WATER AVAILABILITY
ALONG THE ARCTIC GAS PIPELINE ROUTE
FROM PRUDHOE BAY, ALASKA
TO THE MACKENZIE DELTA, YUKON TERR.

M.L. JONES
AQUATIC ENVIRONMENTS LIMITED

FEBRUARY 1976

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ABSTRACT

A water availability study was conducted along the Prime Route of the Arctic Gas Pipeline from Prudhoe Bay, Alaska, to the Mackenzie Delta, Yukon Territory.

The purposes of this study were to:

1) identify potential water sources along the pipeline route,

2) determine the volumes of water available from these sources,

3) compare the volumes of water available with the estimated volumes of water required,

4) assess the environmental impact of water withdrawn from the potential sources, and

5) present recommendations regarding maximum withdrawal rates, construction procedures, etc., to minimize potential damage to aquatic habitats.

The major conclusions and recommendations of this study are:

1) There are more than adequate quantities of water available to meet the estimated water requirements of the pipeline. Overall,

the total estimated water requirement of 5,508,000 bbl would amount to slightly less than 1% of the approximately 550,967,000 bbl available in the lakes surveyed. In addition, the springs surveyed discharge approximately 5,807,000 bbl/day, slightly more than the total estimated water requirement.

2) Water can be safely withdrawn from most of the lakes surveyed, provided that no more than 10% of the total volume of any one lake is withdrawn.

3) Water can be safely withdrawn from most of the springs surveyed provided that:

   a) water is withdrawn from a single point downstream of fish concentrations and spawning areas, and that collection areas are screened to prevent the entry of fish,

   b) natural spring channels are not excessively rechanneled or closely paralleled by access roads,

   c) angling is strictly prohibited.

It is further recommended that:

1) additional site-specific biological, hydrological and engineering studies be conducted as final selections of water sources be made;

2) during the development of water sources and during water withdrawal, locations with known spawning or overwintering populations of fish be individually monitored by a fisheries biologist familiar with the lakes and springs of the North Slope.

ACKNOWLEDGEMENTS

I wish to acknowledge the help that many people have given during the course of this study. Field assistance was provided by W. Melhorn; editorial assistance by P. McCart and J. McCart; laboratory assistance by G. Williams; and manuscript assistance by C. Gossen, J. McCart, S. Whiston, and J. Harris.

The Arctic Gas Biological Report Series, of which this report is a part, is a series of consultant project reports presenting data based on field and laboratory studies. The format and presentation vary in accordance with the authors' discretion.

The data for this work were obtained as a result of investigations carried out by Aquatic Environments Limited for Canadian Arctic Gas Study Limited and Alaskan Arctic Gas Study Limited. The text of this report may be quoted provided the usual credits are given.

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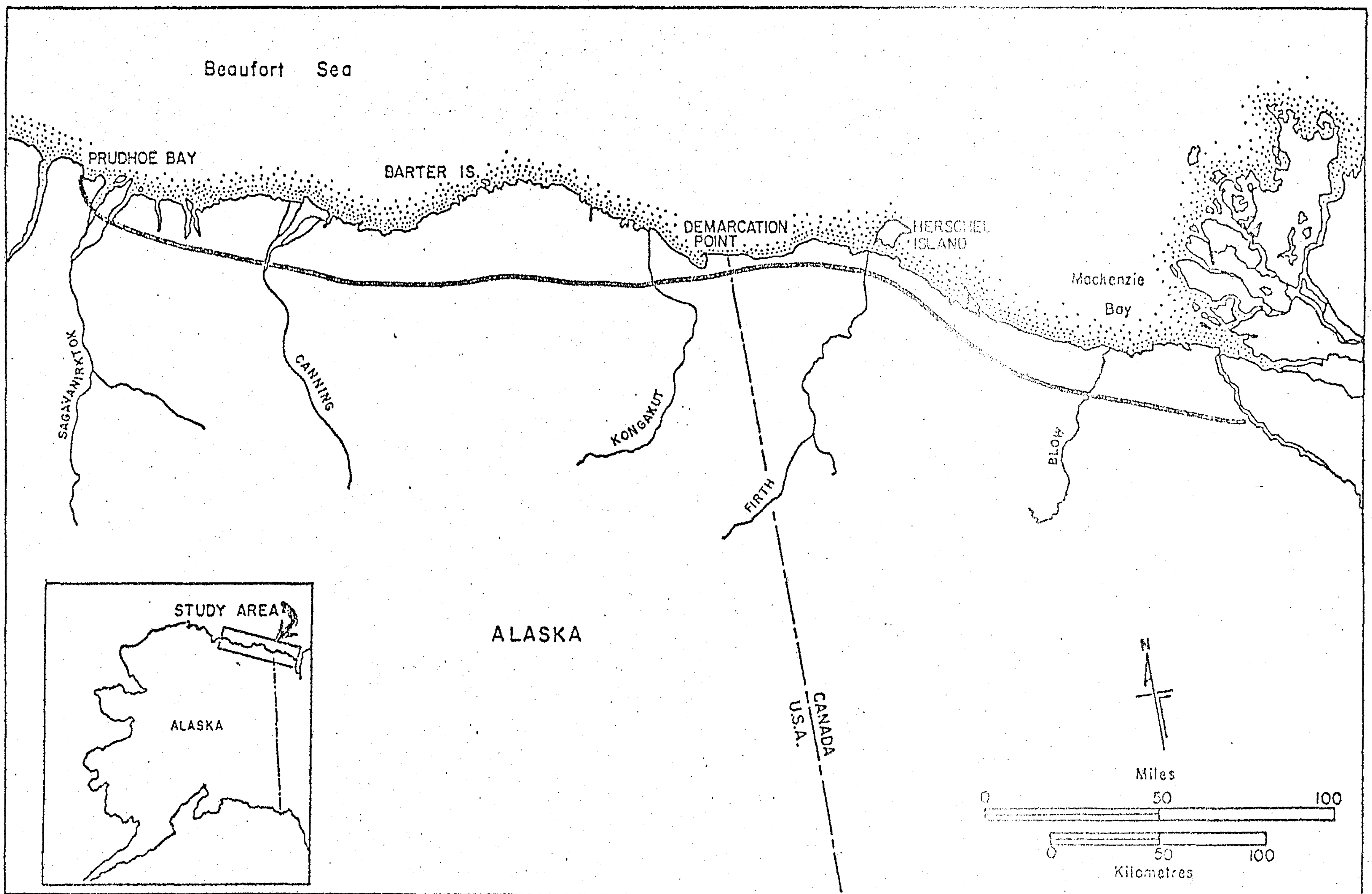
INTRODUCTION

Winter construction of the proposed Alaskan and Canadian Arctic Gas Pipeline will require large supplies of fresh water for the construction of ice and snow roads and for domestic use in the construction camps themselves. Other major uses of water include hydrostatic testing and ditch flooding. Overall water requirements will be greatest in the first months of the winter when the ice and snow roads are under construction, and diminish later in the winter. In some cases, construction camps will require dependable supplies of high quality water throughout the winter.

The purpose of this study was to identify water sources along the proposed pipeline route and to assess their withdrawal potential in relation to the estimates of water requirements prepared for each piepline segment and camp along the pipeline route from Prudhoe Bay to the west side of the Mackenzie Delta.

The study was based on a review of the pertinent literature and field surveys along a 300 mi by 10 mi corridor from Prudhoe Bay, Alaska, to the Mackenzie Delta, Yukon Territory (Figure 1). The objective of these field surveys was to obtain the following:

FIGURE 1. Study Area. The pipeline route from Prudhoe Bay, Alaska, to the Mackenzie Delta, Yukon Territory.



Beaufort Sea
PRUDHOE BAY
BARTER IS.
DEMARCATION POINT
HERSCHEL ISLAND
Mackenzie Bay
SAGAVANIRKTOK
CANNING
KONGAKUT
FIRTH
BLOW
ALASKA
CANADA
U.S.A.
STUDY AREA
ALASKA
N
Miles
0
50
100
0
50
100
Kilometres

a) depth information for lakes considered potential water sources

b) discharge information for springs considered potential water sources

c) water samples from lakes and springs to determine basic water chemistry

d) information on fish utilization of lakes and springs considered potential water sources.

Additional information including discharges, ice thickness, and water chemistry was obtained during a joint AAG and United States Geological Survey (USGS) winter trip to Alaska during November, 1975. Aquatic Environments Limited personnel were present during part of this trip and the information obtained has been incorporated into this report.

In addition to fisheries information obtained during the course of this study, data are available from previous fisheries surveys along the pipeline route in Alaska and the Yukon Territory. These data are referred to in subsequent sections of this report.

For this study, fisheries effort consisted of the following:

a) gillnetting lakes which were potential water sources, and for which no previous fisheries information had been gathered, and

b) surveying springs during the fall of 1975 to determine the distribution of fish.

Some springs along the pipeline route are already known to be spawning and overwintering areas critical to the survival of populations of Arctic char and grayling (Craig 1973). In addition, some of the deeper lakes along the pipeline route support overwintering populations of one or more species including Arctic char, lake trout, grayling, whitefishes, ciscoes, pike, pond smelts, and sticklebacks (McCart *et al.* 1974, deGraff 1975). Water withdrawn from these critical spawning and overwintering sites should be carefully regulated to avoid possible damage to fish populations.

METHODS

During the fall of 1975, AEL conducted field surveys at 50 lakes and 19 springs along the Arctic Gas Pipeline Route from Prudhoe Bay, Alaska, to the Mackenzie Delta. Generally, in areas where there was an abundance of potential water sources, only a few of the larger lakes within a 5 mi strip on either side of the prime pipeline route were examined. In areas where potential sources were few, the corridor was expanded to encompass the nearest lakes or springs that could be considered potential sources of water.

A helicopter equipped with floats was used for transportation and as a platform for sounding water depths and obtaining samples from lakes. Depending on their size, lakes were sounded at three to six stations along the longest axis. Average depths were calculated from these soundings, and, along with areas (obtained from 1:50,000 scale maps using a planimeter), used to calculate volumes.

Water samples were taken with a 3ℓ Kemmerer bottle at a depth of 1m near the centre of the lake. Dissolved oxygen values and temperatures were determined in the field using a Hach OX-10 Dissolved Oxygen Kit and a pocket thermometer. Water samples taken for suspended sediments, turbidity, conductivity, pH, and dissolved organic carbon were preserved and returned to Calgary for analysis.

Each lake was fished for approximately 24 hr using a standard gillnet gang of six 25 ft panels of 1, 1½, 2, 2½, 3½ and 4½ in. stretch mesh monofilament. A 20 ft nylon marquisette minnow seine was used to sample the shallows of the lakes wherever substrate conditions and water depth allowed. Captured fish were identified, measured and released alive whenever possible. Selected specimens were kept for detailed life history analysis as described by McCart and Craig (1973).

Each spring was sampled for fish using a Smith-Root type VA Backpack Electrofisher and a 20 ft nylon marquisette minnow seine. Since most of these springs have been repeatedly examined during previous fisheries surveys, only in unusual cases were fish kept for detailed life history analysis. Most fish were identified, measured, and released alive. In the course of this study, the main emphasis was on verifying the presence or absence and longitudinal distribution of fish in each spring. The distribution of fish within a spring is important because it may limit where, when, and how much water can be withdrawn without affecting fish populations.

Water samples for suspended sediments, turbidity, conductivity, pH, and dissolved organic carbon were taken from each spring at an orifice and preserved for analysis in the laboratory. Dissolved oxygen concentrations and temperature were measured and recorded in the field. At the end of each day, dissolved organic carbon samples (100 ml) from lakes and springs were preserved by freezing and sent to Chemex Laboratories Limited in Calgary, Alberta for analysis. All other water samples (500 ml) were preserved with 1 mg of 0.4% copper sulfate solution and shipped to the AEL laboratory. Tests performed in the laboratory included specific conductivity (Beckman RB4-250 Solu-Bridge), pH (Radiometer pH Meter, type 29, with GK 2311C electrode), turbidity (Hach Model 2100A turbidimeter), and suspended sediments (gravimetric method, dried at 180°C).

RESULTS AND DISCUSSION

Water Quality

Water quality data are summarized in Table 1. In general, the water in the lakes sampled was of high quality and slightly alkaline (pH 7.4 to 8.5) in character. Two were slightly acidic (pH 6.2 to 6.7). Except for some suspended material stirred up by wave action, turbidity and suspended sediment values were uniformly low. Specific conductivities ranged from a low of 15 to a high of 504μmhos/cm. Some of the lakes were slightly stained, yellow or brown, probably as a result of decay of organic materials.

Of the springs sampled, all those that were potential water sources had high quality water. Conductivities ranged from 29 to 399μmhos/cm and turbidity values and suspended concentrations were low. All springs sampled were slightly alkaline. One small hotspring, located approximately 30 mi south of Milepost 120, was sampled. This spring flows into the Okpilak River near the base of Mt. Michelson. The temperature of the water was 48°C (118°F) at the spring orifice. Because of its distance from the pipeline route and its small discharge (.008m^3/sec .3cfs) this spring has little potential as a water source for pipeline development.

TABLE 1. Water chemistry summary, Water Availability Study 1975.

Location/Milepost	Sample No.	Date	Water Temp. (°C)	O_2	Cond.	pH	Turbidity Shaken (FTU)	Turbidity Settled (FTU)	Susp. Solids mg/l	Dissolved Org. Carbon µg/lc
Lake 3 mi. E 2.0	S-95 Y-48	23 Aug.	6	12	483	-	12.0	7.9	-	9.0
Lake 1 mi. E 3.0	S-359 Y-37	23 Aug.	6	12	257	8.0	11.0	8.9	8.4	3.0
Lake 48 3.5 mi. S 5.0	S-169 Y-32	23 Aug.	6	12	301	8.0	8.5	6.7	8.0	2.5
Lake 1 mi. S 12.0	S-211 Y-43	22 Aug.	8	12	284	8.1	11.0	10.0	8.4	4.0
Lake 1 mi. N 13.0	S-357 Y-56	22 Aug.	9	12	320	8.0	7.1	6.2	6.4	3.5
Lake 2 mi. S 16.5	S-332 Y-31	22 Aug.	8	12	336	8.2	21.0	13.0	17.6	4.5
Lake 1 mi. S 22.0	S-171 Y-21	22 Aug.	7	12	112	7.4	3.2	2.7	4.0	5.5
Lake 79 3 mi. S 24.0	S-339 Y-34	22 Aug.	6	13	215	-	6.2	4.6	5.2	2.5
Lake 1 mi. S 26.0	S-342 Y-25	22 Aug.	6	12	137	-	2.9	2.2	1.0	4.5
Lake 3 mi. S 26.0	S-362 Y-39	22 Aug.	7	13	223	8.1	5.6	3.1	1.0	4.5

(Continued)

TABLE 1. Continued.

Location/Milepost	Sample No.	Date	Water Temp. (°C)	O_2	Cond.	pH	Turbidity Shaken (FTU)	Turbidity Settled (FTU)	Susp. Solids mg/1	Dissolved Org. Carbon µg/1c
Lake 26 2 mi. N 32.0	S-361 Y-41	22 Aug.	6	12	441	8.0	5.0	3.6	1.8	2.5
Lake 2 mi. N 34.0	S-52 Y-24	22 Aug.	6.5	13	504	8.2	14.0	8.7	6.4	3.5
Lake 1 mi. S 39.0	S-358 Y-23	22 Aug.	6	22	132	7.9	3.4	3.1	2.0	7.0
Lake 2 mi. N 47.0	S-331 Y-28	21 Aug.	6	13	188	-	4.8	2.7	2.2	4.0
Lake 0.5 mi. N 51.0	S-338 Y-22	21 Aug.	7	13	197	8.1	3.4	2.3	<1.0	3.5
Lake 317 1.5 mi. S 53.0	S-334 Y-38	21 Aug.	6	11	296	-	9.8	4.8	6.2	3.0
Lake 1.5 mi. S 62.0	S-178 Y-29	21 Aug.	6	12	103	-	2.4	1.4	<1.0	2.5
Lake 1.5 mi. S 63.0	S-175 Y-57	21 Aug.	6	12	200	-	8.3	2.9	9.8	3.5
Katakturuk Sps.W.Fork 5 mi. S 86.5	S-173 Y-55	20 Aug.	2	12	260	-	0.62	0.25	1.3	1.0
Katakturuk Sps.E.Fork 5 mi. S 87.0	S-336 Y-16	20 Aug.	5	11	293	-	1.2	0.24	<1.0	0.5

(Continued)

TABLE 1. Continued.

