,979 chums in 2-mile stretch from highway bridge to Blue Creek.

3 November. Many chums present along river edge from highway bridge along pipeline area.

6 November. From air; large schools of chum salmon just above pipeline crossing and at mouth of Delta River and scattered all along south shore (see Figure 11).

SUMMARY AND DISCUSSION

Aerial surveys covering the potential salmon spawning grounds of the Tanana River above Delta Junction, Alaska, were conducted from early October to early November 1976. This period should have bracketed the peak spawning periods for fall chum and coho salmon. In addition, spot checks were made where the Alcan Highway and Haines Pipeline crossed tributary streams.

No salmon were observed in the Tanana River or its tributaries above the known major spawning areas near Bluff Cabin Slough, east of Delta Junction. A number of springs and clear sloughs and channels, similar in appearance to areas utilized in lower parts of the river, were noted, but there was no evidence of salmon usage in 1976. The scattered salmon or occasional pair could have been overlooked, but it is unlikely that any concentrations were missed, since visual and flying conditions were for the most part good and known salmon areas near Big Delta were readily apparent by the presence of the fish themselves and their predators and scavengers. Holden (Bio/West, Inc., 1976) captured no fingerling salmon in summer sampling of fish populations in tributary streams.

Based on observations of a few salmon spawning in 1975, local reports, the presence of associated animals in 1976, and the apparently ideal conditions, the upper Chisana River undoubtedly supports at least a small chum salmon run. The Nabesna River seemed to present a similar situation and likely sustains a salmon run during some years. An area on the Tanana River near the mouth of the Tetlin River appeared to present good spawning conditions and local Indians have reported salmon spawning there in the past. Crystal Springs, near Tanacross, and Sam Creek also appeared to offer potential although no salmon have been reported there nor were any observed in 1976.

Whitefish, principally the humpback (Coregonus pidschian) and round (Prosopium cylindraceum) are common residents of this area (Pearse, 1975) and are fall breeders, migrating out of the lakes and large rivers into the smaller tributaries for spawning. Although whitefish are more difficult to see than salmon, under the ideal conditions for most of the survey period, spawning aggregations should have been detectable in the small, clear streams. No whitefish were observed.

In terms of how weather and escapement may have influenced the abundance of salmon and the observations presented, the following may be of pertinence. As to climatology, 1976 was an unusually mild fall for interior Alaska. There was relatively little snowfall and temperatures in the 40's were recorded into early November. This warm weather caused the glacial rivers to be less clear than usual, in particular, the Tanana was somewhat murky through October with probably less snow and ice cover than normal.

Escapements of fall chums in 1976 to several Yukon River tributaries were much lower than in other recent years. Counts in the Sheenjek River were only 12,000 compared to 78,000 in 1975 and 40,000 in 1974; the Toklat had 20,000 in 1976 compared to 34,000 in 1975, but only 7,000 in 1974; Fishing Branch River had only 9,000 in 1976 compared to 353,00 in 1975 and 32,000 in 1974. However, the Delta River in 1976 had about an average count of nearly 5,000 compared to 4,000 in 1975 and 1974 and 8,000 in 1973; Bluff Cabin Slough had 4,000 in 1976 compared to 5,000 in both 1975 and 1974. It thus appears that while escapements to some major spawning areas were drastically reduced, those to the known spawning areas of the Tanana were near normal and lack of salmon in upstream areas cannot be ascribed to below average escapement. However, a very large run undoubtedly would force salmon further upstream to find spawning areas -- a situation that may prevail during some years. If survival in such upstream Tanana systems as the Chisana should be similar to the Sheenjek or Fishing Branch Rivers, then we may have witnessed in 1976 the results of extremely poor survival conditions.

Superficially the Delta, Gerstle, Johnson and Robertson Rivers appear to be similar glacial, braided streams, but the Delta supports a significant chum salmon run while the others apparently do not. One obvious difference was noted between the Delta and the others that may be related to the success of salmon spawning and egg incubation and survival. The Delta River in the winter originates from a series of springs discharging in the lower 3/4 mile (See Figure 13). Above that point the river bed is completely dry and frozen; in the lower section the river is open and flows all winter with salmon spawning in abundance throughout the area. The other rivers have spring flow in the upper areas, but the lower areas at the mouth were completely ice covered as of November 6. The Robertson River, in particular, flows year-round with mile after mile of ideal appearing spawning gravel in the upper areas, but the lower 1 1/2 miles below the highway bridge was largely ice covered with no evidence of visible flow or groundwater discharge in that area (Figure 7). The Johnson River likewise presented a picture of some potential spawning areas in the upstream areas, but with the mouth frozen over and no visible flow, (Figure 8). The Gerstle River was completely frozen over at the mouth and for a distance of some 15 miles.

Winter observations in future years should be made on these glacial streams to determine mid-winter flows and to test the hypothesis that the lack of groundwater upwelling in the lower areas and icing over at the mouth precludes chum salmon utilization. Brook trout (Salvelinus fontinalis) are able to detect and select areas of upwelling spring water for spawning, even using heavily silted bottom if groundwater is available (Webster and Eiriksdottir, 1976), and it appears that chum salmon may exhibit a similar behavior.

Further surveys should be made on those areas of most promise such as the upper Chisana River and mouth of the Tetlin River. Annual fluctuations in abundance of salmon populations or cycles could account for the apparent absence of spawners this year and the streams should be rechecked in subsequent years. Spring areas such as from Tanacross to Crystal Springs, Sam Creek, and those on the Robertson River should be examined throughout the season as they may be important in terms of rearing and wintering areas for salmonid juveniles. Since some of these spring areas are near the pipeline right-of-way, further studies may justify their classification as sensitive areas. Further research should also be done on the main-stem Tanana, via a netting program, to determine if salmon use it during the summer and early fall.

CONCLUSION

Based on the results of this survey of potential salmon spawning areas of the upper Tanana River basin, and other presented evidence, it can be concluded that there were few salmon spawning between Delta Junction and the Canadian border during the fall of 1976. Scattered spawners could have been missed, but certainly there were no important concentrations as indicated not only by the lack of fish, but also by the lack of salmon predators and scavengers at the expected peak of spawning. The areas that appear to have the most potential for utilization by spawning salmon are not near the pipeline right-of-way. Thus, the impact on Yukon River salmon resources of the proposed Alcan natural gas pipeline above Delta Junction could be considered negligible.

ACKNOWLEDGMENTS

I greatly appreciate the assistance of ADFG biologists Kim Francisco and Fred Andersen in providing information on their work in progress and for reviewing a draft of this report.

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A L C A N   P I P E L I N E

S T U D Y   R E P O R T

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DEMOGRAPHIC SURVEY OF NATIVE COMMUNITIES LOCATED ALONG THE ALASKAN HIGHWAY

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Report prepared for and by contract to the ALCAN Pipeline Company through Gulf Interstate Engineering Company, Houston, Texas.

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PREFACE: Demographic Study of Native Communities Adjacent to the Alcan Highway

The following report is based on research undertaken as part of a series of social/cultural impact studies carried out under contract with Gulf Interstate Engineering Company on behalf of the ALCAN Pipeline Company, Dr. Larry L. Naylor and Dr. Lawrence A. Gooding, co-principal investigators. The ALCAN Pipeline Company has proposed a pipeline route for the transportation of Alaskan natural gas from the Arctic Slope of Alaska to consumers in the lower forty-eight states. While the ALCAN proposed route traverses portions of Alaska, Canada and the continental United States, the studies being done under the present contract concentrate only on the State of Alaska. The primary purpose of the social/cultural impact studies is to identify those impacts to cultures and communities along the proposed route in Alaska that would be brought about by the project.

During the initial phase of the social/cultural impact studies, the major goals have been: to locate and evaluate existing information on all pipeline impacts in the state; to gather together existing materials on the actual cultures and communities that would be impacted; and, to begin the process of acquiring baseline information. With respect to the first two of the goals, a bibliography has been produced on both pipeline impacts and the ethnographic materials available on the cultures and communities that have already been impacted or will be impacted by additional pipelines. Our immediate concern with respect to the last goal, has been the acquisition of basic demographic data on the populations and communities contiguous to the proposed route, particularly along the southern portion of the Alaskan segment of the eventual pipeline. The lack of reliable demographic information on the native communities is especially apparent from any review of the existing literature. The following report which emphasizes the native communities located along the Alcan Highway has been done in response to that need.

The demographic study represents the culmination of work done by a variety of persons and the contributions of many others. The project was under the direction of the co-principal investigators who also completed the initial preparations for the study in the communities and directed the fieldwork phase. The bulk of the effort in tabulating and analyzing the data accumulated was done by Dr. G. Richard Scott, physical anthropologist, University of Alaska. The task of actually gathering the data in the field was accomplished by Charles Deburlo and Brian Stocklin, graduate students in anthropology at the University of Alaska. The assistance of the Tanana Chiefs Conference and their representatives is gratefully acknowledged. The study would not have been possible without the support, time and effort of the community leaders and inhabitants who supplied the data on which the study report is based. The co-principal investigators take full responsibility for any deficiences in the report which might be present.

University of Alaska — Larry L. Naylor

Fairbanks, Alaska — November 18, 1976

INTRODUCTION

When studying the potential social/cultural effects of such an activity as the construction and maintenance of a pipeline, a first prerequisite is to delineate the specific populations and communities that would be impacted. Under most circumstances, this would normally entail some review of the available census data. In unusual cases where a population census is lacking, or where the existing material is demonstrated as unreliable, the accumulation, tabulation, and analysis of the populations are necessary and of immediate concern. With specific reference to the native communities of Norway, Tetlin, Dot Lake and Tanacross, the census material was found to be deficient. This deficiency, when combined with recent events which have caused substantial fluctuations in populations of native communities, determined the need to correct and update existing demographic information. In view of the peculiar circumstances, the study focused on the native populations and communities. Beyond the basic demographic information accumulated, the study also made some attempt to assess the community infrastructure for each of the communities under scrutiny.

The need for current and in-depth studies of these communities is also recognized and proposals have been submitted to undertake such study. In order to place the present report in some perspective, a brief description of the communities under consideration will be presented, as well as some discussion of the survey form utilized and circumstances of data accumulation. Sketch maps for each community are presented as Appendix I.

Village Descriptions

All four of the villages studied lie within the confines of the Doyon Corporation and Tanana Chiefs Conference areas of responsibility. Virtually all of the native inhabitants in the area are interior Athabascans, but diversity within this general culture group is evident. The diversity reflects the unique histories and experiences of each community. Such events as the construction of the Alcan Highway have effected each community but in slightly different ways. The history of culture contacts has been different in each separate case. Some natives in the area have lived under the special status of the Alaskan native (as free citizens with full citizenship status without being wards of the government) while others have lived within the confines of the established reservation system and as wards of the government. A detailed review of the actual history of these communities is beyond the scope of this particular study. In lieu of this, only the brief outlines below are possible.

Dot Lake: Dot Lake is located just off the Alcan Highway approximately 40 miles from Tok and some 167 miles southeast of Fairbanks, Alaska. While the community exhibits a high level of traditional culture activity, because of its location directly on the Alcan Highway, it also exhibits a high degree of acculturation owing to the extensive culture contact facilitated by the highway. The community is made up of a mixed population of native and white Euro-Americans with the native segment in the majority. As a result of the Alaska Natives Claims Settlement Act, the Dot Lake Native Corporation controls some 69,120 acres of land. Historically, the existence of Dot Lake has been attributed to the construction of the highway.

Tanacross: This community is also located just off the Alcan Highway, some 12 miles from Tok and 196 miles southeast of Fairbanks. As the original settlement of 1912 located the village on the north bank of the Tanana River, it must be pointed out that the village has recently completed a resettlement across the river and adjacent to the airfield also located in the area. The population of Tanacross, as with Dot Lake, is predominantly native. Even though the community has been in close proximity to the highway, it has only been recently this has been established in a direct sense, thus the amount of culture contact and history is different for this community as compared to others. As a result of the Alaska Native Claims Settlement Act, Tanacross Incorporated presently controls some 92,160 acres of land. As with Dot Lake, Tanacross exhibits substantial acculturation while at the same time the people continue to pursue a native and traditional lifestyle.

Tetlin: Tetlin is actually located on the Tetlin River within the confines of the Tetlin Reservation, some 20 miles southeast of Tok. While not presently connected by road to the Alcan Highway, discussions have been occurring for some time about this eventuality. The village is inhabited almost entirely by natives, who have elected to pursue the more traditional native lifestyle. Even with this trend toward the more traditional pattern, the people do exhibit a degree of acculturation toward the Euro-American lifestyle. A significant difference between this community and others included in the study resides in the fact that the people of Tetlin have elected to retain their reservation status and, thus do not presently share in the native claims settlements.

Northway: While natives have inhabited the general area of the present village, Northway did not actually become an established village until

World War II. During this period, the highway was constructed and an airfield, with accompanying FAA complex was established in the area. The community closely followed these two events. Today, Northway is physically and ethnically divided into two parts. A relatively stable, yet transitory white population is present to staff the FAA complex. This group, housed in government facilities on the complex is located some seven miles from the Alcan Highway. Because of the nature of this group, excepting for their inclusion in the total population figures presented in the study, they have not been analyzed in detail. The other part of Northway, located some two miles apart from the FAA complex, is composed largely of natives.

Census Form

The primary objective of the demographic phase of the ALCAN pipeline social/cultural impact survey was to delineate the population, socioeconimic, and general village charaterisitcs of Northway, Tanacross, Tetlin, and Dot Lake, Alaska. To facilitate this goal, data collection forms were designed, in part, according to the standard methodology for total household canvassing (Bogue, 1969). However, considering the nature of the communities and the kinds of information desired, the forms were adapted to collect other types of data not obtained from a standard census form. Examples of these forms for household and village charateristics are presented as Appendices II and III.

The initial step of the survey was to determine the individual composition of the village populations by age, sex, and ethnic group. These data can be obtained directly from the household census forms. The advantage of collecting data by households is apparent in that it is also possible to tabulate the number, composition, and size of the actual household units. In terms of job-related information, the maximum potential work force of the villages can be estimated from the population data. Other socioeconomic data were obtained through questions on: (1) educational attainment, (2) job skills/training and work experience, (3) the relative importance of subsistence and wage labor activities to total "income," and (4) the seasonal basis of subsistence activities and wage employment.

Village characteristics were updated and expanded from a previous survey by the Fairbanks Town and Village Association, Rural Information Program (October 1975). Descriptive information for each village was obtained on housing, roads and trails, retail services, governmental agencies, health services, schools, churches, communication systems, and water-sewerage systems. These updated village characteristics are presented as Appendix IV.

Procedure

Prior to the actual data gathering or fieldwork phase of the study, contacts were established with the Tanana Chiefs Conference as well as the leadership within the communities to be surveyed. During on-site trips to each individual community, careful attention was given to making sure that each community understood what the study was for, what information was being sought, and how participation would potentially effect the community. Together with the local leadership, agreements were made as to how best to do the survey and by whom it would be done. It was arranged that the survey team would be augmented with a native assistant from the community to help in the data gathering. Native assistants were to be paid for the time and

and effort spent in assisting in the study. Upon entry to a community, the team would contact a specified person who would help them in obtaining the native assistant as well as to help them in their ultimate task. All communities agreed to support the research effort being proposed.

Upon arrival within the community to be surveyed, the research team contacted the individual previously arranged for who would assist them or facilitate the study within the community. Together with a local native assistant the team collected the demographic information. Attempts were made to locate and speak with every individual by visiting each household in or nearby the community. Native assistants were particularly helpful in this regard because of their familiarity with the area and the village residents. For individuals not actually present in the village at the time of the survey, assistants or other native informants were able to provide the necessary information. Normally, individuals were quite willing to be interviewed and responded readily to the questions of the interviewers. Before commencing each interview, the surveyors explained what they were doing, how it was being done and the value to the individual. Only verbal responses were solicited during the interviews. These verbal responses were written down by the surveyors on the prepared forms. In addition to the gathering of demographic data, the surveyors also made inventories of community infrastructures and prepared sketch maps for each individual community visited. A total of five days were spent in the gathering of the raw census material. The raw data was then tabulated and analyzed utilizing a variety of techniques, to include both visual and computer tabulations.

POPULATION CHARACTERISTICS

The individual composition of the villages of Northway, Tanacross, Tetlin, and Dot Lake, broken down by age category, sex, and ethnic group, is shown in Tables 1 - 4. Northway, with a population of 215 (excluding individuals in the FAA complex), is almost twice as large as Tanacross (125) and Tetlin (112) and is more than three times as large as the small village of Dot Lake (63). Below, these data are compared to the population numbers for these villages compiled during the last three national censuses:

Figure I - Population Statistics

	Village				
Year	Northway	Tanacross	Tetlin	Dot Lake	Total
1950	196	137	73	-	406
1960	196	102	122	56	476
1970	40* (190)	84	114	42	280* (430)
1976	215	125	112	63	515

*Only counted 30 whites and 10 natives in FAA complex; later estimate of 190 individuals in Northway village (minus FAA complex) used to calculate revised total population estimate of 430 in 1970.

In comparing the 1970 census with the current study results, a number of discrepancies can be noted. While the actual differences in population for Tanacross and Dot Lake could be accounted for on the basis of internal population growth and immigration between 1970 and 1976, the Northway census data is patently incorrect. The 1970 census takers enumerated on the white segment of the population and overlooked the largest component of the community which was comprised primarily of natives. The physical division of the community probably led to this oversite.

The Tanana Chiefs Health Authority undertook their own demographic survey in 1975 (Cathie Ipalook, personal communication), and the data they obtained showed some differences from the numbers derived from the present study. The Health Authority reported a total of 200 natives for Northway; 100 natives for Tanacross, 113 natives for Tetlin and 87 natives for Dot Lake. Ethnic groups were not considered in the survey. Some problems and inconsistencies were noted for this survey and thus the survey was not given detailed consideration in this present study. It might be useful to point out that a notable difference appears for the village of Dot Lake which might be reconciled if the individuals in the Dot Lake Orphanage and lodge are added to the population count obtained in this study (63 + 16 = 78). A significant difference also exists in the figures reported for the village of Tanacross.

Over the last 25 years, the population of Northway has remained stable. Stability in numbers also characterizes Tetlin and Dot Lake over the past 15 years, although Tetlin did show a major increase between 1950 and 1960. There is no 1950 census for Dot Lake as this village was not established until 1954. Tanacross exhibits the greatest fluctuation in population size with a trend to decreasing numbers from 1950 to 1970 followed by a resurgence between 1970 and 1976. In the near future, the population of Tanacross will increase by another 10 percent upon the completion of a new housing project.

The total village population count of 515 does not include 22 transient personnel working at the FAA complex in Northway or the 15 individuals at the North Star Orphans' Home located outside of Dot Lake. If these numbers are added to 515, the population would be 552.

Table 1. Population census of Northway, Alaska, by age category, sex, and ethnic group.

	Ethnic group											
	Native			White			Miscellany			Total		
Age category	M	F	T	M	F	T	M	F	T	M	F	T
0-1	2	0	2	0	0	0	0	0	0	2	0	2
1-4	7	8	15	1	0	1	0	0	0	8	8	16
5-9	11	7	18	3	2	5	0	0	0	14	9	23
10-14	11	14	25	0	0	0	0	0	0	11	14	25
15-19	11	14	25	0	2	2	0	0	0	11	16	27
20-24	8	12	20	1	1	2	2*	0	2	11	13	24
25-29	11	8	19	0	0	0	0	0	0	11	8	19
30-34	4	5	9	2	1	3	0	0	0	6	6	12
35-39	6	1	7	2	1	3	0	0	0	8	2	10
40-44	6	3	9	0	0	0	0	0	0	6	3	9
45-49	5	2	7	1	0	1	0	0	0	6	2	8
50-54	1	3	4	1	0	1	0	0	0	2	3	5
55-59	1	1	2	0	0	0	0	0	0	1	1	2
60-64	0	3	3	1	0	1	0	0	0	1	3	4
65-69	2	2	4	0	0	0	0	0	0	2	2	4
70+	3	6	9	0	0	0	0	0	0	3	6	9
TOTAL	89	89	178	12	7	19	2	0	2	103	96	199+

*Navajo and Puerto Rican males

Census does not include: FAA personnel (22)

6 adults (4 male, 2 female), 10 children (1 male, 7 female, 2 unknown sex)

+Total population: 215 (108 male, 105 female, 2 unknown sex)

Table 2. Population census of Tanacross, Alaska, by age category, sex, and ethnic group.

	Ethnic group											
	Native			White			Miscellany			Total		
Age category	M	F	T	M	F	T	M	F	T	M	F	T
0-1	2	3	5	0	0	0	0	0	0	2	3	5
1-4	5	3	8	0	0	0	0	0	0	5	3	8
5-9	5	6	11	0	0	0	0	0	0	5	6	11
10-14	5	4	9	0	0	0	0	0	0	5	4	9
15-19	1	3	4	0	0	0	0	0	0	1	3	4
20-24	10	9	19	1	0	1	0	0	0	11	9	20
25-29	10	10	20	3	0	3	0	1*	1	13	11	24
30-34	5	2	7	0	1	1	0	0	0	5	3	8
35-39	3	0	3	0	0	0	0	0	0	3	0	3
40-44	5	0	5	0	0	0	0	0	0	5	0	5
45-49	4	3	7	0	0	0	0	0	0	4	3	7
50-54	2	4	6	0	0	0	0	0	0	2	4	6
55-59	0	1	1	0	0	0	0	0	0	0	1	1
60-64	4	1	5	0	0	0	0	0	0	4	1	5
65-69	1	1	2	0	0	0	0	0	0	1	1	2
70+	3	3	6	1	0	1	0	0	0	4	3	7
TOTAL	65	53	118	5	1	6	0	1	1	70	55	125

*Sioux female

Census does not include: individuals scheduled to move into newly constructed houses (6 adults, 6 children)

Table 3. Population census of Tetlin, Alaska, by age category, sex, and ethnic group.

	Ethnic group											
	Native			White			Miscellany			Total		
Age category	M	F	T	M	F	T	M	F	T	M	F	T
0-1	2	0	2	0	0	0	0	0	0	2	0	2
1-4	5	2	7	0	0	0	0	0	0	5	2	7
5-9	8	2	10	0	0	0	0	0	0	8	2	10
10-14	8	7	15	0	0	0	0	0	0	8	7	15
15-19	5	6	11	0	0	0	0	0	0	5	6	11
20-24	4	5	9	0	0	0	0	0	0	4	5	9
25-29	4	2	6	0	0	0	1*	0	1	5	2	7
30-34	6	2	8	0	0	0	0	0	0	6	2	8
35-39	0	0	0	0	0	0	0	0	0	0	0	0
40-44	1	1	2	0	0	0	0	0	0	1	1	2
45-49	1	3	4	0	0	0	0	0	0	1	3	4
50-54	4	1	5	0	0	0	0	0	0	4	1	5
55-59	0	0	0	0	0	0	0	0	0	0	0	0
60-64	1	2	3	0	0	0	0	0	0	1	2	3
65-69	0	1	1	0	0	0	0	0	0	0	1	1
70+	3	3	6	0	0	0	0	0	0	3	3	6
TOTAL	52	37	89	0	0	0	1	0	1	53	37	90+

*Eskimo male

Census does not include: 11 adults (5 male, 6 female), 11 children (3 male, 2 female, 6 unknown sex)

+Total Population: 112 (61 male, 45 female, 6 unknown sex)

Table 4. Population census of Dot Lake, Alaska, by age category, sex, and ethnic group.

	Ethnic group											
	Native			White			Miscellany			Total		
Age category	M	F	T	M	F	T	M	F	T	M	F	T
0-1	0	1	1	0	0	0	0	0	0	0	1	1
1-4	3	3	6	1	0	1	0	0	0	4	3	7
5-9	2	4	6	0	0	0	0	0	0	2	4	6
10-14	5	2	7	0	4	4	0	0	0	5	6	11
15-19	0	2	2	0	1	1	1*	0	1	1	3	4
20-24	2	1	3	0	0	0	0	0	0	2	1	3
25-29	1	0	1	0	0	0	0	1+	1	1	1	2
30-34	1	1	2	0	1	1	0	0	0	1	2	3
35-39	3	1	4	2	2	4	0	0	0	5	3	8
40-44	0	2	2	1	1	2	1°	0	1	2	3	5
45-49	2	0	2	0	0	0	0	0	0	2	0	2
50-54	0	0	0	0	1	1	0	0	0	0	1	1
55-59	0	0	0	0	1	1	0	0	0	0	1	1
60-64	2	1	3	1	0	1	0	0	0	3	1	4
65-69	0	0	0	0	1	1	0	0	0	0	1	1
70+	1	2	3	1	0	1	0	0	0	2	2	4
TOTAL	22	20	42	6	12	18	2	1	3	30	33	63

*Eskimo male
+Sioux female
°Polynesian male

Census does not include: North Star orphan's home (5 adults, 10 children)
Lodge (1 adult male)

Age Composition

In terms of the age profile, the median age of the natives from the four villages is 22 years. This is significantly higher than the median age of 18 years for all Alaskan natives in 1970. The median ages for the natives in the individual villages are: Northway - 20.5, Tanacross - 25.5, Tetlin - 19, Dot Lake - 15.5. These medians are altered only slightly for the first three villages if all ethnic groups are considered, but there is a notable change for the Dot Lake population from 15.5 to 24 years. Dot Lake has the highest proportion of non-natives and the median age for this segment of the population is 34 years. When the young native component and older non-native component are considered together, the median for the total Dot Lake population assumes an intermediate value (24). Besides the median age of Dot Lake, Tanacross is distinctive in having a relatively high median age of 25.5 years.

The median age of 22 years indicates the four villages are transitional between a young and growing pre-industrial population (median age 15 - 19 years) and an older, more stable modern population (median age 24 - 29 years). To illustrate, the median age of the pre-industrial United States population of 1800 was 16.0 years, whereas, following a long period of industrialization, urbanization, and population stabilization, the median age in the United States in 1960 was 29.5 years (Peterson, 1969).

Another demographic measurement instructive in showing the age of a population is the percent of individuals under the age of 15 years. Consider the summary data on the measurement taken from Peterson (1969) for the populations of major geographic regions when compared to Alaskan natives in 1970 and the combined figure for the four interior Athabascan populations:

Figure 2 - Population Summary

Africa	Asia	Latin America	Europe	United States	All Native Alaskans (1970)	Four Village Populations
43	40	42	25	31	43.6	34.8

Underdeveloped and developing third world countries have variable crude death rates but both are characterized by high birth rates. In these young and growing populations, over 40 percent of the individuals are under the age of 15 years. In sharp contrast, modern industrialized countries have lowered both the birth and death rates with the resultant being older, more stabilized populations with only 25 - 30 percent of the total under the age of 15 years. While the general Alaskan native population of 1970 is aligned with third world countries with an "under 15 years" percent of 43.6, the four Athabascan village populations have a mean percentage of 34.8 for the under 15 category which is intermediate relative to the figures for underdeveloped or developing countries in Africa, Asia, Latin America, and modern western countries. Native Athabascan groups along the Alcan Highway are clearly in the transitional stage between these extremes: they are gradually lowering birth rates through birth control and family planning, at the same time they are also lowering death rates through improved medical services.

The inter-village variation in the under 15 age category breaks down as follows: Northway 35.3%, Tanacross - 26.4%, Tetlin - 40.2%, Dot Lake - 39.7%. The relatively high percentage for Tetlin and the intermediate percentage for Northway conform to the different acculturative statuses of these villages. That is, Northway has a history of more intensive contact with Euro-American society which has more strongly influenced the birth and death rates in this village than is true for the more traditional and less impacted village of Tetlin. Because of the small population size and the recency of settlement, the high percentage of individuals under 15 years at Dot Lake does not necessarily indicate a traditional population such as Tetlin. More likely, the high percentage is reflective of a heterogeneous (high percent of non-natives) and unstabilized population. The exceptionally low percentage for the under 15 age category at Tanacross is deserving of further study as this parallels closely the figure for highly industrialized populations. The same situation applies to the higher median age category (25.5 years) for Tanacross relative to the other villages. This finding is important insofar as the varying age compositions correlate directly with the potential work forces and proportions of dependents in the villages. This, in turn, suggests the potential for differential impact through intensive construction activities.

