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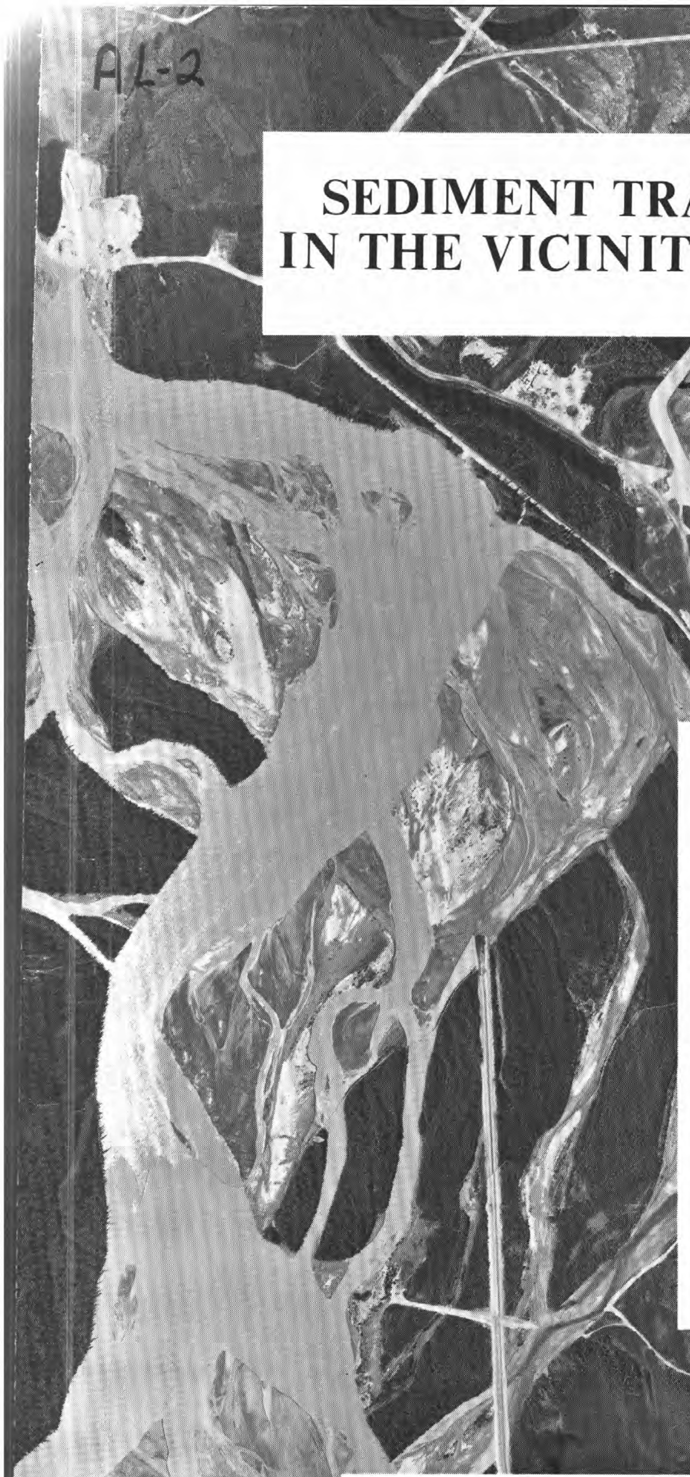

SEDIMENT TRANSPORT IN THE TANANA RIVER IN THE VICINITY OF FAIRBANKS, ALASKA, 1977-78

Prepared by the United States
Department of the Interior
Geological Survey
in cooperation with
U.S.Army Corps of Engineers
Alaska District

OPEN FILE REPORT 79-1539

U.S. DEPARTMENT OF THE INTERIOR
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DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

SEDIMENT TRANSPORT IN THE TANANA RIVER

IN THE VICINITY OF FAIRBANKS, ALASKA, 1977-78

By Robert L. Burrows, Bruce Parks, and William W. Emmett

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UNITED STATES DEPARTMENT OF THE INTERIOR

CECIL D. ANDRUS, Secretary

GEOLOGICAL SURVEY

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Water Resources Division
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Anchorage, Alaska 99501

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FACTORS FOR CONVERSION OF UNITS

The following factors may be used to convert the inch-pound units published herein to the International System of Units (SI).

Multiply inch-pound units	by	to obtain SI units
inches (in)	25.4	millimeters (mm)
feet (ft)	0.3048	meters (m)
miles (mi)	1.609	kilometers (km)
pounds (lb)	0.4536	kilograms (kg)
ton, short (t)	0.9072	metric ton (t)
cubic feet per second (ft^3/s)	0.02832	cubic meters per second (m^3/s)
pounds per foot (lb/ft)	1.488	kilograms per meter (kg/m)

Suspended-sediment concentrations are given only in milligrams per liter (mg/L) because these values are (within the range of values presented) numerically equal to equivalent values expressed in parts per million.

LIST OF SYMBOLS

Symbol		
A	-	Cross-sectional area of flow (ft^2)
D	-	Mean depth of flow (ft)
GH	-	Gage height (ft)
Q	-	Discharge of flow rate (ft^3/s)
S	-	Slope (ft/ft)
V	-	Mean velocity of flow (ft/s)
W	-	Surface width of flow (ft)
d	-	Particle size (mm)
G_B	-	Bedload-transport rate (tons/day)
G_S	-	Suspended-sediment transport rate (tons/day)
r	-	Correlation coefficient

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ABSTRACT

Measurements of the sediment load of the Tanana River in the vicinity of Fairbanks, Alaska, show that suspended-sediment transport rate, G_S, in tons per day, relates to water discharge, Q, in cubic feet per second, as

$$G_S = 5.717 \times 10^{-8} Q^{2.713} \qquad (r^2 = 0.967).$$

The bedload-transport rate is approximately one to two percent of the suspended-sediment transport rate.

Data collected at Fairbanks and upstream from Fairbanks near North Pole, Alaska, show little difference in size distribution of suspended sediment between the two locations. The median particle size of suspended sediment is generally in the silt range, but at some low-water discharges, the median particle size is in the very fine sand range.

The median particle size of bedload near North Pole is generally in the gravel range, but at some low transport rates, the median particle size is in the medium sand range. At Fairbanks, data collected in 1977 indicate median particle sizes of bedload comparable to those of the upstream location, while data collected in 1978 indicate a marked decrease in median particle size of bedload between the two locations.

For both locations and at all water discharges and sediment-transport rates, particles constituting the suspended load are significantly smaller than particles constituting the bedload.

INTRODUCTION

To facilitate design and operation of engineering structures on the Tanana River and quarrying of gravel from the river in the vicinity of Fairbanks, the U.S. Army Corps of Engineers, Alaska District, requested that the U.S. Geological Survey collect and evaluate sediment-transport and river-hydraulic data during periods of principal runoff, beginning in 1977.

A report by Emmett, Burrows, and Parks (1978) presented results of data collected in 1977. The present report includes all data collected through 1978; it supersedes the earlier report. Data are presented in tabular and graphical form, and the majority of the text is devoted to explanation of the tables and graphs. The primary purpose of this report is to provide the Corps of Engineers information that is pertinent to their design computations.

The study program is funded by the Corps of Engineers through a cooperative agreement with the U.S. Geological Survey. All field work and the compilation of data were conducted by personnel of the U.S. Geological Survey. Most laboratory analyses of particle-size determinations and suspended-sediment concentrations in 1977 were done by personnel of the Corps of Engineers. Laboratory analyses for the April 1977 data, and those since October 1977, were done by personnel of the Geological Survey.

STUDY OBJECTIVES

The primary objectives of the study are to define for two stations near Fairbanks, suspended-sediment and bedload-transport rates as functions of stream discharge, and size distributions of suspended sediment and bedload. These objectives were agreed upon by the U.S. Geological Survey and the Corps of Engineers. Data-collection sites were established at the U.S. Geological Survey gaging station, Tanana River at Fairbanks, Alaska (station 15485500), and at a newly established water-data station, Tanana River near North Pole, Alaska (unnumbered miscellaneous site). The station near North Pole is approximately 15 river miles upstream from the Fairbanks station; station locations are shown on the index map in figure 1. Existing streamflow data for the Fairbanks station may be found in the annual publications of the U.S. Geological Survey entitled "Water Resources Data for Alaska." New data for both stations will be published in future issues of the same series.

INSTRUMENTATION AND DATA COLLECTION

Gage heights during the open water season at the Fairbanks station were documented by a continuous trace on a Stevens A-35 recorder. The continuous trace was analyzed to determine daily mean gage heights and corresponding daily mean discharges. During the winter flow period, November through April, values of daily mean discharge were estimated using periodic discharge measurements, climatological data, and correlation with data available from the gaging station, Tanana River at Nenana, Alaska. At the North Pole station, only water-surface elevations at the times of discharge measurements and (or) collection of samples were recorded. All measurements were made from a boat. The boat was positioned using sextant readings on a base line for cross-channel stationing and visual reference to the cross-section end markers for on-station locationing.

A P-61 suspended-sediment sampler (Guy and Norman, 1970) was used to collect depth-integrated samples for analysis of concentration and particle-size

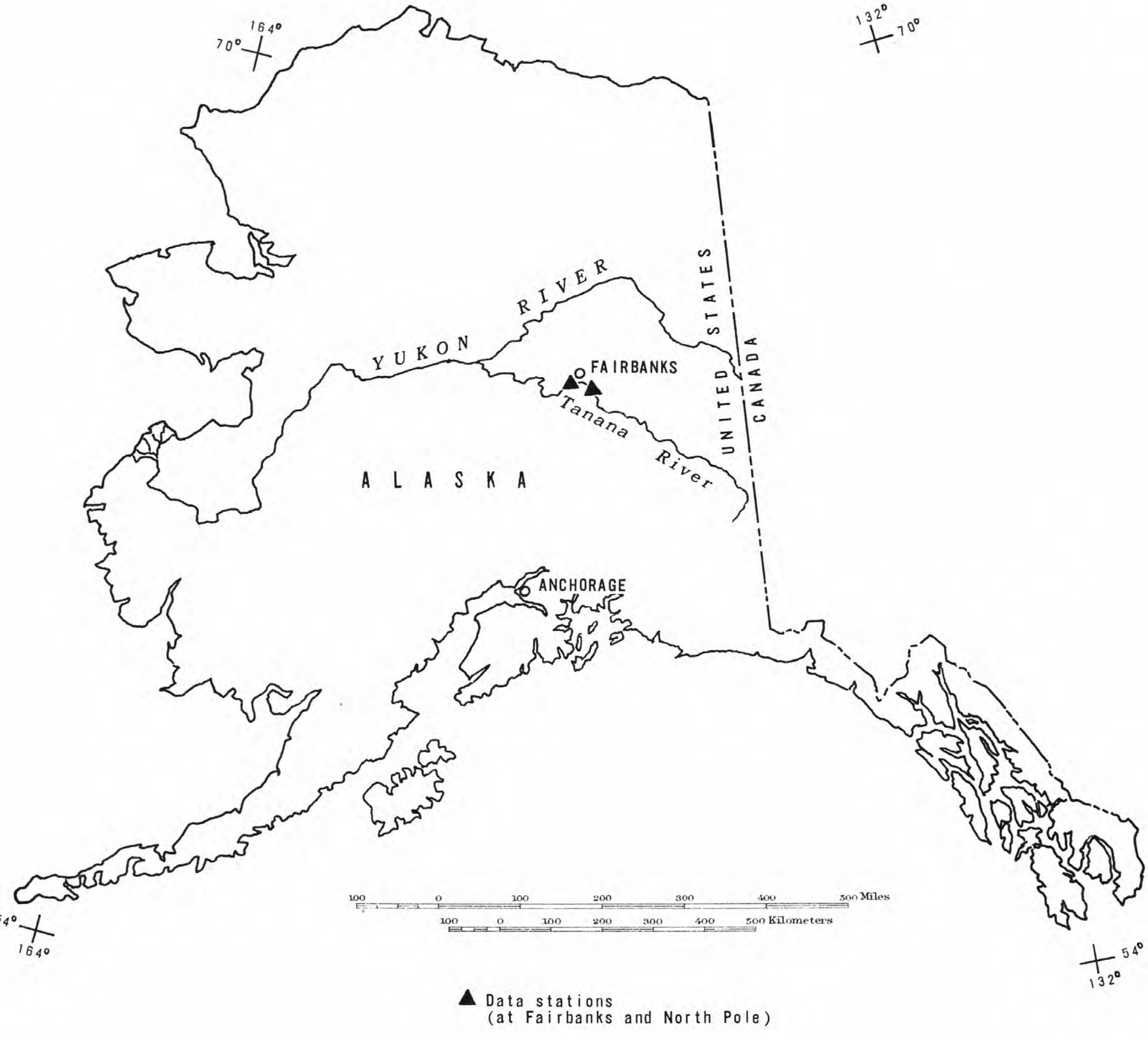

Figure 1.--Location of Tanana River and data-collection stations.

