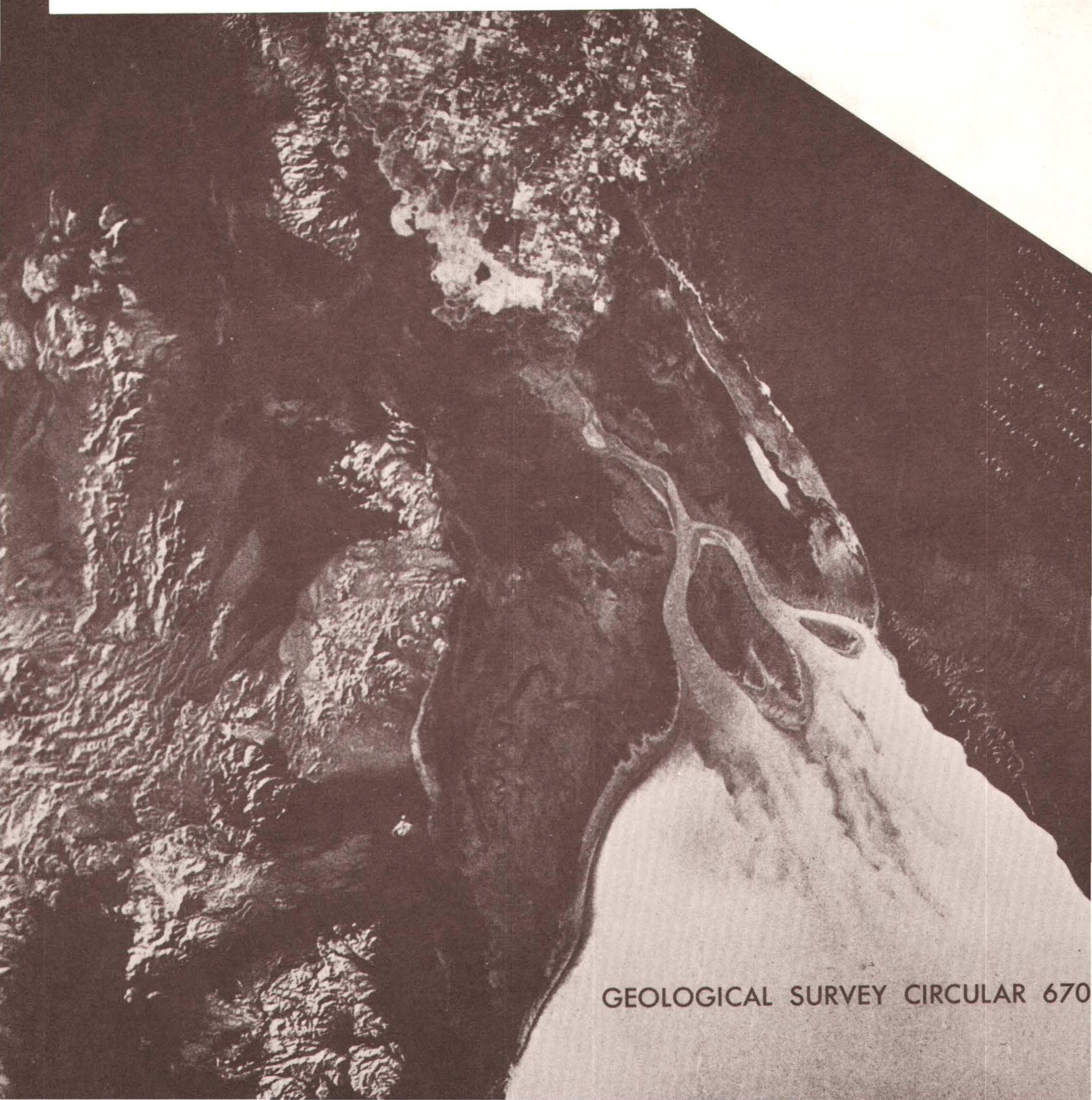
Fluvial-Sediment Discharge to the Oceans from the Conterminous United States



GEOLOGICAL SURVEY CIRCULAR 670

Fluvial-Sediment Discharge to the Oceans from the Conterminous United States

By W. F. Curtis, J. K. Culbertson, and E. B. Chase

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A contribution to the International Hydrologic Decade

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By W. F. Curtis, J. K. Culbertson, and E. B. Chase

ABSTRACT

This report is a contribution to the UNESCO-sponsored project of the International Hydrological Decade called the World Water Balance. Annual fluvial-sediment discharge from the conterminous United States averages 491,449,600 short tons, of which 14,204,000 is discharged to the Atlantic Ocean, 378,179,000 to the Gulf of Mexico, and 99,066,600 to the Pacific Ocean. Data from 27 drainage areas were used to estimate the average annual discharge, yield, and concentration of fluvial sediment. The data may be used to extrapolate part of the total world sediment yield to the marine environment.

INTRODUCTION

Sediment is defined as fragmental material derived primarily from the physical and chemical disintegration of rocks from the earth's crust. Once the sediment particles are detached, they may be transported either by gravity, wind, or water, or by a combination of these agents. When the transporting agent is water, the sediment is termed "fluvial sediment." The terms "fluvial sediment" and "suspended sediment" are used synonymously in this report to mean inorganic material that is transported in suspension by streams and rivers.

Knowledge of the amount of sediment transported by the various rivers of the world is important for many reasons. For example, reservoirs should be designed with enough space to store the sediment expected to accumulate in them and yet retain full effectiveness during their design life, and sediment yield can be an indication of the rate of erosion in the drainage basin. A summation of sediment yields by basins may indicate a regional, continental, and even an approximate world rate of erosion (Holeman, 1968). This report, which is a contribution to the UNESCO-sponsored project of the International Hydrological Decade called the World Water Balance, summarizes the quantity of fluvial sediment discharged to the Atlantic and Pacific Oceans and the Gulf of Mexico from the conterminous United States. The data given here may be useful to obtain the present total of world sediment yield to the marine environment.

The average annual amounts of suspended sediment discharged into the oceans from 27 major drainage areas were computed from suspended-sediment records from the files of the U.S. Geological Survey, the International Boundary and Water Commission, and the U.S. Army Corps of Engineers. These drainage areas and the location of selected sediment stations within the areas are shown in figure 1. The data for these areas are given in table 4 in the back of the report, and an explanation of the data is given below.

EXPLANATION OF DATA

DRAINAGE AREA AND WATER DISCHARGE

The names, total drainage areas, and water discharges for the 27 drainage areas used in this report were taken from Wilson and Iseri (1967). Some of the data used in that report have since been revised (Alfonso Wilson and K. T. Iseri, oral commun., 1971) and the revised data are identified in table 4. Water and sediment discharged into the Great Lakes from the United States are not included in this report.