Sex Ratio

The sex ratio for a population is computed by dividing the total number of males by the total number of females and multiplying this quotient by 100. The 1970 census indicates a sex ratio of 105.6 for all Alaskan natives (28,100 males, 26,604 females) which is slightly lower than the ratio of 111.6 for the combined native population of the four villages (241 males, 216 females). When individuals of other ethnic groups are considered along with native Athabascans, the sex ratios for the four villages are: Northway - 102.9, Tanacross - 127.3, Tetlin - 135.6, Dot Lake - 90.0. While the Northway and Dot Lake populations include an almost equal number of males and females, Tanacross and Tetlin both have approximately 25 percent more males than females in their village populations. This inter-village variation has implications regarding the nature of the work force (and associated types of skills) and also prospective social/cultural impacts.

A finer breakdown of the sex ratios for the village populations is shown in Table 5. Considering this ratio for only natives in the villages, Tetlin is unusual in having twice as many males as females under the age of 15 years but an almost equal number of males and females above this age. The other three villages, although varying to some degree in overall sex ratios, show a pattern of increase in the sex ratio from the below 15 to above 15 age categories. This may reflect the suggestion that young adult females in rural Alaskan villages have more mobility than their cohort males (Berremen, 1965; Taylor, 1966; Milan, 1970; Milan and Pawson, 1975). That is, females are more successful than males in moving to urban centers and finding employment and/or spouses.

Data on the native population of Fairbanks, Alaska, collected by Milan and Pawson (1975) clearly reflects the difference between native males and females in migrating from rural to urban communities. In 1968 - 70, 1,029 natives resided in Fairbanks and, of these, there were 473 males and 556 females (sex ratio = 85). With respect to the native villages under consideration, the age category most critical for marriage and reproduction (21 - 30 years), there were 64 males and 107 females (sex ratio = 60). It should be noted that for the total village populations, the sex ratio imbalance is insignificant in the 20 - 29 age category (50 males:47 females, S.R. = 106), but is pronounced in the 30 - 49 age category (52 males:26 females, S.R. = 200). In any event, the actual and potential differential in male-female emigration from the native villages warrants further in-depth study because of the disruptive effect it could have (and may be having) on mating and reproduction, therefore village life in general.

Table 5. Sex ratio (Male/Female X 100) in villages of Northway, Tanacross, Tetlin, and Dot Lake, Alaska, by age category and ethnic group.

		Ethnic group		
Village	Age category	Native	White	Total*
Northway	<15	88.9	200.0	94.7
	≥15	100.0	160.0	107.5
	Total	95.9	171.4	102.9
Tanacross	<15	106.3	-	106.3
	≥15	129.7	500.0	135.9
	Total	122.6	500.0	127.3
Tetlin	<15	200.0	-	200.0
	≥15	106.3	-	109.4
	Total	133.3	-	135.6
Dot Lake	<15	100.0	25.0	78.6
	≥15	120.0	62.5	100.0
	Total	110.0	50.0	90.0

*Although sex ratios are not presented for the miscellany category due to small sample sizes, individuals from this category are included in the overall sex ratio for each village.

Ethnic Composition

The data on ethnic composition shown in Table 6 reflect the percentage of native Athabascans to the total village populations. The two extreme populations for this demographic characteristic are Tetlin and Dot Lake. In the former village, 99.2 percent of the population is native Athabascan whereas one-third of the Dot Lake population is derived from non-Athabascan ethnic groups (primarily American whites). Between these two extremes, but falling closer to Tetlin than to Dot Lake, are the villages of Tanacross and Northway where 94.4 percent and 90.1 percent of the populations, respectively, are of interior Athabascan derivation. These percentages differ very little from those of the 1970 census which were: Tanacross - 91.7%, Tetlin - 94.7%, Dot Lake - 69.0%. This census which also indicated that only 10 of 40 individuals in Northway were native Alaskans was in error as noted earlier. The total percent of native Athabascans in the four villages in 1976 is 90.3%.

Table 6. Ethnic composition in villages of Northway, Tanacross, Tetlin, and Dot Lake, Alaska, by age category and sex. Measurement indicates percent of native Alaskan Athabascans to total population.

		Alaskan Athabascan (%)		
		Age category		
Village	Sex	<15	≥15	Total
Northway	M	88.9	86.1	87.0
	F	94.7	92.5	93.3
	Total	91.9	89.2	90.1
Tanacross	M	100.0	90.6	92.9
	F	100.0	94.9	96.4
	Total	100.0	92.4	94.4
Tetlin	M	100.0	97.1	98.4
	F	100.0	100.0	100.0
	Total	100.0	98.5	99.2
Dot Lake	M	90.9	63.2	73.3
	F	71.4	52.6	60.6
	Total	80.0	57.9	66.7

Work Force and Dependency Ratio

The Maximum potential work force in the four interior villages as measured by the number of individuals between the ages of 15 and 65 years is shown in Table 7. These numbers provide only a general estimate of the individuals that actually could or would work in some capacity. They underestimate the work force insofar as some five to six percent of the individuals in the four villages below the age of 15 years and above the age of 65 years are involved in subsistence activities and/or wage labor employment. The numbers overestimate the force in that some individuals between 15 and 65 might be physically unable to work or choose not to work (at least in terms of wage labor) for various reasons.

Table 7. Maximum available work force (all individuals between 15 and 65 years of age) in villages of Northway, Tanacross, Tetlin, and Dot Lake, Alaska, by sex and ethnic group.

		Ethnic group			
Village	Sex	Native	White	Miscellany	Total
Northway	M	57	8	2	67
	F	54	5	0	59
	Total	111	13	2	126
Tanacross	M	44	4	0	48
	F	33	1	1	35
	Total	77	5	1	83
Tetlin	M	31	0	1	32
	F	28	0	0	28
	Total	59	0	1	60
Dot Lake	M	11	4	2	17
	F	8	7	1	16
	Total	19	11	3	33

With the above limitations in mind, the total work force in the villages of Northway, Tanacross, Tetlin, and Dot Lake is 302 individuals. This number represents 58.6 percent of the total village populations (by village the work force percentages are: Northway - 58.6%; Tanacross - 66.4%; Tetlin - 53.6%; Dot Lake - 51.6%). The total work force percent of these villages exceeds that of 52.9 percent reported for all Alaskan natives in 1970.

A converse measure of the work force commonly computed is the dependency ratio or the number of individuals less than 15 years plus the number of individuals over 65 years divided by the number of individuals between 15 and 65 years times 100. This ratio of dependents to the potential work force is primarily a reflection of the key parameters that determine the nature of a population profile, i.e. crude birth rates and crude death rates. In underdeveloped third world countries with high birth rates and high death rates, the dependency ratio varies between 90 and 100 (about half of the population is in the work force with the other half as dependents). In developing countries where the birth rate is still high (35 - 45 per 1,000) but the death rate has been lowered significantly, the dependency ratio has also been lowered to the 80 - 90 range. Finally the modern industrial countries where both birth rates and death rates have been lowered, the dependency ratio is further reduced to the 50 - 60 range. The work force comprises about two-thirds of the total population. In 1970, the dependency ratio for all Alaskan natives was 89.0

Considering the four village populations, the dependency ratios are: Northway - 70.6; Tanacross - 50.6; Tetlin - 86.7; Dot Lake - 90.0. These ratios, not surprisingly, reflect the same phenomenon as the percentages for the under 15 age category. That is, the dependency ratios for Tetlin and

Dot Lake are in the range for developing/underdeveloped countries while that for Tanacross aligns with the ratio for modern industrialized countries. Northway is intermediate between these extremes in showing the ratio of 70.6 which is very similar to the mean dependency ratio of 70.5 for all the villages. Again, the overall characterization of the villages illustrates their transitional status as through time an increasingly larger proportion of the populations are in the age range of the work force.

HOUSEHOLD CHARACTERISTICS

In Tables 8 - 11, the households in Northway, Tanacross, Tetlin, and Dot Lake, respectively, are broken down by number and mean size for twelve household categories and three mating types. Categories 1 - 3 represent husband-wife families, 4 - 7 represent incomplete families, and 8 - 12 refer to non-families. Although native households are predominant in the four villages (101/126, 78.9%), white and mixed households are also shown. The mixed households are classified as such when the spouses come from different ethnic groups. This generally indicates white-native marriages but a few miscellany (e.g. Polynesian) native marriages are also represented.

Mean household size in the villages varies between 3.7 at Tanacross to 4.5 at Tetlin. Northway and Dot Lake, with mean household sizes of 4.0 and 4.2, respectively, are intermediate to Tetlin and Tanacross. Again, the village of Tetlin is demographically distinctive in having the largest households which corresponds to their more traditional status. With its reduced household size, Tanacross most closely approximates the condition of modern industrial populations. Mean household size for the villages combined is 4.0 persons/household.

Figure 3 - Explanation of household categories in Tables 8 - 11.

Household category	Composition
1	mating pair + children + grandparent(s)
2	mating pair + children
3	mating pair (no children)
4	single male + children + granparent(s)
5	single female + children + grandparent(s)
6	single male + children
7	single female + children
8	single male
9	single female
10	single males (no head of household)
11	single females (no head of household)
12	miscellany

Table 8. Household number and size in Northway, Alaska, by composition and ethnic group.

Household category*	Native No.	Native $\bar{x}$	White No.	White $\bar{x}$	Mixed+ No.	Mixed+ $\bar{x}$	Total No.	Total $\bar{x}$
1	4	4.8	0	-	0	-	4	4.8
2	20	5.5	2	4.0	7	5.7	29	5.9
3	1	2.0	1	2.0	0	-	2	2.0
4	0	-	0	-	0	-	0	-
5	0	-	0	-	0	-	0	-
6	1	3.0	0	-	0	-	1	3.0
7	5	2.6	1	3.0	0	-	6	2.7
8	5	1.0	1	1.0	0	-	6	1.0
9	1	1.0	2	1.0	0	-	3	1.0
10	1	2.0	0	-	0	-	1	2.0
11	2	2.5	0	-	0	-	2	2.5
12	0	-	0	-	0	-	0	-
Total	40	4.1	7	2.3	7	5.7	54	4.0

*see key 1 for explanation of household categories

+households are classified as mixed when head of household and spouse of head are from different ethnic groups

Table 9. Household number and size in Tanacross, Alaska, by composition and ethnic group.

Household category*	Native No.	Native $\bar{x}$	White No.	White $\bar{x}$	Mixed+ No.	Mixed+ $\bar{x}$	Total No.	Total $\bar{x}$
1	3	7.0	0	-	0	-	3	7.0
2	12	4.6	0	-	2	5.0	14	4.6
3	3	2.0	1	2.0	0	-	4	2.0
4	0	-	0	-	0	-	0	-
5	0	-	0	-	0	-	0	-
6	3	2.3	0	-	0	-	3	2.3
7	3	2.3	0	-	0	-	3	2.3
8	2	1.0	0	-	0	-	2	1.0
9	1	1.0	0	-	0	-	1	1.0
10	1	2.0	1	3.0	0	-	2	2.5
11	0	-	0	-	0	-	0	-
12	2	3.0	0	-	0	-	2	3.0
Total	30	3.7	2	2.5	2	5.0	34	3.7

*see key 1 for explanation of household categories

+households are classified as mixed when head of household and spouse of head are from different ethnic groups

Table 10. Household number and size in Tetlin, Alaska, by composition and ethnic group.

Household category*	Ethnic group: Native No.	Native $\bar{x}$	White No.	White $\bar{x}$	Mixed[+] No.	Mixed[+] $\bar{x}$	Total No.	Total $\bar{x}$
1	2	11.5	0	-	0	-	2	11.5
2	11	5.9	0	-	0	-	11	5.9
3	4	2.0	0	-	0	-	4	2.0
4	0	-	0	-	0	-	0	-
5	0	-	0	-	0	-	0	-
6	0	-	0	-	0	-	0	-
7	1	3.0	0	-	0	-	1	3.0
8	3	1.0	0	-	0	-	3	1.0
9	1	1.0	0	-	0	-	1	1.0
10	0	-	0	-	0	-	0	-
11	0	-	0	-	0	-	0	-
12	3	3.0	0	-	0	-	3	3.0
Total	25	4.5	0	-	0	-	25	4.5

*see key 1 for explanation of household categories

[+]households are classified as mixed when head of household and spouse of head are from different ethnic groups

Table 11. Household number and size in Dot Lake, Alaska, by composition and ethnic group.

Household category*	Ethnic group: Native No.	Native $\bar{x}$	White No.	White $\bar{x}$	Mixed[+] No.	Mixed[+] $\bar{x}$	Total No.	Total $\bar{x}$
1	3	4.7	0	-	0	-	3	4.7
2	2	3.5	2	4.5	5	5.2	9	4.7
3	0	-	1	2.0	1	2.0	2	2.0
4	0	-	0	-	0	-	0	-
5	0	-	0	-	0	-	0	-
6	0	-	0	-	0	-	0	-
7	1	3.0	0	-	0	-	1	3.0
8	0	-	0	-	0	-	0	-
9	0	-	0	-	0	-	0	-
10	0	-	0	-	0	-	0	-
11	0	-	0	-	0	-	0	-
12	0	-	0	-	0	-	0	-
Total	6	4.2	3	3.7	6	4.7	15	4.2

*see key 1 for explanation of household categories

[+]households are classified as mixed when head of household and spouse of head are from different ethnic groups

An illustrative method of characterizing various types of households is shown in Table 12. First, households are broken down into two general types: families and non-families. The "families" type is divided into husband-wife families and incomplete families (i.e. one spouse plus offspring) with incomplete families further broken down by sex of household head. The "non-families" type is subdivided only by the sex of the household head. In the table, the percentages of native household types are given for the four villages individually and are also combined to allow for comparison with similar percentages derived for American white and non-white (primarily American black) households of 1965 (Brogue, 1969).

Considering the percentages for the total native household types in camparison with United States white and non-white household data, the striking point in Table 12 is the similarity and intermediacy of the native percentages. The three groups have similar frequencies for the broad family and non-family household types as, for each, slightly more than 8 of 10 households is of the "family" type. While most of the family households are of the husband/wife type, the incomplete families for the three groups exhibit the same phenomenon regarding sex of the household head: three to six times as many of these households are headed by females. This, of course, reflects the occurrence of separation and/or divorce with the female generally retaining custody of the children.

The most revealing data in Table 12 are in the non-family household type. Although the three groups show similar total non-family percentages, the proportion of male to female heads of such households differs significantly. For United States whites and non-whites, almost twice as many females as males head non-family households but in native non-family households, this situation is reversed with males heading such households more than twice as often as females. This finding supports the comments made in an eariler section of this report. There are not enough marriageable females in the villages so a proportionately larger number of males in the villages head households without spouses. One aspect of this problem is reflected in the data on mixed marriages which will now be discussed.

Referring again to Tables 8 - 11, one can note that 15 of the 128 (11.7%) households of all types involves a mixed marriages with spouses of different ethnic backgrounds. If only husband-wife families are considered, this figure is 15 of 87 (17.6%). Not surprisingly, the two villages with the largest number of whites (Northway and Dot Lake) have the highest proportions of mixed households (7/54, 13.0%; 6/15, 40.0%, respectively). One very important piece of information on mixed households not shown in the tables is the ethnic background of each spouse. In 10 of 15 mixed households, the female is a native Athabascan and the male head is either American white (8), Puerto Rican (1), or Polynesian (1). In other cases, native males married Sioux (2) or American White (3) females. Thus, the mixed marriages are largely one-sided as the native females are the ones who are primarily pulled out of the marriageable pool. This fact, taken in conjunction with the native females greater success at leaving the village permanently to find work and/or spouses in urban communities, diminishes significantly the opportunity for the native male to marry and establish a husband-wife family household in the village. This problem is not an isolated one but appears to affect many rural Alaskan native communities. In his demographic study of the Konyag Eskimos of Karluk village on Kodiak Island, Taylor(1966) makes the following observation:

> ...almost certainly the primary influence on the emigration imbalance, has to do with the marriage of Karluk women to non-Karluk men, especially to Whites. Contact between Konyags and American society is still primarily with White men rather than women, especially in the village situation. Those few White women encountered are generally married. It is still exceptional for a Konyag man to marry a White woman, while marriage between Konyag women and White men has been relatively common for many years. Thus the male emigrant is more likely to be single and to be attempting the extremely difficult process of competing economically in White society. The female emigrant is more likely to enter White society as the wife of a White man and the adjustment she has to make, while by no means easy, is many times less difficult than that of the young male emigrant. In fact, there are in Karluk a number of young men who have made the attempt to move into White society, have found themselves overcome by the many difficulties of the situation, and have returned to re-immerse themselves in village life. (Taylor, 1966: 219).

Milan (1970) found a similar situation in the Wainright Eskimo population. Of the 41 females over the age of 20 born to now-living Wainright mothers, 10 of these married white males, 8 married Eskimo males from villages other than Wainright, 5 married Wainright males, and only 5 remained in the village unmarried. In contrast, of the 44 male cohorts over 20, none married white females and remained in (or returned to) the village. In addition, 13 left the village for the Army or employment outside, and, importantly, 13 remained in the village as unmarried males. To illustrate this phenomenon in an urban community, Milan and Pawson (1975) recorded 91 instances of mixed marriages in Fairbanks, Alaska: 77 involved non-native male - native female matings (83.7%) with only 14 native males marrying non-native females (15.2%)!

Large scale construction activities in this region will have two major effects that will only enhance the problem of the native male. First, these activities will provide training and employment opportunities for the females that will further increase their mobility and success in establishing permanent residence away from the village. Second, increased white-native interaction (as already evidenced in Northway and Dot Lake to some degree) will potentially lead to even more white male-native female marriages as, presumably, most of the construction workers brought in will be males.

Table 12. Characterization of native households in Northway, Tanacross, Tetlin, and Dot Lake, Alaska, by types of families and non-families and comparisons with United States white and non-white household types in 1965 (comparative data from Bogue, 1969)

Type of household	Total household no.=	Percent of household types: Northway (40)	Tanacross (31)	Tetlin (25)	Dot Lake (8)	Total native (104)	1965 census: U.S. white	U.S. non-white
Families		77.5	83.9	84.0	100.0	82.7	83.6	81.2
Husband-wife families		62.5	64.5	72.0	87.5	67.3	74.1	59.5
Incomplete families		15.0	19.4	12.0	12.5	15.4	9.5	21.7
male head		2.5	9.7	0.0	0.0	3.8	2.0	2.6
female head		12.5	9.7	12.0	12.5	11.5	7.5	19.1
Non-families		22.5	16.1	16.0	0.0	17.3	16.4	18.8
male head		15.0	12.9	12.0	0.0	12.5	5.5	7.7
female head		7.5	3.2	4.0	0.0	4.8	10.9	11.1

EDUCATION

On the census schedule, one question posed to members of the village populations was the highest grade of formal education completed. After these data were analyzed, it became evident that there were no significant inter-village or sex differences in the degree of formal education. However, considering the relatively recent emphasis on rural educational opportunities for Alaskan native communities, it is not surprising that a pronounced directional shift to more formal education in the younger age categories was found. The mean number of grades completed in formal education and the percentages of individuals completing at least 12 grades are shown below for all natives (males and females combined) in the four interior villages:

Figure 4 - Education Statistics

	AGE CATEGORY				
	20-29	30-39	40-49	50-59	60+
Number of individuals	86	33	24	21	44
Grades of formal education completed	10.9	9.3	6.8	4.9	0.8
Percent completing 12 or more grades	50.0	27.3	12.5	8.3	0.0

The data in the table illustrate in dramatic fashion the trend in increasing emphasis on formal education for native Alaskans over the past 60 years. Progressing from the oldest to youngest age categories, one can note that the percentage of individuals completing 12 or more grades of school just about doubles from one age category to the next. This trend will no doubt continue and it would not be surprising if the present 10 - 19 age category were to again ultimately double with 90 - 100% completing at least 12 grades. Thus, the transitional nature of the four village populations is again evident in the area of educational attainment. Educational attainment is also closely correlated to occupation and work experience.

OCCUPATIONAL SKILLS, WORK EXPERIENCE AND JOB TRAINING

To characterize the occupational/vocational skills and experience of the inhabitants of Northway, Tanacross, Tetlin, Dot Lake, 31 categories were delineated during the household survey to indicate job skills and work experience in each of the villages that indicated skill or experience in a given category are noted in Table 13. Some individuals noted more than one skill or area of work experience so they are represented in more than one category in the table. Conversely, some declared no job skills or experience in wage labor employment and thus are not noted.

The category deemed applicable in the greatest number of cases (39) is for general laborer which, of course, indicates work experience rather than a specific skill. The following four most common categories are more indicative of certain skills: carpenter (19), heavy equipment operator, including truck drivers (20), secretary-clerical (21), and maid/janitor (17). It is evident that the first two of these categories are male-dominated whereas the latter two fall primarily within the realm of female vocations. In fact, most of the skill/experience categories that are adequately represented exhibit a sexual dichotomy. It should be added that almost half of the categories (12/31) are represented by three or fewer individuals.

Table 13. Occupational/vocational skills of males and females in the villages of Northway, Tanacross, Tetlin, and Dot Lake, Alaska.

Skill		Village									
		Northway		Tanacross		Tetlin		Dot Lake		Total	
No.	Description	M	F	M	F	M	F	M	F	M	F
1	painter	3	0	0	0	0	0	0	0	3	0
2	welder	4	0	1	0	1	0	1	0	7	0
3	plumber	1	0	0	0	0	0	0	0	1	0
4	carpenter	8	1	5	0	5	0	0	0	18	1
5	carpenter's helper	4	0	0	0	4	0	1	0	9	0
6	laborer	15	5	15	1	1	2	8	2	39	10
7	pipefitter	1	0	0	0	0	0	0	0	1	0
8	mechanic	3	0	2	0	5	0	0	0	10	0
9	surveyor	2	0	1	0	2	0	0	0	5	0
10	heavy equipment operator	8	0	8	0	1	0	3	0	20	0
11	highway construction	1	0	1	0	1	0	2	0	5	0
12	warehouseman	0	0	0	0	0	0	1	0	1	0
13	cook	1	3	0	0	0	0	1	4	2	7
14	cook's helper	1	1	0	0	0	0	0	1	1	2
15	maid/janitor	1	3	1	8	1	2	1	0	4	13
16	secretary-clerical	0	10	0	6	0	2	0	3	0	21
17	teacher	0	3	0	2	0	1	0	0	0	6
18	teacher's aide	0	0	0	0	1	0	0	0	1	0
19	counselor	1	2	1	2	2	0	0	3	4	7
20	administrator	0	2	0	0	0	0	0	1	0	3

Table 13 (cont.).

Skill		Village									
		Northway		Tanacross		Tetlin		Dot Lake		Total	
No.	Description	M	F	M	F	M	F	M	F	M	F
21	businessman	2	2	0	0	1	0	1	1	4	3
22	airplane pilot	1	0	3	0	0	0	0	0	4	0
23	air traffic controller	1	0	0	0	0	0	0	0	1	0
24	firefighter	13	5	13	1	3	0	1	0	30	6
25	youth corps	3	10	2	0	0	3	2	1	7	14
26	health aide	0	2	0	0	1	1	0	2	1	4
27	adult aide	1	1	0	1	0	0	0	0	1	2
28	licensing agent	0	1	0	0	0	0	0	0	0	1
29	policeman	2	0	0	0	0	0	1	0	3	0
30	home service	0	1	0	0	0	0	0	0	0	1
31	missionary-priest	1	0	0	0	0	0	0	0	1	0

A total of 208 individuals indicated some skill and/or work experience. Of this number, five individuals were under the age of 15 years while an additional seven were over 65. If these twelve individuals are removed from the total, it can be stated that 64.9% (196/302) of the work force (15-65 years) notes at least one skill or area of work experience. Considering only the natives in the villages, these percentages are: Northway - 63.1%, Tanacross - 74.0%, Tetlin 45.8%, Dot Lake - 88.9%. While the Northway percentage is similar to the overall percentage for the villages, the figures for Tanacross and Dot Lake show that a high proportion of the potential work forces in these villages indicate a skill or area of work experience. In Tetlin, this situation holds for less than half of the potential work force which again illustrates the decreased emphasis on wage employment in this village.

In terms of formal vocational training (not including on-the-job training), 66 individuals (35 males, 31 females), or 21.9% of the total work force, have noted such training. This is a minimum count and probably underestimates the total number because, in those instances where information was obtained from informants, they could not always recall specific information on training.

The majority of the males (25/35) have received training in areas that could be considered construction related: carpenters (9); mechanics (6); surveying (2); heavy equipment operation (2); metal working (2); welding (1); tirebusting (1); oil drilling (1); and, oil orientation (1). By far the most common type of training received by females was in the clerical area (i.e. 19 of 31; primarily secretarial but also bookkeeping and office administration). In addition, four females and one male received training as health aides.

The increasing amount of formal education obtained by individuals in the younger age categories is paralleled by the recent emphasis on vocational training. Two-thirds of the individuals that have received some type of training are in the 18 - 29 age category. The mean age of the trainees is 28.1 years for males and 28.6 years for females.

SUBSISTENCE ACTIVITIES AND WAGE EMPLOYMENT

As part of the demographic survey, an attempt was made to collect information on the important topic of subsistence. The goal was to relate such activities to wage labor employment and public assistance (e.g. pensions, disability, welfare) in order to obtain some understanding of the "income" profiles of the communities.

To characterize the primary economic base for individuals in the villages, information was sought on subsistence activities, wage employment, and public assistance for all those over 15 years of age. This information was obtained through either direct interviews or through informants for 230 individuals in the four populations. It should be emphasized that this represents only a preliminary assessment of the means of livelihood for the village inhabitants. Only through a longer-term study (minimum of 12 months for sufficient coverage of annual cycle of activities) could the researcher obtain exacting information on cash flow in the communities, the percent of the diet provided by hunting, fishing, trapping, and gathering activities and the seasonality in subsistence and/or wage labor activities.

In this study, it was necessary to set up six highly arbitrary and generalized categories in an attempt to estimate the relative importance of various economic activities. For example, category one individuals support themselves primarily through traditional subsistence efforts whereas, those classified in category five are largely dependent on wage employment. Categories two, three, and four represent gradations between primary reliance on subsistence (1) to primary reliance on wage employment (5). Category six was established to include individuals who rely on public assistance as their primary source of support. These categories and the assignation of 230 idividuals from the four villages to specific categories are shown in Table 14. As these data are based on brief interviews and are, thus, subjective and impressionistic, any conclusions derived therefrom can only be of a limited and general nature.

Of the four villages, Northway and Tanacross have the highest proportion (ca. 60%) of inhabitants involved in wage labor on a regular part-time or full-time basis. Still, the natives have few opportunities available for regular wage employment in these villages. In Northway for example, jobs are available in the post office (1), school (4), laundromat (1), and at the FAA complex (4). In addition, there are two positions for health aides. During the summer, the youth corps and BLM firefighting units contribute significantly to the job pool. The restricted wage employment opportunities of Northway are reflected in part by the number of individuals who have migrated seasonally to Fairbanks (11), Tok (2), or Delta (1) to obtain primarily union or pipeline related jobs. In Tanacross, as in Northway, state and federal jobs provide the bulk of the wage labor opportunities (e.g. firefighting,

Table 14. Measurement of the relative importance of subsistence activities, wage labor employment, and public assistance to total "income" in the village populations of Northway, Tanacross, Tetlin, and Dot Lake, Alaska.

	Village									
	Northway		Tanacross		Tetlin		Dot Lake		Total	
Category*	%	no.	%	no.	%	no.	%	no.	%	no.
1	3.8	(3)	0.0	(0)	9.1	(5)	0.0	(0)	3.5	(8)
2	6.3	(5)	8.3	(5)	23.6	(13)	2.8	(1)	10.4	(24)
3	8.9	(7)	0.0	(0)	16.4	(9)	22.2	(8)	10.4	(24)
4	30.4	(24)	23.3	(14)	14.5	(8)	25.0	(9)	23.9	(55)
5	31.6	(25)	41.7	(25)	7.3	(4)	8.3	(3)	24.8	(57)
6	19.0	(15)	26.7	(16)	29.1	(16)	41.7	(15)	27.0	(62)

*1: subsistence activities exclusively
2: subsistence activities primary, wage labor employment secondary
3: equal dependence on subsistence activities and wage labor employment
4: wage labor employment primary, subsistence activities secondary
5: wage labor employment exclusively
6: public assistance programs (e.g. old age pensions, welfare, disability)

new home construction, and general labor projects such as brush clearing for the highway department). Additional jobs are made available by Tanana Chiefs Conference, e.g. health aides. Individuals from Tanacross have also travelled to larger communities such as Fairbanks (13) and Tok (2) to work on the pipeline or other construction projects. Only a small percentage of the individuals from Northway and Tanacross are primarily dependent on traditional hunting and gathering activities.