Location/Milepost	Sample No.	Date	Water Temp. (°C)	O_2	Cond.	pH	Turbidity Shaken (FTU)	Turbidity Settled (FTU)	Susp. Solids mg/1	Dissolved Org. Carbon µg/1c
Sadlerochit Sps. 6 mi. S 111.0	S-273 Y-58	20 Aug.	14	10	399	-	0.49	0.26	<1.0	2.0
Hula Hula Sps. 1 mi. N 116.5	S-340 Y-53	20 Aug.	2	10	231	-	1.4	1.0	5.8	1.0
Okpilik R. (Hot Sps.) 30 mi. S 120.0		26 Sept.	48	1.5	680	8.4	2.3	1.8	6.5	-
Lake 4 mi. N 131.0	S-91 Y-20	17 Aug.	9	10	120	-	8.7	5.4	4.5	5.5
Okerokovik Sps. @ 138.0	S-88 Y-52	17 Aug.	1	6.5	278	8.3	0.4	0.25	<1.0	1.5
Ekaluakat Sps. 5 mi. S 162.0	S-51 Y-51	17 Aug.	2	8	336	-	0.62	0.26	<1.0	2.0
Kongakut Sps. 4 mi. N 173.0	S-202 Y-54	16 Aug.	4	11	231	8.2	4.6	1.3	2.2	1.5
Kongakut Sps. 6 mi. S 174.0	S-363 Y-9	16 Aug.	2	6	257	8.5	0.82	0.6	<1.0	0.5
Clarence R. Sps. 5 mi. S 190.0	S-354 Y-9	16 Aug.	10	10	257	8.4	1.3	0.89	<1.0	2.5
Clarence Sps. 9 mi. S 192.0	S-262	25 Sept.	2	11	-	-	-	-	-	-

(Continued)

TABLE 1. Continued.

Location/Milepost	Sample No.	Date	Water Temp. (°C)	O_2	Cond.	pH	Turbidity Shaken (FTU)	Turbidity Settled (FTU)	Susp. Solids mg/l	Dissolved Org. Carbon μg/lc
Lake 2 mi. N 192.0	S-166 Y-19	15 Aug.	10	10	124	8.0	3.6	2.3	5.8	2.5
Lake 2 mi. N 193.0	S-96 Y-11	15 Aug.	11	10	211	-	2.5	1.2	<1.0	7.5
Lake 4 mi. N 193.0	S-337 Y-14	15 Aug.	11	10	236	-	5.4	2.6	5.8	1.5
Craig Ck. 3 mi. S 197.0	S-1003	9 Oct.	2	11	250	8.0	8.0	0.3	22.7	-
Spring 2 mi. S 198.0	S-387	10 Sept.	5	10	265	-	0.7	0.3	1.3	1.5
Lake 2 mi. N 214.0	S-227 Y-74	10 Sept.	4	10	78	-	2.1	1.2	<1.0	4.5
Fish Ck. Sps. 2 mi. N 217.5	S-186 Y-35	10 Sept.	5	9	271	-	0.8	0.3	1.2	2.5
Malcolm R. Sps. 2 mi. N 225.0	S-391 Y-42	9 Sept.	5	10	237	-	0.4	0.6	<1.0	0.5
Firth Sps. 2 2 mi. N 227.0	S-394 Y-27	9 Sept.	1	11	325	-	2.7	1.1	2.8	2.0
Lake 103 2 mi. S 231.0	S-389 Y-49	10 Sept.	3	10	86	-	1.8	1.3	<1.0	2.5

(Continued)

TABLE 1. Continued.

Location/Milepost	Sample No.	Date	Water Temp. (°C)	O_2	Cond.	pH	Turbidity Shaken (FTU)	Turbidity Settled (FTU)	Susp. Solids mg/1	Dissolved Org. Carbon µg/1c
Firth R. Sps. 2 mi. N 233.0	S-333 Y-71	10 Sept.	5	9	29	-	0.9	0.5	1.5	1.5
Lake 1 mi. N 233.0	N/T	10 Sept.	2	10	-	-	-	-	-	-
Lake 111 1 mi. N 240.0	S-388 Y-44	9 Sept.	2	11	110	-	7.1	4.5	5.2	2.5
Lake 1 mi. N 242.5	S-364 Y-73	9 Sept.	3	10	90	-	1.6	1.2	<1.0	4.0
Lake 1 mi. E 250.0	S-379 Y-30	9 Sept.	3	11	185	-	3.8	3.1	1.1	7.5
Lake 109 2 mi. N 252.0	S-385 Y-69	9 Sept.	3	11	70	-	5.0	2.7	4.1	3.5
Spring R. Sps. 2 mi. N 256.0	S-390 Y-68	9 Sept.	2	11	35	-	0.8	0.8	<1.0	1.5
Lake 1 mi. N 259.0	S-386 Y-67	9 Sept.	2	11	153	6.7	1.9	1.4	<1.0	6.0
Bloomfield Lake 3.5 mi. N 264.0	S-215 Y-26	10 Sept.	3	10	190	-	8.7	5.1	6.8	2.5
Crow R. Sps. 2 mi. N 268.0	S-203 Y-66	9 Sept.	2	12	271	-	0.7	0.6	<1.0	1.5

(Continued)

TABLE 1. Continued.

Location/Milepost		Sample No.	Date	Water Temp. (°C)	O_2	Cond.	pH	Turbidity Shaken (FTU)	Turbidity Settled (FTU)	Solids mg/1	Dissolved Org. Carbon µg/1c
Lake 101 2 mi. S	272.0	S-89 Y-72	4 Sept.	7	11	41	-	8.1	5.5	3.1	5.5
Lake 2 mi. S	274.0	S-97 Y-70	4 Sept.	6	11	122	-	9.1	5.6	3.8	4.0
Lake 2 mi. N	281.0	S-83 Y-64	4 Sept.	7	11	30	-	7.1	4.6	3.2	4.0
Lake 1 mi. N	289.0	S-330 Y-63	4 Sept.	7.5	12	28	-	8.6	5.7	1.6	5.0
Lake 1.5 mi. E	290.0	S-355 Y-50	3 Sept.	9	10	25	7.0	3.8	3.1	1.8	5.0
Lake 5 mi. N (Shallow Bay Route)	295.0	S-380 Y-61	3 Sept.	8	11	36	-	7.0	3.7	5.7	5.5
Lake 1 mi. S (Shallow Bay Route)	302.5	S-270 Y-1	5 Aug.	10	11	15	6.2	5.4	3.9	8.2	5.0
Lake 3 mi. N (Shallow Bay Route)	306.5	S-201 Y-46	3 Sept.	8.5	11	83	-	9.1	4.8	7.0	3.5
Lake 3 mi. S (Shallow Bay Route)	307.0	S-274 Y-7	7 Aug.	9	10	82	8.6	22.0	12.0	86.4	13.0

(Continued)

TABLE 1. Continued.

Location/Milepost	Sample No.	Date	Water Temp. (°C)	O_2	Cond.	pH	Turbidity Shaken (FTU)	Turbidity Settled (FTU)	Susp. Solids mg/1	Dissolved Org. Carbon µg/1c
Lake 1 mi. N 313.0 (Shallow Bay Route)	S-269 Y-8	7 Aug.	9	10	61	7.2	78.0	34.0	27.6	21.0
Lake 1 mi. S 315.0 (Shallow Bay Route)	S-335 Y-40	4 Sept.	7	11	38	7.1	12.0	7.4	4.8	11.0
Lake 3.5 mi. S 315.5 (Shallow Bay Route)	S-54 Y-65	3 Sept.	9	10	61	-	8.6	6.7	2.9	8.0
Lake 3.5 mi. S 318.5 (Shallow Bay Route)	S-341 Y-45	3 Sept.	8	12	35	-	8.4	4.7	6.5	7.5

In general, only minimal water treatment (e.g. filtration and chlorination) should be necessary to provide potable water for domestic use in the construction camps. However, water quality in lakes deteriorates in winter as minerals and solids become concentrated in the free water below the ice cover, so that some additional water treatment may be necessary in areas where no groundwater sources are available for domestic use.

Water Availability by Spreads

In this section of the report, each segment of the prime coastal pipeline corridor is examined relative to:

a) the volumes of water available in the lakes and streams surveyed,
b) the proportion of the available water required for pipeline development,
c) any additional or alternate water sources that might be considered,
d) special environmental considerations (e.g. critical spawning and overwintering areas for fish,
e) specific recommendations regarding maximum withdrawal rates, construction procedures, etc., which minimize the potential damage to aquatic habitats.

Detailed Appendix tables have been prepared which show water requirements, water volumes available in lakes, discharge rates of springs, and fish utilization of potential water sources along the pipeline route.

Appendix Table 1 shows the uses and estimated monthly water requirements for each section of pipeline during various phases of construction.

Appendix Table 2 summarizes the morphometric characteristics of the lakes surveyed, including: the average depths, surface areas, total volumes, and the calculated maximum volumes of free water remaining after ice accumulations of .73 and 1.5m.

Appendix Table 3 shows the depths, velocities, and discharges of the springs surveyed during the course of this study. Summaries of the information in the Appendix tables are presented for each segment of the pipeline route in the following section-by-section discussion.

Appendix Table 4 summarizes water availability information from a joint USGS/AAG hydrological survey in November, 1975.

Appendix Table 5 summarizes fisheries information for each potential water source along the pipeline route.

Spread 8: Milepost 0 to 56

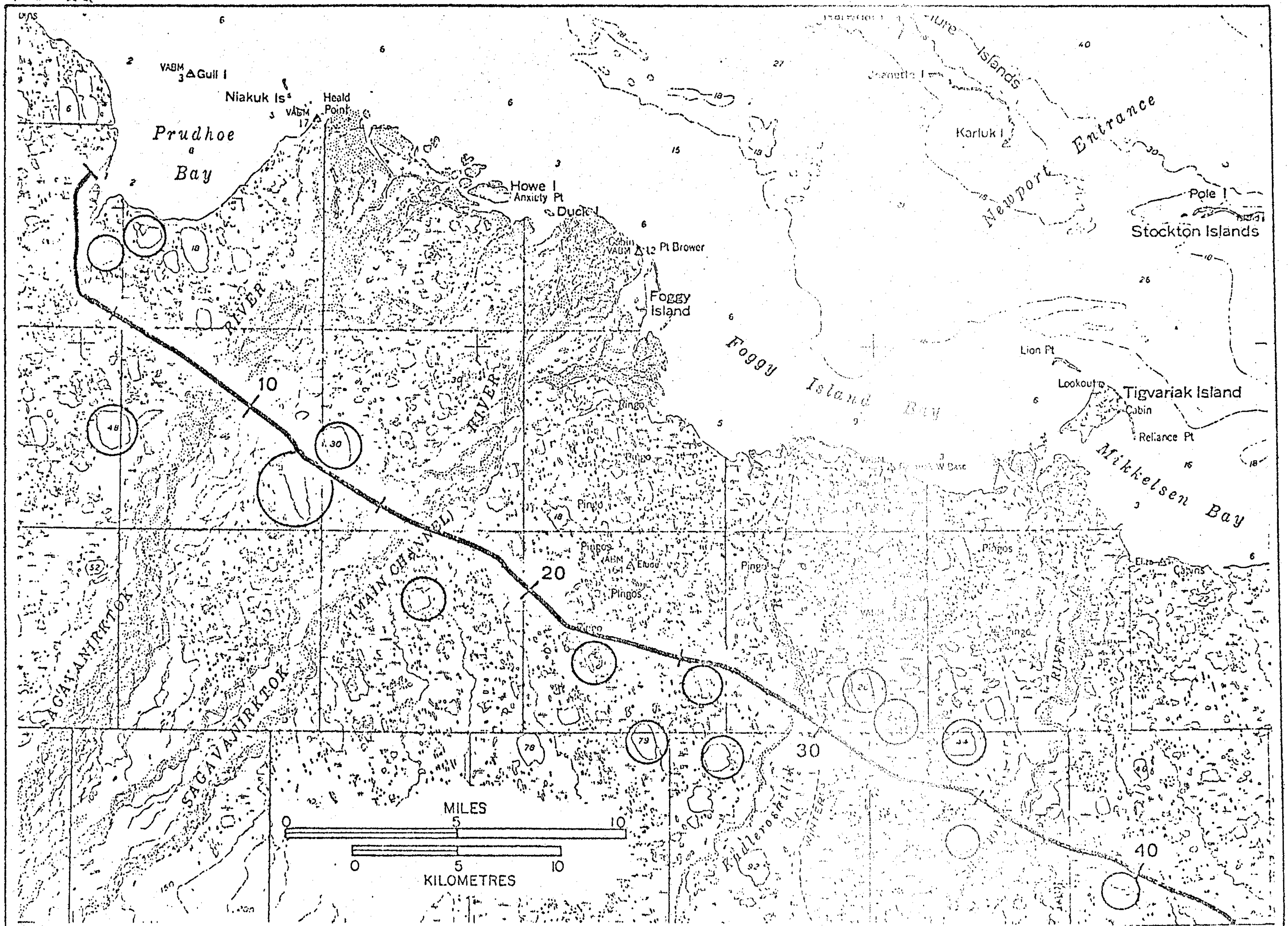
This segment of the proposed Arctic Gas Pipeline extends south and east from Prudhoe Bay to the vicinity of the Canning River. The area is characterized by low-lying coastal plain dotted with numerous shallow lakes. Figure 2 (a and b) shows the location of the lakes surveyed in this section of the pipeline corridor.

In these lakes, available water is more than adequate to meet the requirements for pipeline development (Table 2). As indicated in the table, only small percentages of the total available water are required and the mean drawdown would be minimal. In mid and late winter, however, conditions change and water supplies are more limited. Appendix Table 2 shows that up to 88% of the average volume of the lakes in this segment is frozen after ice accumulates to a depth of 1.5m, and seven of the 19 lakes freeze solid. It is likely, therefore, that in many years, most, if not all, of these lakes could be frozen solid by the end of the winter.

Hobbie (1962) conducted limnological studies spanning parts of three winters on Lake Peters, a deep Arctic lake in the Brooks Range, Alaska. Hobbie found that 90% of the ice thickness was produced in the first four months of winter, and reached a maximum thickness of up to 2m by May (Figure 3). He also found a relationship between the amount of snow accumulation on the ice and the rate of ice production. In 1961, for instance, when there was a heavy snowfall, the ice was thinner than in 1959, a year of light snowfall. Thus, the greater the snow accumulation

Figure 2a. Locations of waterbodies surveyed between Milepost 0 and 56.

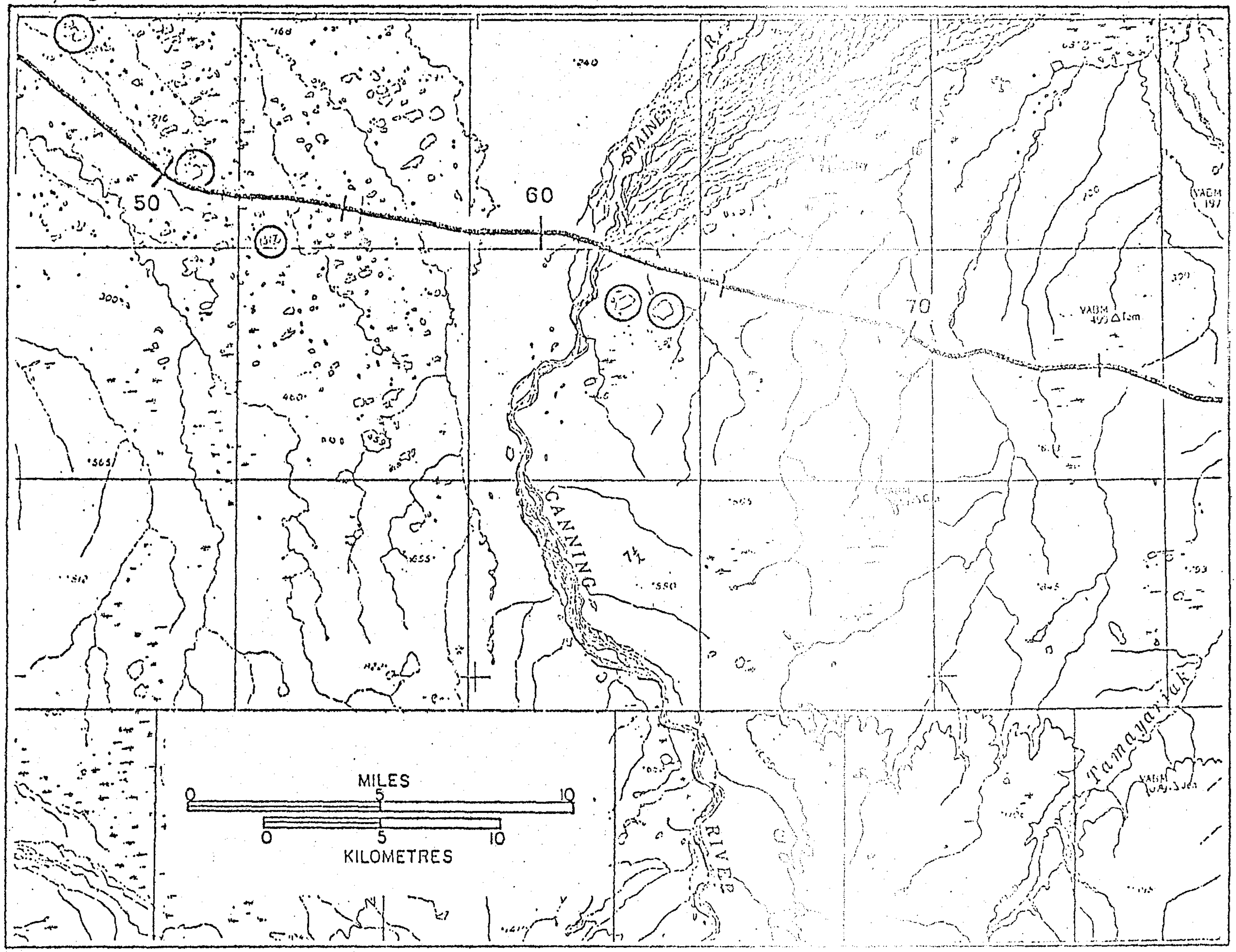
FIG 2a



Prudhoe Bay
Gull I
Niakuk Is
Heald Point
Howe I
Anxiety Pt
Duck I
Pt Brower
Foggy Island
Foggy Island Bay
Islands
Karluk I
Newport Entrance
Pole I
Stockton Islands
Lion Pt
Lookout
Tigvariak Island
Cabin
Reliance Pt
Mikkelsen Bay
SAGAVANIRKTOK
RIVER
SAGAVANIRKTOK
(MAIN CHANNEL)
RIVER
Pingos
Pingo
10
20
30
40
MILES
0
5
10
0
5
10
KILOMETRES

Figure 2b. Locations of waterbodies surveyed between Mileposts 0 and 56.