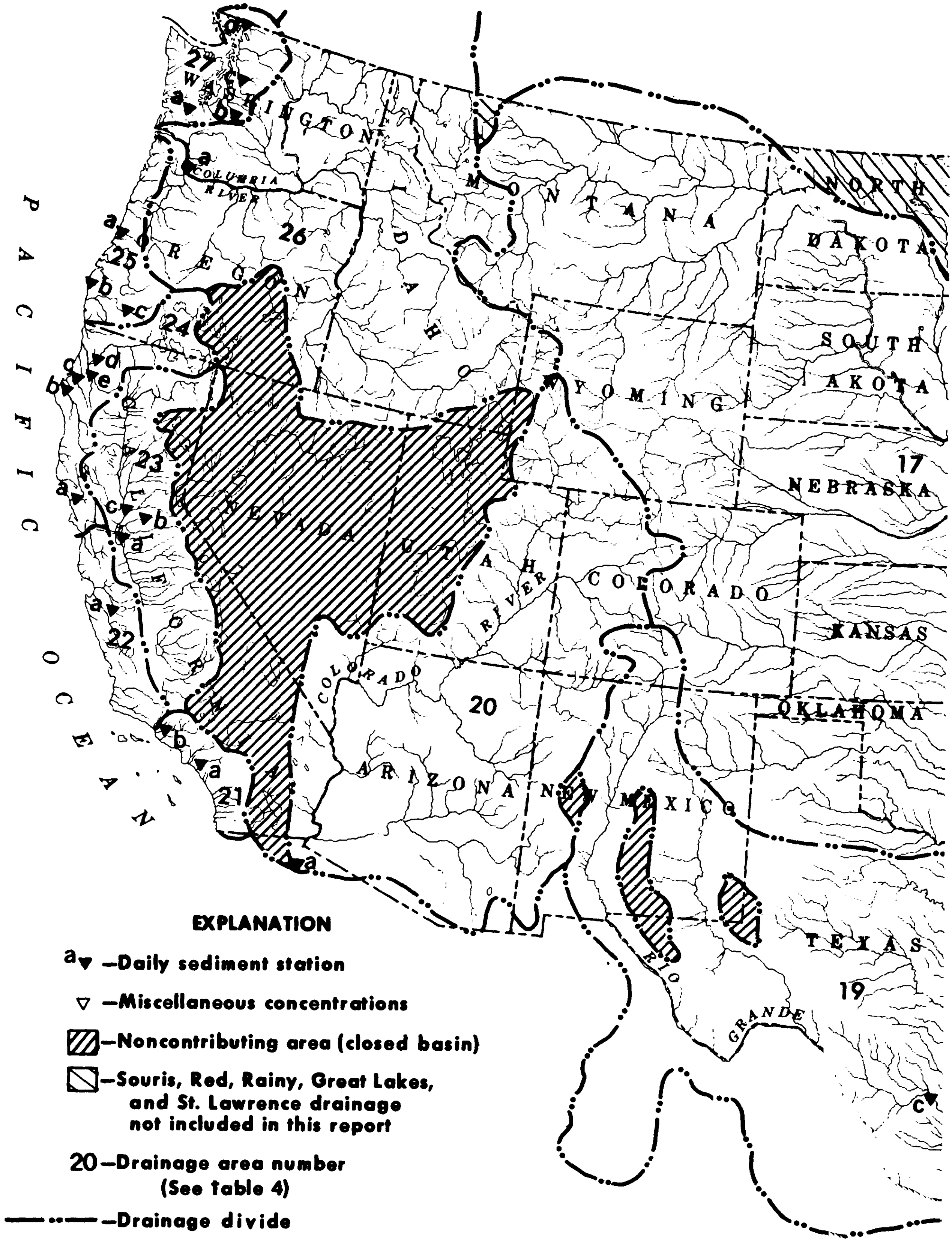

FIGURE 1 (above and right).—Drainage areas and location of sediment stations.

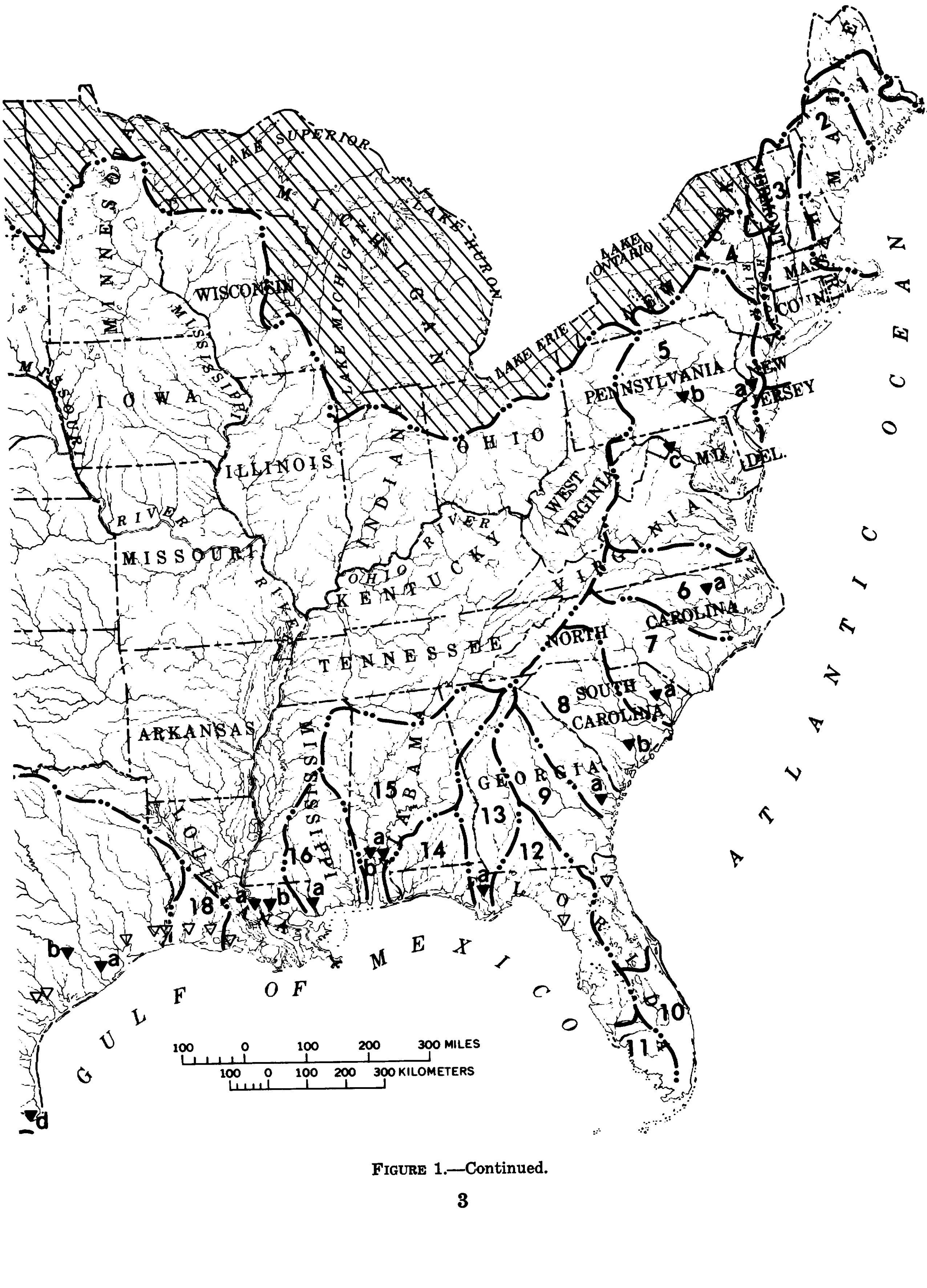

FIGURE 1.—Continued.

PERIOD OF RECORD

To keep this report as up to date as possible, and yet provide a sufficient period of record for a meaningful average, the 1950–69 period was chosen. Although a longer period of record may be desirable, a 20-year period can be expected to span one or more extreme events, dry and wet years, and is a reasonable base for statistical summary.

