Suspended-Sediment Characteristics of Indiana Streams, 1952–84

United States Geological Survey Water-Supply Paper 2404

Prepared in cooperation with the Indiana Department of Natural Resources

AVAILABILITY OF BOOKS AND MAPS OF THE U.S. GEOLOGICAL SURVEY

Instructions on ordering publications of the U.S. Geological Survey, along with prices of the last offerings, are given in the current-year issues of the monthly catalog "New Publications of the U.S. Geological Survey." Prices of available U.S. Geological Survey publications released prior to the current year are listed in the most recent annual "Price and Availability List." Publications that may be listed in various U.S. Geological Survey catalogs (**see back inside cover**) but not listed in the most recent annual "Price and Availability List" may be no longer available.

Order U.S. Geological Survey publications **by mail** or **over the counter** from the offices given below.

BY MAIL

Books

Professional Papers, Bulletins, Water-Supply Papers, Techniques of Water-Resources Investigations, Circulars, publications of general interest (such as leaflets, pamphlets, booklets), single copies of Earthquakes & Volcanoes, Preliminary Determination of Epicenters, and some miscellaneous reports, including some of the foregoing series that have gone out of print at the Superintendent of Documents, are obtainable by mail from

U.S. Geological Survey, Information Services
Box 25286, Federal Center, Denver, CO 80225

Subscriptions to periodicals (Earthquakes & Volcanoes and Preliminary Determination of Epicenters) can be obtained ONLY from the

Superintendent of Documents
Government Printing Office
Washington, DC 20402

(Check or money order must be payable to Superintendent of Documents.)

Maps

For maps, address mail orders to

U.S. Geological Survey, Information Services
Box 25286, Federal Center, Denver, CO 80225

OVER THE COUNTER

Books and Maps

Books and maps of the U.S. Geological Survey are available over the counter at the following U.S. Geological Survey Earth Science Information Centers (ESIC), all of which are authorized agents of the Superintendent of Documents:

- **ANCHORAGE, Alaska**—Rm. 101, 4230 University Dr.
- **LAKEWOOD, Colorado**—Federal Center, Bldg. 810
- **MENLO PARK, California**—Bldg. 3, Rm. 3128, 345 Middlefield Rd.
- **RESTON, Virginia**—USGS National Center, Rm. 1C402, 12201 Sunrise Valley Dr.
- **SALT LAKE CITY, Utah**—Federal Bldg., Rm. 8105, 125 South State St.
- **SPOKANE, Washington**—U.S. Post Office Bldg., Rm. 135, West 904 Riverside Ave.
- **WASHINGTON, D.C.**—Main Interior Bldg., Rm. 2650, 18th and C Sts., NW.

Maps Only

Maps may be purchased over the counter at the following U.S. Geological Survey offices:

- **ROLLA, Missouri**—1400 Independence Rd.
- **STENNIS SPACE CENTER, Mississippi**—Bldg. 3101

Suspended-Sediment Characteristics of Indiana Streams, 1952–84

By CHARLES G. CRAWFORD and LAWRENCE J. MANSUE

Prepared in cooperation with the Indiana
Department of Natural Resources

U.S. GEOLOGICAL SURVEY WATER-SUPPLY PAPER 2404

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
Gordon P. Eaton, Director

Printed in the Eastern Region, Reston, Va.

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1996

For sale by the
U.S. Geological Survey, Information Services
Box 25286, Federal Center, Denver, CO 80225

Library of Congress Cataloging in Publication Data

Crawford, Charles G.
Suspended-sediment characteristics of Indiana streams, 1952–84 /
by Charles G. Crawford and Lawrence J. Mansue.
p. cm. — (U.S. Geological Survey water-supply paper ; 2404)
"Prepared in cooperation with the Indiana Department of Natural Resources."
Includes bibliographical references.
Supt. of Docs. no.: I 19.13:2404
1. Sediment, Suspended—Indiana. I. Mansue, Lawrence J. II. Title. III. Series.
GB1399.8.I6C73 1996
551.3'53'09772—dc20 92–36186
CIP

CONTENTS

FIGURES

TABLES

(in back of paper)

CONVERSION FACTORS AND ABBREVIATIONS

For use of readers who prefer to use metric (International System) units, rather than the inch-pound terms in this report, the following conversion factors are provided:

Multiply inch-pound unit	By	To obtain metric unit
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
cubic foot per second per square mile [(ft^3/s)/mi^2]	0.01093	cubic meter per second per square kilometer
cubic foot per second per year [(ft^3/s)/yr]	0.02832	cubic meter per second per year
foot per mile (ft/mi)	0.1894	meter per kilometer
inch (in.)	25.4	millimeter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
square ton per day squared (ton^2/d^2)	0.8230	square megagram per day squared (Mg^2/d^2)
ton, short (ton)	0.9072	megagram
ton per acre per year [(ton/acre)/yr]	2.242	megagram per hectare per annum
ton per day (ton/d)	0.9072	megagram per day
ton per day per year (ton/d/yr)	0.9072	megagram per day per annum
ton per square mile per year [(ton/mi^2)/yr]	0.3503	megagram per square kilometer per annum
ton per year (ton/yr)	0.9072	megagram per annum

Temperature in degrees Fahrenheit (°F) can be converted to degrees Celsius (°C) as follows:

$$°C = 5/9(°F-32)$$

The following term and abbreviation are also used in this report:

milligram per liter (mg/L)

Suspended-Sediment Characteristics of Indiana Streams, 1952–84

By Charles G. Crawford *and* Lawrence J. Mansue

Abstract

Suspended-sediment concentration and discharge data were collected at 7 daily record stations and 70 partial-record stations during 1952–84. Median suspended-sediment concentrations ranged from 24 to 61 milligrams per liter at daily record stations; concentrations ranged from 6 to 539 milligrams per liter at partial-record stations. Most suspended sediment transported in Indiana streams is silt and clay size (particles between 0.062 and 0.004 millimeter in diameter and particles less than 0.004 millimeter in diameter).

Large suspended-sediment concentrations were associated with storm runoff but not always with peak streamflow. Some peak concentrations of suspended sediment preceded peak streamflow by as much as 18 to 30 hours during storms. Suspended-sediment concentrations frequently were largest during a storm that occurred after a period of low streamflow, when large amounts of sediment were eroded and transported into the stream and little base flow was available for dilution. For most of the streams studied, reliable predictive equations could not be developed to quantify the relation between suspended-sediment concentration and streamflow because of the extreme variability in the data.

Annual suspended-sediment yields at four daily record stations ranged from 186 to 1,914 tons per square mile. Annual suspended-sediment yields for 70 partial-record stations, estimated by use of the suspended-sediment transport, flow-duration-curve method, ranged from 11 to 2,310 tons per square mile. However, because of the poor correlation between suspended-sediment discharge and streamflow, these estimates are imprecise.

Periods of record at 4 daily record and 32 partial-record stations were sufficient to test for trends. The trend in suspended-sediment concentration, adjusted for streamflow, was significant for only 9 of the 36 stations. At six of the nine stations, flow-adjusted suspended-sediment concentrations decreased with time.

INTRODUCTION

Sediment is inorganic and organic material that is transported by, suspended in, or deposited by streams. The quantity of sediment transported by a stream is designated the sediment load. The sediment load can be divided into two components on the basis of the mode of transportation (Colby, 1963, p. A12). Suspended sediment is material held in suspension by turbulent currents or by colloidal suspension. Bedload is material that remains very close to the streambed and is transported by sliding, skipping, or rolling along the bed. The rate of movement of sediment past a point in a stream is designated the sediment discharge.

Suspended sediment is generally considered to be the most significant nonpoint contaminant, by volume, for surface waters (McElroy and others, 1976, p. 29). Silt- and clay-sized particles can remain suspended for long periods and can cause medium to large levels of turbidity in the receiving streams. Large sediment discharges in streams can result in the destruction of aquatic habitat and a decrease in aquatic populations (Cordane and Kelly, 1961; Gammon, 1970). Some metal ions, pesticides, and nutrients may be sorbed on sediment particles and transported with the sediment.

Knowledge of the quantity and characteristics of suspended sediment is useful for managing the State's water resources. For example, information on long-term sediment discharge, concentrations, and particle-size composition of the sediment is important in the design of reservoirs. Information about sediment discharges and concentrations is essential for evaluating water-quality issues and for designing water-treatment plants. The evaluation of conservation and land-use practices is commonly based on sediment data. Examples of such studies are Mansue and Anderson (1974) and Reed (1978).

The U.S. Geological Survey has been collecting suspended-sediment data in Indiana since 1952. The objectives of the data-collection program are to determine (1) suspended-sediment yields for streams throughout the State, (2) particle-size distribution of suspended sediment, and (3) trends in suspended-sediment concentration and discharge.

Johnson (1971) described the suspended-sediment data-collection program and presented mean annual suspended-sediment yields for stations in Indiana sampled through 1969. The suspended-sediment program in Indiana has expanded since 1969, and considerably more data have been collected.

The purpose of this report is to describe the results of a study summarizing suspended-sediment data collected in Indiana. Included in the report are summaries of (1) suspended-sediment concentration and discharge, (2) particle-size distribution of suspended sediment, (3) suspended-sediment yields, and (4) trends in suspended-sediment concentration and discharge. The report also describes in detail the methodology used to estimate suspended-sediment yields and the variance of the estimated yields. The information contained in this report is based on suspended-sediment data collected by the U.S. Geological Survey in Indiana, in cooperation with the Indiana Department of Natural Resources, from 1952 to 1984, and consists of 23,153 estimates of daily mean suspended-sediment concentration and 21,766 estimates of daily mean suspended-sediment discharge collected at seven stream stations. The number of estimates of daily mean suspended-sediment concentration ranges from 784 to 6,050 at the seven stream stations. The number of estimates of daily mean suspended-sediment discharge ranges from 784 to 5,889 at the seven stream stations. There are also 3,946 instantaneous observations of streamflow, suspended-sediment concentration and discharge collected at 70 stream stations, the number of which range from 9 to 154 per station. The sampling stations have drainage basins ranging in size from 6.8 to 29,234 square miles (mi^2).

The basic data used for this study are not presented in this report. The data have been published in the U.S. Geological Survey Water-Supply Paper series, "Quality of Surface Waters of the United States, Parts 3, 4, and 5: Ohio River Basin, St. Lawrence River Basin, and Upper Mississippi River Basin," for data collected prior to October 1964, and in the U.S. Geological Survey Water-Data Report series, "Water Resources Data for Indiana," for data since October 1964.

PHYSICAL SETTING OF THE STUDY AREA

Drainage Basins

Eighty percent of Indiana is drained by streams that discharge into the Ohio River. The largest river in Indiana, the Wabash, drains 32,910 mi^2. Of this total area, 8,700 mi^2 are in Illinois and 285 mi^2 are in Ohio. The White River, a tributary to the Wabash, has two subbasins of nearly equal size, the main stem and the East Fork, with a total drainage area of 11,349 mi^2. The Whitewater River, which drains 1,369 mi^2, discharges into the Great Miami River in southern Ohio. The Kankakee and Iroquois Rivers are part of the Illinois River drainage; they drain about 17 percent of Indiana (2,581 mi^2) and flow westward into Illinois. The Illinois River is part of the upper Mississippi River drainage. Approximately 10 percent of Indiana is drained by three rivers that are part of the Great Lakes basin. The Calumet and St. Joseph Rivers drain into Lake Michigan, and the Maumee River drains into Lake Erie. Both Lake Michigan and Lake Erie are part of the Saint Lawrence River drainage. Major drainage basins in Indiana are shown in figure 1, and minor drainage basins are shown in figure 2.

Glacial Geology and Geomorphology

During the Pleistocene Epoch, glacial ice extended into Indiana several times. As a result, Indiana can be divided into three general geomorphic zones: (1) the northern moraine and lake region, (2) the Tipton till plain, and (3) the unglaciated bedrock geomorphic units of southern Indiana (fig. 3).

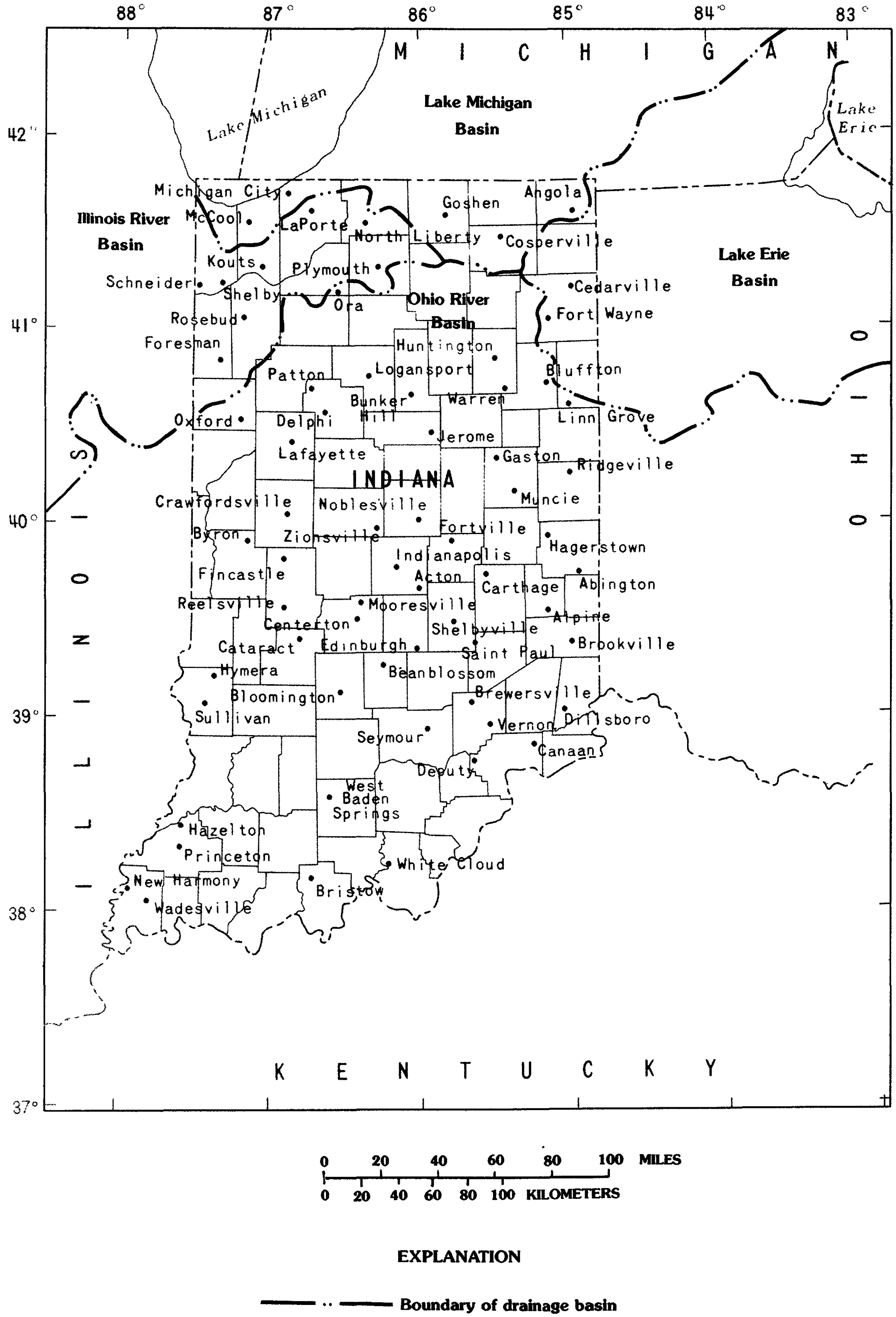


Figure 1. Major drainage basins.

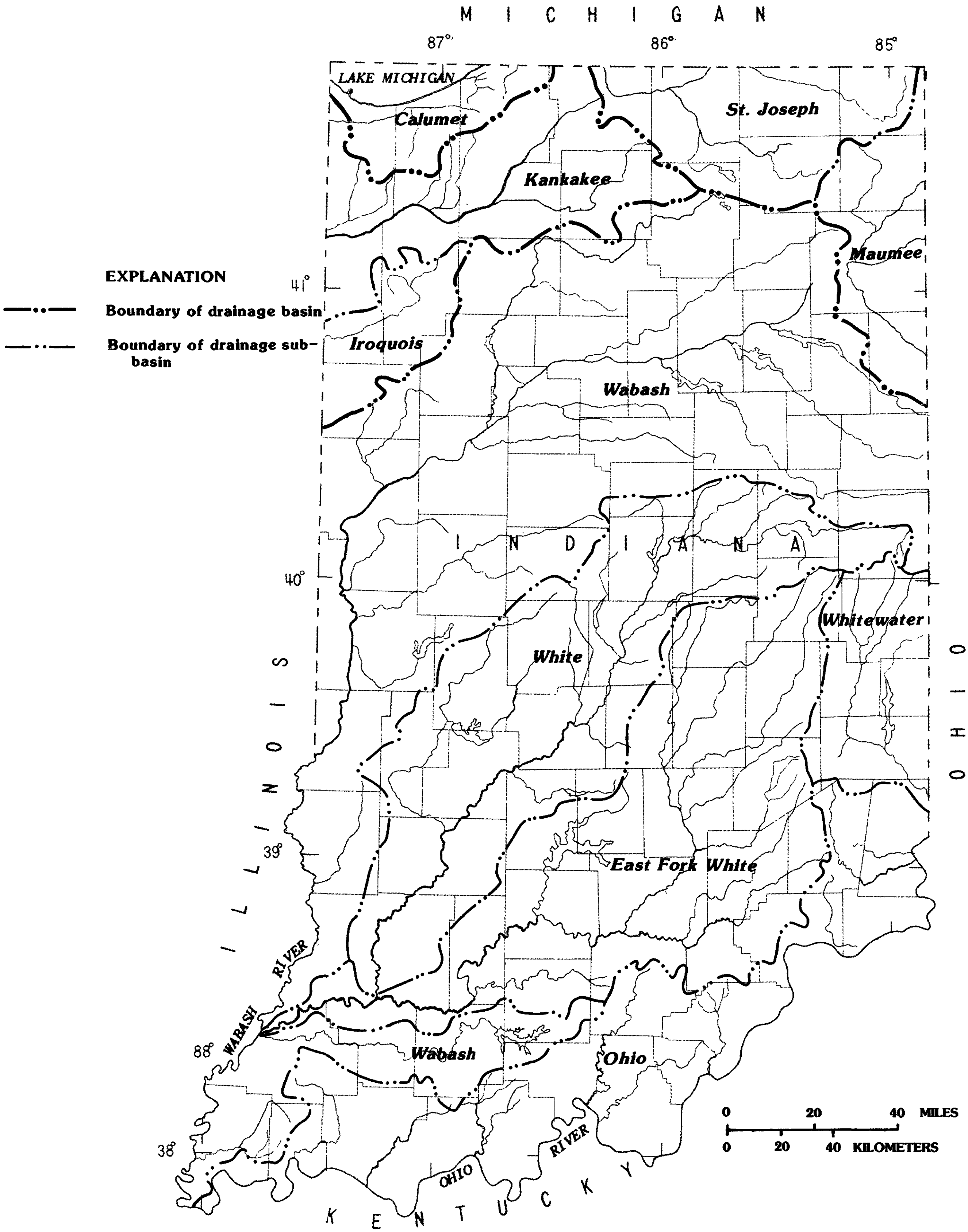


Figure 2. Minor drainage basins.

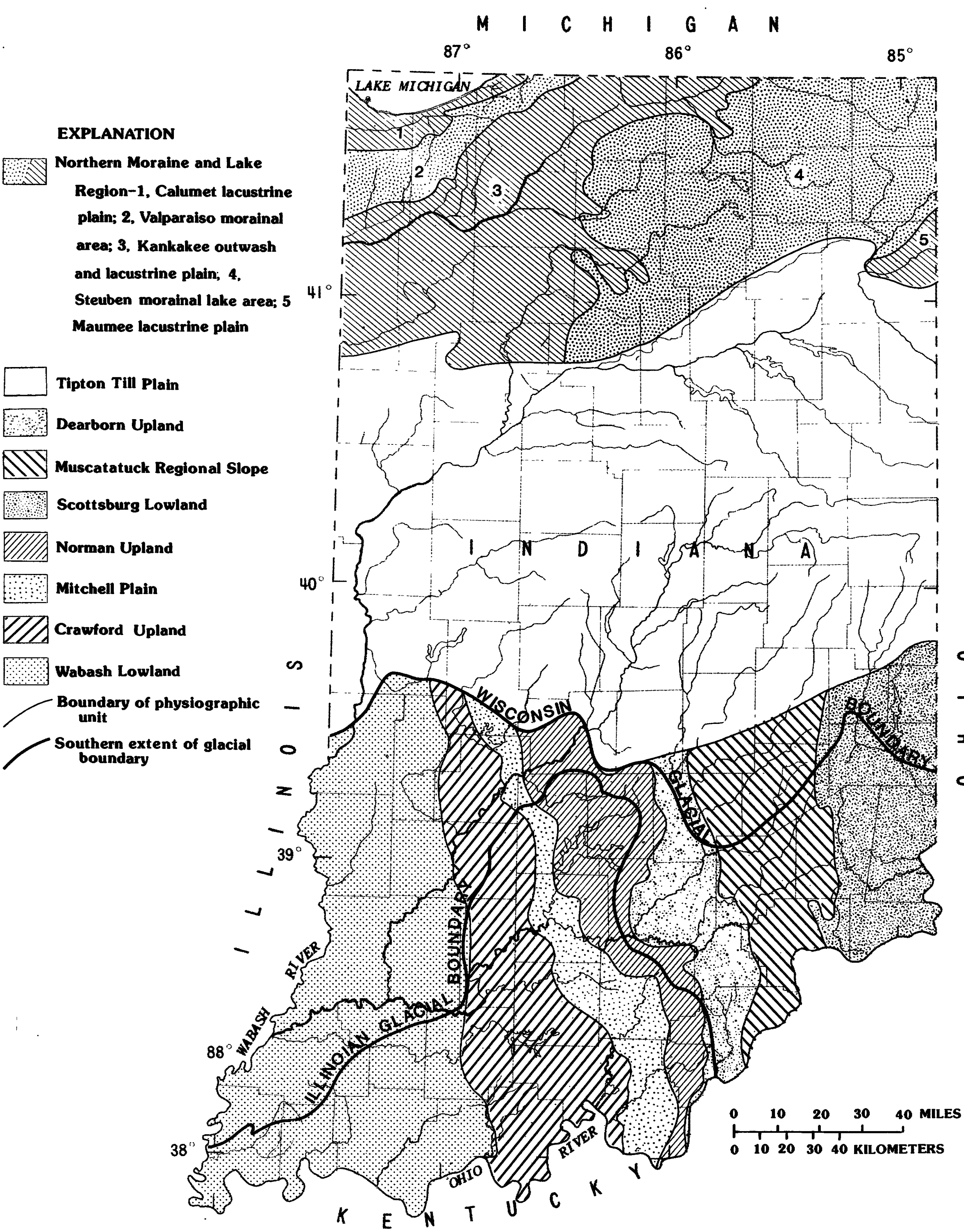


Figure 3. Glacial boundaries and physiographic units. From Schneider (1966).

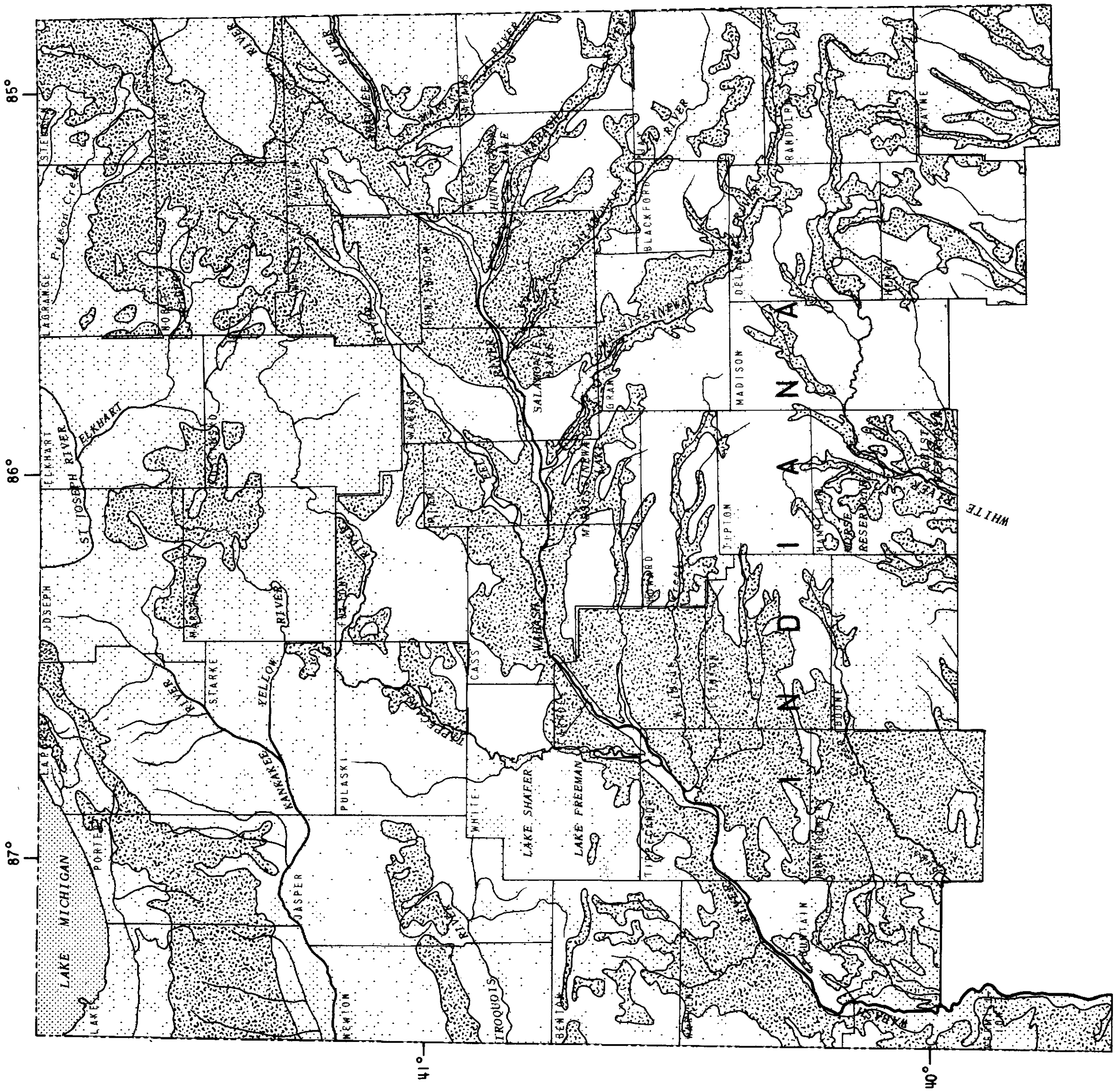


Figure 4. Northern half.

