SEDIMENT TRANSPORT CHARACTERISTICS OF SELECTED STREAMS IN THE SUSITNA RIVER BASIN, ALASKA: DATA FOR WATER YEAR 1985 AND TRENDS IN BEDLOAD DISCHARGE, 1981-85

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by James M. Knott, Stephen W. Lipscomb, and Terry W. Lewis

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1987

DEPARTMENT OF THE INTERIOR

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CONVERSION TABLE

For the convenience of readers who prefer metric (International System) units rather than the inch-pound units used in this report, the following conversion factors may be used:

Multiply inch-pound unit	by	to obtain metric unit
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter(m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
acre-foot (acre-ft)	1,233	cubic meter (m^3)
foot per second (ft/s)	0.3048	meter per second (m/s)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
ton, short	0.9072	megagram (Mg)
ton per day (ton/d)	0.9072	megagram per day (Mg/d)
degree Fahrenheit (°F)	°C=5/9 (°F-32)	degree Celsius (°C)

Other abbreviations in this report:

mg/L, milligrams per liter
NTU, nephelometric turbidity units

Sea level:

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

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ABSTRACT

The upper reaches of the Susitna River have been considered for development of a large power-generation system for southcentral Alaska. This report presents a summary and discussion of sediment and hydraulic data obtained from October 1984 to September 1985 (water year 1985) at selected sites on the Susitna, Chulitna, Talkeetna and Yentna Rivers. Sediment data include measurements of suspended-sediment and bedload discharge, and analyses of particle-size distribution of suspended sediment, bedload, and bed material; hydraulic data include measurements of channel width, average depth and velocity of water, and water-surface slope. Relations between water and sediment discharge are developed for each site.

Sediment loads for water year 1985 were estimated for the Yentna, Chulitna, and Talkeetna Rivers and for three sites on the Susitna River. About 31 million tons of sediment were transported by the Susitna River at Susitna Station during the year. The Yentna and Chulitna Rivers contributed about 21 million tons of sediment to the Susitna River.

INTRODUCTION

The Susitna is one of the major rivers in Alaska, ranking fifth in drainage area. The upper reaches of the river have been considered as potential sites for several large dams and reservoirs. In 1986, plans for large-scale hydropower development of the upper Susitna River were discontinued, at least temporarily.

This report presents a summary and discussion of sediment and hydraulic data collected at selected sites in the Susitna River basin in the area between the proposed damsites and Cook Inlet. Figure 1 and table 1 summarize locations and availability of data. Subsequent data presented in this report were collected during the period October 1984 to September 1985 as part of a cooperative program between the Alaska Power Authority and the U.S. Geological Survey. In addition, selected data from historical records, data for water years 1981-84 (Knott and Lipscomb, 1983 and 1985; Knott and others, 1986), and data collected in 1985 are used to estimate the total amount of sediment (suspended sediment and bedload) transported by the major streams in the basin during water year 1985. Relations between water and sediment discharge are developed for various sites in the basin.

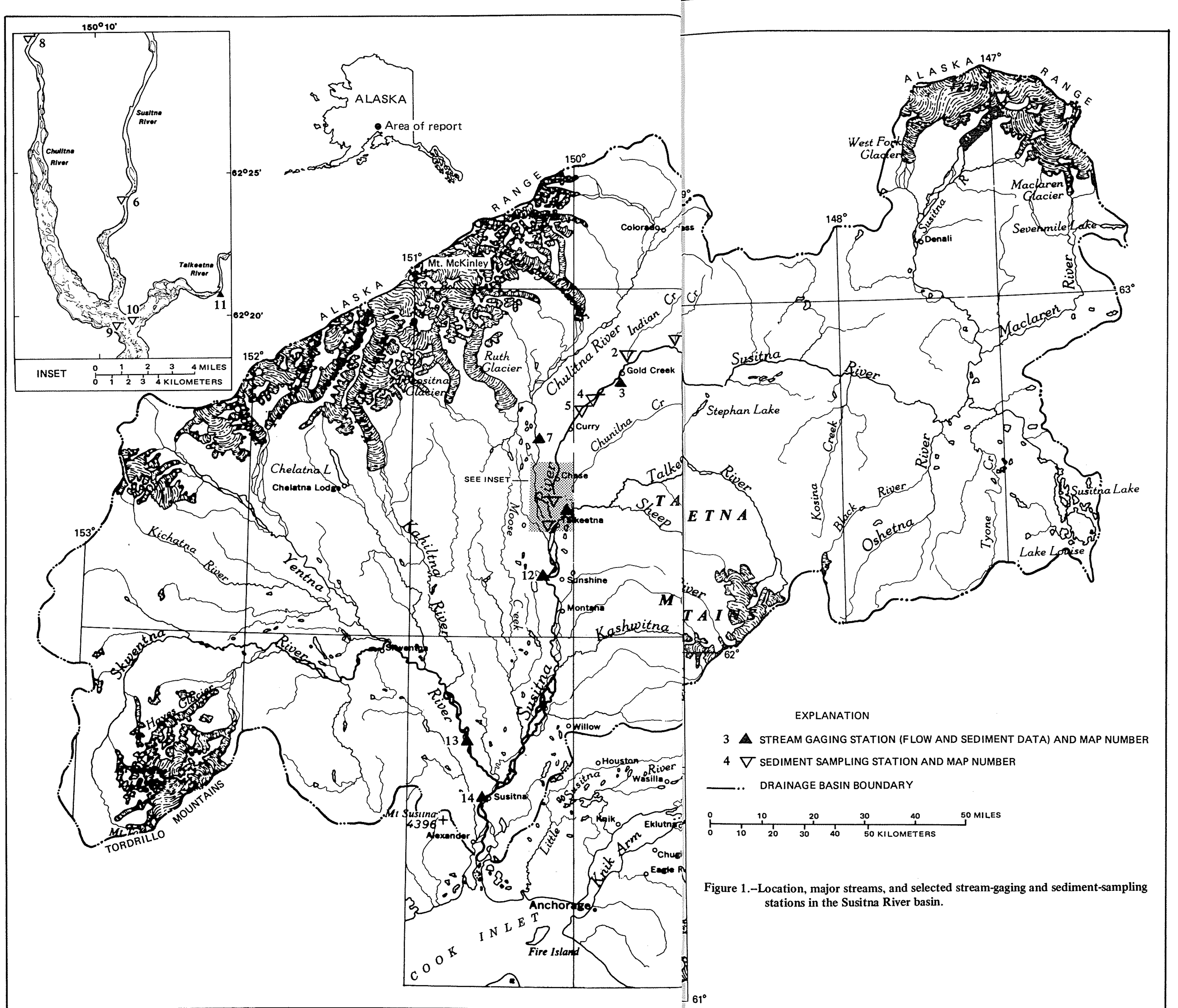

Figure 1.–Location, major streams, and selected stream-gaging and sediment-sampling stations in the Susitna River basin.

DESCRIPTION OF AREA

The Susitna River basin (fig. 1) lies on the southern flank of the Alaska Range in southcentral Alaska. The relief of the basin, which has a drainage area of about 19,400 mi^2, is a contrast of steep, rugged mountains towering above wide valley lowlands. Altitudes range from 20,320 ft at Mt. McKinley to sea level where the Susitna River empties into Cook Inlet.

Tributaries to the Susitna River are commonly referred to as either glacial or nonglacial streams. The nonglacial streams are noted for their clarity, even during intense summer rainstorms. Glacial streams are turbid throughout most of the open-water season (May through September). Glacial and nonglacial streams in the Susitna River basin are both characteristically low in turbidity (less than 10 NTU) during most winter months (November through March). The Susitna River and its larger tributaries are all affected to some degree by glacier runoff.

CLIMATE

The climate of the Susitna River basin is divided into two broad categories (Searby, 1968). The higher altitude parts of the basin are included in the Continental Zone, where diurnal and annual temperature variations are great. Mean annual temperatures range from 15 to 25 °F (Hartman and Johnson, 1978). The lowlands lie in the Transition Zone, where temperatures are less variable. Mean annual temperatures here generally range from 25 to 35 °F. Mean annual precipitation in the basin ranges from less than 20 in. near the mouth of the Susitna River to more than 80 in. at higher altitudes (National Weather Service, 1972).

Climatological records for the weather station at Talkeetna probably are representative of lowland areas. A summary of data for this station (Selkregg, 1974) indicates that mean daily temperatures range from 38 to 62 °F in summer, and from -9 to 18 °F in winter; extremes range from -44 to 85 °F. Annual precipitation at Talkeetna averages 28 in., about 60 percent of which is rainfall.

DATA COLLECTION AND ANALYSIS

Beginning in 1981, systematic measurements of sediment discharge and stream hydraulic properties were begun to define the amount and distribution of sediment transported by the Susitna River and its major tributaries between Gold Creek and Sunshine (fig. 1). In 1981, data were collected at four sites in July, August, and September. Two sites were on the Susitna River, one at Gold Creek (No. 3 on map) and the other at the Parks Highway crossing at Sunshine (No. 12). The remaining two sites were on major tributaries to the Susitna River, one each on the Chulitna (No. 7) and Talkeetna (No. 11) Rivers.

During 1982 the data-collection program was expanded to obtain weekly samples during the open-water season (May to September). A new sampling site (No. 6 on map) was established on the Susitna River upstream from the Chulitna River confluence. The stream-gaging station and the monthly collection of suspended-sediment samples were continued at Gold Creek. Bedload sampling sites (Nos. 9 and

10 on map) were established on the Susitna River in 1983 and on the Susitna (No. 14) and Yentna (No. 13) Rivers in 1984. Suspended-sediment data have been obtained for the Susitna River at Susitna Station and Yentna River sites since 1975 and 1981, respectively (Still and Jones, 1985). From 1983 to 1985, samples have been collected monthly with occasional sampling during storm periods. At each site, data collection included:

1) Suspended-sediment samples
2) Bedload samples
3) Bed-material samples
4) Water-discharge measurements
5) Measurements of water depth and channel width

Selected samples of suspended sediment, bedload, and bed material were analyzed for particle-size distribution. Streamflow characteristics were defined from data available for existing stream-gaging stations. At sampling sites that did not coincide with stream-gaging stations, sufficient discharge measurements were obtained to develop stage-discharge relations. Summer measurements were made from a boat; either a cableway or sextant was used to determine stationing along the measuring section. Winter measurements were made by attaching a sampler to a rod and lowering the sampler through holes drilled in the ice.

Depth-integrated, suspended-sediment samples were collected using a standard point-integrating P-61 sampler (Guy and Norman, 1970). Samples include those particles (usually finer than 2.0 mm) transported in the stream between the water surface and a point about 0.5 ft above the streambed. Two samples were obtained at each of five selected verticals in the stream cross section (at centroids of flow) and analyzed to determine average values of suspended-sediment concentration and the particle-size distribution of sediment in the water-sediment mixture. The two samples from each vertical profile were generally composited to obtain one analysis, but in a few instances the individual samples were analyzed.

Sediment transported within 0.25 ft of the streambed was sampled using a bedload sampler (Helley and Smith, 1971) designed for collecting coarse material (0.25-76.2 mm). Sampling time, number of sampling points, stream width and depth, and weight of dry sediment were recorded as a basis for calculating bedload discharge. Trap efficiency of the sampler was assumed to be 1.0. Characteristics of the Helley-Smith sampler and procedures for its use have not yet been fully evaluated. In the interim, the Geological Survey follows a provisional method of obtaining samples at about 20 equally spaced verticals based largely on field tests by Emmett (1980).

Some of the sediment transported in suspension cannot be accurately sampled by the P-61 because the lowest depth accessible to the sampler is about 0.5 ft above the riverbed. Silt-clay concentrations are generally assumed to be uniformly distributed throughout the total depth of the river and the concentration of this material near the riverbed (between riverbed and 0.5 ft above bed) is considered to be approximately the same as that in the sampled zone. The concentration of suspended sand near the riverbed, however, is generally larger than that in the sampled zone because sand particles tend to settle toward the riverbed if flow velocities are not sufficient to keep them in suspension. At least part of the medium to coarse sand fraction (0.25-2.0 mm) moving near the riverbed is trapped by the bedload sampler (from riverbed to 0.25 ft).

A preliminary examination of the amount of sand transported in suspension and as bedload suggests that attempting to account for sand that is not sampled by either sampler would generally increase reported concentrations of suspended sand (table 2) at most sites by about 1 percent. At some sites, however, such as the Yentna River and the Susitna River at Susitna Station, the amount of sand that is not sampled is perhaps 10 percent of the total suspended sand.

A few bed-material samples were obtained at each site using a 6-inch diameter pipe dredge. At some sites, deep water and a swift current, armoring, and the presence of coarse particles on the streambed made sampling difficult. Although indicative of the sizes of particles present in the streambed (less than 150 mm), bed-material data presented in this report may not be representative of actual particle-size distributions. Surface and sub-surface samples also were obtained where the streambed was exposed or where water depths were less than 2 ft. These samples, obtained with a sampler similar to a McNeil sampler (McNeil and Ahnell, 1964) are probably representative of actual particle-size distributions.

Measurements of water depth and channel width at sampling sections were usually made during bedload measurements. Depths were measured by sounding with the Helley-Smith sampler at 16 to 25 points in the cross section. Stream width was determined from station markings on cableways or from sextant readings. Average velocity was determined by dividing the rated discharge of the stream by the cross-sectional area (width x depth).

SEDIMENT DISCHARGE

Sediment Transport and Particle-Size Characteristics

Sediment particles may be transported in suspension, by rolling and bouncing along the streambed, or as a combination of both. Suspended sediment, as the name implies, consists of particles that are transported in a stream while being held in suspension by the turbulent components of the flowing water. Coarse sediment that is transported on or near the streambed constitutes the bedload. Clay- and silt-size particles usually are moved in suspension, while gravel particles move on or near the streambed. Sand-size particles may be transported either as suspended load, as bedload, or both.

Suspended-Sediment Concentration

Suspended-sediment data for the period October 1984 to September 1985 are listed in table 2. During 1985, only two significant storms occurred, and these were small compared to those that occurred in the period 1981-84. Most samples were collected during periods of low to moderately high flows.

A few samples were collected in the winter (October 1984 to April 1985). Suspended-sediment concentrations for these samples range from 2 to 21 mg/L, typical of concentrations measured during previous winters.

Spring "breakup" occurred in mid- to late May at most sampling sites. The sampling dates in May generally reflect the timing of the ice-breakup event within the basin (table 2). Ice cover on the rivers disintegrates first in the lower basin near Susitna Station. Breakup then generally proceeds upstream and occurs last near Gold Creek. Concentrations of suspended sediment increase rapidly during the breakup process and then generally decrease through June. In 1985, concentrations ranged from about 500 to 1,000 mg/L in May and then decreased to about 200 to 400 mg/L in late June. An exception to this pattern was the station Chulitna River below canyon, where the higher concentration (1,240 mg/L) of suspended sediment reflects glacier runoff. The percentages of silt-clay sediment in May and June (prior to glacier runoff) are generally low (18-52 percent) relative to sand (48-82 percent) at all sites in the basin.

In July and August, glacier runoff and storms commonly result in high concentrations of suspended sediment for long periods. When a major storm occurs, suspended-sediment concentrations can increase rapidly to several thousand milligrams per liter. During warm periods between storms, glacier runoff increases and concentrations remain high.

The Susitna River near Talkeetna (No. 6 on map) and the Talkeetna River near Talkeetna (No. 11) are least affected by glacier runoff; glaciers cover 5 and 7 percent of their respective drainage areas. Sampled concentrations of suspended sediment at these sites ranged from about 200 to 700 mg/L during July and August 1985. Silt-clay percentages (47-62 percent) are about the same as for sand (38-53 percent).

The Chulitna River is the most affected by glacier runoff; glaciers cover 27 percent of the drainage area. Summer concentrations of suspended sediment in the Chulitna River are typically more than twice as high (1,000 to 2,000 mg/L) as those for either the Susitna or Talkeetna Rivers near Talkeetna. Silt-clay percentages are significantly higher (63-79 percent) than those for sand (21-37 percent) during storm and glacier-runoff periods.

Suspended-sediment data obtained at the sampling site designated Susitna River below Chulitna River near Talkeetna (map Nos. 9 and 10 for the right and left channels, respectively) are representative of the combined discharge of the Susitna River near Talkeetna and Chulitna River below canyon near Talkeetna (map No. 8). The site, about 1 mi below the confluence of the Chulitna and Susitna Rivers, includes two major channels (separated by a stable, vegetated island) and several minor channels. At this site, the right channel (as viewed looking downstream) of the Susitna River carries the entire flow of the Chulitna River along with smaller but varying amounts of "crossover" flow from the Susitna's left channel. Suspended-sediment concentration and water discharge for the right channel were several times higher than that of the left channel during July and August 1985.

Suspended-sediment concentrations for the Susitna River at Sunshine ranged from about 900 to 1,700 mg/L during July and August 1985. Suspended-sediment concentrations at this site represent the result of the mixing of water from the Chulitna, Susitna, and Talkeetna Rivers.

The Yentna River, which a drains an area of 6,180 mi^2 (above the gaging station), is the largest tributary to the Susitna River. Concentrations of suspended sediment in samples collected in July and August ranged from 600 to 800 mg/L. Concentrations for the Susitna River at Susitna Station (500 to 800 mg/L) fall within the range in concentration for the Yentna River and Susitna River at Sunshine. The percentage of silt-clay material for these three sites was consistently higher (61-79 percent) than that for sand (21-39 percent).

Suspended-sediment concentrations and water discharge usually decline during September and October as cooler weather reduces the melting rate of high-altitude snowpacks and glaciers. In 1985, a moderately large storm occurred during this period, and sampled concentrations at the sites Susitna and Talkeetna Rivers near Talkeetna were variable, ranging from 69 to 503 mg/L. Concentrations for the Chulitna and Yentna Rivers declined substantially below summer values but remained greater than 300 mg/L in September. By mid-September the percentage of silt-clay material (34-46 percent) was less than that for sand (54-66 percent) at most sites.

Relation Between Suspended-Sediment Discharge and Water Discharge

A common method for analyzing sediment-transport characteristics at a site is to construct a relation of sediment discharge versus water discharge. This relation is usually illustrated as a plot on logarithmic paper and is referred to as a sediment-transport curve. Data for May to September 1981-84 reported by Knott and Lipscomb (1983 and 1985), and by Knott and others (1986), and data given in this report were used to develop sediment-transport curves for the silt-clay and sand-size fractions of suspended sediment for the Susitna, Chulitna, Talkeetna, and Yentna Rivers (figs. 2-8). Historical data (U.S. Geological Survey, 1953-85) were used to extend the curves for extreme high and low flows. Transport curves of suspended-sediment discharge were developed by first dividing the total range of water discharge into small increments and then averaging both water discharge and suspended-sediment discharge for each increment (Colby, 1956). For flow ranges at which the trend of the data points appeared to define a straight-line relation on logarithmic graph paper, the line of best fit was computed using the least-squares method.

The relations between water and suspended-sediment discharge, for all sampling sites in the Susitna River basin, follow a linear-logarithmic trend during the open-water season (May to September). The relation is in the form of the equation: $Q_s = aQ^b$, where Q_s is suspended-sediment discharge, in tons per day; Q is water discharge, in cubic feet per second; and a and b are constants. The rate at which sediment discharge increases relative to water discharge is defined by the exponent "b". The constant "a" can be considered as an indicator of the amount of sediment transported at a given water discharge. For example, if the exponents "b" for two rivers were similar, the river having the larger value of "a" would transport more sediment at the same water discharge.

Transport curves of silt-clay discharge indicate that silt-clay discharge increases with water discharge at exponential rates ranging from 2.37 to 3.18. The largest exponential rates occur for sites on the Susitna River below Chulitna River, Susitna River near Talkeetna, and Talkeetna River near Talkeetna. The increase in silt-clay discharge with increasing water discharge is considerably smaller for sites on the Yentna River and Susitna River at Susitna Station.

Transport curves of suspended-sand discharge indicate a greater variation in exponents than those for silt-clay discharge. Exponents range from 1.55 to 3.54. A trend of decreasing exponents with distance downstream from Talkeetna also occurs for the transport of suspended sand. Exponents for sites on the Yentna and Susitna Rivers near Susitna Station are also small relative to those for upstream sites.

Transport curves of total suspended-sediment discharge for winter periods (October to April) (figs. 9-15) were prepared from historical data obtained in U.S. Geological Survey Water-Data reports (1953-85). Suspended-sediment data available for winter months are few, and most relations between water and suspended-sediment discharge for October to April periods are not well defined.

Bedload Discharge and Hydraulic Characteristics

Bedload and hydraulic data obtained for the sampling sites during the 1985 water year are summarized in table 3. Bedload data are expressed both as discharge in tons per day, and in terms of their particle-size distribution in percent finer than the indicated sieve size.

Winter samples (under ice cover) of bedload have been collected several times at all sites -- in March 1983, in February 1984, and in February and April 1985. Bedload discharges computed from samples collected in February and March probably indicate near-minimum rates of transport, because these are the months of minimum streamflow. Winter bedload discharges at the upper sites -- Chulitna, Susitna, and Talkeetna Rivers near Talkeetna -- ranged from zero to about 15 ton/d. Downstream from the confluence of the Chulitna and Susitna Rivers, bedload discharge is significantly greater. Bedload discharge at the lower sites during February and April ranged from 15 to 130 ton/d. Bedload at all sites was predominantly sand during the winter.

