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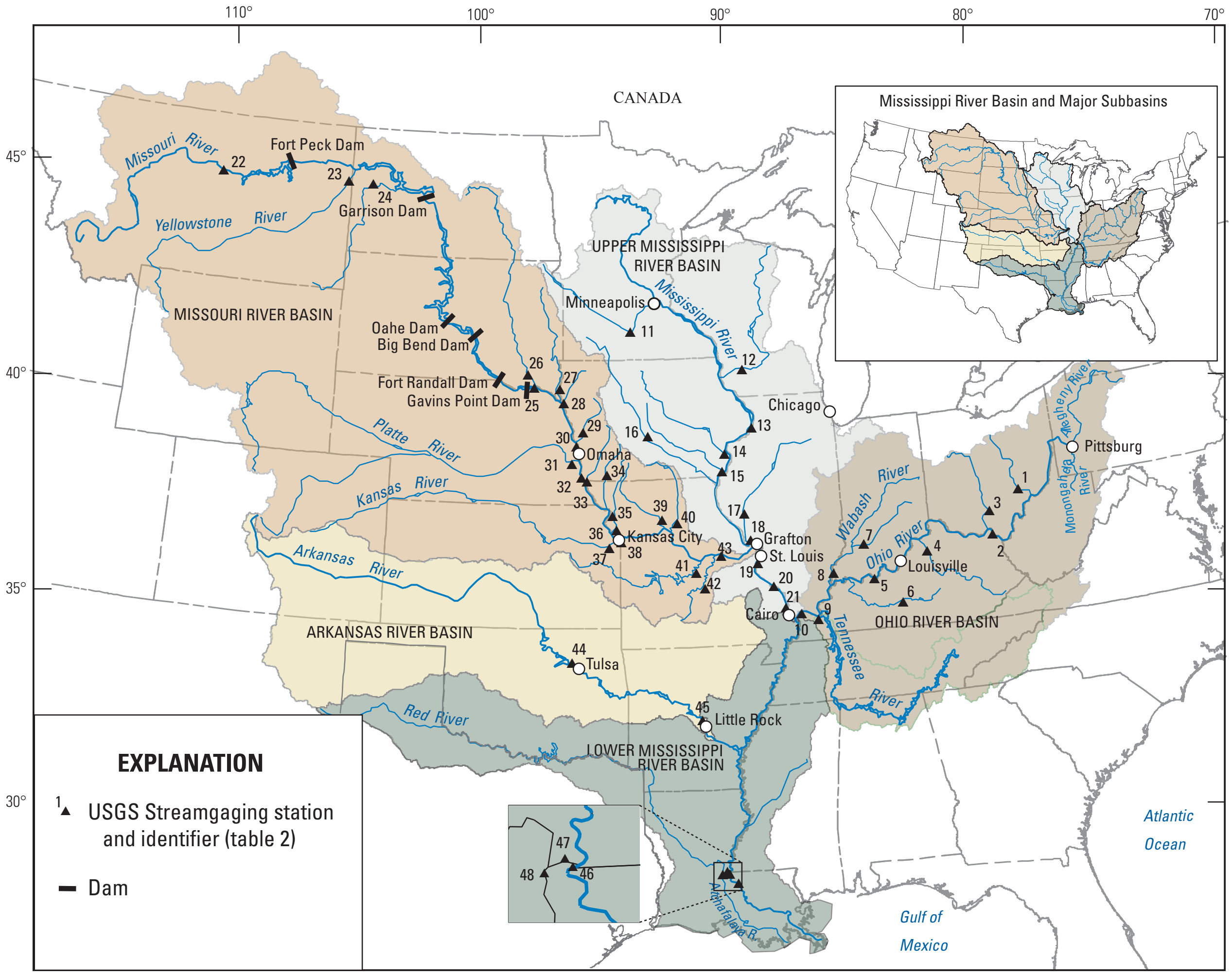
Suspended-Sediment and Suspended-Sand Concentrations and Loads for Selected Streams in the Mississippi River Basin, 1940–2009



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Cover Illustration: Figure 1 from this report.

