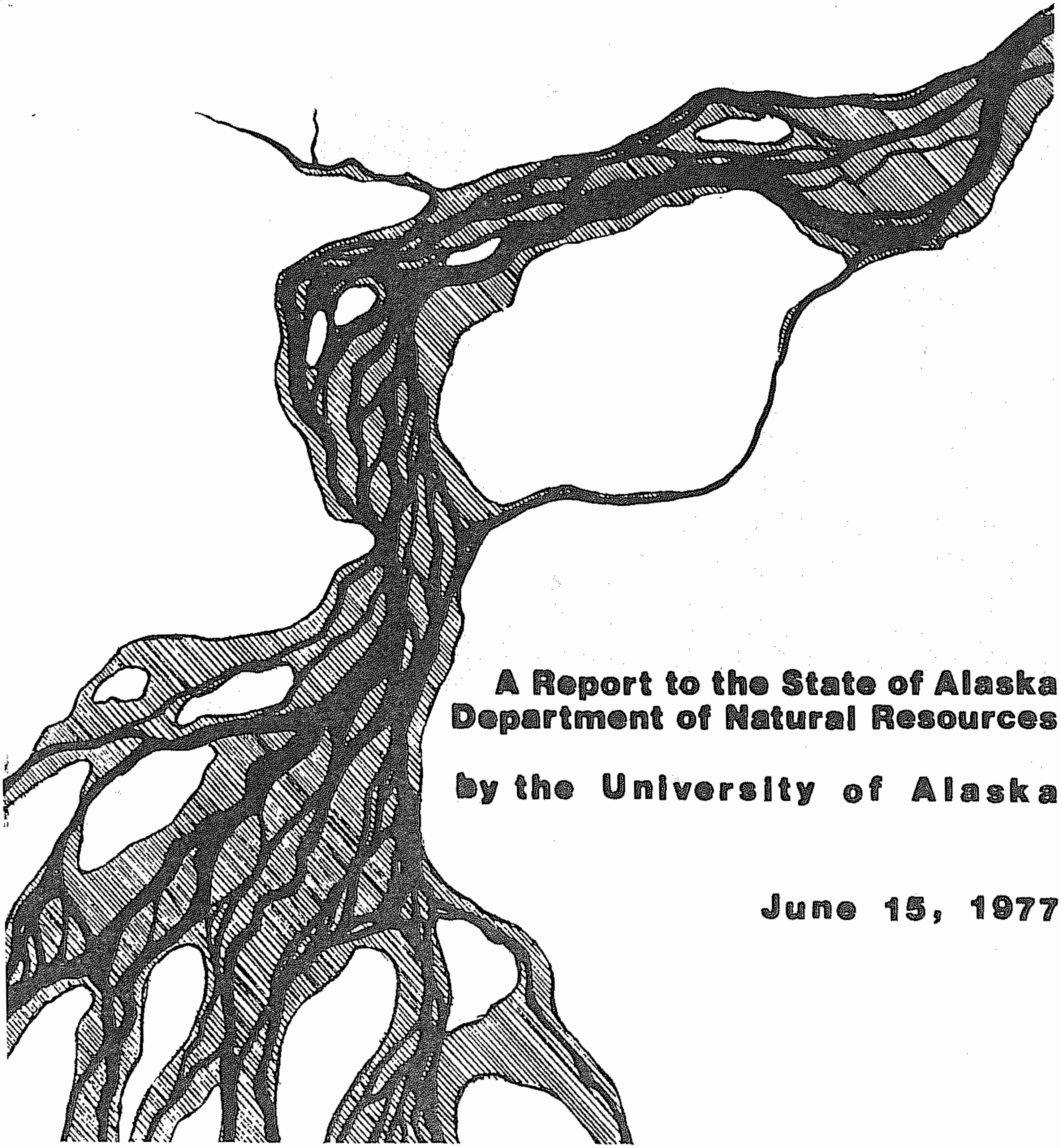
NORTH SLOPE BOROUGH WATER STUDY

A Background for Planning



A Report to the State of Alaska Department of Natural Resources

by the University of Alaska

June 15, 1977

NORTH SLOPE BOROUGH
WATER STUDY
A Background for Planning

North Slope Borough Water Study: A Background for Planning
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Prepared for

Alaska Department of Natural Resources
Planning and Research Section

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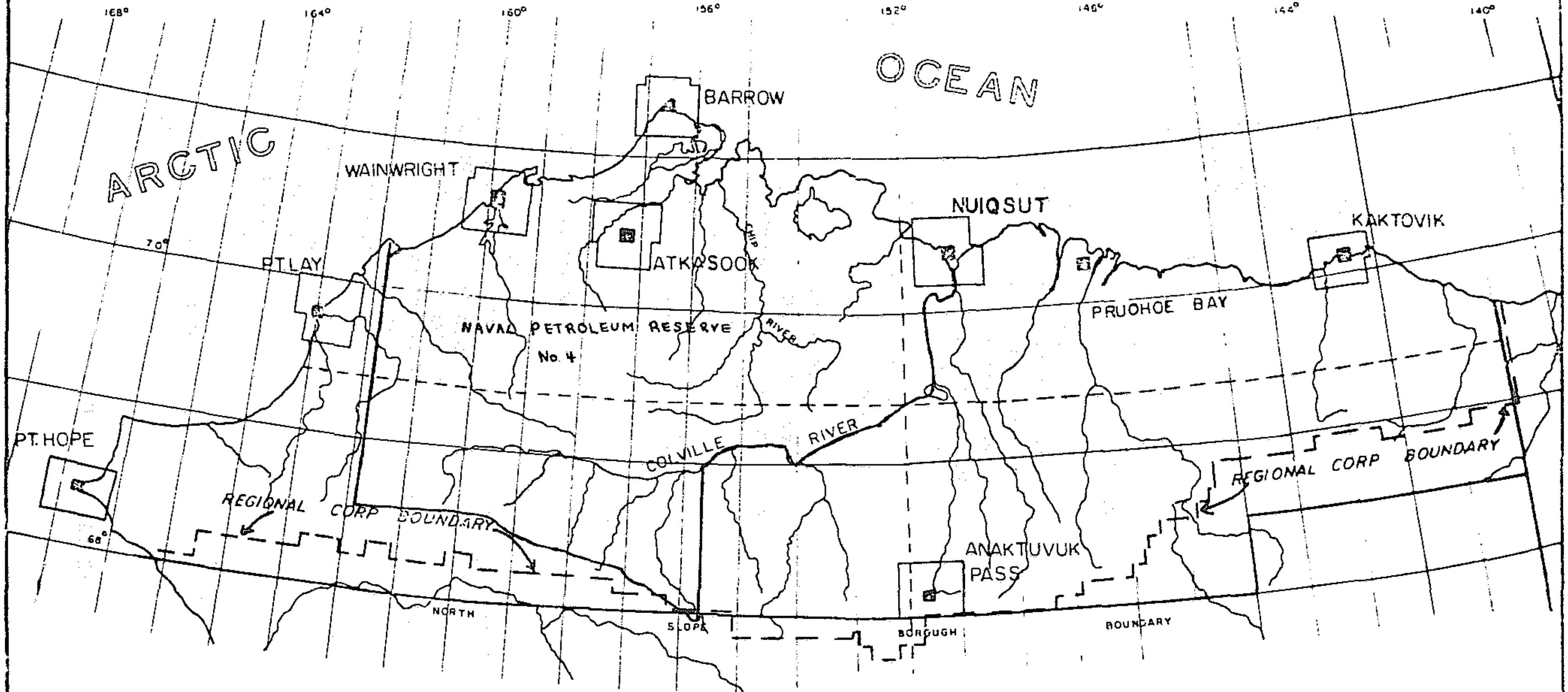

SCALE = 1" = 65 MILES

NORTH SLOPE BOROUGH
AND
ARCTIC SLOPE REGIONAL CORPORATION BOUNDARIES

Dupere and Associates, 1973, p. 36.

NORTH SLOPE BOROUGH WATER STUDY

INTRODUCTION

The Planning and Research Section of Alaska Dept. of Natural Resources initiated this pilot water study with the North Slope Borough and the University of Alaska's Arctic Environmental Information and Data Center and Institute of Water Resources. Traditional and present water uses in the eight North Slope Borough villages are examined to assist in evaluating and planning for present and future water use, treatment, and disposal requirements.

The physical, biological, and man-made resources of the arctic region have been compiled in three major works - the Environmental Atlas of Alaska (Johnson and Hartman 1969), the Alaska Regional Profiles; Arctic Region (Alaska. University. Arctic Environmental Information and Data Center 1975), and the North Slope Borough Reconnaissance Study; An Inventory of the Borough and Its Communities (Dupere and Associates 1973). The general bibliography contains references that apply to the entire region. Specific village studies are listed in the bibliography under each village.

Information on the location, physical setting, and traditional and present land use for each village is summarized from the Alaska Regional Profiles, the North Slope Borough Reconnaissance Study, and the Alaska Community Survey (Alaska Planning and management 1972). Information on village water supply, use and treatment was supplemented by an on-site visit at each village during August 1976.

ANAKTUVUK PASS

A. LOCATION AND SETTING

The village of Anaktuvuk Pass is located between the headwaters of the John and Anaktuvuk Rivers at an elevation of 2,200 feet on the continental divide of the Brooks Range. It is 223 air miles north of Fairbanks, 90 miles north of Bettles, and 293 miles southeast of Barrow.

Precipitation averages about 11 inches annually, including 63 inches of snow. Mean monthly temperatures range from minus 22 degrees F in winter to 61 degrees F in summer. Extremes of minus 56 degrees F and 91 degrees F have been recorded. For two months in summer, the sun never drops completely below the horizon and never rises above it for two months in winter. The channeling effect of the two-mile-wide pass causes frequent winds. Permafrost is continuous except in areas adjacent to rivers. Several small ponds are present in the tundra valley, which supports grasses, brush, willow, and forbes. In summer the active layer may extend three to four feet below the surface.

B. TRADITIONAL AND PRESENT LAND USE

Anaktuvuk Pass evolved into a permanent settlement between 1949 and 1960 as caribou populations began to rise after a disastrous drop in their numbers during the late 1920s. Large migrations of caribou passed near the village, and this attracted families of Nunamiut Eskimo (literally, people of the land or inland Eskimos) who moved from dwellings along the Killik River and near Chandler Lake to Tulugak Lake and finally to the present village site at the summit of the pass. This location also allowed the Nunamiut to range into other historic use areas along the Killik and Chandler Rivers, Ernie Pass, the north fork of the Koyukuk, the Itkillik and John Rivers, and around the Hunt Fork and Publituk Creek areas to hunt, trap, and fish. Anaktuvuk subsistence land use still includes these regions.

At first, most of the people's needs could be met by the land. A small amount of cash income was derived from furs and, since 1959, the sale of caribou face masks. However, in 1962 a critical shortage of wood near the village required residents to order fuel oil for home heating for the first time, and as the community developed to include a store, church, and school, more modern services were required. Additionally, the caribou herds have gone into another cyclical decline, increasing the dependence on a cash economy. Fire fighting, construction, and the implementation of the Alaska Native Claims Settlement Act (ANCSA) provide some income. The community life-style now combines the subsistence way of life with the conveniences (and costs) of electricity, snowmobiles, and air travel.

The village corporation selected lands along the John and Anaktuvuk Rivers and tributaries, which are important for travel and subsistence activities. The regional corporation selected much of the remainder of the lands within the village withdrawal area except the high mountain peaks. Legislation which would make the surrounding area a national park is now before the Congress.

C. PRESENT WATER SUPPLY AND USE

1. Present Supply

In 1971 the U.S. Geological Survey conducted a hydrologic reconnaissance of surface and groundwaters to help develop a water supply for the village school. Based on their recommendations, in 1974 the U.S. Public Health Service drilled a well in Contact Creek to test the availability of groundwater. Although boulders were encountered, they determined that flow was sufficient for village use (Figure 1). They drilled a 72-foot well in the center of the village downhill from the school which produces 30 gallons per minute with no drawdown. The North Slope Borough supplied a generator for the pump house. Villagers use the well as long as the piping system stays thawed; otherwise they obtain ice from Eleanor Lake, one-half mile northeast of the village. One resident stores ice in an ice celler and melts it for drinking water during summer.

Before the well and pump system were built, residents hauled water from Contact Creek from mid-June to late August. If Contract Creek went dry, water was carried from springs near the south end of the airstrip or from Eleanor Lake (Sloan 1972). Residents melted snow and ice from Eleanor Lake in winter.

2. Water Quality

In 1974 the U.S. Geological Survey tested the chemical quality of water from the well, which met the 1962 U.S. Public Health Service recommended drinking water standards (Figure 2). The creek

Figure 1

Anaktuvuk Pass - Well Logs

Well No. 1 U.S. Public Health Service, Contact Creek, Anaktuvuk Pass

Material	Thickness (ft.)	Depth (ft.)
Sand and gravel	10	10
Sand and gravel	20	30
Sand and gravel	20	50
Sand and gravel	15	65
Sand and gravel	6	71

Static water level 14 ft. - Driller reports show of water at 30 ft.