distribution of the suspended sediment. A Helley-Smith type bedload sampler (Helley and Smith, 1971) was used to collect bedload samples that enabled determination of bedload-transport rate and particle-size distribution of the bedload. The Helley-Smith bedload sampler has not been adopted by the U.S. Geological Survey as standard equipment; therefore, results obtained through its use cannot be certified for accuracy. However, a field determination of the sediment-trapping characteristics of the Helley-Smith bedload sampler (Emmett, 1979) indicates that no correction factor need be applied to the bedload data as collected. Additionally, the sampler has been used with apparent success in other rivers (Emmett, 1976; Emmett and Thomas, 1978) that have bedload-transport rates and bedload particle-size characteristics similar to those of the Tanana River.

For most of the bedload-data collection, samples were obtained at 50-ft increments across the part of stream width that is active in the bedload-transport process. Generally, this resulted in collection of 18 to 20 samples across the stream width. Sampling duration was 30 seconds at each location. For most traverses of the stream, each individual bedload sample was given equal consideration in the determination of average stream-wide transport rate. In the few instances where duplicate samples were obtained at a given location, these samples were averaged, and the average value used in the same manner as individual values. Samples collected at each end of the traverses were given the same consideration as other individual samples, regardless of the incremental width of channel associated with the samples collected near each bank.

Streamflow Data and Channel Geometry

Table 1 presents a summary of discharge measurements made during the periods of sediment sampling on the Tanana River at Fairbanks. Cross-section data for several of the discharge measurements included in table 1 are plotted in figure 2 and illustrate several characteristics of the river. As river stage changed, there was considerable shifting of bed material from the sand and gravel bar area to the thalweg, and vice versa. Spanning two seasons of runoff, Spring 1977 to Fall 1978, there was a net lateral movement of bed material sufficient to change the general configuration of the cross section. Whereas in June 1977, the thread of maximum depth was near the south or left bank (about station 1,250 ft), by September 1978, deposition in this area and scour in the sand and gravel bar area had combined to shift the thalweg about 400 ft toward the north bank (about station 850 ft). This is illustrated in the bottom part of figure 2 by observing the sequence of channel shapes from June 1977 to September 1978. Indeed, a low-flow measurement in October 1978 actually showed emergence of the bar between stations 1,100 and 1,200 ft, and the creation of two separate channels.

Although much of the lateral shifting of the channel occurs during high flow, July and August, as illustrated in the top part of figure 2, significant shaping of the channel appears to occur during the recession of high-to-low flow. That is, even as less transport of bed material occurs in the downstream direction, significant lateral shifting of the channel is still occurring. This is best illustrated by comparing the cross section of August 1978 (top of fig. 2) to the cross section of September 1978 (bottom of fig. 2), and noting the dramatic change in appearance in less than one month's time.

Table 1.--*Summary of discharge measurements made during period of sediment samplings, Tanana River at Fairbanks, Alaska.*

Date	Gage height (ft)	Discharge (ft^3/s)	Flow area (ft^2)	Surface width (ft)	Mean velocity (ft/s)	Mean depth (ft)
6-07-77	28.09	26,500	5,140	865	5.16	5.94
6-16-77	29.28	40,100	8,420	1,060	4.76	7.94
6-29-77	30.10	46,700	10,900	1,180	4.28	9.24
7-06-77	28.82	41,200	7,620	1,070	5.41	7.10
7-12-77	28.93	38,100	7,020	1,060	5.43	6.62
7-20-77	29.56	44,800	8,800	1,180	5.09	7.49
7-26-77	29.60	50,200	9,090	1,280	5.52	7.13
8-03-77	30.56	59,300	10,000	1,300	5.93	7.69
8-11-77	30.42	51,500	9,350	1,220	5.51	7.66
8-18-77	30.16	51,100	9,070	1,240	5.63	7.31
8-31-77	28.95	49,800	8,310	1,000	5.99	8.31
10-03-77	26.92	20,900	4,090	440	5.11	9.30
5-18-78	26.75	20,000	3,970	475	5.03	8.36
5-30-78	26.50	18,400	3,550	380	5.19	9.34
6-20-78	27.66	28,400	5,320	680	5.34	7.82
7-10-78	28.59	34,700	6,850	1,040	5.06	6.61
7-17-78	30.71	58,100	10,840	1,520	5.36	7.13
7-31-78	30.20	51,500	9,170	1,320	5.62	6.95
8-08-78	30.60	54,400	10,490	1,310	5.18	8.01
8-14-78	30.48	57,900	10,560	1,360	5.49	7.76
8-25-78	29.44	43,000	8,120	1,200	5.29	6.79
9-07-78	28.57	34,100	6,240	910	5.46	6.88
10-04-78	26.16	14,500	3,160	505	4.59	6.26

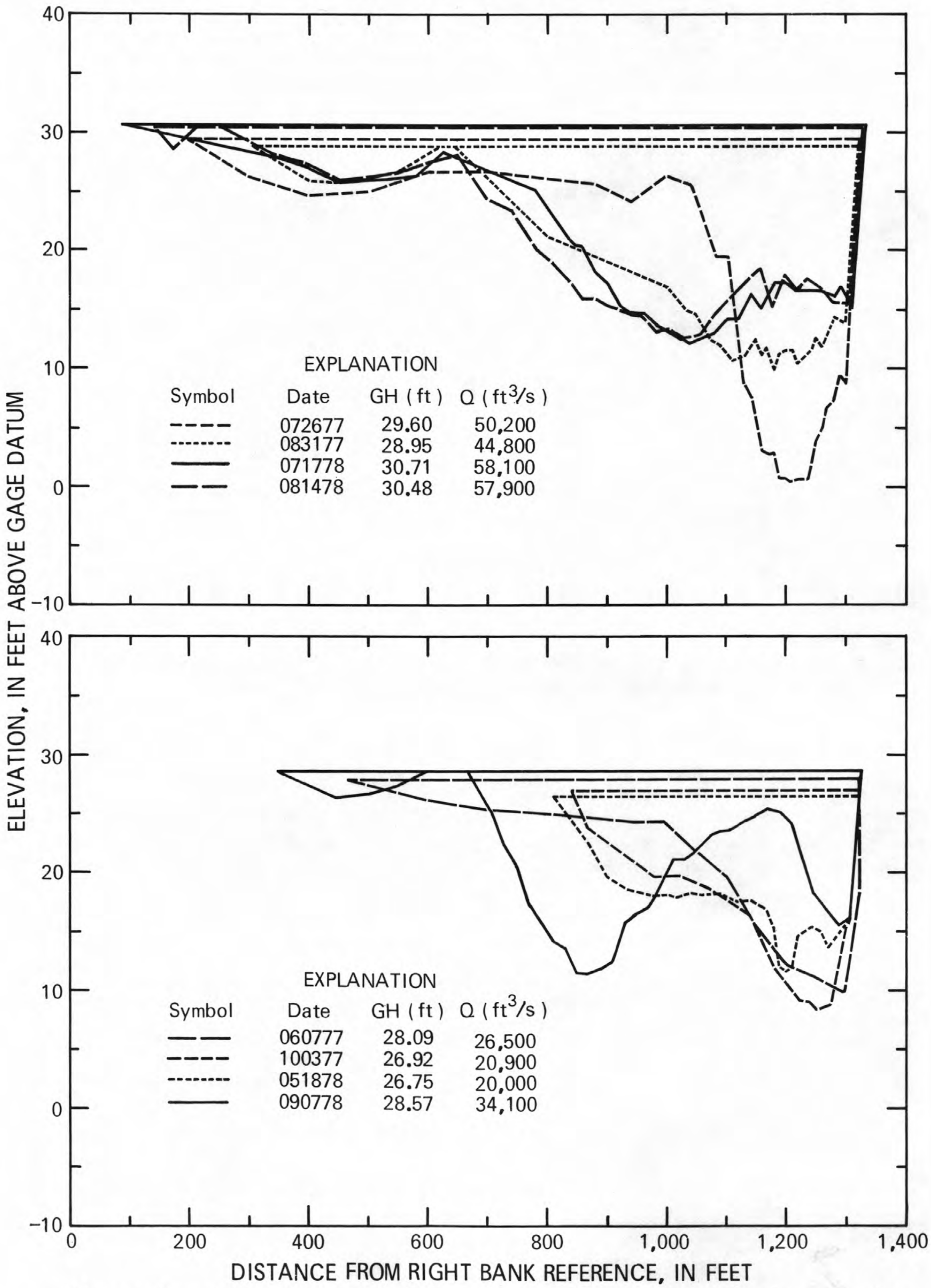

Figure 2.--Cross section of the Tanana River at Fairbanks, Alaska. Top: beginning and end of peak runoff, 1977 and 1978. Bottom: beginning and end of general runoff, 1977 and 1978.

Despite considerable instability in the cross-sectional configuration of the channel, there is surprising consistency in the relations of hydraulic and channel geometry. Data from the discharge measurements in table 1 are plotted as at-a-station values of hydraulic geometry (Leopold and Maddock, 1953) in figure 3. Plotted data of figure 3, in concert with the cross sections illustrated in figure 2, show that at river stages less than about 27 ft (approximately 22,000 ft^3/s), all of the flow is confined to deeper portions of the channel; above a stage of about 27 ft, sand and gravel bar areas become submerged, and the surface width of the river increases rapidly. Because mean depth is a computed parameter (flow area divided by surface width), there is a corresponding decrease in computed mean depth with the rapid increase in surface width. This may imply an erroneous impression that depth is decreasing with increasing discharge, while, in reality, the main body of water is increasing in depth with increases in discharge.