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Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter (mm)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
	Mass	
ton, short (2,000 lb)	0.9072	metric ton (Mt)

Suspended-Sediment and Suspended-Sand Concentrations and Loads for Selected Streams in the Mississippi River Basin, 1940–2009

By David C. Heimann, Teri L. Cline, and Lori M. Glaspie

Abstract

This report presents suspended-sediment concentration and streamflow data, describes load-estimation techniques used in the computation of annual suspended-sediment loads, and presents annual suspended-sediment loads for 48 streamgaging stations within the Mississippi River Basin. Available published, unpublished, and computed annual total suspended-sediment and suspended-sand loads are presented for water years 1940 through 2009. When previously published annual loads were not available, total suspended-sediment and sand loads were computed using available data for water years 1949 through 2009. A table of suspended-sediment concentration and daily mean streamflow data used in the computation of annual loads is presented along with a table of compiled and computed annual suspended-sediment and suspended-sand loads, annual streamflows, and flow-weighted concentrations for the 48 stations.

Introduction

The U.S. Geological Survey (USGS), U.S. Army Corps of Engineers (USACE), and multiple State and local agencies have collected suspended-sediment concentration data at numerous river monitoring stations within the Mississippi River Basin (MRB) for decades. Information on sediment transport, including the temporal variability in sediment loads and concentrations, is an important tool in the management and restoration of major rivers in the MRB. The selection and compilation of sediment data are the first step in the temporal analyses of these data.

Assessments of changes in water-quality constituents, including sediment, over time are a primary goal of the U.S. Geological Survey's National Water-Quality Assessment (NAWQA) program (Gilliom and others, 2001). Therefore, suspended-sediment data were compiled for 1940 through 2009 and assessed for use in the analyses of relative subbasin sediment contributions and the temporal change in annual sediment loads, flow-weighted concentrations, flow-adjusted concentrations, and streamflows at selected MRB stations.

Purpose and Scope

This report presents suspended-sediment concentration and streamflow data, describes load-estimation techniques used in the computation of annual suspended-sediment loads, and presents annual suspended-sediment loads for 48 stations within the MRB (fig. 1). At each station, available published, unpublished, and computed annual suspended-sediment loads (SSLs) and suspended-sand (suspended material greater than 0.0625 millimeters) loads (SSDLs) are presented for water years 1940 through 2009 (water year is defined as the 12-month period from October 1 through September 30 and is designated by the year the period ends). When previously published annual loads were not available, SSLs and SSDLs were computed using available suspended-sediment concentration (SSC) and daily streamflow data for water years 1949 through 2009. The sediment data used in the computation of SSLs and SSDLs and flow-adjusted concentrations are stored in the USGS National Water Information System (NWIS) database. The streamflow data primarily were from NWIS, but included additional sources. The data characteristics utilized in the computations of loads and flow-adjusted concentrations include SSCs, computed suspended-sand concentrations (SSDCs), and daily mean streamflows.

Station Selection

Station selection began with an assessment of published SSLs or SSCs and daily streamflow data at USGS streamgaging stations within each of the major subbasins of the MRB (fig. 1). Primary subbasins include the Ohio, upper Mississippi, Missouri, and Arkansas River Basins. A search of the