All sediment stations (43) selected for this study did not have records covering the full 20-year period; however, all records available within this period were used. For those stations with relatively short periods of record that included one or more extreme floods, the average annual suspended-sediment discharge was revised downward to reflect conditions more compatible with the long-term discharge. For example, in 1969, three stations in California experienced a flood of approximately the 100-year recurrence interval; thus, the 1969 sediment records for those stations were not used. Also, two other stations, Rouge River at Raygold, Oreg. (25c), and Skagit River near Mt. Vernon, Wash. (27d), each had only 1 year of record, 1912 and 1910, respectively (Van Winkle, 1914a, b); these records were used although they were outside the period of record selected for the report. For some of the drainage areas, no continuous records were available and the data presented in table 4 are estimates by the authors from miscellaneous sediment samples, upstream sediment records, and (or) water-sediment relations for adjacent or similar basins; thus, no period of record was given.

SUSPENDED-SEDIMENT DISCHARGE

The suspended-sediment discharge data presented in this report are based on analyses of samples collected with discharge-weighted suspended-sediment samplers used in the United States ([U.S.] Inter-Agency Committee on Water Resources, Subcommittee on Sedimentation, 1963). These samplers are used to collect representative samples of the entire depth of flow with the exception of a zone (the unsampled zone) between the streambed and about 0.3 to 0.5 foot (9 to 15 centimeters) above the streambed. Most of the sediment moved by rivers and streams is held in suspension and is transported at about the mean velocity of flow. The remainder of the sediment moves more slowly on or near the streambed in the unsampled zone and generally is referred to as bedload plus saltation load, or simply unmeasured load. Computations of bedload or unmeasured load may be made using various theoretical formulas; however, for long-term estimates, an unmeasured sediment discharge of 10 percent of the suspended-sediment discharge frequently is used. Unmeasured load is not included in this report. Figure 2 shows the sampled and unsampled zones in sediment sampling.

Daily sediment discharge, in tons per day, is determined by multiplying water discharge, in cubic feet per second, by the concentration of suspended sediment, in milligrams per liter, times a coefficient and assuming a specific gravity of 2.65 for sediment. The daily records are then summed to give the annual sediment discharge. To determine the average annual suspended-sediment discharge at a station, the authors summed the annual sediment discharges and divided that sum by the number of years of record. When there were no long-term records (see "Period of Record") the average annual suspended-sediment discharge for a drainage area was estimated All data are given in English units unless otherwise specified.

For this report, the sediment records used were from the sediment station, in the flowing part of the river above tide, closest to the mouth of the chosen river. The latitude and longitude of the individual stations, the sources of the sediment-discharge data used in computing the average annual suspended-sediment discharge and concentration, and the station identification numbers used by the agency collecting the data and by the Office of Water Data Coordination (U.S. Geological Survey, Office of Water Data Coordination, 1971) are given in table 5 in the back of the report.

SUSPENDED-SEDIMENT YIELD

Average annual suspended-sediment yields were computed for the 27 drainage areas and for the areas encompassed by the 43 selected

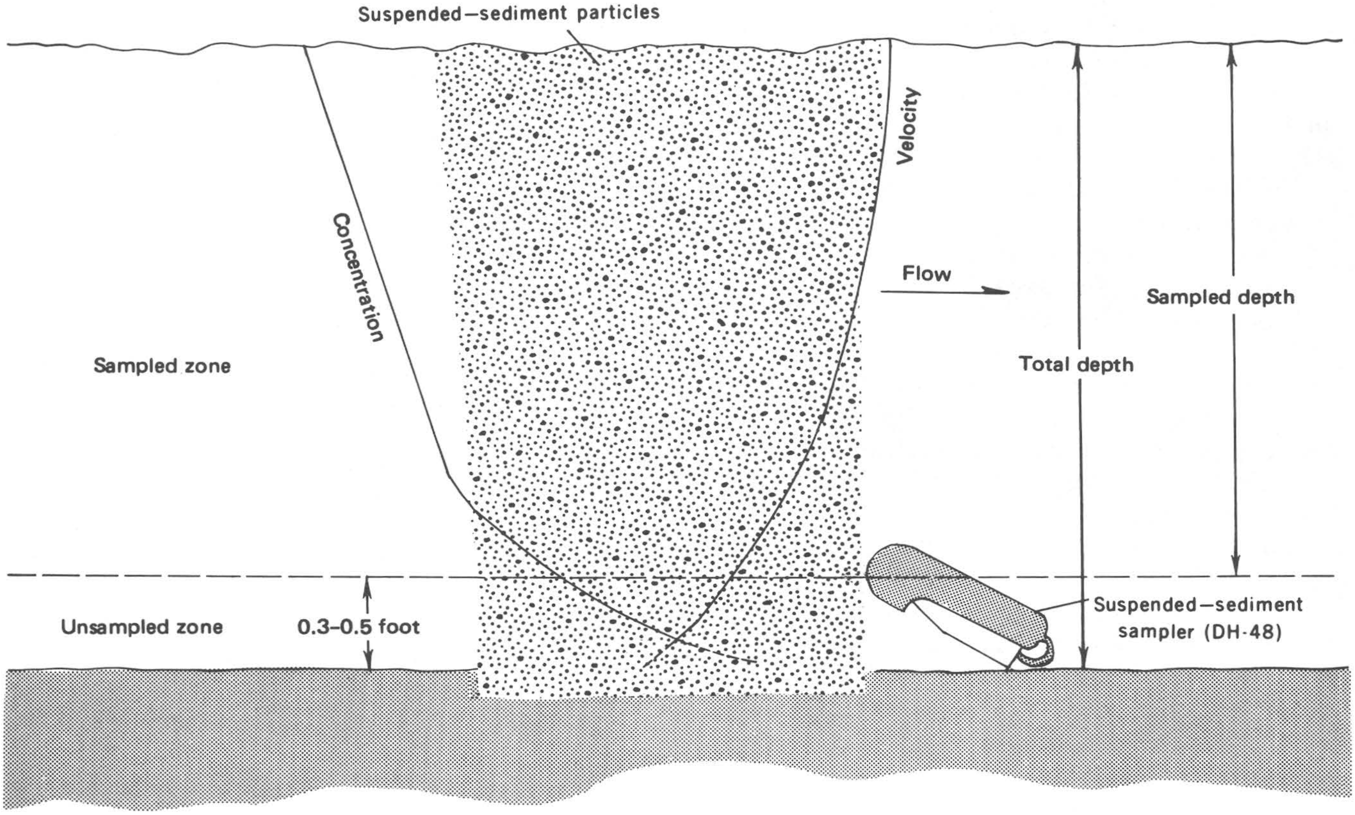

FIGURE 2.—Section of river showing zones of sampled sediment and unsampled sediment (modified from Guy and Norman, 1970).

sediment stations. The sediment yields were determined by dividing the annual average suspended-sediment discharge by the total drainage area. In some instances, the values for sediment yield may be relatively meaningless in terms of the total drainage area because reservoirs and diversions within the area may trap 75 to 95 percent of the sediment. (See "Colorado River Drainage Area.")

