SEDIMENT TRANSPORT AND SOURCE AREAS OF SEDIMENT AND RUNOFF, BIG SANDY RIVER BASIN, WYOMING

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The bedload data were compared to the Einstein bedload function and total load data were compared to the Colby method. The bedload comparison showed a higher estimation of transport rates with Helley-Smith sampler measurements than with the Einstein bedload function. The Colby method yielded higher transport rates at high flows and lower transport rates at low flows than the measured total transport rate.

The Big Sandy Reservoir acts as a control in the basin. The area upstream of the reservoir was interpreted separately from the area downstream for source-area determination. In the arid plains upstream of the reservoir, the amount of sediment transported increased 98 percent with an increase in runoff of only 1 percent.

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METRIC CONVERSIONS AND VERTICAL DATUM

Inch-pound units used in this report may be expressed as metric units by use of the following conversion factors:

Multiply	By	To obtain
inch	25.40	millimeter
foot	0.3048	meter
mile	1.609	kilometer
square foot per second	0.0929	square meter per second
acre	0.4047	hectare
foot per mile	0.1893	meter per kilometer
square mile	2.59	square kilometer
cubic foot per second	0.02832	cubic meter per second
ton	0.9074	megagrams or metric ton
ton per acre	2.242	metric ton per hectare
pound	0.4536	kilogram
pound per second per foot	7.22×10^{-6}	kilogram per second per foot
degree Fahrenheit (°F)	(temp°F-32)/1.8	degree Celsius (°C)

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

SEDIMENT TRANSPORT AND SOURCE AREAS OF SEDIMENT AND RUNOFF, BIG SANDY RIVER BASIN, WYOMING

By James E. Kircher

ABSTRACT

A study was conducted to determine sediment transport and sediment and runoff source areas in the Big Sandy River basin, southwestern Wyoming. Suspended-sediment and bedload data were collected in order to determine total sediment transport at several locations within the basin.

Bedload data obtained by a Helley-Smith bedload sampler were compared to the Einstein bedload function and total load data were compared to the Colby method. The bedload comparison showed a greater estimation of transport rates with the Helley-Smith measurements than with the Einstein bedload function. The Colby method yielded greater transport rates at high flows and smaller transport rates at low flows than the measured total transport rate.

The Big Sandy Reservoir acts as a control in the basin. The area upstream from the reservoir was interpreted separately from the area downstream for source-area determination. In the arid plains upstream from the reservoir, the amount of sediment transported increased 98 percent with an increase in runoff of only 1 percent. Downstream from the reservoir, Pacific Creek contributes 7 percent of the runoff and 70 percent of the sediment load that reaches the mouth of the Big Sandy River.

INTRODUCTION

Water demands in the Green River Basin of Wyoming are increasing rapidly due to the development of extensive coal, oil, gas, uranium, and trona resources (Lowham and others, 1976). The potential also exists for future development of extensive oil-shale resources. To meet these demands, increased use of surface water in the basin is being considered.

Sediment load is an important water-quality factor in determining water use and in assessing possible impacts of these uses with time. Definition of sediment loads, concentrations, and particle-size distributions also are important in the design of dams, diversion structures, and canals, as well as in the evaluation of water-quality problems.

The Big Sandy River is a major contributor of sediment to the Green River in Wyoming. The purpose of this report is to describe the quantity of sediment transport and the source areas of sediment and runoff in the Big Sandy River basin.

LOCATION-NUMBERING SYSTEM

Streamflow Stations

Stations where streamflow is measured or sampled on a regular basis are assigned eight-digit numbers, such as 09212500. The first two digits (09) identify the major drainage in which the site is located; in this case the Colorado River drainage. The remaining six digits identify the relative location of the site, with numbers increasing progressively in the downstream direction.

Miscellaneous Sites

Sites at which only a few streamflow measurements or samples have been obtained are not assigned regular downstream station numbers. Instead, these sites are identified by a 15-digit number, such as 421229109252701. The first six digits designate latitude of the site, the next seven digits designate longitude, and the last two digits are sequence numbers to distinguish between sites that may have the same latitude and longitude.

DESCRIPTION OF THE STUDY AREA

The Big Sandy River drains an area of 1,785 square miles on the western slope of the Wind River Mountains in western Wyoming (fig. 1). Topography in the basin ranges from rugged mountains in its headwaters to relatively flat, desert-like terrain at the mouth (figs. 2-6). Elevations range from more than 10,500 feet above NGVD of 1929 in the headwaters to 6,240 feet at the mouth. Tributaries of the Big Sandy River form a dendritic drainage pattern. Stream gradients range from 8 feet per mile near the mouth to 365 feet per mile in the headwaters. Longitudinal profiles of selected streams are shown in figure 7.

Geology, Physiography, and Soils

The Big Sandy River basin lies within the geomorphic province known as the Wyoming Basin (Hunt, 1974). The headwaters are underlain mainly by crystalline and metamorphic rocks and glacial deposits. The remainder of the basin is underlain mainly by sedimentary rocks. The major geologic units within the basin are shown in figure 8, and a description of the lithology of each unit is given in table 1.

Canyons and distinctive ridges and buttes dominate much of the landscape along the Continental Divide. Topographic relief in this area is from 400 to 600 feet.

The western boundary of the Big Sandy basin is characterized by tablelands dissected by gullies, canyons, and to a lesser extent by broad ancient valleys. Topographic relief in this area is from 200 to 400 feet.

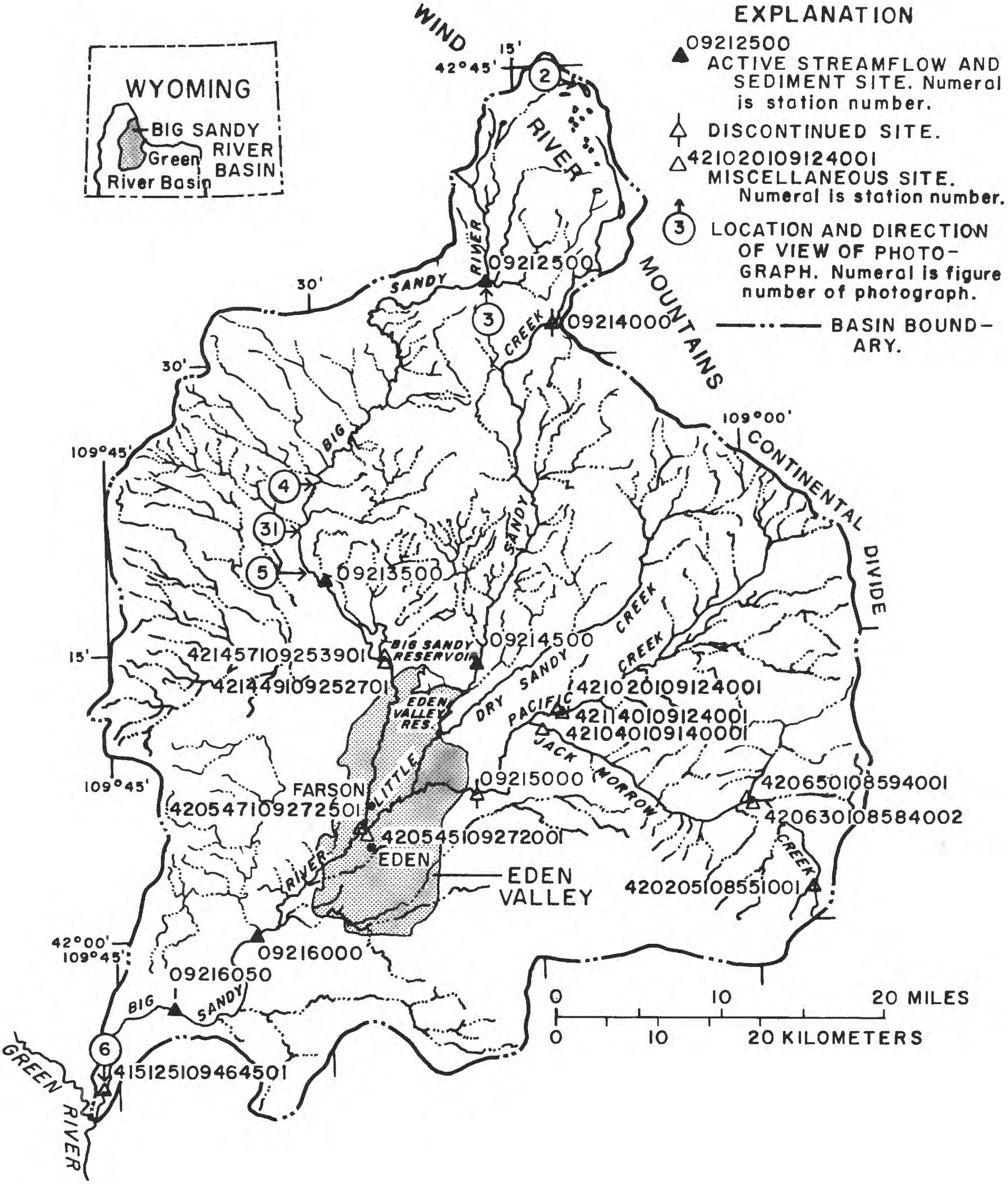


Figure 1.--Big Sandy River basin and sampling-site locations.

Figure 2.--Headwaters of the Big Sandy River in the Wind River Mountains.

Figure 3.--View of the Big Sandy River upstream from streamflow-gaging station 09212500, Big Sandy River at Leckie Ranch, near Big Sandy. Wind River Mountains are in background.

Figure 4.--The Big Sandy River between streamflow-gaging stations 09212500, Big Sandy River at Leckie Ranch, near Big Sandy, and 09213500, Big Sandy River near Farson. View is upstream with Wind River Mountains in background.

Figure 5.--The Big Sandy River near streamflow-gaging station 09213500, Big Sandy River near Farson. View is downstream. Wind River Mountains are in background.

Figure 6.--The Big Sandy River near mouth. View is downstream.

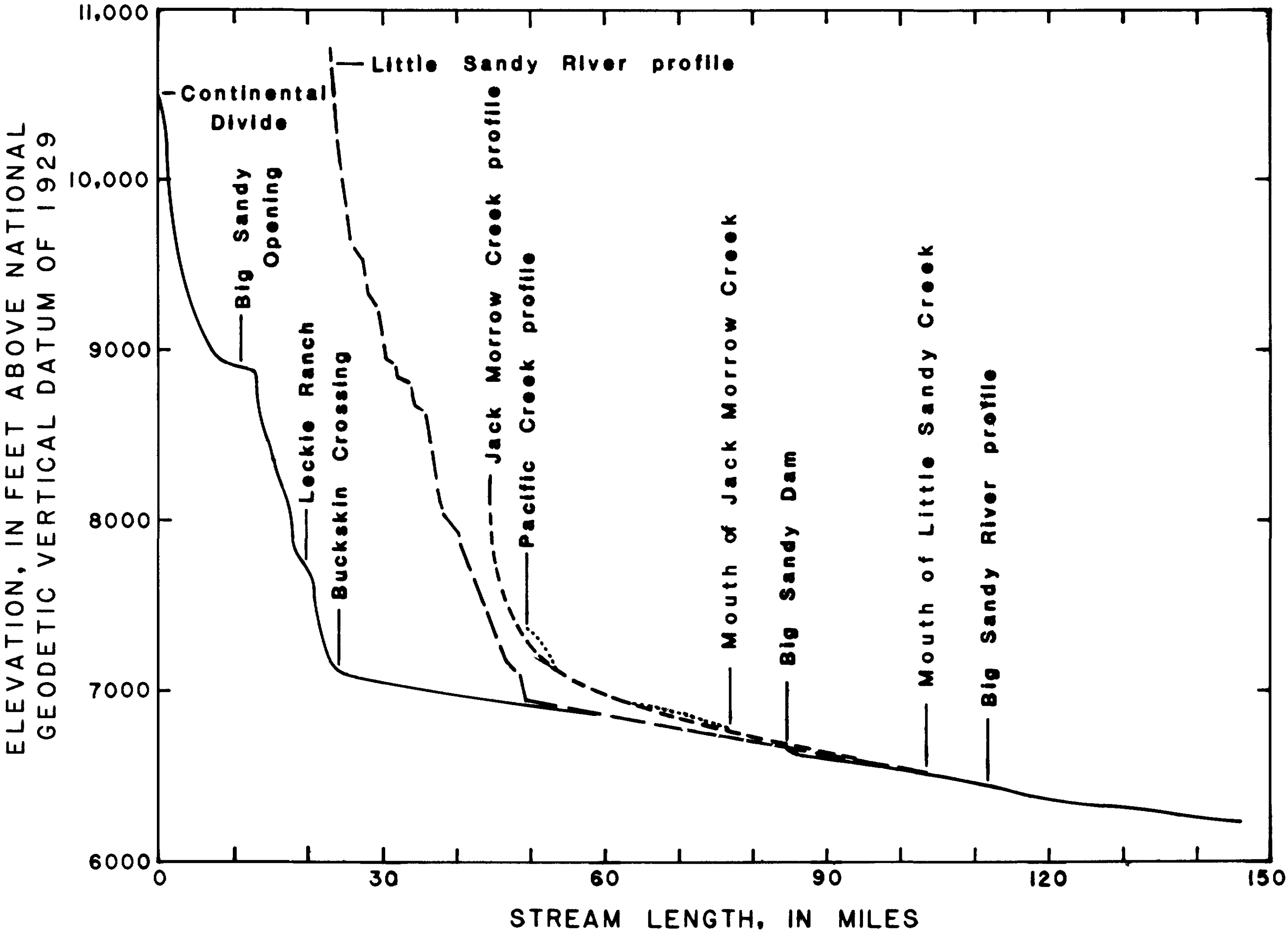
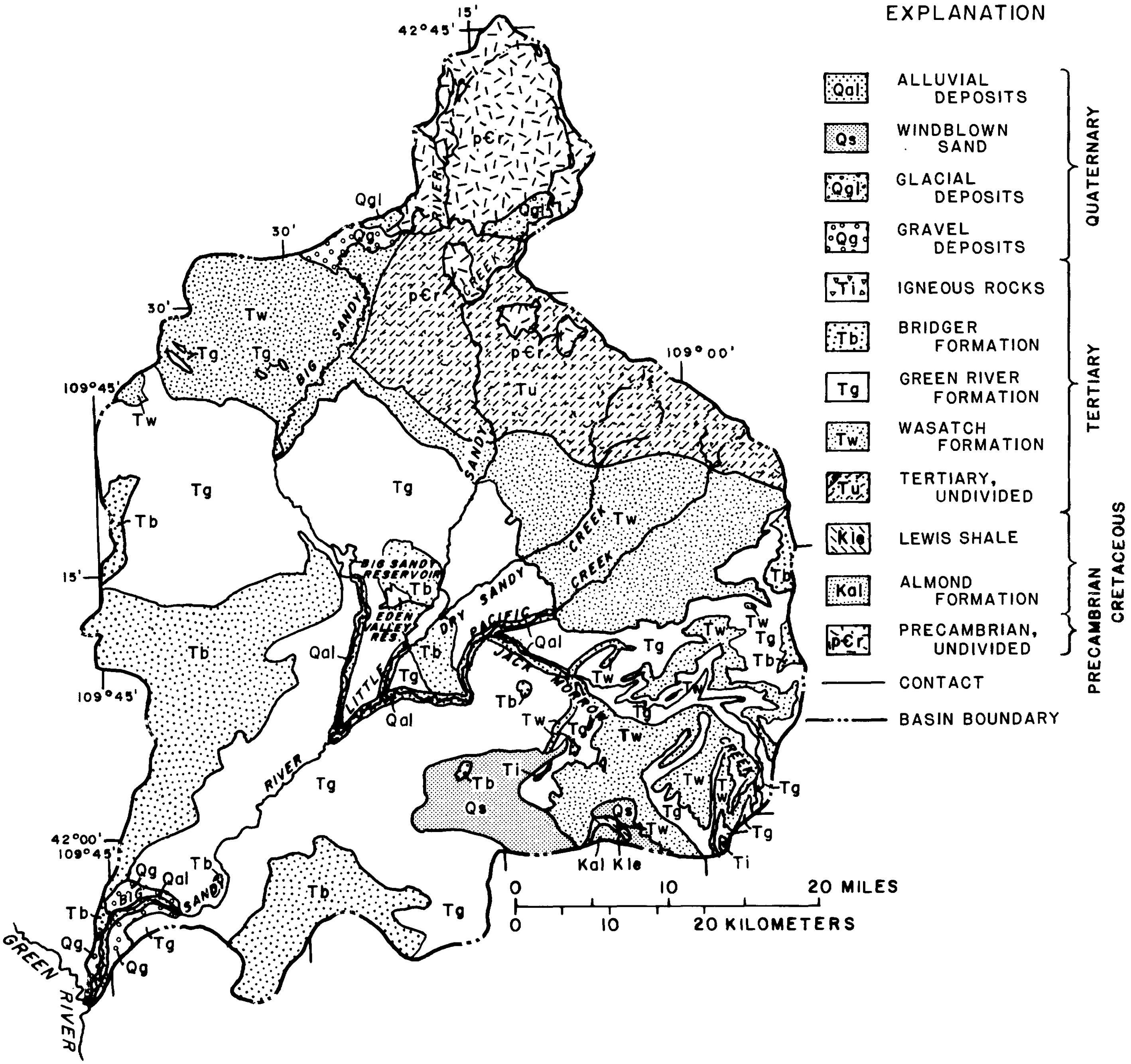


Figure 7.--Longitudinal profiles for the Big Sandy River and its principal tributaries.