Fig 2b

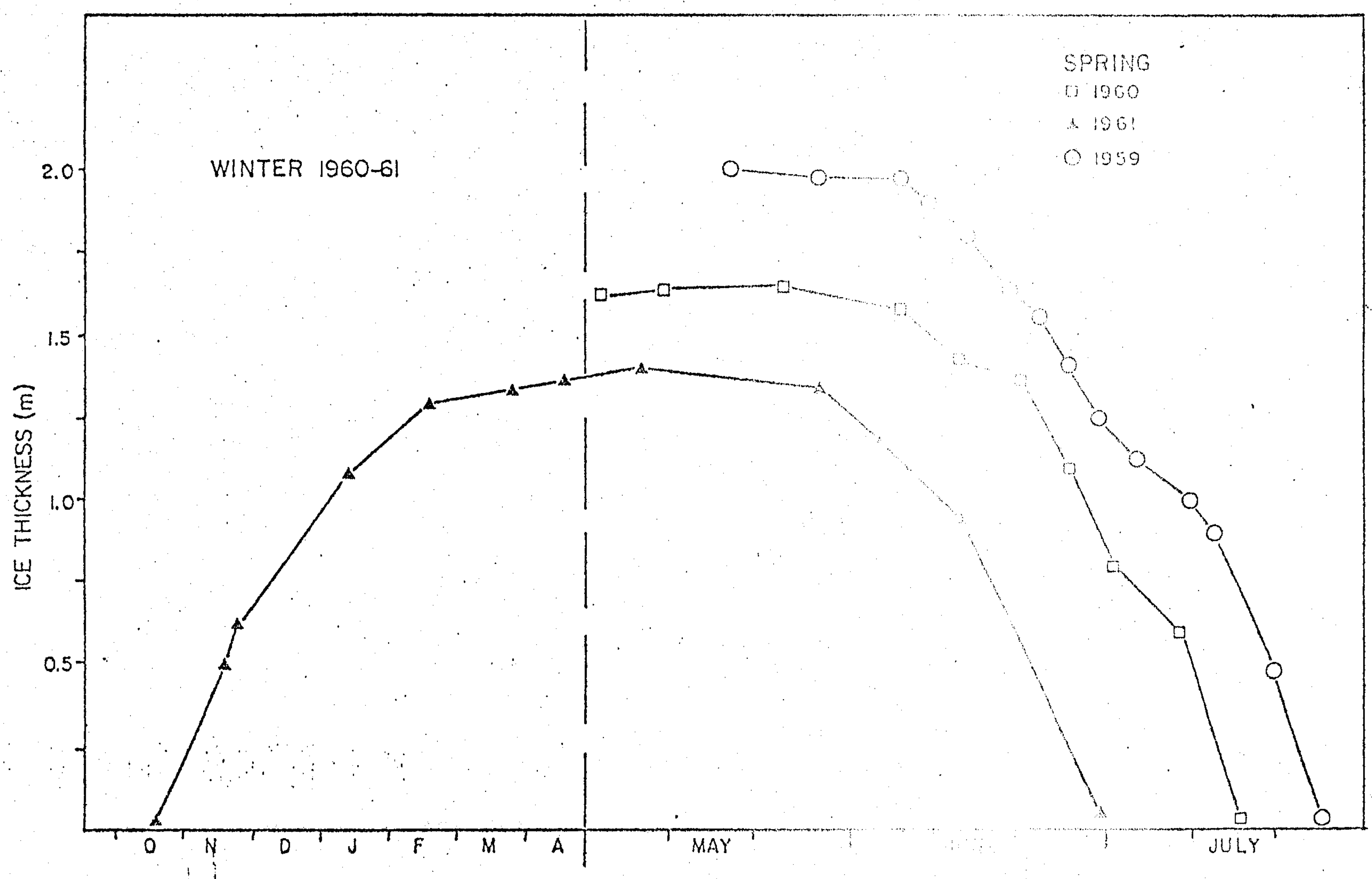


50
60
70
STAINES R.
CANNING
RIVER
Tamayariak
MILES
0
5
10
0
5
10
KILOMETRES

TABLE 2. Water Availability. Spread 8. Milepost 0 to 56. All volumes are thousands of Imperial Barrels.

MILEPOST	Volume Required	Number of Lakes	Surface Area (m^2 x 1000)	Mean Depths (m)	Lake Volumes	Mean Volume	Per cent Required	Mean Drawdown (m)
0-17	234	6	1,164	1.25	8,892			
Camp 0	198		1,265	1.8	13,908	15,505	2.8	0.04
			2,409	2.0	29,435			
			2,489	1.5	22,812			
			1,867	1.85	11,101			
			803	1.4	6,868			
17-34	247	8	642	1.9	7,457	[illegible]	2.8	0.04
			1,485	1.7	15,429			
			522	2.1	6,697			
			1,224	1.6	11,970			
			1,465	1.8	16,116			
			201	0.6	736			
			442	0.8	2,159			
			1,445	1.25	11,038			
Camp 44	189	5	682	0.5	2,085	[illegible],561	6.7	0.1
34-56	51		301	2.0	3,679			
			361	1.9	4,195			
			321	2.4	4,710			
			321	1.6	3,140			

Figure 3. Ice buildup and melt at Lake Peters, Alaska, 1959 to 1961 (Hobbie 1962).



WINTER 1960-61
SPRING
1960
1961
1959
ICE THICKNESS (m)
2.0
1.5
1.0
0.5
O
N
D
J
F
M
A
MAY
JULY

and the earlier in the season the accumulation begins, the thinner the ice will be. Particularly in years of light snowfall then, the camps planned for Mileposts 9 and 44 may have to develop alternative water supplies in the late winter months. One method of retarding ice development and maximizing the availability of free water would be to encourage snow accumulation by constructing snow fences on the ice of lakes selected as water sources.

There is a possibility that some flowing water persists in the Sagavanirktok and Canning Channels, or that sub-gravel water may be available in these rivers throughout the winter. Conditions, however, appear to vary. In November and April of 1973, for example, no flow was found at pipeline crossings in any of the drainages crossed by the pipeline from Prudhoe Bay up to and including the Canning River (Ward and Craig 1974). In late November of 1975, however, a flow of 228 cfs was measured in the Canning River at the pipeline crossing. In addition, two smaller drainages, the Shaviovik River and Kavik River, at Mileposts 36 and 37, had discharges of 12.2 and 0.5 cfs. In the West Channel of the Sagavanirktok River, at the pipeline crossing, there was approximately .9 m of free water under .7 m of ice. The velocity of the water was lower than the threshold velocity needed to operate the measuring instruments so discharge, if any, could not be calculated (Appendix table 4).

The precise extent of the free water in these drainages and the potential of sub-gravel water as a water source is not known, although it could be determined by geophysical programs (e.g. drilling and pumping tests conducted in winter).

In the lakes surveyed between Mileposts 0 and 56, the only fish captured were ninespine stickleback. These small fish are apparently tolerant of the low oxygen levels and other marginal habitat conditions that characterize these lakes in winter. Their presence does however indicate that in the lakes where they occur, at least some free water persists throughout the winter. The withdrawal of large amounts of water from these lakes could render conditions unsuitable for even the nine-spine stickleback. Since there are numerous lakes in addition to those surveyed within the pipeline corridor, AEL recommends that no more than 10% of the total volume of water be withdrawn from any given lake. The 10% limit is an arbitrary one. If it is observed, however, it is unlikely that any serious ecological damage would result from water withdrawal anywhere along the pipeline route.

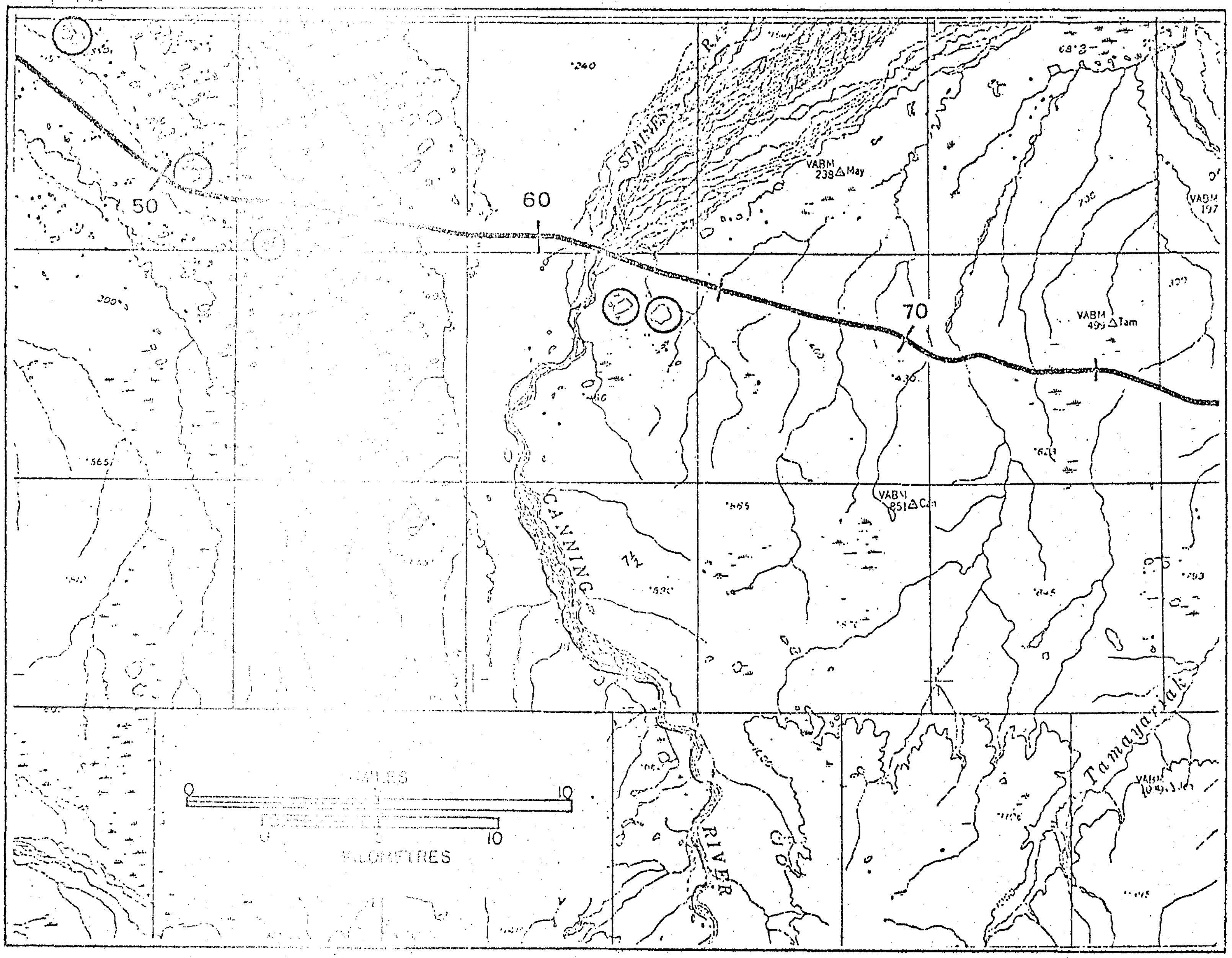
Spread 8: Milepost 56 to 112

At Milepost 62, the pipeline route crosses the Canning River and leaves the low, lake-studded coastal plain to enter rolling uplands characterized by numerous ephemeral drainages. Only two lakes, two springs, and possibly the Canning River itself can be considered potential sources of water for this segment of the pipeline route (Figure 4, a and b).

Adequate water for the section of pipeline between Mileposts 56 and

Figure 4a. Locations of waterbodies surveyed between Mileposts 56 and 112.

Fig 11a



50
60
70
STAINES R.
CANNING
RIVER
Tamayariak
VABM 239 △ May
VABM 499 △ Tam
VABM 851 △ Can
VABM 197
MILES
0
10
KILOMETRES
0
10

Figure 4b. Locations of waterbodies surveyed between Mileposts 56 and 112.

Fig 4.b

80
100
110
River
Marsh
Creek
Carter
Creek
Creek
RIVER
Natamarok Cr
KATAKTURUK
Itkilyariak
Mount Weller
Sunset Pass
SADLEROCHIT
Sadlerochit Spring
Kingak Hill
HULAHULA
SADLEROCHIT
0
10
0
5
10
KILOMETRES

73 can be obtained from the two lakes in the vicinity of Milepost 63 (Table 3). Between Mileposts 73 and 83 (including the camp at Milepost 83), water requirements are large. The closest sources of water are two springs on the Katakturuk River about 5 mi south of Milepost 87, one on the east fork and one on the west fork of the river. Each spring flows from multiple orifices into small channels leading to an aufeis area about [illegible] [illegible] variation in [illegible] adequate [illegible] to meet total requirement of 535,000 bbl.

Despite repeated surveys, no fish have been captured or observed in these springs, but they do support an abundant growth of riparian vegetation (similar to that shown in Plate 1), as well as populations of benthic invertebrates.

Since, even in springs with no known fish populations, every effort should be made to preserve as much as possible of the natural environment of the spring, we recommend that water withdrawal be confined to a single area as far downstream as possible from the orifices, preferably at a point just above the *aufeis* field. It may be possible to extract water from a sump or dugout adjacent to the spring channels, using intra-gravel flow and not disturbing the channels. Site-specific hydrological surveys including gravel drilling and pump tests, should be conducted to determine the feasibility of these methods of water withdrawal.

TABLE 3. Water Availability. Spread 8. Milepost 56 to 112. All volumes and discharges are Imperial Barrels x 1000.

MILEPOST	Volume Required	Number of Lakes	Surface Area (m^2 x 1000)	Mean Depth (m)	Volumes	Mean Volume	Percent Required	Mean Drawdown (m)	Spring Sources	Daily Discharge
56-73	136	2	381	2.8	6,525	6,942	[illegible]	0.05		
			482	2.5	7,359					
73-83	233	0								
Camp 83	320								Katakturuk	354
83-12	414	0							Sadlerochit	645

The stretch of pipeline from Milepost 83 to 112 has no known water sources except for Katakturuk Springs, already described, which lie just to the west, and Sadlerochit Spring which rises approximately 7 mi south of Milepost 111. Sadlerochit Spring is a large, warmwater spring (10 to 14°C) flowing primarily from a single orifice (Plate 2). The spring channel parallels the Sadlerochit River channel north for approximately 6 mi, and enters the river channel after passing through a large *aufeis* field lying just [illegible] of the pipeline crossing. In August 1975, the discharge from the spring was approximately 648,000 bbl/day. At this rate of flow, it would require less than one day's flow to meet the entire water requirement (414,000 bbl) for this section of pipeline. The discharge of warm water keeps the spring channel open for at least 5 mi during the winter, providing an excellent source of water close to the pipeline route.

There are, however, some important environmental considerations. The spring is inhabited by a large population of stream-resident Arctic char similar to those described by McCart and Craig (1973) as well as a sizeable overwintering population of grayling, mostly juveniles. During fisheries surveys in the fall of 1975, these fish were concentrated in the upper one-third of the spring. Fry and juvenile char occurred in small numbers, however, as far downstream as the *aufeis* field.

After a safe withdrawal site has been selected, collection ponds and the inlet to the pump should be screened to avoid pumping fish out of the spring channel. The screen or barrier should be far enough from the pump to ensure that the velocity of the water passing through the screen won't result in small fish and fry becoming exhausted and pinned against the screen. Mesh size of the screen should be 1/8 in. or smaller to prevent the passage of young-of-the-year char.