To circumvent this anomalous condition, only the data in table 1 for discharges above 22,000 ft^3/s were used to determine best-fit relations to the plotted data (fig. 3). The technique utilized was a log-transformed least-squares linear regression. The resulting relations for gage height, width, depth, flow area, and velocity are

$$GH = 8.31\ Q^{0.118} \qquad (r^2 = 0.953),$$
$$W = 0.55\ Q^{0.71} \qquad (r^2 = 0.799),$$
$$D = 0.80\ Q^{0.21} \qquad (r^2 = 0.248),$$
$$A = 0.44\ Q^{0.92} \qquad (r^2 = 0.969),$$

and

$$V = 2.27\ Q^{0.08} \qquad (r^2 = 0.061).$$

For the surface-width and mean-depth parameters in figure 3, variation between plotted data for discharges greater than 22,000 ft^3/s and less than 50,000 ft^3/s show the anomalous conditions created by the sudden change in channel width. For width and depth data of figure 3, measured values below 22,000 ft^3/s were connected to measured values above 50,000 ft^3/s by smooth transitional curves. These curves are labeled effective width and effective depth in figure 3; they are, in physical meaning, the appropriate values of surface width and computed mean depth associated with the conveyance of water and sediment.

Although there is significant lateral shifting of the channel, there is no corresponding shifting in the relations for gage height (rating curve), flow area, or velocity. Indeed, the high degree of correlation for the flow-area relation is indicative of the river's complex adjustments in maintaining a consistent relation of channel size to discharge.

Water-surface slopes shown in figure 3 were obtained as part of a special study in 1973 by the U.S. Geological Survey in cooperation with the U.S. Army Corps of Engineers. For the Fairbanks location, the relation for water-surface

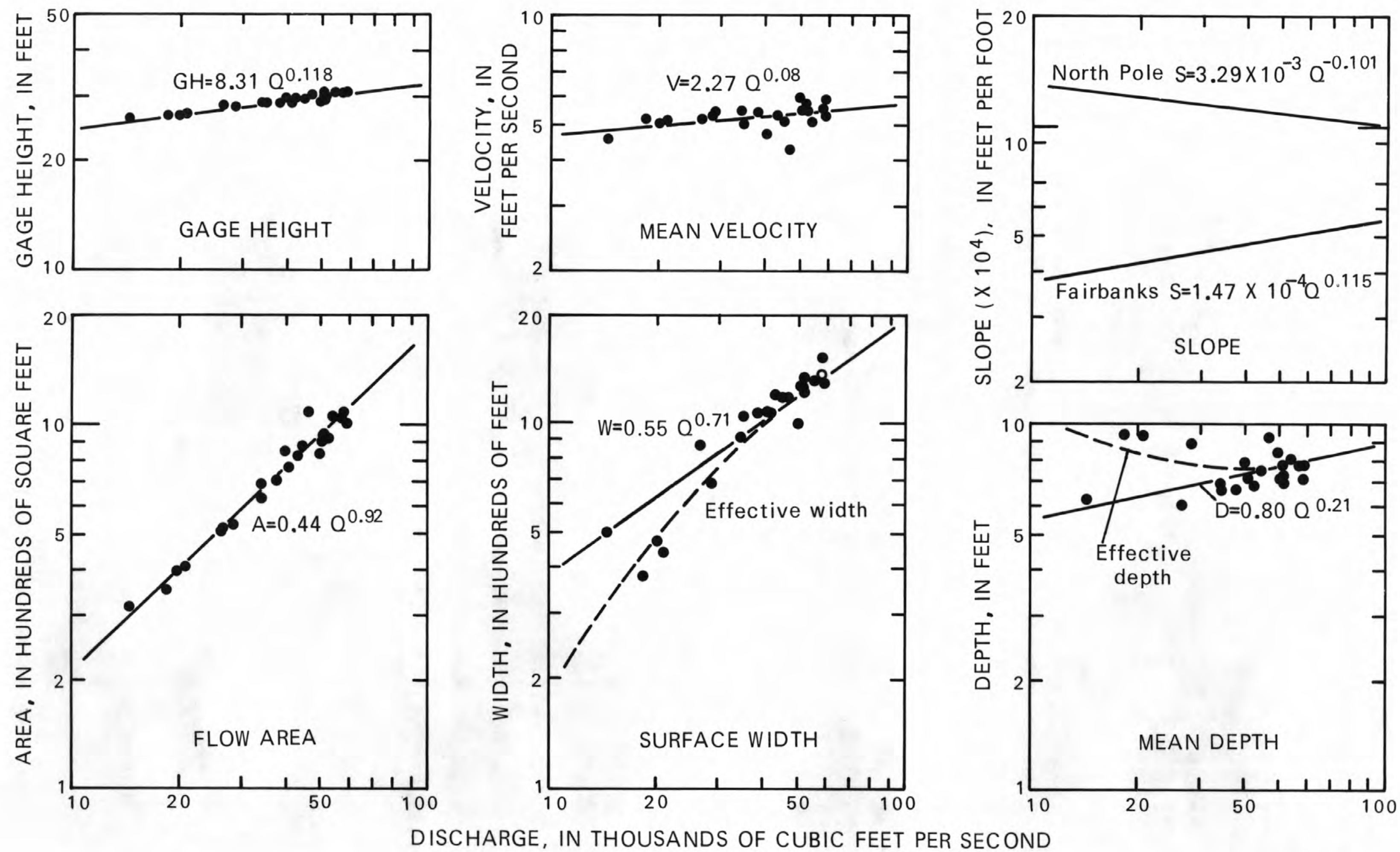

Figure 3.--At-a-station relations of hydraulic and channel geometry, Tanana River at Fairbanks, Alaska.

slope shows increasing values of slope with increasing discharge. The relation shown is

$$S = 1.47 \times 10^{-4} Q^{0.115} \qquad (r^2 = 0.594).$$

For the location near North Pole, water-surface slope decreases with increasing discharge. The relation shown is

$$S = 3.29 \times 10^{-3} Q^{-0.101} \qquad (r^2 = 0.758).$$

Sufficient discharge measurements to determine all of the at-a-station relations of hydraulic geometry for the location near North Pole are not available. However, observations of channel width made in the field at the times of sediment sampling enable relations of effective channel width as functions of discharge. For the south channel near North Pole, the width relation is

$$W = 222 Q^{0.096} \qquad (r^2 = 0.252),$$

and for the north channel the width is

$$W = 1.38 \times 10^{-4} Q^{1.486} \qquad (r^2 = 0.984),$$

but with a minimum value of 400 ft. The total effective width of channel near North Pole is determined by adding the widths as determined for the separate channels.

Values of daily mean discharge for the Tanana River at Fairbanks are presented in tables 2 and 3 for water years 1977 and 1978, respectively. Because a continuous record of the stage is not obtained for the location near North Pole, daily mean discharges are not determined for that station. However, except for a travel-time difference of less than a day, data of daily mean discharge are approximately applicable for either location.

Sediment-Transport Data

Tables 4 and 5, for the locations at Fairbanks and near North Pole, respectively, list values of instantaneous water discharge, suspended-sediment concentration and transport rate, and median particle size of suspended sediment. The suspended-sediment transport rate, G_S, in tons per day is computed as

$$G_S = 0.0027 \times \text{concentration (mg/L)} \times \text{water discharge (ft}^3\text{/s)}.$$

Tables 6 to 8, for the locations at Fairbanks, the separate channels near North Pole, and the combined channels near North Pole, respectively, list values of river hydraulics and bedload-transport rate. The total bedload transport rate, in tons per day, was computed by applying the measured unit transport rate over the effective width of the channel. (Utilization of the effective width concept creates modest computational difference with results presented in the 1978 report by Emmett, Burrows, and Parks; however, the basic data remain the same.) The hydraulic data shown are taken from the relations in figure 3.

Table 2.--*Values of daily mean discharge (ft³/s), 1977 water year*[1/], *Tanana River at Fairbanks, Alaska*

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	13,000	6,000	4,500	4,500	5,200	6,200	5,400	14,000	30,600	51,400	54,800	40,900
2	12,600	6,000	4,500	4,500	5,200	6,200	5,400	15,000	30,600	48,000	59,400	38,800
3	12,200	6,000	4,500	4,500	5,200	6,200	5,600	16,000	29,000	48,100	59,800	35,300
4	12,000	6,000	4,500	4,500	5,400	6,000	5,600	19,000	27,300	47,800	58,000	33,100
5	12,000	5,000	4,500	4,500	5,400	6,000	5,600	23,600	27,000	42,600	59,800	31,000
6	11,800	5,000	4,500	4,500	5,600	6,000	5,800	26,000	28,000	39,000	62,100	30,900
7	11,800	5,000	4,500	4,500	5,800	5,800	6,000	28,000	27,300	37,300	60,300	28,700
8	11,700	5,000	4,500	4,500	5,800	5,800	6,200	29,000	24,800	36,400	56,200	28,600
9	11,000	5,000	4,500	4,500	5,800	5,800	6,400	29,000	23,800	36,400	52,600	27,600
10	11,000	5,000	4,500	4,500	5,800	5,800	6,400	28,300	23,300	38,900	52,500	25,400
11	10,500	5,000	4,500	4,500	5,800	5,800	6,600	24,300	24,000	40,600	53,400	23,800
12	10,000	5,000	4,500	4,500	6,000	5,800	6,800	16,900	25,500	40,600	52,000	25,000
13	10,000	5,000	4,500	4,500	6,000	5,800	7,000	16,600	31,100	43,200	52,000	26,900
14	10,000	5,000	4,500	4,500	6,000	5,600	7,000	16,800	38,700	45,100	52,000	27,000
15	9,000	5,000	4,500	4,500	6,000	5,600	7,000	16,700	38,800	46,800	54,000	26,200
16	9,000	5,000	4,500	4,500	6,000	5,600	7,000	17,300	39,800	48,400	52,000	26,000
17	9,000	5,000	4,500	4,500	6,000	5,600	8,000	17,100	41,000	48,400	52,000	25,600
18	9,000	5,000	4,500	4,500	6,000	5,600	8,000	16,800	41,700	48,000	51,600	25,200
19	8,000	5,000	4,500	4,500	6,200	5,400	8,000	18,400	43,400	47,500	53,000	24,400
20	8,000	5,000	4,500	4,500	6,200	5,400	8,000	24,500	43,600	47,400	56,000	24,000
21	8,000	5,000	4,500	4,500	6,200	5,400	9,000	24,800	40,600	45,800	57,000	25,000
22	8,000	5,000	4,500	4,500	6,200	5,400	9,000	19,600	41,400	45,600	54,000	25,000
23	8,000	4,500	4,500	4,500	6,200	5,400	9,000	17,300	46,400	47,000	55,000	25,000
24	7,000	4,500	4,500	4,500	6,200	5,400	10,000	16,500	49,000	48,300	56,000	24,000
25	7,000	4,500	4,500	4,500	6,200	5,400	10,000	15,700	50,000	49,000	54,000	23,000
26	7,000	4,500	4,500	4,500	6,200	5,400	10,000	15,600	50,000	48,300	52,000	23,200
27	7,000	4,500	4,500	4,500	6,200	5,400	10,000	16,600	50,800	47,700	49,000	23,300
28	7,000	4,500	4,500	4,500	6,200	5,400	11,000	18,800	50,600	49,200	46,000	23,500
29	6,000	4,500	4,500	4,800	-----	5,400	12,000	20,200	49,900	50,100	44,000	23,600
30	6,000	4,500	4,500	4,800	-----	5,400	13,000	23,000	54,100	49,800	40,700	24,800
31	6,000	-----	4,500	5,000	-----	5,400	------	26,000	-----	50,600	40,600	------

[1/]**Winter flow period, November through April, estimated based on periodic discharge measurements, climatological records, and correlation with data obtained for Tanana River at Nenana, Alaska.**

Table 3.--*Values of daily mean discharge* (ft^3/s), *1978 water year*[1/], *Tanana River at Fairbanks, Alaska*