Geology from Welder and McGreevy, 1966, and Welder, 1968

Figure 8.--Generalized geology.

Table 1.--Generalized description of geologic units

System	Series	Geologic Units	Lithology
Quaternary	Pleistocene and Holocene	Alluvial deposits	Clay, silt, sand, and gravel; some slopewash material (Welder, 1968; Welder and McGreevy, 1966).
		Windblown sand	Sand and silt, unconsolidated. Both active and inactive sand dunes widely scattered throughout area (Welder and McGreevy, 1966).
		Glacial deposits	Clay, silt, sand, gravel, and boulders (Welder and McGreevy, 1966; Welder, 1968).
		Gravel deposits	Gravel, pebble to boulder size; sand; and silt (Welder and McGreevy, 1966; Welder, 1968).
Tertiary	Pliocene(?)	Igneous rocks	Alkalic intrusive and extrusive rocks (Welder and McGreevy, 1966; Welder 1968).
	Eocene	Bridger Formation	Sandy, tuffaceous mudstone. Interbedded medium-grained tuffaceous sandstone; minor amounts of shale, limestone, and dolomite. As much as 15 to 20 percent of formation is volcanic ash (Bradley, 1964; Welder and McGreevy, 1966; Welder, 1968).
	Paleocene and Eocene	Green River and Wasatch Formations and Tertiary, undivided.	Calcareous sandstone, siltstone, marlstone, mudstone, some oil shale, and minor amounts of dolomite. (Bradley 1964; Welder, 1968; Welder and McGreevy, 1966).
		Main body of the Wasatch Formation	Sandy, variegated mudstone, fine- to medium-grained calcareous sandstone, carbonaceous shale, small amounts of oil shale and coal, conglomeratic sandstone near periphery (Bradley, 1964; Welder, 1968; Welder and McGreevy, 1966).
Cretaceous	Upper Cretaceous	Lewis Shale	Sandstone, siltstone, limestone, and bentonite (Haun, 1961; Welder and McGreevy, 1966).
		Almond Formation	Sandstone, siltstone, coal, and carbonaceous shale (Welder and McGreevy, 1966).
PRECAMBRIAN		Igneous and metamorphic rocks	Granite, gneiss, and schist (Welder and McGreevy, 1966).

The soils of the basin are classed with the desert soil groups of the Wyoming Basin. In his discussion of these soils, Hunt (1974) writes: "The surface layer typically contains little organic matter and is calcareous, for leaching is slight. Subsoils * * * contain a layer enriched with lime and/or gypsum, * * *. Because the Wyoming Basin is semiarid and weathering correspondingly slight, the soil textures and compositions are dominated by the parent materials."

There are three basic types of parent material: (1) Coarse-textured older alluvium (water-transported sediments) from the Wind River Mountains that has formed coarse-textured soils (sandy) in the northeastern part of the area; (2) sedimentary rocks (sandstone, shale, and siltstone) that have weathered to form mostly shallow soils (thickness 10 to 20 inches) and moderately thick soils (thickness 20 to 40 inches) in the western and eastern parts of the area; and (3) wind-deposited sand that has formed soils in the southern part of the area. Stream channels have formed wetlands, bottom lands, and perpetually wet soils on water-transported sediments (U.S. Bureau of Land Management, 1978, p. 2-3).

Climate

Precipitation within the basin varies widely. Annual precipitation in the Wind River Mountains is as much as 40 inches, which is mostly snow that accumulates during the winter months. The plains receive as little as 6 inches per year in some areas. The variation in precipitation can be seen in table 2, which shows monthly averages and mean annual values for representative weather stations. Although two of these stations, Rock Springs and Pinedale, are outside the basin, they give an indication of precipitation for the southern (Rock Springs) and northern (Pinedale) parts of the basin.

The average distribution of precipitation within the year in the interior of the basin is rather uniform. Almost 40 percent of the annual precipitation at the lower elevations of the basin falls during April, May, and June, when most of the snow is melting in the mountains.

Few recorded data are available on intensity of rainfall in the basin, but the available records indicate that the most intense rainfall occurs during the summer months. The foothills probably receive a greater amount of intense rainfall than the areas at lower elevations.

Variations in temperature can be seen in table 3. Monthly and mean annual temperatures at the representative weather stations are shown for the 30-year period, 1941-70.

Winds are relatively strong, especially in the plains areas. Wind velocities average about 15 miles per hour during winter and spring and about 8 miles per hour during summer. Strong winds of 30 to 40 miles per hour with stronger gusts sometimes prevail for several days. Wind direction is predominately from the west.

Table 2.--Monthly and annual precipitation normals, in inches, 1941-70

[From U.S. Department of Commerce, 1973, p. 2]

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Farson[1]------------	0.36	0.31	0.46	0.61	1.16	1.29	0.44	0.77	0.64	0.73	0.44	0.40	7.61
Pinedale[2]----------	.73	.59	.63	.92	1.57	1.60	.77	1.02	.94	.84	.71	.91	11.23
Rock Springs FAA AP[3]	.46	.54	.68	1.02	1.11	1.14	.49	.74	.72	.87	.53	.49	8.79

Table 3. --Mean monthly and mean annual temperatures, in degrees Fahrenheit, 1941-70

[From U.S. Department of Commerce, 1973, p. 1]

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Farson[1]------------	9.3	14.6	23.9	37.8	47.8	55.9	63.4	60.8	51.6	39.8	24.6	13.2	36.9
Pinedale[2]----------	11.5	15.3	20.9	34.4	44.5	52.6	60.2	57.5	49.2	39.1	25.0	15.4	35.5
Rock Springs FAA AP[3]	19.2	23.4	28.9	40.1	50.4	58.9	68.2	66.1	56.4	44.7	30.7	22.6	42.5

[1] Located near center of study area (fig. 1).

[2] Located about 56 miles northwest of Farson.

[3] Operated by the Federal Aviation Administration at the Rock Springs airport, about 42 miles southeast of Farson.

Vegetation and Land Use

The Big Sandy River basin has ten major vegetation types: Sagebrush-grass, saltbrush, meadow, grass, greasewood, perennial forbes, mountain shrub, conifer, barren, and waste (U.S. Bureau of Land Management, 1978, p. 2-3). The distributions of these vegetation types are shown in figure 9. Sagebrush-grass is the dominant vegetation type in the Big Sandy River basin.

Land is used chiefly for grazing but can be productive farmland where irrigated. Farming in the Big Sandy River basin is concentrated in the Eden Valley, with some farming on individual ranches along the Big Sandy River and Little Sandy Creek flood plains.

The Eden Project is a large irrigation project located near Farson and Eden. This project includes approximately 17,000 acres of irrigated land. Water for irrigation comes from the Eden Valley and Big Sandy Reservoirs and from the Big Sandy River and Little Sandy Creek (fig. 9). Irrigation is done primarily by flooding.

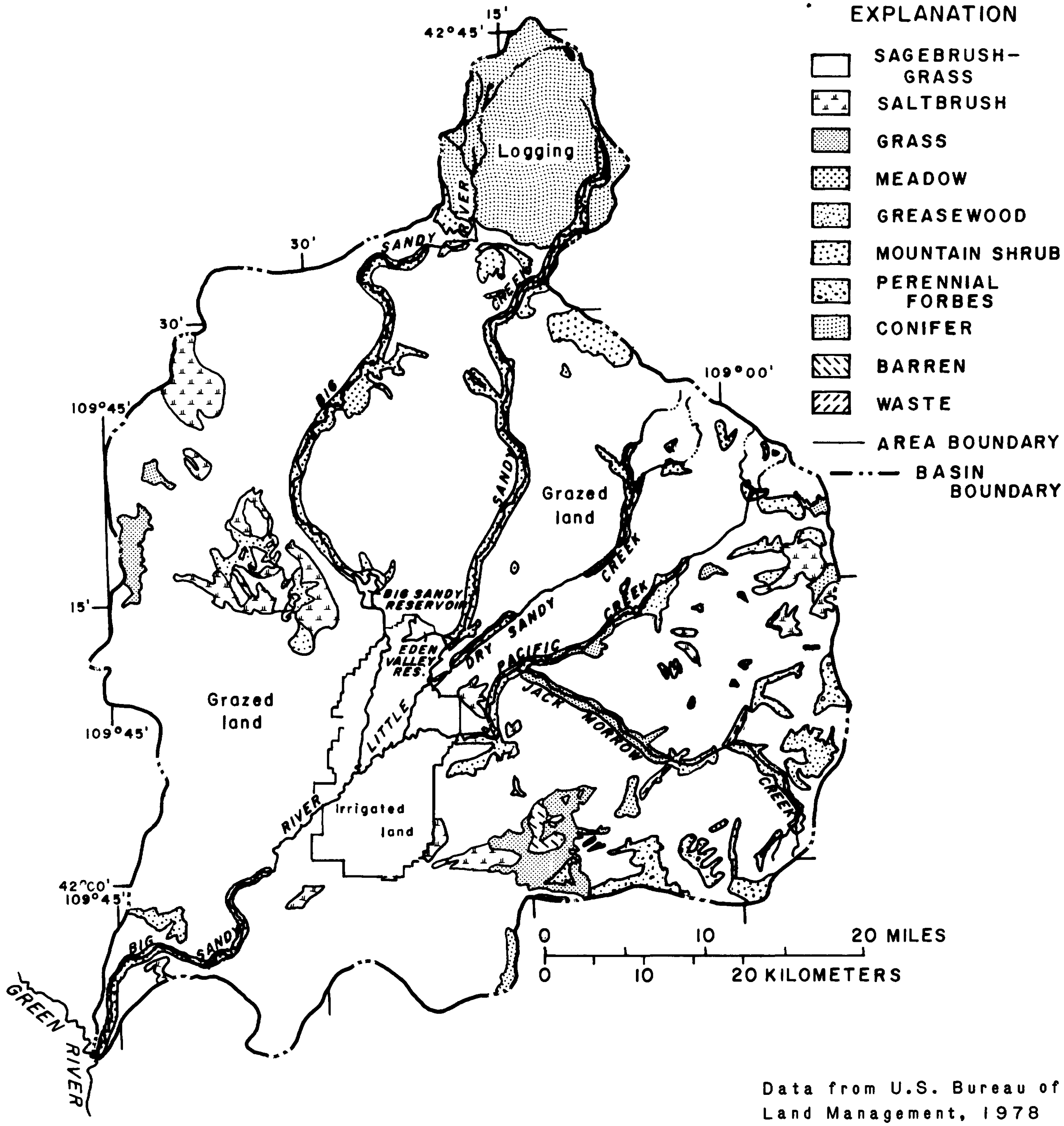
Logging in the northern part of the basin (fig. 9) is the other major land use in the area. Recreational activities, including hunting, fishing, and hiking, are popular.

STREAMFLOW

The Big Sandy River and Little Sandy Creek originate in the mountains where the greatest precipitation occurs and ground-water inflows sustain base flows. The major part of the annual runoff for these streams occurs during spring and early summer as a result of snowmelt. Late summer, fall, and winter flows are mainly the result of ground-water inflows. Daily discharge of the Big Sandy River at streamflow gaging stations upstream and downstream from the Big Sandy Reservoir are shown in figures 10 and 11.

Many of the tributaries to the Big Sandy River and Little Sandy Creek originate in the plains area. These tributaries are ephemeral or intermittent; that is, they flow mainly in response to direct runoff from rainstorms or snowmelt. Only one streamflow-gaging station has been operated on an intermittent or ephemeral stream in the area. An average hydrograph for this station (09215000, Pacific Creek near Farson) is shown in figure 12. Small increases of streamflow occurring during the fall and winter months may be the result of storms that have occurred during individual years. The relative monthly distribution of the annual runoff in Pacific Creek is shown in figure 13.

A comparison of the hydrographs for the Big Sandy River upstream (fig. 10) and downstream (fig. 11) from the Big Sandy Reservoir shows the decrease of high flows in the river caused by the reservoir and the irrigation project, particularly during May, June and July. The high flows during March and April at the station downstream from the Big Sandy Reservoir are caused by the early snowmelt on Pacific Creek and are unaffected by the reservoir. The monthly discharge for a common period of record for the two stations (fig. 14) further illustrates the change in flow characteristics due to the reservoir and show that the high flows have been reduced as would be expected.



Data from U.S. Bureau of Land Management, 1978

Figure 9.--Major vegetation types.

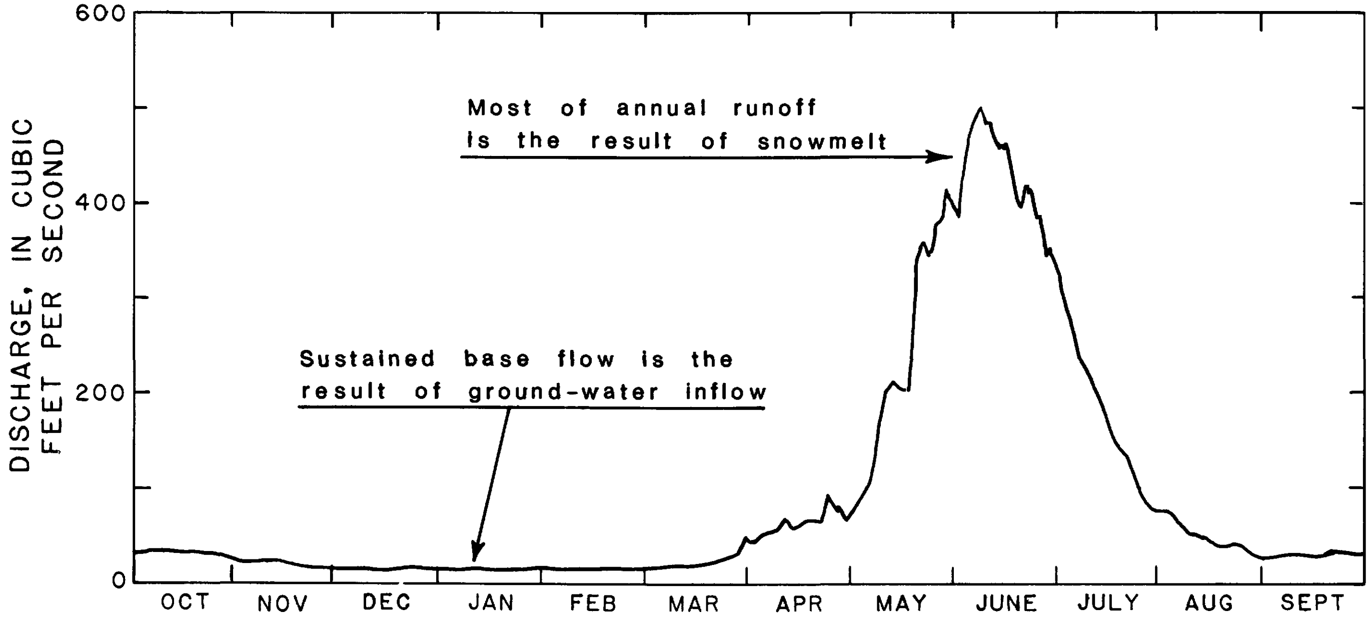


Figure 10.--Daily discharge at streamflow-gaging station 09213500, Big Sandy River near Farson (average of 1914-17, 1920-24, 1926-34, 1953-77 water years).