The ice extended farther south in the Wabash and Ohio River drainage basins than in any other region of the Northern Hemisphere during this time. In the area north of the Wisconsin glacial boundary (the most recent glaciation), nearly all the landscape is of glacial origin. Between the southern boundary of the Wisconsin glaciation and the extent of maximum glaciation (the southern boundary of the Illinoian glaciation) are bedrock features and features formed by glacial deposition. In the unglaciated part of the State, landforms have been affected by glacial-outwash sand and gravel and by silt and clay deposits in lakes formed by glacial meltwater (Wayne, 1966, p. 21). A more detailed description of these landforms can be found in Schneider (1966) and Malott (1922).

Soils

Indiana soils are derived from glacial drift and the local bedrock (Clark, 1980, p. 16). The composition of glacial deposits varies, as demonstrated by the wide variety of textures and types of soils throughout the State.

Many areas throughout Indiana have potential for severe soil erosion. The State Soil and Water Conservation Committee and the Indiana Department of Natural Resources estimated the amount of erosion for 1978–79 land-use conditions. These estimates considered vegetative cover, land management, and erosion-control practices on the land. Average annual soil loss (gross erosion), estimated by the universal soil loss

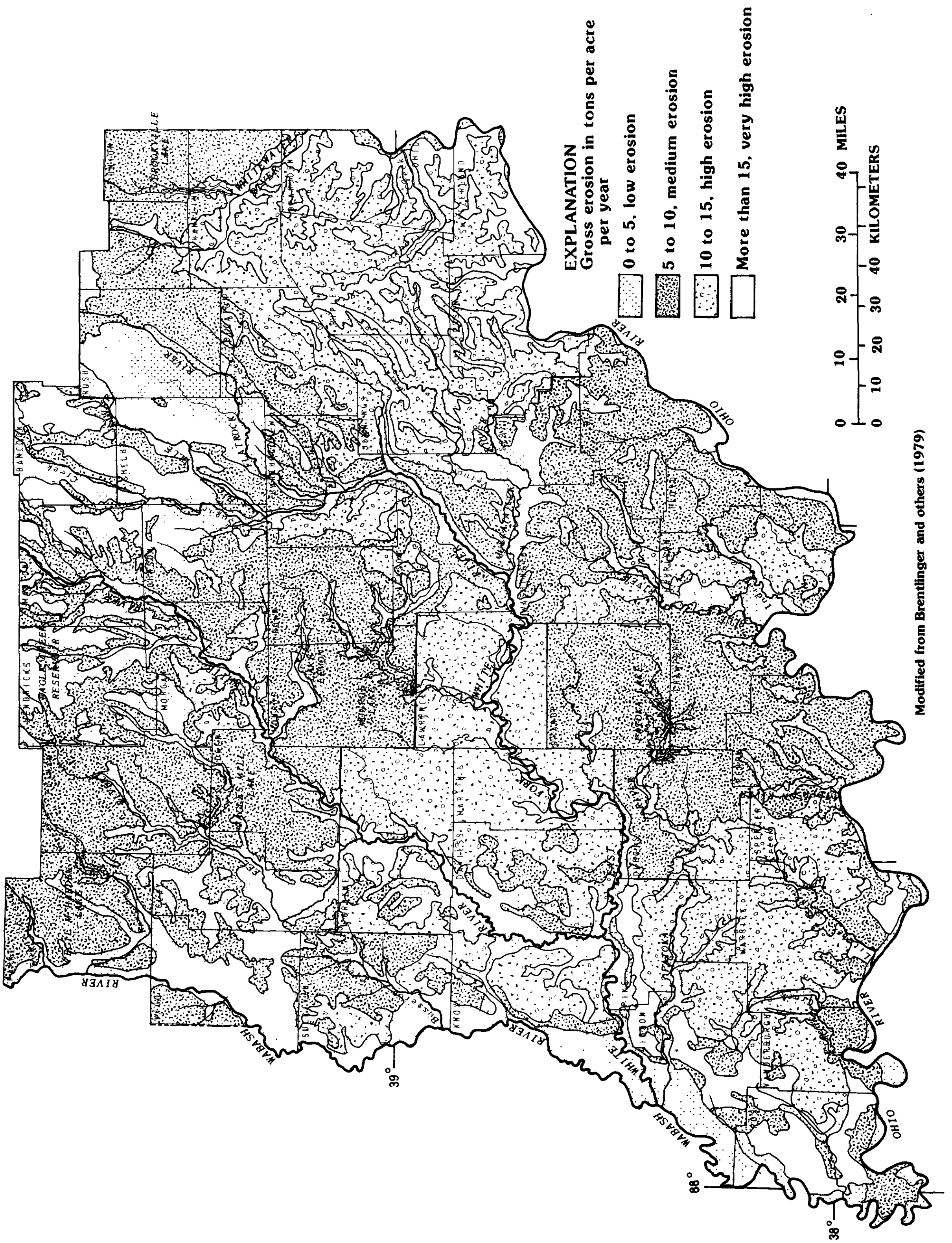


Figure 4. Estimated annual soil erosion.

equation (Brentlinger and others, 1979, p. 9), is shown in figure 4. Soil associations having small average annual soil loss of 0 to 4.9 tons per acre per year [(tons/acre)/yr] are deep, very poorly to somewhat poorly drained, and on nearly level and depressionable land; those having medium annual soil loss of 5 to 9.9 (tons/acre)/yr are deep, somewhat poorly drained, and on nearly level to slightly sloping land; those having large annual soil loss of 10 to 14.9 (tons/acre)/yr are deep, well-drained, and on moderately to steeply sloped land; most of those having annual soil loss of 15 (tons/acre)/yr or larger are deep, well-drained, and on steeply sloped land.

Climate and Precipitation

Average maximum daily temperature in Indiana ranges from 34 to 46 degrees Fahrenheit (°F) in January and 84 to 90 °F in July. Average minimum daily temperatures range from 18 to 28 °F in January and 62 to 68 °F in July (Schaal, 1966, p. 162). Average growing season (about 170 days) ranges from 150 days in northeastern Indiana to more than 200 days in southwestern Indiana.

Average annual precipitation is 38 inches (in.) and ranges from 36 in. in northern Indiana to 44 in. in southern Indiana (Schaal, 1966, p. 157). The distribution of precipitation is fairly even throughout the year. Average monthly precipitation is largest in April, May, June, and July (about 4 in.) and smallest in February and October (2–2.5 in.). Average annual snowfall ranges from 10 in. in southern Indiana to 60 in. in northern Indiana (Schaal, 1966, p. 157).

Runoff

Average annual surface runoff in Indiana (the depth to which the State would be covered if all runoff for an average year were distributed uniformly over the State) ranges from about 10 in. in the northeast to about 18 in. in the south-central part of the State (fig. 5). Runoff is usually largest from January through June and smallest from August through October.

SUSPENDED-SEDIMENT SAMPLING METHODS

Samples were collected at seven stream stations once daily during normal flows and several times daily during storm runoff. Usually, a sample was collected from one vertical in the stream cross section; detailed cross-sectional samples also were collected periodically. The data were used to provide information about (1) magnitude, frequency, and duration of suspended-sediment concentration and discharge and (2) long-term yields and trends.

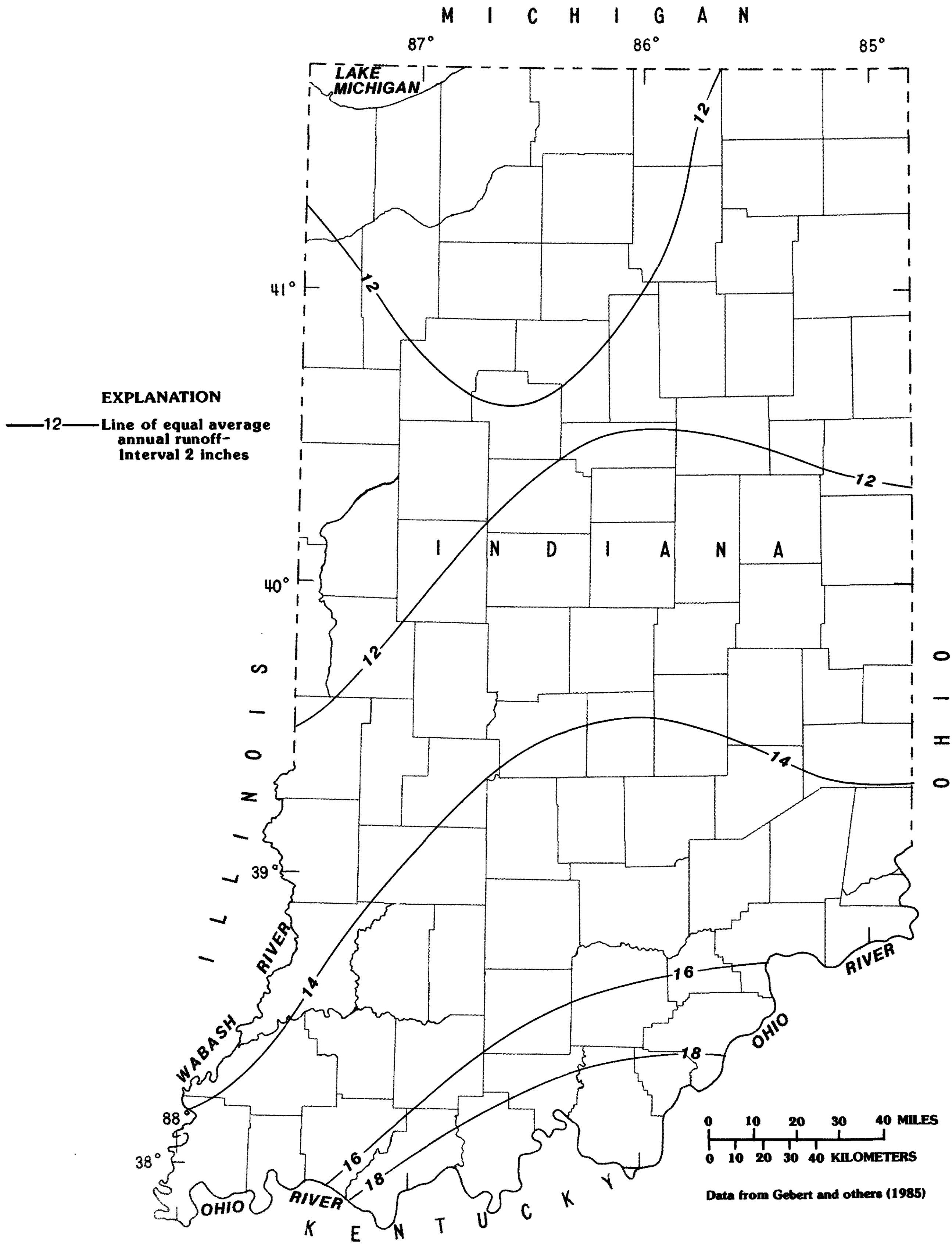
Data were collected periodically every 1 to 4 months and occasionally more often during storms at 70 stream stations. These partial records were used to provide information about regional suspended-sediment characteristics. Partial records provide less information than daily records for a given station; however, the substantially lower cost of partial records allows more stations to be sampled. Partial records also can be used to estimate suspended-sediment yield. The locations of the daily record and partial-record stations are shown in figure 6.

Suspended-sediment stations were chosen from existing U.S. Geological Survey streamflow-gaging stations in Indiana. A description of the streamflow-gaging network in Indiana may be found in Marie and Swisshelm (1970) or Stewart and others (1986). Each streamflow-gaging station has an assigned eight-digit number for identification. The first two digits of this number refer to the primary basin in which the station is located. Stations whose number begins "03" are in the Ohio River basin, "04" are in the Saint Lawrence River basin, and "05" are in the upper Mississippi River basin. The remaining six digits are assigned in a downstream order. For reference purposes, these downstream-order station numbers are given in the tables, as well as the numbers showing station locations given in figure 6.

Data collected daily at a station are used to estimate a record of daily mean suspended-sediment concentration for that station. Data collected at a station on a periodic basis are instantaneous suspended-sediment concentrations. To compare the two data-collection methods, daily and partial records were compiled independently for three stations: Eel River near Logansport, Big Raccoon Creek near Fincastle, and East Fork White River at Seymour. Although both types of records are for the same station, they are discussed separately under the appropriate sections pertaining to daily record and partial-record stations. Daily record and partial-record stations were selected to provide representation of the major drainages and physiographic provinces of Indiana.

Suspended-sediment samples were collected in depth-integrating samplers, using procedures described by Guy and Norman (1970). Suspended-sediment concentration and particle size were

Figure 5. Average annual runoff, 1951–80. →



M I C H I G A N
87°
86°
85°
LAKE MICHIGAN
41°
40°
39°
38°
88°
EXPLANATION
—12— Line of equal average annual runoff– Interval 2 inches
12
12
12
12
14
14
16
16
18
18
I N D I A N A
I L L I N O I S
O H I O
K E N T U C K Y
WABASH RIVER
OHIO RIVER
OHIO RIVER
OHIO
RIVER
0 10 20 30 40 MILES
0 10 20 30 40 KILOMETERS
Data from Gebert and others (1985)

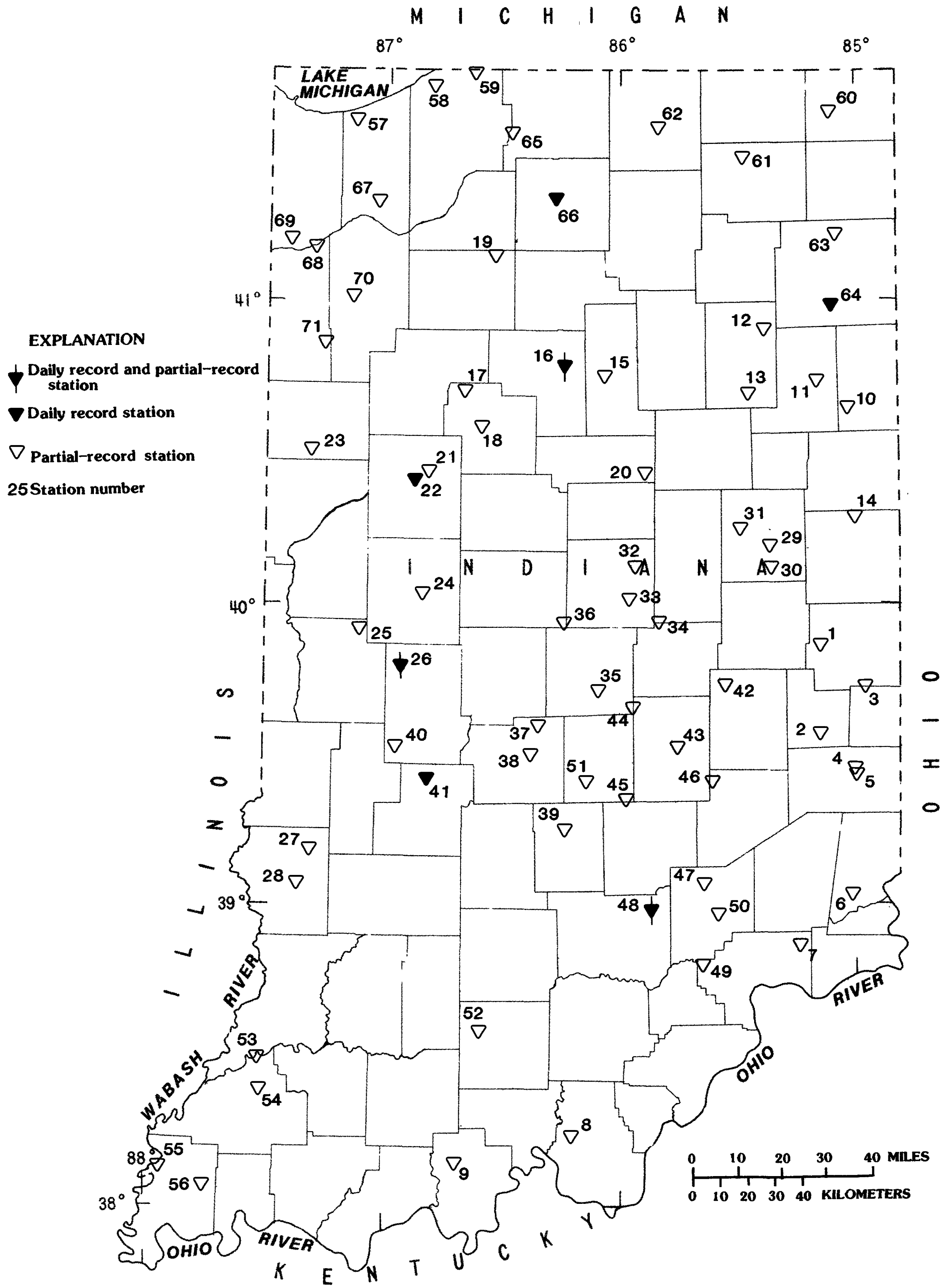


Figure 6. Locations of suspended-sediment sampling stations.

determined using laboratory procedures described by Guy (1969).

Suspended-sediment discharge is calculated by the following equation:

$$Q_s = kQ_wC_s, \quad (1)$$

where

- Q_s is the suspended-sediment discharge, in tons per day;
- k is a units conversion factor ($k = 0.0027$ when Q_w is in cubic feet per second, C_s is in milligrams per liter, and Q_s is in tons per day);
- Q_w is the water discharge, in cubic feet per second; and
- C_s is the suspended-sediment concentration, in milligrams per liter.

SUSPENDED-SEDIMENT CONCENTRATION AND DISCHARGE

Daily Record Stations

Summaries of daily mean suspended-sediment data collected at stations through September 1981 (the end of the 1981 water year and the last year of data collection) are presented in table 1 (concentration) and table 2 (discharge). (Tables begin on p. 35.) The water year used for this study is the 12-month period beginning October 1 and ending September 30.

Daily station data indicate that 64 to 97 percent of the suspended-sediment load occurred in only 10 percent of the time (table 3). A similar analysis shows that 18 to 69 percent of the suspended-sediment load occurred during only 1 percent of the time. These percentages mean that suspended sediment in Indiana is transported in a relatively short period of time (a few days each year). Very large flows (water discharges that are equaled or exceeded only 1 percent of the time) transported from 9 to 61 percent of the suspended-sediment load. Flows equaled or exceeded more than 10 percent of the time, but less than 1 percent of the time, transported from 33 to 59 percent of the suspended-sediment load. Flows equaled or exceeded more than 25 percent of the time, but less than 10 percent of the time, transported from 5 to 33 percent of the suspended-sediment load. Flows equaled or exceeded more than 50 percent of the time (less than the median flow) transported only 1 to 7 percent of the suspended-sediment discharge. The percentage of suspended-sediment load contributed for days when the suspended-sediment discharge was equaled or exceeded by 1 and 10 percent of the time exceeds the percentage of suspended sediment transported for days where the water discharge was equaled or exceeded only 1 and 10 percent of the time. This percentage indicates that a large portion of suspended sediment is transported by large water discharges, but that the largest suspended-sediment discharges are not associated always with the largest water discharge. Daily duration of streamflow, suspended-sediment concentration, and suspended-sediment discharge are given in table 4. Because the data for the different stations were not necessarily collected over the same period of time, comparisons between stations are inappropriate.

Seasonal variations of mean monthly streamflow, suspended-sediment concentration, and suspended-sediment discharge for four daily record suspended-sediment stations are shown in figure 7. Data for other daily record stations are not shown because of the short period of record. Suspended-sediment concentrations generally were largest during spring and summer and smallest during autumn. Suspended-sediment discharge does not always follow this same trend. From two-thirds to three-fourths of the annual suspended-sediment discharge occurs from December through April. Mean monthly suspended-sediment discharge was typically largest in March, near the time that mean monthly streamflow was largest.

The relation between suspended-sediment concentration and streamflow for two Indiana streams during selected periods of runoff is shown in figures 8 and 9. Peak suspended-sediment concentration preceded peak streamflow by approximately 30 hours for the station at Eel River near Logansport. Peak suspended-sediment concentration preceded peak streamflow by 18 to 24 hours for the station at East Fork White River at Seymour. The effect of antecedent condition on sediment loading during a storm can be seen in figure 9. Sediment concentrations are much larger before the first streamflow peak than before the second, even though the size of the second streamflow peak is larger.

Partial-Record Stations

A summary of suspended-sediment data collected at partial-record stations for which instantaneous streamflow was also measured is presented in table 5. Shown in the table are the number of observa-

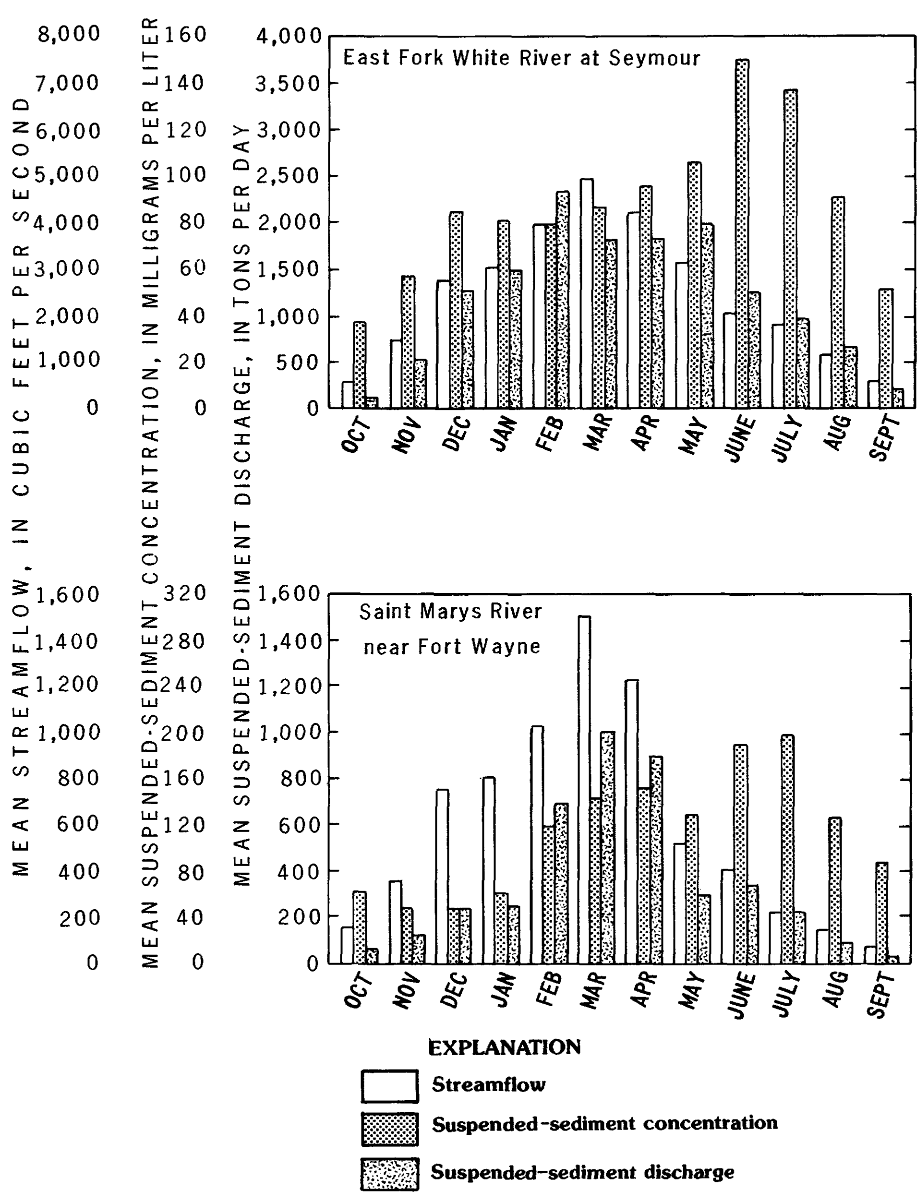


Figure 7. Relation of mean monthly streamflow, suspended-sediment concentration, and suspended-sediment discharge for selected streams.

tions made at each station and the median, minimum, maximum, and interquartile range (the range between the lower and upper quartiles) of the suspended-sediment concentrations and discharges measured.

The data observed at these stations are a function of when they were collected as much as they are of the stream from which they were collected; therefore, station-to-station comparisons based on these values are not valid. However, the data are an indication of the range of values to be found in a given stream. The larger the number of observations, the more likely these data reflect the true range of values to be expected in a given stream.