Well No. 2 U.S. Public Health Service, Anaktuvuk Pass

Material	Thickness	Depth
Gravel - frozen	15	15
Sand and gravel	10	25
Silt and sand	40	65
Sand and gravel	7	72

Static water level 50 ft. - Screen set from 68 ft. to 72 ft.

Source: U.S. Geological Survey, Water Resources Division, Anchorage.

Figure 2

Anaktuvuk Pass - Chemical Data

Parameter	Eleanor Lake (2/10/61)	Contact Creek (8/6/61)	Small Lake (6/17/71)	Well (5/2/74)
Color (platinum cobalt units)	5	10	10	2
Conductivity (micromhos)	9	122	145	177
pH	6.8	7.9	7.4	7.7
Calcium (mg/l)	1	17	25	28
Iron (mg/l)	0.05	0.5	0.00	0.04
Magnesium (mg/l)	1	8	3.9	3.8
Potassium (mg/l)	-	-	0.2	0.3
Sodium (mg/l)	1	1	0.1	0.2
Bicarbonate (mg/l)	-	-	91	97
Chloride (mg/l)	1	1	0.8	0.7
Fluoride (mg/l)	0.1	0.1	0.0	0.0
Nitrate (mg/l)	1	1	0.4	0.57
Sulfate (mg/l)	-	-	0.2	5.8
Total Hardness (mg/l)	4	78	77	86
Total Dissolved Solids (mg/l)	20	88	78	92

Source: Arnow, G.M. and G.L. Hubbs, 1962, p. 21.
Sloan, C.E., 1972, p. 9.
U.S. Geological Survey, Water Resources Division, Anchorage.

water is clear and has an excellent taste. The inorganic chemical quality of Eleanor Lake and Contact Creek (sampled in 1961) and a small lake at the south edge of the village (sampled in 1971) also met the recommended standards. The total dissolved solids content of all three sources was less than 100 mg/1.

By 1971 the surface waters in Anaktuvuk Pass and other communities were reported to be subject to bacterial contamination (Sloan 1972), and this was a major reason for developing a groundwater source. Since outhouses were used in the village in the past, and pathogens may still be present in the ground, the well water is chlorinated on a batch basis. Chlorine imparts a distasteful flavor according to some villagers, and a few of them still water directly from the creek. According to villager James Tobuk, some oil seeped into Contact Creek below the old school. Since he does not like the taste of chlorine in the well water and does not think the well is sealed properly (only sand and gravel around it), he obtains water from the creek above the school.

Six out of seven bacteriological samples analyzed by the Alaska Department of Health and Social Services (1976) showed a total coliform count of 0/100 ml (Figure 3). The seventh, taken from the school kitchen, indicated 20/100 ml. Although these data indicate the bacteriological quality to be good, they could be inconclusive because of the infrequency of sampling and analysis.

Figure 3

Anaktuvuk Pass - Bacteriological Data

Date	Total Coliform/100 ml. Water	Source
3/3/70	0/100 ml. Many non-coliform	Melted Ice at School
2/4/75	0/100 ml.	Pumphouse
12/16/75	0/100 ml.	School Kitchen
2/10/75	0/100 ml. Many non-coliform	School Kitchen
4/1/75	20/100/ ml.	School Kitchen
6/1/76	0/100 ml.	Public Water Well
6/23/76	0/100 ml.	Public Water Well

Source: Alaska Dept. of Health and Social Services, Fairbanks.

3. Present Demands

Since individual homes do not have water piped to or within them, consumption is a low two gallons per person per day. The storage tank next to the pump house holds about 250 gallons--enough to supply the 150 residents for less than one day if the pump fails. The two-story borough bunkhouse and the temporary school are the only two buildings in town with internally piped water.

D. PRESENT WASTE DISPOSAL

There is no piped sewage system. Honey buckets are used exclusively to dispose of fecal matter. A truck hauls these and other wastes to a dump located about one-half mile east of town on the opposite side of the airstrip. An inspection in August 1976 noted no detectable odor at the dump, but chemical additives could be leaching from the dump into the stream without causing odors. The existing village water supply, however, appears safe from contamination by the dump. Maintaining the road is important for continued use of the dump.

E. EVALUATION OF WATER SUPPLY AND WASTE DISPOSAL

1. Adequacy of Available Information

Well logs, chemical quality data, and bacteriological data are available for the community well. Chemical quality data are available for Contact Creek and Eleanor Lake. Surficial geology and soils have been surveyed, and snow survey data are published annually. No detailed studies have been done on alternate water sources, but aerial photos of winter icings indicate potential groundwater availability beneath creek beds in the area (Sloan 1972).

2. Problems and Limitations

Villagers are generally pleased with the well water, but they would like a system that does not freeze in the winter. Joe Mekiana said the well pump house still worked at least 50 percent of the time using electrical heat tape.

Residents recognize the need to plan for future increased water demand and a distribution system. The people we talked to who gathered at Zaccharias Hugo's house appreciated the need to know the costs and other details of various system improvements so they could decide what they wanted for themselves as well as for any facilities needed for future national park or tourist accommodations.

3. Future Growth and Management Recommendations

Water quantities from the well and Contact Creek are sufficient to supply the community at its current population of 150. Any sudden or major increase in demand, however, might require further development. Two potential water sources were identified during the 1971 U.S. Geological Survey reconnaissance--Eleanor Lake, with a depth of 45 feet and a surface area of 30 acres, and a small lake at the southwest edge of the village. The distance of Eleanor Lake from the school makes the cost of using it as a water supply for the village expensive. It would be more economical to construct an all-weather road to Eleanor Lake and haul water to heated storage tanks at the school rather than to build a heated pipeline. Eleanor

Lake is occasionally used by float planes. The effect on water quality would have to be monitored. The small lake nearer the village is subject to bacteriological contamination, and the dissolved solids may become too concentrated in water beneath the ice in winter to be potable without treatment. Potential groundwater sources would have to be verified by drilling, and boulders in the gravels may hamper drilling operations. At present, the North Slope Borough is investigating the feasibility of drilling an additional well in the village for the school. The usual problem of how to dispose of wastes in permanently frozen ground also exists.

Outside capital will be needed if the villagers decide to construct, maintain, and operate improved water, sewer, and other facilities. Except for some North Slope Borough capital improvement construction work, which has been stopped because of oil company litigation over the tax limit, only a few sources of cash income are available in the village. Their economic condition is further aggravated by the poor caribou yield lately. Any new facilities should be carefully planned to meet the real needs of the community at a cost they can afford to pay.

ATKASOOK

A. LOCATION AND SETTING

Atkasook is on the west bank of the Meade River near Ikmakrak Lake, 58 miles south of Barrow. It is being more fully developed as a permanent community under the sponsorship of the Arctic Slope Regional Corporation and the North Slope Borough. Residents are living in tents but construction of the village has started.

Precipitation averages about five inches annually, including about 20 inches of snow. Mean monthly temperatures range from about minus 30 degrees F in winter to 60 degrees F in summer. From May to July the sun never drops completely below the horizon and from mid-November to mid-January never rises completely above it. High winds are common. The flat, marshy terrain is underlain by continuous permafrost except for small areas adjacent to the Meade River and larger lakes.

B. TRADITIONAL AND PRESENT LAND USE

The Meade River area has traditionally been used for subsistence hunting and fishing. Seasonal use is fairly high, but permanent occupancy has been just sufficient to qualify Atkasook as a village under the Alaska Native Claims Settlement Act (ANCSA). Ataksook had a post office from 1951 to 1957 under the name of Meade River. A test well for oil and natural gas was drilled here in August 1950, but only traces of either were found. A subbituminous coal mine in the area supplied Barrow with fuel for a short time but it is no longer in operation.

The village corporation selected land along the Meade River and its tributaries; however, since the village is within the boundaries of Naval Petroleum Reserve No. 4, regional selections have not been made and the regional corporation does not hold title to the subsurface estate of village lands. Instead, the regional corporation has made in-lieu selections outside the petroleum reserve.

C. PRESENT WATER SUPPLY AND USE

1. Present Supply

Villagers report three present sources of water: Ikmakrak Lake, the Meade River, which is used when the lake is turbid, and a small stream that flows parallel to the present airstrip. In winter, ice is cut from Ikmakrak Lake and thawed.

2. Water Quality

The river water tasted fine in August 1976 but was slightly yellow. Resident Walter Akpik said the water under the river ice in winter has a reddish cast. These colors may be caused by the presence of iron and humus. Ikmakrak Lake was turbid on the day of our visit because of winds from the west. Residents do not collect lake water on windy days, but they said it is crystal clear on calm days. The stream near the airstrip was clear. No bacteriological data and limited chemical data have been reported (Figure 4).

3. Present Demands

Residents use between one and two gallons of water per person per day for cooking, drinking, and washing.

Figure 4

Atkasook - Chemical Data

Parameter	Meade River (4/18/76)
Color (platinum cobalt units)	-
Conductivity	450
pH	7.3
Calcium (mg/l)	-
Iron (mg/l)	-
Magnesium (mg/l)	-
Potassium (mg/l)	1.9
Sodium (mg/l)	6.8
Bicarbonate (mg/l)	226
Chloride (mg/l)	9.8
Fluoride (mg/l)	.1
Nitrate (mg/l)	.53
Sulfate (mg/l)	1.7
Total Hardness (mg/l)	222
Total Dissolved Solids (mg/l)	-

Source: U.S. Geological Survey, Water Resources Division, Anchorage

D. PRESENT WASTE DISPOSAL

A privy located about 100 feet uphill from Ikmakrak Lake in the new village serves the residents and some construction workers. The danger of seepage from the privy to the lake, the village's primary water source is apparent. Honey buckets are also used. The old dump is located about one-half mile south of the new village and is not close to any water sources except the stream by the airstrip. The new dump is downstream from the townsite beyond Kigakrak Lake, the proposed sewage lagoon.

E. EVALUATION OF WATER SUPPLY AND WASTE DISPOSAL

1. Adequacy of Available Information

Information on the water supply at Atkasook is limited. Water sampling of Ikmakrak Lake by the U.S. Geological Survey in January 1976 was limited as most of the lake was frozen. Studies of water availability and quality in the lake should be conducted in summer before a water supply system is developed. The flow of water between Ikmakrak Lake and any adjacent land area or water body that might be used for solid or liquid waste disposal should be tested.

2. Problems and Limitations

As the village will continue to utilize three current sources of water for the foreseeable future, it is imperative that their quality be protected. Ikmakrak Lake is in the most immediate danger since village facilities already lie on land sloping towards the lake. Both the outhouse and some fuel bladders are located on this slope, and one fuel bladder has already sprung a leak, probably resulting in some seepage into the lake. Road erosion is also a problem, and any additional road construction should avoid drainage into the lake.

3. Future Growth and Management Recommendations

Several alternatives for water supply and waste disposal systems were prepared for the North Slope Borough by Crews, MacInnes and Hoffman (1976). Their designs are based on the construction of 32 houses initially and 16 more later, a school, community center-vocational education building, public works building, public safety building, hotel, and store. They estimated a population of 169 after the first 32 houses were built.

The firm considered more than 50 basic elements and combinations of water, waste and sewage disposal, and heating and generating systems. Many were eliminated during meetings with North Slope Borough's representatives, Construction Systems Management, and the U.S. Public Health Service. Finally four possible combinations of utility systems were presented in detail to the borough and the people of Atkasook. Descriptions of these systems are presented below:

COMBINED SYSTEM A

Power and Heat (Diesel Generation and Oil Heat Basic System)—Electricity would be generated by diesel generators and distributed to all buildings by a plank-covered cable. A diesel generator located at the school would provide standby and emergency power. Heat from the generators would be used to warm the water storage tank and power plant building only. All other buildings would have their own oil-fired heaters. Coal, which can be used in the heaters, would be the standby fuel for heating all buildings except the school and community center.

Water and Waste (Basic System With Watering Point, No Fire Protection System)--The water system would consist of an intake in Ikmakrak Lake, portable pipe to a water treatment plant, water storage tank of 1,000,000 gallons capacity, water line in a utilidor to the school and community center, and a watering point for all other buildings. Waste disposal would consist of a gravity sewer line in a utilidor from the school and community center to a holding tank and pumping station with an outfall to a lagoon for disposal. Other buildings would have separate holding tanks for gray water from washing and honey bags for black water from toilets which would be collected by a tank truck, dumped at the central holding tank, and pumped to the disposal lagoon. Solid wastes would kept gathered in compactors or other containers at individual buildings and hauled away by a garbage truck to a sanitary landfill. Fire protection would be limited to fire extinguishers for most buildings, but the school and community building would have the added protection of pumped water.

COMBINED SYSTEM B

Power and Heat (Diesel Electric Generation and Coal-Fired Central Heat)--In this system electricity would be generated by diesel generators as in System A. Power would be distributed in insulated utilidors that would also contain other utility lines. Waste heat from power generation would be used for heating the power plant facility, utilidors, and the water storage tank. A standby and emergency diesel generator would be located at the school. Central heat would be produced by coal-fired boilers; fuel could be locally mined. Heat pipes would run to all buildings through the utilidors. Coal is the standby fuel for all buildings except the school and community center.