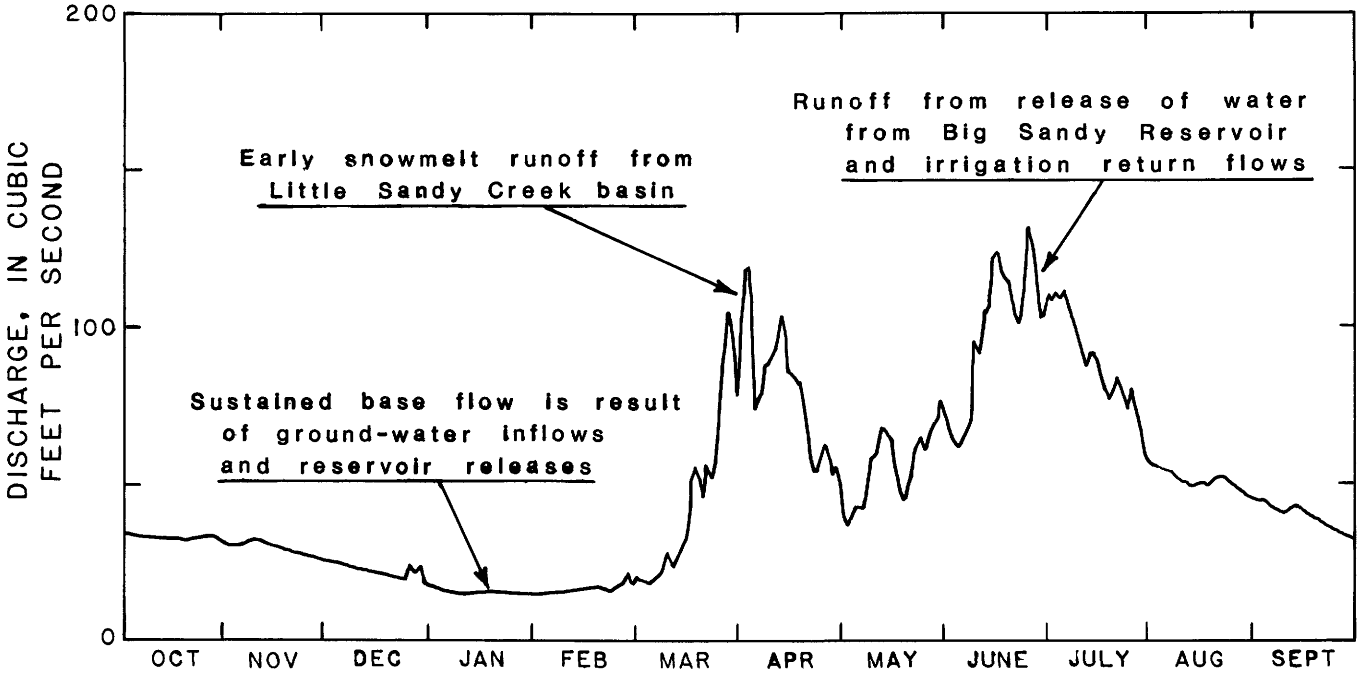


Figure 11.--Daily discharge at streamflow-gaging station 09216000, Big Sandy River below Eden (average of 1954-77 water years).

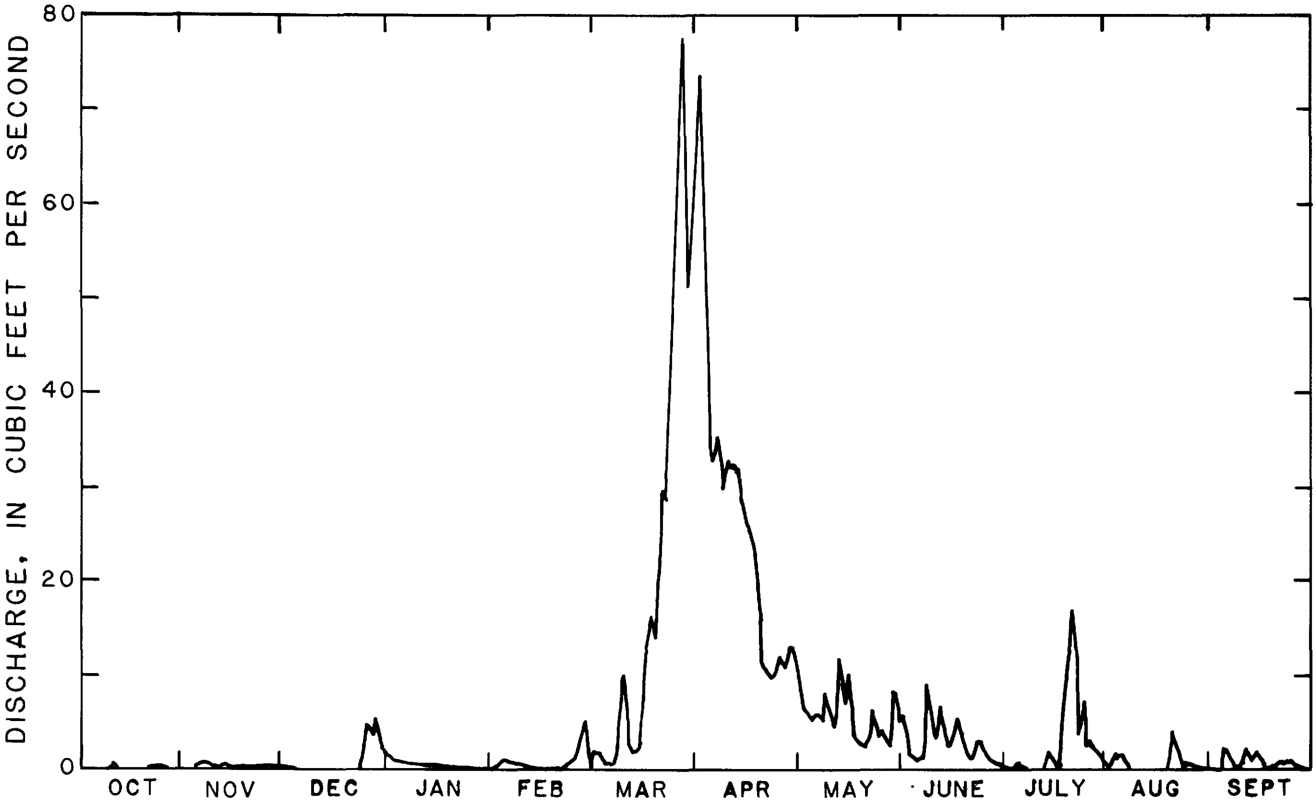


Figure 12.--Daily discharge at streamflow-gaging station 09215000, Pacific Creek near Farson (average of 1954-73 water years).

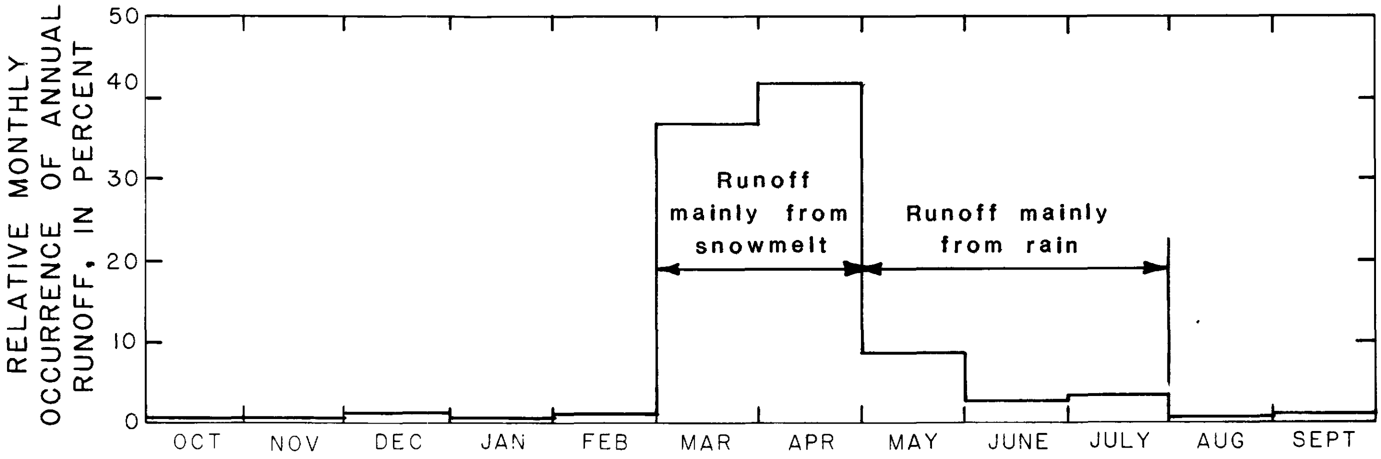


Figure 13.--Relative monthly occurrence of annual runoff for Pacific Creek near Farson, streamflow-gaging station 09215000 (average 1954-73 water years).

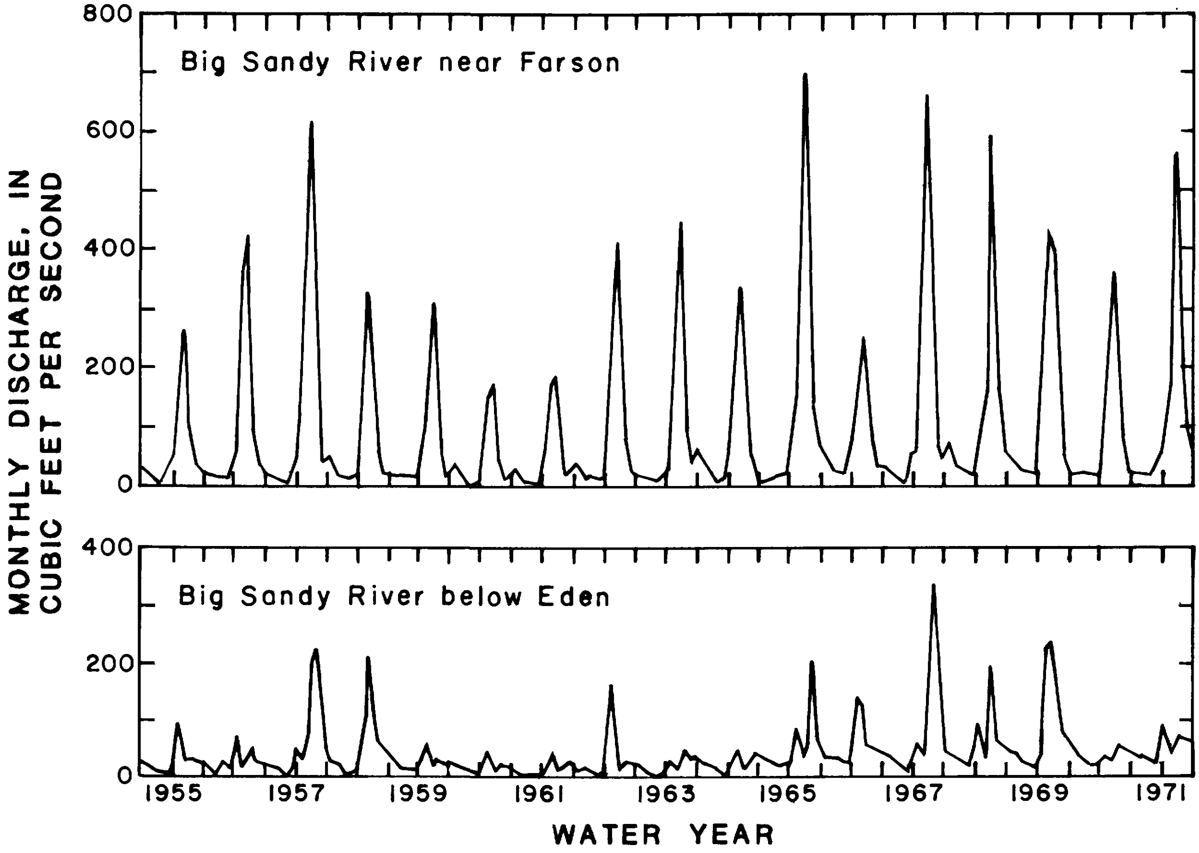


Figure 14.--Monthly discharge for the Big Sandy River near Farson, streamflow-gaging station 09213500, and below Eden, streamflow-gaging station 09216000 (1955-71 water years).

The hydrographs for Pacific Creek and the Big Sandy River below Eden for water year 1968 (fig. 15) show the coincidence of the spring runoff from Pacific Creek with the peak flow in the Big Sandy River below Eden. The hydrographs also show a peak flow during the summer, indicating that water was released from the Big Sandy Reservoir that year with some flow coming from irrigation return flows. Little Sandy Creek contributes little to the flow of the Big Sandy River because flow is diverted to the Eden Valley Reservoir.

Streamflow data are summarized for seven gaging stations within the basin in table 4, which shows the period of record for each gaging station, the drainage area, the mean annual discharge, and the effects of man on the individual streams near each gaging station. The mean annual runoffs are variable within the basin, ranging from rates of about 1.0 cubic foot per second per square mile at station 09214000, Little Sandy Creek near Elkhorn, to about 0.01 cubic foot per second per square mile at station 09215000, Pacific Creek near Farson.

CHANNEL SHAPE AND SIZE

The shape of stream channels is highly organized and is similar for rivers of the same size in comparable climatic and geologic settings. Channel shape is a complex result of many interacting factors of which there are two general classes: (1) Factors related to the size, lithology, amount, and depositional forms of the sediment load and (2) hydraulic factors related to water flow. The channel is formed by the water in the channel and the sediment it carries.

The hydraulic geometry exhibits the consistent manner in which natural stream channels are shaped to carry water and sediment load imposed from upstream. This consistency indicates that natural channels, self-formed and self-maintained, seek a shape and size consistent with the sediment yield and water discharge. Alteration in this natural shape and size will lead to erosion or deposition as the channel processes operate toward re-establishment of quasi-equilibrium under the new conditions.

Data to prepare relations of hydraulic geometry for all the streamflow-gaging stations given in table 5 were obtained from discharge measurements. All open-water discharge measurements for each station were used with no biasing by elimination of data.

These data were transformed using logarithms and a two-variable regression run to arrive at the power function of the form $y = aX^n$ and, in this instance:

$$W = aQ^b, \tag{1}$$

$$D = cQ^f, \text{ and} \tag{2}$$

$$V = kQ^m \tag{3}$$

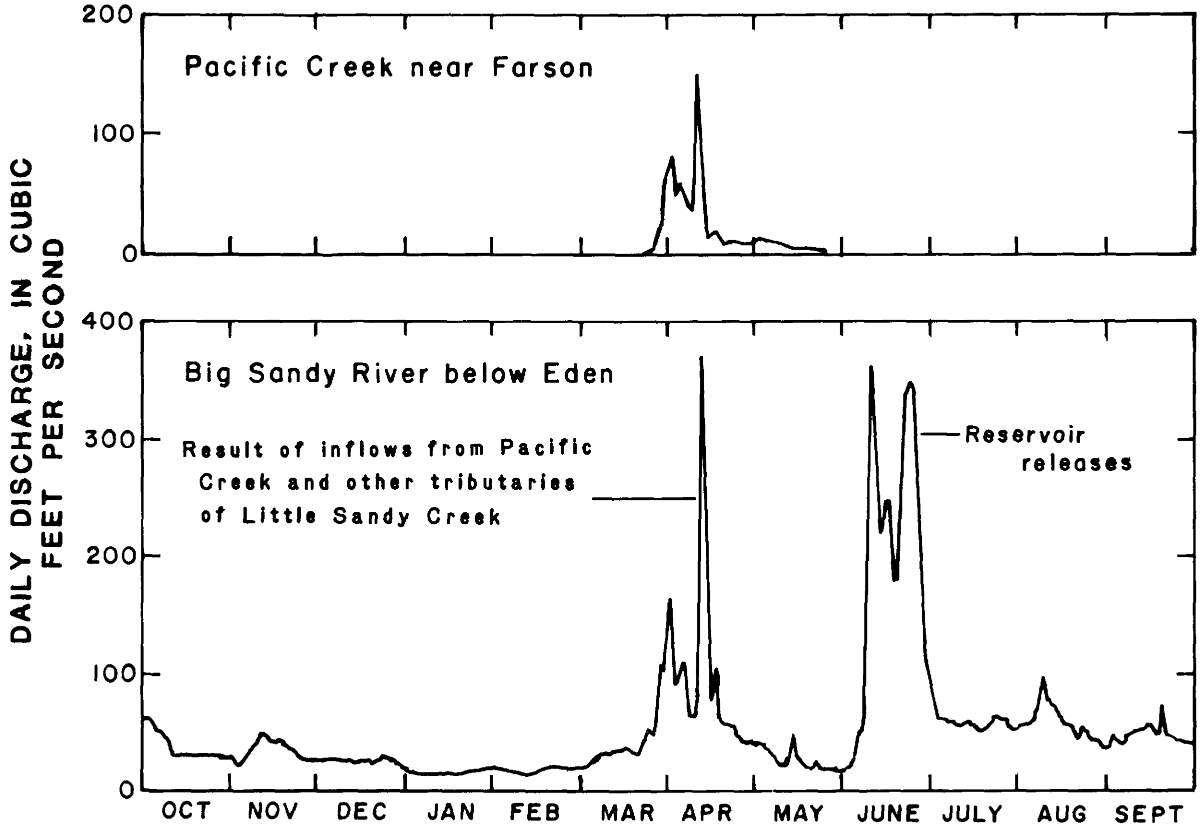


Figure 15.--Daily discharge at streamflow-gaging stations 09216000, Big Sandy River below Eden, and 09215000, Pacific Creek near Farson (1968 water year).

