Instrumentation, Methods of Flood-Data Collection and Transmission, and Evaluation of Streamflow-Gaging Network in Indiana

By Dale R. Glatfelter and Gerard K. Butch

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CONVERSION FACTORS

Multiply	By	To obtain
inch (in.)	2.54	centimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
acre-foot (acre-ft)	1,233	cubic meter
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

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ABSTRACT

Floods destroy more lives and property than any other type of natural disaster in the Nation. In Indiana, several major floods have occurred since 1900. Flooding can occur at any time and place in Indiana. The degree of flooding can vary from a minor inconvenience to a major disaster that results in loss of life and extensive property damage. The streamflow-gaging network in Indiana as it exists in 1989 is evaluated in this study on the basis of meeting flood-data needs of various governmental agencies.

The study area (Indiana and adjacent areas in Illinois, Michigan, and Ohio) was divided into 12 basins and 1 urban area. Each basin and the Indianapolis area were analyzed on the basis of hydrologic characteristics, flood potential, and availability and benefits of real-time data. A set of guidelines for evaluating existing streamflow-gaging stations without telemetry was developed so quantitative comparisons could be made between stations. Two major components comprise the guidelines: characteristics of the site (drainage area, peak discharge, and population of the nearby area) and flood-warning management and planning use of the data. From the analyses, determinations were made concerning modifications or additions to the network to improve flood-data collection and transmission. These determinations were discussed at interagency meetings to ensure agreement.

The study results indicate that installation of 15 new sites would improve flood-data collection. These 15 new sites, plus equipping 26 existing streamflow-gaging stations with telemetry (preferably data-collection platforms with satellite transmitters), would improve transmission of flood data for potential users.

INTRODUCTION

Floods destroy more lives and property than any other type of natural disaster in the Nation. About 200 people die from flood-related causes each year, and nearly $5 billion in property damages are incurred annually (Federal Interagency Advisory Committee on Water Data, Hydrology Subcommittee, 1985).

In Indiana, flash floods caused by local intense thunderstorms affect small drainage basins each year. The severity of flooding can vary from a minor inconvenience to a major disaster that results in the loss of life and extensive damage to agriculture, industry, transportation, housing, and commerce. Because the risk of flooding exists at any time and place in Indiana, collecting and transmitting dependable and timely data from flooded areas might be limited by the existing streamflow-gaging network. The U.S. Geological Survey (USGS), in cooperation with the Indiana Department of Natural Resources, Division of Water, has determined that this network must be evaluated to identify the modifications or additions that would improve data collection and transmission during floods. Recent advances in technology have made collecting and transmitting real-time data practical.

Purpose and Scope

This report describes the results of a study to evaluate the streamflow-gaging network in Indiana as it exists in 1989 and identifies modifications or additions that would improve data collection and transmission of information during floods.

The study is limited to such interagency flood-related concerns as real-time or near real-time data recording, spatial distribution of gaged sites, and data dissemination. Drainage basins that have fewer than optimal streamflow-gaging stations and existing stations that would provide useful information if telemetry were installed are identified.

For the study, Indiana was divided into 12 river basins; the Indianapolis area also was evaluated. Each was analyzed on the basis of (1) hydrologic site characteristics, (2) flood potential, and (3) availability and benefits of real-time data.

Background

In Indiana, several major floods have occurred since 1900. The March 1913 flood brought such disaster and ruin to the Wabash, White, East Fork White, Maumee, Whitewater, and Patoka River basins that it will long be remembered and be compared to future floods. The devastating January 1937 flood on the Ohio River and the January–February 1959 floods in the Ohio, Whitewater, East Fork White, and upper Wabash River basins were caused by heavy rain falling on frozen soil. The floods of June–July 1957 in the Wabash and White River basins in central Indiana and the July–August 1979 floods in the White, East Fork White, Patoka, Ohio, and lower Wabash River basins were caused by the remnants of hurricanes that moved through the Ohio River Valley. Snowmelt floods in March 1978 and March 1982 produced extensive flooding in the St. Joseph, Maumee, Kankakee, and upper Wabash River basins. Since the inception of the National Flood Insurance Program (NFIP) in 1971, Indiana has received presidential flood disaster declarations in 1978, 1979, and 1982.

The spatial distribution of rain gages presented in this report is based on information provided by the National Weather Service, the U.S. Army Corps of Engineers, the Indiana Department of Natural Resources, and the U.S. Geological Survey. Locations where additional rain gages might assist network operations are identified.

Areas in Illinois, Michigan, and Ohio that drain into Indiana are included in the study. These areas are approximately one-fourth the size of Indiana. Ohio River tributaries in Kentucky are not analyzed.

Acknowledgments

The cooperation and contributions of a number of Federal and State agencies are gratefully acknowledged. Among these are the Indiana Department of Natural Resources, Division of Water; the U.S. Army Corps of Engineers, Louisville, Chicago, and Detroit Districts; the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, River Forecast Centers (Minneapolis, Minn., and Cincinnati, Oh.) and Weather Service Forecast Office (Indianapolis, Ind.); and the Federal Emergency Management Agency. Personnel from these agencies supplied data-collection information concerning data-collection networks operated by their agency and met on several occasions to discuss the contents of this report.

INSTRUMENTATION

During floods, more people are concerned about the elevation of the water surface (stage) than about the amount of water flowing (discharge). Stage is measured in Indiana streams by a variety of automatic and manual equipment. Brief descriptions of the various types of data-collection instrumentation are from Rantz and others (1982) and Buchanan and Somers (1968).

Measurement of precipitation determines the vertical depth of water that would accumulate if all components were in the form of water. The objective in gaging precipitation is to obtain a sample that is representative of precipitation over a specific area. Brief descriptions presented in this report of several instruments and methods for measurement of precipitation are from the U.S. Geological Survey (1977) and the U.S. Department of Commerce (1970).

Stage

Automatic (recording) equipment includes graphic recorders, digital recorders, and data-collection platforms connected to floats in stilling wells or pressure-sensitive bubble-gage systems. Examples of manual (nonrecording) equipment are electric-tape gages, staff gages, and wire-weight gages. The type of equipment at a location depends on several factors, including the intended use of the data.

Nonrecording Equipment

The standard vertical staff gage (fig. 1) consists of porcelain-enameled iron sections, each 4 in. wide, 3.4 ft long, and graduated every 0.02 ft. The vertical staff gage is used in stilling wells as an inside reference gage or in the stream as an outside gage. Stage is read directly by observing where the water surface cuts the staff scale.

The standard wire-weight gage (fig. 2) consists of a drum wound with a single layer of cable, a bronze weight attached to the end of the cable, a graduated disc, and a counter—all within a metal box. The disc is graduated in tenths and hundredths of a foot and is permanently connected to the counter and to the shaft of the drum. The diameter of the drum is such that each complete turn represents a 1-ft movement of the weight. The gage is set so that when the bottom of the weight is at the water surface, the gage height is indicated by the combined readings of the counter and the graduated disc. The wire-weight gage is commonly mounted on a bridge handrail, parapet wall, or pier for use as an outside gage. Stage is read by lowering the weight until it touches the water surface and then reading the stage on the counter and disc.

The electric-tape gage (fig. 3) consists of a steel tape graduated in feet and hundredths of a foot, to which is fastened a cylindrical weight; a reel in a frame for the tape; a battery; and a voltmeter. One terminal of the battery is attached to a ground connection, and the other to one terminal of the voltmeter. The other terminal of the voltmeter is connected to the weight through the frame, reel, and tape. The weight is lowered until it contacts the water surface. This contact completes the electric circuit and produces a signal on the voltmeter. With the weight held in the position of first contact, the tape reading is observed at the index provided on the reel mounting. The electric-tape gage usually is used as an inside reference gage.

Methods of Sensing Stage

The float and tape system (fig. 4) consists of a tape or cable passing over a pulley attached to a counterweight at the opposite end of the tape. The float follows the rise and fall of the water level and transfers the stage to the recorder system through the float tape. Stages then can be read manually or recorded by mechanical or electronic data loggers.

The bubble-gage sensor (fig. 5) consists of a gas-purge system, a servomanometer assembly, and a servocontrol unit. The gas-purge system transmits the pressure head of water in the stream

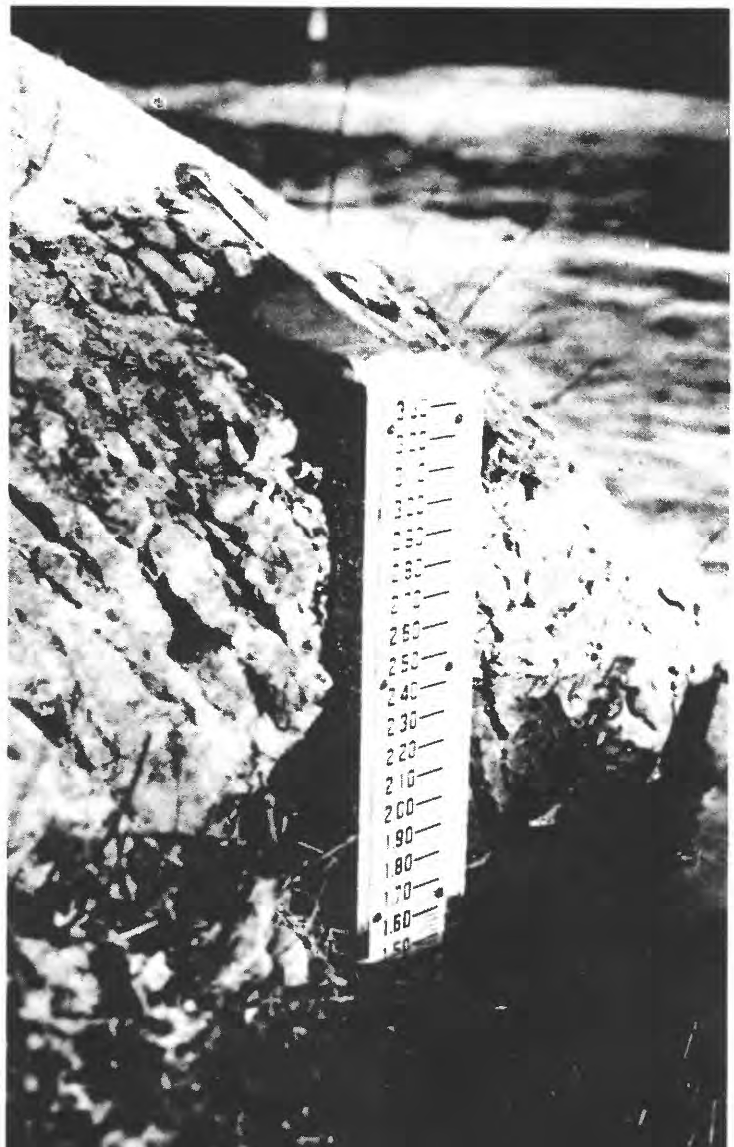


Figure 1.-- Staff gage.

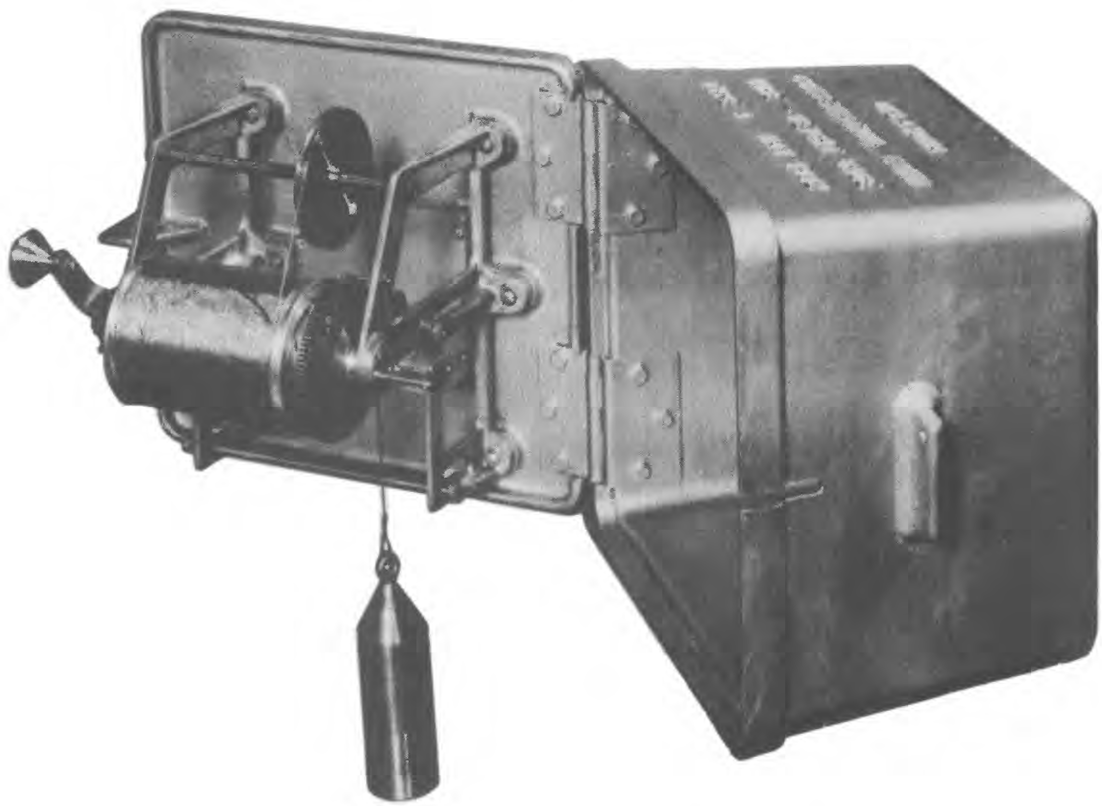


Figure 2.-- Wire-weight gage.

