Overview of Environmental and Hydrogeologic Conditions at Bethel, Alaska

By Joseph M. Dorava and Eppie V. Hogan

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CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATED WATER-QUALITY UNITS

Multiply	By	To obtain
millimeter (mm)	0.03937	inch
centimeter (cm)	0.3937	inch
meter (m)	3.2808	foot
kilometer (km)	0.6214	mile
square kilometer (km^2)	0.3861	square mile
meter per kilometer (m/km)	5.2801	foot per mile
liter (L)	0.2642	gallon
liter per second (L/s)	15.85	gallon per minute
liter per day (L/d)	0.2642	gallon per day
cubic meter per second (m^3/s)	35.31	cubic foot per second
degree Celsius (°C)	$°F = 1.8 \times °C + 32$	degree Fahrenheit (°F)

Sea level:

In this report "sea level" refers to the National Geodetic Vertical Datum of 1929--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

Abbreviated water-quality units used in this report:

mg/L, milligram per liter
mL, milliliter

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Abstract

The city of Bethel is on the alluvial plain of the Kuskokwim River in southwestern Alaska. It has long cold winters and short summers. Bethel obtains its drinking water from a deep aquifer underlying permafrost. Surface spills and disposal of hazardous materials combined with possible annual flooding of the Kuskokwim River could affect the quality of drinking water. Alternative drinking-water sources are available from local lakes, streams, the Kuskokwim River, and possible undiscovered aquifers. The Federal Aviation Administration owns or operates airway support facilities in Bethel. They wish to consider the severity of contamination and the current environmental setting when evaluating options for compliance with environmental regulations at their facilities. This report describes the ground- and surface-water hydrology, geology, climate, vegetation, soils, and flood potential of the area surrounding Bethel.

INTRODUCTION

The Federal Aviation Administration (FAA) owns and (or) operates airway support and navigational facilities throughout Alaska. At many of these sites, fuels and potentially hazardous materials such as solvents, polychlorinated biphenyls, and pesticides may have been used and (or) disposed of. To determine if environmentally hazardous materials have been spilled or disposed of at the sites, the FAA is conducting environmental studies mandated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or "Superfund Act") and the Resource Conservation and Recovery Act (RCRA). To complete these more comprehensive environmental studies, the FAA requires information on the hydrology and geology of areas surrounding the sites. This report, the product of compilation, review, and summary of existing hydrologic and geologic data by the U.S. Geological Survey, in cooperation with the FAA, provides such information for the FAA facility and nearby areas at Bethel, Alaska. Also presented in this report is a description of the history, socioeconomics, and physical setting of the Bethel area.

BACKGROUND

Location

Bethel is in southwestern Alaska (fig. 1) at lat 60°48" N. and long 161°45" W., on the banks of the Kuskokwim River approximately 645 km west of Anchorage. The city is in the southeastern part of the Yukon-Kuskokwim Coastal Lowland, a large delta formed by the Yukon and Kuskokwim Rivers. The FAA facilities in Bethel are concentrated at the municipal airport about 3.5 km west of the city. A detailed list of these facilities can be found in a report by Ecology and Environment, Inc. (1992).

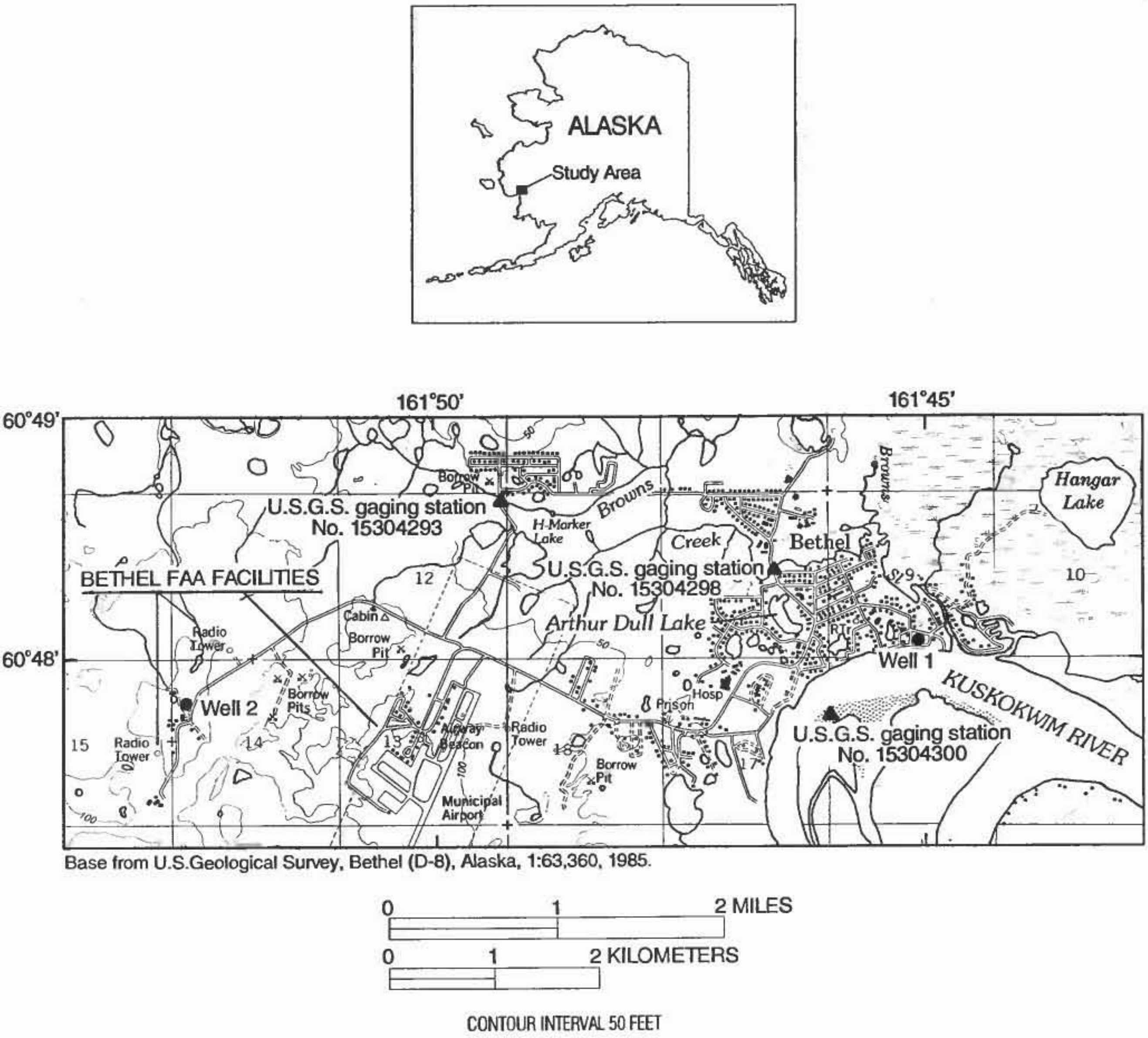

Figure 1. Location of Bethel, Alaska, and Federal Aviation Administration facilities.

History and Scioeconomics

At the time of first western contact, the Bethel area was occupied by the Yupik Eskimos who utilized the Kuskokwim River and its tributaries for subsistence fishing. A Moravian mission was established in 1885 and Bethel has since evolved into a transportation and commercial center for the lower Yukon and Kuskokwim Rivers area, as well as for most of southwestern Alaska. Bethel residents maintain some traditional Yupik life-styles: 70 percent of the population engages in subsistence food gathering and 40 percent speaks or understands Yupik (Darbyshire and Associates, 1979). Principal subsistence foods gathered in the area are fish, berries, and game birds.

The population of Bethel has increased by more than 4,000 people during the last 40 years. In 1950, the population was 650; in 1979 the population was about 3,900; and in 1990 it was 4,674 (Darbyshire and Associates, 1979; U.S. Bureau of Census, 1991). According to the 1990 census, 2,986 people are American Indian, Eskimo, or Aleut; 1,551 people are Caucasian, and the rest are of Asian, Pacific Islander, Black, or Hispanic origin. According to Harry Parsi (Bethel Public Works, written commun., 1994) the population of Bethel in June 1994 was 5,023 people.

Bethel is located approximately 100 km upstream from the Bering Sea and has become a transportation center for the region. Barges, mostly from Seattle and the Anchorage area, deliver food, fuel, construction supplies, and miscellaneous goods to the city port where they are distributed throughout the region by boat and plane.

In an area with few roads, the Kuskokwim River acts as a river highway system connecting Bethel with 48 other villages (U.S. Army Corps of Engineers, 1982). During the summer months, the river is used by boats and during the winter months, it becomes a frozen highway for dog-sleds, snowmobiles, and automobiles. The Bethel airport ranks third in Alaska for total flights and plays a key role in public transportation for the entire southwest region of Alaska (Darbyshire and Associates, 1979).

During and immediately following World War II, the Civil Aeronautics Administration (predecessor to the FAA) operated the Bethel Airport. At that time, the airport was on the east side of the Kuskokwim River. Frequent flooding caused the airport to be relocated in the early 1960's to the west side of the Kuskokwim River, about 3.5 km west of the city (fig. 1). The airport is currently operated and maintained by the Alaska Department of Transportation and Public Facilities. A detailed account of FAA owned, leased, or transferred properties in or near Bethel and a listing of suspected sources of contamination near these facilities can be found in an environmental compliance investigation report by Ecology and Environment, Inc. (1992).

PHYSICAL SETTING

Climate

Bethel lies in the transitional climate zone, where maritime conditions prevail during the summer and continental conditions dominate during the winter (Hartman and Johnson, 1984). Little precipitation and low humidity are typical in the long cold winter, while cloudy humid conditions characterize the short summer. The mean annual temperature is -1.6 °C, but temperatures range from a July mean maximum of 19.2 °C to a February mean minimum of about -18.4 °C (Leslie, 1989). Mean annual precipitation is about 430 mm, with most rainfall occurring in August and September. Approximately 1,300 mm of snow falls annually. Mean monthly temperature, precipitation, and snowfall are summarized in table 1.

Table 1. Mean monthly temperature, precipitation, and snowfall for the period 1923 to 1987, Bethel

[Modified from Leslie (1989); °C, degree Celsius; mm, millimeter]

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Temperature (°C)													
Mean maximum	-10.6	-4.9	-1.0	4.1	12.6	17.7	19.2	17.8	13.6	5.3	-0.5	-5.9	5.6
	(Record maximum, 30.0 °C, July 1951)												
Mean minimum	-18.0	-18.4	-15.4	-9.4	-0.1	5.8	8.6	8.0	3.4	-4.4	-11.2	-17.6	-5.7
	(Record minimum, -43.3 °C, January 1973)												
Mean	-14.1	-13.7	-10.9	-4.1	4.6	10.8	12.6	11.5	7.3	-0.8	-8.1	-13.9	-1.6
Precipitation (mm of moisture)	20.6	18.0	20.3	16.5	21.1	32.8	55.4	92.7	65.5	37.6	24.9	24.1	429.3
Snowfall (mm)	185.4	167.6	213.4	142.2	45.7	2.5	0	0	2.5	101.6	195.6	228.6	1,285.2

Vegetation

Vegetation on the wet tundra near Bethel consists of sedges, sphagnum moss, Labrador tea, dwarf birch, and other low-growing tundra shrubs (Hinton and Girdner, 1966: Viereck and Little, 1972). Shrub thickets consisting of dense growths of alder, willows, and resin birch are found in some areas near Bethel, primarily along the Kuskokwim River. South of Bethel, where the land slopes toward the Kuskokwim River, the vegetation is moist tundra which consists of sedges, scattered willows, and dwarf birches (Viereck and Little, 1972).

Bedrock Geology

The geology of the Bethel area has been described by Spurr (1900), Maddren (1915), Mertie (1938, 1940), Rutledge (1948), Payne (1955), Cady and others (1955), Coonrad (1957), and Hoare and Coonrad (1959). Bedrock exposures in the Bethel area lie south and east of the city in the Kuskokwim and Kilbuck Mountains. The mountains run in a north-northeasterly direction approximately 65 km southeast of the city. The bedrock exposures consist mainly of volcanic and sedimentary rocks (Hoare and Coonrad, 1959). Little data are available on the depth to bedrock in the Bethel area. A Pan American Petroleum Company well, drilled approximately 26 km west of Bethel, reported permafrost to 107 m, a fresh-water zone from 107 to 143 m, and bedrock starting at 143 m below the land surface; however, two Department of Energy test wells drilled in 1980 in Bethel penetrated only unconsolidated deposits to depths of approximately 230 m below the land surface (appendix 1).

Surficial Geology and Soils

Bethel is on the alluvial plain of the Kuskokwim River. Major surficial deposits surrounding Bethel are Quaternary-age alluvium consisting of mud, silt, sand, gravel, and boulders, intermixed with wood, peat, and other organic material (Hoare and Coonrad, 1959). The alluvial plain is bounded on the west by a terrace escarpment of older silt and sandy silt Yukon-Kuskokwim delta deposits.