Water and Waste (Full Utilidor System)--Water supply intake, treatment and storage would be the same as in System A. Water would be distributed to all buildings from the storage tank in utilidors. Water would be constantly warmed and circulated in the storage tank to prevent freezing. Sewer lines would serve all buildings via utilidors. A vacuum system would allow smaller lines and help prevent freezing. Sewage would be collected in a holding tank, and pumped to the disposal lagoon. Solid wastes would be collected and disposed of as in System A.

COMBINED SYSTEM C

Power and Heat (Coal-Electric Generation and Coal-Fired Central Heat)--Locally produced coal would fire boilers to produce steam for turbine-powered generators and hot water for central heat. Diesel could be used for emergency power at the power plant and standby and emergency power at the school. This system has high installation costs but lower operational costs than System A as well as good standby and emergency features. Power and heat would be distributed as in System B.

Water and Waste - Full Utilidor System--Water supply and waste disposal would be the same as System B.

COMBINED SYSTEM D

Power and Heat (Coal All-Electric System and Waste Heat Recovery)--All power and heat would be supplied by coal-fired boilers with steam turbine-generators. Waste heat could be recovered and used to supplement heat at the school and community center. Other buildings would be heated electrically. Standby equipment would include a diesel generator in the power plant and a second in the school. Coal is again the standby heating fuel for individual buildings. All power and heat would be distributed through utilidors.

Water and Waste - Full Utilidor System--Water supply and waste disposal would be the same as in System B.

The costs for each of these utility systems are tabulated in Figure 5. As the convenience of the system increases, the initial cost also rises significantly, however, when yearly operation and maintenance costs are considered, the increase is not as significant. Monthly operation and maintenance costs per house (shown in the last column of the table) are significantly less for a full utilidor system and central heat than for System A where individual buildings would be heated by oil-fired furnaces.

Crews, MacInnes, and Hoffman concluded that the choice depends on the degree of convenience desired and the ability to pay initial

Figure 5

Atkasook - Costs of Utilities System

Combined System	First Cost	Yearly Financing Cost	Yearly Operation & Maintenance	Total Yearly Cost	Monthly Operation & Maintenance Cost Per House
A Diesel Electric Watering Point No Central Heat	$1,838,800	$156,439	$84,967	$241,406	$519*
B Diesel Electric Utilidors Coal Central Heat	$2,512,750	$209,124	$75,801	$284,925	$296
C Coal Electric Utilidors Coal Central Heat	$2,806,250	$226,769	$71,963	$298,732	$303
D Coal All Electric Utilidors	$2,637,050	$214,016	$73,134	$287,150	$336
Addition for Ice Melting	$ 100,000	$ 8,718	$12,500	$ 21,218	$ 38 (or 21¢/gallon)

*Including individual oil heat (30 native houses)

Source: Crews, MacInnes and Hallman, 1976, p. IV-7.

costs. Operation and maintenance costs should receive careful consideration. All systems require lengthy lead times for bidding, manufacturing, and transportation before construction can begin.

Unfortunately, village leaders were in Barrow to discuss a construction shutdown when we visited the village. The villagers we talked to knew little about the alternatives presented by Crews, MacInnes and Hoffman. The construction project manager told us that the consultants had not adequately explained the various systems when they met with residents. Two-thirds of the monthly water and sewer operation and maintenance costs for a village of 32 families would range from $90 to $118 per family, not including heat costs shown in Figure 5. The biggest need is for a safe water supply and waste disposal system that the village can afford. The feasibility of using coal is crucial to implementing any of the proposed systems and should be carefully analyzed for effects on water quality.

BARROW

A. LOCATION AND SETTING

Barrow is located on the Chukchi Sea, 10 miles southwest of Point Barrow.

Precipitation averages five inches annually, including 29 inches of snow. Mean monthly temperatures range from minus 25 degrees F in winter to 44 degrees F in summer. Extremes of minus 56 and 78 degrees F have been recorded. Daylight is continuous from May 10 to August 10, and the sun does not rise above the horizon from November 18 to January 23. Prevailing winds are from the east in summer and the northeast in winter, but storm winds often come from the west. Barrow is only 22 feet above sea level, and the hazards of coastal flooding and erosion are high, particularly near Browerville slightly northeast of Barrow. Permafrost is 1,000 to 1,800 feet deep. The active layer thaws to a depth of one or two feet annually.

B. TRADITIONAL AND PRESENT LAND USE

The Barrow area historically encompasses the site of two Eskimo villages, Nuwuk on the point and Utkiakvik. The people have historically depended on the sea for subsistence, supplemented with hunting and fishing in inland areas. The village was mentioned as early as 1831 by Capt. Beechey. In 1881 a U.S. meteorological and magnetic research station was established by Lt. Ray, half a mile northeast of the Native village. Browerville, founded by Charles D. Brower, developed as a whaling center and later as a trading post near Ray's station. A post office established in 1901 helped the name Barrow become dominant. The Naval Arctic Research Laboratory (NARL) was founded in 1946. The main offices of the North Slope Borough government and Arctic Slope Regional Corporation are located in Barrow, which is the ninth largest community in Alaska.

Under provisions of the Alaska Native Claims Settlement Act the village corporation has selected all the lands available in its withdrawal area except the townsite which is patented to the U.S. Bureau of Land Management as trustee and other withdrawals for the naval research facility and the Barrow gas field. Since the regional corporation cannot acquire the subsurface estate to village selections in the petroleum reserve, it has made in-lieu selections outside its boundaries.

Subsistence hunting and fishing continue to be vital to the economy and life-style, along with increasing seasonal and full-time employment for cash income. Whales and seals are seasonally hunted offshore and waterfowl, caribou, and fish are harvested along the coast and inland. The Barrow "area of interest" extends from Peard Bay to Harrison Bay in the east and inland to Omalik River and includes many traditional and active fishing and hunting camps.

C. PRESENT WATER SUPPLY AND USE

1. Present Supply

The Naval Arctic Research Laboratory (NARL) desalinates water from Imikpuk Lake, which was fresh water until a storm surge flooded it in 1963. Water is piped to the dining hall and laboratory and hauled by truck from the boiler to storage tanks in other buildings.

The U.S. Bureau of Indian Affairs and the U.S. Public Health Service share a water and sewer system in Barrow that serves the hospital, school, and employee residences. Raw water from Esatkuat Lagoon is pumped to the plant, distilled, and chlorinated. Some villagers haul water or ice from Emaiksoun Lake about four miles south of town. Some buy it from borough, corporation, or privately operated water trucks, which obtain it from the BIA-PHS distillation plant. With a four cent per gallon subsidy from the borough, villagers pay about 15 cents per gallon. Residents can also purchase untreated water or ice hauled by truck from Emaiksoun Lake.

2. Water Quality

Salinity in Esatkuat Lagoon ranges from about 200 to more than 1,000 ppm (Jones 1972). After distillation at the BIA-PHS plant, total dissolved solids content is negligible. The water has the slightly flat taste characteristic of distilled water, but otherwise is good. The hotel water, which is purchased from the BIA-PHS plant and stored, tastes bad due to excess chlorination or the pipe system. Emaiksoun Lake had a total dissolved solids content of 168 mg/l in September 1961 (Figure 6); organic matter comprised about 25 percent of this (Arnow and Hubbs 1962). Of 51 bacteriological samples taken since 1970 in various locations around the village (Figure 7), 47 showed no coliforms (Alaska Dept. of Health and Social Services 1976).

Figure 6

Barrow - Chemical Data

Parameter	Emaiksoun Lake (9/8/61)	Esatkuat Lagoon (7/10/72)	Esatkuat Creek (6/13/73)	Esatkuat Creek (7/10/72)	Esatkuat Creek (8/29/72)
Color (platinum cobalt units)	10	10	40	20	40
Conductivity (micromhos)	294	1230	53	76	184
pH	7.1	7.6	6.1	7.1	6.9
Calcium (mg/l)	7	13	3.4	5.8	15
Iron (mg/l)	0.05	0.21	.39	0.11	0.06
Magnesium (mg/l)	6	22	2.1	3.0	7.2
Potassium (mg/l)	-	9.8	2.4	0.4	0.8
Sodium (mg/l)	43	190	5.5	4.7	11
Bicarbonate (mg/l)	-	34	11	29	56
Chloride (mg/l)	1	328	11	9.5	21
Fluoride (mg/l)	0.1	0.1	0.0	0.0	0.2
Nitrate (mg/l)	1	0.02	0.02	-	0.01
Sulfate (mg/l)	-	53	2.7	0.6	13
Total Hardness (mg/l)	44	122	17	27	67
Total Dissolved Solids (mg/l)	168	633	34	38	97

Source: Arnow, G.M. and G.L. Hubbs, 1962, p. 22.
U.S. Geological Survey, 1974, p. 292.
_____, 1973, pp. 376-377.

Figure 7

Barrow - Bacteriological Data

Date	Total Coliform/100 ml. Water	Source
4/10/70	0/100 ml.	FAA Public Water
4/28/70	0/100 ml. Many non-coliform	Cistern at Al's Eskimo Cafe
7/11/73	0/100 ml.	Lake at Top of the World Hotel
7/11/73	0/100 ml.	Brower's Cafe
7/31/73	0/100 ml.	Kitchen Tap at Al's Eskimo Cafe
7/31/73	9/100 ml.	Brower's Cafe
8/1/73	0/100 ml.	Bathroom Tap at Top of World Hotel
9/5/73	14/100 ml.	Kitchen Tap at Brower's Cafe
9/6/73	2/100 ml.	Kitchen at Al's Eskimo Cafe
12/19/73	0/100 ml.	Lab Tap PHS Hospital
1/10/74	0/100 ml.	Bathroom Tap PHS Hospital
3/24/74	0/100 ml.	Bathroom Tap PHS Hospital
8/20/74	0/100 ml.	Kitchen Tap PHS Hospital
12/16/74	0/100 ml.	Bathroom Tap PHS Public Water
1/6/75	0/100 ml.	Lab 121 Sink at NARL
1/10/75	0/100 ml.	PHS Water System
1/14/75	0/100 ml.	Early Childhood Development Center Kitchen
1/14/75	0/100 ml.	Kitchen Tap at Al's Eskimo Cafe
1/14/75	0/100 ml.	Barrow School Kitchen
1/14/75	0/100 ml.	Kitchen Tap at Top of World Hotel
2/6/75	0/100 ml.	PHS Hospital
2/20/75	0/100 ml.	PHS Water System
4/8/75	0/100 ml.	PHS Water System
4/21/75	0/100 ml.	Top of World Hotel
4/22/75	0/100 ml.	Barrow Public Water
5/6/75	0/100 ml.	Barrow Public Water
5/7/75	0/100 ml.	NARL Kitchen
7/23/75	0/100 ml. Heavy non-coliform	NARL Kitchen
7/29/75	0/100 ml.	Brower's Cafe Kitchen Tap
7/29/75	0/100 ml. Few non-coliform	Fresh Water Lake at Barrow Public Water
7/29/75	1/100 ml.	Delivery Truck Barrow Public Water
7/30/75	0/100 ml.	Kitchen Tap Top of World Hotel
8/11/75	0/100 ml. Moderate non-coliform	PHS Water System

Figure 7 continued

Date	Total Coliform/100 ml. Water	Source
8/26/75	0/100 ml.	PHS Hospital
9/15/75	0/100 ml.	PHS Water System
9/30/75	0/100 ml.	NARL Kitchen Tap
10/8/75	0/100 ml.	NARL Kitchen Tap
10/20/75	0/100 ml.	Coffee Sink Tap at Vocational Education Building
10/21/75	0/100 ml.	Barrow Public Water
10/21/75	0/100 ml.	Primary Section-Barrow School
10/21/75	0/100 ml.	High School Fountain
10/21/75	0/100 ml. Loaded with non-coliform	Kitchen at Top of World Hotel
10/21/75	0/100 ml.	10 Plex Kitchen at Barrow School
10/22/75	0/100 ml.	PHS Water System
10/29/75	0/100 ml.	PHS Water System
1/14/76	0/100 ml.	House No. 1 at NARL
1/14/76	0/100 ml.	U.S. Weather Service House No. 2 NARL
1/14/76	0/100 ml.	NARL Duplex
1/15/76	0/100 ml.	Lab Sink No. 121 NARL
2/21/76	0/100 ml.	PHS Hospital
3/17/76	0/100 ml.	PHS Hospital
4/1/76	0/100 ml.	PHS Hospital
4/7/76	0/100 ml.	Lab No. 121 Sink at NARL
4/8/76	0/100 ml. Overgrown with non-coliform	High School Fountain
4/9/76	0/100 ml. Overgrown with non-coliform	10 Plex Kitchen Tap Barrow School
5/5/76	0/100 ml. Few non-coliform	PHS Hospital
7/14/76	0/100 ml.	PHS Water System
8/16/76	0/100 ml.	Lab 121 Sink NARL

Source: Alaska Dept. of Health and Social Services, Fairbanks.