Estimates of the flow-weighted, mean suspended-sediment concentrations and discharges also are given in table 5. These estimates are computed from a method that uses the relation between suspended sediment and streamflow and a mean daily flow-duration curve. The method is similar to that proposed by Miller (1951) for suspended-sediment yields and is described in the section "Suspended-Sediment Yield." Estimates of the discharge-weighted mean values presented in table 5 are subject to considerable error, but they are more accurate than estimates obtained by a simple mathematical average of the observed data. (A more detailed discussion of the

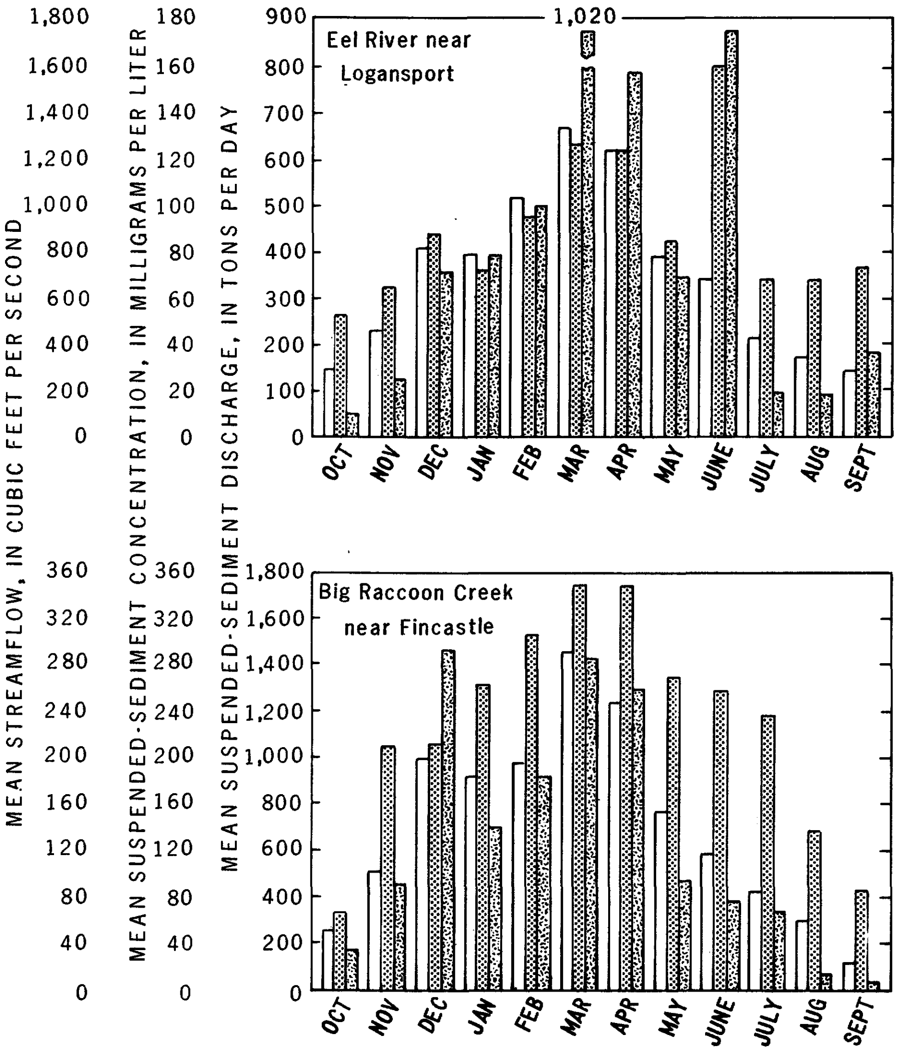


Figure 7. Continued.

error inherent in this method is presented in the section "Suspended-Sediment Yield.")

Linear regression was used to evaluate the relation between suspended-sediment concentration and streamflow for the 70 partial-record stations. This relation is typically referred to as a sediment rating curve and is established by regressing sediment concentration (or discharge) against streamflow using linear or nonlinear functions on the log transformed variables (Grenney and Heyse, 1985). Four such functions were evaluated in this study:

First-order polynomial:

$$\ln C_s = b0+b1(\ln Q_w)+e, \quad (2)$$

Second-order polynomial:

$$\ln C_s = b0+b1(\ln Q_w)+b2(\ln Q_w)^2+e, \quad (3)$$

Third-order polynomial:

$$\ln C_s = b0+b1(\ln Q_w)+b2(\ln Q_w)^2+b3(\ln Q_w)^3+e, \quad (4)$$

A function described by Hoerl (1954),

$$\ln C_s = b0+b1(\ln Q_w)+b2Q_w+e, \quad (5)$$

where

$\ln C_s$ is the natural logarithm of the suspended-sediment concentration;

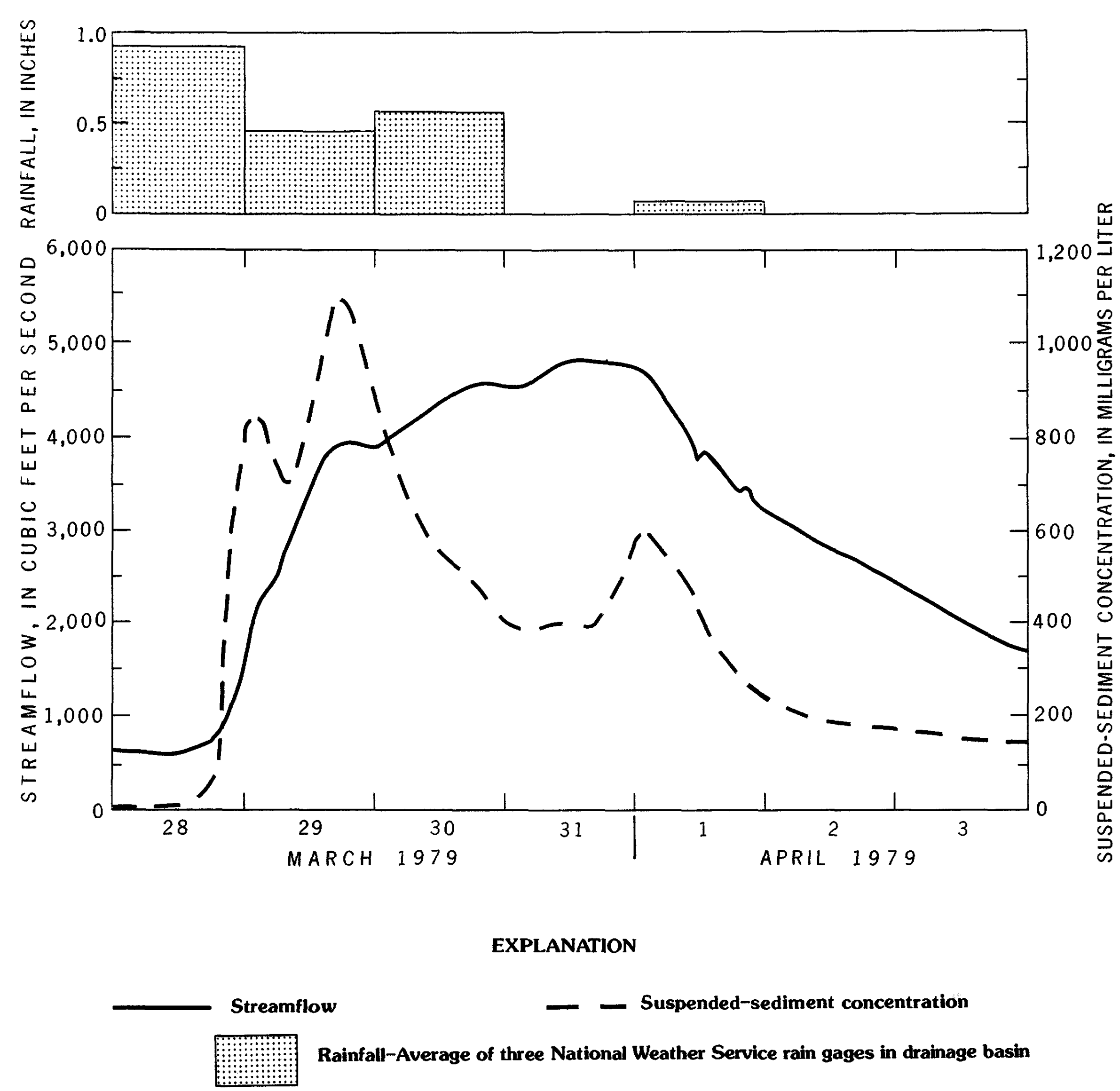


Figure 8. Relation of streamflow and suspended-sediment concentration during a selected period of runoff, Eel River near Logansport.

ln Q_w is the natural logarithm of the water discharge;

Q_w is the water discharge;

$b0$, $b1$, $b2$, and $b3$ are regression coefficients; and

e is the residual error (the amount that any value of ln C_s differs from the regression line).

The following criteria applied to the logarithmic equations were used to select the best fitting regression equation:

1. R-square: a statistic that measures the proportion of the total variation of the dependent variable explained by the regression.
2. Residuals analysis: the residuals were evaluated to determine if the assumptions of linear regression (that the residuals are independent, have constant variance, and are normally distributed) were violated.

For a more detailed discussion of these criteria, see Chatterjee and Price (1977, p. 9–10, 55–56), Daniel and Wood (1980, p. 17, 27–43), or Draper and Smith (1981, p. 19, 141–182).

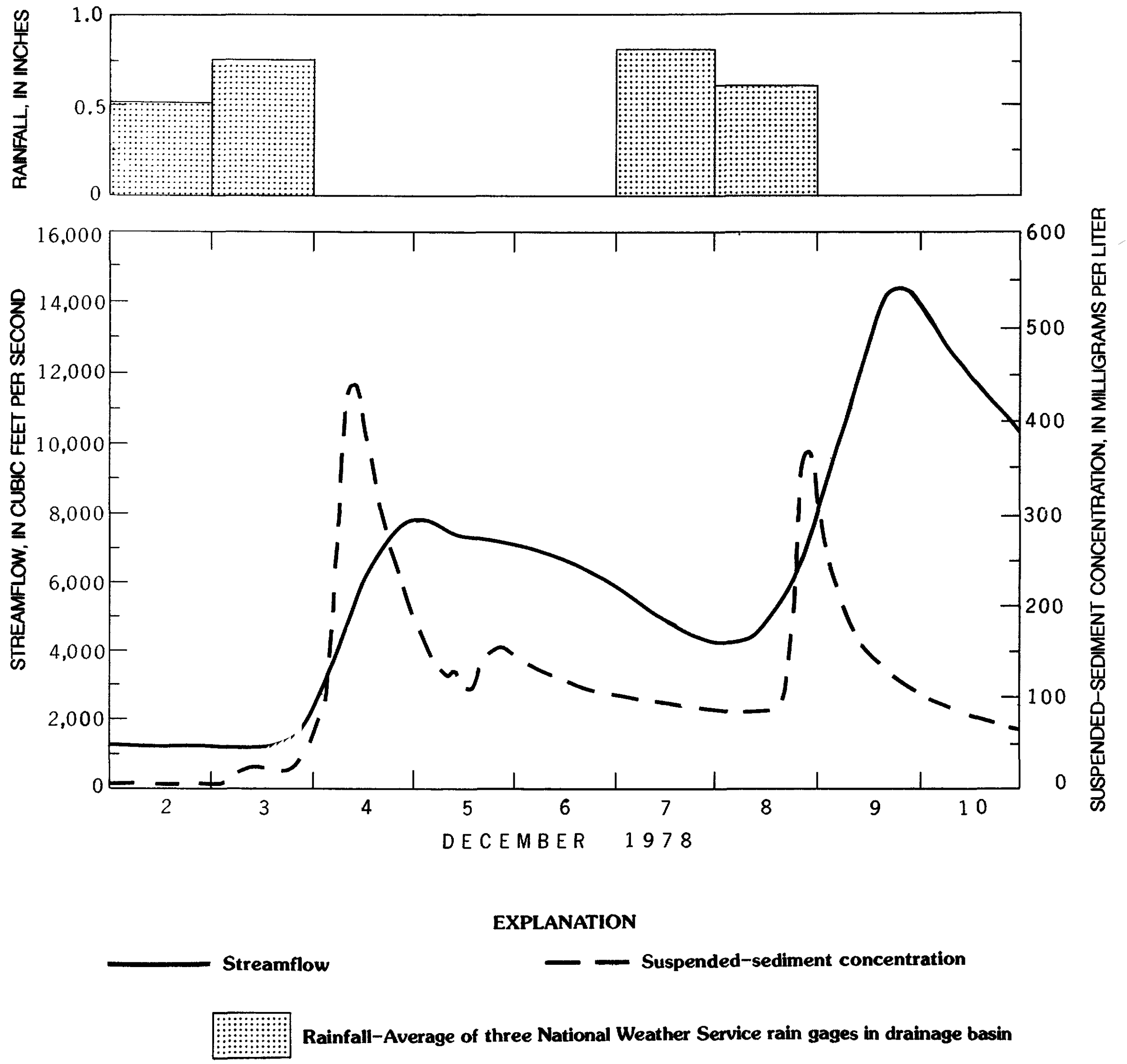


Figure 9. Relation of streamflow and suspended-sediment concentration during a selected period of runoff, East Fork White River at Seymour.

A statistically significant (at the 90-percent confidence level) regression relation between suspended-sediment concentration and streamflow was determined for 66 of the 70 partial-record stations. However, this relation typically only accounted for a small part of the variation in the data. The R-square of the best model for each station ranged from 0.00 to 0.70. Streamflow accounted for less than 50 percent of the variation in the suspended-sediment concentration at 47 of the 70 stations. The standard error of the regression equations ranged from 47 to 550 percent. Separate regression equations developed for individual seasons and months (where possible) did not improve the relations substantially.

The poor correlation between suspended-sediment concentration and streamflow can be attributed to the fine-grained particles that constitute the major portion of suspended sediment in Indiana streams. Silt- and clay-sized particles, specifically, particles between 0.062 and 0.004 and less than 0.004 millimeter (mm) in diameter, suspended in streams, typically originate from the erosion of landforms and are transported to the stream by surface runoff (Colby, 1963, p. A22). Rhoton and others (1979) found that fine clays were eroded preferentially over larger particles from the soil horizons in five small drainage basins in Ohio. The concentration of these materials in streams is more dependent on available source material than on stream hydraulics (Vanoni, 1975, p. 472).

Large suspended-sediment concentrations are common during storms that follow a period of low flow. Two examples of this type of storm that correspond to the two largest suspended-sediment concentrations measured at the partial-record stations are presented in table 6. Both concentrations were observed at Big Raccoon Creek near Fincastle during short-duration, intense storms in the summer of 1971. Silt- and clay-sized particles accounted for 97 percent or more of both samples, indicating that the material was washed into the stream by overland runoff. These extremely large concentrations may be attributable to the small amount of dilution afforded by the low base flow, and the availability of source material resulting from early summer agricultural activity in the basin.

Silt- and clay-sized materials constituted an average 90 percent of the suspended sediment for stations sampled, and ranged from 75 percent at the Vernon Fork Muscatatuck River at Vernon to 99 percent at the Salamonie River near Warren. Clay-sized material is the single most dominant fraction at most stations. A summary of particle-size analysis of suspended sediment is presented in table 7. The summary given in table 7 includes some observations not summarized in table 5 because instantaneous streamflow was not measured.

SUSPENDED-SEDIMENT YIELD

Sediment yield is the total quantity of sediment transported from a drainage basin at a given location in a specified period of time. It is typically expressed as an annual average in tons per square mile per year. The sediment yield is not equivalent to the denudation or erosion rate of the drainage basin, primarily because of storage and changes in storage within the basin. The total sediment discharge consists of suspended-sediment discharge and bedload discharge. Studies by Jordan (1965, p. 86) and Anttila and Tobin (1978, p. 46–49) on streams similar to streams in Indiana indicate that bedload discharge generally does not consist of more than 10 percent of the total sediment discharge and is negligible at some locations. For this report, the contribution of bedload discharge was assumed to be insignificant; therefore, only suspended-sediment yield is reported and discussed.

Daily Record Stations

Suspended-sediment yields for four of the seven long-term, daily record stations were computed by averaging the annual suspended-sediment discharge for the period of record at a station, divided by its drainage area. Periods of record for the remaining three stations were insufficient to calculate sediment yields. Years with periods of missing record were not included in the average. Suspended-sediment yields computed from daily record data are presented in table 8. Confidence limits were calculated by the following equation (Walpole and Myers, 1978, p. 199):

$$CL = \hat{Y} \pm \frac{t_{\alpha/2} s}{\sqrt{n}} \qquad (6)$$

where

CL is the upper or lower confidence limit, in tons per square mile per year;
$\hat{Y}$ is the estimated mean annual suspended-sediment yield, in tons per square mile per year;
$t_{\alpha/2}$ is the value of the t distribution with n–1 degrees of freedom and 100(1–α) probability;
s is the standard deviation of the annual suspended-sediment yield; and
n is the number of years of record.

Partial-Record Stations

Suspended-sediment yields for partial-record stations were estimated by the method described by Miller (1951) using the data summarized in table 5. An instantaneous sediment-transport curve and a flow-duration curve are used in this method. An instantaneous sediment-transport curve is prepared by plotting instantaneous sediment discharge and streamflow on logarithmic coordinates. This method assumes that the measured instantaneous values represent the average for the entire 24-hour period. Colby (1956, p. 10–25) discusses the use of sediment-transport curves. As with suspended-sediment concentration, linear regression was used to quantify the relation between suspended-sediment discharge and streamflow.

Four functions were evaluated:

First-order polynomial:

$$\ln Q_s = b0 + b1(\ln Q_w) + e, \qquad (7)$$

Second-order polynomial:

$$\ln Q_s = b0 + b1(\ln Q_w) + b2(\ln Q_w)^2 + e, \qquad (8)$$

Third-order polynomial:

$$\ln Q_s = b0 + b1(\ln Q_w) + b2(\ln Q_w)^2 + b3(\ln Q_w)^3 + e, \qquad (9)$$

A function described by Hoerl (1954),

$$\ln Q_s = b0 + b1(\ln Q_w) + b2(Q_w) + e, \qquad (10)$$

where

$\ln Q_s$ is the natural logarithm of the suspended-sediment discharge;
$\ln Q_w$ is the natural logarithm of water discharge;
Q_w is the water discharge;
$b0$, $b1$, $b2$, and $b3$ are regression coefficients; and
e is the error (the amount that any value of $\ln Q_s$ differs from the regression line).

Model selection was based on *R*-square and residuals analysis, as discussed in the section "Suspended-Sediment Concentration and Discharge."

Functions of the form shown in equations 7 through 10 must be transformed from logarithmic to arithmetic scale before they can be used to obtain estimates of suspended-sediment discharge. A simple inverse transformation of the logarithmic form of the model will result in biased estimates of suspended-sediment discharge. The reader is referred to Miller (1984) for a discussion of transformation bias in curve fitting. A nonparametric retransformation correction, the smearing estimate (Duan, 1983), was used to correct for transformation bias in equations presented in this report. By use of the smearing estimate, an unbiased estimate of the mean suspended-sediment discharge for a given water discharge was obtained from the following equation:

$$\hat{Q}_s = \exp[\hat{f}(\ln Q_w, Q_w)]\frac{\Sigma \exp[\hat{e}]}{n}, \qquad (11)$$

where

$\hat{Q}_s$ is an estimate of the mean suspended-sediment discharge, in tons per day;
exp indicates that the base of the natural logarithm, approximately 2.718, is raised to the power expressed by the quantity inside the brackets;
$\hat{f}(\ln Q_w, Q_w)$ is one of the functions describing $\ln Q_s$, in terms of $\ln Q_w$ and Q_w, given by equations 7 through 10 with estimated regression coefficients (except for the residual error);
$\hat{e}$ is the estimate of the error (from equations 7–10); and
n is the number of observations used with linear-regression analysis to obtain the coefficients of the equation.

A discussion of transformation methods as related to sediment transport may be found in Farr and Clarke (1984), Ferguson (1986a, 1986b), and Koch and Smillie (1986).

Equation 11 gives an estimate of the expected suspended-sediment discharge for any given water discharge. In the sediment-transport, flow-duration-curve method, weighted estimates for representative flows are summed to obtain an estimate of the mean daily suspended-sediment discharge:

$$\hat{Q}_{SD} = \sum_{i=1}^{I} F_i \hat{Q}_{si},$$

$$= \sum_{i=1}^{I} F_i \exp[\hat{f}(\ln Q_{wi}, Q_{wi})]\frac{\Sigma \exp[\hat{e}]}{n}, \qquad (12)$$

where

$\hat{Q}_{SD}$ is the estimate of the mean daily suspended-sediment discharge;
I is the total number of water discharges in the flow duration;
i is a subscript denoting the *i*th water discharge;
F_i is the frequency with which a given water discharge occurs;
$\hat{Q}_{si}$ is the estimate of the mean suspended-sediment discharge for the *i*th water discharge;

exp indicates that the base of the natural logarithm, approximately 2.718, is raised to the power expressed by the quantity inside the brackets;

$\hat{f}(\ln Q_{wi}, Q_{wi})$ is one of the functions describing $\ln Q_s$, in terms of $\ln Q_w$ and Q_w, given by equations 7 through 10 with estimated regression coefficients (except for the residual error);

$\hat{e}$ is the estimate of the error (from equations 7–10); and

n is the number of observations used with linear-regression analysis to obtain the coefficients of the equation.

An estimate of the mean annual sediment yield, $\hat{Y}$, is obtained by multiplying the estimated mean daily suspended-sediment discharge, $\hat{Q}_{SD}$, by 365 and dividing by the drainage area.

The standard deviation of the suspended-sediment yield was calculated by a method proposed by Duan and others (1982, p. 92–94), who showed that the variance of an average value predicted for a group of individual observations with explanatory variables E is, for large n, approximately:

$$\hat{Var}[\hat{Q}_{SD}] = \left[\left(\frac{1}{J}\sum_{j=1}^{J}\exp[E_jB]\right)^2(\exp[MSE]-1-MSE)\exp[MSE] + \left(\frac{1}{J}\sum_{j=1}^{J}\exp[E_jB]E_j\right)\xi^{-1}\left(\frac{1}{J}\sum_{j=1}^{J}\exp[E_jB]E_j\right)' MSE\ \exp[MSE]\right]/n, \qquad (13)$$

where

$\hat{\mathrm{Var}}[\hat{Q}_{SD}]$ is an estimate of the variance of the estimated mean daily suspended-sediment discharge;

J is the number of individual observations used to obtain the group average;

j is a subscript denoting the jth individual observation;

exp indicates that the base of the natural logarithm, approximately 2.718, is raised to the power expressed by the quantity inside the brackets;

E_j is a vector containing the explanatory variables for the jth individual observation (the vector has n elements, one for each of the n explanatory variables);

B is a vector containing the regression coefficients;

MSE is the mean square error of the regression;

ξ^{-1} is the limit of the $[X'X]^{-1}$ matrix from the regression divided by n, the number of observations, as n approaches infinity (X is a matrix containing the E_j vectors for all j);

$'$ is a symbol denoting the transpose of the matrix represented by the terms inside the parentheses; and

n is the number of observations used in the regression to obtain the coefficients of the equation.

The method assumes that $X'X/n$ is a positive definite matrix as n approaches infinity, that the model contains an intercept, and that the error about the regression line is normally distributed with a mean zero and variance MSE.

For the sediment-transport, flow-duration-curve method of estimating sediment yields, each mean water discharge for a percentage interval is an individual observation, in the context of Duan's equation (Duan and others, 1982, p. 92–94). The method developed by Duan applies to the case where all individual observations have equal weights. Since the individual observations in the sediment-transport, flow-duration-curve methods are weighted by the percentage of time that the observation occurs, a modification to the Duan method was necessary. For this application, the factor $1/J$ was replaced by F, where F is the frequency with which an individual observation occurred.

The estimated standard deviation of the estimated mean daily suspended-sediment discharge is the square root of the variance

$$\hat{\mathrm{Std}}[\hat{Q}_{SD}] = \sqrt{\hat{\mathrm{Var}}[\hat{Q}_{SD}]}, \qquad (14)$$

where $\hat{\mathrm{Std}}[\hat{Q}_{SD}]$ is the estimated standard deviation of the estimated mean daily suspended-sediment discharge.

An estimate of the standard deviation of the mean annual suspended-sediment yield, $\hat{\mathrm{Std}}[\hat{Y}]$, can be obtained by multiplying $\hat{\mathrm{Std}}[\hat{Q}_{SD}]$ by 365 and dividing by the drainage area. Approximate 95-percent confidence limits can be obtained by

$$CL = \hat{Y} \pm 2\ \hat{\mathrm{Std}}[\hat{Y}], \qquad (15)$$

where CL is the upper or lower confidence limit, in tons per square mile per year.

Flow durations used to estimate sediment yields were computed from the base period 1951–80 (water years), except for stations having fewer than 30 years of record during the period for which all available data within the 1951–80 period were used.

The sediment-transport, flow-duration-curve method used to estimate sediment yields is illustrated in table 9 by the computation for the Whitewater River near Hagerstown and the following discussion. For this station, equation 7 was used to estimate Q_s. The following steps were used for the estimation method in table 9:

Step 1. Mean water discharges for a given percentage of time were taken from the flow-duration curve computed for the base period (columns 1–3 of table 9). More intervals were selected at extreme-flow durations (lower percentages) because of the large differences in streamflow at the upper extreme. The mean water discharge for a percentage interval was calculated as the mean of the water discharges equaled or exceeded at the percent-flow duration points at both ends of the percentage interval. The peak water discharge of record was used for the 0.0-percent-flow duration.

Step 2. The mean suspended-sediment discharge for an interval (column 4) was calculated by equation 11.

Step 3. The mean water discharge for each percentage interval was multiplied by the percentage of time in that interval (column 5).

Step 4. The mean suspended-sediment discharge for an interval was multiplied by the percentage of time in that interval (column 6).

Step 5. The quantity $F \exp [E_j B]$ was calculated (column 7). The frequency F is equal to column 2 divided by 100. The quantity $[E_j B]$ is equal to the logarithm of the predicted mean suspended-sediment discharge obtained from the regression equation.

Step 6. The quantity $F \exp [E_j B]$ (column 7) was multiplied by the first explanatory variable to obtain column 8. The first explanatory variable is the intercept; thus, $E1_j = 1$. (Because of this, column 8 is equal to the value in column 7, obtained in step 5.)

Step 7. The quantity $F \exp [E_j B]$ (column 7) was multiplied by the value of the second explanatory variable to obtain column 9. The second explanatory variable, $E2_j$, is the logarithm of the mean water discharge for the interval (given in column 3).

Step 8. The mean annual water discharge was computed as the sum of the products in column 5 divided by 100. This computed mean was compared to the true mean annual water discharge (the sum of the annual means divided by the number of years of record). If the difference between the true and computed means was larger than 3 percent, the percentage intervals in column 1 were adjusted by adding additional intervals and decreasing the size of the intervals until the difference was less than 3 percent.

Mean annual water discharge computed from flow-duration curve = 7,330/100=73.3 cubic feet per second (ft^3/s).

Mean annual water discharge = 72.7 ft^3/s.
Percentage error in computed mean annual water discharge = 0.9 percent.

Step 9. The mean daily suspended-sediment discharge was computed by summing the products in column 6 and dividing by 100.

Estimated mean daily suspended-sediment discharge = (2,920/100) = 29.2 tons per day (tons/d).

Step 10. The estimated standard deviation of the estimated mean daily suspended-sediment discharge was calculated by equations 13 and 14.

Number of observations used to calculate regression coefficients =73.

Mean square error of regression equation =0.576462.

ξ^{-1} matrix from regression =

$$\begin{bmatrix} 12.246854 & -2.698895 \\ -2.697795 & 0.647123 \end{bmatrix}$$

Estimated variance of estimated mean daily suspended-sediment discharge =

$[(22.946273)^2(\exp [0.576462]-1-$

0.576462) exp [0.576462]+ [22.946272×134.862225]

$$\begin{bmatrix} 12.246854 & -2.697795 \\ -2.697795 & 0.647123 \end{bmatrix} \begin{bmatrix} 22.946272 \\ 134.862225 \end{bmatrix}$$

(0.576462) exp [0.576462]] /73=24.0 (tons/d)^2.