During the 1985 open-water period (May to September), bedload discharge of the Susitna River near Talkeetna ranged from 67 to 590 ton/d (table 3). During this same period, water discharge ranged from 14,300 to 46,400 ft^3/s. The transported material consisted primarily of sand (84-100 percent) and lesser amounts of gravel (0-16 percent).

Bedload discharge of the Chulitna River below the canyon ranged from 3,590 to 6,990 ton/d and water discharges from 14,300 to 39,000 ft^3/s. During low-flow periods in September, the particle-size distribution of bedload on the Chulitna River tended toward a high percentage of sand (51-66 percent). Gravel was the primary constituent of the bedload (58-73 percent) during spring and the summer.

During the open-water period, bedload discharge of the Talkeetna River near Talkeetna ranged from 384 to 1,850 ton/d for water discharges ranging from 5,900 to 17,100 ft^3/s. Typically, bedload at this site consisted mainly of sand (53-92 percent). The percentage of gravel exceeded that of sand only during the high flows of May 28 and August 15, 1985.

Bedload discharge at Susitna River below the Chulitna River was measured separately in each of two major channels about 1 mi downstream from the confluence. Bedload transport rates in each channel roughly correspond to rates measured at upstream sites on the Chulitna and Susitna Rivers near Talkeetna. A large part of the water discharge, however, crosses over from the Susitna River and mixes with flow originating in the Chulitna River. Bedload transport rates in the right channel are similar to those measured at the upstream Chulitna River site. Transport rates ranged from 680 to 5,530 ton/d with gravel constituting about 50 to 90 percent of the bedload. The percentage of sand was higher than gravel only on September 4 during a low-flow period. Bedload rates in the left channel are typically much lower than those in the right channel and are similar to those measured at the Susitna River near Talkeetna. Bedload ranged from 135 to 1,030 ton/d, with sand composing about 80 to 90 percent of the material.

Bedload discharge of the Susitna River at Sunshine ranged from 584 to 2,590 ton/d at flows ranging from 46,900 to 76,500 ft^3/s. No samples representative of very high or very low flows were obtained during the open-water period at this site. During the summer, sand generally constituted from 60 to 90 percent of the bedload discharge. The percentage of gravel was larger (56-69 percent) on September 16 and May 31.

Bedload discharges during 1985 for the Yentna and Susitna Rivers near Susitna Station were considerably higher than those for any of the other sites. The Yentna River transported from 4,360 to 13,300 ton/d of bedload, most of which was sand (85-96 percent). The Susitna River at Susitna Station transported bedload at rates ranging from 4,690 to 20,900 ton/d. This material was also predominantly sand (62-93 percent).

Relation Between Bedload Discharge and Water Discharge

It is generally assumed that bed material is furnished to a stream in quantities that are larger than the capacity of the channel to transport the material and that the stream will transport the load at capacity (Einstein and Johnson, 1959). Most theories of bedload transport are based on the assumption that bedload discharge is a function of water discharge, and that as the discharge increases the bedload discharge will also increase. A few recent studies, however, suggest that if the supply of transportable sediment is not uniformly distributed along a reach of the river an inconsistent relation between bedload transport and water discharge can be expected (Klingeman and Emmett, 1982). Klingeman and Emmett discuss the occurrence of transport-loop relations during transient runoff events as bed material is moved from storage areas (large supplies of sediment) to sampling sites. Meade (1985) discusses the movement of bedload sediment as a wavelike pulse by which bedload is moved from storage areas through riffles to storage areas farther downstream.

The bedload-transport relations for streams in the Susitna River basin, formerly thought to be poorly defined, seem to agree very well with the relations described by the above authors. Bedload-transport data for all the sampling sites in this study show a varying degree of scatter, depending on the supply of transportable sediment at the sampling site, the supply available in upstream storage areas, and water discharge.

Transport curves of bedload discharge were generally developed by first dividing the total range of water discharge into small increments and then averaging both water discharge and bedload discharge for each increment (Colby, 1956). If the trend of the data points appeared to define a straight-line relation on a logarithmic scale, the line of best fit was computed using the least-squares method. If the scatter was large and no reasonable relation was apparent, a loop-type relation was assumed and an average relation was developed by visually fitting a line to the data.

Bedload-discharge data for the study period (1981-85) were divided into components of sand and gravel discharge. The relations developed for each component are shown in figures 16 through 22.

Bedload-discharge data representative of the upper Susitna River were obtained at two sites. Most of the data were collected at Susitna River near Talkeetna (No. 6 on map) during the period 1982-85. Three measurements of bedload discharge were made at Gold Creek (No. 3) in 1981. The river reach between the sites and the reach extending about 10 mi upstream from Gold Creek consists of a straight, uniform channel or split channels separated by stable, vegetated islands. The few gravel bars present are unstable and shift after floods (R and M Consultants, 1985). The riverbed is generally armored by cobbles and small boulders. The line of best fit, computed by the least-squares method, provides a reasonable relation between bedload and water discharge for the Susitna River near Talkeetna (fig. 16).

Bedload-discharge data for the Chulitna River also were obtained at two sites. In 1981, the measurements were made at the gaging station. In 1982, the sampling site was moved to a location 4.0 mi downstream. The Chulitna River, upstream from the site "Chulitna River below canyon" (No. 7), flows through a narrow canyon for about 8 mi. The river varies in width from about 300 to 600 ft and flows in a relatively straight, single channel. The channel is constricted by bedrock in the narrow reaches and armored with cobbles to small boulders in the wider reaches. About 100 to 150 ft of the channel width (center) commonly consists of sand and gravel. Upstream from the canyon the river divides into numerous braided channels. The braided reach varies in width from 1,000 to 7,000 ft and extends for a distance of about 20 mi. Storage of sand-and gravel-size material in the braided reach is estimated to be in excess of 100 times that within the canyon reach.

Bedload data for the Chulitna River site have an extremely large scatter (fig. 17) relative to other streams in the basin. The distribution of the data is unusual in that bedload appears to increase with increasing discharge at relatively low flows, decreases abruptly, increases at higher flows, decreases abruptly again, and finally increases again at still higher flows. This cascading-type of pattern, which occurs for both sand- and gravel-size material, suggests that the supply of this transportable bed material is limited and that the river generally transports sand and gravel at less than capacity. If the extreme variability in bedload discharge is assumed to be due largely to changes in supply, the river will transport sand and gravel at "above average" rates (upper curve on top part of fig. 17) when the supply is large and at lower rates (lowest curve on top part of fig. 17) when the supply is small. Recent work by Emmett and Klingeman (1982) seems to apply to the Chulitna River. Their studies indicate that, if a large part of the transported bed material originates in upstream storage areas, the occurrence of a transient runoff event can temporarily deplete the stored bed material at the sampling site and bedload transport will decrease. When sufficient time passes, bedload transport increases and large amounts of bed material continue to move past the sampling site for a long time into the streamflow recession period.

The previously discussed concepts of a variable supply of bed material were used to develop some approximate relations between bedload discharge for the Chulitna River site. The scatter of data for this site is such that the definition of one or more relations is subject to individual interpretation.

Three relations are estimated for the transport of sand and gravel at the Chulitna River site. The transport relations for high flows (greater than 29,000 ft^3/s) assume that the supply of sand and gravel at the sampling site is rapidly depleted during storm events and that a minimum supply exists. The transport curve for high flows is probably indicative of bedload transport in the canyon if no large storage areas existed upstream.

River-reach characteristics upstream from the site "Susitna River below Chulitna River" are complex. The reach upstream from the right channel (No. 9) consists of numerous braided channels that shift daily. The reach is about 4,000 ft wide and 8 mi long. The reach upstream from the left channel (No. 10) is narrower (2,000 ft) and less braided. It extends for a distance of only about 2 mi above the confluence of the Susitna and Chulitna Rivers.

Bedload data for the Susitna River below Chulitna River (fig. 18) have a large scatter, but the data indicate a rough trend of increased bedload with increases in discharge. The relations between sand and gravel discharge and water discharge were obtained by least-squares analysis.

Upstream from the sampling site the Talkeetna River follows a meandering course through unconsolidated glacial-moraine deposits. The flow is generally divided into several channels. Gravel bars are numerous, but do not account for a large supply of bed material. The nearest source of a large supply of bed material occurs in braided reaches near glaciers about 40 to 50 mi upstream.

The scatter of bedload data for the Talkeetna River (fig. 19) shows several of the same trends as described for the Chulitna River. The supply of sand and gravel is limited and bedload discharges decrease and appear to follow a separate relation for flows greater than 17,000 ft^3/s. Sand discharges seem to occur in separate groups that follow similar trends depending on the available supply. Three relations between bedload and water discharge are estimated for the transport of sand and one relation is estimated for the transport of gravel.

The river reach upstream from Susitna River at Sunshine varies in width (1,000 to 5,000 ft) and is braided from about 1 mi upstream from the sampling site to the confluence of the Chulitna and Susitna Rivers. The sampling section is leveed on one bank and is confined by riprap boulders on the other. Most of the riverbed consists of sand and gravel.

With a seemingly inexhaustible supply of sand and gravel upstream, the river would be expected to transport this material at near capacity rates. The scatter of data, however, is large (fig. 20) and suggests an inconsistent relation of bedload to water discharge. The average relations developed for this site are based on the assumption that the higher bedload discharges are due to non-uniform erosion or transport conditions upstream from Sunshine. These conditions may include major shifting of river channels or bed material waves originating from large upstream storage areas.

Only 2 years of bedload data are available for the sampling sites on the Yentna and Susitna Rivers near Susitna Station. Only one relation is developed for each of these sites. There are, however, indications that inconsistent relations apply to bedload discharge. The average relations are based on the same assumptions used for the Susitna River at Sunshine.

TRENDS IN BEDLOAD DISCHARGE, 1981-85

The transport relations developed for four sampling sites (figs. 16-17 and 19-20) were used in conjunction with records of daily water discharge to construct graphs of average sand and gravel discharge for the period 1981-85 (figs. 23-26). Values of measured bedload discharge plotted on the graphs show reasonable agreement with the computed values during extended periods of low to moderate flows. Measured values show poor agreement with the computed values, however, for periods coincident with and following major storm runoff.

Measured bedload discharges appear to follow a cyclical pattern similar to that described by Klingeman and Emmett (1982) for bedload transport behavior during transient runoff events. Their analysis indicated that in river reaches where the supply of transportable sediment was not uniformly distributed, the sediment supply at a sampling site downstream from an area in which large amounts of transportable sediment were stored would be depleted during the rising stage of storm runoff. This depletion in supply would result in reduced bedload discharges. During the recession stage of storm runoff, the supply of transportable sediment at the sampling site would be replaced by sediment scoured from the upstream storage area and bedload discharges would increase.

Sand and gravel data for the Chulitna, Susitna, and Talkeetna Rivers (figs. 23-25) suggest that the available supply of this material is severely depleted during periods of high runoff. Measured bedload discharges for these periods are generally a small fraction of average bedload discharge values computed from the transport relations. Sand and gravel data for the Susitna and Talkeetna Rivers (figs. 23 and 25) agree reasonably well with the computed values during periods of low to intermediate flows. Above-average discharge of sand and gravel occasionally occurs at the Talkeetna River site following major storm runoff.

Extreme cyclical fluctuations in sand and gravel discharge at the Chulitna River site (fig. 24) are attributed to the effects of huge sediment storage areas located about 8 mi upstream from the sampling site. Depletion of the sediment supply seems to occur rapidly at the sampling site during periods of high runoff. Enrichment of sediment supplies generally occurs a few weeks after peak flow and reaches a maximum about 20 to 40 days after the peak.

Longer term changes in sand and gravel supply also seem to occur after extremely large floods such as those that occurred in July and August 1981. Following periods of severe depletion in July and August, the sediment supply increased substantially in September 1981 and generally remained high through July 1982. Another large storm in July 1982 resulted in another cycle of sand and gravel depletion during high runoff. The supply of sand and gravel was then increased in August 1982. Additional cycles of depletion and enrichment are indicated for September 1982 through June 1983, August and September 1983, August and September 1984, and August and September 1985.

Cyclic trends in bedload discharge are also apparent for the Susitna River at Sunshine (fig. 26). The closer proximity of the sampling site to upstream storage areas, however, probably results in less depletion of sand and gravel supplies during periods of high runoff. Supplies of sand and gravel at all four of the sampling sites appear to have increased in June 1982 and then followed a general decline in succeeding years.

BED MATERIAL

A few samples of bed material were collected during 1985. Analyses of these samples are listed in table 4. Representative samples of bed material were extremely difficult to obtain in submerged parts of the channels because the rivers were too deep and swift for direct access to streambeds. Samples considered representative of particles finer than 128 mm, however, were obtained at most of the sampling sites.

ESTIMATED SEDIMENT LOAD

The sediment load passing a site is commonly expressed in terms of weight (short or metric tons) or volume (acre-feet or cubic meters). Sediment loads may be estimated by different methods, depending on the amount and type of available data. If daily records of streamflow are available, but sediment discharge has been measured only infrequently, the method most commonly used requires defining a relation between instantaneous sediment discharge and water discharge and applying this relation to daily values of water discharge. This method was used to estimate suspended-sediment load for this study.

Relations between bedload and water discharge are inconsistent at most sites and development of more than one relation is subjective. The inconsistent relations are believed to be due to non-uniform supplies of bed material in river reaches upstream from the sampling sites and limited supplies of material.

The most critical relations concern the amount of sand and gravel transported during high flows. The supply of this material appears to be limited at all of the sampling sites near Talkeetna. Extrapolation of the average transport curves results in estimates of bedload discharge that are 4 to 17 times that of the measured data during periods of high flow. Estimates of monthly bedload discharge for these sites are based on the assumption that bedload discharge does not increase above the upper limit of the transport curves shown in figures 16-19.

The second type of inconsistent relations concerns the occurrence of high bedload discharges during recession flows. These high bedload discharges probably occur during periods of moderate flow as well as during major floods. A detailed assessment of the frequency of occurrence or duration of these high bedload discharges is beyond the scope of this study. The transport curves, representative of higher than average bedload transport (figs. 17, 19-20), were not used to estimate monthly bedload discharge for the 1985 water year.

Estimated total sediment loads for the 1985 water year are summarized in table 5. Monthly and annual loads are given for four sites on the Susitna River and for one site on each tributary, the Chulitna, Talkeetna, and Yentna Rivers.

Total sediment load (sum of suspended load and bedload) of the Susitna River increases from 3.3 million tons in the middle reach of the river near Talkeetna to about 31 million tons near the mouth at Susitna Station. The Chulitna, Talkeetna, and Yentna Rivers account for most of the increase, contributing 7.9, 1.8, and 13.6 million tons, respectively.

Suspended-sediment load of the Susitna River and its tributaries ranged from about 88 to 98 percent of the total load in 1985. A large part of the suspended load consisted of silt-clay size material (table 5) which is easily held in suspension and generally is transported large distances at nearly the same velocity as the flowing water. It is unlikely that any appreciable deposition occurs in the reach from Talkeetna to Susitna Station as the monthly amount of silt-clay size material transported at upstream sites is about the same as that transported at downstream sites. Similar comparisons for suspended-sand loads also show a fair agreement in the amount of this material transported at upstream and downstream sites.

Bedload, which generally consists of medium sand to very coarse gravel (0.25-64.0 mm) at most sites, is subject to large variations in transport rate, depending on flow characteristics and the available supply of coarse sediment.

Annual bedload transport at the various sampling sites in 1985 ranged from about 70,000 to 1.6 million tons. Annual bedload was smallest at Susitna River near Talkeetna and largest at Susitna River at Susitna Station. Medium to coarse sand accounted for about 75 to 80 percent of the total bedload.

SUMMARY AND CONCLUSIONS

The total sediment load of the Susitna River near its mouth (at Susitna Station) during the 1985 water year was estimated to be about 31 million tons. This estimate and estimates of sediment load for other sites on the Susitna River and its tributaries are based on measurements of suspended-sediment and bedload discharge made during the 1981-85 water years. Suspended-sediment relations for 1981-85 are representative of similar hydrologic conditions -- most data were collected during 4-day sampling periods. Suspended-sediment data collected prior to 1981 were used for various sites where the 1981-85 data were insufficient to develop an adequate relation between water and suspended-sediment discharge.

Estimates of total sediment load for the major tributaries to the Susitna River and the Susitna River near Talkeetna site account for most of the sediment passing Susitna Station. The Yentna and Chulitna Rivers contributed about 21 million tons of sediment, or 70 percent of the total for the 1985 water year. The Susitna and Talkeetna Rivers accounted for an additional 5 million tons during the same period. The combined drainage area of the above sites is about 17,000 mi^2, or 88 percent of that for the Susitna River at Susitna Station.

Relations developed between water and suspended-sediment discharge generally provide a reasonable fit to the data except where too few data are available (winter relations). The most reasonable relations are shown as solid lines. Relations based on sparse data are shown as dashed lines.

Relations developed between water and bedload discharge are less consistent than those for suspended sediment. The inconsistent relations are believed to be due to nonuniform and (or) limited supplies of bed material in river reaches upstream from the sampling sites. At some sampling sites, the supply of material is temporarily depleted during transient flows and bedload discharges decrease dramatically. Bedload discharges increase after major storms and commonly reach maximum values weeks after peak flows.

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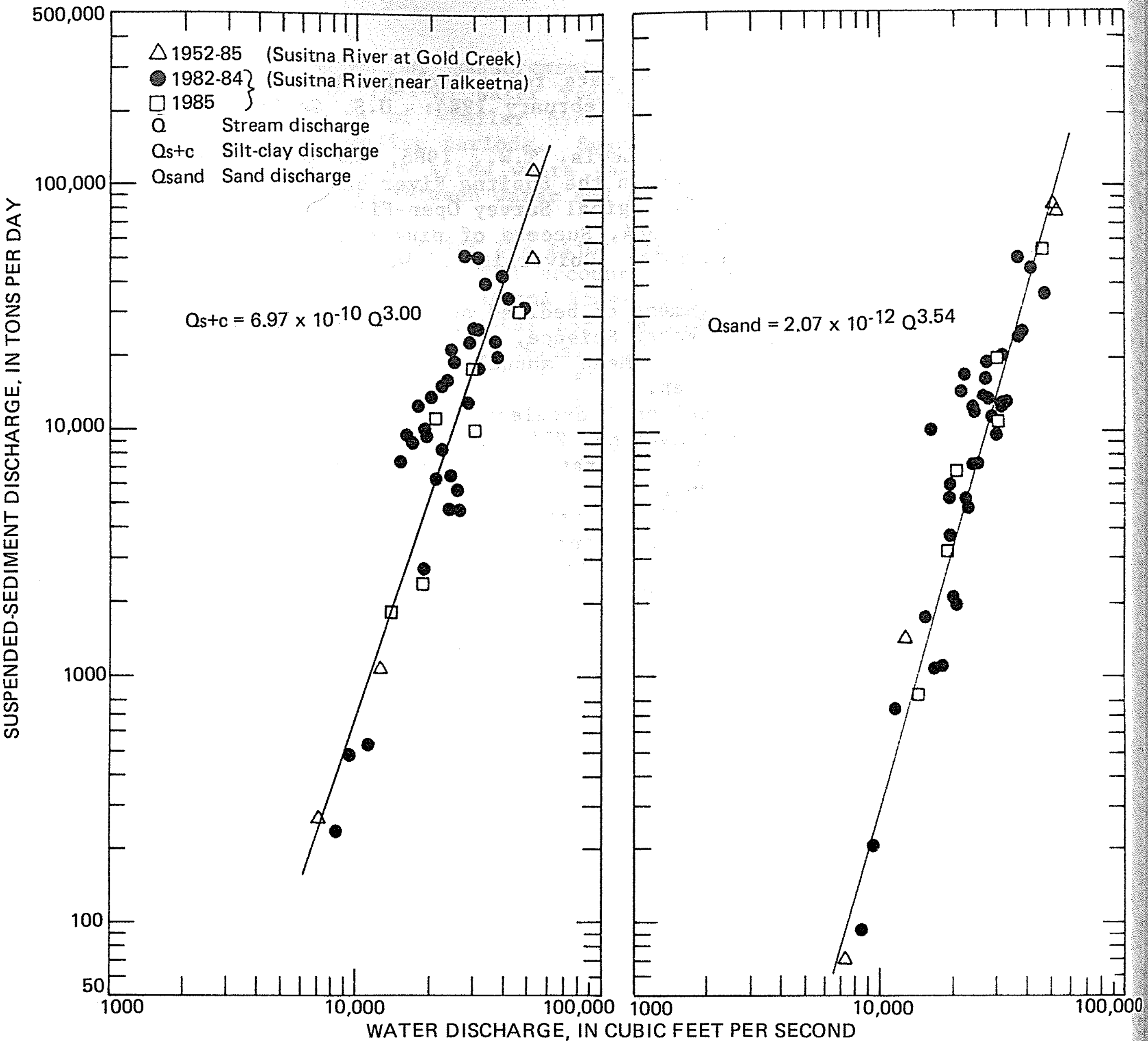

Figure 2.--Sediment-transport curves of suspended silt-clay and sand discharge for Susitna River near Talkeetna, May to September, 1981-85.