3. Present Demands

The per capita water use in Barrow, excluding the Naval Arctic Research Laboratory, is approximately 10 gallons per day for about 2,600 people. The water treatment plant processes 20,000 gpd and supplies the hospital, school, and hotel which have flush toilets. Recycled water is used in the hotel toilets. NARL averages 130 gallons per capita per day for 225 people.

D. PRESENT WASTE DISPOSAL

The city of Barrow and NARL also maintain separate waste disposal systems. Boyd, Klubek and Boyd (1972) summarized the waste treatment methods that NARL has tried since 1946 when solid waste was collected in 55 gallon oil drums and left on the ice to go out to sea during breakup. A health problem developed because some barrels returned to the beach, and this method was abandoned. An insulated sewer line was then built from the galley, bathhouse, laundry, and laboratory into the ocean. Middle Salt Lagoon was used for solid waste disposal from 1954 to 1961, and in 1961 both NARL and the City of Barrow began using South Salt Lagoon. Other experiments included toilets flushed by fuel oil which heated a boiler, toilets flushed by sea water using the old sewer line, and self-incinerating toilets. When the laboratory was reconstructed in 1969, Middle Salt Lagoon was selected for sewage disposal. Wastewater from the laboratory is fed into a comminutor to pulverize wastes prior to primary and secondary treatment and discharge into the lagoon. Kitchen, shower, and washing wastewater are still discharged into the ocean in the sewer line. The Department of the Navy built an incinerator next to South Salt Lagoon in the early 1970s but it has never been used due to technological and management problems and lack of operating funds.

In the city of Barrow, school and hospital sewage is treated by extended aeration, chlorinated, and dumped into a sewage lagoon only 10 feet from Esatkuat Lagoon, the present water supply. The sewage lagoon, which is in the center of town, did not smell the day we were there, but the discharge from the treatment plant did. According to the plant operator, the effluent coliform count was only 10 to 20 per 100 ml total coliform. The danger with this system is that spray from the plant outfall would be picked up by the wind, transferring pathogens from the sewage lagoon to the water supply lagoon. The U.S. Public Health Service is building a dam to shift the water supply source to an upper lagoon, which should substantially reduce this risk. Trash and honey bucket wastes are hauled to the dump at South Salt Lagoon about a mile from the edge of town.

E. EVALUATION OF PRESENT WATER SUPPLY AND WASTE DISPOSAL

1. Adequacy of Available Information

There are a number of reports on the physical, chemical, and biological aspects of the tundra ecosystem at Barrow, and the period of record is much longer and more consistent than for other communities in the Arctic. Alternative methods of augmenting the water supply and disposing of wastes have been studied. Planning documents published since 1970 have identified many city problems, and some of the recommendations have been implemented. (Construction of the dam across Esatkuat Lagoon was option II in the 1972 Link-Thompson study.) The solid waste disposal problem still needs to be resolved, but the data base for Barrow is adequate.

2. Problems and Limitations

The villagers we talked with did not express strong feelings either way about the water situation. Some obtained water from the lake and some from the plant. Fred Brown, U.S. Public Health Service, said essentially few of the local residents knew of the Public Health Service's efforts to build a new plant. If the dam across the upper end of Esatkuat Lagoon is used as a road to transport garbage to South Salt Lagoon dump, the new water supply could be contaminated. If there is no alternate route, care must be taken to prevent waste materials from reaching the water supply.

3. Future Growth and Management Recommendations

Fred Brown indicated that the new water treatment system should be finished in about a year. Plans call for physical-chemical treatment of water obtained from the reservoir about the new dam, including coagulation, filtration, and disinfection and a capacity of 250 gallons per minute. The treated water will be stored in a 600,000 gallon tank which will serve as a watering point.

This new system will be able to supply 5,000 people with 120 gallons of water per day--ten times the present use and twice the population--and will cost $6,000,000. A system that would pipe water to individual homes could cost as much as $18,000,000 (Linck-Thompson 1972), and this amount of money is simply not available. However, the U.S. Public Health Service is investigating preliminary engineering feasibility of water and sewer utilidors to serve part of Barrow.

The water supply can be augmented at minimal expense by using snow fences. A study conducted in 1973 (Slaughter et al.) concluded that water could be produced for a cost of one cent per 0.2 cubic meters or 52.8 gallons amortized over a ten year period if the only cost were erecting the snow fence. Snow fences will be used next winter to increase the amount of snow for meltwater in the reservoir, and to decrease ice formation, which should reduce the brine content in the reservoir water.

Water will begin to flow from the new reservoir in July of 1977. The utilidor containing the transmission line is almost completed. After brine is pumped out from under the ice in March the remaining water should be of lower salinity than that currently being used. Lower salinity should reduce scaling in the distillation equipment.

Unfortunately the problem of waste disposal for Barrow is still unresolved, and "honey buckets" probably will be used for the foreseeable future.

KAKTOVIK

A. LOCATION AND SETTING

Kaktovik faces the Beaufort Sea on the north coast of Barter Island, about 310 miles east of Barrow and 90 miles west of the Alaska-Canada border. Federal land surrounds the community; a Defense Department withdrawal (the Barter Island DEW-line site) is on one side and the Arctic National Wildlife Range is on the other.

Precipitation averages seven inches annually, including 45 inches of snow. Mean monthly temperatures range from minus 20 degrees F in winter to 45 degrees F in summer. Extremes of minus 59 and 75 degrees F have been recorded. The sun never completely falls below the horizon for two months in summer and never completely rises above it for 72 days in winter.

B. TRADITIONAL AND PRESENT LAND USE

Although the area historically served as a trading place for the nomadic Eskimos of both Canada (Herschel Island) and Alaska, the village of Kaktovik is a comparatively new settlement dating back to about 1923 when a trading post was established. When the Barter Island DEW line site was established in 1947, the settlement was relocated. The community was moved again to its present site in the northeast of Barter Island in August and September 1964.

Hunting, fishing, and trapping activities provide a majority of the annual village food supply. The main fish and wildlife resources are caribou, marine mammals, and fish, which are used for both food and clothing. Other village wildlife resources include Dall sheep, wolf, fox, wolverine, ptarmigan, squirrels, and bear. Fish caught from either the ocean or rivers such as the Jago and Hulahula and the lagoons include Arctic cisco, whitefish, Arctic char, and grayling. Much of this harvest comes from within a 30- to 40-mile radius south of the community, although the Kaktovik "area of interest" extends along the coast from the Canning River to the Canadian border and inland to the Brooks Range and Peters and Schrader Lakes.

Most of the western part of the island is a military withdrawal for the DEW-line and White Alice communication station. When this withdrawal was reduced in size in 1975, the village corporation selected surplus military lands as part of their entitlement under the Alaska Native Claims Settlement Act. The village also selected lands traditionally used for subsistence activities from its withdrawal area along the Beaufort Sea coastline and inland along the Hulahula and Jago Rivers. Since these lands were totally within the Arctic National Wildlife Refuge, the regional corporation could not acquire the subsurface rights and selected equivalent acreage elsewhere. Kaktovik has selected village deficiency lands in an area west of the Canning River.

C. PRESENT WATER SUPPLY AND USE

1. Present Supply

Kaktovik residents obtain almost all their water from a lake located about seven-tenths of a mile southwest of the village. The lake appears clear and clean, is about nine feet deep, and freezes to a depth of six feet in winter. As long as the ice is less than two feet thick, villagers saw completely through it and remove blocks, which are hauled to the homes. After the ice thickens, cracks form and the blocks are removed by working around the cracks. Residents set up a portable pump by the lake when it thaws. Most people to haul the water to their homes over a gravel road. Villagers also obtain water by melting glacial sea ice.

2. Water Quality

The lake water tastes good in the summer. The total dissolved solids level in the lake (Figure 8) ranged from 49 mg/l in spring to 853 mg/l in December (Arnow and Hubbs 1962). Since the lake freezes almost completely through in winter, the residual water is brackish and muddy; however, the DEW-line station use it year-round. The quality of water from glacial ice is excellent. It is sometimes covered with a layer of cloudy sea ice which must be chopped off before melting.

Seven out of nine samples tested (Figure 9) for total coliforms were negative; the water container at the school had 200 coliform/100 ml water in May 1976 (Alaska Dept. of Health and Social Services 1976).

3. Present Demands

Present usage by the 123 residents appears to be about two gallons per capita per day in individual homes. Consumption is probably higher at the school which has the convenience of interior piping. Some homes have storage tanks inside that can hold several hundred gallons. The mayor said he is building his own interior piping system.

Figure 8

Kaktovik - Chemical Data

Parameter	Lake 4/20/61	Lake 10/12/61	Lake 12/22/61
Color (platinum cobalt units)	5	15	20
Conductivity (micromhos)	49	533	853
pH	7.9	7.2	7.6
Calcium (mg/l)	1	36	80
Iron (mg/l)	0.5	0.2	0.1
Magnesium (mg/l)	6	14	14
Potassium (mg/l)	-	-	-
Sodium (mg/l)	6	5	42
Bicarbonate (mg/l)	-	-	-
Chloride (mg/l)	10	113	205
Fluoride (mg/l)	0.15	0.1	0.3
Nitrate (mg/l)	1	1	1
Sulfate (mg/l)	-	-	-
Total Hardness (mg/l)	28	147	260
Total Dissolved Solids (mg/l)	40	350	813

Source: Arnow, G.M. and G.L. Hubbs, 1962, p. 22.

Figure 9

Kaktovik - Bacteriological Data

Date	Total Coliform/100 ml. Water	Source
12/2/70	0/100 ml.	Lake
12/4/70	11/100 ml.	Lake
12/15/70	0/100 ml.	Lake
12/15/70	0/100 ml.	Public Drinking Fountain
8/28/75	0/100 ml. Moderate non-coliform	BIA Day School Kitchen
11/14/75	0/100 ml.	BIA Day School Kitchen
4/6/76	0/100 ml.	Storage Tanks at School
5/20/76	0/100 ml. Few non-coliform	BIA Day School Kitchen
5/20/76	200/100 ml.	Water Container at School

Source: Alaska Dept. of Health and Social Services, Fairbanks.

The 80 people at the DEW line station use 60 gallons per capita per day.

D. PRESENT WASTE DISPOSAL

Honey buckets and trash are dumped into the DEW-line dump at the edge of the ocean about one-half mile west of the village. Unfortunately, a lot of these wastes washed out to the sea, and some can be seen along the beaches. According to Herman Aishanna, DEW-line site authorities had agreed to keep the trash covered with gravel but have not been doing so. We noticed no obvious odors when we visited the dump on August 4.

E. EVALUATION OF PRESENT WATER SUPPLY AND WASTE DISPOSAL

1. Adequacy of Available Information

Because Barter Island is a DEW-line site, some data exist on precipitation, ice thickness, flooding, and geology that are adequate for planning purposes. Studies performed at Barrow, such as those for augmenting the water supply by snow fencing, would be applicable to Kaktovik.

2. Problems and Limitations

Villagers we talked with understood the high costs involved in upgrading water and sewer systems. The mayor wants to have piping in the homes with individual storage tanks, and he and others mentioned their desire for a tank truck to keep them supplied. Honey buckets are considered the only economical solution for sewage at the moment, but a new dump site should be considered. Unfortunately, this would probably involve some road construction. Contamination of the lake is of critical concern for the villagers.

Camping and construction are prohibited around the shores to maintain its quality.

3. Future Growth and Management Recommendations

The lake must be protected at all costs because it is Kaktovik's only water supply. If it is kept clean, any future water treatment can be kept to a minimum. The supply is adequate for present demands, but desalination techniques, discussed in more detail in alternative technologies, should be considered if the demand greatly increases. The U.S. Public Health Service plans to install a central watering point with a storage tank in 1978. The tank will be filled from the lake during the summer to supply the village with water throughout the winter.

NUIQSUT

A. LOCATION AND SETTING

Nuiqsut is on the west bank of the Nechelik channel of the Colville River delta, 150 miles east of Barrow and 35 miles from the coast.

Precipitation averages about five inches annually, including about 20 inches of snow. Mean monthly temperature range from minus 38 degrees F in winter to 30 degrees F in summer. The sun never completely drops below the horizon from May to July and never completely rises above it from mid-November to mid-January. High winds are common. The land has low relief and extensive flat marshy areas overlying about three feet of ice-rich silts. Below this are permanently frozen sands. The active layer thaws to a depth of one to two feet in summer.

B. TRADITIONAL AND PRESENT LAND USE

Every year the Inupiat Eskimos from the coast and interior have traditionally gathered near Nuiqsut to trade goods, and the region abounds with fish, waterfowl, marine mammals, caribou, and moose. Seasonal use is fairly high, but permanent occupancy barely qualified Nuiqsut as a village under the Alaska Native Claims Settlement Act. The present village and airstrip were constructed in 1974 under the sponsorship of the Arctic Slope Regional Corporation. About 30 houses have already been built. Subsistence resources are still heavily used by the Nuiqsut people.