Waller (1957) describes the lithology from well 1 (fig. 1), a 119-m-deep well drilled in the flood plain near Bethel. A generalized lithologic log of this well (fig. 2) shows that the soil was frozen to a depth of about 115 m. A thawed coarse-gravel aquifer yielded water between 116 m and the bottom of the well at 119 m. A generalized lithologic log from well 2 (fig. 2), a 202-m-deep well drilled in the delta deposits near Bethel (fig. 1), indicates permafrost to a depth of about 184 m below land surface. A silty sand and pebble aquifer underlies the permafrost (Feulner and Schupp, 1964).

The soils of the Bethel area are similar to those found along Alaska's western coastal plain and deltas (Rieger and others, 1979). The upland area east of Bethel is mantled with wind-blown silt; however, exposures of stratified sand and alluvial silt sediments deposited by the Yukon and Kuskokwim Rivers are present. The silty soils are susceptible to frost and are generally saturated over shallow permafrost at depths ranging from 12 to 75 cm below land surface (Rieger and others, 1979; Hinton and Girdner, 1966).

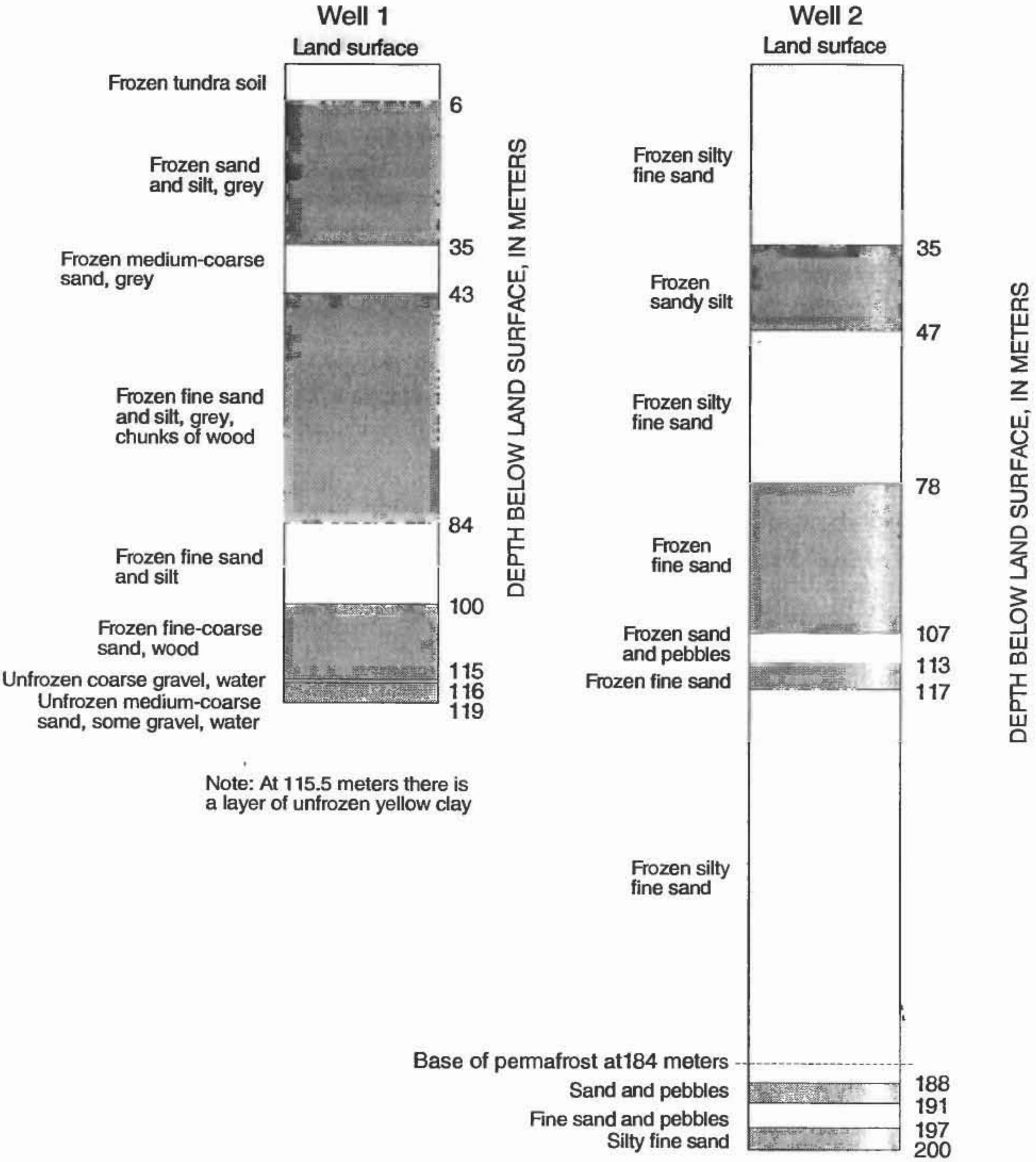

Figure 2. Generalized lithologic logs for well 1 and well 2 near Bethel. (See figure 1 for well locations.) [Well 1 modified from Waller (1957); well 2 modified from Feulner and Schupp (1964)].

Six principal soil series have been identified and mapped in the Bethel area (Hinton and Girdner, 1966). Soil identified as the Kuskokwim-Kwethluk complex makes up about 37 percent of the mapped area. This soil is found in small areas on low knolls, on convex slopes bordering drainages, and adjacent to drained thaw lakes. Kuskokwim silt loam accounts for 36 percent of the mapped area. This soil consists of poorly drained silty soils having shallow permafrost tables and is primarily found on the wet tundra. Susitna fine loam accounts for about 12 percent of the mapped area. This well-drained soil is found on alluvial plains bordering the Kuskokwim River. The three other soil groups—Napaishak, Tuluksak, and Tupuknuk— occupy only 14 percent of the mapped area and primarily occur along the shores of small lakes and streams (Hinton and Girdner, 1966).

The Bethel area is near the southern border of the continuous permafrost zone (Ferrians, 1965). The city and most of the area west of the Kuskokwim River appear to be underlain with permafrost; however, the area east of the river and isolated areas to the west appear to be free of permafrost to a depth of 60 m (Waller, 1957). In isolated areas west of the river, thawed zones exist where there is or was an overlying body of surface water. These thawed zones may have been created by a tributary of the Kuskokwim River within comparatively recent times (Feulner and Schupp, 1964) (fig. 3).

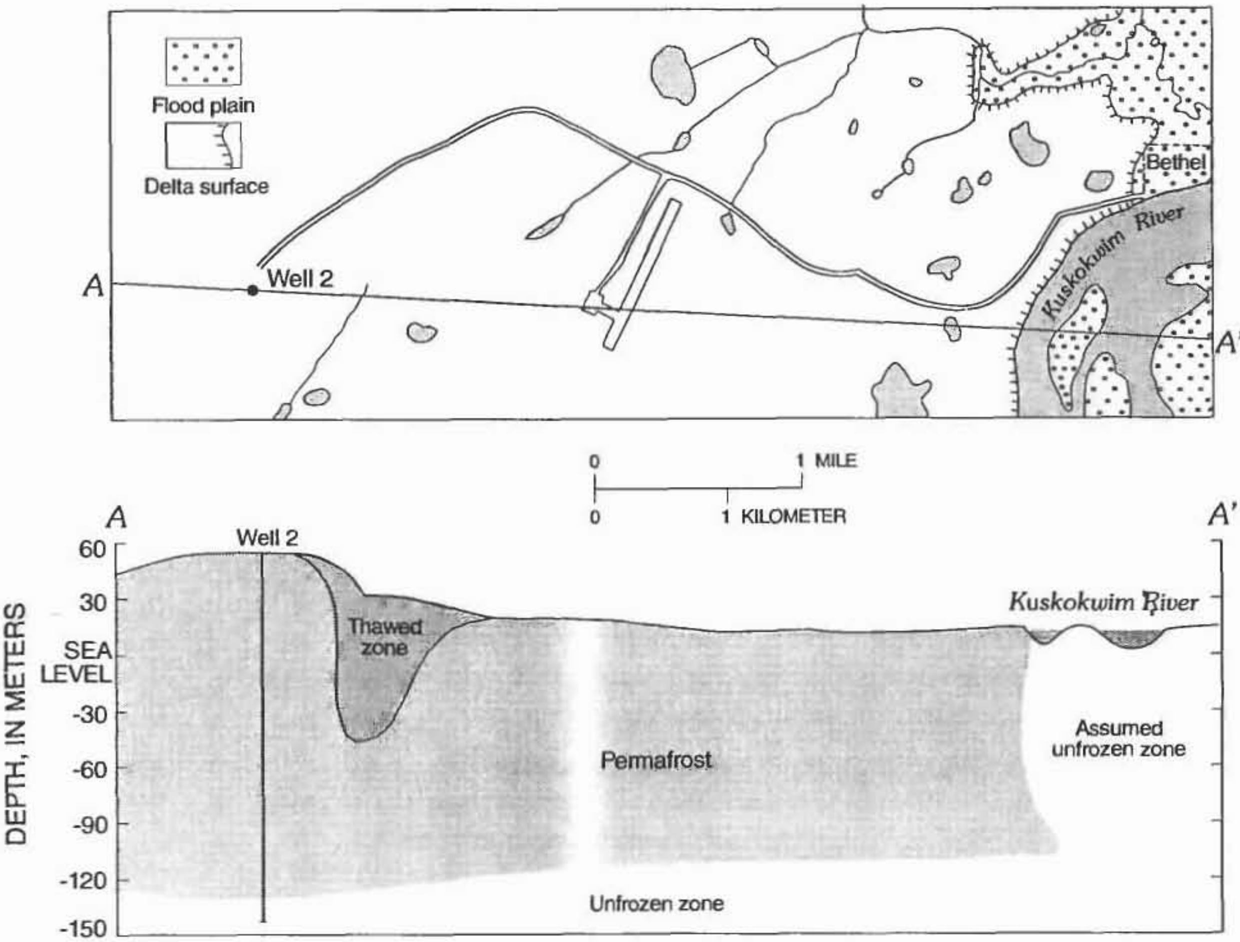

Figure 3. Location of well 2 near Bethel showing approximate thickness of permafrost (modified from Feulner and Schupp, 1964).

HYDROLOGY

Surface Water

The Kuskokwim River is the principal fresh-water body near Bethel and flows from northeast to southwest along the southern edge of the city. The river stage is influenced by diurnal tidal backwater effects. Corresponding with the normal flood and ebb flow, velocities in the river range from 0.25 to 0.67 m/s (Lanning, 1987). Despite tidal influences, saltwater does not infiltrate into areas near Bethel. Surrounding the city in all directions are numerous small lakes, ponds, and marshes that are characteristic of the Yukon-Kuskokwim Coastal Lowlands.

Daily flow of the Kuskokwim River near Bethel has not been measured; however, from 1951 to 1993, data were collected at an upstream location: Kuskokwim River at Crooked Creek (USGS gaging-station No. 15530400). This gaging-station is approximately 225 km northeast of Bethel and has a drainage area of about 50,000 km^2 (U.S. Geological Survey, 1994). Mean monthly flow data for the Kuskokwim River at Crooked Creek are given in table 2. The mean monthly flow of the river changes significantly from summer to winter. Peak flows during spring breakup in May and June average about 2,300 m^3/s. Fall rains in August and September also cause an increase in discharge from the summer low in July. Flow in the river drops rapidly after freeze-up to a winter low of about 300 m^3/s in March (U.S. Geological Survey, 1994).

Table 2. Mean monthly flows for the water years 1985-93, Kuskokwim River at Crooked Creek (USGS gaging-station No. 15530400)

[Values in cubic meters per second]

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
370	330	300	390	2,200	2,400	1,940	2,150	2,000	1,220	590	430

The mean monthly flow of the Kuskokwim River near Bethel has been estimated from the record at Crooked Creek. During the open-water months from May to September, the estimated mean flow of the Kuskokwim River near Bethel is about 1,700 m^3/s and during winter months, from November to March, mean flow is about 425 m^3/s (U.S. Army Corps of Engineers, 1982). The Kuskokwim River drains an area of about 111,000 km^2 upstream from the city of Bethel (U.S. Army Corps of Engineers, 1968). The Kuskokwim River typically freezes in late October or early November and breaks up in May. Although the river is important to residents of Bethel, it has also caused damage to the community by flooding and erosion of the riverbanks.

Browns Creek, a small tributary stream draining the area north and west of Bethel, flows from northeast to southwest between the city and the airport (fig. 1). This stream drains an area of about 27 km^2 upstream from USGS gaging-station No. 15204298, Browns Creek at Bethel, where peak flow discharges have been collected from 1985 to 1993. The peak discharge for this period was 9.9 m^3/s on May 7, 1985. In the 1993 water year, rainfall runoff on September 10 caused a maximum discharge of 6.4 m^3/s, and snowmelt runoff on April 22 caused a discharge of about 3.6 m^3/s (U.S. Geological Survey, 1994).