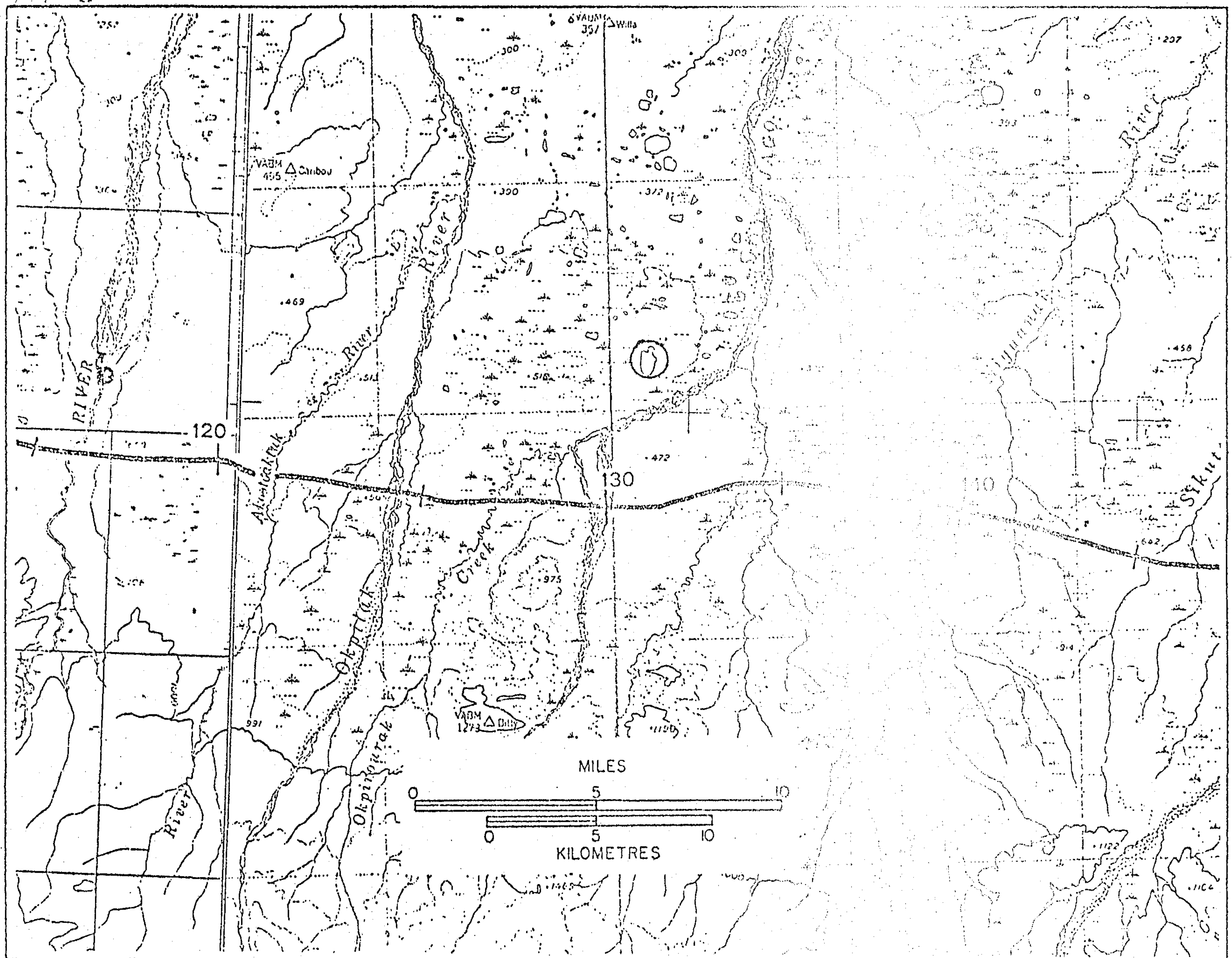
It is possible that a sump excavated in the gravel adjacent to the main channel could supply all the necessary water from intragravel flow with minimal effect on stream habitat. The gravel remaining between the sump and spring channel would provide a barrier to fish movement into the collection pond. A sump of this kind would have to be sufficiently far downstream to preclude drawing the flow down far enough to dewater char redds in the main channel.

The Sadlerochit Spring area is one of a number of Alaskan North Slope areas under consideration by the National Park Service as Natural Landmarks. Sadlerochit Spring, along with the Sagavanirktok River, Kadleroshilik River and Plain, Jago River and Clarence Plain are considered to have distinctive ecological and geological characteristics.

Spread 8: Mileposts 112 to 168

This segment of the pipeline route has fewer and smaller water sources than any other segment of the route. Within the pipeline corridor, there are only three small spring sources and one lake (Figure 5, a and b). These water sources, however, are adequate to meet the requirements (Table 4) although transport distances will be considerable. If necessary, the two large springs just beyond the ends of this pipeline

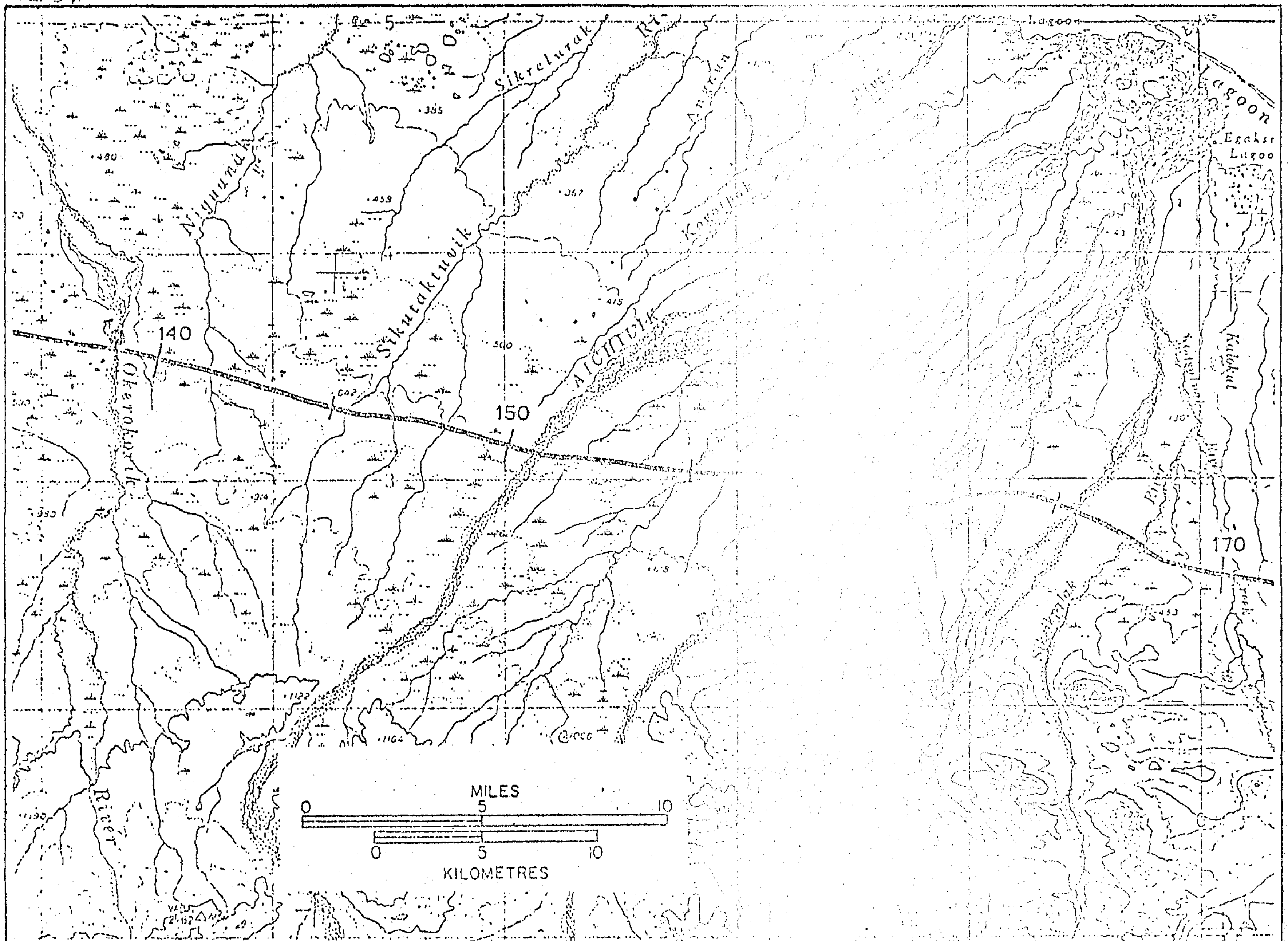
Figure 5a. Locations of waterbodies surveyed between Mileposts 112 and 168.



VABM 357 Willa
VABM 455 Caribou
VABM 1273 Billy
RIVER
River
Akualaktuk
Okpilak
Okpiourak
Creek
Sikut
120
130
140
MILES
0
5
10
KILOMETRES
0
5
10

Figure 5b. Locations of waterbodies surveyed between Mileposts 112 and 168.

Fig. 5 b



Lagoon
Kalokut
Sikrelurak
Sikutaktuvik
Niguanak
Aichilik
Okerokovik
River
140
150
170
MILES
0
5
10
KILOMETRES

TABLE 4. Water Availability. Spread 8. Milepost 112 to 168. All discharges and volumes are Imperial Barrels x 1000.

MILEPOST	Volume Required	Number of Lakes	Surface Area (m^2)	Mean Depth (m)	Volume	Per cent Required	[illegible] (m)	Spring Sources	Daily Discharge
112-129	241								
Camp 129	341	0						Hula Hula	153
129-146	241	1	763	1.6	7,456	3.2		Okerokovik	50
146-168	52	0						Ekaluakat	432

segment, Sadlerochit Spring and the large groundwater sources in the Kongakut Delta, can be used to augment the water supply. The only other possible sources of water are a small number of widely scattered lakes 10 to 20 mi north of the pipeline route.

For the segment of the pipeline between Mileposts 112 and 129, water could be [illegible] Sadlerochit Spring at Milepost 111 [illegible] the Hula Hula [illegible] south of [illegible] The [illegible] Milepost 129 will have a water requirement of [illegible] bbl, the major part of the 582,000 bbl requirement for this section of pipeline development. Hula Hula Springs have a discharge of approximately 150,000 bbl/day, more than adequate to handle the expected maximum daily water requirement of about 15,000 bbl/day.

Even though no fish were observed in the Hula Hula Springs during the survey in November 1975, they are a potential overwintering area for Arctic char. Conversations with native fishermen in the village of Kaktovik on Barter Island indicate that in past years this spring was used by small numbers of overwintering anadromous Arctic char. At present, most of the Hula Hula River char population overwinters in a second larger spring about 25 mi further upstream (south) of the pipeline crossing.

AEL recommends that water be taken from a point just above the *aufeis* where the spring channels converge, or from a sump dug in the gravel alongside the active channel. If water is withdrawn directly from the spring channel, we recommend that the pump intake be screened to prevent the intake of fish. To preserve the spring area in as natural a condition as possible, rechannelization or collection pond construction should be avoided.

From Milepost 129 to 146, the total water requirement is 241,[illegible] There is a lake located [illegible] 5 mi [illegible] [illegible]

In addition to the lake, there is a small spring (Plate 1) on the Okerokovik River lying close to the pipeline route at Milepost 138. This spring discharges approximately 50,000 bbl/day and is apparently uninhabited by fish. The spring has a number of channels which rise from small orifices and wind their way independently toward the *aufeis* field.

Once again, AEL recommends that the area of the spring near the orifices be avoided. Any rechannelization in the permanent spring channels could destroy plant and animal communities associated with them. In order to preserve as many of the natural channels of the spring as possible, water should be withdrawn either further downstream where the spring channels enter the river floodplain, or from a sump in the gravel.

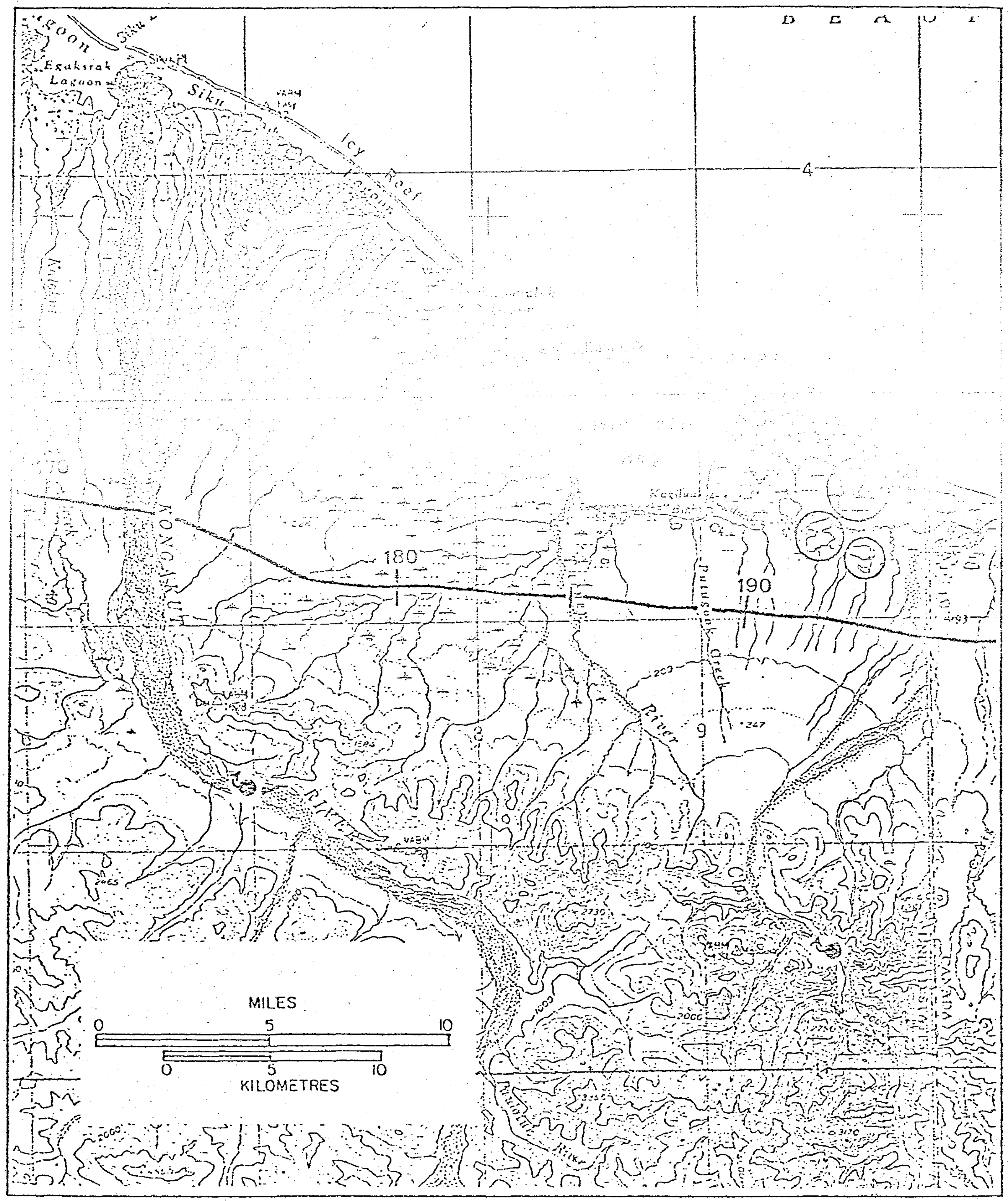
The water requirements between Mileposts 146 and 168 are small (52,000 bbl). The nearest source of water is the Ekaluakat River Springs located about 5 mi south of Milepost 162. These large springs were flowing at a rate of approximately 432,000 bbl/day when surveyed. The Ekaluakat Springs are, however, some of the most environmentally sensitive springs on the Alaskan portion of the pipeline route. They serve as an important spawning and overwintering site for anadromous and non-anadromous Arctic char. Plate 3 shows the numerous groundwater sources of [illegible] about 1 mi downstream. [illegible]

If this spring is selected as a water source, then detailed surveys should be carried out during the Final Design Phase to fix the timing and location of spawning. Provisionally, AEL recommends that water be withdrawn from this spring only below those areas utilized by Artic char. In this way, dewatering of char redds and sedimentation of spawning and overwintering areas could be avoided. As mentioned before, fish should be prevented from entering collection ponds and the vicinity of the pump intake with screens or barriers. A simple method might be to take advantage of intragravel flow by placing a sump in the gravel downstream near the *aufeis*.

Spread 9: Mileposts 168 to 190

This segment of the pipeline route crosses the upper end of the Kongakut Delta then drops down out of the rolling uplands to the flat, marshy, coastal plain. There are a number of potential sources of water in this region (Figure 6).

Figure 6. Locations of waterbodies surveyed between Mileposts 168 and 190.


Egaksrak
Lagoon
Siku
Icy Reef
Lagoon
KONGAKUT
RIVER
180
190
Putugook Creek
River
200
347
2730
2000
1000
3170
4
MILES
0
5
10
KILOMETRES

A large source of groundwater is located in the Kongakut Delta approximately 7 mi north of Milepost 174. This source has a discharge in excess of 1,500,000 bbl/day. Four days' flow would provide all the water needed for construction of the Arctic Gas Pipeline from Prudhoe Bay to the Mackenzie Delta. There are additional springs upstream on the Kongakut and on the Clarence River. These springs are heavily populated with Arctic char, but they should not be used as sources of water.

[illegible] requirement for this segment of the pipeline is [illegible] bbl. The springs in the Kongakut Delta could easily supply all of this water. If the haul distance to the east end of this segment is prohibitive, there are a number of lakes three to four miles north of Milepost 193 that could be used. The volume of water available and the requirements for this segment of the pipeline appear in Table 5.

Ward and Craig (1974) describe the Kongakut Delta Springs as important rearing and overwintering areas for large numbers of juvenile Arctic char. If pumping facilities are used in this area, water collection areas and pump inlets should be screened to avoid drawing fish into the pumps. Care should be taken to avoid diversion works or excessive pumping from one channel that might result in dewatering those channels with overwintering fish.