The village corporation selected lands largely along the Colville River and its tributaries and along Harrison Bay. The outer and eastern parts of the Colville Delta are state owned. The regional corporation will not acquire subsurface title to any lands selected west of the Nechelik Channel if they lie within the boundaries of Naval Petroleum Reserve No. 4. Exact boundaries are under dispute. They will receive subsurface estate to lands selected outside the petroleum reserve.

C. PRESENT WATER SUPPLY AND USE

1. Present Supply

In summer the 152 villagers obtain water from a creek that originates in a lake about 1.5 miles south of the village and passes between the village and the airstrip before flowing into the Colville. In August the creek is only a few feet wide near its source, and the average depth in the lake is 12 feet. In winter villagers cut ice from a 20-foot-deep lake across the Colville River. Supply appears adequate for the present level of use.

2. Water Quality

Water quality in the winter supply lake meets most of the U.S. Public Health Service standards but not the recommended limits for iron, turbidity, and color. They measured up to 2.3 ppm, 17 jackson turbidity units, and 22 color units in March 1976 (CH_2M Hill 1976). The Colville River appeared to be muddy in August and becomes saline in the winter.

3. Present Demands

The few people we interviewed reported very low per capita use--about one gallon per day. This is probably because the water is hand carried from quite a distance. The resulting drawdown in the lake south of the village is negligible.

D. PRESENT WASTE DISPOSAL

Honey bucket wastes and trash are supposed to be collected and trucked to a dump about 1.5 miles west of the village. In August when we observed the trail to the dump it was boggy and rutted because it lacks a sand or gravel base. Since the truck could not reach the dump, trash was accumulating in the village.

E. EVALUATION OF WATER SUPPLY AND WASTE DISPOSAL

1. <u>Adequacy of Available Information</u>

Specific information is extremely limited and more comprehensive surveys on the quantity and quality of existing and proposed water supplies should be conducted. The movement of water between the water supply and any land area or water body proposed for solid or liquid waste disposal should be determined.

2. <u>Problems and Limitations</u>

The villagers are living in new buildings but water supply and waste disposal methods have not improved. Problems regarding the proposed systems are discussed below.

3. <u>Future Growth and Management Recommendations</u>

The engineering firm of CH_2M Hill prepared a study for U.S. Public Health Service and the North Slope Borough concerning water, sewer, and waste disposal systems for Nuiqsut. The final report proposes three alternatives for the village. These designs are based on a present population of 200 and 50 homes and a projected population of 400, 122 homes, and a school. They are outlined below:

Full Service System--This system would provide running water at each house, vacuum toilets flushed by water, and water for fire fighting would be continually available at adjacent houses. Water use would average 45 gallons per capita per day.

Community-Haul System--Community haul would use 30 gallons per capita per day. A village truck would replenish individual water tanks at each house, carry away wastewater, and could be easily regulated to eliminate the need for full-service waste disposal. The haul truck could be used for firefighting and would be more effective than under the individual haul concept. Either honey buckets or humus toilets would provide for sanitary waste disposal.

Individual Haul System--Individual haul facilities would require the least amount of water, 5 gallons per capita per day. Water for general household use and fire fighting would be hand carried from a central watering point in buckets. Either humus toilets or honey buckets would be used for sanitary waste disposal. This system is the cheapest and the least subject to failure because of its simplicity. Acceptance by the community would, however, require that public shower and laundry facilities be included in the school when it is built.

The representatives from CH_2M-Hill spent about an hour and a half explaining the concepts to the villagers, but, as at Atkasook, many of them did not understand. The villagers may not be able to afford the more expensive options with operation and maintenance costs of up to $300 per month per family for 50 homes which is more than they now pay for rent plus electricity. The individual haul option with operation and maintenance costs of about $70-$80 for 50 homes seems more realistic. The capital required for construction of an individual haul system would total $2,270,000, about $45,400 per home for 50 homes, which is similar to that for Atkasook. CH_2M Hill presents a capital cost per house of $18,600 for both 50 and 122 homes. If cost sharing is anticipated for the initial 50 homes, it is not indicated. It is important to note that discussions between CH_2M Hill and North Slope Borough staff and representatives revealed that the ultimate development is not expected to exceed 50 homes, although the ultimate population may reach 400 (CH_2M Hill, 1976. p. 2-2).

Villagers were concerned about potential contamination of the water supply lake by the sewage lagoon CH_2M-Hill proposed to build nearby. Any slight drawdown of water in the supply lake or overflow of the sewage lagoon during breakup could contaminate the water source. If the present dump is to be used year-round, a gravel road must be constructed. This will be expensive as the nearest gravel is about six miles from the village, according to Steve Stephenson, construction head.

All phases of the water and sewer plan for Nuiqsut require further study to achieve an understanding of what constitutes an acceptable compromise between costs and services, including the amount of water per capita provided.

POINT HOPE

A. LOCATION AND SETTING

Point Hope is located on the foreland that terminates at Point Hope on the Chukchi Sea coast. The village is situated toward the end of a low spit-like flat peninsula that juts into the Chukchi Sea for several miles. The village is about 270 miles north of Nome, 330 miles southwest of Barrow, and 570 miles northwest of Fairbanks.

Precipitation averages 10 inches annually, including 36 inches of snow. The climate is maritime subarctic. Mean monthly temperatures range from minus 16 degrees F in winter to 49 degrees F in summer. Extremes of minus 49 and 72 degrees F have been recorded. High velocity winds are frequent. The active permafrost layer thaws to a depth of 45 feet in summer.

Point Hope is exposed to the full force of storms from the north, west, and south. The village has been flooded several times by storm surges in the Chukchi Sea. A U.S. Army Corps of Engineers study determined that the peninsula was eroding at a rate of about 8.8 feet per year at Tigara Midden and 8.6 feet per year on the north side and was growing at a rate of about 2.9 feet per year on the south side. The study concluded that the village was in no immediate danger but found the construction of a seawall economically unfeasible. The study also stated that the flooding danger would probably increase each year until the village site eroded away. For these and other reasons the village recently moved to its new site.

B. TRADITIONAL AND PRESENT LAND USE

Archaeological investigations indicate that the general vicinity has been inhabited for about 2,500 years, probably because it is an exceptionally good location for hunting whales, walrus, and seals. Life at Point Hope has traditionally revolved around seasonal periods of sea mammal hunting. Moose, caribou, and freshwater fish are also important subsistence resources.

The Point Hope "area of interest" extends inland to the headwaters of the Kukpowruk River and along the coast to Cape Seppings to the south and Cape Beaufort to the north. Under provisions of the Alaska Native Claims Settlement Act, the village selected all the available land within its withdrawal area and from the adjacent village deficiency area. Regional corporation selections cover additional lands the Point Hope people use for subsistence activities.

Coal deposits exist in the vicinity of Point Hope. Others more distant along the Chukchi Sea coast and the Kukpowruk River reportedly are of high quality for coking purposes. These deposits have not been thoroughly surveyed, and their economic potential is not completely known. Oil and gas provinces also exist in the area. Exploration for these resources is underway pursuant to regional corporation and oil company agreements.

C. PRESENT WATER SUPPLY AND USE

1. Present Supply

In summer villagers obtain all their water from three shallow dug wells, one east of the old village (gallery well no. 1) and one west (gallery well no. 2) and the other east of the new village. The wells are two to four feet deep into the center of the spit. According to Amos Lane, a member of the borough planning commission, the wells are providing adequate quantities of water. Other villagers concurred.

U.S. Public Health Service files indicate that old village wells were adequate for domestic needs plus filling the school storage tank. One school employee told us the withdrawal of three gallons per minute from the old well to fill the three school tanks results in no noticeable drawdown. U.S. Public Health Service data also stated that a trench 10 feet by 3 feet by 20 feet at the new townsite yielded 50,000 gallons of water in one and one-half days with no increase in salinity. The U. S. Bureau of Indian Affairs drilled two wells to between 35 and 50 feet in 1969. Well log data is presented in Figure 10.

Villagers haul ice by snowmobile from a lake five miles east of the new town when the groundwater freezes. Amos Lane told us that a few years ago the villagers obtained water from a shallow well until December by covering it and heating it. This ended when the fuel supply was exhausted.

Figure 10

Point Hope - Well Log

Well No. 2 U.S. Bureau of Indian Affairs, Point Hope

Material	Thickness (ft.)	Depth (ft.)
Frozen gravel and sand	17	17
Frozen medium to fine sand	5	22
Sand and gravel	14	36
Loose gravel	1.5	37.5
Sand and gravel - salt water	2.5	38

Source: U.S. Geological Survey, Water Resources Division, Anchorage.

2. Water Quality

The water from the shallow dug wells looks clear and tastes good. U.S. Geological Survey data indicate that although the water near the surface is fresh, the water 30 feet down is highly saline. This is confirmed by chemical data from the U.S. Bureau of Indian Affairs wells (Figure 11). A freshwater acquifer is often underlain by heavier saltwater in coastal areas. The water table is higher in the center of the spit than along the shores.Amos Lane said the direction of groundwater flow appears westerly, which indicates that the best drinking water source is probably the well east of the new village.

Coliform tests conducted by the Alaska Dept. of Health and Social Services during the last five years showed coliform counts of over 20/100 ml in about half the samples (Figure 12). This is well over the U.S. Public Health Service drinking water standards of less than 1/100 ml. Recent data obtained by U.S. Army Cold Regions Research and Engineering Laboratory last summer confirms these earlier results and indicate the surface water to be grossly contaminated by coliforms even outside the village sites.

3. Present Demands

Per capita water use is estimated at about two gallons per day for the 400 residents. The water is generally hand carried to individual homes. Since ice must be hauled five miles in winter per capita consumption probably declines. The school's water storage of about 100,000 gallons only lasts until January. It is kept in a heated building and distributed to the classrooms and teachers quarters in heated utilidors.

Figure 11

Point Hope - Chemical Data

Parameter	BIA Well No. 1 (11/14/69)	BIA Well No. 2 (11/14/69)	Gallery Well No. 1 (9/19/72)	Gallery Well No. 2 (9/20/72)
Color (platinum cobalt units)	15	15	5	0
Conductivity (micromhos)	61,850	51,400	431	90
pH	7.5	7.5	8.2	8.2
Calcium (mg/l)	700	480	47	33
Iron (mg/l)	0.06	0.06	0.5	0.04
Magnesium (mg/l)	2,000	1,700	8.0	9.8
Potassium (mg/l)	500	380	2.1	1.9
Sodium (mg/l)	12,000	10,340	29	30
Bicarbonate (mg/l)	360	297	145	110
Chloride (mg/l)	25,200	20,350	61	63
Fluoride (mg/l)	0.1	1	0.1	0.0
Nitrate (mg/l)	0.7	0.90	0.6	0.9
Sulfate (mg/l)	760	2,200	10	12
Hardness (mg/l)	9,850	8,250	151	124
Total Dissolved Solids (mg/l)	41,300	89,600	235	209

Source: U.S. Geological Survey, Water Resources Division, Anchorage.

Figure 12

Point Hope - Bacteriological Data

Date	Total Coliform/100 ml. Water	Source
3/13/70	0/100 ml.	Barrel Tap at Head Start Program
7/10/71	Too overgrown to count	Public Water System
7/20/71	70/100 ml.	Public Well
7/20/71	100 colonies/100 ml.	Public Well
7/20/71	Over 25/100 ml. overgrown by other bacteria	Public Well
7/20/71	70/100 ml.	Public Well
7/20/71	Too overgrown to count	Public Well
10/18/72	0/100 ml.	School Tap
4/24/75	71/100 ml.	55 Gallon Drum in Kitchen at Rock's Coffee Shop
4/26/75	0/100 ml.	School Kitchen
4/26/75	0/100 ml.	Head Start Program
10/22/75	0/100 ml. Moderate non-coliform	School Kitchen
10/24/75	0/100 ml.	School Kitchen
3/20/76	0/100 ml.	School Kitchen
7/20/76	Too overgrown to count	Public Well
7/20/76	Over 20/100 ml. overgrown with non-coliform	Public Well

Source: Alaska Dept. of Health and Social Services, Fairbanks.

D. PRESENT WASTE DISPOSAL

The dump just west of the old village is being phased out. Current plans call for the use of gravel pits southeast of the new village as the new disposal sites for both trash and honey buckets. Some individual homes and the school use privies.

One school worker, Sid Keith, said one pit four feet by four feet by three feet could hold all the human wastes from the school for three years. The two school privies we saw were saturated. Much of the waste water from the school is simply on the ground, forming "glacial" ice in the winter, but all traces of this disappear from the surface by the end of summer. Waste disposal in this case is aided by the highly permeable gravel subsurface.

E. EVALUATION OF WATER SUPPLY AND WASTE DISPOSAL

1. Adequacy of Available Information

Much of the data on Point Hope are unpublished or in studies completed in 1976. Although the water supply is adequate, the bacteriological quality is questionable. Present data are not sufficient to determine whether drinking water is adequately protected from pathogen movement from outhouses and the dump.

2. Problems and Limitations

Villagers do not seem to mind hauling water to their homes in summer, but they want to improve the situation in winter. Sid Keith stated that he thought the use of privies and percolation of decaying matter into the surrounding subsurface during the summer months were an adequate method of human waste disposal, but he agreed that the water supply had to be closely watched for contamination. He was vehemently against the idea of installing sophisticated water supply or waste disposal systems in the Arctic.