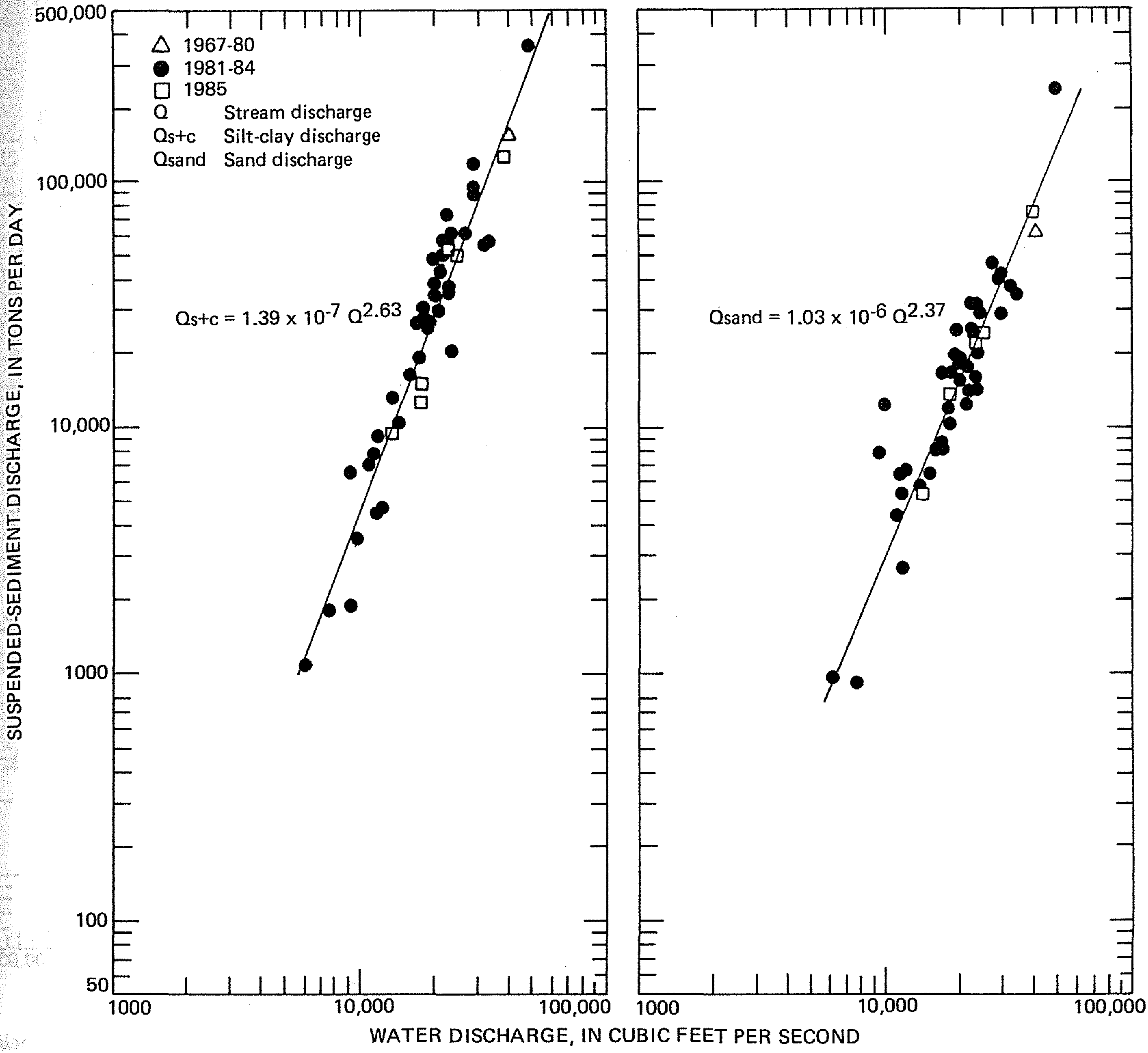

Figure 3.--Sediment-transport curves of suspended silt-clay and sand discharge for Chulitna River below canyon near Talkeetna, May to September, 1981-85.

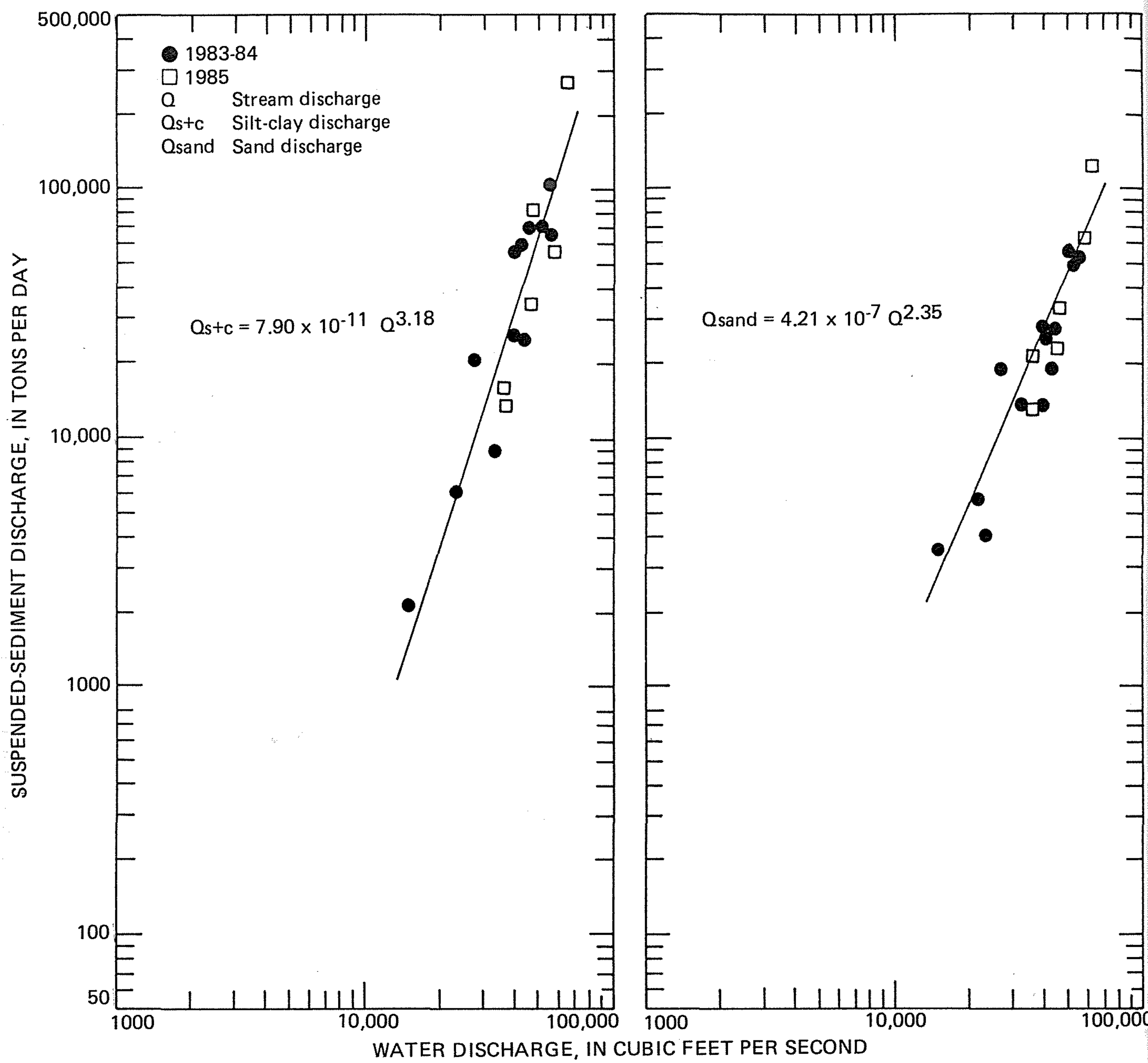

Figure 4.--Sediment-transport curves of suspended silt-clay and sand discharge for Susitna River below Chulitna River near Talkeetna (sum of right and left channels), May to September, 1983-85.

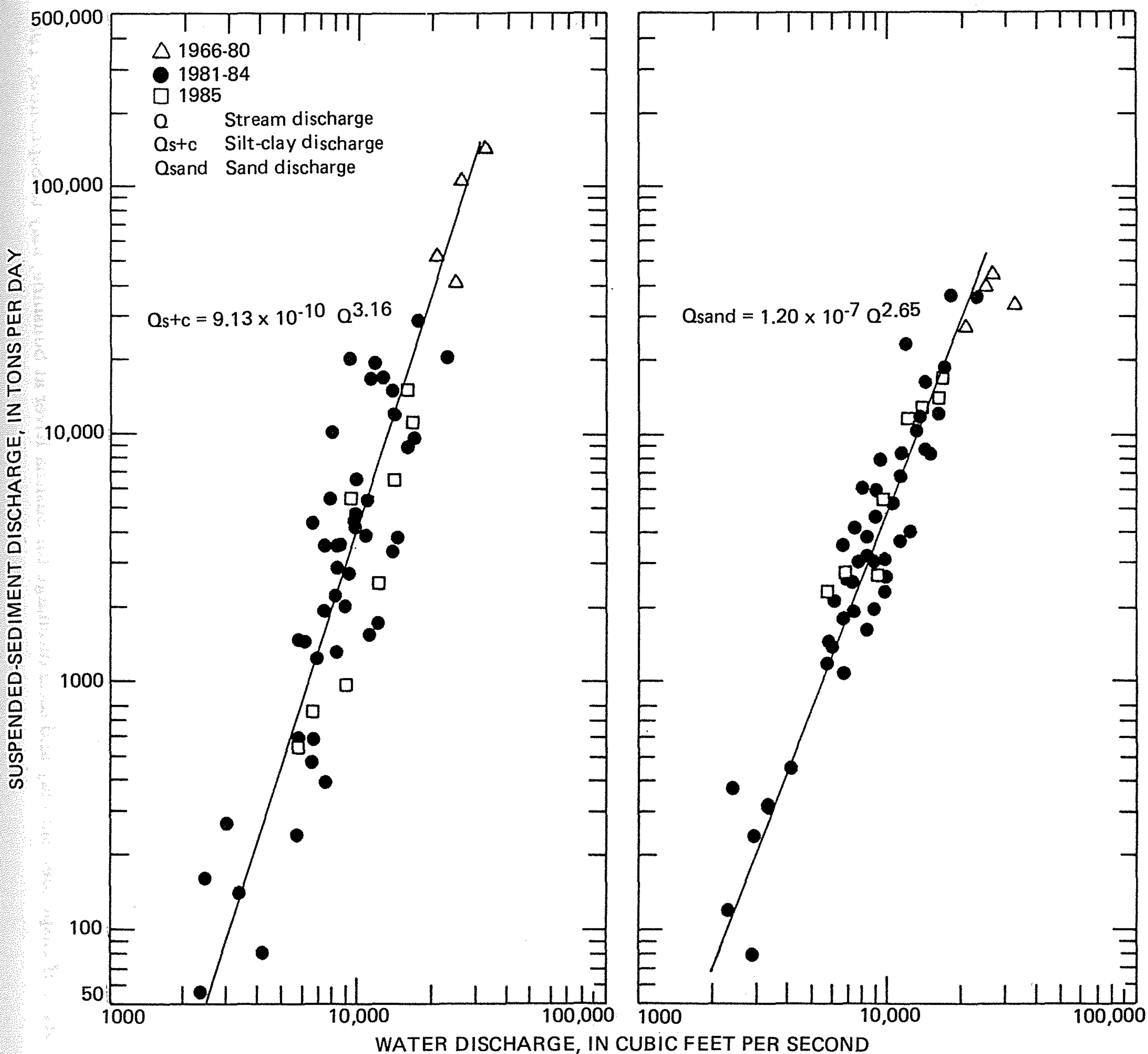

Figure 5.--Sediment-transport curves of suspended silt-clay and sand discharge for Talkeetna River near Talkeetna, May to September, 1981-85.

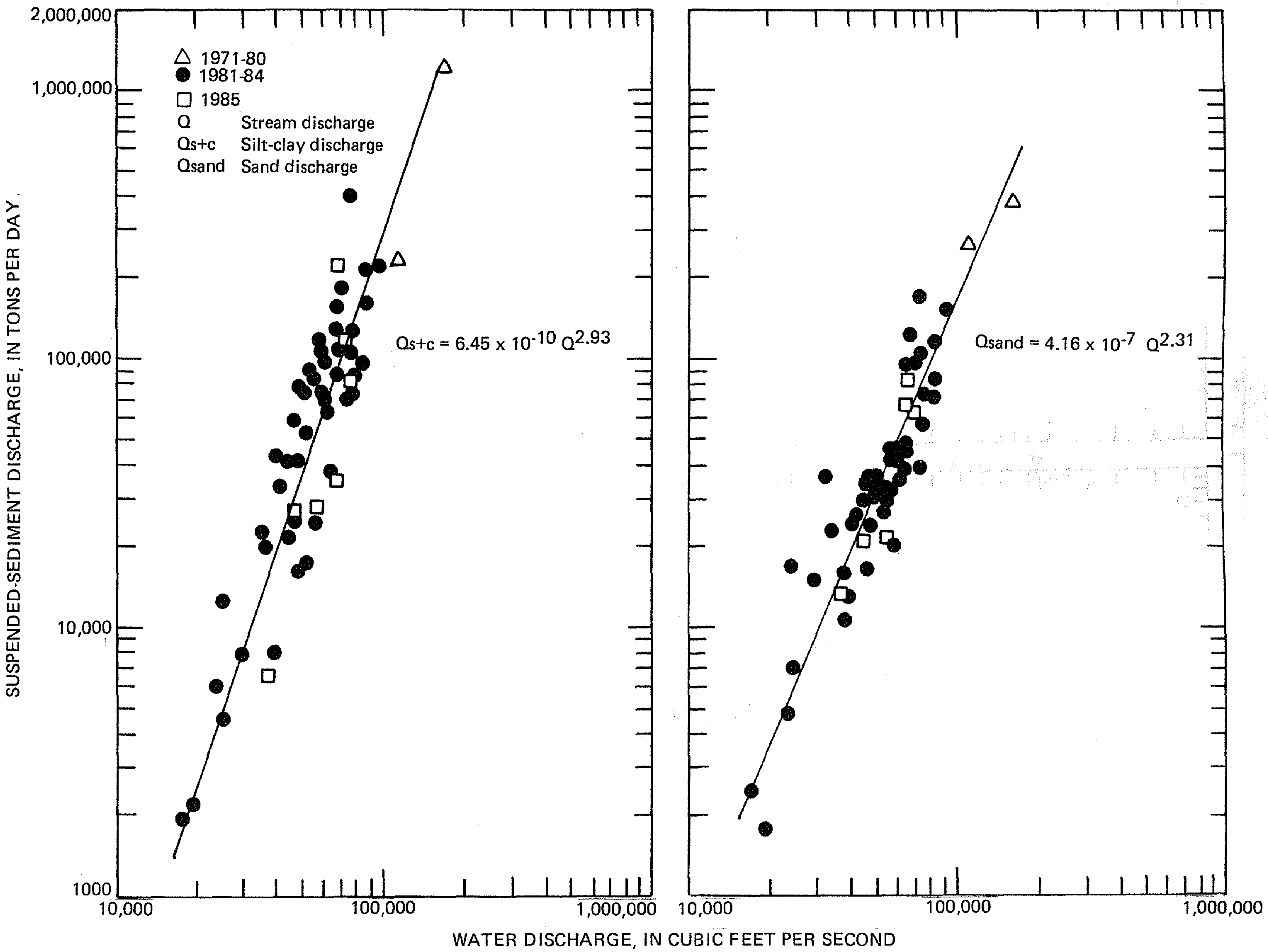

Figure 6.--Sediment-transport curves of suspended silt-clay and sand discharge for Susitna River at Sunshine, May to September, 1981-85.

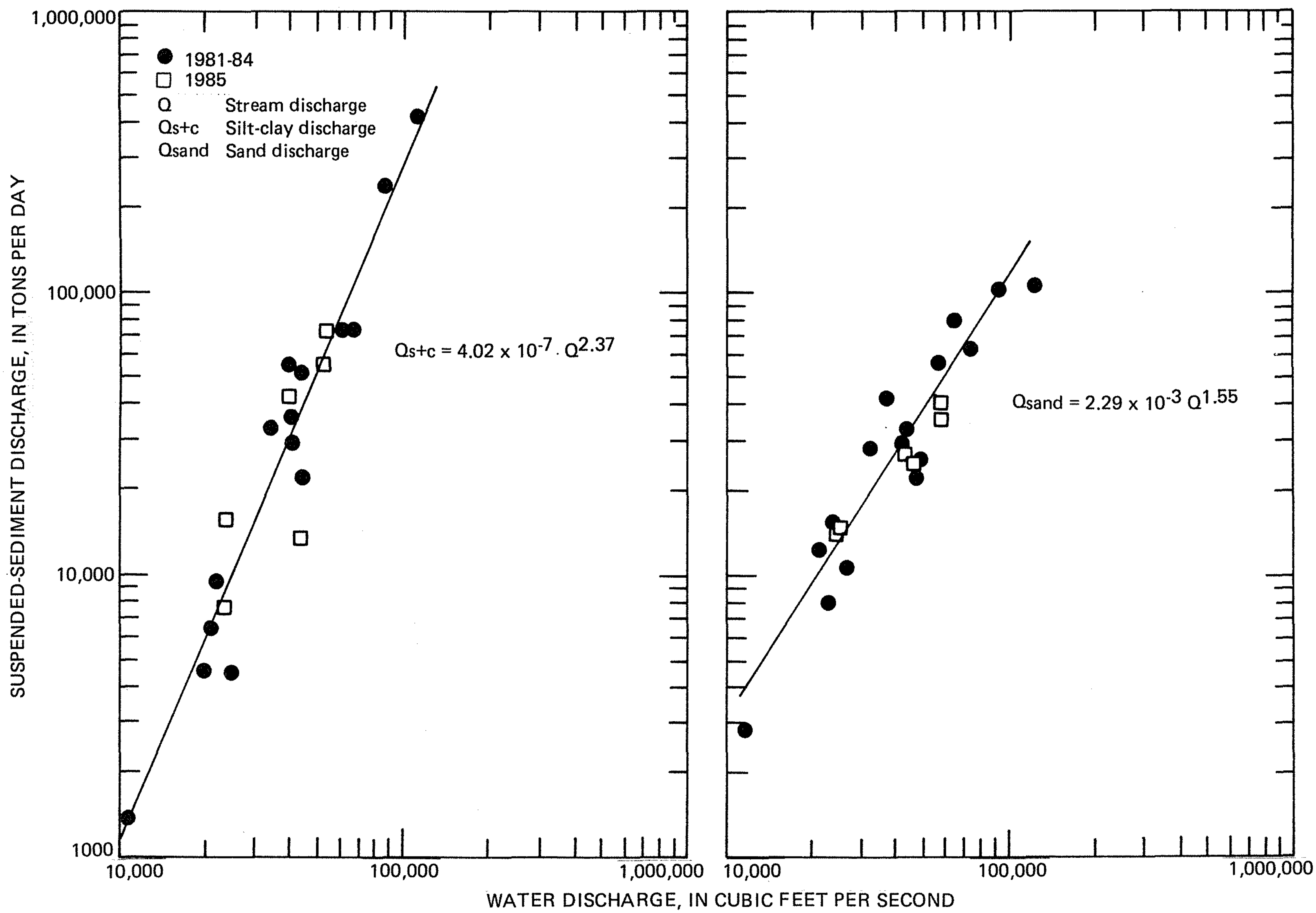

Figure 7.--Sediment-transport curves of suspended silt-clay and sand discharge for Yentna River near Susitna Station, May to September, 1981-85.