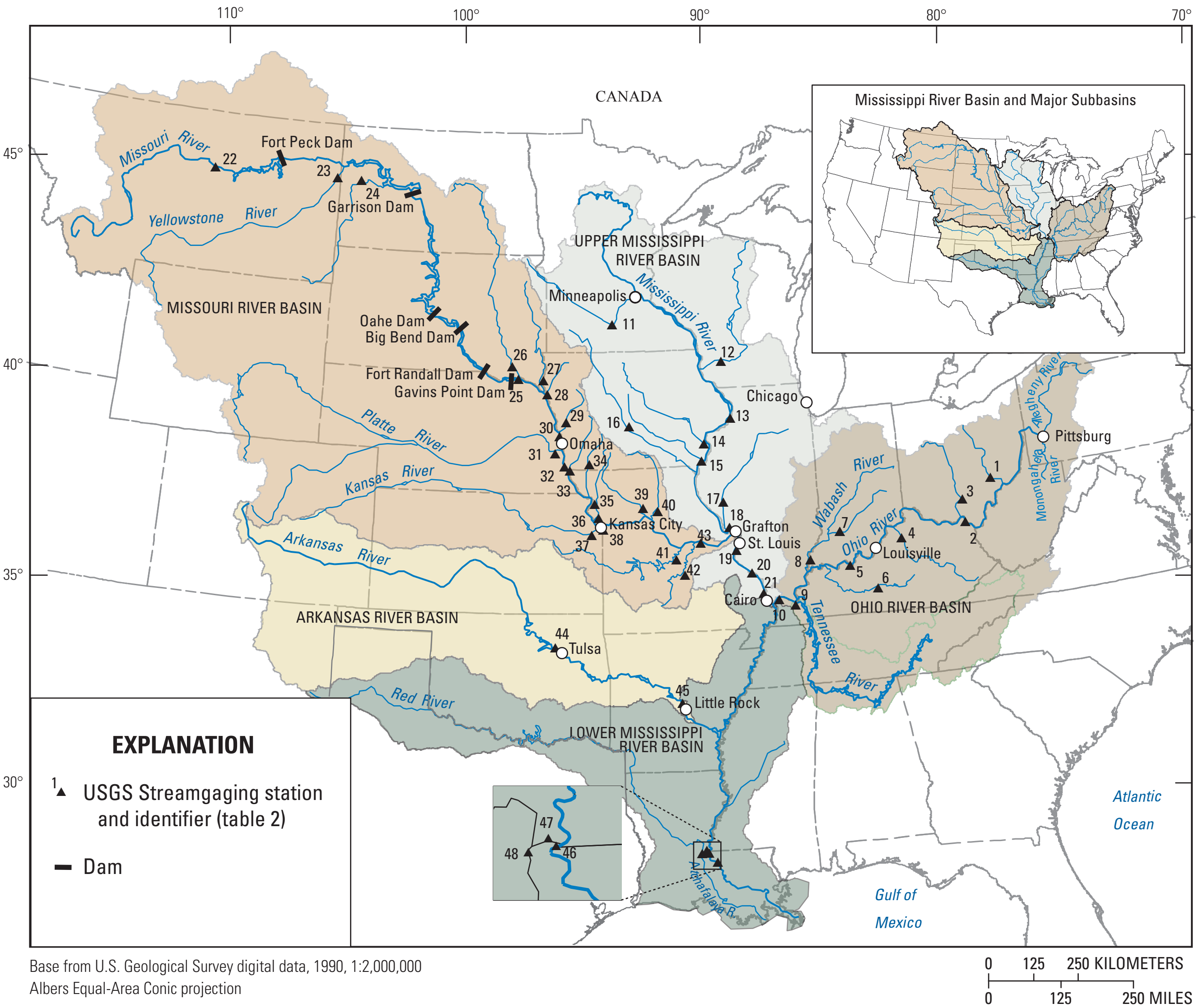

Figure 1. Mississippi River Basin, major Mississippi River subbasins, upper Missouri River impoundments, and U.S. Geological Survey streamgaging and sediment stations included in study.

USGS NWIS database was conducted for those main stem and primary tributary stations of at least 1,000 square miles with available SSLs, or SSCs and SSDCs and concurrent daily streamflow record, of at least 10 years. Further selection criteria used for those stations for which loads were not already determined included selecting stations with SSC and SSDC samples distributed throughout the water year and over the range of observed streamflows. At a minimum, data from the most-downstream station with adequate suspended sediment record from each major Mississippi River subbasin were selected for temporal analyses.