Amos Lane was concerned that the well west of the new village might become contaminated because of the westerly groundwater flow.

3. Future Growth and Management Recommendations

With heat, a well could be kept open much of the winter. Dan Rogness, U.S. Public Health Service, was skeptical about keeping it operable past January, but this would significantly shorten the time that ice has to be hauled from Teshepak Lake.

The extensive gravel deposits on the spit minimize disruption of the environment. This type of subsurface strata might also permit underground disposal of sewage if the strata allowed some groundwater percolation without extensive flows. The rate of contaminant die-off in such an environment requires investigation.

More attention should be given to water quality, particularly bacterial contamination. The pattern of groundwater flow should be determined to optimize well locations and minimize the danger of contamination from outhouses or from the dump. Wells should be covered and hand or windmill-operated pumps installed. The U.S. Public Health Service plans to construct a shallow test well in the new village site this summer. If the recharge of water is adequate, this will be converted to a permanent well and a storage tank will be constructed.

POINT LAY

A. LOCATION AND SETTING

The old village of Point Lay is located on a gravel barrier island near the Chukchi Sea about 300 miles southwest of Barrow and 150 miles northeast of Point Hope. Point Lay is one of the traditional Inupiat villages identified in the Alaska Native Claims Settlement Act. To facilitate access, the village moved to a new site near the mouth of the Kokolik River in 1974 under the sponsorship of the Arctic Slope Regional Corporation. Plans are being finalized to relocate again to a site adjacent to the DEW-line station and airstrip across the bay from the barrier island where the village originated.

Precipitation averages seven inches annually, including 21 inches of snow. The climate is subarctic maritime. Mean monthly temperatures range from minus 27 degrees F in winter to 53 degrees F in summer. Extremes of minus 55 and 78 degrees F have been recorded. The sun never completely drops below the horizon for two months in summer nor completely rises above it for 72 days in winter. Prevailing winds are from the east except in winter when they blow from the northeast.

B. TRADITIONAL AND PRESENT LAND USE

The people of Point Lay have traditionally depended on the products of the sea for their livelihood and to a large extent they still do. Seal, walrus, and occasionally whales are hunted offshore. Waterfowl, caribou, squirrel, and marmot are hunted inland, and wolf, fox, and wolverine are trapped for their fur. Several fish camps are located along the inland rivers.

Village and regional land selections encompass the entire village withdrawal area, and most of the other lands between the naval petroleum reserve boundary and the sea have also been selected by the regional corporation. A land exchange is pending with the State. The military DEW-line site withdrawal still exists but has diminished in size.

C. PRESENT WATER SUPPLY AND USE

1. Present Supply

Villagers haul water from the Kokolik River upstream from the community site in summer and cut ice from a lake across the river in winter. When the river gets saline because of onshore winds or other causes, the villagers obtain water further upstream. Resident Willy Tukrook said they sometimes obtain water in summer and ice for thawing in winter from several small lakes east of the village. From the absence of tracks to them, we surmised that they are not used much, at least in summer.

2. Water Quality

From the air the Kokolik River looked turbid in the vicinity of the village. The village site is certainly close enough to the sea for saline intrusion. An individual at the DEW-line site said the lake from which they obtain their water also gets turbid at times. In 1961 the river had a total dissolved solids content of 224 mg/1 (Figure 13), organic matter was 101 and chloride 51 mg/1, respectively (Arnow and Hubbs 1962). Samples taken at the school (Figure 14) should no coliform (Alaska Dept. of Health and Social Services 1976).

Figure 13

Point Lay - Chemical Data

Parameter	Kokolik River (6/24/61)	Kokolik River (8/22/61)	Lake (4/15/76)
Color (platinum cobalt units)	10	25	-
Conductivity (micromhos)	320	95	700
pH	7.7	7.5	6.8
Calcium (mg/l)	23	5	-
Iron (mg/l)	0.1	0.1	-
Magnesium (mg/l)	23	11	-
Potassium (mg/l)	-	-	3.4
Sodium (mg/l)	30	6	57
Bicarbonate (mg/l)	-	-	264
Chloride (mg/l)	51	10	110
Fluoride (mg/l)	0.1	0.1	0.1
Nitrate (mg/l)	1	1	0.17
Sulfate (mg/l)	-	-	1.7
Hardness (mg/l)	156	60	270
Total Dissolved Solids (mg/l)	224	84	-

Source: Arnow, G.M. and G.L. Hubbs, 1962, p. 22.
U.S. Geological Survey, Water Resources Division, Anchorage.

Figure 14

Point Lay - Bacteriological Data

Date	Total Coliform/100 ml. Water	Source
10/27/75	Broken in Transit	School
12/22/75	Broken in Transit	School
3/17/76	0/100 ml. Few non-coliform	Water Storage Tank at School
4/29/76	0/100 ml. Overgrown with non-coliform	Igloo Type Container at School
4/29/76	0/100 ml. Overgrown with non-coliform	Igloo in North Classroom at School

Source: Alaska Dept. of Health and Social Services, Fairbanks.

3. Present Demands

Since almost all the 51 villagers were living on the barrier island at the original site this summer, river water had to be transported several miles by boat, which kept consumption down to an estimated two gallons per capita per day. We saw no storage tanks larger than about 10 gallons in individual homes. At the DEW-line station 15 people use 33 gallons per person per day.

D. PRESENT WASTE DISPOSAL

All wastes from the old village on the barrier bar are dumped about one-half mile north of the village on the bar. Individual privies are sometimes used. The dump site for the new village, where virtually no one lives in summer, is about three-tenths of a mile east of the new village.

E. EVALUATION OF WATER SUPPLY AND WASTE DISPOSAL

1. Adequacy of Available Information

Basic data and detailed information for Point Lay are lacking. However, information on water supply and waste disposal systems for other communities is pertinent.

2. Problems and Limitations

Most of the villagers we talked with did not seem to mind hauling water from the river upstream of the new village in the summer and cutting ice from the lake in winter, especially, as Willy Tukrook commented, if the alternative is a high monthly operation and maintenance cost for a modern system. He and Bill Tracey, the mayor, said the villagers cannot afford running water, but they would like to have a Bombardier tracked vehicle to haul ice and water to individual homes.

The residents were unhappy about moving to a new village. They liked living on the island especially in the summer. Besides being close to one source of food, the ocean, they appreciated the smaller numbers of mosquitoes on the island. The drier ground also created easier walking conditions on the island.

Conversely, they enjoy having access to the phone and movies at the DEW-line site. Two women from Wainwright who had used the laundry-water facility at Alaska Village Demonstration Project appreciated the convenience and Willy Tukrook expressed interest in building such a facility at Point Lay.

3. <u>Future Growth and Management Recommendations</u>

The village is only prepared to modernize its water and sewage system if it can pay the costs. Even using a vehicle to haul water might necessitate building some gravel roads, and this might be too expensive. Since some people like to live in the old village in summer, perhaps some provision should be made for their needs too.

An insulated storage tank could be filled in summer using temporary pipe laid from the water source to the tank, which could be used as a watering point year-round. No utilidor would be needed, and operation and maintenance costs would be low. The new village already has a windmill, and perhaps one could also be used to pump water in the summer.

WAINWRIGHT

A. LOCATION AND SETTING

Wainwright is located on the Chukchi Sea coast, three miles northeast of the estuary of the Kuk River, and about 100 miles southwest of Barrow.

Precipitation averages six inches annually, including 12 inches of snow. The climate is polarmaritime. Mean annual temperatures range from minus 26 degrees F in winter to 59 degrees F in summer. Extremes of minus 56 and 80 degrees F have been recorded. The sun never completely drops below the horizon for two months in summer nor completely rises above if for two months in winter. Prevailing winds are easterly. Permafrost is continuous, and the active layer thaws to a depth of only six inches in summer.

B. TRADITIONAL AND PRESENT LAND USE

Wainwright has traditionally been a sealing and whaling village, and it still depends on these marine resources to a large extent. Beluga and bowhead whale, seal, and walrus are supplemented by caribou, whitefish, trout, tom cod, and waterfowl. Income is also obtained from the pelts of wolf, fox, and wolverine, ivory carving and skin sewing.

Several historic village sites have existed between Wainwright Inlet and the sea. A post office was established at the present site in 1916. A fur trading post started by Charles D. Brower before World War II.

Coal has been mined in the area in the past. The closest mine is seven miles from the village, and it and several others produced coal to heat the village. Today most Wainwright homes are heated by fuel oil.

Under provisions of the Alaska Native Claims Settlement Act the village has selected most of the lands in its withdrawal area, except a military withdrawal for the DEW-line site. Subsurface rights to village lands were not acquired by the regional corporation because Wainwright is located inside Naval Petroleum Reserve No. 4. In-lieu lands have been selected elsewhere.

C. PRESENT WATER SUPPLY AND USE

1. Present Supply

Water was hauled from a lake about one and a half miles southwest of the village in the summer and ice cut in the winter prior to the 1972 construction of U.S. Environmental Protection Agency's Alaska Village Demonstration Project. The lake was used again after the facility was destroyed by fire in November 1973. Now that it is rebuilt, most villagers obtain water from a 1,000,000 gallon storage tank with a nine month storage capacity. At the end of each summer water is pumped from the lake into the tank to supply the village throughout the winter. The Alaska Village Demonstration Project (AVDP) were authorized by Sect. 113 of PL 92-55 to demonstrate how sanitary conditions in Alaskan Native villages could be improved. The critical concepts at both the Emmonak and Wainwright projects are central community facilities and water conservation.

2. Water Quality

According to Barry Reid of the U.S. Environmental Protection Agency, the lake water is very clean with negligible salinity (Figure 15). The total dissolved solids content is about 200 mg/l (Arnow and Hubbs 1962). Ten samples of tap water taken for one and a half years (Figure 16) at the school showed no coliforms (Alaska Department of Health and Social Services 1976). A few villagers still rely almost entirely on blocks of ice from the lake for their drinking water. The ice is stored in cold cellars and melted as needed. These residents prefer the taste of the melted ice to the chlorinated water from the tank.

Potable water at the AVDP facility is treated with the carbon filtration method and chlorinated. Plant capacity for potable water for drinking, showers, laundry, and toilets is 12,000 gallons per day with 5,000 gallons of storage provided. Effluent water from the showers and laundry, called gray water, is recycled an average of two and one-half times. Gray water treatment includes disinfection, flocculation and sedimentation, sand filtration, carbon filtration, and post chlorination. The treated effluent can then be reused in laundry and toilets and is available for fire protection. A maximum of 25,000 gallons of gray water can be treated each day, with 5,000 gallons of storage provided for untreated gray water.

Figure 15

Wainwright - Chemical Data

Parameter	Lake (8/17/61)	Lake (10/2/70)	Lake (10/2/70)	Lake (4/15/76)
Color (platinum cobalt units)	10	20	50	-
Conductivity (micromhos)	340	472	199	375
pH	7	6.9	6.5	6.0
Calcium (mg/l)	10	14	5.0	-
Iron (mg/l)	0.2	1.4	1.3	-
Magnesium (mg/l)	10	9.9	5.8	-
Potassium (mg/l)	-	2.3	1.3	2.7
Sodium (mg/l)	33	60	22	32
Bicarbonate (mg/l)	-	48	20	50
Chloride (mg/l)	88	114	45	94
Fluoride (mg/l)	0.2	0.2	0.1	0.1
Nitrate (mg/l)	1	0.4	1.1	.31
Sulfate (mg/l)	-	5.7	1.6	5.2
Hardness (mg/l)	66	76	36	100
Total Dissolved	215	233	92	-

Source: Arnow, G.M. and G.L. Hubbs, 1962, p. 22
U.S. Geological Survey, Water Resources Division, Anchorage.

Figure 16

Wainwright - Bacteriological Data

Date	Total Coliform/100 ml. Water	Source
1/15/75	0/100 ml.	Wainwright Head Start
4/3/75	0/100 ml.	Kitchen Tap at School
5/27/75	0/100 ml.	BIA Day School Kitchen Tap
9/11/75	0/100 ml.	Kitchen Tap at School
9/26/75	0/100 ml. Overgrown non-coliform	BIA Day School Kitchen Tap
10/22/75	0/100 ml. Few non-coliform	Janitor Sink at School
11/18/75	0/100 ml. Many non-coliform	Wainwright Head Start
1/29/76	0/100 ml. Few non-coliform	Kitchen Tap at School
2/26/76	0/100 ml.	BIA Day School
5/4/76	0/100 ml. Moderate non-coliform	BIA Day School

Source: Alaska Dept. of Health and Social Services, Fairbanks.

3. Present Demands

The previous use of water from the AVDP facility averaged about 21,000 gallons per month, or about two gallons per capita per day for the 400 residents. About half of this went to the school and half to households. This figure did not include water for laundry, showering, or toilets at the facility or the ice hauled by hand. Since the water at the facility was recycled and low flow showers were timed (saunas were available for warming up), per capita use was still a low four gallons per day. Use at the DEW-line station is 33 gallons per capita per day for 15 people.