Estimated standard deviation of estimated mean daily suspended-sediment discharge = $\sqrt{24.0}$ = 4.9 tons/d.

Step 11. The estimated mean annual suspended-sediment discharge was computed by multiplying the respective estimated mean daily suspended-sediment discharge by 365 days. The estimated standard deviation of the estimated mean annual suspended-sediment discharge was computed by multiplying the estimated standard deviation of the respective estimated mean daily suspended-sediment discharge by 365 days.

Estimated mean annual suspended-sediment discharge=29.2×365=10,658 tons per year (tons/yr).

Estimated standard deviation of estimated mean annual suspended-sediment discharge =4.9×365=1,789 tons/yr.

Step 12. The estimated mean annual suspended-sediment yield and its estimated standard deviation were computed by dividing the respective estimated mean annual suspended-sediment discharge and its estimated standard deviation by the drainage area of the station.

Drainage area=58.7 mi^2.

Estimated mean annual suspended-sediment yield=10,658/58.7=182 tons per square mile per year [(tons/mi^2)/yr].

Estimated standard deviation of estimated mean annual suspended-sediment yield=1,789/58.7=30 (tons/mi^2)/yr.

Statistics pertaining to computation of the estimated mean suspended-sediment yields for the partial-record stations are presented in table 10.

Limitations of Yields Estimated for Partial-Record Stations

Yields presented for partial-record stations should be used with caution. There is extensive variation in the data used to obtain the sediment-transport curves on which these yields are based. For example, suspended-sediment discharges differed by one to two orders of magnitude for the same water discharges at some stations. Standard errors for the regression equations ranged from 49 to 540 percent; the standard error of the regression equation exceeded 100 percent for 25 of the 70 stations for which yields were calculated.

The second- and third-order polynomial functions used in this study (eqs. 8 and 9) can result in sediment-transport curves that have upward curvature at high streamflows. Typically, however, a sediment-transport curve is either a straight line (on a log-log scale) or a line with downward curvature at high streamflows. The degree of curvature at high streamflows in sediment-transport curves developed in this study is influenced by the relative lack of measurements at high streamflows, the large degree of scatter typical of suspended-sediment data, and the equal emphasis of all data in the regression (real curvature in the regression line at low and medium streamflows can influence curvature in the regression line at high streamflows that may or may not be reasonable for high streamflows).

Examples of typical sediment-transport curves used to estimate suspended-sediment yields from partial-record stations are presented in figures 10 to 15. The three general forms of the transport curve used in this study are shown: linear (figs. 11 and 14), downward curvature at high streamflows (figs. 12, 13, and 15), and upward curvature at high streamflows (fig. 10). Representatives of the best curves are shown in figures 10 to 12; these curves are well defined over the entire range of their use and have relatively little scatter about the regression line. Representatives of the worst curves are shown in figures 13 to 15; few data were available for defining these curves, and it was necessary to extrapolate the curves to discharges not represented in the measured data.

Eleven of the 70 suspended-sediment-transport curves listed in table 10 turn upward at high streamflows. Suspended-sediment yields calculated from transport curves that turn upward at high streamflows are more suspect than those that are not, especially where substantial extrapolation is involved in the calculations. This uncertainty generally is reflected in the

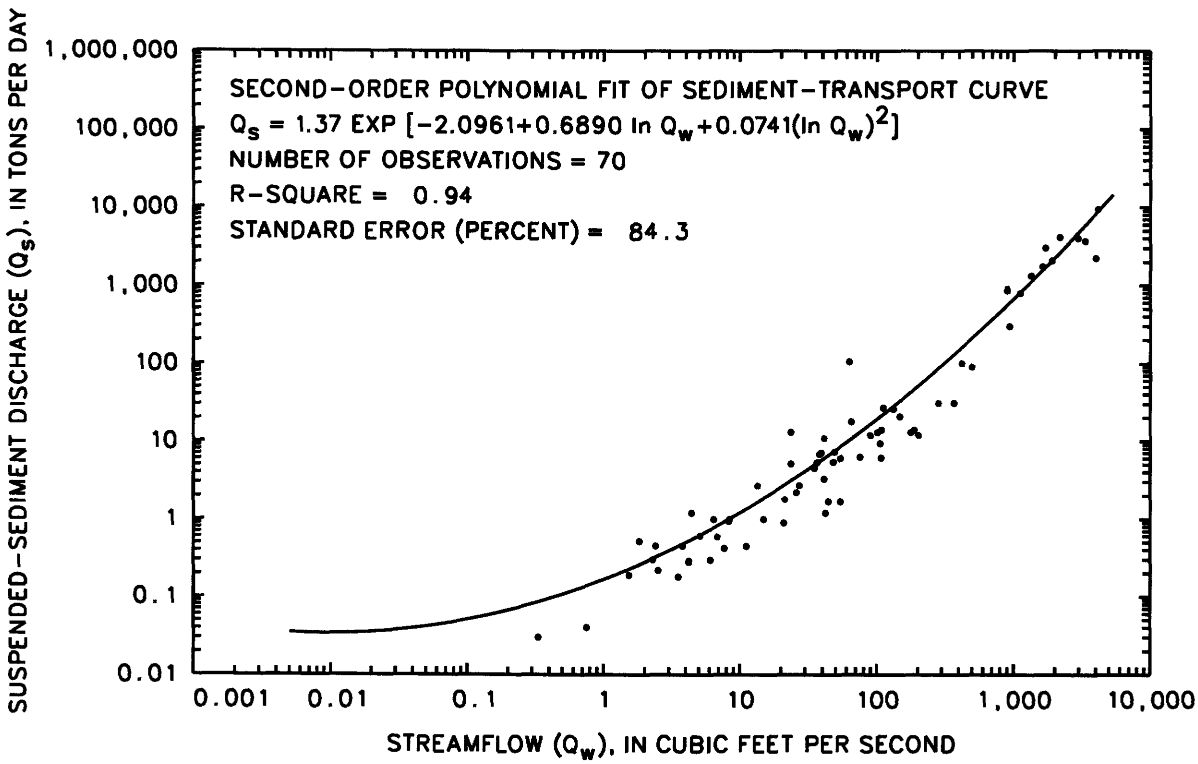


Figure 10. Suspended-sediment transport curve, Eagle Creek at Zionsville.

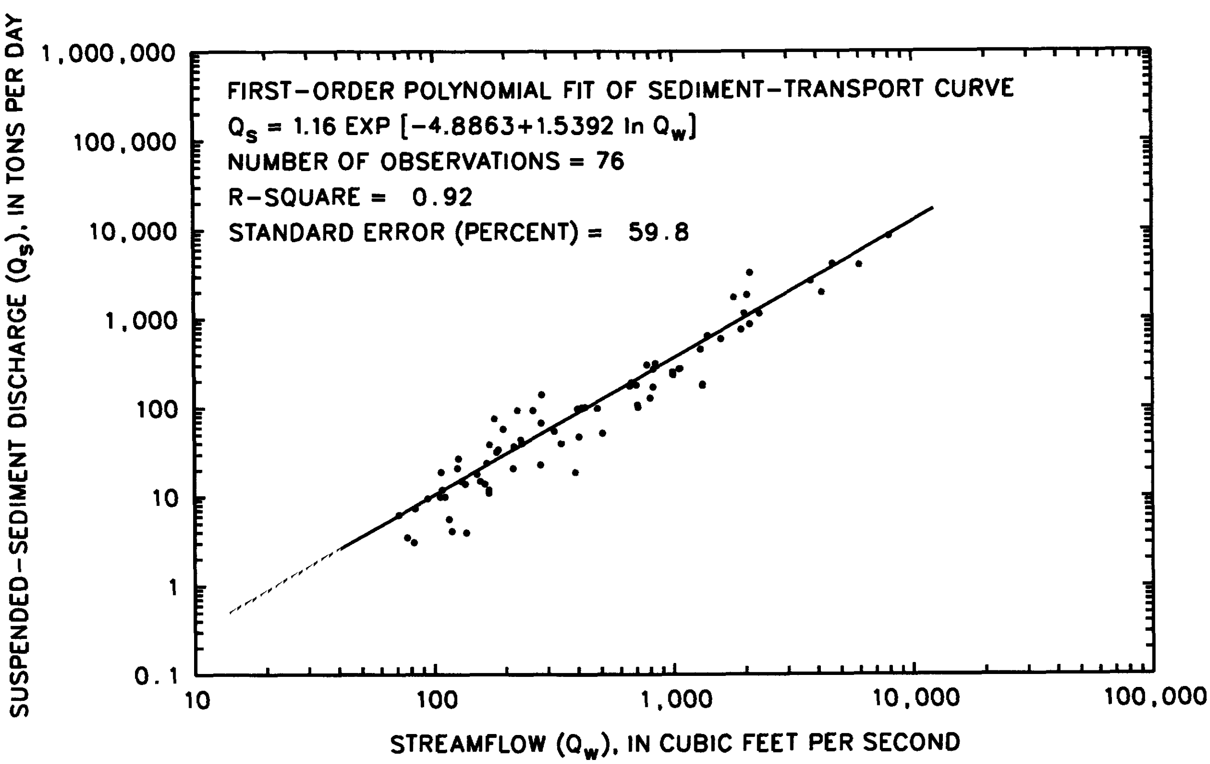


Figure 11. Suspended-sediment transport curve. Big Blue River at Shelbyville.

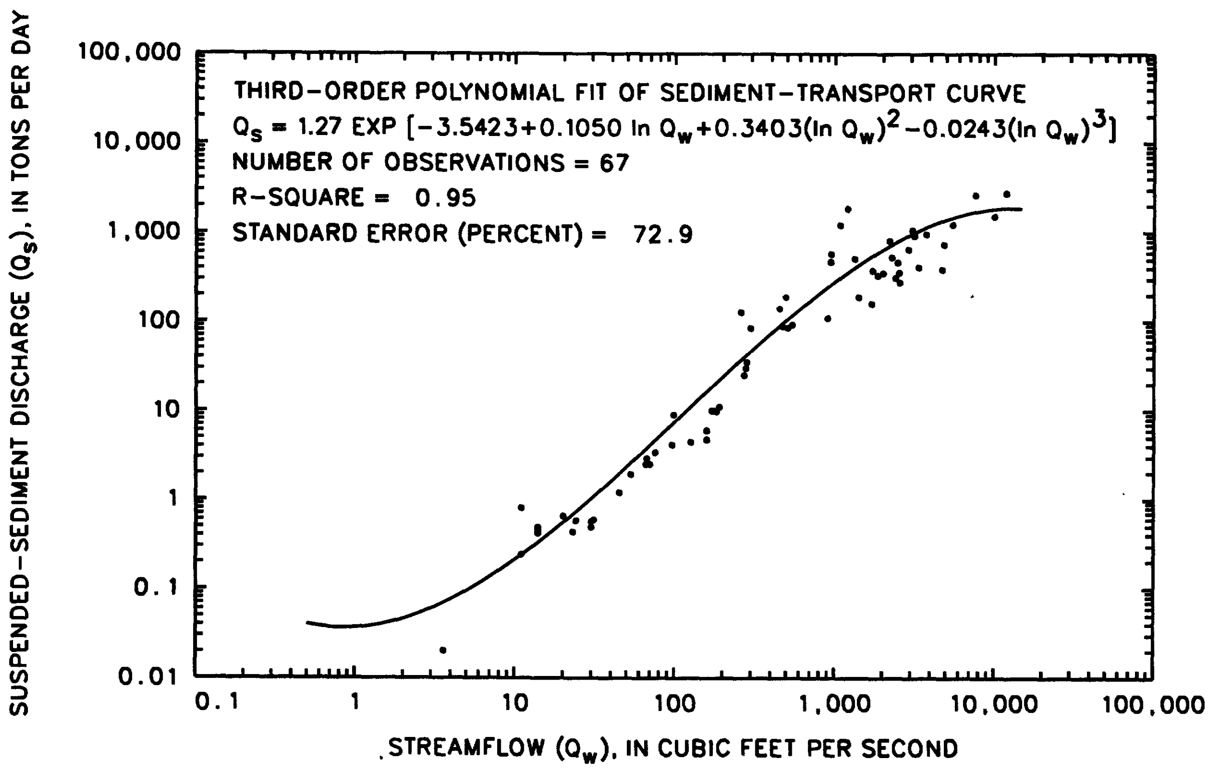


Figure 12. Suspended-sediment transport curve, Patoka River near Princeton.

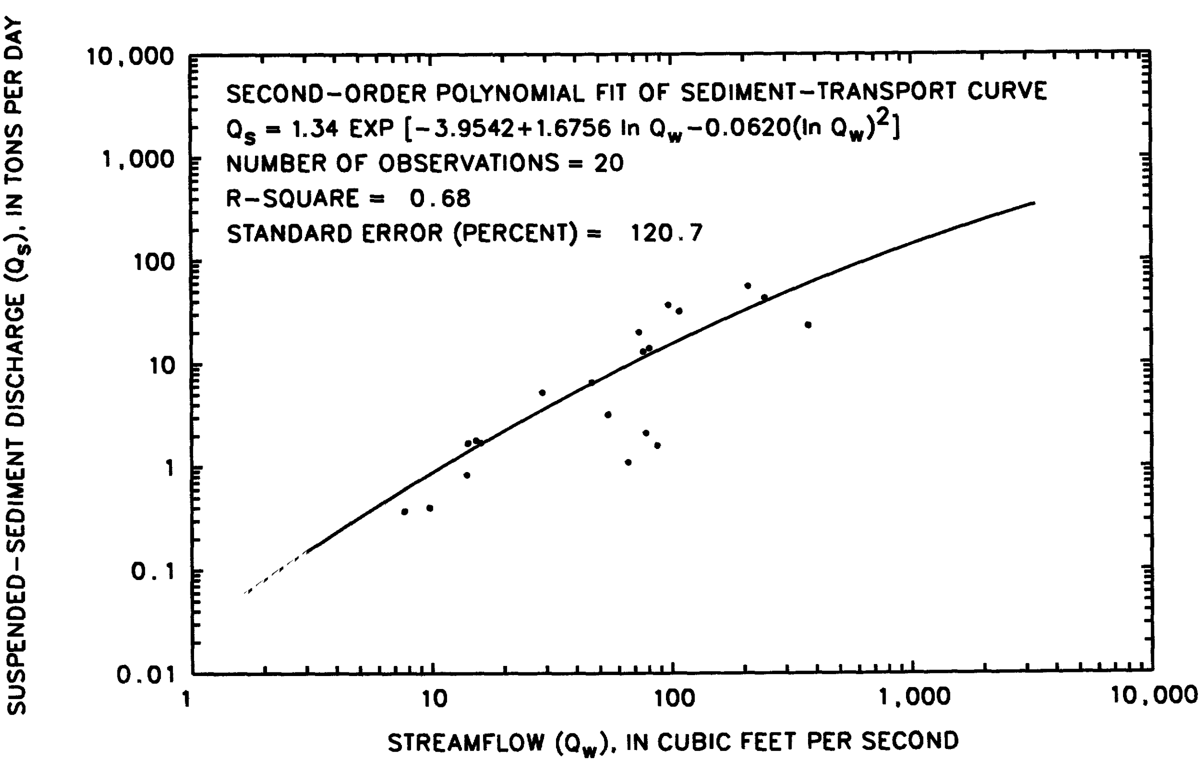


Figure 13. Suspended-sediment transport curve, Pipe Creek near Bunker Hill.

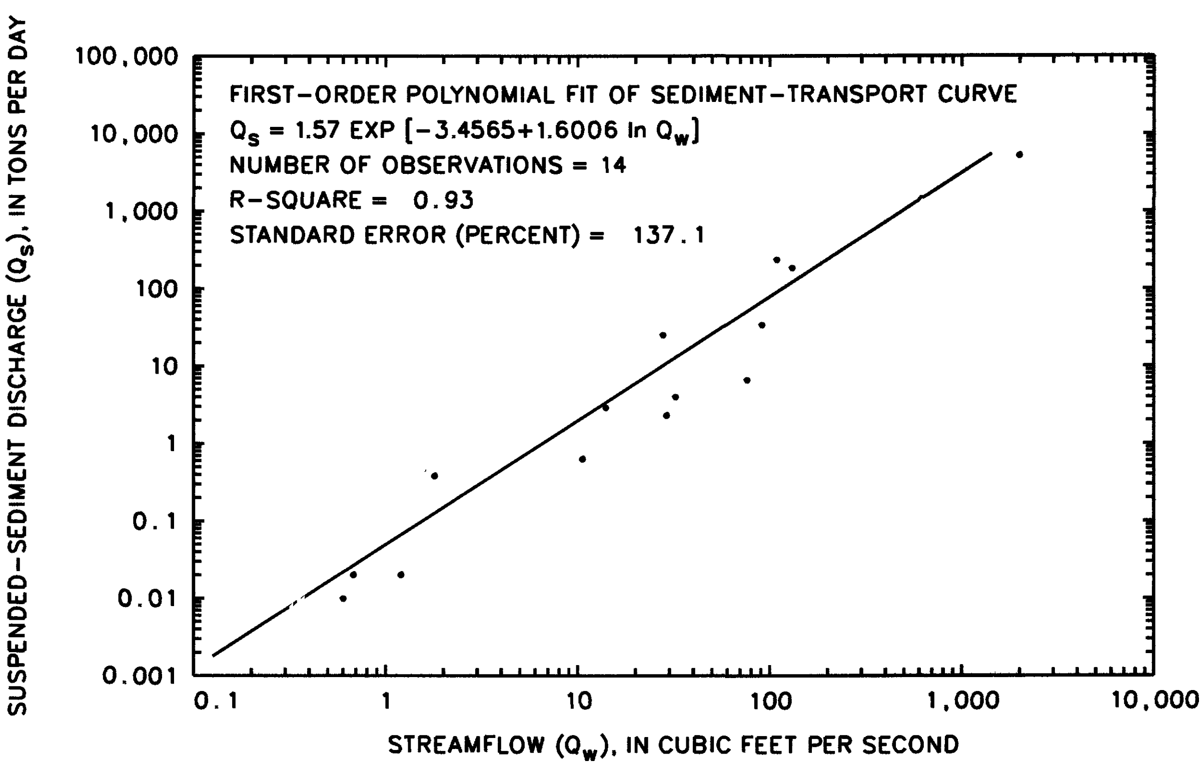


Figure 14. Suspended-sediment transport curve, Mud Pine Creek near Oxford.

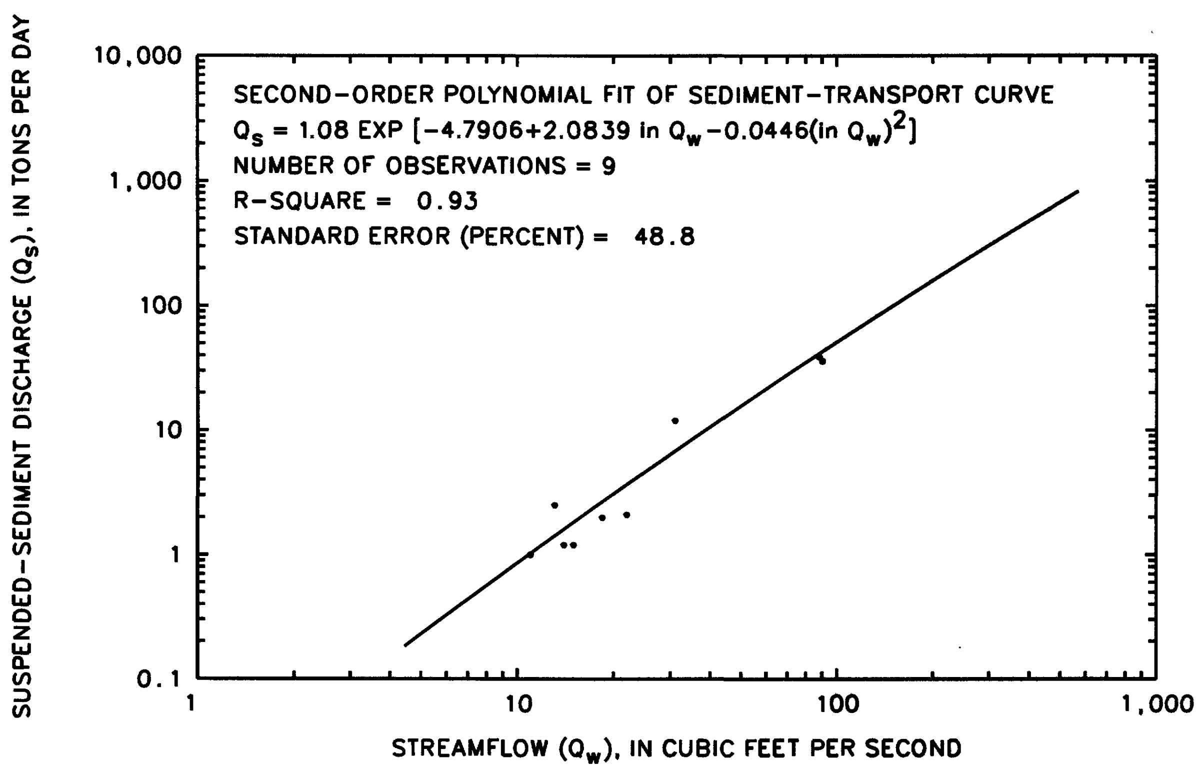


Figure 15. Suspended-sediment transport curve, Cobb ditch near Kouts.

large standard error for these yields. For example, the standard errors of the yields calculated from the three well-defined transport curves shown in figures 10 to 12 are 16.2, 10.2, and 11.9 percent. In contrast, the standard errors of the yields calculated from the three poorly defined sediment-transport curves shown in figures 13 to 15 are considerably larger—106, 54, and 81 percent.

Walling (1977) evaluated the sediment-transport, flow-duration-curve method of estimating sediment yields. He also reported considerable scatter in sediment-transport curves and attributed it to three major groups of causal factors: field- and laboratory-measurement error, factors related to the dynamics of erosion and sediment-transport processes, and nonstationarity of drainage basin response. The most significant of these causes are those related to the dynamics of erosion and sediment-transport processes. Factors in this group are: (1) hysteretic effects, where suspended-sediment concentrations are larger in the rising stage of a hydrograph than in the falling stage, as documented by Guy (1964, p. E12–E13); (2) peak suspended-sediment concentrations rarely coinciding with peak streamflow; (3) seasonal differences in land cover and types of storms (frontal-type storms contrasted with convective-type storms); (4) suspended-sediment concentration decreasing for successive storms because of depletion of readily erodible material; and (5) distribution and movement of rainfall over the drainage basin.

Another potential problem exists for yields calculated from partial-record data. Sediment-transport curves developed from partial-record data are based on the relation between instantaneous suspended-sediment transport and instantaneous streamflow. This relation is used to estimate mean daily suspended-sediment transport from mean daily streamflow. Colby (1956, p. 14–15) and Walling (1977) have reported that the use of instantaneous data with the sediment-transport, flow-duration-curve method may give erroneous results. Values are presented in table 11 for suspended-sediment yields estimated by (1) the daily record method and (2) the sediment-transport, flow-duration-curve method for the three stations where both partial and daily records were maintained. The flow duration used with method 2 corresponds to the period of suspended-sediment record of the daily stations and not the base period used in table 10.

The difference between estimates of yield calculated by the two methods ranged from –5 to 151 percent (for the sediment-transport, flow-duration-curve method based on partial-record data) and from –23 to 37 percent (for the sediment-transport, flow-duration-curve method based on daily record data). Based on the results of this analysis, yields estimated from partial-record data seem to be only slightly less accurate than those estimated from the daily record data. Comparisons of the suspended-sediment transport curves developed from the daily record and partial-record data for the Eel River near Logansport, Big Raccoon Creek near Fincastle, and the East Fork White River at Seymour are shown in figures 16 to 18.

Yield in Big Raccoon Creek

The suspended-sediment yield estimated for Big Raccoon Creek near Fincastle is much larger than that estimated for any other drainage basin in the data-collection network for sediment in Indiana. This yield also is much larger than yields for 51 drainage basins in Ohio, where yields ranged from 56 to 627 (tons/mi^2)/yr (Anttila and Tobin, 1978, p. 47). Gottschalk (1964, p. 17–28), however, reported sedimentation rates of two reservoirs in Illinois that are of the same magnitude [1,020 and 1,976 (tons/mi^2)/yr] as the suspended-sediment yield of Big Raccoon Creek near Fincastle.