Table 4.--Streamflow characteristics at gaging stations

Station name	Station No.	Period of streamflow record (water years)	Period of sediment-load record (water years)	Drainage area (square miles)	Mean annual discharge (cubic feet per second)	Factors affecting natural flow
Big Sandy River at Leckie Ranch, near Big Sandy	09212500	1910, 1911, 1939-77	1975-77	94	86.0	Diversion for irrigation of about 50 acres upstream from station.
Big Sandy River near Farson	09213500	1914-17, 1920-24, 1926-34, 1953-77	1971-77	322	86.5	Diversion for irrigation of about 1,000 acres above station.
Little Sandy Creek near Elkhorn	09214000	1939-71	---	20.9	21.2	Transbasin diversion of water from Little Sandy Creek to Sweetwater River (appropriation permits total 22.71 cubic feet per second). Diversion for irrigation of 680 acres.
Little Sandy Creek above Eden	09214500	1954-77	1971-77	134	18.7	Diversion upstream from station for irrigation of about 1,720 acres of which about 150 acres are downstream from station.
Pacific Creek near Farson	09215000	1954-73	1971-73	500	4.99	Diversion for irrigation of 50 acres upstream from station. Water is imported into the basin from Sweetwater River.
Big Sandy River below Eden	09216000	1954-77	1971-77	1,610	46.6	Natural flow of stream affected by storage reservoirs and diversion for irrigation of about 19,300 acres.
Big Sandy River at Gasson Bridge, near Eden	09216050	1972-77	1975-77	1,720	70.9	Do.

Table 5.--Hydraulic characteristics at streamflow-gaging stations

[Q_B is bankfull discharge, in cubic feet per second; W_B is bankfull width, in feet; and D_B is bankfull depth, in feet.]

Station name	Station No.	Width equation	Depth equation	Velocity equation	Q_B	W_B/D_B
Big Sandy River at Leckie Ranch, near Big Sandy	09212500	$W=12.5Q^{0.28}$	$D=0.27Q^{0.32}$	$V=0.29Q^{0.40}$	964	35
Big Sandy River near Farson	09213500	$W=13.0Q^{0.32}$	$D=0.09Q^{0.50}$	$V=0.90Q^{0.18}$	876	57
Little Sandy Creek above Eden	09214500	$W=5.91Q^{0.35}$	$D=0.23Q^{0.46}$	$V=0.75Q^{0.18}$	105	15
Pacific Creek near Farson	09215000	$W=5.3Q^{0.46}$	$D=0.24Q^{0.35}$	$V=0.76Q^{0.20}$	378	25
Big Sandy River below Eden	09216000	$W=9.76Q^{0.37}$	$D=0.14Q^{0.42}$	$V=0.71Q^{0.22}$	335	53
Big Sandy River at Gasson Bridge, near Eden	09216050	$W=19.8Q^{0.25}$	$D=0.08Q^{0.53}$	$V=0.68Q^{0.22}$	--	--

where: W = flow width of stream, in feet;

D = mean flow depth of stream, in feet;

V = mean flow velocity of stream, in feet per second; and

Q = water discharge, in cubic feet per second;

using the symbols introduced by Leopold and Maddock (1953), in which a, c, and k are coefficients and b, f, and m are the exponents. The coefficients represent the theoretical values of width, depth, and velocity when the discharge is unity (1.0), but on many rivers the discharge is never actually 1 ft^3/s and so the coefficients have no physical meaning. The values of b, f, and m are the slopes of the respective lines.

Variations in the values of b, f, and m among stations can be explained by the general station locations. The station Big Sandy River at Leckie Ranch, near Big Sandy is located near the headwaters of the river; therefore, smaller values for b and f and a larger value for m are obtained. This is due to the bedrock control of the width and depth causing a greater increase in velocity with increasing discharge. Pacific Creek is located in the plains where the erodible channel allows a change in depth and width with increasing discharge; therefore, a smaller increase in velocity occurs with increasing discharge than at the station on the Big Sandy River at Leckie Ranch.

Some errors in the values of b, f, and m in table 5 are present due to the techniques of data collection. Data collection during the high flows on the Big Sandy River at Gasson Bridge near Eden were made from a bridge, while at low flows other cross sections were used. The bridge measurements yielded a smaller than average value for b and a larger than average value for f because the bridge revetments confine the width of flow, causing the depth to increase more rapidly. At other locations where wading measurements were made, for example the Big Sandy River near Farson, the original cross section was not always used during subsequent measurements. Wider than average sections were used at high discharges to obtain depths shallow enough for wading.

Bankfull values of discharge and the bankfull width-depth ratio (H. W. Lowham, U.S. Geological Survey, written commun., 1978), also are presented in table 5. The bankfull discharge is commonly considered the most important factor in forming the channel. The width-depth ratio is an indicator of the main type of sediment load carried by a stream. A large width-depth ratio generally indicates a bedload stream while a small ratio generally indicates a suspended-load stream. The nature of these types of loads is explained more fully in later sections of the report.

SEDIMENT TRANSPORT

Source of Sediment Transport

In general, there are two sources of sediment transported by a stream: (1) The streambed material, and (2) the wash load, which is fine material that comes from the banks and upstream parts of the watershed. Both materials come from the watershed; however, a distinction between them is important because bed-material transport is limited by the transport capability of the stream and is functionally related to measurable hydraulic variables, while the wash load is not. Instead, the wash load depends on the availability of fine material (Richardson and others, 1975).

Mode of Sediment Transport

Sediment particles are transported by rolling or sliding on the bed (bedload) or by suspension in the water by the turbulence of the stream (suspended-sediment load). Just as there is no sharp distinction between bed-material discharge and wash load, there is no sharp distinction between bedload and suspended-sediment load. A particle may move part of the time in contact with the bed and at other times be suspended by the flow (Richardson and others, 1975).

Suspended-Sediment Load

For this study, suspended sediment was sampled with standard depth-intergrating samplers described by the U.S. Interagency Committee on Water Resources, Subcommittee on Sedimentation (1963). Samples were collected at 15 to 20 verticals to determine the average concentration and particle-size distribution of the sediment in the streamflow. Samples of suspended sediment include particles transported in the depth interval between the surface and a point 0.3 or 0.5 foot above the bed, depending on the sampler used (fig. 16).

Suspended-sediment samples were collected by the author at six sites in the Big Sandy River basin. Data from these samples supplemented data collected during previous years by the U.S. Geological Survey to define relations between sediment concentration and water discharge.

Suspended sediment is related to the amount of water available for transport of the material. In general, larger concentrations occur with larger streamflows.

Concentration of suspended sediment in a stream can generally be related to water discharge by the equation:

$$C_s = pQ^j \qquad (4)$$

where:

C_s = concentration, in milligrams per liter;

Q = streamflow, in cubic feet per second; and

p and j = regression coefficients.

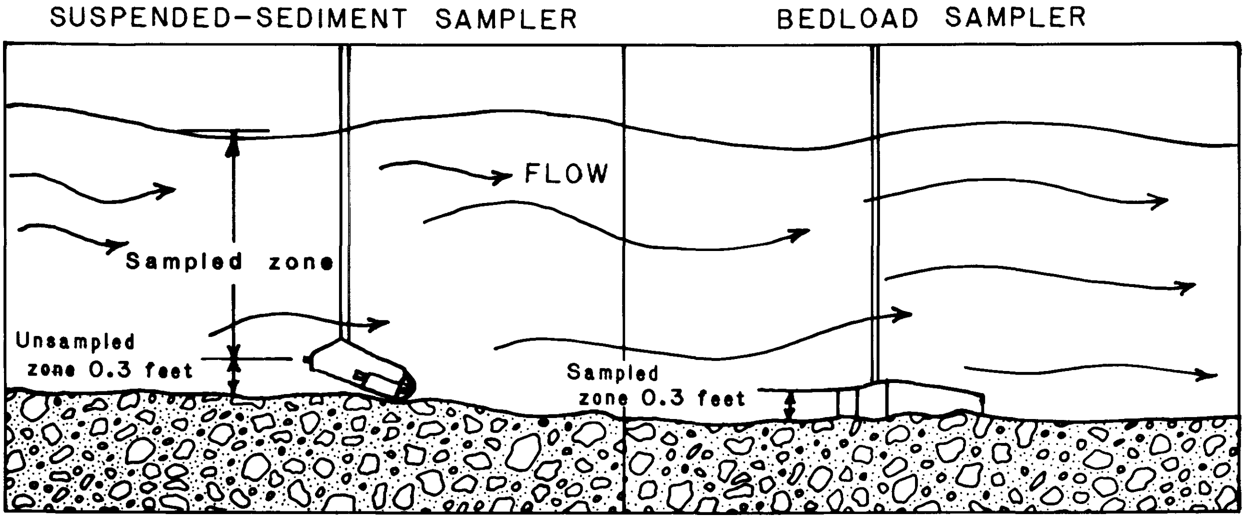


Figure 16.--Effective sampling zones of USDH-48 suspended-sediment sampler and Helley-Smith bedload sampler.

This relation was determined for each of six sampling sites located at streamflow gaging stations as shown in figure 17. A relation similar to equation 4 exists between suspended-sediment transport rate and water discharge. This relation is:

$$Q_s = aQ^b \tag{5}$$

where:

Q_s = suspended-sediment transport rate, in tons per day,
and a and b = regression coefficients.

Equations 4 and 5 are shown in table 6 for the six sites where sufficient data existed to regress the relations.

A comparison of figure 17 and the correlation coefficients in table 6 shows that generally the stations with larger suspended-sediment concentration have relations with larger correlation coefficients while those with smaller concentrations have relations with smaller correlation coefficients. Station 09216000, Big Sandy River below Eden, and station 09216050, Big Sandy River at Gasson Bridge, near Eden, are exceptions to this general relationship. The smaller correlation coefficients probably are due to the variations in streamflow at the stations. Both these stations are downstream from Big Sandy Reservoir, and occasionally streamflow consists of relatively large flows with relatively small suspended-sediment concentrations from reservoir releases. Streamflow at these stations also consists of relatively large flows with relatively large suspended-sediment concentrations from Little Sandy Creek. Therefore, streamflow at these stations may have two very different suspended-sediment concentrations for the same magnitude of discharge.

The larger suspended-sediment concentrations occur as a result of greater availability of finer, more easily eroded and transported material in the Pacific Creek drainage basin, which is underlain principally by sandstone, mudstone, and siltstone (fig. 8). In summary, for areas of the basin where fine-grained materials are available for erosion and transport, suspended-sediment concentrations tend to be large.

Using equation 4, which was defined on the basis of periodic samples, a long-term record of the suspended-sediment transport rate may be developed for a site. Such computations were made using the relation (DeLong, 1977):

$$\bar{L} = (b/d)\sum_{j=i}^{d} C_j Q_j \tag{6}$$

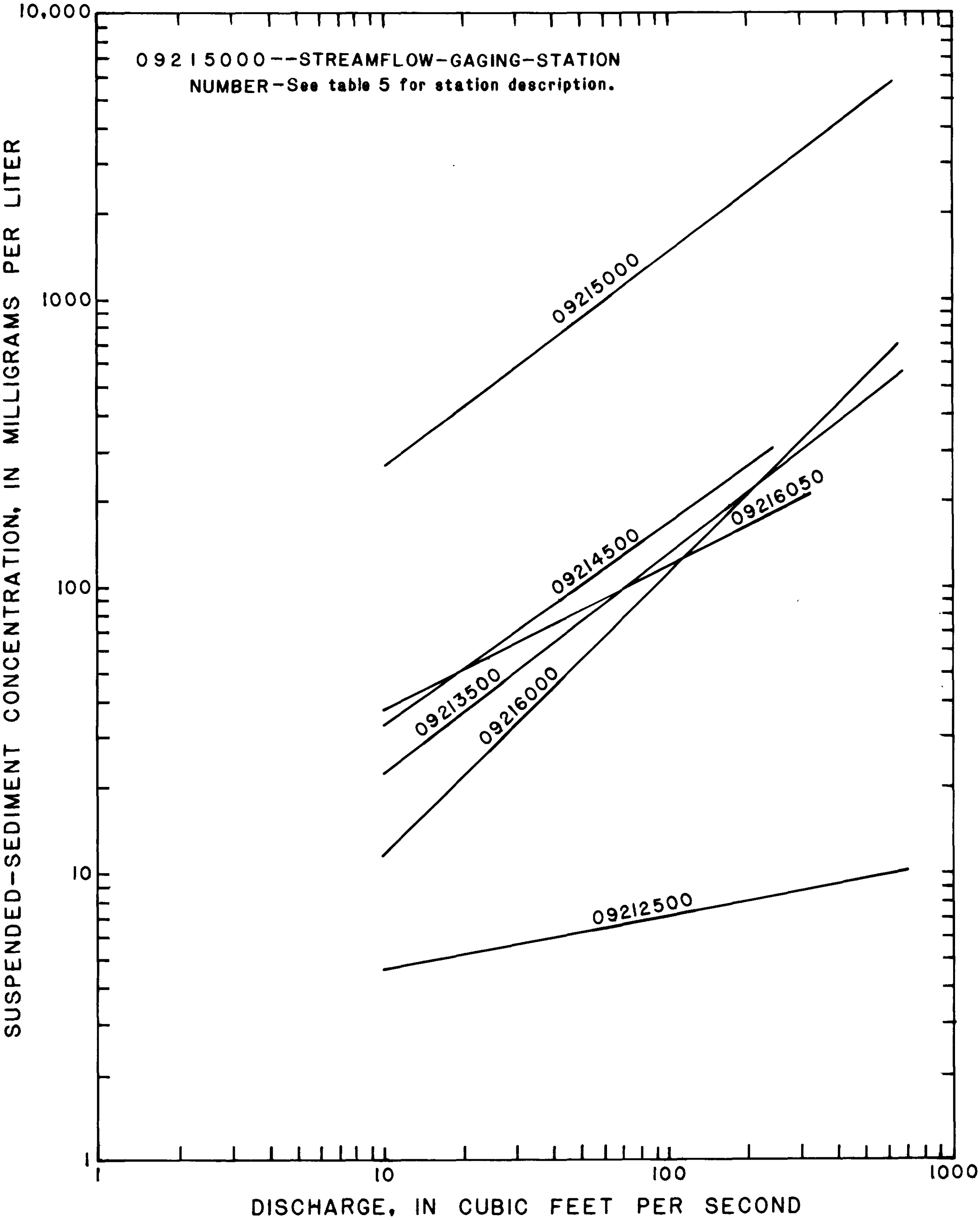


Figure 17.--Relations of suspended-sediment concentration to discharge at six streamflow-gaging stations in the Big Sandy River basin.

Table 6.--Summary of regression relations for suspended-sediment data

[n is number of data points used in regression analysis; r is correlation coefficient]

Station name	Station No.	n	Statistical values for suspended-sediment concentration versus water discharge		Statistical values for regression relations of suspended-sediment transport rate versus water discharge	
			r	Regression equation	r	Regression equation
Big Sandy River at Leckie Ranch, near Big Sandy	09212500	31	0.32	$C_s=3.17Q^{0.17}$	0.92	$Q_s=0.0086Q^{1.17}$
Big Sandy River near Farson	09213500	73	.77	$C_s=3.78Q^{0.77}$	.94	$Q_s=0.010Q^{1.78}$
Little Sandy Creek above Eden	09214500	47	.77	$C_s=6.47Q^{0.71}$	.94	$Q_s=0.0148Q^{1.77}$
Pacific Creek near Farson	09215000	6	.83	$C_s=46.4Q^{0.76}$	.96	$Q_s=0.1226Q^{1.77}$
Big Sandy River below Eden	09216000	83	.55	$C_s=1.18Q^{0.99}$	.80	$Q_s=0.0032Q^{1.99}$
Big Sandy River at Gasson Bridge, near Eden	09216050	44	.34	$C_s=11.4Q^{0.51}$	.73	$Q_s=0.0314Q^{1.50}$

where:

$\bar{L}$ = monthly mean transport rate, in tons per day;
b = 0.0027, a conversion factor to convert milligrams per liter X cubic feet per second to tons per day;
d = days per month;
j = days of month;
C_j = daily concentration, in milligrams per liter; and
Q_j = daily discharge, in cubic feet per second.

