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# HYDROLOGIC RECONNAISSANCE OF THE BELUGA, PETERS CREEK, AND HEALY COAL AREAS, ALASKA

U.S. GEOLOGICAL SURVEY
WATER-RESOURCES INVESTIGATIONS 81-56

PREPARED IN COOPERATION WITH THE
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**16. Abstract (Limit: 200 words)**

Surface-water hydrology and water quality of three coal areas were studied during 1975-1978.

Mean annual discharge in the Beluga area is estimated to range from 2.2 to 3.4 cubic feet per second per square mile. The 7-day low flow with a 10-year recurrence interval is estimated to be 0.3 to 0.6 cubic feet per second per square mile. The surface waters are a calcium bicarbonate type, have low concentrations of nutrients, and may contain dissolved iron and manganese in concentrations in excess of recommended limits. The pooled diversity index of the benthic invertebrate community ranges from 2.93 to 4.06.

Water quality of streams in the Peters Creek coal area is similar to surface waters of the Beluga area. Streamflow characteristics in the Peters Creek area are not defined due to poor correlations with nearby gaging stations.

In the Healy coal area, streamflow characteristics of the two major basins studied are dissimilar. Lignite Creek is estimated to have less yield than Healy Creek. The dissolved-solids concentration of studied tributaries ranged from 111 to 636 milligrams per liter and are of a calcium bicarbonate or magnesium bicarbonate type. Iron and manganese concentrations are high at times. Sodium and chloride concentrations increase significantly in the lower reaches of Lignite Creek.

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By David R. Scully, Andrea P. Krumhardt, and Donald R. Kernodle

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1981

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| Multiply | By | To obtain |
|---|---|---|
| inch (in.) | 25.4 | millimeter (mm) |
| foot (ft) | 0.3048 | meter (m) |
| mile (mi) | 1.609 | kilometer (km) |
| square foot ($ft^2$) | 0.09290 | square meter ($m^2$) |
| square mile ($mi^2$) | 2.590 | square kilometer ($km^2$) |
| ton, short (2,000 lb) | 0.9072 | megagram (Mg)<br>metric ton (t) |
| foot per second (ft/s) | 0.3048 | meter per second (m/s) |
| inch per year (in/yr) | 25.4 | millimeter per year (mm/yr) |
| ton per day (ton/d) | 0.9072 | megagram per day (Mg/d) |
| ton per year (ton/yr) | 0.9072 | megagram per year (Mg/yr) |
| ton per square mile per year [($ton/mi^2$)/yr] | 0.3503 | megagram per square kilometer per year [($Mg/km^2$)/yr] |
| gallon per minute (gal/min) | 0.6309 | liter per second (L/s) |
| cubic foot per second ($ft^3/s$) | 0.02832 | cubic meter per second ($m^3/s$) |
| cubic foot per second per square mile [($ft^3/s$)/$mi^2$] | 0.01093 | cubic meter per second per square kilometer [($m^3/s$)/$km^2$] |
| degree Fahrenheit (°F) | (°F-32)0.555 | degree Celsius (°C) |

Milligram per liter (mg/L) is a standard reporting unit for which no inch-pound equivalent is used.

Note: The National Geodetic Vertical Datum of 1929 (NGVD of 1929) is a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "mean sea level."

# HYDROLOGIC RECONNAISSANCE OF THE BELUGA, PETERS CREEK, AND HEALY COAL AREAS, ALASKA

By David R. Scully, Andrea P. Krumhardt, and Donald R. Kernodle

## ABSTRACT

The Beluga, Peters Creek, and Healy coal areas in Alaska were studied during 1975-78, with major emphasis on surface-water hydrology and water quality.

In the Beluga coal area, mean annual discharge is estimated to range from 2.2 to 3.4 cubic feet per second per square mile of drainage area. The 7-day low flow having a 10-year recurrence interval is estimated to be 0.3 to 0.6 cubic feet per second per square mile. The dilute surface waters are a calcium bicarbonate type, have low concentrations of nutrients, and at times may contain dissolved iron and manganese in concentrations in excess of U.S. Environmental Protection Agency recommended limits. The pooled diversity index of the benthic invertebrate community ranges from 2.93 to 4.06. No ground-water wells have been drilled in the potential mining areas.

Water quality of streams in the Peters Creek coal area is similar to that of streams in the Beluga coal area. No attempt is made to define streamflow characteristics in the Peters Creek coal area due to poor correlations with nearby gaging stations.

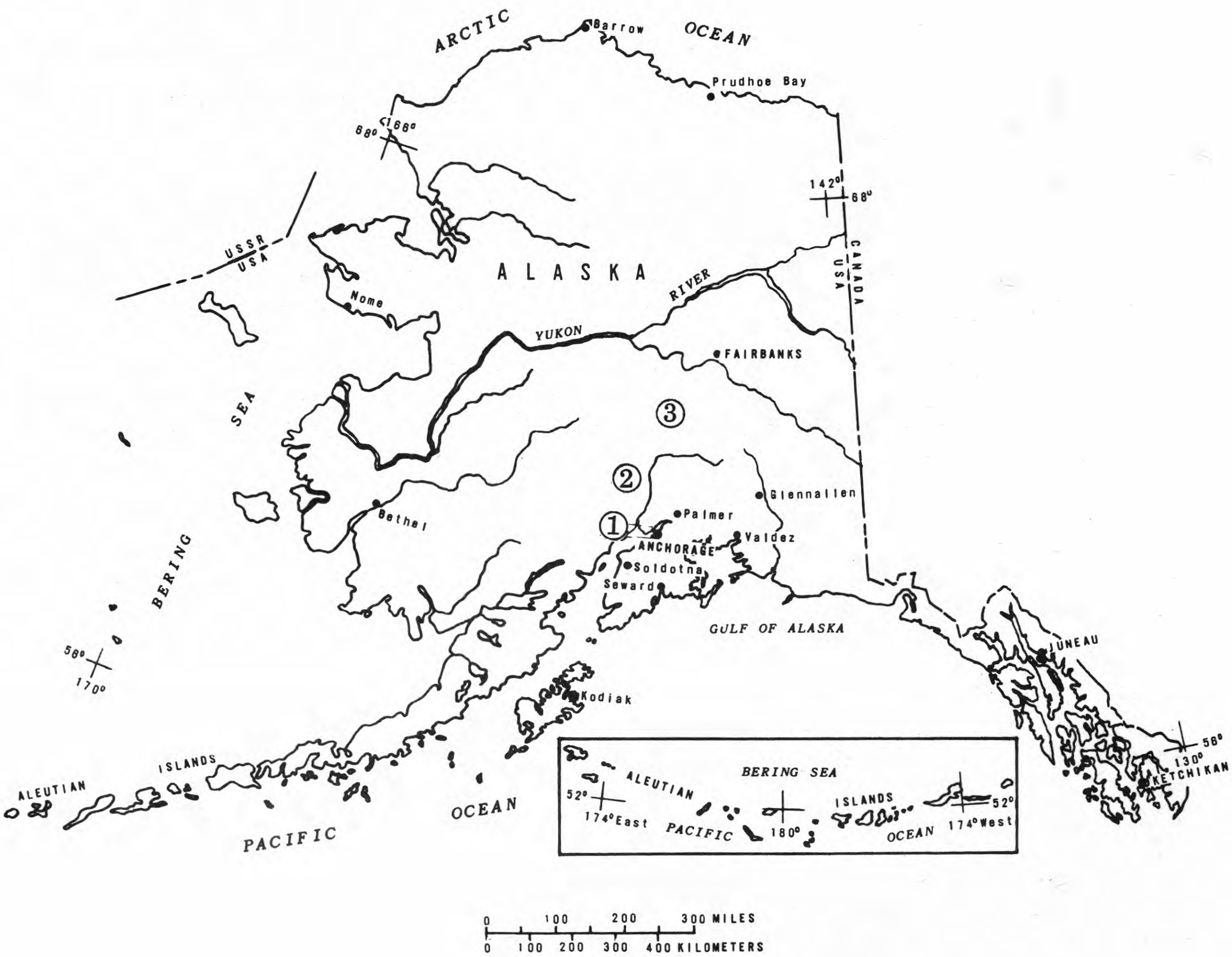
In the Healy coal area, streamflow characteristics of the two major basins studied are dissimilar. Lignite Creek is estimated to have less yield than Healy Creek. Studied tributaries of Healy and Lignite Creeks have a dissolved-solids range of 111 to 636 milligrams per liter and have calcium and bicarbonate or magnesium and bicarbonate as principal ions. Iron and manganese concentrations are high at some times of the year. The concentrations of sodium and chloride increase significantly in the lower reaches of Lignite Creek.

## INTRODUCTION

Five major Alaskan coal regions were first described by Barnes in 1967. Each of these coal regions contains several districts or coal fields. This hydrologic reconnaissance study is limited to parts of the coal districts or fields, which are hereafter termed coal areas. The following coal areas were studied: 1) Beluga; 2) Peters Creek; and 3) Healy and Lignite Creek (collectively referred to as the Healy coal area). The locations of these areas are shown in figures 1 and 2.

### Purpose

At the present time (1981), the only coal-mining operation active in Alaska is at Healy, about 80 mi southwest of Fairbanks. However, the current energy crisis




EXPLANATION

1. Beluga coal area
2. Peters Creek coal area
3. Healy coal area

Figure 1. -- General locations of coal areas studied in this report.

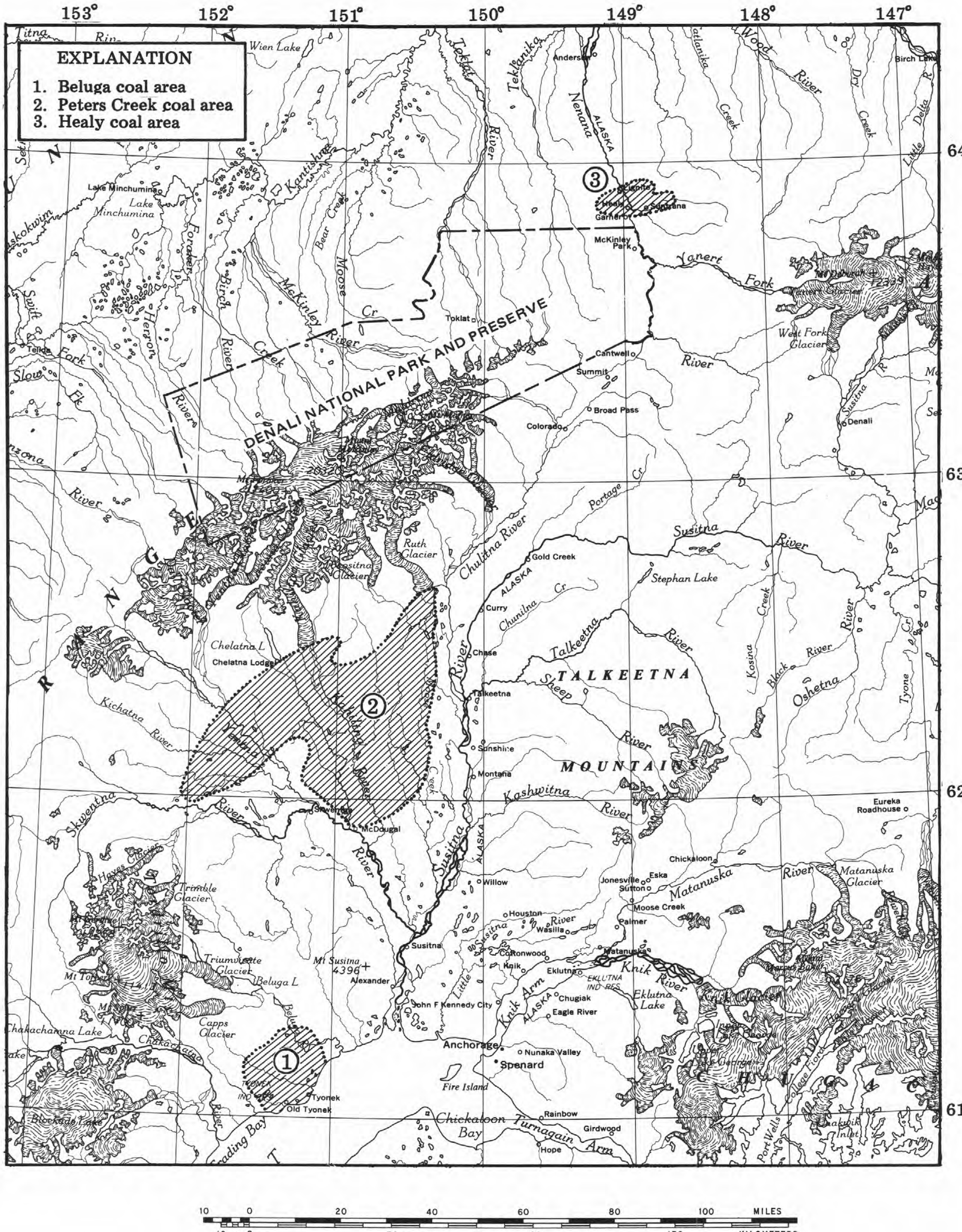



Figure 2.--Location of coal districts where hydrologic information was collected in this study.

and the renewed attention to mineral development have increased dramatically the probability of developing Alaska's coal resources. Domestic and foreign resource developers are showing interest in the coal potential of the State. The purpose of this study is to provide baseline reconnaissance hydrologic information for two coal-bearing areas having potential for development in the near future and for the coal-bearing area currently being mined.

## Scope

Hydrologic information was collected from July 1975 to October 1978. The amount and variety of data collected differed in the three areas. The Beluga coal area is considered to have the greatest potential for large-scale development; therefore most of the project effort was in that area. Six partial-record stations (a site where limited streamflow data are collected systematically over a period of years) were established in addition to installing a gaging station on the Chuitna River for the collection of continuous discharge and water temperature records. Periodic measurements of discharge, chemical quality, suspended sediment, and the aquatic benthic invertebrate community were obtained at each of these sites. In the Healy coal area, seven partial-record stations were established at which periodic measurements of discharge, chemical quality, and suspended sediment were made. In the Peters Creek coal area, data collection was limited to two partial-record stations on Peters Creek at which discharge, chemical quality, and suspended-sediment data were collected. Streamflow, temperature, suspended sediment, chemical quality, and benthic invertebrate community were collected by standard methods.

The basic data for this study are published in Scully, Krumhardt, and Kernodle (1980).

# BELUGA COAL AREA

## Introduction

### Setting

The Beluga coal area lies between 40 and 70 mi west of Anchorage in the lowlands of the Susitna River valley on the west side of upper Cook Inlet. The study area extends from the headwaters of Capps Creek on the northwest to the shore of Cook Inlet on the southeast (fig. 3). Streams studied in the area are the Chuitna River, Chuit Creek, Capps Creek, and Bishop Creek.

Surficial deposits on the hillsides are of glacial and colluvial origin; those in the valley bottoms are alluvial. The thickness of these deposits varies from a few feet to 300 feet. Conglomerate, sandstone, and siltstone of the West Foreland Formation are exposed in the upper parts of the basins, except in upper Capps Creek where sandstone, siltstone, coal, and conglomerate of the Tyonek Formation crop out. The coal-bearing beds of economic interest are in the Tyonek Formation. The Beluga Formation consists primarily of claystone and coal and underlies the area east of the Bruin Bay fault. The Tyonek and Beluga Formations compose the Kenai Group, which overlies the West Foreland Formation (fig. 4).

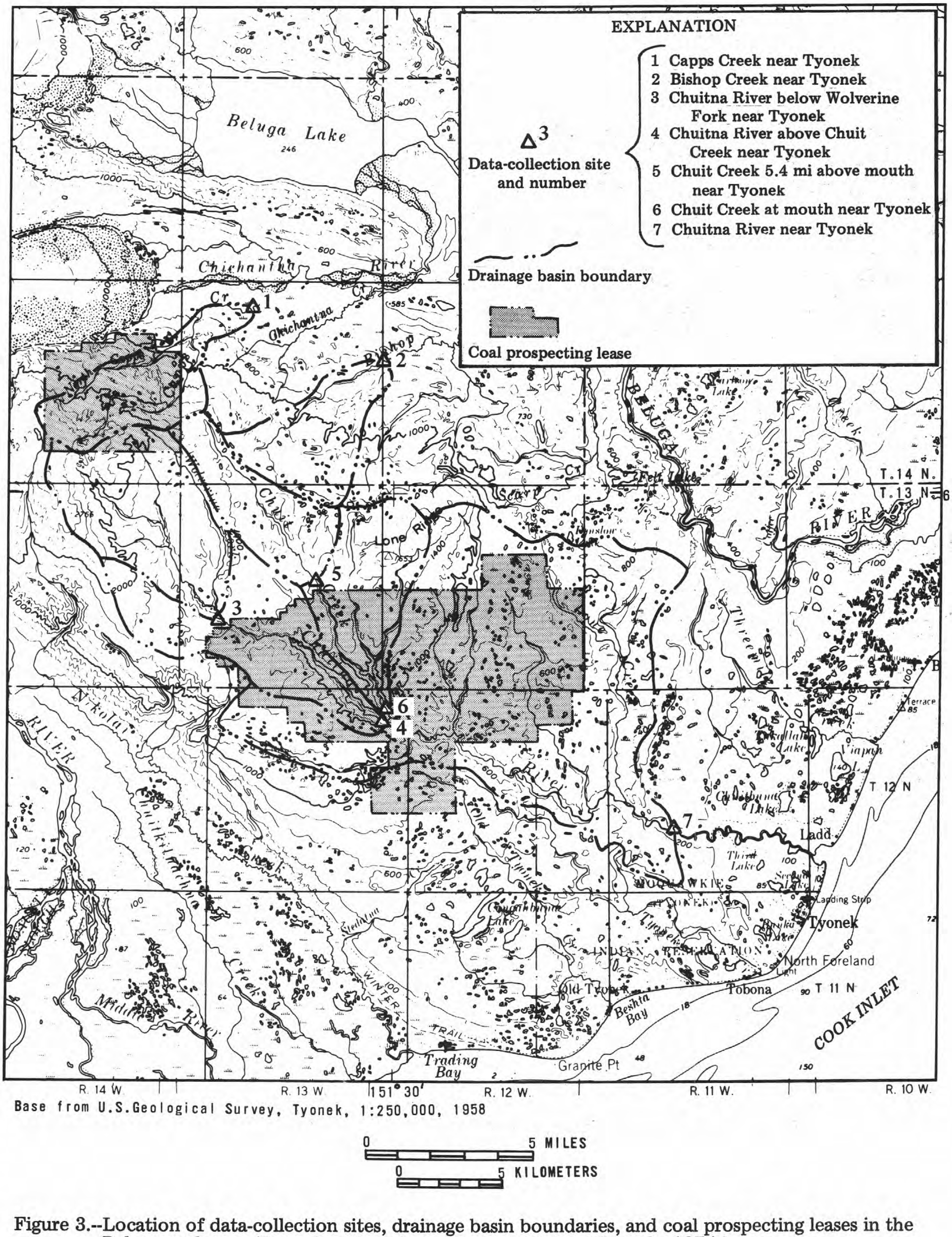



Figure 3.--Location of data-collection sites, drainage basin boundaries, and coal prospecting leases in the Beluga coal area. (Lease locations from Alaska Division of Lands, 1974.)

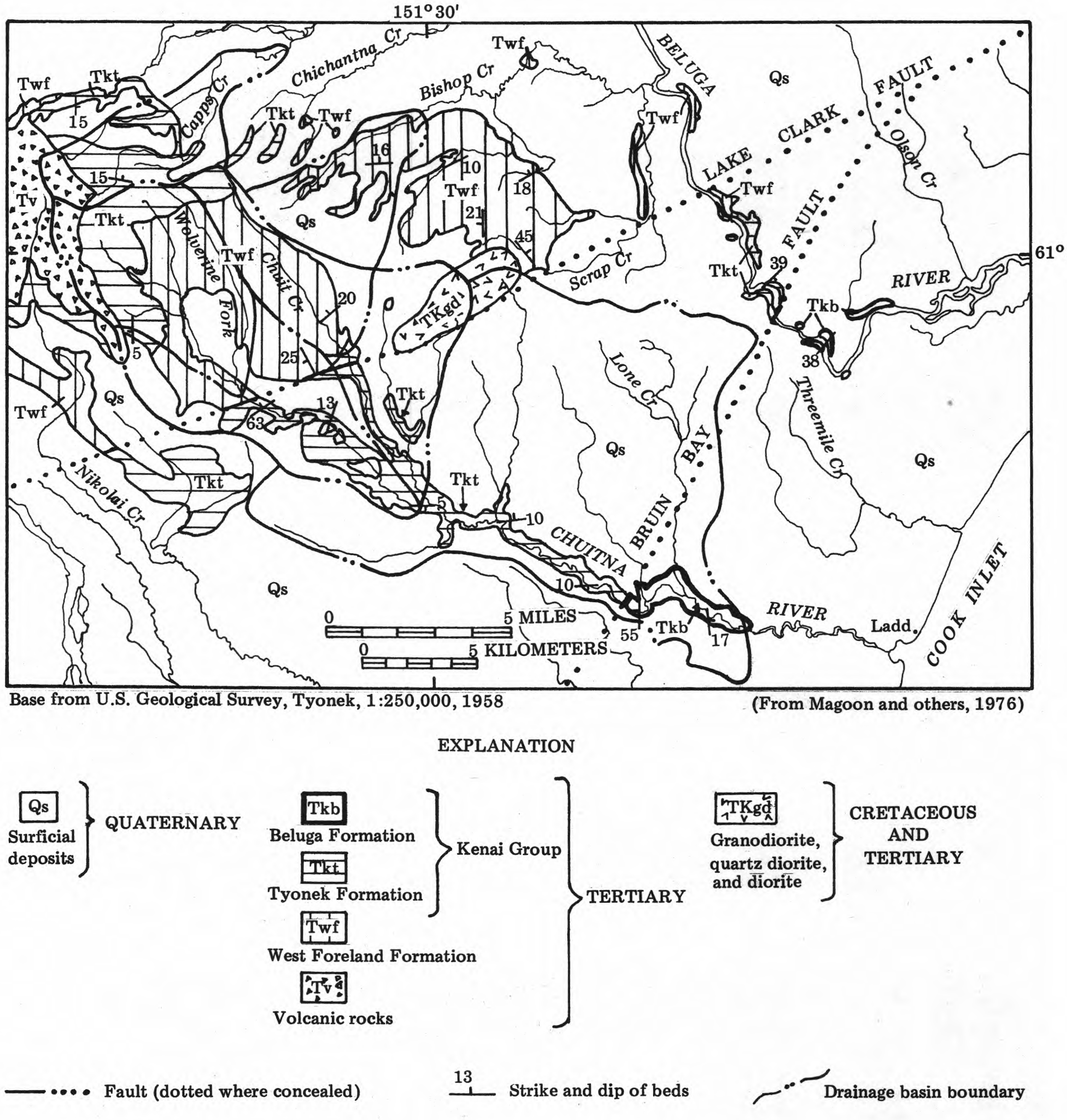



Figure 4.--Geology and drainage basin boundaries of the Beluga coal area.

Above elevations of about 1,500 ft, the streams are incised in a broad piedmont lowland that is covered with a thin mantle of muskeg vegetation. Small lakes and swampy areas are prevalent in this treeless area and are probably indicative of the poor surface drainage. At lower elevations the basins have more vegetation and more local relief. Streams exhibit a meander pattern as their gradients decrease. Elevations range from sea level to 2,800 ft, and all streams studied drain glacier-free areas.

The Chuitna River flows southeastward and drains an area of about 150 $mi^2$, part of which is underlain by the West Foreland Formation (near site 3). Major tributaries are Wolverine Fork, Chuit Creek, and Lone Creek. Some exploratory drilling has occurred in the coal areas in the upper half of the Chuitna River basin, and some gas and oil exploratory wells have been drilled in the lower half of the basin. Roads constructed for this latter drilling are the only evidence of man's activity in the uninhabited basin. The piedmont area on the south side of the Chuitna River between sites 3 and 4 drains the coal-bearing Tyonek Formation and has high potential for coal mining.

Capps and Bishop Creeks are in the Beluga River drainage basin and flow northward from the piedmont lowlands. At about 600 ft elevation the stream courses bend to the east, their gradients decrease, and the streams exhibit a marked meander pattern. Both basins are uninhabited, but there has been exploratory drilling in the coal areas of Capps Creek basin. The coal in the upper Capps Creek basin has high potential for mining. Figure 3 also shows the coal prospecting leases in the Capps Creek and Chuitna River basins.

Table 1 describes the seven sites. (Locations are shown in figure 3.) There are no lakes of significant size in the basins studied.

Table 1.--Drainage area, elevation range, and location of seven hydrologic data-collection sites in the Beluga coal area

| Site no. | Site name and location | Drainage area ($mi^2$) | Elevation range (ft) |
|---|---|---|---|
| 1 | Capps Creek near Tyonek<br>61°19'46" 151°37'36" | 11.6 | 470 - 2,700 |
| 2 | Bishop Creek near Tyonek<br>61°18'23" 151°30'27" | 10.9 | 500 - 1,500 |
| 3 | Chuitna River below Wolverine Fork near Tyonek<br>61°11'52" 151°39'20" | 19.5 | 1,300 - 2,800 |
| 4 | Chuitna River above Chuit Creek near Tyonek<br>61°09'16" 151°30'11" | 37.3 | 650 - 2,800 |
| 5 | Chuit Creek 5.4 mi above mouth near Tyonek<br>61°12'44" 151°33'54" | 9.80 | 1,200 - 1,900 |
| 6 | Chuit Creek at mouth near Tyonek<br>61°09'18" 151°30'11" | 23.0 | 650 - 1,900 |
| 7 | Chuitna River near Tyonek<br>61°06'31" 151°15'07" | 131 | 160 - 2,800 |

## Climate

The weather station closest to the Beluga study area is at Beluga on the shore of Cook Inlet. The station is at 75 ft elevation and has a complete record since August 1973. The average air temperature there for 5 years of record (1974-78) was 35.6°F; the average annual precipitation in the same period was 24.73 in. Based on a comparison with the Kenai FAA Airport (45 mi to the south) and Anchorage precipitation records, precipitation at Beluga was probably slightly less than average and air temperature was near the average during the study period, August 1975 to October 1978 (fig. 5). However, the period of record is so short that no attempt was made to quantify the deviation from the average.

Climate for this area is typified by heavy snowfall and below-freezing temperatures from November through March. The spring and early summer months are dry. Most of the year's rainfall occurs in September and October.

Surface-water runoff in the Chuitna River basin was about 1.6 times greater than the amount of precipitation at Beluga during the 1976-78 water years. As there would be some loss from evapotranspiration, the average annual precipitation over the basin was estimated to be more than 40 in. A similar analysis in the Capps Creek basin shows that average annual precipitation there is probably more than 50 in.

## Streamflow

### Chuitna River near Tyonek

A gaging station, Chuitna River near Tyonek, was installed in October 1975 on the Chuitna River 6.1 mi upstream from its mouth at Cook Inlet. No major tributaries enter the Chuitna River between this gaging station, where the drainage area is 131 $mi^2$, and the mouth of the river, where the drainage area is about 150 $mi^2$.

Figure 6 shows daily hydrographs for the Chuitna River near Tyonek for the 1976-78 water years. The long winter recession, the sustained flow during the snowmelt period, and the rapid response to intense rainstorms are readily apparent for each year. Generally, annual-minimum streamflow occurs at the end of the winter recession in February or March when discharges are 60 to 80 $ft^3/s$ [0.5 to 0.6 $(ft^3/s)/mi^2$]. Streamflow begins to increase at the start of the snowmelt season during the second half of April and increases rapidly through May. Snowmelt peaks occur in late May or early June and range from about 2,000 to 4,000 $ft^3/s$ [15 to 30 $(ft^3/s)/mi^2$]. Streamflow recedes from the snowmelt peak through July and reaches its summer minimum in late August and early September when streamflow is about 80 to 100 $ft^3/s$ [0.6 to 0.8 $(ft^3/s)/mi^2$]. Rains in September and October again increase streamflow. The annual maximum instantaneous discharge in 2 of the 3 years occurred in September as a result of intense rainfall. Because of the fall rains and low evaporation and transpiration, the autumn base flow remains relatively high. The discharge is in the 1 to 3 $(ft^3/s)/mi^2$ range at the time of freeze-up in November or December. Approximately 50 percent of the annual flow is direct runoff from snowmelt, 30 percent base flow, and 20 percent direct runoff from rainstorms. The mean discharge for each of the 3 years of record is shown in table 2.