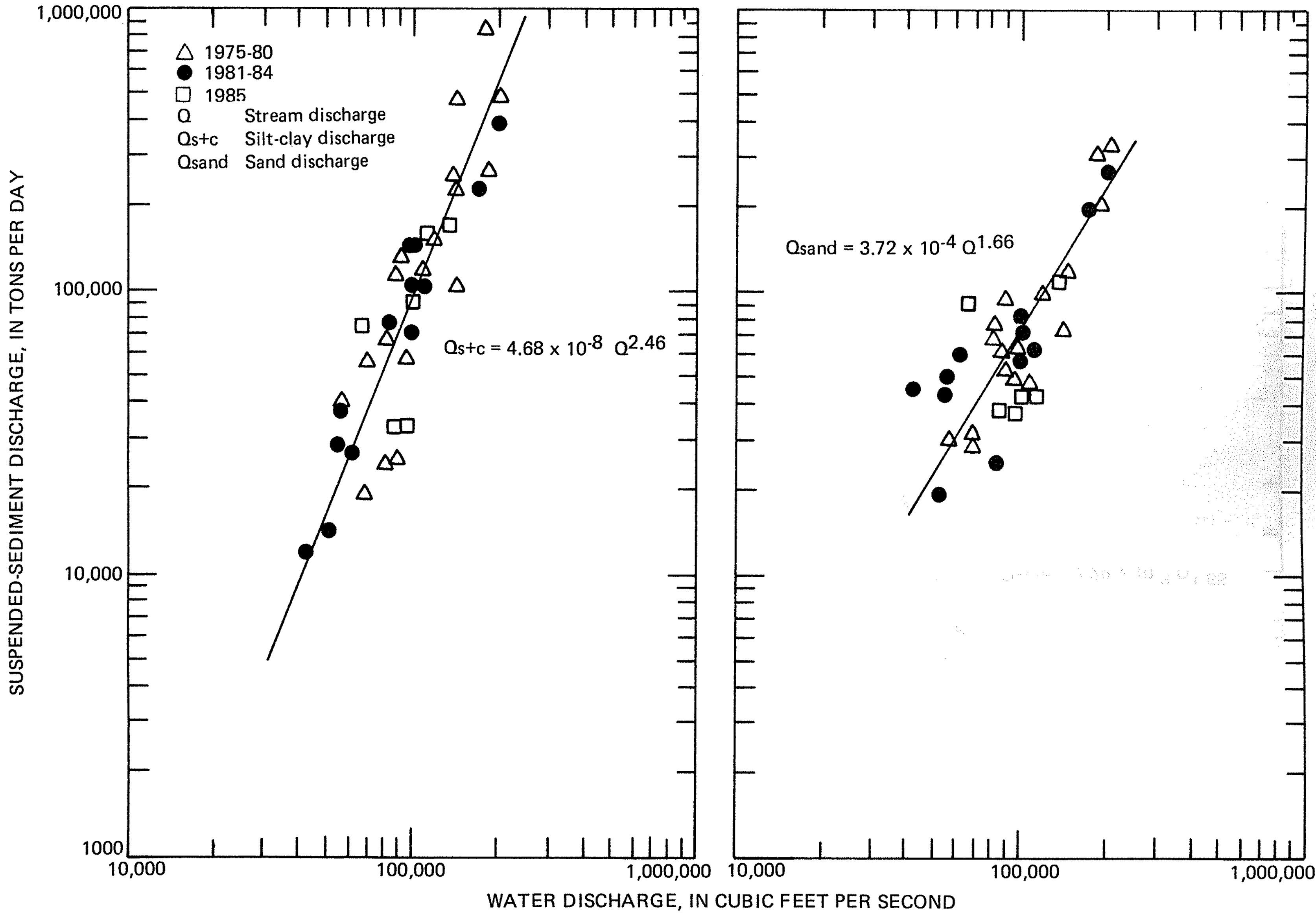

Figure 8.--Sediment-transport curves of suspended silt-clay and sand discharge for Susitna River at Susitna Station, May to September, 1981-85.

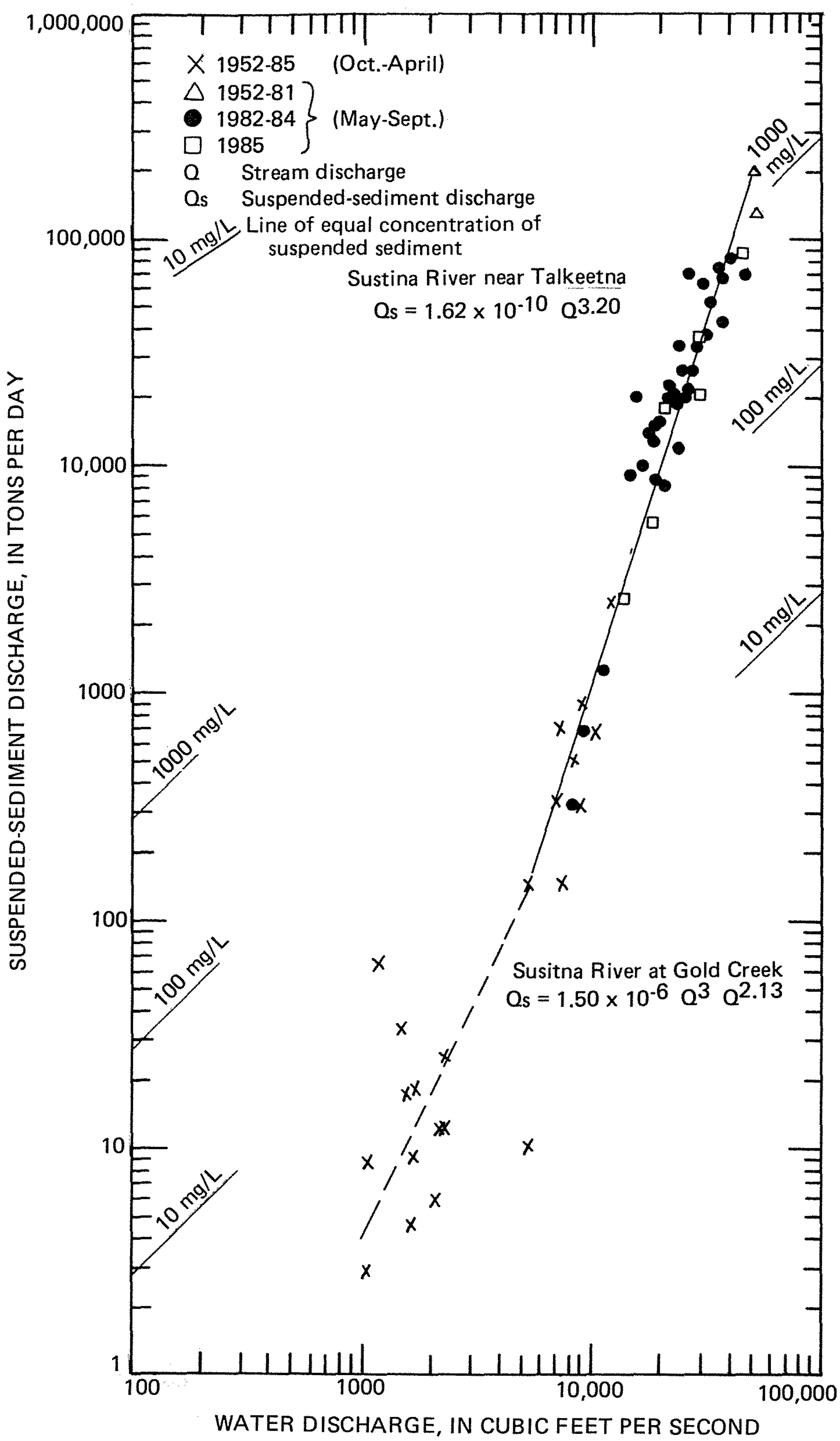

Figure 9.--Relation of mean suspended-sediment concentration and discharge to water discharge for Susitna River near Talkeetna, May to September, 1981-85 and Susitna River at Gold Creek, October to April, 1952-85.

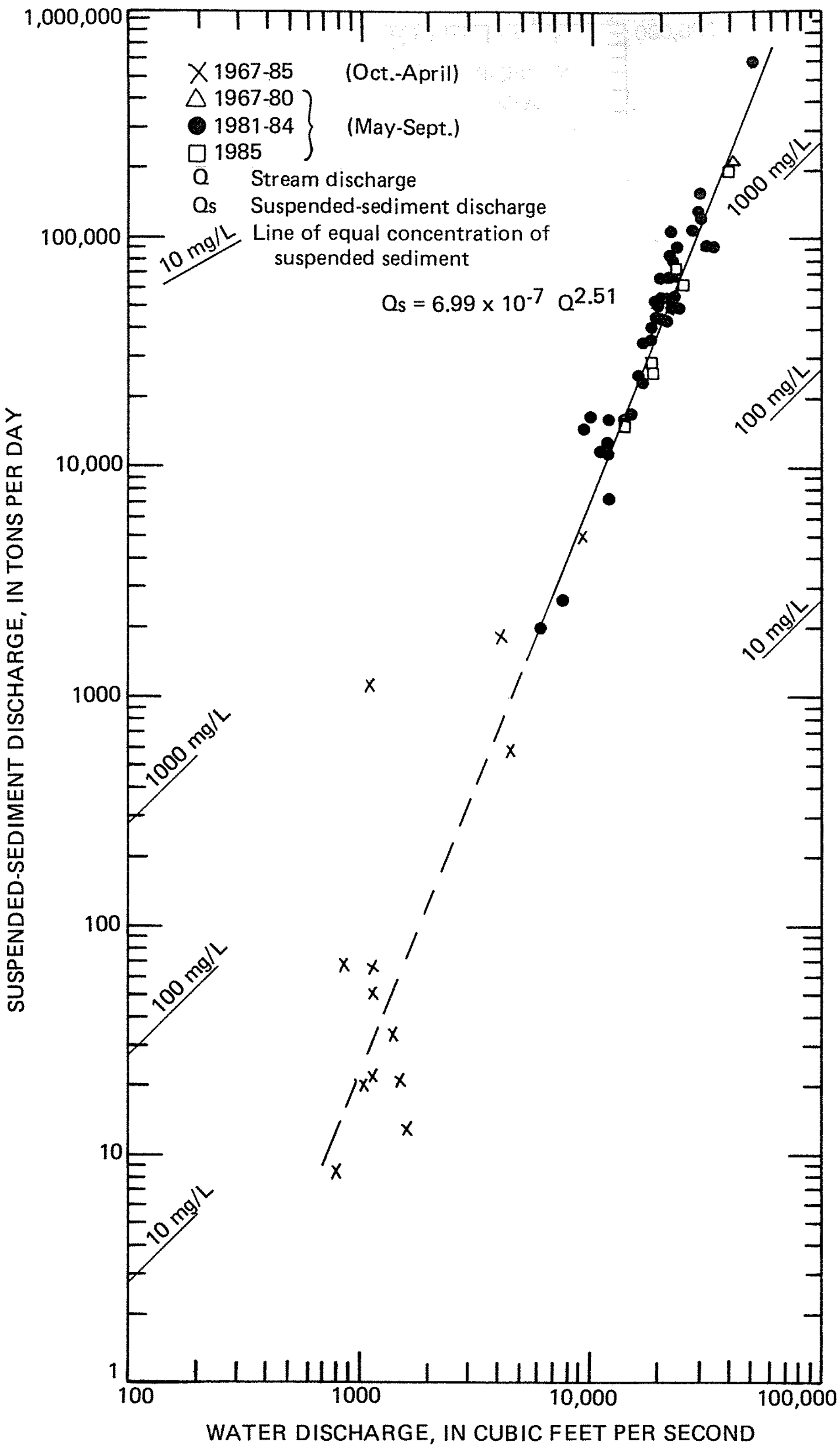

Figure 10.--Relation of mean suspended-sediment concentration and discharge to water discharge for Chulitna River below canyon near Talkeetna, 1981-85.

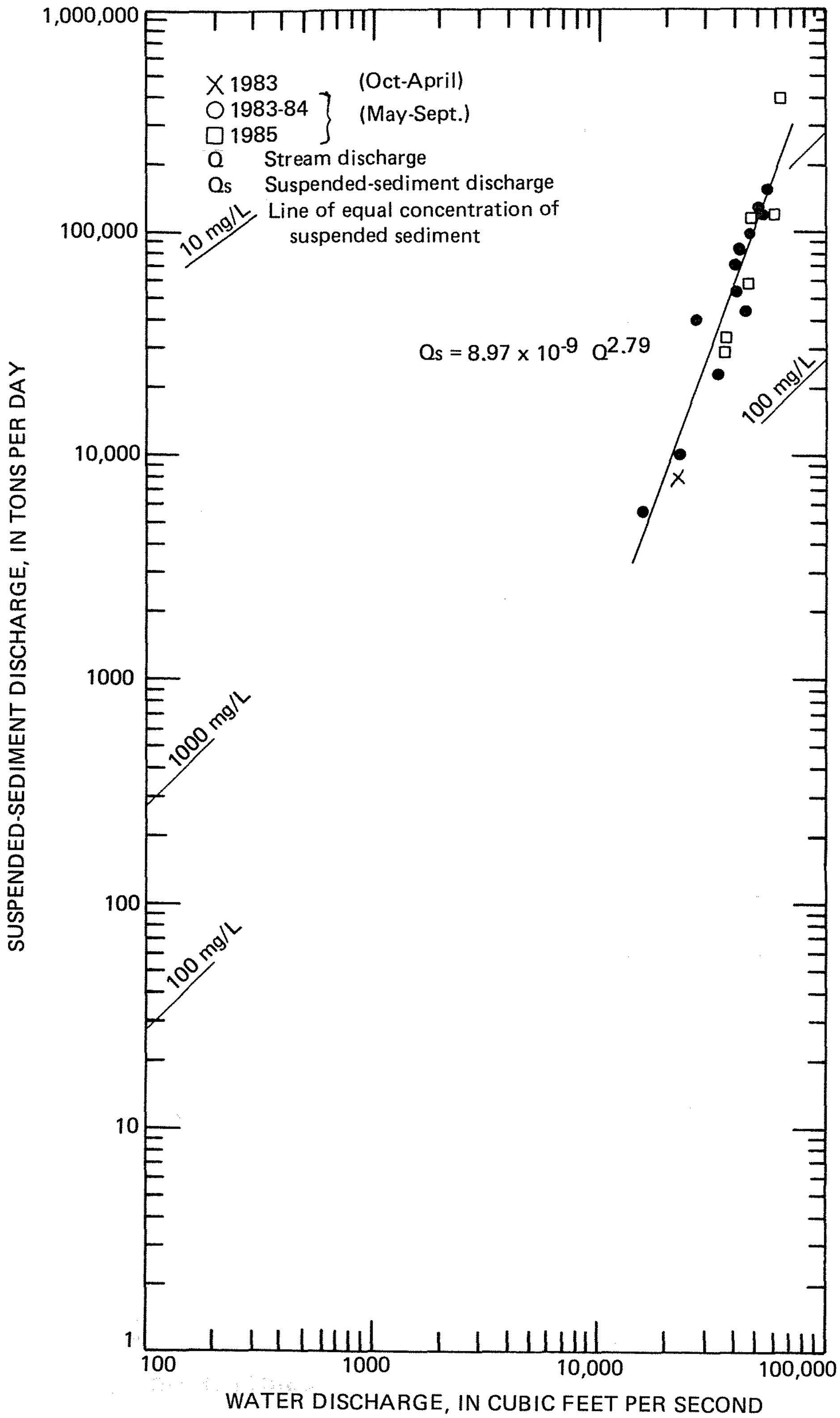

Figure 11.--Relation of mean suspended-sediment concentration and discharge to water discharge for Susitna River below Chulitna River near Talkeetna (sum of right and left channels), May to September, 1983-85.

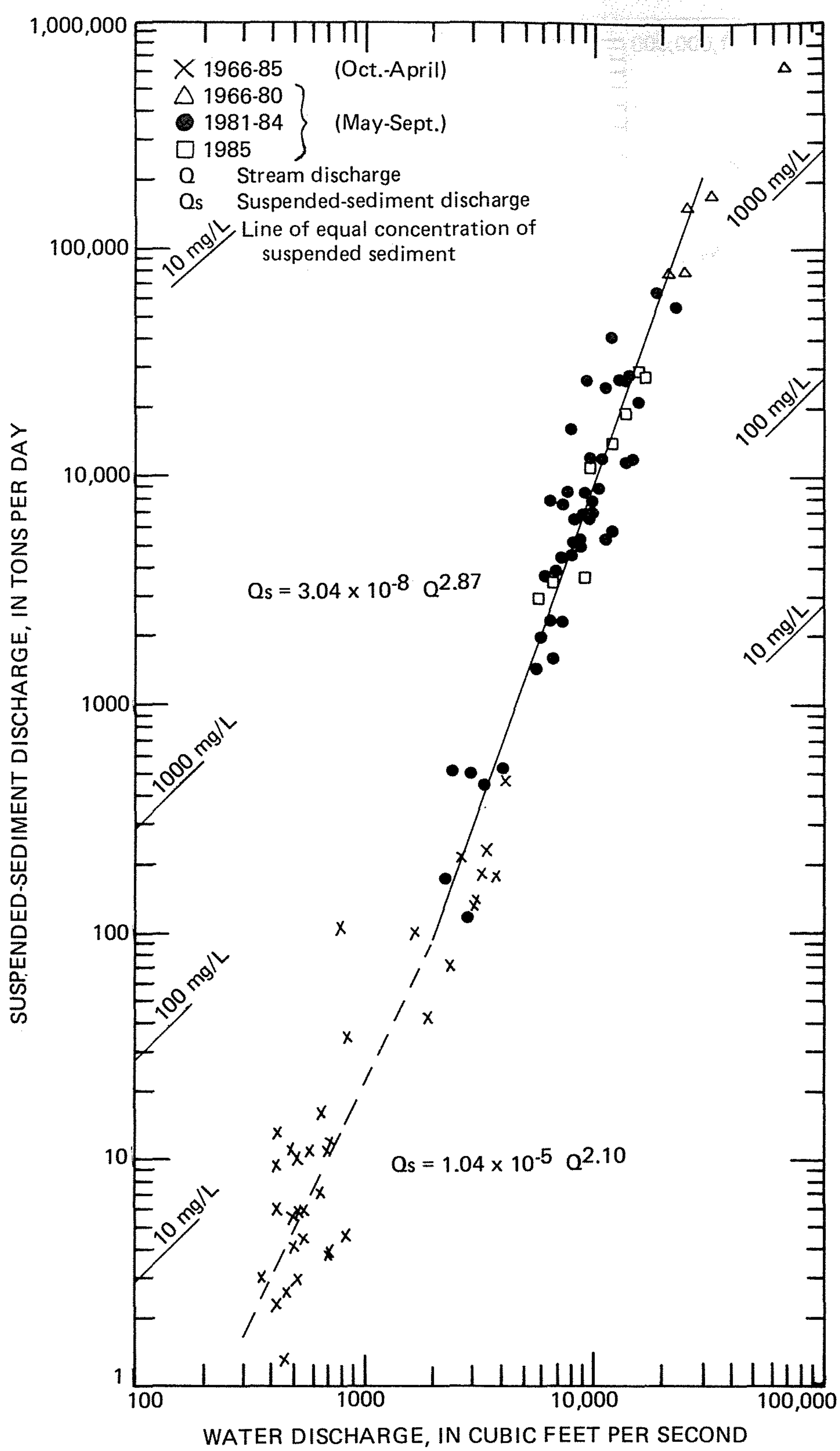

Figure 12.--Relation of mean suspended-sediment concentration and discharge to water discharge for Talkeetna River near Talkeetna, May to September, 1981-85 and October to April, 1966-85.

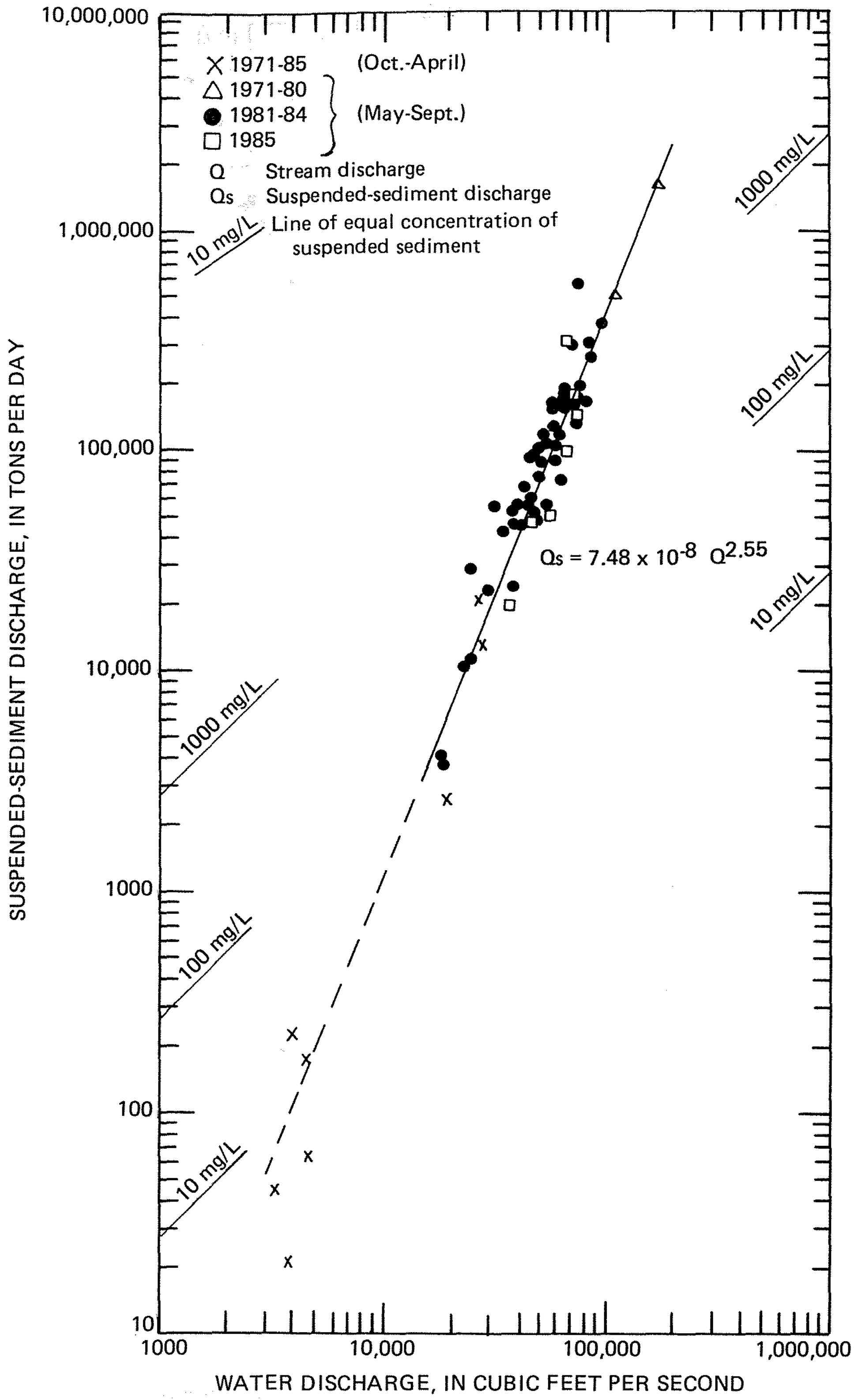

Figure 13.--Relation of mean suspended-sediment concentration and discharge to water discharge for Susitna River at Sunshine, 1981-85.