Because of the large number of calculations involved, equations 4 and 6 were incorporated into a computer program developed by Glover (1978). The basic procedure is illustrated in figure 18. Daily loads are calculated, and monthly loads are then determined by summing the daily values. Monthly mean suspended-sediment transport rates for six sites in the study area are shown in figures 19-24.

Bedload

Bedload was sampled at five locations in the Big Sandy River basin with Helley-Smith bedload samplers (fig. 25), using a technique developed by Emmett (1979). Samples were collected at 20 or more vertical sections at each site to determine the average bedload and particle-size distribution in the cross section (table 7).

Although the Helley-Smith bedload sampler is used widely by the U.S. Geological Survey, other Federal and State agencies, and university and private organizations, it has not been officially sanctioned by the Federal Inter-Agency Sedimentation Committee (Water Resources Council) nor certified for its technical performance by the U.S. Geological Survey. This certification is awaiting completion of rigorous laboratory testing of the sediment-trapping characteristics of the sampler under direction of the U.S. Geological Survey and the Federal Inter-Agency Sedimentation Committee. Laboratory testing of the sampler probably will not be completed until the mid-1980's.

The average channel-wide transport rates in table 7 were determined from a cross-sectional series of measurements and multiplied by the cross-sectional width to obtain the total bedload transport rate. The few measurements available show that the total bedload transport rate is directly proportional to water discharge. At most of the stations the total bedload transport rate increases at a faster rate with increasing discharge than does the suspended-sediment transport rate.

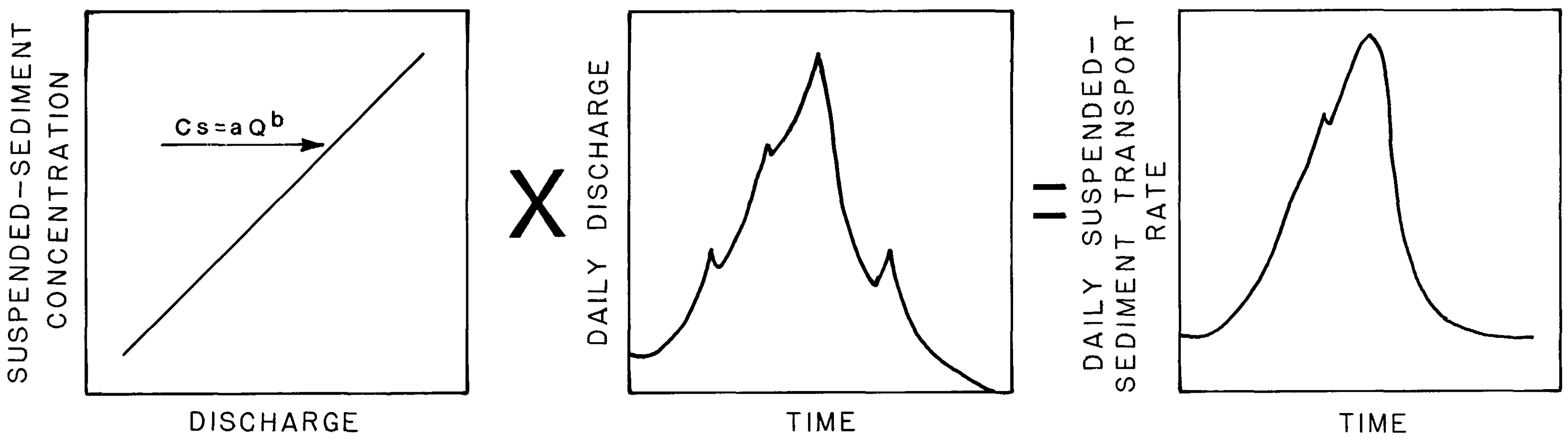


Figure 18.--Procedure used to model suspended-sediment transport-rate graphs.

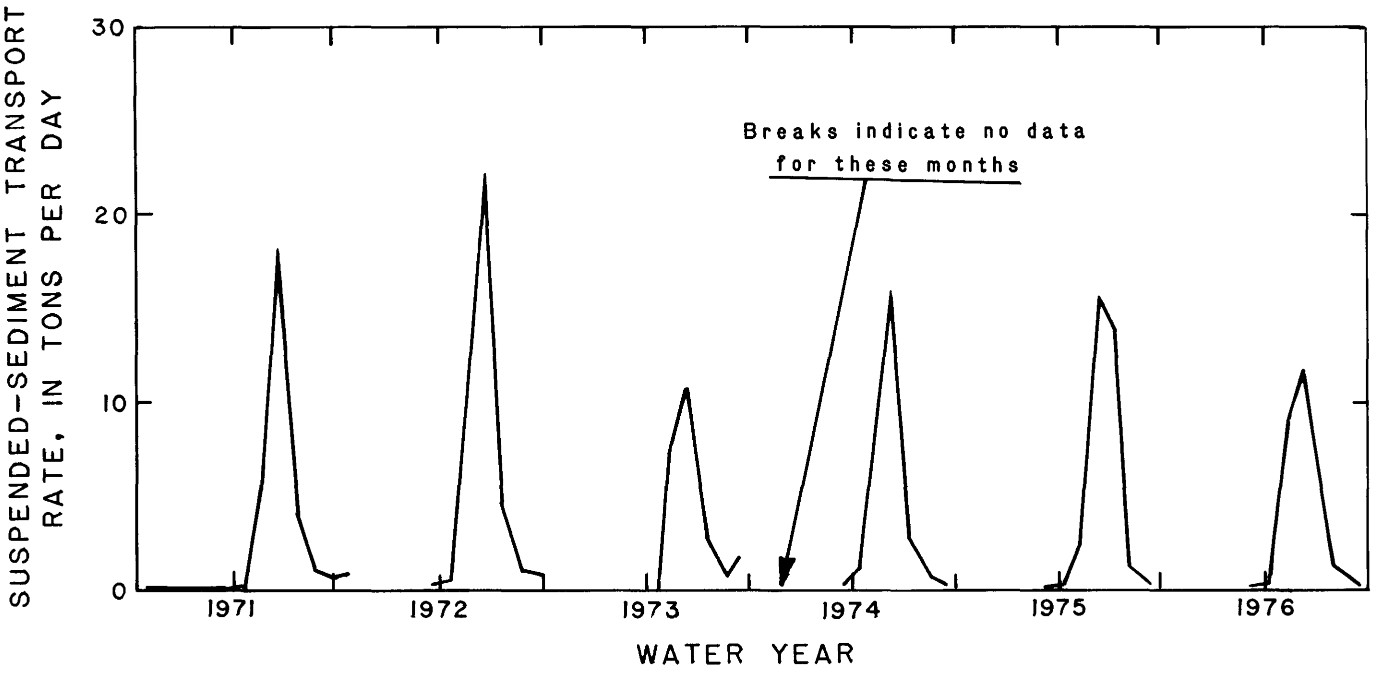


Figure 19.--Monthly mean suspended-sediment transport rate at streamflow-gaging station 09212500, Big Sandy River at Leckie Ranch, near Big Sandy.

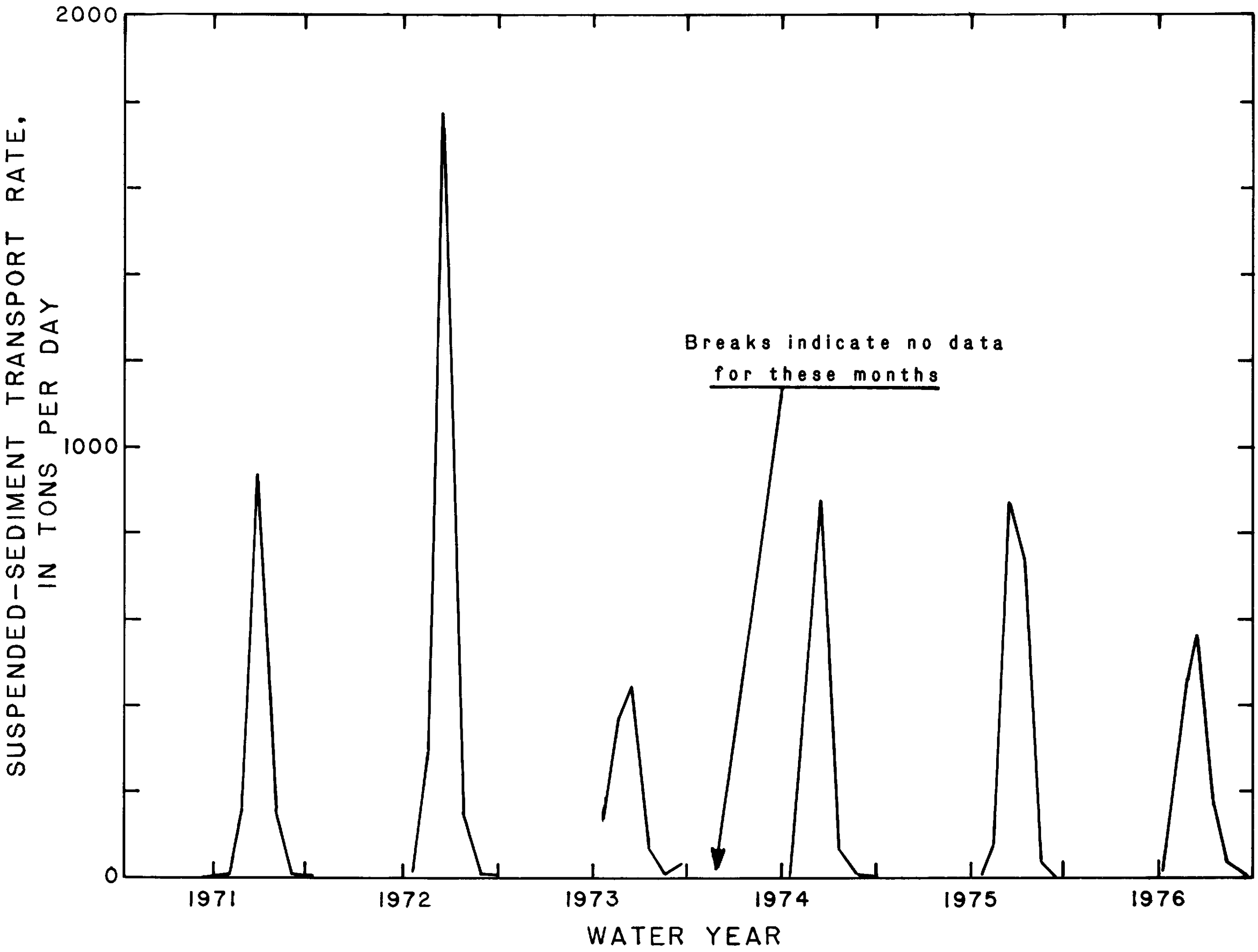


Figure 20.--Monthly mean suspended-sediment transport rate at streamflow-gaging station 092135000, Big Sandy River near Farson.

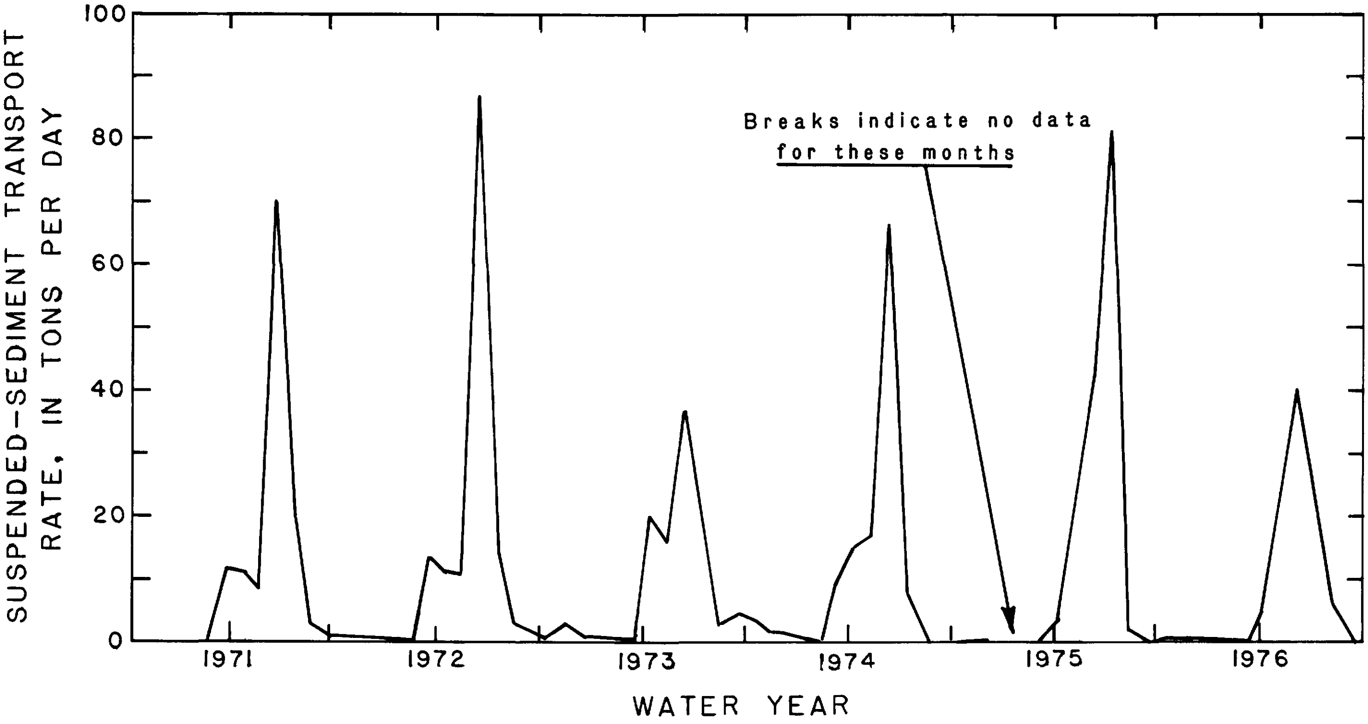


Figure 21.--Monthly mean suspended-sediment transport rate at streamflow-gaging station 09214500, Little Sandy Creek above Eden.

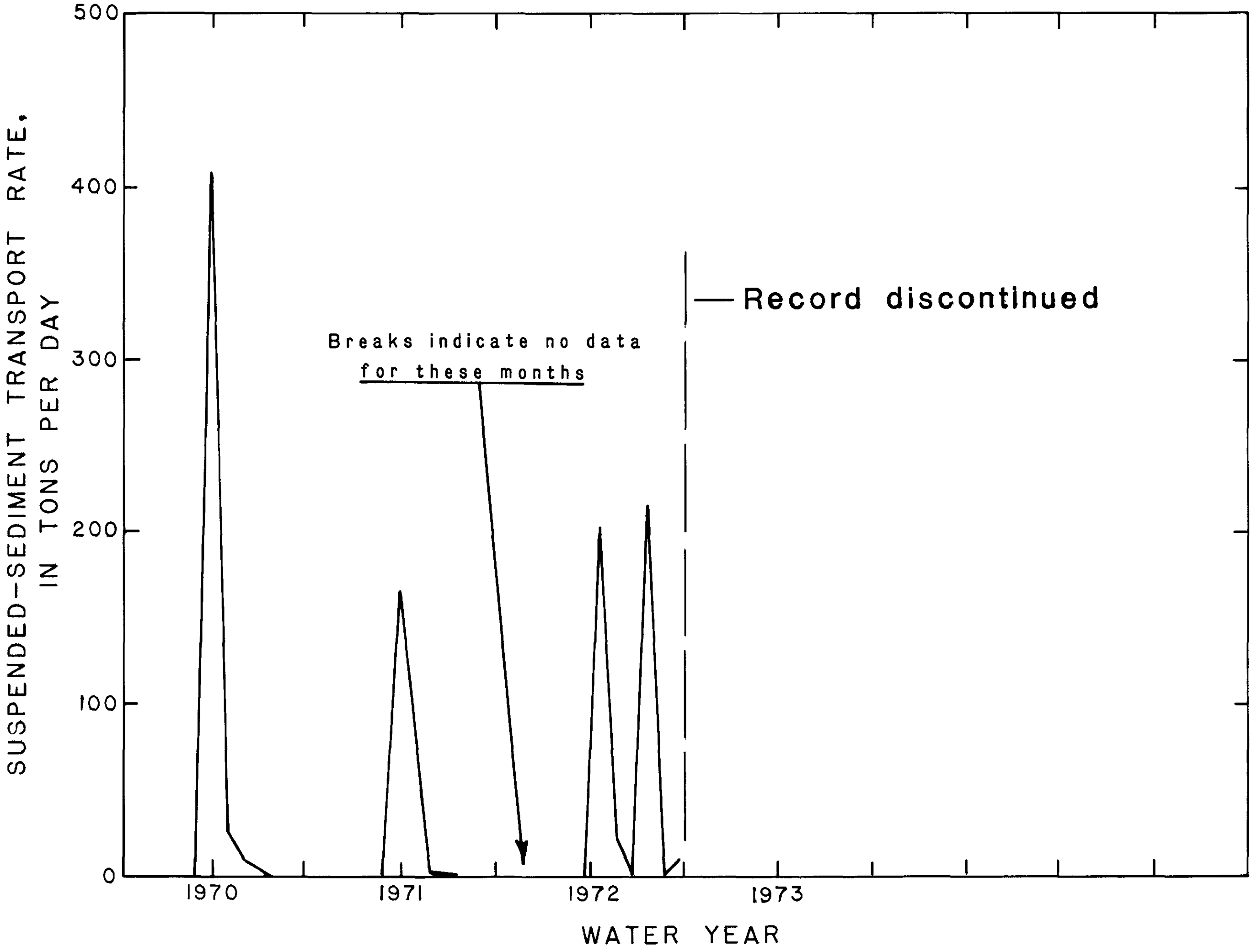


Figure 22.--Monthly mean suspended-sediment transport rate at streamflow-gaging station 09215000, Pacific Creek near Farson.