Annual suspended-sediment yield at Big Raccoon Creek near Fincastle ranged from 170 to 6,220 (tons/mi^2)/yr. Mean daily suspended-sediment discharge, mean daily streamflow, and maximum daily streamflows are presented in figure 19. High values of mean daily suspended-sediment discharges are associated with high peak and average water discharges. However, the variability in Big Raccoon Creek is much larger than in any other of the daily record stations. Large amounts of suspended sediment are transported by single storms. For example, the mean daily suspended-sediment discharge in 1968 (2,370 tons/d) is the largest on record. One-third of the total suspended-sediment discharge in 1968 was transported in just 1 day. This information, and the very high percentage of silt- and clay-sized particles in samples collected from Big Raccoon Creek, are an indication that the drainage basin contains a highly erodible source area. However, soil-erosion factors for soils in the drainage basin near the sampling station (Robards, 1981, p. 133–135) are not unusually high for soils in

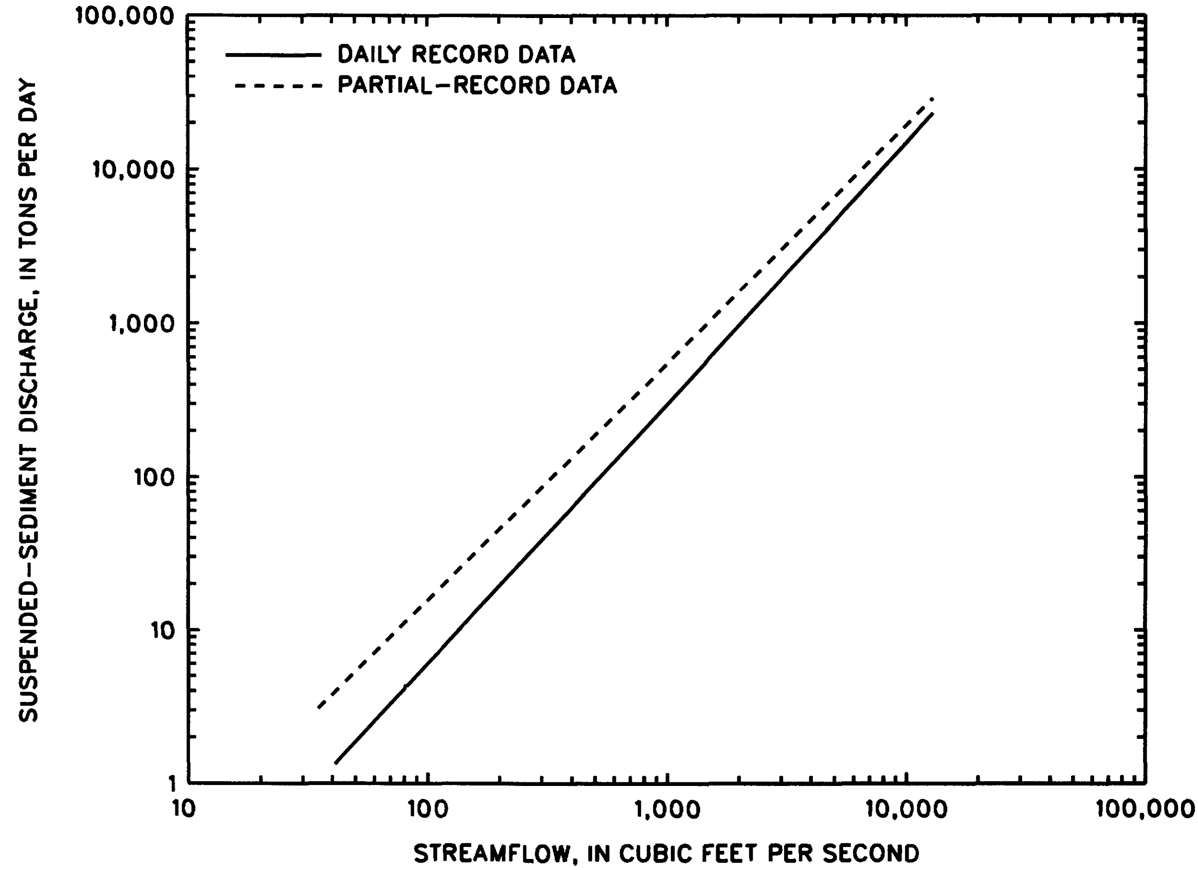


Figure 16. Suspended-sediment transport curves developed from daily record and partial-record data, Eel River near Logansport.

central Indiana. Local land-use practices could be affecting either the rate of soil erosion or the proportion of eroded soil reaching the stream.

Prediction of Suspended-Sediment Yield From Drainage-Basin Characteristics

Stepwise regression was used to determine the relation between suspended-sediment yield and the following drainage-basin characteristics:

1. The amount of forested land in the drainage basin, expressed as a percentage of total area;
2. The amount of open water in the drainage basin, expressed as a percentage of total area;
3. The channel slope, expressed as the difference in elevation of points 10 percent and 85 percent of the distance from the station to the drainage-basin boundary, divided by the distance between the two points;
4. The average annual excess of precipitation for the drainage basin;
5. A soil-runoff coefficient that relates storm runoff to soil permeability by major hydrologic soil groups;
6. The peak unit discharge with a recurrence interval of 2 years;
7. The peak unit discharge with a recurrence interval of 10 years; and
8. The peak unit discharge with a recurrence interval of 25 years.

Davis (1974, p. 6–7) discusses the average annual excess of precipitation and the soil-runoff coefficient. Because the estimated yield for Big Raccoon Creek near Fincastle was anomalously high, it was not included in the regression calculations.

The equation that best fit the data had the form

$$\ln Y = b0 + b1(S) + b2(\ln CDA) + b3(\ln FL) + b4(\ln UP10) + e, \quad (16)$$

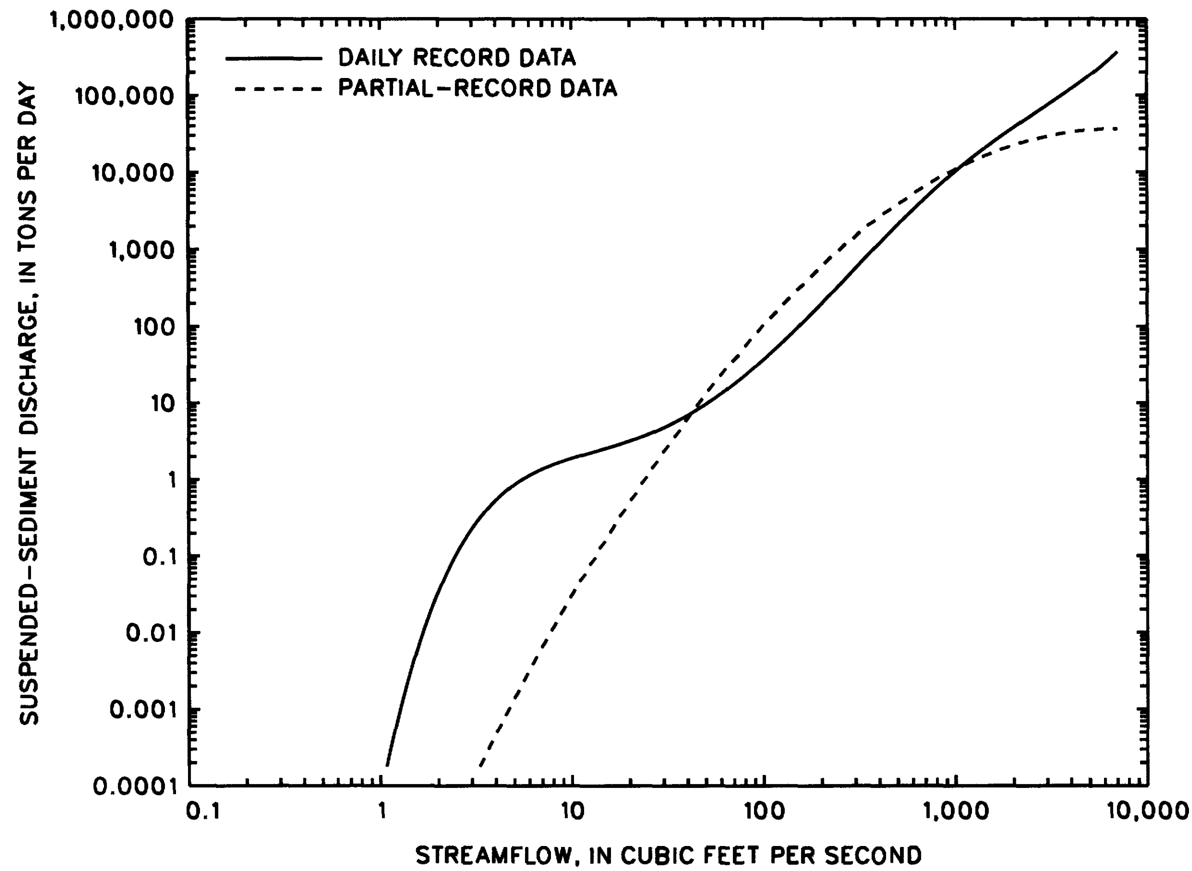


Figure 17. Suspended-sediment transport curves developed from daily record and partial-record data, Big Raccoon Creek near Fincastle.

where

- ln Y is the natural logarithm of the suspended-sediment yield, in tons per square mile per year;
- S is the channel slope, in feet per mile;
- ln CDA is the natural logarithm of the contributing drainage area, in square miles;
- ln FL is the natural logarithm of the amount of forested land in the drainage basin, in percent;
- ln $UP10$ is the natural logarithm of the peak unit discharge with a recurrence interval of 10 years, in cubic feet per second per square mile;
- $b0$, $b1$, $b2$, $b3$, and $b4$ are regression coefficients; and
- e is the error (the amount that any value of ln Y differs from the regression line).

The estimates of the regression coefficients are $\hat{b}0=1.615$, $\hat{b}1=-0.062$, $\hat{b}2=0.186$, $\hat{b}3=-0.161$, and $\hat{b}4=0.951$. As before, the smearing-estimate correction for transformation bias was used to obtain an unbiased estimate of the yield, $\hat{Y}$, the expected or mean suspended-sediment yield for given values of the predictor variables. The transformed equation is

$$\hat{Y}= 1.096 \exp[1.615] \exp[-0.062S] CDA^{0.186} FL^{-0.161} UP10^{0.951}, \quad (17)$$

where

- exp indicates that the base of the natural logarithm, approximately 2.718, is raised to the power expressed by the quantity inside the brackets; and
- S, CDA, FL, and $UP10$ are as previously defined.

The value 1.096 is the smearing estimate of the bias-correction factor.

This equation explained about 64 percent of the variation in the logarithm of the yields estimated for the partial-record stations and had a standard error of 49 percent. With respect to the transformed data, this standard error means that about two-thirds of the actual or true yields will fall within +59 percent and

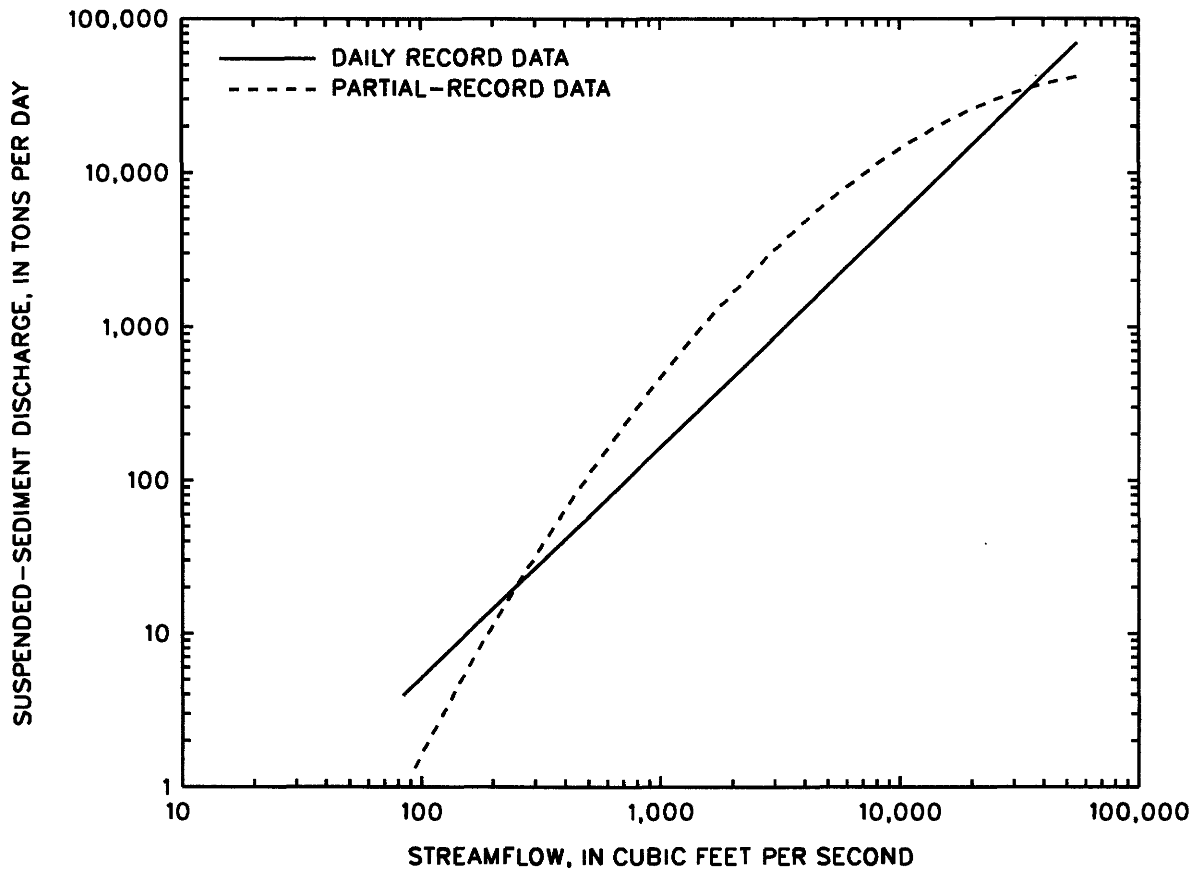


Figure 18. Suspended-sediment transport curves developed from daily record and partial-record data, East Fork White River at Seymour.

−37 percent of the yield predicted from this equation. Ninety-five percent of the actual or true yields will fall within +153 percent and −60 percent of the yield predicted by this equation. The equation should not be used for stations having drainage areas less than 10 mi^2 or more than 2,500 mi^2.

Equation 17 was used to estimate suspended-sediment yields for 102 stations in the U.S. Geological Survey stream-gaging network in Indiana, for which the necessary drainage-basin characteristics were available (table 12). The estimated yields presented in table 12 are subject to considerable errors and should be used with caution. However, they are believed to be a better estimate than could be obtained by other methods, such as extrapolating data from nearby stations.

REGIONAL PATTERNS OF SUSPENDED SEDIMENT

Suspended-sediment yields calculated from the daily records ranged from 186 (tons/mi^2)/yr at East Fork White River at Seymour to 1,914 (tons/mi^2)/yr at Big Raccoon Creek near Fincastle. Suspended-sediment yields computed for partial-record stations ranged from 11 (tons/mi^2)/yr at Little Calumet River near McCool to 2,310 (tons/mi^2)/yr at Big Raccoon Creek near Fincastle. The median yield for the partial-record stations was 160 (tons/mi^2)/yr. All but 7 of the 70 yields calculated were less than 400 (tons/mi^2)/yr. Only the yield estimated from partial records for Big Raccoon Creek near Fincastle exceeded 1,000 (tons/mi^2)/yr. A summary of the frequency distribution of the estimated yields is given in table 13.

Suspended-sediment yields for stations in Indiana are shown in figure 20. Suspended-sediment yields in the northern moraine and lake region were much less than those in other parts of the State. The median yield in this region was 68 (tons/mi^2)/yr and ranged from 11 to 202 (tons/mi^2)/yr, whereas the median yield in the rest of the State was 195 (tons/mi^2)/yr and ranged from 50 to 2,310 (tons/mi^2)/yr. No other regional trend is apparent in suspended-sediment

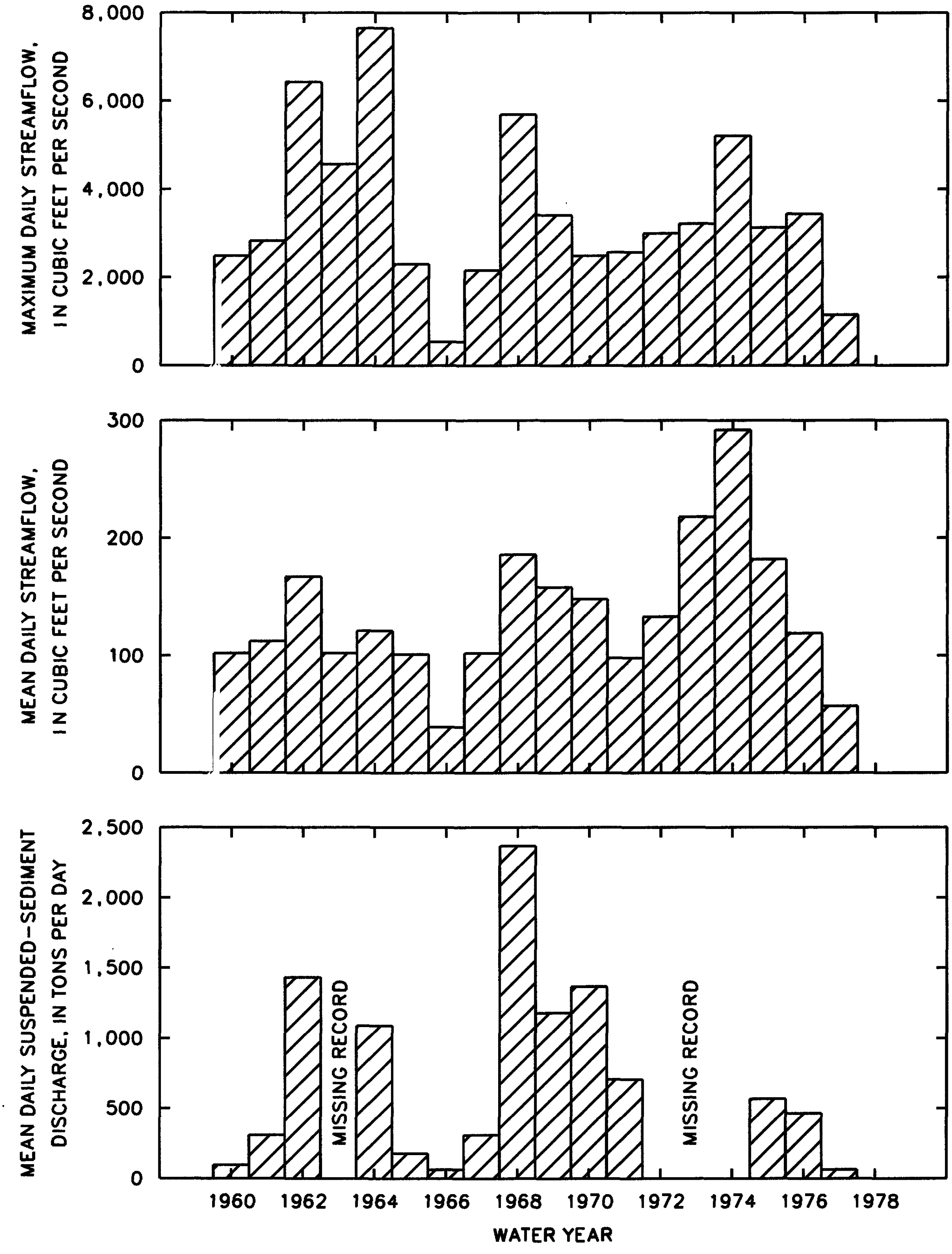
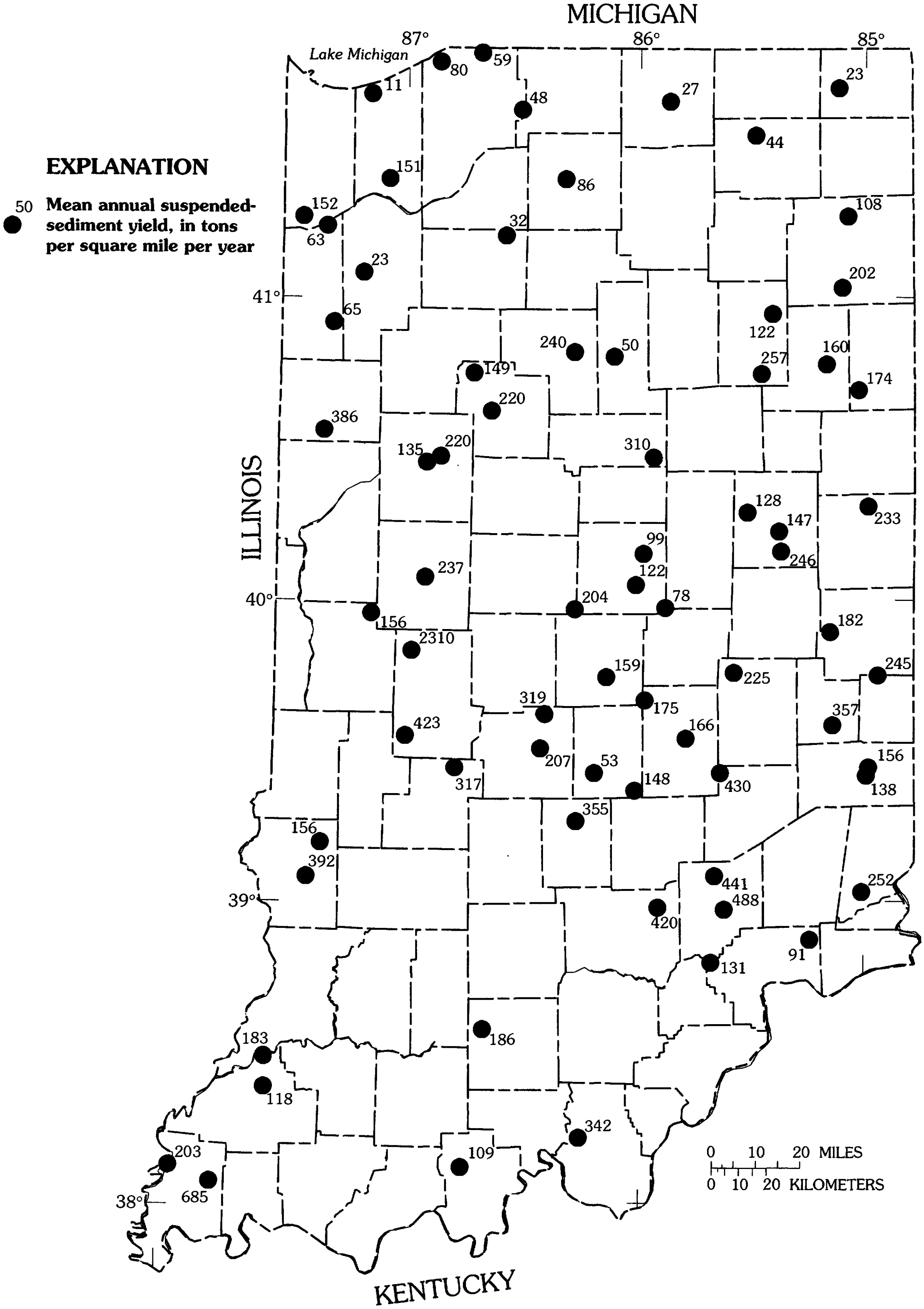


Figure 19. Relation of maximum daily streamflow, mean daily streamflow, and mean daily suspended-sediment discharge, Big Raccoon Creek near Fincastle.

Figure 20. Mean annual suspended-sediment yields. →


EXPLANATION
50 Mean annual suspended-sediment yield, in tons per square mile per year
MICHIGAN
Lake Michigan
87°
86°
85°
41°
40°
39°
38°
ILLINOIS
OHIO
KENTUCKY
0 10 20 MILES
0 10 20 KILOMETERS
59
80
11
48
27
23
44
151
86
152
63
32
108
23
202
65
122
240
50
160
257
149
174
220
386
135
220
310
128
147
233
99
246
237
122
204
78
156
182
2310
159
225
245
319
175
357
423
166
207
53
156
317
148
430
138
355
156
392
441
252
488
420
91
131
183
186
118
342
203
109
685

yield in Indiana. The estimated yields for regions of the State other than the northern moraine and lake region vary greatly. Efforts to explain the variability in the estimated suspended-sediment yield by glacial province, drainage basin, or physiographic unit were unsuccessful.

Mean suspended-sediment concentrations for partial-record stations in Indiana are shown in figure 21. Suspended-sediment concentrations were also smaller in the northern moraine and lake region of the State than in other areas. As with suspended-sediment yield, no other regional trend in suspended-sediment concentration is apparent.

Suspended-sediment yields and suspended-sediment concentrations that are smaller in the northern moraine and lake region than elsewhere in the State can be attributed to the low gross soil erosion for the region (fig. 4). The large yield for Big Creek near Wadesville [685 (tons/mi^2)/yr] can be attributed to an area of very high gross soil erosion in the southern part of the State. Little other correlation seems to occur between gross soil erosion and suspended-sediment characteristics of Indiana streams. For example, the Patoka River near Princeton drains an area of medium to very high gross soil erosion, yet its suspended-sediment yield [118 (tons/mi^2)/yr] is one of the lowest in the southern part of the State. Big Raccoon Creek near Fincastle, on the other hand, drains an area with medium gross soil erosion but has the largest estimated suspended-sediment yield for any stream in the State.

TRENDS IN SUSPENDED-SEDIMENT CONCENTRATION AND DISCHARGE

Trend Analysis Methods

The procedure used to test for trends in time in suspended sediment is a modified form of Kendall's tau (Kendall, 1975, p. 3–8), derived by Hirsch and others (1982). In Kendall's tau test, all possible pairs of successive suspended-sediment data values are compared. If a subsequent value (in time) is larger, a plus is recorded. If a subsequent value is smaller, a minus is recorded. If there is no trend in the data, the probability of a subsequent value being larger or smaller than any previous value is 0.50, and the number of pluses and minuses should be approximately equal. If the number of pluses greatly exceeds the number of minuses, the subsequent values in the series are more often larger than those earlier in the series, and an uptrend is indicated. If the number of minuses greatly exceeds the number of pluses, a downtrend is indicated. In this modified Kendall's tau, the problem of seasonality is considered by comparing only observations from the same season or time of year. The data were assumed to exhibit monthly seasonality; thus January data were compared only with other January data, and so on.

The seasonal Kendall slope estimator was used to determine trend magnitude (Hirsch and others, 1982). The slope estimate is the median of the slopes of the ordered pairs of data compared in the seasonal Kendall test. Median monthly values for the daily record stations were used in the seasonal Kendall test to minimize the problem of serial correlation in the data. A discussion of the seasonal Kendall test and seasonal Kendall slope estimator and its use is given in Smith and others (1982, p. 5–6).

Because suspended sediment and streamflow are related, apparent trends in suspended sediment may be due only to fluctuations in streamflow rather than to changes in the processes that affect the introduction and fate of suspended sediment in streams. Even though suspended-sediment concentration and streamflow were not related enough to develop a reliable predictive equation, the relation still was statistically significant in most streams.