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	22,800	7,400	6,000	5,800	5,600	5,500	5,500	19,000	19,200	27,900	54,400	34,200
2	21,400	7,400	6,000	5,800	5,600	5,500	5,600	17,500	19,700	27,400	54,500	32,600
3	20,400	7,400	6,000	5,800	5,600	5,500	5,600	17,000	21,400	27,400	56,400	32,600
4	19,800	7,400	6,000	5,800	5,600	5,500	5,700	17,500	21,600	27,500	55,600	32,600
5	19,400	7,400	6,000	5,800	5,600	5,500	5,800	18,000	21,500	28,500	55,800	33,300
6	18,700	7,000	6,000	5,800	5,600	5,500	5,800	19,000	22,100	30,900	58,100	33,700
7	18,000	7,000	6,000	5,800	5,600	5,500	5,900	20,000	22,000	33,700	58,300	33,800
8	17,500	7,000	6,000	5,800	5,600	5,500	6,000	21,000	22,100	34,500	56,800	32,000
9	17,100	7,000	6,000	5,800	5,600	5,500	6,100	22,000	22,600	34,400	54,900	30,900
10	16,600	7,000	6,000	5,800	5,600	5,500	6,200	21,500	22,800	35,000	57,800	30,600
11	15,900	6,600	6,000	5,800	5,600	5,500	6,300	21,600	23,600	37,300	56,900	29,800
12	15,300	6,600	6,000	5,800	5,600	5,500	6,400	21,200	24,800	40,300	57,000	29,800
13	14,700	6,600	6,000	5,800	5,600	5,500	6,600	21,000	26,900	42,300	56,000	29,000
14	14,600	6,600	6,000	5,800	5,600	5,500	6,800	20,800	27,700	45,000	55,400	28,200
15	14,300	6,600	6,000	5,800	5,600	5,500	7,000	20,500	29,600	54,300	53,900	26,800
16	13,000	6,600	6,000	5,800	5,600	5,500	7,200	20,200	29,900	59,000	52,100	24,800
17	10,000	6,600	6,000	5,800	5,600	5,500	7,400	19,900	30,000	57,900	50,800	23,400
18	7,000	6,200	6,000	5,800	5,600	5,500	7,600	19,200	29,300	53,700	50,100	22,900
19	6,400	6,200	6,000	5,800	5,600	5,500	8,000	18,300	27,100	50,100	48,900	21,800
20	6,400	6,200	6,000	5,800	5,600	5,500	8,400	17,500	26,200	49,000	47,800	21,000
21	6,600	6,200	6,000	5,800	5,600	5,500	8,600	16,900	25,700	49,000	48,300	20,200
22	6,800	6,200	6,000	5,800	5,600	5,500	9,000	16,800	24,600	47,000	47,800	19,700
23	7,200	6,200	6,000	5,800	5,600	5,500	9,400	15,900	23,900	46,000	47,300	18,600
24	7,400	6,200	6,000	5,800	5,600	5,500	9,800	15,300	25,600	48,000	46,000	18,200
25	7,800	6,200	6,000	5,800	5,600	5,500	10,500	15,500	27,000	47,000	42,900	17,600
26	8,000	6,000	6,000	5,800	5,600	5,500	11,000	16,000	26,800	46,000	40,800	17,100
27	8,100	6,000	6,000	5,800	5,600	5,500	13,000	16,600	26,800	49,000	38,600	17,000
28	8,000	6,000	6,000	5,800	5,600	5,500	15,000	16,700	27,200	52,000	37,300	17,000
29	7,800	6,000	6,000	5,800	-----	5,500	20,000	17,000	27,600	54,000	36,700	16,800
30	7,600	6,000	6,000	5,800	-----	5,500	20,500	17,600	28,300	53,000	36,100	16,300
31	7,400	-----	6,000	5,800	-----	5,500	------	18,600	------	52,200	35,400	------

[1/]Winter flow period, November through April, estimated based on periodic discharge measurements, climatological records, and correlation with data obtained for Tanana River at Nenana, Alaska.

Table 4.--*Summary of suspended-sediment data, Tanana River at Fairbanks, Alaska*

Date	Discharge (ft^3/s)	Suspended sediment Concentration (mg/L)	Transport rate (t/day)	Median particle size (mm)
4-13-77	6,950	58	1,090	-----
4-26-77	10,200	146	4,020	0.19
6-07-77	26,500	952	68,100	.077
6-16-77	40,100	1,640	178,000	.033
6-29-77	46,700	1,860	235,000	.062
7-06-77	41,200	1,510	168,000	.077
7-12-77	38,100	1,490	153,000	.053
7-20-77	44,800	2,210	267,000	.059
7-26-77	50,200	1,820	246,000	.033
8-03-77	59,300	4,340	695,000	.023
8-11-77	51,500	3,270	455,000	.040
8-18-77	51,100	2,620	362,000	.029
8-31-77	49,800	2,020	271,000	.092
10-03-77	20,900	563	31,800	.16
5-18-78	20,000	769	41,500	.13
5-30-78	18,400	476	23,600	.11
6-20-78	28,400	975	74,800	.062
7-10-78	34,700	1,790	168,000	.016
7-17-78	58,100	3,700	580,000	.024
7-31-78	51,500	2,700	375,000	.029
8-08-78	54,400	2,870	422,000	.018
8-14-78	57,900	2,680	419,000	.025
8-25-78	43,000	1,250	145,000	.048
9-07-78	34,100	1,020	93,900	.033
10-04-78	14,500	389	15,200	.18

Table 5.--*Summary of suspended-sediment data, Tanana River near North Pole, Alaska*

Date	Discharge (ft^3/s)	Suspended sediment: Concentration (mg/L)	Suspended sediment: Transport rate (t/day)	Median particle size (mm)
8-04-77	59,000	3,100	494,000	0.023
8-19-77	59,100	1,730	276,000	.045
5-31-78	18,600	594	29,800	.080
6-21-78	25,500	860	59,200	.060
7-11-78	37,800	2,820	288,000	.020
7-18-78	54,000	2,980	434,000	.029
8-01-78	54,900	2,640	391,000	.018
8-09-78	55,000	2,850	423,000	.023
8-15-78	53,600	2,110	305,000	.019
9-08-78	32,100	685	59,400	.021
10-05-78	14,400	160	6,220	.16

Table 6.--*Summary of river hydraulics and bedload data, Tanana River at Fairbanks, Alaska*

Date	Discharge (ft^3/s)	Width: Surface (ft)	Width: Effective (ft)	Depth: Mean (ft)	Depth: Effective (ft)	Mean velocity (ft/s)	Flow area (ft^2)	Slope (ft/ft)	Bedload-transport rate: Unit ((lb/s)/ft)	Bedload-transport rate: Total (t/day)	Median particle size (mm)
6-07-77	26,500	780	670	6.64	7.70	5.09	5,170	0.00047	0.0260	753	9.0
6-29-77	46,700	1,170	1,150	7.46	7.60	5.32	8,710	.00050	.1668	8,290	10
7-06-77	41,200	1,070	1,050	7.27	7.40	5.27	7,770	.00050	.0441	2,000	20
7-12-77	38,100	1,010	950	7.15	7.60	5.23	7,230	.00049	.0627	2,570	1.8
7-20-77	44,800	1,140	1,120	7.40	7.50	5.30	8,390	.00050	.0304	1,470	16
8-03-77	59,300	1,390	1,390	7.84	7.84	5.42	10,900	.00052	.1072	6,440	15
8-11-77	51,500	1,250	1,250	7.62	7.62	5.36	9,530	.00051	.0834	4,500	20
8-18-77	51,100	1,250	1,250	7.60	7.60	5.36	9,470	.00051	.0466	2,520	.44
8-31-77	49,800	1,220	1,220	7.56	7.60	5.35	9,240	.00051	.0424	2,230	.30
10-03-77	20,900	500	500	7.80	8.30	4.99	4,[illegible]60	.00046	.0455	980	.30
5-18-78	20,000	480	480	7.80	8.30	4.97	3,990	.00046	.0195	400	.21
5-30-78	18,400	430	430	7.90	8.60	4.94	3,700	.00045	.0234	430	.21
6-20-78	28,400	820	720	6.73	7.70	5.11	5,510	.00048	.0561	1,740	.25
7-10-78	34,700	950	880	7.02	7.50	5.20	6,630	.00049	.0184	700	.19
7-17-78	58,100	1,370	1,370	7.81	7.81	5.41	10,700	.00052	.1082	6,400	.28
7-31-78	51,500	1,250	1,250	7.62	7.62	5.36	9,530	.00051	.0478	2,580	.26
8-08-78	54,400	1,300	1,300	7.70	7.70	5.38	10,000	.00051	.0506	2,840	.26
8-14-78	57,900	1,360	1,360	7.80	7.80	5.41	10,600	.00052	.1013	5,950	.40
8-25-78	43,000	1,100	1,060	7.34	7.60	5.28	8,080	.00050	.0489	2,240	.29
9-07-78	34,100	940	860	6.99	7.60	5.19	6,520	.00049	.0523	1,940	.29
10-04-78	14,500	320	320	8.00	9.30	4.85	2,970	.00044	.0210	290	.32

Table 7.--*Summary of bedload data, north and south channels of Tanana River near North Pole, Alaska*

Date	North channel				South channel			
	Effective width (ft)	Bedload-transport rate		Median particle size (mm)	Effective width (ft)	Bedload-transport rate		Median particle size (mm)
		Unit ((lb/s)/ft)	Total (t/d)			Unit ((lb/s)/ft)	Total (t/d)	
8-04-77	800	0.0944	3,260	12	615	0.0359	954	15
8-19-77	715	.0741	2,290	11	655	.0309	873	5.4
5-31-78	400	.0617	1,070	.26	570	.0077	191	2.3
6-21-78	480	.0137	284	.19	590	.0107	272	.26
7-11-78	870	.0694	2,610	7.7	610	.0318	837	13
7-18-78	1,480	.0328	2,100	.26	630	.0532	1,450	9.5
8-01-78	1,510	.0460	3,000	11	630	.0495	1,350	20
8-09-78	1,520	.0335	2,200	.28	630	.0856	2,330	9.0
8-15-78	1,460	.0479	3,020	.29	630	.0433	1,180	12
9-08-78	680	.0274	804	.42	600	.0071	184	.26
10-05-78	400	.0080	139	.30	560	.0038	93	.24

Table 8.--*Summary of bedload data, composite channels of Tanana River near North Pole, Alaska*

Date	Discharge (ft^3/s)	Slope (ft/ft)	Effective width (ft)	Bedload-transport rate		Median particle size (mm)
				Unit ((lb/s)/ft)	Total (t/d)	
8-04-77	59,000	0.00109	1,420	0.0688	4,220	13
8-19-77	59,100	.00109	1,370	.0534	3,160	9.6
5-31-78	18,600	.00122	970	.0301	1,260	.26
6-21-78	25,500	.00118	1,070	.0120	556	.22
7-11-78	37,800	.00114	1,480	.0538	3,440	8.4
7-18-78	54,000	.00110	2,110	.0388	3,540	.34
8-01-78	54,900	.00109	2,140	.0471	4,350	13
8-09-78	55,000	.00109	2,150	.0488	4,530	1.6
8-15-78	53,600	.00110	2,090	.0465	4,200	.33
9-08-78	32,100	.00115	1,280	.0179	989	.35
10-05-78	14,400	.00125	960	.0056	232	.27

The relations of sediment-transport rate to discharge are illustrated in figure 4. The data are from tables 4, 5, 6, and 8. For suspended sediment, a log-transformed least-squares linear regression describing the relation is

$$G_S \text{ (tons/day)} = 5.717 \times 10^{-8}\ Q^{2.713} \qquad (r^2 = 0.967).$$

For bedload, the relation is

$$G_B \text{ (tons/day)} = 4.569 \times 10^{-6}\ Q^{1.886} \qquad (r^2 = 0.794).$$

For comparative analysis, typical computed transport rates of bedload and suspended load are shown below.