Another gaging-station, Browns Creek near Bethel (USGS gaging-station No. 15304293, fig. 1), is approximately 3 km northwest of Bethel and has a drainage area of 12.4 km^2. For the period 1985-93, mean monthly flows from April to October are all less than 0.4 m^3/s and are summarized in table 3 (U.S. Geological Survey, 1994). The greatest mean flows on Brown's Creek are observed during spring breakup when water is abundant from snowmelt. Little rainfall occurs during June and July when summer low flows are often less than 0.08 m^3/s. Rainstorms in late August and early September are the source of increased flow during the fall, and the creek is believed to freeze completely during winter months. Discharge measurements were not obtained from November to March.

Table 3. Mean monthly flows for the water years 1985-93, Browns Creek near Bethel (USGS gaging-station No.15304293)

[Values in cubic meters per second]

April	May	June	July	August	September	October
0.248	0.362	0.077	0.020	0.100	0.183	0.074

Numerous sloughs and small lakes in meander scars near Bethel (fig. 1) indicate that the Kuskokwim River has changed its course over time. Hangar Lake, approximately 1 km^2 in size, is about 3 km east of Bethel and is used for a seaplane anchorage. H-Marker Lake, approximately 0.5 km^2 in size, is about 2 km west of Bethel immediately north of the airport.

A gradual topographical gradient of approximately 10 m/km is present between the Bethel Airport and the city of Bethel (fig. 3). The northeasterly slope generally causes runoff to flow towards tributaries that drain to the Kuskokwim River. Little data are available to determine the degree to which runoff is infiltrating the aquifer, but the quantity of surface water in the immediate area and the presence of extensive permafrost indicate that infiltration is minimal.

Floods

Bethel is flooded to some extent annually and is considered to have a high flood hazard (U.S. Army Corps of Engineers, 1982 and 1993a). Although flooding during spring breakup is caused primarily by ice jams, late summer and early fall rains can also be a source of flooding (U.S. Army Corps of Engineers, 1987). Autumn rain falling on saturated soils and areas where permafrost exists, runs off rapidly causing a subsequent rapid rise in the river (U.S. Army Corps of Engineers, 1987).

Ice-jam flooding is the predominant type of flooding in the Bethel area. This type of flooding occurs during spring breakup, when ice begins to move in the river. As the ice breaks up, it flows downstream until its movement is blocked. The blockage restricts water flow which produces a rise in water level or "backwater" effect upstream from the ice jam. When the ice jam releases, a flood wave propagates downstream and large ice volumes are mobilized (Beltaos, 1990).

On the Kuskokwim River downstream from Bethel, tight meander bends and islands create narrow channels that work together to produce frequent ice-jam formations and subsequent backwater floods in the city. In addition, the Kuskokwim River near Bethel flows through low-gradient topography with little velocity to clear ice jams (Larry Rundquist, National Weather Service River Forecast Center, oral commun., 1994)

Backwater effects from ice-jam floods are responsible for most of the reported damage to personal property and buildings in Bethel (Federal Emergency Management Agency, 1984). Ice-jam floods may cause several times more damage than open-water floods because of the large ice volumes transported (Beltaos, 1990). The flood records and subsequent flood heights (table 4) are from the U.S. Army Corps of Engineers (1982) with reference to mean lower low water datum of the Kuskokwim River.

Table 4. Flood records for the Kuskokwim River at Bethel

Date	Height (meters above mean lower low water datum)
Ice-jam floods	
Spring 1941	4.3
5-14-76	4.3
5-14-89	4.1
Runoff floods	
9-1-63	3.8
6-9-64	4.4

Floods on small drainages in the Bethel area are similar to those occurring on the Kuskokwim River. Peak flooding on smaller streams usually occurs during spring breakup in April or May; however, a peak caused by rainstorms in the fall can be comparable. On Browns Creek near Bethel, eight out of nine annual peaks occurred during spring breakup U.S. Geological Survey, 1994).

Low-relief terrain, frozen ground, and poor drainage exacerbate small flooding problems in the Bethel area. Snow and ice clog stream channels in the spring, causing water to flow in overbank areas. In addition, frozen culverts at road crossings force meltwater to collect up slope, thereby making roads susceptible to flooding and erosion.

The FAA facilities near the airport are not affected by flooding on the Kuskokwim River because they are at an elevation higher than the 100-year flood (U.S. Army Corps of Engineers, 1970). However, the facilities may be affected by potential flooding in small unnamed streams that drain the airport area during heavy rainfall or snowmelt runoff periods. Not enough detail on the local topography is available to quantify this flood potential at specific FAA facilities.

Flood Protection Measures

No specific flood protection measures have been constructed in the Bethel area; however, emergency sandbagging and evacuations have been undertaken during times of flooding (U.S. Army Corps of Engineers, 1968). The National Weather Service (NWS) and the Alaska Division of Emergency Services (ADES) have set up a warning system to keep residents along the Kuskokwim River informed of potential flooding (U.S. Army Corps of Engineers, 1987). Officials from the NWS, U.S. Army Corps of Engineers, and the ADES are in the field each spring monitoring breakup and reporting ice conditions that might endanger the population. The ADES coordinates emergency flood protection and evacuation measures carried out by various Federal, State, and local agencies (U.S. Army Corps of Engineers, 1987).

Erosion

Erosion in Bethel has been a problem since the community was settled. Initially the waterfront in Bethel was separated from the main channel of the Kuskokwim River by a series of small islands. By 1939, the river had eroded the protective islands and had begun migrating towards the city (U.S. Army Corps of Engineers, 1993b). Two types of erosion occur along the river: during spring breakup localized high velocity water influences the shape of the riverbed and the location of the main channel, and during summer months warm-water eddies thaw the permanently frozen riverbanks, making them susceptible to sloughing (Lanning, 1987).

Factors that may exacerbate erosion problems along the Kuskokwim River at Bethel include a steep riverbank that is composed of easily erodible material, a riverbank that has a southeast aspect which results in direct sun causing the melting of permafrost, and heavy foot traffic that destroys protective vegetation. These factors, combined with wave action from prevailing winds and wakes from boat traffic, create an unstable riverbank. The result is 5 m or more of bank erosion during the last 50 years (U.S. Army Corps of Engineers, 1982; Lanning, 1987).

Since 1966, the city of Bethel and the U.S. Army Corps of Engineers have been working together to find solutions to the erosion problem. Potential solutions, such as erecting a timber bulkhead and driving steel pilings 10-15 m below the ground, have been tried. The first official erosion control structure was a 914-m-long timber bulkhead that was built in 1965-66. By 1971, this structure had been undermined by scour and became ineffective. Following the failure of this bulkhead, the local community began to place junked cars and other large objects along the waterfront. Although this was moderately successful in controlling erosion, the Alaska Department of Environmental Conservation prohibited any further placement of additional cars because of contamination concerns. In 1982 and 1984, the city used State funding to erect sheet pile walls in hopes of alleviating the situation. These actions have helped, but have not solved the erosion problem. Further studies and planning continue (U.S. Army Corps of Engineers, 1993b; Lanning, 1987).

Ground Water

Ground water is abundant in the Bethel area and is present as a confined aquifer in the deep subpermafrost silt, sand, and pebble deposits west of the Kuskokwim River, and in permafrost-free areas along the east side of the river. Little relief is present near Bethel, and adequate data are not available to define flow directions or depths of ground water. On a regional scale, however, the subpermafrost ground water is probably flowing towards the southwest, matching the flow direction of the Kuskokwim River (Waller, 1957). The shallow ground water above permafrost probably flows in the direction of topographic gradients to local surface-water drainages such as Browns Creek.

Waller (1957) reports that well 1 (fig. 1) was drilled to a depth of about 119 m and reached water that rose in the well to a depth of 2.74 m below the land surface. The uncased well was pumped at a rate of 1.3 L/s which resulted in a 7.62 m drawdown. The water level recovered completely within 41 minutes. The well was then cased and a static water level was maintained between 2.74 and 3.0 m below land surface. After 6 hours of pumping at a rate of 0.3 L/s, drawdown in this well was 5.8 m. After this pumping, the water again returned to a level maintained between 2.74 and 3.0 m below land surface.

Two test wells drilled east of the city indicated the existence of an isolated thawed area within the permafrost, called a "talik," which contains ground water (Waller, 1957). However, because of the presence of extremely fine-grained sediment, development of this supra-permafrost aquifer would not be practical (Waller, 1957). Shallow zones of unfrozen ground were also found east of the city near Hangar Lake (fig. 1). These unfrozen zones appear to be ubiquitous throughout the region and are probably the result of local thawing under the numerous lakes and ponds in the area. Taliks may also represent thawing under a former position of the Kuskokwim River (Waller, 1957; Williams, 1970). In the event of a surface release of contaminating materials, permafrost, acting as an impermeable layer, would inhibit flow of these materials to the underlying aquifer.

Ground Water and Surface Water Interaction

Typically, discharges of local rivers fluctuate from a snowmelt maximum in late May or early June to a pre-breakup minimum in late March or April. In addition, several rainfall-induced peaks may be observed in late summer. This seasonal fluctuation of discharge from local streams is illustrated by the hydrograph for the Kuskokwim River at Crooked Creek (fig. 4). When permafrost does not confine flow to a narrow zone or strip adjacent to the river, shallow ground water flows into and out of the riverbanks as the elevation of the river rises and falls. These "bank storage effects" fluctuate with river stages, and decrease with distance from the river (Linsley and others, 1982) (fig. 5). The extent of ground-water/surface-water interaction at Bethel has not been documented, but frozen banks were likely to significantly reduce bank storage.

DRINKING WATER

Present Drinking Water Supplies

The main source of drinking water in the Bethel area is ground water, located predominately under the permafrost at depths greater than 114 m (Waller, 1957; Williams, 1970). Public drinking water in Bethel comes from two wells: one has a capacity of approximately 28 L/s and the other approximately 4 L/s. Bethel has a public utility that provides approximately 4,750 residents with drinking water (Harry Parsi, Bethel Public Works, written commun., 1994). The public utility water is filtered for sediment, treated with chlorine, and stored in two storage tanks with a combined capacity of approximately 379,000 L. The water is distributed by truck to about 2,290 people and by piping through an above-ground system to another 2,460 people. The remaining people in the Bethel area do not receive water services from the public utility. Long-range plans are being formulated to serve the entire city with the above-ground drinking-water distribution utility (Harry Parsi, Bethel Public Works, oral commun., 1994).

Four wells have been reportedly owned by the FAA in Bethel (appendix 2). Well SB00807213ACBB1 002 is the only well that currently supplies water to the FAA facilities. The others have been abandoned or use by the FAA has been discontinued (Ecology and Environment, 1992).

The estimated average residential water consumption rate for Bethel's piped system users is 10 times greater than that for hauled system users. The approximately 736 residences and businesses using truck-hauled water consume an estimated 50,400 L/d of water, while the approxi-

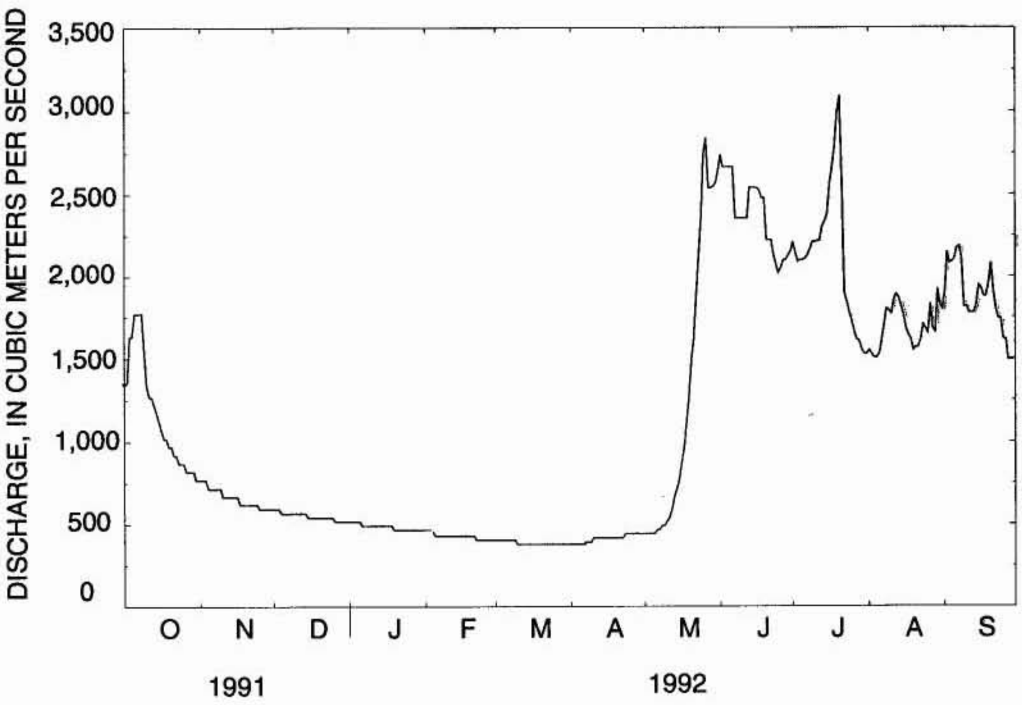

Figure 4. Discharge for the Kuskokwim River at Crooked Creek, 1992 water year.