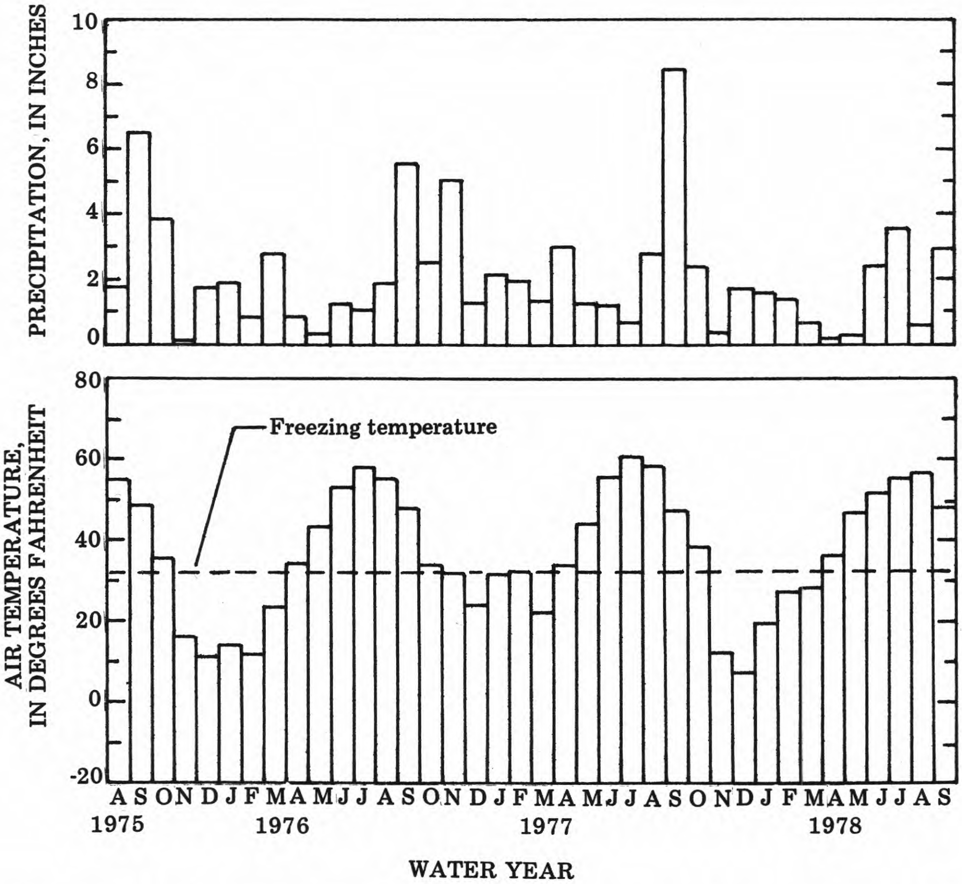



Figure 5.--Monthly precipitation and monthly average air temperature at Beluga, from August 1975 to October 1978. (From National Oceanic and Atmospheric Administration, 1975-78.)

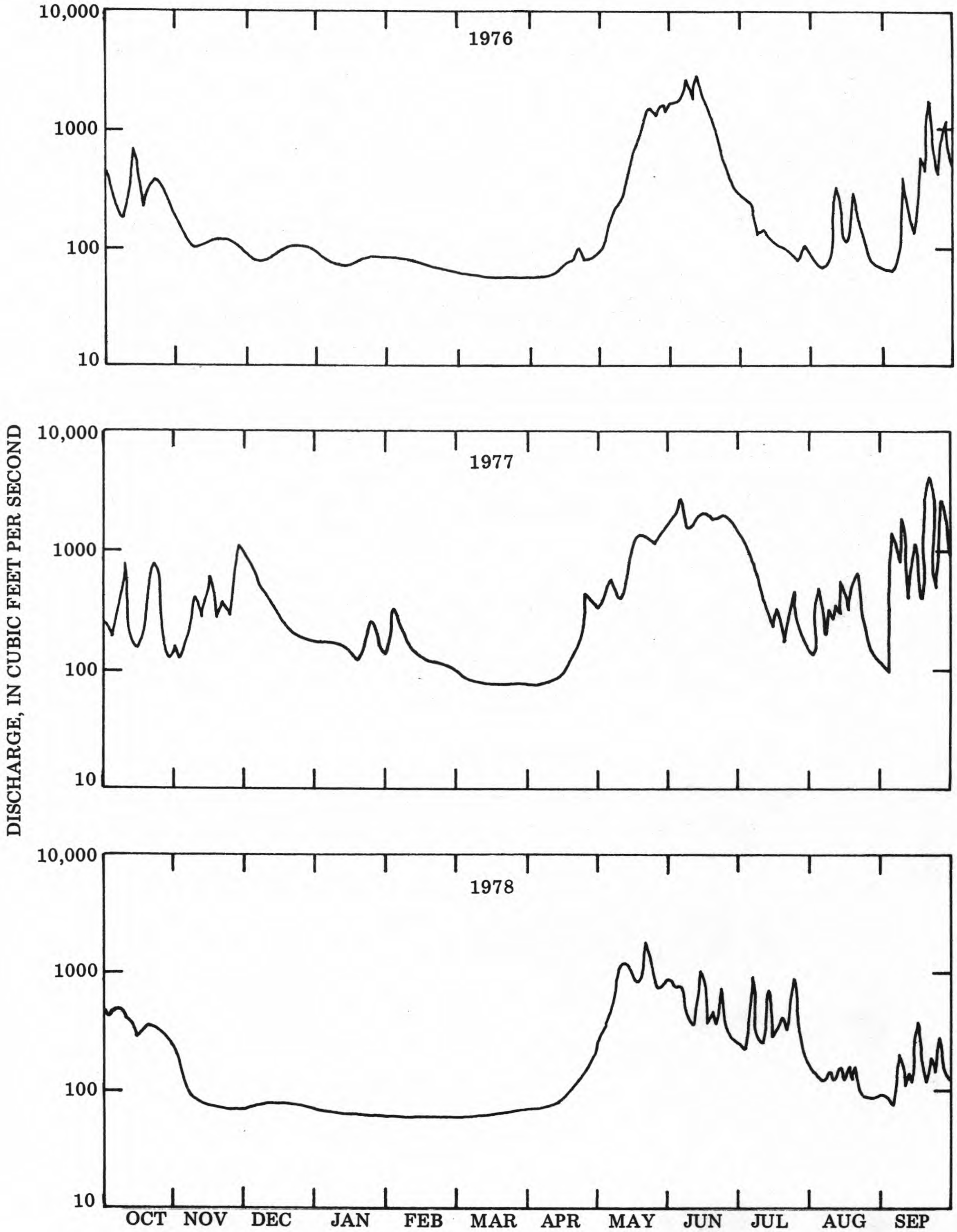



Figure 6.--Daily streamflow hydrographs, Chuitna River near Tyonek, 1976-78 water years.

Table 2.--Mean discharge, Chuitna River near Tyonek, 1976-78 water years

| Water year | Mean discharge ($ft^3/s$) | (in.) | [($ft^3/s$)/$mi^2$] |
|---|---|---|---|
| 1976 | 289 | 30.00 | 2.21 |
| 1977 | 559 | 57.94 | 4.27 |
| 1978 | 243 | 25.17 | 1.86 |

The long-term mean discharge at the gaging station at Chuitna River near Tyonek was estimated by two methods. One method developed a relationship between the mean flow for all gaging stations in the Cook Inlet basin having 10 or more years of continuous record and their mean flow in the 1976-78 period. Twenty gaging stations fit this criterion. A plot of the values is shown in figure 7, and a line was fitted to the values using least-squares regression on the logarithms of the values. Using the equation for this line, the mean flow for the Chuitna River near Tyonek is estimated to be 350 $ft^3/s$ with a standard error of 10 percent.

The second method of estimating the long-term mean discharge is by summing the flow-duration curve. The flow-duration curve based on 3 years of record was adjusted to a longer term based on the flow-duration curve for an index station, Resurrection Creek near Hope. (See figure 8.) This method indicates the mean flow is about 310 $ft^3/s$. Averaging the estimates from both methods gives a mean discharge of 330 $ft^3/s$ [34 in. per year, 2.5 ($ft^3/s$)/$mi^2$].

Annual low flow at the gaging station at Chuitna River near Tyonek during the 1976-78 study period occurred from February to April, at the end of the winter flow recession. However, summer low flows were only slightly greater than the winter low flows. During August and early September, when evaporation and transpiration were high and rainfall was light, streamflow in the Chuitna River decreased to its summer low. During an extended rainless period in late August or early September, the summer low flow could be less than the winter low flow. Winter and summer low flows for the 3 years of record are shown in table 3.

Table 3.--Winter and summer low flows, Chuitna River near Tyonek, 1976-78 water years

| Water year | Minimum daily discharge ($ft^3/s$): Winter | | Summer (July - September) | |
|---|---|---|---|---|
| | Discharge | Date | Discharge | Date |
| 1976 | 60 | Mar. 1 - Apr. 15 | 74 | Sept. 6 |
| 1977 | 80 | Mar. 11 - Apr. 5 | 97 | Sept. 5 |
| 1978 | 60 | Feb. 12 - Mar. 12 | 85 | Sept. 4 |

Low flows of the Chuitna River were compared with those from other gaging stations in Cook Inlet basin having longer periods of record. The best agreement was with Resurrection Creek near Hope, which has 11 years (1968-78) of record. A

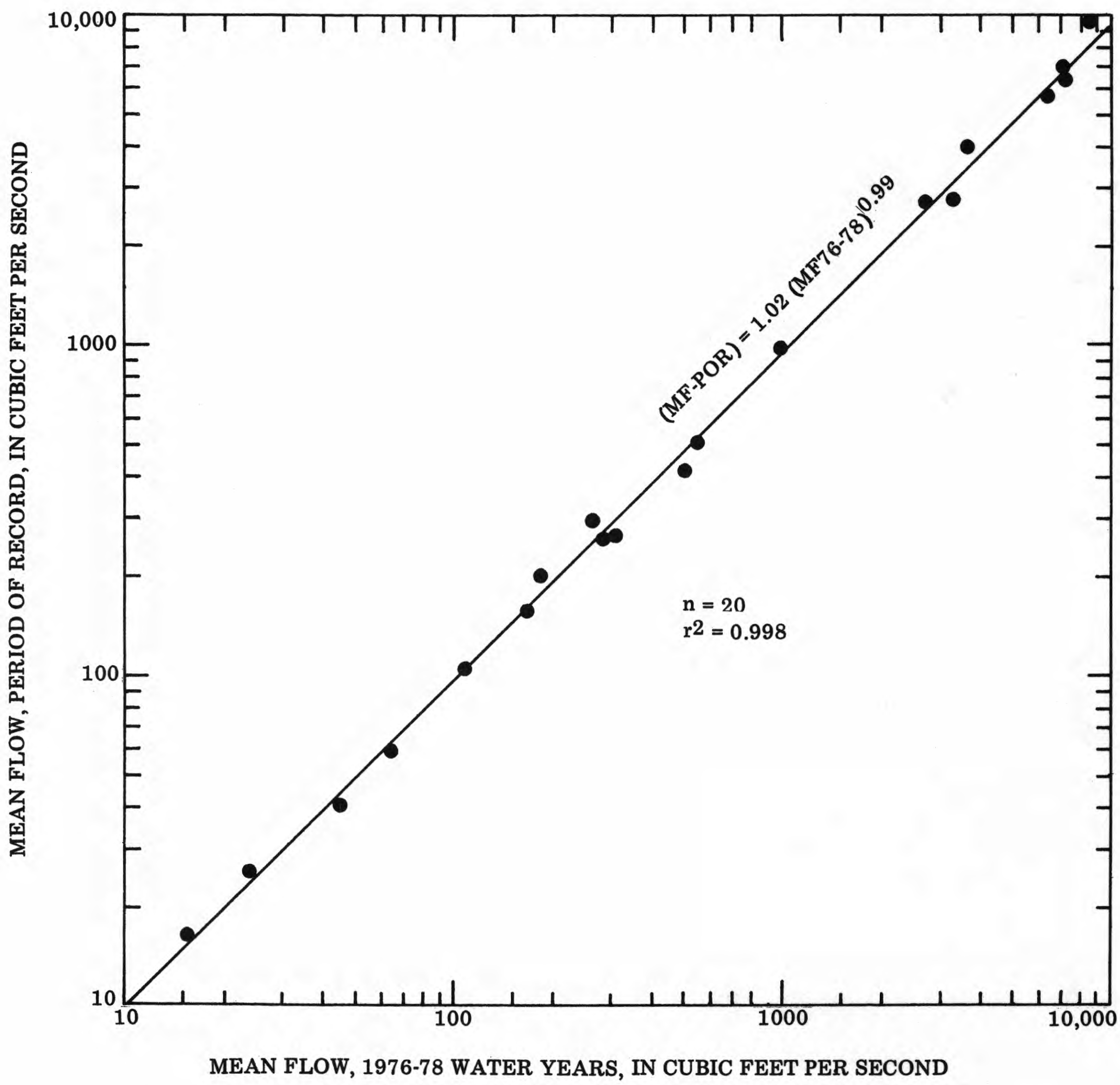



Figure 7.--Mean flow for the period of record (MF-POR) as related to mean flow during the 1976-78 water years (MF76-78) for all gaging stations in Cook Inlet Basin with 10 or more years of record.

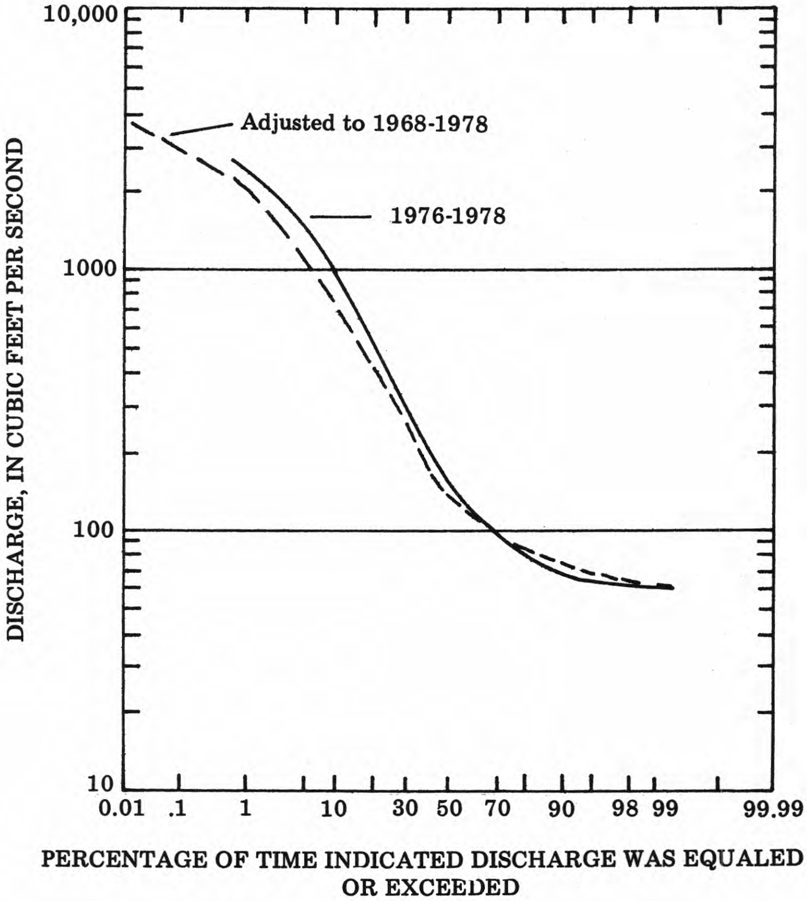



Figure 8.--Flow-duration curves for Chuitna River near Tyonek.

low-flow relation between Chuitna River near Tyonek and Resurrection Creek near Hope was defined using mean daily discharges for selected concurrent low flows. This line of relation was computed using least-squares regression on the logarithms of the values. The line and its equation are shown in figure 9.

The equation relating low flow at the two sites was used to estimate low-flow discharges and their frequencies for Chuitna River near Tyonek as shown in table 4. Low-flow values and their frequencies were computed for Resurrection Creek near Hope using a log-Pearson Type III frequency distribution of the daily low-flows recorded during the 1967-78 period of operation. Low-flow values for 7 and 30 consecutive days for the annual and summer period at the gage on Resurrection Creek were computed for recurrrence intervals of 2, 10, and 20 years and then used to estimate comparable information for Chuitna River near Tyonek. The frequencies are expressed as recurrence intervals, which are average times between occurrences. For the stated recurrence interval, the discharge values will be less than or equal to the value shown.

Table 4.--Estimate of low-flow frequency discharges, Chuitna River near Tyonek

| Period | Number of consecutive days | Discharge ($ft^3/s$) Recurrence interval, years 2 | 10 | 20 |
|---|---|---|---|---|
| Annual | 7 | 62 | 58 | 56 |
| Annual | 30 | 62 | 58 | 57 |
| Summer | 7 | 91 | 81 | 78 |
| (July-Sept.) | 30 | 96 | 84 | 81 |

Knowledge of variation of streamflow is often useful. A frequency diagram shows the percentage of time that streamflow is within a certain range of discharge. An integration of the frequency diagram gives the flow-duration curve that depicts the flow characteristics of a stream throughout the range of discharge for the period of time being analyzed.

The daily-mean discharges for the 1976-78 water years for Chuitna River near Tyonek were used to develop the flow-duration curve shown in figure 8. A method developed by Searcy (1959), which utilizes an index station, was used to adjust this flow-duration curve to a longer term. Resurrection Creek near Hope was selected as the index station after comparing the flow-duration curve of Chuitna River with flow-duration curves for other gaging stations in the Cook Inlet basin. Figure 10 shows the correlation between Resurrection Creek and Chuitna River based on discharges of equal percent duration during the period of common record, 1976-78. It is assumed that this curve also represents the relation between the stations for the longer period. The adjusted flow-duration curve for Chuitna River near Tyonek is obtained by using this relation with the longer term flow-duration curve for Resurrection Creek near Hope. The adjusted flow-duration curve is also shown in figure 8. The difference in flow-duration curves for Chuitna River near Tyonek for the short- and long-term periods is not large. This indicates that streamflow during 1976-78 was near the long-term normal and also reflects the

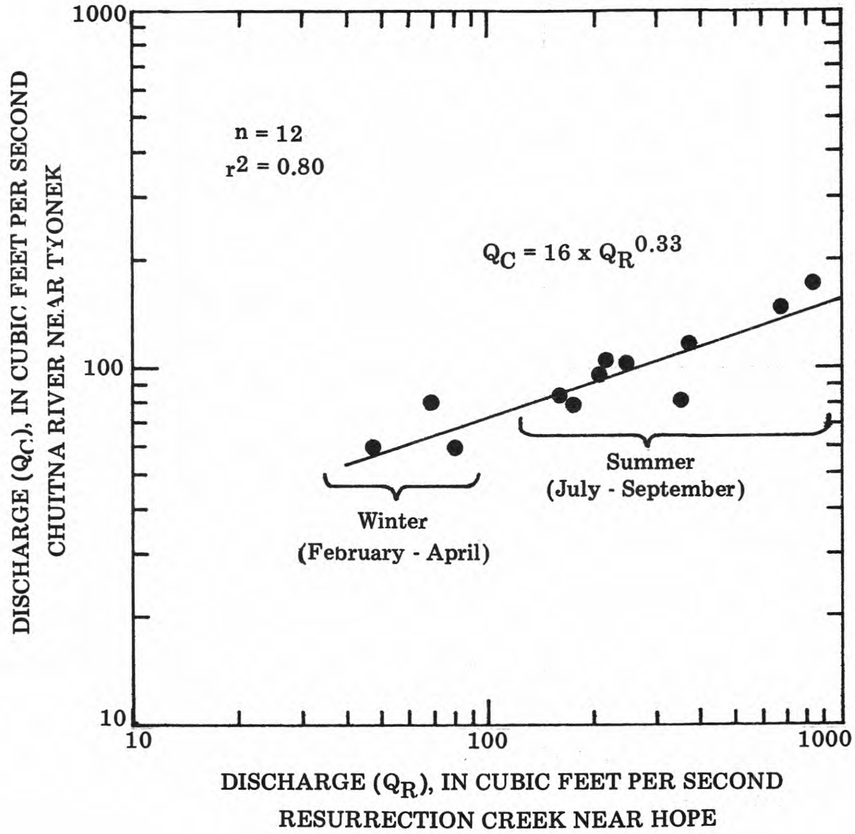



Figure 9.--Low flow of Chuitna River near Tyonek related to low flow of Resurrection Creek near Hope.

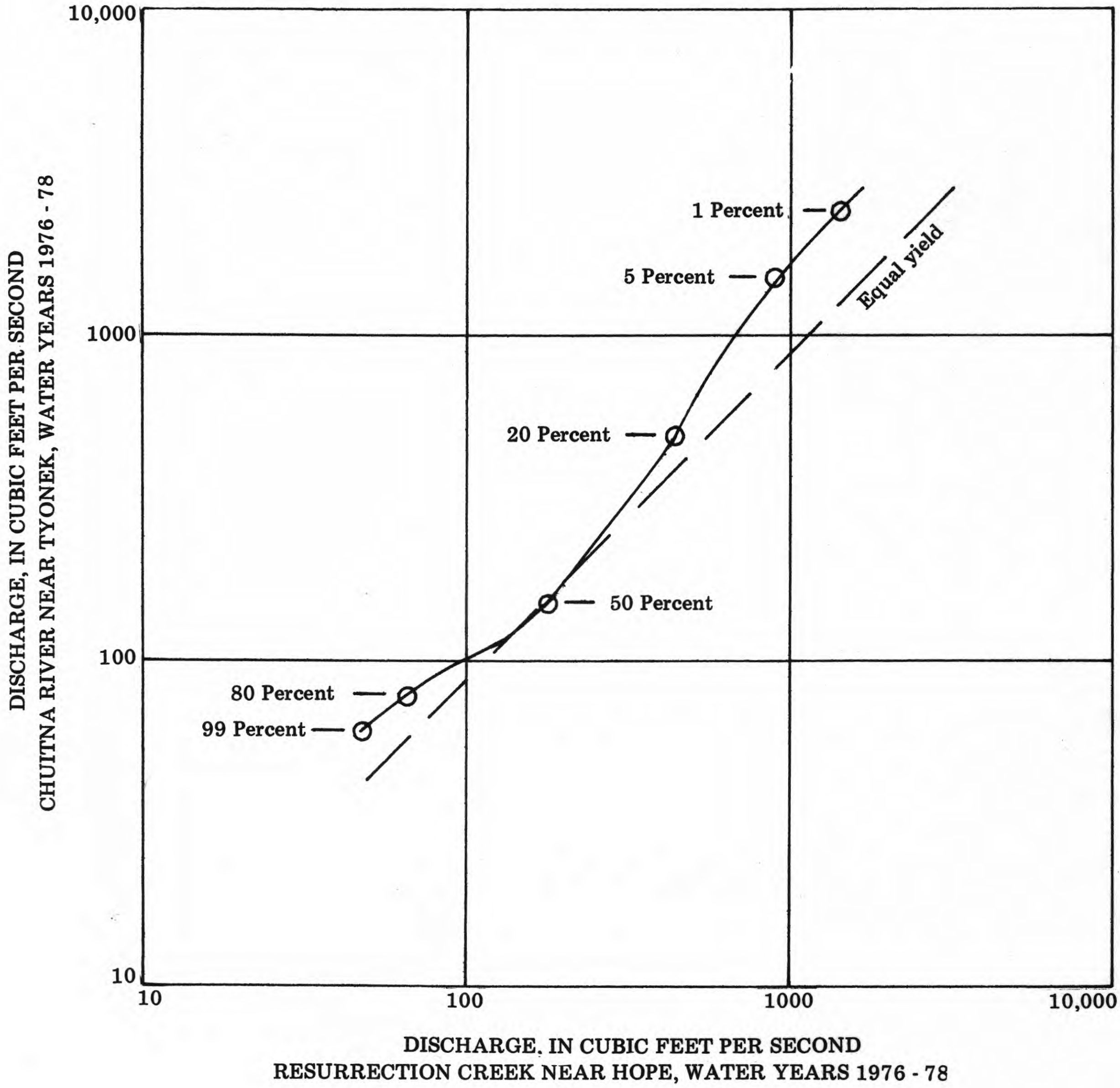



Figure 10.--Correlation between Resurrection Creek and Chuitna River, based on discharge of equal percent duration.

relatively low variability in annual flows in Cook Inlet basin streams. (See Freethey and Scully, 1980.)

High flow in the Chuitna River basin is a result of snowmelt runoff in May and June and rainstorms in the fall. The annual maximum discharge in 1976 and 1977 occurred in September as the result of heavy rains; the 1978 annual maximum discharge occurred in late May due to snowmelt. Annual peak discharge from snowmelt shows less variation than peaks from rainstorms. In the 3 years of record the peak in the snowmelt period at the gaging station ranged from 1,940 to 3,770 $ft^3/s$ [15 to 29 $(ft^3/s)/mi^2$], whereas the annual peak from rainstorms ranged from the 1978 peak of 1,700 $ft^3/s$ to 6,700 $ft^3/s$ [13 to 51 $(ft^3/s)/mi^2$]. Shown in table 5 are the independent peak discharges greater than 2,200 $ft^3/s$ and the annual maximum discharge (denoted with an *).

Table 5.--Peak discharges, Chuitna River near Tyonek

| Water year | Date | Instantaneous peak discharge ($ft^3/s$) | Instantaneous peak discharge [$(ft^3/s)/mi^2$] | Cause |
|---|---|---|---|---|
| 1976 | June 6 | 3,390 | 25.9 | Snowmelt with rain |
| | Sept 20 | 4,380* | 33.4 | Rain |
| | Sept 28 | 2,440 | 18.6 | Rain |
| 1977 | June 5 | 3,770 | 28.8 | Snowmelt with rain |
| | June 17 | 2,830 | 21.6 | Snowmelt |
| | Sept 10 | 4,940 | 37.7 | Rain |
| | Sept 21 | 6,700* | 51.1 | Rain |
| | Sept 28 | 4,160 | 31.8 | Rain |
| 1978 | May 24 | 1,940* | 14.8 | Snowmelt |

## Partial-Record Stations

An estimate of mean discharge was made at six partial-record stations in the Beluga area by correlating periodic discharge measurements made in the 1978 water year with concurrent mean-daily discharge at an index gage. Base-flow discharge measurements made at the partial-record sites during 1976-78 were correlated with mean-daily discharge at the index gage to obtain an estimate of base-flow characteristics. Chuitna River near Tyonek was used as the index gage because it is the only continuous-discharge gaging station in the area even though it has only 3 years of discharge record.