Tetlin, the single village of the four not directly connected to the Alcan Highway by a road, is characterized by the highest percentage of individuals (ca. 30%) who are primarily reliant on traditional subsistence, only a few individuals have been stimulated to go to Fairbanks (3) or Tok (2) to obtain wage employment. Some local wage labor has been generated in Tetlin by the recent construction of new housing. In addition, several individuals are employed at the village school.

At Dot Lake, a relatively large proportion of the population is receiving some form of public assistance. In terms of wage employment and subsistence activities, Dot Lake is intermediate between Northway-Tanacross and Tetlin in showing an almost equal reliance on wage labor and subsistence for support. Wage labor outside the village has been obtained by a few individuals in Fairbanks (3) and Tok (1). Relative to the other villages, the proportion of individuals from Dot Lake who have worked outside the community is about equal to that of Northway, is lower than that of Tanacross, and exceeds the proportion from Tetlin. In Dot Lake, the highway department has employed four individuals for various projects.

In summary, one point should be stressed regarding Table 14. That is, individuals in all categories (including 5 and 6) are to some extent dependent on hunting, fishing, trapping, and gathering activities. Subsistence has been formally defined as "an economy in which production and other behaviors are directly related to the environment and motivated by immediate survival" (Collins, 1975: 486). Although the inhabitants of the four villages are not practicing a subsistence economy in the strict sense of that term, even individuals with well paying year round jobs become involved in such activities as much as possible. The stimulus for this involvement is partly economic (e.g. saving money on store purchased goods or the lack of economic opportunities) but more importantly, the social institutions, and traditional culture patterns surrounding subsistence activities are a long-standing part of the cultural heritage of these groups. From the standpoint of a Euro-American, it would be concluded that most of the individuals in the villages are involved in wage employment or receive public assistance and they supplement limited cash income received through traditional subsistence activities. For only about one-fourth of the populations could it be said that subsistence efforts are supplemented by wage labor activities. Still, if the village inhabitants were queried on this specific point, the majority would state that subsistence activities are primary and wage labor activities are supplementary.

Another aspect of subsistence that should be emphasized is the seasonality of various activities. That is, a specific period of the year is optimal for obtaining a certain species of fish and game, trapping small mammals, gathering certain berries, and so forth. For a native to maintain a full-time job week after week may be possible during some parts of the year, but when the season comes for a high priority subsistence activity (*e.g.* hunting moose, netting salmon) some part of the native work force will simply leave their jobs to engage in that activity. This does not indicate lack of interest in sustained wage employment or work performance, but rather, the continued importance of traditional subsistence activities for both economic and social/cultural reasons. Thus, an intensive analysis of the seasonal cycle of subsistence and wage labor activities is a prerequisite for maximizing the involvement of the native work force and minimizing the social/sultural impacts brought about by construction activities in this area.

SUMMARY AND CONCLUSIONS

In this final section, a summary characterization of major population and socioeconomic parameters is presented for the villages of Northway, Tanacross, Tetlin, and Dot Lake, Alaska. Data from these four villages are combined so specific interest in one village may be checked against appropriate sections of the text and/or tables. Secondly, conclusions are drawn from the demographic data and relevant population problems are noted. Finally, a prospectus for future research is presented.

Summary Statistics

1. Total population: 515 individuals

    a. native - 465
    b. white/other - 50

2. Median age: 23 years

    a. native - 22 years
    b. white/other - 28 years

3. Percent of population under 15 years of age: 33.1%

   a. native - 34.8%
   b. white/other - 22.0%

4. Sex ratio: 113.0

   a. native - 111.5
   b. white/other - 127.5

5. Ethnic composition: 90.3% of the total village populations are interior Alaskan Athabascan Indians

6. Work force (potential): 302 individuals

   a. native - 266
   b. white/other - 36
   c. male - 164
   d. female - 138

7. Total household number and average size: 128 (4.0 persons/household)

   a. native - 101 (4.1 persons/household)
   b. white - 12 (2.7 persons/household)
   c. mixed - 15 (5.2 persons/household)

8. Mixed households: 15 of 87 (17.2%) of the husband-wife family households involve spouses from different ethnic backgrounds.

9. Job skills - work experience: 208 individuals indicated at least one job skill or area of work experience; 12 of these individuals were under 15 or over 65 years of age so 196 of 302, or 64.9%, of the work force is represented (primary skill-experience areas are: laborer, carpenter, heavy equipment operator, maid/janitor, secretary-clerical).

10. Vocational training: a minimum of 66 individuals have received formal vocational training; training emphasis for males is in construction-related activities and for females, in clerical/office work.

11. Wage labor/subsistence: considering natives only, 24.8% of the village inhabitants are primarily dependent on wage employment. Although only a small proportion (ca. 5%) of the total population is considered to be wholly reliant on subsistence activities, almost all individuals are dependent on these activities (hunting, fishing, trapping, gathering) to some extent. In most cases, wage labor supplements subsistence activities or the reverse.

Conclusions

One of several recurrent themes running throughout the course of this population study was the demographically transitional status of the four interior Athabascan villages. This characterization results from the consideration of key demographic measurements (e.g. median age, percent of population under 15 years, dependency ratio, etc.) which are shifting from the measurements that are associated with underdeveloped/developing third world countries to those of industrialized western populations. This shifting is primarily a reflection of the changes in crude birth and crude death rates. Although precise data were not collected on fertility and mortality in the four villages (this was beyond the bounds of the present study), it can probably be concluded that improved medical care is bringing about a decrease in mortality rates and at the same time, family planning and education is resulting in decreasing birth rates. One socioeconomic consequence of this trend has been a decrease in the dependency ratio which indicates that an increasingly larger segment of the population is in the work force. This consequence has direct relevance in competition for available jobs in the villages and/or emigration to urban communities to seek employment when none is available in the villages.

Information obtained on formal education, job skills/work experience, and vocational training indicates that the younger members of the village communities are becoming more oriented to the economic activities and lifestyles of the Euro-American type of society and less oriented to the traditional subsistence economic mode. If the villages do not develop a broader and more stable economic base, an increasingly larger proportion of young individuals will move away from the villages in order to utilize the skills they have developed through education and training.

Another recurrent theme in the demographic data was the distinctiveness of Tetlin and Tanacross. As Tetlin is the only village of the four that is not accessible by car or truck, isolation is presumably a major factor in the ability of the Tetlin inhabitants to maintain a more traditional way of life. This is particularly notable in their significantly greater reliance on traditional subsistence activities. However, in spite of their greater isolation, Tetlin has kept pace with the other villages in terms of formal education and job training. How this situation is reconciled with the fact that Tetlin has the lowest percentage of the work force indicating job skills and/or work experience will have to be determined in a follow-up study on subsistence patterns.

Tanacross is as distinctive as Tetlin but it is at the other extreme for demographic characteristics. That is, the parameters reflecting age of the population are all closely aligned with a modern industrial country rather than a traditional hunting and gathering population. Additionally at Tanacross, there is much greater emphasis placed on wage employment with three-fourths of the work force indicating some skill or area of work experience.

Although specific data on migration patterns were not obtained, this is a primary area for subsequent research. In the four villages considered, there appears to be an unequal loss of native females from the marriageable pool because of differential emigration and mixed marriages. This pattern characterizes other rural Alaskan communities as well. There is some indication that increased white-native interaction leads to an increased number of mixed marriages and, importantly, the majority of these marriages involve native females and non-native males. As construction projects generally involve a majority of male-dominated activities, it is presumed that any pipeline project would bring a relatively large number of white males into contact with the village populations in this region. The potential effect this interaction could have on native-white marriages and subsequent emigration of the mixed hosueholds to urban communities should be carefully considered.

One final point which should be emphasized because of its implications for future research among prospectively impacted village populations is the inter-village variation in major demographic characteristics. In the summary characterization, population data were presented for the combined villages and so obscured the variation present. In terms of the critical parameters relating to age of the population, Tetlin and Tanacross reflect polar extremes ("young" and moderately "old" populations, respectively) while Northway and Dot Lake are intermediate. Regarding ethnic composition, Tetlin inhabitants, with but one exception, are all Athabascan Indians. Dot Lake on the other hand has a high proportion of whites. Northway and Tanacross fall between these extremes for ethnic composition. In terms of sex ratio, Tetlin and Tanacross have a significantly greater number of males than Northway and Dot Lake. In other words, this consistent variation that can be observed for any population characteristic, indicates that further research cannot be restricted to a single village for the sake of expediency because it would not be possible to generalize to the potential impacts on all villages. In fact, the presence of this variation should better allow researchers to delineate the causal factors involved in certain kinds of impacts. Thus, considering all the potential impacts of large scale construction activities in this region and the inter-village variation in both acculturative status and population characteristics, there is an urgent need for in-depth studies in all four village communities.

Research Prospectus

In view of the conclusions presented above, a number of research projects are indicated. A number of these studies have already been proposed to the ALCAN Pipeline Company. As a result of the demographic study now concluded, there are some changes to be made in some proposed projects, as with time to be allotted or specific focus to be emphasized. The results reported here on the demographic profiles of the people and communities provide a good base from which many of the studies suggest can be initiated. The studies that were seen to be required as a result of this research study are outlined.

1. In-depth community studies should be undertaken in each of the four communities addressed in the demographic survey in lieu of the variation demonstrated.
   a. Pre-contact history should be addressed to help delineate traditional lifestyle.
   b. The history of contact should be addressed, particularly with regard to village contacts, cross-cultural contacts and the interactions that have surrounded education, health care and economic change.
2. A subsistence study should be under taken throughout the entire area as a specific topic in urgent need of clarification.

a. Subsistence levels need to be quantified and qualified.

b. Kinds of subsistence activities need to be determined and the relative importance of each established.

c. The economic reliance on subsistence needs to be clarified.

d. The social/cultural reliance on subsistence needs to be determined.

e. The seasonality of such activity needs to be specified both as it consumes the time of the people and as it interfers with participation in wage-labor.

f. The relationship of land and land usage to subsistence activities need to be clearly understood.

g. Substantial time must be allotted for subsistence studies to be done, a minimum of one year is normally viewed as essential to observe the yearly round of subsistence activity. In view of the relative significance of this topic and its importance in Alaska, anything less would be insufficient and open to criticism.

3. A study on the migration patterns of the people of the subject communities should be undertaken as movements of people are significant in establishing areas of impact.

   a. The actual parameters of movement in and out of the communities for whatever reason should be emphasized.

   b. The sex differential in emigration patterns is of special significance and in need of emphasis.

   c. The seasonality or relative permanence of movement should be examined to determine whether movements are cyclical, periodic or other.

4. In terms of the transitory nature of the native groups, the relation

of birth and death rate patterns to mental health areas is another area in need of attention. Any construction effort will undoubtedly effect these rates and surface in community and individual areas.

a. As much data on reproductive history should be gathered as possible.

b. Mortality profiles in each community should be obtained both diachronically and syncronically.

5. In view of the mixed populations and community profiles, an urgent need for research into ethnic interaction is established.

6. In response to the interaction experience of the field researchers with the community inhabitants, there is a need for study on community attitudes.

7. Native participation in pipeline related jobs is another area to be researched.

APPENDIX I - Community Sketch Maps

Figure - 5

SKETCH MAP — NORTHWAY

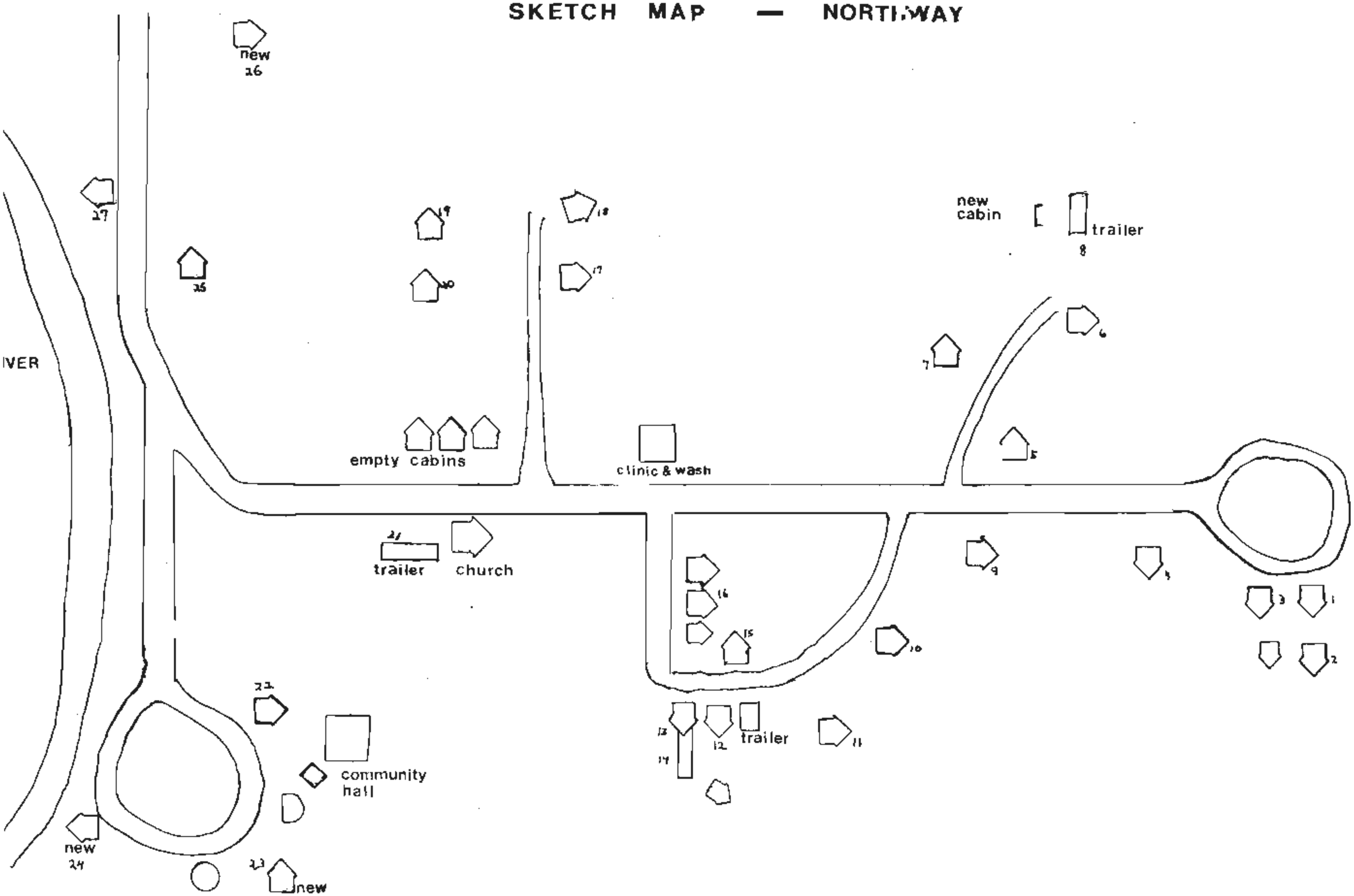


Figure - 6

SKETCH MAP — NORTHWAY

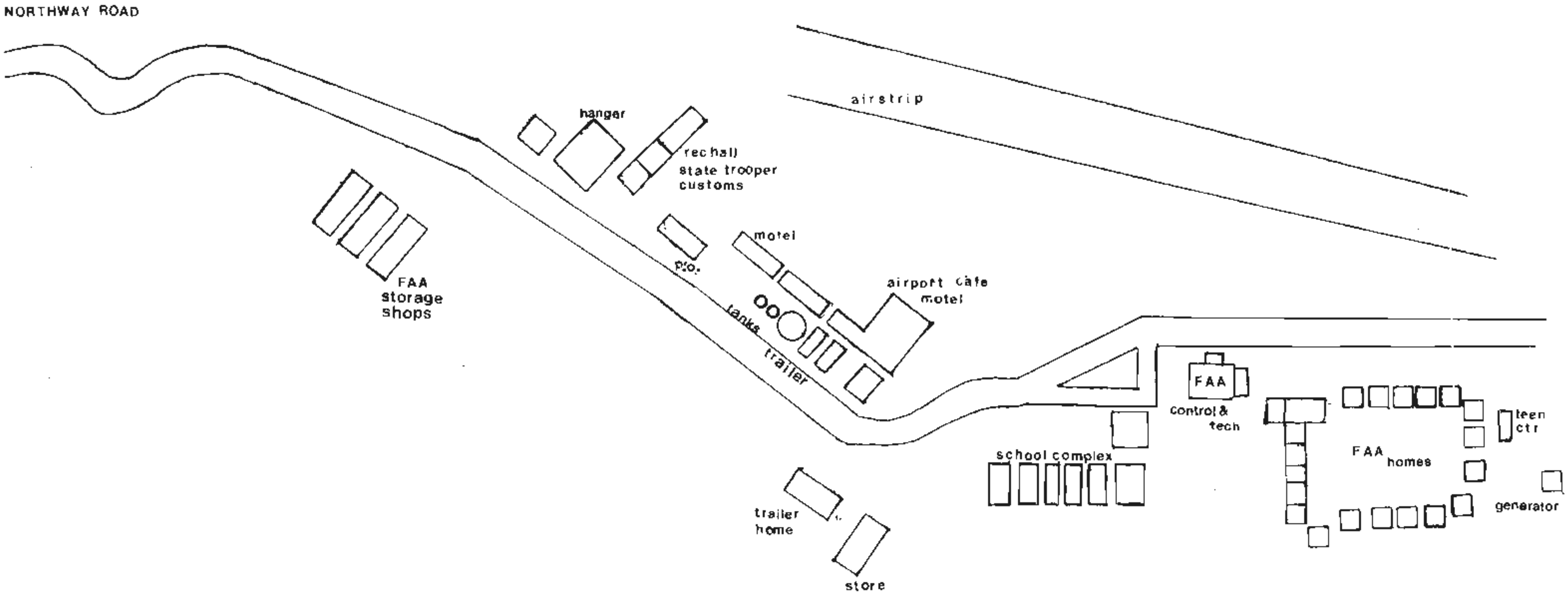


Figure - 7

SKETCH MAP — NORTHWAY ROAD AREA

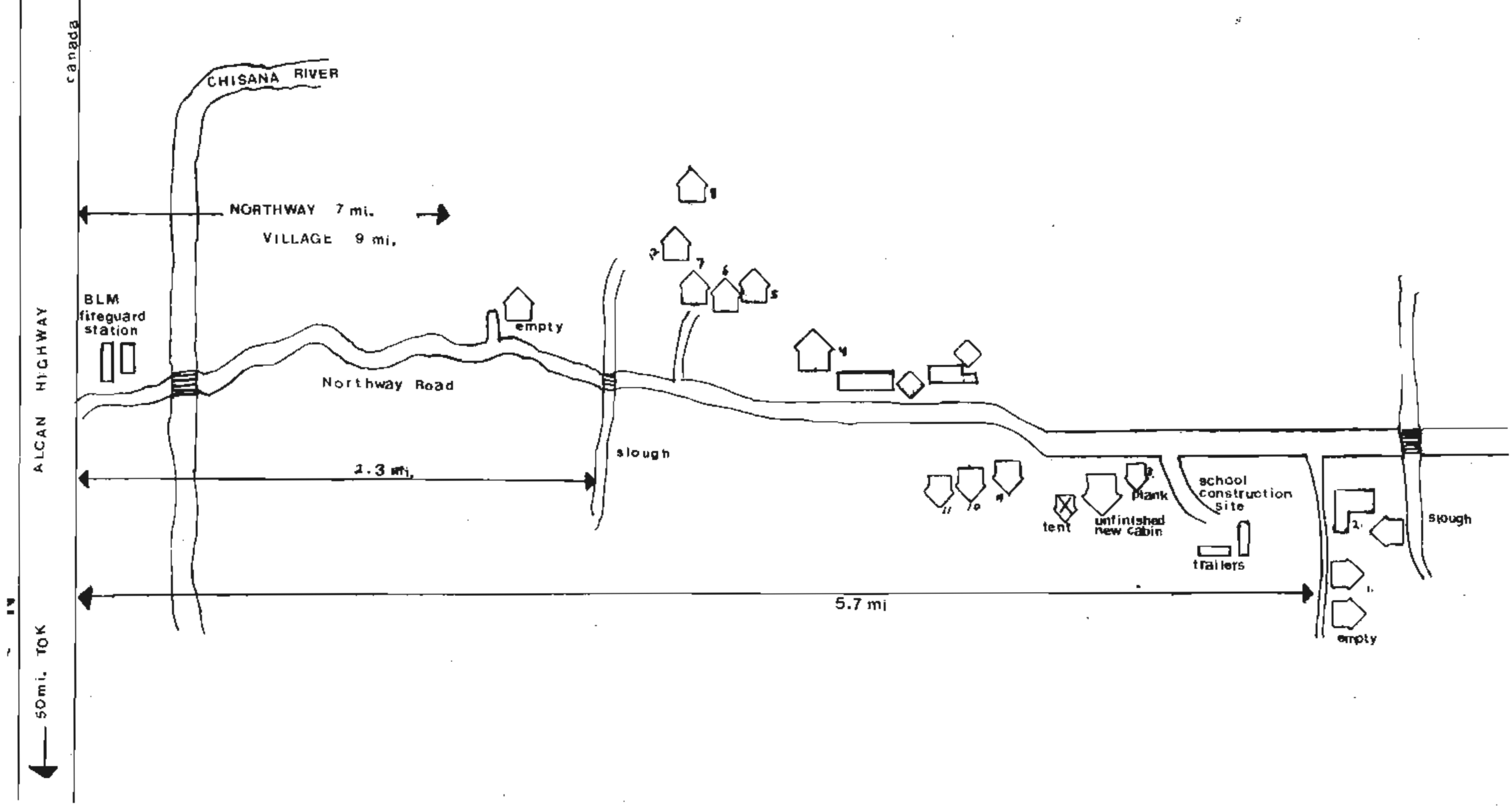
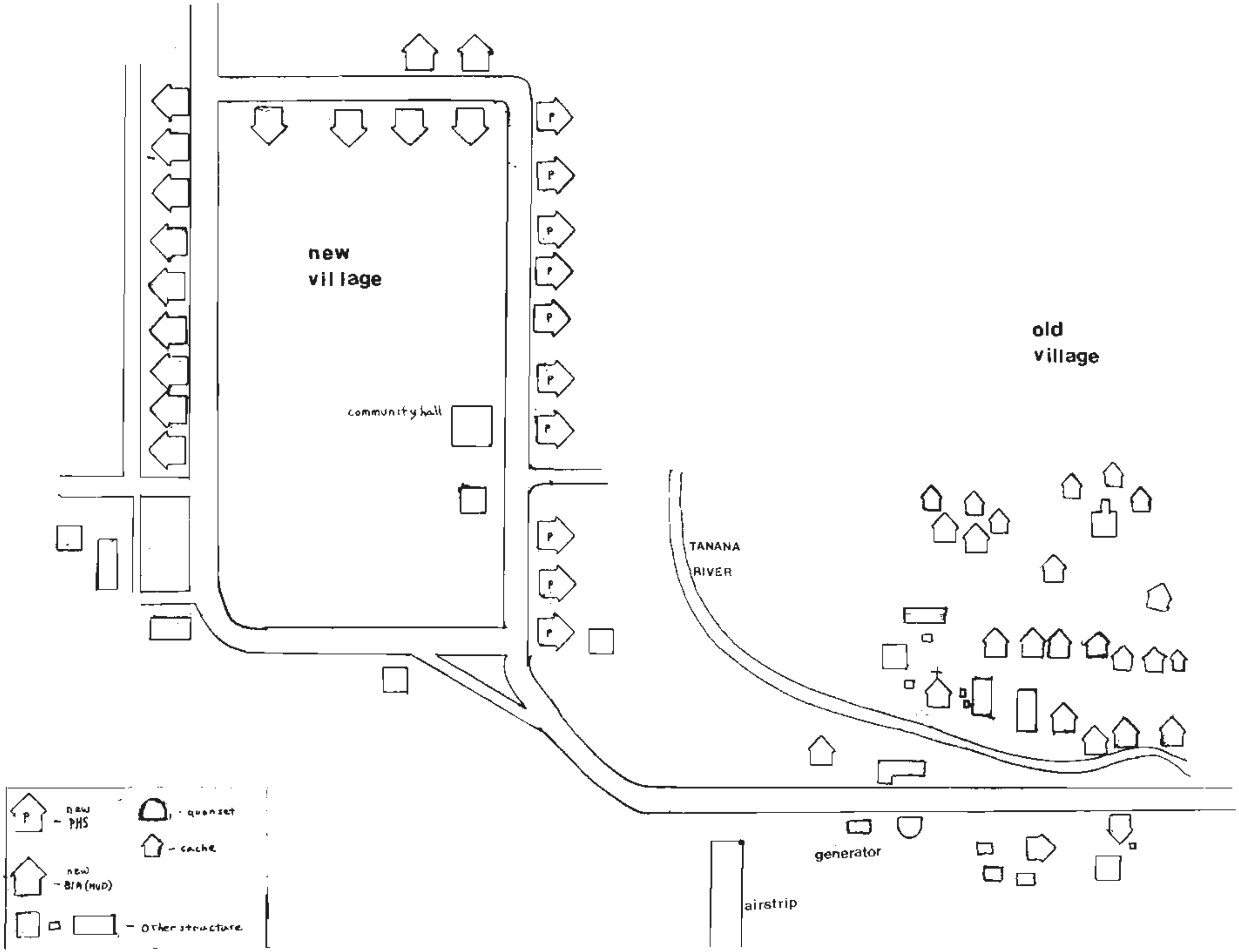