TABLE 5. Water Availability. Spread 9. Milepost 168-190. All discharges and volumes are Imperial Barrels x 1000.

MILEPOST	Volume Required	Number of Lakes	Spring Sources	Daily Discharge
168-177	16	0	Kongakut	1,558
Camp 177	156			281
177-190	34	0	Clarence	37

Spread 9: Milepost 190 to 224

This segment of the pipeline corridor continues along the Coastal Plain close to the Beaufort Sea. In the vicinity of Milepost 210, the Coastal Plain narrows to a width of 5 mi.

Four lakes and three springs were surveyed along this portion of the route (Figure [illegible], Table [illegible]). The total water requirement for this segment is approximately [illegible] and would require about [illegible] of the total volume of the lakes surveyed. Alternatively, the three springs surveyed could supply the total water requirement with only 1.5 days' discharge.

Between Mileposts 190 and 207, large volumes of water are available from the lakes located 4 mi north of Milepost 193. There are also two small springs in the area, one on Craig Creek and one on a tributary of Craig Creek, about 3 mi south of Milepost 197. These springs emerge from multiple orifices, generally into divergent channels, to wind independently across the floodplain to an *aufeis* area. Although the springs appear to be uninhabited by fish, aquatic and riparian vegetation and benthic invertebrates are abundant. To avoid disturbing the vegetation and invertebrates in the channels, AEL recommends that, if possible, water be withdrawn from a sump located on the floodplain.

From Milepost 207 to 216 (including the camp proposed at Milepost 216) water can either be drawn from the lake located about 2 mi north of

Figure 7. Locations of waterbodies surveyed between Mileposts 190 and 224.

Fig 7

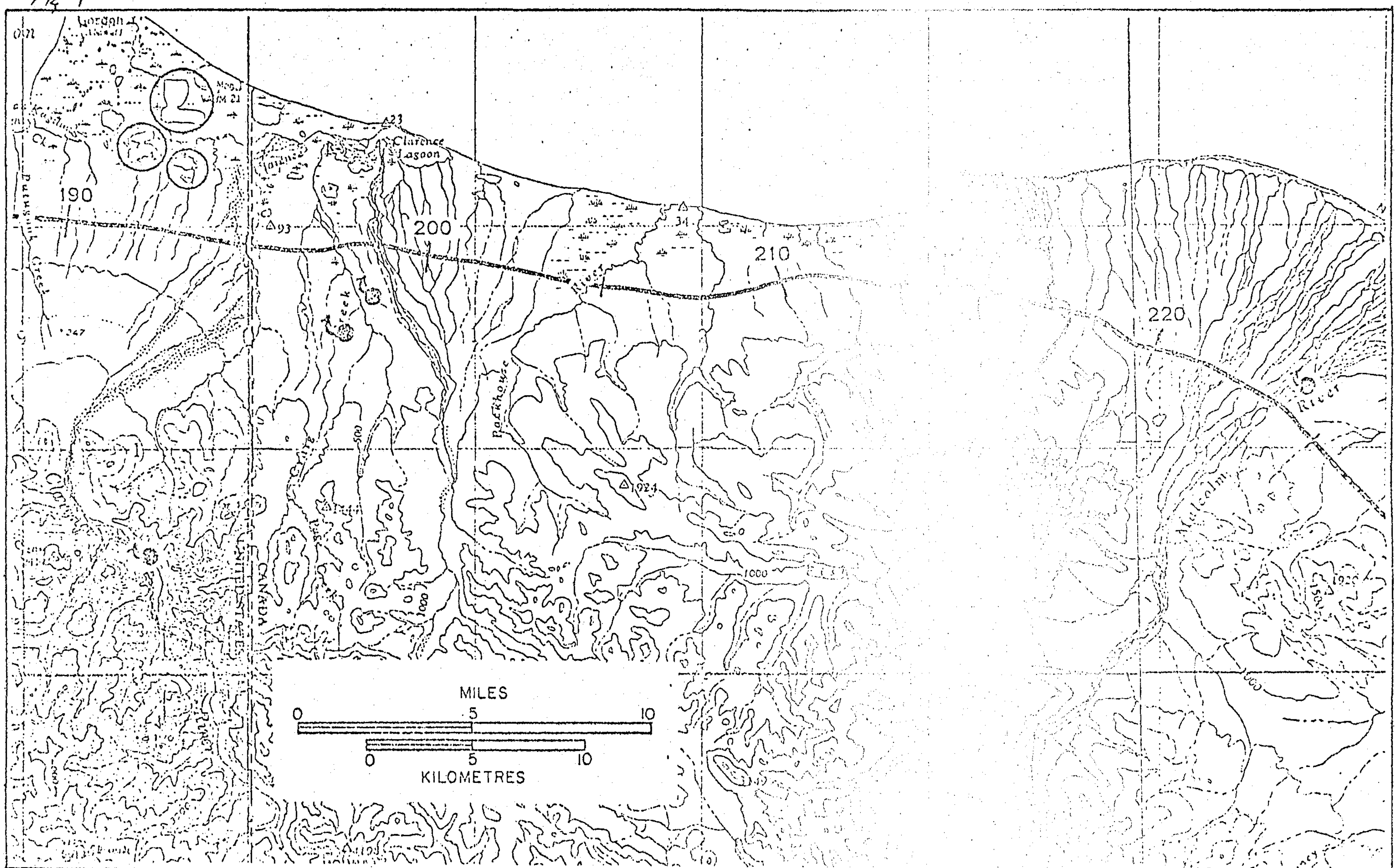

Clarence Lagoon
190
200
210
220
Malcolm
River
CANADA
UNITED STATES
MILES
0
5
10
KILOMETRES
0
5
10

TABLE 6. Water Availability. Spread 9. Milepost 190 to 224. All volumes and discharges are Imperial Barrels x 1000.

MILEPOST	Volume Required	Number of Lakes	Surface Area (m^2)	Mean Depth (m)	Volumes	Mean Volume	Per cent Required	Mean Drawdown (m)	Spring Sources	Daily Discharge
190-207	228	3	1,204	2.7	19,869				Craig Cr.	50
			521	2.8	8,929	20,695	1.1	0.03	Craig Cr. Trib.	175
			2,369	2.3	33,286					
207-216	118	1	550	2.8	9,410	9,410	[illegible]	0.09		0
Camp 216	201									
216-224	144	0							Fish Creek	236

Milepost 215 or from the springs on Fish Creek, 2 mi north of Milepost 217.5. The DEW Line site at Komakuk uses this lake for its water supply, however, so there may be some conflict over water use, especially in mid-winter when most of the water is frozen.

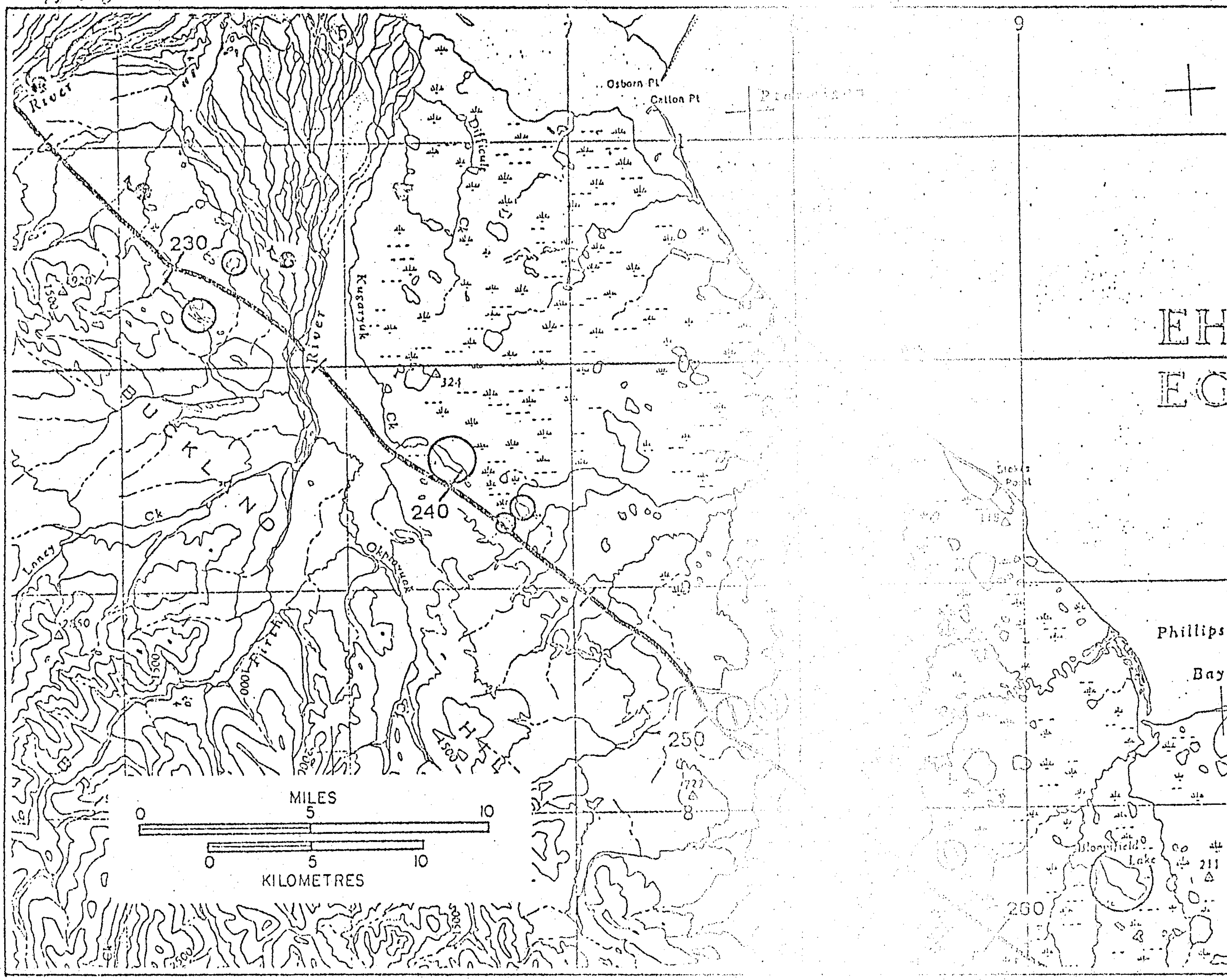
Fish Creek Springs had a discharge of 236,000 bbl/day when surveyed. This spring [illegible] could be [illegible] the spring [illegible] habitat [illegible] the fish in the spring. There is a second larger spring on Fish Creek, located approximately 6 mi upstream of the pipeline crossing. This spring is a critical spawning and overwintering area for Arctic char and should not be utilized as a water source.

Spread 9: Mileposts 224 to 280

After crossing the Malcolm and Firth River deltas, the pipeline route veers away from the coast and re-enters the rolling uplands. The terrain differs from similar terrain on the Alaskan side of the border in that upland lakes are more abundant. Many of these lakes are deep and harbour overwintering populations of fish. There are also springs within this portion of the pipeline corridor that are potential sources of water for pipeline development (Figure 8, a and b).

Between Mileposts 224 and 246, water requirements are small, totalling 37,000 bbl. While it is apparent that any one of the sources surveyed (Table 7) could fulfill all the water requirements

Figure 8a. Locations of waterbodies surveyed between Mileposts 224 and 280.



River
Osborn Pt
Callon Pt
Difficult
Ck
Kugaryuk
River
230
240
250
260
BUCKLAND
Okpiovuk
Firth
Phillips
Bay
Lake
211
9
8
MILES
0
5
10
KILOMETRES

Figure 8b. Locations of waterbodies surveyed between Mileposts 224 and 230.

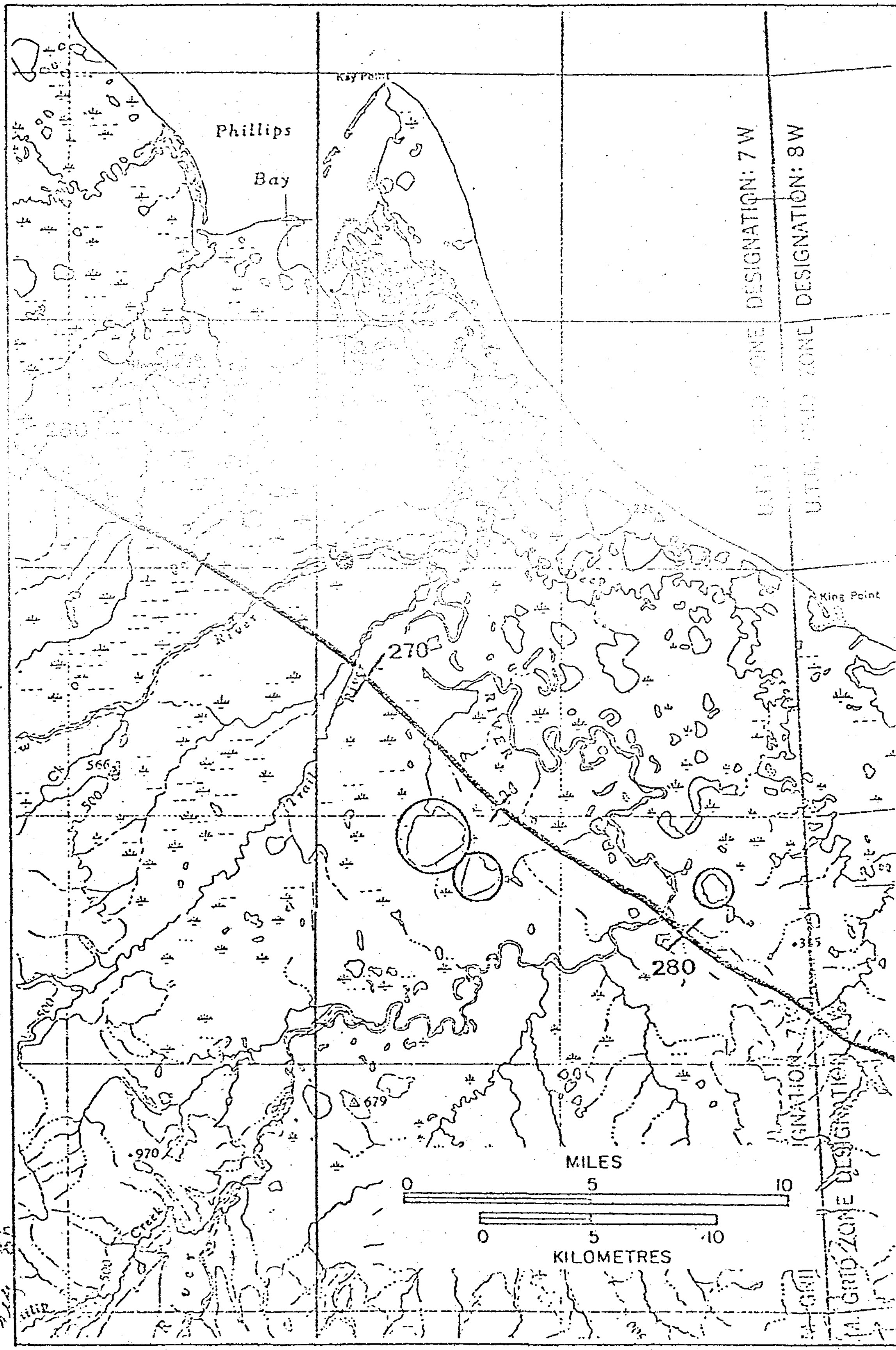

Kay Point
Phillips
Bay
King Point
270
280
566
500
679
970
365
River
Trail
Creek
MILES
0
5
10
0
5
10
KILOMETRES
U.T.M. GRID ZONE DESIGNATION: 7 W
U.T.M. GRID ZONE DESIGNATION: 8 W

TABLE 7. Water Availability. Spread 9. Milepost 224 to 280. All [illegible] and discharges are Imperial Barrels x 1000.

MILEPOST	Volume Required	Number of Lakes	Surface Area (m^2)	Mean Depth (m)	Volumes	Mean Volume	[illegible]	Mean Drawdown (m)	Spring Sources	Daily Discharges
224-246	37	6	125	4.3	3,284				Malcolm R.	342
			50	13.6	4,154					
			175	1.8	1,924	4,848	[illegible]	0.02	Firth 2	400
			688	2.9	12,182					
			250	2.3	3,513				Firth Delta	868
			300	2.2	4,033					
246-263	236	4	2,500	2.7	42,800					
			150	2.3	2,475	14,78[illegible]	[illegible]	0.08	Spring R.	91
Camp 263	220		500	2.2	6,721					
			488	2.4	7,149					
263-280	275	3	2,050	2.4	30,062	30,7[illegible]	[illegible]	0.02	Crow River	135
			4,013	3.1	76,004					
			1,675	1.3	13,305					

for this section, several of the springs and lakes serve as critical spawning and overwintering habitat for fish.

The springs on the east side of the Malcolm Delta, for example, are densely populated with juvenile Arctic char and grayling. In October, 1975, fish were concentrated in the upper one-third of the spring [illegible] provided [illegible] and [illegible] to prevent the entry of fish.