To estimate the runoff from subbasins in the Chuitna River drainage basin and two adjacent basins in the Beluga River drainage basin, a method developed by Riggs (1969) was employed. Discharge measurements were made monthly during the summer and, because winter discharges in the area are steady and low, every 2 months during the 6 winter months. Therefore, nine discharge measurements made during the 1978 water year were used to determine the 1978 water year mean discharge at each of the six partial-record stations. This method is illustrated in figure 11 where the concurrent discharges during the 1978 water year are plotted for one of the partial-record stations, Bishop Creek near Tyonek, and the index station. The mean discharge at the partial-record station for each time period is estimated by con-

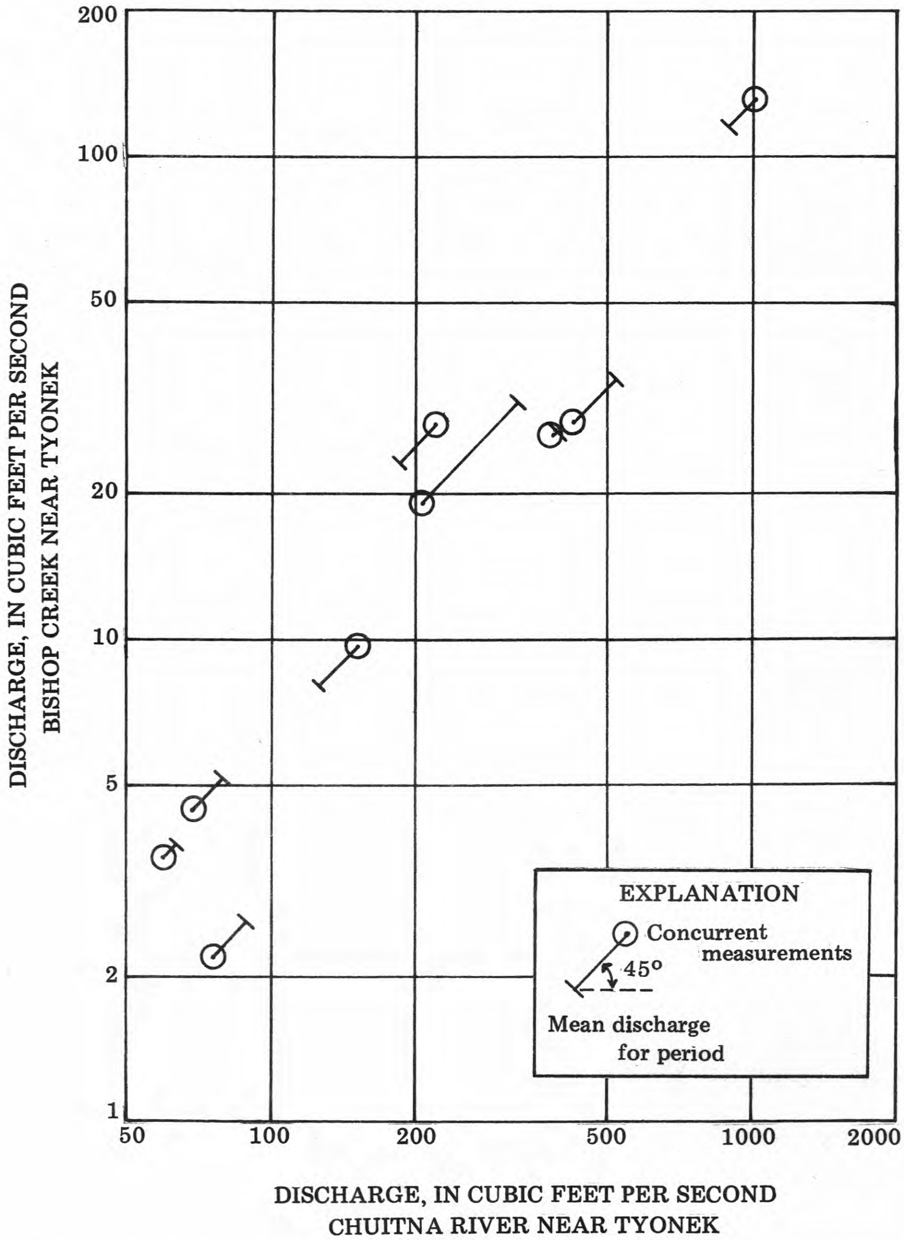



Figure 11.--Estimation of mean discharge of Bishop Creek near Tyonek based on concurrent discharge measurements of Chuitna River near Tyonek, 1978 water year.

structing a 45-degree line through the concurrent discharge measurements for that period and transferring the mean discharge at the index gage for the same period through the line. The graph shows the discharge relation between the two stations, the spread in discharge between the concurrent discharge measurements and the mean discharge for each period, and the range in discharge measurements at the partial-record station during the 1978 water year. Table 6 shows the concurrent discharge measurements made at the two stations, the mean discharge at the index gage for each period, and the computation of mean discharge at Bishop Creek near Tyonek for the 1978 water year.

Table 6.--Computation of 1978 water year mean discharge at Bishop Creek near Tyonek

| Concurrent discharge | | | Mean discharge | | Mean discharge computation | | |
|---|---|---|---|---|---|---|---|
| Periodic measurement date | Index gage (mean daily) ($ft^3/s$) | Bishop Creek near Tyonek ($ft^3/s$) | Month | Index gage ($ft^3/s$) | Period | Index gage ($ft^3/s$) | Bishop Creek near Tyonek ($ft^3/s$) |
| 10-18-77 | 204 | 19 | Oct. 1977 | 325 | Oct. 1977 | 325 | 30 |
| | | | Nov. | 99.6 | | | |
| 12-13-77 | 75 | 2.2 | Dec. | 75.2 | Nov., Dec. | 87.2 | 2.6 |
| | | | Jan. 1978 | 66.7 | | | |
| 2-16-78 | 60 | 3.5 | | 60.8 | Jan., Feb. 1978 | 63.9 | 3.7 |
| | | | Mar. | 62.7 | | | |
| 3-30-78 | 68 | 4.4 | Apr. | 96.0 | Mar., Apr. | 79.1 | 5.1 |
| 5-11-78 | 1,020 | 131 | May | 888 | May | 888 | 114 |
| 6-20-78 | 425 | 28 | June | 519 | June | 519 | 34 |
| 7-17-78 | 383 | 27 | July | 391 | July | 391 | 28 |
| 8-14-78 | 150 | 9.5 | Aug. | 125 | Aug. | 125 | 7.9 |
| 9-12-78 | 218 | 28 | Sept. | 184 | Sept. | 184 | 24 |
| | | Mean discharge, 1978 water year | | | | 243 | 22 |

Similar calculations were made for the other five partial-record stations to estimate the mean discharge for the 1978 water year. To extend these values to represent an estimate of the long-term mean discharge, they were multiplied by the ratio of the mean discharge at the index station to the 1978 annual mean discharge at the index station. Table 7 shows the estimates of mean discharge for the 1978 water year and the long-term mean discharge for the six partial-record stations. Comparable values for the index station and unit discharges for the long-term mean discharges are also shown.

Table 7.--Estimate of 1978 water year mean discharge and long-term mean discharge for stations in the Beluga coal area

| Station | Drainage area ($mi^2$) | Discharge: 1978 water year mean ($ft^3/s$) | Discharge: Long-term mean ($ft^3/s$) | Discharge: Long-term mean [$(ft^3/s)/mi^2$] |
|---|---|---|---|---|
| Capps Creek near Tyonek | 11.6 | 29 | 39 | 3.4 |
| Bishop Creek near Tyonek | 10.9 | 22 | 30 | 2.8 |
| Chuitna River below Wolverine Fork near Tyonek | 19.5 | 48 | 65 | 3.3 |
| Chuitna River above Chuit Creek near Tyonek | 37.3 | 82 | 110 | 3.0 |
| Chuit Creek 5.4 mi above mouth near Tyonek | 9.80 | 21 | 29 | 3.0 |
| Chuit Creek at mouth near Tyonek | 23.0 | 45 | 61 | 2.7 |
| Chuitna River near Tyonek | 131 | 243 | 330 | 2.52 |

The Chuitna River basin can be divided into five areas using four partial-record stations and the index station. The yield from each area is determined by subtracting inflow into that area from outflow from the area. Figure 12 shows the estimated long-term yields in the five sub-areas in the Chuitna River basin in addition to those of Capps Creek and Bishop Creek. Yields range from 2.2 $(ft^3/s)/mi^2$ in the lower part of the Chuitna River basin to 3.4 $(ft^3/s)/mi^2$ in the Capps Creek basin and 3.3 $(ft^3/s)/mi^2$ in the upper Chuitna River basin. Yields generally increase from the west shore of Cook Inlet to the uplands of the Chuitna River basin, probably as a result of greater precipitation at higher elevations due to orographic lifting.

Base-flow discharge measurements were made during the winter and summer in 1976-78 at the six partial-record stations. Nine base-flow measurements were made on Capps Creek, seven on Bishop Creek, and eight at the other four stations. These measurements were correlated with the concurrent mean daily discharges at the index gage, Chuitna River near Tyonek, and are shown on figure 13. A line of relation was developed for each station using a least-squares regression on the logarithms of the discharge. This line and an equal yield line (a line indicating the same unit runoff) are shown for each partial-record station on the same figure.

The unit base flow at the partial-record stations was about the same as at the index station during the winter. The two exceptions were Chuitna River below Wolverine Fork near Tyonek where winter unit base flow ranged from 0.5 to 1.0 $(ft^3/s)/mi^2$ (more than at the index station) and Bishop Creek near Tyonek where it ranged from 0.2 to 0.4 $(ft^3/s)/mi^2$ (less than at the index station). However, at greater base flow, such as in summer, unit base flow was larger at all the partial-record stations than at the index station. Using the relation with the 7-day 10-year minimum discharge for Chuitna River near Tyonek, the estimates of $M_{7,10}$ discharges and unit discharges are obtained (table 8). ($M_{7,10}$ = lowest discharge for 7 consecutive days having a recurrence interval of 10 years.)

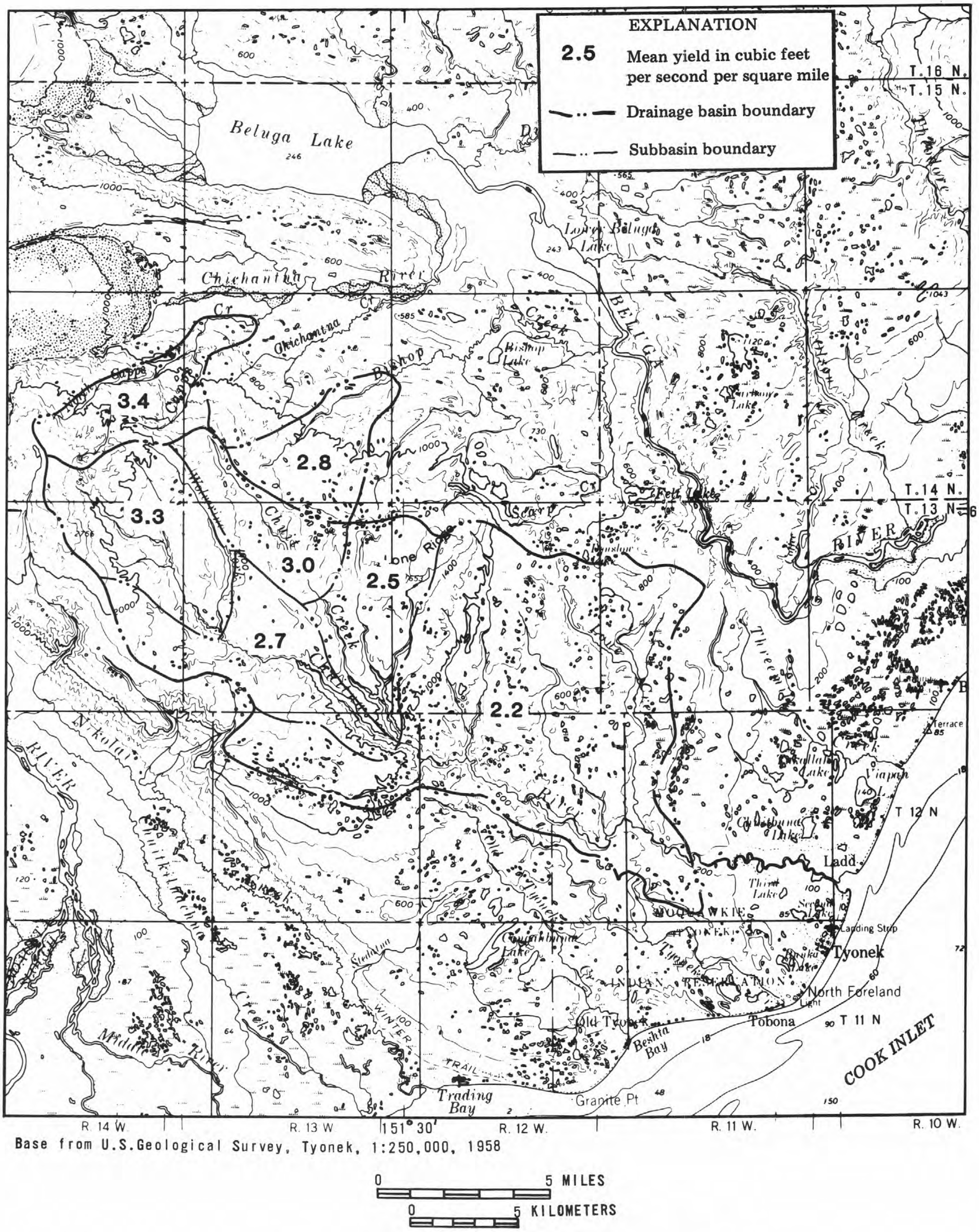



Figure 12.--Mean yield in the Capps and Bishop Creek basins and in the Chuitna River subbasins.

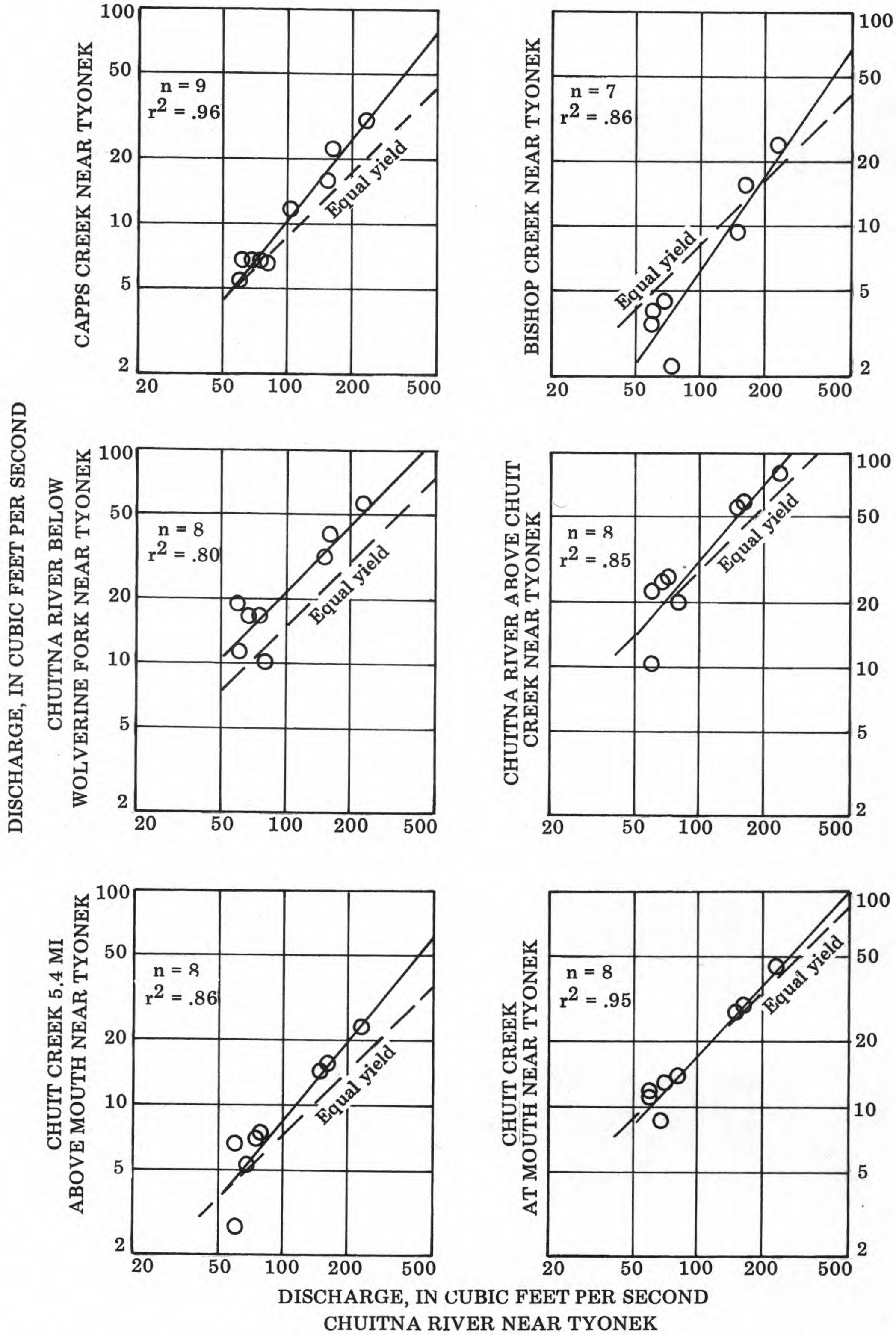



Figure 13.--Correlation of base-flow discharge measurements at six partial-record stations with Chuitna River near Tyonek.

Table 8.--Estimate of $M_{7,10}$ discharge at partial-record stations in the Beluga coal area

| Station | $M_{7,10}$ discharge ($ft^3/s$) | $M_{7,10}$ discharge [$(ft^3/s)/mi^2$] |
|---|---|---|
| Capps Creek near Tyonek | 5.3 | 0.46 |
| Bishop Creek near Tyonek | 2.9 | .27 |
| Chuitna River below Wolverine Fork near Tyonek | 12 | .62 |
| Chuitna River above Chuit Creek near Tyonek | 16 | .43 |
| Chuit Creek 5.4 mi above mouth near Tyonek | 4.4 | .45 |
| Chuit Creek at mouth near Tyonek | 9.6 | .42 |

## Capps Creek Basin Low-Flow Investigation

The upper part of the Capps Creek drainage basin has large deposits of mineable coal. Interest in strip mining this coal in the near future has been increasing. Data on the ground-water contribution to streamflow may be helpful in assessing water availability in the mining area.

Low flow was investigated in this basin August 24, 1978, to determine the contribution to streamflow from various parts of the basin. Streamflow on the day of the investigation is considered to be derived entirely from ground water. It had been 7 days since any measurable precipitation had fallen at the closest weather station (Beluga). Streamflow at the nearest recording gaging station, Chuitna River near Tyonek, had been in a recession for 4 days after a minor peak of 301 $ft^3/s$ [2.30 $(ft^3/s)/mi^2$] on August 20. Mean daily discharge at the gage on August 24, 1978, was 103 $ft^3/s$ [0.79 $(ft^3/s)/mi^2$].

Results of the low-flow measurements are given in table 9. Figure 14 shows the location of the measuring sites referred to in the table.

Table 9.--Discharge measurements in the Capps Creek basin, August 24, 1978

| Site no. | Stream | Drainage area ($mi^2$) | Measured discharge ($ft^3/s$) | Measured discharge [$(ft^3/s)/mi^2$] |
|---|---|---|---|---|
| 1c | Capps Creek above tributary 1 near Tyonek | 0.80 | 1.00 | 1.25 |
| 2c | Capps Creek tributary 1 at mouth near Tyonek | 0.66 | 0.57 | 0.86 |
| 3c | Capps Creek above tributary 2 near Tyonek | 2.02 | 2.56 | 1.27 |
| 4c | Capps Creek tributary 2 at mouth near Tyonek | 0.82 | 0.88 | 1.07 |
| 5c | Capps Creek above North Capps Creek near Tyonek | 4.97 | 5.39 | 1.08 |
| 6c | North Capps Creek at 1,500 ft elevation near Tyonek | 2.23 | 2.69 | 1.21 |
| 7c | North Capps Creek at mouth near Tyonek | 4.90 | 4.78 | 0.98 |
| 8c | Capps Creek below North Capps Creek near Tyonek | 10.52 | 10.78 | 1.02 |
| 1 | Capps Creek near Tyonek | 11.60 | 11.59 | 1.00 |

The yield from each subbasin is obtained by subtracting the inflow into the subbasin from the outflow and dividing by the intervening drainage area. The yield for each of the nine subbasins is shown in figure 14. Because some of the subbasin discharges are the difference between two numbers of about the same magnitude, the indicated yields may have significant errors as affected by small inaccuracies in open-channel measurements.

All subbasins in the Capps Creek basin contributed water to the streams. Capps Creek subbasins at the higher elevations yielded significantly more water than those at lower elevations of Capps Creek. The area above an elevation of 1,800 ft yielded 1.2 $(ft^3/s)/mi^2$, whereas the area at a lower elevation yielded 0.8 $(ft^3/s)/mi^2$.

## Water Quality

### Suspended Sediment

During the study period, 23 suspended-sediment samples were collected at the Chuitna River gaging station. The times of collection were selected in order to sample a wide range of discharges and during both snowmelt and rainstorm periods. Discharges at the times of sampling ranged from 157 to 6,450 $ft^3/s$, and concentrations ranged from 1 to 1,570 mg/L. The highest suspended-sediment concentration was measured on the same day as the maximum discharge during the study period.

Figure 15 shows a plot of the suspended-sediment discharge ($Q_s$) as a function of water discharge ($Q_w$). A linear least-squares fit to the logarithms of the values gives the equation: $Q_s = 6.74 \times 10^{-7} Q_w^{2.76}$, which has a standard error estimate of 51 percent. Lines of equal concentration are also shown on figure 15 to illustrate the increase in suspended-sediment concentration with increase in discharge.

The long-term average sediment yield at the Chuitna River gaging station was estimated from the suspended-sediment discharge equation and the long-term flow-duration curve using a method developed by Miller (1951). This method was used for determining sediment-duration curves and mean annual suspended-sediment discharge for 38 Ohio basins (Antilla and Tobin, 1978) and for computing suspended-sediment discharge in the Susquehanna River basin (Lystrom and others, 1978). The sediment-duration curve for Chuitna River near Tyonek indicates that about 86 percent of the suspended sediment is discharged during 10 percent of the time. Using Miller's method the estimated suspended-sediment discharge is 42 ton/d or 15,000 ton/yr, which gives a mean yield of 120 $(ton/mi^2)/yr$ when averaged over the entire basin. Although it is not possible to calculate a probable error for this estimated sediment yield, derivation of the sediment yield is subject to many uncertainties. A larger number of samples collected at high discharge, when most of the suspended sediment is transported, and sampling over more rainstorms and snowmelt events over a period of several years would result in a better defined suspended-sediment discharge curve. The flow-duration curve is also subject to change as data are collected over more years of record, but streamflow should have less variability than the suspended-sediment discharge. The relatively low variability of south-central Alaska's streamflow, both seasonally and from year to year, would tend to reduce the inaccuracy inherent in a flow-duration curve based on a limited period of record.

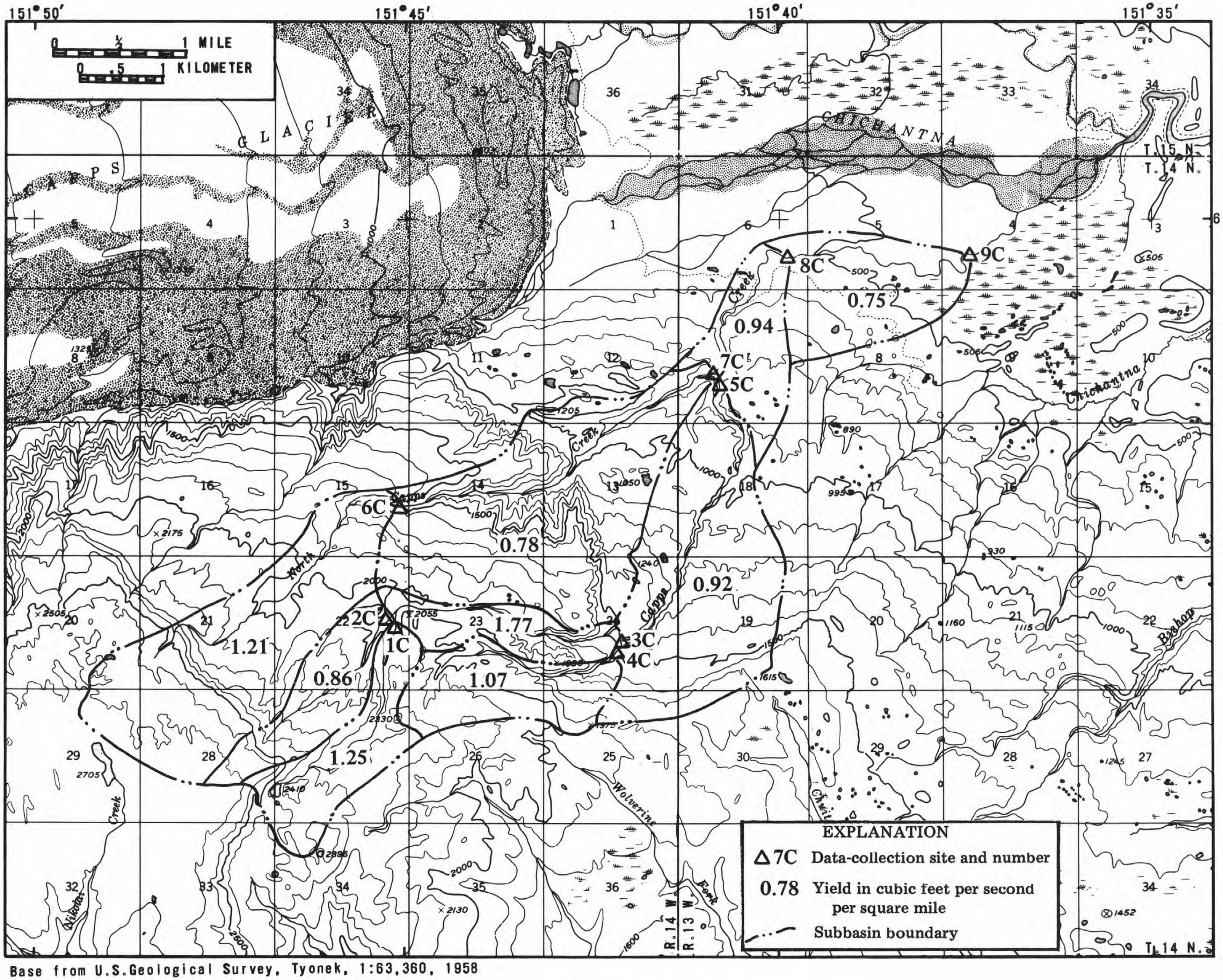



Figure 14.--Subbasin yield in the Capps Creek drainage basin on August 24, 1978.