Figure-8

SKETCH MAP — TANACROSS



SKETCH MAP — TETLIN

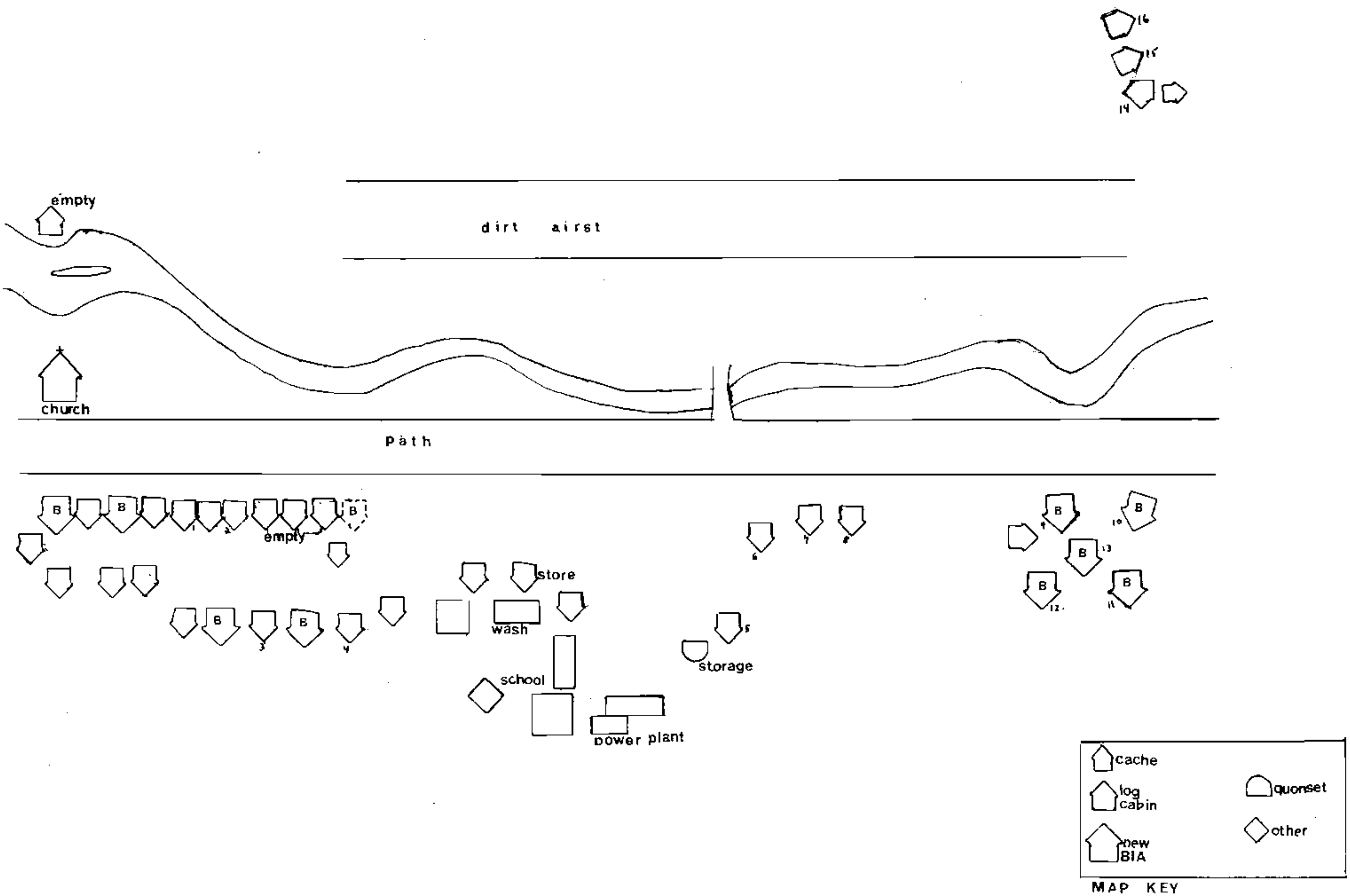
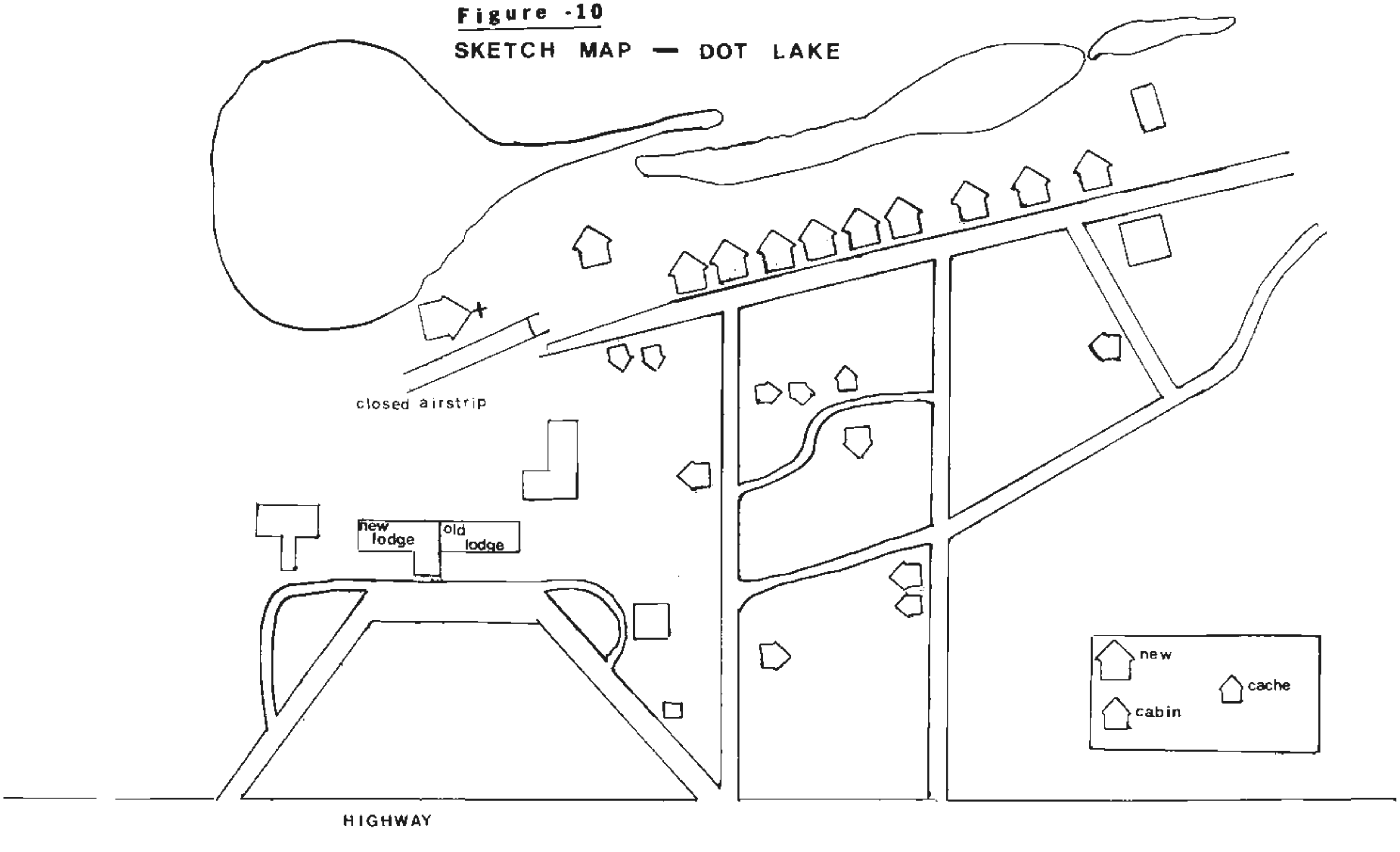


Figure -10

SKETCH MAP — DOT LAKE



APPENDIX II - Village Household Census

APPENDIX II

Date ____________________ VILLAGE ____________________

Observer ________________

ALCAN PROJECT: VILLAGE HOUSEHOLD CENSUS
August 1976

NAME	Head	Wife of head	Son./dau.	Grandpar.	Other rel	Nonrel.	Sex	Birth date	Birthplace	Ethnic group	Education (highest year)
								- -			
								- -			
								- -			
								- -			
								- -			
								- -			
								- -			
								- -			
								- -			
								- -			
								- -			
								- -			

(if more than 12 in household, continue on additional sheet)

SEASONAL MOVEMENT OF HOUSEHOLD MEMBERS	Name	Location	Time of Year	Activity

TRANSPORTATION ____

Village household census/2

VOCATIONAL TRAINING	Name	Type of training	Construction related	Duration

INCOME AND WAGE EMPLOYMENT	Name	Source of income	Occupation	Industry	Time of year

APPENDIX III - Village Characteristics

APPENDIX III

Date ____________________ VILLAGE __________________
Observer ________________

ALCAN PROJECT: VILLAGE CHARACTERISTICS
August 1976

A. HOUSES

1. Number ____________________

2. Condition ____________________

B. ROADS/TRAILS

C. SERVICES

1. Restaurants ____________________

2. Bars ____________________

3. Grocery stores ____________________

4. Retail stores ____________________

5. Gas stations ____________________

6. Other (specify) ____________________

Village characteristics/2

D. GOVERNMENTAL AGENCIES

1. Federal ______________________________

____

2. State ______________________________

____

3. Local ______________________________

____

____

E. HEALTH SERVICES

____

____

F. SCHOOLS

____

G. CHURCHES

____

H. COMMUNICATIONS

____

____

I. WATER-SEWERAGE SYSTEM

____

____

____

J. OTHER OBSERVATIONS ON COMMUNITY SERVICES (specify)

____

____

____

APPENDIX IV - Community Inventories

Date ______________
Observer ______________

VILLAGE Northway

ALCAN PROJECT: VILLAGE CHARACTERISTICS
August 1976

A. HOUSES

1. Number Northway village: 31 (26 occupied and 3 empty log cabins; 2 trailors); airport complex: 4 (1 frame house, 3 trailors); Northway road: 18 (13 log cabins, 2 frame houses, 3 other)

2. Condition Northway village: 3 new log cabins- good condition, 22 log cabins- fair condition; Northway road: 12 cabins- good/fair, 1 cabin unfinished, 1 cabin new- good, 2 frame- good.

B. ROADS/TRAILS

Northway road off Alcan, improved dirt- 7 miles to FAA complex, 9 miles to village

C. SERVICES

1. Restaurants Northway Lodge (Floyd Miller Enterprises); Lakeview Cafe and Inn (6 miles east on Alcan from Northway junction)

2. Bars Northway Lodge

3. Grocery stores Airport Store (Floyd Miller Enterprises); Stout's Store on Alcan (1 mile east on Alcan from Northway junction)

4. Retail stores Airport Store (all-purpose, some clothing, hardware, etc.) Stout's Store (some hardware)

5. Gas stations Airport Store; Stout's Store

6. Other (specify) Air: Polar Airways at airport; Floyd Miller's air service

D. GOVERNMENTAL AGENCIES

1. **Federal** Federal Aviation Administration (flight services)

U. S. Customs

2. **State** State Troopers

3. **Local** Northway Natives, Inc. (Rosemarie Maher, President);

Northway Village Council (Lorraine Felix, President)

E. HEALTH SERVICES

Village clinic (1 health aide, D. John); PHS nurse from Tok clinic; nearest hospital in Glenallen

F. SCHOOLS

Northway School, grades k-10, 2 teachers (presently), status pending

G. CHURCHES

Pentacostal Holiness Church (new log structure in Northway village)

H. COMMUNICATIONS

Telephone in Airport Lodge and Village clinic (Southeastern Telephone Co.)

H.F. radio in village clinic (installed 1971)

I. WATER-SEWERAGE SYSTEM

Village laundromat: washing clothes, showers, drinking water

School obtains water from FAA well

No sewer system in Northway village; Floyd Miller placing sewer line from motel to rear of store (septic tank/leach field)

J. OTHER OBSERVATIONS ON COMMUNITY SERVICES (specify)

Village community hall (new log building)

Village cabins use wood stoves for heating

Northway Power and Light, Inc., provides power to Northway village

Paved runway at airport, 4300' asphalt
FAA sanitary landfill (for garbage disposal)

Date ______________ **VILLAGE** Tanacross

Observer ______________

ALCAN PROJECT: VILLAGE CHARACTERISTICS
August 1976

A. HOUSES

1. **Number** Total- 31 (15 BIA/HUD frame- completed but not fully occupied; 12 PHS frame- fully occupied; 3 log cabins, 1 frame)

2. **Condition** PHS homes-completed in 1974; BIA/HUD completed 1976; 2 cabins- good condition, 1 cabin- poor/fair, 1 frame- good

B. ROADS/TRAILS

Improved dirt road through village from Alcan highway

C. SERVICES

1. **Restaurants** None

2. **Bars** None

3. **Grocery stores** None

4. **Retail stores** None

5. **Gas stations** None

6. **Other (specify)** Air service: Polar Airways- twice weekly from Fairbanks
Warbler Brother's Air Service; 5100' asphalt airfield, unattended;
Weaver Brother's (shipping)
Bus service: Alaska Coachways (from Fairbanks)
Community hall (recent log construction)

D. GOVERNMENTAL AGENCIES

1. Federal Post Office

BLM fire station

2. State None

3. Local Tanacross, Inc.

E. HEALTH SERVICES

Village clinic

PHS nurse from Tok

F. SCHOOLS

None

G. CHURCHES

Central Alaska Mission; Episcopal Church

H. COMMUNICATIONS

Alaska Power and Telephone Company

BLM VHF/HF radio

I. WATER-SEWERAGE SYSTEM

PHS homes have circulating water systems

Septic system (as of 11/74)

BIA homes. Hook-up completed- 1976

J. OTHER OBSERVATIONS ON COMMUNITY SERVICES (specify)

Alaska Music Company service pool table in community hall

Date ____________
Observer ____________

VILLAGE Tetlin

ALCAN PROJECT: VILLAGE CHARACTERISTICS
August 1976

A. HOUSES

1. Number Total- 34 (25 log cabins; 9 BIA frame houses)

2. Condition BIA frame houses- 8 in good condition, 1 unfinished; log cabins in fair condition

B. ROADS/TRAILS

Midway Lake trail (begins 30 miles west of Northway Road-Alcan highway intersection and runs to village; in use only during winter)

C. SERVICES

1. Restaurants None

2. Bars None

3. Grocery stores None

4. Retail stores None

5. Gas stations None

6. Other (specify) Air service: Floyd Miller Enterprises (from Northway); Air Ventures: twice weekly from Tok; ca. 1000' sod strip, unattended and in fair condition

D. GOVERNMENTAL AGENCIES

1. **Federal** Post Office (branch of Tok P.O.)

BIA teacher

2. **State** Alcohol program

3. **Local** Village council (Ray Demit, President)

Village Co-op (business corporation)

E. HEALTH SERVICES

proposed clinic for fall, 1976

PHS nurse from Tok; nurse's aide-Kathleen Mark

F. SCHOOLS

BIA school - grades 1 to 8; one teacher and one teacher's aide (for grades 1-3)

G. CHURCHES

Pentacostal Church

H. COMMUNICATIONS

Telephone in community hall

BIA VHF/HF radio

I. WATER-SEWERAGE SYSTEM

one water main with BIA pump; laundry facility inoperable

School sewer line under construction summer 1976

All households utilize latrines

J. OTHER OBSERVATIONS ON COMMUNITY SERVICES (specify)

27 homes anticipated to have electric power in near future;

school has electricity at present time (IRA from Tok)

Community hall (log structure built in 1968)

Date ______________ · VILLAGE Dot Lake
Observer ______________

ALCAN PROJECT: VILLAGE CHARACTERISTICS
August 1976

A. HOUSES

1. Number Total- 16 (9 PHS frame houses, 4 log cabins, 3 trailers)

2. Condition PHS housing new/good; 3 trailers in good condition;
2 log cabins in good condition

B. ROADS/TRAILS

one-fourth mile north-east of Alcan highway
gravel road runs through village

C. SERVICES

1. Restaurants Dot Lake Lodge

2. Bars None

3. Grocery stores Dot Lake Lódge- minimal for groceries

4. Retail stores Dot Lake Lodge- minimal for retail items

5. Gas stations Dot Lake Lodge

6. Other (specify) No regular air service; landing strip closed for two years, planes currently land on Alcan highway
Community hall (recent log structure)

D. GOVERNMENTAL AGENCIES

1. **Federal** Post Office

2. **State** Orphanage: North Star Institution, Tri-Church, Inc.

3. **Local** Dot Lake Native Corporation (Carl Charles, President)

E. HEALTH SERVICES

Community Health Aide- Hazel Kanaleiwi; PHS nurse from Tok

nearest hospital- Fairbanks; nearest clinic- Delta

F. SCHOOLS

Dot Lake School

G. CHURCHES

Dot Lake Little Chapel

H. COMMUNICATIONS

Private telephones; AM/FM radio (Fairbanks, Anchorage, Glennallen); television (Fairbanks channels 9 and 11, translator cables)

I. WATER-SEWERAGE SYSTEM

PHS houses have plumbing-septic tanks; school gets water from well

J. OTHER OBSERVATIONS ON COMMUNITY SERVICES (specify)

Dot Lake Electric Company supplies electricity

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A L C A N   P I P E L I N E

S T U D Y   R E P O R T

1 9 7 6

ALASKAN PIPELINE IMPACT

BIBLIOGRAPHY: SOCIAL/CULTURAL

Parts - I & II

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&

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Fairbanks, Alaska

Report prepared for and by contract to the ALCAN Pipeline Company through Gulf Interstate Engineering Company, Houston, Texas.

PREFACE: Pipeline Bibliography - 1976

The Alaskan Pipeline Impact Bibliography: Social/Cultural was compiled as one of a series of projects carried out under contract with Gulf Interstate Engineering Company acting on behalf of the ALCAN Pipeline Company in support of a proposed pipeline route for the transportation of Alaskan gas to lower forty-eight markets in the mid-west, Larry L. Naylor and Lawrence A. Gooding, co-principal investigators. The primary purpose of the bibliography has been to compile in one location a listing of the various references that were pertinent to the topic of social/cultural impacts of pipeline construction in Alaska. Due to this central concern, the resulting bibliography concentrates on the various materials available on the social/cultural impacts of the Trans-Alaskan Oil Pipeline in Alaska as well as addresses the projected impacts of the various proposals for the transportation of Alaskan gas to outside markets, including the ALCAN proposed route. When complete, the bibliography will consist of three sections: (1) a bibliography by author on the pipeline impacts in social/cultural areas; (2) a bibliography by author concentrating on the cultures and communities that will, or already have been impacted by pipeline construction activity; and, (3) an annotated bibliographic presentation of the sources listed in sections one and two. The third presentation will depend on available resources to complete.

The Pipeline Impact Bibliography aims to be complete, as complete as possible when the references to pipeline impact seem to increase almost daily. The project which resulted in this bibliography proposed to list the currently available resources with an on-going update as new materials became available. The bibliography will never be complete in this sense but the present listings should prove valuable to those who are or will be researching in the area. Because of the current timeliness of such a bibliography it was felt that a presentation now would be in order. This makes no apologies for the gaps in the listings. The authors take full responsibility for the deficiencies which might be found.

The effort is in substantial measure, the culmination of work done by a number of persons, numerous offices of government and individuals working on pipeline impacts. The bibliography is really the result of combining all the references obtained from all of these sources. Madrilena Bradley and Kevin Short sought out the available references from the state and local governmental offices, research units of the University of Alaska, various Alaskan Libraries, city governments, and some Native corporations. The State Library of the Department of Education was particularly helpful in this effort. Also significantly helpful in this part of the effort were representatives of the Institute of Social, Economic Research, University of Alaska, Fairbanks, Alaska. The Center for Northern Educational Research made valuable contributions to the bibliography. The various impact information offices in Fairbanks were especially helpful in contributing to the present bibliography.

Many, many other offices and individuals gave whatever information was available to them in the total effort. Unfortunately, all those who did contribute cannot be listed here for the task would require almost as much space as the bibliography itself. All those who assisted know what part they played and know that we do indeed acknowledge and thank them. A partial listing of the sources of the references contained in the bibliography is attached as Appendix I to Part I.

It is hoped that the bibliography will be updated as materials become available. It represents a beginning, but only a beginning upon which scholars and others working on pipeline impacts in Alaska will build continually. Corrections and additions are solicited and will indeed be welcomed.

University of Alaska
October, 1976

Larry L. Naylor
Lawrence A. Gooding

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APPENDICES

APPENDIX I

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- Department of Labour
- Department of Education
- State Pipeline Co-ordinators Office
- Office of the Governor (Dona Lehr)

Alaska Area Native Health Service - Anchorage, Alaska

Bureau of Land Management, Department of the Interior

Center for Northern Educational Research, University of Alaska, Fairbanks, Alaska

Criminal Justice Center - Anchorage, Alaska

Doyon Corporation - Fairbanks, Alaska

Fairbanks Environmental Center (Gill Semansky)

Fairbanks Town and Village Association (Jery Schmetzer, Director)

Fairbanks North Star Borough Impact Information Office (Sue Fison, Director)

Fairbanks Library - Fairbanks, Alaska

Greater Anchorage Area Borough Planning Department - Anchorage, Alaska

Institute of Social-Economic Research, University of Alaska, Fairbanks, Alaska (Judy Kleinfeld)

Tanana Chiefs Conference - Fairbanks, Alaska

Support Services, North Star School District

University of Alaska Library - Fairbanks, Alaska

APPENDIX II

Fairbanks North Star Borough.
Impact Information Reports
Sue Fison, Information Officer

Impact Report Number One. July 11, 1974.

Non-resident questionnaires through Alyeska.
Work force
Increase in commerce
Addendum--MUS System

Impact Report Number Two. July, 22, 1974

Population
Vehicular traffice Volumes
Building permits
Telephone service
Electrical service
Municipal water service
Rental housing
Employment
Postal service
Transient housing

Impact Report Number Three. August 7, 1974

Housing
Impact Committee members
Medical facilities

Impact Report Number Four. August 21. 1974

Inflation
Food prices
Construction costs
Alcohol-related problems
Alaska hire
Freight-rate increase

Impact Report Number Five. September 4, 1974

Consumer price index surveys
Review of Impact assumptions
Divorce rate
MUS service
Highway traffice
Health care costs
Market Basket survey
Winter recreation program

Impact Report Number Six. September 18. 1974

Inflation survey
Alcoholism
Building permits
Airport activity
Credit for divorced women
Transient housing
Heating Oil price survey
Social services impact
Library impact
Market Basket survey
Sanitary landfill activity

Impact Report Number Seven. October 2, 1974

Traffic increase
University of Alaska student involvement
Family survey
Grant proposal
Housing for the elderly
On-going projects

Impact Report Number Eight. Oct. 16, 1974

Crime increase
Air quality
Child care
Child welfare
Rent survey
Divorce rate
Heating oil prices
Prostitution/gambling
Positive financial impact
Sanitary landfill activity
Winter recreation
Air pollution
Child abuse

Impact Report Number Nine. November 13, 1974

North Pole impact
Child-care and costs
Market Basket survey
Heating oil prices
Divorce rates
Carbon Monoxide as an Air Pollutant
Rescue Mission
Alcoholism
Criminal Activity

Impact Report Numer Ten. November 27, 1974

Cost of living surveys
Consumer prices/personal income
Health care
Wage rate
Borough bond rating
Pipeline family survey
School district enrollment

Impact Report Number Eleven. December 18, 1974

Local businesses
Telephone traffic
Wien earnings
Ft. Wainwright project
Divorce rates
Heating oil prices
Motor fuel consumption
Student involvement
Rental housing
Physician assistants
State sanitariums
Consumer price index

Impact Report Number Twelve. January 15, 1975

Heatin oil prices
Market Basket survey
Pipeline wage scale
Social services by religious organizations
Landfill activity
Divorce rates
Pipeline family survey
Rental housing
Motor Fuel Utilization
Traffic survey
Vehicle registration
IIC activites

Special Report Number One. February 1, 1975

Minority Hire and Alaska Hire on the Pipeline

Impact Report Number Thirteen. February 19, 1975

Impact on teenagers
Teenagers in the labor force
Juvenile arrests
Police department activities
Divorces
Minority and Alaska hire
Food purchasing/low income persons
Food cost survey
Auto accidents and repair costs
Rental prices

Report Number Thirteen con't.

- Housing assistance
- Salvation Army
- Heating oil prices
- IIC evaluation
- BLS consumer price index
- Cargo movement
- Project housing
- Population
- Alcan border traffic
- Pipeline family survey
- Building permits

Impact Report Number Fourteen. March 19. 1975

- Cumulative socio-economic effects of two pipelines
  - Auto repair costs
  - Land for development
  - Juvenile arrests
  - Senior citizens
  - Careage North
- Fairbanks Memorial Hospital
- Child care and welfare
- Minority and Alaska hire
- North Pole housing

Impact Report Number Fifteen. April 16, 1975

- Region X Impact Centers plan.
- Food survey
- Cost of living survey
- Building supplies shortages
- Minority and Alaska hire
- Wage rate comparison
- Rental housing
- Rescue Mission
- Consumer protection agency
- Gas Pipeline hearings
- Pipeline family survey
- Community forum
- Alcan border traffic

Impact Report Number Sixteen. May 21, 1975

- Motel/hotel survey
- General relief
- Post office impact
- Camper facilities
- Mobile home lots
- Minority and Resident hire
- Rental survey

Impact Report Number Seventeen. June 18, 1975.

Pipeline family survey
School enrollments
Landfill activity
Wage rates
Cost of living survey
Rural Impact Information Program
Bank deposits
Airport activity
Alcan border traffic
Traffic volume
Rent survey
Rescue Mission
General relief
Environmental health
Gas pipelines
Twelve month index

Impact Report Number Eighteen. July 16, 1975

Housing
Pipeline Family Survey
Border crossings
Airport activites
Traffic volumes
Tax revenues
Wage rate comparisons
Food survey
Senior citizens

Impact Report Number Nineteen. August 20, 1975

Alaska hire
Police Department activites
School capacity
Senior citizens
New businesses
Traffic volume
Vehicle registration
Alcan border traffic
Airport activites
Rent survey
Landfill activites
Waste oil
Food prices

Special Report Number Two. June 25, 1975

Senior Citizens:The Effects of Pipeline Construction on Persons Living in Fairbanks.

Impact Report Number Twenty. September 17, 1975.

Pipeline work force reduction
School enrollments
Alaska hire
Telephones
Water treatment plant
Halfway houses
Houisng
Traffic volume
Alcan border traffice
Airport activity

Impact Report Number Twenty-one. October 15, 1975

Unemployment insurance
Mental health
Population estimates
Drivers licenses
Housing
Planning for growth in North Pole
Consumer price index
Food prices

Special Report Number Three. December 12, 1975.

Questions and Answers About the Cost of Living in Fairbanks.

Impact Report Number Twenty-two. November 19, 1975

Impact assumptions
University of Alaska-Fairbanks
Population
Pipeline family survey
Planning and zoning
Heating oil prices
Parking garage
Chena river flood control program
Housing
Air quality
Food prices

Impact Report Number Twenty-three. January 21, 1976.

GVEA
Apprenticeship program
Air quality
Traffic volume
Pipeline family survey
Alcan border traffic
Airport activites
Hospital services
Housing
Rescue Mission actitivites
Landfill activites

Impact Report Number Twenty-Four. February 18, 1976

Trans-Alaska Pipeline taxable investment
Consumer price index
Food prices
Air quality
Fairbanks Police department
Automobile accidents
Traffice volume
Rent survey
Child care
Community attitudes
Airport activites

Impact Report Number Twenty-Five. March 17, 1976

MUS
Public assistance
School enrollments
Traffice volume
Air quality
Housing
Student involvement

Impact Report Number Twenty-Six. April 21, 1976

Housing market
Building permits
Rental housing survey
Food survey
Airport Activities
Church survey
Traffic volume
Food stamps

Impact Report Number Twenty-Seven. May 19, 1976.

Housing market
Apartment complexes survey
Housing for rent
Emergency rent review board
Traffic volumes
Medical care

Impact Report Number Twenty-Eight. June 16, 1976

Emergency Rent Review Board
Medical Care
New Businesses
Food retailers
Cost of living
Housing market
Airport activity
Traffic volumes
Housing advertised

Impact Report Number Twenty-Nine. July 21, 1976.

Emergency Rent Review Board
Housing advertised
Commercial banks
Auto insurance
Auto repairs
Traffice volume
Postal vacancy
Food survey
Science conference

Town and Village Association
Rural Impact Information Reports
Judy Vick, Project Co-ordinator

Impact Report Number One. March 19, 1975

Minority and Alaska hire
Job training
Housing

Impact Report Number Two. April 30, 1975

Pipeline employment
Local impact
Transportation

Impact Report Number Three. May 30, 1975

Sanitary facilities in Tanana Chiefs Conference region
Transient housing/Delta Junction
Fairbanks North Star Borough Sales Tax Exemption
Rural Pipeline Impact Project activites
Community baseline information

Impact Report Number Four. June 18, 1975

Community surveys/Tetlin-Tok-Delta Junction
Pipeline training/employment
Alaska hire
Alaska Plan
ASMUS (Alaska State Manpower Utilization System)

Impact Report Number Five. July 31, 1975

Tok traffic
Delta Junction Police activity
Anvik flood
Food price comparison
Apprentice training schedule

Impact Report Number Six. September, 1975

Delta Junction Sales TAx
Union Hall hiring procedures
Crime rate statistics
Tok traffic
Motor vehicle registrations
Public works projects
Laborers training schedule

Trade Union Hiring Hall Procedures. September, 1975.

- Carpenters
- Culinary Workers
- Electrical Workers
- Ironworkers
- Laborers
- Operating Engineers
- Painters
- Plasterers and Cement Masons
- Plumbers and Steamfitters
- Sheetmetal Workers
- Teamsters

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- Pipeline employment
- Local impact
- Transportation
- Availability
- Community spirit and well-being
- Communications

Interim Report. June, 1975

- Pipeline employment
- Impact on local projects and local jobs
- Population changes

Report on Questionnaire Surveys. June, 1975

- Pipeline employment and the effects of pipeline construction
- Fuel costs and availability
- Food costs and availability
- Survey on pipeline employment)
- Survey on effects of pipeline construction)
- Survey on fuel costs and availability) Tables.
- Survey on food availability)
- Food price survey, 1975)

Transportation in Interior Alaska. December, 1975

- Map of air transportation
- Air transportation and freight service
- Scheduled flights--Fall 1973, Fall 1975
- Scheduled flights--Spring 1974, Spring 1975
- Aircraft capacity of air taxi operators
- Map of river transportation
- River transportation and barge service
- Base freight rates
- Cost of fuel products to communitites
- Map of highway links
- Highway transportation and freight service

Communications in Interior Alaska. March, 1976.

- Table of long distance facilities
- Local dial telephone exchanges
- Table of resources and earnings of certificated telephone utilities
- Table of interior communities served by telephone utilities
- Long distance communication survey
- Table of survey data
- Single VHF radiotelephones
- High frequency radios
- Application technology satellite
- Small earth stations

Summary of Program Activities with Recommendations. March, 1976

- Summary of activities in response to Informational Need Number I.
- Conclusion and recommendations
- Summary of activities in response to Informational Need Number II.
- Conclusion and recommendations.
- Summary of activities in response to Informational Need Number III.
- Conclusion and recommendations.
- Summary of activities in response to Informational Need Number IV.
- Conclusion and recommendations.
- Evaluation of program.