Discharge (ft^3/s)	Sediment-transport rate: Suspended load (tons/day)	Sediment-transport rate: Bedload (tons/day)	Bedload as a percentage of suspended load
20,000	26,700	589	2.2
30,000	80,100	1,270	1.6
40,000	175,000	2,180	1.2
50,000	320,000	3,320	1.0
60,000	525,000	4,680	.9

The transport rate of bedload, compared to that of suspended sediment, varies from about two percent at low discharges to about one percent at high discharges. It will be shown later that more than half of the total suspended load is transported at discharges exceeding 40,000 ft^3/s. Considering the total quantities of sediment transported, bedload is on the order of one percent of suspended load. There is considerable consistency to the measured data; bedload-transport rate is always in the range of 0.5 to 5.0 percent of the corresponding suspended-sediment transport rate, and the one percent relation shown on figure 4 is visually a good fit to the bedload data.

The relations described above and shown on figure 4 were determined for the composite of data from the two locations. However, visual inspection of the plotted data and the results of separate statistical analyses for the two locations show no significant differences in transport functions between the stations. Because the stations experience the approximate same water discharges, there appears to be no loss or gain of total sediment in the reach.

Particle-Size Data

Tables 9 and 10, for the locations at Fairbanks and North Pole, respectively, present the size-distribution data for suspended sediment. Size determination was made by sieve analysis for particles larger than silt (>0.062 mm), and pipet analysis for particles of silt size and smaller. In all instances, data are expressed in percentage, by weight, finer than indicated particle size. Values of median particle size were determined graphically and are included as part of the

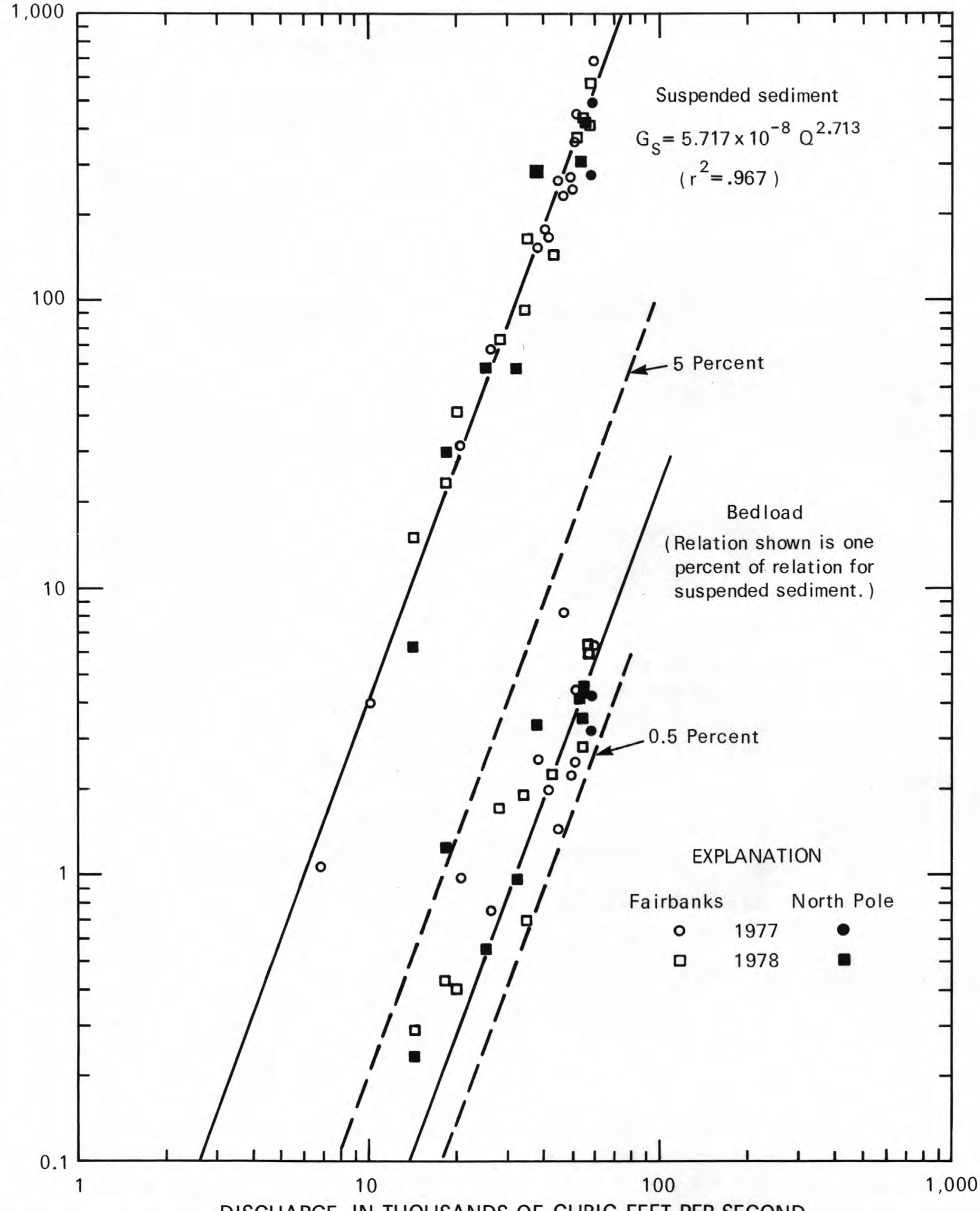

Figure 4.--Sediment-transport rate as a function of discharge, Tanana River at Fairbanks and near North Pole, Alaska.

Table 9.--*Particle-size distribution of suspended sediment, Tanana River at Fairbanks, Alaska*

[Percentage, by weight, finer than particle size indicated]

Particle size (mm)	4-26-77	6-07-77	6-16-77	6-29-77	7-06-77	7-12-77	7-20-77	7-26-77	8-03-77	8-11-77	8-18-77	8-31-77
1.0	---	---	---	---	100	---	---	---	---	---	---	---
.50	100	100	100	100	99	100	100	100	100	100	100	100
.25	90	95	99	96	94	97	97	97	98	98	97	95
.125	44	68	89	74	71	77	75	85	88	81	83	61
.062	28	45	69	51	43	52	52	63	71	61	62	41
.031	---	37	49	35	29	44	36	49	56	45	51	31
.016	---	29	38	30	20	33	31	34	43	36	39	25
.008	---	22	24	16	16	23	23	31	27	26	27	18
.004	---	16	15	9	14	15	14	18	21	19	20	12
.002	---	10	11	6	8	6	5	14	12	8	11	5

Particle size (mm)	10-03-77	5-18-78	5-30-78	6-20-78	7-10-78	7-17-78	7-31-78	8-08-78	8-14-78	8-25-78	9-07-78	10-04-78
1.0	---	---	---	---	---	---	---	---	---	---	---	---
.50	100	100	100	100	100	100	100	100	100	100	100	100
.25	88	92	94	97	99	99	98	99	99	99	97	89
.125	32	47	56	68	89	91	87	92	88	79	73	32
.062	20	29	37	50	76	74	64	77	71	56	57	19
.031	14	23	28	40	63	56	52	62	55	42	49	---
.016	10	17	21	33	50	42	39	48	41	31	39	---
.008	6	12	15	28	37	30	29	36	30	23	28	---
.004	4	8	10	22	25	22	22	28	24	16	20	---
.002	2	6	7	16	18	18	16	22	18	13	16	---

Table 10.--*Particle-size distribution of suspended sediment, Tanana River near North Pole, Alaska*

[Percentage, by weight, finer than particle size indicated]

Particle size (mm)	8-04-77	8-19-77	5-31-78	6-21-78	7-11-78	7-18-78	8-01-78	8-09-78	8-15-78	9-08-78	10-05-78
1.0	---	---	---	---	---	---	---	---	---	---	---
.50	100	100	100	100	100	100	100	100	---	100	100
.25	99	99	92	96	99	98	98	99	100	98	83
.125	90	89	62	67	88	84	91	89	90	78	41
.062	70	72	44	51	73	67	77	72	75	66	31
.031	56	39	33	44	59	51	61	56	61	56	---
.016	43	36	24	37	45	39	48	43	47	46	---
.008	29	32	16	31	32	27	32	32	35	35	---
.004	23	18	10	26	22	23	21	23	24	24	---
.002	11	12	7	19	17	18	17	17	19	20	---

suspended-sediment data presented in tables 4 and 5. Regression of median particle size as a function of water discharge yields

$$d_{50}(\text{mm}) = 16.5 \times 10^3\ Q^{-1.22} \qquad (r^2 = 0.629).$$

Typical values of median particle size of suspended sediment are computed below.

Discharge (ft^3/s)	Median particle size (mm)
20,000	0.095
30,000	.058
40,000	.041
50,000	.031
60,000	.025

Median particle size is, therefore, generally in the silt range (<0.062 mm, >0.004 mm) and only at discharges less than about 28,000 ft^3/s is median particle size within the very fine sand range (>0.062 mm, <0.125 mm). The reasonably-defined relation of median particle size of suspended sediment decreasing as discharge increases suggests a watershed source of sediment during snowmelt runoff and a within-channel source of sediment during lower runoff periods.

Tables 11 to 13, for the locations at Fairbanks, the separate channels near North Pole, and the combined channels near North Pole, respectively, present size-distribution data for bedload as determined by dry-sieve analysis. Data are expressed in percentage, by weight, finer than sieve size indicated. Statistics of the particle-size determinations (table 11 to 13) are presented in tables 14 to 16, respectively. This latter compilation of data is especially useful in visualization of bedload particle sizes as functions of discharge or bedload-transport rate. The median particle size, d_{50}, from this compilation is included in tables 6 to 8 as part of the bedload data. In 1977, for both locations (tables 6 and 8 or 14 and 16), the median particle size of bedload was generally in the gravel range (>2.0 mm, <64 mm), but at several low bedload-transport rates, the median particle size was in the medium sand range. This abrupt change in median particle size has been observed previously (Emmett, 1976), and is apparently related to the availability and mobility of particle sizes composing the bed material. In 1978, both locations showed a decrease in median particle size of bedload over that recorded for 1977. This is clearly indicated by the transport-rate weighted, yearly-composite size distribution of bedload, as presented in table 17 and illustrated in figure 5. The transport-rate weighted, composite size distribution is obtained by utilizing the actual weights of samples collected at nearly uniform increments of time over the runoff period. Thus, samples collected at higher transport rates carry more "weight" because their actual weights are greater. At the upstream location near North Pole, decrease in median particle size was modest; in 1977, about 68 percent of the bedload was gravel, while in 1978, about 45 percent was gravel. However, at Fairbanks, in 1977, about 65

Table 11.--*Particle-size distribution of bedload, Tanana River at Fairbanks, Alaska*

[Percentage, by weight, finer than particle size indicated]