SUSPENDED-SEDIMENT CONCENTRATION

Average annual suspended-sediment concentrations for the 27 major drainages also were computed by dividing the daily average suspended-sediment discharge, in tons, by the daily average water discharge, in cubic feet per second (cfs), and using appropriate conversion factors. As an example, for area 1 where the average annual sediment discharge is 460,000 short tons and the daily average water discharge is 23,500 cfs, the conversion factor is 0.0027, and average annual daily sediment concentration, in milligrams per liter (mg/l) is computed as follows:

$$\frac{460{,}000 \text{ short tons}}{365 \text{ days} \times 23{,}500 \text{ cfs} \times 0.0027} = 20 \text{ mg/l.}$$

In the metric system, the water discharge is 665 cubic meters per second (cms), the sediment discharge is 417,000 metric tons, and the conversion factor is 0.0864; thus

$$\frac{417{,}000 \text{ metric tons}}{365 \text{ days} \times 665 \text{ cms} \times 0.0864} = 20 \text{ mg/l.}$$

SEDIMENT DISCHARGE TO THE ATLANTIC OCEAN

Sediment discharge to the Atlantic Ocean was determined for 10 major drainage areas (table 4*A*). Of these 10 areas, no long-term sediment records were available for six of the areas, which represent about 46 percent of the total water discharged to the Atlantic Ocean. Thus, estimates of sediment discharge for these six areas were based on samples collected intermittently within the areas during 1950–69. Suspended-sediment discharges range from 134,000 tons per year for area 10 to 5,800,000 tons per year for area 5.

For the 10 areas, the average annual suspended-sediment yields range from about 12 tons per square mile for area 10 to 73.2 tons per square mile for area 5, which contributes 28.8 percent of the total water discharged and 37.6 percent of the total sediment discharged to the Atlantic Ocean and contains the three river basins that have the highest sediment yields (Delaware River at Trenton, N.J., 111 tons per square mile; Potomac River at Point of Rocks, Md., 81.4 tons per square mile; and Susquehanna River at Harrisburg, Pa., 81 tons per square mile).

The average annual suspended-sediment concentrations for the 10 areas range from 20 mg/l for area 1 to 58 mg/l for area 5. For the entire Atlantic Ocean drainage area the discharge-weighted average annual suspended-sediment concentration is 40 mg/l.

SEDIMENT DISCHARGE TO THE GULF OF MEXICO

GULF OF MEXICO DRAINAGE AREA

Sediment discharge to the Gulf of Mexico was determined for nine major drainage areas (table 4*B*). Long-term sediment records were not available for four of these areas, and estimates of sediment discharge were based on miscellaneous samples collected at several locations within these areas. The suspended-sediment discharges for the Gulf of Mexico area range from 37,000 tons per year for area 11 to 326,468,000 tons per year for area 17.

For the nine areas, the average annual suspended-sediment yields range from about 6 tons per square mile for area 11 to 259 tons per square mile for area 17. Interestingly, the single river basin with the highest sediment yield (Brazos River, Tex., 398 tons per square mile) is in area 19, whereas area 17, which has the highest annual tonnage, contains the river basin with the second highest sediment yield.

The average annual suspended-sediment concentrations range from 15 mg/l for areas 11, 12, and 13 to 820 mg/l for area 19. Area 17, which has the highest average annual tonnage in the Gulf of Mexico drainage area, has an average annual suspended-sediment concentration of 510 mg/l. For the entire Gulf of Mexico drainage area the discharge-weighted average annual suspended-sediment concentration is 433 mg/l.

MISSISSIPPI RIVER DRAINAGE BASIN

The Mississippi River drains 1,262,000 square miles (3,268,580 square kilometers) or 47.4 percent of the total area covered in this report and contributes about 37 percent of the total amount of water and 66 percent of the suspended-sediment discharge from the conterminous United States. Sediment sampling had been carried on intermittently at different locations along the lower Mississippi River since 1838. At the beginning of the 1950 water year, the U.S. Army Corps of Engineers began a formal continuing program of sediment sampling.

The lower Mississippi River system (fig. 3) is highly controlled and regulated, both for normal flow and flood flow. Prior to 1963, some of the Mississippi River flood flows went into the Red-Atchafalaya system through a connecting channel. In 1963, the Corps of Engineers completed a control structure on the by-pass channel to keep flow in the two river systems separated.

Data for six stations within this complex system were used by the authors in computing the average annual suspended-sediment discharge for the Mississippi and Atchafalaya Rivers. These stations and their periods of record are listed below. Figure 3 shows the location of the six stations, and table 5 gives their latitude and longitude.

Station	*Period of record*
1. Mississippi River at Baton Rouge, La	1950–67
2. Mississippi River at Red River Landing, La	1958–63
3. Mississippi River at Tarbot Landing, La	1963–69
4. Atchafalaya River at Simmesport, La	1952–69
5. Wax Lake Outlet at Calumet, La	1966–68
6. Atchafalaya River at Morgan City, La	1966–68

Data for the three stations on the Mississippi River at Baton Rouge, La., Red River Landing, La., and Tarbot Landing, La., were combined to