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SEISMIC RISK AND THE DENALI FAULT

Part I.

Tectonic History, Seismicity and the Development of Design Earthquakes and Computer Models

R. B. Forbes
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GEOLOGIC SETTING OF THE DENALI FAULT

The tectonic framework of Alaska is dominated by several arcuate faults which are believed to have large magnitude strike-slip displacement. Grantz (1966), St. Amand (1957), and others have cited various lines of evidence for right-lateral displacement along the Tintina, Kaltag, Nixon-Iditarod, Denali, and Castle Mountain Faults (Figure 1).

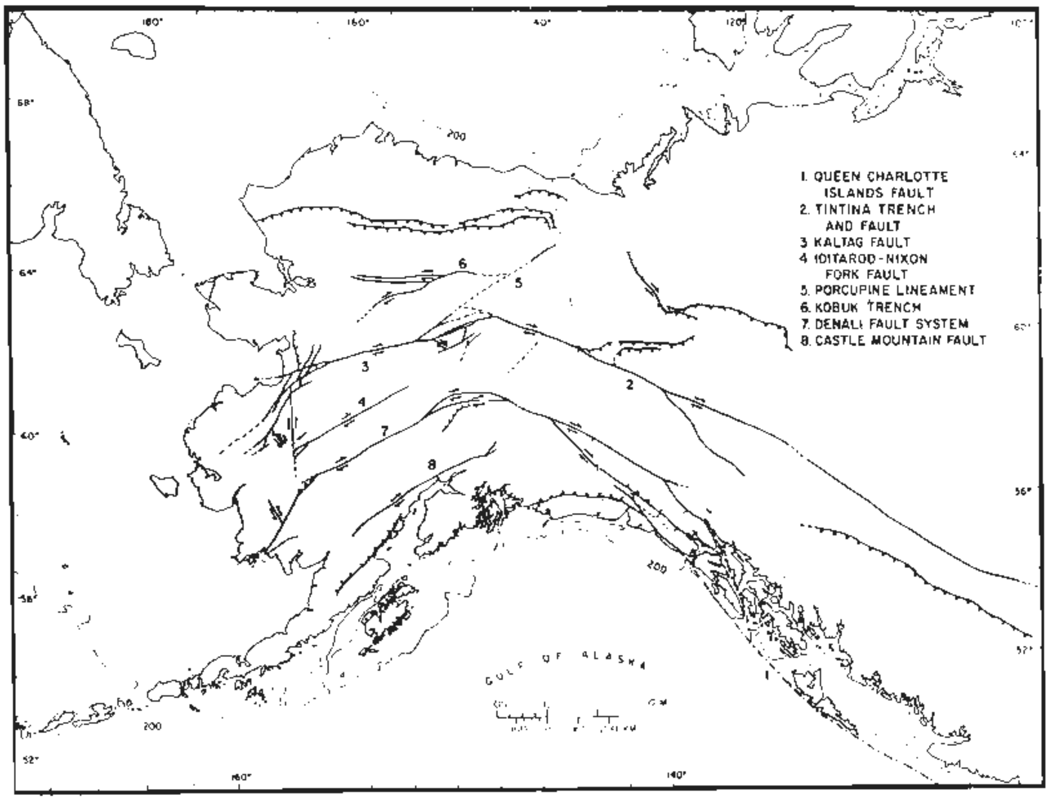

Figure 1. Major faults of Alaska (as taken from Stone, 1973).

The Denali has the most dramatic topographic expression of all the large scale strike-slip faults in Alaska, as it forms a deeply incised fault line valley which can be traced for several hundred miles through the Alaska Range and into the Shackwak Valley, Yukon Territory, Canada.

The Denali Fault is of priority importance to Alaskan tectonics, as it separates the vast crystalline terrane of the Yukon-Tanana Complex from younger fold belts to the south; cuts rocks ranging from Precambrian to Quaternary age; and displays geologic evidence of recurrent right-lateral displacement over a relatively long span of geologic time.

The Denali Fault System includes the Hines Creek and McKinley strands, and the Hines Creek strand appears to have been bypassed by later separation and movement along the McKinley strand. Concordant biotite and hornblende $^{40}K/^{40}Ar$ ages of the Buchanan Creek pluton which cuts the Hines Creek strand indicate that significant lateral displacement has not occurred along this strand in the last 95 million years (Figure 2).

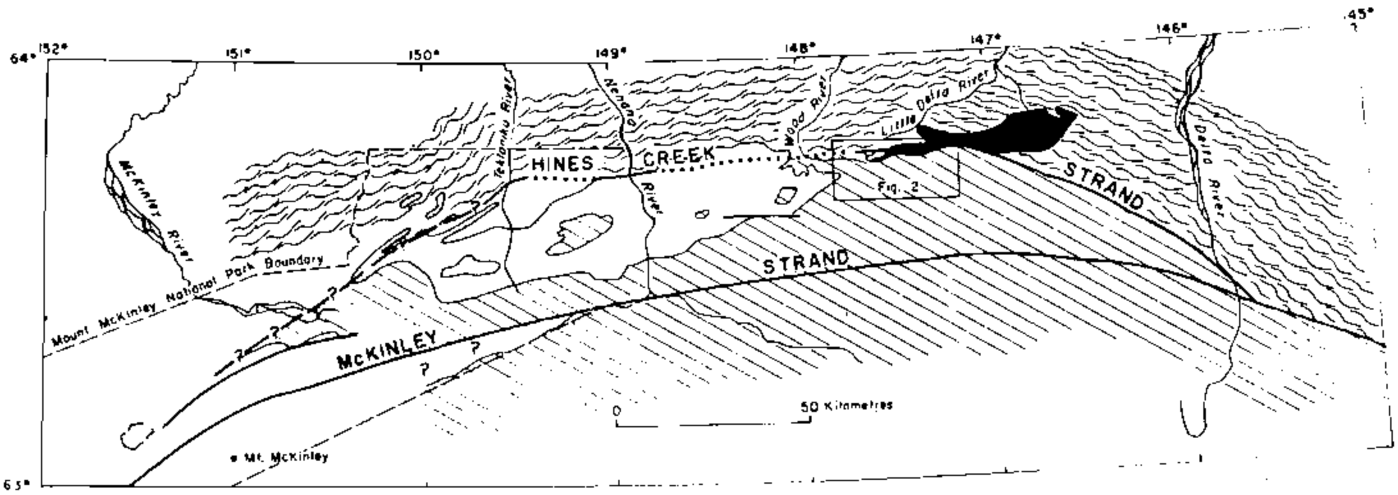

Figure 2. Denali Fault System in central Alaska Range. Stipple pattern, Cantwell Formation; black, Buchanan Creek Pluton; wiggles, continental tectonite terrane; diagonal lines, terrane of probable oceanic origin (as taken from Wahrhaftig, Turner, Weber, and Smith, 1975).

Until recently, fault solutions with proved large magnitude right-lateral offset have been remarkably elusive, with the exception of a well-documented 40 to 80 mile offset of Cretaceous rocks along the Kaltag Fault, as reported by Patton and others (1968); a proposed offset of 220 to 260 miles along the Tintina Fault, as suggested by Roddick (1967); and separations of 120 and 50 miles along the Chatham Strait Fault, as suggested by Lathram (1964) and Brew et al. (1966), respectively.

MEASURED DISPLACEMENT

Geodetic Measurements of Contemporary Offset or Creep

Richardson Highway Transect: In 1972, B. R. Meade of NOAA (Coffman and Von Hake, 1972) reported trilateration measurements of two quadrilaterals crossing the Denali Fault near Isabelle Pass, which indicated 25 centimeters of right-lateral displacement between 1941 and 1970. Subsequently, Page (1972) resurveyed the same quadrilaterals and reported no significant lateral slip within the $\sim$ 5 cm resolution of the data. Savage (1975) re-analyzed the survey data taken by both agencies, and found no statistically acceptable evidence for lateral deformation along this segment of the fault. According to Savage (op. cit.), however, extension normal to the fault was equivalent to about 23 ± 4 μ strain...which was interpreted as strain release during the 1964 Alaska earthquake. Savage also concluded that the rate of strain accumulation along this segment of the fault must be quite small (engineering strain rate = 0.1 μ strain/year, or less).

McKinley Transect: In 1967-68, Page and Lahr (1971) established a quadrilateral in the southeast corner of Mt. McKinley National Park, which straddles a recently offset 6-meter scarp. This scarp is believed by Page to have formed within the last 200 to 300 years. However, a resurvey of the quadrilateral in 1968 and 1969 indicated slip less than 3 mm/year, if not zero; much less than the minimum average Holocene rate of 2 cm/year, calculated from field evidence.

Page and Lahr (op. cit.) concluded that this segment of the fault is currently locked, and that strain is probably accumulating; a conclusion that is reinforced by the high microseismicity of the same area.

Page (1972) returned to the McKinley quadrilateral again in 1970 with a laser geodimeter, and again detected no significant lateral slip near the Alaska Railroad. Similar to the Richardson transect, however, an extensional strain of about 10 to 15 ppm was measured normal to the fault over a zone 20 to 25 km wide.

Historic Offset

To date, historic earthquake generated offset has not been documented along the Denali Fault. The only possibility known to us is a rather improbable correlation of a 1912 magnitude 7.4 earthquake which may have occurred near or along the fault (Page and Lahr, 1971), and a six-meter scarp cutting unconsolidated sediments on the McKinley Strand in the southeast corner of McKinley Park. This scarp is considered to be 200 to 300 years old or less by Page and Lahr (1971).

Quaternary Displacement

Stout et al. (1973) have reported scarps cutting Holocene alluvial fans and drainages along the McKinley strand near the Delta River, which indicate as much as 50 to 60 meters of right-lateral offset during the last 10,000 years. Vertical movement of 60 to 10 meters is displayed by the same south-facing scarps. Stout et al. (op. cit.) also reported 6.5 km right-lateral offsets of older drainages which had occurred since early Wisconsin or early Illinoian time. These displacements could be as little as 1 km, using an alternate offset solution.

Richter and Matson (1971) have discussed Holocene offset along the southeastern segment of the Denali Fault. According to these authors, the most recent vertical movement has occurred west of Mentasta Pass, where an alluvial fan has been uplifted about 6 meters. Other fault scarps are mentioned, ranging from gentle breaks in slope to 30-meter scarps. In contrast to the south-facing scarps described by Stout to the northwest near Isabelle Pass, these scarps face northeast...indicating a relative upward displacement of the south block.

Richter and Matson (op. cit.) also observed evidence for Holocene lateral movement in the eastern Alaska Range, but none along that segment of the fault "between the Nabesna and Chisana Rivers, nor along the short segment of the Shakwak Fault in Alaska." They cite five localities along 160 km of the fault, where right-lateral offset of moraines, glaciofluvial deposits and streams has been detected. Their measurements document right-lateral separations increasing from 110 meters near the Nabesna River to 350 meters west of Mentasta Pass. Richter and Matson (op. cit.) interpreted this difference as "a marked decrease in Holocene fault activity to the southeast" and calculated Holocene movement rates of 1.1 and 3.5 cm/year for the above offsets. A 3 km Pleistocene right-lateral offset of Bone Creek (northwest of the Denali-Totschunda Fault junction) was also reported.

Richter and Matson (op. cit.) were also the first to discuss the significance of the convergence of the Totschunda and Denali Fault systems (Figure 3). Most importantly, they recognized the Totschunda as a possible new transform, which short circuits the southeast section of the Denali Fault System; thus explaining why there is very little evidence of Holocene and Pleistocene offset from the juncture of the two systems southeastward to the Shakwak segment of the fault in the Yukon Territory.

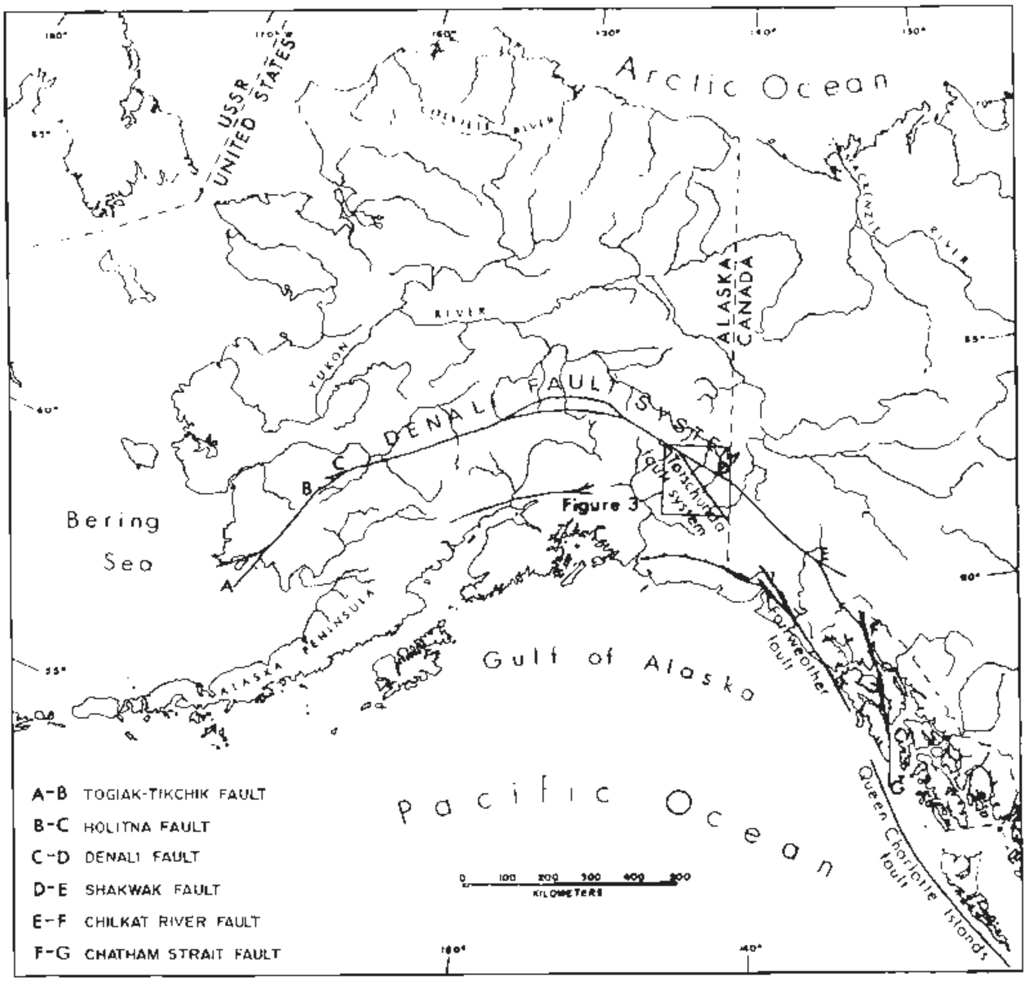

Figure 3. Index map of Alaska showing some major structural elements (compiled in part from Grantz, 1966; as taken from Richter and Matson, 1971).

Tertiary and Mesozoic Displacement

Foraker-McGonagall Pluton Offset: Based on similar mineralogy, chemistry, and $^{40}K/^{40}Ar$ ages, Reed and Lanphere (1974) concluded that the Foraker and McGonagall plutons are parts of a larger granodiorite body that has been cut by the McKinley strand of the Denali Fault. Biotite and hornblende $^{40}K/^{40}Ar$ mineral ages from the plutons indicate that the parent mass crystallized 38 m.y. ago. The two plutons appear to have been separated by 38 km of post crystallization right-lateral offset (Figure 4).

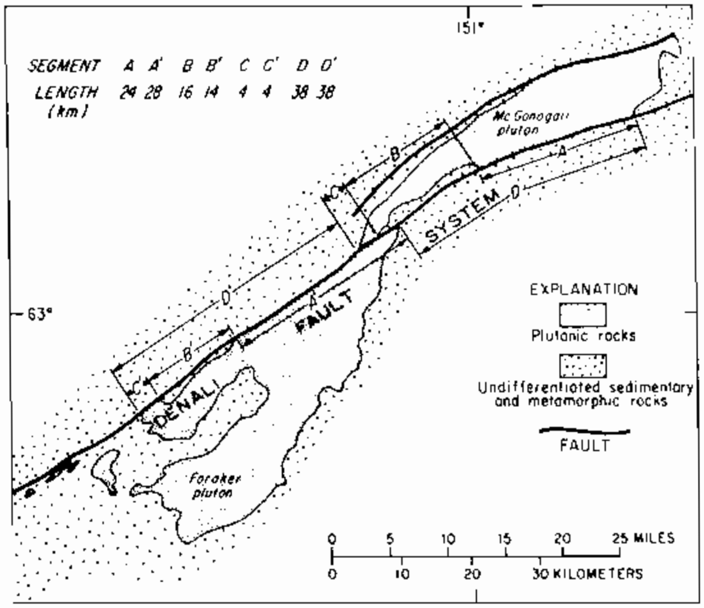

Figure 4. Geologic sketch map of part of McKinley segment of Denali Fault System showing probable offset of contacts of Foraker and McGonagall plutons (as taken from Reed and Lanphere, 1974).

If movement began immediately after crystallization in Oligocene time, the average displacement rate has been .1 cm/year over the last 38 m.y. Unfortunately, there is no way of determining whether separation began immediately after crystallization, or at some later time; and the calculated average displacement rate should be treated as a minimum rate of slip.

Maclaren Belt-Kluane Offset: In 1970, Forbes and Smith became aware of striking petrologic and structural similarities between the Coast range metamorphic belt near Juneau and the Maclaren metamorphic belt in the central Alaska Range. Forbes suggested that the Maclaren belt could be a segment of the Coast Range metamorphic belt that had been offset by right-lateral displacement along the Denali Fault.

A study of published geologic mapping in Alaska and the Yukon Territory indicated the possibility of two alternative offsets that appeared to be geologically reasonable: a Maclaren belt-Haines offset, and a Maclaren belt-Kluane Lake (Y.T.) offset (Forbes et al., 1973).

In 1972, Forbes and Turner completed two geological traverses across the western Ruby Range igneous and metamorphic complex near Kluane Lake to further explore the possibility of the Kluane offset. Twenty-four K-Ar mineral dates were determined for Kluane rock samples, and 50 ages were determined for Maclaren belt and related rocks. Based on petrologic, structural, and geochronologic evidence, the Kluane and Maclaren belts are segments of the same terrane, and a 400-km (250-mile) right-lateral offset is implied since early Cretaceous time (Figure 5) (Forbes et al., 1974).

Vertical Versus Horizontal Displacement

In general, rocks on the north side of the Denali Fault tend to be older than those to the south. Several workers, including Cady et al. (1955), Twenhofel and Sainsbury (1958), and Muller (1967) have interpreted this as evidence for large-scale vertical displacement, with the north side up.

Recent work, however, indicates that the sense and magnitude of vertical movement has varied with time along different segments of the Denali Fault. For example, Reed and Lanphere (1974) report north-facing scarps 4 to 6 meters high on the Farewell segment, west of Mt. McKinley; and Hickman and Craddock (1973) observed 3 to 4 meter south-side-up displacements of Holocene deposits in the McKinley Park area. Stout et al. (1973) have discussed south-facing fault scarps up to 10 meters high in the Delta River area, while Richter and Matson have reported scarps indicating south-side-up movement in the eastern Alaska Range.

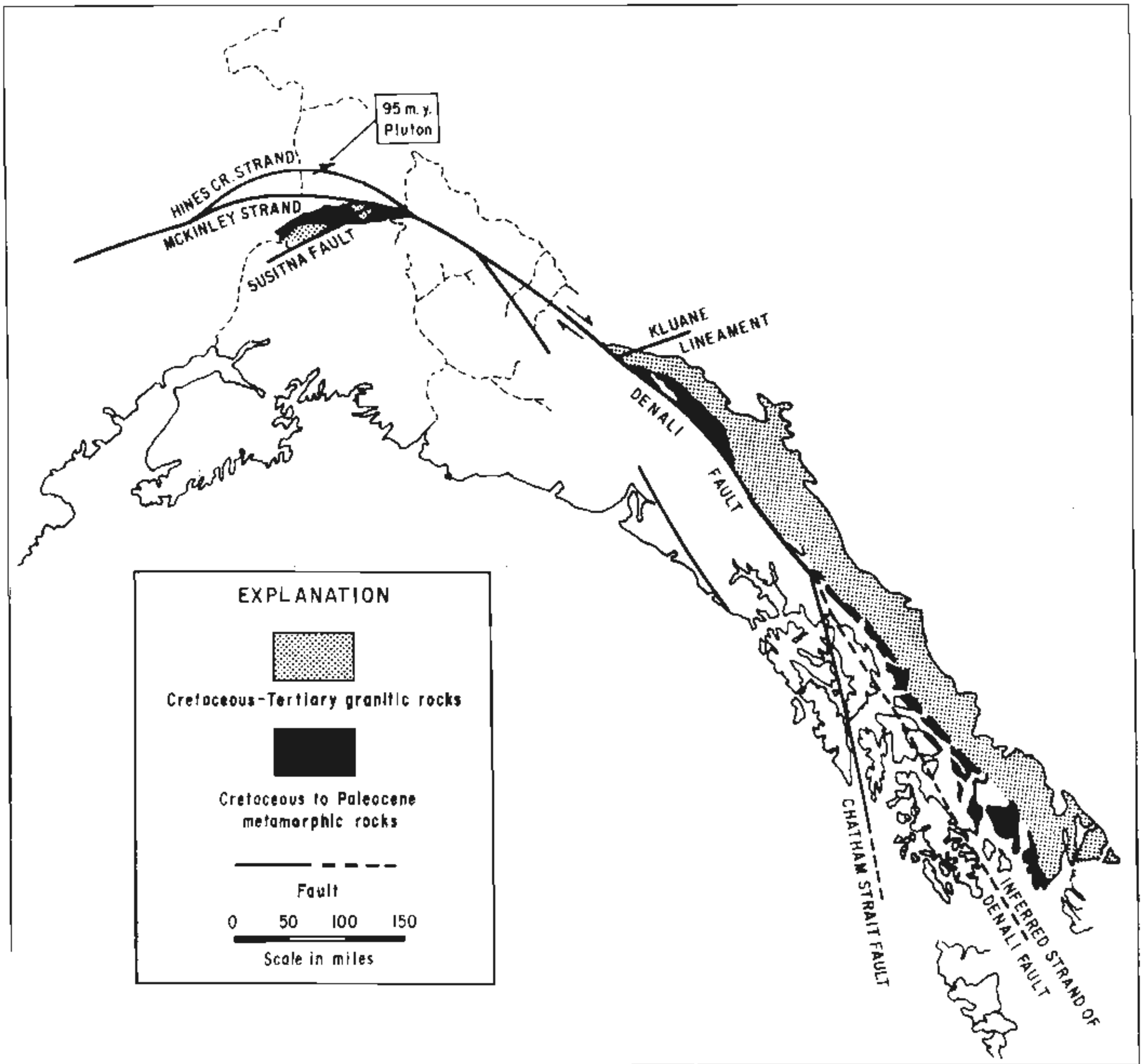

Figure 5. Metamorphic belts and pre-Denali Fault lineaments that are offset along the Denali Fault System (as taken from Forbes, Smith, and Turner, 1974).

The largest vertical displacement yet suggested is 3 km of south-side-up movement since middle Tertiary time, as inferred from the north scarp of the Mt. McKinley massif (Reed and Lanphere, 1974).

Although there is good evidence for Holocene and Tertiary vertical movement, horizontal displacement has been the dominant component of movement along the Denali Fault.

SEISMICITY OF THE DENALI FAULT

Shallow and Intermediate Depth Earthquakes

Tobin and Sykes (1966), using a least squares iterative method, located the hypocenters of about 300 earthquakes which occurred in Alaska from January 1, 1954, to March 28, 1964. As shown in Figure 6, epicenters of intermediate earthquakes (D $\geqq$ 70 km) define a northeast trending belt extending from the Alaska Peninsula and lower Cook Inlet to the Alaska Range. Although the hypocenters in the north part of this zone cannot be correlated with strain release along the Denali Fault, it is interesting to note that the zone of intermediate depth hypocenters does not extend more than 25 km north of the trace of the Denali Fault.

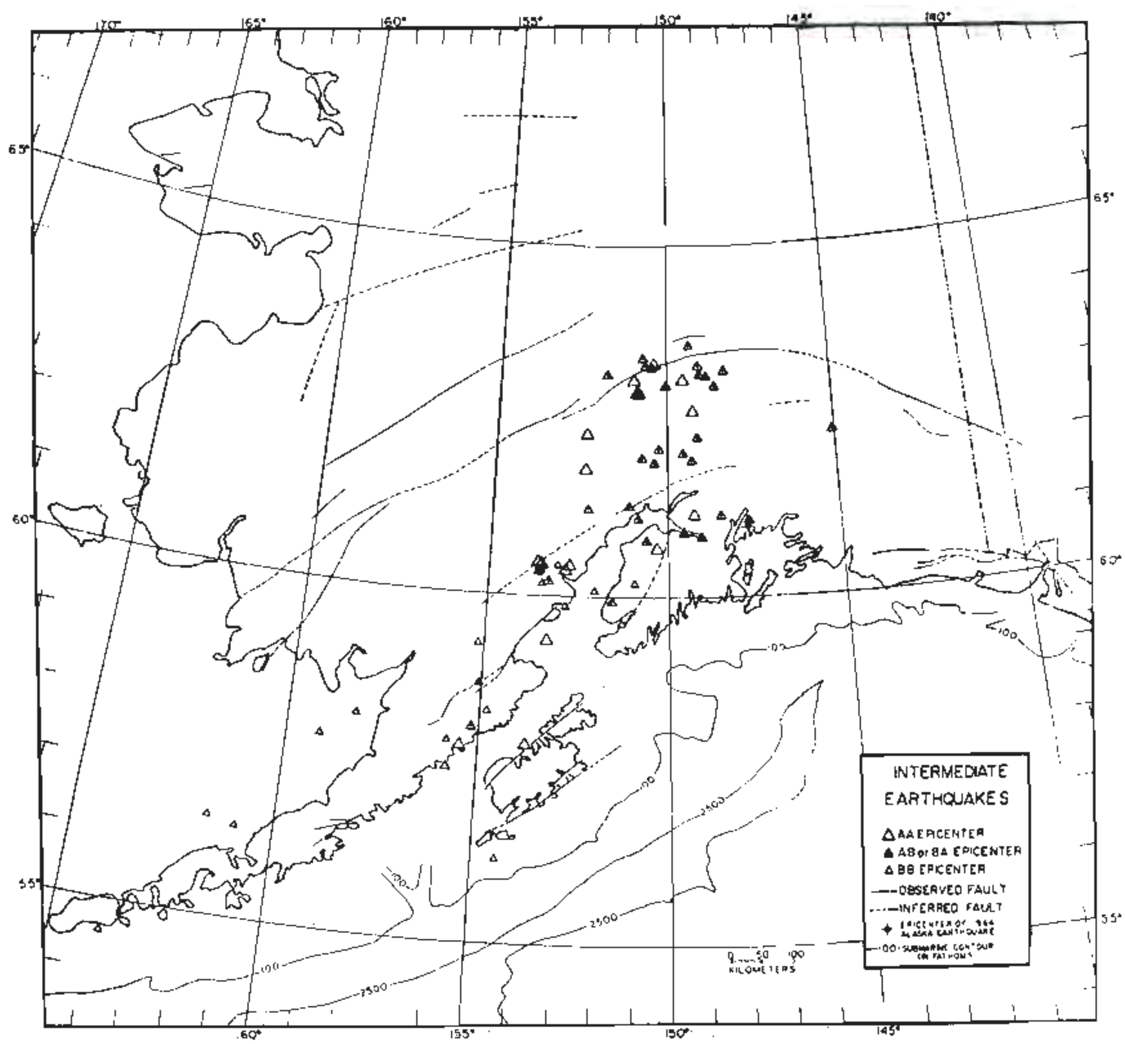

Figure 6. Epicenters of intermediate earthquakes (depth equal to or greater than 70 km). The more accurately located hypocenters are represented by larger symbols (as taken from Tobin and Sykes, 1966).