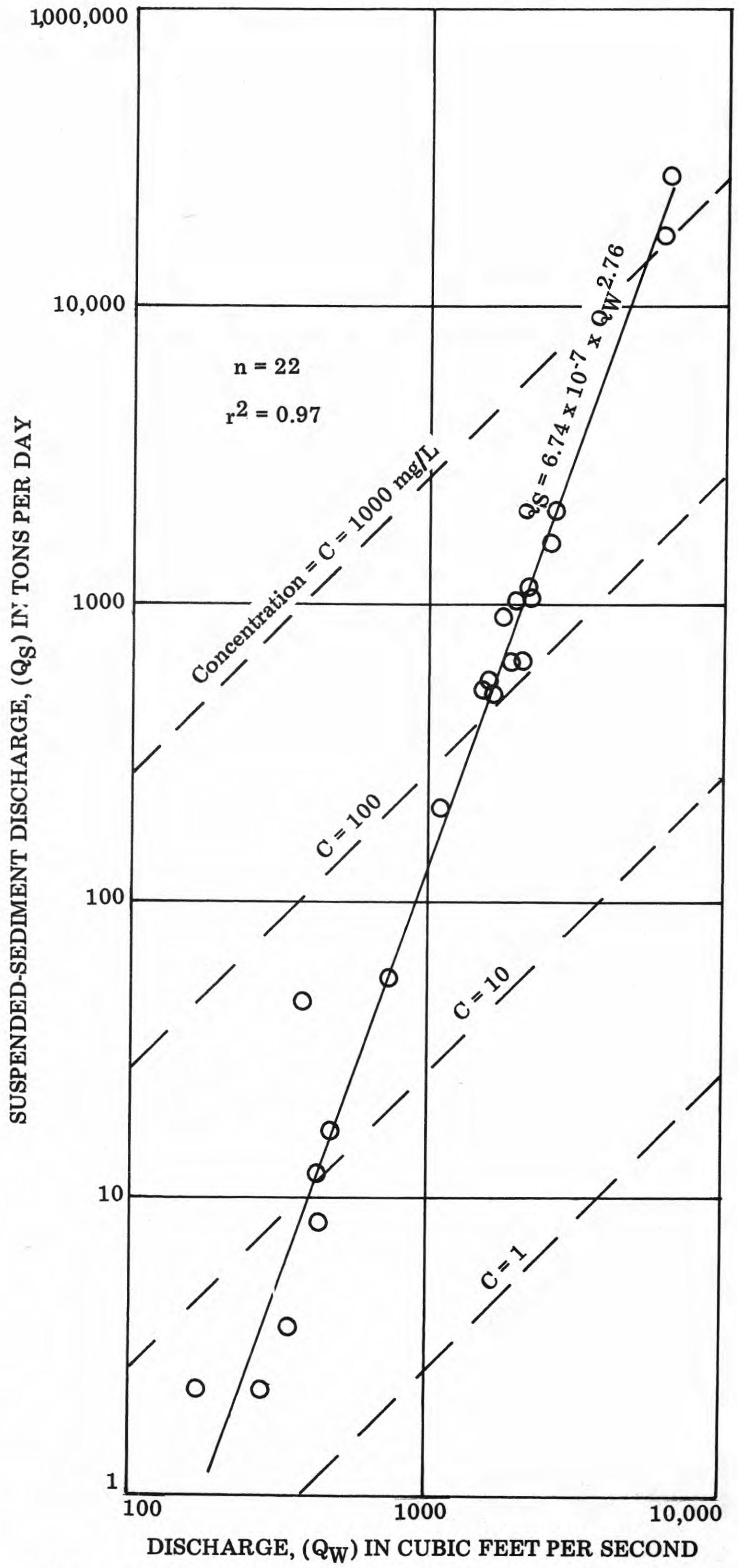



Figure 15.--Suspended-sediment discharge as a function of discharge at Chuitna River near Tyonek.

Two complete particle-size analyses (0.002 - 2.00 mm) and eight sand-size analyses (0.062 - 2.00 mm) were made from suspended-sediment samples taken at medium and high flow (discharge range 750 to 6,450 $ft^3/s$) at Chuitna River near Tyonek. These 10 size determinations are shown in table 10. These determinations show that 30 to 70 percent of the suspended sediment consisted of sand particles; the rest was silt and clay.

Table 10.--Suspended-sediment particle-size analyses, Chuitna River near Tyonek

| Date | Time | Discharge ($ft^3/s$) | Percent finer than size indicated, in millimeters | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0.002 | 0.004 | 0.008 | 0.016 | 0.031 | 0.062 | 0.125 | 0.250 | 0.500 | 1.00 | 2.00 |
| 5-26-76 | 1330 | 1,110 | -- | -- | -- | -- | -- | 61 | 69 | 82 | 98 | 100 | -- |
| 6-07-76 | 1430 | 1,500 | -- | -- | -- | -- | -- | 38 | 46 | 66 | 95 | 100 | -- |
| 5-13-77 | 0900 | 750 | -- | -- | -- | -- | -- | 66 | 74 | 86 | 97 | 100 | -- |
| 5-29-77 | 0100 | 1,930 | -- | -- | -- | -- | -- | 37 | 51 | 78 | 96 | 98 | 100 |
| 6-11-77 | 2030 | 2,560 | -- | -- | -- | -- | -- | 43 | 57 | 74 | 96 | 100 | -- |
| 6-12-77 | 0030 | 2,700 | -- | -- | -- | -- | -- | 38 | 51 | 79 | 98 | 100 | -- |
| 6-12-77 | 0630 | 2,250 | -- | -- | -- | -- | -- | 31 | 42 | 70 | 97 | 100 | -- |
| 6-12-77 | 1200 | 2,020 | -- | -- | -- | -- | -- | 29 | 39 | 66 | 95 | 100 | -- |
| 9-21-77 | 1110 | 6,450 | 12 | 20 | 30 | 42 | 54 | 63 | 74 | 88 | 99 | 100 | -- |
| 9-21-77 | 1315 | 6,180 | 10 | 17 | 26 | 37 | 47 | 56 | 68 | 84 | 98 | 100 | -- |

Periodic suspended-sediment samples were taken at the six partial-record stations during low and medium flows. No attempt was made to sample at high flow because the streams were not wadable. Plots of suspended-sediment discharge as a function of discharge are shown in figure 16. A curve of relation was not defined because of scatter of the data and the absence of high flow samples. Lines of equal concentration are also shown on the graphs. Capps Creek generally had the highest concentration of suspended sediment of the sampled basins. Its concentrations were three to four times greater than those at Chuitna River near Tyonek for the same unit runoff. The upper elevations of the study area are relatively flat and swampy and are covered with muskeg vegetation, which tends to inhibit soil erosion. This lack of soil particles is reflected in lower suspended-sediment discharge per unit area in these upper elevation streams.

## Water Temperature

A continuously recording thermograph was installed at the gaging station Chuitna River near Tyonek in May 1976. Record for most of 3 years is available. In general, the water temperature begins to increase from the freezing point in early May. This increase is moderate during May and early June when the streamflow is also increasing from snowmelt. The water temperature increases more rapidly during late June and July when the streamflow is receding from the snowmelt peak. The annual maximum water temperature occurs in late July or early August. The maximum recorded water temperature during the 1976-78 period was 22.5°C; and water temperature reached at least 19°C during each of the 3 years. The water temperature has a diurnal range of about 3° to 5°C during July and August. The water temperature decreases throughout September and is usually at the freezing point by late October and remains there throughout the period of ice cover, November through

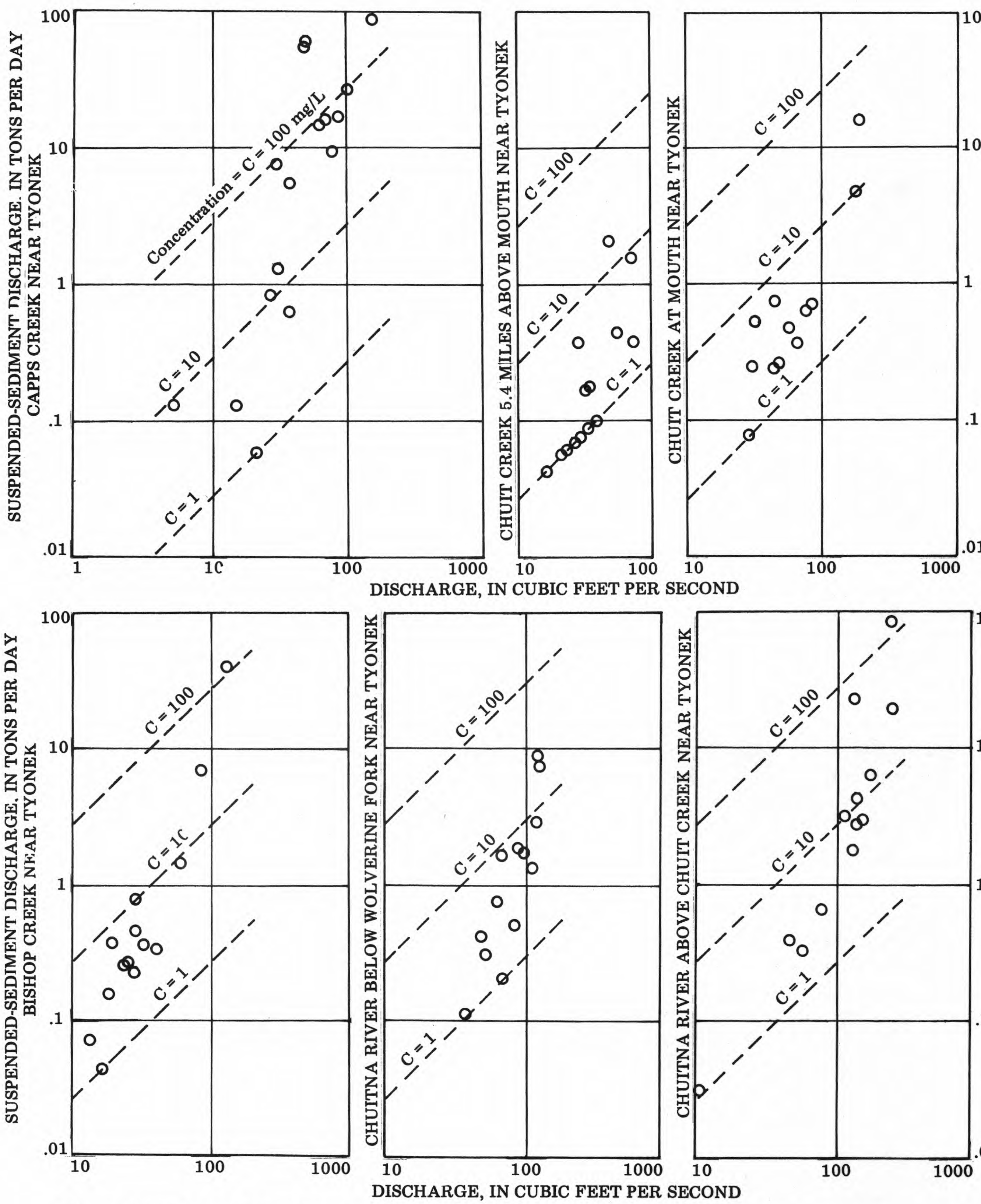



Figure 16.--Suspended-sediment discharge as a function of discharge for six partial-record stations in the Beluga coal area.

April. Figure 17 shows the maximum and minimum daily water temperatures during May to October at the gaging station.

Water temperatures were measured at the six partial-record stations at the time of discharge measurements. These temperatures are plotted against the concurrent water temperature at the Chuitna River near Tyonek gage in figure 18. Generally, the summer water temperatures were from 1° to 4°C lower at the partial-record stations than at Chuitna River near Tyonek. The difference was greater at higher temperatures and was partly due to the elevation difference between stations. From November to April, the water temperature is at or near the freezing point at all stations.

## Chemical Quality

The chemical quality of surface water in basins in the Beluga study area is similar. The water is a calcium bicarbonate type and has low dissolved-solids concentrations. During the study period the pH ranged from 6.5 to 7.7 units. Figure 19 shows the relation of dissolved solids to unit discharge for all basins, and figure 20 shows the relation of dissolved solids to specific conductance. The trilinear diagram in figure 21 shows the relative concentration of the major ions. There was no discernible difference in relative cation or anion composition among the seven basins or at different rates of discharge or seasons. All major cation and anion concentrations are well below limits recommended or stipulated by government agencies for various water uses. However, the low concentration of bicarbonate is indicative of poorly buffered water. Hence, if a basic or acidic effluent were added to a stream, the pH would probably be altered significantly.

Observed concentrations of dissolved silica ranged from 6 to 17 mg/L. The proportion of dissolved silica to dissolved solids averaged 35 percent in the 25 samples.

Thirty-six dissolved-oxygen measurements were made during the study. The only winter measurements were made in early April 1976. At that time the streams were mostly covered by ice but had small, intermittent open leads. Dissolved oxygen in early April 1976 at the seven sites ranged from 76 to 100 percent of saturation. The remaining 29 dissolved-oxygen measurements were made during the open-water period from May to October. In these samples the dissolved-oxygen concentration ranged from 90 to 100 percent of saturation and averaged 98 percent of saturation.

Dissolved-iron concentrations from all basins ranged from less than 0.01 to 0.5 and averaged 0.23 mg/L. The dissolved-iron concentrations in the Capps Creek basin were greater than in the other basins and averaged 0.36 mg/L, based on eight samples. Total-iron concentrations were significantly greater than dissolved-iron concentrations, and the difference was greater at higher discharges. The maximum concentration of total iron was about 10 mg/L. The recommended maximum limit for iron in domestic water supplies is 0.3 mg/L [Environmental Protection Agency (EPA), 1976].

Dissolved-manganese concentrations in the samples ranged from less than 0.01 to 0.03 mg/L in six of the basins and from 0.03 to 0.08 mg/L in the Capps Creek basin. Most of the total-manganese concentrations were less than 0.10 mg/L,

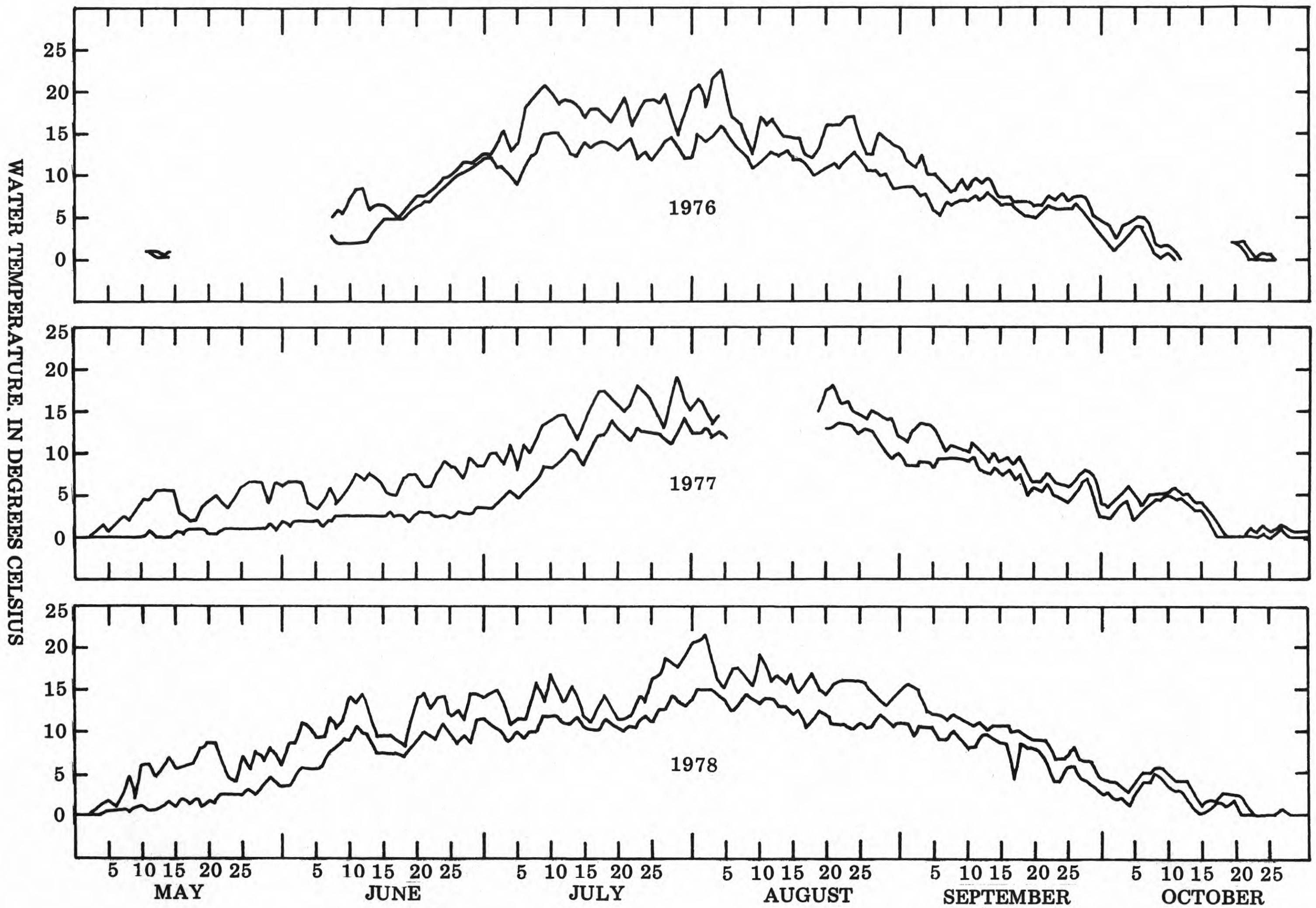



Figure 17.--May to October maximum and minimum daily water temperatures at Chuitna River near Tyonek, 1976-78.

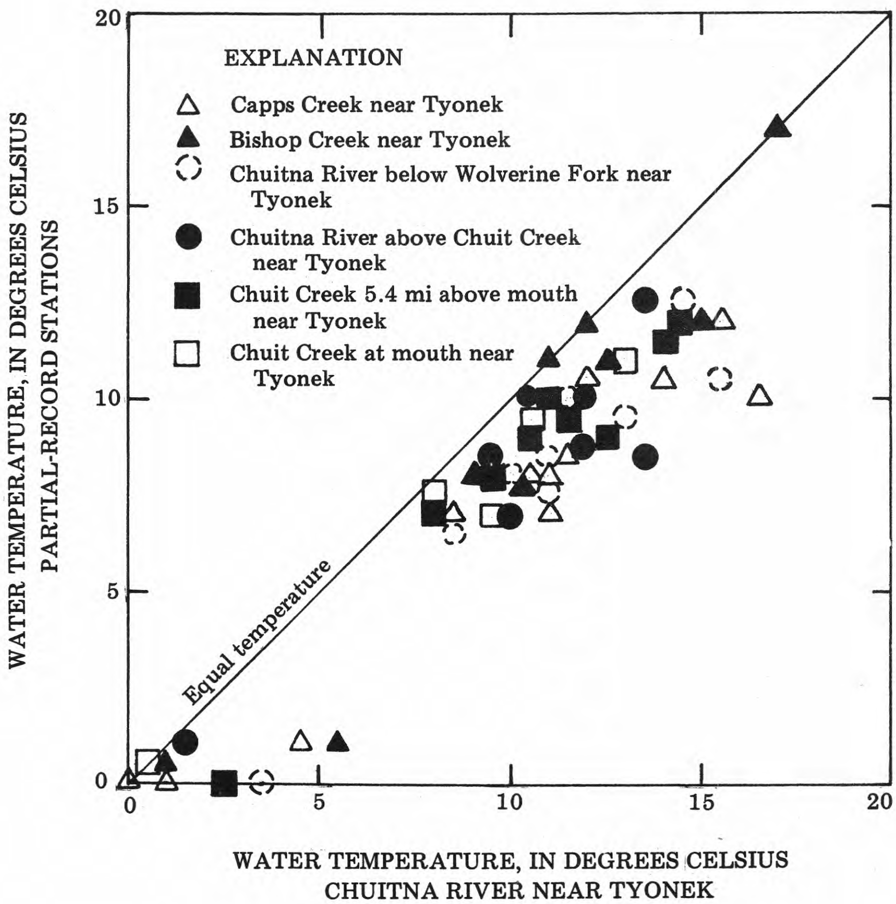



Figure 18.--Comparison of water temperatures at the six partial-record stations in the Beluga coal area with the concurrent water temperature at the Chuitna River near Tyonek gaging station.

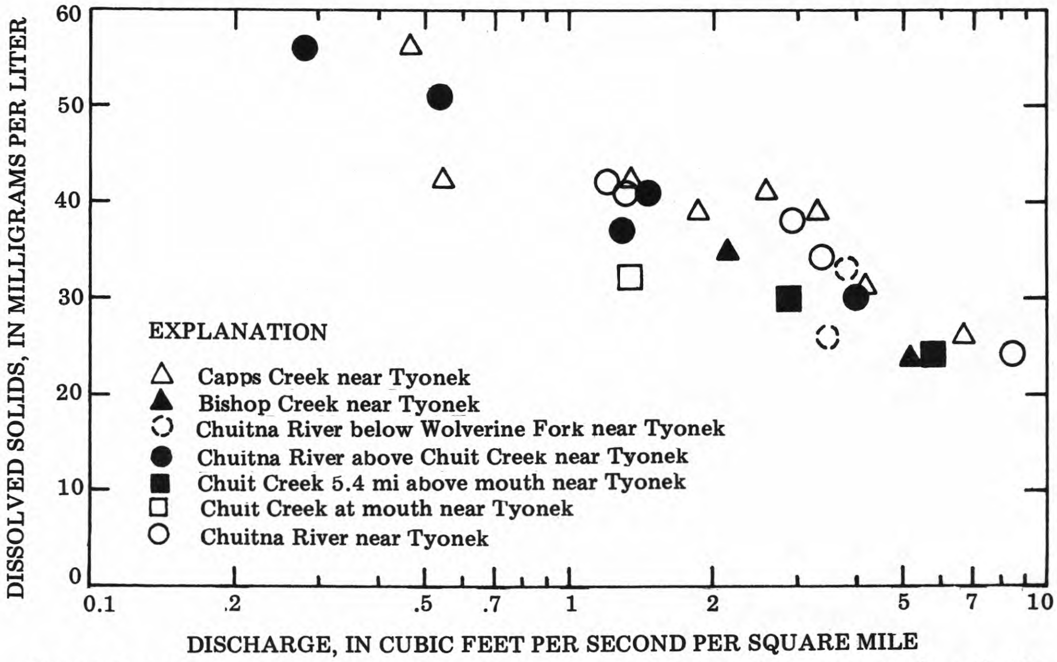



Figure 19.--Dissolved solids as a function of unit discharge for seven stations in the Beluga coal area during the 1975-78 water years.

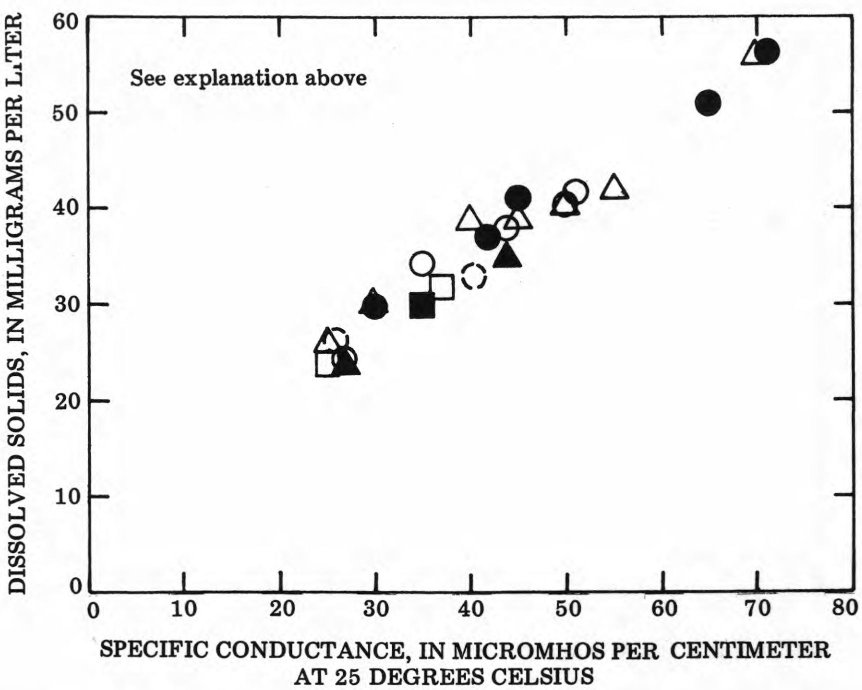



Figure 20.--Dissolved solids as a function of specific conductance for seven stations in the Beluga coal area during the 1975-78 water years.

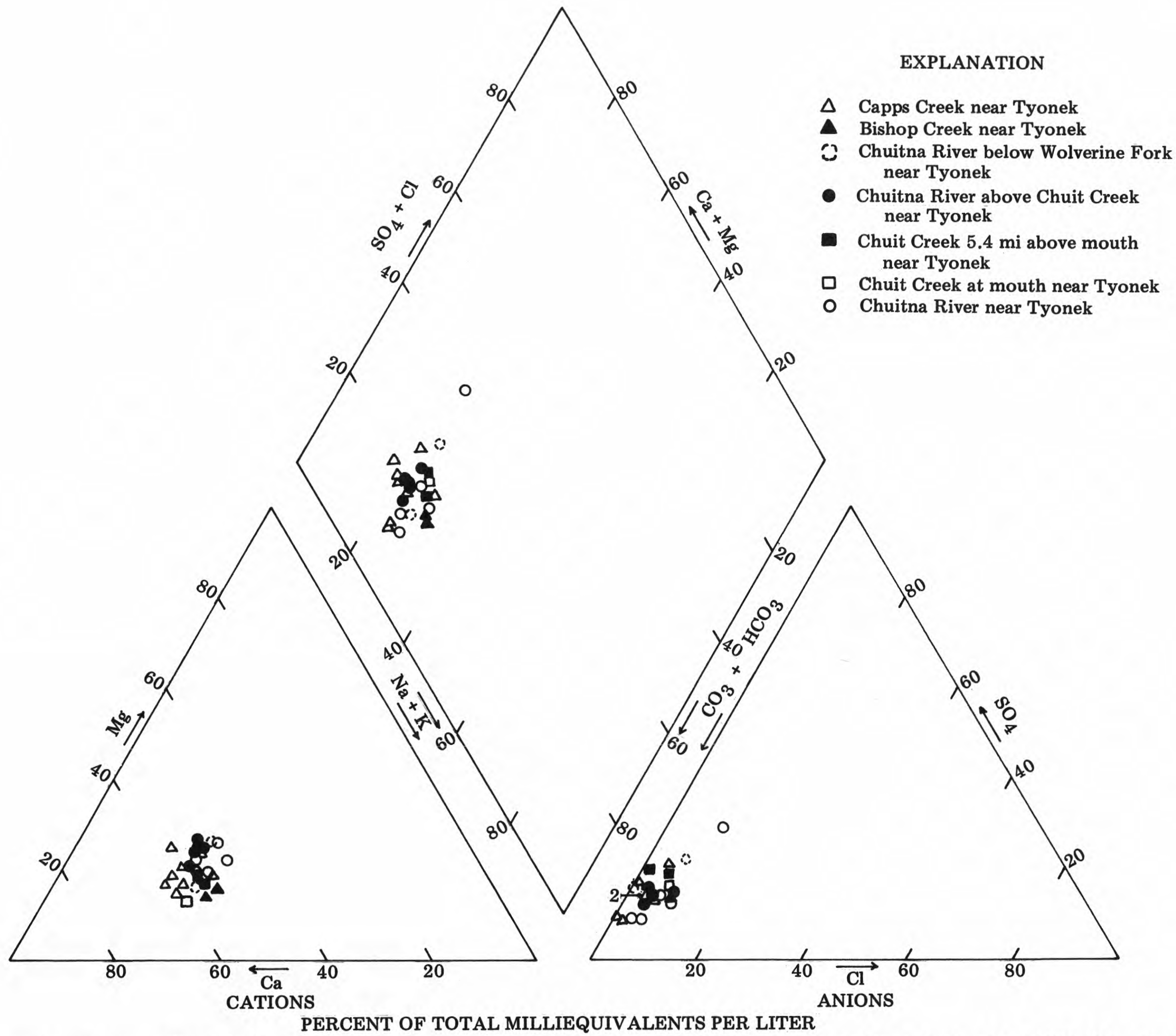



Figure 21.--Piper (trilinear) diagram of water analyses for seven stations in the Beluga coal area during the 1975-78 water years.

although one sample from Capps Creek had 0.23 mg/L. The recommended maximum limit for manganese in domestic water supplies is 0.05 mg/L (EPA, 1976).

Total concentrations of other minor elements were low and below the recommended maximum limits for domestic water supplies. There appeared to be no spatial or temporal pattern to variations in minor element concentrations.

The streams in the Beluga study area have low nutrient concentrations and only a small amount of natural organic enrichment. Dissolved phosphorus was at the lower limit of detection of the method used (0.01 mg/L), and total phosphorus averaged about 0.03 mg/L. Concentrations of organic nitrogen were higher than nitrate concentrations, and there was only a trace of ammonia. Total organic nitrogen averaged 0.13 mg/L and showed little seasonal variation. The concentration of total nitrite plus nitrate (as N) averaged 0.11 mg/L, and almost all of this was dissolved. Total ammonia (as N) averaged 0.01 mg/L. Dissolved organic carbon ranged from 1.0 to 4.6 mg/L and averaged 2.7 mg/L, based on 16 samples.