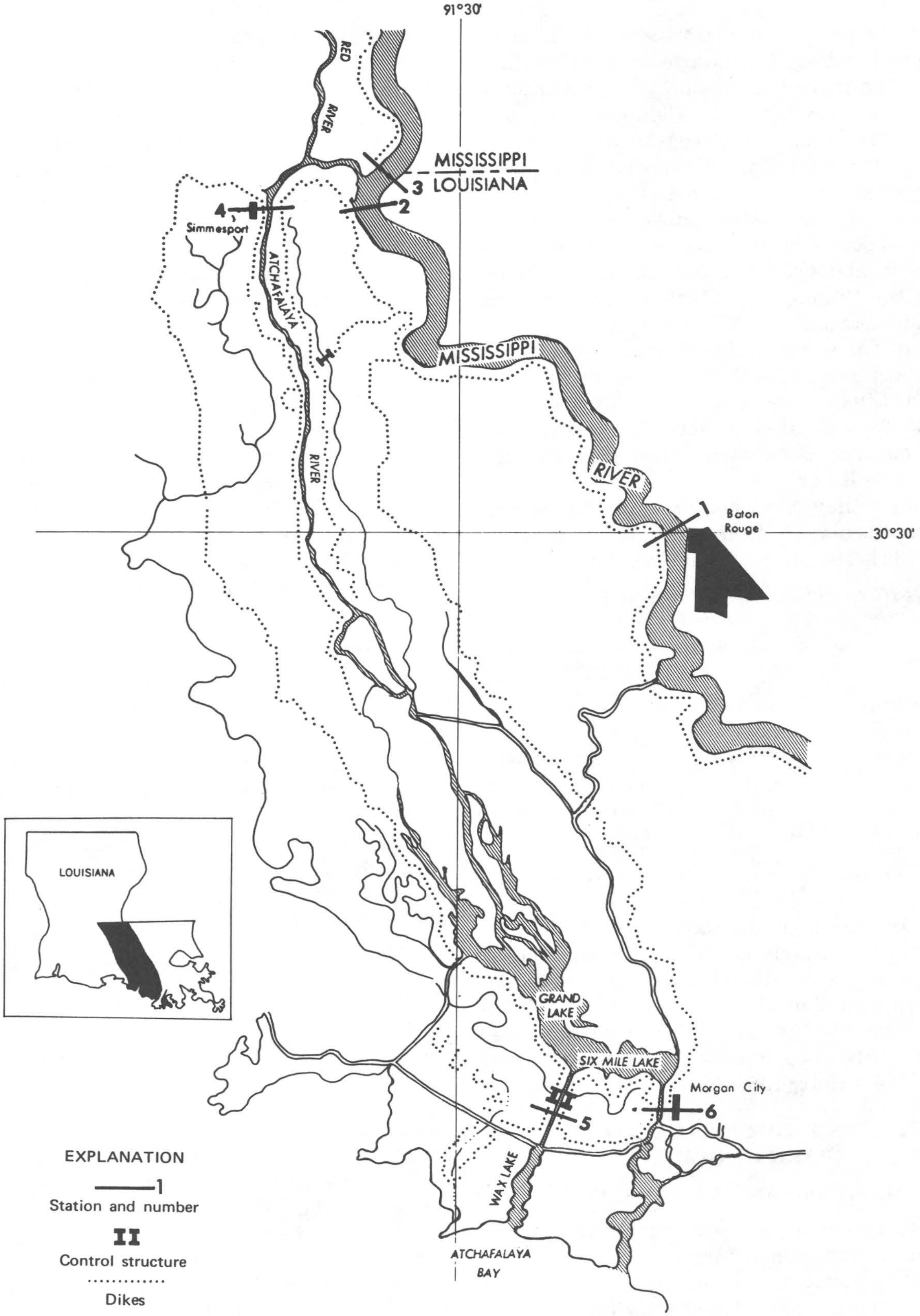

FIGURE 3.—Sketch map of the lower Mississippi River drainage basin showing location of stations used to compute sediment discharge for the Mississippi River (area 17). Numbers correspond to list in text, "Mississippi River Drainage Basin."

compute the record for the Mississippi River at Red River Landing, La. (station 17a, table 4*B*). Data for the three stations on the Atchafalaya River at Simmesport, La., Calumet, La., and Morgan City, La., were used to compute the record for the Atchafalaya suspended-sediment discharge (station 17b, table 4*B*).

A study of the suspended-sediment records for Simmesport, Calumet, and Morgan City indicated that about 31 percent of the sediment passing the Simmesport station was deposited in Grand Lake and Six Mile Lake; therefore, 69 percent of the suspended-sediment discharge at Simmesport for 1950–65 was used and a summation of the Calumet and Morgan City stations for 1966–69 was used in deriving the average annual suspended-sediment discharge for the Atchafalaya River.

Although they were not used in this report, historical sediment-discharge data obtained during 1851–1931 are summarized in table 1. If

TABLE 1.—*Historical suspended-sediment discharge data for the lower Mississippi River*

[Data from U.S. Army, Corps of Engineers, New Orleans District]

Location	Period of record	Suspended-sediment discharge, in tons per—	
		Day	Year
New Orleans	Feb. 17, 1851–Feb. 15, 1852.	945,000	345,000,000
New Orleans	Feb. 16, 1852–Feb. 20, 1853.	1,364,000	498,000,000
Passes	1879–1893	934,000	341,000,000
New Orleans	Dec. 19, 1879–Oct. 8, 1880.	995,000	363,000,000
Red River Landing	Mar. 3, 1929–June 22, 1929.	1,136,000	--
Red River Landing	Sept. 23, 1930–Feb. 26, 1931.	296,000	--

the annual sediment discharges shown are assumed to be relatively accurate, it would appear that the average annual suspended-sediment discharge contributed by the main stem Mississippi River to the Gulf of Mexico has been reduced by about 30 percent during the 100-year period (1851–1931, 1950–69).

SEDIMENT DISCHARGE TO THE PACIFIC OCEAN

PACIFIC OCEAN DRAINAGE AREA

Sediment discharge to the Pacific Ocean was determined for eight major drainage areas (table 4*C*). Suspended-sediment discharges for this area range from 10,600 tons per year for area 20 to 67,816,000 tons per year for area 24.

Sediment yields from the area draining into the Pacific Ocean in terms of tons per square mile are considerably greater than the yields from areas draining into the Atlantic Ocean or the Gulf of Mexico. The average annual suspended-sediment yields, exclusive of area 20 (Colorado River) range from 60.5 tons per square mile for area 26 to 3,108 tons per square mile for area 24. Area 24, which contains the individual river that has the greatest sediment yield (Eel River, Calif., 9,426 tons per square mile), has the greatest sediment yield for any area draining into the oceans from the conterminous United States.

The average annual suspended-sediment concentrations range from 49 mg/l for area 27 to 1,634 mg/l for area 21. Area 24 has the highest discharge and yield and the second highest sediment concentration (1,630 mg/l). For the entire Pacific Ocean drainage area the discharge-weighted average annual suspended-sediment concentration of discharge is 201 mg/l.

COLORADO RIVER DRAINAGE BASIN

The Colorado River drainage basin (area 20) has the lowest sediment discharge (10,600 tons per year) and sediment yield (0.04 ton per square mile per year) of any contributing area draining into the oceans from the conterminous United States. However, even with this extremely low sediment yield, the average annual suspended-sediment concentration (165 mg/l) is greater than that from any contributing area draining into the Atlantic Ocean.

The apparent low sediment yield for this drainage basin is the result of better land-use practices and sediment entrapment in the highly developed reservoir system on the Colorado River. Data for the station Colorado River at Yuma, Ariz., are used to illustrate the dramatic effect these changes have had on the sediment discharge. During 1911–16, the average annual suspended-sediment discharge at Yuma was 234,600,000 tons (966 tons per square mile). As a result of the development of the reservoir system and the increased use of water for irrigation the suspended-sediment discharge was reduced considerably and for 1965–67 the average annual suspended-sediment discharge was

152,600 tons (0.63 ton per square mile). At the station used in this report, Colorado River at Miguel C. Rodriguez, Mexico, which is about 52 miles downstream from Yuma, the average annual suspended-sediment discharge for the period 1965–69 was further reduced to 10,600 tons (0.04 ton per square mile), largely due to diversion of water for irrigation. Hydrographs of water discharge and suspended-sediment discharge for the Colorado River at Yuma, Ariz., for 1911–67 are shown in figure 4 and clearly indicate the major changes that have occurred during this period.

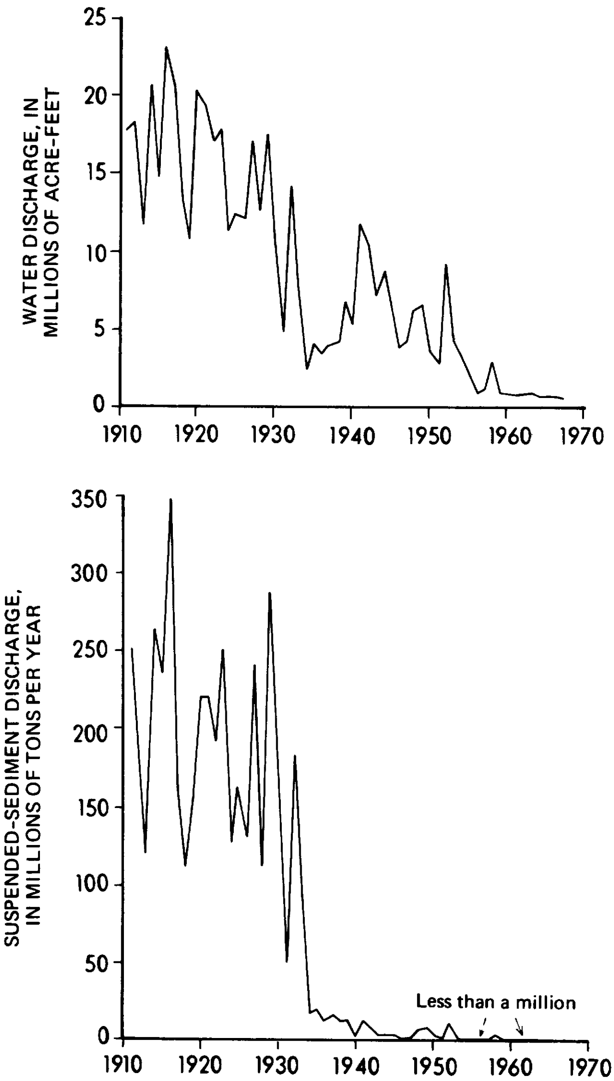

FIGURE 4.—Water discharge and suspended-sediment discharge for the Colorado River at Yuma, Ariz., 1911–67.