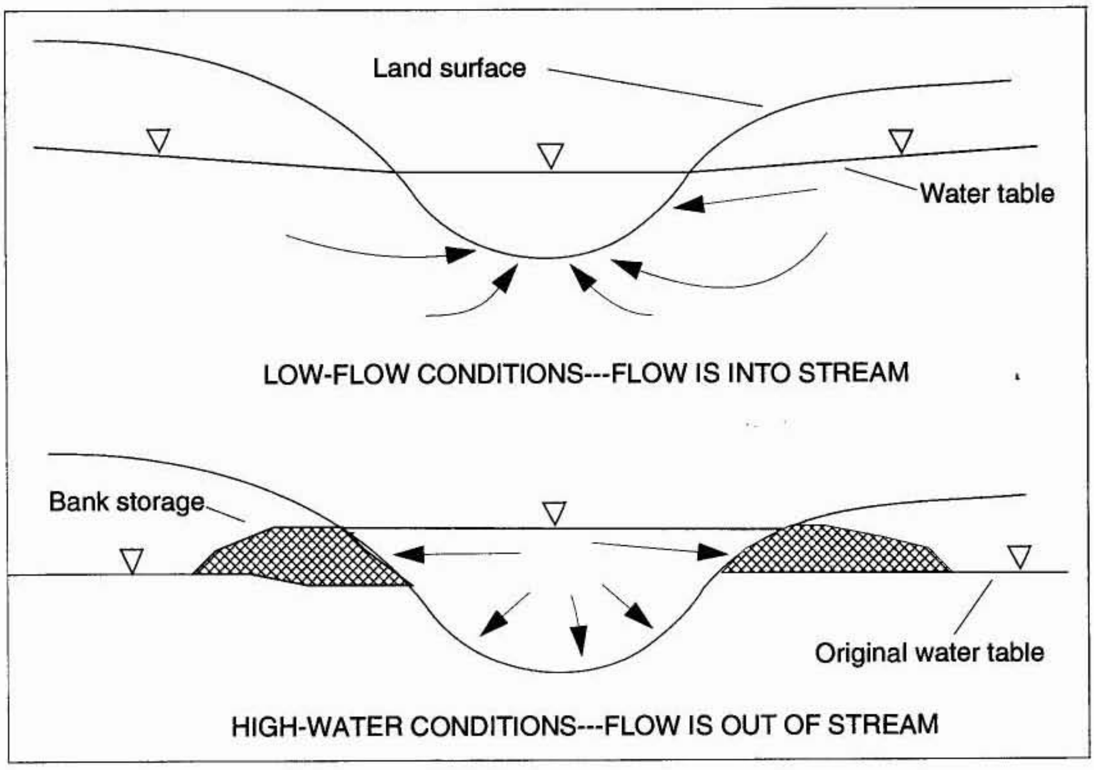

Figure 5. Ground-water/surface-water interaction.

mately 794 piped system residences consume an estimated 528,900 L/d, or 22 L/d per person, of water, for a combined total of 579,300 L/d of water drawn from the Bethel public system overall. The water use in the city of Bethel is less than 20 percent of the average water use of 1,950 L/d per person for the State of Alaska (Solley and Pierce, 1993).

Quality of the Water Supply

The aquifer on the west side of the Kuskokwim River lies below permafrost. Waller (1957) found that this water typically has iron concentrations higher than the U.S. Environmental Protection Agency (USEPA, 1992) secondary maximum contaminant level of 0.30 mg/L. Water-quality analyses of samples from one well at the airport and two wells about 2 km west of the airport (Feulner and Schupp, 1964) also indicated iron concentrations above the USEPA secondary maximum contaminant level. These samples contained dissolved iron contents of less than 0.87 mg/L, a silica content ranging from 9.8 to 34 mg/L, and a hardness as $CaCO_3$ ranging from 98 to 118 mg/L. Silica and hardness may create scale in plumbing or boilers but is generally of little concern to most users.

Water samples were collected by the USGS in 1959 from two wells at the airport owned by the FAA. Analyses of the water samples indicated that major inorganic constituents were at concentrations acceptable for drinking water. A 132-m-deep well produced water having an iron content of 0.130 mg/L, and a silica content of 34 mg/L. A 128-m-deep well produced water that had an iron content of 3.2 mg/L. Although the iron content is higher than the 0.30 mg/L secondary maximum contaminant level guidelines set by the USEPA (1992) for drinking water, it does not prohibit this water from being utilized for drinking. The USGS Ground-Water Site Inventory contains information on approximately 35 wells located within 40 km of Bethel (appendix 2).

Water-quality analyses of samples obtained each month from a well at the FAA facilities indicate that the water is of acceptable quality for a drinking-water supply (Harry Gilmore, Federal Aviation Administration, written commun., 1994). Analyses made from May 1990 through July 1992 for volatile and semi-volatile organic carbons, radio-chemicals, and some metals are shown in appendix 3.

Alternative Drinking-Water Sources

Alternative drinking-water sources for Bethel may include local lakes, streams, the Kuskokwim River, and undiscovered aquifers. Many of the local lakes may be too small to supply the city with adequate drinking water. Shallow lakes may freeze completely in the winter or to such depths that dissolved salts are concentrated in the unfrozen water. Hangar Lake, H-Marker Lake, and Arthur Dull Lake (fig. 1) may supplement the water supply, but the quantity and quality are unknown.

The flow from Browns Creek near Bethel, measured at USGS gaging-station No. 15304293, (fig. 1) is controlled directly by the amount of runoff present. During winter and dry periods in the summer, flow may be inadequate (table 3) to supply the estimated water use for Bethel. However, when runoff is abundant from snowmelt or rainfall, this source may be used to augment the drinking water supply. Browns Creek is vulnerable to contamination by human activities in the Bethel area.

The Kuskokwim River represents an abundant source of drinking water for Bethel. During months of low discharge in the winter, mean flow of the Kuskokwim River at Bethel is approximately 425 m^3/s and is more than 60,000 times the quantity of estimated water use at Bethel.

Exploratory drilling for aquifers deeper than the presently used aquifer has not been conducted. Permafrost is found at depths between 107 and 184 m below land surface (appendix 1). Almost all of the Bethel's residents utilize the confined subpermafrost aquifer for drinking water. Contamination of the present drinking-water supply would likely require the development of a surface-water collection and treatment system.

Quality of the Alternative Sources

The quality of the Kuskokwim River water was monitored at a stream-gaging station in Bethel (No. 15304300) (fig. 1) during 1954-55 and 1970-71. The limited record of water quality indicates that with appropriate treatment facilities, the Kuskokwim River could be used as a drinking-water source. The most recent water sample from the Kuskokwim River at Bethel, taken in 1970, indicated dissolved iron concentrations of 0.02 mg/L, a hardness as $CaCO_3$ of 26 mg/L, and silica concentrations of 12 mg/L.

The quality of the Kuskokwim River has been monitored at Crooked Creek (USGS gaging-station No. 15530400) for more than 35 years as part of the USGS National Stream-Quality Accounting and Radiochemical Network. The record of water quality indicates that the number of fecal coliform in the water, especially during the fall season following salmon spawning, has exceeded drinking-water regulations. On October 5, 1989, the fecal coliform count was 43 colonies/100 mL of water (U.S. Geological Survey, 1991). The suspended-sediment concentration in the water was measured at 316 mg/L on July 16, 1991 (U.S. Geological Survey, 1992).

In 1955, water-quality samples were collected by the U.S. Geological Survey from Hangar Lake near Bethel. Sample analysis indicates a silica content of 4.0 mg/L, a hardness as $CaCO_3$ of 7.0 mg/L, and dissolved iron concentrations as high as 0.29 mg/L (Waller, 1957). Data to determine the quality of water in Browns Creek have not been obtained.

SUMMARY

Bethel's remote location makes it dependent on the airport and the river for transportation. The subsistence lifestyle of the Native residents makes them dependent on a sustainable environment. Flooding caused by ice jams and runoff are a hazard for Bethel residents. Most residents currently obtain drinking water from a single subpermafrost aquifer. If this aquifer becomes contaminated, the potential for developing new wells in undiscovered aquifers is unknown. The Kuskokwim River, Browns Creek, and local lakes may represent alternative drinking-water sources; however, the quality and quantity of these water resources have not been adequately documented.

REFERENCES CITED

Beltaos, Spyridon, 1990, Breakup jams, *in* Ryan, R.L., and Crissman, R.D., eds., Cold regions hydrology and hydraulics: American Society of Civil Engineers Monograph, p. 485-510.

Cady, W.M., Wallace, R.E., Hoare, J.M., and Webber, E.J., 1955, The central Kuskokwim region, Alaska: U.S. Geological Survey Professional Paper 268, 132 p.

Coonrad, W.L., 1957, Geological reconnaissance in the Yukon-Kuskokwim delta region, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-223, scale 1:500,000.

Darbyshire and Associates, 1979, City of Bethel comprehensive development plan—Volume 1, Community survey analysis—A statement of Bethel community attitudes: U.S. Department of Housing and Urban Development, and Alaska Department of Community and Regional Affairs, variously paged.

Ecology and Environment, Inc., 1992, Environmental compliance investigation report, Bethel FAA station, Bethel Alaska: Anchorage [Draft report available from Federal Aviation Administration, Alaskan Region], variously paged.

Federal Emergency Management Agency, 1984, Flood insurance study—City of Bethel, Alaska: Federal Emergency Management Agency, 10 p.

Ferrians, O.J., Jr., 1965, Permafrost map of Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-445, 1 sheet, scale 1:250,000.

Feulner, A.J., and Schupp, R.G., 1964, Temperature and chemical quality of water from a well drilled through permafrost near Bethel, Alaska, *in* Geological survey research, 1964: U.S. Geological Survey Professional Paper 501-D, p. D145-D148.

Hartman, C.W., and Johnson, P.R., 1984, Environmental atlas of Alaska: University of Alaska Fairbanks, Institute of Water Resources/Engineering Experiment Station, 95 p.

Hinton R.B., and Girdner C.L., 1966, Soils of Bethel area, Alaska: U.S. Soil Conservation Service report, 29 p.

Hoare, J.M., and Coonrad, W.L., 1959, Geology of the Bethel quadrangle, Alaska: U.S. Geological Survey Miscellaneous Geologic Map I-285, scale 1:250,000.

Lanning, D.C., 1987, Kuskokwim River bank erosion—Bethel Alaska: The Northern Engineer, v. 18, nos. 2 & 3, 6 p.

Leslie, L.D., 1989, Alaska climate summaries (2d ed.): University of Alaska Anchorage, Arctic Environmental Information and Data Center, Alaska Climate Center Technical Note 5, variously paged.

Linsley, R.K., Kohler, M.A., and Paulhus, J.L., 1982, Hydrology for engineers (3d ed.): McGraw Hill Book Company, 508 p.

Maddren, A.G., 1915, Gold placers of the lower Kuskokwim, *with a note on* Copper in the Russian Mountains: U.S. Geological Survey Bulletin 622-H p. 292-360.

Mertie, J.B., Jr., 1938, The Nushagak district, Alaska: U.S. Geological Survey Bulletin 903, 96 p.

_____1940, The Goodnews platinum deposits, Alaska: U.S. Geological Survey Bulletin 918, 97 p.

Payne, T.G., 1955, Mesozoic and Cenozoic tectonic elements of Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-84, scale 1:5,000,000.

Rieger, Samuel, Schoephorster, D.B., and Furbush, C.E., 1979, Exploratory soil survey of Alaska: Soil Conservation Service report, 213 p.

Rutledge, F.A., 1948, Investigation of the Rainy Creek mercury prospect, Bethel District, Kuskokwim Region, southwestern Alaska: U.S. Bureau of Mines Report of Investigations 4361, 7 p.

Solley, W.B., and Pierce, R.R., 1993, Estimated use of water in the United States in 1990: U.S. Geological Survey Circular 1081, 76 p.

Spurr, J. E., 1900, A reconnaissance in southwestern Alaska in 1898: Twentieth Annual Report of the U.S. Geological Survey, 1898-99, part VIIb, p. 31-264.

U.S. Army Corps of Engineers, 1968, Flood plain information, Kuskokwim River, Bethel, Alaska: U.S. Army Corps of Engineers, variously paged.

_____1970, Flood insurance study—Kuskokwim River, Bethel, Alaska: U.S. Army Corps of Engineers, Alaska District [prepared for Federal Insurance Administration], 11 p.

_____1982, Bank stabilization, Bethel, Alaska, final environmental impact statement and feasibility report: U.S. Army Corps of Engineers, variously paged.