## Benthic Invertebrate Community

Two techniques were used to survey the benthic invertebrate community in the study area. Artificial substrate basket samplers (rock-filled vegetable wash baskets) were used at the gaging station Chuitna River near Tyonek. Dip nets were used at the gage and also at the six partial-record stations. See figure 4 for the location of sampling sites.

A diversity index was computed for each artificial substrate basket and dip net sample using the method of Slack and others (1973). The diversity index is computed as $\sum_{i=1}^{s} \frac{n_i}{n} \log_2 \frac{n_i}{n}$ where $n_i$ is the number of individuals per taxon, $n$ is the total number of individuals, and $s$ is the total number of taxa in the sample of the community. In addition, a pooled diversity index (Wilhm, 1970) was computed for each set of artificial substrate basket samples. All diversity indexes were computed using insects only.

Artificial substrate basket samplers were placed approximately at the midpoint of the three centroids of discharge at the cableway. See figure 22 for a plan view of the sampling site on the Chuitna River. The water depth over the substrate samplers was from 2 to 4 ft at low flow. Each set of samplers was placed at the same location each time to minimize inaccuracies due to variations in streambed habitat with respect to location.

Three samplers were placed in the river in October 1977 and March, July, and September 1978. These samplers were retrieved during the following visit. However, the sampler at station 40 placed in October 1977 was not retrieved until July 1978 because it could not be located through the ice cover in March 1978. Samplers from stations 50 and 60 were retrieved in March 1978 after cutting 3 x 4-ft openings through the 3.5-ft-thick ice cover. After the ice was removed, the samplers were located with the aid of an underwater viewer and retrieved with a grappling hook. Thus, two samplers were on the streambed for about 5½ months during which time the stream was mostly ice covered and discharge was low.

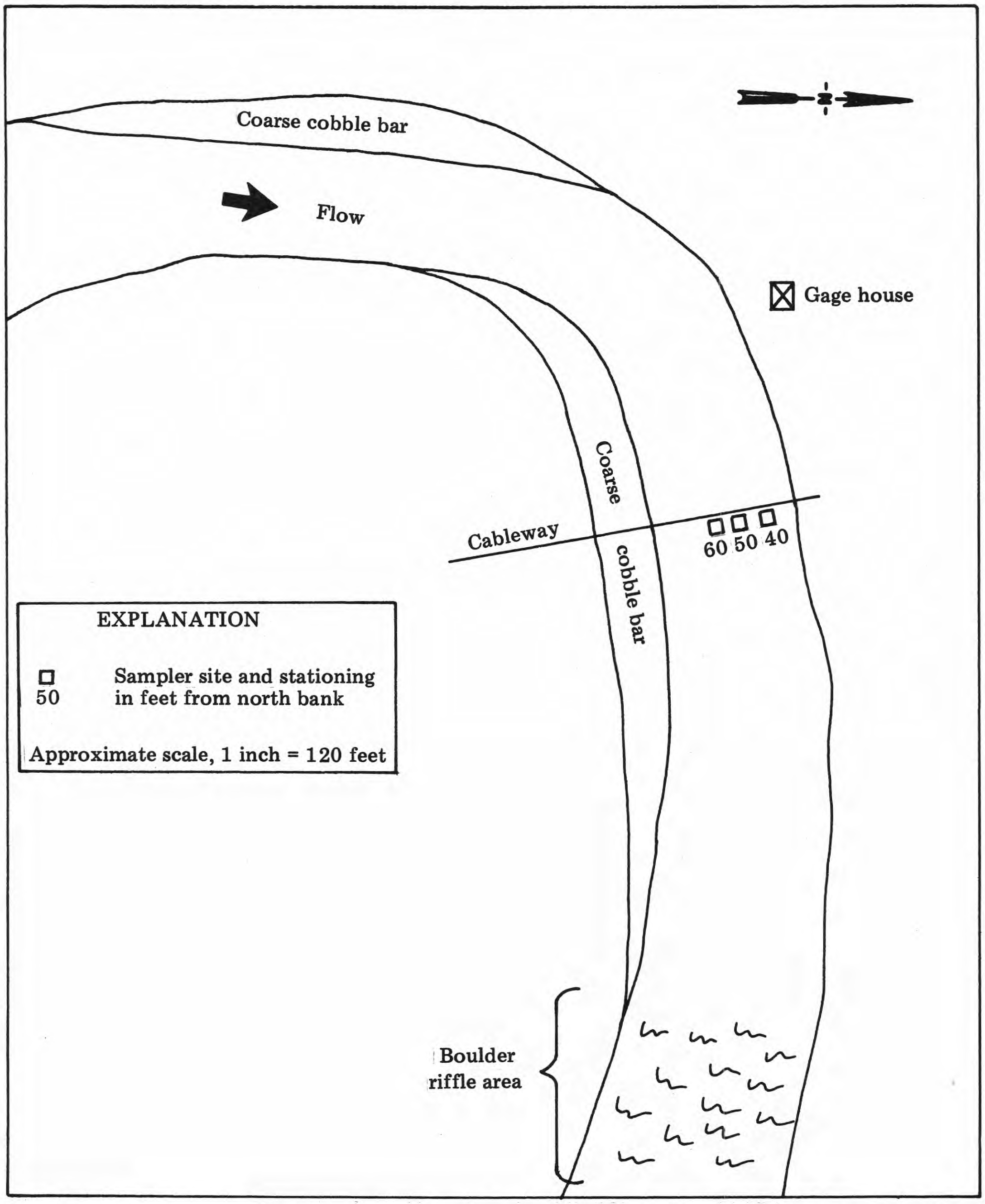



Figure 22.--Location of artificial substrate basket samplers at Chuitna River near Tyonek.

The second set of samplers was in the stream from March 29 to July 17, 1978, spanning breakup and the high-flow period during snowmelt. The third set of samplers was in the stream during the low-flow summer period from July 17 to September 12, 1978, and the last set of samples covered the period September 12 to October 16, 1978, during which time the streamflow varied due to fall rainstorms. Table 11 lists the extremes of discharge, water temperature, and velocity for each sampling period.

Table 11.--Discharge, water temperature, and velocity during each sampling period for artificial substrate basket samplers at Chuitna River near Tyonek

| Period | Instantaneous discharge ($ft^3/s$) | | Water temperature (°C) | | Cableway stationing (ft) Velocity at 80 percent of depth (ft/s) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 40 | | 50 | | 60 | |
| | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. |
| 10-18-77 to 03-29-78 | 329 | 60 | 1.5 | 0.0 | --- | --- | 1.2 | 0.4 | 1.8 | 0.8 |
| 10-18-77 to 07-17-78 | 1,940 | 60 | 17.0 | 0.0 | 4.6 | 0.6 | --- | --- | --- | --- |
| 03-29-78 to 07-17-78 | 1,940 | 68 | 17.0 | 0.0 | 4.6 | .6 | 4.7 | .4 | 4.3 | .8 |
| 07-17-78 to 09-12-78 | 1,200 | 85 | 21.5 | 8.0 | 3.5 | .7 | 3.3 | .5 | 3.4 | .9 |
| 09-12-78 to 10-16-78 | 2,280 | 125 | 11.0 | 0.0 | 5.1 | .9 | 5.3 | .6 | 4.7 | 1.1 |

Plecoptera and Chironomidae were the dominant types of organisms collected in substrate samplers during the study, followed by Trichoptera and Ephemeroptera. There were fewer organisms and taxa in samples from station 50 than from the other two sampling stations. At station 50 the water was deeper and velocities were slightly greater than at stations 40 or 60. The number of insects collected was lowest during the winter and ice-breakup periods. As would be expected, more insects were found during the summer and autumn because insect populations reach their peak before winter.

Artificial substrate basket sample analyses are summarized in table 12. Individual diversity indexes for all 12 samples ranged from 2.05 to 3.82. The pooled diversity index ranged from 2.93 (during the breakup and snowmelt runoff period) to 4.06 (during autumn). However, the other two pooled diversity indexes were only slighly lower, being 3.87 for the summer low-flow period and 3.92 for the winter low-flow period. These values are indicative of waters which can generally be considered pollution free (Slack and others, 1973).

Dip net samples of the benthic invertebrate community were obtained at seven sites in the study area on five visits. Samples were collected in the summer and fall when the streams were wadable. Sampling lasted 30 minutes at each site on the initial trip (July 18, 1977) and 15 minutes on the four subsequent trips.

In analyzing dip net samples the important factor is the number of different categories of organisms (taxa) collected rather than the total number of organisms. Although dip net samples are more qualitative than artificial substrate samples, they are more representative of the natural population.

Table 12.--Summary of artificial substrate basket samples, Chuitna River near Tyonek

| | Sampling period | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 10-18-77 to 3-29-78 | | 10-18-77 to 7-17-78 | 3-29-78 to 7-17-78 | | | 7-17-78 to 9-12-78 | | | 9-12-78 to 10-16-78 | | |
| Cableway stationing (ft)→ | 50 | 60 | 40 | 40 | 50 | 60 | 40 | 50 | 60 | 40 | 50 | 60 |
| Total number organisms | 25 | 80 | 51 | 28 | 13 | 102 | 287 | 132 | 287 | 337 | 116 | 283 |
| Total number insects | 25 | 80 | 47 | 26 | 11 | 85 | 285 | 126 | 262 | 327 | 114 | 280 |
| Number insect taxa | 10 | 19 | 15 | 10 | 7 | 12 | 21 | 17 | 21 | 26 | 20 | 23 |
| Insect diversity index | 3.00 | 3.79 | 3.33 | 3.04 | 2.40 | 2.05 | 3.22 | 3.71 | 3.23 | 3.73 | 3.73 | 3.82 |
| Pooled: Total number insects | 105 | | -- | | 122 | | | 673 | | | 721 | |
| Pooled: Insect diversity index | 3.92 | | -- | | 2.93 | | | 3.87 | | | 4.06 | |
| Stream conditions | Winter low flow | | Winter low flow and high flow during breakup and snowmelt | High flow during breakup and snowmelt | | | Summer low flow | | | Variable streamflow | | |

Dip net samples were collected in July and October 1977 and July, September, and October 1978. Dip net sample analyses and stream characteristics are summarized in table 13. Although the discharge, velocity, and depth values come from the cross section in the stream where the discharge measurement was made, they can be considered fairly representative of the reach in which the dip net sample was collected.

Dip net samples collected in October 1977 and 1978 were obtained as freeze-up was starting, and collection conditions were poor. Shore ice, anchor ice, and slush in varying amounts were present at all sites.

Diversity indexes are calculated for dip net samples in the same manner as for artificial substrate samples. The lowest diversity value, 0.70 from the Chuitna River gage on July 17, 1978, was due to the large numbers of Ephemeroptera nymphs (Baetis sp.) collected in the dip net samples. This dominance of Ephemeroptera nymphs at one location could result from factors such as the environmental conditions at the time of sampling or cyclic population densities. At this site, silver and king salmon were observed during the July sampling trip. Salmon fry averaging 2 to 3 in. long were observed in all of the streams except Capps Creek.

The dip net sample data suggest little variation in the benthic invertebrate community among the seven stations sampled and no apparent seasonal difference in taxa and diversity for each station. Organisms which are commonly thought to suggest unpolluted water (Ephmeroptera, Trichoptera, and Plecoptera) were well represented at all sites on the dates sampled.

## Ground Water

The evaluation of ground-water availability in the Beluga coal area is based on spring flow and streamflow data and observations of sedimentary bedrock outcrops as there are no known water wells farther inland than 10 mi from the west shore of Cook Inlet. Some drilling has been done as part of coal exploration in the western part of the area. However, well logs from this drilling were not available for this report.

Several springs issue from the Tyonek Formation in the upper Capps Creek and upper Chuitna River area. Five of these springs were investigated as part of this study. Discharges ranged from 2 to 180 gal/min. Figure 23 shows the locations and discharges of the five springs.

The quantity of ground-water discharge from the area can be estimated from streamflow data. Streamflow consists of direct runoff of precipitation, snowmelt, and drainage of ground water to the stream from adjacent aquifers. In the Chuitna River basin the ground-water component of streamflow was estimated from a simple hydrograph separation of the Chuitna River near Tyonek record to be about 30 percent of the annual discharge. Using this estimate for the 3 years during which the Chuitna River gage has been operated, the average ground-water effluent is about 110 $ft^3/s$ for the 131-$mi^2$ basin, or about 0.8 $(ft^3/s)/mi^2$.

The Kenai Group, consisting of the Tyonek and Beluga Formations, overlies the West Foreland Formation. The West Foreland Formation is the oldest unit exposed in

Table 13.--Summary of dip net samples and channel hydraulic characteristics at the time of sampling in the Beluga coal area. Sites are shown in figure 3.

| Station | Date | Dip net samples: Total number insects | Dip net samples: Number insect taxa | Dip net samples: Insect diversity index | Channel hydraulic characteristics: Discharge ($ft^3/s$) | Channel hydraulic characteristics: Cross-section area ($ft^2$) | Channel hydraulic characteristics: Mean velocity (ft/s) | Channel hydraulic characteristics: Mean depth (ft) |
|---|---|---|---|---|---|---|---|---|
| Capps Creek near Tyonek (site 1) | 07-18-77* | 571 | 24 | 2.78 | 156 | 55 | 2.81 | 1.2 |
| | 10-18-77 | 539 | 14 | 2.03 | 28 | 26 | 1.08 | 0.7 |
| | 07-17-78 | 170 | 14 | 2.25 | 39 | 31 | 1.27 | 0.8 |
| | 09-12-78 | 522 | 20 | 1.95 | 63 | 37 | 1.70 | 0.9 |
| | 10-16-78 | 1,718 | 26 | 2.32 | 31 | 32 | 0.98 | 0.9 |
| Bishop Creek near Tyonek (site 2) | 07-18-77* | 1,490 | 19 | 2.68 | 13 | 12 | 1.09 | 0.6 |
| | 10-18-77 | 1,416 | 16 | 1.76 | 19 | 11 | 1.69 | 0.4 |
| | 07-17-78 | 221 | 12 | 1.72 | 27 | 15 | 1.80 | 0.7 |
| | 09-12-78 | 1,143 | 18 | 2.12 | 28 | 17 | 1.62 | 0.7 |
| | 10-16-78 | 687 | 21 | 2.25 | 24 | 15 | 1.58 | 0.5 |
| Chuitna River below Wolverine Fork near Tyonek (site 3) | 07-18-77* | 6,811 | 31 | 2.55 | 131 | 60 | 2.18 | 1.5 |
| | 10-18-77 | 221 | 11 | 1.50 | -- | -- | -- | -- |
| | 07-17-78 | 357 | 27 | 3.70 | 73 | 46 | 1.57 | 1.2 |
| | 09-12-78 | 97 | 13 | 2.41 | 135 | 62 | 2.16 | 1.5 |
| | 10-16-78 | 710 | 22 | 2.34 | 55 | 40 | 1.37 | 1.3 |
| Chuitna River above Chuit Creek near Tyonek (site 4) | 07-18-77* | 4,416 | 27 | 3.14 | 158 | 72 | 2.21 | 1.5 |
| | 10-18-77 | 72 | 9 | 1.18 | 36 | 53 | 0.69 | 1.3 |
| | 07-17-78 | 292 | 16 | 1.82 | 136 | 62 | 2.19 | 1.2 |
| | 09-12-78 | 42 | 13 | 3.25 | 138 | 60 | 2.29 | 1.2 |
| | 10-16-78 | 244 | 20 | 2.86 | 81 | 54 | 1.51 | 1.3 |
| Chuit Creek 5.4 miles above mouth near Tyonek (site 5) | 07-18-77* | 2,881 | 32 | 2.87 | 32 | 24 | 1.31 | 1.0 |
| | 10-18-77 | 643 | 20 | 2.85 | 21 | 18 | 1.16 | 1.1 |
| | 07-17-78 | 381 | 14 | 2.20 | 29 | 20 | 1.44 | 1.3 |
| | 09-12-78 | 129 | 16 | 2.85 | 48 | 20 | 2.45 | 1.3 |
| | 10-16-78 | 1,434 | 27 | 2.68 | 23 | 14 | 1.66 | 1.1 |
| Chuit Creek at mouth near Tyonek (site 6) | 07-18-77* | 2,854 | 33 | 3.53 | 46 | 26 | 1.77 | 1.0 |
| | 10-18-77 | 237 | 19 | 2.55 | 21 | 23 | 0.91 | 1.2 |
| | 07-17-78 | 553 | 16 | 1.84 | 68 | 32 | 2.12 | 1.1 |
| | 09-12-78 | 236 | 16 | 2.89 | 33 | 23 | 1.47 | 0.9 |
| | 10-16-78 | 306 | 26 | 3.70 | 45 | 23 | 1.94 | 0.8 |
| Chuitna River near Tyonek (site 7) | 07-18-77* | 2,072 | 25 | 2.45 | 231 | 154 | 1.50 | 1.4 |
| | 10-18-77 | 222 | 23 | 3.09 | 186 | 139 | 1.34 | 1.3 |
| | 07-17-78 | 903 | 17 | 0.70 | 353 | 185 | 1.91 | 1.4 |
| | 09-12-78 | 298 | 16 | 1.83 | 165 | 133 | 1.24 | 1.3 |
| | 10-16-78 | 841 | 25 | 2.48 | 220 | 150 | 1.47 | 1.3 |

*Sampling was conducted for 30 minutes on this date; all other sampling was for 15 minutes.

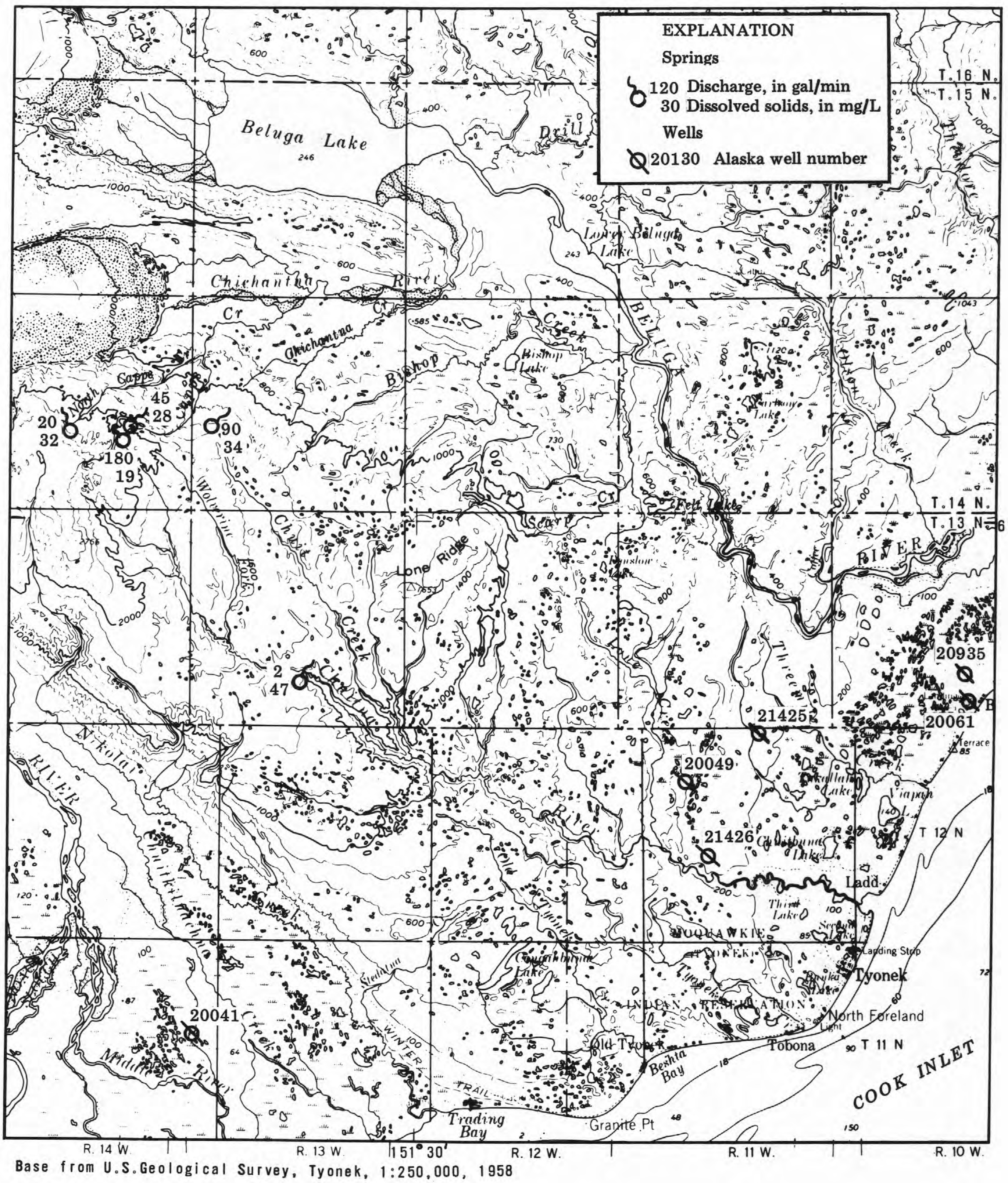



Figure 23.--Location and characteristics of selected springs and wells in the Beluga coal area.

the study area. Although it probably underlies the other formations throughout the study area, it is exposed principally west of the Lake Clark fault. The West Foreland Formation contains more conglomerate than the other two formations, and it may, therefore, have the best potential for ground-water development depending on the degree of cementation and amount of fracturing. However, drilling and aquifer testing are necessary before the formation can be adequately evaluated.

Available well-log data indicated significant differences in driller terminology and reporting. The data are summarized as follows with no attempt to correlate the rock units between the wells. A well log of an oil company exploratory well (Alaska well 20041, fig. 23) near the Chakachatna River reports 816 ft of unconsolidated materials, the upper 190 ft of which were sand and gravel. The log from Alaska well 20049 indicated sedimentary bedrock was penetrated at a depth of 124 ft. A water well at the Chugach Electric Co. powerplant (Alaska well 20935) was completed in a sandy gravel aquifer from 240 to 304 ft below the land surface after initially penetrating 420 ft of unconsolidated materials. Water wells at Tyonek have been drilled as deep as 180 ft without reaching bedrock. Large quantities of ground water (for example, 500 gal/min for the Chugach Electric Co. well) are available from the thick unconsolidated materials near the coast.

In October 1977, the U.S. Geological Survey drilled Alaska well 21426, 5 mi west of Cook Inlet and about one-quarter mile north of the Chuitna gaging station. This well penetrated 22 ft of unconsolidated material and 296 ft of the Beluga Formation. It was terminated in permeable rock (indicated by a significant loss of drilling fluid) 320 ft below the land surface. Periodic water-level measurements were made at this well from October 1977 to October 1978. A continuous record of water-level fluctuations is available from November 1, 1978 to June 8, 1979. Figure 24 shows the trend in water level at this well for that period. In the time since the recorder was installed, the water level has ranged from about 20 to about 30 ft below the land surface. Fluctuations of more than one-half foot in several hours have been recorded on some days at this well. These fluctuations are indicative of pressure changes in confined aquifers. In this case, claystone of the Beluga Formation is probably the confining layer.

The well record shows a gradual decline in water level throughout the winter and then a rise of 2 ft in late March and more than 6 ft in late April 1979, possibly in response to infiltration of low-elevation spring snowmelt, thawing of the seasonal frost layer and (or) a loading effect of the Chuitna River. However, the cause of the recharge events is questionable due to the nature of the well's construction. A leaky annulus may be the cause of the water-level response, which appears too rapid to represent hydraulic changes in the zone monitored.

The quality of water in the Kenai Group cannot be generalized on the basis of the few samples analyzed. Samples from the five springs in the upper Capps Creek and upper Chuitna River area contained less than 50 mg/L of dissolved solids and had no physical constituents or properties in excess of the EPA (1976) drinking-water standards. The water was calcium bicarbonate type. Two samples from well 21426 contained 88 and 65 mg/L, respectively, of dissolved solids. The dissolved-iron concentrations of samples from well 21426 (0.41 and 0.96 mg/L) were the only values to exceed the EPA (1976) recommended domestic water supply standard of 0.30 mg/L.

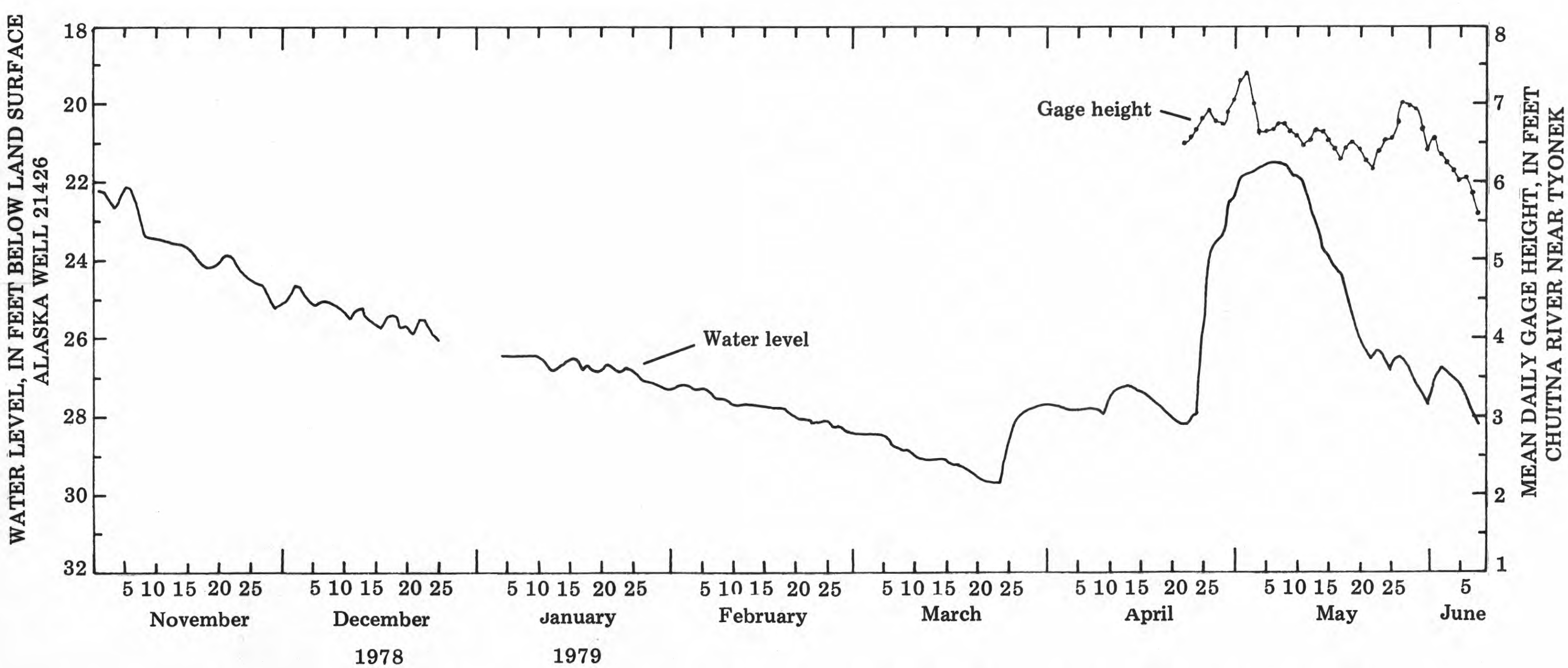



Figure 24.--Water levels in U.S. Geological Survey test well (Alaska well 21426), November 1, 1978 to June 8, 1979, and mean daily gage height for the Chuitna River near Tyonek, April 22 to June 8, 1979.

Water in the unconsolidated sediments near the coast commonly contains more iron than recommended in the drinking-water standards. Water from well 20049, about 2 mi north of the Chuitna River, contained arsenic (0.16 mg/L) in excess of the domestic water supply standard of 0.05 mg/L (EPA, 1976).