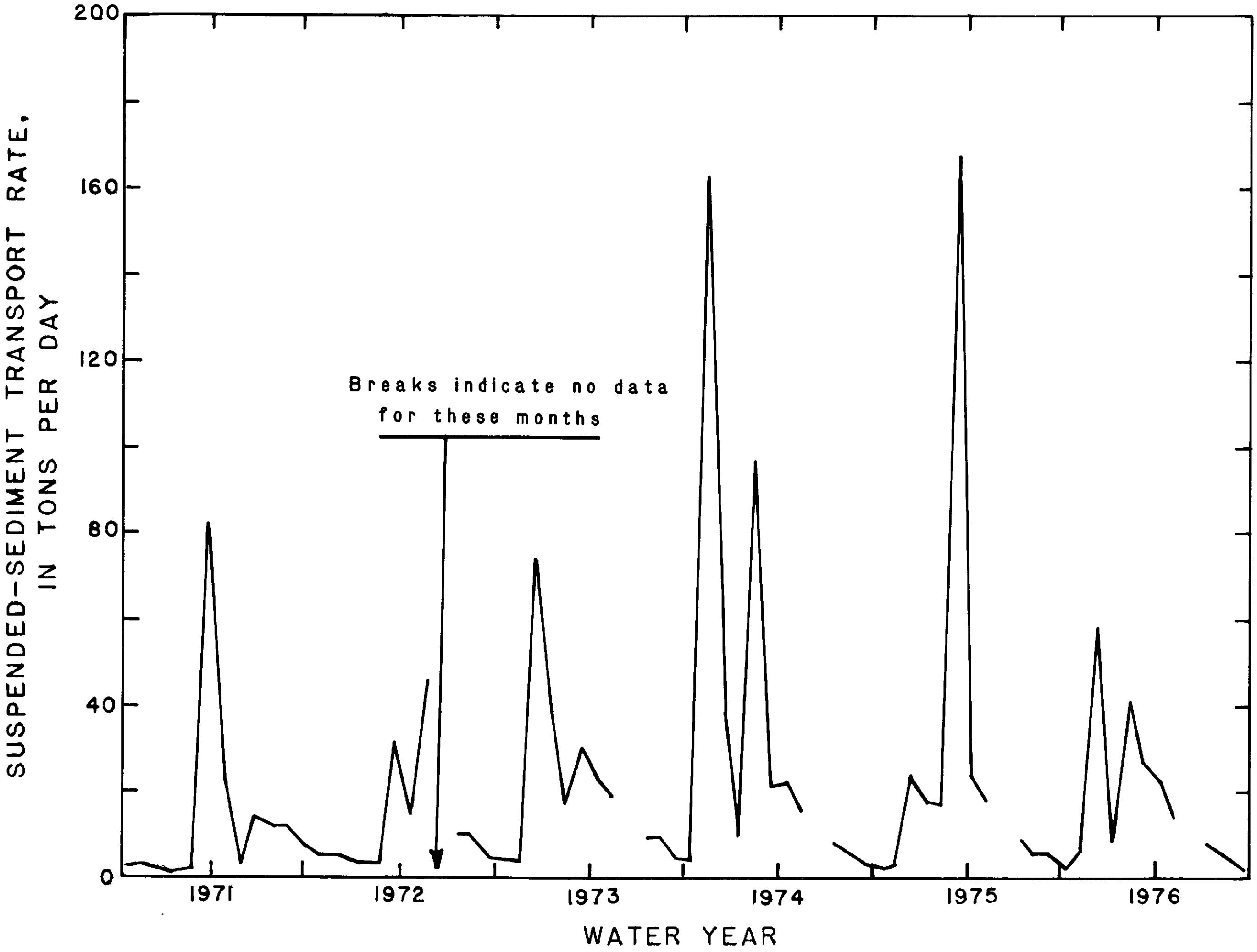


Figure 23.--Monthly mean suspended-sediment transport rate at streamflow-gaging station 09216000, Big Sandy River below Eden.

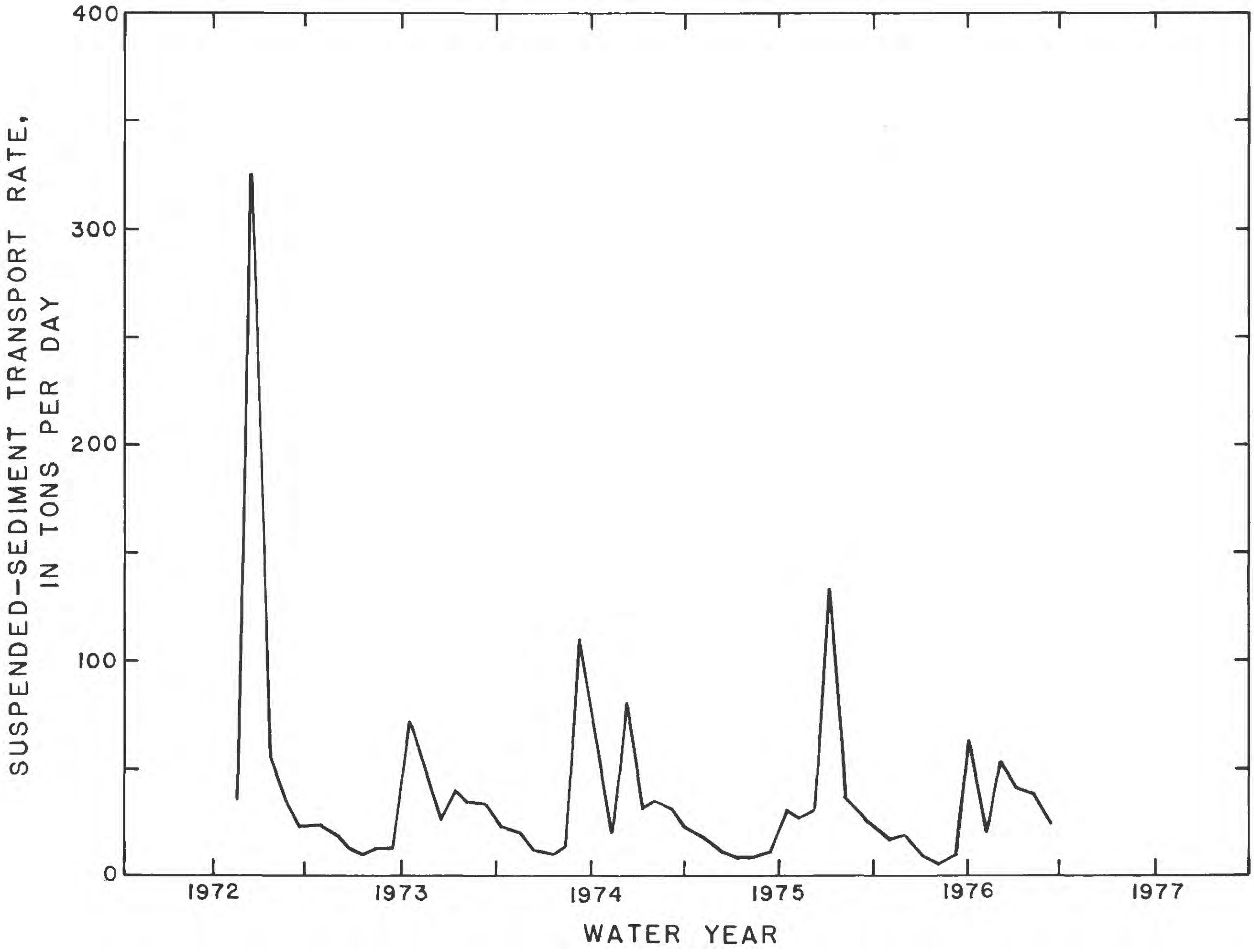


Figure 24.--Monthly mean suspended-sediment transport rate at streamflow-gaging station 09216050, Big Sandy River at Gasson Bridge, near Eden.

Figure 25.--Bedload sampling with the Helley-Smith bedload sampler.

Table 7.--Results of Helley-Smith bedload sampling, June-July 1978

Station name	Station No.	Date	Time	Discharge (cubic feet per second)	Width (feet)	Number of sections	Weight sampled (grams)	Average channel-wide bedload transport rate (tons per day per foot)	Total-bedload transport rate (tons per day)	Average total-bedload transport rate (tons per day)
Big Sandy River at Leckie Ranch, near Big Sandy	09212500	6-13-78	1250	621	64	22	247.6	0.14	9.15	
		6-13-78	1400	603	64	22	235.5	.135	8.69	8.92
		6-22-78	1200	752	75	22	557.6	.322	24.12	
		6-22-78	1400	721	75	22	487.8	.281	21.10	22.61
		7-19-78	1045	263	63	29	43.3	.019	1.19	
		7-19-78	1115	263	63	29	10.6	.005	.29	.74
Big Sandy River near Farson	09213500	6-15-78	0930	870	90	16	4,513	3.579	322.07	
		6-15-78	1030	857	90	16	4,258	3.376	303.88	313
		6-23-78	1100	665	90	22	3,556	2.051	184.57	
		6-23-78	1200	646	90	22	2,451	1.413	127.20	156
		7-19-78	1630	260	87	22	1,548	.893	77.67	
		7-19-78	1700	260	87	22	2,372	1.368	119.01	98.3
Little Sandy Creek above Eden	09214500	6-15-78	1500	104	21	20	1,141	.724	15.20	
		6-15-78	1615	107	21	20	2,071	1.314	27.59	21.4
		6-24-78	1400	115	22	20	1,819	1.154	25.39	
		6-24-78	1530	115	22	20	1,971	1.250	27.50	26.5
		7-19-78	1345	68	18	17	485	.362	6.52	
		7-19-78	1415	68	18	17	442	.330	5.94	6.23
Big Sandy River below Eden	09216000	6-12-78	1100	22	30	20	916	.581	17.43	
		6-12-78	1145	22	30	20	622	.395	11.84	14.6
		6-21-78	1430	46	48	23	2,590	1.429	68.58	
		6-21-78	1530	46	48	23	1,256	.693	33.56	51.1
Big Sandy River at Gasson Bridge, near Farson	09216050	6-12-78	1000	35	54	27	1,393	.655	35.35	
		6-12-78	1145	34	54	27	1,626	.764	41.26	38.3
		6-21-78	1200	71	56	28	2,546	1.154	64.60	
		6-21-78	1300	71	56	28	2,370	1.074	60.14	62.4

Table 7.--Results of Helley-Smith bedload sampling, June-July 1978--Continued

Station name	Station No.	Date	Time	Sieve analysis of bedload Percentage of total in each size category (millimeters)								
				<0.062	0.062-0.125	0.125-0.250	0.250-0.500	0.500-1.000	1.000-2.000	2.000-4.000	4.00-8.00	>8.0
Big Sandy River at Leckie Ranch, near Big Sandy	09212500	6-13-78	1250	0.1	0.1	5.7	26.5	30.1	27.4	8.4	1.7	
		6-13-78	1400	.1	.2	2.3	15.3	29.4	34.6	15.4	2.7	
		6-22-78	1200	.1	.1	2.7	18.3	25.1	30.0	18.9	4.2	0.6
		6-22-78	1400	.1	.1	2.9	23.0	33.3	27.1	11.0	2.2	.3
		7-19-78	1045	.2	.5	2.1	22.7	41.6	25.0	7.2	.7	
		7-19-78	1115	0	1.0	2.9	25.2	36.0	25.2	8.7	1.0	
Big Sandy River near Farson	09213500	6-15-78	0930	.2	.6	6.1	17.2	24.3	26.3	15.1	6.4	3.8
		6-15-78	1030	.3	.5	5.7	15.3	21.6	25.8	17.6	9.6	3.6
		6-23-78	1100	.2	.6	8.8	24.8	22.8	21.8	13.4	4.8	2.8
		6-23-78	1200	.2	.7	8.3	27.8	33.5	21.9	6.6	1.0	
		7-19-78	1630	0	.2	4.8	19.3	25.8	31.3	15.0	3.1	.5
		7-19-78	1700	.1	.1	4.1	22.1	32.0	26.3	11.3	3.3	.7
Little Sandy Creek above Eden	09214500	6-15-78	1500	.5	.6	4.6	18.4	27.8	31.0	14.3	2.8	0
		6-15-78	1615	.2	.2	3.0	28.6	42.2	19.8	5.0	1.0	0
		6-24-78	1400	.3	.4	2.9	16.8	39.0	29.4	9.7	1.3	.2
		6-24-78	1530	.2	.2	2.5	17.3	38.5	29.1	9.3	2.5	0
		7-19-78	1345	.1	.4	4.2	24.7	34.8	23.3	10.6	1.9	0
		7-19-78	1415	.3	.4	3.3	16.3	33.1	31.8	12.5	2.1	.2
Big Sandy River below Eden	09216000	6-12-78	1100	.1	.1	1.5	12.8	31.1	34.5	16.4	2.4	1.1
		6-12-78	1145	.1	.1	1.4	21.6	33.7	27.3	12.6	3.2	0
		6-21-78	1430	0	.2	1.5	21.8	36.7	26.4	11.4	1.4	.6
		6-21-78	1530	0	.1	1.6	15.3	29.5	30.9	16.5	4.9	1.2
Big Sandy River at Gasson Bridge, near Farson	09216050	6-12-78	1000	0	.1	1.8	16.0	37.9	31.3	9.3	2.2	1.4
		6-12-78	1145	0.1	.1	.9	13.7	37.0	35.0	10.5	1.4	1.3
		6-21-78	1200	0	.2	1.1	19.8	44.8	26.2	6.7	1.0	.2
		6-21-78	1300	0	.2	1.2	17.9	42.3	29.6	7.4	1.4	0

In order to obtain a better idea of how the Helley-Smith bedload sampler compares with an established technique of computing bedload, the Helley-Smith bedload results were compared to the Einstein bedload function. Because the bedload data in the Big Sandy River basin were limited, some of W. W. Emmett's numerous data (Emmett, 1975; 1976; 1979; Emmett and others, 1978; Emmett and Seitz, 1974) also were plotted. This comparison is shown in figure 26. Both the Einstein curve and the Brown modification of the Einstein function were drawn to compare with the Helley-Smith bedload data. The dimensionless functions used were defined by Brown (1950) as:

$$\Phi = \frac{q_s}{g\rho_s F}\left[\frac{\sqrt{\rho}}{\rho_s-\rho}\right]\left[\sqrt{1/gd^3}\right], \tag{7}$$

$$F = \sqrt{\left[\frac{2}{3}+\frac{36v^2}{gd^3(\rho_s/\rho-1)}\right]} - \sqrt{\left[\frac{36v^2}{gd^3(\rho_s/\rho-1)}\right]}, \text{ and} \tag{8}$$

$$\frac{1}{\psi} = \frac{\rho R'_b S}{(\rho_s-\rho)d} \tag{9}$$

where:

Φ = intensity of sediment transport;

q_s = sediment-transport rate of channel width, in pounds per second per foot, measured with Helley-Smith bedload sampler;

g = gravitational constant (32 feet per second per second);

ρ_s = specific gravity of sediment, which was assumed equal to 2.65;

F = dimensionless function of fall velocity;

ρ = specific gravity of water, which is equal to 1;

v = kinematic viscosity, in square feet per second, which was assumed to have a value of 1.12×10^{-5} square feet per second;

d = representative size of bed material, in feet, which was assumed to be the d_{35} size;

d_{35} = sediment size of which 35 percent is finer, in feet;

ψ = intensity of shear on particle;

R'_b = hydraulic radius due to grain roughness, in feet; and

S = energy slope, in feet per foot.