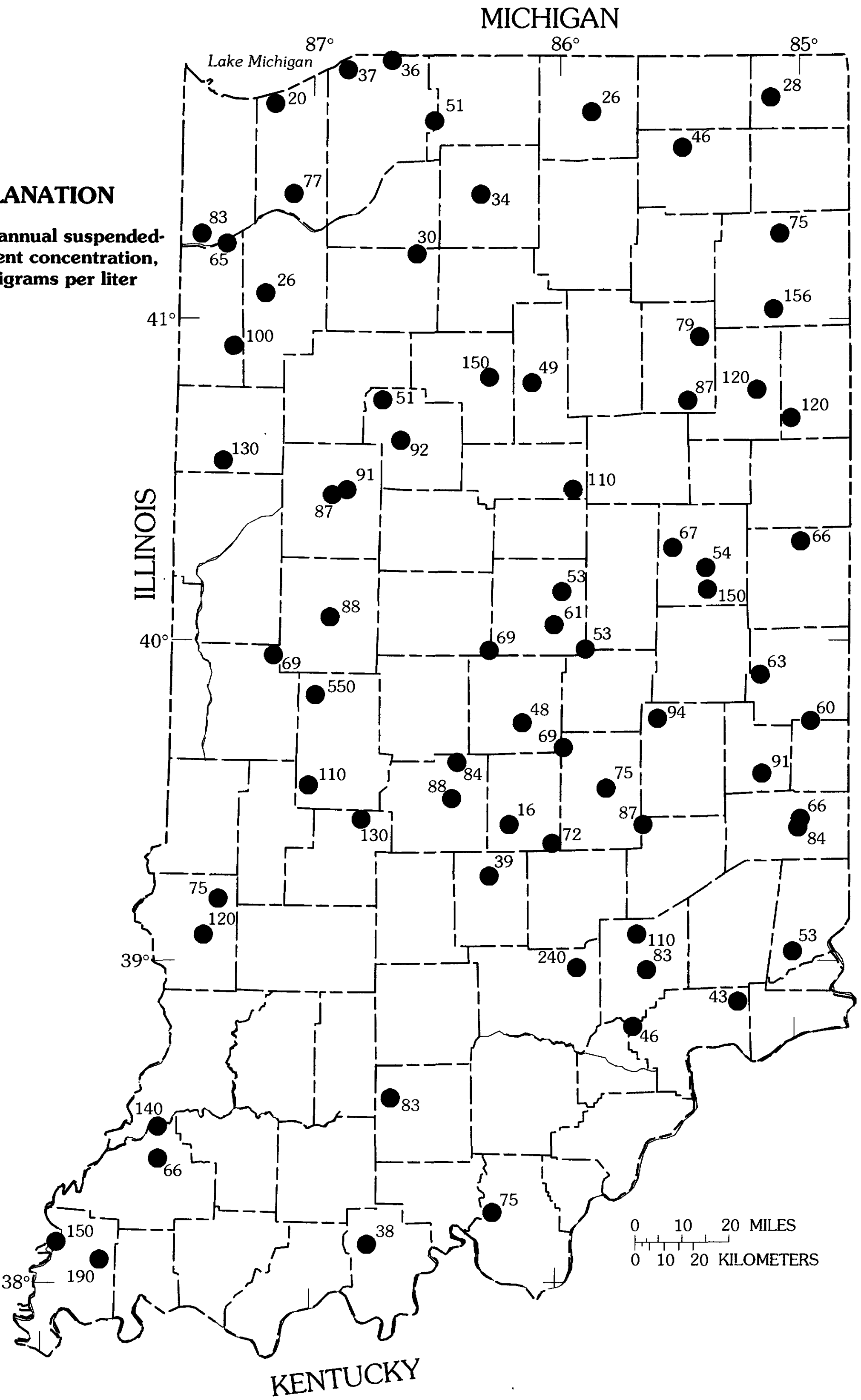
The effects of streamflow must be eliminated to test for trends in the processes that affect suspended sediment. Smith and others (1982, p. 6–8) described a flow-adjustment procedure suitable for this purpose. Their procedure consists of developing a time series of flow-adjusted concentrations (*FAC's*) and of testing that series for trend. *FAC* is defined as the actual concentration minus the expected concentration predicted from the relation of suspended-sediment concentration and streamflow. The *FAC* should be randomly distributed about zero during the period if the processes that affect suspended sediment have not changed.

The procedures used to quantify the relation between suspended-sediment concentration and streamflow and between suspended-sediment discharge and streamflow for the partial-record stations previously discussed also were used to quantify these relations for the daily record stations.

Figure 21. Flow-weighted mean suspended-sediment concentrations. →

EXPLANATION

● 69 **Mean annual suspended-sediment concentration, in milligrams per liter**



The models used in the flow-adjustment procedure were logarithmic. Consequently, the residuals or *FAC* used in the seasonal Kendall procedure are dimensionless. The median slope of these residuals was converted to trend in percent per year by the following equation:

$$\text{Trend} = 100\,[\exp\,[S]-1], \qquad (18)$$

where

exp indicates that the base of the natural logarithm, approximately 2.718, is raised to the power expressed by the quantity inside the brackets; and

S is the median slope of the residuals.

Results of Trend Analysis

Periods of record were sufficient at 4 daily record stations and 32 partial-record stations to test for trends in suspended sediment. Results of the seasonal Kendall trend test for the individual stations are presented in table 14. The probability levels given in table 14 are a measure of the statistical significance of the trend, that is, the probability that the observed trend was due entirely to chance. For example, if a station has a trend with a probability level of 0.50, there is a 50-percent chance that the trend is due entirely to random variability. A probability level of 0.05 indicates that only a 5-percent chance exists that the trend is due entirely to random variability. A summary of the results for all stations is given in table 15.

At most stations there was no significant trend in suspended sediment. A significant trend in suspended-sediment concentration was found at only 14 of the 36 stations. A significant trend in the *FAC* was found at nine stations. A significant trend in suspended-sediment discharge was found at 14 of the stations.

SUMMARY AND CONCLUSIONS

Suspended-sediment data have been collected by the U.S. Geological Survey in Indiana since 1952. Daily suspended-sediment data were compiled for seven stream stations. Data were collected periodically at 70 stream stations.

Median daily suspended-sediment concentration measured at the seven daily record stations ranged from 24 to 61 milligrams per liter (mg/L). Maximum daily concentrations for the same seven stations ranged from 501 to 27,900 mg/L. The largest concentrations were observed at Big Raccoon Creek near Fincastle. Large suspended-sediment concentrations at several stations were associated with storms but not always with peak streamflow. Some peak suspended-sediment concentrations preceded peak streamflow by as much as 18 to 30 hours during storms. Concentrations were generally largest during storms that ended a period of low flow, when large amounts of sediment were eroded and transported into the stream and little base streamflow was available for dilution.

Most of the suspended sediment was transported in a few days each year. On the basis of an average of daily records data, about 75 percent of the total suspended-sediment load was transported during 10 percent of the time; about 30 percent of the total suspended-sediment load was transported during only 1 percent of the time. High flows (water discharge equaled or exceeded 1 percent of the time) transported an average of only 24 percent of the total suspended-sediment load. Two-thirds to three-fourths of the annual suspended-sediment load occurs from December through April. Mean monthly suspended-sediment discharge typically was largest in March.

Median suspended-sediment concentrations ranged from 6 to 539 mg/L at the 70 partial-record stations. The largest instantaneous suspended-sediment concentration observed was 44,500 mg/L. This concentration, at Big Raccoon Creek near Fincastle, was eight times the maximum concentration observed at any other partial-record station.

Silt- and clay-sized material (particles between 0.062 and 0.004 and less than 0.004 mm in diameter) were the dominant fraction of the suspended sediment in most Indiana streams. Materials of this size constituted an average 90 percent of the suspended sediment for the stations sampled.

Suspended-sediment yields at daily record stations ranged from 186 to 1,914 (tons/mi^2)/yr. The sediment-transport, flow-duration-curve method was used to estimate suspended-sediment yields for the 70 partial-record stations; yields ranged from 11 to 2,310 (tons/mi^2)/yr. All but seven of the estimates were less than 400 (tons/mi^2)/yr. However, because of the poor correlation between suspended-sediment concentration and streamflow, these estimates are imprecise.

Linear regression was used to obtain a relation between suspended-sediment yield and drainage-basin characteristics for the partial-record stations. The equation that best explained the variability in the data was

$$\hat{Y} = 1.096 \exp\,[1.615] \exp\,[-0.062S]\; CDA^{0.186}\; FL^{-0.161}\; UP10^{0.951}$$

where

- Y is the estimated yield, in tons per square mile per year;
- exp indicates that the base of the natural logarithm, approximately 2.718, is raised to the power expressed by the quantity inside the brackets;
- S is the channel slope, in feet per mile;
- CDA is the contributing drainage area in square miles;
- FL is the amount of forested land in the drainage basin, in percent; and
- $UP10$ is the peak unit discharge, in cubic feet per second per square mile.

This equation explained about 64 percent of the variation in the data and has a standard error of 49 percent. The equation applies to stations having drainage areas between 10 and 2,500 mi^2. Estimates of suspended-sediment yield obtained from this equation are subject to considerable error but are probably better than estimates obtained from other methods, such as extrapolating data from nearby stations. Suspended-sediment yields for 102 stations in the U.S. Geological Survey stream-gaging network, for which no suspended-sediment data were available, were estimated by this equation.

Suspended-sediment yields in the northern moraine and lake region of Indiana were smaller than in other regions of the State. Yields in this region ranged from 11 to 202 $(tons/mi^2)/yr$ compared with 50 to 2,310 $(tons/mi^2)/yr$ for the other areas of the State. Mean suspended-sediment concentrations were also smaller in the northern moraine and lake region than in other areas of the State. Suspended-sediment yields and concentrations varied greatly throughout the rest of the State; no other regional trends were apparent.

Enough data were available to test for trends at 32 partial-record and 4 daily record stations, but at most of these, no significant trends occurred. A significant trend in the flow-adjusted suspended-sediment concentration was observed at only 9 of the 36 stations. Six of the nine significant trends were downward.

REFERENCES CITED

Anttila, P.W., and Tobin, R.L., 1978, Fluvial sediment in Ohio: U.S. Geological Survey Water-Supply Paper 2045, 58 p.

Brentlinger, J.L., Hays, J.B., Lauster, R.L., and Pierce, C.S., 1979, Agricultural erosion assessment for the nondesignated and designated 208 planning areas of Indiana: Indiana Department of Natural Resources, State Soil and Water Conservation Committee, 363 p.

Chatterjee, Samprit, and Price, Bertram, 1977, Regression analysis by example: New York, John Wiley, 228 p.

Clark, G.D., ed., 1980, The Indiana water resource: Indianapolis, Indiana Department of Natural Resources, 508 p.

Colby, B.R., 1956, Relation of sediment discharge to streamflow: U.S. Geological Survey Open-File Report, 170 p.

———1963, Fluvial sediments—A summary of source, transportation, deposition, and measurement of sediment discharge: U.S. Geological Survey Bulletin 1181–A, 47 p.

Cordane, A.J., and Kelly, D.W., 1961, The influence of inorganic sediment on the aquatic life of streams: California Fish and Game, v. 47, p. 189–228.

Daniel, Cuthbert, and Wood, F.S., 1980, Fitting equations to data (2d ed.): New York, John Wiley, 458 p.

Davis, L.G., 1974, Floods in Indiana—Technical manual for estimating their magnitude and frequency: U.S. Geological Survey Circular 710, 40 p.

Draper, N.R., and Smith, H., 1981, Applied regression analysis (2d ed.): New York, John Wiley, 407 p.

Duan, Naihua, 1983, Smearing estimate—A nonparametric retransformation method: Journal of the American Statistical Association, v. 78, p. 605–610.

Duan, Naihua, Manning, W.G., Jr., Morris, C.N., and Newhouse, J.P., 1982, A comparison of alternative methods for the demand for medical care: Santa Monica, Calif., The Rand Corporation, 110 p.

Farr, I.S., and Clarke, R.T., 1984, Reliability of suspended load estimates in Chalk streams: Archiv für Hydrobiologie, v. 102, p. 1–19.

Ferguson, R.I., 1986a, River loads underestimated by rating curves: Water Resources Research, v. 22, p. 74–76.

———1986b, Reply to comment on River loads underestimated by rating curves, by A.W. Koch and G.M. Smillie, 1986 (in Water Resources Research, v. 22, p. 2121–2122): Water Resources Research, v. 22, p. 2123–2124.

Gammon, J.R., 1970, The effect of inorganic sediment on stream biota: U.S. Environmental Protection Agency Water Pollution Control Research Series 18050 DWC 12/70, 140 p.

Gebert, W.A., Graczyk, D.J., and Krug, W.R., 1985, Average annual runoff in the United States, 1951–80: U.S.

Geological Survey Open-File Report 85–627, scale 1:2,000,000.

Gottschalk, L.C., 1964, Reservoir sedimentation, *in* Chow, V.T., ed., Handbook of applied hydrology: New York, McGraw-Hill, p. 17–1 through 17–34.

Grenney, W.J., and Heyse, Edward, 1985, Suspended sediment—River flow analysis: American Society of Civil Engineers, Proceedings, Journal of the Environmental Engineering Division, v. 111, p. 790–803.

Guy, H.P., 1964, An analysis of some storm-period variables affecting stream sediment transport: U.S. Geological Survey Professional Paper 462–E, 46 p.

———1969, Laboratory theory and methods for sediment analysis: U.S. Geological Survey Techniques of Water-Resources Investigations, bk. 5, chap. C1, 58 p.

Guy, H.P., and Norman, V.W., 1970, Field methods for measurement of fluvial sediment: U.S. Geological Survey Techniques of Water-Resources Investigations, bk. 3, chap. C1, 59 p.

Hirsch, R.M., Slack, J.R., and Smith, R.A., 1982, Techniques of trend analysis for monthly water quality data: Water Resources Research, v. 18, p. 107–121.

Hoerl, A.E., Jr., 1954, Fitting curves to data, *in* Perry, J.H., ed., Chemical business handbook: New York, McGraw-Hill, p. 20/55–20/77.

Johnson, L.E., 1971, Continuing sediment investigations in Indiana: U.S. Geological Survey Open-File Report, 17 p.

Jordan, P.R., 1965, Fluvial sediment of the Mississippi River at St. Louis, Missouri: U.S. Geological Survey Water-Supply Paper 1802, 89 p.

Kendall, M.G., 1975, Rank correlation methods: London, Charles Griffin and Co., 202 p.

Koch, A.W., and Smillie, G.M., 1986, Comment on River loads underestimated by rating curves, by R. I. Ferguson, 1986 (*in* Water Resources Research, v. 22, p. 74–76): Water Resources Research, v. 22, p. 2121–2122.

Malott, C.A., 1922, The physiography of Indiana, *in* Logan, W.N., ed., Handbook of Indiana geology: Indianapolis, Indiana Department of Conservation Publication 21, part 2, p. 59–256.

Mansue, L.J., and Anderson, P.W., 1974, Effects of land use and retention practices on sediment yields in the Stony Brook basin, New Jersey: U.S. Geological Survey Water-Supply Paper 1798–L, 33 p.

Marie, J.R., and Swisshelm, R.V., Jr., 1970, Evaluation of and recommendations for the surface-water data program in Indiana: U.S. Geological Survey Open-File Report, 27 p.

McElroy, A.D., Chin, S.Y., Nebgen, J.W., Aleti, A., and Bennett, F.W., 1976, Loading functions for assessment of water pollution from nonpoint sources: Washington, D.C., U.S. Environmental Protection Agency, Environmental Protection Technology Series 600/2–76–151, 465 p.

Miller, C.R., 1951, Analysis of flow-duration sediment-rating method of computing sediment yield: Denver, Colo., U.S. Bureau of Reclamation, 55 p.

Miller, D.M., 1984, Reducing transformation bias in curve fitting: American Statistician, v. 38, p. 124–126.

Reed, L.A., 1978, Effectiveness of sediment-control techniques used during highway construction in central Pennsylvania: U.S. Geological Survey Water-Supply Paper 2054, 57 p.

Rhoton, F.E., Smeck, N.E., and Wilding, L.P., 1979, Preferential clay mineral erosion from drainage basins in the Maumee River basin: Journal of Environmental Quality, v. 8, p. 547–550.

Robards, M.H., 1981, Soil survey of Putnam County, Indiana: U.S. Soil Conservation Service, 139 p.

Schaal, L.A., 1966, Climate, *in* Lindsey, A.A., ed., Natural features of Indiana: Indianapolis, Indiana Academy of Science and Indiana State Library, p. 156–170.

Schneider, A.F., 1966, Physiography, *in* Lindsey, A.A., ed., Natural features of Indiana: Indianapolis, Indiana Academy of Science and Indiana State Library, p. 40–56.

Smith, R.A., Hirsch, R.M., and Slack, J.R., 1982, A study of trends in total phosphorus measurements at NASQAN stations: U.S. Geological Survey Water-Supply Paper 2190, 34 p.

Stewart, J.A., Miller, R.L., and Butch, G.K., 1986, Cost effectiveness of the U.S. Geological Survey stream-gaging program in Indiana: U.S. Geological Survey Water-Resources Investigations Report 85–4343, 92 p.

Vanoni, V.A., ed., 1975, Sedimentation engineering: New York, American Society of Civil Engineers, 745 p.

Walling, D.E., 1977, Limitations of the rating curve technique for estimating suspended sediment loads, with particular reference to British rivers, *in* Erosion and solid matter transport in inland waters symposium, Paris, 1977, Proceedings: Paris, International Association of Hydrological Sciences Publication 122, p. 34–48.

Walpole, R.E., and Myers, R.H., 1978, Probability and statistics for engineers and scientists (2nd ed.): New York, Macmillan, 580 p.

Wayne, W.J., 1966, Ice and land, *in* Lindsey, A.A., ed., Natural features of Indiana: Indianapolis, Indiana Academy of Science and Indiana State Library, p. 21–39.

TABLES 1–15

Table 1. Summary of daily mean suspended-sediment concentration data

Suspended-sediment sampling-station number (fig. 6)	Station number	Station name	Drainage area (square miles)	Period of record (water year)	Number of observations	Suspended-sediment concentration (milligrams per liter)				
						Mean	Median	Minimum	Maximum	Interquartile range
16	03328500	Eel River near Logansport	789	1969–72, 1974–80.	3,630	89	53	5	1,790	52
22	03335500	Wabash River at Lafayette	7,267	1978–80	784	61	45	5	677	44
26	03340800	Big Raccoon Creek near Fincastle.	139	1960–71, 1974–79.	6,050	262	41	0	27,900	86
42	03361000	Big Blue River at Carthage	184	1978–80	1,048	77	47	7	1,550	59
48	03365500	East Fork White River at Seymour.	2,341	1966–80	5,538	87	54	2	1,560	62
64	04182000	St. Marys River near Fort Wayne.	762	1953–67	5,264	155	61	0	12,000	101
66	05516500	Yellow River at Plymouth	294	1979–81	839	40	24	2	501	31

Table 2. Summary of daily mean suspended-sediment discharge data

Suspended-sediment sampling-station number (fig. 6)	Station number	Station name	Drainage area (square miles)	Period of record (water year)	Number of observations	Suspended-sediment discharge (tons per day)				
						Mean	Median	Minimum	Maximum	Interquartile range
16	03328500	Eel River near Logansport	789	1969–72, 1974–80.	3,601	396	46	1	26,400	109
22	03335500	Wabash River at Lafayette	7,267	1978–80	784	1,882	451	21	79,600	1,341
26	03340800	Big Raccoon Creek near Fincastle.	139	1960–71, 1974–79.	5,889	743	3	0	295,000	29
42	03361000	Big Blue River at Carthage	184	1978–80	1,048	114	20	1	7,100	47
48	03365500	East Fork White River at Seymour.	2,341	1966–80	5,529	1,177	196	1	179,000	653
64	04182000	St. Marys River near Fort Wayne.	762	1953–67	4,116	360	14	0	30,800	117
66	05516500	Yellow River at Plymouth	294	1979–81	799	52	8	0	1,230	24

Table 3. Summary of daily mean suspended-sediment transport during periods of heavy suspended-sediment or water discharge

Suspended-sediment sampling-station number (fig. 6)	Station number	Station name	Drainage area (square miles)	Period of record (water year)	Number of days	Percentage of total daily suspended-sediment load contributed by suspended-sediment discharge equaled or exceeded during:		Percentage of total daily suspended-sediment load transported by water discharges equaled or exceeded during:			
						1 percent of period of record	10 percent of period of record	1 percent of period of record	10 percent of period of record	25 percent of period of record	50 percent of period of record
16	03328500	Eel River near Logansport	789	1969–72, 1974–80.	3,601	30	82	18	77	91	96
22	03335500	Wabash River at Lafayette	7,267	1978–80	784	20	64	18	58	79	93
26	03340800	Big Raccoon Creek near Fincastle.	139	1960–71, 1974–79.	5,889	69	97	61	94	99	99
42	03361000	Big Blue River at Carthage	184	1977–81	1,048	24	74	12	68	87	95
48	03365500	East Fork White River at Seymour.	2,341	1966–81	5,529	28	71	23	64	84	96
64	04182000	St. Marys River near Fort Wayne.	762	1953–67	4,116	63	93	20	73	95	99
66	05516500	Yellow River at Plymouth	294	1979–81	799	18	73	9	45	78	95

Table 4. Daily duration of streamflow, suspended-sediment concentration, and suspended-sediment discharge for daily record stations

[Q_w, water discharge, in cubic feet per second; C_s, mean daily suspended-sediment concentration, in milligrams per liter; Q_s, mean daily suspended-sediment discharge, in tons per day]

Suspended-sediment sampling-station number (fig. 6)	Station number	Station name	Data collected	Period of record (water year)	Percentage of time value was equaled or exceeded									Water years excluded from analysis with missing record exceeding 5 percent of year
					1	5	10	25	50	75	90	95	99	
16	03328500	Eel River	Q_w	1969–72,	4,860	2,650	1,640	777	404	238	185	164	108	1969, 1973,
		near	C_s	1974–80.	775	327	184	91	55	35	23	17	7.0	1978–79.
		Logansport.	Q_s		7,810	2,020	707	136	47	20	7.6	2.6	1.1	
22	03335500	Wabash River	Q_w	1978–80	35,000	21,300	16,800	7,910	4,000	2,360	1,680	1,550	1,270	1978
		at	C_s		308	184	121	73	43	26	15	10	7.0	
		Lafayette.	Q_s		26,000	7,270	4,110	1,480	443	202	94	72	33	
26	03340800	Big Raccoon	Q_w	1960–71,	1,580	443	260	105	39	13	6.4	4.4	2.7	1963,
		Creek near	C_s	1974–79.	4,200	1,300	456	100	40	19	9.0	6.0	2.0	1972–74.
		Fincastle.	Q_s		13,700	1,230	289	24	3.0	1.0	.1	.0	.0	
42	03361000	Big Blue	Q_w	1978–80	1,680	742	487	254	144	94	66	63	58	1978
		River at	C_s		633	257	175	91	50	29	19	15	10	
		Carthage.	Q_s		1,930	642	250	61	20	8.9	4.9	3.6	2.3	
48	03365500	East Fork	Q_w	1966–80	20,900	9,700	6,200	3,080	1,470	649	385	312	215	
		White River	C_s		594	278	178	96	55	34	20	13	5.0	
		at Seymour.	Q_s		14,500	5,270	2,620	729	202	66	30	16	6.0	
64	04182000	St. Marys	Q_w	1953–67	5,620	2,780	1,680	581	141	41	21	17	14	1953,
		River near	C_s		911	440	262	132	81	34	11	6.0	2.0	1961–65.
		Fort Wayne.	Q_s		6,090	2,160	1,000	177	19	5.0	2.0	1.0	.0	
66	05516500	Yellow	Q_w	1979–81	1,190	820	626	258	144	80	45	35	29	1979, 1981
		River at	C_s		329	120	84	47	31	16	10	8.0	7.0	
		Plymouth.	Q_s		620	186	96	29	12	4.4	1.8	1.1	.8	