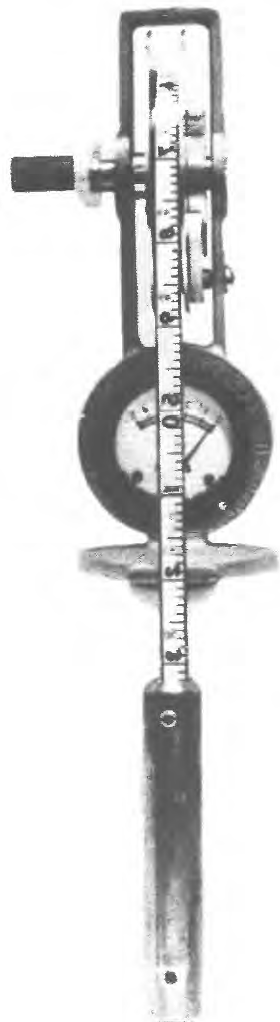


Figure 3.– Electric-tape gage.

fig 4

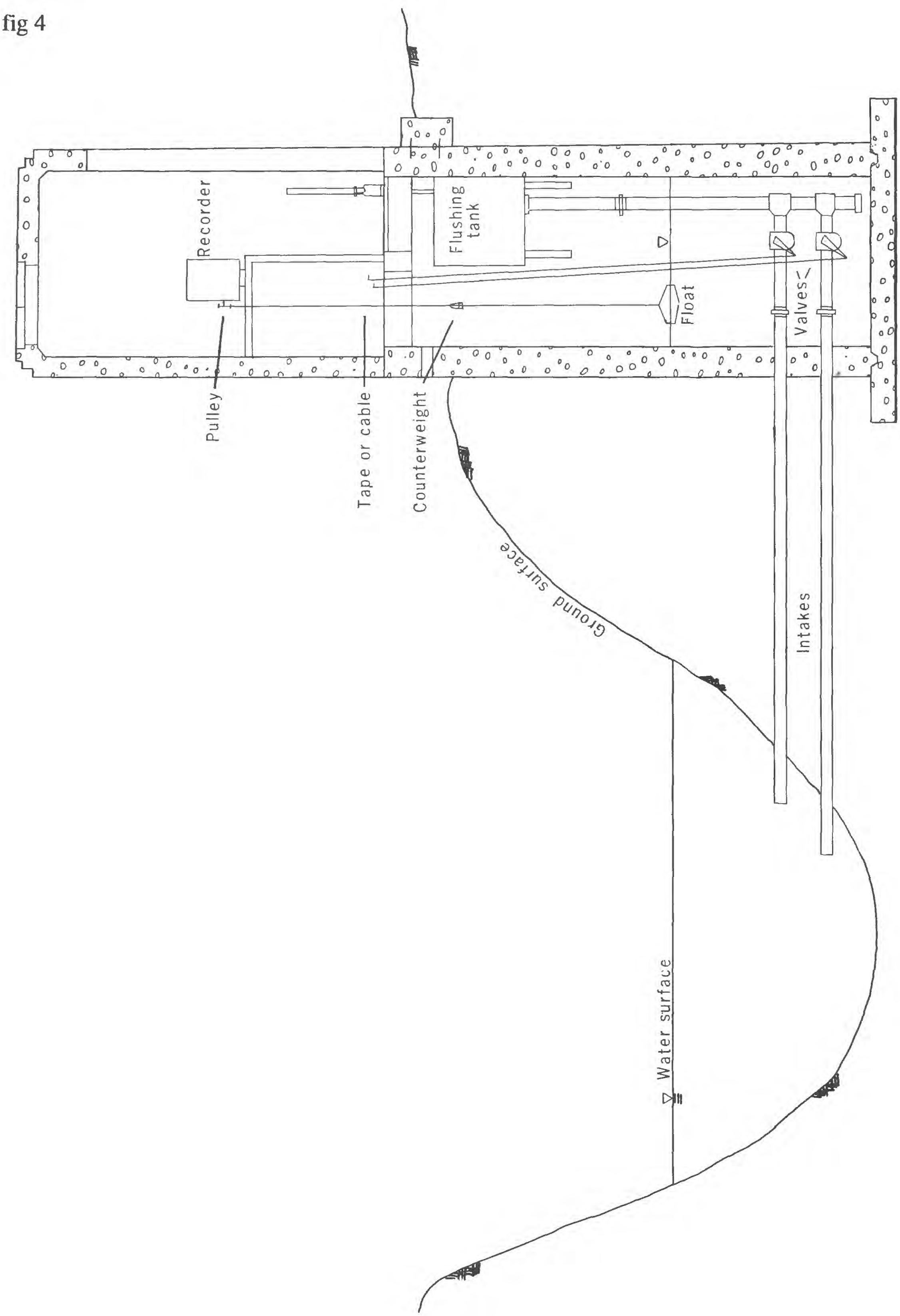


Figure 4.-- Stilling-well installation showing float sensor.

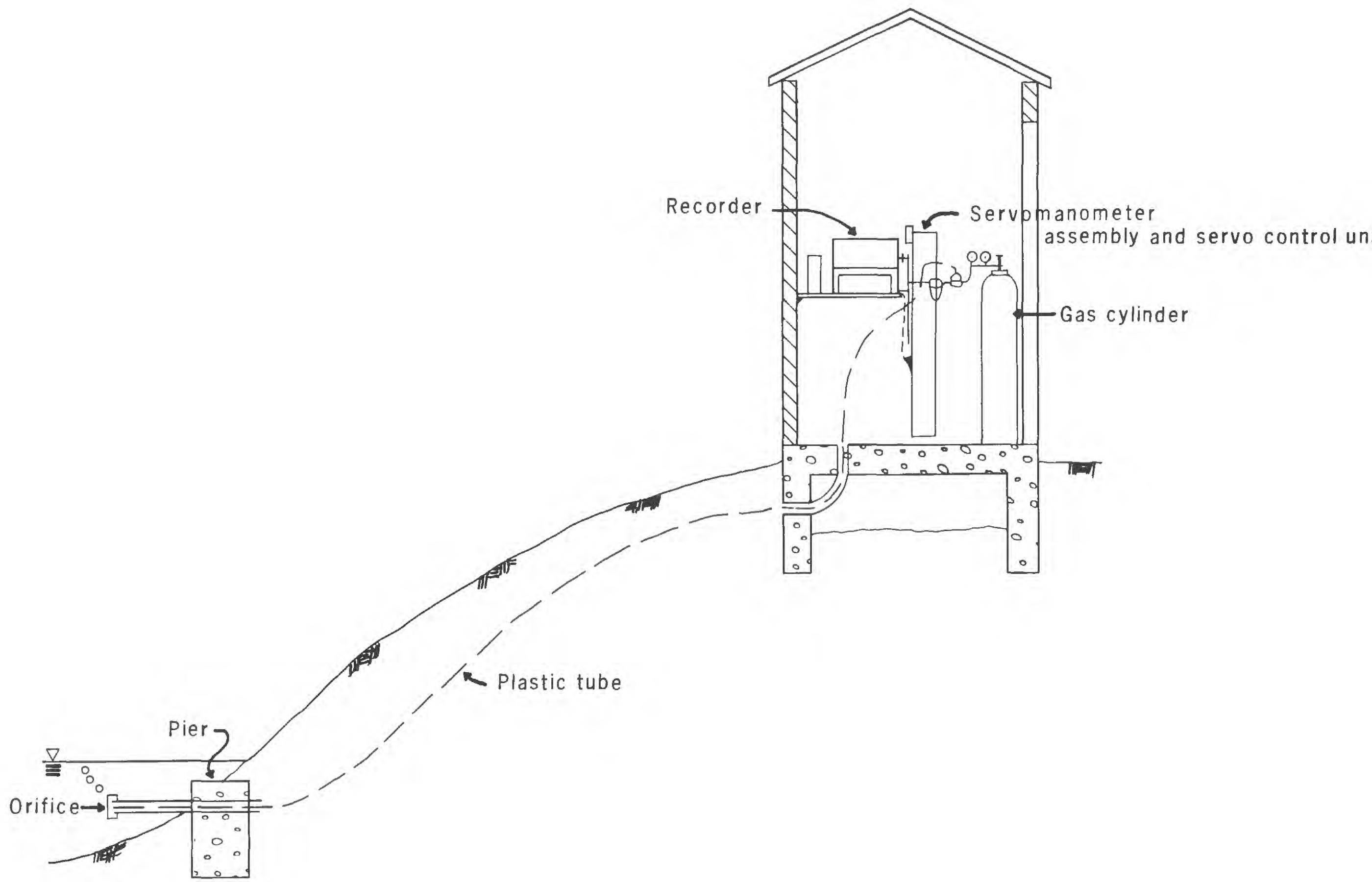


Figure 5.-- Installation showing bubble-gage sensor.

to the manometer location. A gas, usually nitrogen, is fed through a tube and bubbled freely into the stream through an orifice at a fixed elevation in the stream. The gas pressure in the tube is equal to the pressure head on the bubble orifice at any stage. The servomanometer assembly converts the pressure in the gas-purge system to a shaft rotation for driving a water-stage recorder. Proper placement of the orifice is essential for an accurate stage record. The orifice should be located where the weight of water above it represents the stage in the river. The bubble-gage sensor is used primarily at sites where it is not physically possible or cost effective to install a stilling well.

Recording Equipment

A water-stage recorder is an instrument for producing a graphic, punched-tape, or electronic record of the rise and fall of a water surface with respect to time. The recorder consists of a time element and a stage element which, when operating together, produce a record of the fluctuations of the water surface. The time element is controlled by a clock that is driven by a spring, a weight, or an electronic mechanism. The stage element is actuated by a float or a bubble-gage sensor. Digital recorders, graphic recorders, and data-collection platforms can be used with either a float or a bubble-gage sensor.

The digital recorder used by the U.S. Geological Survey (fig. 6) is a battery-operated slow-speed paper-tape punch which records a 4-digit number on a 16-channel paper tape at pre-selected time intervals. Stage is recorded by the instrument in increments of a hundredth of a foot from 00.00 to 99.99 ft and is transmitted to the instrument by rotation of the input shaft. Shaft rotation is converted by the instrument into a coded punch-tape record. Electronic timers activate the digital recorder at pre-selected time intervals, usually from 5 minutes to 1 hour. The activated sequence of operations for one reading includes punching the paper tape, advancing the tape, and compressing the punch spring for the next cycle. Electronic translators are used in the office to transfer the stage data into the computer for analysis.

The graphic or analog recorder (fig. 7) furnishes a continuous pen trace of stage with respect to time on a chart. The stage element moves the pen stylus, and the time element moves the chart. Most graphic recorders can record an unlimited range in stage by a stylus-reversing device. Manual (visual) interpretation of the data is required; therefore, graphic recorders rarely are used as the primary source of record. Graphic recorders, however, are used often as a secondary (backup) recorder at sites subject to rapidly changing stage, ice conditions, or other hydrologic factors that are better analyzed with graphic documentation.

The data-collection platform (fig. 8) provides an alternative to digital and graphic recorders. There is no paper tape or chart associated with the data-collection platform; rather, stage data are stored electronically at pre-selected intervals or on occurrence of specific events. Storage capability varies among manufacturers and models. Stored stage data can be transmitted by telephone, radio, or satellite, or data can be retrieved with a portable field computer. The use of data-collection platforms for the collection, storage, and transmission of stage data has increased rapidly during the past decade and likely will become commonplace as this technology continues to advance.

Precipitation

Precipitation amount is expressed in terms of the vertical depth of water that would accumulate if all components, including snow and ice, were in the form of water. The objective in gaging precipitation is to obtain a sample that is representative of precipitation over a specific area. A precipitation gage typically consists of a collector and a measuring device. Measurements can be made either manually or automatically.

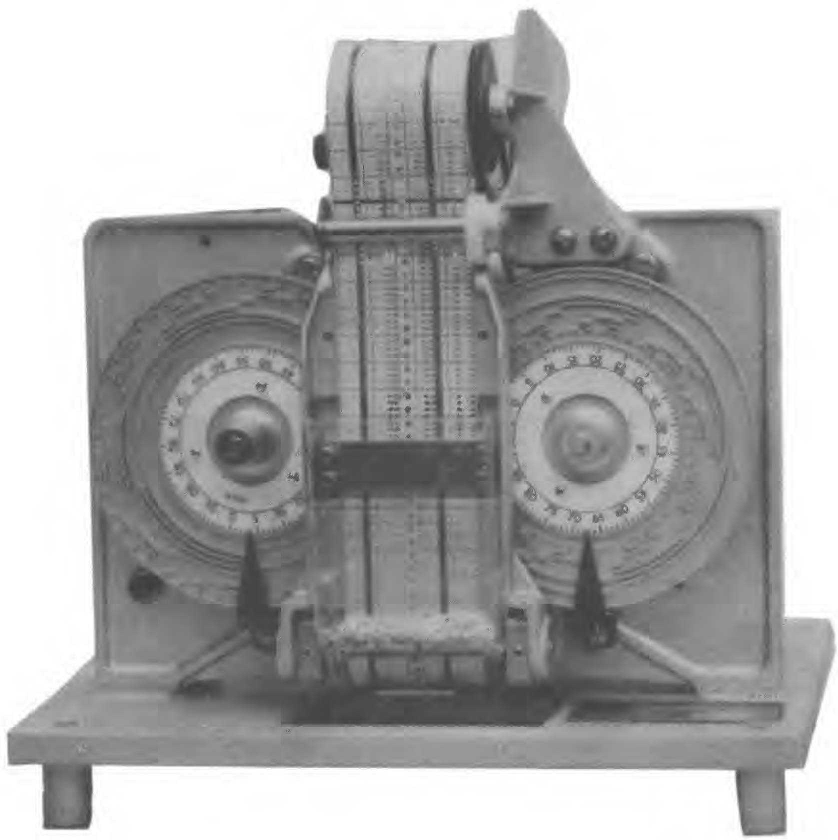


Figure 6.-- Digital recorder.

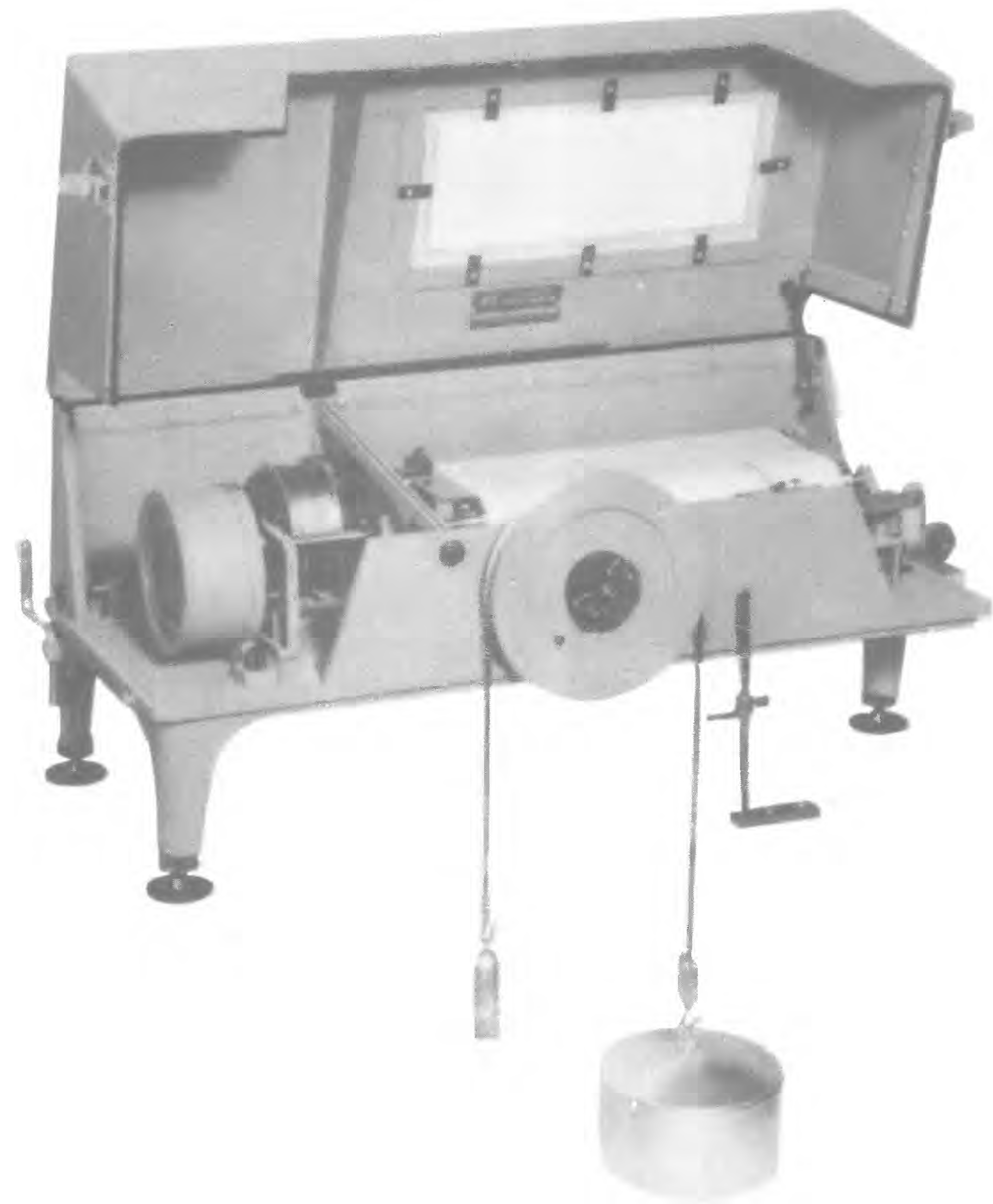


Figure 7.-- Graphic recorder.