The next spring lies mid-way between the Malcolm and Firth rivers, 1 mi north of Milepost 228. This spring is a critical spawning and overwintering area for anadromous Arctic char. On October 9, 1975, char were found actively spawning throughout the open water of the spring, and redd sites in the Channel (Plate 4) extended downstream to and beyone the point where the channels were frozen over. During earlier surveys carried out in the fall and winter of 1972 and 1973 (McCart *et al.* 1974), no adult fish were found in the open water of the spring. Juveniles and fry were present, however, and since there are deep pools above, in, and below the *aufeis* field, it is likely that the adult anadromous char overwinter in these pools under the ice cover. This spring may also support a stream-resident population of Arctic char as several small male char were captured during surveys in 1975.

In some respects, this spring in unique. It is closer to the coast than other areas where Arctic char are known to spawn, and it is not directly associated with a major river system. The fish utilizing this spring may be a separate population from that inhabiting the Firth or Malcolm river systems. Both because this spring is unusual and because it would be difficult to withdraw water from it without [illegible] of the [illegible] [illegible] sources [illegible] pipeline [illegible] sump downstream near the [illegible] field might jeopardize fish over-wintering in pools under the ice cover.

The springs in the Firth Delta (2 mi north of Milepost 233) have a discharge of approximately 868,000 bbl/day. These springs (Plate 5) are not heavily utilized by overwintering fish, and water can be safely withdrawn from screened collection ponds or from sumps in the gravel. The entire Firth River drainage, however, is under consideration as an Ecological Reserve under the International Biological Program, so disturbance of aquatic habitats in the region of the spring should be confined to as small an area as possible.

Two lakes, Lake 103 and Lake 104, located 2 mi south of Milepost 231, support slow-growing populations of lake-resident Arctic char. These lakes are both deep, Lake 103 averaging 4.3 m and Lake 104 averaging 13.6 m. If withdrawal is carefully regulated to less than 10% of the volume of either lake, water could be safely withdrawn from them. We would recommend, however, that there be a strict prohibition on angling in these lakes.

Four other lakes were surveyed in this area, one a mile north of Milepost 253, one a mile north of Milepost 240, and two small ones in the vicinity of Milepost 242. Apparently these lakes are inhabited [illegible]

[illegible] springs were surveyed (Table 7). As indicated, there is abundant water to meet the water requirements for pipeline development.

Three of the lakes in this section support large populations of fish during the summer. These lakes have never been fished in the winter, but it is likely that at least some of the fish are year-round residents. In the case of Lake 100 (5 mi north of Milepost 255) and Lake 101 (2 mi south of Milepost 272), lake volumes are so large that the total water requirement for this section of pipeline would amount to less than 1% of their total volume, a drawdown of only a few centimeters.

The third lake, Lake 109 (2 mi north of Milepost 252) is both smaller and shallower than Lakes 100 and 101. Unregulated water withdrawal from a lake of this size could draw water levels down to the point where conditions could be unfavourable to the survival of fish. If, however, water withdrawal is restricted to 10% of the total volume of the lake there should be no serious effects.

The construction camp planned for the vicinity of Milepost 263 could use Bloomfield Lake as a water source. The estimated water requirements for this camp total 220,000 bbl. This amount is less than 1% of the volume of Bloomfield Lake. No fish were caught in Bloomfield Lake during surveys in [illegible]

The small springs on the Spring River (about 2 mi north of Milepost 256) and those on the Crow River (2 mi north of Milepost 268) could also be developed as water sources for the camp at Milepost 256. These springs had discharges of approximately 90,000 and 135,000 bbl/day when they were surveyed in August of 1975. Seasonal variation, however, could be great. During the October survey, for example, the Spring River spring had little open water and a small *aufeis* field, so that diminished discharge during the winter months is indicated. Although neither of these springs supports an overwintering fish population, care should be taken to avoid unnecessary disruption of the spring channels and the aquatic vegetation and invertebate populations associated with them.

Figure 9a. Locations of waterbodies surveyed between Mileposts 280 and 336.

Fig. 7c

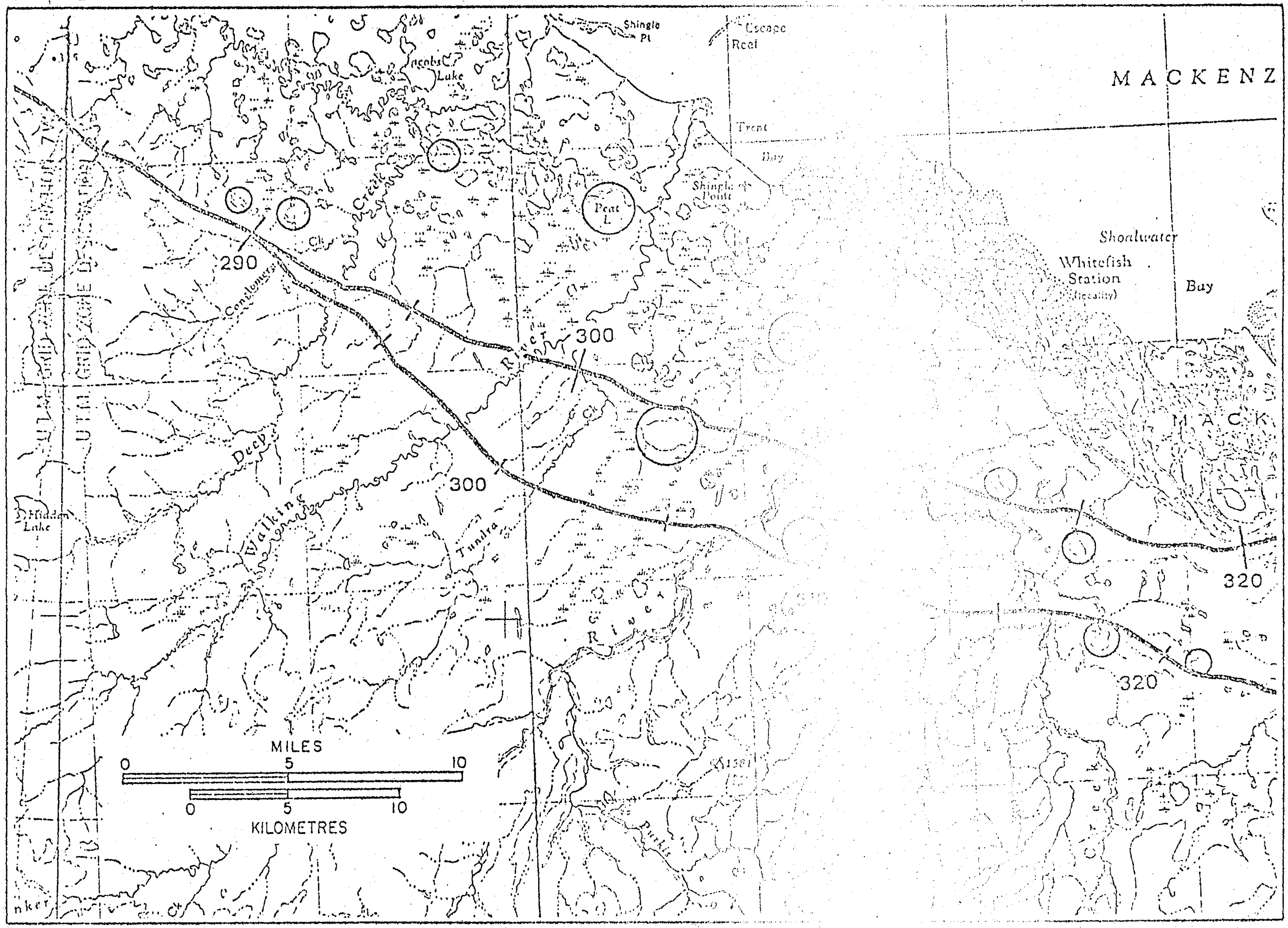
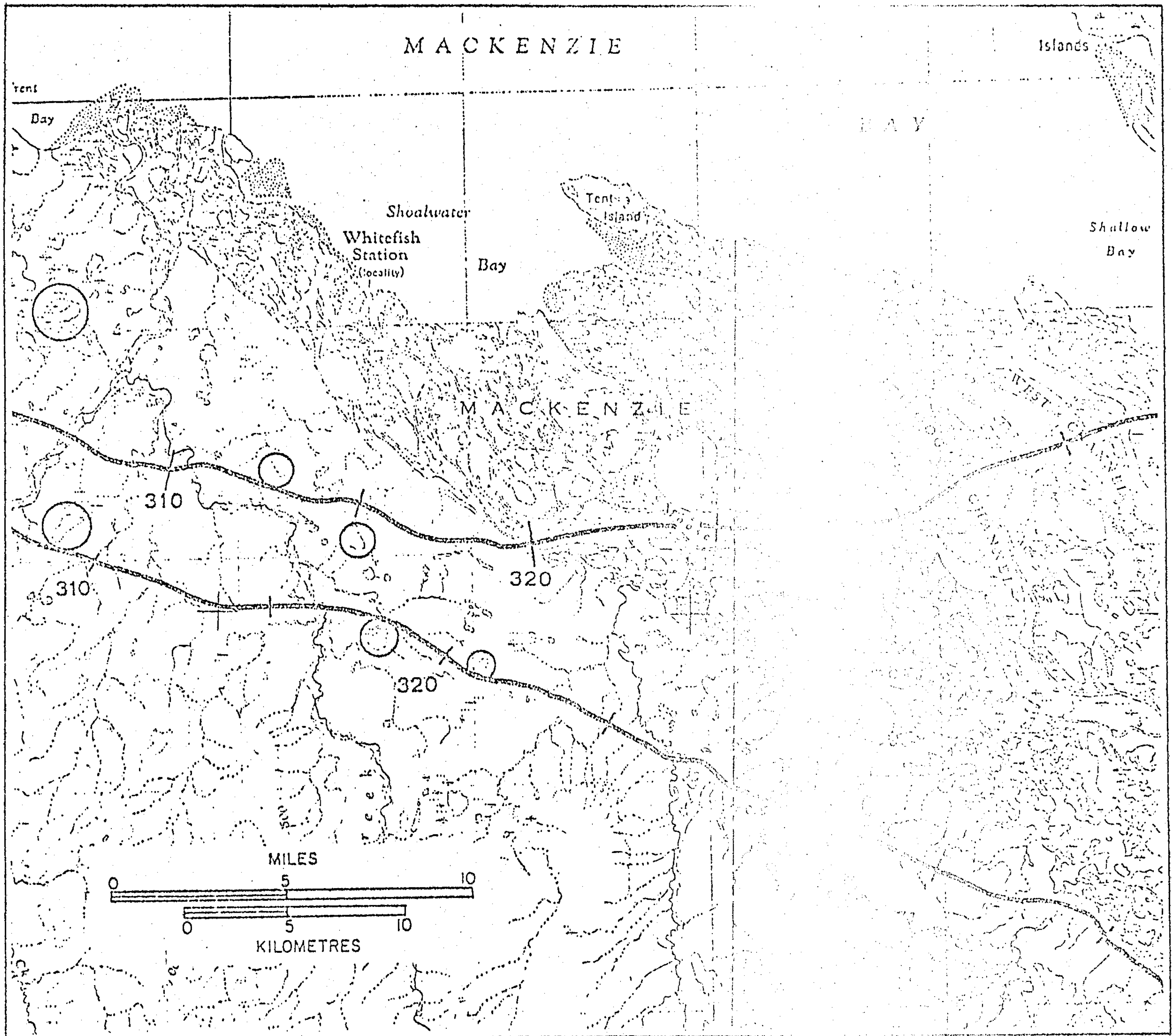

MACKENZ
Shingle Pt
Escape Reef
Trent Bay
Shingle Point
Jacobs Lake
Peat L.
Creek
Conglomerate
290
300
300
320
320
Deep
Walking
Tundra
River
Purkis
Hidden Lake
Shoalwater
Whitefish Station (locality)
Bay
MACK
UTM GRID ZONE DESIGNATION
MILES
0
5
10
0
5
10
KILOMETRES

Figure 9b. Locations of waterbodies surveyed between Mileposts 280 and 336.

Fig. 7b



MACKENZIE
Tent
Bay
Shoalwater
Bay
Whitefish
Station
(locality)
Tent Island
MACKENZIE
Islands
BAY
Shallow
Bay
WEST CHANNEL
310
310
320
320
MILES
0
5
10
0
5
10
KILOMETRES

TABLE 8. Water Availability. Spread 9. Milepost 280 to 336. All [illegible] are Imperial Barrels x 1000.

MILEPOST	Volume Required	Number of Lakes	Surface Area (m^2)	Mean Depth (m)	[illegible]	Mean Volume	Per cent Required	Mean Drawdown (m)
280-300	24	4	1200	2.1	[illegible]	6,187	4.0	0.09
Camp 300	310		275	4.0	[illegible]			
			113	2.8	[illegible]			
			750	1.9	[illegible]			
300-319	270	8	2,275	1.1	[illegible]	11,967	4.4	0.09
			2,575	2.5				
			775	2.6				
			750	1.6				
			400	2.3				
			437	2.1				
			550	2.0				
			250	2.3				
319-336	252	0						

Spread 9: Mileposts 280 to 336

Twelve lakes were surveyed along this segment of the pipeline route (Figure 9, a and b; Table 8). The water available in these lakes will easily fill the estimated requirements for pipeline development, and there are numerous other lakes within 5 to 10 mi of the pipeline [illegible] [illegible]

Three of the lakes surveyed are known to have populations of fish during at least part of the year. Two of the lakes are deep enough to suggest that they are suitable for overwintering. One lake (Plate 6), 1 mi north of Milepost 290, has an average depth of 4 m and was inhabited by grayling during surveys in 1975. This lake, which is typical of many lakes in this region, is sufficiently deep to support overwintering fish, but small enough to require regulation of water withdrawal. A maximum withdrawal of 10% of the total volume of the lake would ensure adequate overwintering conditions for fish.

The second lake (6.5 mi north of Milepost 309) has a population of lake whitefish. However, this lake is deep enough and large enough to permit withdrawal of up to 10% of the volume with little or no effect on fish populations.

Steigenberger *et al.* (1975) report catching one grayling in a third lake (0.5 mi north of Milepost 321). However, no fish were caught in this lake during the course of this study, so it is unlikely that it is regularly utilized by grayling. Water from this lake could be used to supply the construction camp planned in the vicinity of Milepost 300. All of the water required by the camp (310,000 bbl) and all the water required for the section of pipeline between Mileposts 300 and 319 (270,000 bbl) could come from this lake without utilizing more than 1.5% of its total volume.

The [illegible] that some of these lakes are inhabited periodically by grayling or other species of fish, we recommend that not more than 10% of the volume of any one source be withdrawn.

Beyond Milepost 320, the pipeline route lies close to the western edge of the Mackenzie River Delta. In addition to the adequate quantities of water available in the lakes surveyed, there are large amounts of water available from both the western channel of the Mackenzie River and from the numerous lakes in the delta.

CONCLUSIONS AND RECOMMENDATIONS

These are the general conclusion and recommendations of this study.

1) [illegible] total estimated water requirement of 5,508,000 bbl would amount to slightly less than 1% of the 550,967,000 bbl of water available in the lakes surveyed. In addition, the springs surveyed discharge 5,807,000 bbl/day (or slightly more than the total estimated water requirements.

Besides the lake and spring sources surveyed, other sources of water might be utilized (e.g. sub-gravel flow in rivers where surface flow is frozen).

2) Water can be withdrawn from most of the lakes and springs surveyed (or from others) without serious environmental damage provided proper safeguards and precautions are observed. The maximum lake draw-down needed to provide the estimated water requirements is less than 10 cm. Provided withdrawal is spread out among the sources surveyed, and that no more than 10% of the total volume is taken from any one source, the effects upon aquatic habitats (including waterfowl) should be minimal.

3) A preliminary selection of water sources can be made on the basis of the information provided in this report. However, additional site-specific biological, hydrological and engineering studies are needed before final selection of water sources is made. These studies should include the following:

a) [illegible] determine spawning and overwintering areas in springs and lakes,

b) hydrological assessments of recharge rates, seasonal and annual variability in spring discharge rates, and precise volumetric measurements of lakes known to be overwintering areas for fish,

c) engineering studies including geophysical and drilling programs, as well as pump tests to determine the availability of sub-gravel flows in river channels, and studies to determine the feasibility of using sumps in the vicinity of springs,

d) since a number of springs (including Hula Hula, Malcolm, Firth, Spring and Crow River springs) are located a short distance downstream (north) of the pipeline crossings on these rivers, some attempt should be made to find out whether or not the deep burial of the pipeline in river channels above these springs might interfere with the aquifers that feed these springs.

4) During the construction phase, we recommend that:

a) The volume of water withdrawn from any one [illegible]
[illegible]

b) During development of sources and during water withdrawal, each location with known populations of spawning or overwintering fish should be individually monitored by a fisheries biologist familiar with the lakes and springs of the North Slope.

c) Springs known to support fish populations should not be developed as sources of water if suitable alternative sources are available.

d) When springs are developed as water sources, damage to the aquatic environment can be minimized by:

- avoiding rechannelization of natural spring channels
- using sumps in the gravel downstream toward the *aufeis* and away from the spring orifice
- providing suitable barriers or screens to prevent fish from entering sumps or collection ponds
- avoiding long parallels between spring channels and access roads.