Table 5. Summary of suspended-sediment concentration

Suspended-sediment sampling-station number (fig. 6)	Station number	Station name	Drainage area (square miles)	Period of record (water year)	Number of observations
1	03274750	Whitewater River near Hagerstown	58.7	1978–81	73
2	03275000	Whitewater River near Alpine	529	1968–79	46
3	03275600	East Fork Whitewater River at Abington	200	1967–79	116
4	03276000	East Fork Whitewater River at Brookville	380	1964–77	56
5	03276500	Whitewater River at Brookville	1,224	1975–84	83
6	03276700	South Hogan Creek near Dillsboro	38.1	1969–84	73
7	03291780	Indian-Kentuck Creek near Canaan	27.5	1978–81	20
8	03303000	Blue River near White Cloud	476	1968–82	61
9	03303300	Middle Fork Anderson River at Bristow	39.8	1964–80	103
10	03322900	Wabash River at Linn Grove	453	1971–82	69
11	03323000	Wabash River at Bluffton	532	1968–71	29
12	03324000	Little River near Huntington	263	1970–78	67
13	03324300	Salamonie River near Warren	425	1964–76	118
14	03325500	Mississinewa River near Ridgeville	133	1976–82	50
15	03327520	Pipe Creek near Bunker Hill	159	1978–81	20
16	03328500	Eel River near Logansport	789	1973–79	49
17	03329400	Rattlesnake Creek near Patton	6.83	1979–81	15
18	03329700	Deer Creek near Delphi	274	1969–80	73
19	03331500	Tippecanoe River near Ora	856	1968–79	48
20	03333450	Wildcat Creek near Jerome	146	1979–82	100
21	03335000	Wildcat Creek near Lafayette	794	1968–80	84
22	03335500	Wabash River at Lafayette	7,267	1964–82	59
23	03335690	Mud Pine Creek near Oxford	39.4	1979–81	15
24	03339500	Sugar Creek at Crawfordsville	509	1972–79	56
25	03340000	Sugar Creek near Byron	670	1968–70	14
26	03340800	Big Raccoon Creek near Fincastle	139	1973–80	25
27	03342150	West Fork Busseron Creek near Hymera	14.4	1978–81	21
28	03342300	Busseron Creek near Sullivan	138	1978–82	73
29	03347000	White River at Muncie	241	1978–80	27
30	03347500	Buck Creek near Muncie	35.5	1979–82	62
31	03348020	Killbuck Creek near Gaston	25.5	1978–80	27
32	03348500	White River near Noblesville	828	1968–74	41
33	03350700	Stony Creek near Noblesville	50.8	1979–82	104
34	03351500	Fall Creek near Fortville	169	1964–79	38
35	03353180	Bean Creek at Indianapolis	4.40	1978–80	113
36	03353200	Eagle Creek at Zionsville	103	1969–79	70
37	03353800	White Lick Creek near Mooresville	212	1978–82	24
38	03354000	White River near Centerton	2,444	1964–77	34
39	03354500	Beanblossom Creek at Beanblossom	14.6	1978–82	154
40	03357500	Big Walnut Creek near Reelsville	326	1969–82	73
41	03358000	Mill Creek near Cataract	245	1969–80	51
42	03361000	Big Blue River at Carthage	184	1979–81	20
43	03361500	Big Blue River at Shelbyville	421	1968–80	76
44	03361850	Buck Creek at Acton	78.8	1978–81	69
45	03362500	Sugar Creek near Edinburgh	474	1968–79	68
46	03363500	Flatrock River at St. Paul	303	1969–82	76
47	03365000	Sand Creek near Brewersville	155	1969–80	44
48	03365500	East Fork White River at Seymour	2,341	1973–82	56
49	03366500	Muscatatuck River near Deputy	293	1968–78	51
50	03369500	Vernon Fork Muscatatuck River at Vernon	198	1978–81	12
51	03372300	Stephens Creek near Bloomington	10.9	1978–82	151
52	03373700	Lost River near West Baden Springs	287	1978–81	19

and discharge data collected at partial-record stations

Suspended-sediment concentration (milligrams per liter)					Suspended-sediment discharge (tons per day)				
Median	Minimum	Maximum	Inter-quartile range	Estimated flow-weighted mean	Median	Minimum	Maximum	Inter-quartile range	Estimated flow-weighted mean
56	3	1,540	53	63	7	0	3,210	18	29
78	3	1,430	172	91	76	1	23,300	723	520
25	0	1,220	47	60	6	0	17,500	25	130
35	1	687	72	66	15	0	2,470	75	160
56	5	1,770	58	84	107	9	19,200	348	460
40	3	442	47	53	1	0	1,220	4	26
20	10	234	28	43	0	0	439	2	7
49	1	983	82	75	71	0	19,800	277	450
21	1	578	39	38	2	0	739	9	12
86	3	992	88	120	17	0	15,600	91	220
84	20	368	141	120	35	2	3,700	190	230
52	11	720	69	79	8	1	1,960	40	88
54	5	567	83	87	12	0	9,480	50	300
24	2	1,310	59	66	1	0	13,800	9	85
45	6	141	48	49	4	0	56	21	22
347	51	1,230	482	150	3,320	55	20,100	6,264	520
43	6	683	172	51	0	0	223	26	3
60	14	1,800	98	92	22	1	26,200	96	170
25	6	112	28	30	53	4	894	121	75
53	3	3,240	90	110	12	0	20,600	134	120
58	3	1,058	68	91	50	1	31,400	134	480
66	6	980	74	87	714	13	81,500	1,726	2,700
46	0	977	320	130	3	0	5,250	71	42
49	8	2,350	84	88	30	2	49,900	391	330
69	10	397	62	69	56	5	10,600	340	290
539	0	11,900	1,862	550	1,085	0	55,900	13,068	880
41	0	780	108	75	0	0	1,940	2	6
40	6	1,930	95	120	4	0	4,670	49	150
63	8	1,060	113	54	10	1	15,500	412	97
158	24	2,990	139	150	17	1	6,690	87	24
55	20	2,070	50	67	2	0	5,640	11	9
34	6	909	43	53	33	0	5,080	126	230
53	2	544	57	61	4	0	820	14	17
45	6	164	64	53	11	0	1,200	27	36
30	1	951	39	48	0	0	379	0	2
48	11	843	67	69	6	0	9,400	27	58
86	4	956	198	84	57	0	24,200	450	190
32	4	893	69	88	120	5	7,160	801	1,400
17	0	1,150	27	39	0	0	2,490	1	14
80	5	1,420	237	110	59	0	21,100	483	380
80	6	4,250	158	130	47	0	9,850	1,324	210
127	15	804	265	94	110	3	8,080	1,061	110
73	11	581	100	75	85	3	8,520	256	190
53	5	986	70	69	5	0	10,400	22	38
59	12	618	51	72	37	3	7,760	146	190
68	8	2,010	137	87	61	0	15,600	386	360
36	4	5,160	59	110	5	0	32,900	28	190
286	14	1,210	297	240	5,570	20	56,700	10,717	2,700
34	3	274	54	46	8	0	3,270	83	110
77	4	372	219	83	39	0	2,960	1,004	264
6	0	319	8	16	0	0	444	0	2
71	8	267	88	83	35	0	3,750	163	150

Table 5. Summary of suspended-sediment concentration and

Suspended-sediment sampling-station number (fig. 6)	Station number	Station name	Drainage area (square miles)	Period of record (water year)	Number of observations
53	03374100	White River at Hazelton	11,305	1974–84	86
54	03376500	Patoka River near Princeton	822	1964–80	67
55	03378500	Wabash River at New Harmony	29,234	1975–84	67
56	03378550	Big Creek near Wadesville	104	1978–82	23
57	04095000	Little Calumet River near McCool	149	1978–80	14
58	04095300	Trail Creek at Michigan City	54.1	1978–81	29
59	04096100	Galena River near La Porte	17.2	1978–81	22
60	04099510	Pigeon Creek near Angola	106	1978–81	140
61	04100222	North Branch Elkhart River at Cosperville	142	1978–82	21
62	04100500	Elkhart River at Goshen	594	1964–77	33
63	04180000	Cedar Creek near Cedarville	270	1979–81	9
65	05515000	Kankakee River near North Liberty	174	1978–81	132
66	05516500	Yellow River at Plymouth	294	1979–82	95
67	05517890	Cobb Ditch near Kouts	30.3	1979–80	9
68	05518000	Kankakee River at Shelby	1,179	1964–79	30
69	05519000	Singleton Ditch at Schneider	123	1979–82	14
70	05521000	Iroquois River at Rosebud	35.6	1978–80	16
71	05524500	Iroquois River near Foresman	449	1968–80	63

discharge data collected at partial-record stations—Continued

Suspended-sediment concentration (milligrams per liter)					Suspended-sediment discharge (tons per day)				
Median	Minimum	Maximum	Inter-quartile range	Estimated flow-weighted mean	Median	Minimum	Maximum	Inter-quartile range	Estimated flow-weighted mean
109	14	513	101	140	2,420	67	30,700	8,115	5,700
40	2	570	71	66	85	0	2,710	459	280
116	27	601	148	150	6,240	391	76,600	22,080	16,000
74	8	2,240	110	190	2	0	2,800	15	200
20	5	67	28	20	11	2	54	21	5
33	5	182	53	37	4	1	368	14	12
33	7	94	27	36	2	0	14	3	3
22	2	143	26	28	2	0	139	5	7
25	4	188	58	46	9	1	207	22	17
25	6	105	13	26	34	2	964	72	44
53	11	267	52	75	6	1	786	202	80
50	5	188	39	51	17	2	133	26	23
17	3	519	26	34	11	1	1,510	22	69
40	30	166	112	77	2	1	39	23	13
59	19	183	60	65	294	30	1,240	462	300
73	17	945	200	83	19	3	3,600	254	51
21	11	261	25	26	1	0	266	3	2
79	9	520	66	100	72	2	1,520	79	80

Table 6. Effect of short-duration, intense storms on suspended-sediment concentration during low flow for two selected periods of runoff, Big Raccoon Creek near Fincastle

[n.d., no data]

Date (1971)	Mean daily suspended-sediment concentration (milligrams per liter)	Instantaneous suspended-sediment concentration (milligrams per liter)	Time of instantaneous sampling	Instantaneous streamflow at time of sampling (cubic feet per second)	Mean daily streamflow (cubic feet per second)	Flow duration (percent)	Percentage by weight of clay- and silt-sized particles (<0.062 millimeter) in instantaneous samples
June 11	2,190	n.d.	n.d.	n.d.	69	41	n.d.
12	11,300	[1]22,600	1300	[2]3,820	2,570	.4	97
13	1,540	n.d.	n.d.	n.d.	657	4	n.d.
July 18	60	n.d.	n.d.	n.d.	23	67	n.d.
19	24,100	[3]44,500	0700	[2]700	462	6	98
20	2,260	n.d.	n.d.	n.d.	119	26	n.d.

[1]Sample was collected during rising stage of runoff period.
[2]Estimated.
[3]Sample was collected near peak stage of runoff period.

Table 7. Summary of particle-size analyses of suspended sediment

[n.d., no data]

Suspended-sediment sampling-station number (fig. 6)	Station number	Station name	Water discharge range[1] (cubic feet per second)	Sediment concentration range[1] (milligrams per liter)	Particle-size percentage by weight: Clay and silt (particles less than 0.062 millimeters in diameter)			Clay (particles less than 0.004 millimeters in diameter)		
					Number of samples	Range	Mean	Number of samples	Range	Mean
1	03274750	Whitewater River near Hagerstown	47–1,790	97–1,540	7	84–100	95	0	n.d.	n.d.
2	03275000	Whitewater River near Alpine	998–11,800	133–1,430	8	76–98	90	6	38–68	51
3	03275600	East Fork Whitewater River at Abington	1,440–8,020	197–1,220	5	76–94	85	4	38–57	48
5	03276500	Whitewater River at Brookville	960–6,260	56–433	6	78–99	90	1	n.d.	80
6	03276700	South Hogan Creek near Dillsboro	3.7–1,100	45–328	9	74–100	95	5	53–85	72
8	03303000	Blue River near White Cloud	6,080–11,000	312–636	2	88–98	93	2	34–58	46
9	03303300	Middle Fork Anderson River at Bristow	4.5–987	77–238	5	86–99	95	4	64–98	78
10	03322900	Wabash River at Linn Grove	108–5,810	74–992	10	58–100	95	10	38–92	81
11	03323000	Wabash River at Bluffton	201–3,720	313–368	2	97–98	97	3	88–93	91
12	03324000	Little River near Huntington	644–3,230	85–720	5	83–98	94	5	36–80	65
13	03324300	Salamonie River near Warren	488–5,940	122–567	8	95–100	99	10	32–96	84
14	03325500	Mississinewa River near Ridgeville	151–2,190	39–266	3	95–97	96	1	n.d.	88
15	03327520	Pipe Creek near Bunker Hill	16–81	40–65	2	76–92	84	0	n.d.	n.d.
16	03328500	Eel River near Logansport	216–8,210	51–2,130	60	48–100	86	25	53–88	72
17	03329400	Rattlesnake Creek near Patton	1.7	102	1	n.d.	84	0	n.d.	n.d.
18	03329700	Deer Creek near Delphi	328–2,850	178–1,800	5	74–99	88	6	43–72	61
21	03335000	Wildcat Creek near Lafayette	3,170–11,000	249–1,060	10	62–96	78	7	45–73	53
22	03335500	Wabash River at Lafayette	5,220–23,600	98–185	6	93–98	95	3	54–88	68
23	03335690	Mud Pine Creek near Oxford	28–1,990	333–977	4	98–98	98	0	n.d.	n.d.
24	03339500	Sugar Creek at Crawfordsville	1,880–8,030	163–817	7	77–98	87	5	47–64	59
25	03340000	Sugar Creek near Byron	1,530–9,850	304–397	3	68–96	81	4	37–64	50
26	03340800	Big Raccoon Creek near Fincastle	7–7,270	135–44,500	45	72–100	97	42	17–95	47
27	03342150	West Fork Busseron Creek near Hymera	0.5–1,850	50–780	5	81–94	89	0	n.d.	n.d.
29	03347000	White River at Muncie	256–4,040	113–622	6	85–99	95	2	76–78	77
30	03347500	Buck Creek near Muncie	25–862	37–944	47	58–99	83	0	n.d.	n.d.
31	03348020	Killbuck Creek near Gaston	24–171	98–186	2	94–95	94	0	n.d.	n.d.
32	03348500	White River near Noblesville	1,830–8,280	80–909	3	89–100	95	3	78–83	80
33	03350700	Stony Creek near Noblesville	24–643	82–448	7	65–98	87	0	n.d.	n.d.
34	03351500	Fall Creek near Fortville	1,200–1,740	100–163	2	92–98	95	1	n.d.	78
35	03353180	Bean Creek at Indianapolis	1.9–355	35–845	9	63–91	83	0	n.d.	n.d.
36	03353200	Eagle Creek at Zionsville	500–3,980	67–709	9	77–99	95	5	62–84	76
37	03353800	Whitelick Creek at Mooresville	1,760–11,500	473–956	5	58–96	79	0	n.d.	n.d.
38	03354000	White River near Centerton	5,780	268	1	n.d.	78	1	n.d.	51
39	03354500	Beanblossom Creek at Beanblossom	33–435	38–428	2	83–95	89	0	n.d.	n.d.
40	03357500	Big Walnut Creek near Reelsville	316–7,030	192–1,420	7	73–99	84	5	31–58	43
41	03358000	Mill Creek near Cataract	1,140–6,890	134–1,240	8	86–98	91	5	49–62	56
42	03361000	Big Blue River at Carthage	102–4,070	110–804	6	85–97	90	0	n.d.	n.d.
43	03361500	Big Blue River at Shelbyville	1,390–7,990	172–581	7	85–97	94	6	58–70	64
44	03361850	Buck Creek at Acton	23–2,410	51–495	13	70–99	92	0	n.d.	n.d.
45	03362500	Sugar Creek near Edinburgh	1,220–10,200	139–419	7	73–99	91	7	69–94	79
46	03363500	Flatrock River at St. Paul	1,190	379	1	n.d.	98	1	n.d.	62
47	03365000	Sand Creek near Brewersville	964–1,090	354–584	2	99–99	99	3	60–72	66
48	03365500	East Fork White River at Seymour	1,940–35,600	111–1,210	55	70–100	94	30	40–89	67
49	03366500	Muscatatuck River near Deputy	3,480	205	1	n.d.	98	2	44–61	52
50	03369500	Vernon Fork Muscatatuck River at Vernon	2,950	372	1	n.d.	75	0	n.d.	n.d.
55	03378500	Wabash River at New Harmony	26,100–75,800	197–324	2	90–98	94	2	33–74	54
58	04095300	Trail Creek at Michigan City	40	38	1	n.d.	76	0	n.d.	n.d.
59	04096100	Galena River near La Porte	11–50	45–94	2	79–99	84	0	n.d.	n.d.
60	04099510	Pigeon Creek near Angola	21–373	20–143	6	90–99	95	0	n.d.	n.d.
64	04182000	St. Marys River near Fort Wayne	1,730–2,720	446–576	2	98–98	98	2	91–93	92
65	05515000	Kankakee River near North Liberty	78–374	63–188	13	68–93	81	0	n.d.	n.d.
66	05516500	Yellow River at Plymouth	66–110	81–179	2	84–97	90	0	n.d.	n.d.
70	05521000	Iroquois River at Rosebud	9.5–378	63–261	2	57–98	77	0	n.d.	n.d.
71	05524500	Iroquois River at Foresman	2,480–2,930	74–192	3	99–99	99	4	43–94	79

[1]The water discharge and sediment concentration ranges shown are the ranges that correspond to the clay and silt (particles less than 0.062 millimeters in diameter) samples. They do not correspond to the clay samples.

Table 8. Mean suspended-sediment yield at long-term, daily record stations

Suspended-sediment sampling-station number (fig. 6)	Station number	Station name	Years of record	Mean suspended-sediment yield (tons per square mile per year)	Ninety-five percent confidence limits (tons per square mile per year)
16	03328500	Eel River near Logansport	8	188	109–267
26	03340800	Big Raccoon Creek near Fincastle	14	1,914	886–2,942
48	03365500	East Fork White River at Seymour	15	186	145–227
64	04182000	St. Marys River near Fort Wayne	9	202	123–281

Table 9. Computation of mean annual suspended-sediment yield for the Whitewater River near Hagerstown

(1) Percentage interval	(2) Percentage of time	(3) Mean water discharge for interval (cubic feet per second)	(4) Mean suspended-sediment discharge for interval (tons per day)	(5) Water discharge multiplied by percentage of time (cubic feet per second)	(6) Suspended-sediment discharge multiplied by percentage of time (tons per day)	(7) [1]F exp $[E_jB]$	(8) [1]F exp $[E_jB]E1_j$	(9) [1]F exp $[E_jB]E2_j$
0.00–0.05	0.05	1,690.0	2,280.0	84.5	114.0	0.896834	0.896834	6.665706
.05–.11	.06	1,400.0	1,690.0	84.0	101.0	.794138	.794138	5.752919
.11–.30	.19	1,200.0	1,310.0	228.0	250.0	1.960716	1.960716	13.901626
.30–.41	.11	1,005.0	987.0	111.0	109.0	.852540	.852540	5.893389
.41–.82	.41	840.0	739.0	344.0	303.0	2.378810	2.378810	16.017481
.82–1.37	.55	705.0	557.0	388.0	306.0	2.404877	2.404877	15.771660
1.37–1.81	.44	590.0	418.0	260.0	184.0	1.443192	1.443192	9.207742
1.81–2.16	.35	500.0	320.0	175.0	112.0	.878796	.878796	5.461370
2.16–2.82	.66	425.0	246.0	280.0	162.0	1.274713	1.274713	7.714677
2.82–3.70	.88	355.0	184.0	312.0	162.0	1.271051	1.271051	7.463760
3.70–4.38	.68	295.0	136.0	201.0	92.8	.728409	.728409	4.142443
4.38–5.45	1.07	250.0	104.0	267.0	112.0	.877402	.877402	4.844538
5.45–6.54	1.09	210.0	78.8	229.0	85.9	.674516	.674516	3.606707
6.54–8.21	1.67	175.0	58.7	292.0	98.0	.769920	.769920	3.976474
8.21–9.94	1.73	150.0	45.8	259.0	79.2	.621859	.621859	3.115907
9.94–12.13	2.19	130.0	36.3	285.0	79.6	.624818	.624818	3.041323
12.13–15.41	3.28	109.0	27.3	358.0	89.7	.704123	.704123	3.303287
15.41–19.35	3.94	90.0	20.1	355.0	79.1	.620830	.620830	2.793617
19.35–24.94	5.59	75.5	15.1	422.0	84.5	.663302	.663302	2.868204
24.94–31.51	6.57	63.5	11.4	417.0	75.1	.589521	.589521	2.447126
31.51–39.58	8.07	53.5	8.7	432.0	69.9	.549109	.549109	2.185278
39.58–46.81	7.23	45.0	6.6	325.0	47.4	.372057	.372057	1.416296
46.81–53.90	7.09	38.0	5.0	269.0	35.4	.277695	.277695	1.010140
53.90–61.54	7.64	32.0	3.8	244.0	28.9	.226737	.226737	.785809
61.54–66.90	5.36	27.0	2.9	145.0	15.4	.120911	.120911	.398504
66.90–74.46	7.56	23.0	2.2	174.0	16.8	.131643	.131643	.412767
74.46–81.80	7.34	19.5	1.7	143.0	12.5	.097910	.097910	.290833
81.80–89.27	7.47	16.5	1.3	123.0	9.7	.076089	.076089	.213304
89.27–95.02	5.75	13.5	.9	77.6	5.4	.042361	.042361	.110252
95.02–96.58	1.56	11.5	.7	17.9	1.1	.008871	.008871	.021667
96.58–98.22	1.64	9.9	.6	16.3	.9	.007383	.007383	.016962
98.22–99.29	1.07	8.2	.4	8.8	.4	.003525	.003525	.007416
99.29–99.75	.46	6.9	.3	3.2	.1	.001147	.001147	.002215
99.75–100.00	.25	5.8	.2	1.5	.1	.000471	.000471	.000828
			Total[2]	7,330	2,920	22.946273	22.946273	134.862225

[1]Term from equation 13 used to calculate variance of mean daily suspended-sediment discharge.

[2]Columns may not add to totals because of rounding.

Table 10. Suspended-sediment yields

[*b*0, *b*1, *b*2, and *b*3 are the regression coefficients; POLY1 indicates the function used to POLY2 indicates the function used to describe the suspended-sediment transport curve is suspended-sediment transport curve is a third-order polynomial (equation 9); and HOERL function described by

Suspended-sediment sampling-station number (fig. 6)	Station number	Station name	Base period (water years)	Coefficient of determination (*R*-square)	Standard error (percent)	Type of function describing sediment-transport curve
1	03274750	Whitewater River near Hagerstown	1971–80	0.88	88.3	POLY1
2	03275000	Whitewater River near Alpine	1951–80	.91	97.7	POLY1
3	03275600	East Fork Whitewater River at Abington	1966–80	.85	130.9	POLY1
4	03276000	East Fork Whitewater River at Brookville	1956–80	.69	158.0	POLY1
5	03276500	Whitewater River at Brookville	1951–80	.66	115.0	POLY1
6	03276700	South Hogan Creek near Dillsboro	1962–80	.89	101.9	POLY2
7	03291780	Indian-Kentuck Creek near Canaan	1970–80	.87	113.6	POLY1
8	03303000	Blue River near White Cloud	1951–80	.90	96.4	POLY1
9	03303300	Middle Fork Anderson River at Bristow	1962–80	.89	113.5	POLY1
10	03322900	Wabash River at Linn Grove	1965–80	.86	123.4	POLY1
11	03323000	Wabash River at Bluffton	1951–71	.88	95.4	POLY1
12	03324000	Little River near Huntington	1951–80	.88	82.6	POLY1
13	03324300	Salamonie River near Warren	1958–80	.88	96.1	POLY2
14	03325500	Mississinewa River near Ridgeville	1951–80	.84	162.6	POLY1
15	03327520	Pipe Creek near Bunker Hill	1969–80	.68	120.7	POLY2
16	03328500	Eel River near Logansport	1951–80	.68	96.1	POLY1
17	03329400	Rattlesnake Creek near Patton	1969–80	.94	98.4	POLY3
18	03329700	Deer Creek near Delphi	1951–80	.90	89.6	POLY1
19	03331500	Tippecanoe River near Ora	1951–80	.74	74.9	POLY2
20	03333450	Wildcat Creek near Jerome	1962–80	.83	172.6	POLY1
21	03335000	Wildcat Creek near Lafayette	1955–80	.92	76.0	POLY1
22	03335500	Wabash River at Lafayette	1951–80	.88	62.3	POLY1
23	03335690	Mud Pine Creek near Oxford	1972–80	.93	137.1	POLY1
24	03339500	Sugar Creek at Crawfordsville	1951–80	.91	96.5	POLY1
25	03340000	Sugar Creek near Byron	1951–71	.89	89.7	POLY1
26	03340800	Big Raccoon Creek near Fincastle	1958–80	.85	395.1	POLY2
27	03342150	West Fork Busseron Creek near Hymera	1967–80	.91	154.7	POLY1
28	03342300	Busseron Creek near Sullivan	1967–80	.93	97.1	HOERL
29	03347000	White River at Muncie	1951–80	.90	108.8	POLY1
30	03347500	Buck Creek near Muncie	1955–80	.84	79.2	POLY1
31	03348020	Killbuck Creek near Gaston	1969–80	.93	73.4	POLY2
32	03348500	White River near Noblesville	1951–74	.82	110.5	POLY1
33	03350700	Stony Creek near Noblesville	1968–80	.85	95.7	POLY1
34	03351500	Fall Creek near Fortville	1951–80	.83	91.9	POLY1
35	03353180	Bean Creek at Indianapolis	1971–80	.79	129.3	POLY3
36	03353200	Eagle Creek at Zionsville	1958–80	.94	84.3	POLY2
37	03353800	White Lick Creek near Mooresville	1958–80	.93	88.9	POLY1
38	03354000	White River near Centerton	1951–80	.90	83.2	POLY2
39	03354500	Beanblossom Creek at Beanblossom	1952–80	.88	100.2	POLY2
40	03357500	Big Walnut Creek near Reelsville	1951–80	.93	90.6	POLY1

estimated from partial-record data

describe the suspended-sediment transport curve is a first-order polynomial (equation 7); a second-order polynomial (equation 8); POLY3 indicates the function used to describe the indicates the function used to describe the suspended-sediment transport curve is the Hoerl (1954) (equation 10)]

Model coefficients				Bias correction factor	Mean suspended-sediment yield (tons per square mile per year)	Standard deviation of mean suspended-sediment yield (tons per square mile per year)	Ratio of highest daily discharge used in estimating yield to highest instantaneous discharge observed during sediment data collection	Ratio of highest predicted sediment discharge used in estimating yield to highest instantaneous sediment discharge observed during sediment data collection
b0	*b1*	*b2*	*b3*					
−4.5075	1.6145	0.0000	0.0000	1.27	182	30	0.93	0.71
−7.2539	1.8862	.0000	.0000	1.34	357	83	1.96	6.97
−6.5668	1.7922	.0000	.0000	1.68	245	54	.95	1.22
−5.0463	1.5040	.0000	.0000	1.66	156	66	10.91	13.01
−4.1387	1.3223	.0000	.0000	1.64	138	26	7.60	2.44
−2.6053	.8101	.0764	.0000	1.37	252	102	3.15	9.82
−3.0773	1.2136	.0000	.0000	1.51	91	37	2.01	1.05
−6.3234	1.7150	.0000	.0000	1.33	342	74	2.36	4.48
−3.4149	1.2384	.0000	.0000	1.02	109	16	3.04	2.66
−2.8108	1.2661	.0000	.0000	1.42	174	43	1.42	.50
−2.7289	1.2615	.0000	.0000	1.30	160	47	2.16	1.95
−3.1262	1.2918	.0000	.0000	1.30	122	21	1.12	1.54
−.7083	.2079	.1034	.0000	1.32	257	61	1.58	3.03
−4.3996	1.5063	.0000	.0000	1.83	233	104	2.58	1.74
−3.9542	1.6756	−.0620	.0000	1.34	50	53	8.95	6.19
−4.6581	1.5477	.0000	.0000	1.32	240	37	1.57	1.44
−2.4741	.7250	.0871	.0224	1.26	149	65	1.61	6.61
−4.8204	1.6138	.0000	.0000	1.30	220	39	1.45	1.29
−9.4274	2.7865	−.1140	.0000	1.22	32	4	1.28	.77
−4.5012	1.5803	.0000	.0000	2.16	310	64	.77	.61
−5.9744	1.6792	.0000	.0000	1.24	220	30	1.64	1.69
−6.5993	1.5832	.0000	.0000	1.16	135	19	1.61	1.44
−3.4565	1.6006	.0000	.0000	1.57	386	203	.73	1.08
−4.9877	1.5549	.0000	.0000	1.40	237	45	2.24	.90
−4.8986	1.4998	.0000	.0000	1.25	156	62	2.41	3.20
15.8997	−5.7906	−.3280	.0000	2.32	2,310	3,354	1.70	.65
−2.4971	1.2363	.0000	.0000	1.83	156	68	.40	.27
−5.2125	1.8310	−.0005	.0000	1.49	392	67	.91	.86
−5.1311	1.5808	.0000	.0000	1.42	147	43	1.87	1.16
−2.6958	1.4701	.0000	.0000	1.25	246	28	1.37	.41
−1.5901	.4779	.1265	.0000	1.20	128	27	.92	.42
−5.8813	1.5549	.0000	.0000	1.54	99	25	2.58	4.58
−3.9526	1.5293	.0000	.0000	1.30	122	18	1.53	1.41
−3.6820	1.3104	.0000	.0000	1.33	78	17	2.11	2.34
−3.2287	1.1594	.2330	−.0262	1.48	159	41	.42	.64
−2.0961	0.6890	.0741	.0000	1.37	204	33	1.32	1.63
−4.8835	1.6315	.0000	.0000	1.26	319	86	.87	1.32
−11.6113	2.7327	−.0577	.0000	1.38	207	83	2.95	11.94
−3.4191	.7320	.1447	.0000	1.49	355	115	1.51	5.22
−5.2118	1.6807	.0000	.0000	1.31	423	73	2.46	4.49