COMPARISON OF PRESENT AND PREVIOUS ESTIMATES OF SUSPENDED-SEDIMENT DISCHARGE

One of the difficulties in comparing present and past estimates of sediment yields is the difference in time periods used and the amount of data available at the time of the various studies. Also, different drainage areas may have been used by the various writers.

Trends of sediment yield for a given river or basin can never be determined very accurately until long-term records of comparable accuracy are available. As more and more records become available, more accurate and reasonable estimates of sediment yield and rate of denudation can be made. Some comparisons can be made, however, between the data presented in this report and past estimates for several of the major rivers and basins in the United States.

Regional erosion rates in the United States were estimated by Dole and Stabler (1909) and rates of regional denudation of the United States were estimated by Judson and Ritter (1964). A summary of data comparing estimates of these authors with present estimates is given in table 2. Average annual suspended-sediment discharges given in the table were computed by using the contributing drainage area values given in this report and the sediment yields estimated by the previous authors.

Holeman (1968) presented estimates of sediment yields of the major rivers of the world. For selected river basins of North America he estimated an average annual suspended-sediment yield of 245 tons per square mile. The total drainage area contributing sediment discharge to the oceans from the United States is 2,658,776 square miles. Using this drainage area and Holeman's estimate of 245 tons per square mile per year for North America. the average annual suspended-sediment discharge to the oceans from the conterminous United States would be 651,400,000 tons as compared with 491,449,600 tons determined by this study. Most of the difference between Holeman's estimate and the authors' is due to the fact that he used the records for the station Colorado River at Grand Canyon Ariz., 1925–57, which is upstream of most of the present reservoir system.

TABLE 2.—*Comparison between present and past estimates of sediment yields for selected rivers discharging to the oceans from the conterminous United States*

Area or river basin	Average annual suspended-sediment yield, in tons per square mile			Drainage area, in square miles	Average annual suspended-sediment discharge, in thousands of tons		
	This report	Judson and Ritter (1964)	Dole and Stabler (1909)		This report	Judson and Ritter (1964)	Dole and Stabler (1909)
Atlantic Ocean:	49.5	----	97.2	287,166	14,204	----	27,900
Delaware River	111	147	56	6,780	749	998	380
Susquehanna River	81.0	----	35	24,100	1,953	----	845
Potomac River	81.4	----	95	9,651	786	----	913
Pee Dee River	15.2	----	154	8,830	442	----	1,360
Ogeechee River	23.2	----	225	2,650	61.6	----	596
Gulf of Mexico:	217.4	----	220	1,739,200	378,179	----	382,600
Apalachicola River	10.1	----	159	17,200	173	----	2,740
Tombigbee River	128	120	104	19,200	2,454	2,300	2,000
Alabama River	115	97	178	22,000	2,528	2,140	3,920
Pearl River	133	----	58	6,630	881	----	385
Mississippi River	259	244	269	1,262,000	244,900	308,000	340,000
Pacific Ocean:	157	623	----	632,410	99,067	[1] 394,100	----
Colorado River	.04	1,190	387	245,000	10.6	292,000	94,800
San Francisco Bay	75.4	----	77	47,570	3,585	----	3,660
Sacramento River	116	94	86	23,530	2,719	2,215	2,020
Eel River	9,426	5,846	----	3,113	29,345	18,200	----
Mad River	5,549	3,711	----	485	2,691	1,800	----
Trinity River	1,919	1,141	----	2,865	5,497	3,270	----
Columbia River	60.5	125	----	258,200	15,620	32,300	----

[1] Sum of Colorado, Pacific Slopes, California, and Columbia Regions.

Based on the data given in this report, the average annual suspended-sediment yield from the conterminous United States to the oceans is 184.8 tons per square mile.

SUMMARY

Suspended-sediment discharge data obtained from 27 drainage areas during the period 1950–69 were used to estimate the sediment contributed to the oceans from the conterminous United States. The data are based on suspended-sediment samples obtained with standard United States depth-integrating samplers and, therefore, do not include that part of the total sediment discharge moving as bedload. The quantity of sediment transported as bedload may be estimated at about 10 percent of the sediment transported in suspension.

The amount of sediment discharged each day into the Atlantic and Pacific Oceans is 38,915 tons and 271,400 tons, respectively. The Gulf of Mexico receives about three times more sediment than both of these areas, a total of 1,037,000 each day. A more pictorial way of expressing these figures is to transport this sediment discharge by train (a boxcar is equivalent to 100,000 pounds or 50 tons). Each day of the year it would take a train of 778 boxcars to transport the suspended-sediment discharged to the Atlantic Ocean and 5,428 boxcars to transport the Pacific Coast sediment; to move the Gulf of Mexico sediment, it would take a daily train 20,740 boxcars long.

Average yearly sediment yields range from 49.5 tons per square mile for the Atlantic Ocean drainage area to 217.4 tons per square mile for the Gulf of Mexico drainage area; the Pacific Ocean drainage area falls into the middle with 156.6 tons per square mile. The mean for the entire conterminous United States (excluding the Great Lakes drainage area) is 184.8 tons per square mile. However, yields computed on the basis of total drainage area can be deceiving because good land-use practices and multiple reservoirs in the drainage area can dramatically reduce the amount of sediment delivered to the sea. The Colorado River drainage basin is a good example. The yield of the station Colorado River at Yuma, Ariz., was reduced from 966 tons per square mile during the period 1911–16 to 0.63 ton per square mile during the period 1965–67.

Concentrations of suspended sediment range from about 15 mg/l along the southern part of the Atlantic Coast to over 1,600 mg/l along the southern part of the Pacific Coast. The Gulf Coast region has the most drainage basins with the lowest (15 mg/l) sediment concentration.

The amount of suspended-sediment discharged to the oceans from the conterminous United States is 491,449,600 tons per year. (See table 3.) If this amount was deposited in Washington, D.C., on the mall between tne Capitol and the Lincoln Memorial (an are^ 11,000 feet long and 600 feet wide), it would r^ach a depth of about 1,400 feet or 2½ times a^ high as the Washington Monument.