The comparison shows some scatter, but an analysis can be made from this plot. The Einstein bedload function is determined by the curve with the equation:

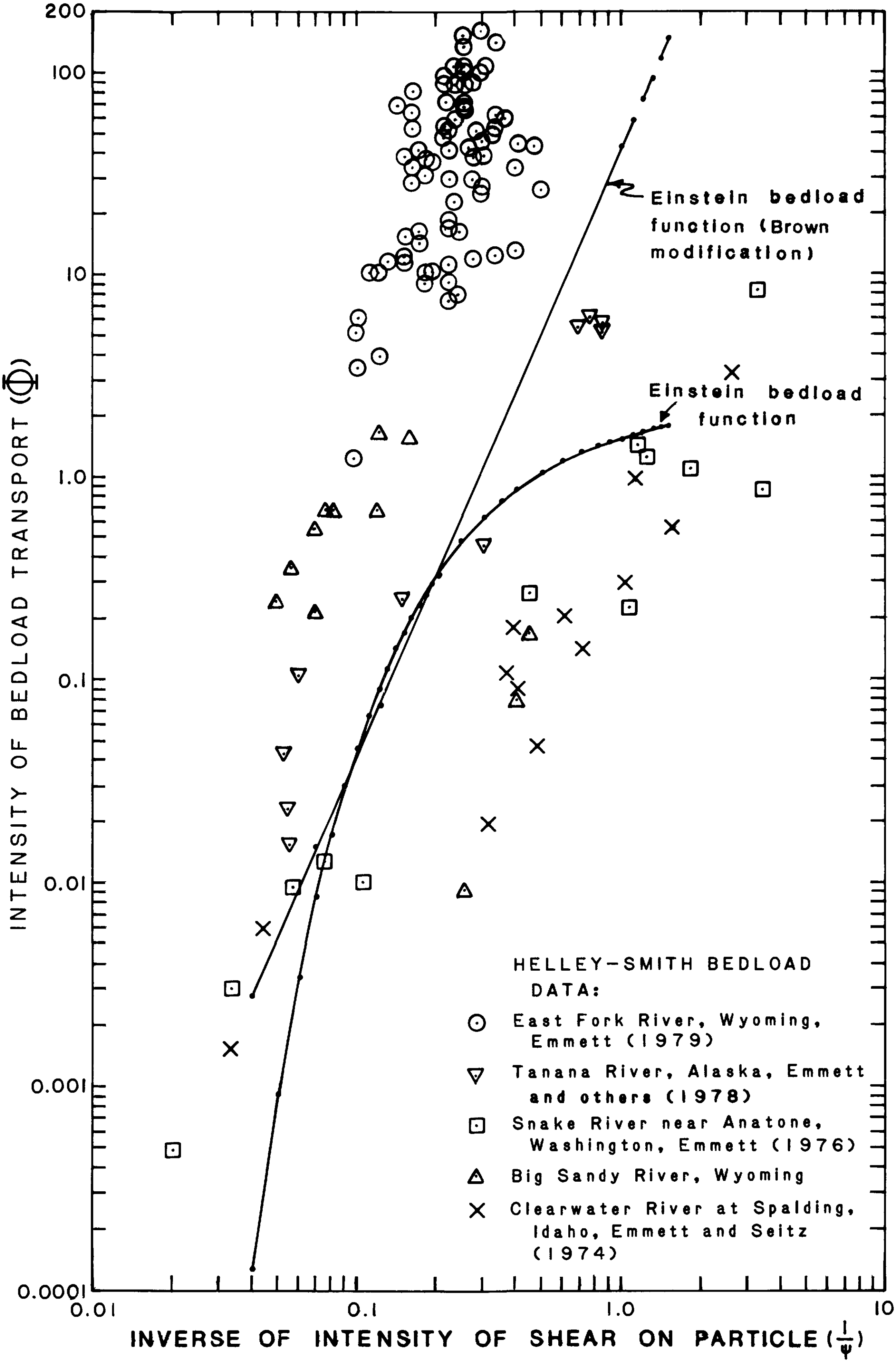


Figure 26.--Comparison of Helley-Smith bedload data with the Einstein bedload function.

$$\Phi = 2.1505e^{-0.391\psi}, \tag{10}$$

while Brown (1950) showed that the relation

$$\Phi = 40\left(\frac{1}{\psi}\right)^3 \tag{11}$$

fits the data more closely. The Helley-Smith data conform more closely to the Brown version of the Einstein bedload function than to the original Einstein function in figure 26. Using the Einstein and Brown-Einstein bedload functions as a guide, the Helley-Smith data can be analyzed in general terms. The data points to the right of the curves in all instances come from streams having large quantities of both fine and coarse sediment, with the sediment sizes in between contributing very little to the actual sediment load. In these types of streams, the larger particles have a shielding effect by trapping the smaller particles between them. This shielding effect causes a smaller amount of sediment to be transported than the stream has capacity to carry. In addition, Emmett (1979) stated that due to the Helley-Smith's size and the paucity of large particles moving, particles larger than the sampler nozzle are not picked up by the sampler, and the rate of movement of the larger particles is such that they may not pass the sampling section at the time and place of sampling. This would result in a measured transport rate less than what actually occurs along the bed.

The data points above the curves indicate more transport than the Brown-Einstein relation. A reason for this may be the inclusion of part of the wash load in the Helley-Smith sample. Einstein included only that part of the bedload occurring in appreciable quantities in the bed in his development of the bedload function, which underestimates the actual sediment load near the bed. Another reason for the large measured load by the Helley-Smith bedload sampler may be the scooping effect the sampler can have when set on the bed of a stream. This will inherently give a larger transport rate than is actually present. Even with proper use of the Helley-Smith sampler, it is difficult to eliminate this scooping completely while collecting a sample.

In developing the modified Einstein relation, Colby and Hembree (1955) arbitrarily divided the bedload intensity by two. This procedure was applied in figure 27 to see if it improved the comparison of the Helley-Smith bedload data with the Einstein bedload function. When the Colby adjustment was applied to the data, there was no improvement. The data points actually remained the same or moved further away from the Einstein and Brown-Einstein functions. Therefore, it can be said that the Colby adjustment did not improve the Einstein bedload function in this case.

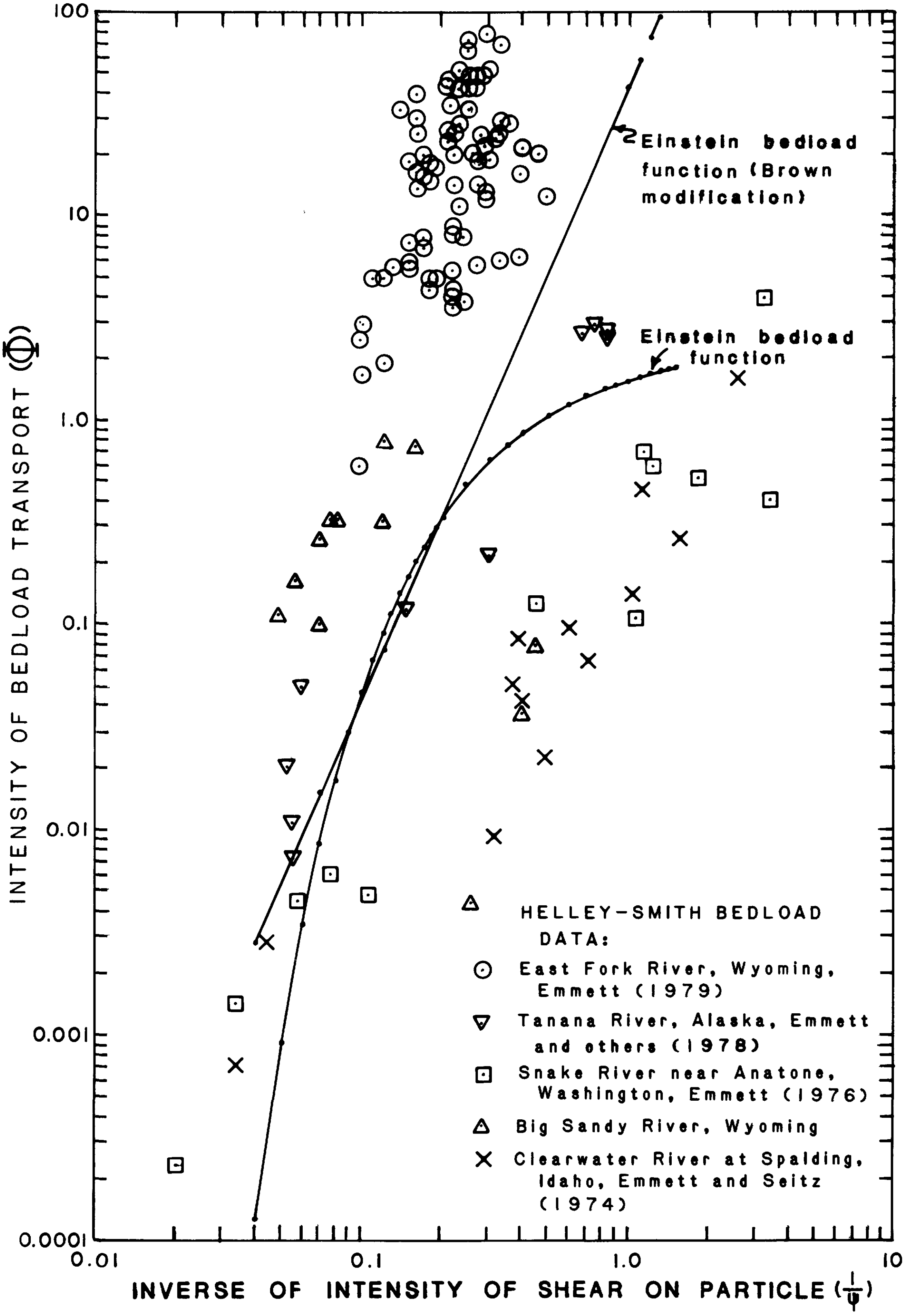


Figure 27.--Comparison of Helley-Smith bedload data with the Einstein bedload function using Colby's modification of the bedload intensity.

Total Transport Rate

Total transport rate was determined by two methods. One method combines the measured bedload transport rate and the measured suspended-sediment transport rate. The other method, used mainly as a check for the measured total transport rate, was developed by Colby (1957). The Colby method uses a relation of unmeasured sediment discharge to mean velocity and to concentration of measured suspended sediment to predict the total transport rate. The two methods are compared in table 8 for those stations where the bedload-transport rate was measured. Calculations of total transport rate using the Colby method were not made for the Big Sandy River at Leckie Ranch because this method cannot be used for gravel and cobble streambeds.

The results in table 8 show that the Colby method gives larger transport rates at high flows and smaller transport rates at low flows than the measured total transport rate. However, more data are needed to compare the methods over a wider range of flow conditions.

SOURCE AREAS OF SEDIMENT AND RUNOFF

The sediment load of a stream generally is not supplied equally from all areas of the drainage basin. Some areas may contribute a relatively large part of the annual sediment load, while other areas contribute relatively minor quantities of sediment. Similarly, runoff is seldom supplied evenly from throughout a drainage basin. Sediment and runoff source areas commonly can be identified for a drainage basin provided the sediment loads and runoff are measured or estimated at several points within the basin (Andrews, 1978).

Because the Big Sandy Reservoir forms a control on the Big Sandy River, the basin was divided into two parts for the purpose of determining the source areas of sediment in the drainage basin. The relative contributions of sediment transport and runoff at various sites in the drainage basin in relation to the totals at station 09213500, Big Sandy River near Farson, and at station 09216050, Big Sandy River at Gasson bridge below Eden are shown in figure 28.

Although there is very little runoff gain between stations 09212500 and 09213500 upstream from Big Sandy Reservoir, there is a large increase in both suspended-sediment transport rate and total transport rate (fig. 28). Pacific Creek, with a drainage area of about 500 square miles, contributes only 7 percent of the runoff but 70 percent of the suspended-sediment load for the drainage downstream from Big Sandy Reservoir (fig. 28). The total load value for Pacific Creek consists of only suspended-sediment data because no bedload data were available.

To further aid in determining areas that contribute the sediment load, samples were collected during the spring of 1976, the fall of 1977, and the spring of 1978. These results are shown in figures 29 and 30. During these periods only suspended-sediment data were collected. The results indicate that very little sediment is transported during the fall and that most of the sediment during the spring is supplied by Little Sandy Creek to the Big Sandy River downstream from Big Sandy Reservoir.

Table 8.--Summary of total transport rate computations

Station name	Station No.	Date	Time	Width (feet)	Discharge (cubic feet per second)	Mean velocity (feet per second)	Mean depth (feet)	Measured bedload transport rate (tons per day)	Measured suspended-sediment transport rate (tons per day)	Total transport rate, Colby's method (tons per day)	Total transport rate (measured) (tons per day)	Percentage difference
Big Sandy River at Leckie Ranch, near Big Sandy	09212500	6-13-78	1330	64	612	3.78	2.53	8.92	74	---	---	---
		6-22-78	1300	75	737	4.07	2.41	22.61	64	---	---	---
		7-19-78	1100	63	263	2.69	1.55	.74	7	---	---	---
Big Sandy River near Farson	09213500	6-15-78	1000	90	864	2.45	3.92	313	9,700	11,103	10,013	- 9.8
		6-23-78	1130	90	656	2.41	3.02	156	5,190	6,273	5,346	-14.8
		7-19-78	1645	87	260	2.28	1.31	98.3	98	264	196	-25.8
Little Sandy Creek above Eden	09214500	6-15-78	1530	21	105	1.74	2.87	21.4	440	526	461	-12.4
		6-24-78	1445	22	115	1.77	2.95	26.5	110	154	137	-11.0
		7-19-78	1400	18	68	1.61	2.35	6.23	28	48	34	-29.2
Big Sandy River below Eden	09216000	6-12-78	1130	30	22	1.41	.52	14.6	3	11	17.6	+37.5
		6-21-78	1500	48	46	1.65	.58	51.1	16	47	67	+42.6
Big Sandy River at Gasson Bridge, near Eden	09216050	6-12-78	1045	54	35	1.45	.45	38.3	16	44	54	+22.7
		6-21-78	1230	56	71	1.70	.75	62.4	45	101	107.4	+ 6.3

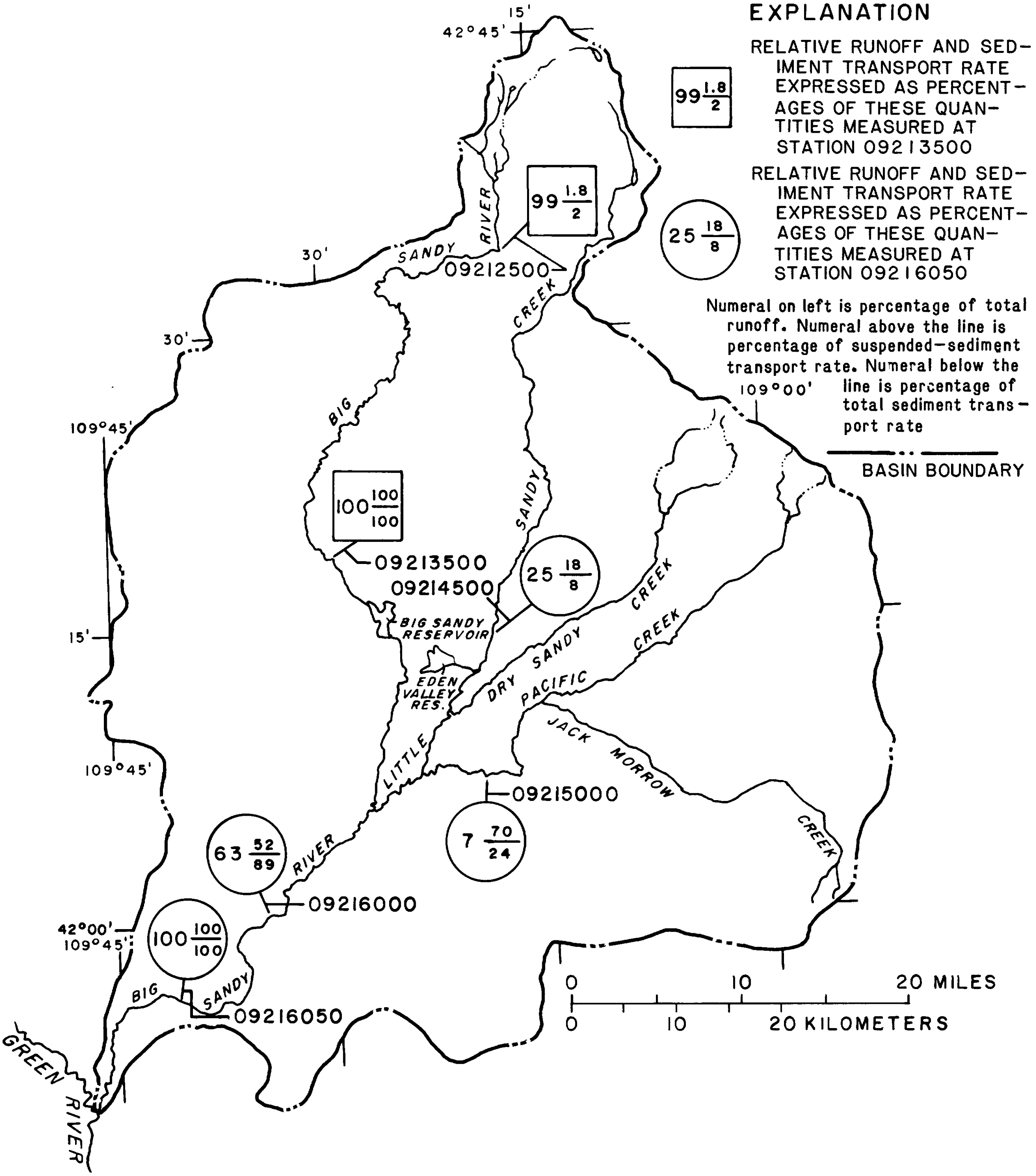


Figure 28.--Relative contributions of sediment and runoff at selected streamflow-gaging stations.