D. PRESENT WASTE DISPOSAL

Honey buckets are used for disposal of human excreta and hauled with trash via Bombardier (tracked) vehicles to a dump about four miles northeast of the village. Blackwater wastes from the six recirculating chemical toilets in the AVDP facility were originally incinerated. However, the incinerator was destroyed by fire in November 1973. In the reconstructed facility, the wastes are treated biologically via extended aeration and lime disinfection. Sludge from both the blackwater and graywater treatment systems is hauled to a dump site. The sewage effluent and excess gray water is dumped onto the sand near the ocean.

E. EVALUATION OF WATER SUPPLY AND WASTE DISPOSAL

1. Adequacy of Available Information

Wainwright has the most detailed and up-to-date published information on cold climate water supply and waste treatment systems.

Problems of installation, maintenance, and operator training have been assessed and should be considered by other villages.

2. Problems and Limitations

The villagers whom we talked with were happy with the first Alaska Village Demonstration Project facility and are looking forward to the second resuming operation. Even those who obtained their drinking water by hauling ice from the lake still used the facility for doing the laundry and showering. Villagers all thought the service charge of four to six cents per gallon was reasonable.

Performance of the AVDP gray water treatment system has not been consistent in the past. Removal efficiencies of more than 97 percent of the chemical oxygen demand (COD) and suspended solids have been reported, but the plant has also had periods of poor performance due to biological growth and decomposition in the accumulated sludges. Long term performance and reliability cannot be assessed until the new facility is fully operational.

3. Future Growth and Management Recommendations

Any future plans for village expansion must be considered with care. When the U.S. Environmental Protection Agency designed the Alaska Village Demonstration Project, single phase current was the only source available. Now, the borough has installed a three phase system in the new school.

If the North Slope Borough constructs a power plant adjacent to the AVDP, large quantities of waste heat will be available, and the reconstructed plant is designed for this eventuality. Such integration of facilities offers some promise for an economical water and waste treatment system, especially if a local source of fuel is developed. The present system is powered by a 50 kilowatt diesel generator. Much of the waste heat recovered from the exhaust stack is used for heating the utilidor which carries potable water to and waste water from the school. At an efficiency of 40 percent, this system should save almost 2,400 gallons of fuel per year (Puchtler and Reid 1976).

ALTERNATIVE TECHNOLOGIES

No single solution exists for arctic water supply and waste disposal problems. Each community presents a unique physical and social environment, and every community has different levels of financial resources and technological knowledge. Where to obtain water, what type of treatment will it require, and how to dispose of both liquid and solid sewage wastes are the first questions that need to be answered in any water and sewage plan. Understanding the suitability of various systems for particular applications is prerequisite to developing water supply or waste disposal facilities.

Water Treatment

Most communities know where the best water source in their area is and are already using it. A secondary source may be necessary if demand rises. Water quality should be checked periodically, and it should meet the water quality standards set for various uses by the U.S. Public Health Service, the U.S. Environmental Protection Agency, and the Alaska Department of Environmental Conservation. Obtaining drinking water of adequate chemical quality can reduce costs in developing arctic water supplies. Potable water should be disinfected or filtered to eliminate problems related to biological quality, as all surface water sources are subject to bacteriological contamination. A recent report (Sargent et al. 1976) indicated that about half the rural villages in Alaska need immediate improvement to their domestic water supplies. This same percentage was found to be in severe danger of contaminating natural waters with untreated sewage.

Many water treatment processes may be suitable for use in the Arctic. Chemical treatment includes coagulation and disinfection, while physical treatment includes aeration, sedimentation, flotation, and filtration. In addition to these basic processes, there are advanced processes such as activated carbon, distillation, ion exchange, reverse osmosis, electrodialysis, freezing, and desalination. Chemicals used in water treatment must be protected from moisture and used in the proper quantities to be effective. As much as 10 times the amount of chlorine may be required to disinfect the same amount of water at 38 degrees F as at 72 degrees F.

Many Alaskan waters are high in iron and manganese. Excessive amounts of these materials are aesthetically objectionable rather than a health problem, and the removal process is expensive in small communities (Ryan 1973a). At Akiachak, the iron content was reduced from 174 to .4 mg/l by aeration followed by batch lime treatment and sedimentation (Alter 1969 b). The amount of chemicals required for coagulation of iron and manganese compounds in the Fairbanks area is reduced by warming the waters to 60 degrees F and adjusting the pH (Alter 1969 b). If the iron is complexed with organics, aeration and sedimentation are not effective, but Kim (1973) found that color and organics could be removed by using synthetic resinous absorbents.

Although conventional water treatment processes remove most suspended solids, advanced processes are required to treat brackish and saline waters. Both NARL and the City of Barrow are using distillation. Several 1,000 gallon per day reverse osmosis units have been tested by the U.S. Public Health Service with varying degrees of success (Kim 1973). The complex vapor compression units used at Kotzebue and by the City of Barrow are difficult to maintain in such isolated regions.

A new ion exchange process has recently been developed in Australia that can reduce salt concentrations up to 80 percent at costs competitive with reverse osmosis and electrodialysis for total dissolved salt concentrations less than 3,000 mg/l (Calmon and Gold 1976). For a 1.2 million gallon per day plant, the salinity was reduced from 2,314 to 500 mg/l at a yield of 72 percent. The operating costs were 42¢/1,000 gallons with fuel costing 6¢/200,000 BTU to maintain the water at 90 degrees C. These costs, notably fuel, would be higher for the Arctic, but no chemicals are required to regenerate the ion exchange resin, as in reverse osmosis units.

Freezing can also reduce salt concentrations. Studies performed by Harker and Cohen (1972) showed that batch-freeze desalination could produce brackish water with only seven percent of the original salinity after two months and less than 500 mg/l dissolved solids after a second freezing. The total costs, excluding delivery, were about $30/1,000 gallons. Batch-freezing systems need much less maintenance than reverse osmosis or distillation systems. After the pumping operations are completed, no additional manpower, equipment, or fuel is required as the salt migrates out of the ice. The other systems contain sophisticated switches, relays, and valves. The freezing system does require more initial capital, however, because of the cost of the large storage tank to hold the melt water.

Unfortunately, other types of desalination systems are probably not feasible in small villages because of their complexity, energy requirements, and expense. However, desalination methods could be useful for industry. Industrial workers would presumably have the skills to maintain and operate such a plant, and industrial overhead costs might absorb operational expenses. Elsewhere in the United States, the energy costs for treating seawater are much larger than those for treating surface and groundwater sources where the dissolved solids levels are not excessive. For example, a six-effect evaporator or a secondary-refrigerant freezing system would require 60 kwhr/1,000 gallons (Iammartino 1975) compared to 8 kwhr/1,000 gallons for treating municipal wastewater by physical-chemical means (Garber et al. 1975). The latter is presumed to be on the same order as water treatment.

Waste Treatment

Sewage treatment methods used for wastewater purification range from some physical-chemical operations to biological processes or combinations of both. Physical-chemical operations are not normally used in cold regions because of the operating complexity and the unavailability of the required chemicals. Alyeska operates physical-chemical plants in some of its camps, and even they found it took a long time to get the facilities operating properly and that costs were very high (Alyeska Pipeline Service Company 1975). Chemicals, particularly chlorine, are common disinfectants in cold regions (Alter 1969 a), but at temperatures near freezing, high concentrations and extremely long contact times are required. Coagulation may be enhanced by low temperatures, but sedimentation and filtration are retarded because of increased viscosity. Skimming tanks for the removal of grease and oil operate more efficiently at cold temperatures; however, screening operations can be hampered by icing and the formation of frazil ice in the channel following the screen unless the screen is heated.

A variety of biological treatment processes is used in northern regions. In order of increasing complexity, they are: septic systems, facultative lagoons, aerated lagoons, rotating biological discs, and the activated sludge process. Cold temperatures retard anaerobic processes most significantly (Alter 1969 a), so septic systems and facultative lagoons usually need to be heated. Septic tank-leach field combinations can work well under certain conditions (Chanlett 1973). In the Arctic, such a combination may be suitable if permafrost-free gravel can be used for a drain field. Unfortunately, such gravel areas normally occur near bodies of water that the leachate would pollute or the gravels are thawed only during summer.

Reduction of BOD (biochemical oxygen demand) in a facultative pond with an algal surface layer may approach 80 percent during certain times of the year (Tchobanoglous 1975). Efficiency drops drastically, however, during cold months and during periods of rising sludge or algal blooms in the summer. To maintain efficiency, wastes must be stored during the winter, either in holding tanks or in the pond under the ice. In addition, it is not always possible to construct suitable ponds in permafrost regions.

Aerated lagoons are also inoperative during arctic winters and are slightly more complex than facultative ponds because they need oxygen. Uusually, air is injected through perforated tubes which oxygenates the surrounding water and helps mix the contents of the lagoon. Because oxygen decomposes wastes more rapidly, aerated lagoons provide higher BOD removals than facultative lagoons for given detention times, but they are subject to more operational problems such as clogging of the diffusers. Of the 17 aerated lagoons now operating in Alaska (Reid 1975), only the one at Palmer consistently meets 1977 EPA standards.

Rotating biological filters and the activated sludge process are two indoor biological processes already used today in the Arctic. Extended aeration is simply a modification of the latter. The chamber for biological activity in any of these is followed by a clarifier where the solids settle and form a sludge. The clarifier effluent is discharged after chlorination, but most of the sludge is recycled to the aeration or biological-disc tank to provide a "seed" for the bacterial cells. The half-submerged circular discs are filled with bacterial matter and aerate as they rotate. For the first two processes about two to six hours is required in the aeration tank or 18 to 36 hours for extended aeration. The BOD removal efficiency for any of these processes can easily exceed 90 percent if properly operated (Tchobanaglous 1975). When operated in a heated building, they should perform as well as those in temperate climates. Furthermore, McKinney (1975) maintains that a properly operating system can produce an effluent having 5-10 mg/l suspended solids without requiring a filter.

Incinerators have been tried at Wainwright and Barrow, but neither proved satisfactory. They have been used successfully for solid waste disposal at several pipeline camps with proper maintenance.

More information is needed on pathogen movement and decay in permafrost soils. Alter (1969 a) pointed out that there is little quantitative knowledge of these phenomena, even though all sanitary systems presently planned or built in the Arctic discharge wastes into the soil, and the biological and physical state of many cold regions soils precludes the use of normal drainage practices for sewage disposal.

Murphy and Greenwood (1971) stated that pathogens survive almost indefinitely in the frozen state. However, the superpermafrost layer is not frozen all the time, and bacteria do decay to some extent during each thaw period. Several studies (Dyer et al 1945, Caldwell and Parr 1973, Chanlett 1973) performed in a warmer environment revealed that coliform bacteria move less than 35 feet, even when a waste disposal pit was in direct contact with groundwater. The soils were sand loams with some clay, and the groundwater flow was one to three meters per day. With no groundwater flow, coliform bacteria were never found more than five feet from a pit. These and other tests should be performed in permafrost soils. To know the distance that the water supply would be safe from sewage effluent or solid waste leachate is vital information for planning facilities.

Education in sanitary and personal hygiene and improved medical care also contribute to better public health. Mitchell (1976) noted that health improved immensely at Fort Yukon when the people combined sound sanitation practices with the installation of an infiltration gallery at a watering point instead of drawing water directly from the Yukon River. Ryan (1973 a) pointed out that mortality rates for waterbourne diseases are reduced even further when water distribution and sewage collection systems were provided in addition to a watering point. This kind of information can help villagers decide which water and waste disposal system will give them the greatest benefits in convenience and better health.

Heated sanitation facilities will significantly raise the total operation and maintenance costs, so salvaging and using waste heat is important. Ryan

(1973b) pointed out that a 60 kw diesel generator operating at full capacity has recoverable waste heat of 270,000 BTU/hour in cooling water and exhaust gases. Additionally, buildings and utilidors built on permafrost must be properly insulated so they will not thaw the permafrost and collapse. Such considerations may also prevent the choice of a lagoon as a treatment process.

Technological suitability is meaningless if the community cannot adequately finance and maintain the facility. Both Buzzell (1974) and Ryan (1973a) suggested that the sophistication of a system should match the community's ability to operate and maintain it. For example, the advantage of more effective treatment in an activated sludge system as compared to a septic system may be lost if it is not properly maintained and operated. The cost of a facility includes initial capital, maintenance, and operation. If a village only has to pay for operating costs, it might choose a different system than if it had to pay for total costs. Ryan (1973a) pointed out that piped water distribution and sewage collection systems cost more to construct but they are more convenient and less expensive to operate than haul-type operations. Alyeska Pipeline Service Company (1975) stated that the operating costs for its sewage treatment plants amount to 2.9¢/gallon exclusive of fuel and original capital. If a village used a similar system and had a moderate sewage discharge of 20 gpcd (gallons per capita per day), the operating costs would exceed $100/month/family. Statistics like this may encourage water conservation practices.