_____1987, Interim water resource study, Yukon and Kuskokwim Rivers, Alaska: U.S. Army Corps of Engineers, variously paged.

_____1993a, Alaskan communities—Flood hazard data: U.S. Army Corps of Engineers, Alaska District, 335 p.

_____1993b, Environmental assessment, bank stabilization plan, Bethel, Alaska: U.S. Army Corps of Engineers, variously paged.

U.S. Bureau of Census, 1991, Percent distribution Alaska population by sex, race and Hispanic origin—1990 census: Compiled by Alaska Department of Labor, Research and Analysis, 3 p.

U.S. Geological Survey, 1991 Water resources data for Alaska, water year 1990: U.S. Geological Survey Water-Data Report AK-90-1, 252 p.

_____1992, Water resources data for Alaska, water year 1991: U.S. Geological Survey Water-Data Report AK-91-1, 415 p.

_____1994, Water resources data for Alaska, water year 1993: U.S. Geological Survey Water-Data Report AK-93-1, 373 p.

Viereck, L.A, and Little, E.L., 1972, Alaska trees and shrubs: U.S. Department of Agriculture, Agriculture Handbook No. 410, 265 p.

Waller, R.M., 1957, Groundwater and permafrost at Bethel, Alaska: U.S. Geological Survey Hydrological Data Report 2, 11 p.

Williams, J.R., 1970, Ground water in the permafrost regions of Alaska: U.S. Geological Survey Professional Paper 696, 60 p.

APPENDIX 1

Well logs from the Pan American Petroleum Company

and U.S. Department of Energy

9-185
(October 1950)

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

WELL SCHEDULE

Date MARCH 27, 19 63 Field No.

Record by VY Office No.

Source of data CPY LTR. W. VAN ALLEN to T.L. PEWE 3-19-63

1. *Location:* State ALASKA County
   Map 1900' S/NL; 800' E/W L (BETHEL AREA)
   ¼ ¼ sec. 20 T 8 (N) S R 74 E (W)
2. *Owner:* PAN-AMOIL - PAN AM OIL Address NAPAKIK CREEK
   Tenant CORE HOLE #1 Address
   Driller Address
3. *Topography*
4. *Elevation* 35± ft. above / below
5. *Type:* Dug, drilled, driven, bored, jetted 19 61
6. *Depth:* Rept. 470 ft. Meas. ft.
7. *Casing:* Diam. in., to in., Type
   Depth ft., Finish
8. *Chief Aquifer* From ft. to ft.
   Others
9. *Water level* ft. rept. / meas. 19 above / below
   which is ft. above / below surface
10. *Pump:* Type Capacity G. M.
    Power: Kind Horsepower
11. *Yield:* Flow G. M., Pump G. M., Meas., Rept. Est.
    Drawdown ft. after hours pumping G. M.
12. *Use:* Dom., Stock, PS., RR., Ind., Irr., Obs.
    Adequacy, permanence
13. *Quality* Temp °F.
    Taste, odor, color Sample Yes / No
    Unfit for
14. *Remarks:* (Log) Analyses, etc.) pfst to 350'
    fresh water zone 350 to 470'
    bedrock @ 470'

U. S. GOVERNMENT PRINTING OFFICE 16—62891-1

SURFACE FROZEN QUATERNARY
350' BASE OF PERMA FROST
470' TOP OF CONSOLIDATED SEDIMENTS
(BED ROCK)

WELL DATA FOR BETHEL, ALASKA - DEPARTMENT OF ENERGY WELLS
1DATE: 02/06/
95

C001 Site ID (station number) 604734161450401
C009 Latitude 604734
C010 Longitude 1614504
C014 Name of location map BETHEL D-8
C016 Altitude of land surface 45.
C020 Hydrologic unit code 19030502
C021 Date well constructed 19800920
C028 Depth of well 800.
C900 Station name SB00807109CDCD2 010
C161 Owner BETHEL AQUIFER
THERMAL STOR PROJ
C161 Owner DOE BETHEL THERMAL
RESISTIVITY & SPONTANEOUS
C091 Depth to top of interval 0.
C092 Depth to bottom of interval 6.
C093 Aquifer code 110QRNR
C096 Lithology code SAND
C097 Description of material BROWN, FINE GRAINED,
MOIST - DRY & NOT FROZEN
C091 Depth to top of interval 6.
C092 Depth to bottom of interval 10.
C093 Aquifer code 110QRNR
C096 Lithology code PEAT
C097 Description of material BROWN & SOFT, STIFF,
MOIST - WET W/SOME FINE SAND & SILT. NOT FROZEN.
C091 Depth to top of interval 10.
C092 Depth to bottom of interval 14.
C093 Aquifer code 110QRNR
C096 Lithology code PEAT
C097 Description of material FROZEN, NO VISIBLE
ICE. PEAT IS MORE MATTED & DECAYED,DENSER.
C091 Depth to top of interval 14.
C092 Depth to bottom of interval 45.5
C093 Aquifer code 110QRNR
C096 Lithology code SDST
C097 Description of material GREY SILTY VERY FINE
SAND, NOT FROZEN 7 SATURATED WHEN T HAWED. SMALL AMOU
(cont) NT OF GRAVEL AS
DRILLED DEEPER. SAMPLE FROM 30F
C091 Depth to top of interval 45.5
C092 Depth to bottom of interval 74.
C093 Aquifer code 110QRNR
C096 Lithology code SDST
C097 Description of material GREY W/TRACE OF
GRAVEL & FEW TRACE LAYERS OF CLAY
C091 Depth to top of interval 74.
C092 Depth to bottom of interval 100.
C093 Aquifer code 110QRNR
C096 Lithology code STCL
C097 Description of material WASH RETURNS INDICATE
CLAYEY SILT
C091 Depth to top of interval 100.

C092 Depth to bottom of interval 134.
C093 Aquifer code 110QRNR
C096 Lithology code STCL
C097 Description of material FROM WASH SAMPLE.
GREY, CLAYEY, SANDY SILT. OCCASIONAL CLAY LAYERS W/VER
(cont) Y FINE SAND &
OCCASIONAL GRAVEL < 1/4 INCH
C091 Depth to top of interval 134.
C092 Depth to bottom of interval 136.
C093 Aquifer code 110QRNR
C096 Lithology code SDST
C097 Description of material GREY, FINE GRAINED
SAND & FROZEN
C091 Depth to top of interval 136.
C092 Depth to bottom of interval 140.
C093 Aquifer code 110QRNR
C096 Lithology code SAND
C097 Description of material FINE - MEDIUM SAND
C091 Depth to top of interval 140.
C092 Depth to bottom of interval 178.
C093 Aquifer code 110QRNR
C096 Lithology code STCL
C097 Description of material GREY CLAYEY, SANDY,
SILT. VERY FINE SAND W/ AN OCCASIONAL 1 INCH GRAVEL LA
C091 Depth to top of interval 178.
C092 Depth to bottom of interval 183.
C093 Aquifer code 110QRNR
C096 Lithology code OTHR
C091 Depth to top of interval 183.
C092 Depth to bottom of interval 191.
C093 Aquifer code 110QRNR
C096 Lithology code SDST
C097 Description of material GREY SILTY SAND W/
WOOD CHIPS.
C091 Depth to top of interval 191.
C092 Depth to bottom of interval 199.
C093 Aquifer code 110QRNR
C096 Lithology code SAND
C097 Description of material WASH INDICATES GREY,
FINE - MEDIUM GRAINED SAND W/SOME SILT AND NUMEROUS PI
C091 Depth to top of interval 199.
C092 Depth to bottom of interval 215.
C093 Aquifer code 110QRNR
C096 Lithology code COBB
C091 Depth to top of interval 215.
C092 Depth to bottom of interval 229.
C093 Aquifer code 110QRNR
C096 Lithology code SDST
C091 Depth to top of interval 229.
C092 Depth to bottom of interval 284.
C093 Aquifer code 110QRNR
C096 Lithology code SAND
C097 Description of material MEDIUM - FINE GRAINED
C091 Depth to top of interval 284.
C092 Depth to bottom of interval 291.
C093 Aquifer code 110QRNR
C096 Lithology code OTHR

C097 Description of material ABUNDANT WOOD
FRAGMENTS
C091 Depth to top of interval 291.
C092 Depth to bottom of interval 374.
C093 Aquifer code 110QRNR
C096 Lithology code SDST
C097 Description of material FROM WASH RETURNS,
GREY SILT & SAND W/WOOD FRAGEMNTS @ 306FT.
C091 Depth to top of interval 374.
C092 Depth to bottom of interval 399.
C093 Aquifer code 110QRNR
C096 Lithology code OTHR
C097 Description of material PERMAFROST BOUNDRY
C091 Depth to top of interval 399.
C092 Depth to bottom of interval 457.
C093 Aquifer code 110QRNR
C096 Lithology code SDST
C097 Description of material GREY SILTY SAND, NOT
FROZEN & SATURATED
C091 Depth to top of interval 457.
C092 Depth to bottom of interval 494.
C093 Aquifer code 110QRNR
C096 Lithology code OTHR
C097 Description of material UNABLE TO READ LOG
C091 Depth to top of interval 494.
C092 Depth to bottom of interval 502.
C093 Aquifer code 110QRNR
C096 Lithology code SAND
C097 Description of material FROM WASH, GREY SAND.
C091 Depth to top of interval 502.
C092 Depth to bottom of interval 518.
C093 Aquifer code 110QRNR
C096 Lithology code SAND
C097 Description of material FROM WASH, GREY SAND.
C091 Depth to top of interval 518.
C092 Depth to bottom of interval 532.
C093 Aquifer code 110QRNR
C096 Lithology code SILT
C097 Description of material SANDY
C091 Depth to top of interval 532.
C092 Depth to bottom of interval 594.
C093 Aquifer code 110QRNR
C096 Lithology code OTHR
C097 Description of material UNABLE TO READ LOG
C091 Depth to top of interval 594.
C092 Depth to bottom of interval 610.
C093 Aquifer code 110QRNR
C096 Lithology code SILT
C097 Description of material GREY
C091 Depth to top of interval 610.
C092 Depth to bottom of interval 695.
C093 Aquifer code 110QRNR
C096 Lithology code SILT
C097 Description of material INCREASING SAND
LENSES W/DEPTH
C091 Depth to top of interval 695.
C092 Depth to bottom of interval 703.

C093	Aquifer code	110QRNR
C096	Lithology code	SILT
C097	Description of material	W/ SILTY SAND LAYER
BETWEEN	698. - 700.	
C091	Depth to top of interval	703.
C092	Depth to bottom of interval	707.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	SILTY SAND
C091	Depth to top of interval	707.
C092	Depth to bottom of interval	709.
C093	Aquifer code	110QRNR
C096	Lithology code	GRVL
C091	Depth to top of interval	709.
C092	Depth to bottom of interval	711.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	SILTY
C091	Depth to top of interval	711.
C092	Depth to bottom of interval	714.
C093	Aquifer code	110QRNR
C096	Lithology code	SILT
C091	Depth to top of interval	714.
C092	Depth to bottom of interval	716.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	SILTY
C091	Depth to top of interval	716.
C092	Depth to bottom of interval	719.
C093	Aquifer code	110QRNR
C096	Lithology code	SILT
C091	Depth to top of interval	719.
C092	Depth to bottom of interval	722.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	SILTY
C091	Depth to top of interval	722.
C092	Depth to bottom of interval	724.
C093	Aquifer code	110QRNR
C096	Lithology code	OTHR
C097	Description of material	RIG HESITATION,
DRILLER	ASSUMES GRAVEL LAYER	
C091	Depth to top of interval	724.
C092	Depth to bottom of interval	727.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	SILTY
C091	Depth to top of interval	727.
C092	Depth to bottom of interval	739.
C093	Aquifer code	110QRNR
C096	Lithology code	SILT
C097	Description of material	SANDY
C091	Depth to top of interval	739.
C092	Depth to bottom of interval	741.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	SILTY

C091	Depth to top of interval	741.
C092	Depth to bottom of interval	745.
C093	Aquifer code	110QRNR
C096	Lithology code	SILT
C097	Description of material	SANDY
C091	Depth to top of interval	745.
C092	Depth to bottom of interval	747.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	SILTY
C091	Depth to top of interval	747.
C092	Depth to bottom of interval	760.
C093	Aquifer code	110QRNR
C096	Lithology code	SILT
C097	Description of material	SANDY
C091	Depth to top of interval	760.
C092	Depth to bottom of interval	764.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	SILTY
C091	Depth to top of interval	764.
C093	Aquifer code	110QRNR
C096	Lithology code	SILT