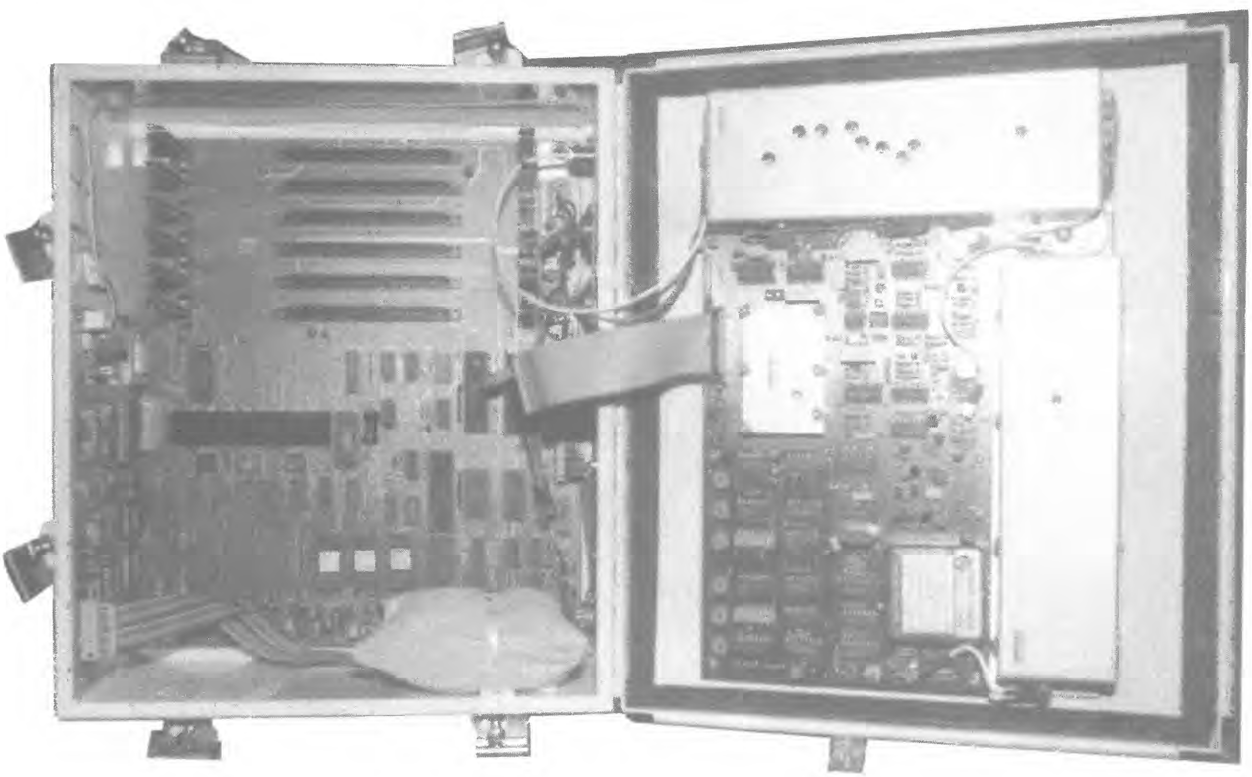


Figure 8.-- Data-collection platform.

Nonrecording Equipment

A standard 8-in.-diameter precipitation gage (fig. 9) is used for measuring precipitation over short time periods and where continuous records are not required. The standard precipitation gage consists of an overflow pan, an 8-in.-diameter funnel, and a measuring tube (U.S. Department of Commerce, 1970). During warm weather, the measuring tube is placed in the overflow can, and the funnel is fitted over its top. During cold weather, the funnel and measuring tube are removed from the gage so that they will not interfere with the accumulation of snow. Standard nonrecording precipitation gages in the National Weather Service (NWS) network are read daily by observers using a measuring stick.

Precipitation also can be measured with a variety of other nonstandard, nonrecording gages. An example is the 4-in.-diameter plastic gage, receiver, and measuring tube (fig. 10) which is similar to the standard 8-in.-diameter gage. Nonstandard precipitation gages are not used in the NWS network, but are used where additional data are required. Data from these gages supplement precipitation data from the NWS network.

Recording Equipment

Recording precipitation gages are used when continuous record of precipitation is required. Two types of precipitation recorders are in general use: the weighing type and the tipping-bucket type. The weighing type is designed to measure any form of precipitation; the tipping-bucket type is used primarily to measure rainfall.

With the weighing-type precipitation gage (fig. 11), the weight of the receiving container (bucket) plus the precipitation that has fallen since the record began is recorded continuously with a spring mechanism or with a system of balance weights. All precipitation, as it falls, is recorded on a graphic chart or punch tape. These units also can be interfaced to a data-collection platform with a potentiometer. This type of instrument is useful for recording snow, hail, and mixtures of snow and rain because the instrument does not require that the solid precipitation be melted before it is measured and recorded.

In the tipping-bucket-type precipitation gage (fig. 12), a lightweight container divided into two equal compartments, or buckets, is balanced above a horizontal axis. Two stops, one on each side of the container, limit its motion. Rain flows from a collecting funnel into one of the compartments until the pair of buckets becomes unbalanced and tips to its other position. This motion drains the water out of the first compartment and places the second compartment in position to receive water from the funnel. The tipping of the bucket operates an electrical contact that "counts" the number of tips. Given the specific amount of rain required to produce a tip, the accumulated amount of precipitation can be recorded at predetermined intervals or stored in computer memory. The tipping-bucket-type gage is a cost-effective alternative to the weighing-type gage. The accuracy of the data, however, might be reduced when rainfall intensity exceeds 6 in. per hour.

METHODS OF FLOOD-DATA COLLECTION AND TRANSMISSION

As the streamflow-gaging network exists in 1989, stage is collected at 226 stations in the study area by the U.S. Geological Survey and other agencies using recording and nonrecording devices. Ninety-six of these stations have some form of telemetry that can provide stage data on a real-time basis.

Precipitation data are collected with recording and nonrecording equipment at 500 locations in the study area. Much of the data is supplied by observers who daily read standard and nonstandard precipitation gages and forward their readings to the National Weather Service.

Figure 9.-- Standard, 8-inch-diameter, nonrecording precipitation gage.

Figure 10.-- Nonstandard, 4-inch-diameter, nonrecording precipitation gage.

Figure 11.– Weighing-type recording precipitation gage.

Figure 12.– Tipping-bucket-type recording precipitation gage.

Existing Streamflow-Gaging and Precipitation Networks

There were 226 locations in the study area (fig. 13) where stage automatically is recorded or where it can be measured manually. Most of these locations (202) are in the network of streamflow-gaging stations operated in Indiana, Michigan, Ohio, and Illinois by the U.S. Geological Survey in cooperation with other Federal, State, and local agencies. The remainder are in networks operated by the National Weather Service, U.S. Army Corps of Engineers, or other agencies. Of the 226 streamflow-gaging stations in the study area, 130 have no telemetry (table 1, at back of report). At 23 of the streamflow-gaging stations with no telemetry, observers collect stage data and transmit the data by telephone. Of the 96 streamflow-gaging stations that have telemetry, 36 have telephone access only, 21 have satellite transmitters only, 33 have telephone access and satellite transmitters, and 6 have telephone access and NWS ultrahigh-frequency (UHF) radio transmission.

Precipitation data are collected at about 500 locations in the study area. Most of these data are collected within various networks operated by or for the National Weather Service. Precipitation is measured with nonrecording or recording equipment, depending on the network. Data from about 170 locations are supplied voluntarily by observers in the National Weather Service amateur radio network. These data are collected with standard and nonstandard nonrecording precipitation gages. Data from about 100 other locations (fig. 14) are collected and forwarded on a daily basis by observers and are published in monthly climatological data reports. Data from about 40 additional locations are collected and forwarded periodically by observers, but they are not published. Hourly precipitation data for about 65 locations (fig. 14) are collected with recording precipitation gages; these data are published on a monthly basis. Instantaneous precipitation data are available at 11 locations (fig. 14) in the Maumee River basin equipped with Automated Local Evaluation in Real Time (ALERT) equipment, and 12 locations (fig. 14) throughout the State that are equipped with a Limited Automatic Remote Collector (LARC) data-collection platform and telephone line. Current data from nonrecording gages are transmitted to the National Weather Service over the telephone by the observer.

The U.S. Army Corps of Engineers maintains a network of about 15 nonrecording precipitation gages, primarily to provide data for use in reservoir project operation. The Indiana Department of Natural Resources, Division of Water, maintains a network of about 50 nonrecording precipitation gages as part of a climatic network. The U.S. Geological Survey maintains about 30 tipping-bucket-type recording precipitation gages for the U.S. Corps of Engineers. These rain gages are located at streamflow-gaging stations. Current data from the U.S. Geological Survey-maintained precipitation gages are relayed by satellite from the field location to the receiving office. Additionally, at some sites, rain data can be obtained by synthesized voice or modem.

Routine Operation of U.S. Geological Survey Streamflow-Gaging Stations

The study area also included 202 U.S. Geological Survey streamflow-gaging stations that are used to measure and record stage. For 195 of these stations, daily mean discharge values are published annually in State water-data reports. Daily mean discharge is determined from the record of stage and a stage-discharge relation developed on the basis of current-meter discharge measurements. The discharge measurements are made on a cyclic basis (usually about every 4 to 6 weeks), at which time data are retrieved and all equipment is serviced to ensure that correct stage values are being recorded or transmitted. The seven stage-only gaging stations are serviced on the same schedule, but no direct discharge measurements are made.

Figure 13.--Location of Streamflow-gaging stations in the study area.

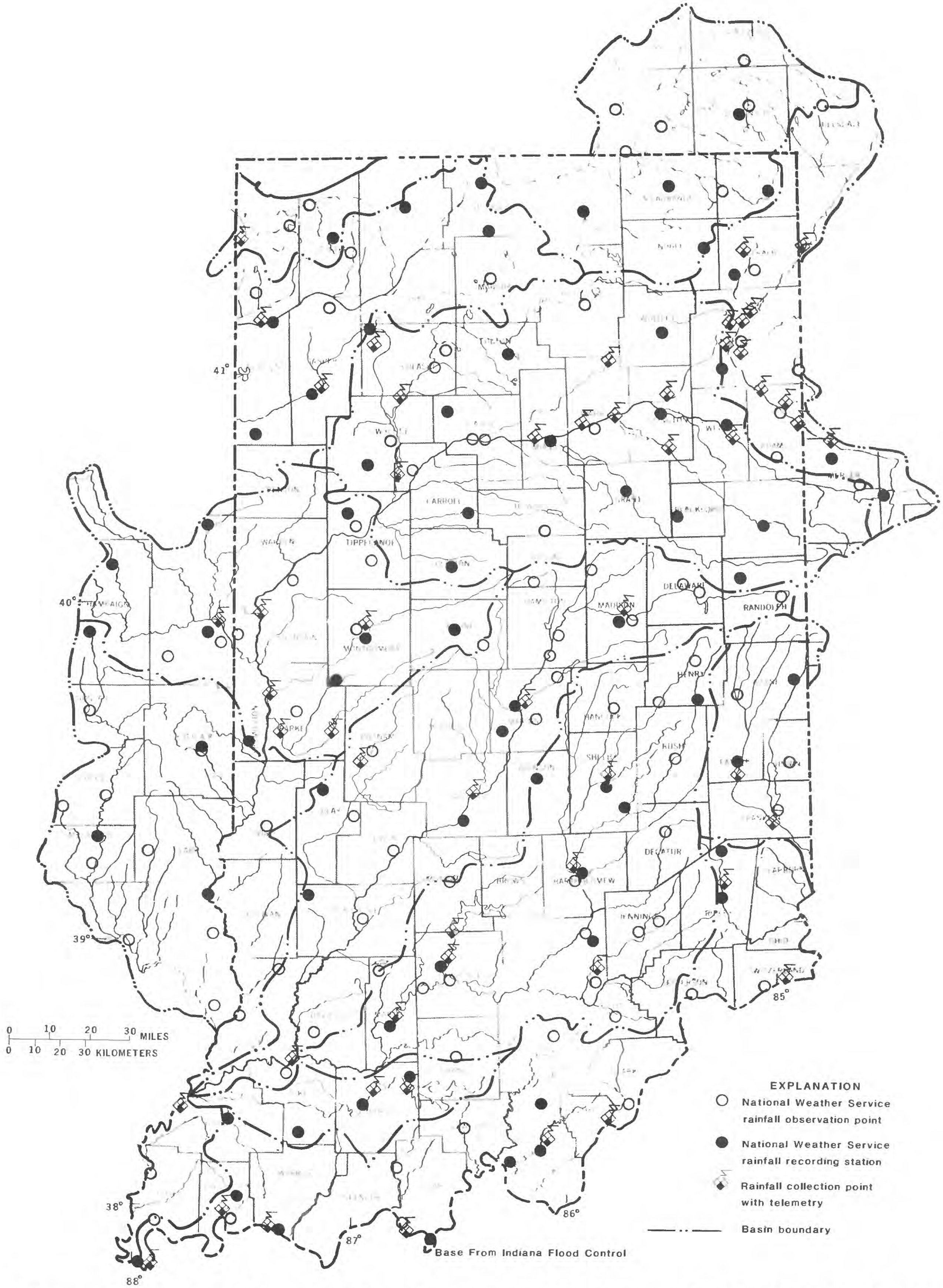


Figure 14.-- Location of selected precipitation gages in the study area.

For the 107 streamflow-gaging stations with no telemetry and with no visual observers, a punched-paper tape is the primary source of stage data; this data must be manually entered into the computer files by an electronic reader. Stage data from the 56 streamflow-gaging stations equipped with data-collection platforms and satellite transmitters are automatically relayed to the computer through a Geostationary Operational Environmental Satellite (GOES). Because the satellite-relayed stage data are transmitted every 4 hours, these data are readily available. There might be as much as a 4-hr. and 59-minute lag between the last value received and the next set of four hourly values because of the transmit time slot. For example, the 1000-hour value might be in the computer, but the 1100-, 1200-, 1300-, and 1400-hour values might not be transmitted until 1459 hours.