LITERATURE CITED

Craig, P. and P. McCart, 1974. Fall spawning and overwintering areas of fish populations along routes of proposed pipeline between Prudhoe Bay and the Mackenzie Delta 1972 to 1973. *In*: P. McCart (ed.), Fisheries Research Associated with Proposed Gas Pipeline Routes in Alaska, Yukon and Northwest Territories. Arctic Gas Biological Report Series, Vol. [illegible]

[illegible] Pallas [illegible] Territory. *In*: P. McCart (ed.), Life Histories of Three Species of Freshwater Fishes in the Beaufort Sea Drainages, Yukon Territory. Arctic Gas Biological Report Series, Vol. 18 (2) 100 p. (Also MSc Thesis, Department of Biology, University of Calgary, Calgary, Alberta).

Hobbie, J. 1962. Limnological cycles and primary productivity of two lakes in the Alaskan Arctic. PhD Thesis, Department of Zoology, Indiana University, 123 p.

McCart, P. and P. Craig, 1973. Life history of Arctic char (*Salvelinus alpinus*) in spring-fed tributaries of the Canning River, Alaska. J. Fish Res. Bd. Can. 30:1215-1220.

McCart P., W. Griffiths, C. Gossen, H. Bain and D. Tripp. 1974. Catalogue of lakes and streams in Canada along routes of the proposed Arctic Gas pipeline from the Alaskan/Canadian border to the 60th parallel. Arctic Gas Biological Report Series, Vol. 16, 251 p.

Steigenberger, L., R. Robertson, K. Johansen, M. Elson. 1975. Biological/engineering evaluation of the proposed pipeline crossing site in northern Yukon Territory. Canada Department of the Environment, Fisheries and Marine Service, Pacific Region, March 1975, 456 p.

Ward, D. and P. Craig. 1974. Catalogue of streams, lakes and coastal areas in Alaska along routes of the proposed gas pipeline from Prudhoe Bay to the Alaskan/Canadian border. Arctic Gas Biological Report Series, Vol. 19, 381 p.

APPENDIX TABLE 1. Estimated monthly water requirements for various construction periods.

Milepost/Water Use	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	[illegible]	Mar.	Apr.	Total Water Requirement
				Monthly Water Requirements (Thousands of Imperial [illegible])						
(1978-1979)										
0-Prudhoe Bay										
Camp	16	17	9	37	42					
Testing						[illegible]				
Ditch Flood										
Snow Coat										
Snow Roads			37							198
0-17										
Ditch Flood						21				
Snow Coat						[illegible]				
Snow Roads			147	61						234
17-34										
Ditch Flood										
Snow Coat										
Snow Roads				122	86					247
34-44										
Testing								2		
Ditch Flood								12		
Snow Coat								3		
Snow Roads					12					29
44										
Camp					14	52		48	20	189
44-56										
Ditch Flood								11	8	
Snow Coat								[illegible]	1	22

(Continued)

Appendix Table 1. Continued.

Milepost/Water Use	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total Water Requirement
				Monthly Water Requirements (Thousands of Imperial Barrels)						
(1979-1980)										
56										
Testing						40				40
56-73										
Ditch Flood						3				
Snow Coat						7				
Snow Roads					86					96
73-83										
Ditch Flood							[illegible]			
Snow Coat							[illegible]			
Snow Roads				186	37					233
83										
Camp	16	17	9	37	56	52		48	20	
Snow Roads				10						320
83-90										
Ditch Flood										
Snow Coat										
Snow Roads				86						90
90-112										
Testing								2		
Ditch Flood								2	6	
Snow Coat								7	2	
Snow Roads			244	61						324

(Continued)

Appendix Table 1. Continued.

Milepost/Water Use	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total Water Requirement
				Monthly Water Requirements (Thousands of Imperial Barrels)						
(1980-1981)										
112										
Testing						40				40
112-129										
Ditch Flood						24				
Snow Coat						9				
Snow Roads			184	24						241
129										
Camp	16	17	9	37	56	52	[illegible]	48	20	
Snow Roads				31						341
129-146										
Ditch Flood							[illegible]			
Snow Coat										
Snow Roads				128	80					241
146-168										
Testing								2		
Ditch Flood								20	6	
Snow Coat								9	3	
Snow Roads					12					52
168-177										
Ditch Flood								5	6	
Snow Coat								2	3	16
177										
Camp						33		48	20	156

Appendix Table 1. Continued.

Milepost/Water Use	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total Water Requirement
	Monthly Water Requirements (Thousands of Imperial Barrels)									
177-190										
Testing								2		
Ditch Flood								13		
Snow Coat								7		
Snow Roads					12					34
190-207										
Ditch Flood							[illegible]			
Snow Coat										
Snow Roads				122	86					228
207-216										
Ditch Flood						3				
Snow Coat						5				
Snow Roads			49	61						118
216-Komakuk Beach										
Camp	16	17	9	37	56	19				
Snow Roads			47							201
216-224										
Testing						40				
Ditch Flood						2				
Snow Coat						4				
Snow Roads			98							144

(Continued)

Appendix Table 1. Continued.

Milepost/Water Use	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total Water Requirement
	Monthly Water Requirements (Thousands of Imperial Barrels)									
(1979-1980)										
216-Komakuk Beach										
Camp							22	48	20	90
224-246										
Testing								2		
Ditch Flood								14	2	
Snow Coat								5	2	
Snow Roads					12					37
246-263										
Ditch Flood							[illegible]			
Snow Coat							[illegible]			
Snow Roads				141	73					236
263										
Camp	16	17	9	37	56	52	33			220
263-280										
Testing						40				
Ditch Flood						16				
Snow Coat						5				
Snow Roads			177	37						275
280-300										
Ditch Flood								16	5	
Snow Coat								2	1	24

(Continued)

Appendix Table 1. Continued.

Milepost/Water Use	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	[illegible]	Mar.	Apr.	Total Water Requirement
				Monthly Water Requirement (Thousands of Imperial Barrels)						
300-Shingle Point										
Camp	16	17	9	37	56	52	[illegible]	48	20	
Snow Roads			98							310
300-319										
Testing								2		
Ditch Flood							[illegible]	3		
Snow Coat										
Snow Roads			122	116						270
319-336										
Testing						40				
Ditch Flood						14				
Snow Coat						2				
Snow Roads				98	98					252

APPENDIX TABLE 2 . Summary of the morphometric characteristics of the lakes surveyed, Water Availability Study, 1975. Volumes are imperial barrels x 1000.

Location/Milepost	Average Depth (m)	Surface Area (m^2 x 1000)	Total Volume	Free[illegible] with 0.[illegible] ice	Freewater Volume with 1.5 m of ice
3 mi E MP 2	1.25	1,164	8,892	[illegible]	0
1 mi E MP 3	1.8	1,265	13,908	[illegible]	2,318
3.5 mi S MP 5	2.0	2,409	29,435	[illegible]	7,359
1 mi S MP 12	1.5	2,489	22,812	[illegible]	0
1 mi N MP 13	1.85	1,867	21,101	[illegible]	3,992
2 mi S MP 16.5	1.4	803	6,868	[illegible]	0
1 mi S MP 22	1.9	642	7,457	[illegible]	1,570
3 mi S MP 24	1.7	1,485	15,429	[illegible]	1,815
1 mi S MP 26	2.1	522	6,697	[illegible]	1,913
3 mi S MP 26	1.6	1,224	11,970	[illegible]	748
2 mi N MP 32	1.8	1,465	16,116	[illegible]	2,686
2 mi N MP 33	0.6	201	736	[illegible]	0
2 mi N MP 33	0.8	442	2,159	[illegible]	0
2 mi N MP 34	1.25	1,445	11,038	[illegible]	0
2 mi S MP 34	0.5	682	2,085	[illegible]	0
1 mi S MP 39	2.0	301	3,679	[illegible]	920
2 mi N MP 47	1.9	361	4,195	[illegible]	883
0.5 mi N MP 51	2.4	321	4,710	[illegible]	1,766

(Contin[illegible]

APPENDIX TABLE 2. Continued.

Location/Milepost	Average Depth (m)	Surface Area (m^2 x 1000)	Total Volume	Freewater Volume with 0.75 m of ice	Freewater Volume with 1.5 m of ice
1.5 mi S MP 53	1.6	321	3,140	1,707	196
1.5 mi S MP 62	2.8	381	6,525	[illegible]	3,029
1.5 mi S MP 63	2.5	482	7,359	[illegible]	2,943
4 mi N MP 131	1.6	763	7,457	[illegible]	466
2 mi N MP 192	2.7	1,204	19,869	[illegible]	8,831
2 mi N MP 193	2.8	521	8,928	[illegible]	4,145
4 mi N MP 193	2.3	2,369	33,286	[illegible]	11,578
2 mi N MP 215	2.8	550	9,410	[illegible]	4,369
2 mi S MP 231	4.3	125	3,284	[illegible]	2,139
2 mi S MP 231	13.6	50	4,155	[illegible]	3,696
1 mi N MP 233	1.8	175	1,924	[illegible]	321
1 mi N MP 240	2.9	687	12,182	[illegible]	5,881
0.5 mi N MP 242	2.3	250	3,513	[illegible]	1,222
1 mi N MP 242.5	2.2	300	4,033	[illegible]	1,283
1 mi E MP 250	2.7	150	2,474	[illegible]	1,100
2 mi N MP 252	2.2	500	6,721	[illegible]	2,139
5 mi N MP 255	2.3	2,500	42,800	[illegible]	19,925
1 mi N MP 259	2.4	487	7,149	[illegible]	2,680

(Continued)

APPENDIX TABLE 2. Continued.

Location/Milepost	Average Depth (m)	Surface Area (m^2 x 1000)	Total Volume	Free[illegible] with [illegible]	Freewater Volume with 1.5 m of ice
3.5 mi N MP 264	2.4	2,050	30,062	[illegible]	11,273
2 mi S MP 272	3.1	4,012	76,004	[illegible]	39,228
2 mi S MP 274	1.3	1,675	13,305	[illegible]	0
2 mi N MP 281	2.1	1,200	15,397	[illegible]	4,399
1 mi N MP 289	4.0	275	6,721	[illegible]	4,201
1.5 mi E MP 290	2.8	113	1,925	[illegible]	894
8 mi N MP 298	1.9	750	8,707	[illegible]	1,833
9 mi N MP 304	1.1	2,275	15,290	[illegible]	0
3 mi N MP 305	2.5	2,575	39,334	[illegible]	15,733
6.5 mi N MP 309	2.6	775	12,312	[illegible]	5,209
1 mi N MP 309	1.6	750	7,332	[illegible]	458
4 mi N MP 315	2.3	400	5,621	[illegible]	1,955
3 mi N MP 317.5	2.1	437	5,613	[illegible]	1,609
0.5 mi S MP 318	2.0	550	6,721	[illegible]	1,680
0.5 mi N MP 321	2.3	250	3,513	[illegible]	1,222

APPENDIX TABLE 5. Depths, velocities, and discharges of the springs surveyed, Water Availability Study 1975.

Name/Milepost	Mean Depth (m)	Mean Velocity (m/sec)	Di[illegible]	Discharge cfs	Daily Discharge Imp.Bbl.x1000
Katakturuk W. Fork	0.12	0.44	[illegible]	8.50	-
5 mi. S. M.P.86.5	0.06	0.05	[illegible]	0.45	-
(4 channels)	0.05	0.08	[illegible]	0.39	181
	0.10	0.15	[illegible]	2.75	-
Katakturuk E. Fork	0.13	0.23	[illegible]	7.67	-
5 mi. S. M.P. 87	0.09	0.21	[illegible]	3.91	173
(2 channels)					
Sadlerochit R.	0.25	0.46	[illegible]	43.20	645
7 mi. S. M.P. 111					
Hula Hula R.	0.13	0.14	[illegible]	4.83	153
1 mi. N. M.P. 116.5	0.17	0.20	[illegible]	5.43	-
(2 channels)					
Okpilik (Hot Sps.)	0.03	0.10	[illegible]	0.27	4
Okerokovik R.	0.03	0.09	[illegible]	0.31	-
@ M.P. 138	0.06	0.11	[illegible]	1.25	-
(4 channels)	0.04	0.13	[illegible]	0.75	-
	0.05	0.13	[illegible]	1.04	50
Ekaluakat R.	0.13	0.34	[illegible]	22.40	432
5 mi. S. M.P. 162					
Kongakut Delta	0.31	0.36	[illegible]	73.59	-
6 mi. N. M.P. 173	0.06	0.40	[illegible]	7.87	-
(4 channels)	0.04	0.17	[illegible]	2.56	1558
	0.12	0.27	[illegible]	20.22	-

(Continued)

APPENDIX TABLE 3. Continued.

Name/Milepost	Mean Depth (m)	Mean Velocity (m/sec)	Discharge [illegible]	Discharge cfs	Daily Discharge Imp.Bbl.x1000
Kongakut R. 6 mi. S. M.P. 174	0.12	0.30	[illegible]	18.8	281
Clarence R.	0.10	0.21	[illegible]	2.48	37
Craig Cr. 3 mi. S. M.P. 197	0.11	0.28	[illegible]	3.37	50
Craig Cr. Trib. 2 mi. S. M.P. 198 (10 channels)	0.10	0.27	[illegible]	6.95	-
	0.04	0.10	[illegible]	0.44	-
	0.04	0.10	[illegible]	0.44	-
	0.04	0.10	[illegible]	0.44	-
	0.04	0.10	[illegible]	0.44	-
	0.04	0.10	[illegible]	0.44	-
	0.04	0.10	[illegible]	0.44	-
	0.04	0.10	[illegible]	0.44	-
	0.05	0.15	[illegible]	0.81	-
	0.045	0.12	[illegible]	0.84	175
Fish Cr. 2 mi. N. M.P. 217.5	0.12	0.21	[illegible]	3.42	-
	0.15	0.61	[illegible]	12.35	236
Malcolm R. 2 mi. N. M.P. 225	0.19	0.44	[illegible]	22.91	342
Firth 2 Spring 2.2 mi. N. M.P. 227	0.15	0.40	[illegible]	26.78	400

(Continued)

APPENDIX TABLE 3. Continued.

Name/Milepost	Mean Depth (m)	Mean Velocity (m/sec)	Discharge m^3/sec	Discharge cfs	Daily Discharge Imp.Bbl.x1000
Firth Delta 2 mi. N. M.P. 233	0.15	0.40	1.6[illegible]	58.04	868
Spring R. 2 mi. N. M.P. 256	0.17	0.22	0.[illegible]7	6.07	91
Crow R. 2 mi. N. M.P. 268	0.26	0.17	[illegible]	9.03	135

APPENDIX TABLE 4. Summary of water availability information from joint U.S.G.S./Alaskan Arctic Gas hydrological survey. November, 1975.

Location/Milepost	Ice Thickness (m)	Water Depth (m)	Specific Conductivity (µmhos)	[illegible]	Discharge (cfs)	Date November
Sagavanirktok River, W Channel 3 mi S PLC	0.73	0.88	400		0-5	11
Sagavanirktok River, E Channel	0.67	0.06	460		0	11
Lake 1 mi S MP 12	0.67	0.49	620		-	10
Lake 1 mi N MP 13	0.46	1.20	600		-	8
Lake 3 mi S MP 26	0.63	0.67	510		-	10
Kadleroshilik River, @ PLC	0.46	0	-		-	10
Lake 2 mi N MP 22	0.76	0.76	990		-	10
Shaviovik River, @ PLC	0.76	0.58	340		12.2	7
Kavik River, 2 mi S MP 37	0.82	0.18	390		0-1	9
Canning River, L mi S MP 61	0.70	0.61	320		228	8
Canning River Delta	1.50	0	-		0	30
Lake 13 mi N MP 82	1.10	1.06	220		-	30
Sadlerochit Springs	0	0.15	360		38.7	16
Hula Hula Springs	0	0.21	225		4.6	26
Hula Hula River, near mouth	0.76	0	-		0	22
Lake 24 mi N MP 126	0.98	0.92	520		-	25
Lake 20 mi N MP 124	1.09	0.79	115		-	22

APPENDIX TABLE 4. Continued.

Location/Milepost	Ice Thickness (m)	Water Depth (m)	Specific Conductivity (µmhos)	[illegible]	Discharge (cfs)	Date November
Okerokovik River, @ PLC	0	0.06	300	0	2.6	24
Lake 1 mi E Jago, 4 mi from coast	0.82	1.5	80	1	-	17
Lake 3 mi E Jago, 1 mi from coast	0.85	2.2	280	0	-	17
Aichilik River, 1 mi S PLC	1.2	0.1	370	[illegible]	0-0.25	25
Aichilik River, near mouth	1.09	0	-		0	23
Egaksrak River, 1 mi S PLC	0.92	0	-		0	24
Egaksrak River, near mouth	1.07	2.06	560	[illegible]	0-25	23
Ekaluakat River, 2 mi N PLC	0.92	0	-		0	24
Lake, Aichilik Delta	1.04	2.2	600		-	24
Kongakut Delta Springs	0	0.27	210		88.4	18
Lake near Demarcation Point	0.85	1.3	410	[illegible]	-	18
Clarence River Springs	0	0.09	250	[illegible]	4.7	18

APPENDIX TABLE 5. Summary of fisheries information for the potential water sources surveyed along the pipeline route.