## PETERS CREEK COAL AREA

### Introduction

#### Setting

The Peters Creek coal area, which is part of the Yentna River coal district of the Susitna coal field, is about 20 mi west of the Chulitna River near Talkeetna. Peters Creek flows southeastward from the Dutch Hills through the Peters Hills and then southward into the Kahiltna River, a tributary of the Yentna River. This study was limited to the drainage basins of Peters Creek above the mouth of Martin Creek (fig. 25).

Bedrock in the north half of the study area is undifferentiated metasedimentary rocks; these are overlain by unconsolidated deposits in the valley bottoms. The surficial materials south of the Peters Hills are unconsolidated glacial and alluvial deposits. Coal-bearing rocks of the Kenai Group are exposed along Peters Creek (Barnes, 1966). Coal in this area is of either doubtful or unknown value, as the coal-bearing formations are generally under an overburden ranging from a few tens to several thousand feet (Holloway, 1977).

Principal tributaries of Peters Creek in the study area are Cottonwood Creek and Deep Creek. Seasonal placer mining takes place in the basin from the Dutch Hills to Petersville. A gravel road runs along Peters Creek from the mouth of Martin Creek to the Dutch Hills. The basin has only a few permanent residents.

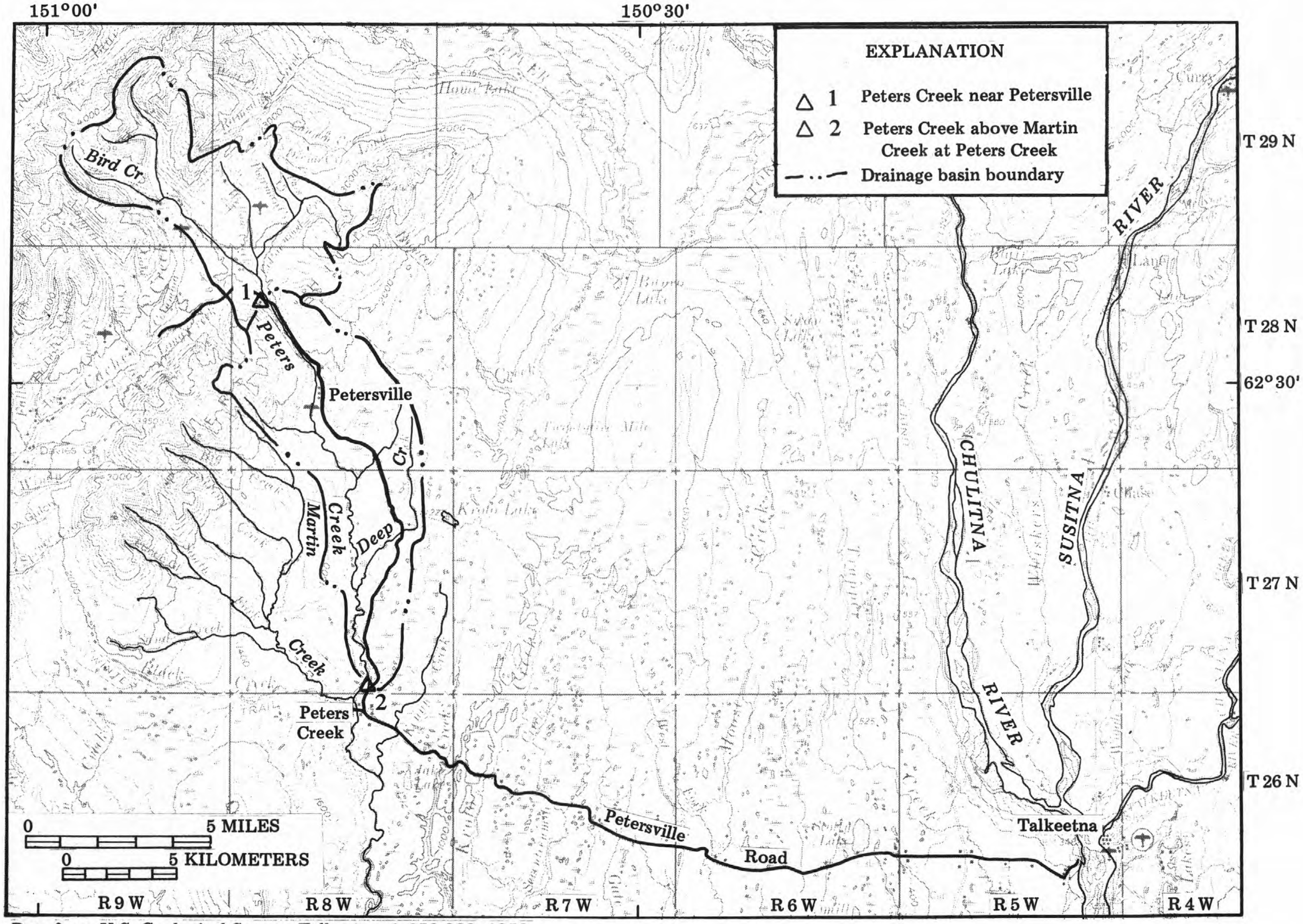
The upstream station, Peters Creek near Petersville, has a drainage area of 25.4 $mi^2$ and is upstream from most of the exposed coal-bearing rocks. The lower station, Peters Creek above Martin Creek at Peters Creek, is 0.7 mi upstream from the mouth of Martin Creek, and has a drainage area of 53.1 $mi^2$. The drainage between the stations contains some exposed coal-bearing rocks.

The elevation of the upstream drainage basin ranges from 1,750 to 4,900 ft. The downstream station is at about 1,150 ft. There are no lakes in the study area, but bogs and marshes are common in the lower part.

The data for this study are published in Scully, Krumhardt, and Kernodle (1980).

#### Climate

The closest weather station to the Peters Creek study area is at Talkeetna airport approximately 25 mi to the southeast (fig. 25). This station has 58 years of temperature record and 51 years of precipitation record through 1978 and is at 345-ft elevation. Over the period of record, the air temperature has averaged




Base from U.S. Geological Survey, Talkeetna, 1:250,000, 1958

Figure 25.--Location of hydrologic data-collection sites on Peters Creek. (Talkeetna Airport, the closest weather station to the Peters Creek study area, is in the southeast corner of the figure.)

32.8°F, and the average annual precipitation has been 28.64 in. During the 1975-78 study period the average air temperature at Talkeetna was about 1.5°F above normal, while annual precipitation averaged about 5 in. below normal. Figure 26 shows the monthly precipitation and the average monthly air temperature at Talkeetna for the study period.

In this area March, April, and May are the driest months; only 14 percent of the annual precipitation is received then. In contrast, 45 percent of the annual precipitation falls during July, August, and September. July is the warmest and December the coldest month, averaging 58°F and 9°F, respectively, at Talkeetna.

## Streamflow

During the study period, seven discharge measurements were made at Peters Creek near Petersville and ten at Peters Creek above Martin Creek at Peters Creek. The discharge measurements were primarily made to be used in conjunction with suspended-sediment and water-quality analyses. The relation between measured discharge and mean daily discharge for concurrent days was studied using statistical correlation methods. The degree of correlation was low, and a definite relation was not apparent. Therefore, no attempt was made to define streamflow characteristics based on these miscellaneous measurements. On March 13, 1978 (late winter), the discharge at Peters Creek above Martin Creek at Peters Creek was 21 $ft^3/s$, or 0.40 $(ft^3/s)/mi^2$. The yield is similar to streams in the Beluga coal area.

## Water Quality

### Suspended Sediment

Periodic suspended-sediment samples were taken at the two partial-record stations at low and medium flow. It was not possible to sample at high flow because the streams were not wadable. Graphs of suspended-sediment discharge as a function of discharge are shown in figure 27. Lines of equal concentration are also shown on each graph. No attempt was made to define a curve of the relation because of the scatter of the data and the absence of high-flow samples. The suspended-sediment concentrations and discharges were consistently higher at the upstream station and may reflect the effects of placer mining in the upper parts of the basin. The decrease in sediment load may occur in the mine tailings located approximately 3 mi downstream from the upper site and (or) in the extensive flats above the lower site. A sand analysis was made on the suspended-sediment sample having the greatest concentration. This sample was from Peters Creek near Petersville on June 23, 1976. It had suspended-sediment concentration of 128 mg/L and contained 2 percent sand and 98 percent silt and clay, by weight.

### Chemical Quality

There is no significant difference in water quality at the two locations on Peters Creek. The surface water is a calcium bicarbonate type and has low dissolved-solids concentrations. During the study period the pH values for Peters Creek ranged from 6.1 to 7.7 units. Figure 28a shows the relation of dissolved solids to unit discharge for both sites, and the trilinear diagram in figure 29 shows the relative concentrations of the major ions. No useful relationship could

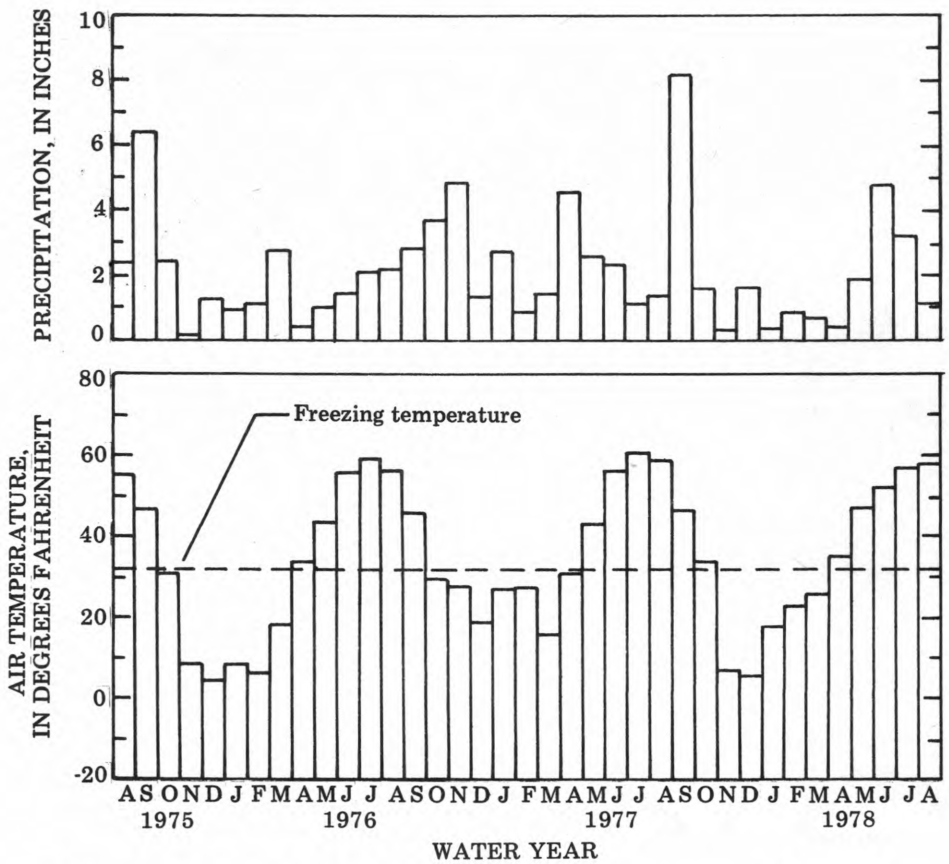



Figure 26.--Monthly precipitation and monthly average air temperature at Talkeetna, from August 1975 to August 1978. (From National Oceanic and Atmospheric Administration, 1975-78.)

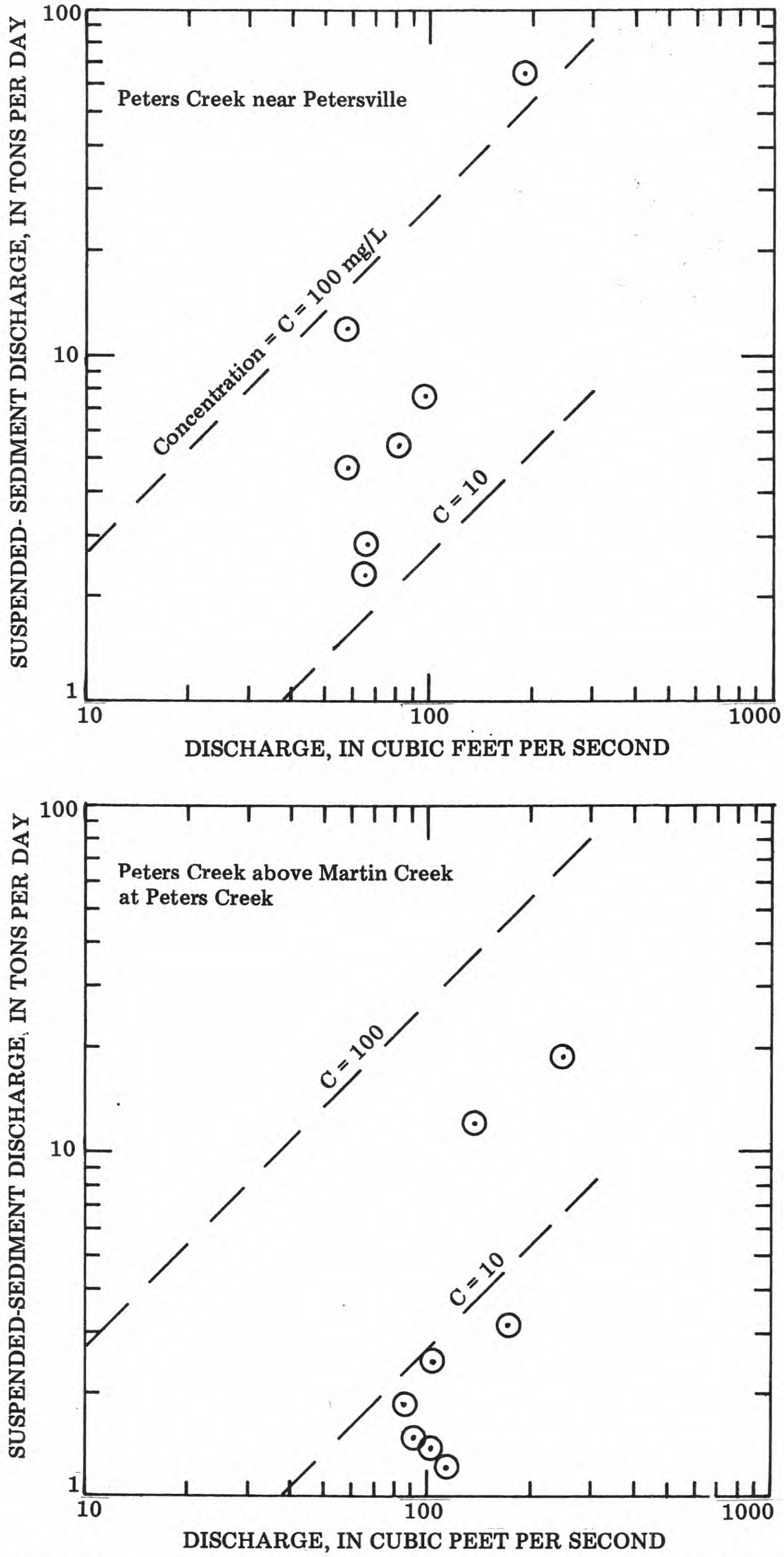



Figure 27.--Suspended-sediment discharge as a function of discharge for two stations on Peters Creek during the 1975-78 water years.

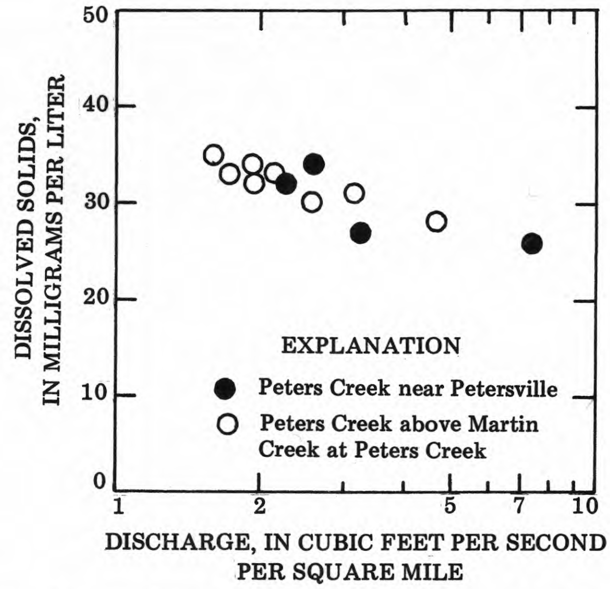



Figure 28a.--Dissolved solids as a function of unit discharge for two stations on Peters Creek during the 1975-78 water years.

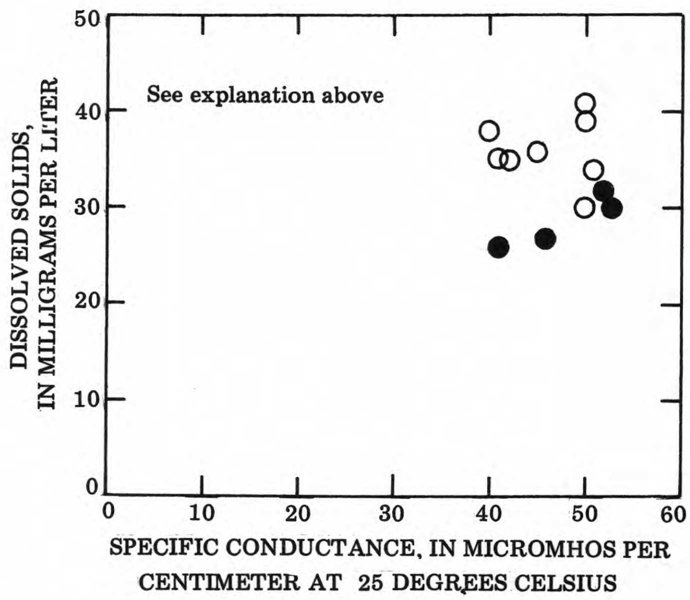



Figure 28b.-- Dissolved solids as a function of specific conductance for two stations on Peters Creek during the 1975-78 water years.

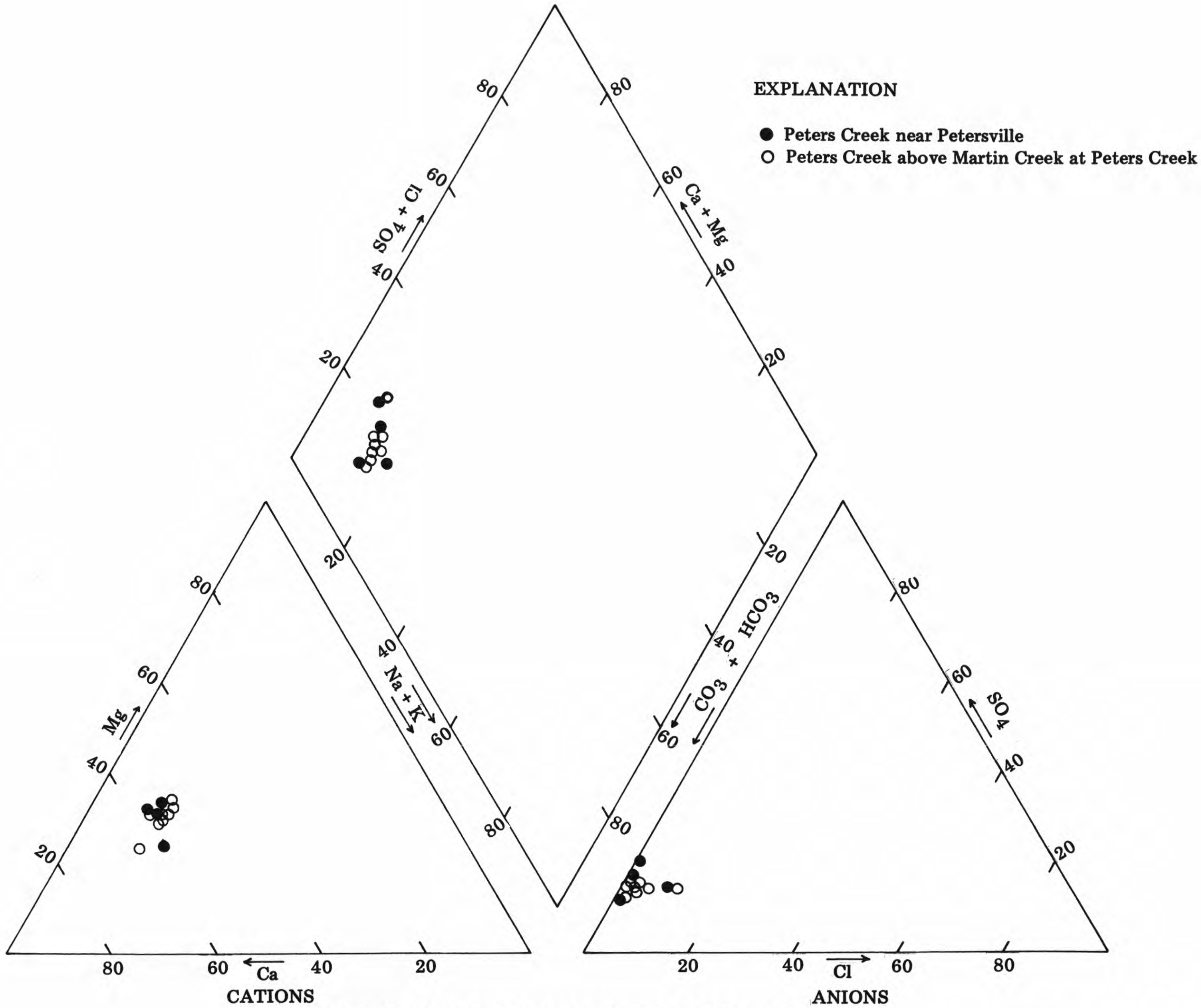



Figure 29.--Piper (trilinear) diagram of water analyses for two stations on Peters Creek during the 1975-78 water years.

be made between dissolved solids and specific conductance (fig. 28b) because of the limited range of values. Differences in relative cation or anion composition between the two sites or at different rates of discharge or seasons do not appear to be significant.

Observed concentrations of dissolved silica ranged from 5 to 8 mg/L. The proportion of dissolved silica to dissolved solids averaged 20 percent in the 12 samples. Dissolved oxygen was near saturation for three samples taken at each station during the open-water period.

Dissolved-iron concentrations were noticeably greater at the downstream station. At the time of concurrent sampling in August and October 1975, the dissolved-iron concentration was 0.04 mg/L both times at the upstream station and 0.12 and 0.15 mg/L, respectively, at the downstream station. Dissolved-iron concentrations have been reported as high as 0.23 mg/L at the downstream station during the study period. The increase in dissolved-iron concentration between the two stations may have been due to inflow from tributaries draining swampy areas. Total-iron concentrations, ranging from 0.44 to 5.4 mg/L, were much greater than dissolved-iron concentrations. Dissolved-manganese concentrations ranged from 0.01 to 0.07 mg/L in the nine samples. Total-manganese concentrations ranged from 0.02 to 0.13 mg/L. Total concentrations of other minor elements were low and were below recommended maximum limits for domestic water supplies. Although the number of samples and sampling stations is small, no spatial or temporal pattern to variations in minor element concentrations is evident.

Based on limited sampling during the 1975-77 water years, Peters Creek has low nutrient concentrations and only a small amount of natural organic enrichment. Nutrient concentrations were determined for three samples at the upper station and five samples at the lower station. Dissolved-phosphorus concentration was below the lower detection limit (0.01 mg/L) in five of the eight samples, and the maximum concentration was 0.03 mg/L. Total-phosphorus concentration was as much as 0.14 mg/L. Total organic nitrogen averaged 0.11 mg/L, whereas total nitrite plus nitrate (as N) averaged 0.06 mg/L and was almost entirely dissolved. Total ammonia (as N) ranged from 0 to 0.02 mg/L. Dissolved organic carbon ranged from 0.9 to 14 mg/L, in five samples.

# HEALY COAL AREA

## Introduction

### Setting

The Nenana coal field (figs. 1 and 2) is in the northern foothills of the Alaska Range near Healy, which is about 80 mi southwest of Fairbanks. The Nenana River flows northward through the foothills, and Healy and Lignite Creeks, the two major creeks studied are tributary to the Nenana River.

In this area, Tertiary coal-bearing rocks lie unconformably over schist of either Precambrian or early Paleozoic age (Beikman, 1980) (fig. 30). Tertiary sedimentary rocks and the schist are unconformably overlain by discontinuous Quaternary deposits of alluvium and glacial residuum.

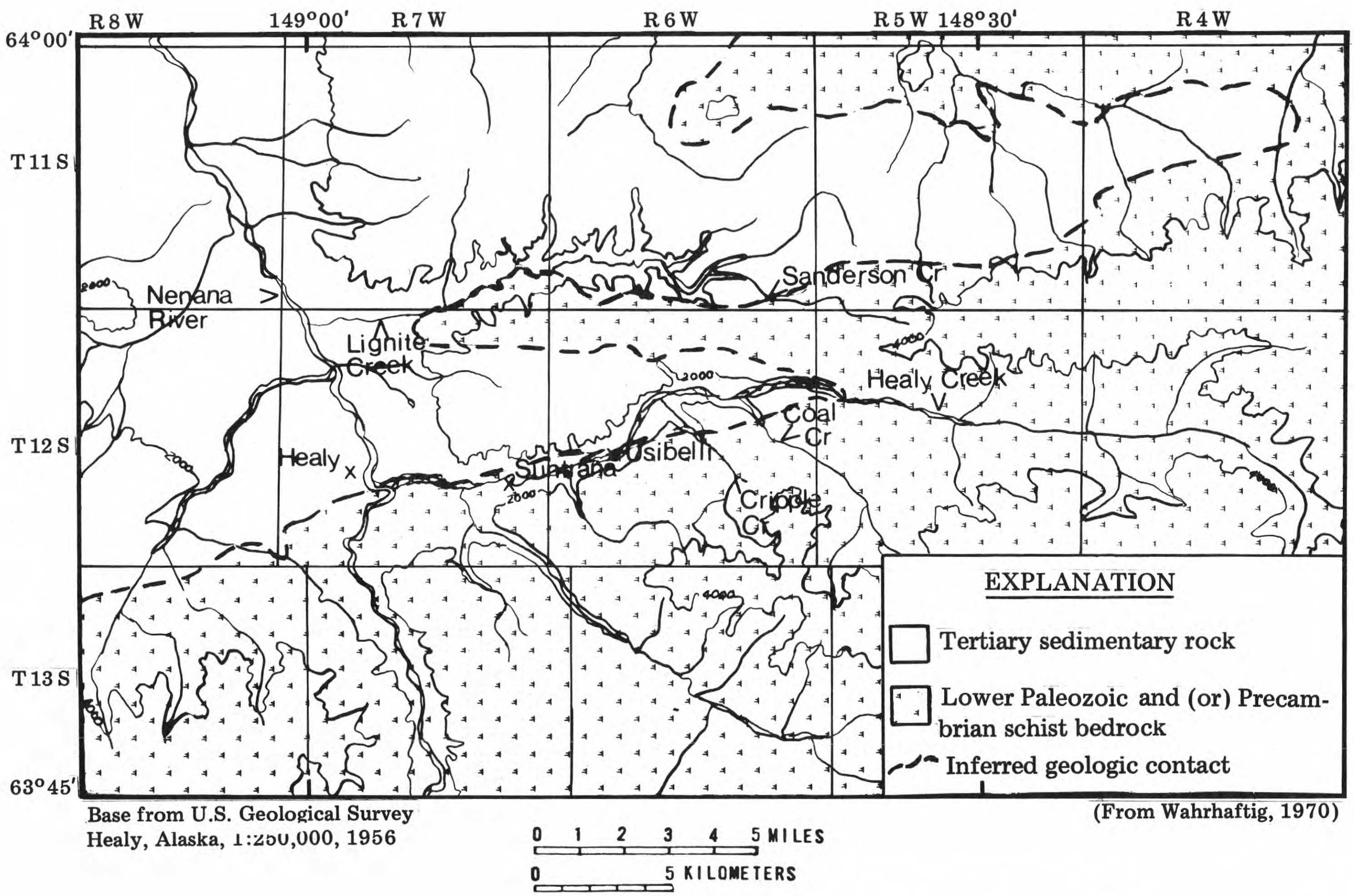



Figure 30.--Generalized bedrock geology of the Healy coal area.