Stage data are available on an instantaneous basis from streamflow-gaging stations equipped with alternate telemetry, such as telephone systems or UHF radio. In addition to relaying stage data via satellite, 33 of the 56 data-collection platforms in the network can be interrogated manually or electronically over a telephone line to obtain stage readings between satellite transmissions. Data from another 26 data-collection platforms without satellite transmitters can be obtained in the same manner. In addition to the data-collection platforms, these 26 stations also are equipped with a primary recorder because the alternate telemetry equipment usually has no recording capability.

Instantaneous stage data also can be obtained from 10 streamflow-gaging stations equipped with Telemark equipment. The Telemark gage (fig. 15) codes instantaneous stage and signals this information audibly over telephone circuits. Telemark gage response to the telephone ring is automatic, and the distance of transmission is unlimited. The Telemark gage consists of a positioning element, which is actuated by a float or bubble-gage sensor, and a signaling element. When triggered, the signaling element drives a contact across drums that are positioned in correspondence with the stage. Telemark gages are nonrecording, and only the instantaneous stage at the time of the telephone call can be obtained.

Instantaneous stage data are available through UHF radio for six stations (five U.S. Geological Survey, one National Weather Service) in the ALERT network in the Maumee River basin. Special equipment is needed to interrogate the ALERT equipment, and permission to access the network is required from the City of Fort Wayne.

Data Collection During Floods

Although stage and precipitation data are routinely collected and transmitted, during a flood there is an urgent need by many people to have current (real-time) stage and precipitation data. These data are used in making crucial decisions, such as predicting flood height, planning flood-fighting efforts, and implementing evacuation plans. It is imperative that the data be accurate and timely—in some cases, lives are at stake. At the 130 gages without telemetry, real-time data can be obtained only if the site is visited, the stage data observed, and the observation communicated by telephone.

Stage data can be obtained during a flood from the 10 gages equipped with a Telemark gage and telephone line (table 2, at back of report), if the telephone line is operating and not already in use. These data can be obtained only by telephonic interrogation of the Telemark gage. The instantaneous stage at the time of the telephone call is the only piece of information received. Therefore, if the stage is rapidly rising or falling, frequent interrogations of the Telemark gage might be required.

Instantaneous stage information also is obtainable for 59 locations equipped with a data-collection platform and telephone line (table 3, at back of report). The data-collection platform can be interrogated manually or by computer. In addition to the instantaneous reading, data are collected daily by the USGS with an automated computer interrogation program.

Data from 56 streamflow-gaging stations (table 4, at back of report) are transmitted on a 4-hour cycle by GOES. Various Federal and State agencies receive the transmitted signal by using

Figure 15.– Telemark gage.

each agency's computer hardware and software. For example, the U.S. Geological Survey, Indiana District, receives satellite-transmitted data from the direct readout ground station (DRGS) in Harrisburg, Pa., and from telephone-linked computers in Harrisburg and Indianapolis. Data acquired by this method go directly to a data file in the Indiana District computer and are available within several hours. Once the data are stored in the computer, they are available for retrieval. Event transmissions can be programmed if a threshold stage or rate of change is reached. Advantages of satellite-transmitted data are:

1) transmission initiated at the field location;
2) manual intervention is not required, thus saving cost and time;
3) data are automatically entered into the computer;
4) redundant (previously transmitted) data are sent as part of each transmission, decreasing the amount of missing records;
5) functional telephone lines at the field location are not required;
6) background data are available in addition to the most recent readings; and
7) data are available simultaneously to multiple agencies.

Data from the six gages in the Maumee River basin in the ALERT network (table 5, at back of report) routinely are transmitted to the NWS by UHF radio. If a threshold stage or specified rate of rise occurs, an event transmission is made for notification of possible flooding.

Stage data from hydrographers and gage observers also provide flood information. These sources are invaluable not only for the stage data they provide but also for their eyewitness account of stream conditions. Reports from these individuals must be received manually and recorded for later use. Limitations are that hydrographers might not be in the area of flooding or that a local observer might be unable to make an observation.

Data Transmission During Floods

During a flood, it is imperative that a spirit of interagency cooperation exists so that each agency receives the information it needs to make operational decisions. For example, the NWS needs rainfall data (intensity and totals) and streamflow data (stages and rates of rise) to make flood-height predictions. The U.S. Army Corps of Engineers needs the same data to make decisions concerning reservoir project operation. Civil Defense needs to know if evacuation of specific communities will be necessary. A common thread is woven throughout—all need accurate and timely data.

The term "independently dependent" best describes how Federal and State agencies operate to collect and transmit data during a flood. Most Federal agencies in the study area receive satellite-transmitted data through independent systems. If a particular system is inoperative or malfunctioning, data can be obtained from another agency's system.

Data from streamflow-gaging stations with data-collection platforms, Telemark gages, UHF radio, or observers are collected routinely by the NWS throughout the year. These data and other data acquired by the NWS are widely distributed on the NWS weather wire service. From the weather wire, other agencies can obtain not only NWS data but also USGS stage date, U.S. Army Corps of Engineers reservoir-level data, as well as forecasts, watches, and warnings.

Telephone or computer communication remains the biggest link between agencies for the transmission of data. Interagency communication is essential during a flood to continually monitor the extent and severity of the flood. Each agency has a unique, as well as a common, perspective on the flood. In addition, information that is not available on the weather wire or from interrogation of telemetry-equipped stations can be transferred between agencies by telephone or computer. As examples, an observed stage at a station without telemetry and an observation of flooded areas by a hydrographer are pieces of information not quickly transferable by other mechanisms. The amount of data that are available during a flood is limited by the number of gages that can transmit automatically or be interrogated and by those that can be visited by a hydrographer or an observer.

EVALUATION OF STREAMFLOW-GAGING NETWORK

The main objective of this study is to evaluate the overall streamflow-gaging network in the study area to determine what modifications were necessary for improving the collection and transmission of stage data during floods. The study area was divided into 12 river basins (fig. 16); the Indianapolis area also was evaluated. Each basin and the Indianapolis area were analyzed to determine additional sites where data could be collected or which existing streamflow-gaging stations could be equipped with telemetry. Initial determination of need was based on basin characteristics and use of the data. Final determination of need was based on interagency meetings. The analyses indicated that 15 sites at which no stage data are collected need to be gaged and that these 15 sites—plus 26 existing streamflow-gaging stations—need to be equipped with telemetry, preferably data-collection platforms with satellite transmitters. A map (fig. 17) shows the ungaged sites and existing streamflow-gaging stations that need installation of telemetry. Improved data collection and transmission from implementation of this plan would improve flood-warning management and enhance the overall efforts of many agencies in the reduction of flood damage and loss of life.

Evaluation Criteria

A set of guidelines for evaluating the need for telemetry at an existing streamflow-gaging station without telemetry (table 6, at back of report) was developed so that quantitative comparisons could be made between stations. The factors and points contained in the guidelines were agreed upon at interagency meetings. Two major components comprise the guidelines: characteristics of the site and flood-warning management. A station whose aggregate point total was 20 or more was considered eligible for telemetry installation. Subsequent interagency meetings were held to determine which existing station data are needed on a near real-time basis.

Drainage area is the area contributing directly to surface runoff. This area can be measured from topographic maps or, for Indiana locations, obtained from Hoggatt (1975). The drainage area of the 226 streamflow-gaging stations in the study area ranges from 3 to 108,000 mi^2 (tables 1-5). The drainage area of the 130 streamflow-gaging stations without any telemetry (table 1) ranges from about 3 to 13,700 mi^2. This indicates that most large drainage basins have been given a priority over smaller drainage basins in the installation of telemetry. Stations having a drainage area larger than 300 mi^2 were given more points in the evaluation based on network design recommendations of the World Meteorological Organization (1970).

Peak discharge values during the period of record or from historic information for each of the streamflow-gaging stations in the study area also are shown in tables 1-5. The peak discharges are shown as both the instantaneous flow rate and the unit discharge (instantaneous flow rate divided by the drainage area). Stations having a peak instantaneous discharge greater than 10,000 ft^3/s—and a unit discharge greater than 100 $(ft^3/s)/mi^2$—were given more points in the evaluation. Because peak discharge for the period of record depends on the length of record, a large discharge is more likely to occur during a long period of record than during a short period. To ensure that the evaluation was not biased towards stations with longer periods of record, the instantaneous flow rate and unit discharge of the 50-year recurrence interval flood also are provided for each station in table 1. Points were assigned to an individual station on the basis of the larger of the two discharges—peak discharge during period of record or discharge of 50-year flood.

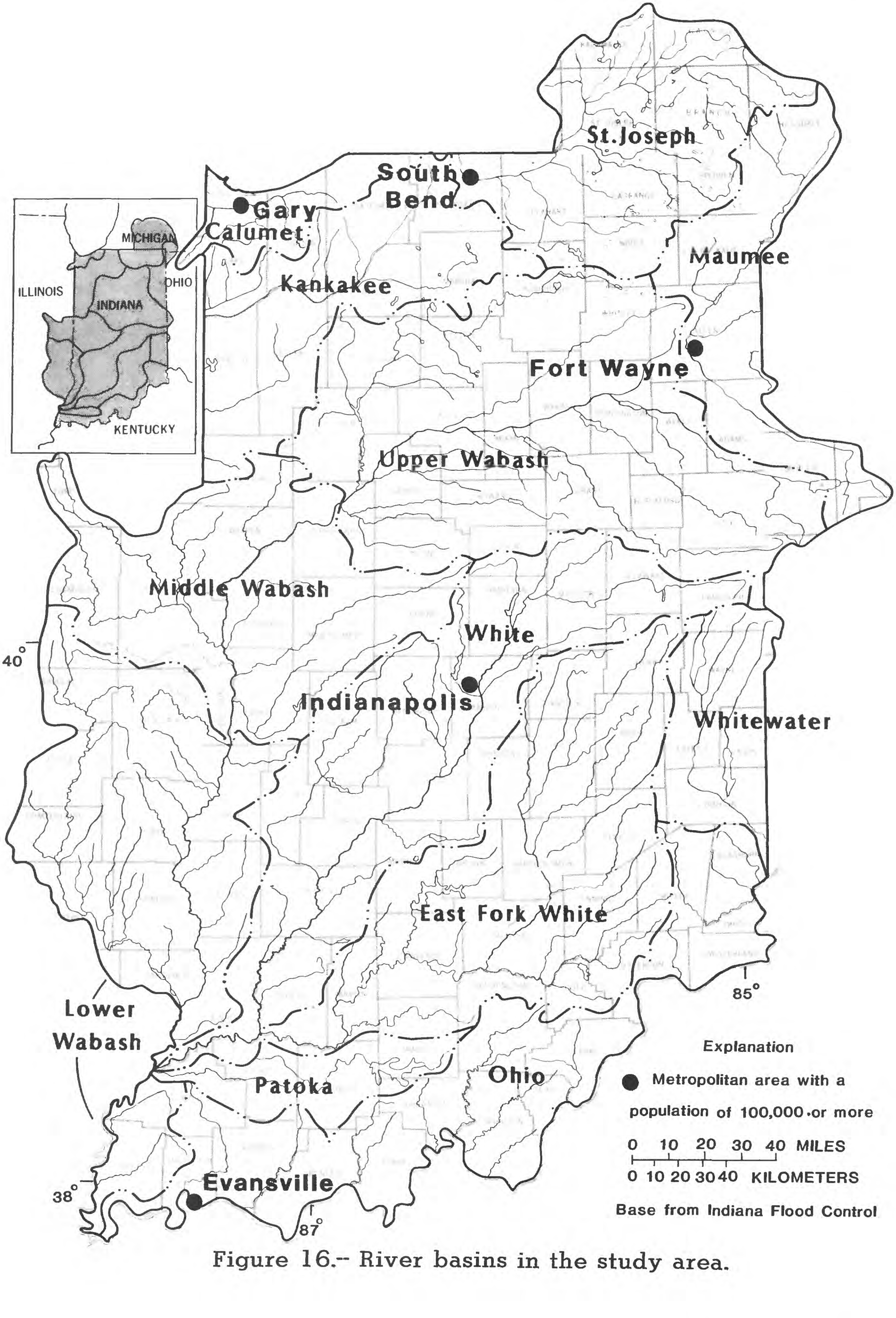


Figure 16.-- River basins in the study area.

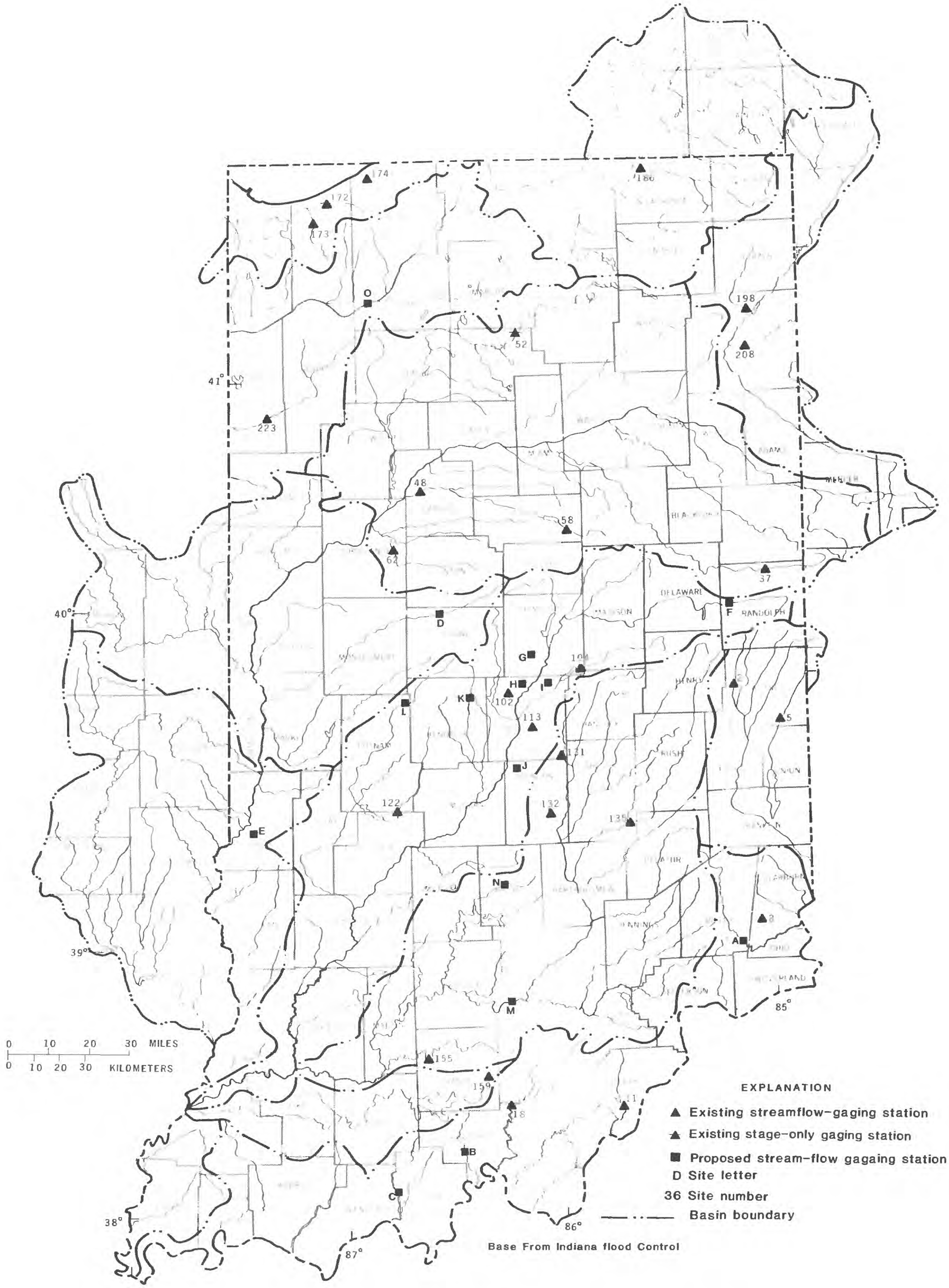


Figure 17.- Potential sites for installation of telemetry.