TABLE 3.—*Summary of suspended-sediment discharge to the oceans from the conterminous United States*

[Upper numbers are English units; lower numbers are metric units]

	Drainage area (mi^2/km^2)	Water discharge		Suspended-sediment discharge			
		cfs/cms	Percent	Tons per year (short/metric)	Percent	Tons per mi^2/km^2	Milligrams per liter
Atlantic Ocean (areas 1–10)	287,166 743,760	359,350 10,180	20.6 20.6	14,204,000 12,885,726	2.9 2.9	49.5 17.3	40 40
Gulf of Mexico (areas 11–19)	1,739,200 4,504,528	887,400 25,120	50.8 50.8	378,179,000 343,080,207	77.0 77.0	217.4 76.1	433 433
Pacific Ocean (areas 20–27)	632,410 1,637,942	499,065 14,132	28.6 28.6	99,066,600 89,872,229	20.1 20.1	156.6 54.9	201 201
Total or mean	2,658,776 6,886,230	1,745,815 49,432	100.0 100.0	491,449,600 445,838,162	100.0 100.0	184.8 64.7	286 286

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TABLES 4 AND 5

TABLE 4.—*Suspended-sediment discharge from the conterminous United States to the Atlantic Ocean, Gulf of Mexico, and the Pacific Ocean*

[Drainage area and water-discharge data from Wilson and Iseri (1967); asterisk (*) indicates revised data (Alfonso Wilson and K. T. Iseri, oral commun., 1971). E=estimated. N.d.=not determined]

Drainage area (See figure 1 and table 5 for location.)				Water discharge		Period of record	Average annual suspended-sediment—				
							Discharge, in thousands of tons per year		Yield, in tons per square kilometer or square mile		Concentration, in milligrams per liter
No.	Name	Square kilometers	Square miles	Cubic meters per second	Cubic feet per second		Metric tons	Short tons	Metric tons	Short tons	
	A. Atlantic Ocean										
1.	Passamaquoddy Bay to Penobscott Bay	30,047	11,601	665	23,500	------	471	460	13.9	39.6	20
2.	St. George River to Cape Cod Bay	54,134	20,901	1,162	41,020	------	1,179	1,300	21.8	62.2	32
3.	Cape Cod Bay to New York-Connecticut State line	46,537	17,968	986	34,810	------	780	860	16.8	47.9	25
4.	New York-Connecticut State line to Cape May	50,391	19,456	928	32,770	------	970	1,070	19.2	55.0	33
5.	Cape May to Cape Henry	205,283	79,260	2,866	101,200	------	5,262	5,800	25.6	73.2	58
	a. Delaware River at Trenton, N. J	17,560	6,780	------	-----	1950–69	680	749	38.7	111	----
	b. Susquehanna River at Harrisburg, Pa[1]	62,419	24,100	------	-----	1964–68	1,771	1,953	28.4	81.0	----
	c. Potomac River at Point of Rocks, Md	24,996	9,651	------	-----	1961–69	723	786	28.9	81.4	----
6.	Cape Henry to Neuse River	73,199	28,262	779	27,500	------	1,361	1,500	18.6	53.1	54
	a. Tar River at Tarboro, N.C	5,542	2,140	------	-----	1959–67	105	116	19.0	54.1	----
7.	Cove Sound to Black River	75,247	29,053	805	28,400	------	1,270	1,400	16.9	48.2	50
	a. Pee Dee River at Pee Dee, S. C	22,870	8,830	------	-----	1967–69	401	442	17.5	15.2	----
8.	Santee River to Sapela Island	102,525	39,585	999	35,290	------	943	1,040	9.2	26.3	30
	a. Ogeechee River near Eden, Ga	6,863	2,650	------	-----	1963–64	55.8	61.6	8.1	23.2	----
	b. Edisto River near Givhans, S. C	7,071	2,730	------	-----	1967–69	19.1	21.1	2.7	7.7	----
9.	Altamaha River to Cape Kennedy	77,130	29,780	732	25,860	------	580	640	7.5	21.5	25
10.	Cape Kennedy to Cape Sable	E29,267	E11,300	255	9,000	------	122	134	4.2	11.9	15
	Total or annual average	743,760	287,166	10,180	359,350	------	12,886	14,204	17.3	49.5	40
	B. Gulf of Mexico										
11.	Cape Sable to Alligator Creek	E15,540	E6,000	71	2,500	------	33.6	37.0	2.2	6.2	15
12.	Peace River to New River	67,599	26,100	770	27,200	------	363	400	5.4	15.3	15
13.	Apalachicola River	51,800	20,000	756	26,700	------	354	390	6.8	19.5	15
	a. Apalachicola River at Chattahoochee, Fla	44,548	17,200	------	-----	1967–69	157	173	3.5	10.1	----
14.	Wetappo Creek to Perdido River	36,778	14,200	711	25,100	------	907	1,000	24.6	70.4	40
15.	Mobile Bay	114,737	44,300	1,818	64,200	------	6,259	6,900	54.6	156	109
	a. Tombigbee River near Jackson, Miss	49,728	19,200	------	-----	1952–64	2,226	2,454	44.8	128	----
	b. Alabama River at Claiborne, Ala	56,980	22,000	------	-----	1952–69	2,293	2,528	40.2	115	----
16.	Pascagoula River to Pearl River	51,023	19,700	883	31,200	------	2,268	2,500	44.5	127	81
	a. Pearl River near Bogalusa, La	17,172	6,630	------	-----	1967–68	799	881	46.5	133	----
17.	Mississippi River	*3,268,580	*1,262,000	18,400	650,000	------	296,165	326,468	90.6	259	510
	a. Mississippi River at Red River Landing (see text)	2,923,851	1,128,900	------	-----	1950–69	222,168	244,900	76.0	217	----
	b. Atchafalaya River (see text)	--------	--------	------	-----	1950–69	73,987	81,557	-----	------	----

18. Vermilion, Mermentau, and Calcasieu Rivers	22,533	8,700	306	10,800	------	816	900	36.3	103	85
19. Sabine River to Rio Grande	875,938	338,200	1,407	49,700	------	36,400	40,124	41.6	119	820
a. Brazos River at Richmond, Tex	114,012	44,020	------	-----	1966–69	15,893	17,519	139	398	----
b. Colorado River at Columbus, Tex	106,371	41,070	------	-----	1957–69	1,901	2,096	17.9	51	----
c. Nueces River near Three Rivers, Tex	40,404	15,600	------	-----	1951–52	445	491	11.0	31.5	----
d. Arroyo Colorado at Mercedes, Tex. Rio Grande near Brownsville, Tex., North Floodway near Sebastian, Tex.	N.d.	N.d.	N.d.	N.d.	1966–69	1,229	1,355	N.d.	N.d.	----
Total or annual average	4,504,528	1,739,200	25,120	887,400	------	343,080	378,179	76.1	217.4	433
C. Pacific Ocean										
20. Colorado River	634,550	245,000	1.8	65	------	9.6	10.6	0.015	0.04	165
a. Colorado River at Miguel C. Rodriquez, Mexico	634,550	245,000	1.8	65	1965–69	9.6	10.6	0.015	.04	----
21. Tia Juana River to Ventura River	31,572	12,190	14	500	------	730	805	23.1	66	1,634
a. San Juan Creek near San Juan Capistrano, Calif	275	106	------	-----	1967–68	85.5	94.3	311	890	----
b. Santa Clara River at Saticoy, Calif	4,131	1,595	------	-----	1968	68.7	75.7	16.6	47.5	----
22. San Jose Creek to Pesadero Creek	28,801	11,120	68	2,400	------	3,320	3,660	115	329	1,548
a. Salinas River near Spreckels, Calif	10,767	4,157	------	-----	1966–68	531	586	49.3	141	----
23. San Francisco Bay	*123,206	*45,570	861	30,400	------	3,252	3,585	26.4	75.4	120
a. San Joaquin River near Vernalis, Calif	35,069	13,540	------	-----	1956–69	350	386	10	28.5	----
b. Consumnes River at Michigan Bar, Calif	1,388	536	------	-----	1963–69	143	158	103	295	----
c. Sacramento River at Sacramento, Calif	60,943	23,530	------	-----	1957–69	2,464	2,719	40.4	116	----
24. Lagunitas Creek to Smith River	56,514	21,820	1,192	42,100	------	61,521	67,816	1,089	3,108	1,630
a. Russian River near Guerneville, Calif	3,471	1,340	------	-----	1958–69	4,135	4,559	1,191	3,402	----
b. Eel River at Scotia, Calif	8,063	3,113	------	-----	1958–69	26,621	29,345	3,302	9,426	----
c. Mad River at Arcata, Calif	1,256	485	------	-----	1957–69	2,441	2,691	1,944	5,549	----
d. Klamath River at Orleans, Calif	22,015	8,500	------	-----	1967–69	2,389	2,631	108	310	----
e. Trinity River near Hoopa, Calif [2]	7,420	2,865	------	-----	1968–69	4,987	5,497	672	1,919	----
25. Oregon coastal area	43,771	16,900	1,509	53,300	------	2,993	3,300	68.3	195	63
a. Siuslaw River near Mapleton, Oreg	1,523	588	------	-----	1968–69	104	114	68.3	193.9	----
b. Sixes River at Sixes, Oreg	300	116	------	-----	1968–69	199	220	663	1,897	----
c. Rouge River at Raygold, Oreg	5,317	2,053	------	-----	1912	59.2	65.3	11.1	31.8	----
26. Columbia River	668,738	258,200	7,963	281,200	------	14,170	15,620	21.2	60.5	56
a. Columbia River at Vancouver, Wash	624,190	241,000	------	-----	1964–69	9,704	10,697	15.5	44.4	----
27. Naselle River to Nooksack River	50,790	19,610	2,523	89,100	------	3,873	4,270	76.3	218	49
a. Chehalis River at Porter, Wash	3,351	1,294	------	-----	1962–68	115	127	34.3	97.8	----
b. Skykomish River at Monroe, Wash	2,160	834	------	-----	1967–69	244	269	113	323	----
c. Snoqualmie River near Carnation, Wash	1,562	603	------	-----	1968–69	263	290	168	481	----
d. Skagit River near Mt. Vernon, Wash	8,011	3,093	------	-----	1910	330	364	41.2	118	----
Total or annual average	1,637,942	632,410	14,131.8	499,065	------	89,872.2	99,066.6	54.9	156.6	201