Generally, the coal-bearing rocks group consists of poorly consolidated quartz sandstone, siltstone, and shale interbedded with platy or blocky subbituminous coal in lenticular or thick laterally persistent beds (Wahrhaftig, 1970). According to Conwell (1977, p. 21), the coal has "... an average ash content of 10 percent, moisture of 25 percent, and 0.20 percent sulphur."

Healy Creek and Lignite Creek drainage basins have generally rugged topography, with steep slopes adjacent to many of the streams. The higher ridges range in elevation from 3,000 to 6,000 ft, and the main valley floor rises from 1,000 to 2,000 ft. Sparse growths of spruce, birch, and poplar are found from the valley bottoms up to timberline at 2,500 ft. Moss, willows, and grass are prolific where gravels are well drained. There are no lakes or glaciers in either basin.

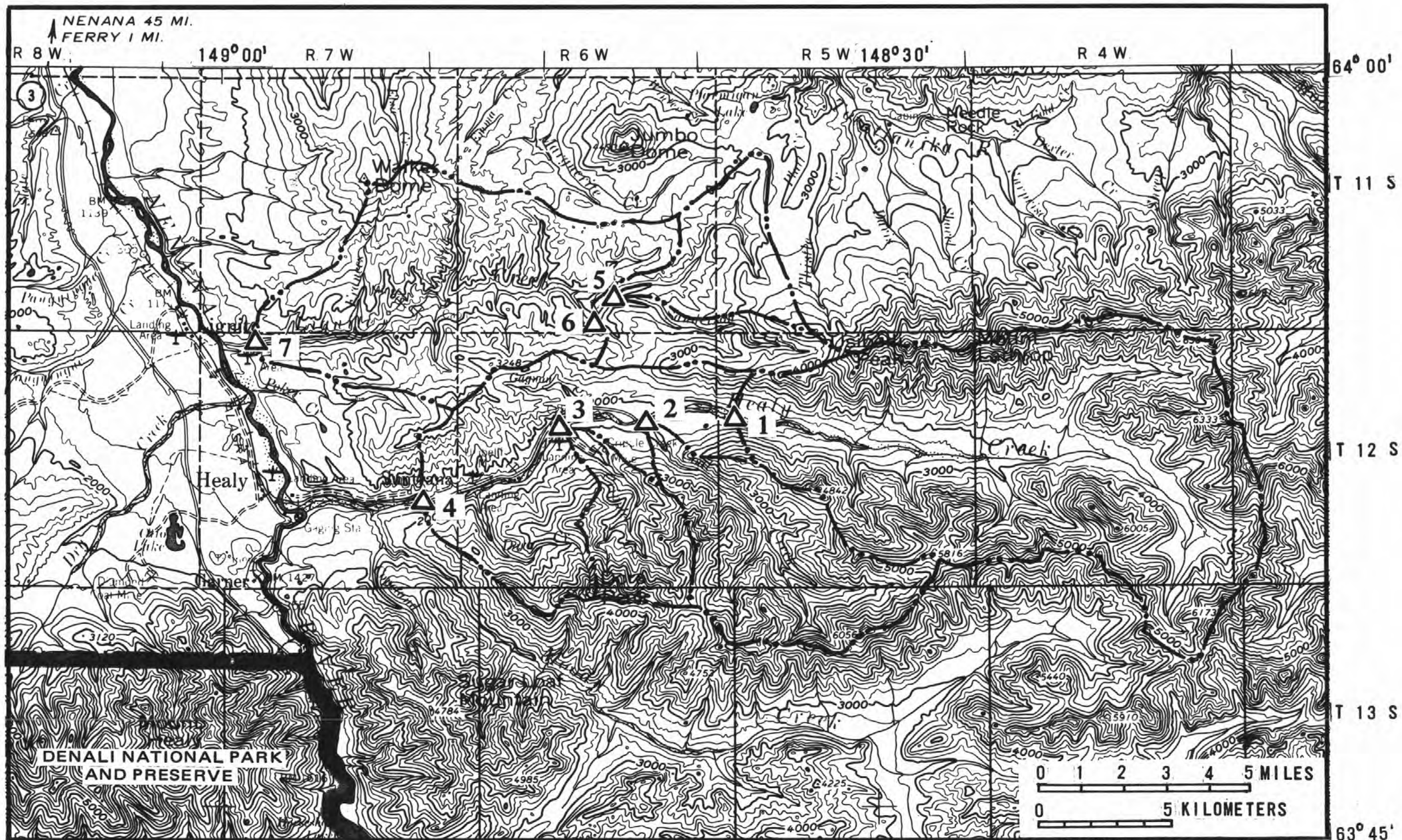
Healy Creek flows westward and drains about 200 mi². Major tributaries are Moody, Cripple, and Coal Creeks which enter Healy Creek from the south. Over the past 60 years coal has been mined in Cripple, Coal, and Healy Creek basins.

Lignite Creek also flows westward and has a drainage area of about 50 mi². Sanderson Creek is a principal tributary of Lignite Creek. There has been some coal mining in the Lignite Creek basin.

Seven locations were chosen for data collection in the study area (figs. 31 and 32). Sites were selected on the basis of their relation to past and present coal mining. Because there has been no mining on Moody Creek, Healy Creek was studied in the basin upstream from the mouth of Moody Creek. Table 14 lists the sample sites and other basin characteristics.

Table 14.--Drainage area, percentage of each basin underlain by schist and Tertiary sedimentary rocks, and location of seven hydrologic data-collection sites in the Healy coal area

| Site no. | Site name latitude and longitude | Drainage area (mi²) | Schist (percent) | Tertiary sedimentary rocks (percent) |
|---|---|---|---|---|
| 1 | Healy Creek near Usibelli 63°53'08" 148°38'20" | 58.8 | 100 | 0 |
| 2 | Coal Creek near Usibelli 63°52'47" 148°40'37" | 18.1 | 98 | 2 |
| 3 | Cripple Creek near Usibelli 63°52'45" 148°44'06" | 7.33 | 95 | 5 |
| 4 | Healy Creek at Suntrana 63°51'10" 148°50'37" | 107 | 92 | 8 |
| 5 | Lignite Creek above Sanderson Creek near Usibelli 63°55'17" 148°42'10" | 8.37 | 32 | 68 |
| 6 | Lignite Creek below Sanderson Creek near Usibelli 63°54'53" 148°42'37" | 15.6 | 33 | 67 |
| 7 | Lignite Creek near Healy 63°54'26" 148°58'17" | 48.6 | 24 | 76 |




Base from U.S. Geological Survey, Healy, Alaska, 1:250,000, 1956

Figure 31.-- Drainage areas and data-collection sites in the Healy coal area. (See figure 32 for site names.)

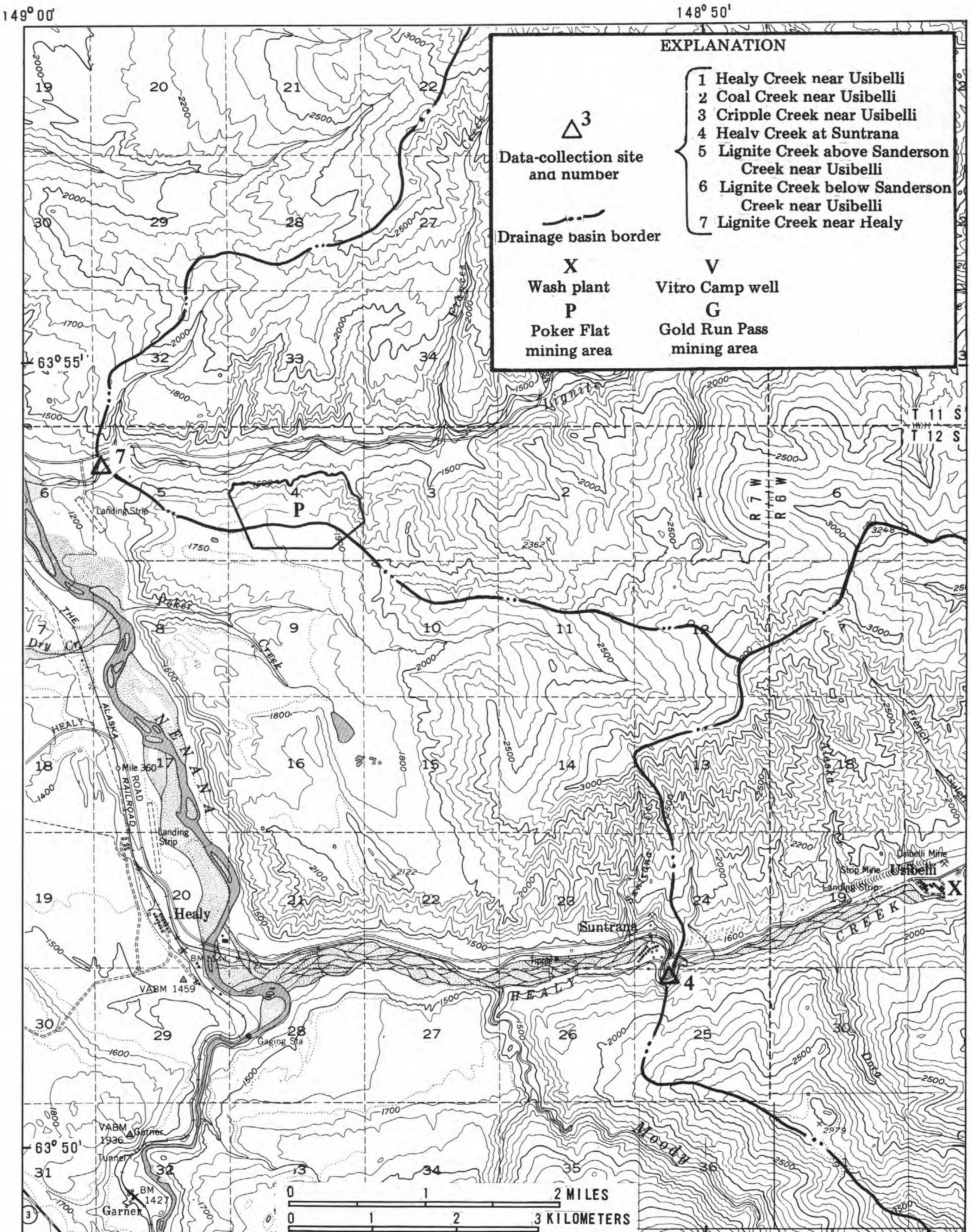


Figure 32. --Location of data-collection sites, current mining areas, Vitro Camp well, and the wash plant in the Healy Coal area.

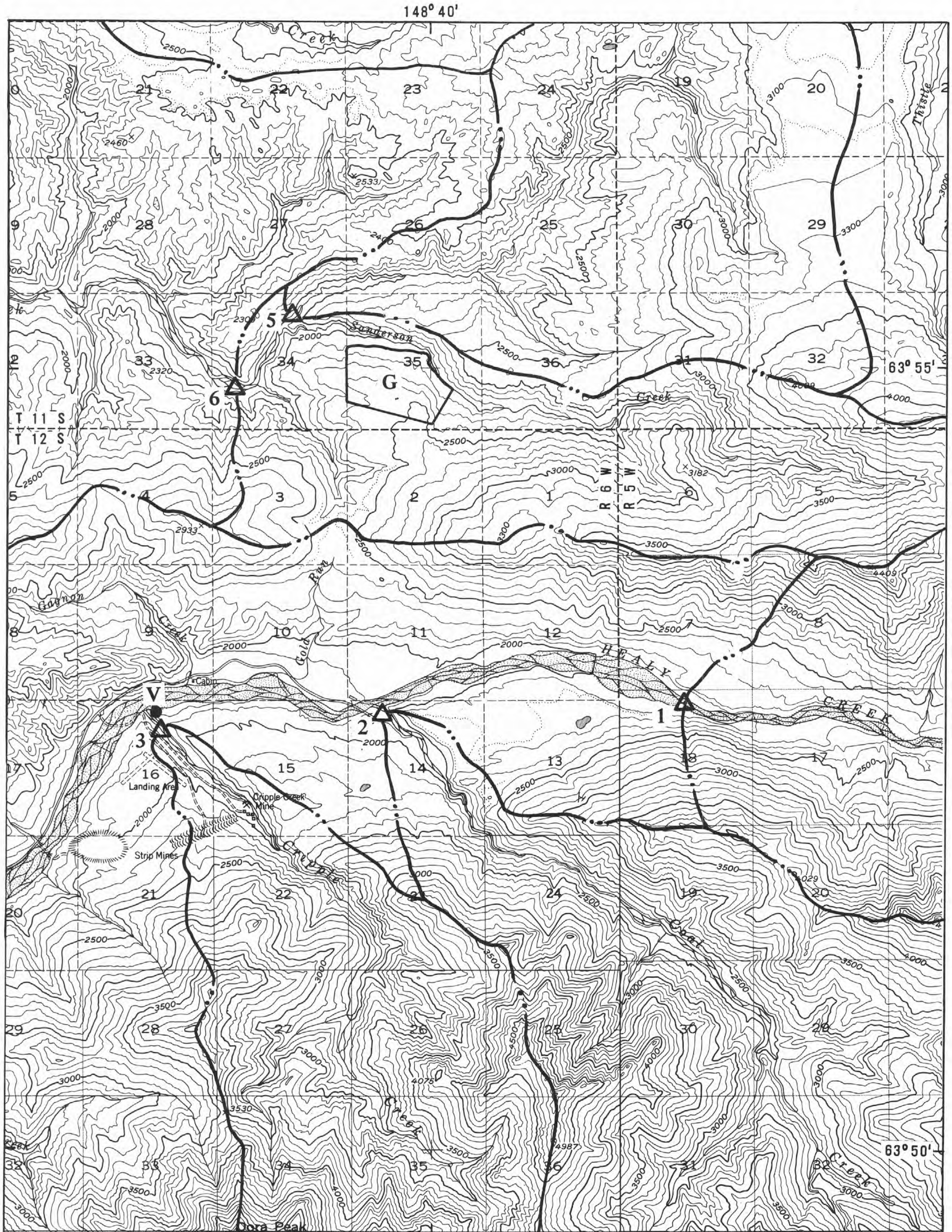


Figure 32. -- Continued

The basin upstream from the upper site on Healy Creek is entirely underlain by schist and has not been mined. Some coal has been mined in the extreme lower parts of the Coal and Cripple Creek basins, but less than 5 percent of their area is underlain by coal-bearing rocks. Extensive coal mining has taken place in the coal-bearing rocks in the drainage area between the lower Healy Creek site (Healy Creek at Suntrana) and the three sites mentioned above. Mining operations have, at one time or another, extended to the boundaries of the Tertiary sedimentary rocks on Healy Creek. Therefore, it was not possible to select a site representative of undisturbed Tertiary sedimentary rocks.

Coal has been mined in the Sanderson Creek drainage of the Lignite Creek basin. Therefore, data-collection sites were established on Lignite Creek both upstream and downstream from the mouth of Sanderson Creek. About two-thirds of these basins are underlain by coal-bearing rocks and one-third by schist. Seventy-six percent of the basin at the most downstream site, Lignite Creek near Healy, is underlain by the coal-bearing rocks. The difference between the geologic units exposed in the Healy and Lignite Creek basins is reflected in the streamflow characteristics and chemical quality of the creeks.

The data for this study are published in Scully, Krumhardt, and Kernodle (1980).

## Climate

Long-term climatic observations have been taken at Denali National Park and Preserve Headquarters (formerly Mount McKinley National Park Headquarters) 9 mi south of Healy at 2,070 ft elevation. The record consists of 53 years of temperature data and 49 years of precipitation data through 1978. Over this period, the air temperature has averaged 26.9°F and the average annual precipitation has been 15.12 in. During the study period, July 1975 to September 1978, the average air temperature at Denali National Park and Preserve Headquarters was 0.7°F above normal, while annual precipitation averaged about 2 in. below normal. Figure 33 shows the monthly precipitation and the average monthly air temperature at Denali National Park and Preserve Headquarters for the study period.

July is the warmest month, averaging 55°F, whereas December and January are the coldest months, averaging 1°F. February, March, and April are the driest months; only 12 percent of the annual precipitation falls. June, July, and August are the wettest months, receiving 51 percent of the annual precipitation. Streams in the Healy area are ice covered from about mid-October until the first half of May.

## Mining Activities

The Usibelli coal mine is presently the only large-scale working coal mine in Alaska. As it has been operating for more than 60 years, mining influences, if any, should be reflected in the data. The following brief discussion of the history of mining activities is therefore pertinent to the understanding of existing hydrologic conditions.

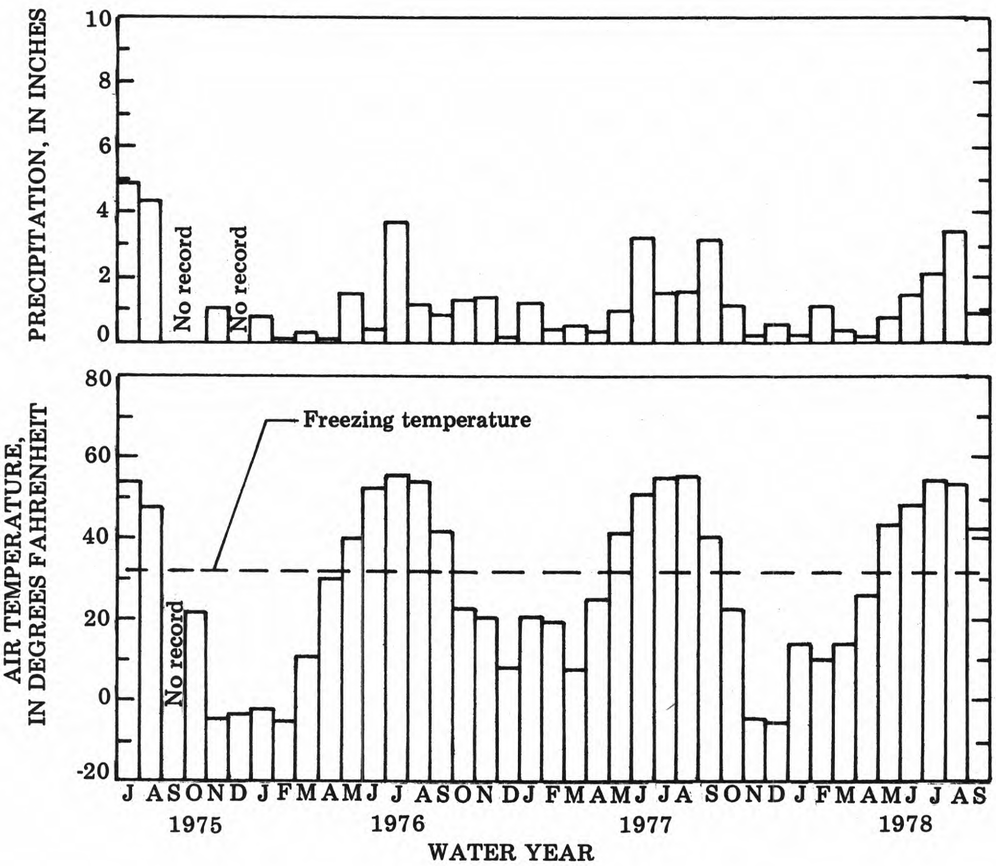



Figure 33.--Monthly precipitation and monthly average air temperature at Denali National Park and Preserve Headquarters from July 1975 to September 1978. (From National Oceanic and Atmospheric Administration, 1975-78.)

Coal mining began in the early 1920's on Healy Creek under the direction of the Usibelli Coal Company and the Healy Creek Coal Company. The latter was sold and renamed Suntrana Mining in 1955, and then sold again in 1961 to Usibelli Coal Company. Usibelli Coal Company has primarily operated a strip mine, whereas the Healy Creek Coal Company and the subsequent Suntrana Mining were chiefly underground operations. There has been no underground mining since the early 1960's. At present, coal is being mined at the Gold Run Pass area on upper Lignite Creek and at the Poker Flat area on lower Lignite Creek (fig. 32). Annual coal production has increased from a little more than 35,000 tons in the 1920's to the current production of more than 700,000 tons.

Stripping procedures vary with the geological structure. In Healy Creek, where the beds dip steeply, the pit depth was 300 ft; stripping ratio limit was 3:1. Following the strike of the beds, coal was mined from three prominent seams within the pit. The uppermost seam is 8-16 ft thick, the middle seam is 10-30 ft thick, and the lower seam is 40-100 ft thick.

The gently dipping seams typical of the Lignite Creek basin allow a more conventional type box cut, and the coal seams are mined in benches. On upper Lignite Creek at the Gold Run Pass area where a pit was opened in 1972, three coal seams totaling 40 ft thick are mined. The coal seam at the Poker Flat mining area is 17 ft thick and under 85 ft of overburden. This overburden is stripped off with a dragline equipped with a 33-cubic-yard bucket.

Once the overburden is stripped and removed, the coal seams are blasted. This method results in better fragmentation and a minimum amount of dust. The coal is then hauled to the tipple, stockpiles, or wash plant. Only coal from the middle bed from Healy Creek, the upper 4 ft of the coal seam from lower Lignite Creek, and that coal contaminated during mining operations are washed. Stripping, washing, and stockpiling are done during the summer. The equipment is then converted for hauling coal during the winter.

Reclamation of mined lands in the Healy coal area began in the early 1970's. At that time reclamation consisted of planting grass on the spoil banks and mine footwalls of the Healy Creek pits. Presently, in the Lignite Creek basin, the overburden is hauled to pits no longer in use. There it is leveled, fertilized, and planted with grasses, legumes, or hay. In addition to reclamation of spoil banks and overburden, coal seam faces left exposed in discontinued or temporarily discontinued pits are covered to prevent spontaneous combustion of the coal.

## Streamflow

Periodic discharge measurements made at the partial-record stations in the Healy coal area indicate that the annual minimum flow occurs during midwinter. Observations of no flow have been made on Coal Creek near Usibelli, Cripple Creek near Usibelli, and Lignite Creek near Healy on some visits during the winter. Summer base flows are significantly higher than winter base flows.

Miscellaneous discharge measurements made at Healy Creek at Suntrana were correlated with concurrent discharges at an index station, Berry Creek near Dot Lake, to define a relation that was used to estimate low-flow characteristics.

Berry Creek near Dot Lake, about 135 mi east of Healy in the foothills of the Alaska Range, has only 5 percent of its drainage area covered by glaciers. Other basin characteristics such as latitude, elevation, terrain, and basin size (65.1 $mi^2$) are comparable to those of the Healy Creek basin.

Figure 34 is a plot of the discharge measurements made on Healy Creek at Suntrana versus the concurrent mean daily discharges at Berry Creek near Dot Lake. A line of relation was computed using least-squares regression on the logarithms of the values. The equation relating the discharges is $Q_H = 19 \times Q_B^{0.49}$, where $Q_H$ is the discharge of Healy Creek at Suntrana and $Q_B$ is the discharge of Berry Creek near Dot Lake. The line, its equation, and the equal yield line are shown in the figure. The position of the equation line relative to the equal yield line indicates that Healy Creek has a higher sustained unit base flow than Berry Creek.

The equation was used to estimate the annual low-flow frequency discharges at Healy Creek at Suntrana. Using the standard Log Pearson III regression analysis, low-flow frequency curves for Berry Creek near Dot Lake that relate low flow to its probability of nonexceedance or to its recurrence interval were computed. Specific values of low-flow frequency were substituted in the above equation to give the low-flow frequency estimates for Healy Creek at Suntrana. The low-flow frequency discharges for Healy Creek at Suntrana for the annual 7-day consecutive period are shown in table 15. Because of the long winter recession, the 7-day and 30-day consecutive period frequency values are virtually identical.

Table 15.--Estimate of annual 7-day consecutive period low-flow frequency discharges for Healy Creek at Suntrana

| Recurrence interval (years) | Discharge ($ft^3/s$) |
|---|---|
| 2 | 41 |
| 10 | 19 |
| 20 | 15 |

Discharge measurements made at Healy Creek near Usibelli, Coal Creek near Usibelli, Cripple Creek near Usibelli, and Lignite Creek near Healy were plotted against those from Healy Creek at Suntrana to compare yield from the different basins. These graphs are shown in figure 35 together with equal yield lines. Too few measurements were made at the Lignite Creek stations above and below Sanderson Creek to warrant a mathematical comparison.

Coal Creek and Cripple Creek probably have annual yields similar to that of Healy Creek, but their base-flow yield is less than that of Healy Creek. The yields of the upper and lower Healy Creek basins are quite similar, but the upper basin may have a higher annual yield because of greater precipitation over the higher elevations. The discharge relation between Lignite Creek near Healy and Healy Creek at Suntrana is poor. The two highest measurements from Lignite Creek, taken during the high flows of spring breakup, plot above the equal yield line. The other data points for Lignite Creek are scattered below the equal yield line, indicating that the Lignite Creek basin probably has less yield and is hydro-

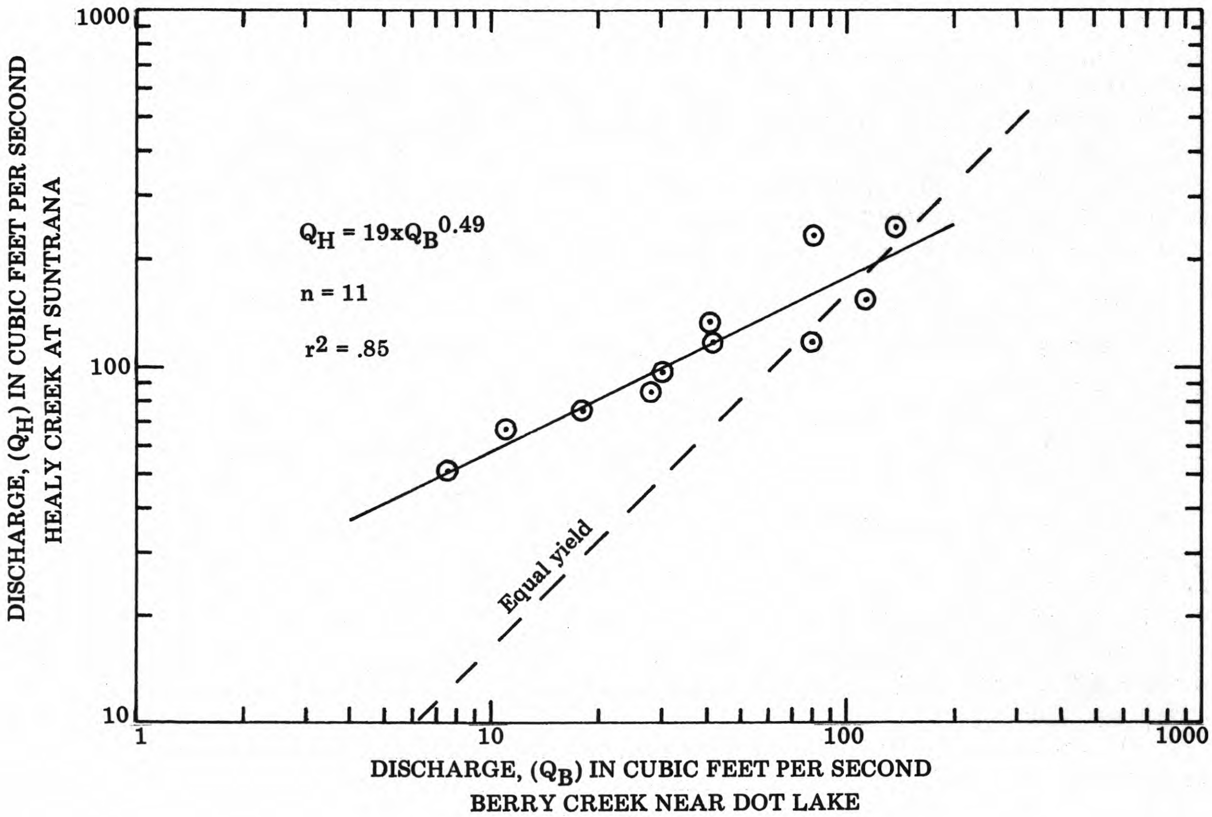



Figure 34.--Discharge of Healy Creek at Suntrana as related to mean daily discharge of Berry Creek near Dot Lake.