The construction of impoundments in the upper main stem of the Missouri River Basin had a substantial effect on sediment transport in the lower Missouri and Mississippi Rivers downstream from St. Louis (Keown and others, 1981; Tuttle and Combe, 1981; Kesel, 1988; Meade and Moody, 2010). To assess changes in sediment transport in main stem and tributary sites between pre- and post-impoundment periods, available stations with continuous or non-continuous sediment record spanning both periods were selected. As with previous studies (Keown and others, 1986; Jacobson and others, 2009) the pre-impoundment period in this study was defined as pre-1953—before the closure of the Fort Randall Dam. The post-impoundment period was defined as post-1967—after the last completed reservoir, Sharpe Reservoir, formed by Big Bend Dam (fig. 1), was filled.

Final station selection and temporal analysis periods were based on maximizing the number of stations within multiple selected analysis periods based on record availability. Stations were selected from each major subbasin as shown in figure 1 and table 1. Published loads and data used for the computation of suspended-sediment loads and temporal changes in constituents spanned the 1940 through 2009 period.

Sources of Sediment and Streamflow Data

Suspended-sediment and streamfow data were compiled from selected stations within the MRB based on data availability and suitability for analyses of subbasin contributions and temporal changes in sediment transport. The data included SSLs, SSDLs, SSCs, sediment particle size, and annual and daily mean streamflows. Whereas total sediment transport includes bed load and suspended-sediment transport, only the suspended part of total loads are included in the data compilations.

Annual SSLs and SSDLs were obtained from preexisting published or unpublished computed daily or annual loads and loads calculated specifically for this study using SSCs or SSDCs and daily mean streamflow data. Preexisting daily published or unpublished loads were computed by the U.S. Army Corps of Engineers (U.S. Army Corps of Engineers, 1951, 1957, 1965, 1970, 1972, 1976; U.S. Army Corps of Engineers, unpublished data, 1975–81, Keown and others, 1981) or the U.S. Geological Survey (Jordan, 1965; U.S. Geological Survey, 2009; Heimann and others, 2010). Preexisting loads were available for selected stations and were computed using the tabular day-by-day method (U.S. Army Corps of Engineers, 1951, 1957, 1965, 1970, 1972, 1976; Porterfield, 1977), Load Estimator (LOADEST) regression technique (Runkel and others, 2004), or turbidity surrogate method (Rasmussen and others, 2009). Annual SSLs and SSDLs also were computed specifically for this study using the LOADEST technique, sediment concentration and particle-size data, and streamflows obtained from the U.S. Geological Survey (2009) and the Tennessee Valley Authority (Kreis Weatherington, Tennessee Valley Authority, unpublished Kentucky Lake outflow data, 1976–2009).

Methods of Sediment Load Estimation

SSLs and SSDLs were computed for those stations and years within the 1949 through 2009 water year period for which loads had not previously been determined, and sufficient concentration and streamflow data were available. The S-LOADEST version of the program LOADEST, written for the commercial statistical package TIBCO Spotfire S+ (TIBCO Software Inc., version 8.1), was used to compute load estimates as described in Heimann and others (2010). LOADEST incorporates explanatory variables of streamflow, time, and season into one of nine predefined regression models. These models were fit to observed streamflow-SSC or streamflow-SSDC data pairs using the maximum likelihood estimation (MLE) method (Cohn and others, 1992). Model fit was judged using the Akaike Information Criterion (AIC) (Judge and others, 1988). The MLE method is contingent upon the assumption that model residuals were normally distributed and this was assessed by means of the Turnbull-Weiss likelihood ratio (Turnbull and Weiss, 1978) within S-LOADEST.

When available, the stored composite SSCs and sand-percentage values were used in determining load estimates; otherwise, the arithmetic average of sediment data from multiple-vertical samples was computed and used in load determinations. The multiple, depth-integrated (samples obtained from the entire water column) or point samples (samples obtained from selected depths or points in the water column) comprising a sediment sample were averaged (Heimann and others, 2010) to obtain a single mean concentration and particle-size fraction (if available) for a given sample date. SSDCs were determined by multiplying the SSCs by the corresponding sand fraction.