Examination of Figure 7, however, also taken from Tobin and Sykes (op. cit.), shows possible correlations between shallow earthquake hypocenters and major faults. At least eight of these hypocenters appear to be coincident with the trace of the Denali Fault; suggesting that this segment of the fault was seismically active during the period 1954-64, and that less strain was released along the flanking segments of the fault during this same period.

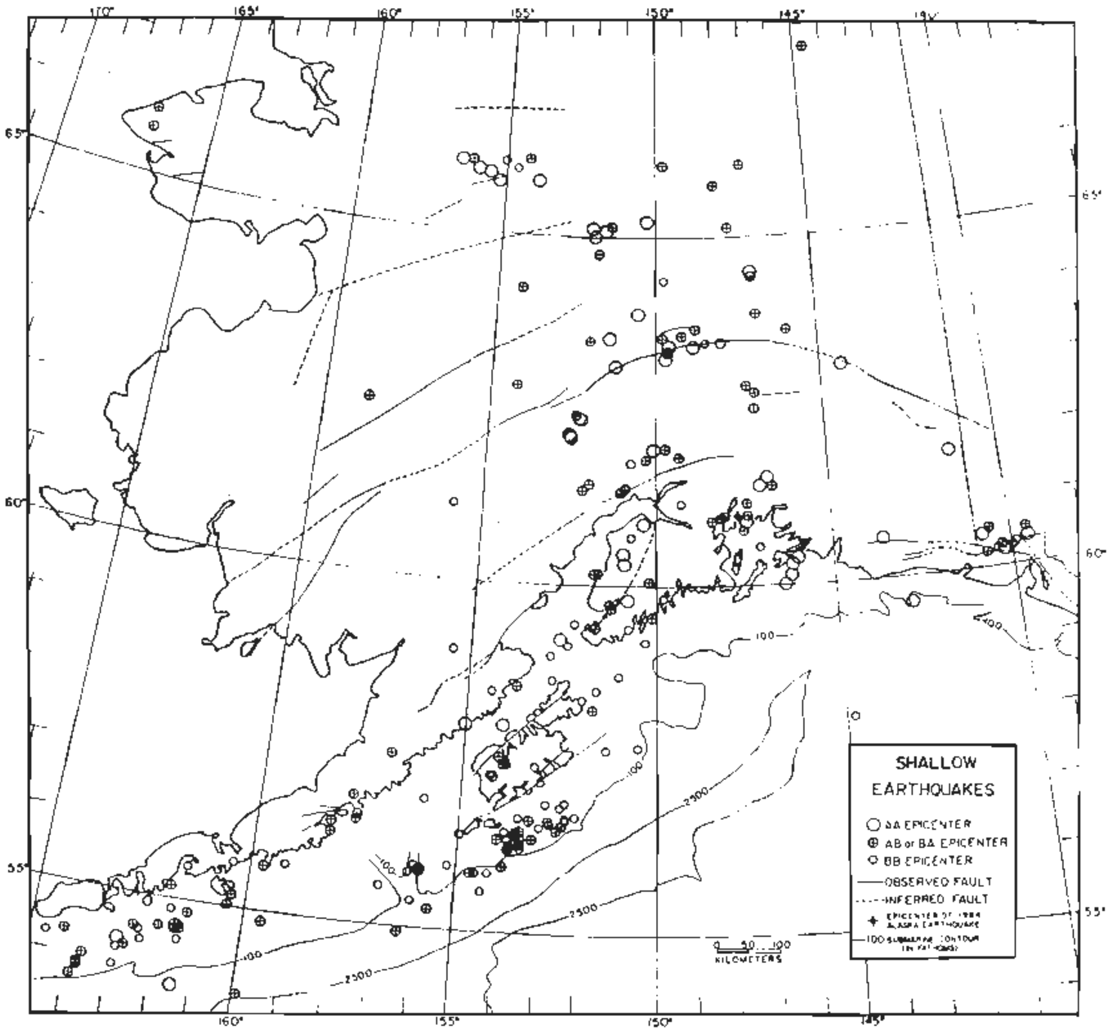

Figure 7. Epicenters of shallow earthquakes (depth less than 70 km). The more accurately located hypocenters are represented by the larger symbols (as taken from Tobin and Sykes, 1966).

Microseismicity

In August, 1965, Boucher, Matumoto and Oliver (1968) conducted a preliminary investigation of microearthquake activity along the Denali Fault in the vicinity of Mt. McKinley National Park. They found that both the McKinley and Hines Creek strands of the fault appeared to be microseismically active. During a 32.6-hour period, 27 microearthquakes were recorded near Windy, just north of the McKinley strand, and 51 shocks were recorded at Station 4, south of the fault (Figure 8). Boucher et al. also observed that recordable microseismicity rapidly decreased away from the trace of the fault.

Subsequently, Boucher and Fitch (1969) conducted a microseismicity survey of the Denali Fault, from McKinley Park to Haines, Alaska, in summer, 1967. High gain portable seismographs were placed at 22 sites for periods ranging from one to three days. Local microearthquakes were recorded at all sites, with a daily average of 5 events with S-P intervals of less than 2 seconds. Figure 9, as taken from Boucher and Fitch (1969), shows the location of the temporary stations, and the daily count of microseismic events with S-P times less than 2, and from 2-6 seconds. Table 1, also taken from Boucher and Fitch (op. cit.), summarizes the seismic data derived from the study.

Three to eighteen Class-A (S-P $<$ 2 seconds) shocks per day were recorded at all but two stations along the Denali Fault; a microseismicity level similar to that reported for the San Andreas Fault by Brune and Allen (1967). Boucher and Fitch (op. cit.) felt that the measured microseismicity was not aftershock activity, as earthquakes with magnitudes $>$ 6.0 had been "rare or nonexistent on the eastern limb of the

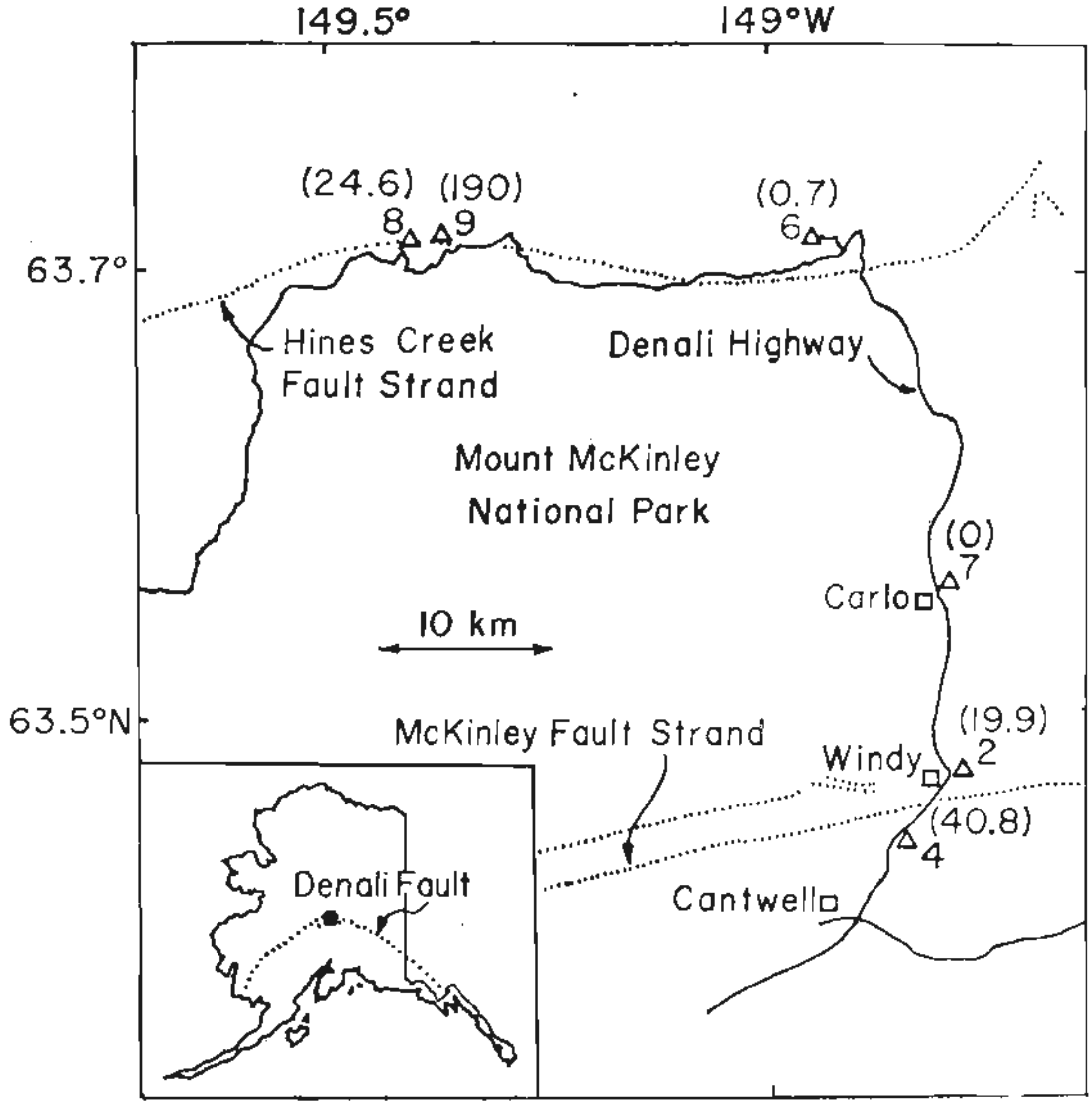

Figure 8. Map showing the seismograph locations occupied in and near Mt. McKinley National Park, Alaska. The numbers of shocks per day with S-P times less than 0.5 sec are given in parentheses (as taken from Boucher et al., 1968).

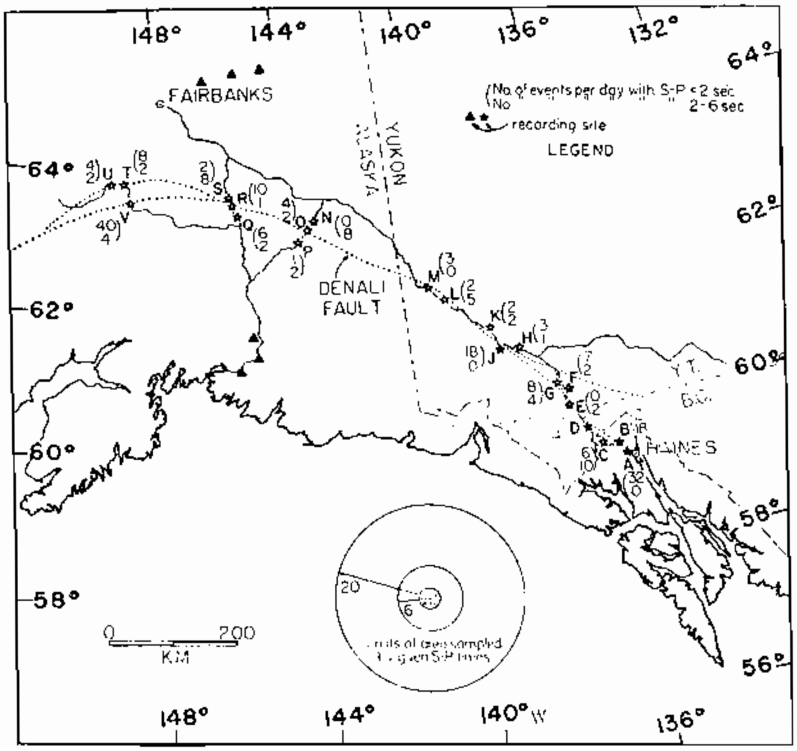

Figure 9. Map showing the distribution of temporary stations in relation to the traces (shown as dotted lines) of the Denali Fault and some of its branches. The upper number in the bracket gives the daily count of events with S-P times less than 2 sec; the lower number gives the count for events with S-P times in the range 2 to 6 sec. The solid triangles represent additional recording sites, located away from the Denali Fault Zone (as taken from Boucher and Fitch, 1969).

Table 1. Summary of microearthquake data (as taken from Boucher and Fitch, 1969).

Point	Attenuation Used	Total Useful Hours	Observed No. of Events per Day			No. of Events per Day, Adjusted to Standard Gain, $b = 1.0$ Assumed		
			0–2 sec	2–6 sec	6–20 sec	0–2 sec Class A	2–6 sec Class B	6–20 sec Class C
A	24	7	16	0	12	32	0	42
B	18	12	2	18	28	2	18	28
C	18	13	6	10	23	6	10	23
D	12	18	0	7	23	0	4	12
E	18	10	0	2	19	0	2	19
F	12	24	14	3	7	7	2	3
G	12	26	16	7	1	8	4	1
H	12	38	6	3	4	3	2	2
J	18	14	20	0	8	20	0	8
K	18	35	2	2	24	2	2	4
L	18	10	2	5	2	2	5	2
M	18	15.5	3	0	0	3	0	0
N	24	30	0	4	0	0	8	0
O	18	57	4	2	8	4	2	8
P	12	11	2	4	6	1	2	3
Q	12	6	12	4	16	6	2	8
R	18	42.5	10	1	13	10	1	13
S	18	10	8	2	18	8	2	18
T	24	48	4	1	13	4	1	26
U	18	24	4	2	23	4	2	23
V	24	14	20	2	32	40	4	64

Denali Fault during the previous 60 years, and events with magnitudes greater than 4.0 were also known to have been rare over the preceding few years."

In two areas, the authors were able to straddle the trace of the Denali Fault with an array of three seismometers (N-O-P and Q-R-S on Figure 9). In each case, recorded shallow microseismic activity (Class A) was higher on the fault than away from it; supporting the contention that the microearthquakes were being generated by a fault-related mechanism, such as creep.

Based on the data recorded by Boucher and Fitch, the McKinley Park and Isabelle Pass segments appear to be more active, microseismically, than the Mentasta segment, although the microseismic events recorded at Mentasta are also significant.

Page (1971) operated a temporary network of 10 seismic stations for four weeks in August-September, 1970, near the intersection of the Denali Fault and the Richardson Highway. Hypocenters for more than 50 microearthquakes were located. Most of the shocks originated from a small source region lying within 5 km of the fault line valley (Denali Strand), at a depth of 10 km or less.

Strain Release from Larger Earthquakes

Various authors have concluded that little strain has been released along the Denali Fault by larger earthquakes in the last 75 years. According to Page and Lahr (1971), a magnitude 7.4 earthquake possibly occurred on the fault in 1912. This epicenter was relocated by Page and Lahr (op. cit.) at 30 km north of the McKinley strand and about 60 km from their Denali survey figure; but the uncertainty of the epicenter is at least 30 km.

Page and Lahr (op. cit.) also noted that no earthquakes larger than magnitude 6 are known to have occurred on the fault within 200 km of the Denali survey figure, but shocks larger than magnitude 5 have occurred in the last 20 years (Tobin and Sykes, 1966).

L. Gedney (unpublished manuscript), Geophysical Institute, University of Alaska, compiled a strain release map for the northern Alaska Range and north central Alaska, derived from *2,719 earthquakes which occurred during the period September, 1967-September, 1971. The method was that employed by Niazi (1964), Allen et al. (1965), and Ryall et al. (1966).

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* Data from the University of Alaska seismic network and NOAA seismographic stations operated by the Palmer Observatory (now under U.S.G.S. aegis).

As noted by Gedney, the northern part of the strain release map (Figure 10) reflects the Rampart earthquake of October, 1968, (M=6.3) and the aftershock zone of the Fairbanks earthquake of June, 1967, (M=6.1).

However, the Alaska Range segment of the map is dominated by strain release concentrations coinciding with the trace of the Denali Fault. Although other authors have minimized the amount of strain released on the Denali Fault since the turn of the century, Gedney's compilation for only four years of data suggests that the cumulative strain release may have been underestimated.

Table 2, from Gedney's paper, lists parameters of the largest earthquakes which occurred on the Denali Fault during the four-year study period. These data indicate that significant, if not large, strain release has occurred along the fault. However, Gedney has also noted that hypocenter depths of the larger earthquakes increase from east to west; and some would argue that because hypocenters > 100 km are within the upper mantle, they are not related to strain release along a srike-slip fault that is believed to be a tear within the lithospheric plate.

Table 2. Parameters for largest earthquakes occurring on Denali Fault during period September, 1967-September, 1971. Figures in parentheses are depths obtained for these events by NOAA/ERL (USCGS) (as taken from Gedney, unpublished manuscript).

Date	Time (GMT)	Latitude (N)	Longitude (W)	Magnitude	Depth (km)
22 Nov 67	02:44:28	63.6	147.0	5.3	10 (2)
4 May 69	09:28:00	63.5	148.3	5.0	40 (N)*
1 May 70	20:58:11	63.5	148.9	5.0	40 (33)
2 Mar 71	12:46:38	63.4	149.8	4.8	100 (111)
20 Jan 71	02:07:37	63.2	150.7	4.8	100 (131)
20 Dec 70	06:01:38	63.1	151.4	5.3	125 (130)

* N denotes restricted depth of 33 km.

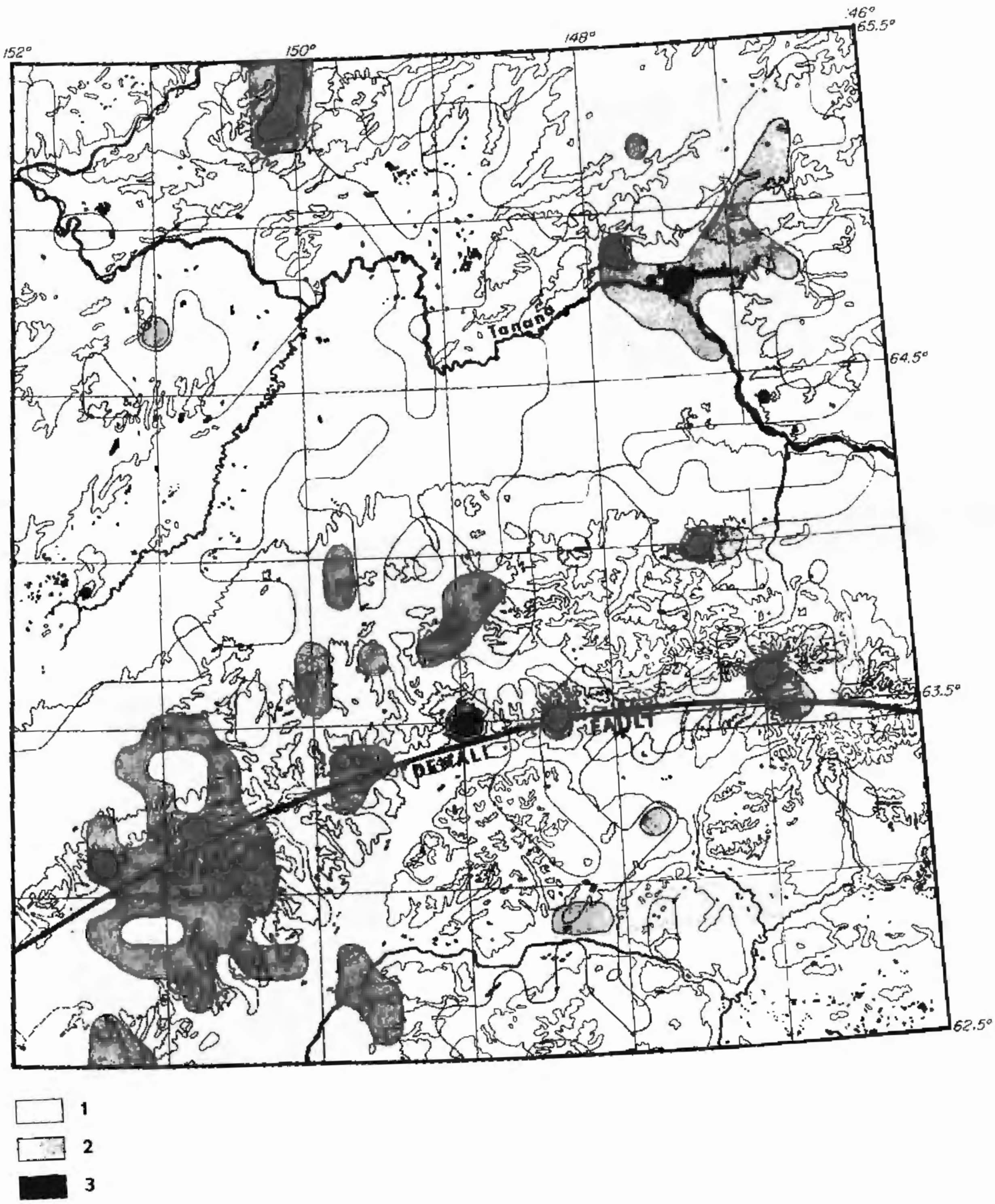

Figure 10. Contour map of seismic strain release during period September, 1967-September, 1971, in central Alaska and along the northern Denali Fault. Coding is as follows: $\log E^{\frac{1}{2}}$ = (1) 7.5-8.4 (2) 8.5-9.4 (3) >9.5 (as taken from Gedney, unpublished manuscript).

STRAIN ACCUMULATION AND RELEASE POTENTIAL

Tertiary and Quaternary Lateral Displacement Rates

As we have discussed in the preceding sections, geologic evidence supports a right-lateral offset of 400 km along the Denali Fault in the last 65 million years (late Cretaceous time); an average slip rate of .62 cm/year.

It is interesting to compare this rate with that calculated for measured offsets in more recent geologic time.

Table 3. Denali Fault displacement data.

Offset	Time Interval	Reference	Average Displacement Rate
(1) 400 km	65 million years	(Forbes et al., 1974)	.62 cm/yr
(2) 38 km	38 million years	(Reed & Lanphere, 1974)	.1 cm/yr
(3) 3 km	(Wisconsin or Illinoian) 300,000 - 600,000 yrs	(Richter & Matson, 1971)	.5-1 cm/yr
(4) 6.5 km	(Wisconsin or Illinoian) 300,000 - 600,000 yrs	(Stout et al., 1973)	1.08-2.17 cm/yr
1 km	300,000 - 600,000 yrs		.17-.33 cm/yr
(5) 110 meters	10,000 yrs	(Richter & Matson, 1971)	1.1 cm/yr
350 meters	10,000 yrs		3.5 cm/yr
(6) 50-60 meters	10,000 yrs	(Stout et al., 1973)	.5-.6 cm/yr

The above table documents a considerable range in Quaternary right-lateral offset, as measured along the Isabelle Pass and Mentasta-Nabesna segments of the fault. Although average offset rates range between .17 and 3.5 cm/year, this range is exaggerated by uncertainty in the age of Pleistocene deposits (e.g., Wisconsin versus Illinoian) and the lack of absolute age determinations of Holocene deposits.

Based on the regional displacement rate of .62 cm/year, calculated over a 65 million year period, and the more reliable data from the above table, we conclude that the average Quaternary displacement rate was between .5 and 1 cm/year; similar to that calculated for Tertiary time.

To date, no one has detected measurable creep along the Denali Fault, even though the microseismicity levels are similar to those recorded along active segments of the San Andreas Fault. Based on high microseismicity, and the occurrence of magnitude 2-5 earthquake epicenters, and recent scarps along the fault line, the *Denali Fault is considered to be active between McKinley Park and the Denali-Totschunda juncture.*

Strain Accumulation and Possible Release

Based on calculated prehistoric displacement rates and the absence of fault-related major earthquakes (> magnitude 7) during the last 100 years, we conclude that strains are accumulating along the Denali Fault.

It is difficult, if not impossible, to calculate the actual strain which may have accumulated, when the historic record covers only 100 years, and the youngest scarps and lateral offsets have not been dated with a resolution any better than Holocene (< 10,000 years). If, however, we accept .5 cm/year as a reasonable average displacement rate and the premise that a major earthquake and measurable offset has not occurred along the Denali Fault in the last 100 years, we can develop some meaningful estimates.

Simplistically, we must assume that very little strain is being relieved by minor earthquakes and that, when release occurs, accompanying fault displacement at the surface will be equal to the average displacement rate times the number of years since the last release. Using 100 years, we derive a potential strain release accompanied by a 50 cm displacement. Stout et al. (1973) cite a 170 year minimum for recent fault movement near Isabelle Pass; a constraint which gives an 85 cm displacement upon release.

We selected .5 cm/year as the preferred displacement rate, based on Holocene offset data given by Stout et al. (1973), which was in excellent agreement with the average Tertiary rate derived by Forbes et al. (1973). If one uses a larger average rate, such as 1.0 or 1.5 cm/year, the strain accumulation becomes more impressive during a 100-year period, but the most significant finding is that strain accumulation necessary for a magnitude 8 earthquake will require from 500 to 1000 years at displacement rates ranging from .5 to 1.5 cm/year.

It is probable that active segments of the Denali Fault have been locked for as long as the last 500 or 1000 years, and that risk studies should reflect the probability of a magnitude 8 earthquake on the Denali Fault.

Department of Interior Risk Estimates

The Department of Interior has discussed the earthquake potential of the Denali Fault in several publications, including a recent Environmental Impact Statement. A paragraph from page 229 of this publication summarizes the release potential of the Denali Fault System, and it is cited below:

> "Between Donnely Dome and Paxson, the route crosses the Denali fault along which there is abundant geologic evidence of large predominantly lateral Holocene offsets (Richter and Matson, 1971; Stout and others, 1973). No major earthquake has been positively identified

with the Denali fault in this century; however, seismic quiescence is observed elsewhere on major faults that have generated large historic earthquakes and is inferred to correspond to a phase of behavior where the fault is locked and strains are accumulating for a future release. The geologic and geophysical evidence suggests that sometime in the future large earthquakes accompanied by large surface displacement will occur on the Denali fault. An earthquake as large as magnitude 8.0 is postulated for the Denali fault system (Page and others, 1972). A fault offset of at least 20 feet could be expected for such an event."

SEISMIC MODELING

Earthquake Parameters

Between Delta Junction and the Alaska-Canada border, the proposed pipeline sub-parallels the Denali Fault zone. Along this segment of the route, the pipeline right-of-way is 50-100 km northeast of the fault. The possibility of a magnitude 8 earthquake has been postulated for this fault (Forbes, Testimony before the Federal Power Commission, 1976; Page et al., 1972).

Therefore, our model will be based on a hypothetical magnitude 8 earthquake which will occur within 50 km of the route. An earthquake generated by the Denali Fault will most likely have a shallow focus, and we shall stipulate a focal depth of 20 km.

Bedrock Motion

For design purposes, the most important parameters of expected bedrock motion are peak acceleration, predominant period, and duration (not necessarily in that order). A number of empirical relationships exist for the above parameters, though actual data for a magnitude 8 earthquake are lacking.

Peak Acceleration: Numerous attempts have been made in the past to correlate peak acceleration with earthquake magnitude, and distance to the hypocenter or causative fault. Figure 11 shows some correlations for a magnitude 6.5 earthquake. The plots indicate that large differences exist for distances of less than 20 km from the fault, due to the lack of sufficient data in that range. Similarly, few data exist for earthquakes with magnitudes larger than 7, making correlation difficult.