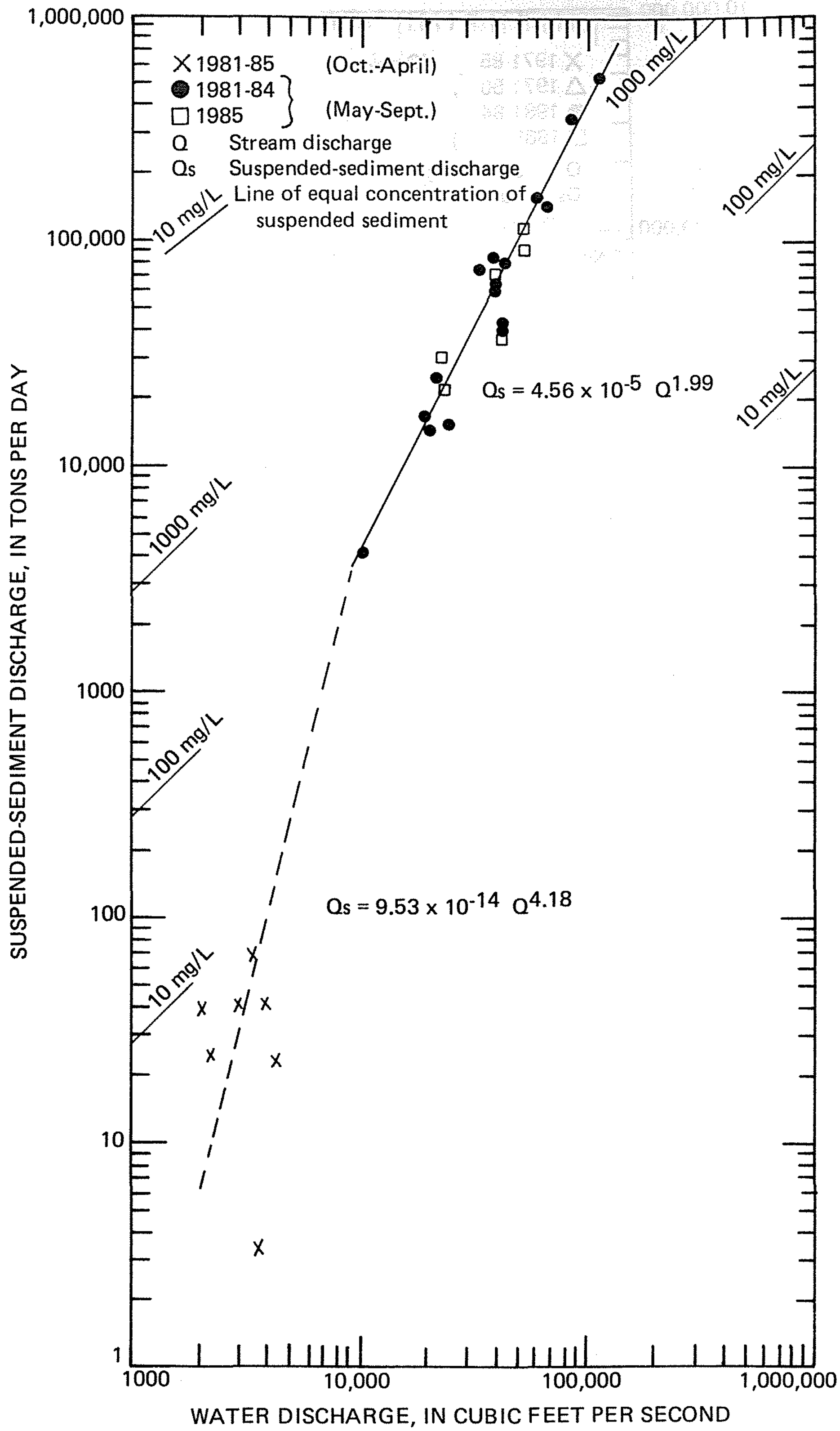

Figure 14.--Relation of mean suspended-sediment concentration and discharge to water discharge for Yentna River near Susitna Station, 1981-85.

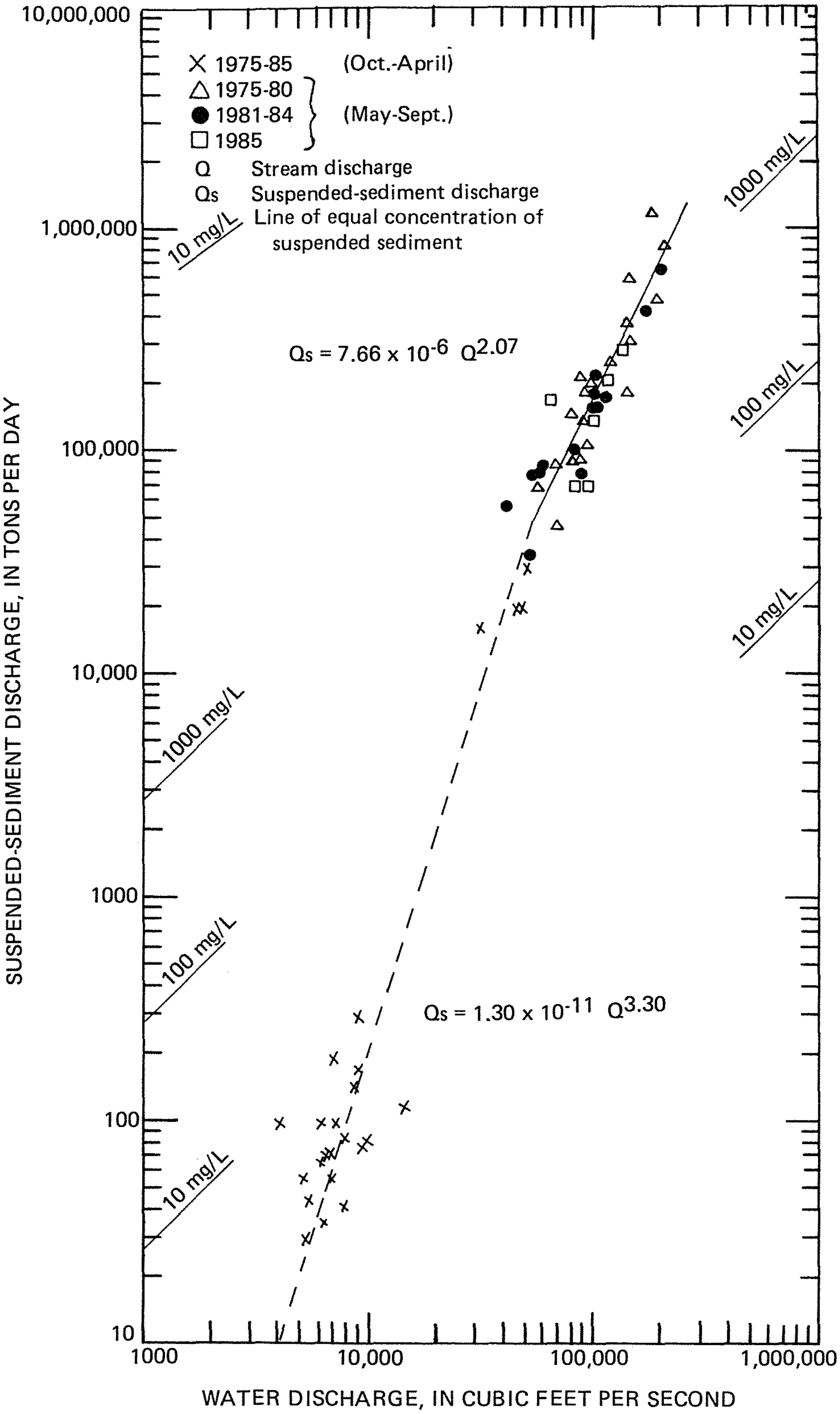

Figure 15.--Relation of mean suspended-sediment concentration and discharge to water discharge for Susitna River at Susitna Station, May to September, 1981-85 and October to April, 1975-85.

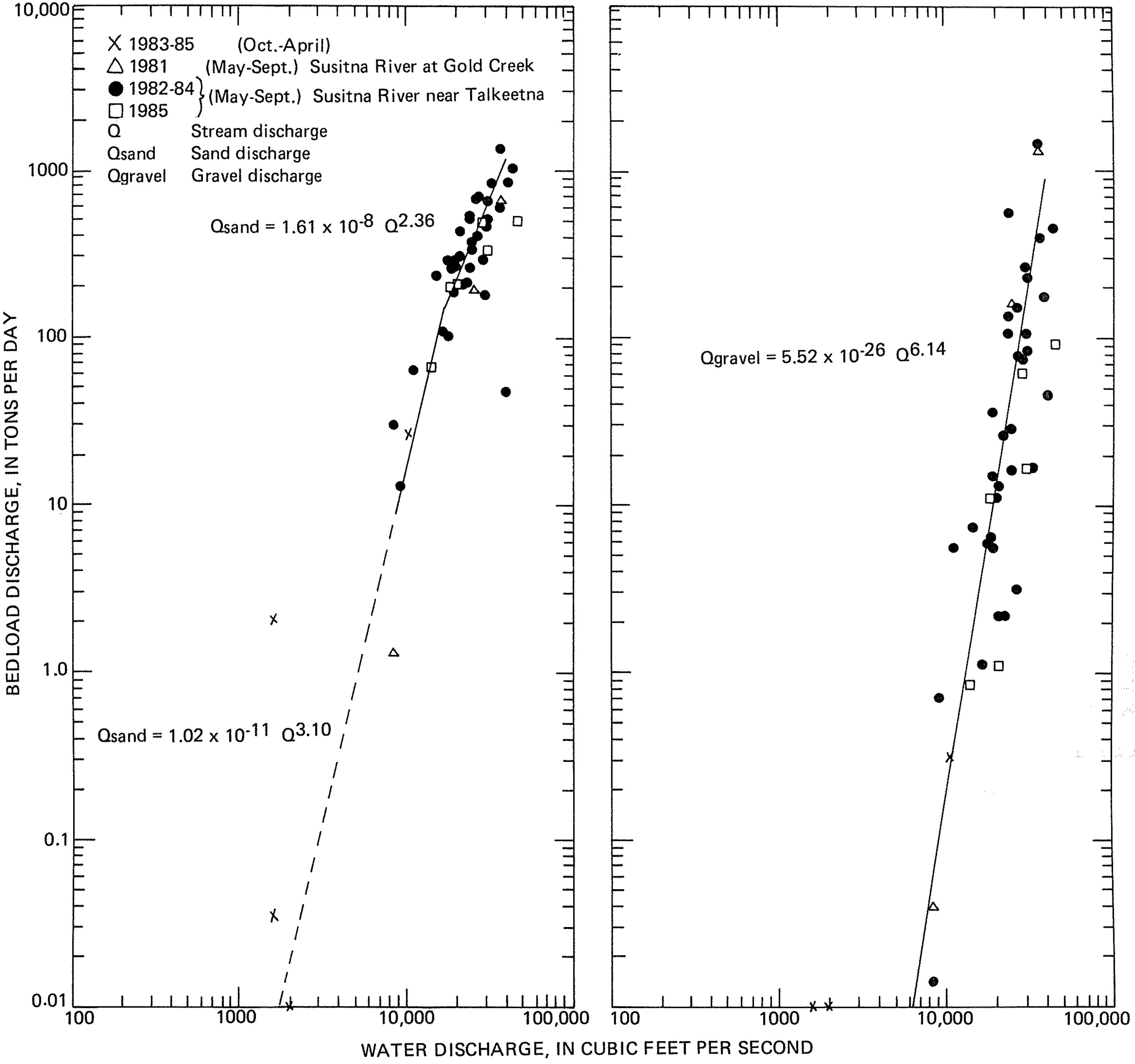

Figure 16.--Bedload-transport curves of sand and gravel for Susitna River near Talkeetna, May to September, 1982-85 and October to April, 1983-85.

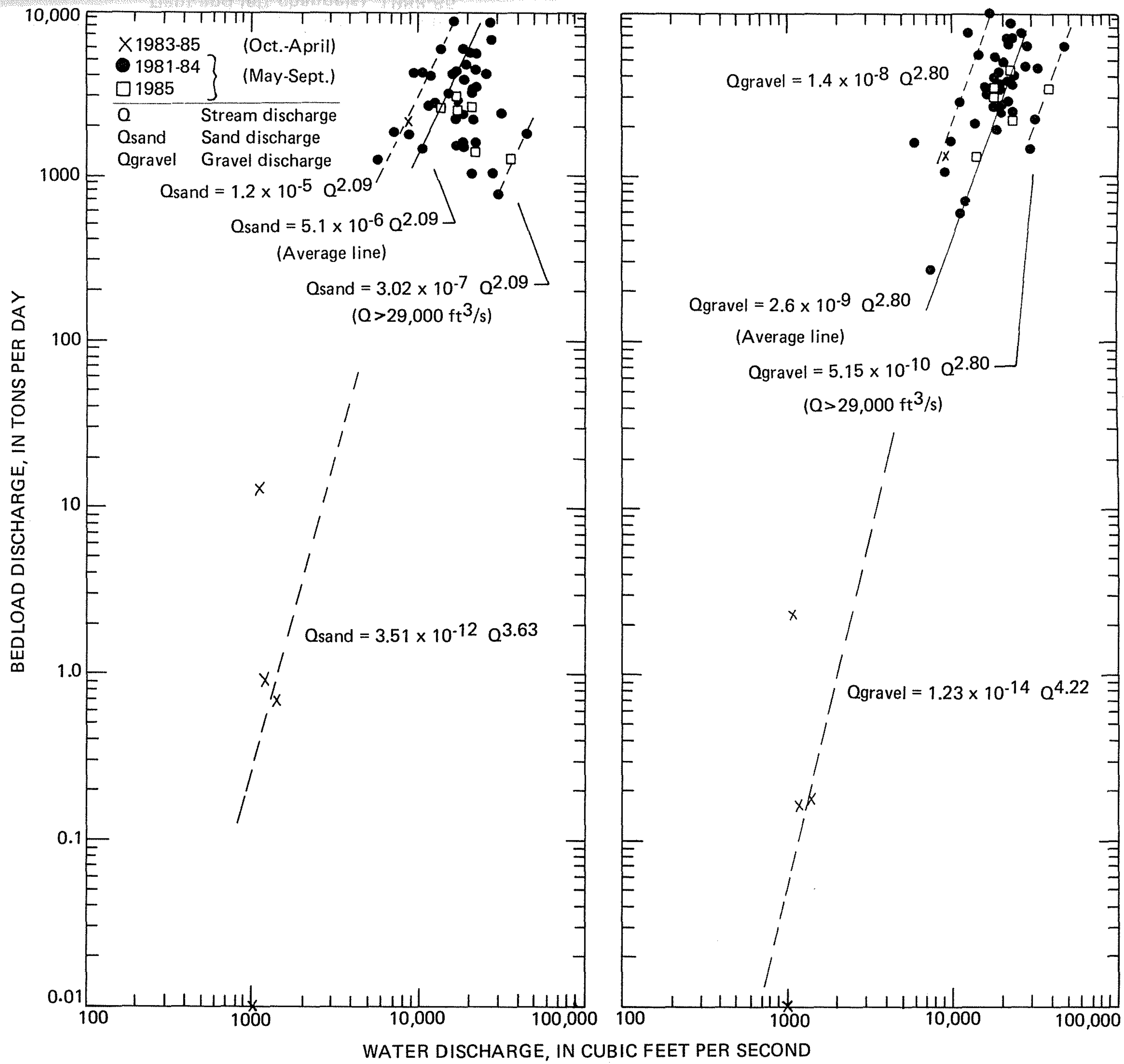

Figure 17.--Bedload-transport curves of sand and gravel for Chulitna River below canyon near Talkeetna, May to September, 1981-85 and October to April, 1983-85.

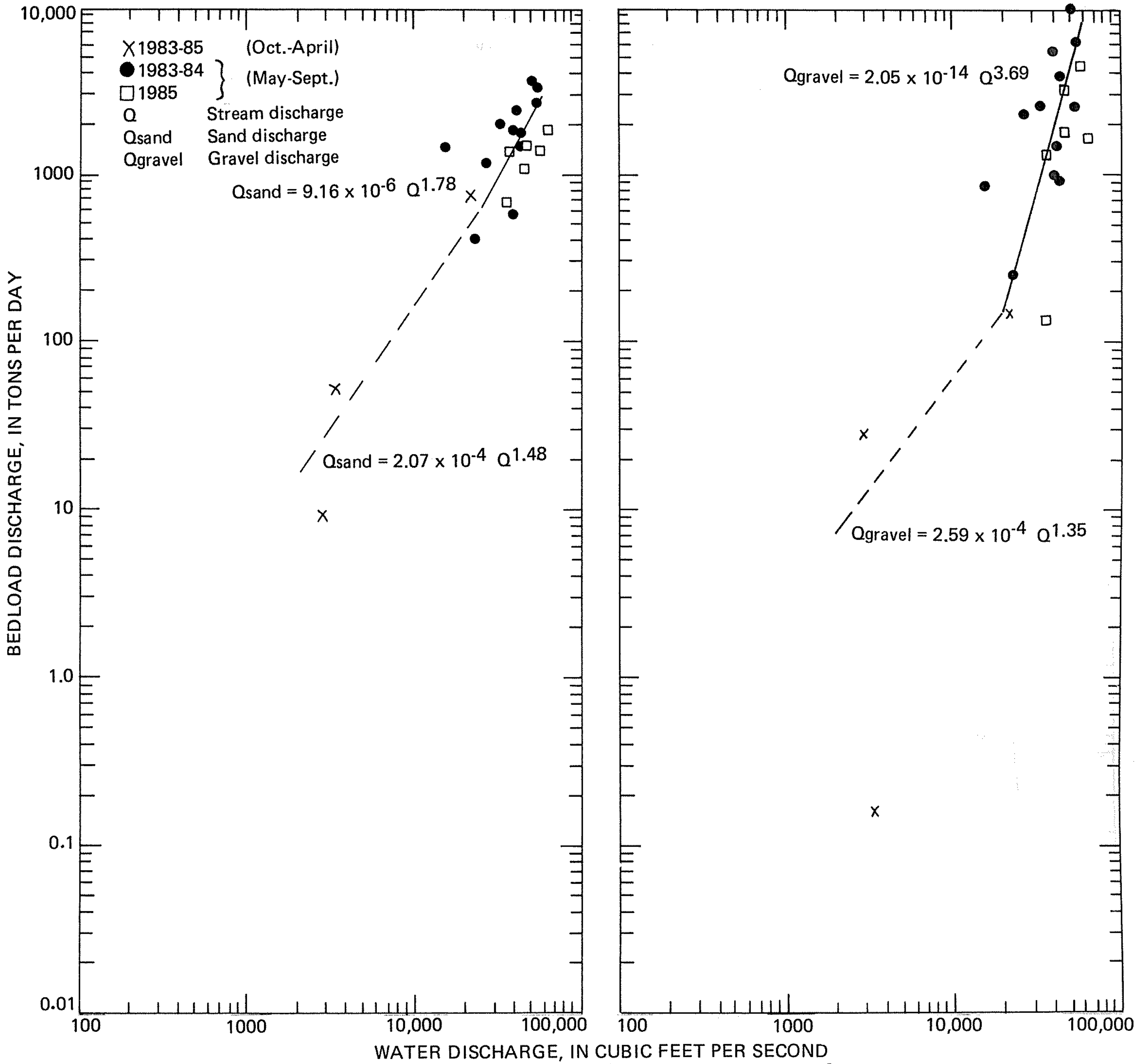

Figure 18.--Bedload-transport curves of sand and gravel for Susitna River below Chulitna River near Talkeetna (sum of right and left channels), 1983-85.