Particle size (mm)	6-07-77	6-29-77	7-06-77	7-12-77	7-20-77	8-03-77	8-11-77	8-18-77	8-31-77	10-03-77
128	-----	-----	100.0	-----	100.0	-----	100.0	-----	-----	-----
64	100.0	100.0	98.0	100.0	99.0	100.0	95.8	100.0	100.0	-----
32	99.0	95.4	84.0	94.0	69.8	82.5	81.5	98.0	99.0	-----
16	76.5	74.0	45.0	73.5	50.0	55.0	48.0	88.0	81.0	-----
8	47.0	41.5	35.0	59.5	35.0	32.0	41.4	70.5	71.0	100.0
4	36.0	26.8	31.2	51.5	28.7	26.5	35.3	62.5	67.8	99.8
2	35.4	25.6	30.0	50.3	27.7	25.3	34.5	61.4	67.2	99.6
1.0	35.1	25.4	29.5	49.0	26.5	25.2	34.0	61.0	67.0	99.5
.5	34.8	25.0	21.5	47.5	25.0	25.1	33.2	54.0	66.2	97.0
.25	15.9	12.5	5.0	21.0	10.0	8.0	15.0	30.0	33.0	33.0
.125	3.0	1.5	.4	2.0	1.5	1.0	2.5	2.0	1.5	8.0
.062	.5	.7	.1	.5	.5	.4	1.2	.9	.7	.3

Particle size (mm)	5-18-78	5-30-78	6-20-78	7-10-78	7-17-78	7-31-78	8-08-78	8-14-78	8-25-78	9-07-78	10-04-78
128	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
64	-----	-----	-----	100.0	100.0	100.0	-----	100.0	100.0	-----	100.0
32	100.0	100.0	-----	93.4	98.9	98.4	100.0	80.2	98.3	100.0	71.3
16	99.1	93.0	100.0	93.4	92.1	95.4	91.4	67.6	92.9	94.4	63.6
8	95.5	90.2	90.4	90.9	88.2	89.2	84.8	60.4	88.8	88.7	60.7
4	92.4	89.6	80.4	89.6	85.5	86.0	81.5	54.9	86.8	86.1	58.8
2	91.7	89.4	79.0	89.2	84.4	85.2	80.5	53.8	86.4	85.5	57.8
1.0	91.6	89.2	78.8	89.0	83.9	84.9	79.8	53.4	86.2	85.2	57.4
.5	91.4	88.9	78.4	88.5	82.4	84.1	77.4	52.7	85.1	84.3	57.0
.25	72.3	72.4	48.0	74.4	32.0	37.0	44.7	26.3	30.4	31.5	39.2
.125	8.6	8.6	7.4	18.7	7.3	3.8	7.8	4.0	3.0	2.9	1.7
.062	1.3	1.7	1.7	5.0	1.7	1.1	2.3	1.2	.5	.4	.2

Table 12.--*Particle-size distribution of bedload, north and south channels of Tanana River near North Pole, Alaska*

[Percentage, by weight, finer than particle size indicated]

Particle size (mm)	North channel										
	8-04-77	8-19-77	5-31-78	6-21-78	7-11-78	7-18-78	8-01-78	8-09-78	8-15-78	9-08-78	10-05-78
128	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
64	100.0	100.0	100.0	-----	100.0	100.0	100.0	-----	100.0	-----	-----
32	81.0	95.5	95.0	-----	86.8	97.8	83.7	100.0	95.9	100.0	100.0
16	59.0	76.0	93.8	-----	72.1	87.4	60.0	95.0	85.2	76.8	97.2
8	39.5	40.5	93.6	-----	50.7	83.2	44.3	90.1	82.7	61.9	89.7
4	33.5	29.5	93.5	-----	41.2	80.9	40.9	87.0	81.8	56.5	86.5
2	33.0	29.0	93.3	-----	39.6	80.1	39.9	85.6	81.3	54.5	82.4
1.0	32.5	28.9	93.2	100.0	39.4	79.6	39.2	84.9	81.0	53.4	80.6
.5	32.0	28.6	92.3	99.8	39.0	78.1	37.7	83.5	79.7	52.4	79.0
.25	18.0	13.0	47.2	76.8	24.2	47.5	22.4	41.9	39.0	32.4	33.4
.125	4.0	1.5	5.3	13.4	4.2	9.7	4.6	8.8	6.0	2.1	.5
.062	1.5	.6	1.4	3.4	1.3	2.4	1.3	2.7	1.7	.3	.1

Particle size (mm)	South channel										
	8-04-77	8-19-77	5-31-78	6-21-78	7-11-78	7-18-78	8-01-78	8-09-78	8-15-78	9-08-78	10-05-78
128	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
64	100.0	100.0	-----	-----	100.0	100.0	100.0	100.0	100.0	-----	-----
32	77.5	82.0	100.0	100.0	91.0	81.9	64.9	78.5	85.4	100.0	-----
16	53.0	69.0	58.2	89.2	54.3	60.8	44.9	64.1	59.1	86.3	100.0
8	35.5	59.0	54.5	82.2	40.2	47.5	33.1	47.0	40.1	78.4	97.6
4	30.0	47.8	51.8	78.2	33.2	41.3	27.3	30.0	33.7	77.2	97.6
2	29.5	45.7	49.8	74.9	29.4	38.8	24.9	19.7	31.3	76.9	97.5
1.0	29.0	45.0	49.0	72.8	27.8	38.2	23.6	17.9	29.7	76.8	97.3
.5	28.5	44.0	48.0	70.8	26.6	37.0	21.8	16.6	28.4	76.1	95.9
.25	12.5	22.0	32.0	48.0	16.0	18.0	9.0	8.2	15.9	49.0	51.6
.125	.8	3.0	3.9	6.0	2.9	3.1	1.3	1.6	3.1	2.2	.6
.062	.4	1.3	1.3	1.4	.9	.9	.5	.6	1.0	.6	.1

Table 13.--*Particle-size distribution of bedload, composite channels of Tanana River near North Pole, Alaska*

[Percentage, by weight, finer than particle size indicated]

Particle size (mm)	8-04-77	8-19-77	5-31-78	6-21-78	7-11-78	7-18-78	8-01-78	8-09-78	8-15-78	9-08-78	10-05-78
128	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
64	100.0	100.0	100.0	-----	100.0	100.0	100.0	100.0	100.0	-----	-----
32	80.0	91.5	95.9	100.0	87.8	90.7	78.2	88.6	95.9	100.0	100.0
16	57.0	74.0	87.4	94.3	67.9	75.5	55.7	78.6	77.8	78.4	98.2
8	38.5	43.5	86.6	90.6	48.2	67.3	41.1	67.2	70.5	64.8	92.6
4	32.5	34.0	86.0	88.5	39.4	63.2	37.0	56.7	68.1	60.2	90.6
2	32.2	33.6	85.5	86.8	37.2	61.6	35.6	50.6	67.1	58.5	87.9
1.0	31.5	33.3	85.2	85.7	36.6	61.1	34.7	49.3	66.4	57.5	86.7
.5	31.0	33.0	84.4	84.5	36.0	59.8	33.1	47.9	65.1	56.6	85.2
.25	16.0	16.0	44.5	61.6	22.3	34.3	18.5	24.0	32.4	35.4	40.0
.125	3.0	2.0	5.1	9.4	3.9	6.8	3.7	5.0	5.2	2.2	.5
.062	1.2	.8	1.4	2.4	1.2	1.8	1.1	1.6	1.5	.4	.1

Table 14.--*Statistical data: particle-size distribution of bedload, Tanana River at Fairbanks, Alaska*

[Particle diameter (mm) at given percent-finer parameter]

Percent-finer parameter	6-07-77	6-29-77	7-06-77	7-12-77	7-20-77	8-03-77	8-11-77	8-18-77	8-31-77	10-03-77
d_5	0.17	0.19	0.25	0.16	0.18	0.21	0.16	0.14	0.15	0.12
d_{16}	.26	.29	.32	.23	.33	.31	.27	.19	.21	.15
d_{35}	.80	7.0	8.0	.32	8.0	9.4	2.5	.27	.27	.26
d_{50}	9.0	10	20	1.8	16	15	20	.44	.30	.30
d_{65}	12	13	28	11	24	20	24	5.8	.40	.32
d_{84}	20	20	32	22	45	34	33	14	17	.37
d_{90}	22	24	36	28	48	39	44	17	22	.40
d_{95}	24	31	58	37	56	45	59	23	27	.43

Percent-finer parameter	5-18-78	5-30-78	6-20-78	7-10-78	7-17-78	7-31-78	8-08-78	8-14-78	8-25-78	9-07-78	10-04-78
d_5	0.10	0.10	0.11	0.06	0.10	0.13	0.09	0.14	0.14	0.14	0.14
d_{16}	.15	.15	.16	.12	.19	.19	.16	.20	.19	.19	.18
d_{35}	.18	.18	.21	.16	.26	.24	.22	.28	.26	.26	.23
d_{50}	.21	.21	.25	.19	.28	.26	.26	.40	.29	.29	.32
d_{65}	.23	.23	.30	.22	.32	.30	.33	13	.33	.34	18
d_{84}	.31	.33	5.6	.31	1.1	.50	7.4	36	.45	.50	43
d_{90}	.43	7.0	8.0	5.5	12	1.0	15	45	11	10	50
d_{95}	7.8	21	11	45	20	16	22	52	21	18	57

Table 15.--*Statistical data: particle-size distribution of bedload, north and south channels of Tanana River near North Pole, Alaska*

[Particle diameter (mm) at given percent-finer parameter]

Percent-finer parameter	North channel										
	8-04-77	8-19-77	5-31-78	6-21-78	7-11-78	7-18-78	8-01-78	8-09-78	8-15-78	9-08-78	10-05-78
d_5	0.13	0.17	0.12	0.08	0.13	0.09	0.13	0.09	0.12	0.14	0.16
d_{16}	.23	.28	.17	.13	.20	.15	.21	.16	.17	.18	.20
d_{35}	4.8	6.5	.23	.17	.35	.21	.40	.22	.24	.27	.26
d_{50}	12	11	.26	.19	7.7	.26	11	.28	.29	.42	.30
d_{65}	19	13	.30	.22	13	.32	19	.34	.34	10	.36
d_{84}	36	19	.37	.28	28	10	33	.60	14	21	2.5
d_{90}	42	24	.42	.31	36	19	41	8.0	23	25	8.5
d_{95}	47	29	32	.36	45	26	50	16	31	28	14

Percent-finer parameter	South channel										
	8-04-77	8-19-77	5-31-78	6-21-78	7-11-78	7-18-78	8-01-78	8-09-78	8-15-78	9-08-78	10-05-78
d_5	0.18	0.14	0.13	0.12	0.14	0.13	0.19	0.20	0.15	0.14	0.14
d_{16}	.28	.23	.19	.17	.25	.23	.35	.48	.25	.16	.16
d_{35}	7.5	.34	.26	.23	5.0	.33	9.4	5.3	5.3	.21	.20
d_{50}	15	5.4	2.3	.26	13	9.5	20	9.0	12	.26	.24
d_{65}	23	12	21	.35	21	19	32	17	19	.30	.28
d_{84}	38	35	28	11	28	34	50	40	31	14	.35
d_{90}	45	42	30	17	31	41	55	49	37	20	.39
d_{95}	48	47	31	25	38	50	60	56	45	26	.46

Table 16.--*Statistical data: particle-size distribution of bedload, composite channels of Tanana River near North Pole, Alaska*

[Particle diameter (mm) at given percent-finer parameter]