Population of the nearby area was considered an important factor in evaluating the need for telemetry. Metropolitan areas with a population of 100,000 or more were given more points in the evaluation. Areas with a 1980 population of more than 100,000 (U.S. Department of Commerce, 1982) are Indianapolis (700,807), Fort Wayne (172,196), Gary (151,953), Evansville (130,496), and South Bend (109,727). These areas are shown in figure 16.

The NWS reports stage information over the weather wire on a daily basis from about 65 streamflow-gaging stations. During floods or high water, the NWS issues flood-height (stage) forecasts at 51 streamflow-gaging stations in the study area (table 7, at back of report). Because data from these gages are crucial, it would be useful to install telemetry at all river forecast points.

The U.S. Army Corps of Engineers, Louisville District, operates eight of the nine major flood-control reservoirs in the study area (table 8, at back of report). Eagle Creek Reservoir is operated by the Indianapolis Department of Public Works. Inflow and outflow data are essential for sound reservoir project management, especially during a flood. Therefore, telemetry is needed at all reservoir inflows and outflows.

The regional applications factor allowed for the additional information provided by the various Federal and State agencies to be accounted for in the preparation of this report. For example, a streamflow-gaging station could be assigned points for use in the comparison evaluation if flooding on the stream were a recurring problem or if flooding caused considerable damage. Points were assigned for this factor based on knowledge acquired over many years; therefore, more points were given to streamflow-gaging stations in areas with known flooding problems.

Individual station point determinations from application of the guidelines for evaluation shown in table 6 were made for 97 stations in Indiana (table 9, at back of report). Nineteen existing gaging stations were shown to have a point total of 20 or more, which indicated they could be considered for telemetry installation. Information from the evaluation was used as a starting point in interagency meetings to develop a list of stations at which telemetry could be installed. Seventeen of the nineteen stations from the preliminary screening were subsequently included in the final list of existing stations needing telemetry installation.

Basin Analyses

Each basin was evaluated for the coverage provided by the existing network. Each basin evaluation contains information from Glatfelter (1984) concerning basin characteristics considered significant in estimating flood magnitudes in that area. Basin characteristics used as independent variables in the estimating equations include drainage area; channel slope; channel length; storage; 1941–70 mean annual precipitation; 2-year, 24-hour precipitation; and rainfall-runoff coefficient. These basin characteristics are defined as follows (Glatfelter, 1984):

1) Drainage area, in square miles, is the area contributing directly to surface runoff.
2) Channel slope, in feet per mile, is the slope of the streambed between points that are 10 and 85 percent of the distance from the location on the stream to the basin divide.
3) Channel length, in miles, is the distance measured along the main channel from the location on the stream to the basin divide.
4) Storage is the percentage of the drainage area covered by lakes, ponds, and wetlands.
5) Mean annual precipitation (in inches) is the arithmetic mean for a 30-year period.
6) Two-year, 24-hour rainfall (in inches) is the maximum 24-hour precipitation having a recurrence interval of 2 years.
7) Rainfall-runoff coefficient relates storm runoff to soil permeability by major hydrologic soil group.

The statewide distribution of the 1941–70 mean annual precipitation; the 2-year, 24-hour rainfall; and the rainfall-runoff coefficient from Glatfelter (1984) are shown in figures 18 to 20. Although 1951–80 mean annual precipitation data have been compiled by the NWS, data for 1941–70 were used in the basin analyses for consistency with Glatfelter (1984).

Although somewhat subjective, the listing of telemetry needs based on evaluations from each basin and area evaluation attempted to fill voids in the existing coverage. Basin characteristics of proposed streamflow-gaging stations could be determined and compared with basin characteristics of existing stations. The range of significant basin characteristics for the existing streamflow-gaging stations in each basin is included to aid in selection of locations for potential new stations. When possible, new stations could be located to expand the range of a particular basin characteristic and enhance future regional applications. Included in the lists of existing and proposed streamflow-gaging stations where installation of telemetry would be beneficial (table 9, at back of report) are those that have drainage areas representative of areas or subbasins, are upstream from metropolitan areas or reservoirs, or are in areas that have had serious flooding. At all streamflow-gaging stations, it is stage that is measured, not discharge. Therefore, for the purposes of this study, it is the water level and rate of rise or fall of the water level that is important. Although this study focuses on streamflow-gaging stations, a brief review of the precipitation network is included at the request of the other participating agencies.

Whitewater River Basin

The Whitewater River basin (fig. 21) covers 1,369 mi^2 of southeastern Indiana and southwestern Ohio. About 50 mi^2 of Indiana drainage downstream from the Whitewater River also is analyzed in this section. A major tributary to the Whitewater River is the East Fork Whitewater River (382 mi^2). There is one flood-control reservoir in the basin, Brookville Reservoir. The two major urban areas are Richmond (population 41,349) and Connersville (population 17,023).

Glatfelter (1984) found drainage area; channel slope; channel length; and 2-year, 24-hour rainfall (fig. 19) to be significant basin characteristics for estimating flood magnitudes in the basin. Channel slopes are steep for all drainages throughout the basin, ranging from 7.3 ft/mi at Whitewater River at Brookville (site 7) to 28.8 ft/mi at Little Williams Creek at Connersville (site 3). The rainfall-runoff coefficient (fig. 20) is 0.70 in the headwaters, increases to 0.80 along the main stem and northern tributaries downstream from Alpine, and is 1.00 for southern tributaries of the Whitewater River between Alpine and Brookville.

There are seven streamflow-gaging stations in the basin, including three with telemetry. One of the stations with telemetry is used by the NWS for flood forecasting. The outflow from Brookville Reservoir is measured at the station on the East Fork Whitewater at Brookville (site 6). The inflow station is the East Fork Whitewater River at Abington (site 5).

Analysis of the telemetry-guidelines table (table 6) indicated a need for telemetry at the station on the East Fork Whitewater River at Abington (site 5, figs. 17 and 21) in order to monitor Brookville Reservoir inflow. This stage also could monitor flow conditions along the East Fork Whitewater River near Richmond, 10 miles upstream. No telemetry is necessary at Richmond because serious flood problems have not been reported in that area. The station on the Whitewater River near Alpine (site 4) drains too large an area (522 mi^2) to be the initial indicator of flooding in the basin. Therefore, telemetry would be beneficial at the station on the Whitewater River near Hagerstown (site 2, figs. 17 and 21) or at another headwater location (Nolands Fork or Greens Fork).

The basin has two rain gages with telemetry. A rain gage with telemetry at Abington (site 5) would provide information about rainfall upstream from Brookville Reservoir. Another rain gage with telemetry in the headwaters of the Whitewater River would be beneficial.

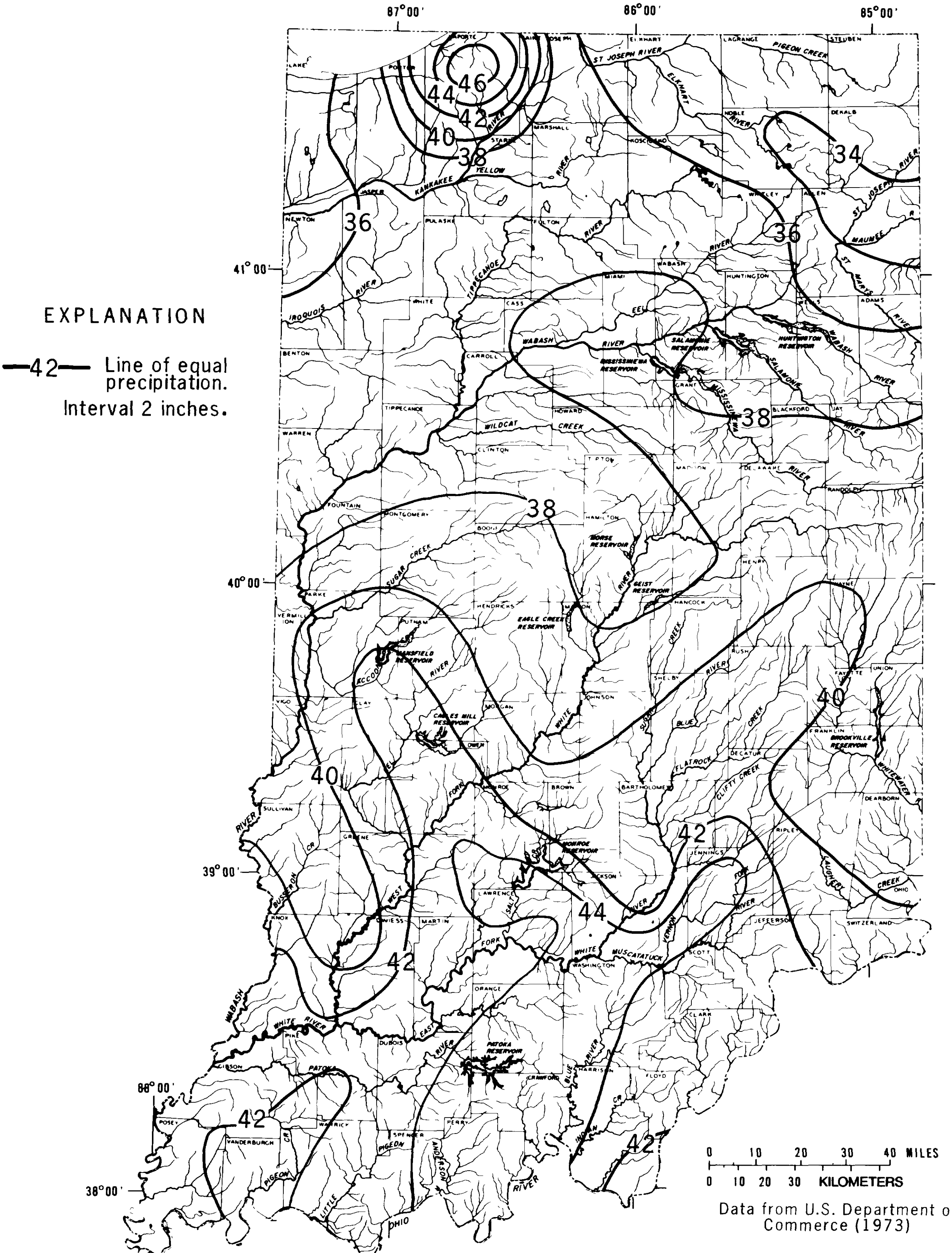
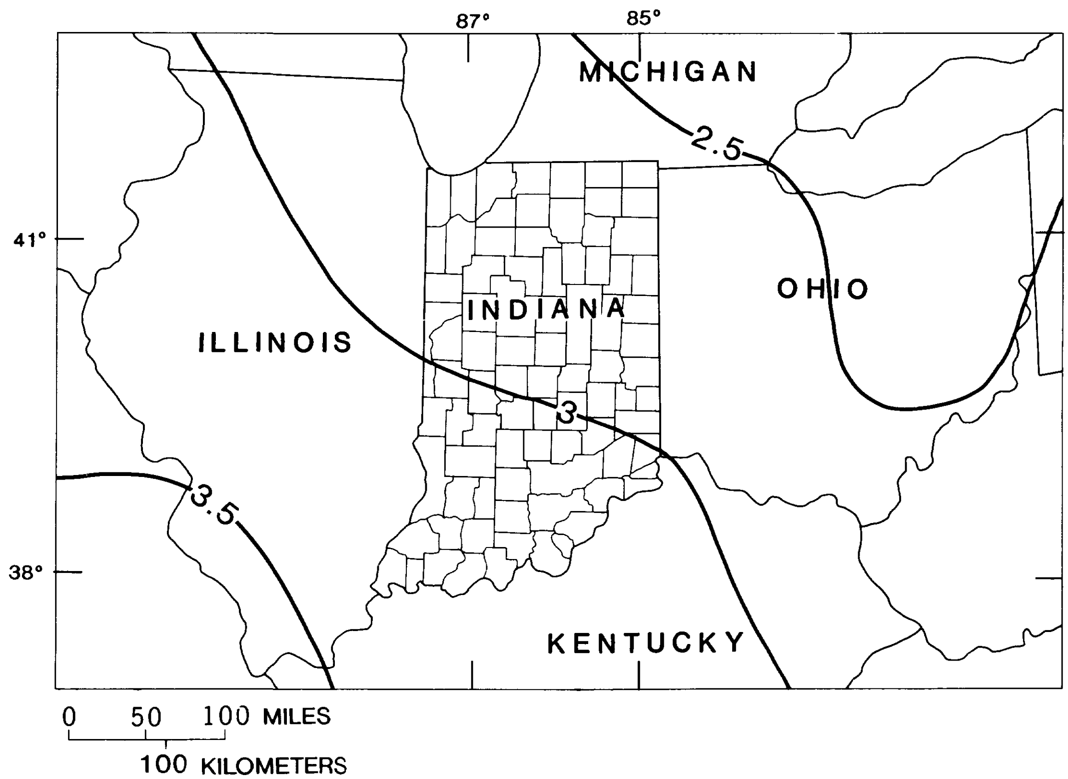


Figure 18.--Mean annual precipitation, 1941-1970.



EXPLANATION

—3.5— Line of equal precipitation. Interval 0.5 inch.

Figure 19.-- Two-year, 24-hour rainfall.