THE OTHER WELL DATA STARTS HERE

C001	Site ID (station number)	604734161450301
C009	Latitude	604734
C010	Longitude	1614503
C014	Name of location map	BETHEL D-8
C016	Altitude of land surface	46.
C020	Hydrologic unit code	19030502
C021	Date well constructed	19800930
C027	Hole depth	789.
C028	Depth of well	789.
C755	Last update for CONS subrecord of CONS file	19880325
C073	Depth to top of this interval	0.
C074	Depth to bottom of this interval	789.
C075	Diameter of this interval	6.
C724	Record number for hole subrecord	1
C161	Owner	BETHEL AQUIFER
THERMAL STOR PROJ		
C161	Owner	DOE BETHEL THERMAL
STORAGE PROJ		
C200	Depth to top of logged interval	0.
C201	Depth to bottom of logged interval	789.
C200	Depth to top of logged interval	0.
C201	Depth to bottom of logged interval	422.
C200	Depth to top of logged interval	15.
C201	Depth to bottom of logged interval	413.
C200	Depth to top of logged interval	15.
C201	Depth to bottom of logged interval	421.
RESISTIVITY LOG AVAILABLE		
C091	Depth to top of interval	0.
C092	Depth to bottom of interval	4.
C093	Aquifer code	110QRNR
C096	Lithology code	SDGL

C097	Description of material	BROWN
C091	Depth to top of interval	4.
C092	Depth to bottom of interval	5.
C093	Aquifer code	110QRNR
C096	Lithology code	PEAT
C097	Description of material	BROWN
C091	Depth to top of interval	5.
C092	Depth to bottom of interval	25.
C093	Aquifer code	110QRNR
C096	Lithology code	SDST
C097	Description of material	GREY, GREEN, SILTY, FINE SAND, DENSE
C091	Depth to top of interval	25.
C092	Depth to bottom of interval	65.
C093	Aquifer code	110QRNR
C096	Lithology code	SDST
C097	Description of material	GREY SILTY SAND W/ RYING AMOUNTS OF SILT LAYERS
C091	Depth to top of interval	65.
C092	Depth to bottom of interval	74.
C093	Aquifer code	110QRNR
C096	Lithology code	STCL
C097	Description of material	GREY SILTY CLAY
C091	Depth to top of interval	74.
C092	Depth to bottom of interval	92.
C093	Aquifer code	110QRNR
C096	Lithology code	GRVL
C097	Description of material	WET GRAVEL W/SOME FINE SAND & WOOD FRAGMENTS
C091	Depth to top of interval	92.
C092	Depth to bottom of interval	139.
C093	Aquifer code	110QRNR
C096	Lithology code	SDST
C097	Description of material	GREY SANDY SILT. FINE GRAINED SAND
C091	Depth to top of interval	139.
C092	Depth to bottom of interval	148.
C093	Aquifer code	110QRNR
C096	Lithology code	SDST
C097	Description of material	INCREASING SAND CONTENT
C091	Depth to top of interval	148.
C092	Depth to bottom of interval	151.
C093	Aquifer code	110QRNR
C096	Lithology code	SILT
C091	Depth to top of interval	151.
C092	Depth to bottom of interval	158.
C093	Aquifer code	110QRNR
C096	Lithology code	SDST
C097	Description of material	INCREASING SAND
C091	Depth to top of interval	158.
C092	Depth to bottom of interval	185.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	GREY SILTY SAND W/ WOOD CHIPS IN WASH
C091	Depth to top of interval	185.

C092	Depth to bottom of interval	225.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	GREY SILTY W/HIGH

ORGANIC CONTENT(WOOD CHIPS) & ICE LAYERS AROUND 215.

C091	Depth to top of interval	225.
C092	Depth to bottom of interval	265.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	GREY SILTY, MEDIUM -

FINE GRAINED SAND

C091	Depth to top of interval	265.
C092	Depth to bottom of interval	336.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	GREY SILTY WELL

SORTED SAND, W/GRVL LAYERS @ 321. & 347FT & WOOD CHIPS

C091	Depth to top of interval	336.
C092	Depth to bottom of interval	338.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	SILTY SAND W/ICE
C091	Depth to top of interval	338.
C092	Depth to bottom of interval	355.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	SILTY
C091	Depth to top of interval	355.
C092	Depth to bottom of interval	368.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	GREY SILTY W/ICE

CRYSTALS

C091	Depth to top of interval	368.
C092	Depth to bottom of interval	406.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	GREY SILTY
C091	Depth to top of interval	406.
C092	Depth to bottom of interval	409.
C093	Aquifer code	110QRNR
C096	Lithology code	OTHR
C097	Description of material	SILTSTONE ROCK CHIPS

& SAND IN WASH. DRILLER BELIEVES GRAVEL/COBBLE LENS.

C091	Depth to top of interval	409.
C092	Depth to bottom of interval	425.
C093	Aquifer code	110QRNR
C096	Lithology code	OTHR
C097	Description of material	OCCASSIONAL ROCKY

DRILLING, POSSIBLE GRAVEL LENSES

C091	Depth to top of interval	425.
C092	Depth to bottom of interval	465.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	GREY SILTY & FINE,

NOT FROZEN

C091	Depth to top of interval	465.

C092 Depth to bottom of interval 474.
C093 Aquifer code 110QRNR
C096 Lithology code SAND
C097 Description of material GREY SILTY SAND,
STIFF W/SOME LARGE WOOD FRAGMENTS
C091 Depth to top of interval 474.
C092 Depth to bottom of interval 611.
C093 Aquifer code 110QRNR
C096 Lithology code SAND
C097 Description of material GREY & SILTY W/SMALL
AMOUNTS OF GRAVEL
C091 Depth to top of interval 611.
C092 Depth to bottom of interval 617.
C093 Aquifer code 110QRNR
C096 Lithology code SAND
C097 Description of material W/WOOD CHIPS
C091 Depth to top of interval 617.
C092 Depth to bottom of interval 625.
C093 Aquifer code 110QRNR
C096 Lithology code SILT
C097 Description of material GREY & SANDY
C091 Depth to top of interval 625.
C092 Depth to bottom of interval 645.
C093 Aquifer code 110QRNR
C096 Lithology code STCL
C097 Description of material GREY CLAYEY SILT W/
SMALL FRACTION OF VERY FINE SAND, STIFF & MOIST
C091 Depth to top of interval 645.
C092 Depth to bottom of interval 725.
C093 Aquifer code 110QRNR
C096 Lithology code SDST
C097 Description of material VERY SANDY SILT,
STIFF W/WOOD CHIPS.
C091 Depth to top of interval 725.
C092 Depth to bottom of interval 737.
C093 Aquifer code 110QRNR
C096 Lithology code SDGL
C097 Description of material GREEN SILTY FINE -
MEDIUM SAND W/GRAVEL, ALTERNATING LAYER OF GREY-BLACK PA
(cont) RTIALLY CONSOLIDATED
SILTSTONE.
C091 Depth to top of interval 737.
C092 Depth to bottom of interval 739.
C093 Aquifer code 110QRNR
C096 Lithology code OTHR
C097 Description of material HARD STREAK
C091 Depth to top of interval 739.
C092 Depth to bottom of interval 745.
C093 Aquifer code 110QRNR
C096 Lithology code SDST
C097 Description of material SILTY W/FEW SAND
GRAINS, VEGITATION INCLUDED. WOOD CHIPS.
C091 Depth to top of interval 745.
C092 Depth to bottom of interval 761.
C093 Aquifer code 110QRNR
C096 Lithology code SAND
C097 Description of material GREY GREEN VERY SITLY

FINE GRAINED SAND

C091	Depth to top of interval	761.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	DARK GREY TO GREEN

APPENDIX 2

Summary of Ground Water Site Inventory data from

wells within 40 km of Bethel

LOCAL WELL NUMBER		PRIMARY USE OF WATER	DEPTH OF WELL (FEET)	WATER LEVEL (FEET)	DATE WELL CONSTRUCTED	OWNER	ASSIGNOR OF OTHER IDENTIFIER	OTHER IDENTIFIER	TYPE OF LOG AVAILABLE
SB00707105DADD1	001	T	79.0	15.75	03-05-63	USBIA OSCARVILLE	--	--	D
SB00707108DDDB1	001	P	71.8	--	01-01-61	NAPAISKIAK VILLAGE	--	--	D
SB00707109CBDC1	001	P	116	8.00	01-01-64	USBIA NAPASKIAK	--	--	D
SB00707217DBBC1	001	T	200	--	01-01-59	VSBIA NAPAKIAK	NAPAKIAK	BIA SCHOOL	-
SB00707217DBBC2	001	P	116	8.00	11-21-64	VBSIA NAPAKIAK	NAPAKIAK	VILLAGE	D
SB00707218DDBA1	001	T	122	8.60	03-26-69	USBIA NAPAKIAK	--	--	D
SB00806905CAAB1	001	T	145	11.00	--	USBIA KWETHLUK	--	--	D
SB00807108DABB1	001	-	--	--	04-27-72	BETHEL HEIGHTS	--	--	-
SB00807109CACC1	009	P	399	--	01-01-60	NICHOLSON A.L.	USGS	BET-18	-
SB00807109CBBD1	006	T	--	--	--	BETHEL SCHOOL	USGS	BET-17	-
SB00807109CDAD1	003	U	112	--	01-01-55	LEIB MAX	WALLER 1957 OFR	BET-01	-
SB00807109CDBB1	004	U	85.0	--	01-01-55	SCHMIDT ALBERT	WALLER 1957 OFR	BET-12	D
SB00807109CDCD1	010	U	39.0	--	01-01-55	USPHS BETHEL	WALLER 1957 OFR	BET-10	-
						--	USPHS	TEST HOLE1	-
SB00807109CDCD2	010	U	800.	--	09-20-80	BETHEL AQUIFER THERM	USS 4117	L06	D
						DOE BETHEL THERMAL S	ATES - TRW	BORING 0-1	-
						--	TRW JOB NUMBER	1008700107	-
						--	BETHEL THERM PJ	BORING 0 1	-
SB00807109CDCD3	010	U	789.	--	09-30-80	BETHEL AQUIFER THERM	ATES - TRW	BORING 0-2	D
						DOE BETHEL THERMAL S	USS 4117	L06	-
						--	TRW JOB NUMBER	1008700101	-
						--	BETHEL THERM PJ	BORING 0 2	-
SB00807109CDDC1	007	H	421	25.00	09-01-69	NORTHERN COMMERCL	NC	WELL-1	-
SB00807109CDDD1	008	H	--	--	08-04-72	MENDOLA JOE	--	--	-
SB00807109DCCB1	005	U	390	9.00	05-01-56	AK HEALTH BETHEL	WALLER 1957 OFR	BET-14	D
SB00807110BACD1	001	U	20.0	.00	06-01-55	AK HEALTH BETHEL	WALLER 1957 OFR	BET-08	D
						--	ADH BETHEL	TEST HOLE1	-
SB00807110BACD2	001	U	15.5	--	06-11-55	AK HEALTH BETHEL	USGS	BET-08A	-
						--	ADH BETHEL	TEST HOLE2	-
SB00807110BACD3	001	U	--	.00	06-11-55	AK HEALTH BETHEL	USGS	BET-08B	-
						--	ADH BETHEL	TEST HOLE3	-
SB00807115DDCC1	001	U	197	22.00	04-05-49	FAA BETHEL	WALLER 1957 OFR	BET-03	D
SB00807115DDCC2	001	U	18.0	--	12-01-48	FAA BETHEL	USGS	BET-03A	-
SB00807117ABCD1001 80003		-	--	--	--	--	--	--	-
SB00807117ABCD2	001	-	454	--	01-01-52	USPHS BETHEL	--	--	D
SB00807117ACAB1	002	U	165	--	01-01-48	USPHS BETHEL	WALLER 1957 OFR	BET-01	-
SB00807122ABAC1	002	T	51.0	9.00	01-01-54	USAF BETHEL	WALLER 1957 OFR	BET-06	-
SB00807122DDAC1	001	U	75.0	18.00	01-01-51	US ARMY BETHEL	WALLER 1957 OFR	BET-04	D
SB00807213ACBB1	002	T	421	90.00	01-01-58	FAA BETHEL	WALLER 1957 OFR	BET-15	D
SB00807213BDAD1	001	T	434	90.00	12-01-58	FAA BETHEL	USGS	BET-16	D
SB00807214CAEB1	001	P	651.	--	11-12-62	USBIA BETHEL	USBIA	BIA-2	D
						--	USAF	USAF-2	-
						--	PROF PAPR 501-D	WELL-2	-
SB00807214CACC1	002	T	202	57.49	02-27-56	USAF BETHEL	WALLER 1957 OFR	BET-13	D
						--	PROF PAPR 501-D	WELL-2	-
SB00807214CACC2	002	U	185	60.00	01-01-49	USAF BETHEL	WALLER 1957 OFR	BET-02	-
SB00807214CCBC1	003	-	290	--	12-27-61	USAF BETHEL	--	--	-
SB01006732CBBC2	001	T	33.0	--	04-06-70	USBIA AKIAK	--	--	-
SB01006936DCAA1	001	P	200	10.40	07-23-66	USBIA AKIACHAK	--	--	D

APPENDIX 3

Selected ground water-quality data

for the FAA well at the Bethel Airport

BET VOC

WALTER J. HICKEL, GOVERNOR

DEPT. OF ENVIRONMENTAL CONSERVATION

Volatile Organics Analysis Data Sheet
Lab Name: Douglas Lab Facility
Method Code: EPA 524.2
Matrix: Water
Date Sampled: 8/27/91
Date Received: 8/27/91
Date Analyzed: 9/05/91
Laboratory No.:91DEC101400

PWS No.:271122
Chain of Custody:NA
Sampler No:SH271122
Lab File ID: >1I04M::
Dilution Factor: 1.0000
Location:FAA BETHEL TRANSIT
Project: VOC MONITORING

Note: Reported values less than the Method Detection Limit are estimated.