To explore the variation, we have calculated the peak accelerations for a magnitude 8 earthquake with a focal depth of 20 km, at a 50 km

HORIZONTAL PEAKS

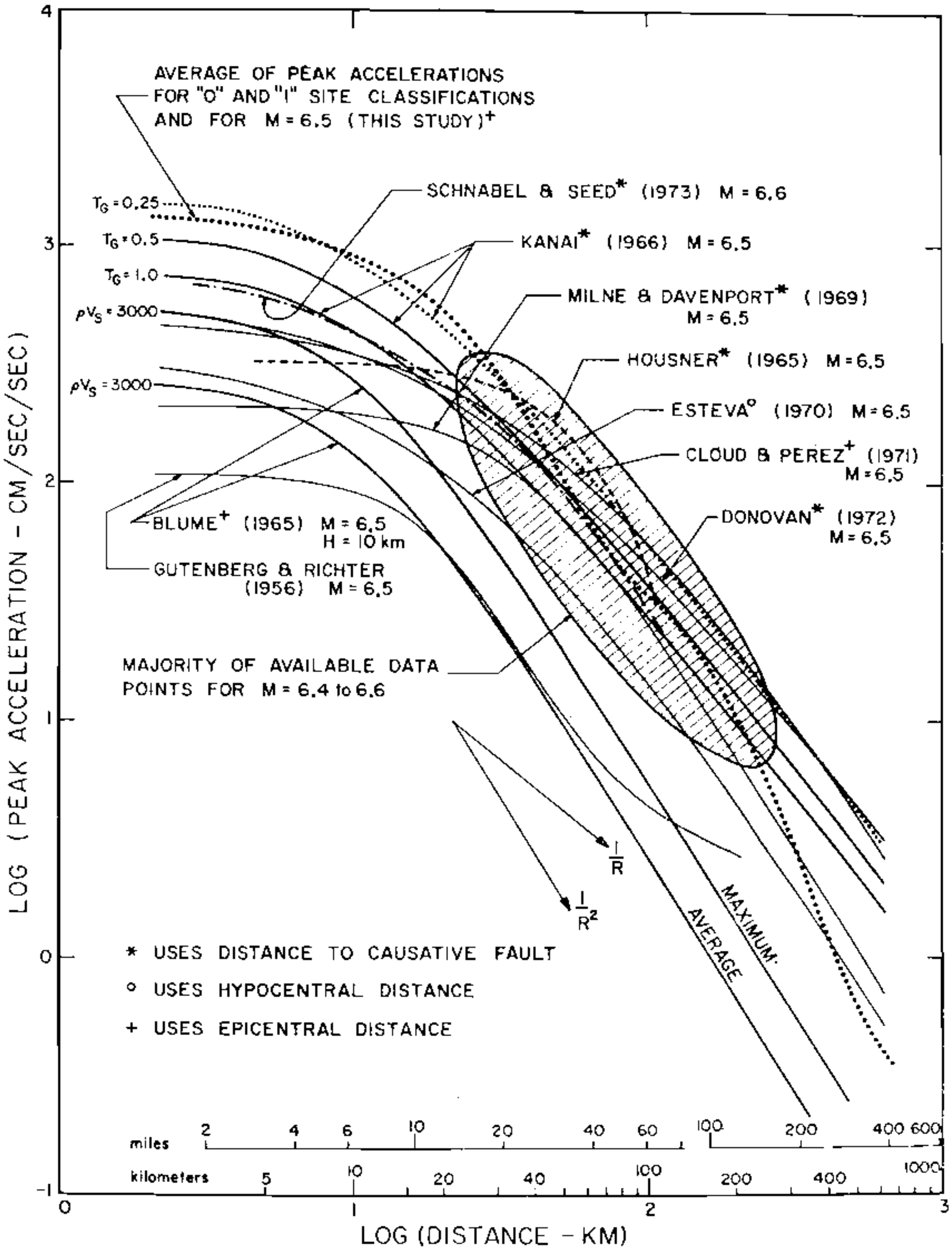

Figure 11. Comparison of the correlations, for a magnitude 6.5 earthquake, of peak acceleration and distance (as taken from Trifunac and Brady, 1976).

distance from the hypocenter, using mathematical relationships proposed by several authors. In the equations below, a_m, M, R, are the maximum acceleration, the magnitude and the hypocentral distance respectively.

1) Kanai (1966):

$$a_m = \frac{1}{T_p} 10^B = \underline{.26\ g}$$

where $B = .61M - (1.66 + \frac{3.6}{R}) \log R$

$+ (0.167 \frac{1.83}{R})$

and $T_p = 0.42$ (T_p is the predominant period of the motion.)

2) As modified from Esteva and Rosenblueth (1963):

$$a_m = \frac{110.e^{.8M}}{R^{1.6}} = .11g$$

3) Esteva (1970):

$$a_m = \frac{1230\ e^{.8M}}{(R+25)^2} = \underline{.12g}$$

4) Schnabel et al. (1972):

average $a_m = \underline{0.22g}$

(from Figure 12)

5) Modified Esteva, used in seismic design studies for the Trans-Alaska Pipeline in the Copper River Valley (Dames and Moore, 1971):

$$a_m = \frac{18.9e^{.8M}}{R^{1.06}} = a_m = .16$$

here $R^2 = d^2 + h^7 + 400$

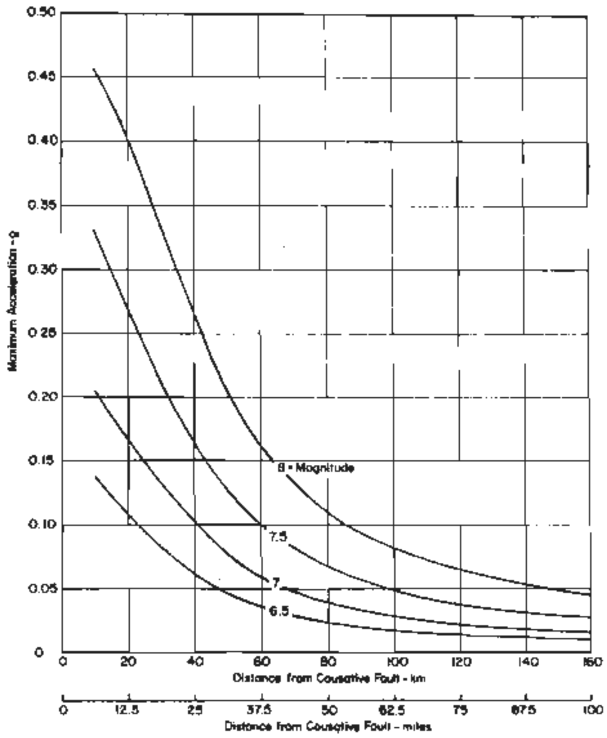

Figure 12. Variation of maximum acceleration with earthquake magnitude and distance from causative fault (as taken from Seed et al., 1969).

6) Trifunac and Brady (1976):

For magnitude 7.9 on a soft alluvial site for the horizontal component;

$$\log a_m = M + \log A_o(R) \quad \log a_o(M)$$

where $A_o(R)$ is the attenuation function, and $a_o(M)$ the magnitude dependent scaling function determined from regression analysis for $M = 7.9$, $a_M = .33$. The values for a_m for plus and minus one standard deviation, are .48g and .23g, respectively.

Duration of Shaking: The duration of shaking near the epicenter will depend upon the propagation velocity of the rupture associated with the earthquake, and upon the length of the rupture zone. With a rupture zone of 200 km and a rupture propagation velocity of 3 km/sec, the duration of shaking would be 66 seconds.

Housner (1965) suggests the empirical relationship $D = 11.2M - 53$, which gives 37 seconds of shaking for a magnitude 8 earthquake.

Trifunac and Brady (1975) suggest the following relationship:

$$D = as + bM + cR \pm \sigma$$

where s, M, R, and σ are site classification (s = o for soft ground, s = 1 intermediate ground, s = 2 for hard ground), magnitude, epicentral distance and standard duration respectively. a, b, and c are the regression coefficients. For horizontal motion on hard ground, we obtain $D = 14 \pm 11$ sec, for a magnitude 7 earthquake.

Predominant Period: Gutenberg and Richter (1956), based on studies of Californian earthquakes with magnitudes ranging from 5.5 to 6.5, suggest a predominant period of .25 seconds for distances up to 50 km. Seed et al. (1969) suggest the relations shown in Figure 13. For M = 8 at 50 km epicentral distance, we would have a predominant period of about .45 sec.

On the basis of the above and our own work, the probable values and limits for a bedrock site, affected by our design earthquake, are shown below:

Maximum acceleration: $.2 \pm .1$g

Predominant period: $.4 \pm .05$ seconds

Duration of motion: 30 ± 10 seconds

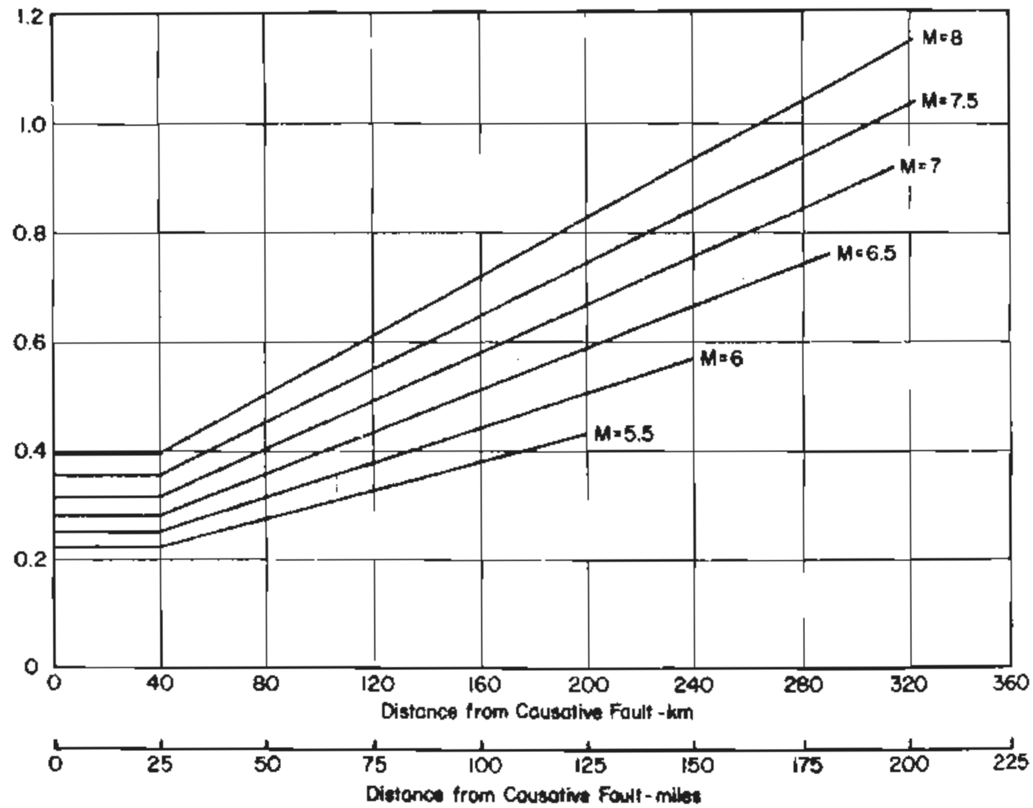

Figure 13. Predominant periods of motion in rock (as taken from Seed et al., 1969).

As our input motion, we have used 25 seconds of the motion recorded at Pasadena from the magnitude 7.7, 1952, Kern County earthquake. The digitized, instrument, and baseline corrected data have been taken from the California Institute of Technology publication of digitized accelerograms. The acceleration coordinates have been scaled to give a maximum acceleration of .1g and .2g, respectively; and the time coordinate has been scaled to give a predominant period of .4 seconds. These data were then used as input motion for our analysis.

SOIL CONDITIONS AND PROPERTIES

Selection of Study Sections

A number of logs from test holes and wells along the proposed pipeline route were available for study. Initially, we have chosen five sections for seismic response analysis. These are shown in Figure 14.

The main type of soils encountered in these profiles are (1) sandy gravels, (2) fine sands, and (3) silts. Analyzed sections are those with the highest potential for producing large surface accelerations and/or liquifaction. Due to limited field data, we can make no statement about the frequency of occurrence. Profile A6-7 (Figure 14), with a substantial layer of unfrozen silt, is probably unusual. Unfrozen fine sands on south slopes and unfrozen gravels or sandy gravels are probably more common. We have not considered permafrost in our initial analyses, since available data (Barnes, 1963; Kaplar, 1963) on frozen soils in the area indicate that frozen ground will behave essentially like bedrock under seismic loading. The only section with permafrost, is again profile A6-7, where a five-foot layer of frozen silt is embedded between unfrozen sands and silts.

In most cases, the depth to bedrock was not known due to the finite depth of the test holes (50 ft.). In these cases, the analysis was made for 60 ft. and 200 ft. of soil thickness respectively.

Only one of the study sections contains a water table (A2-11). All unfrozen silt and sand sequences were relatively dry, at least to 50 ft. A survey of water well logs (Waller and Tolen, 1962a and 1962b) and Highway Department test holes produced only one unfrozen fine sand or silt sequence with a high water table. This sequence was encountered in

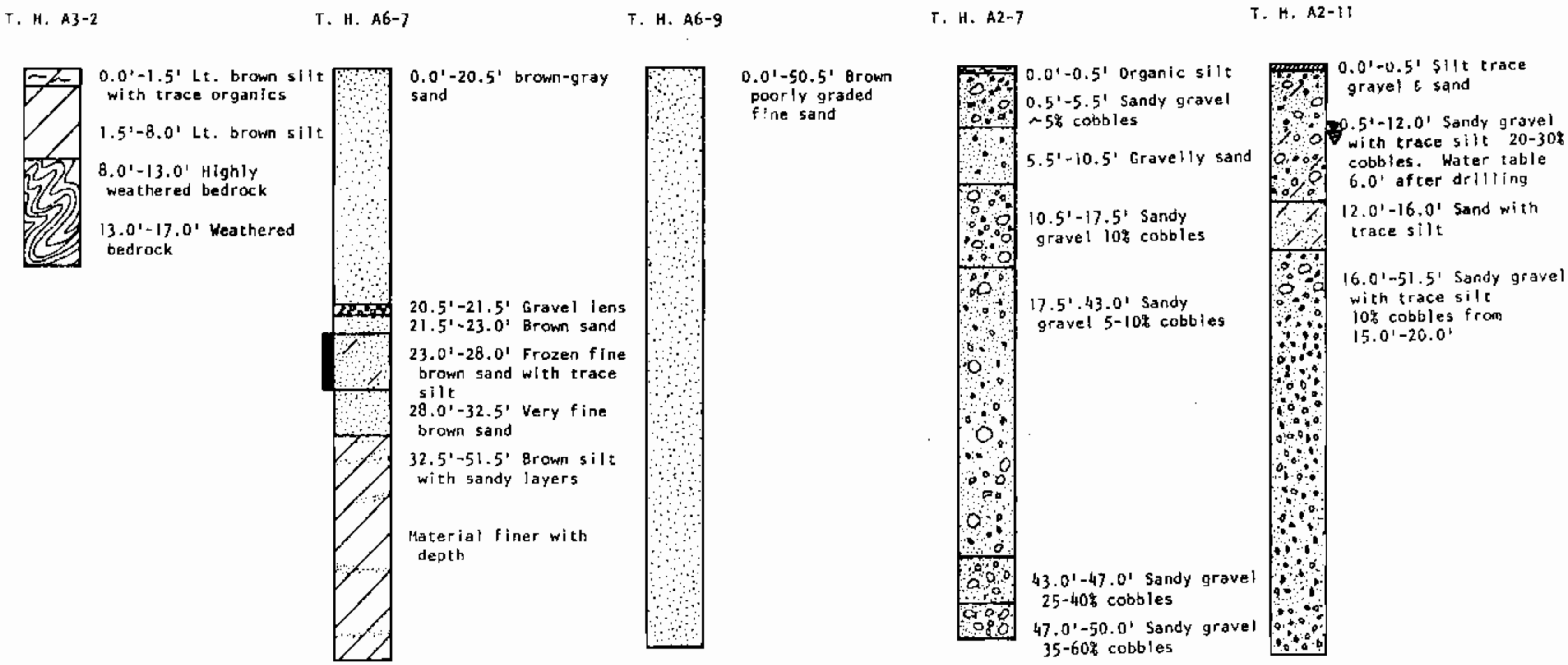

Figure 14. Stratigraphic sections used for seismic response analysis.

three test holes for bridge foundations across Fish Camp Creek, about three miles southwest of the Alaska Highway at Northway junction (Department of Highways, State of Alaska, 1976).

Soils Engineering Data

We reviewed the laboratory data on samples taken from the above holes, to obtain a reasonable estimate of the soil parameters for analysis.

Density: For the fine sands and silts the tests typically indicated γ=100 lbs/ft^3; and for the gravely sands, γ=120 lbs/ft^3.

Relative Density: Relative density values were correlated from standard penetration test blow counts according to Figure 15. We have generally used the criteria suggested by Holtz and Gibbs (1969), but have also used the Bazaraa criteria for comparison purposes in the analysis of the silt sections. Table 4 shows the blow counts and relative density values for these profiles. The small number of available penetration values does not give very reliable data on the relative density of unfrozen material in the area, but profile A6-7 does suggest that unsaturated, poorly compacted, and low relative density silts do occur.

Strain Dependent Shear Moduli and Damping Ratios: The relationships suggested by Seed and Idress (1970) for sands were used for all soils, taking into account the different values of relative density (Figure 16).

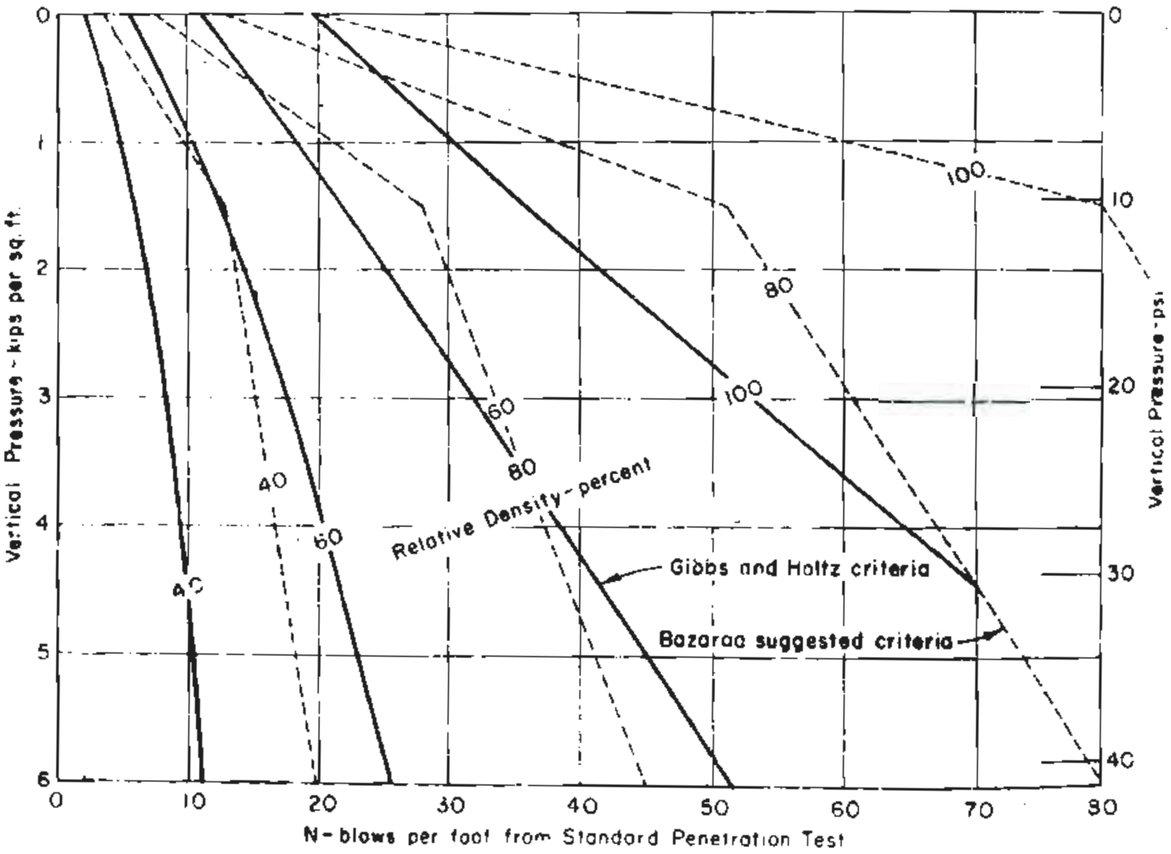

Figure 15. Relative densities calculated from standard penetration resistances (from Holtz and Gibbs, 1969).

Table 4. Blow counts and relative densities for silt profiles. (N is the blow count from a standard split level sampler; R_{D1} and R_{D2} are the relative densities from the Gibbs-Holtz Bazaraa criteria, respectively; K_2 is the corresponding factor for the strain dependent shear modulus relationship.

Depth	Profile A 6-7					Profile A 3-2				
	N	R_{D1}	R_{D2}	K_2	K_2	N	R_{D1}	R_{D2}	K_2	K_2
5	16	80	60	64	52	6	55	40	49	40
10	26	90	65	70	57					
15	42	100	90	75	70					
20	22	70	50	68	46					
25	Frozen									
30	10	45	<40	42	35					
35	16	55	<40	49	35					
40	8	<40	<40	35	35					
45	7	<40	<40	35	35					
50	7	<40	<40	35	35					

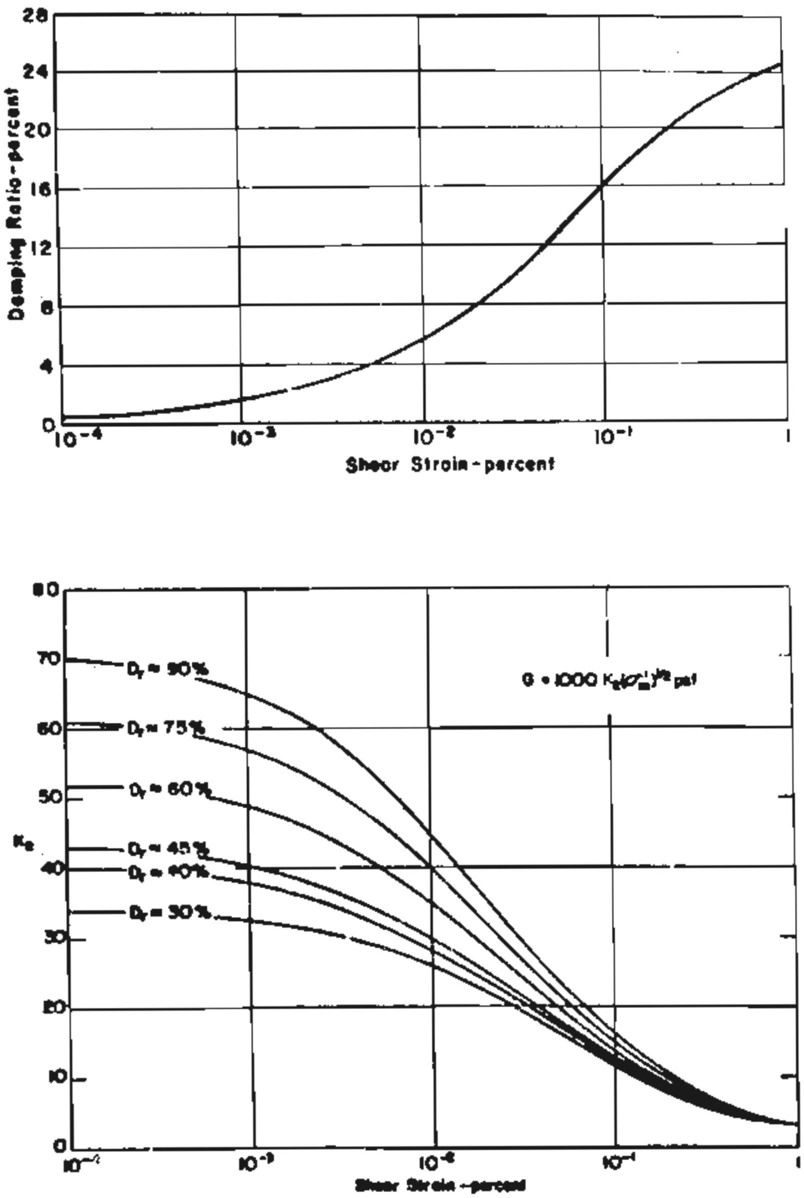

Figure 16. Moduli and damping ratios for sands (from Seed and Idriss, 1970).

SEISMIC RESPONSE ANALYSIS

Analytical Methods

We have subjected the soil profiles shown in Figure 14 to a seismic response analysis. In doing so, we have followed the methods of Seed and Idriss (1969) using a computer program developed by Schnabel et al. (1972) which computes the response in a horizontally layered soil-rock system subjected to transient vertically-traveling shear waves. The method is based on Kanai's solution of the one-dimensional wave equation and the Fast Fourier Transform algorithm. An iterative scheme allows the adjustment of the shear modulus and damping ratio according to the actual strains developed in each layer. Since the major portion of the pipeline route in the study area runs either along the hills of the Yukon-Tanana Complex or within a few miles of the boundary between the valley fill and these hills, it is quite apparent that a horizontally layered model is not optimum. One would rather have a sloping bedrock profile below the pipeline. Dezfulian and Seed (1969) have studied the influence of sloping rock boundaries and compared the results of one- and two-dimensional analyses. Though the sloping boundary does influence the ground response, and its magnitude and extent vary within a wide range, they conclude that "where analyses are conducted for the primary purpose of determining the maximum ground accelerations developed during earthquakes in regions adjacent to sloping rock surfaces, without regard to the direction in which they are developed and where extreme accuracy is not required, semi-infinite layer analyses will usually provide satisfactory results for most practical purposes."

Analytical Results

The results of our analyses are shown in Tables 5 through 8. Tables 5 and 6 give the peak accelerations on top of the different

Table 5. Maximum surface accelerations (in g) developed in different profiles due to Pasadena motion scaled to .1g maximum accelerations. (A6-7a is A6-7 profile with permafrost removed).

Profiles	A3-2	A6-7	A6-7A	A6-9	A2-7	A2-11
Depth to bedrock 60 ft (except in A3-2, 8 ft)	.11	.17	.17	.22	.19	.24
Depth to bedrock 200 ft (except in A3-2, 60 ft)	.24	.13	.14	.11	.18	.19

Table 6. Maximum surface accelerations (in g) developed in different profiles due to Pasadena motion scaled to .2g maximum accelerations. (A6-7a is A6-7 profile with permafrost layer removed.

Profiles	A3-2	A6-7	A6-7A	A6-9	A2-7	A2-11
Depth to bedrock 60 ft (except in A3-2, 8 ft)	.22	.24	.25	.39	.41	.44
Depth to bedrock 200 ft (except in A3-2, 60 ft)	.41	.20	.21	.21	.34	.36

Table 7. Maximum spectral amplication and corresponding periods (.1g peak input).

Profiles	A3-2	A6-7	A6-9	A2-7	A2-11	
Depth to bedrock 60 ft (except in A3-2, 8 ft)	14.4 0.08	4.0 0.63	5.8 0.4	10.5 0.23	7.9 0.3	Spectral Amp. Period
Depth to bedrock 200 ft. (except in A3-2, 60 ft)	5.9 0.44	5.9 1.18	10.1 0.82	8.0 0.61	7.9 0.74	Spectral Amp. Period

Table 8. Maximum spectral amplification and corresponding periods (.2g peak input).

Profiles	A3-2	A6-7	A6-9	A2-7	A2-11	
Depth to bedrock 60 ft (except in A3-2, 8 ft)	12.7 0.08	3.2 0.81	4.0 0.56	6.1 0.29	5.2 0.38	Spectral Amp. Period
Depth to bedrock 200 ft (except in A3-2, 60 ft)	4.2 0.58	4.27 1.51	7.1 0.95	5.6 0.72	5.6 0.85	Spectral Amp. Period

soil profiles, for the true input motions respectively; while Tables 7 and 8 show the maximum spectral amplifications (i.e., the peak value of the soil-system dependent amplification function) and the periods at which they occur. While the highest spectral amplification for all cases considered is about 14, the maximum peak acceleration ratio between closed motion and input motion is 2.4. The high spectral amplification in Profile A32 (with 8 feet to bedrock) occurs at a frequency that was outside the significant frequency content of the input motion, leaving the peak surface acceleration essentially unaltered from that of the input motion. Quite generally, the peak surface acceleration values for the 200 feet to bedrock sections are substantially lower than the corresponding 60 foot sections, since in the former case, the maximum spectral amplification peaks occur at much longer periods, which are again outside the main frequency content of the input motion. Thus, any additional increase of the depth to bedrock would result in further reduction of the peak surface accelerations.

Tables 7 and 8 also indicate the decrease of the maximum spectral amplification and the increase in the fundamental period of the .2g scaled motion as compared to the .1g model. This is because the higher strains developed in the .2g motion reduce the effective dynamic shear moduli, thus increasing the fundamental period; while the increase of the damping ratio under the higher strains reduces the maximum amplification value. Hence, in all the cases studied, we find the ratio between maximum surface and input accelerations to be lower for the stronger input motion. In the strict sense, we are referring to the ratio between the peak acceleration that would occur on the surface of the soil system and the surface of an outcropping rock layer. Due to the presence of the soil system and the elasticity of the rock, the actual input motion is somewhat different in each case. These effects have been accounted for in the analysis.

Realizing the importance of the spectral shape of the input motion, and that of the primarily soil dependent amplification function, the values listed in Tables 5 and 6 provide a reasonable estimate of peak accelerations to be expected from a large earthquake on the Denali Fault. The models reflect actual conditions to be encountered along the pipeline route, including documented soil properties, and use an input motion which is conservative but realistic. Clearly, peak acceleration should not be overemphasized, as a proper evaluation of the time history and duration of the motion (and that of the stresses and the strains) is of fundamental importance to seismic risk considerations.