Percent-finer parameter	8-04-77	8-19-77	5-31-78	6-21-78	7-11-78	7-18-78	8-01-78	8-09-78	8-15-78	9-08-78	10-05-78
d_5	0.14	0.16	0.12	0.09	0.13	0.12	0.14	0.13	0.12	0.14	0.15
d_{16}	.25	.25	.17	.15	.20	.17	.23	.20	.18	.18	.18
d_{35}	6.0	4.8	.23	.20	.44	.25	1.5	.30	.26	.25	.24
d_{50}	13	9.6	.26	.22	8.4	.34	13	1.6	.33	.35	.27
d_{65}	21	13	.32	.26	15	6.6	22	7.4	.50	8.0	.31
d_{84}	37	21	.49	.49	28	24	37	26	22	18	.45
d_{90}	43	28	22	7.6	35	31	45	34	27	22	3.9
d_{95}	47	36	31	21	44	40	54	44	31	26	11

Table 17.--*Composite size distribution (transport-rate weighted) of bedload, Tanana, Alaska*

[Data expressed in percentage by weight]

Particle size (mm)	1977				1978			
	Fairbanks		North Pole		Fairbanks		North Pole	
	Percent retained	Percent finer	Percent retained	Percent finer	Percent retained	Percent finer	Percent retained	Percent finer
128	----	100.0	----	-----	----	-----	----	-----
64	0.5	99.5	----	100.0	----	100.0	----	100.0
32	10.5	89.0	16.0	84.0	5.8	94.2	8.9	91.1
16	24.5	64.5	20.0	64.0	7.0	87.2	16.7	74.4
8	20.0	44.5	24.0	40.0	5.7	81.5	12.0	62.4
4	8.0	36.5	6.5	33.5	3.8	77.7	5.6	56.8
2	1.2	35.3	1.0	32.5	.9	76.8	2.3	54.5
1.0	.3	35.0	.2	32.3	.4	76.4	.9	53.6
.5	1.0	34.0	.3	32.0	1.1	75.3	1.1	52.5
.25	20.0	14.0	16.0	16.0	39.2	36.1	23.2	29.3
.125	12.5	1.5	13.0	3.0	30.3	5.8	25.2	4.1
.062	1.0	.5	2.0	1.0	4.4	1.4	3.0	1.1
<.062	.5	.0	1.0	.0	1.4	.0	1.1	.0

Particle-size statistics

[Particle diameter (mm) at given percent-finer parameter]

Parameter	1977 Fairbanks	1977 North Pole	1978 Fairbanks	1978 North Pole
d_5	0.18	0.15	0.12	0.13
d_{16}	.26	.25	.17	.19
d_{25}	.32	.33	.21	.23
d_{35}	1.0	5.6	.25	.27
d_{50}	10	11	.30	.43
d_{65}	16	16	.37	9.6
d_{75}	21	22	.50	16
d_{84}	28	32	11	23
d_{90}	34	40	22	31
d_{95}	42	46	35	42

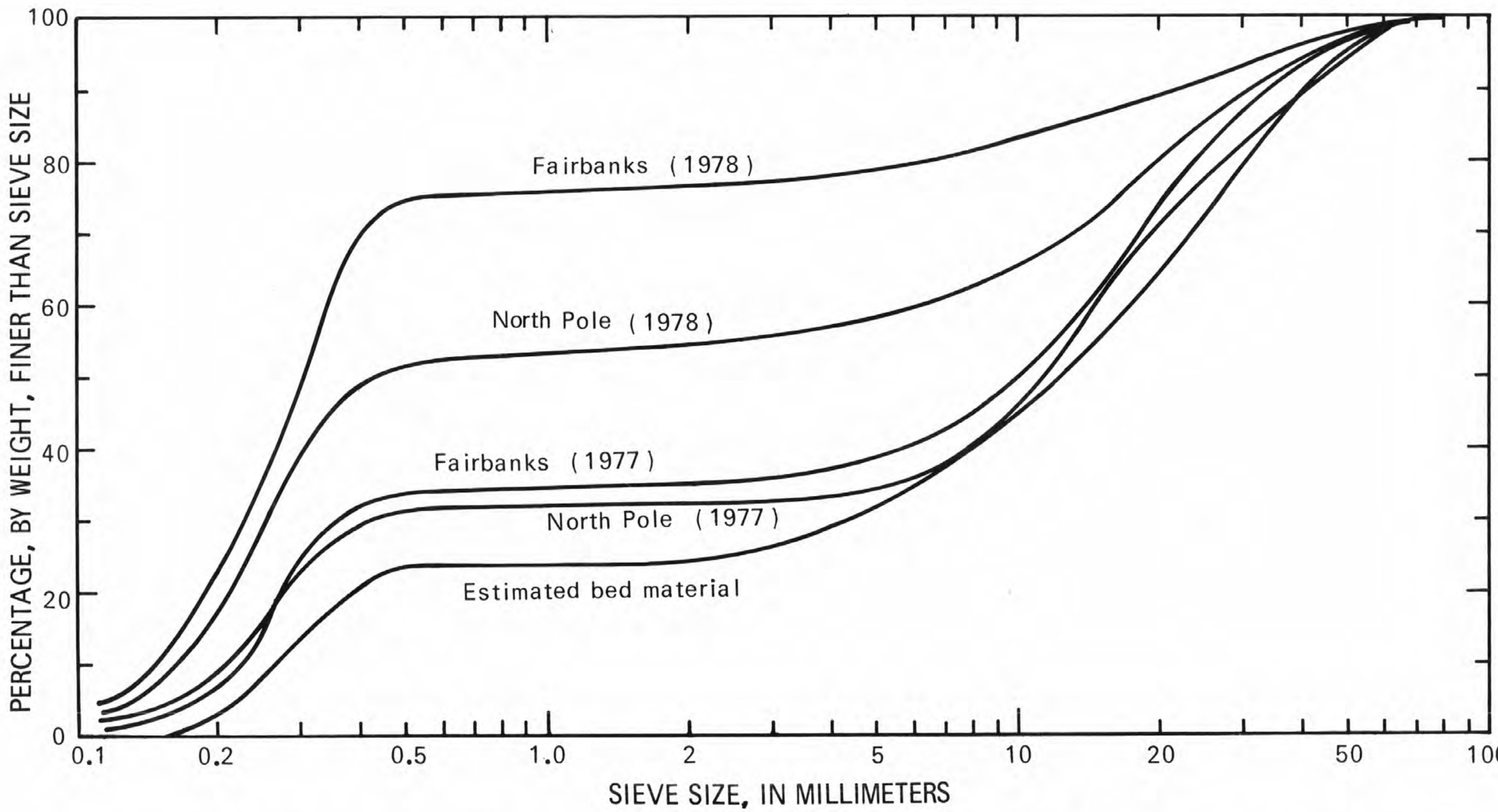

Figure 5.--Particle-size distribution of bedload, Tanana River at Fairbanks and near North Pole, Alaska.

percent of the bedload was gravel, while in 1978, only 23 percent was gravel. Figure 5 shows in graphical form: similarity between particle sizes at both locations in 1977; general decrease in particle size in 1978; and the particular downstream decrease in particle size during 1978.

The bimodal size distributions of bedload shown in figure 4 suggest a bimodal size distribution of bed material. A single representative sample of bed material was not obtained for size analysis; however, size data are available for scattered bed-material samples representative of either sandy or gravelly portions of the bed. A composite of these samples, with consideration given to the percentage of bed area assigned each sample and to the size distribution of measured bedload, provides an estimated size distribution of bed material. This estimated particle-size distribution of bed material is also shown on figure 5. The various particle-size curves in figure 5 are similar, but the bedload curves show a greater percentage of sand than the bed-material curve. This reflects bed material as the source of bedload, but the river has the capability to transport the sand fraction over a greater range in flow than the gravel fraction.

Annual Sediment Loads

Daily mean discharges from tables 2 and 3 can be arranged in order of magnitude to indicate the number of days each discharge or range of discharges occurs. The number of days can then be multiplied by the corresponding sediment-transport rate, in tons per day, to provide the estimated tons of sediment transported by each discharge class. Tonnage can then be accumulated through the yearly range of discharges to provide an estimate of the annual sediment load. Computations for suspended-sediment loads are provided in tables 18 and 19 for the location at Fairbanks, for water years 1977 and 1978, respectively. The cumulative suspended-sediment loads are plotted as a function of percentage of time in figure 6.

In 1977, approximately 28 million tons of suspended sediment were transported through the reach of the Tanana River in the vicinity of Fairbanks. Approximately 50 percent of the total amount was transported during 10 percent of time, and 90 percent was transported during the 3 months of high flow. In 1978, approximately 23 million tons of suspended sediment were transported; again, approximately 50 percent of the total was transported during the month of highest flow, and 90 percent was transported during the 3 months of high flow.

The same type computations may be made on an average year basis by utilizing flow-duration data from the entire station record. Five complete water years of data (1974-78) exist for the Tanana River at Fairbanks; these are the data base for the flow-duration data and subsequent computations of average annual suspended-sediment load listed in table 20 and graphed in figure 6. Based on these five years of record, average annual suspended-sediment load of the Tanana River in the vicinity of Fairbanks is about 26 million tons.

For the five complete years of record, annual mean discharge of the Tanana River ranged from 16,800 ft^3/s to 21,700 ft^3/s and averaged 18,600 ft^3/s. In 1977 and 1978 the annual mean discharge of the Tanana River at Fairbanks was

Table 18.--*Suspended-sediment transport in the Tanana River in the vicinity of Fairbanks, Alaska; water year 1977*

Discharge (ft^3/s)	Number of days	Percentage of time	Sediment-transport rate: Instantaneous (t/d)	Sediment-transport rate: Average (t/d)	Sediment load: Increment (t)	Sediment load: Cumulative (t)	Percentage of annual load
62,400	1	0.3	586,000	-------	586,000	586,000	2.1
62,100	1	.5	578,000	-------	578,000	1,160,000	4.1
60,300	1	.8	534,000	-------	534,000	1,700,000	6.0
60,000	2	1.4	526,000	-------	1,050,000	2,220,000	7.8
58,000	1	1.6	480,000	-------	480,000	2,700,000	9.5
57,000	1	1.9	458,000	-------	458,000	3,160,000	11.2
56,200	1	2.2	441,000	-------	441,000	3,600,000	12.7
56,000	4	3.3	437,000	-------	1,750,000	5,350,000	18.9
55,000	1	3.6	416,000	-------	416,000	5,770,000	20.4
54,100	1	3.8	398,000	-------	398,000	6,160,000	21.8
54,000	5	5.2	396,000	-------	1,980,000	8,140,000	28.8
53,400	1	5.5	384,000	-------	384,000	8,520,000	30.1
53,000	1	5.8	376,000	-------	376,000	8,900,000	31.4
52,600	1	6.0	368,000	-------	368,000	9,270,000	32.8
52,500	1	6.3	366,000	-------	366,000	9,640,000	34.1
52,000	7	8.2	357,000	-------	2,500,000	12,100,000	42.8
51,600	1	8.5	350,000	-------	350,000	12,500,000	44.2
51,400	1	8.8	346,000	-------	346,000	12,800,000	45.2
50,800	1	9.0	335,000	-------	335,000	13,200,000	46.6
50,600	1	9.3	332,000	-------	332,000	13,500,000	47.7
50,000	2	9.9	321,000	-------	642,000	14,100,000	49.8
48,000	10	12.6	287,000	304,000	3,040,000	17,200,000	60.8
46,000	7	14.5	256,000	272,000	1,900,000	19,100,000	67.5
44,000	3	15.3	227,000	241,000	724,000	19,800,000	70.0
40,000	13	18.9	175,000	201,000	2,610,000	22,400,000	79.2
35,000	12	22.2	122,000	149,000	1,780,000	24,200,000	85.5
30,000	7	24.1	80,300	101,000	708,000	24,900,000	88.0
25,000	26	31.2	49,000	64,600	1,680,000	26,600,000	94.0
20,000	20	36.7	26,700	37,800	757,000	27,300,000	96.5
15,000	18	41.6	12,200	19,500	351,000	27,700,000	97.9
10,000	22	47.7	4,080	8,160	179,000	27,900,000	98.6
4,500	191	100.0	467	2,270	434,000	28,300,000	100.0