	UNITS: ug/l	MDL
Benzene	0.0	<1.0
Bromobenzene	0.0	<1.0
Bromochloromethane	0.0	<1.0
Bromodichloromethane	0.0	<1.0
Bromoform	0.0	<1.0
Bromomethane	0.0	<1.0
n-Butylbenzene	0.0	<1.0
sec-Butylbenzene	0.0	<1.0
tert-Butylbenzene	0.0	<1.0
Carbon Tetrachloride	0.0	<1.0
Chlorobenzene	0.0	<1.0
Chlorodibromomethane	0.0	<1.0
Chloroethane	0.0	<1.0
Chloroform	.7	<1.0
Chloromethane	0.0	<1.0
o-Chlorotoluene	0.0	<1.0
p-Chlorotoluene	0.0	<1.0
1,2-Dibromo-3-chloropropane	0.0	<1.0
Dibromomethane	0.0	<1.0
1,4-Dichlorobenzene	0.0	<1.0
m-Dichlorobenzene	0.0	<1.0
o-Dichlorobenzene	0.0	<1.0
Dichlorodifluoromethane	0.0	<3.0
1,1-Dichloroethane	0.0	<1.0
1,2-Dichloroethane	0.0	<1.0
1,1-Dichloroethylene	0.0	<1.0
cis-1,2-Dichloroethylene	0.0	<1.0
trans-1,2-Dichloroethylene	0.0	<1.0
Dichloromethane	0.0	<1.0

Analyst Don LaPasa Date 10-27-91

Reviewed Alan L Lore Date 10/30/91

DEPT. OF ENVIRONMENTAL CONSERVATION

Volatile Organics Analysis Data Sheet
Lab Name: Douglas Lab Facility
Method Code: EPA 524.2
Matrix: Water
Date Sampled: 8/27/91
Date Received: 8/27/91
Date Analyzed: 9/05/91
Laboratory No.:91DEC101400

PWS No.:271122
Chain of custody: NA
Sampler No:SH271122
Lab File ID: >1I04M::
Dilution Factor: 1.00000
Location:FAA BETHEL TRANSIT
Project: VOC MONITORING

Note: Reported values less than the Method Detection Limit are estimated.

	UNITS: ug/l	MDL
1,2-Dichloropropane	0.0	<1.0
1,3-Dichloropropane	0.0	<1.0
2,2-Dichloropropane	0.0	<1.0
1,1-Dichloropropene	0.0	<1.0
1,3-Dichloropropene	0.0	<1.0
Ethylbenzene	0.0	<1.0
Ethylene Dibromide	0.0	<1.0
Fluorotrichloromethane	0.0	<1.0
Hexachlorobutadiene	0.0	<1.0
Isopropylbenzene	0.0	<1.0
p-Isopropyltoluene	0.0	<1.0
Naphthalene	0.0	<1.0
n-Propylbenzene	0.0	<1.0
Styrene	0.0	<1.0
1,1,1,2-Tetrachloroethane	0.0	<1.0
1,1,2,2-Tetrachloroethane	0.0	<1.0
Tetrachloroethylene	0.0	<1.0
TTHM	.7	
Toluene	0.0	<1.0
1,2,3-Trichlorobenzene	0.0	<1.0
1,2,4-Trichlorobenzene	0.0	<1.0
1,1,1-Trichloroethane	0.0	<1.0
1,1,2,-Trichloroethane	0.0	<1.0
Trichloroethylene	0.0	<1.0
1,2,3-Trichloropropane	0.0	<1.0
1,2,4-Trimethylbenzene	0.0	<1.0
1,3,5-Trimethylbenzene	0.0	<1.0
Vinyl Chloride	0.0	<3.0
p-Xylene	0.0	<1.0
m-Xylene	0.0	<1.0
o-Xylene	0.0	<1.0

Analyst Don La Fave Date 10-27-91.
Reviewed Aleon LaFave Date 10/30/91.

BET VOC

WALTER J. HICKEL, GOVERNOR

DEPT. OF ENVIRONMENTAL CONSERVATION

Volatile Organics Analysis Data Sheet
Lab Name: A.D.E.C. Juneau Laboratory
Method Code: US EPA 524.2
Matrix: Water
Date Sampled: 1/06/92
Date Received: 1/08/92
Date Analyzed: 1/13/92
Laboratory No.:92DEC100073

PWS No.:271122
Chain of Custody:NA
Sampler No: 271122
Lab File ID: >1A13P::
Dilution Factor: 1.0000
Location:FAA BETHEL TRANSIT
Project: VOC MONITORING

Note: Results reported below the MDL are estimated.

	UNITS: ug/l	MDL
Benzene	0.0	0.2
Bromobenzene	0.0	0.3
Bromochloromethane	0.0	0.2
Bromodichloromethane	0.0	0.4
Bromoform	0.0	0.6
Bromomethane	0.0	0.3
n-Butylbenzene	0.0	0.4
sec-Butylbenzene	0.0	0.4
tert-Butylbenzene	0.0	0.2
Carbon Tetrachloride	0.0	0.4
Chlorobenzene	0.0	0.2
Chlorodibromomethane	0.0	0.4
Chloroethane	0.0	0.3
Chloroform	.5	0.2
Chloromethane	0.0	0.6
o-Chlorotoluene	0.0	0.4
p-Chlorotoluene	0.0	0.5
1,2-Dibromo-3-chloropropane	0.0	0.4
Dibromomethane	0.0	0.2
1,4-Dichlorobenzene	0.0	0.3
m-Dichlorobenzene	0.0	0.3
o-Dichlorobenzene	0.0	0.3
Dichlorodifluoromethane	0.0	0.4
1,1-Dichloroethane	0.0	0.3
1,2-Dichloroethane	0.0	0.2
1,1-Dichloroethylene	0.0	0.2
cis-1,2-Dichloroethylene	0.0	0.3
trans-1,2-Dichloroethylene	0.0	0.3
Dichloromethane	0.0	0.3

Analyst Don LaFave Date 1-27-92.
Reviewed Alan F Love Date 1-31-92.

WALTER J. HICKEL, GOVERNOR

DEPT. OF ENVIRONMENTAL CONSERVATION

Volatile Organics Analysis Data Sheet
Lab Name: A.D.E.C. Juneau Laboratory
Method Code: US EPA 524.2
Matrix: Water
Date Sampled: 1/06/92
Date Received: 1/08/92
Date Analyzed: 1/13/92
Laboratory No.:92DEC100073

PWS No.:271122
Chain of custody: NA
Sampler No: 271122
Lab File ID: >1A13P::
Dilution Factor: 1.00000
Location:FAA BETHEL TRANSIT
Project: VOC MONITORING

Note: Results reported below the MDL are estimated.

	UNITS: ug/l	MDL
1,2-Dichloropropane	0.0	0.3
1,3-Dichloropropane	0.0	0.2
2,2-Dichloropropane	0.0	0.5
1,1-Dichloropropene	0.0	0.4
1,3-Dichloropropene	0.0	0.2
Ethylbenzene	0.0	0.2
Ethylene Dibromide	0.0	0.2
Fluorotrichloromethane	0.0	0.4
Hexachlorobutadiene	0.0	0.3
Isopropylbenzene	0.0	0.2
p-Isopropyltoluene	0.0	0.4
Naphthalene	0.0	0.4
n-Propylbenzene	0.0	0.4
Styrene	0.0	0.2
1,1,1,2-Tetrachloroethane	0.0	0.3
1,1,2,2-Tetrachloroethane	0.0	0.3
Tetrachloroethylene	0.0	0.4
TTHM	.5	
Toluene	0.0	0.2
1,2,3-Trichlorobenzene	0.0	0.3
1,2,4-Trichlorobenzene	0.0	0.2
1,1,1-Trichloroethane	0.0	0.3
1,1,2,-Trichloroethane	0.0	0.3
Trichloroethylene	0.0	0.2
1,2,3-Trichloropropane	0.0	0.5
1,2,4-Trimethylbenzene	0.0	0.4
1,3,5-Trimethylbenzene	0.0	0.4
Vinyl Chloride	0.0	0.5
p-Xylene	0.0	0.2
m-Xylene	0.0	0.2
o-Xylene	0.0	0.2

Analyst Don LeFaro Date 1-27-92.

Reviewed Alan L Fore Date 1-31-92.

BET VOC

STATE OF ALASKA

WALTER J. HICKEL, GOVERNOR

DEPT. OF ENVIRONMENTAL CONSERVATION

Volatile Organics Analysis Data Sheet
Lab Name: A.D.E.C. Juneau Laboratory
Method Code: US EPA 524.2
Matrix: Water
Date Sampled: 4/27/92
Date Received: 4/28/92
Date Analyzed: 4/30/92
Laboratory No.:92DEC100843

PWS-COMPUTER ENTERED
MAY 11 1992

PWS No.:271122
Chain of Custody:NA
Sampler No: 271122
Lab File ID: >1D29T::
Dilution Factor: 1.0000
Location:FAA BETHEL TRANSIT
Project: VOC MONITORING

Note: Results reported below the MDL are estimated.

	UNITS: ug/l	MDL
Benzene	0.0	0.2
Bromobenzene	0.0	0.3
Bromochloromethane	0.0	0.2
Bromodichloromethane	0.0	0.4
Bromoform	0.0	0.6
Bromomethane	0.0	0.3
n-Butylbenzene	0.0	0.4
sec-Butylbenzene	0.0	0.4
tert-Butylbenzene	0.0	0.2
Carbon Tetrachloride	0.0	0.4
Chlorobenzene	0.0	0.2
Chlorodibromomethane	0.0	0.4
Chloroethane	0.0	0.3
Chloroform	.8	0.5
Chloromethane	0.0	0.6
o-Chlorotoluene	0.0	0.4
p-Chlorotoluene	0.0	0.5
1,2-Dibromo-3-chloropropane	0.0	0.4
Dibromomethane	0.0	0.2
1,4-Dichlorobenzene	0.0	0.5
m-Dichlorobenzene	0.0	0.3
o-Dichlorobenzene	0.0	0.3
Dichlorodifluoromethane	0.0	0.4
1,1-Dichloroethane	0.0	0.3
1,2-Dichloroethane	0.0	0.2
1,1-Dichloroethylene	0.0	0.2
cis-1,2-Dichloroethylene	0.0	0.3
trans-1,2-Dichloroethylene	0.0	0.3
Dichloromethane	0.0	0.3

Analyst David Q Chen Date 5/1/92.
Reviewed Alan L Lane Date 5/4/92.

Volatile Organics Analysis Data Sheet
Lab Name: A.D.E.C. Juneau Laboratory
Method Code: US EPA 524.2
Matrix: Water
Date Sampled: 4/27/92
Date Received: 4/28/92
Date Analyzed: 4/30/92
Laboratory No.:92DEC100843

PWS No.:271122
Chain of custody: NA
Sampler No: 271122
Lab File ID: >1D29T::
Dilution Factor: 1.00000
Location:FAA BETHEL TRANSIT
Project: VOC MONITORING

Note: Results reported below the MDL are estimated.

	UNITS: ug/l	MDL
1,2-Dichloropropane	0.0	0.3
1,3-Dichloropropane	0.0	0.2
2,2-Dichloropropane	0.0	0.5
1,1-Dichloropropene	0.0	0.4
1,3-Dichloropropene	0.0	0.2
Ethylbenzene	0.0	0.5
Ethylene Dibromide	0.0	0.2
Fluorotrichloromethane	0.0	0.4
Hexachlorobutadiene	0.0	0.5
Isopropylbenzene	0.0	0.2
p-Isopropyltoluene	0.0	0.4
Naphthalene	0.0	0.5
n-Propylbenzene	0.0	0.4
Styrene	0.0	0.2
1,1,1,2-Tetrachloroethane	0.0	0.3
1,1,2,2-Tetrachloroethane	0.0	0.3
Tetrachloroethylene	0.0	0.4
TTHM	.8	
Toluene	0.0	0.2
1,2,3-Trichlorobenzene	0.0	0.5
1,2,4-Trichlorobenzene	0.0	0.5
1,1,1-Trichloroethane	0.0	0.3
1,1,2,-Trichloroethane	0.0	0.3
Trichloroethylene	0.0	0.2
1,2,3-Trichloropropane	0.0	0.5
1,2,4-Trimethylbenzene	0.0	0.4
1,3,5-Trimethylbenzene	0.0	0.4
Vinyl Chloride	0.0	0.5
p-Xylene	0.0	0.4
m-Xylene	0.0	0.4
o-Xylene	0.0	0.4

Analyst David G Glover Date 5/1/92.