Location	Milepost	Information* Sources	Fish Species Present **							
			None	NNST	CHAR	GRAY	LKWT	BDWT	LSCO	POND
Lake 3 mi. E	2.0	1	+							
Lake 1 mi. E	3.0	1	+							
Lake 3.5 mi. S	5.0	No Data								
Lake 1 mi. S	12.0	1	+							
Lake 1 mi. N	16.0	1	+							
Lake 2 mi. S	16.5	1	+							
Lake 1 mi. S	22.0	1	+							
Lake 3 mi. S	24.0	1	+							
Lake 1 mi. S	26.0	1	+							
Lake 3 mi. S	26.0	1	+	+						
Lake 2 mi. N	32.0	1	+							
Lake 2 mi. N	33.0	No Data								
Lake 2 mi. N	33.0	No Data								
Lake 2 mi. N	34.0	1	+							
Lake 2 mi. S	34.0	No Data								
Lake 1 mi. S	39.0	1	+							
Lake 2 mi. N	47.0	1	+							
Lake 0.5 mi. N	51.0	1		+						
Lake 1.5 mi. S	53.0	1	+							
Lake 1.5 mi. S	62.0	1		+						
Lake 1.5 mi. S	63.0	1								

(Continued)

APPENDIX TABLE 5. Continued.

Location	Milepost	Information* Sources	Fish Species Present **							
			None	NNST	CHAR	GRAY	[illegible]	BDWT	LSCO	POND
Katakturuk Sps. 5 mi. S	87.0	1,2	+							
Sadlerochit Sps. 7 mi. S	111.0	1,2								
Hula Hula Sps. 1 mi. N	116.5	1,2								
Okpilik Hot Sps. 30 mi. S	120.0	1								
Lake 4 mi. N	131.0									
Okerokovik Sps. @	138.0	1,2	+							
Ekaluakat Sps. 5 mi. S	162.0	1,2								
Kongakut Delta Spr. 7 mi. N	174.0	1,2			+					
Kongakut R. Sps. 6 mi. S	174.0	1,2			+					
Clarence R. Sps. 5 mi. S	190.0	1,2								
Lake 2 mi. N	192.0	1		+						
Lake 2 mi. N	193.0	1		+						
Lake 4 mi. N	193.0	1		+						
Craig Cr. Sps. 3 mi. S	197.0	1,3	+							

(Continued)

APPENDIX TABLE 5. Continued.

Location	Milepost	Information* Sources	Fish Species Present**							
			None	NNST	CHAR	[illegible]	LKWT	BDWT	LSCO	POND
Craig Cr. Trib. Sps. 2 mi. S	198.0	1,3	+							
Lake 2 mi. N	215.0	1		+						
Fish Cr. Sps. 2 mi. N	217.5	1,3								
Malcolm R. Sps. 2 mi. N	225.0	1,3								
Firth Spr. 2 1 mi. N	228.0	1,3								
Lake 103 2 mi. S	231.0	3		+						
Lake 104 2 mi. S	231.0	3		+						
Lake 1 mi. N	233.0	No Data								
Firth R. Delta Sps. 2 mi. N	233.0	1,3								
Lake 1 mi. N	240.0	3	+							
Lake @	242.0	No Data								
Lake 1 mi. N	242.5	No Data								
Lake 1 mi. E	250.0	No Data								
Lake 100 5 mi. N	255.0	3,4		+			+	+		+
Lake 109 2 mi. N	252.0	3					+	+		+
Spring R. Sps. 2 mi. N	256.0	1,3	+							

(Continued)

APPENDIX TABLE 5. Continued.

Location	Milepost	Information* Sources	Fish Species Present**							
			None	NNST	[illegible]	[illegible]	LKWT	BDWT	LSCO	POND
Lake 1 mi. N	259.0	No Data								
Bloomfield 3.5 mi. N	264.0	3	+							
Crow R. Sps. 2 mi. N	268.0	1,3	+							
Lake 101 2 mi. S	272.0	1,3						+	+	
Lake 2 mi. S	274.0	1	+							
Lake 2 mi. N	281.0	1	+							
Lake 1 mi. N	290.0									
Lake 1.5 mi. E	290.0	1		+						
Lake 8 mi. N	298.0	1	+							
Peat Lake 9 mi. N	304.0	1		+						
Lake 3 mi. N	305.0	1		+						
Lake 6.5 mi. N	309.0	1		+			+			
Lake 1 mi. N	309.0	1	+							
Lake 4 mi. N	315.0	1	+							
Lake 3 mi. N	317.5	1	+							
Lake 0.5 mi. S	318.0	5								
Lake 0.5 mi. N	321.0	1		+						

*Information Sources CODE - 1=Water Availability Study 1975

(Continued)

APPENDIX TABLE 5. Continued.

*Information Sources CODE - 2=Ward and Craig, 1974
3=McCart *et al.*, 1974
4=deGraaf, 1974
5=Steigenberger *et al.*, 1975

**Fish Species CODE - None= No fish present
NNST= ninespine stickleback
CHAR= Arctic char
GRAY= Arctic grayling
LKWT= lake whitefish
BDWT= broad whitefish
LSCO= least cisco
POND= pond smelt

PLATE 1. An orifice of Okerokovik Spring. This spring is uninhabited by fish, but aquatic vegetation and invertebrates are abundant.

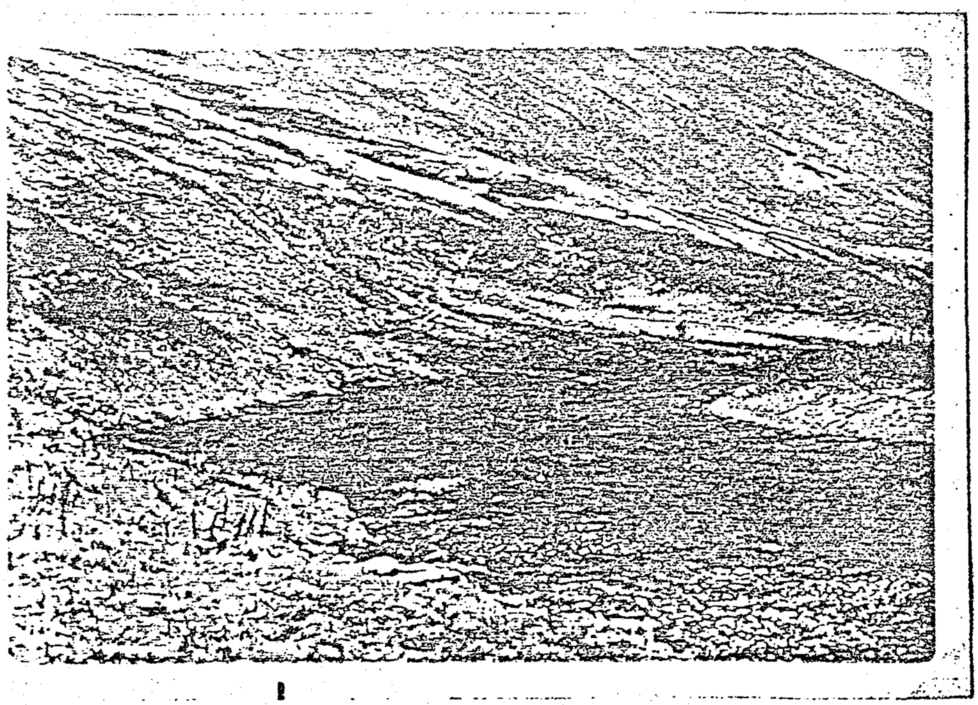


PLATE 2. The main orifice of Sadlerochit Spring. This large spring is densely populated by stream-resident Arctic char and also used by overwintering populations of juvenile grayling.

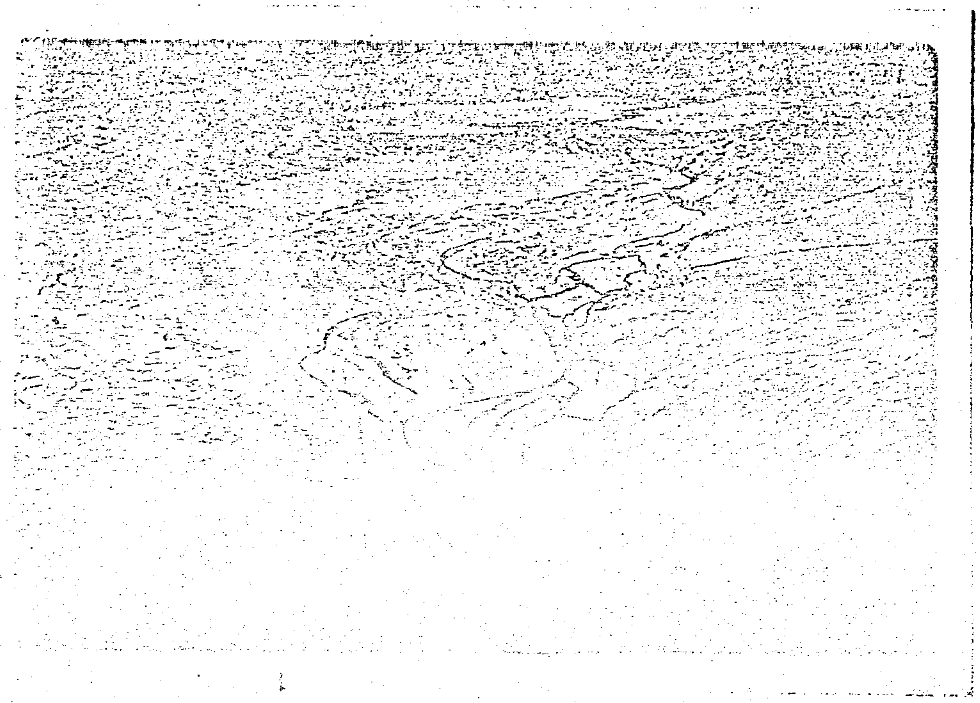


PLATE 3. The Ekaluakat Springs and *aufeis*. This spring is utilized by spawning and overwintering anadromous Arctic char. If developed as a water source, withdrawal should be from a point near the *aufeis*.

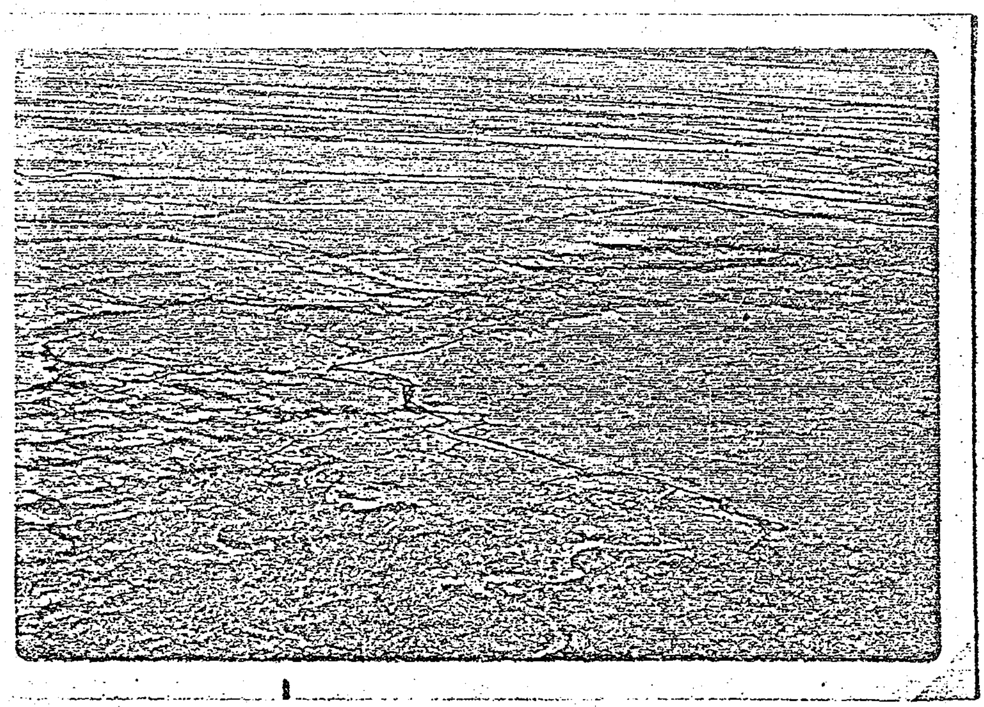


PLATE 4. Springs between Malcolm and Firth rivers. The entire open water channel is heavily utilized for spawning by anadromous Arctic char. This spring is not recommended as a water source for pipeline construction.

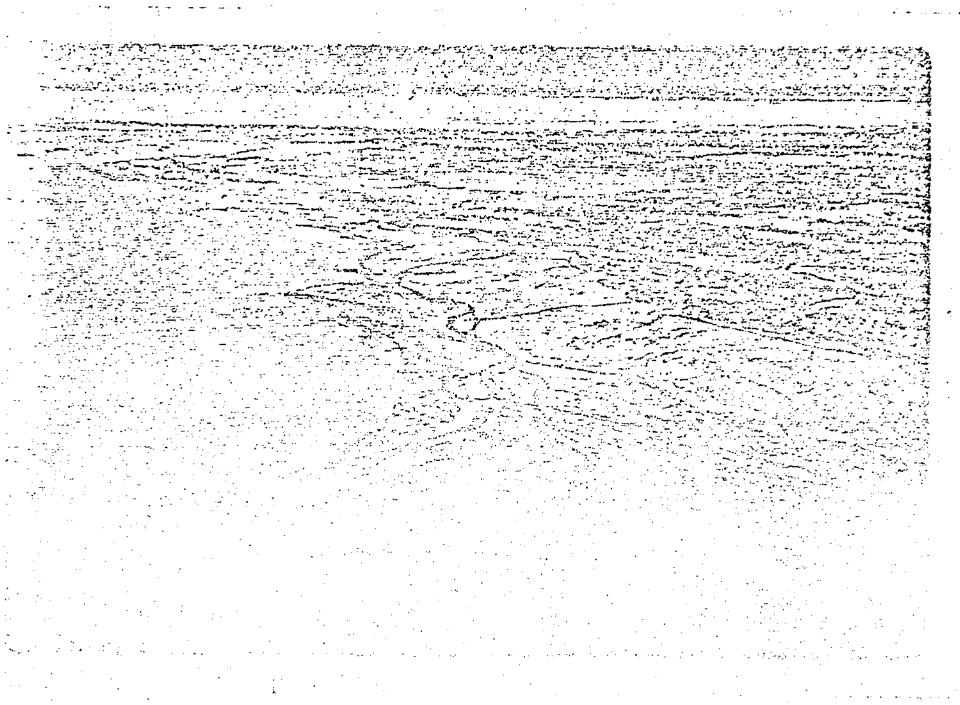


PLATE 5. Firth River Delta Springs and *aufeis*. This large groundwater source is not heavily utilized by fish.

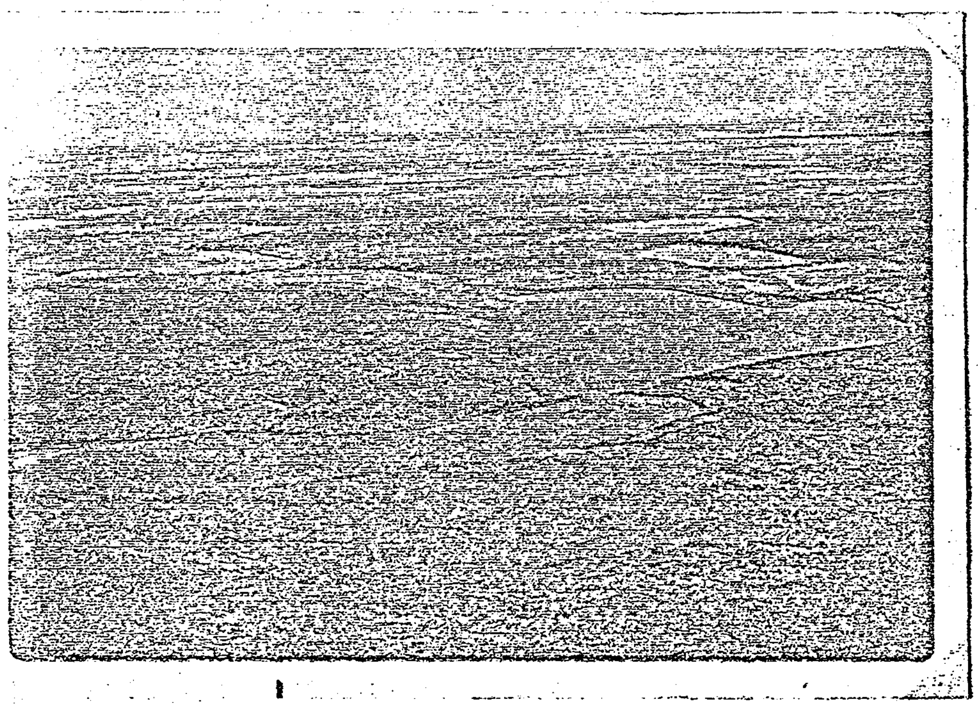


PLATE 6. Lake in rolling uplands near Milepost 290. This lake is 4 m deep and inhabited by grayling in the summer. May also be used for overwintering.