FORESEEABLE DEVELOPMENTS IMPACTING WATER AND LAND USE ALLOCATIONS

Regional Background

Industrial development and economic growth in the North Slope Borough will depend on an array of existing facts and potentials and cause new demands on land and water resources. Facts about the existing scene provide a base for consideration of change. The following list offers a brief description of activities in the area.

1. A viable borough government exists with areawide powers.
2. Eight predominantly Inupiat villages with a total population of 3,500 are all being affected by external forces. Each community wants positive change and as little negative impact as possible. In overall terms they are adequately handling their own affairs in conjunction with borough and Arctic Slope Regional Corporation assistance.
3. The interim conveyance of nearly 4,000,000 acres of village and regional corporation lands under ANCSA has taken place. The Inupiat owners are managing their own economic activity, resources, and lands. The governmental processes leading to final conveyance are proceeding as well as can be expected.
4. The development of Prudhoe Bay oil field facilities is on schedule.
5. Construction of the trans-Alaska oil pipeline is nearly complete. Oil should be flowing by mid-1977.

6. Legislation has been passed which changed the name of Naval Petroleum Reserve No. 4 (NPR No. 4) to the National Petroleum Reserve in Alaska (NPRA) on June 1, 1977, and jurisdiction will switch from the Department of the Navy to the Department of the Interior. The bill also requires that South Barrow gas field management includes consideration of local interests, and it instructs the Department of Interior to fully explore the reserve for oil and gas, and conduct a broad-based land use study of the reserve in conjunction with the State of Alaska and local Inupiat interests in the North Slope Borough and the Arctic Slope Regional Corporation.

7. Oil and gas exploration within Zone A of Naval Petroleum Reserve No. 4 is nearing completion and plans are being readied for Zone B exploration.

8. An aggressive program of environmental research is taking place in the Beaufort Sea to assess the potential for outer continental shelf oil and gas development. The oil industry has already taken the initial steps towards exploration drilling in nearshore waters covered by existing state leases.

9. A decision on the routing of and authorization for a natural gas pipeline from the Prudhoe Bay field is pending Federal Power Commission and presidential recommendation and congressional decision.

10. This summer Congress will discuss recommendations now being readied for national conservation system land dedication affecting the borough.

11. A landmark federal/state jurisdictional case (State of Alaska vs Warner) on the navigability of the Colville River and location of the boundary of NPR No. 4 is before the U.S. District Court.

These situations, all of which have come to pass in only the last five years, collectively give a foundation for the following general regional development scenario for the next five years.

Regional Developments

Major construction activity will shift away from the Prudhoe Bay oil field, pipeline, and haul road as the line becomes operational. Activity will most probably center along the Brooks Range foothills with a base at Umiat and along the Point Lay coastal plain about 20 miles away from Point Lay village.

The first of these areas is large, but oil and gas exploration activity will probably be intensive. Exploration drilling will take place on conveyed lands of the Arctic Slope Regional Corporation, and initial general geophysical surveys will begin in Naval Petroleum Reserve No. 4 followed by exploration drilling. Base activities will probably be concentrated at Umiat at first but one or more other base camp communities will ultimately be located on Arctic Slope Regional Corporation lands or upon yet-to-be selected state lands along the foothills. As NPR No. 4 exploration proceeds west from Umiat, other camp communities are likely to develop within the federal reserve.

Exploratory oil and gas drilling will also occur on Arctic Slope Regional Corporation lands near Point Lay, but camps will probably not be constructed adjacent to the existing community.

These two areas will be the major areas of industrial activity in the foreseeable future.

Major oil or gas activity will probably not occur onshore between Prudhoe Bay and Barrow. Offshore, until a Beaufort Sea lease sale takes place and an exploration program announced, it is impossible to predict where or what the landward impacts will be. Operational activity will continue at Prudhoe Bay, which will also continue to support offshore exploration in the area. Nuiqsut should not be directly impacted in the foreseeable future.

The Federal Power Commission, the President, and Congress will soon decide the route of a proposed pipeline to transport natural gas from the Prudhoe Bay fields to markets in the lower 48. Odds are against the route which would pass through the Arctic National Wildlife Range near the village of Kaktovik. However, in the next decade energy demands are likely to open the Arctic National Wildlife Range to oil exploration in the Marsh Fork anticline area southwest of Kaktovik. Kaktovik can expect some impact when and if this occurs.

As for the Beaufort Sea coast, little or no industrial development can be projected for the lands along the Chukchi Sea coast as far west as Icy Cape. Barrow will continue to grow as a regional center for governmental services, scientific programs, and regional trade. The prospects for moderate cost energy, water, or construction materials (i.e., gravel) to support the growth of Barrow beyond a population of 3,000 to 4,000 are indeed bleak. The Barrow gas field has only limited reserves at present production levels. This situation may be alleviated by the recent discovery of additional large gas reserves in that area. A second possibility would be for Barrow to utilize energy produced from coal development in the Meade River coal district near the village of Atkasook.

If cost/benefit and technological analyses indicate that coal development near Atkasook is feasible, the village would certainly be affected. Besides social change, the demand for water for domestic purposes and industrial processing would rise dramatically. Coal mining and processing adversely affect both groundwater and surface water quality. Proper land and water use planning would be critical.

Coal energy production from the Kuk River district coals near Wainwright is possible but unless highly subsidized by government research and development funds, the prospect of this development appears less than at Atkasook.

The village of Anaktuvuk is in a similar marginal economic position. Modest economic growth could occur, however, if oil or gas reserves are found on Arctic Slope Regional Corporation lands between the mountain front and the Colville River. Energy resources for local use might be transported to the village at relatively modest cost, and some new jobs would be available. Also, it appears likely that Congress will authorize a national park in the central Brooks Range. Direct economic and social effects on the community will depend, to a large degree, on how much involvement the residents decide they want. Cooperative land management agreements between the village and regional corporations and the federal government could be worked out, and the village could provide land, management, and capital for tourist facilities. In any event the village will remain small, but if water and land allocations are adequately planned, sufficient resources exist for modest growth.

Industrial activity will probably by-pass Point Hope village, even if economic reserves of oil and gas are discovered along the Chukchi Sea coastal plain or in the Brooks Range foothills. Transportation from either of these areas would be directed towards the sea through the Ogotoruk valley or a western mountain pass to the Kobuk valley. The village might indirectly benefit from increased employment opportunity.

Figure 17 reflects the previous industrial forecast. For each village projected industrial development or internal growth impact is indicated as low, moderate, or high. Similarly, the adequacy of land and water resources to meet industrial or growth impact is shown as poor, fair, or good. In summary, future industrial development in the North Slope Borough will probably not occur near existing villages.

Figure 17

Future Developments

	Industrial or Growth Impact			Adequacy of Land Space and Water Resources for Expected Impact					
				Land Space			Water Resources		
Village	Low	Moderate	High	Poor	Fair	Good	Poor	Fair	Good
Anaktuvuk		X				X			X
Atkasook		X				X		X*	
Barrow		X				X	X		
Kaktovik	X				X			X	
Nuiqsut	X					X		X	
Point Hope	X					X		X	
Point Lay	X					X		X	
Wainwright	X					X			X

*will need careful protection

APPENDIX I

DRINKING WATER STANDARDS

Parameter	Recommended Maximum Concentration (mg/l)	Detrimental Effects if Present in Greater Concentration
Color (platinum cobalt units)	15	
Iron	0.3	Staining of laundry, dishes and plumbing fixtures; undesirable taste
Chloride	250	Salty taste in water; corroding of plumbing fixtures
Fluoride	0.9-1.7	Mottling and deformation of teeth
Nitrate	45	Hazardous to infants
Sulfate	250	Laxative effect on new users
Total Dissolved Solids (includes calcium, magnesium, potassium, sodium, bicarbonate)	500	

Source: U.S. Public Health Service, 1962.

APPENDIX II

GLOSSARY OF WATER AND WASTEWATER TREATMENT TERMS

Aeration: supplying oxygen to increase biological decomposition of wastes.

Aerated Lagoon: waste pond with biological decomposition augmented by aeration.

Activated Carbon: removal of organic materials by carbon adsorption.

Activated Sludge: aerated bacteria-containing sludge to remove organic materials.

Biochemical Oxygen Demand (BOD): measure of oxygen required to decompose wastes.

Biological Treatment: purification using microorganisms to decompose wastes.

Chemical Treatment: purification using chemical additives to decompose wastes.

Coagulation: clumping together of solids by addition of chemical additive (generally lime).

Coliform Bacteria: indication of biological contamination, including fecal wastes.

Desalination: reduction of total dissolved solids (salts).

Disinfection: removal of disease-carrying organisms and odors, generally with chlorine.

Distillation: heating liquid to vapor or steam to remove impurities.

Effluent: treated wastewater.

Electrodialysis: salt removal using electricity (also ion exchange, reverse osmosis).

Facultative Lagoon: waste pond with biological decomposition without oxygen.

Filtration: separation of solid and liquid wastes.

Leachate: water percolated through dump or landfill.

Pathogen: disease-carrying organism.

Physical Treatment: purification using mechanical means to decompose wastes.

Primary Treatment: removal of sediment.

Secondary Treatment: removal of organic material.

Sedimentation: settling out of solid wastes.

Sludge: solid matter that settles out which must be disposed of (incineration, landfill).

Source: U.S. Federal Water Pollution Control Administration, 1969.

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Economic Analysis of Alaskan Natural Gas Transportation Alternatives

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North Slope Borough: Issues Overview

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Alaska Regional Energy Resources Planning Project - Phase I
Alaska Royalty Natural Gas Market Study
Energy Systems in Arctic and Sub-Arctic - Phase I

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Alaska Environmental Plan
Alaska Water Assessment
Emergency Water Supply Plan
River Basin Water Quality Management Planning
State Solid Waste Management Plan
Statewide Waste Treatment Management Planning
Village Safe Water Act

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Beaufort Sea Estuary Fisheries Study
Investigation of Public Fishing Access and Related Classification

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Freshwater and Coastal Fish Studies in the Eastern Arctic

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Water and Wastewater Feasibility Study for Nuiqsut, Alaska

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Environmental Report, Alcan Pipeline Project, Alaska

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Evaluation of Fish and Wildlife Habitat Changes along the Trans-Alaska Oil Pipeline

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Technical and Economic Feasibility - Surface Mining Coal Deposits - North Slope, Alaska

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Point Hope Water Supply Evaluation

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Fuels Availability System
Mineral Studies of d-2 Lands in Alaska under the Alaska Native Claims Settlement Act
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National Water Assessment

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Community Systems Management (Alaska Village Demonstration Project)

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Biological Survey of Kaktovik Village Selection
Effects of the Trans-Alaska Pipeline on Arctic Slope Waterbirds and Their Wetland Resources

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Anaktuvuk Pass Phosphate and Oil Shale Resources
Arctic Environmental Studies Program
Arctic Reconnaissance of Aquatic Invertebrates
Arctic Water Resources and Environmental Studies
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Cooperative Snow Survey Program for Alaska
Soil Survey

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Compilation of Cold Climate Oil Spill Research and Technology
Reclamation of Land Damaged by Oil Spills
Revegetation Research for Proposed Natural Gas Pipeline
Tundra Rehabilitation Research

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Climate of Alaska's North Slope
Precipitation Gauges
Snow Fences
Study of Windblow and Drifted Snow on the Arctic Slope of Alaska

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Effects of Road Construction upon Nearby Lakes on Alaska's North Slope
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Factors Affecting Cost of Mining in Alaska
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Development of A Study Plan for the Socio-Economic Studies Associated with Alaskan OCS Development

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The Human Ecology of Three Arctic Rural Communities and Implications for Change

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Native Cultures of Alaska

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Effects of Abiotic and Biotic Factors and Canopy Structures and Carbon Assimilation in Tundra Plant Forms

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Radiation Ecology Studies of Northern Alaska (Anaktuvuk Pass)
Ecological Investigations of Alaskan North Slope Oil Field Development

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Dynamic and Ecological Role of Sestonic Detritus in Alaskan Arctic Lakes

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Vegetation Mapping at Prudhoe Bay, Alaska
Gradient Analysis of the Diversity and Production of Arctic Tundra Vegetation

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Vegetational Succession along Moisture and Climatic Gradients in the Arctic Tundra

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Zooplankton Species Distribution and Production in Alaskan Arctic Lakes

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Arctic Tundra Bluff Coasts
Colville River Delta Study

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Aquatic Ecosystem Modeling and the Role of Bacteria in Alaskan Arctic Lakes
Effect of Oil on Tundra Thaw Ponds

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Controls of Zoobenthos in North Slope Lakes - Fish Predation in Nitella Bed

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The Role of Zooplankton Grazing in Alaskan North Slope Tundra Lakes

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Soil and Soil Organic Characteristics of Selected Tundra Environments
Soil Mapping at Prudhoe Bay

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Primary Production Modeling and Water Relations in Arctic Tundra Plants
Dynamics of Arctic Tundra Ecosystems

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Investigation of Oil Persistence in Tundra and Its Impact on the Belowground Arctic Ecosystem

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Gravel Removal Studies in Selected Arctic and Subarctic Streams in Alaska