Reviewed Alan L Love Date 5/4/92.

BET VOC

WALTER J. HICKEL, GOVERNOR

DEPT. OF ENVIRONMENTAL CONSERVATION

Volatile Organics Analysis Data Sheet
Lab Name: A.D.E.C. Juneau Laboratory
Method Code: US EPA 524.2
Matrix: Water
Date Sampled: 7/1/92
Date Received: 7/2/92
Date Analyzed: 7/08/92
Laboratory No.:92DEC101413

PWS No.:271122
Chain of Custody:NA
Sampler No: 271122
Lab File ID: >1G08H::
Dilution Factor: 1.0000
Location:FAA BETHEL TRANSIT QTR
Project: VOC MONITORING

Note: Results reported below the MDL are estimated.

PWS-COMPUTER ENTERED SEP 02 1992

	UNITS: ug/l	MDL
Benzene	0.0	0.2
Bromobenzene	0.0	0.3
Bromochloromethane	0.0	0.2
Bromodichloromethane	0.0	0.4
Bromoform	0.0	0.6
Bromomethane	0.0	0.3
n-Butylbenzene	0.0	0.4
sec-Butylbenzene	0.0	0.4
tert-Butylbenzene	0.0	0.2
Carbon Tetrachloride	0.0	0.4
Chlorobenzene	0.0	0.2
Chlorodibromomethane	0.0	0.4
Chloroethane	0.0	0.3
Chloroform	1.6	0.5
Chloromethane	0.0	0.6
o-Chlorotoluene	0.0	0.4
p-Chlorotoluene	0.0	0.5
1,2-Dibromo-3-Chloropropane	0.0	0.4
Dibromomethane	0.0	0.2
1,4-Dichlorobenzene	0.0	0.5
m-Dichlorobenzene	0.0	0.3
o-Dichlorobenzene	0.0	0.3
Dichlorodifluoromethane	0.0	0.4
1,1-Dichloroethane	0.0	0.3
1,2-Dichloroethane	0.0	0.2
1,1-Dichloroethylene	0.0	0.2
cis-1,2-Dichloroethylene	0.0	0.3
trans-1,2-Dichloroethylene	0.0	0.3
Dichloromethane	0.0	0.3

Analyst Don LiFara Date 7-22-92.

Reviewed [signature] Date 7/27/92.

WALTER J. HICKEL, GOVERNOR

DEPT. OF ENVIRONMENTAL CONSERVATION

Volatile Organics Analysis Data Sheet

Lab Name: A.D.E.C. Juneau Laboratory
Method Code: US EPA 524.2
Matrix: Water
Date Sampled: 7/1/92
Date Received: 7/2/92
Date Analyzed: 7/08/92
Laboratory No.:92DEC101413

PWS No.:271122
Chain of custody: NA
Sampler No: 271122
Lab File ID: >1G08H::
Dilution Factor: 1.00000
Location:FAA BETHEL TRANSIT QTR
Project: VOC MONITORING

Note: Results reported below the MDL are estimated.

	UNITS: ug/l	MDL
1,2-Dichloropropane	0.0	0.3
1,3-Dichloropropane	0.0	0.2
2,2-Dichloropropane	0.0	0.5
1,1-Dichloropropene	0.0	0.4
1,3-Dichloropropene	0.0	0.2
Ethylbenzene	0.0	0.5
Ethylene Dibromide	0.0	0.2
Fluorotrichloromethane	0.0	0.4
Hexachlorobutadiene	0.0	0.5
Isopropylbenzene	0.0	0.2
p-Isopropyltoluene	0.0	0.4
Naphthalene	0.0	0.5
n-Propylbenzene	0.0	0.4
Styrene	0.0	0.2
1,1,1,2-Tetrachloroethane	0.0	0.3
1,1,2,2-Tetrachloroethane	0.0	0.3
Tetrachloroethylene	0.0	0.4
TTHM	1.6	
Toluene	0.0	0.2
1,2,3-Trichlorobenzene	0.0	0.5
1,2,4-Trichlorobenzene	0.0	0.5
1,1,1-Trichloroethane	0.0	0.3
1,1,2,-Trichloroethane	0.0	0.3
Trichloroethylene	0.0	0.2
1,2,3-Trichloropropane	0.0	0.5
1,2,4-Trimethylbenzene	0.0	0.4
1,3,5-Trimethylbenzene	0.0	0.4
Vinyl Chloride	0.0	0.5
p-Xylene	0.0	0.4
m-Xylene	0.0	0.4
o-Xylene	0.0	0.4

Analyst Don LaFarg Date 7-22-92.

Reviewed Alan L Love Date 7/27/92.

CHEMICAL & GEOLOGICAL LABORATORY

A DIVISION OF COMMERCIAL TESTING & ENGINEERING CO.

5633 B STREET ANCHORAGE, ALASKA 99518 TELEPHONE (907) 562-2343 FAX: (907) 561-5301

ANALYSIS RESULTS for INVOICE # 53700
Chemlab Ref.# 92.2066 Sample # 1 Matrix: WATER

Client Sample ID : DRINKING WATER FAA BETHEL WSM SINK
PWSID : 271122
Collected : 05/12/92 @ 08:30 hrs.
Received : 05/12/92 @ 15:05 hrs.
Preserved with : AS REQUIRED

Client Name :FEDERAL AVIATION ADMINISTRATION
Client Acct :FEDAVIA
BPO# :DTFA04-92-P-20046 PO# :
Req# :
Ordered By :

Analysis Completed : 11/13/92
Laboratory Supervisor : STEPHEN C. EDE
Released By : [signature]

Send Reports to:
1)FEDERAL AVIATION ADMINISTRATION
2)DOT FAA BET SPO

Parameter	Results	Units	Method	Allowable Limits
GROSS ALPHA	LT 2	pCi/L	EPA 900.0	15

Sample Remarks: ROUTINE SAMPLE COLLECTED BY: R. ATKINS, WITNESSED BY C.S.
RESULT ANALYZED BY CONTROLS FOR ENVIRONMENTAL POLLUTION, INC., SANTA FE, NEW MEXICO.

1 Tests Performed
ND- None Detected
NA- Not Analyzed
* See Special Instructions Above
** See Sample Remarks Above
LT-Less Than, GT-Greater Than
UA-Unavailable

SGS Member of the SGS Group (Société Générale de Surveillance)

CHEMICAL & GEOLOGICAL LABORATORY

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5633 B STREET ANCHORAGE, ALASKA 99518 TELEPHONE (907) 562-2343 FAX: (907) 561-5301

ANALYSIS RESULTS for INVOICE # 55455

Chemlab Ref.# 92.3192 Sample # 1 Matrix: WATER

Client Sample ID : DRINKING WATER BETHEL FAA TRANSIENT QTRS
PWSID : 271122
Collected : 07/01/92 @ 11:23 hrs.
Received : 07/01/92 @ 14:12 hrs.
Preserved with : AS REQUIRED

Client Name : FEDERAL AVIATION ADMINISTRATION
Client Acct : FEDAVIA
BPO# : DTFA04-92-P-20046 PO# :
Req# :
Ordered By : CHARLES SMITH

Analysis Completed : 11/13/92
Laboratory Supervisor : STEPHEN C. EDE
Released By : [signature]

Send Reports to:
1)FEDERAL AVIATION ADMINISTRATION
2)DOT FAA BET SFO

Parameter	Results	Units	Method	Allowable Limits
GROSS ALPHA	LT 2	pCi/L	EPA 900.0	15

Sample Remarks: ROUTINE SAMPLE COLLECTED BY: WILLIAM BULL, WITNESSED BY C.A. RESULT ANALYZED BY CONTROLS FOR ENVIRONMENTAL POLLUTION, INC., SANTA FE, NEW MEXICO.

1 Tests Performed
ND- None Detected
NA- Not Analyzed
* See Special Instructions Above
** See Sample Remarks Above
LT-Less Than, GT-Greater Than
UA-Unavailable

CHEMICAL & GEOLOGICAL LABORATORY

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5633 B STREET ANCHORAGE, ALASKA 99518 TELEPHONE (907) 562-2343 FAX: (907) 561-5301

ANALYSIS RESULTS for INVOICE # 56793

Chemlab Ref.# 92.3988 Sample # 1 Matrix: WATER

Client Sample ID : WSM SINK
PWSID : 271122
Collected : 08/05/92 @ 08:00 hrs.
Received . 08/06/92 @ 08:30 hrs.
Preserved with : AS REQUIRED

Client Name :FEDERAL AVIATION ADMINISTRATION
Client Acct :FEDAVIA
BPO# :DTFA04-92-P-20046 PO# :NONE RECEIVED
Req# :
Ordered By :

Analysis Completed : 11/13/92
Laboratory Supervisor : STEPHEN C. EDE
Released By : [signature]

Send Reports to:
1)FEDERAL AVIATION ADMINISTRATION
2)DOT, FAA, BET, SPO

Parameter	Results	Units	Method	Allowable Limits
GROSS ALPHA	LT 2	pCi/L	EPA 900.0	15

Sample Remarks: ROUTINE SAMPLE COLLECTED BY: N.A.
RESULT ANALYZED BY CONTROLS FOR ENVIRONMENTAL POLLUTION, INC., SANTA FE, NEW MEXICO.

1 Tests Performed
ND- None Detected
NA- Not Analyzed
* See Special Instructions Above
** See Sample Remarks Above
LT-Less Than, GT-Greater Than
UA-Unavailable

SGS Member of the SGS Group (Société Générale de Surveillance)

BET INORG. CHEM

NORTHERN TESTING LABORATORIES, INC.

2505 FAIRBANKS STREET
3330 INDUSTRIAL WAY

ANCHORAGE, ALASKA 99503
FAIRBANKS, ALASKA 99701

907-277-8378 • FAX 274-9645
907-456-3116 • FAX 456-3125

Federal Aviation Administration
222 West 7th Avenue, #14
AAL-463
Anchorage AK 99513-7587

Attn: Harry Gilmore

Report Date: 06/22/90

Date Arrived: 05/14/90
Date Sampled: 05/14/90
Time Sampled: 0930
Collected By: RA

Our Lab #: A100514
Location/Project: FAA Bethel
Your Sample ID: Tapwater-Club
Sample Matrix: Water
Comments:

Flag Definitions
U = Below Detection Limit
DL Stated in Result
B = Below Regulatory Min.
H - Above Regulatory Max.
E = Below Detection Limit
Estimated Value

Method	Parameter	Units	Result	Flag
EPA 206.2	Arsenic	mg/l	0.001	U
EPA 208.2	Barium	mg/l	0.08	
EPA 213.2	Cadmium	mg/l	0.0011	
EPA 218.2	Chromium	mg/l	0.002	
EPA 239.2	Lead	mg/l	0.0029	
EPA 245.1	Mercury	mg/l	0.0003	
EPA 270.2	Selenium	mg/l	0.007	
EPA 272.2	Silver	mg/l	0.003	U
EPA 300.0	Nitrate-N	mg/l	0.6	
SM 413C	Fluoride	mg/l	0.1	

Reported By: Francois Rodigari
Anchorage Operations Manager

Harding Lawson Associates

APPENDIX C

FAA Drinking Water Sampling
Summary of Sample Locations and Analytical Data
(continued)

LEAD & COPPER

Site	Location	Laboratory	Wells Used	Lead[a] (mg/L)	Copper[b] (mg/L)
Yakutat	State Parks House	93.4442-1	2 wells, alternated	0.0050 U	0.82
	National Weather Service No. 3	93.4442-2	2 wells, alternated	0.0050 U	0.31
	National Weather Service No 5	93.4442-3	2 wells, alternated	0.0050 U	0.51
	FAA Quarters 102-4	93.4442-4	2 wells, alternated	0.0050 U	1.30
	FAA Quarters 101-4	93.4442-5	2 wells, alternated	0.0050 U	1.30
Bethel	MarkAir Air Terminal (Bushflight Coffee Shop)	93.4582-1	Untreated well	0.0050 U	0.05 U
	FAA Transient, #101-2	93.4582-2	Treated well	0.013	0.84
	National Weather Transient #B-2	93.4582-3	Treated well	0.005	1.20
	FAA Fourplex, #107-1	93.4582-4	Treated well	0.025	0.56
	FAA Fourplex, #105-2	93.4582-5	Treated well	0.41	7.00
	Tower Manager Quarters (FAA House 110 8-6)	93.4598-1	Treated well	0.011	0.050 U

[a] The Environmental Protection Agency (EPA) action level for lead is 0.015 mg/L.
[b] The EPA action level for copper is 1.3 mg/L.

mg/L = Milligrams per liter.
U = Undetected, reported value is the practical quantification limit.

1093R
Approved by: KAS

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