LOADEST sediment-load models were developed using a moving window approach. The load model for a given year was computed using 3, 5, or 7 years of SSC or SSDC data (determined by data availability) centered about the computation year. This method was selected to emulate the computation of existing published annual SSLs in which loads primarily were computed using data from the current water year. Because data used in load estimates for adjacent windows overlapped, only the results of the central years in non-overlapping moving windows of the LOADEST analyses, the corresponding flow-weighted concentrations (computed as the ratio of the annual SSL or SSDL and annual streamflow), and annual-mean streamflows of these central values were used in analyses in order to avoid cross-correlation effects.

Data Used in Analyses of Sediment Concentrations and Loads

Suspended-Sediment Concentrations and Streamflow

SSC-daily mean streamflow and SSDC-daily mean streamflow data pairs for the computation of sediment loads or flow-adjusted sediment concentrations were available at 38 of the 48 USGS streamgaging stations. SSLs were published for the remaining 10 stations, but the corresponding SSC or SSDC data were not available. All SSCs, SSDCs, and corresponding daily streamflow data used in the LOADEST models or

Table 1. Selected U.S. Geological Survey (USGS) streamgaging stations in the Mississippi River Basin used in study.

[mi^2, square mile; --, not applicable]

Map reference number (fig. 1)	USGS station name	USGS station number	Period of record used in analyses	Area (mi^2)
	Ohio River Basin			
1	Muskingum River at McConnelsville, Ohio	03150000	1979–86	7,422
2	Ohio River at Greenup Dam near Greenup, Kentucky	03216600	1976–85, 1997–2007	62,000
3	Scioto River at Higby, Ohio	03234500	1979–86	5,131
4	Kentucky River at Lock 2 at Lockport, Kentucky	03290500	1979–86	6,180
5	Ohio River at Cannelton Dam at Cannelton, Indiana	03303280	1976–86, 1996–2009	97,000
6	Green River at Munfordville, Kentucky	03308500	1952–78, 1982–93, 2004–2008	1,673
7	White River at Hazelton, Indiana	03374100	1976–84,1991–2009	11,305
8	Wabash River at New Harmony, Indiana	03378500	1976–86, 1997–2008	29,234
9	Tennessee River at Highway 60 near Paducah, Kentucky	03609750	1976–88, 1997–2009	40,330
10	Ohio River at Dam 53 near Grand Chain, Illinois	03612500	1976–2009	203,100
	Upper Mississippi River Basin			
11	Minnesota River at Mankato, Minnesota	05325000	1976–2009	14,900
12	Wisconsin River at Muscoda, Wisconsin	05407000	1978–93	10,400
13	Mississippi River at Clinton, Iowa	05420500	1943–87, 1991–2009	85,600
14	Iowa River at Wapello, Iowa	05465500	1978–2006	12,500
15	Skunk River at Augusta, Iowa	05474000	1976–2009	4,312
16	Des Moines River near Saylorville, Iowa	05481650	1978–93	5,841
17	Illinois River at Valley City, Illinois	05586100	1976–2009	26,743
18	Mississippi River below Grafton, Illinois	05587455	1976–2009	171,300
19	Mississippi River at Saint Louis, Missouri	07010000	1949–2009	697,000
20	Mississippi River at Chester, Illinois	07020500	1998–2009	708,600
21	Mississippi River at Thebes, Illinois	07022000	1998–2009	713,200
	Missouri River Basin			
22	Missouri River near Landusky, Montana	06115200	1949–51, 1959–62, 1964–65, 1969, 1971–2006	40,987
23	Yellowstone River near Sidney, Montana	06329500	1948–2009	69,083
24	Little Missouri River near Watford, North Dakota	06337000	1949–76	8,310
25	Missouri River at Yankton, South Dakota	06467500	1940–59, 1961–68, 2001–08	279,500
26	James River near Scotland, South Dakota	06478500	1975–91	20,653
27	Big Sioux River at Akron, Iowa	06485500	1941–51, 1971–94	7,879
28	Missouri River at Sioux City, Iowa	06486000	1976–2000, 2004–09	314,600
29	Boyer River at Logan, Iowa	06609500	1940–51, 1969–74, 2004–09	871
30	Missouri River at Omaha, Nebraska	06610000	1940–2009	322,800
31	Platte River at Louisville, Nebraska	06805500	1940–51, 1953–71, 1973–2009	85,370
32	Missouri River at Nebraska City, Nebraska	06807000	1976–2009	410,000
33	Nishnabotna River above Hamburg, Iowa	06810000	1940–51, 1982–93, 2004–09	2,806
34	Nodaway River at Clarinda, Iowa	06817000	1976–91	762
35	Missouri River at Saint Joseph, Missouri	06818000	1949–2009	426,500
36	Platte River at Sharps Station, Missouri	06821190	1980–91	2,380