EXPLANATION

Hydrologic soil group	Rainfall-runoff coefficient
A	0.30
B	0.50
C	0.70
D	0.80
E	1.00

Hydrologic soil group boundary

(Use a runoff coefficient of 0.30 for streams in group B that are directly below lakes)

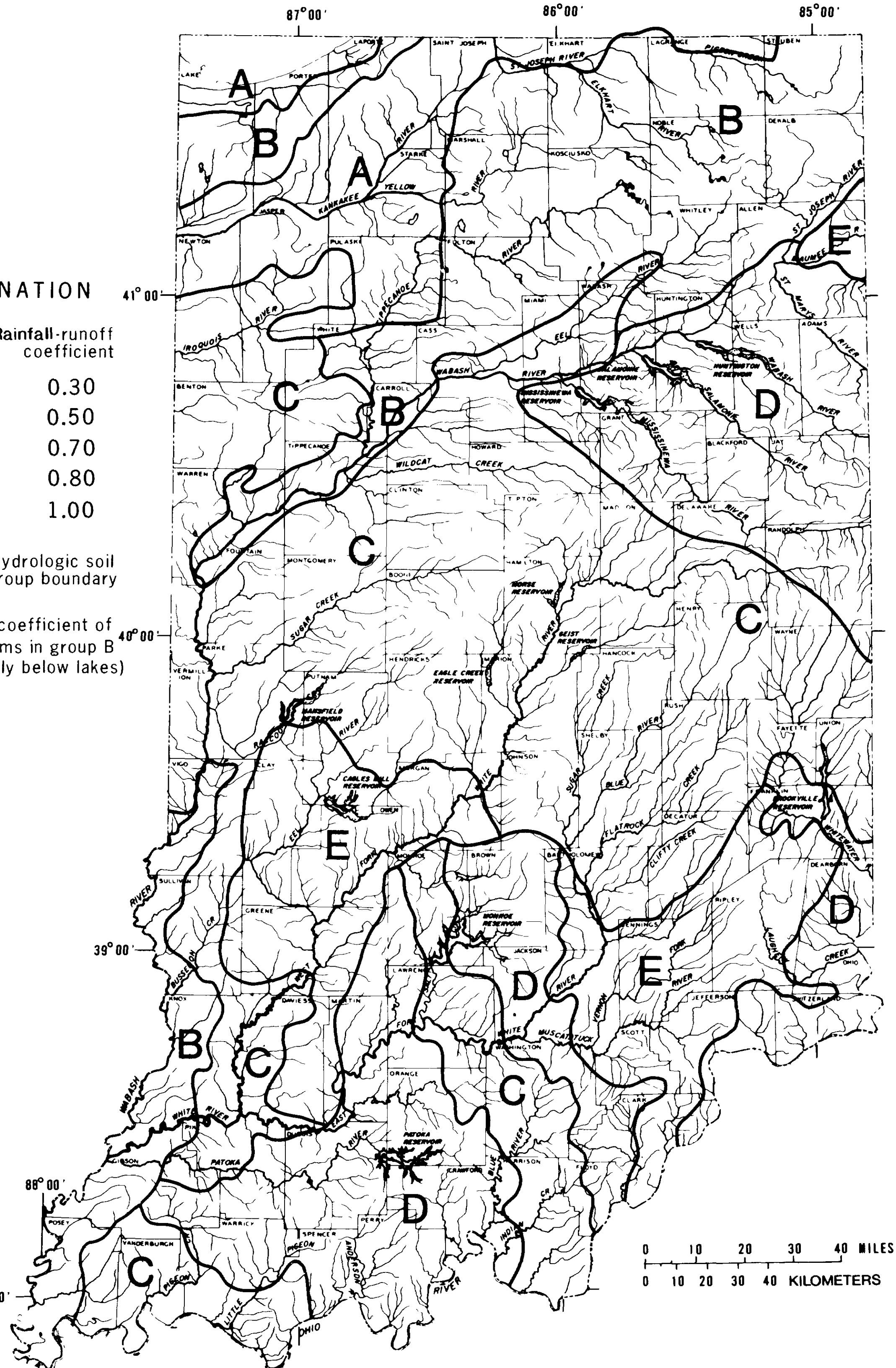


Figure 20.--Rainfall-runoff coefficients.

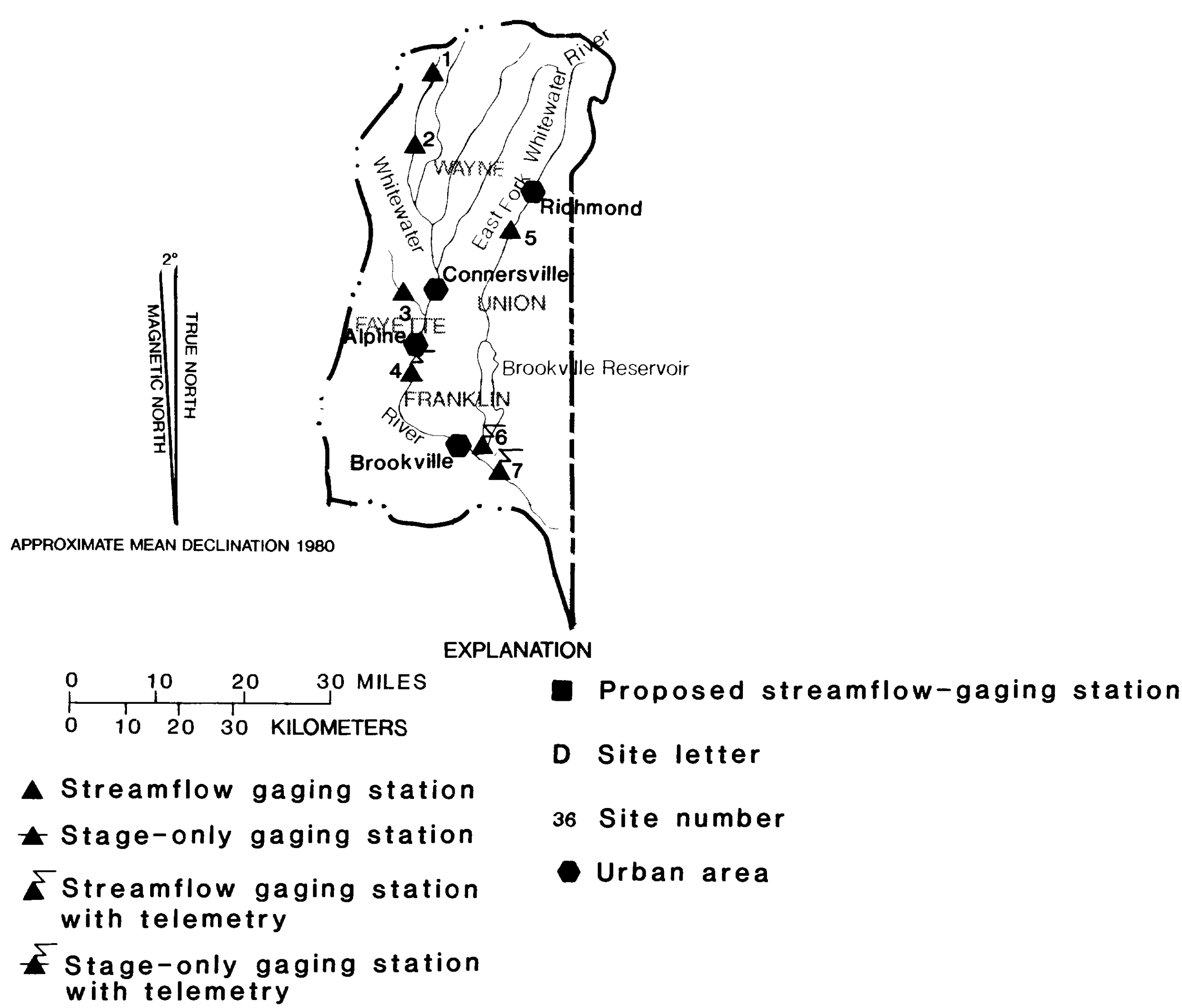


Figure 21.-- Whitewater River basin.

Ohio River Basin

The Ohio River basin (fig. 22) covers about 4,200 mi^2 of southern Indiana. The main-stem Ohio River and its Indiana tributaries are analyzed in this section. Major Indiana tributaries include Pigeon Creek (368 mi^2), Little Pigeon Creek (360 mi^2), Laughery Creek (343 mi^2), Blue River (330 mi^2, contributing), Anderson River (258 mi^2), Silver Creek (219 mi^2), and Indian Creek (185 mi^2, contributing). Major urban areas in the basin are along the Ohio River and include Evansville (population 130,496), New Albany (population 37,103), Jeffersonville (population 21,220), Clarksville (population 15,164), and Madison (population 12,472).

Glatfelter (1984) reported drainage area; channel slope; channel length; and 2-year, 24-hour rainfall (fig. 19) to be significant basin characteristics for estimating flood magnitudes in the basin. Channel slopes are steep in small tributaries, ranging from 15.4 ft/mi at Middle Fork Anderson River at Bristow (site 22) to 36.8 ft/mi at West Fork Blue River at Salem (site 17). Larger streams have slopes of 4 to 6 ft/mi. Runoff is rapid, except in the southwestern part of the basin where slopes are flatter. The rainfall-runoff coefficient ranges from 0.70 to 1.00 (fig. 20).

There are 20 streamflow-gaging stations in the basin, including eight with telemetry. Seven stations with telemetry monitor the Ohio River. Whiskey Run at Marengo (site 19) is the only tributary station with telemetry.

The Ohio River produced widespread flooding in 1937. There are seven stations with telemetry on the Ohio River along the Indiana border and many others upstream. Analysis of the telemetry-guidelines table (table 6) indicated a need for telemetry at stations on South Hogan Creek near Dillsboro (site 8, figs. 17 and 22), Silver Creek near Sellersburg (site 11, figs. 17 and 22), and the Blue River at Fredericksburg (site 18, figs. 17 and 22). Dillsboro is located in an area of rapid runoff. Despite the small drainage area (38.1 mi^2), the flood of January 1959 produced 16,300 ft^3/s (428 $(ft^3/s)/mi^2$). Telemetry at Sellersburg and Fredericksburg would be useful to indicate the extent of flooding on larger streams.

Telemetry stations on the Anderson River, Little Blue River, and Laughery Creek would be beneficial. The Anderson River experienced serious flooding in June 1979. Although considered for telemetry installation as a result of the evaluation, the station on the Middle Fork Anderson River at Bristow (site 22) is regulated by control structures and is too small (39.8 mi^2) to represent the area. A station with telemetry on the Anderson River near Fulda (site C, figs. 17 and 22) would be beneficial. English also experienced serious flooding in 1979. A discharge of 21,600 ft^3/s was measured from the 27.2 mi^2 drainage area of the Little Blue River at English (site B, figs. 17 and 22). A station in this vicinity would be beneficial. Laughery Creek drains a large area of rapid runoff; a gage would be beneficial. A station with telemetry on Laughery Creek near Friendship (site A, figs. 17 and 22) would be beneficial. As a result of the evaluation, Pigeon Creek near Fort Branch (site 26) was considered for installation of telemetry. No telemetry is necessary on Pigeon Creek or Little Pigeon Creek because flooding in these basins is caused primarily by backwater from the Ohio River, which is adequately monitored.

The basin has eight rain gages with telemetry, including six along the Ohio River. Rain gages at Corydon and Versailles are the only gages with telemetry on tributaries. Rain gages with telemetry on Little Blue River and Blue River would be beneficial.

Upper Wabash River Basin

The upper Wabash River basin (fig. 23) has a drainage area of 7,267 mi^2, including 300 mi^2 in Ohio. Major tributaries to the Wabash River are the Tippecanoe River (1,950 mi^2), Mississinewa River (817 mi^2), Eel River (815 mi^2), Wildcat Creek (805 mi^2), Salamonie River (560 mi^2), Deer Creek (303 mi^2), and Little River (288 mi^2).

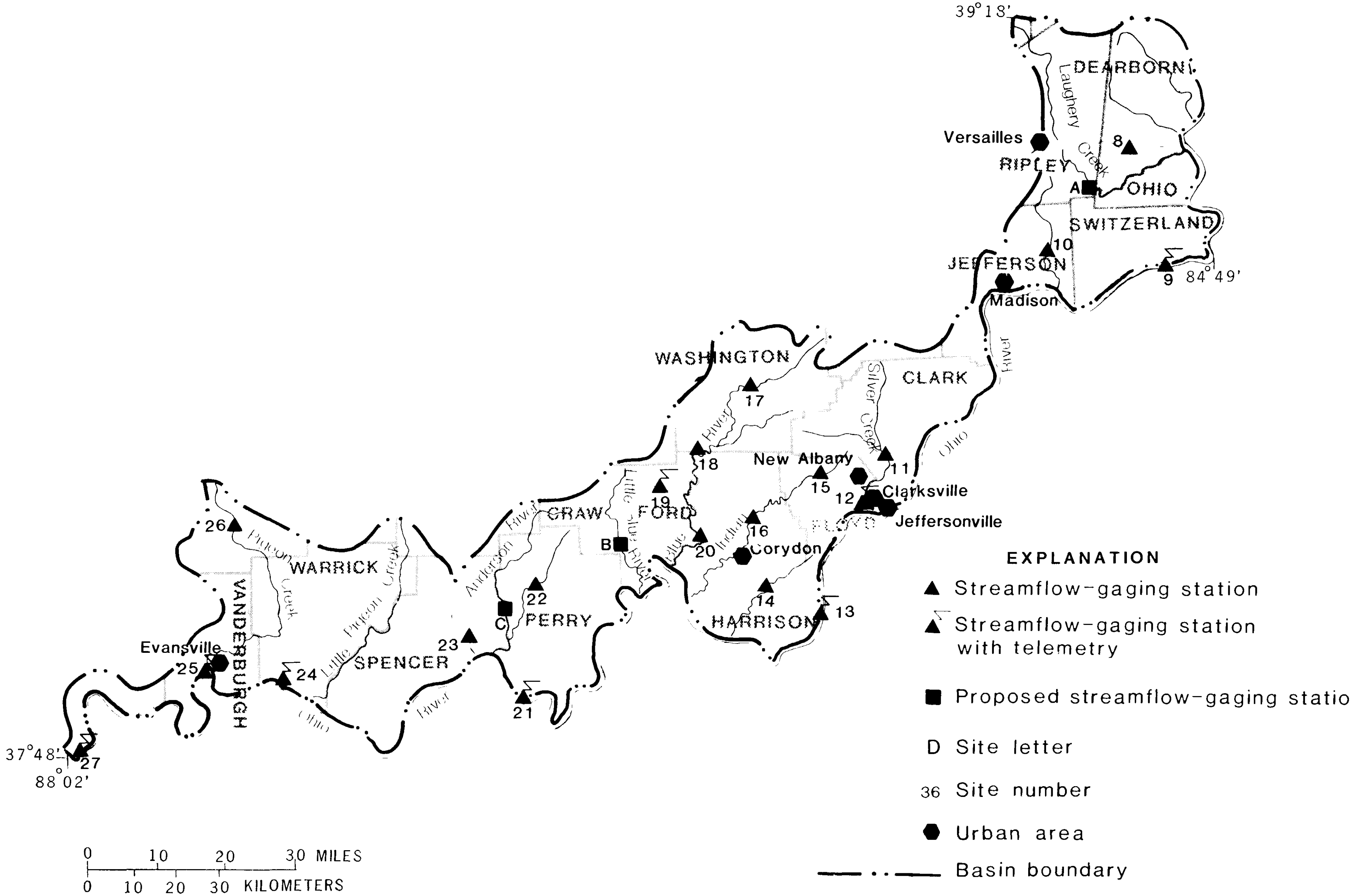


Figure 22.-- Ohio River basin.

Figure 23.-- Upper Wabash River basin.

Major urban areas in the basin are Kokomo (population 47,808), Lafayette (population 43,011), Marion (population 35,874), West Lafayette (population 21,247), Logansport (population 17,899), Huntington (population 16,202), Frankfort (population 15,168), Peru (population 13,764), Wabash (population 12,985), and Warsaw (population 10,647). The three flood-control reservoirs in the basin are the Huntington, Salamonie, and Mississinewa Reservoirs. Interbasin flow from the Maumee River basin into the upper Wabash River basin can occur during exceptionally high stages on the St. Marys River in Fort Wayne. In March 1982, for example, 525 ft^3/s was measured flowing into Little River.