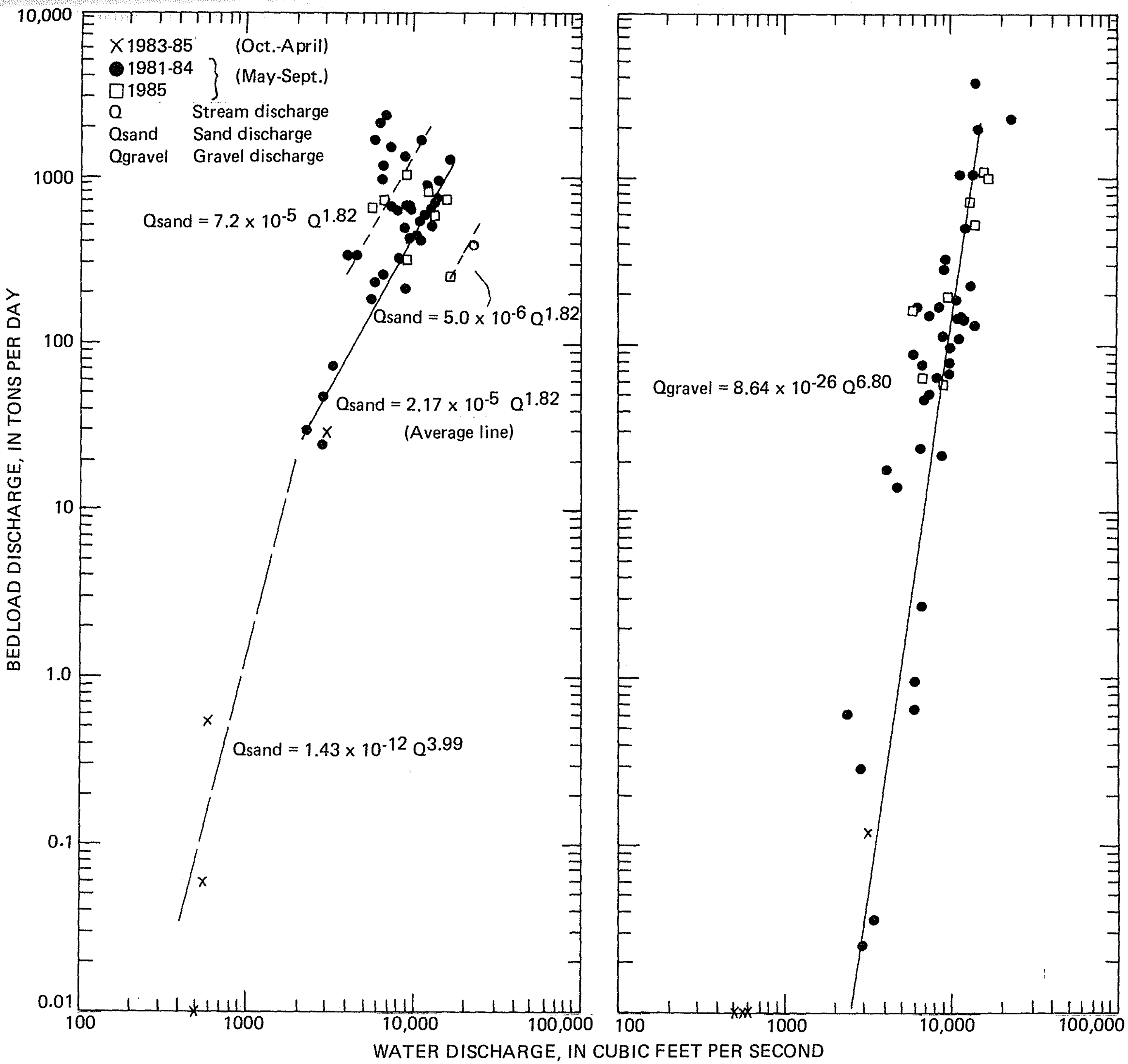

Figure 19.--Bedload-transport curves of sand and gravel for Talkeetna River near Talkeetna, May to September, 1981-85 and October to April, 1983-85.

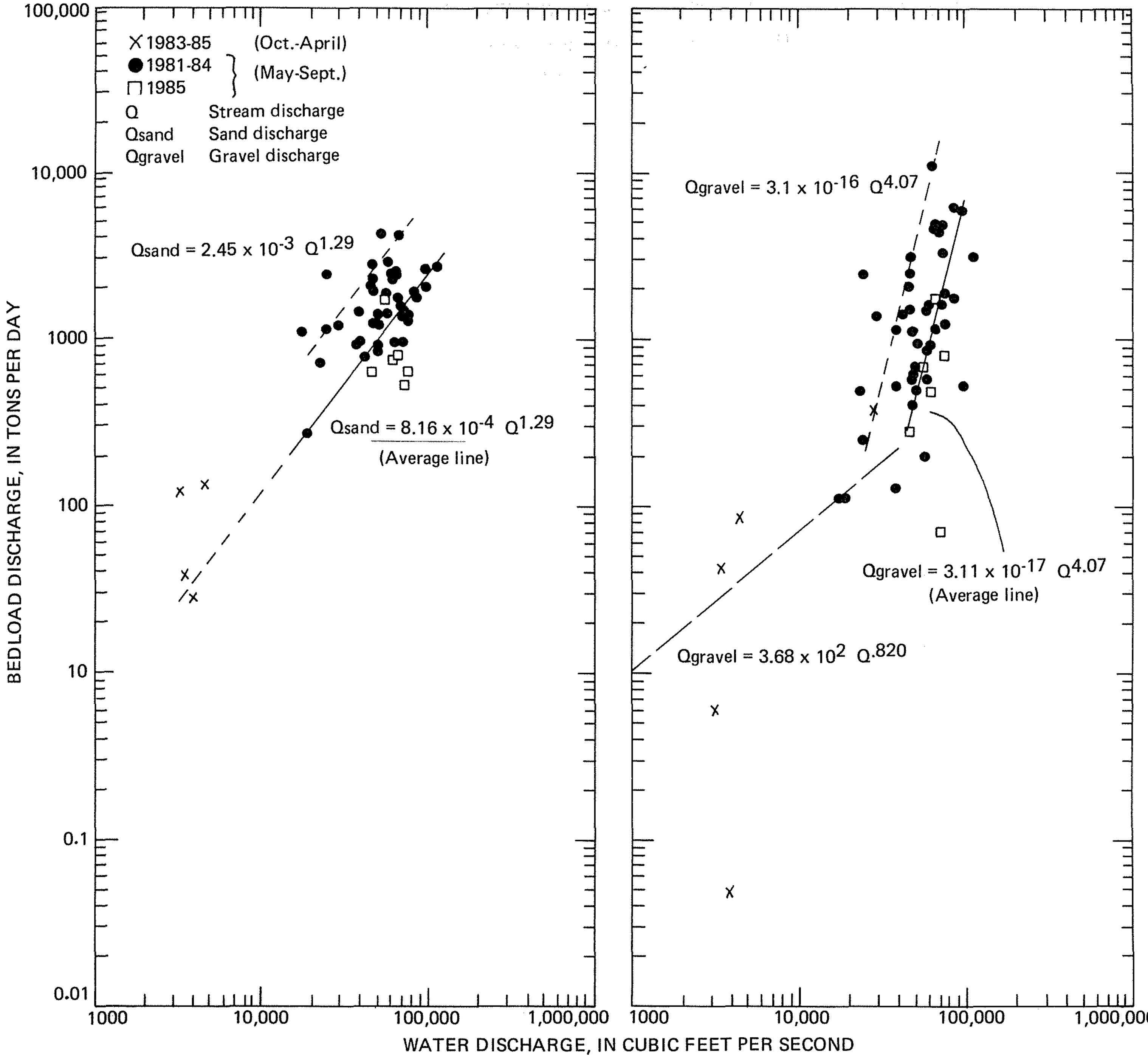

Figure 20.--Bedload-transport curves of sand and gravel for Susitna River at Sunshine, May to September, 1981-85 and October to April, 1983-85.

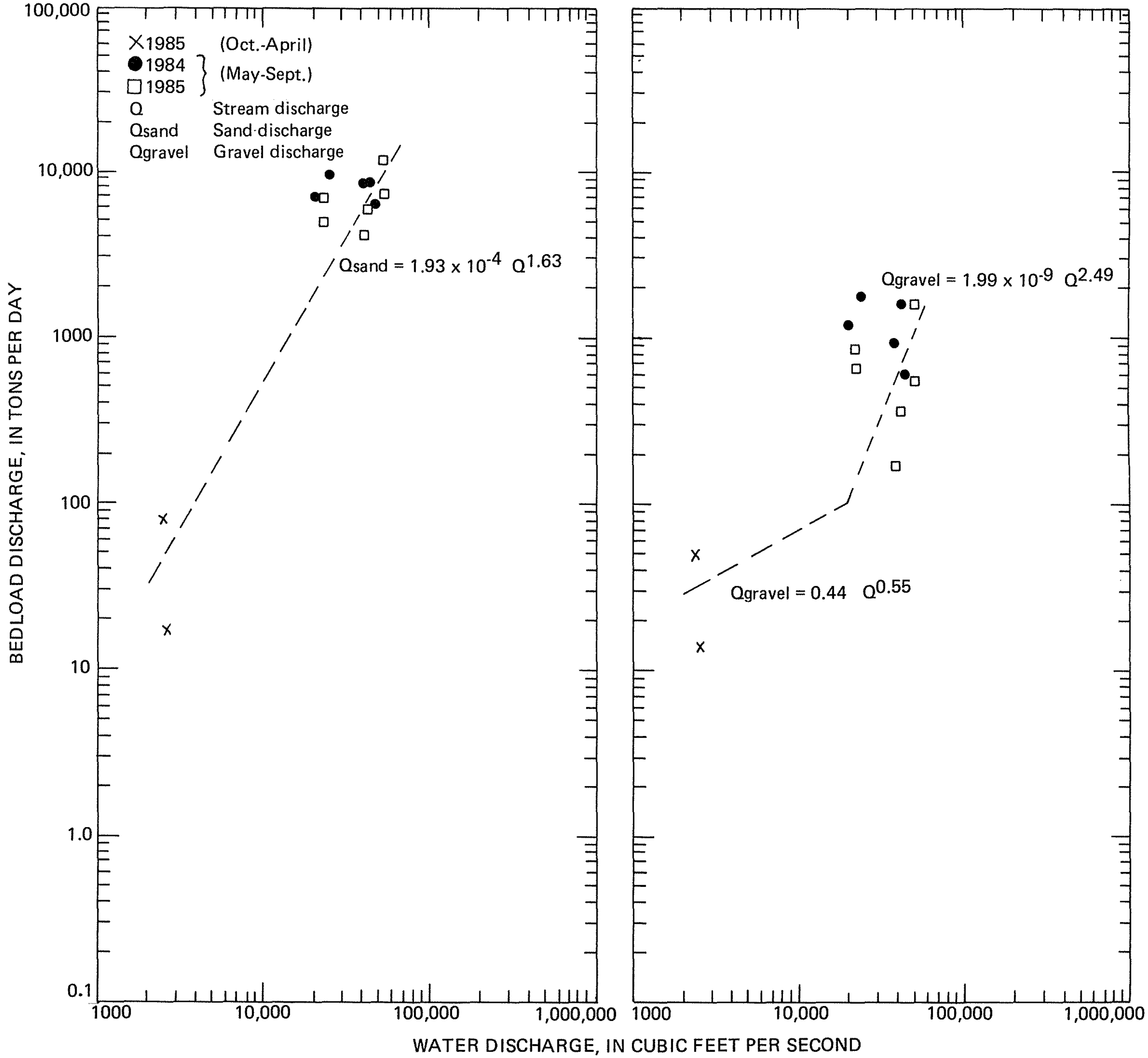

Figure 21.--Bedload-transport curves of sand and gravel for Yentna River near Susitna Station, May to September, 1984-85 and October to April, 1985.

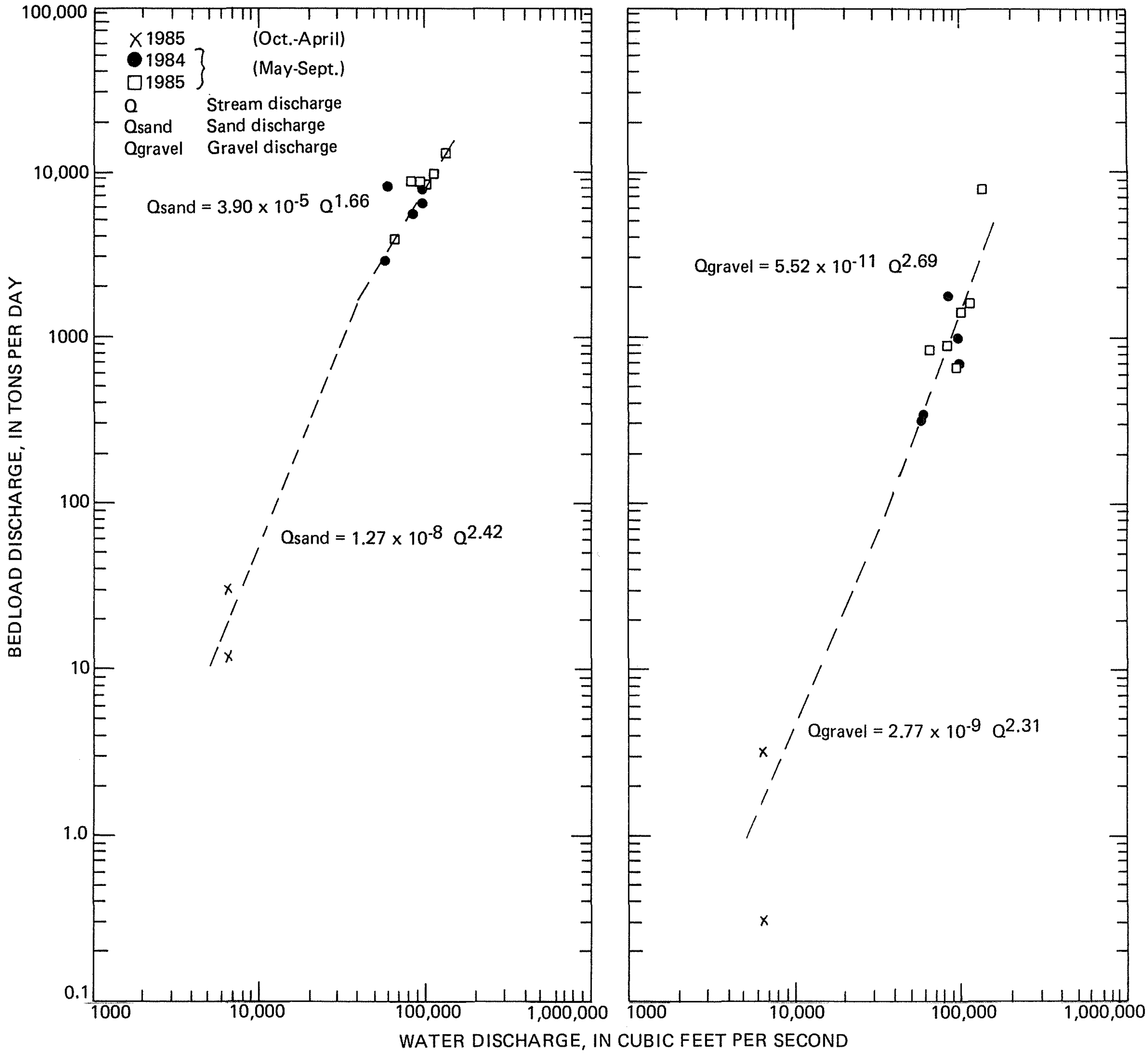

Figure 22.--Bedload-transport curves of sand and gravel for Susitna River at Susitna Station, 1984-85 and October to April, 1985.

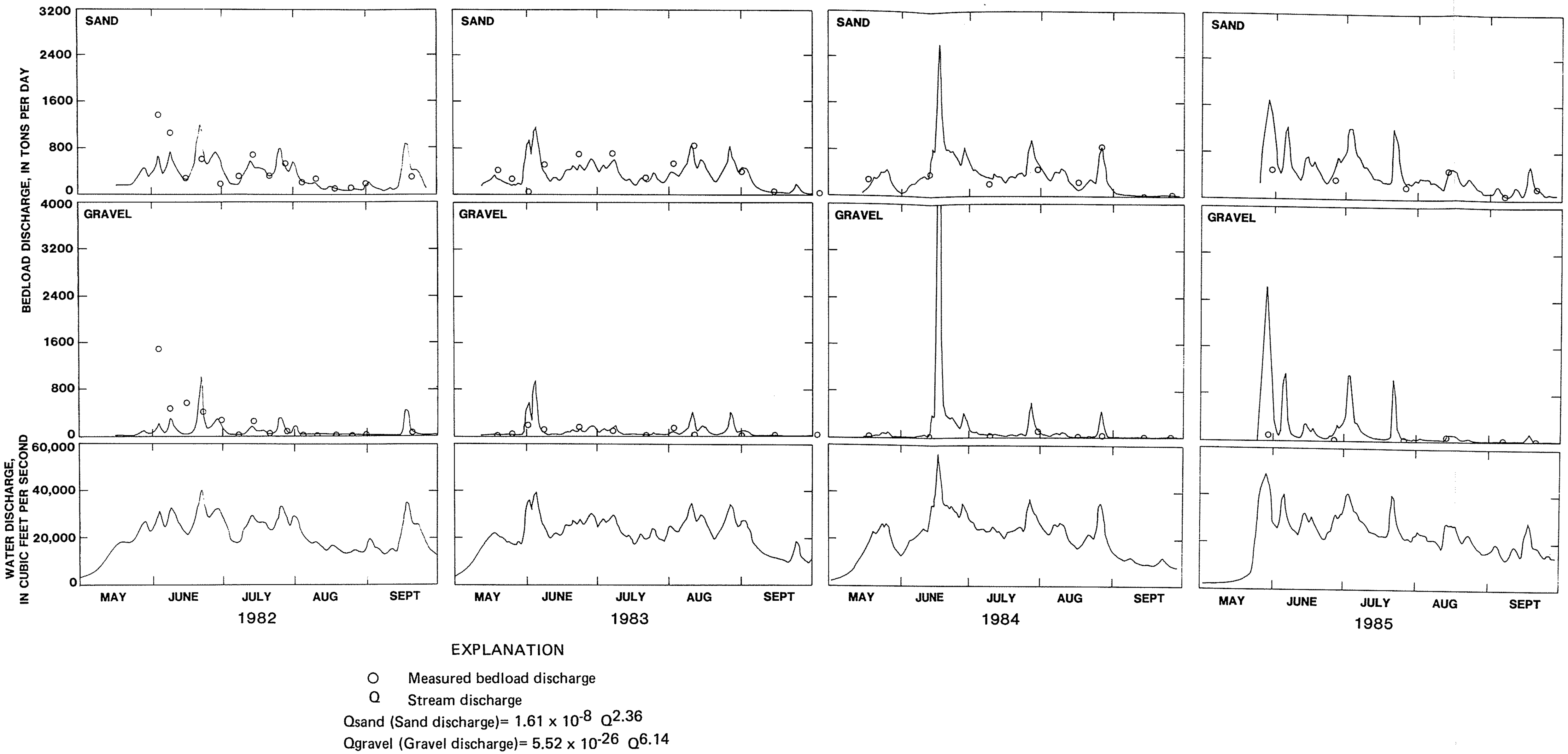

Figure 23.--Variability of water and bedload discharge for Susitna River near Talkeetna, May to September, 1982-85.

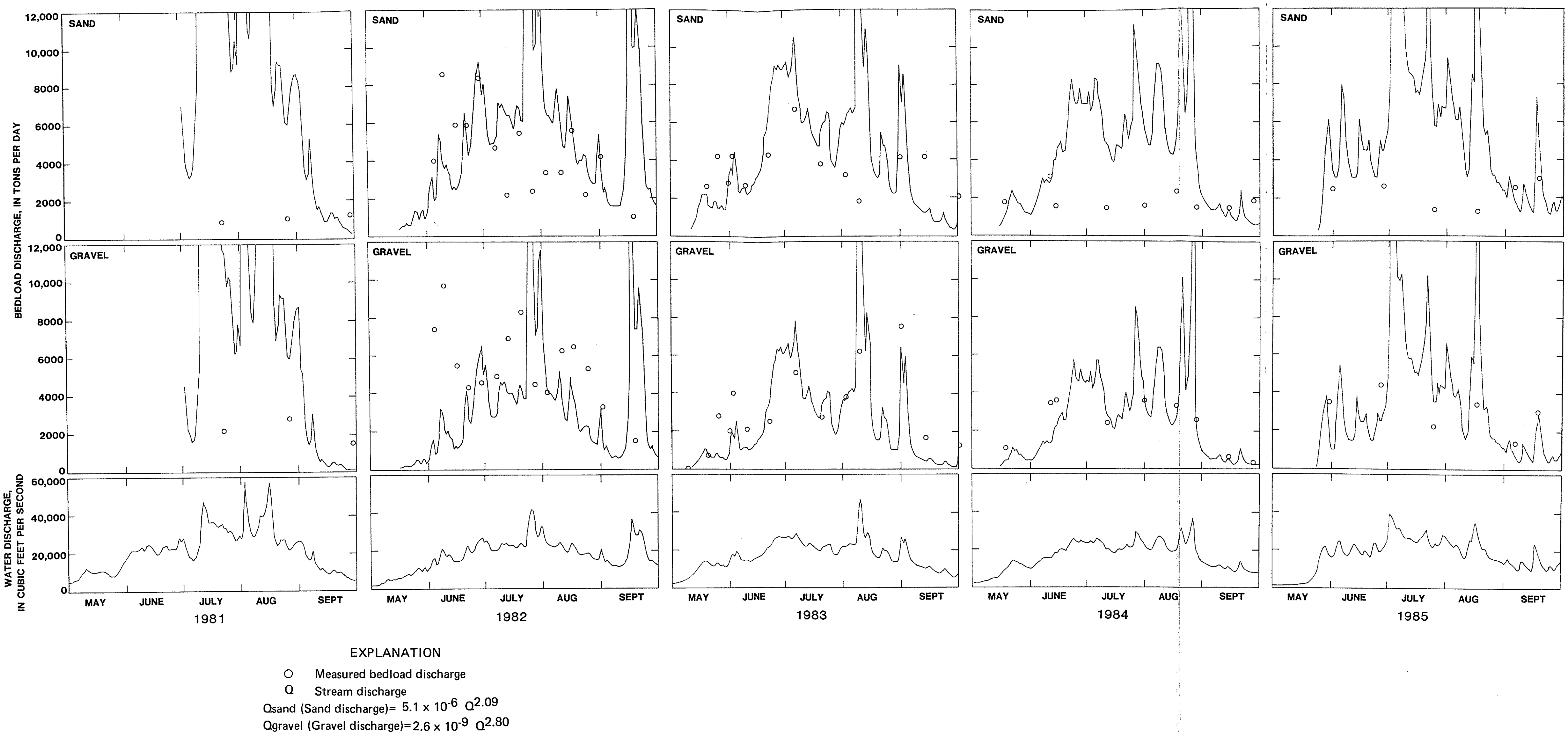

Figure 24.--Variability of water and bedload discharge for Chulitna River below canyon near Talkeetna, May to September, 1981-85.