[1] Three dams between station and mouth of river (Williams and Reed, 1972).
[2] Tributary to Klamath River.

TABLE 5.—*Identification of river stations used to compute sediment data*

[OWDC, U.S. Geological Survey, Office of Water Data Coordination. Agency collecting data: GS, U.S. Geological Survey; CE, U.S. Army Corps of Engineers; IBW, International Boundary and Water Commission]

Station No.			Station name	Latitude north	Longitude west	Agency collecting data
This report	Agency collecting data	OWDC				
5a	01–463500	51178	Delaware River at Trenton, N. J	40°13′18″	074°46′38″	GS.
5b	01–570500	54044	Susquehanna River at Harrisburg, Pa	40°15′10″	076°52′27″	GS.
5c	01–638500	54253	Potomac River at Point of Rocks, Md	39°16′25″	077°32′35″	GS.
6a	02–083500	52159	Tar River at Tarboro, N.C	35°53′38″	077°32′00″	GS.
7a	02–131000	54435	Pee Dee River at Pee Dee, S.C	34°12′15″	079°32′55″	GS.
8a	02–202500	67025	Ogeechee River near Eden, Ga	32°10′	081°25′	GS.
8b	02–175000	53536	Edisto River near Givhans, S.C	33°01′40″	080°23′30″	GS.
13a	02–358000	53276	Apalachicola River at Chattahoochee, Fla	30°42′03″	084°51′33″	GS.
15a	02–470040	54582	Tombigbee River near Jackson, Ala	31°31′	087°56′	CE.
15b	02–429500	54581	Alabama River at Claiborne, Ala	31°32′48″	087°30′45″	CE.
16a	02–489500	53935	Pearl River near Bogalusa, La	30°47′35″	089°49′15″	GS.
17a			Mississippi River at Baton Rouge, La	29°57′	090°08′	CE.
17a			Mississippi River at Red River Landing, La	31°00′	091°36′	CE.
17a	01100	54880	Mississippi River at Tarbot Landing, La	31°00′30″	091°37′25″	CE.
17b	03045	54776	Atchafalaya River at Simmesport, La	30°58′57″	091°47′54″	CE.
17b	03720	68001	Wax Lake Outlet at Calumet, La	29°42′09″	091°22′07″	CE.
17b	03783	54758	Atchafalaya River at Morgan City, La	29°41′47″	091°12′39″	CE.
19a	08–114000	52812	Brazos River at Richmond, Tex	29°34′56″	095°45′27″	GS.
19b	08–161000	52824	Colorado River at Columbus, Tex	29°42′20″	096°32′05″	GS.
19c	08–210000	63409	Nueces River at Three Rivers, Tex	28°26′10″	097°51′36″	GS.
19d	08–470300	52761	Arroyo Colorado at Mercedes, Tex	26°07′24″	097°54′33″	GS.
19d	08–475000	52834	Rio Grande near Brownsville, Tex	25°52′35″	097°27′15″	GS.
19d	08–468500	52833	North Floodway near Sebastian, Tex	26°18′54″	097°46′37″	GS.
20a			Colorado River at Miguel C. Rodriquez, Mexico	32°16′	115°01′	IBW.
21a	11–046500	61625	San Juan Creek near San Juan Capistrano, Calif	33°10′08″	113°37′27″	GS.
21b	11–113920	-----	Santa Clara River at Saticoy, Calif	34°16′29″	119°08′11″	GS.
22a	11–152300	66196	Salinas River near Spreckels, Calif	36°33′14″	121°32′50″	GS.
23a	11–303500	69832	San Joaquin River near Vernalis, Calif	37°40′34″	121°15′51″	GS.
23b	11–335000	51533	Consumnes River at Michigan Bar, Calif	38°30′00″	121°02′45″	GS.
23c	11–447500	51605	Sacramento River at Sacramento, Calif	38°35′20″	121°30′15″	GS.
24a	11–467000	51632	Russian River near Guerneville, Calif	38°30′00″	122°56′05″	GS.
24b	11–477000	51658	Eel River at Scotia, Calif	40°29′30″	124°05′55″	GS.
24c	11–481000	51662	Mad River at Arcata, Calif	40°54′35″	124°03′35″	GS.
24d	11–523000	51671	Klamath River at Orleans, Calif	41°18′13″	123°32′00″	GS.
24e	11–530000	51678	Trinity River at Hoopa, Calif	41°03′00″	123°40′15″	GS.

25a	14-307620	62966	Siuslaw River near Mapleton, Oreg	44°03'45''	123°52'55''	GS.
25b	14-327150	62967	Sixes Rixer at Sixes, Oreg	42°49'05''	124°29'00''	GS.
25c	14-359000	-----	Rouge River at Raygold, Oreg	42°26'15''	122°59'10''	GS.
26a	14-144700	54203	Columbia River at Vancouver, Wash	45°37'15''	122°40'20''	GS.
27a	12-031000	51906	Chehalis River at Porter, Wash	46°56'20''	123°18'45''	GS.
27b	12-141100	-----	Skykomish River at Monroe, Wash	47°50'48''	121°58'10''	GS.
27c	12-149000	-----	Snoqualmie River near Carnation, Wash	47°39'55''	121°55'30''	GS.
27d	12-200500	51963	Skagit River near Mt. Vernon, Wash	48°26'40''	122°20'25''	GS.