Glatfelter (1984) reported drainage area, storage, 1941–70 mean annual precipitation (fig. 18), and the rainfall-runoff coefficient (fig. 20) to be significant basin characteristics for estimating flood magnitudes in the upper one-half of the basin. In the lower one-half of the basin (downstream from the mouth of the Eel River), the drainage area; the soil-runoff coefficient; and the 2-year, 24-hour rainfall (fig. 19) are the significant basin characteristics. Generally, slopes are flat to moderate throughout the basin. Tributary slopes are less than 10 ft/mi for stations with drainage areas less than 100 mi^2 and less than 5 ft/mi for larger drainages—except for South Fork Wildcat Creek near Lafayette (site 62), which is 7.1 ft/mi, and Deer Creek near Delphi (site 48), which is 5.6 ft/mi. The slope of the main-stem Wabash River is about 2 to 3 ft/mi. The rainfall-runoff coefficient of the soil is 0.80 in the basin upstream from Wabash and 0.70 in southern tributaries, the lower Eel River, and the Wabash River between Wabash and Logansport. The coefficient is 0.50 downstream from Logansport and in the headwaters of the Eel River, and is 0.30 to 0.50 along the Tippecanoe River.

There are 37 streamflow-gaging stations in the basin, 19 with telemetry. Eight stations are used by the NWS for flood forecasting. Seven of these stations are equipped with a data-collection platform or Telemark gage; the other station is a nonrecording gage read daily by a NWS observer. The outflow stations at the flood-control reservoirs are Wabash River at Huntington (site 30), Salamonie River at Dora (site 34), and Mississinewa River at Peoria (site 40). The inflow stations are Wabash River at Linn Grove (site 28), Salamonie River near Warren (site 33), and Mississinewa River at Marion (site 39).

Analysis of the telemetry-guidelines table (table 6) indicated a need for telemetry at the streamflow-gaging stations on the Mississinewa River near Ridgeville (site 37, figs. 17 and 23) and the South Fork Wildcat Creek near Lafayette (site 62, figs. 17 and 23). Telemetry at the station on the Mississinewa River near Ridgeville would provide information from the headwaters of the Mississinewa River. The station on the Tippecanoe River near Ora (site 54) is equipped with telemetry, but has a drainage area of 856 mi^2. Telemetry on the Tippecanoe River at Talma (site 52, figs. 17 and 23), which has a drainage area of 483 mi^2, would provide early warning and regional information. Additional telemetry at the station on Deer Creek near Delphi (site 48, figs. 17 and 23) would be beneficial from a regional perspective, especially with the steeper slopes in that area. Telemetry at the station on Wildcat Creek near Jerome (site 58, figs. 17 and 23) would be beneficial to the NWS because of its location upstream from Kokomo. No telemetry is necessary at the NWS flood-forecasting station on the Tippecanoe River at Winamac (site 55) because of its proximity to other telemetry stations.

The basin has 10 rain gages with telemetry, the most of any basin in the study area. Most of the telemetry is along the Wabash River, and very few data are available from the tributaries. A rain gage with telemetry would be beneficial upstream from Mississinewa Reservoir in order to monitor rainfall in the headwaters of the Mississinewa River. Rain gages with telemetry also would be beneficial in the headwaters of the Tippecanoe River and Wildcat Creek.

Middle Wabash River Basin

The middle Wabash River basin (fig. 24) has a drainage area of 4,454 mi^2, including 1,507 mi^2 of drainage area in Illinois. The main-stem Wabash River end points defining this basin are about 4 mi downstream from Clinton and just downstream from Lafayette. Major tributaries include the Vermilion River (1,434 mi^2), Sugar Creek (811 mi^2), Big Raccoon Creek (520 mi^2), and Big Pine Creek (327 mi^2). There is one flood-control reservoir in the basin, Cecil M. Harden Reservoir, and several flood-water retarding structures in the Little Raccoon Creek Conservancy District. Major urban areas are Crawfordsville (population 13,325) and Lebanon (population 11,456).

Glatfelter (1984) reported drainage area and channel slope to be significant basin characteristics for estimating flood magnitudes in the middle Wabash River basin downstream from Sugar Creek. In the remainder of the basin drainage area, the rainfall-runoff coefficient (fig. 20) and the 2-year, 24-hour rainfall (fig. 19) are significant basin characteristics. Slopes are flat along the Wabash and lower Vermilion River, ranging from 1.8 ft/mi at Wabash River at Covington (site 66) to 1.6 ft/mi at Wabash River at Montezuma (site 74). Most tributary slopes in Indiana are moderate. Slopes in Indiana drainage basins of less than 100 mi^2 are about 10 ft/mi, whereas slopes in larger tributaries are from 5 to 10 ft/mi. The rainfall-runoff coefficient of soil along the Wabash River upstream from Covington and on the lower part of Big Pine Creek is 0.50. The coefficient for the remainder of the basin is 0.70, except for a small part of Big Raccoon Creek between Ferndale and Coxville where it is 1.00.

There are 14 streamflow-gaging stations in the basin, seven with telemetry. Five stations are used by the NWS for flood forecasting. There are 10 stations in the Indiana part of the basin, six with telemetry. The outflow station to Cecil M. Harden Reservoir is Big Raccoon Creek at Ferndale (site 76). The inflow station is Big Raccoon Creek near Fincastle (site 75).

Runoff into Indiana from Illinois is monitored adequately by telemetry at the station on the Vermilion River near Danville, Ill. (site 70). Analysis of the telemetry-guidelines table (table 6) indicated no additional telemetry is necessary at existing stations in Indiana because of the very small rural drainages or proximity to other stations with telemetry. An additional station with telemetry in the headwaters of Sugar Creek near Lebanon (site D, figs. 17 and 24) would be beneficial. The construction of flood-retarding structures along Little Raccoon Creek appears to have decreased flooding along that stream. No telemetry is necessary on Big Pine Creek because serious flood problems have not been reported in that area.

There are six rain gages with telemetry in the basin. The rain gage on the Vermilion River near Danville (site 70) can provide beneficial information about rainfall in Illinois that potentially could move into Indiana. A rain gage with telemetry would be beneficial upstream from Cecil M. Harden Reservoir, on Little Raccoon Creek, or in the headwaters of Sugar Creek or Big Pine Creek.

Lower Wabash River Basin

The lower Wabash River basin (fig. 25) has a drainage area of 5,124 mi^2, including 3,343 mi^2 of drainage area in Illinois. The main-stem Wabash River end points defining this basin are the mouth of the Wabash River in extreme southwestern Indiana and 226 mi upstream from the mouth near Clinton. The two major tributaries are the Embarras River (2,440 mi^2) and Brouilletts Creek (330 mi^2), both from the Illinois drainage. Illinois drainage downstream from the Embarras River is excluded from analysis because most of the runoff from this area enters the Wabash River 15 miles upstream from the mouth. Major urban areas are Terre Haute (population 61,125) and Vincennes (population 20,857).

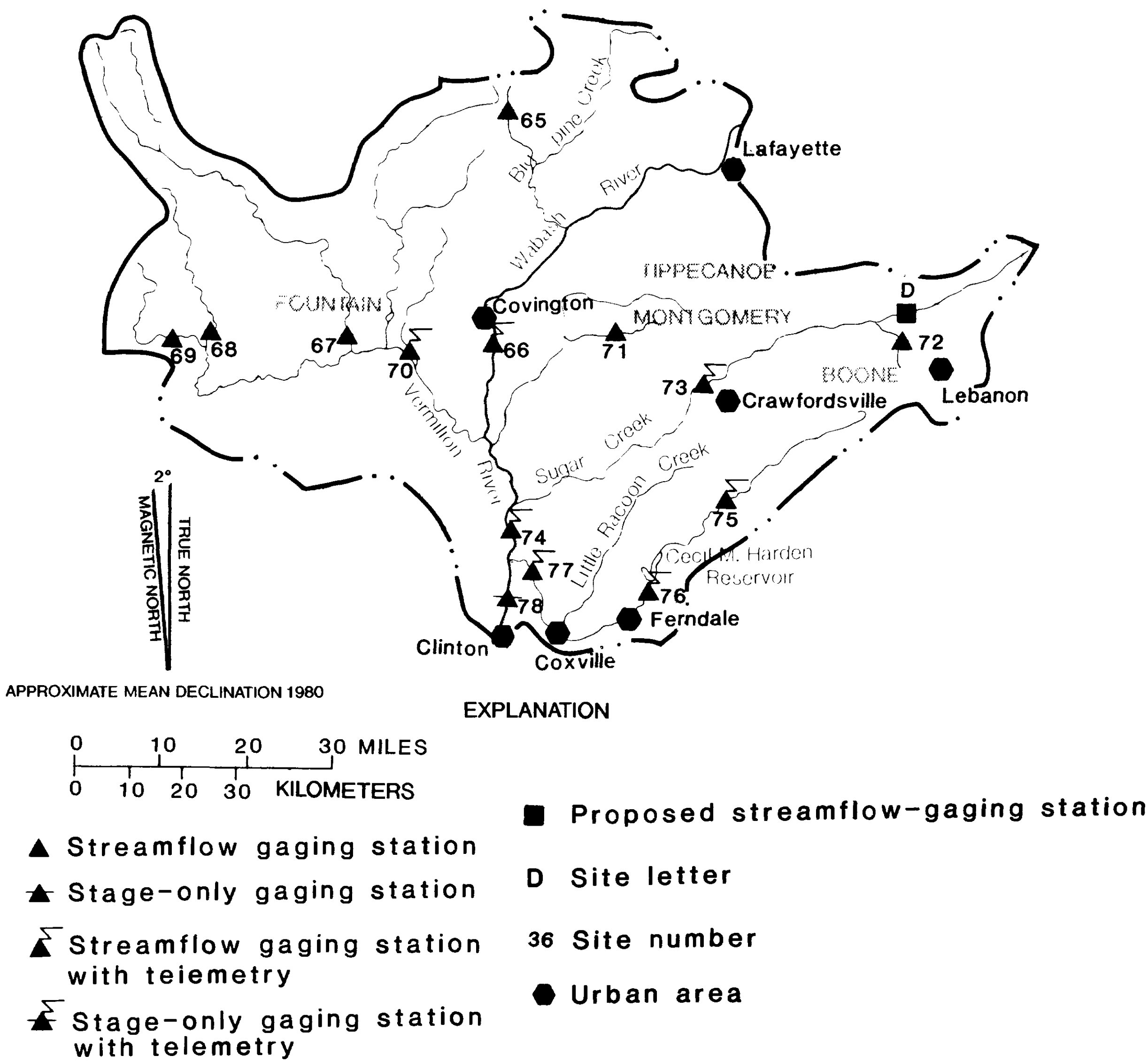


Figure 24.--Middle Wabash River basin.

Glatfelter (1984) reported drainage area and channel slope to be significant basin characteristics for estimating flood magnitudes in the basin. Slopes in tributary drainage areas of less than 100 mi^2 are about 10 ft/mi, and from 3 to 5 ft/mi on larger tributaries. The main-stem Wabash River has flat slopes, ranging from 1.6 ft/mi at Terre Haute (site 79) to about 1.0 ft/mi at New Harmony (site 167). In Indiana, the rainfall-runoff coefficient (fig. 20) of the soil in a narrow area in the northeastern part of the basin is 1.0. The coefficient ranges from 0.50 to 0.70 for the remainder of the Indiana part of the basin, with the lowest values along the Wabash River.

The basin has 15 streamflow-gaging stations, six with telemetry. Six stations are used by the NWS for flood forecasting. The Indiana part of the basin has 11 stations, 5 of which have telemetry.

Runoff into the Wabash River from Illinois is adequately monitored by the telemetry at the station on the Embarras River at Ste. Marie, Ill. (site 88). Analysis of the telemetry-guidelines table (table 6) indicated no additional telemetry is necessary at existing stations in Indiana because of very small drainages or proximity to other stations with telemetry. A station with telemetry on Honey Creek near Terre Haute (site E, figs. 17 and 25) would provide beneficial information because of recurring flooding problems.

The entire basin has one rain gage with telemetry. Existing rain gages with telemetry outside the basin at Carmi, Ill., and Uniontown, Ky., can provide information about rainfall moving into extreme southwestern Indiana. A rain gage with telemetry would be beneficial on the Embarras River and on the Wabash River between Vincennes and Terre Haute.

White River Basin

The White River basin (fig. 26), excluding the East Fork White River, has a drainage area of 5,603 mi^2 in Indiana. Runoff from the East Fork White River (5,746 mi^2) contributes to the flow of the lower 50 mi of the White River. The White River is a long narrow basin with few major tributaries. Excluding the East Fork White River, significant tributaries are the Eel River (1,208 mi^2), Fall Creek (318 mi^2), White Lick Creek (291 mi^2), Cicero Creek (226 mi^2), and Eagle Creek (210 mi^2). The Eel River is formed by Mill Creek (387 mi^2) and Big Walnut Creek (332 mi^2). Major urban areas are Indianapolis (population 700,807), Muncie (population 77,216), Anderson (population 64,695), Lawrence (population 25,591), Greenwood (population 19,327), Carmel (population 18,272), Beech Grove (population 13,196), Speedway (population 12,641), Noblesville (population 12,056), Washington (population 11,325), Martinsville (population 11,311), and Elwood (population 10,867). The basin has two flood-control reservoirs—Cagles Mill and Eagle Creek Reservoirs.

Glatfelter (1984) reported drainage area and channel slope to be significant basin characteristics for estimating flood magnitudes in nonurban areas of the basin. Two-year, 24-hour rainfall (fig. 19) also is significant for the White River drainage upstream from the mouth of Eel River. Generally, slopes are steep (10 to 15 ft/mi) in drainage areas of less than 100 mi^2. Larger drainages have slopes of about 5 ft/mi, except for White Lick Creek at Mooresville (site 115, 9.0 ft/mi) and Eagle Creek at Zionsville (site 110, 15.2 ft/mi). Main-stem White River slopes range from 4.7 ft/mi at Muncie (site 91) to 1.9 ft/mi at Petersburg (site 157). The rainfall-runoff coefficient (fig. 20) is 1.00 between Mooresville and Newberry, 0.80 in a small part of the headwaters, 0.70 in most of the basin, and 0.50 in a small area downstream from Petersburg. No coefficient is available for the urbanized area of Indianapolis, but the large unit discharges on tributaries (tables 1–4) indicate rapid runoff. A separate analysis of the Indianapolis area follows the river-basin analyses.

There are 40 streamflow-gaging stations in the basin, 20 with telemetry. Fourteen stations are used by the NWS for flood forecasting. The outflow station at Eagle Creek Reservoir is Eagle Creek at Indianapolis (site 111) and the inflow station is Eagle Creek at Zionsville (site 110).