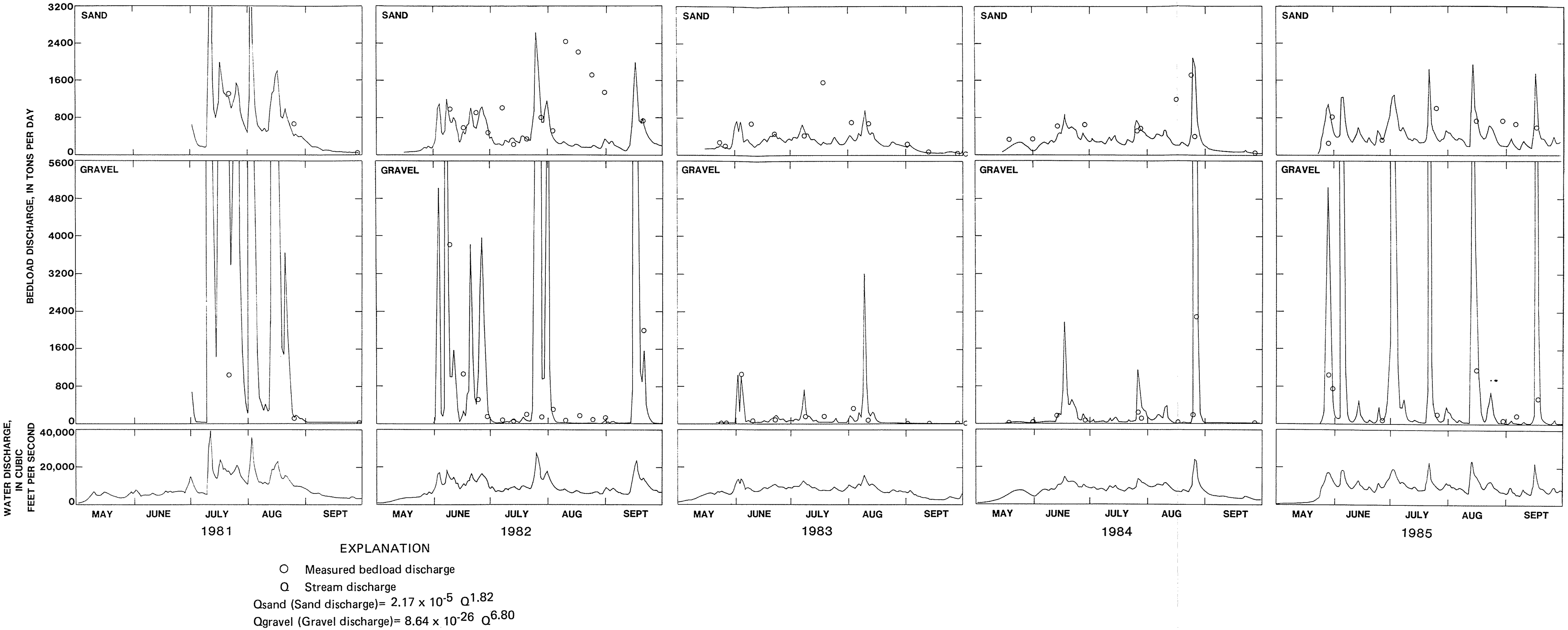

Figure 25.--Variability of water and bedload discharge for Talkeetna River near Talkeetna, May to September, 1981-85.

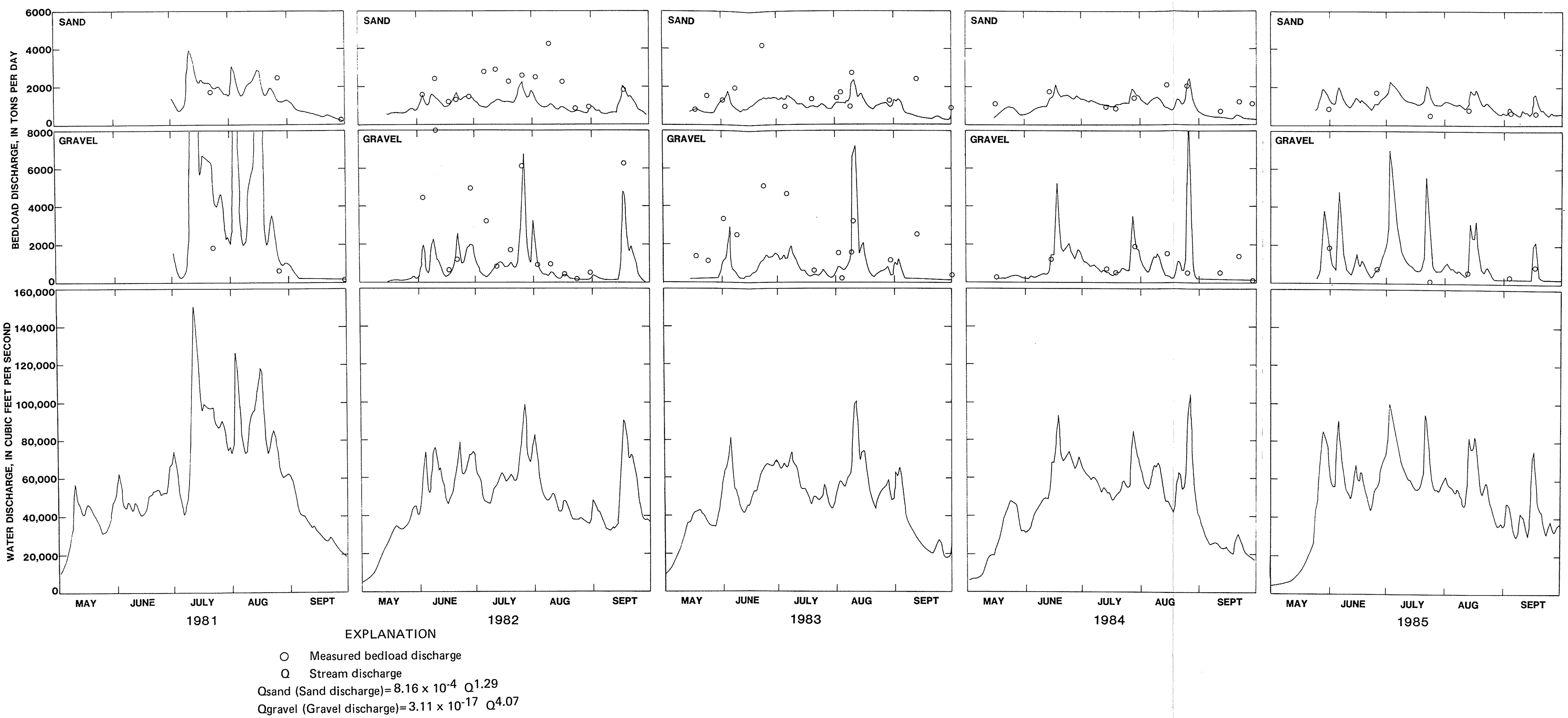

Figure 26.--Variability of water and bedload discharge for Susitna River at Sunshine, May to September, 1981-85.

Table 1.--Summary of streamflow and sediment data for selected stations in the Susitna River basin
[From Still and Jones, 1985 and U.S. Geological Survey, Alaska District files]

Map No. (fig. 1)	Station number	Station name	Drainage area (square mile)	Data type	Period of record
1	625000149223500	Portage Creek near Gold Creek	--	Streamflow	1984
				Suspended sediment	1984
				Bedload	1984
				Bed material	1984
2	624718149393600	Indian Creek near Gold Creek	--	Streamflow	1984
				Suspended sediment	1984
				Bedload	1984
				Bed material	1984
3	15292000	Susitna River at Gold Creek	6,160	Streamflow	1949-85
				Suspended sediment	1952-57, 1962, 1967, 1974-85
				Bedload	1981
				Bed material	1981
4	---	Susitna River at river mile 128.7 near Sherman Creek	--	Bed material	1984
5	---	Susitna River at river mile 125.6 near Skull Creek	--	Bed material	1984
6	15292100	Susitna River near Talkeetna	6,320	Streamflow	1982-85
				Suspended sediment	1982-85
				Bedload	1982-85
				Bed material	1982-85
7	15292400	Chulitna River near Talkeetna	2,570	Streamflow	1958-77, 1979-85
				Suspended sediment	1967-72, 1980-85
				Bedload	1981
				Bed material	1981
8	15292410	Chulitna River below canyon near Talkeetna	2,580	Streamflow	1982-85
				Suspended sediment	1982-85
				Bedload	1982-85
				Bed material	1982-85
9 10	15292439 and 15292440	Susitna River below Chulitna River near Talkeetna	8,950	Streamflow	1983-85
				Suspended sediment	1983-85
				Bedload	1983-85
				Bed material	1983-85
11	15292700	Talkeetna River near Talkeetna	2,006	Streamflow	1964-85
				Suspended sediment	1966-85
				Bedload	1981-85
				Bed material	1981-85
12	15292780	Susitna River at Sunshine	11,100	Streamflow	1981-85
				Suspended sediment	1971, 1977, 1981-85
				Bedload	1981-85
				Bed material	1981-85
13	15294345	Yentna River near Susitna Station	6,180	Streamflow	1980-85
				Suspended sediment	1981-85
				Bedload	1984-85
				Bed material	1984-85
14	15294350	Susitna River at Susitna Station	19,400	Streamflow	1974-85
				Suspended sediment	1975-85
				Bedload	1984-85
				Bed material	1984-85

Table 2.--Suspended-sediment data for selected stations in the Susitna River basin, October 1984 to September 1985

[ft^3/s, cubic feet per second; °C, degrees Celsius; mg/L, milligrams per liter; ton/d, tons per day]

Map No. (fig. 1)	Station name and number	Date of collection	Discharge (ft^3/s)	Water temperature (°C)	Sediment concentration (mg/L)	Sediment discharge (ton/d)	Suspended sediment, 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	1.000
3	Susitna River	May 29	--	--	610		--	--	--	--	--	33	46	58	97	100
	at Gold Creek	June 27	29,800	--	419	33,700	3	7	--	15	--	35	49	74	99	100
	(15292000)	July 24	25,500	--	435	29,900	20	27	34	42	50	58	67	83	99	100
		Aug. 28	14,700	--	97	3,850	--	--	--	--	--	69	77	89	100	--
		Sept. 24	14,400	--	38	1,480	--	--	--	--	--	36	47	70	98	100
6	Susitna River	May 29	46,000	4.0	703	87,300	6	9	--	18	--	37	54	84	99	100
	near	June 26	30,900	9.0	251	20,900	5	8	--	22	--	47	62	81	100	--
	Talkeetna	July 26	21,000	12.5	310	17,600	25	29	41	50	56	62	70	88	100	--
	(15292100)	Aug. 13	30,000	9.5	474	38,400	8	12	18	25	35	47	65	87	100	--
		Sept. 6	14,200	7.5	69	2,650	24	34	43	52	62	68	74	85	99	100
		Sept. 19	18,900	3.5	110	5,610	--	--	--	--	--	43	50	78	99	100
8	Chulitna River	May 31	18,000	2.0	594	28,900	12	18	25	33	43	53	64	82	97	100
	below canyon	June 27	22,700	6.5	1,240	76,000	19	29	40	53	71	80	91	99	100	100
	near	July 24	24,600	6.5	985	65,400	28	40	52	64	72	79	84	92	98	98
	Talkeetna	Aug. 16	38,900	7.0	1,920	202,000	18	26	35	43	53	63	74	89	97	100
	(15292410)	Sept. 5	13,800	4.5	410	15,300	22	31	41	50	57	64	69	80	96	100
		Sept. 17	18,200	3.0	544	26,700	16	23	30	36	42	49	58	76	99	100
9	Susitna River	May 30	34,000	2.5	912	83,700	9	14	20	28	38	52	66	81	99	100
	below Chulitna	June 25	31,500	7.5	591	50,300	20	29	38	46	54	64	73	85	98	100
	River (right	July 25	33,700	10.5	1,120	102,000	23	33	45	55	64	73	76	84	98	100
	channel) near	Aug. 15	39,000	7.5	3,400	358,000	9	15	22	32	45	69	85	92	98	100
	Talkeetna	Sept. 4	26,000	8.0	365	25,600	10	19	--	39	--	53	60	64	93	100
	(15292439)	Sept. 18	27,000	3.5	388	28,300	12	17	--	28	--	39	45	65	96	100
10	Susitna River	May 30	24,000	3.5	554	35,900	--	--	--	--	--	37	50	80	100	--
	below Chulitna	June 25	14,400	9.0	193	7,500	7	13	--	26	--	40	47	74	100	--
	River (left	July 25	13,600	12.0	390	14,300	22	31	41	49	58	63	72	91	100	--
	channel) near	Aug. 15	25,000	10.0	508	34,300	11	16	23	33	45	58	71	93	100	--
	Talkeetna	Sept. 4	9,800	10.0	126	3,330	21	29	--	52	--	70	77	92	100	--
	(15292440)	Sept. 18	10,000	4.0	222	5,990	--	--	--	--	--	40	48	83	100	--
11	Talkeetna	Jan. 11	712	0.0	2	3.8	--	--	--	--	--	--	--	--	--	--
	River near	May 28	17,100	3.0	607	28,000	5	9	--	19	--	39	56	83	95	100
	Talkeetna	May 30	12,600	--	409	13,900	--	--	--	--	--	18	30	67	94	100
	(15292700)	June 26	9,320	6.0	146	3,670	--	--	--	--	--	26	38	64	100	--
		July 25	9,730	--	418	11,000	14	20	27	35	42	50	60	85	99	100
		Aug. 15	15,900	8.5	680	29,200	11	18	25	34	43	52	63	81	96	100
		Aug. 29	6,800	8.5	192	3,530	--	--	--	--	--	22	33	55	97	100
		Sept. 5	5,860	8.0	181	2,860	--	--	--	--	--	19	--	--	--	--
		Sept. 16	13,900	6.0	503	18,900	--	--	--	--	--	34	49	81	99	100
12	Susitna River	March 19	4,000	0.0	21	227	--	--	--	--	--	48	65	83	100	--
	at Sunshine	May 31	66,600	3.5	560	101,000	6	9	--	19	--	35	52	83	99	100
	(15292780)	June 25	55,600	--	333	50,000	15	23	32	39	48	57	65	80	100	--
		July 23	72,200	11.0	912	178,000	18	27	36	46	53	64	72	88	100	--
		Aug. 12	67,700	8.5	1,680	307,000	8	13	20	32	52	73	88	96	100	--
		Sept. 3	46,400	--	381	47,700	16	25	33	41	49	57	66	83	99	100
		Sept. 16	75,700	6.5	710	145,000	11	17	23	32	42	56	73	93	99	100
		Sept. 24	36,800	4.0	199	19,800	6	9	--	19	--	34	46	78	99	100
13	Yentna River	May 23	23,100	5.0	494	30,800	6	9	--	22	--	52	76	98	100	--
	near Susitna	June 20	42,800	8.5	322	37,200	--	--	--	--	--	34	48	83	100	--
	Station	July 17	53,700	10.5	784	114,000	21	30	40	49	57	64	73	87	100	--
	(15294345)	Aug. 14	52,600	9.0	657	93,300	17	25	--	42	--	61	72	90	100	--
		Aug. 19	39,800	8.0	669	71,900	20	29	38	47	55	63	73	89	100	--
		Sept. 18	22,700	4.0	355	21,800	14	19	23	26	30	35	44	72	99	100
14	Susitna River	March 27	6,020	--	4	65	--	--	--	--	--	79	--	--	--	--
	at Susitna	May 24	65,000	4.5	958	168,000	4	6	--	16	--	45	65	90	100	--
	Station	June 21	95,700	9.0	272	70,300	11	17	--	31	--	47	58	86	100	--
	(15294350)	July 18	116,000	12.5	656	205,000	26	38	50	61	70	79	86	97	100	--
		Aug. 14	137,000	9.5	762	282,000	14	21	29	37	49	61	74	91	100	--
		Aug. 20	101,000	--	496	135,000	20	29	39	48	57	68	80	97	100	--
		Sept. 19	85,000	4.5	306	70,200	11	15	--	28	--	46	64	94	100	--

Table 3.--Hydraulic and bedload data for selected stations in the Susitna River basin, October 1984 to September 1985
[ft^3/s, cubic feet per second; ft/s, feet per second; ton/d, tons per day; mm, millimeters]