Table 19.--*Suspended-sediment transport in the Tanana River in the vicinity of Fairbanks, Alaska; water year 1978*

Discharge (ft^3/s)	Number of days	Percentage of time	Sediment-transport rate		Sediment load		Percentage of annual load
			Instantaneous (t/d)	Average (t/d)	Increment (t)	Cumulative (t)	
59,000	1	0.3	503,000	-------	503,000	503,000	2.2
58,300	1	.5	487,000	-------	487,000	990,000	4.3
58,100	1	.8	482,000	-------	482,000	1,470,000	6.4
57,900	1	1.1	478,000	-------	478,000	1,950,000	8.4
57,800	1	1.4	476,000	-------	476,000	2,430,000	10.5
57,000	1	1.6	458,000	-------	458,000	2,880,000	12.5
56,900	1	1.9	456,000	-------	456,000	3,340,000	14.5
56,800	1	2.2	454,000	-------	454,000	3,790,000	16.4
56,400	1	2.5	445,000	-------	445,000	4,240,000	18.4
56,000	1	2.7	437,000	-------	437,000	4,680,000	20.2
55,800	1	3.0	432,000	-------	432,000	5,110,000	22.1
55,600	1	3.3	428,000	-------	428,000	5,540,000	24.0
55,400	1	3.6	424,000	-------	424,000	5,960,000	25.8
54,900	1	3.8	414,000	-------	414,000	6,370,000	27.6
54,500	1	4.1	406,000	-------	406,000	6,780,000	29.4
54,400	1	4.4	404,000	-------	404,000	7,180,000	31.1
54,300	1	4.7	402,000	-------	462,000	7,580,000	32.8
54,000	1	4.9	396,000	-------	396,000	7,980,000	34.6
53,000	3	5.8	376,000	386,000	1,160,000	9,140,000	39.6
52,000	3	6.6	357,000	367,000	1,100,000	10,200,000	44.3
50,000	3	7.4	321,000	339,000	1,020,000	11,300,000	48.7
48,000	6	9.0	287,000	304,000	1,830,000	13,100,000	56.6
46,000	8	11.2	256,000	272,000	2,170,000	15,300,000	66.0
40,000	5	12.6	175,000	216,000	1,080,000	16,300,000	70.7
35,000	7	14.5	122,000	149,000	1,040,000	17,400,000	75.2
30,000	15	18.6	80,300	101,000	1,520,000	18,900,000	81.8
25,000	25	25.5	49,000	64,600	1,620,000	20,500,000	88.8
20,000	33	34.5	26,700	37,800	1,250,000	21,800,000	94.2
15,000	42	46.0	12,200	19,500	818,000	22,600,000	97.7
10,000	8	48.2	4,080	8,160	65,300	22,600,000	98.0
5,500	189	100.0	805	2,440	461,000	23,100,000	100.0

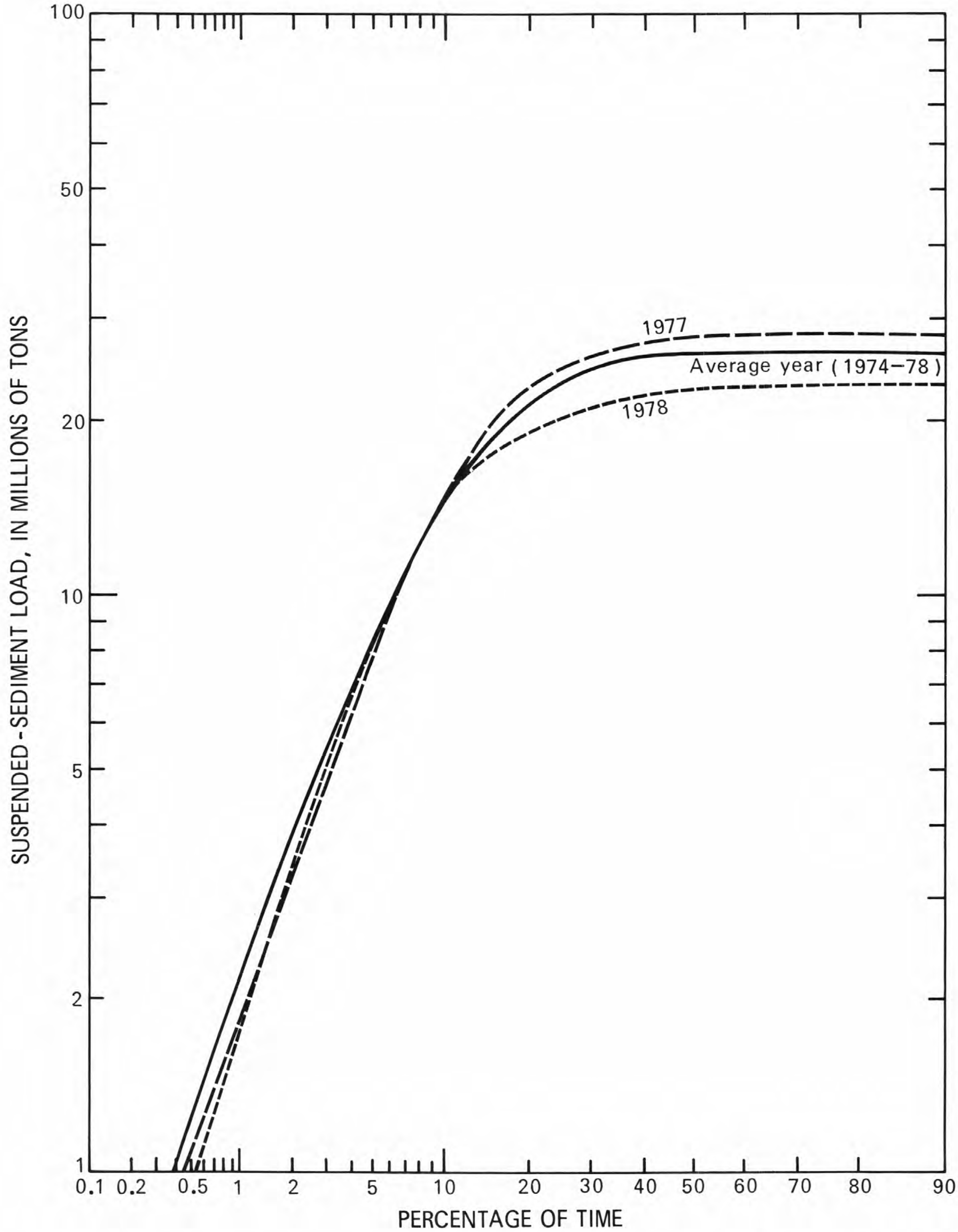

Figure 6.--Suspended-sediment load as a function of percentage of time, Tanana River in the vicinity of Fairbanks, Alaska.

Table 20.--*Average annual suspended-sediment transport in the Tanana River in the vicinity of Fairbanks, Alaska; water years 1974-78*

Discharge (ft^3/s)	Number of days	Percentage of time	Sediment-transport rate		Sediment load		Percentage of annual load
			Instantaneous (t/d)	Average (t/d)	Increment (t)	Cumulative (t)	
66,000	2	0.1	680,000	680,000	272,000	272,000	1.0
60,000	11	.7	526,000	603,000	1,330,000	1,600,000	6.1
55,000	35	2.6	416,000	471,000	3,300,000	4,900,000	18.7
50,000	84	7.2	321,000	369,000	6,200,000	11,100,000	42.4
46,000	83	11.7	256,000	289,000	4,800,000	15,900,000	60.7
42,000	52	14.6	200,000	228,000	2,370,000	18,300,000	69.8
38,000	70	18.4	152,000	176,000	2,460,000	20,700,000	79.0
35,000	35	20.3	122,000	137,000	959,000	21,700,000	82.8
32,000	52	23.2	95,400	109,000	1,130,000	22,800,000	87.0
29,000	51	26.0	73,100	84,300	860,000	23,700,000	90.5
26,000	61	29.3	54,300	63,700	777,000	24,500,000	93.5
24,000	35	31.3	43,700	49,000	343,000	24,800,000	94.7
22,000	37	33.3	34,500	39,100	289,000	25,100,000	95.8
20,000	49	36.0	26,700	30,600	300,000	25,400,000	96.9
15,000	111	42.1	12,200	19,500	433,000	25,800,000	98.5
10,000	108	48.0	4,080	8,140	176,000	26,000,000	99.2
6,500	223	60.2	1,260	2,670	119,000	26,100,000	99.6
3,100	717	100.0	170	715	103,000	26,200,000	100.0

19,000 ft^3/s and 17,900 ft^3/s, respectively. The above values of annual water discharge and sediment load suggest that annual suspended-sediment loads in the Tanana River near Fairbanks are on the order of 20 to 40 million tons. Assuming, for simplicity, a unit weight of sediment of 100 lb/ft^3, about 15 to 30 million cubic yards of suspended sediment are transported annually.

The estimated tonnage transported past the location at Fairbanks also is applicable to the location near North Pole because data from both locations define the same sediment rating and both locations experience the approximate same flows.

Bedload, as explained earlier, can be approximated as about one percent of suspended load; therefore, about 280,000 tons of bedload were transported in 1977 and 230,000 tons in 1978. In 1977 the estimated tonnage by particle-size class was about the same for the two locations. In 1978 the downstream decrease in median particle size between the two locations resulted in a decrease of about 50,000 tons of gravel being transported past the location at Fairbanks, with an equivalent increase in the amount of sand-size bedload. The estimated quantities of bedload, by particle-size class, transported past the two locations in 1978 are listed in table 21. The decrease in gravel size from North Pole to Fairbanks may be attributed to gravel mining between the two locations or to utilization of gravel in the bar-building processes (as illustrated in fig. 2).

In each of the years 1977 and 1978, about 75,000 cubic yards (approximately 100,000 tons) of bed material were quarried from the Tanana River channel between the Fairbanks and North Pole sediment-sampling locations. If half of the quarried sediment were gravel size, gravel mining alone would explain the decrease in particle size as bedload travels through the reach. But overall, the quantities of material quarried from the river bed were less than one percent of the total sediment transported by the river, and result in the agreement of sediment-transport rates measured at the two locations (see fig. 4).

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Table 21.--*Estimated quantity of bedload, by particle-size class, transported in 1978, Tanana River near North Pole, Alaska and at Fairbanks, Alaska*

Particle size class (mm)	1978 Bedload (t)		Gain or loss	
	Fairbanks	North Pole	(t)	Percent
>128	-------	-------	-------	---
64 - 128	-------	-------	-------	---
32 - 64	13,400	20,600	-7,200	-35
16 - 32	16,200	38,600	-22,400	-58
8 - 16	13,200	27,700	-14,500	-52
4 - 8	8,800	12,900	-4,100	-32
2 - 4	2,100	5,300	-3,200	-60
1.0 - 2	900	2,100	-1,200	-57
.5 - 1.0	2,500	2,500	0	0
.25 - .5	90,600	53,600	+37,000	+69
.125 - .25	70,000	58,200	+11,800	+20
.062 - .125	10,200	6,900	+3,300	+48
<.062	3,200	2,500	+700	+28
Total	231,000	231,000		