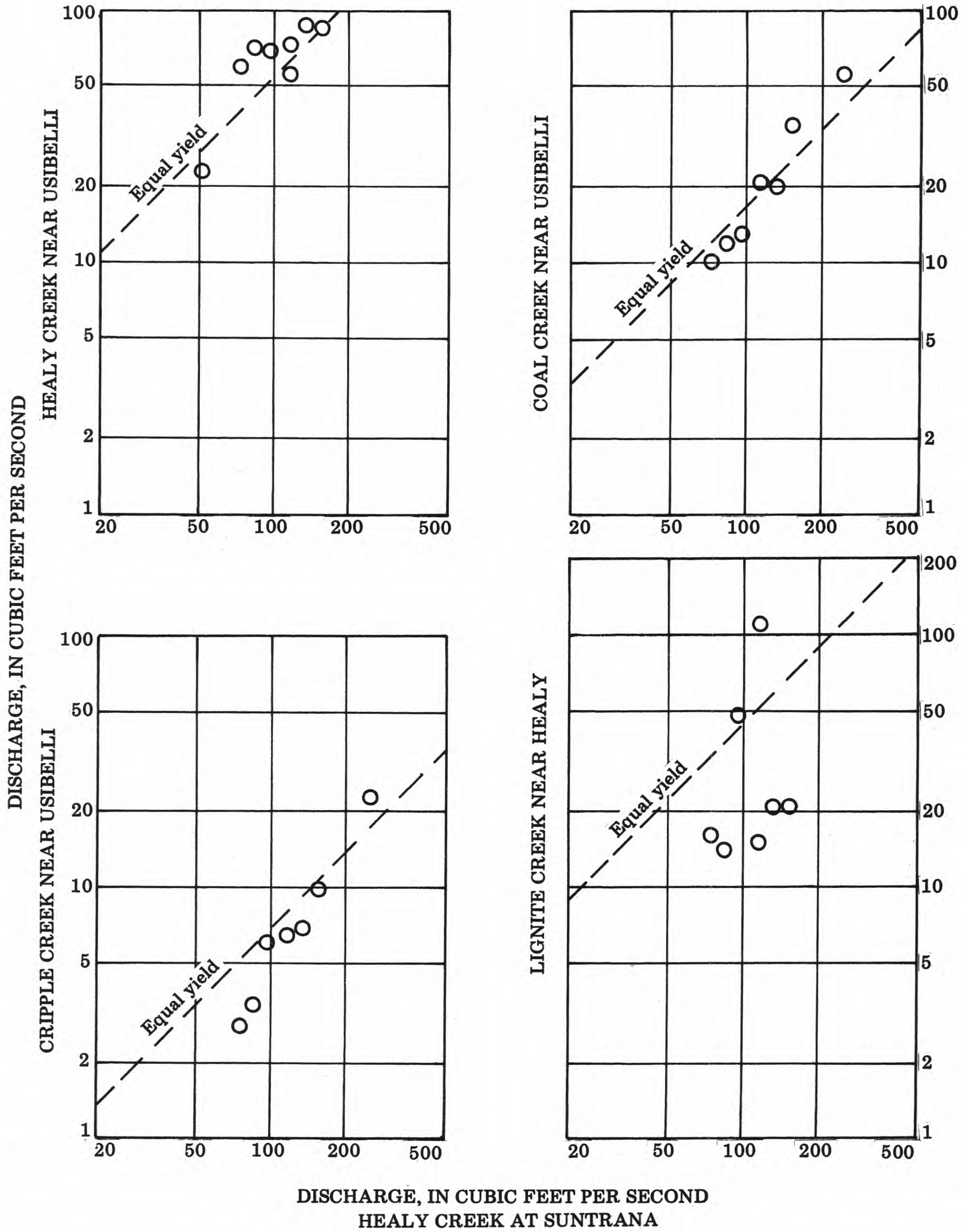



**Figure 35.--Comparison of discharge measurements at four partial-record stations in the Healy coal area with Healy Creek at Suntrana.**

logically dissimilar to the Healy Creek basin. One explanation may be that Lignite Creek is losing water to the alluvium.

## Water Quality

### Suspended Sediment

A poor relation exists between suspended-sediment concentration and discharge at each site in the Healy coal area. However, suspended-sediment concentrations are generally higher during spring breakup and after intense summer rainstorms. (See Scully and others, 1980.)

The paucity of samples collected from unmined and mined drainages precludes any attempt to define a cause-and-effect relationship between strip mining and suspended-sediment discharge. However, during the period of study, the suspended-sediment discharge generally increased in the reach between Healy Creek near Usibelli and Healy Creek at Suntrana, excluding the Coal and Cripple Creek drainages. The intervening drainage area contributing to this reach is approximately 23 $mi^2$. Suspended-sediment discharge gain within the 23-$mi^2$ area was as much as 180 ton/d. The source of the additional sediments may reflect an increase in the Tertiary sedimentary rocks and (or) an increase in mining activities.

### Chemical Quality

Most of the streams in the Healy coal area have high concentrations of dissolved solids, but the composition of the dissolved solids varies from basin to basin. The high concentrations of bicarbonate give the streams a high buffering capacity. The waters of Coal and Cripple Creeks are a magnesium bicarbonate type, whereas those of upper Healy Creek are a calcium bicarbonate type. The percentage of sulfate is high and constant throughout the Healy Creek basin. The water of upper Lignite Creek basin has fewer dissolved solids than that of the lower reaches of Lignite Creek. Concentrations of sodium and chloride increase significantly in the lower reaches of Lignite Creek. The sulfate concentration in Lignite Creek increases below the mouth of Sanderson Creek.

Figure 36a shows dissolved solids plotted against unit discharge for 39 samples collected from 1975 to 1978 in the Healy coal area. Values of dissolved solids ranged from 111 to 636 mg/L. Dissolved-solids values were higher during periods of winter or summer low flow. During these periods, streamflow is derived primarily from effluent ground water. Although the relation is weak, it appears that those creeks in the Healy coal area draining schist generally have higher dissolved-solids concentrations than those draining other terranes.

Figure 36b shows the relation between dissolved solids and specific conductance for the Healy coal area. The trilinear diagram in figure 37 is a plot of the relative concentrations of major ions based on all analyses for the Healy coal area.

Although Coal, Cripple, and upper Healy Creek basins contain nearly equal percentages of schist, the percentages of magnesium and calcium in Coal and Cripple Creeks differ from those in upper Healy Creek. The cation composition, based on

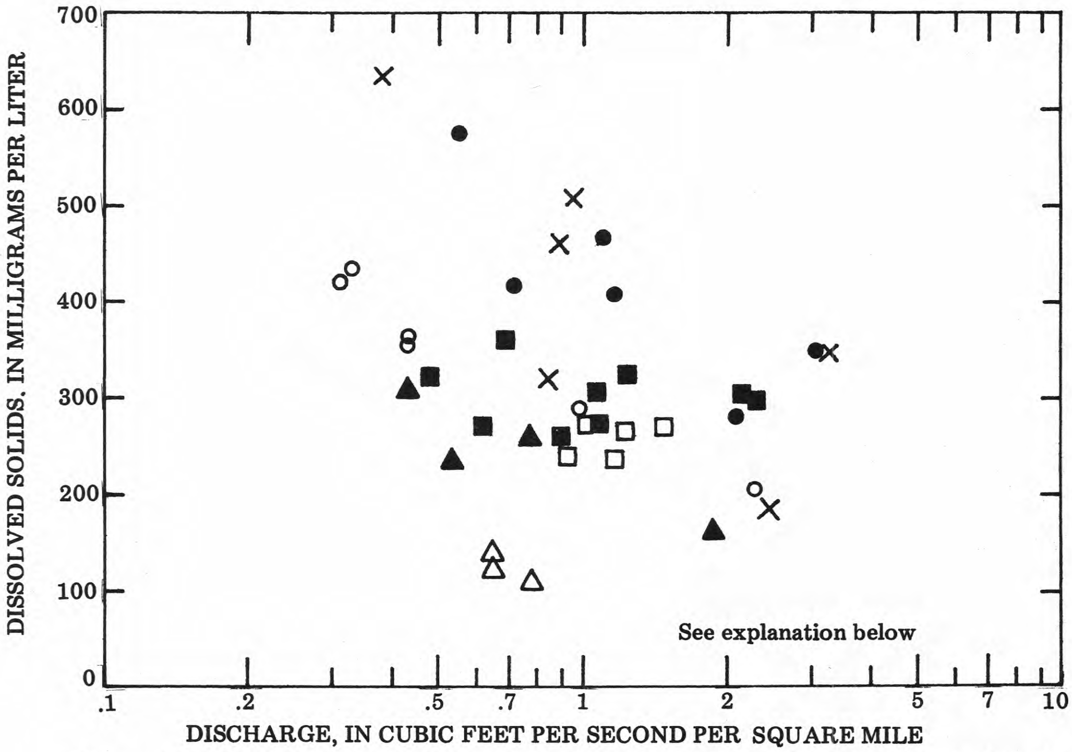



Figure 36a.--Dissolved solids as a function of unit discharge for seven stations in the Healy coal area during the 1975-78 water years.

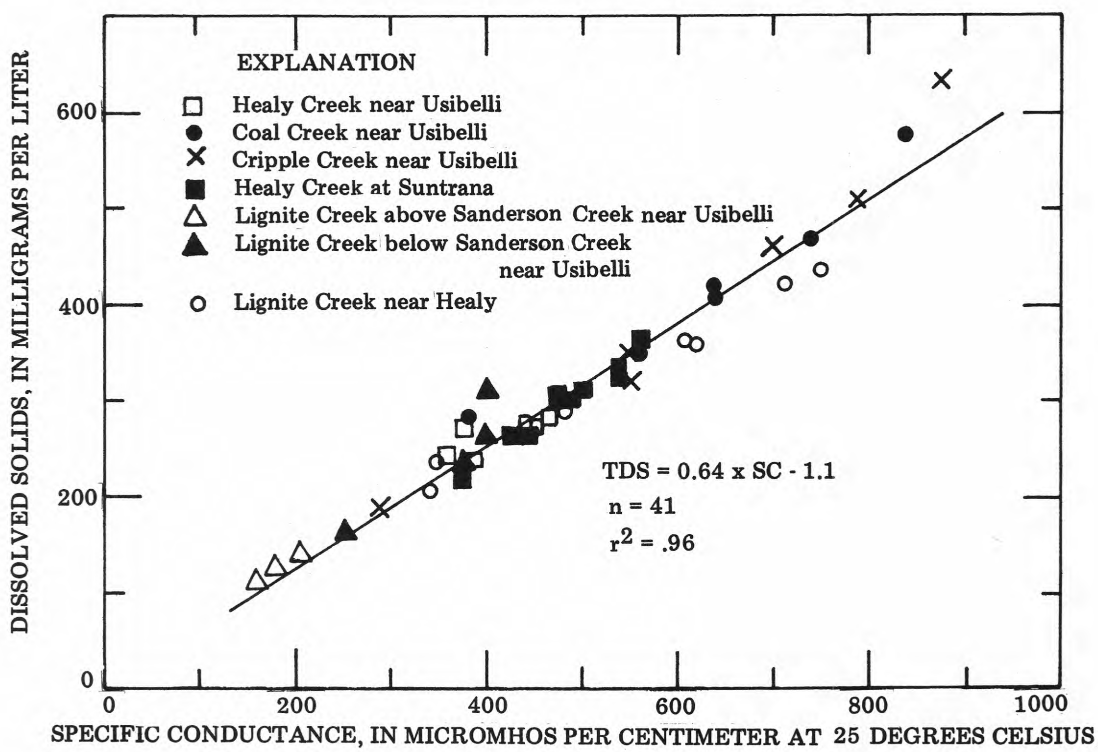



Figure 36b.--Dissolved solids as a function of specific conductance for seven stations in the Healy coal area during the 1975-78 water years.

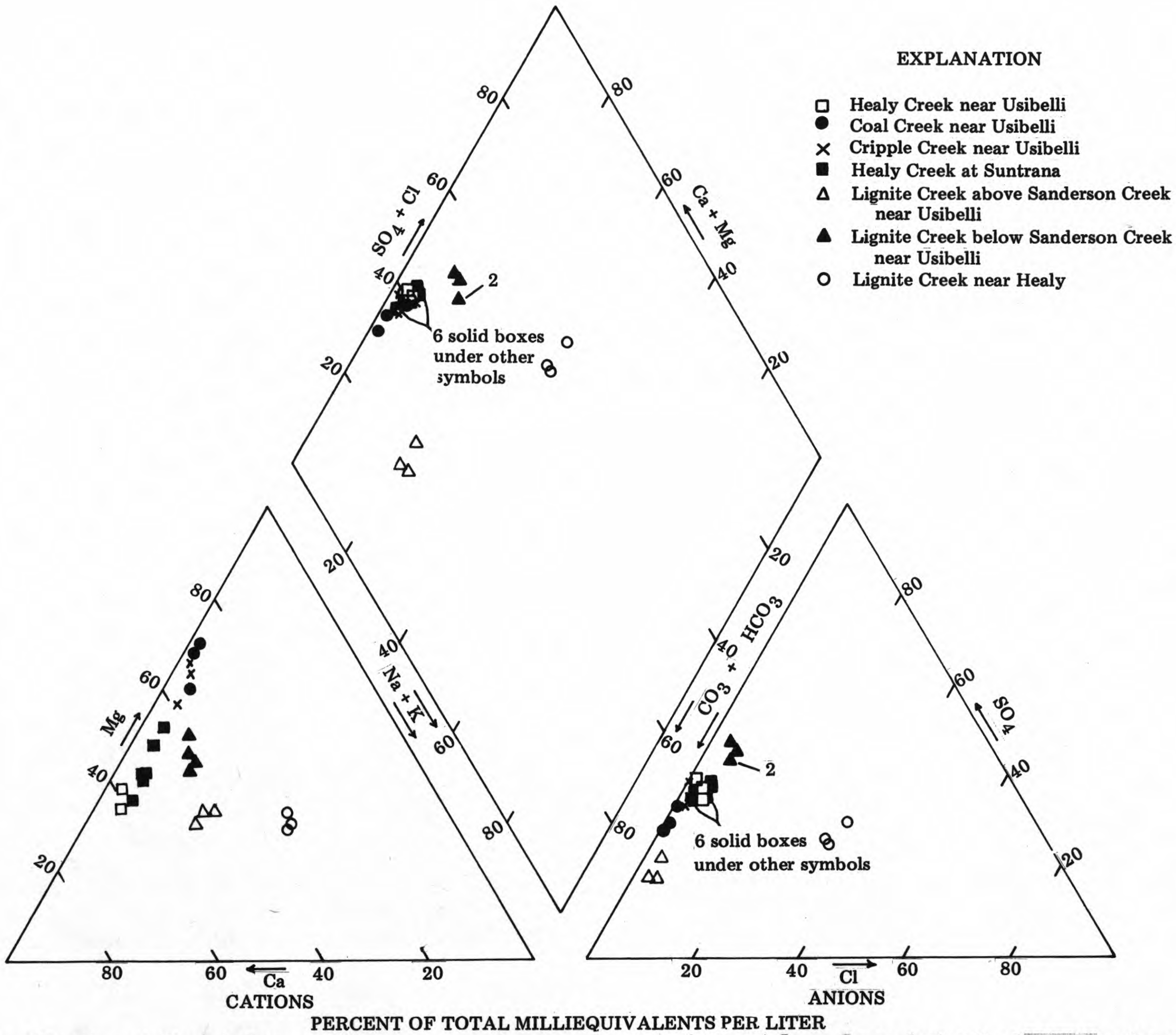



Figure 37.--Piper (trilinear) diagram of water analyses for seven stations in the Healy coal area during the 1975-78 water years.

milliequivalents per liter (meq/L), of Coal and Cripple Creeks averages about 64 percent magnesium and 33 percent calcium, whereas in upper Healy Creek the averages are about 35 percent magnesium and 60 percent calcium. Magnesium and calcium concentrations at the lower Healy Creek site reflect a mixture of the upstream basins, averaging 44 percent and 52 percent, respectively. The dominance of the magnesium ion in Coal and Cripple Creeks might be a local difference in the chemical composition of the schist, which is known to contain greenschists of metavolcanic origin. Concentrations of sodium and potassium are low throughout the Healy Creek basin.

Bicarbonate and sulfate are the dominant anions in the Healy Creek basin; concentrations of chloride, nitrate, and fluoride are much lower. Bicarbonate averages about 60 percent, whereas sulfate averages about 35 percent of the anions in the Healy Creek basin. Although the sulfate ion is a common leachate from strip-mining spoil banks and overburden, Tertiary sedimentary rocks and disseminated pyrite are abundant and readily available natural sources of sulfur in the Healy coal area. At the uppermost site on Healy Creek, which has not been affected by coal mining and drains only schist, sulfate concentrations are similar to those at the downstream sites. Average percentages of the major ions of the waters in the Healy Creek basin are shown in table 16.

Table 16.--Average percentages of the major ion composition, in meq/L, of the waters in the Healy Creek basin

| Ion | Healy Creek near Usibelli | Coal Creek near Usibelli | Cripple Creek near Usibelli | Healy Creek at Suntrana |
|---|---|---|---|---|
| Cations | | | | |
| calcium | 60 | 31 | 35 | 52 |
| magnesium | 35 | 66 | 62 | 44 |
| potassium | 1 | 1 | 1 | 1 |
| sodium | 4 | 2 | 2 | 4 |
| Anions | | | | |
| bicarbonate | 59 | 65 | 62 | 59 |
| chloride | 3 | 1 | 1 | 3 |
| sulfate | 37 | 33 | 37 | 37 |
| nitrate | 1 | 1 | 1 | 1 |

Lignite Creek above the mouth of Sanderson Creek contains the smallest concentrations of ions of the basins in the Healy coal area. Calcium is the dominant cation and bicarbonate is the dominant anion (table 17). In Lignite Creek below the mouth of Sanderson Creek the concentrations of magnesium and sulfate increase severalfold, whereas calcium and bicarbonate have moderate increases. This suggests that Sanderson Creek, which drains an area currently being mined, is carrying large concentrations of magnesium and sulfate. Water at the lower Lignite Creek site, Lignite Creek near Healy, contains about equal percentages of six major ions. The concentrations of sodium and chloride are significantly increased in the reach of Lignite Creek below the mouth of Sanderson Creek. Figure 37 illustrates the differences in relative ion composition at the three sites on Lignite Creek.

The chemical composition of the surface water of the Lignite Creek basin appears to be influenced by the underlying Tertiary sedimentary rocks, particularily those of the coal-bearing group. That part of Lignite Creek basin above the mouth of Sanderson Creek is underlain primarily by Tertiary sedimentary rocks. Sanderson Creek, a tributary to upper Lignite Creek, drains a 5.6-$mi^2$ basin underlain by approximately 20 percent Tertiary rocks and 80 percent schist. Tertiary rocks also underlie most of the lower part of the Lignite Creek basin. Coal sequences characteristically contain shale, claystone, and sandstone which are impregnated with salts and trace elements (Elphic and Stokes, 1975). Upon exposure, these salts and trace elements are more readily available to the hydrologic system. In the Lignite Creek basin, the coal-bearing group is extensively exposed on nearly vertical slopes shaped by Lignite Creek.

Table 17.--Average percentages of the major ion composition, in meq/L, of the waters in the Lignite Creek basin

| Ion | Lignite Creek above Sanderson Creek near Usibelli | Lignite Creek below Sanderson Creek near Usibelli | Lignite Creek near Healy |
|---|---|---|---|
| | Downstream ⟶ | | |
| Cations | | | |
| calcium | 46 | 42 | 31 |
| magnesium | 32 | 45 | 30 |
| potassium | 2 | 1 | 3 |
| sodium | 20 | 12 | 36 |
| Anions | | | |
| bicarbonate | 77 | 48 | 39 |
| chloride | 3 | 5 | 33 |
| sulfate | 19 | 46 | 27 |
| nitrate | 1 | 1 | 1 |

During the study period the pH of the surface waters in the Healy coal area ranged from 6.7 to 8.6 units for 52 determinations. Acid mine drainage is not now a problem in the Healy coal area. Values of pH from Healy Creek at Suntrana, the site most likely to be subject to acid drainage, ranged from 7.4 to 8.4 units.

Color determinations were made on 15 samples from the Healy Creek basin and 10 samples from the Lignite Creek basin. Color values ranged from 1 to 43 platinum-cobalt units in the Healy Creek basin and from 9 to 220 units in the Lignite Creek basin. Two of the 10 samples in Lignite Creek exceeded the upper limit of 75 color units set for domestic water supplies (EPA, 1976). Generally, the color values were higher during the spring and fall, reflecting an influx of organic debris usually abundant during those seasons.

Fewer analyses were made for minor or trace elements than for the major ions. Emphasis was placed on iron, manganese, and to a lesser extent, lead. Dissolved-iron concentrations in the Healy coal area ranged from 0 to 2.4 mg/L and averaged 0.24 mg/L; the highest concentrations have usually occurred during spring breakup. Total-iron concentrations were as much as 100 mg/L. Concentrations are highest during periods of high discharge caused by spring breakup and summer storms. The recommended maximum limit for iron in domestic water supplies is 0.3 mg/L (EPA, 1976). Dissolved-manganese concentrations in the Healy Creek basin ranged from 0 to 0.10 mg/L and averaged 0.02 mg/L. In contrast, in the Lignite Creek basin, values ranged from 0.14 to 0.34 mg/L and averaged 0.25 mg/L. The recommended maximum limit for manganese in domestic water supplies is 0.05 mg/L (EPA, 1976). None of the total-lead concentrations in the seven samples analyzed exceed the detection limit of 0.1 mg/L. A few analyses for other minor elements are available for most of the sites. Concentrations of these minor elements are mostly below detection limits of the analytical methods used.

## Ground Water

Ground-water data in the Healy coal area are sparse. Private water wells, usually a principal source of ground-water data, are primarily west of the Nenana River, a major hydrologic boundary. In addition, most of the wells are completed in Tertiary sedimentary rocks; no wells are known to be completed in the early Paleozoic and (or) Precambrian schist (bedrock).

Schist in the Healy coal area is similar in age, general rock type, and fracture pattern to schist in the uplands north of Fairbanks. In the Fairbanks uplands, ground water is transmitted primarily through multiform fractures. Water quality and quantity in the schist vary vertically as well as horizontally, depending on size of fractures, structure, and chemical composition of the rock. Generally, well yields from the schist in the Fairbanks area range from 1 to 5 gal/min, although some wells obtain as much as 15 gal/min. Ground water from the schist characteristically is of a calcium bicarbonate type. Similar types and amounts of ground water may be expected from the bedrock in the Healy coal area.

The sandstone, siltstone, claystone, and coal of the Tertiary formations have different aquifer characteristics. In general, clay and silt have high porosity and low permeability, sand has high porosity and moderate permeability, and coal has low porosity and high fracture permeability. Cementation, compaction, folding, and faulting (all of which have occurred in the Healy coal area) will change the porosity and permeability. Wells completed in the Tertiary sedimentary rocks on the west side of the Nenana River yield as much as 70 gal/min.

Two water samples taken from the Vitro Camp well (fig. 32) near the mouth of Coal Creek were analyzed. Ground water from the well, completed in Tertiary sedimentary rocks, is of the calcium bicarbonate type and has a low dissolved-solids concentration. All constituents generally have lower values than those from surface-water samples taken during both open-water and winter base-flow conditions.

The Healy coal area lies in a zone of discontinuous permafrost (Ferrians, 1965). Permafrost is influenced by vegetation, topography, and climate and can be expected on north-facing slopes, lower slopes, and valley bottoms in this area. Depths to the base of the permafrost are not known for the area; however, a well at Denali National Park and Preserve Headquarters penetrated 100 ft of permafrost (Ferrians, 1965). Permafrost can act as a barrier to ground water, permitting neither recharge to nor discharge from an aquifer. Ground water may also be confined by seasonal frost.

The creeks in the Healy coal area appear to be hydraulically connected to the ground-water system. This is indicated by aufeis and flow over the ice during the winter and by sustained base flow during the prolonged summer dry spells. Surface-water quality data collected during base flow may be a useful indicator of the chemical quality of the ground water.

## SUMMARY

This study was limited to three areas in Alaska that have high potential for coal development. The report primarily describes the streamflow and water quality of major streams in each of the areas. Due to the lack of wells the description of ground-water hydrology is limited.

### Beluga coal area

Mean flow at the Chuitna River near Tyonek gaging station is estimated to be 330 $ft^3/s$ or 2.5 $(ft^3/s)/mi^2$. The mean yield in the Beluga coal area is estimated to range from 2.2 to 3.4 $(ft^3/s)/mi^2$. There are two distinct low-flow periods, late winter and late summer. The 7-day low flow with a 10-yr recurrence interval is estimated to range from 0.3 to 0.6 $(ft^3/s)/mi^2$. High flow in the area is a result of snowmelt runoff in late spring and rainstorms in the fall. High flows greater than 50 $(ft^3/s)/mi^2$ can be expected on the Chuitna River. A summer seepage investigation in the Capps Creek basin shows that all subbasins contribute water to the streams, but subbasins at higher elevations yield significantly more water than those at lower elevations.

The suspended-sediment discharge at Chuitna River near Tyonek is estimated to be 15,000 ton/yr. Among the basins sampled, Capps Creek appears to have the highest concentrations of suspended sediment. The annual maximum water temperature at Chuitna River near Tyonek is about 20°C.

Surface waters in the area have low dissolved-solids concentrations and are a calcium bicarbonate type. They have relatively high concentrations of dissolved iron and manganese; some values exceed EPA limits for domestic water supplies. They contain only low concentrations of other minor elements and nutrients.

Artificial substrate samplers and dip nets were used to sample the benthic invertebrate community. The pooled diversity index from the artificial substrate samples at the Chuitna River near Tyonek ranged from 2.93 to 4.06, which is indicative of unpolluted water.

Surficial deposits or unconsolidated sediments are thin over most of the Beluga coal area, but are thicker near the coast. Ground-water data are scarce, as there are no wells in the potential mining areas.

Peters Creek coal area

Only a few discharge measurements were made in the Peters Creek area, and no attempt was made to define streamflow characteristics. The water quality of Peters Creek is similar to that of streams in the Beluga coal area.

Healy coal area

In the Healy coal area the annual minimum flow occurs during midwinter. Observations of no flow were made on some creeks. Summer base flows are significantly higher than winter base flows. At Healy Creek at Suntrana the 7-day low flow with a 10-yr recurrence interval is estimated to be 19 $ft^3/s$. The Lignite Creek basin is estimated to have less yield and is hydrologically dissimilar to the Healy Creek basin.

The streams in the Healy coal area have high concentrations of dissolved solids. Acid mine drainage is not now a problem in the area. The waters of Coal and Cripple Creeks are a magnesium bicarbonate type, whereas those of upper Healy Creek are a calcium bicarbonate type. The percentage of sulfate is high and constant throughout the Healy Creek basin. The waters of upper Lignite Creek have lower dissolved-solids concentrations than those of the lower reaches of Lignite Creek. The concentrations of sodium and chloride increase significantly in the lower reaches of Lignite Creek. The concentrations of magnesium and sulfate in Lignite Creek below the mouth of Sanderson Creek also increase.

## NEED FOR ADDITIONAL STUDY

Additional detailed studies, including thorough ground-water appraisals, are required to detect any effects of coal mining on the local hydrology. For example, continuous monitoring of discharge and water quality at several locations are required to determine the effects of coal mining in the Healy coal area. Additional studies in combination with studies such as this one are prerequisite to the development of any predictive methods.

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