Map No. (fig. 1)	Station name and number	Date of collection	Water discharge (ft^3/s)	Average depth (feet)	Width (feet)	Average velocity (ft/s)	Bedload discharge (ton/d)	Particle-size distribution of bed sediment: Percentage, by weight, finer than size (mm) indicated											
								0.062	0.125	0.25	0.50	1.0	2.0	4.0	8.0	16.0	32.0	64.0	76.0
6	Susitna River	Feb. 21	1,600	--	--	--	0.04	--	--	0	81	99	99	100	--	--	--	--	--
	near	May 29	46,400	7.8	658	9.0	590	--	0	2	65	82	84	86	88	91	100	--	--
	Talkeetna	June 26	30,600	6.3	621	7.8	348	--	0	1	72	94	95	96	98	100	--	--	--
	(15292100)	July 26	21,000	5.8	607	5.9	212	--	0	1	82	99	100	--	--	--	--	--	--
		Aug. 13	29,400	6.3	622	7.5	560	--	0	1	68	88	89	90	91	91	100	--	--
		Sept. 6	14,300	4.2	560	6.0	67	--	--	0	70	98	99	99	100	--	--	--	--
		Sept. 19	18,900	5.2	594	6.1	212	--	0	1	75	94	95	96	96	100	--	--	--
8	Chulitna River	Feb. 27	1,200	--	--	--	1.1	--	0	2	19	68	85	89	93	100	--	--	--
	below canyon	April 4	1,100	--	--	--	15	--	--	0	6	76	85	98	100	--	--	--	--
	near	May 31	18,300	7.6	340	7.0	6,010	--	0	1	12	35	42	53	71	82	95	100	--
	Talkeetna	June 27	22,300	8.6	345	7.5	6,990	--	0	1	15	33	37	43	50	65	83	98	100
	(15292410)	July 24	23,600	9.2	345	7.4	3,590	--	0	1	13	31	39	46	55	71	92	100	--
		Aug. 16	39,000	11.1	395	8.9	4,670	--	0	1	12	24	27	34	46	61	80	100	--
		Sept. 5	14,300	7.4	338	5.7	3,900	--	0	1	20	50	66	73	79	88	97	100	--
		Sept. 17	18,200	8.2	340	6.5	6,020	--	0	1	18	45	51	56	63	76	92	100	--
9	Susitna River	Feb. 10	1,300	--	--	--	37	--	0	1	10	20	24	29	38	49	57	100	--
	below	May 30	34,000	3.7	1,100	8.4	5,530	--	--	0	9	18	21	25	40	67	92	100	--
	Chulitna River	June 25	31,500	4.3	810	9.1	3,610	--	--	0	7	11	12	15	22	40	75	100	--
	(right	July 25	33,700	5.0	940	7.2	2,740	--	--	0	13	34	38	43	53	71	93	100	--
	channel) near	Aug. 15	39,000	3.3	1,660	7.1	2,440	--	0	1	22	41	45	48	55	70	87	100	--
	Talkeetna	Sept. 4	26,000	4.6	820	6.9	680	--	0	1	45	79	83	86	89	92	94	100	--
	(15292439)	Sept. 18	27,000	4.8	820	6.9	2,320	--	0	1	25	43	46	52	59	72	96	100	--
10	Susitna River	Feb. 20	1,600	--	--	--	0.10	--	0	3	58	92	99	100	--	--	--	--	--
	below	May 30	24,000	2.9	1,540	5.4	290	0	1	5	59	76	78	80	82	88	93	100	--
	Chulitna River	June 25	14,400	3.6	790	5.1	741	--	0	6	80	90	90	92	92	93	96	100	--
	(left channel)	July 25	13,600	3.4	740	5.4	572	--	0	2	62	78	79	80	82	86	96	100	--
	near	Aug. 15	25,000	2.7	1,700	5.4	1,030	--	0	2	58	74	75	76	77	80	85	100	--
	Talkeetna	Sept. 4	9,800	3.2	540	5.7	135	--	0	1	63	84	86	88	90	98	100	--	--
	(15292440)	Sept. 18	10,000	2.8	780	4.7	371	--	0	1	75	85	85	86	87	88	97	100	--
11	Talkeetna	Feb. 28	490	--	--	--	0	--	--	--	--	--	--	--	--	--	--	--	--
	River near	May 28	17,100	7.0	350	7.0	1,290	--	--	0	8	15	20	23	29	41	61	82	100
	Talkeetna	May 30	12,600	--	--	--	1,570	--	0	2	25	49	53	57	65	77	93	100	--
	(15292700)	June 26	9,420	5.0	340	5.6	384	--	--	0	42	81	85	86	88	90	98	100	--
		July 25	9,630	5.2	334	5.5	1,220	--	0	3	48	80	84	86	88	91	97	100	--
		Aug. 15	15,800	6.6	342	7.0	1,850	--	0	1	16	36	40	42	44	52	69	94	100
		Aug. 29	6,860	4.3	328	4.8	802	--	0	1	36	89	92	95	97	99	100	--	--
		Sept. 5	5,900	3.9	327	4.6	836	--	--	0	34	80	89	94	96	97	99	100	--
		Sept. 16	13,800	5.8	350	6.8	1,140	--	0	2	31	53	55	58	63	71	88	100	--
12	Susitna River	Feb. 26	3,500	--	--	--	81	--	0	1	24	46	47	50	55	59	70	100	--
	at Sunshine	April 9	3,900	--	--	--	28	--	--	0	46	93	98	99	100	--	--	--	--
	(15292780)	May 31	67,400	10.6	945	6.7	2,590	--	0	3	22	30	31	34	52	72	90	100	--
		June 25	55,600	9.1	945	6.4	2,380	--	0	1	44	70	71	73	75	80	92	100	--
		July 23	72,900	--	--	--	584	0	1	6	72	87	88	89	90	92	95	100	--
		Aug. 12	63,100	10.3	955	6.4	1,260	0	1	2	48	60	62	64	69	81	99	100	--
		Sept. 3	46,900	7.8	937	6.5	919	--	0	2	52	68	70	72	76	87	97	100	--
		Sept. 16	76,500	11.0	950	7.3	1,430	--	0	1	27	40	44	48	57	78	92	100	--
13	Yentna River	Feb. 28	2,600	--	--	--	31	--	--	0	34	55	56	67	85	100	--	--	--
	near Susitna	April 4	2,400	--	--	--	130	--	0	2	30	52	61	69	82	96	100	--	--
	Station	May 23	23,300	6.8	1,275	2.7	5,720	0	1	14	66	82	85	86	88	94	99	100	--
	(15294345)	June 20	42,600	8.5	1,280	3.9	6,130	--	0	3	70	91	94	96	98	99	100	--	--
		July 17	54,200	9.4	1,290	4.5	8,070	--	0	3	60	90	93	95	98	99	100	--	--
		Aug. 14	52,800	8.7	1,290	4.7	13,300	--	0	2	47	84	88	92	96	99	100	--	--
		Aug. 19	39,700	7.7	1,285	4.0	4,360	--	0	3	57	92	96	97	99	100	--	--	--
		Sept. 18	22,600	5.5	1,285	3.2	7,490	--	0	2	47	84	91	95	98	100	--	--	--
14	Susitna River	Feb. 28	6,500	--	--	--	15	--	0	3	71	79	79	82	89	100	--	--	--
	at Susitna	April 4	6,500	--	--	--	30	--	0	1	77	99	99	100	--	--	--	--	--
	Station	May 24	64,900	8.1	1,670	4.8	4,690	0	1	6	65	81	82	82	85	90	97	100	--
	(15294350)	June 21	94,500	13.5	1,880	3.7	9,240	--	0	4	65	90	93	95	96	98	100	--	--
		July 18	117,000	12.2	1,880	5.1	11,200	--	0	3	62	84	86	89	92	95	99	100	--
		Aug. 14	138,000	14.3	1,880	5.1	20,900	--	0	2	34	57	62	68	76	85	94	100	--
		Aug. 20	102,000	10.8	1,870	5.0	10,100	0	1	8	63	81	86	89	91	94	98	100	--
		Sept. 19	85,000	9.7	1,880	4.6	9,820	0	1	7	53	86	91	94	96	99	100	--	--

Table 4.--Bed-material data for selected stations in the Susitna River basin, May to September 1985
(Sampling point stationing from left bank)

Map No. (fig. 1)	Station name and number	Date of collection	Sampling point	Sample type	Bed material: Percent finer than size indicated, in millimeter 0.062	0.125	0.25	0.50	1.0	2.0	4.0	8.0	16.0	32.0	64.0	128.0
6	Susitna River	May 31	60a	dredged	--	--	--	--	--	--	--	--	--	--	--	--
	near Talkeetna		160a	dredged	--	--	--	--	--	--	--	--	--	--	--	--
	(15292100)		260b	dredged	--	--	--	0	1	1	2	4	9	17	39	100
			360b	dredged	--	--	--	--	--	--	--	--	0	1	4	100
			460c	dredged	--	--	--	--	--	--	--	--	--	--	0	100
			560c	dredged	--	--	--	--	--	--	--	--	--	0	2	100
8	Chulitna River	May 31	50a	dredged	--	--	--	--	--	--	--	--	--	--	--	--
	below canyon		100b	dredged	--	--	0	1	1	2	13	36	62	90	100	--
	near Talkeetna		150b	dredged	--	--	0	2	11	14	18	36	45	69	100	--
	(15292410)		200b	dredged	--	--	0	1	2	11	33	67	89	98	100	--
			250b	dredged	--	--	--	0	1	1	4	6	6	9	66	100
9	Susitna River	May 30	3700bd	dredged	--	--	--	--	--	0	1	2	6	12	42	100
	below Chulitna		3800bd	dredged	--	--	--	--	--	0	1	2	4	11	47	100
	River (right		3900bd	dredged	--	--	0	1	3	6	10	23	47	85	95	100
	channel) near															
	Talkeetna															
	(15292439)															
10	Susitna River	May 30	700bd	dredged	--	--	0	2	3	4	4	4	5	16	71	100
	below Chulitna		800bd	dredged	--	--	--	--	--	--	--	0	1	29	100	--
	River (left		900cd	dredged	--	--	--	--	--	--	--	0	1	1	1	100
	channel)															
	near Talkeetna	June 26	1100bd	surface	--	0	1	1	1	1	1	1	2	9	32	100
	(15292440)		1100bd	sub-sur	2	4	6	12	18	22	27	34	47	68	88	100
			1300bd	surface	1	2	4	5	5	5	6	7	27	68	100	--
			1300bd	sub-sur	1	4	8	19	26	30	35	48	69	96	100	--
			1500bd	surface, sub-sur	0	2	15	83	100	--	--	--	--	--	--	--
			1700bd	surface	0	1	2	2	3	3	3	3	6	39	86	100
			1700bd	sub-sur	2	5	11	18	22	22	24	29	47	73	97	100
			1900bd	surface	1	2	3	4	4	4	4	4	7	27	79	100
			1900bd	sub-sur	2	4	8	15	27	28	34	45	61	80	100	--
			2100bd	surface, sub-sur	9	27	79	98	100	--	--	--	--	--	--	--
			2380bd	surface, sub-sur	45	92	99	100	--	--	--	--	--	--	--	--
			2560bd	surface	1	2	3	3	3	3	4	4	9	19	100	--
			2560bd	sub-sur	2	4	9	14	16	18	22	29	41	58	89	100
			2770bd	surface	--	--	0	1	1	1	1	1	5	29	78	100
			2770bd	sub-sur	2	4	8	14	18	20	24	35	50	76	88	100
11	Talkeetna River	May 28	50a	dredged	--	--	--	--	--	--	--	--	--	--	--	--
	near Talkeetna		100b	dredged	--	--	0	1	6	6	6	6	6	7	22	100
	(15292700)		150c	dredged	--	--	--	--	--	--	--	--	--	0	1	100
			200b	dredged	--	--	--	--	--	--	0	1	6	26	100	--
			250b	dredged	--	--	--	--	--	--	--	--	0	2	21	100
			300c	dredged	--	--	--	--	--	--	--	--	--	--	0	100
12	Susitna River	July 23	200c	dredged	--	--	--	--	--	--	--	--	--	--	0	100
	at Sunshine		300b	dredged	--	--	--	--	--	--	--	--	--	0	11	100
	(15292780)		400b	dredged	--	--	--	--	--	0	1	2	3	9	39	100
			500b	dredged	--	--	--	--	--	--	--	0	1	3	27	100
			600b	dredged	--	--	0	2	3	3	3	4	4	8	100	--
			700b	dredged	--	--	--	--	--	--	--	--	0	8	--	--
			800b	dredged	11	52	97	99	99	100	--	--	--	--	--	--
			900b	dredged	--	--	0	13	57	96	96	97	97	97	100	--
13	Yentna River	Aug. 14	200b	dredged	--	0	2	38	88	80	94	94	99	100	--	--
	near Susitna		400b	dredged	--	0	5	64	90	92	93	95	98	100	--	--
	Station		600b	dredged	--	0	6	65	92	95	96	97	99	100	--	--
	(15294345)		800b	dredged	--	0	4	51	93	93	94	96	98	100	--	--
			1000b	dredged	--	0	3	40	60	62	64	66	70	78	100	--
14	Susitna River	Aug. 14	80a	dredged	--	--	--	--	--	--	--	--	--	--	--	--
	at Susitna		280b	dredged	--	0	6	60	76	78	82	88	95	97	100	--
	Station		480b	dredged	--	0	1	5	8	8	8	9	14	18	100	--
	(15294350)		680b	dredged	--	0	3	55	72	75	78	81	85	95	100	--
			880b	dredged	--	0	1	17	47	62	70	76	89	100	--	--
			1080b	dredged	--	0	2	39	66	70	72	75	82	91	100	--
			1280b	dredged	--	0	3	41	72	73	76	82	92	100	--	--
			1480b	dredged	--	0	6	79	91	93	94	96	99	100	--	--
			1680b	dredged	0	1	27	87	95	96	98	99	100	--	--	--

a Streambed too coarse to obtain samples
b Representative sample obtained for particles finer than 128 mm
c Few particles obtained; non-representative sample
d Stationing from left bank at Susitna River, left channel (15292440)

Table 5.--Water discharge and estimated sediment loads at selected stations in the Susitna River basin, October 1984 to September 1985 [mi^2, square miles; acre-ft, acre-feet]

Map No. (fig. 1)	Station name and number	Drainage area (mi^2)	Period	Water discharge (acre-ft)	Suspended sediment (tons) Silt-clay	Suspended sediment (tons) Sand	Suspended sediment (tons) Total	Bedload (tons) Sand	Bedload (tons) Gravel	Bedload (tons) Total	Total sediment (tons)
6	Susitna River	6,320	October	349,000a	4,500	1,700	6,200	160	0.4	160	6,360
	near		November	186,000a	--	--	1,300	25	0	25	1,320
	Talkeetna		December	149,000a	--	--	750	10	0	10	760
	(15292100)		January	132,000a	--	--	580	7.0	0	7.0	587
			February	96,800a	--	--	330	3.8	0	3.8	334
			March	116,000a	--	--	440	4.2	0	4.2	444
			April	129,000a	--	--	590	8.7	0	8.7	599
			May	811,000a	350,000	330,000	680,000	7,500	5,100	12,600	693,000
			June	1,710,000a	530,000	420,000	950,000	17,000	5,500	22,500	972,000
			July	1,710,000a	540,000	440,000	980,000	16,000	6,500	22,500	1,000,000
			August	1,330,000a	240,000	160,000	400,000	8,800	1,100	9,900	410,000
			September	1,020,000a	130,000	77,000	207,000	4,700	400	5,100	212,000
			October to April	1,160,000	--	--	9,290	219	.4	219	10,400
			May to September	6,580,000	1,790,000	1,430,000	3,220,000	54,000	18,600	72,600	3,290,000
			Total	6,720,000	--	--	3,230,000	54,200	18,600	72,800	3,300,000
8	Chulitna River	2,580	October	290,600	23,000	18,000	41,000	3,300	2,000	5,300	46,300
	below canyon		November	159,100	--	--	8,900	300	110	410	9,310
	near Talkeetna		December	132,900	--	--	5,100	140	46	186	5,290
	(15292410)		January	117,000	--	--	3,800	89	26	115	3,920
			February	77,550	--	--	1,600	26	6.8	33	1,630
			March	71,600	--	--	1,100	14	3.1	17	1,120
			April	67,240	--	--	980	13	3.1	16	996
			May	351,300	170,000	96,000	266,000	30,000	17,000	47,000	313,000
			June	1,125,000	770,000	430,000	1,200,000	140,000	77,000	217,000	1,420,000
			July	1,669,000	2,100,000	1,100,000	3,200,000	180,000	140,000	320,000	3,520,000
			August	1,278,000	1,100,000	600,000	1,700,000	140,000	90,000	230,000	1,930,000
			September	782,700	320,000	200,000	520,000	66,000	31,000	97,000	617,000
			October to April	916,000	--	--	62,500	3,880	2,200	6,080	68,600
			May to September	5,206,000	4,460,000	2,430,000	6,890,000	556,000	355,000	911,000	7,800,000
			Total	6,122,000	--	--	6,950,000	560,000	357,000	917,000	7,870,000
9	Susitna River	8,950	October	624,000b	--	--	60,000b	5,600	2,100	7,700	67,700
	below Chulitna		November	303,000b	--	--	9,000b	1,900	780	2,680	11,700
10	River near		December	245,000b	--	--	5,000b	1,400	580	1,980	6,980
	Talkeetna		January	237,000b	--	--	4,000b	1,300	560	1,860	5,860
	(15292439 and		February	182,000b	--	--	3,000b	920	400	1,320	4,320
	15292440)		March	200,000b	--	--	3,000b	1,000	440	1,440	4,440
			April	212,000b	--	--	3,000b	1,100	490	1,490	4,490
			June	3,000,000b	2,300,000	1,500,000	3,800,000	63,000	140,000	203,000	4,000,000
			July	3,500,000b	3,700,000	2,100,000	5,800,000	73,000	170,000	243,000	6,040,000
			August	2,760,000b	1,800,000	1,200,000	3,000,000	54,000	110,000	164,000	3,160,000
			September	1,920,000b	660,000	560,000	1,220,000	30,000	37,000	67,000	1,290,000
			October to April	2,000,000b	--	--	87,000b	13,200	5,350	18,500	105,000
			May to September	12,500,000b	9,370,000	5,900,000	15,300,000	243,000	500,000	743,000	16,000,000
			Total	14,500,000b	--	--	15,400,000	256,000	505,000	761,000	16,100,000
11	Talkeetna	2,006	October	135,100	1,400	3,000	4,400	780	0.3	780	5,180
	River near		November	68,930	--	--	860	78	0	78	938
	Talkeetna		December	55,140	--	--	520	28	0	28	548
	(15292700)		January	44,070	--	--	320	12	0	12	332
			February	30,410	--	--	170	3.8	0	3.8	174
			March	30,600	--	-	150	3.1	0	3.1	153
			April	31,060	--	--	160	3.3	0	3.3	163
			May	256,700	84,000	85,000	169,000	4,800	8,700	13,500	182,000
			June	618,800	170,000	190,000	360,000	12,000	11,000	23,000	383,000
			July	684,900	240,000	240,000	480,000	13,000	16,000	29,000	590,000
			August	626,200	200,000	200,000	400,000	13,000	13,000	26,000	426,000
			September	501,300	120,000	130,000	250,000	8,700	5,600	14,300	264,000
			October to April	395,300	--	--	6,580	908	0.3	908	7,490
			May to September	2,688,000	814,000	845,000	1,660,000	51,500	54,300	106,000	1,760,000
			Total	3,083,000	--	--	1,670,000	52,400	54,300	107,000	1,770,000
12	Susitna River	11,100	October	759,500	24,000	41,000	65,000	4,900	2,600	7,500	72,000
	at Sunshine		November	372,000	--	--	10,000	1,900	1,400	3,300	13,300
	(15292780)		December	299,900	--	--	5,600	1,500	1,200	2,700	8,300
			January	280,700	--	--	4,700	1,300	1,100	2,400	7,100
			February	212,200	--	--	2,800	900	890	1,790	4,590
			March	230,500	--	--	2,900	1,000	980	1,980	4,880
			April	243,200	--	--	3,500	1,100	970	2,070	5,570
			May	1,583,000	870,000	560,000	1,430,000	15,000	17,000	32,000	1,460,000
			June	3,622,000	2,200,000	1,500,000	3,700,000	37,000	33,000	70,000	3,770,000
			July	4,183,000	3,300,000	2,000,000	5,300,000	44,000	59,000	103,000	5,400,000
			August	3,384,000	1,800,000	1,200,000	3,000,000	33,000	26,000	59,000	3,060,000
			September	2,425,000	770,000	620,000	1,390,000	22,000	11,000	33,000	1,420,000
			October to April	2,399,000	--	--	94,500	12,600	9,140	21,700	116,000
			May to September	15,200,000	8,940,000	5,880,000	14,800,000	151,000	146,000	297,000	15,100,000
			Total	17,600,000	--	--	14,900,000	164,000	155,000	319,000	15,200,000

Table 5.--Water discharge and estimated sediment loads at selected stations in the Susitna River basin, October 1984 to September 1985 -- Continued

Map No. (fig. 1)	Station name and number	Drainage area (mi^2)	Period	Water discharge (acre-ft)	Suspended sediment (tons)			Bedload (tons)			Total sediment (tons)
					Silt-clay	Sand	Total	Sand	Gravel	Total	
13	Yentna River near Susitna Station (15294345)	6,180	October	843,600	110,000	190,000	300,000	36,000	3,000	39,000	339,000
			November	260,200	--	--	5,800	4,100	1,300	5,400	11,200
			December	185,300	--	--	1,200	2,100	1,100	3,200	4,400
			January	182,100	--	--	970	2,000	1,100	3,100	4,070
			February	158,300	--	--	760	1,700	980	2,680	3,440
			March	161,100	--	--	580	1,600	1,000	2,600	3,180
			April	148,800	--	--	460	1,500	980	2,480	2,940
			May	1,186,000	460,000	410,000	870,000	82,000	8,900	90,900	961,000
			June	2,886,000	1,600,000	1,300,000	2,900,000	250,000	29,000	279,000	3,180,000
			July	3,613,000	2,600,000	1,800,000	4,400,000	360,000	48,000	408,000	4,810,000
			August	2,841,000	1,500,000	1,200,000	2,700,000	240,000	27,000	267,000	2,970,000
			September	1,775,000	560,000	620,000	1,180,000	120,000	9,800	130,000	1,310,000
			October to April	1,939,000	--	--	310,000	49,000	9,460	58,500	368,000
			May to September	12,300,000	6,720,000	5,330,000	12,000,000	1,050,000	123,000	1,170,000	13,200,000
			Total	14,240,000	--	--	12,400,000	1,000,000	132,000	1,230,000	13,600,000
14	Susitna River at Susitna Station (15294350)	19,400	October	1,892,000	160,000	250,000	410,000	33,000	2,800	35,800	446,000
			November	651,600	--	--	9,000	2,400	180	2,580	11,600
			December	505,800	--	--	3,400	1,200	96	1,300	4,700
			January	489,900	--	--	3,000	1,100	89	1,190	4,190
			February	385,800	--	--	1,800	710	59	769	2,570
			March	399,700	--	--	1,600	650	56	706	2,310
			April	405,600	--	--	1,800	720	60	780	2,580
			May	2,808,000	1,200,000	880,000	2,080,000	95,000	20,000	115,000	2,200,000
			June	6,706,000	3,900,000	2,700,000	6,600,000	290,000	67,000	357,000	6,960,000
			July	8,281,000	6,300,000	3,800,000	10,100,000	400,000	110,000	510,000	10,600,000
			August	6,686,000	3,700,000	2,700,000	6,400,000	280,000	64,000	344,000	6,740,000
			September	5,005,000	1,900,000	1,700,000	3,600,000	180,000	31,000	211,000	3,810,000
			October to April	4,730,000	--	--	431,000	39,800	3,340	43,100	474,000
			May to September	29,490,000	17,000,000	11,800,000	28,800,000	1,240,000	292,000	1,540,000	30,300,000
			Total	34,220,000	--	--	29,200,000	1,280,000	295,000	1,580,000	30,800,000

a Estimated

b Difference between Susitna River at Sunshine and Talkeetna River near Talkeetna