Table 1. Selected U.S. Geological Survey (USGS) streamgaging stations in the Mississippi River Basin used in study.—Continued

[mi², square mile; --, not applicable]

Map reference number (fig. 1)	USGS station name	USGS station number	Period of record used in analyses	Area (mi²)
	Missouri River Basin–Continued			
37	Kansas River at DeSoto, Kansas	06892350	1949–74, 1976–91, 2000–05	59,756
38	Missouri River at Kansas City, Missouri	06893000	1949–81, 1988–2009	484,100
39	Grand River near Sumner, Missouri	06902000	1975–91	6,880
40	Chariton River near Prairie Hill, Missouri	06905500	1978–86	1,870
41	Osage River below Saint Thomas, Missouri	06926510	1975–91	14,584
42	Gasconade River at Jerome, Missouri	06933500	1978–91	2,840
43	Missouri River at Hermann, Missouri	06934500	1949–2009	522,500
	Arkansas River Basin			
44	Arkansas River at Tulsa, Oklahoma	07164500	1950–95	74,615
45	Arkansas River at David D. Terry Lock and Dam below Little Rock, Arkansas	07263620	1976–2009	158,429
	Lower Mississippi River Basin			
46	Mississippi River at Tarbert Landing, Mississippi	07295100	1950–2009	1,124,900
47	Old River Outflow Channel near Knox Landing, Louisiana	310355091411500	1966–2009	Indeter-minate
48	Atchafalaya River at Simmesport, Louisiana	07381490	1952–2009	87,570[1]

[1] Drainage area does not include that area apportioned to the river based on the fraction of streamflow diverted from the Mississippi River main stem.

flow-adjusted concentration analyses are summarized by site in table 2 (*http://pubs.usgs.gov/ds/593/downloads/table2.xlsx*).

Annual Suspended-Sediment Loads

Preexisting and computed annual SSLs and annual SSDLs (in tons) were compiled for 48 USGS streamgaging stations (fig. 1, table 1) in the Mississippi River Basin for the period 1940 through 2009 (table 3). The annual mean streamflows and flow-weighted concentrations corresponding to the years of available sediment loads also are included in table 3 (*http://pubs.usgs.gov/ds/593/downloads/table3.xlsx*). The period of sediment load record from each of the 48 stations available for use in temporal analyses are presented in table 1.

Summary

This report presents suspended-sediment concentration and streamflow data, describes load-estimation techniques used in the computation of annual suspended-sediment loads, and presents annual suspended-sediment loads for 48 stations within the Mississippi River Basin. Available published, unpublished, and computed annual suspended-sediment and suspended-sand loads are presented for water years 1940 through 2009. When previously published annual loads were not available, total suspended-sediment and sand loads were computed using available data for water years 1949 through 2009.

Annual sediment load values were computed specifically for this study using the Load Estimation (LOADEST) technique and utilized sediment concentration, particle size, and streamflow data obtained from the USGS National Water Information System, U.S. Army Corps of Engineers, and the Tennessee Valley Authority. A table of suspended-sediment concentration and daily mean streamflow data used in the computation of annual loads is presented along with a table of compiled and computed annual suspended-sediment and suspended-sand loads, annual streamflows, and flow-weighted concentrations for the 48 stations.

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