Liquefaction

Since some poorly compacted sands and silts do occur along the proposed pipeline route (though none of these materials showed water saturation), we have applied the available in situ and laboratory soil data to a simplified procedure suggested by Seed and Idriss (1969), to evaluate the liquefaction potential of these soils. Such an analysis was performed by Chrostowski and Wiggins (1976); however, no soil data from along the proposed route was available at that time.

On the basis of the available data, we make the following assumption:

$$h_w = 5 \text{ ft}$$

$$\gamma = 100 \text{ lb/ft}^3$$

$$D_{50} = .1 \text{ mm}$$

$$N = 30$$

where h_w is the depth to the water table, γ the unit weight of the soil, D_{50} the mean grain size of the soil, and N the number of significant stress cycles that would occur during a magnitude 8 earthquake.

We have, following Seed and Idriss, for the average shear stress at depth h:

$$T_{av} = .65 \times \frac{\gamma h}{g} \times r_d\ (h)$$

where r_d (h) is a depth dependent stress reduction coefficient that accounts for the nonrigidity of the soil column.

Figure 17 shows the range of r_d as a function of depth. The stress ratio required to cause liquefaction is given by:

$$(\frac{\tau}{\sigma_o'})_{LD_r} = (\frac{\sigma_{dc}}{2\sigma_a})_{L50}\ C_r\ \frac{D_r}{50}$$

where τ_x and σ_o' are the shear stress and the effective overburden pressure, respectively. $(\frac{\sigma_{dc}}{2\sigma_a})_{L50}$ is the ratio of the cyclic deviation stress and the initial ambient pressure during a laboratory test. Figure 18 shows the relationship between the mean grain size and the above stress ratio that caused liquefaction after 30 cycles. C_r is a correction factor to translate the laboratory results into field conditions and D_r is the relative density.

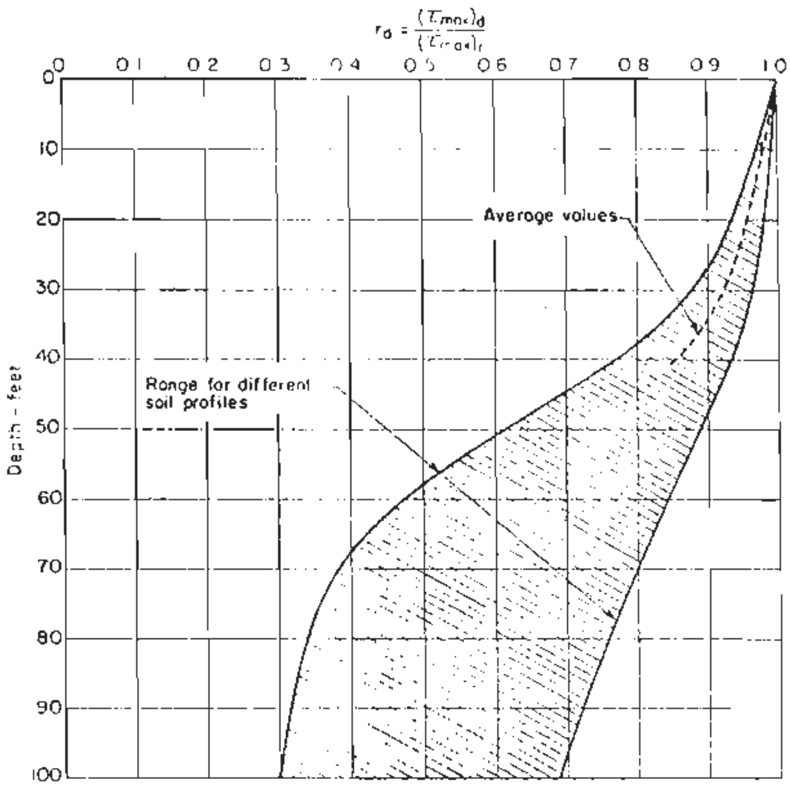

Figure 17. Range of values of r_d for different soil profiles (as taken from Seed and Idriss, 1971).

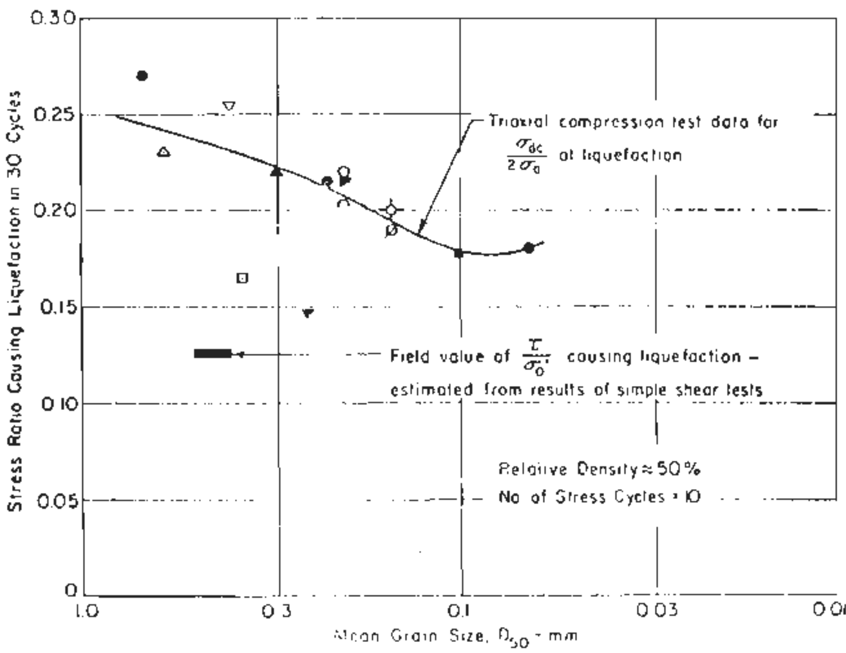

Figure 18. Stress conditions causing liquefaction of sands in 30 cycles (as taken from Seed and Idriss, 1971).

For .1 mm, we have: $\frac{\sigma_{dc}}{2\sigma_a} = .18$

and $\frac{a_{max}}{g} \quad \frac{.18}{.65 \times r_d \times 50} \cdot \frac{\sigma_o'}{\gamma h} \; C_r \; D_r$

or $\frac{a_{max}}{g} = .00005538 \; D_r \; \frac{C_r \sigma_o'}{h} \; r_d$

E.g., for a relative density of 50 percent, we have c_r from Figure 19 equal to .58:

and $\frac{a_{max}}{g} = .001606 \; \frac{\sigma_o'}{h} \; r_d$

the overburden pressure, as a function of depth h, is given by:

$$\sigma_o' = hw_\gamma + (h-h_w) \; (\gamma-\gamma_w)$$

where γ_w is the water density (62.4 lb/ft^3).

We can now calculate the maximum accelerations that will cause liquefaction during 30 cycles. The results are given in Table 9.

Table 9. Maximum ground surface accelerations causing liquefaction of fine loose sand (D_{50} = .1 mm) with relative density of 50 percent.

h(H)	$\sigma_o'(h)$	r_d	a_{max}/g
5	100	.99	.16
10	69	.98	.10
15	58	.96	.08
20	53	.95	.05
30	48	.92	.07
40	45	.85	.06
50	43	.75	.05

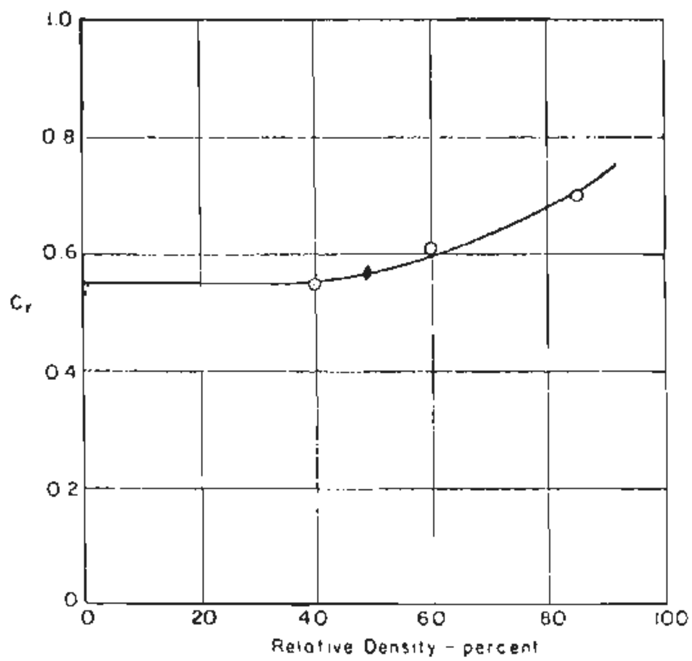

Figure 19. Relationship between c_r and relative density (as taken from Seed and Idriss, 1971).

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. The Denali Fault displays ample evidence of Tertiary and Holocene movement, and it is seismically active from McKinley Park to the Denali-Toschunda fault convergence.
2. Based on calculated average Holocene and Tertiary displacement rates, and the absence of fault-related major earthquakes over the last 100 years, we conclude that strain is accumulating along seismically active segments of the Denali Fault.
3. Strain releases necessary for magnitude 8 earthquakes would require between 500 and 1000 years of strain accumulation, based on average displacement rates of .5 - 1.5 cm/year.
4. It is probable that some segments of the Denali Fault have been locked for 500 or more years, and that seismic risk estimates should include a possible magnitude 8 earthquake.
5. We do not have enough data to predict which fault segment has the highest probability of a large magnitude earthquake. For this study, however, we conclude that such a release could occur between Isabelle Pass and the Alaska-Canada boundary.
6. Our model includes a design earthquake of magnitude 8, with a focal depth of 20 km, and a hypocenter which is 50 km from the pipeline (the closest measured distance between the Denali Fault and the route from Delta Junction to the Alaska-Canada boundary).
7. Using relationships derived by various authors and our own work, we conclude that the design earthquake would produce a peak bedrock acceleration of $.2 \pm .1$g, with a predominant period of $.4 \pm .05$ seconds, and a duration of strong motion of 30 ± 10 seconds. Our

model uses 25 seconds of modified input motion recorded at Pasadena, from the magnitude 7.7, Kern County earthquake of 1952.

8. A seismic response analysis was performed on representative sections recovered from test holes using bedrock peak accelerations of .1 and .2g. Maximum surface accelerations of .44g and .24g were obtained for the .2g and .1g bedrock accelerations, respectively.

9. Using the simplified procedure of Seed and Idriss (1969), a preliminary analysis was made of the liquefaction potential of selected sections along the Delta Junction-Alaska-Canada border segment of the route. The results show that poorly-compacted sands and sandy silts in some locations do have high potential for liquefaction during prolonged shaking, and that further work is needed to develop appropriate engineering design parameters.

Recommendations

1. A seismic strain release map should be produced for the Denali Fault which includes all available seismic data up to the present.
2. Additional seismic response analyses should be made of representative sections along the route, using sections from deeper drill holes and more complete soils engineering data from laboratory analyses.
3. A more thorough study should be made of the probable input motion, and the influence of changing input motion on peak acceleration values and the time history of surface motion.
4. Analyses of the liquefaction potential of soil types along the route should be accelerated. Currently, however, this work is

hampered by the lack of adequate engineering data on materials from critical sections. Additional laboratory analyses of samples taken from test holes by R&M Consultants, Inc. are needed, and we recommend that this work be authorized as soon as possible.

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ALCAN PIPELINE PROJECT
AND THE MAPLE LEAF SYSTEM

SUPPLEMENTAL FINANCING INFORMATION

SUPPLEMENTAL FINANCING INFORMATION

On March 8, 1977 Alcan Pipeline Company submitted certain information to the Commission about its 48-inch alternative proposal. Section 8 of that material addressed the financing of the Alcan Pipeline project, which consists of Alcan, its Canadian cosponsors and certain other companies which would build complementary and connecting facilities.

The material submitted herein addresses the issue of financing both the Alcan Pipeline project and the Maple Leaf project. It assumes that the Alcan Pipeline project goes into service in October 1981 and the Maple Leaf project goes into service in November 1982. The actual timing of the need for the Mackenzie Delta gas reserves proposed to be connected by the Maple Leaf project will be determined by the Canadian government. It is likely that the connection of Mackenzie Delta gas reserves will be delayed beyond November 1, 1982 due to a number of reasons, including settlement of native land claims in the Mackenzie Valley region and the slow development of both the Mackenzie Delta reserves and the Canadian market for those reserves. Exhibits A, B and C detailing and summarizing the total corporate requirements of all sponsor and project financed companies building facilities for either project and the related facility requirements for PG&E, PGT and TransCanada are presented herein.

The portions of Section 8 of the March 8, 1977 material relating to the conceptual framework of the financing and its credit support remain unchanged. The financial advisors to members of the Alcan Pipeline and Maple Leaf projects have reviewed the financing requirements as shown in Exhibits A, B and C and remain of the opinion that 1) the financing plans of their respective clients represent feasible bases for financing each company's requirements; 2) the overall plans for financing the Alcan Pipeline project and the Maple Leaf project, as shown herein, are reasonable; and 3) the financial markets that are planned to be utilized have sufficient capacity to provide the necessary funds.

SUMMARY OF BASIC FINANCING REQUIREMENTS
OF COMPANIES ASSOCIATED WITH THE ALCAN PIPELINE PROJECT -
48" ALTERNATIVE AND THE MAPLE LEAF SYSTEM
(Dollars in Millions)

	1978		1979		1980		1981		1982		1983		Total 1978-1983	
	U.S.	Canada	U.S.	Canada	U.S.	Canada	U.S.	Canada	U.S.	Canada	U.S.	Canada	U.S.	Canada
Bank Loans	$ --	$ --	$ 170	$ 85	$ 105	$ 469	$ 763	$ 599	$ 45	$ 67	$ --	$ (52)	$1,083	$1,168
Long-Term Debt	100	50	968	205	2,485	445	1,975	797	545	648	--	259	6,073	2,404
Preferred Stock	88	125	117	240	--	157	--	125	--	--	--	75	205	722
Common Stock	--	105	356	340	386	388	500	25	--	100	--	49	1,242	1,007
Subtotal	188	280	1,611	870	2,976	1,459	3,238	1,546	590	815	--	331	8,603	5,301
Total	$ 468		$2,481		$4,435		$4,784		$1,405		$ 331		$13,904	

Exhibit A

FINANCING REQUIREMENTS OF COMPANIES
ASSOCIATED WITH THE ALCAN PIPELINE PROJECT - 48" ALTERNATIVE
AND THE MAPLE LEAF SYSTEM
(1978 - 1983)
(Dollars in Millions)

	1978	1979	1980	1981	1982	1983	Total Basic Requirements 1/	Estimated Contingency Requirements 1/	Total Estimated Requirements
Alcan Pipeline									
U.S. Banks	$ --	$ 170	$ 105	$ 288	$ --	$ --	$ 563	$ 113	$ 676
U.S. Long-Term Debt	--	500	1,000	400	--	--	1,900	380	2,280
U.S. Common Stock	--	340	250	250	--	--	840	168	1,008
Total	--	1,010	1,355	938	--	--	3,303	661	3,964
Foothills Pipe Lines (Yukon)									
Canadian Banks	--	85	170	70	--	--	325	65	390
U.S. Long-Term Debt	--	70	330	75	--	--	475	95	570
Canadian Long-Term Debt	--	70	70	60	--	--	200	40	240
U.S. Preferred Stock	88	117	--	--	--	--	205	41	246
Canadian Common Stock	80	60	--	--	--	--	140	28	168
Total	168	402	570	205	--	--	1,345	269	1,614
Alberta Gas Trunk Line									
Canadian Banks	--	--	150	150	--	--	300	400	700
U.S. Long-Term Debt	--	130	185	185	115	--	615	--	615
Canadian Long-Term Debt	50	75	75	90	60	50	400	--	400
Canadian Preferred Stock	75	75	--	75	--	75	300	--	300
Canadian Common Stock	--	75	75	--	75	--	225	--	225
Total	125	355	485	500	250	125	1,840	400	2,240
Westcoast Transmission									
Canadian Banks	--	--	39	129	7	(52)	123	--	175
U.S. Long-Term Debt	100	140	180	200	245	--	865	--	865
Canadian Long-Term Debt	--	60	150	100	75	--	385	--	385
Canadian Preferred Stock	50	75	50	50	--	--	225	--	225
Canadian Common Stock	--	50	100	--	--	--	150	--	150
Total	150	325	519	479	327	(52)	1,748	--	1,800
Pacific Gas & Electric									
U.S. Banks	--	--	--	--	--	--	--	--	--
U.S. Long-Term Debt	--	--	--	388	--	--	388	--	388
U.S. Common Stock	--	--	--	--	--	--	--	--	--
Total	--	--	--	388	--	--	388	--	388
Pacific Gas Transmission									
U.S. Banks	--	--	--	--	--	--	--	--	--
U.S. Long-Term Debt	--	82	205	77	--	--	364	--	364
U.S. Common Stock	--	--	--	--	--	--	--	--	--
Total	--	82	205	77	--	--	364	--	364
Northern Border Pipeline									
U.S. Banks	--	--	--	290	--	--	290	--	290
U.S. Long-Term Debt	--	46	410	465	--	--	921	--	921
U.S. Common Stock	--	16	136	250	--	--	402	--	402
Total	--	62	546	1,005	--	--	1,613	--	1,613
Foothills Pipe Lines (Delta)									
U.S. Banks	--	--	--	185	45	--	230	135	365
Canadian Banks	--	--	110	250	60	--	420	255	675
U.S. Long-Term Debt	--	--	175	185	185	--	545	140	685
Canadian Long-Term Debt	--	--	150	280	295	--	725	120	845
Canadian Preferred Stock	--	90	107	--	--	--	197	40	237
Canadian Common Stock	25	155	213	25	25	--	443	130	573
Total	25	245	755	925	610	--	2,560	820	3,380
TransCanada PipeLines									
Canadian Banks	--	--	--	--	--	--	--	250	250
Canadian Long-Term Debt	--	--	--	267	218	209	694	--	694
Canadian Common Stock	--	--	--	--	--	49	49	--	49
Total	--	--	--	267	218	258	743	250	993
Less Duplications:									
Alberta Gas Trunk Line	45	79	64						
Westcoast Transmission	45	79	64						
	90	158	128						
Total Fund Requirements for Alcan Pipeline Project - 48" Alternative and Maple Leaf System									
U.S. Funds	$ 188	$1,611	$2,976	$3,238	$ 590	$ --	$ 8,603		$ 9,675
Canadian Funds	280	870	1,459	1,546	815	331	5,301		6,681
Total	468	2,481	4,435	4,784	1,405	331	13,904		16,356
Less Duplications	90	158	128	--	--	--	376		376
Grand Total	$ 378	$2,323	$4,307	$4,784	$1,405	$ 331	$13,528		$15,980

1/ Aggregate taken down through each period

SUMMARY OF TOTAL ESTIMATED REQUIREMENTS
OF COMPANIES ASSOCIATED WITH THE ALCAN PIPELINE PROJECT -
48" ALTERNATIVE AND THE MAPLE LEAF SYSTEM
(Dollars in Millions)

	Total 1978 - 1983	
	U.S.	Canada
Bank Loans	$ 1,331	$ 2,190
Long-Term Debt	6,688	2,564
Preferred Stock	246	762
Common Stock	1,410	1,165
Subtotal	9,675	6,681
Total	$16,356	

GEOLOGY OF THE DELTA JUNCTION–ALASKA–YUKON BORDER SECTION OF THE PROPOSED ALCAN GAS PIPELINE ROUTE

Prepared for Gulf Interstate Engineering Company

Compiled By R. B. Forbes
Geophysical Institute
University of Alaska

DATA SOURCES:

Geologic Map of the Nabesna Quadrangle, Alaska: U.S.G.S. Map I-932; by D. H. Richteer (1976).

Reconnaissance Geologic Map of the Tanacross Quadrangle, Alaska: U.S.G.S. Map I-5933; by Helen L. Foster (1970).

Geologic Map of the Mt. Hayes D-3 Quadrangle, Alaska: U.S.G.S. GQ-366; by G. Williaam Holmes and Troy L. Pewe (1965).

Geology of the Mt. Hayes D-4 Quadrangle, Alaska: U.S.G.S. I-394; by Troy L. Pewe annd G. William Holmes (1964).

Geology of the Johnson River Area, Alaska: U.S.G.S. Bull. 1249; by G. William Holmees and Helen L. Foster (1968).

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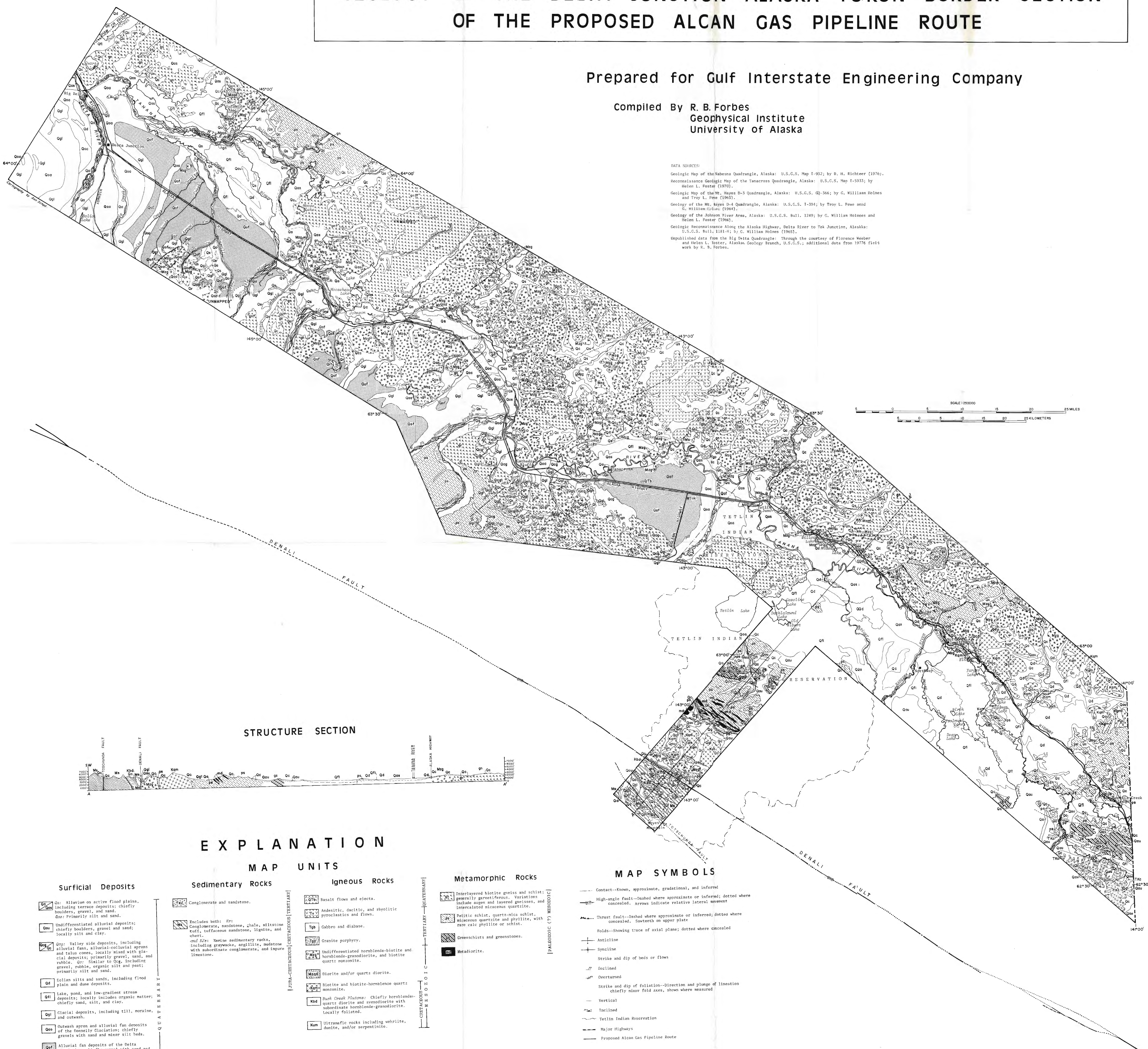
Unpublished data from the Big Delta Quadrangle: Through the courtesy of Florence Weeber and Helen L. Foster, Alaska Geology Branch, U.S.G.S.; additional data from 19776 field work by R. B. Forbes.



STRUCTURE SECTION

EXPLANATION

MAP UNITS

Surficial Deposits

QUATERNARY

- **Qa / Qas** — *Qa:* Alluvium on active flood plains, including terrace deposits; chiefly boulders, gravel, and sand. *Qas:* Primarily silt and sand.
- **Qau** — Undifferentiated alluvial deposits; chiefly boulders, gravel and sand; locally silt and clay.
- **Qcg / Qc** — *Qcg:* Valley side deposits, including alluvial fans, alluvial-colluvial aprons and talus cones, locally mixed with glacial deposits; primarily gravel, sand, and rubble. *Qc:* Similar to Qcg, including gravel, rubble, organic silt and peat; primarily silt and sand.
- **Qd** — Eolian silts and sands, including flood plain and dune deposits.
- **Qfl** — Lake, pond, and low-gradient stream deposits; locally includes organic matter; chiefly sand, silt, and clay.
- **Qgl** — Glacial deposits, including till, moraine, and outwash.
- **Qao** — Outwash apron and alluvial fan deposits of the Donnelly Glaciation; chiefly gravels with sand and minor silt beds.
- **Qof** — Alluvial fan deposits of the Delta Glaciation; chiefly gravel with sand and minor silt beds.
- **Qs** — Silt and peat deposits; silt mixed with peat and finely divided organic material. Commonly frozen below depths of 1 or 2 feet.
- **Ql** — Landslide deposits; mixed coarse and fine debris deposited by landslides, earthflows, and avalanches.
- **Qr** — Rock glacier deposits.

Sedimentary Rocks

- **TKc** — Conglomerate and sandstone. (TERTIARY / CRETACEOUS)
- **Ms** — Includes both: *Kr:* Conglomerate, sandstone, shale, siltstone tuff, tuffaceous sandstone, lignite, and chert. *and KJs:* Marine sedimentary rocks, including graywacke, argillite, mudstone with subordinate conglomerate, and impure limestone. (JURA-CRETACEOUS)

Igneous Rocks

QUATERNARY – TERTIARY – MESOZOIC – CRETACEOUS

- **QTb** — Basalt flows and ejecta.
- **Tv** — Andesitic, dacitic, and rhyolitic pyroclastics and flows.
- **Tgb** — Gabbro and diabase.
- **Tgp** — Granite porphyry.
- **Mzg** — Undifferentiated hornblende-biotite and hornblende-granodiorite, and biotite quartz monzonite.
- **Mzqd** — Diorite and/or quartz diorite.
- **Kqm** — Biotite and biotite-hornblende quartz monzonite.
- **Kbd** — *Buck Creek Plutons:* Chiefly hornblende-quartz diorite and syenodiorite with subordinate hornblende-granodiorite. Locally foliated.
- **Kum** — Ultramafic rocks including wehrlite, dunite, and/or serpentinite.

Metamorphic Rocks

PALEOZOIC (?) MESOZOIC

- **gn** — Interlayered biotite gneiss and schist; generally garnetiferous. Variations include augen and layered gneisses, and intercalated micaceous quartzite.
- **ps** — Pelitic schist, quartz-mica schist, micaceous quartzite and phyllite, with rare calc phyllite or schist.
- **gs** — Greenschists and greenstones.
- **md** — Metadiorite.

MAP SYMBOLS

- Contact--Known, approximate, gradational, and inferred
- High-angle fault--Dashed where approximate or inferred; dotted where concealed. Arrows indicate relative lateral movement
- Thrust fault--Dashed where approximate or inferred; dotted where concealed. Sawteeth on upper plate
- Folds--Showing trace of axial plane; dotted where concealed
  - Anticline
  - Syncline
- Strike and dip of beds or flows
  - Inclined
  - Overturned
- Strike and dip of foliation--Direction and plunge of lineation chiefly minor fold axes, shown where measured
  - Vertical
  - Inclined
- Tetlin Indian Reservation
- Major Highways
- Proposed Alcan Gas Pipeline Route