Suspended-sediment sampling-station number (fig. 6)	Station number	Station name	Base period (water years)	Coefficient of determination (*R*-square)	Standard error (percent)	Type of function describing sediment-transport curve
41	03358000	Mill Creek near Cataract	1951–80	.90	116.9	POLY1
42	03361000	Big Blue River at Carthage	1951–80	.92	64.6	POLY2
43	03361500	Big Blue River at Shelbyville	1951–80	.92	59.8	POLY1
44	03361850	Buck Creek at Acton	1968–80	.88	102.6	POLY1
45	03362500	Sugar Creek near Edinburgh	1951–80	.89	70.9	POLY1
46	03363500	Flatrock River at St. Paul	1951–80	.93	82.9	POLY2
47	03365000	Sand Creek near Brewersville	1951–80	.88	179.2	POLY1
48	03365500	East Fork White River at Seymour	1951–80	.90	70.2	POLY2
49	03366500	Muscatatuck River near Deputy	1951–80	.93	82.0	POLY1
50	03369500	Vernon Fork Muscatatuck River at Vernon	1951–80	.87	228.5	POLY1
51	03372300	Stephens Creek near Bloomington	1971–80	.84	99.6	POLY3
52	03373700	Lost River near West Baden Springs	1966–80	.89	94.2	POLY1
53	03374100	White River at Hazelton	1951–80	.83	72.3	POLY2
54	03376500	Patoka River near Princeton	1951–80	.95	72.9	POLY3
55	03378500	Wabash River at New Harmony	1951–80	.87	58.0	POLY2
56	03378550	Big Creek near Wadesville	1966–80	.88	171.2	POLY1
57	04095000	Little Calumet River near McCool	1951–80	.34	93.7	POLY1
58	04095300	Trail Creek at Michigan City	1970–80	.81	81.7	HOERL
59	04096100	Galena River near La Porte	1970–80	.63	70.7	POLY2
60	04099510	Pigeon Creek near Angola	1951–80	.56	108.7	POLY1
61	04100222	North Branch Elkhart River at Cosperville	1972–80	.45	135.7	POLY2
62	04100500	Elkhart River at Goshen	1951–80	.88	55.7	POLY2
63	04180000	Cedar Creek near Cedarville	1951–80	.95	59.5	POLY2
65	05515000	Kankakee River near North Liberty	1952–80	.55	67.8	POLY1
66	05516500	Yellow River at Plymouth	1951–80	.72	95.1	HOERL
67	05517890	Cobb Ditch near Kouts	1969–80	.93	48.8	POLY2
68	05518000	Kankakee River at Shelby	1951–80	.64	68.6	POLY2
69	05519000	Singleton Ditch at Schneider	1951–80	.88	94.1	POLY1
70	05521000	Iroquois River at Rosebud	1951–80	.94	52.9	POLY3
71	05524500	Iroquois River near Foresman	1951–80	.65	91.8	POLY2

Model coefficients				Bias correction factor	Mean suspended-sediment yield (tons per square mile per year)	Standard deviation of mean suspended-sediment yield (tons per square mile per year)	Ratio of highest daily discharge used in estimating yield to highest instantaneous discharge observed during sediment data collection	Ratio of highest predicted sediment discharge used in estimating yield to highest instantaneous sediment discharge observed during sediment data collection
b0	*b1*	*b2*	*b3*					
−3.3207	1.3539	0.0000	0.0000	1.83	317	54	1.49	1.81
−12.8500	4.3553	−.2201	.0000	1.16	225	37	1.46	.62
−4.8863	1.5392	.0000	.0000	1.16	166	17	1.55	2.05
−3.4380	1.3722	.0000	.0000	1.35	175	34	.82	.27
−4.2025	1.4125	.0000	.0000	1.24	148	21	1.68	2.27
−1.9136	.3280	.1193	.0000	1.30	430	113	3.52	12.00
−4.2647	1.5358	.0000	.0000	1.90	441	189	1.51	1.71
−17.8317	4.9177	−.2131	.0000	1.21	420	43	1.56	.74
−3.7655	1.3126	.0000	.0000	1.25	131	27	5.01	5.73
−5.1983	1.6021	.0000	.0000	2.27	488	479	9.31	54.68
−3.8069	.4853	.0643	.0187	1.55	53	13	.74	1.34
−3.8315	1.3683	.0000	.0000	1.42	186	49	.93	1.40
−11.5128	3.0189	−.0952	.0000	1.20	183	21	1.92	2.01
−3.5423	.1050	.3403	−.0243	1.27	118	14	1.28	.69
−25.8579	5.4410	−.1942	.0000	1.15	203	25	2.45	1.94
−2.6401	1.3836	.0000	.0000	1.78	685	443	5.15	7.25
−3.9012	1.1885	.0000	.0000	1.28	11	5	5.25	4.51
−7.1579	2.1231	−.0011	.0000	1.24	80	18	1.43	2.15
−4.6630	1.9826	−.0885	.0000	1.17	59	11	2.57	3.53
−3.5361	1.1568	.0000	.0000	1.42	23	3	1.42	.55
−9.4343	3.9043	−.2937	.0000	1.54	44	16	1.03	.26
−6.7839	1.9756	−.0510	.0000	1.13	27	3	1.30	.58
−6.9900	2.5961	−.1036	.0000	1.11	108	35	3.10	2.55
−4.2986	1.4370	.0000	.0000	1.18	48	3	1.30	1.38
−8.9163	2.1178	−.0002	.0000	1.57	86	19	2.35	3.44
−4.7906	2.0839	−.0446	.0000	1.08	151	122	6.38	21.44
−27.8545	7.9313	−.4595	.0000	1.17	63	8	1.04	.55
−4.6439	1.6534	.0000	.0000	1.29	152	50	1.80	1.47
−5.6273	4.5173	−1.2823	.1421	1.10	23	4	1.03	1.45
.4276	.3732	.0432	.0000	1.28	65	9	1.92	.86

Table 11. Comparison of suspended-sediment yields estimated by the daily record and the suspended-sediment transport, flow-duration-curve methods

Suspended-sediment sampling-station number (fig. 6)	Station number	Station name	Daily record method	Suspended-sediment transport, flow-duration-curve method			
				Suspended-sediment transport curve based on daily record data		Suspended-sediment transport curve based on partial-record data	
			Yield (tons per square mile per year)	Yield (tons per square mile per year)	Percentage difference from daily record method	Yield (tons per square mile per year)	Percentage difference from daily record method
16	03328500	Eel River near Logansport.	188±79	144±13.5	–23	236±74	26
26	03340800	Big Raccoon Creek near Fincastle.	1,914±1,028	2,620±725	37	1,819±5,170	–5
43	03365500	East Fork White River near Seymour.	186±41	181±7.6	3	466±94	151

Table 12. Suspended-sediment yields estimated from regression equation based on drainage-basin characteristics

Station number	Station name	Latitude (N.)	Longitude (W.)	Channel slope (feet per mile)	Contributing drainage area (square miles)	Amount of forested land in drainage basin (percent of total area)	Peak unit discharge with recurrence interval of two years (cubic feet per second per square mile)	Suspended-sediment yield (tons per square mile per year)
03274650	Whitewater River near Economy	40°00'05"	85°06'56"	11.8	10.4	7.6	89.7	210
03275500	East Fork Whitewater River at Richmond.	39°48'24"	84°54'26"	12.8	121	8.8	96.7	320
03277000	Laughery Creek near Farmers Retreat	38°57'08"	85°04'15"	6.6	248	30.5	83.5	390
03294000	Silver Creek near Sellersburg	38°22'15"	85°43'35"	5.5	189	39.9	66.7	310
03302220	Buck Creek near New Middletown	38°07'13"	86°05'16"	18.6	37.1	29.5	310.0	460
03302300	Little Indian Creek near Galena	38°19'19"	85°55'53"	19.0	16.1	25.5	332.1	420
03302500	Indian Creek near Corydon	38°16'35"	86°06'35"	6.3	118	32.7	123.7	500
03302680	West Fork Blue River at Salem	38°36'19"	86°05'40"	36.8	19.0	10.1	178.9	91
03302800	Blue River at Fredericksburg	38°26'02"	86°11'31"	6.5	206	23.7	102.9	480
03322100	Pigeon Creek at Evansville	38°00'14"	87°32'19"	2.4	323	10.0	24.6	200
03322500	Wabash River near New Corydon	40°33'50"	84°48'10"	3.2	262	7.9	24.5	190
03323500	Wabash River at Huntington	40°51'20"	85°29'53"	2.0	721	9.6	17.3	170
03324200	Salamonie River at Portland	40°25'40"	85°02'20"	5.8	85.6	11.0	38.3	190
03324500	Salamonie River at Dora	40°48'42"	85°41'02"	2.7	557	10.7	22.3	190
03325000	Wabash River at Wabash	40°47'25"	85°49'13"	2.5	1,768	10.7	21.2	230
03326000	Mississinewa River near Eaton	40°19'08"	85°19'10"	3.0	310	9.3	42.3	320
03326070	Big Lick Creek near Hartford City	40°25'20"	85°21'04"	4.2	29.2	13.4	43.8	190
03326500	Mississinewa River at Marion	40°34'34"	85°39'34"	2.9	682	8.5	28.2	260
03327000	Mississinewa River at Peoria	40°43'24"	85°57'27"	3.3	808	9.6	27.4	250
03328000	Eel River at North Manchester	40°59'55"	85°45'50"	2.1	417	11.0	15.6	140
03330500	Tippecanoe River at Oswego	41°19'14"	85°47'21"	3.6	113	13.2	5.7	36
03331110	Walnut Creek near Warsaw	41°12'17"	85°52'11"	5.5	19.6	7.5	17.3	73
03332300	Little Indian Creek near Royal Center.	40°52'53"	86°35'26"	7.1	35	5.3	12.5	56
03332400	Big Monon Creek near Francesville	49°59'03"	86°51'43"	2.4	152	13.4	15.6	110
03333500	Wildcat Creek at Greentown	40°27'25"	85°57'24"	3.3	168	4.9	30.7	230
03333600	Kokomo Creek near Kokomo	40°26'28"	86°05'20"	4.5	24.7	7.8	30.7	140
03333700	Wildcat Creek at Kokomo	40°28'24"	86°09'26"	2.7	242	6.6	30.3	240
03334000	Wildcat Creek at Owasco	40°27'50"	86°38'15"	3.3	396	9.1	22.1	180
03334500	South Fork Wildcat Creek near Lafayette.	40°25'04"	86°46'05"	7.1	243	8.3	39.5	230
03335700	Big Pine Creek near Williamsport	40°19'03"	87°17'26"	4.4	323	3.2	28.5	240
03339108	East Fork Coal Creek near Hillsboro	40°06'06"	87°07'54"	11.6	33.4	4.0	68.6	220
03341000	Big Raccoon Creek at Mansfield	39°40'32"	87°06'05"	6.7	248	14.6	66.9	350
03341200	Little Raccoon Creek near Catlin	39°40'38"	87°13'38"	11.4	133	23.8	112.8	360
03342500	Busseron Creek near Carlisle	38°58'26"	87°25'33"	2.9	228	22.2	25.5	170
03348000	White River at Anderson	40°06'20"	85°40'16"	4.4	406	9.7	33.7	250
03348350	Pipe Creek at Frankton	40°13'38"	85°45'58"	4.5	113	5.8	25.4	160
03349000	White River at Noblesville	40°02'50"	86°01'00"	3.9	858	9.1	21.4	190
03349500	Cicero Creek near Arcadia	40°10'34"	85°59'43"	4.0	131	7.8	23.1	150
03349700	Little Cicero Creek near Arcadia	40°10'32"	86°02'45"	6.2	40.4	3.9	55.2	260
03350100	Hinkle Creek near Cicero	40°06'05"	86°05'10"	18.7	18.5	12.2	158.4	240
03351000	White River near Nora	39°54'35"	86°06'20"	3.7	1,219	8.5	16.6	160
03351310	Crooked Creek at Indianapolis	39°49'47"	86°12'22"	14.8	17.9	9.3	167.0	330
03352200	Mud Creek at Indianapolis	39°53'30"	86°00'57"	6.7	42.4	6.5	32.5	140
03352500	Fall Creek at Millersville	39°51'07"	86°05'15"	5.3	298	10.3	19.0	130

Table 12. Suspended-sediment yields estimated from regression equation based on drainage-basin characteristics—Continued

Station number	Station name	Latitude (N.)	Longitude (W.)	Channel slope (feet per mile)	Contributing drainage area (square miles)	Amount of forested land in drainage basin (percent of total area)	Peak unit discharge with recurrence interval of two years (cubic feet per second per square mile)	Suspended-sediment yield (tons per square mile per year)
03353000	White River at Indianapolis	39°45'05"	86°10'30"	3.5	1,635	9.0	21.7	230
03353160	Pleasant Run at Brookville Road, Indianapolis.	39°45'52"	86°05'43"	15.8	10.1	2.5	205.0	410
03353500	Eagle Creek at Indianapolis	39°46'33"	86°15'01"	6.8	174	11.9	63.8	320
03353620	Lick Creek at Indianapolis	39°42'21"	86°06'13"	11.5	15.6	8.6	137.8	340
03353700	West Fork White Lick Creek at Danville.	39°45'36"	86°30'47"	10.6	28.8	10.3	116.3	330
03359000	Mill Creek near Manhattan	39°29'22"	86°55'50"	5.1	294	20.9	23.0	140
03359500	Deer Creek near Putnamville	39°34'04"	86°52'00"	12.6	59	55.7	163.1	360
03360000	Eel River at Bowling Green	39°22'58"	87°01'14"	5.8	830	26.2	33.0	220
03361650	Sugar Creek at New Palestine	39°42'51"	85°53'08"	9.9	93.9	5.8	20.4	90
03362000	Youngs Creek near Edinburgh	39°25'08"	86°00'18"	4.3	107	44.7	70.9	310
03363000	Driftwood River near Edinburgh	39°20'21"	85°59'11"	5.9	1,060	8.0	27.8	230
03363900	Flatrock River at Columbus	39°14'06"	85°55'36"	5.0	534	8.0	27.2	210
03364000	East Fork White River at Columbus	39°12'00"	85°55'32"	3.8	1,707	7.6	27.1	280
03364200	Haw Creek near Clifford	39°16'04"	85°51'22"	8.9	47.5	1.1	51.8	250
03364500	Clifty Creek at Hartsville	39°16'25"	85°42'10"	10.3	91.4	4.6	85.6	350
03366000	Graham Creek near Vernon	38°55'47"	85°33'45"	9.4	77.2	30.3	159.3	490
03367000	Muscatatuck River near Austin	38°46'13"	85°49'21"	6.2	359	50.5	76.6	370
03368000	Brush Creek near Nebraska	39°04'13"	85°29'10"	28.1	11.4	32.1	309.6	200
03369000	Vernon Fork Muscatatuck River near Butlerville.	39°02'55"	85°32'40"	12.2	85.9	31.4	139.7	370
03371520	Back Creek at Leesville	38°50'48"	86°18'06"	28.4	24.1	36.3	292.5	210
03371600	South Fork Salt Creek at Kurtz	38°57'46"	86°12'12"	13.0	38.2	54.2	149.5	300
03371650	North Fork Salt Creek at Nashville	39°12'06"	86°14'51"	13.5	76.1	69.6	87.8	190
03372000	North Fork Salt Creek near Belmont	39°09'00"	86°20'14"	9.0	120	88.4	99.2	290
03372700	Clear Creek near Harrodsburg	39°02'03"	86°34'01"	19.1	47.8	31.1	172.0	260
03373000	Salt Creek near Peerless	38°56'36"	86°30'36"	2.0	573	66.9	34.2	230
03373200	Indian Creek near Springville	38°57'01"	86°40'30"	12.5	60.7	38.5	101.5	240
03374455	Patoka River near Hardinsburg	38°26'41"	86°23'14"	23.6	12.8	76.6	268.8	210
03374500	Patoka River near Ellsworth	38°26'29"	86°43'31"	3.2	171	45.8	33.2	180
03375500	Patoka River at Jasper	38°24'49"	86°52'36"	2.4	262	47.6	30.4	180
03375800	Hall Creek near Saint Anthony	38°21'45"	86°49'43"	18.2	21.8	24.0	175.2	260
03376260	Flat Creek near Otwell	38°26'12"	87°07'52"	6.4	21.3	10.0	64.8	230
03376300	Patoka River at Winslow	38°22'48"	87°13'00"	1.3	603	39.1	17.7	140
03376350	South Fork Patoka River near Spurgeon	38°17'50"	87°15'39"	9.9	42.8	30.9	90.9	250
04093500	Burns ditch at Gary	41°34'30"	87°17'20"	3.2	160	6.0	15.5	110
04094000	Little Calumet River at Porter	41°37'18"	87°05'13"	6.2	66.2	18.1	30.7	130
04094500	Salt Creek near McCool	41°35'48"	87°08'40"	4.7	74.6	12.6	25.9	130
04099750	Pigeon River near Scott	41°44'56"	85°34'35"	3.5	307	6.8	6.3	53
04100252	Forker Creek near Burr Oak	41°19'58"	85°25'25"	10.0	19.2	32.0	14.2	36
04100465	Turkey Creek at Syracuse	41°25'35"	85°45'16"	10.2	43.8	5.6	3.7	15
04177720	Fish Creek at Hamilton	41°31'55"	84°54'12"	16.0	37.5	6.0	13.1	34
04178000	Saint Joseph River near Newville	41°22'29"	85°48'41"	6.2	610	6.3	11.9	95
04179500	Cedar Creek at Auburn	41°21'57"	85°03'08"	8.0	87.3	10.0	15.5	71
04180500	Saint Joseph River near Fort Wayne	41°10'41"	85°03'19"	2.3	1,060	9.8	10.7	110

Table 12. Suspended-sediment yields estimated from regression equation based on drainage-basin characteristics—Continued

Station number	Station name	Latitude (N.)	Longitude (W.)	Channel slope (feet per mile)	Contributing drainage area (square miles)	Amount of forested land in drainage basin (percent of total area)	Peak unit discharge with recurrence interval of two years (cubic feet per second per square mile)	Suspended-sediment yield (tons per square mile per year)
04181500	Saint Marys River at Decatur	40°50'55"	84°56'16"	2.1	621	5.1	15.6	160
04182590	Harber ditch at Fort Wayne	41°00'27"	85°10'58"	3.9	21.9	4.6	40.5	200
04183000	Maumee River at New Haven	41°05'06"	85°01'19"	2.9	1,967	8.1	9.7	110
05515500	Kankakee River at Davis	41°24'00"	86°42'04"	1.3	400	9.4	3.8	38
05516000	Yellow River near Bremen	41°25'11"	86°10'14"	5.0	131	11.2	13.2	78
05517000	Yellow River at Knox	41°18'10"	86°37'14"	2.3	384	12.9	9.7	82
05517500	Kankakee River at Dunns Bridge	41°13'17"	86°57'52"	.9	1,160	11.4	4.1	49
05519500	West Creek near Schneider	41°12'52"	87°29'36"	2.3	54.7	10.2	29.8	170
05522000	Iroquois River near North Marion	40°58'12"	87°06'50"	2.9	144	10.3	9.7	68
05522500	Iroquois River at Rensselaer	40°56'00"	87°07'44"	2.5	203	8.1	9.1	72
05523000	Bice ditch near South Marion	40°52'00"	87°05'32"	6.4	21.8	5.3	37.3	150
05523500	Slough Creek near Collegeville	40°53'30"	87°09'17"	2.2	83.7	7.9	24.7	160
05524000	Carpenter Creek at Egypt	40°51'58"	87°12'20"	6.4	44.8	.1	46.7	290
05536190	Hart ditch at Munster	41°33'40"	87°28'50"	7.4	70.7	5.9	30.7	150
05536195	Little Calumet River at Munster	41°34'07"	87°31'18"	4.6	90	7.9	12.2	73

Table 13. Percentage distribution of suspended-sediment yields estimated from partial records

Percentage of partial-record stations where estimated suspended-sediment yield was equaled or exceeded	Estimated suspended-sediment yield (tons per square mile per year)
10	390
25	245
50	160
75	106
90	48

Table 14. Seasonal Kendall test results for trends in streamflow and suspended-sediment concentration, flow-adjusted suspended-sediment concentration, and suspended-sediment discharge at daily record and partial-record stations

Suspended-sediment sampling-station number (fig. 6)	Station number	Station name	Period of record (water years)	Streamflow		Suspended-sediment concentration		Flow-adjusted suspended-sediment concentration		Suspended-sediment discharge	
				Probability level	Trend (cubic feet per second per year)	Probability level	Trend (milligrams per liter per year)	Probability level	Trend (percent per year)	Probability level	Trend (tons per day per year)
			Daily Record Stations								
16	03328500	Eel River near Logansport	1969–81	0.147	–7.6	0.155	–1.3	0.001	–4.2	0.240	–1.0
26	03340800	Big Raccoon Creek near Fincastle	1960–79	.001	1.4	.007	1.0	.109	1.8	.001	.2
48	03365500	East Fork White River at Seymour	1966–81	.004	25.0	.019	1.1	.668	.3	.017	4.2
64	04182000	St. Marys River near Fort Wayne	1953–67	.020	–1.3	.096	–1.1	.119	–1.5	.424	–.1
			Partial-Record Stations								
2	03275000	Whitewater River near Alpine	1968–79	.646	64.2	.298	21.0	.108	18.1	.358	32.5
3	03275600	East Fork Whitewater River at Abington.	1967–79	.664	–.6	.076	1.0	.043	5.4	.256	.1
5	03276500	Whitewater River at Brookville	1975–84	.186	45.0	.750	.7	.856	1.0	.466	3.2
6	03276700	South Hogan Creek near Dillsboro	1969–84	.870	.0	.661	.4	.209	2.4	.783	.0
8	03303000	Blue River near White Cloud	1968–82	.295	4.9	.765	–.8	.455	–2.7	.654	.5
9	03303300	Middle Fork Anderson River at Bristow.	1964–80	.018	2.7	.063	.9	.217	4.7	.016	.2
10	03322900	Wabash River at Linn Grove	1971–82	.037	–8.5	.139	–4.5	.511	–2.2	.018	–1.2
12	03324000	Little River near Huntington	1970–78	.074	–4.9	.041	–4.1	.022	–8.7	.083	–1.1
13	03324300	Salamonie River near Warren	1964–76	.147	2.2	.869	.3	.223	3.3	.198	.3
14	03325500	Mississinewa River near Ridgeville	1976–82	.007	9.1	.001	10.1	.181	37.1	.001	.8
18	03329700	Deer Creek near Delphi	1969–80	.218	–5.3	.019	–7.4	.062	–6.8	.037	–2.2
19	03331500	Tippecanoe River near Ora	1968–79	.673	11.1	.669	–.9	1.000	–.3	.673	3.5
21	03335000	Wildcat Creek near Lafayette	1968–80	.553	–4.0	.412	–1.3	.523	–1.8	.218	–1.9
22	03335500	Wabash River at Lafayette	1964–82	.029	214.3	.784	.7	.274	–1.5	.132	37.0
24	03339500	Sugar Creek at Crawfordsville	1972–79	.267	17.5	.026	6.0	.081	8.2	.057	5.0
32	03348500	White River near Noblesville	1968–74	.413	11.2	.623	1.2	.870	4.2	.870	1.0
36	03353200	Eagle Creek at Zionsville	1969–79	.737	.3	.254	2.6	.546	1.2	.381	.1
39	03354500	Beanblossom Creek at Beanblossom	1978–82	.558	.2	.010	3.5	.011	29.1	.137	.0
40	03357500	Big Walnut Creek near Reelsville	1969–82	1.000	.3	.750	–2.0	.671	–2.3	.915	–.1
41	03358000	Mill Creek near Cataract	1969–80	.028	19.4	.927	–2.0	.144	–6.3	.144	2.5
43	03361500	Big Blue River at Shelbyville	1968–80	.017	45.2	.288	5.1	.288	–2.5	.029	11.7
45	03362500	Sugar Creek near Edinburgh	1968–79	.017	29.8	1.000	–.2	.145	–5.6	.180	3.8
46	03363500	Flatrock River at St. Paul	1969–82	.883	1.7	.883	.5	.556	2.5	.556	.4
47	03365000	Sand Creek near Brewersville	1969–80	.006	19.4	.049	11.0	.116	9.6	.031	2.4
48	03365500	East Fork White River at Seymour	1973–82	.260	–197.6	.060	–67.5	.060	–14.6	.133	–894.4
49	03366500	Muscatatuck River near Deputy	1968–78	.051	34.4	1.000	–.2	.445	–9.0	.051	2.3
51	03372300	Stephens Creek near Bloomington	1978–82	.479	–.2	.184	1.0	.616	14.0	.811	.0
53	03374100	White River at Hazelton	1974–84	.558	–152.5	.259	1.8	.867	.4	.802	9.6
54	03376500	Patoka River near Princeton	1964–80	.090	23.5	.924	.0	.188	–6.9	.060	1.7
55	03378500	Wabash River at New Harmony	1975–84	.241	850.0	.443	2.2	.639	.6	.159	450.0
60	04099510	Pigeon Creek near Angola	1978–81	.263	7.2	.012	–3.7	.002	–29.3	.093	–.3
71	05524500	Iroquois River near Foresman	1968–80	.845	1.1	.001	–6.4	.001	–9.8	.067	–3.7

Table 15. Summary of trend test results at the 90-percent confidence level for streamflow and suspended-sediment concentration, flow-adjusted suspended-sediment concentration, and suspended-sediment discharge at daily record and partial-record stations

Type of data	Number of stations showing:		
	Downward trend	No trend	Upward trend
Daily Record Stations			
Streamflow	1	1	2
Suspended-sediment concentration.	1	1	2
Flow-adjusted suspended-sediment concentration.	1	3	0
Suspended-sediment discharge.	0	2	2
Partial–Record Stations			
Streamflow	2	21	9
Suspended-sediment concentration.	5	21	6
Flow-adjusted suspended-sediment concentration.	5	24	3
Suspended-sediment discharge.	5	20	7