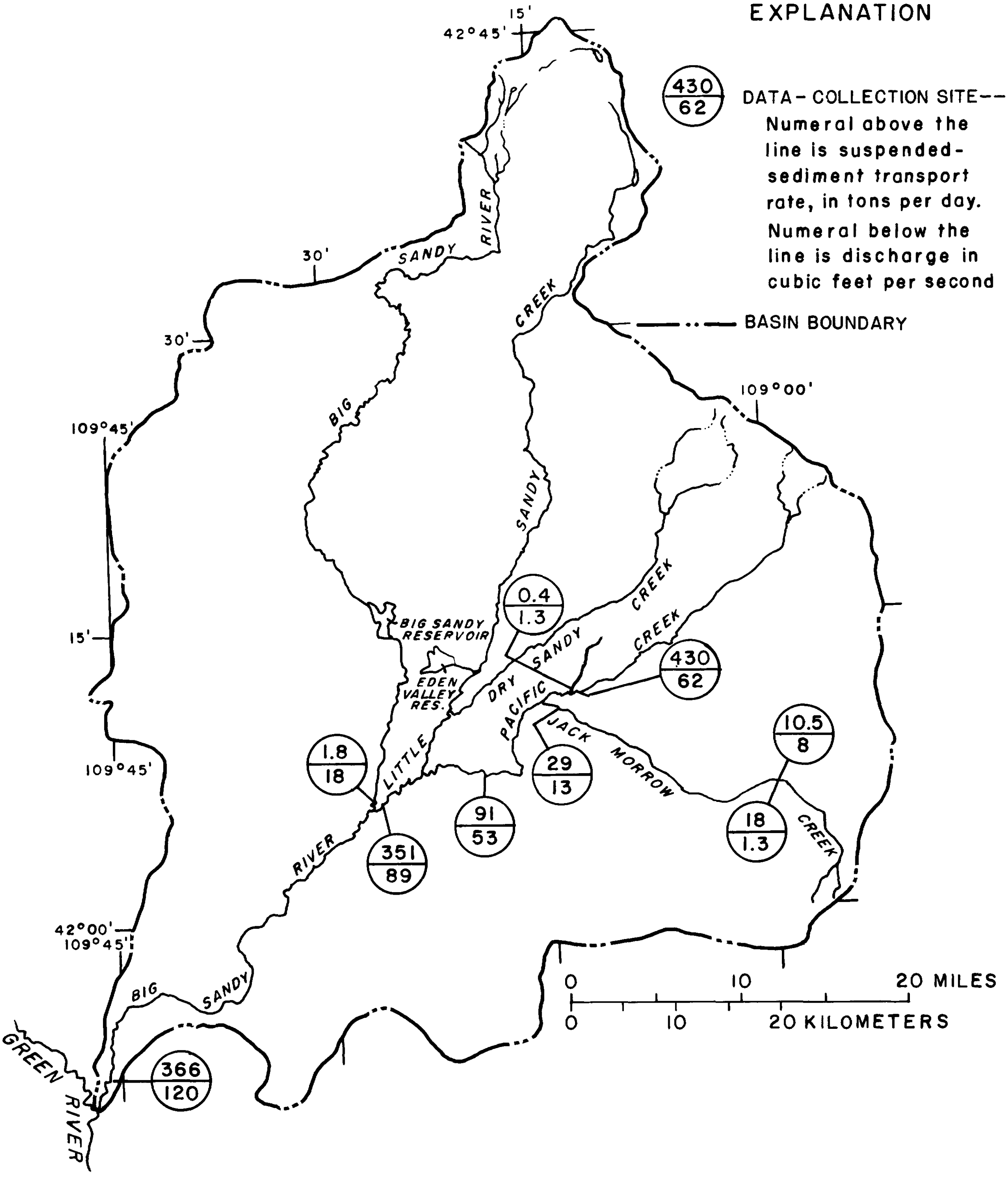


Figure 29.--Instantaneous discharges and suspended-sediment transport rates measured during reconnaissance trip of October 1977.

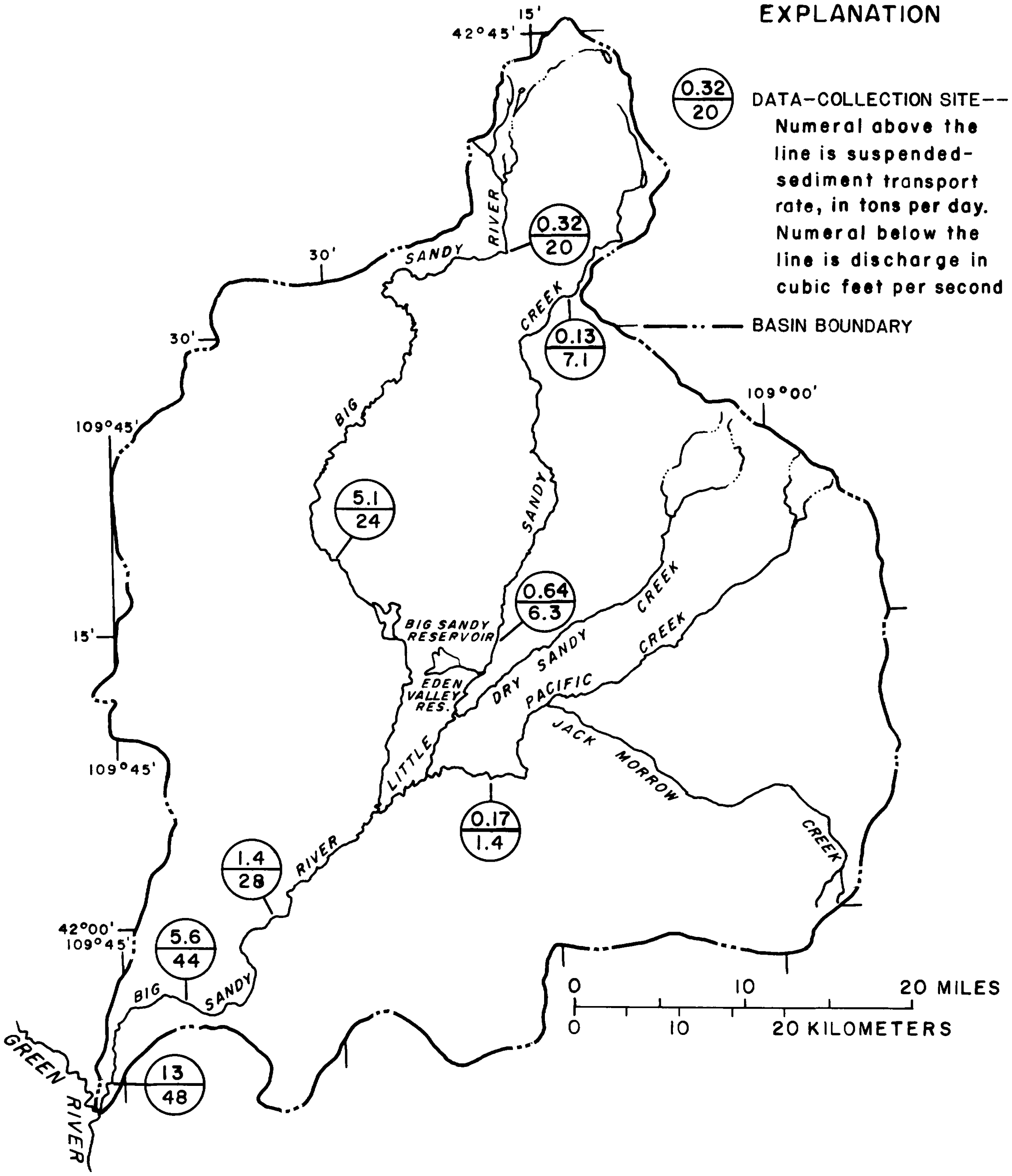


Figure 30.--Instantaneous discharges and suspended-sediment transport rates measured during reconnaissance trip of March 1978.

It is apparent from figures 28-30 that Pacific Creek contributes a significant part of the sediment that enters the Big Sandy River downstream from Big Sandy Reservoir; however, there is a substantial increase in sediment transport between the mouth of Pacific Creek and the mouth of Little Sandy Creek that is unaccounted for. Part of this increase in transport rate may be from Dry Sandy Creek, which has basin characteristics similar to Pacific Creek. Part also may be coming from a flushing of the main channel of Little Sandy Creek. This would be the case when sediment is deposited in the wider main channel of Little Sandy Creek by low flows from narrower Pacific and Dry Sandy Creeks. This type of behavior would most likely occur when irrigation return flows are entering the channels, picking up sediment from the banks, but not having enough flow to transport the material to the Big Sandy River.

FACTORS AFFECTING SEDIMENT YIELDS

The quantity of sediment eroded from a watershed is affected by several factors. Bedrock geology, soil type, vegetation, climate (mainly precipitation and temperature), topography, and land use are the most important, and many of these are interrelated. Therefore, the sediment yields vary considerably throughout the basin. More than 50 percent of the sediment runoff in the basin is supplied by 34 percent of the drainage area downstream from Big Sandy Reservoir, while less than 8 percent of the sediment is supplied by 25 percent of the drainage area. It is useful to consider which of the above-named factors are responsible for the variability of sediment yields within the basin.

Geology

Bedrock of the Big Sandy River basin is composed mostly of Tertiary and Cretaceous siltstone, mudstone, sandstone, and shale, all of which are easily eroded. They crop out widely throughout the basin in all areas where sediment production is large. This indicates that the geology of the region is a major factor contributing to the large sediment production. The erodibility and weathering of the bedrock is noticeable along the Big Sandy River and its major tributaries, so the sediment transport rate in the Big Sandy River and Pacific Creek may be explained in part by the geology.

A reconnaissance trip was made along the Big Sandy River upstream from Big Sandy Reservoir during the summer of 1978. It was observed that: (1) There was a downstream increase in sediment transport rate once the stream left the glacial deposits of the mountains and flowed across the semiarid plains into the Big Sandy Reservoir (fig. 8); (2) the stream was carrying almost no sediment in its upper reach; very few point bars existed, indicating there was large stream capacity for more sediment than was being supplied; (3) many locations along the stream had mass wasting of the banks (fig. 31), and (4) tributaries of the plains area supplied very little inflow to the river, probably due to the lack of precipitation, rapid infiltration rates, significant evaporation, and sublimation of much of the snow by winds. The small amount of inflow is apparent by the similar mean annual discharges measured at stations 09212500, Big Sandy River at Leckie Ranch, near Big Sandy, and 09213500, Big Sandy River near Farson (table 4).

Figure 31.--Bank mass wasting along the Big Sandy River upstream from Big Sandy Reservoir.

These factors, although not all related to the geology, may be used together to partly explain the increase in sediment runoff between stations 09212500 and 09213500. The stream flows through an area of a more erodible material after flowing from the glaciated terrain where the sediment load is small. Where the stream flows through the area of more erodible material, the pattern of the stream changes from a straight channel to a meandering channel, and the stream becomes more sinuous as it flows toward the Big Sandy Reservoir. As the stream flows toward the reservoir, it has a large capacity for sediment, but very little sediment is supplied by the ephemeral tributaries from watershed runoff. Therefore, the easily erodible banks and bed are the main sources of sediment for the stream.

The Pacific Creek drainage basin shows a similar occurrence of bank wasting. The area drained by Pacific Creek contains mostly siltstone, sandstone, and mudstone, all of which are easily eroded, but this alone may not be a significant contributing factor. Some return flow from irrigation, which could cause some bank instability, occurs in this drainage basin, but the quantity and occurrence are small enough that irrigation return flows are probably a minor part of the bank wasting.

Climate

Langbein and Schumm (1958) found that as precipitation increased, annual sediment yield increased until a maximum was reached at a mean annual precipitation of 12 inches. The sediment yield then decreased regardless of additional precipitation. The variation in sediment yield with precipitation can be explained by the interaction of precipitation and vegetation on runoff and erosion. As precipitation increases from zero, sediment yields increase at a rapid rate because more runoff becomes available to move sediment. However, vegetation becomes more abundant as precipitation increases, holding the soil in place and preventing its transport as sediment.

More than 70 percent of the Big Sandy River basin has a mean annual precipitation of about 8 inches per year. This includes all the inner region of the basin, which has the largest sediment production. This same area also has sagebrush-type vegetation, which is not very resistant to erosion. Therefore, Langbein and Schumm's relation may be used to explain the erodibility in the basin. For example, Pacific Creek heads in the low mountains, receives moderate precipitation and runoff, and has a large sediment runoff, while the interior part of the basin receives little precipitation and runoff and has little sediment runoff.

SUMMARY

Sediment samples were collected at six streamflow-gaging stations in the Big Sandy River basin for determining sediment and runoff source areas. Both suspended-sediment and bedload samples were collected in order to determine transport rates at several locations in the basin from which source areas were determined.

The suspended-sediment concentration was plotted against water discharge and the relation was used to predict long-term suspended-sediment transport rates. The method used to determine the transport rates was a modification of a load calculation used by DeLong (1977). The transport rates, supplemented by previously collected data, were used to delineate suspended-sediment source areas.

The bedload samples were collected with a Helley-Smith sampler. These samples were compared to the Einstein bedload function to determine the reliability of the Helley-Smith sampler. The results showed the bedload transport rate measured by the Helley-Smith sampler was greater than that determined by the Einstein bedload function for the East Fork and Big Sandy River data, which have a smaller range of sediment sizes. For rivers or streams where there was a large range of sediment sizes with very little sediment in the median range the inverse was true.

By combining the suspended-sediment and bedload data, total transport rates were determined. These transport rates were then compared to the Colby method of determining total load. The Colby method gave greater transport rates at high flows and smaller transport rates at low flows than the measured total transport rates. The difference between the Colby method and the measured total transport ranged from -29.2 percent at high flows to +42.6 percent at low flows.

The Big Sandy River basin was divided into two areas for determination of sources of sediment and runoff because of the control by the Big Sandy Reservoir. The area upstream from the reservoir receives most of its sediment from the bed and the banks as the river flows from its headwaters to the reservoir. Runoff increased by 1 percent, but the sediment transport increased by 98 percent between stations 09212500, Big Sandy River at Leckie Ranch, near Big Sandy, and 09213500, Big Sandy River near Farson. Erodible bedrock and the sparse vegetation cover associated with a semiarid climate were factors contributing to the sediment increase.

Although the Big Sandy River downstream from the reservoir is widened by irrigation return flows, the river has very little sediment load upstream from the confluence with Little Sandy Creek. Downstream from Little Sandy Creek, there is a large increase in both runoff and sediment load. The sediment comes mainly from the Pacific Creek drainage basin. The major causes of the large sediment load in Pacific Creek are the erodible basin material and the semiarid climate.

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