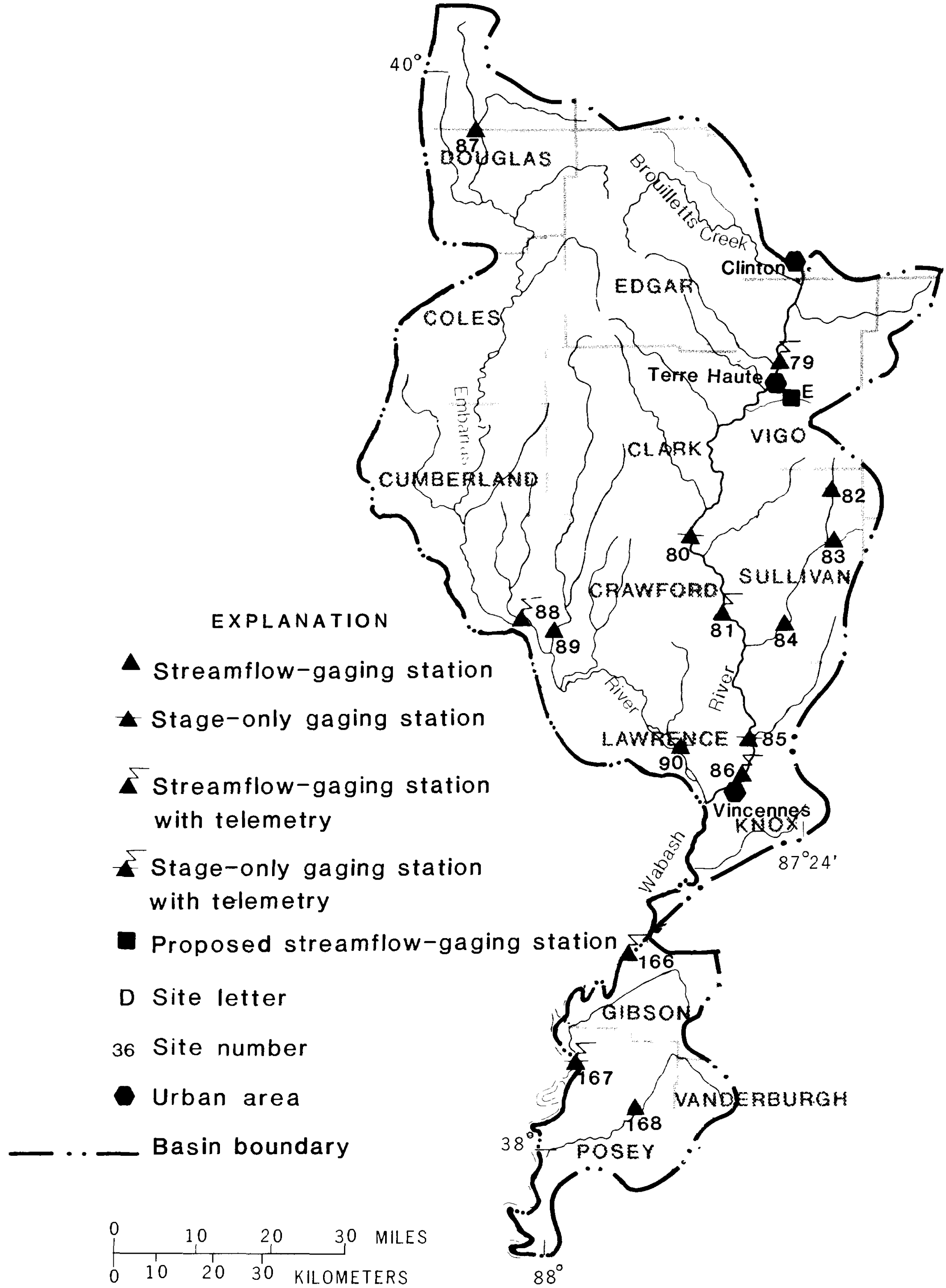


Figure 25.--Lower Wabash River basin.

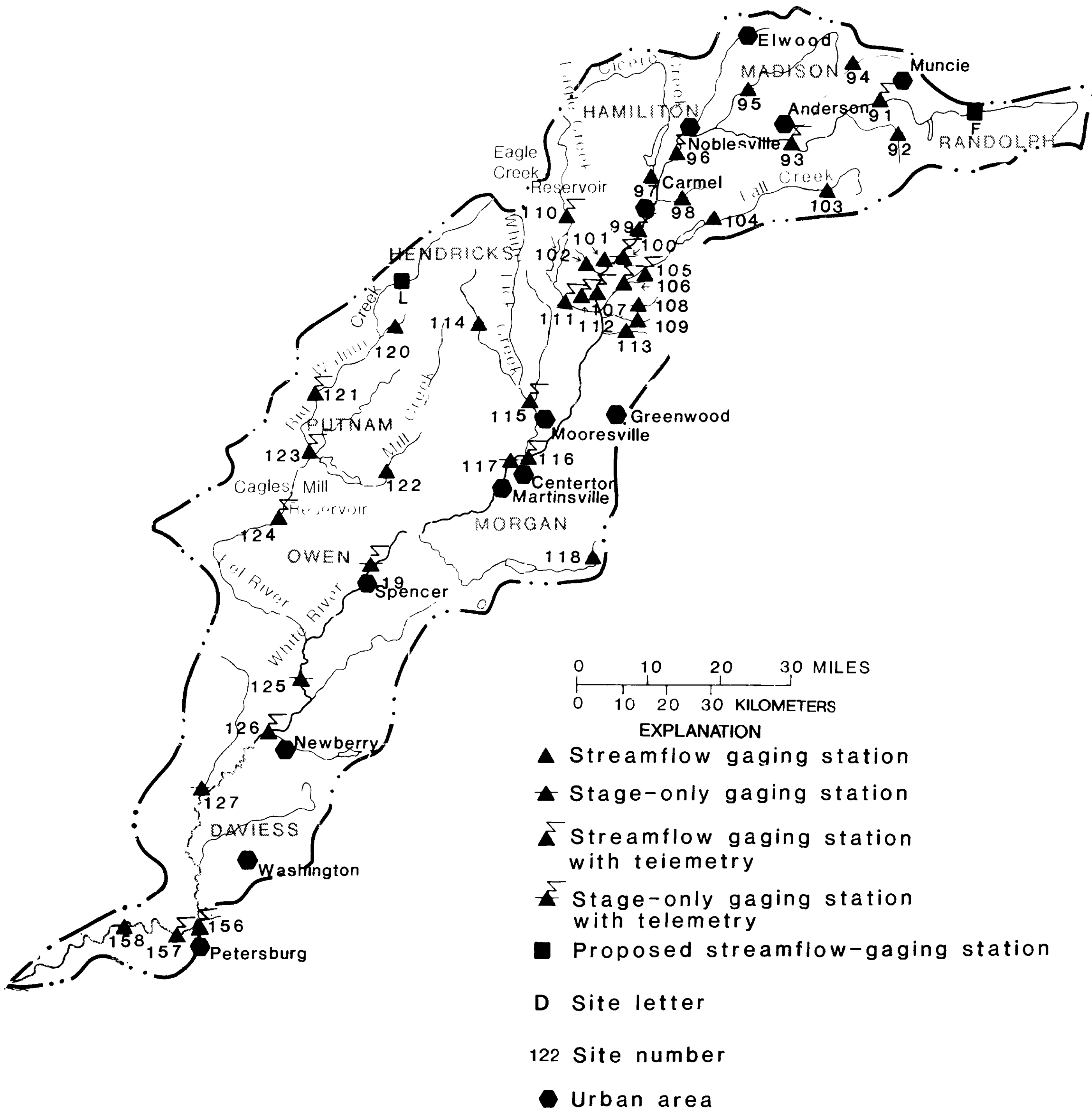


Figure 26.--White River basin.

The outflow station at Cagles Mill Reservoir is Mill Creek near Manhattan (site 123) and the inflow station is Mill Creek near Cataract (site 122). Sixteen stations are on the main-stem White River; 11 are equipped with telemetry, and 5 are non-recording gages read daily by NWS observers.

Analysis of the telemetry-guidelines table (table 6) indicated a need for telemetry at the stations on Mill Creek near Cataract (site 122, figs. 17 and 26) and Fall Creek near Fortville (site 104, figs. 17 and 26). Mill Creek near Cataract would monitor inflow to Cagles Mill Reservoir. Fall Creek near Fortville would monitor flow from a major tributary to the White River into Indianapolis.

A station with telemetry on the White River upstream from Muncie near Windsor (site F, figs. 17 and 26) would provide early flood warning. The station on Big Walnut Creek near Reelsville (site 121) provides information on flow in Big Walnut Creek, which has experienced significant flooding in the past. A station in the headwaters of Big Walnut Creek near Barnard (site L, figs. 17 and 26) would be beneficial. No telemetry is necessary at the NWS flood-forecast points on the White River at Ravenswood (site 101), Centerton (site 117), Elliston (site 125), Edwardsport (site 127), and Hazleton (site 158) because of their proximity to other stations with telemetry.

There are five rain gages with telemetry in the basin, a small number for the size of the basin. Rain gages with telemetry outside the basin at Mount Carmel (site 166, fig. 25), Ferndale (site 76, fig. 24), and Crawfordsville (site 73, fig. 24) can provide information about rainfall moving into the basin. Additional rain gages with telemetry upstream from Cagles Mill and Eagle Creek Reservoirs, on Fall Creek, and on Big Walnut Creek would be beneficial. A rain gage with telemetry between Spencer and Newberry would provide regional information.

East Fork White River Basin

The East Fork White River basin (fig. 27) covers 5,746 mi^2 of Indiana. The East Fork White River begins at the confluence of the Driftwood River (1,165 mi^2) and the Flatrock River (542 mi^2). The Driftwood River begins at the confluence of the Big Blue River (584 mi^2) and Sugar Creek (474 mi^2). Other major tributaries include the Muscatatuck River (1,140 mi^2), Salt Creek (636 mi^2), and Lost River (376 mi^2). The Vernon Fork Muscatatuck River (410 mi^2) is a large secondary tributary in the basin. Major urban areas are Indianapolis (population 700,807), Bloomington (population 52,044), Columbus (population 30,614), New Castle (population 20,056), Seymour (population 15,050), Shelbyville (population 14,989), Bedford (population 14,410), Franklin (population 11,563), and Greenfield (population 11,439). The largest flood-control reservoir in the study area, Monroe Reservoir, is located near Bloomington.

Glatfelter (1984) reported drainage area and channel slope to be significant basin characteristics for estimating flood magnitudes throughout the basin. Two-year, 24-hour rainfall (fig. 19) also is significant upstream from Lost River, as is channel length for the Muscatatuck River basin. Slopes are steep for streams in basins less than 100 mi^2, ranging from 8.9 ft/mi at Haw Creek near Clifford (site 138) to 44.6 ft/mi at Stephens Creek near Bloomington (site 150). Slopes in larger tributaries range from 2.0 ft/mi at Salt Creek near Peerless (site 152) to 9.2 ft/mi at Vernon Fork Muscatatuck River at Vernon (site 145). The main-stem East Fork White River has flatter slopes ranging from 3.8 ft/mi at Columbus (site 137) to 2.0 ft/mi at Shoals (site 154). Runoff generally is rapid in the basin. The rainfall-runoff coefficient (fig. 20) is 1.00 in the Vernon Fork, Sand Creek, and upper Muscatatuck River basins. The coefficient is 0.70 to 0.80 in the remainder of the basin.

EXPLANATION

0 10 20 30 MILES

0 10 20 30 KILOMETERS

APPROXIMATE MEAN DECLINATION 1980

▲ Streamflow gaging station

Stage-only gaging station

Streamflow gaging station with telemetry

Stage-only gaging station with telemetry

■ Proposed streamflow-gaging station

D Site letter

36 Site number

● Urban area

Figure 27.--East Fork White River basin.

There are 28 streamflow-gaging stations in the basin, 10 of which have telemetry. Five stations are used by the NWS for flood forecasting. The outflow station to Monroe Reservoir is Salt Creek near Harrodsburg (site 151). There is no inflow station because flow in each of the small tributaries is irregular and cannot be correlated to the others.

Analysis of the telemetry-guidelines table (table 6) indicated a need for telemetry at the stations on the Flatrock River at St. Paul (site 135, figs. 17 and 27), Buck Creek at Acton (site 131, figs. 17 and 27), and Youngs Creek near Edinburg (site 132, figs. 17 and 27). The Flatrock River, which has recurring floods, accounts for 32 percent of the drainage area of the East Fork White River at Columbus. Telemetry would be beneficial on Buck Creek because Sugar Creek near Edinburgh (site 133) accounts for too large an area (474 mi^2) to be the first indicator of flooding in the basin. Buck Creek also could indicate the extent of flooding in southeastern Indianapolis. Telemetry on Youngs Creek would be regionally beneficial and could represent streamflow conditions in Franklin. Telemetry also would be beneficial at the station on Lost River near West Baden Springs (site 155, figs. 17 and 27), where extensive flooding has occurred despite karst topography that attenuates flood peaks. No telemetry is necessary at two NWS flood-forecast points, East Fork White River at Bedford (site 149) and East Fork White River at Williams (site 153), because of their proximity to other stations with telemetry. A station with telemetry on the East Fork White River at Sparksville (site M, figs. 17 and 27) would be beneficial to the NWS. A station with telemetry on North Fork Salt Creek between Nashville and Belmont (site N, figs. 17 and 27) might be used to monitor inflow to Monroe Reservoir. Monroe Reservoir has no major tributary; a station on North Fork Salt Creek between Nashville and Belmont would account for only 18 to 28 percent of the Monroe Reservoir drainage.

The basin has six rain gages with telemetry. Rain gages with telemetry at Petersburg (site 157, fig. 26), Cuzco (site 160, fig. 28), and Centerton (site 116, fig. 26) provide additional information about rainfall moving into the basin. Only three rain gages with telemetry are in the drainage area upstream from the confluence of the East Fork White River and the Muscatatuck River (3,717 mi^2). Rain gages with telemetry would be beneficial on the Muscatatuck River, the Vernon Fork Muscatatuck River, Sand Creek, the Flatrock River, and the headwaters of Driftwood River. A rain gage with telemetry in the headwaters of Salt Creek also would be beneficial as an indicator of inflow to Monroe Reservoir.

Patoka River Basin

The Patoka River basin (fig. 28) includes 862 mi^2 of southwestern Indiana. All tributaries to the Patoka River have drainage areas less than 100 mi^2. The basin has one flood-control reservoir—Patoka Reservoir. Jasper (population 9,097) and Princeton (population 8,976) are the two largest urban areas in the basin.

Glatfelter (1984) reported drainage area and channel slope to be significant basin characteristics for estimating flood magnitudes in the basin. Downstream areas are characterized by flat slopes, especially along the Patoka River where slopes range from 1.2 ft/mi near Princeton (site 165) to 1.3 ft/mi at Winslow (site 164). Channel slope increases in the headwaters, as indicated by the 18.2 ft/mi at Hall Creek near St. Anthony (site 162) and the 23.6 ft/mi at Patoka River near Hardinsburg (site 159). The rainfall-runoff coefficient (fig. 20) is 0.80 in the upper one-half of the basin and 0.70 and 0.50 in the lower one-half of the basin.

Six of the seven streamflow-gaging stations located in the Patoka River basin are on the main-stem Patoka River, including three with telemetry.

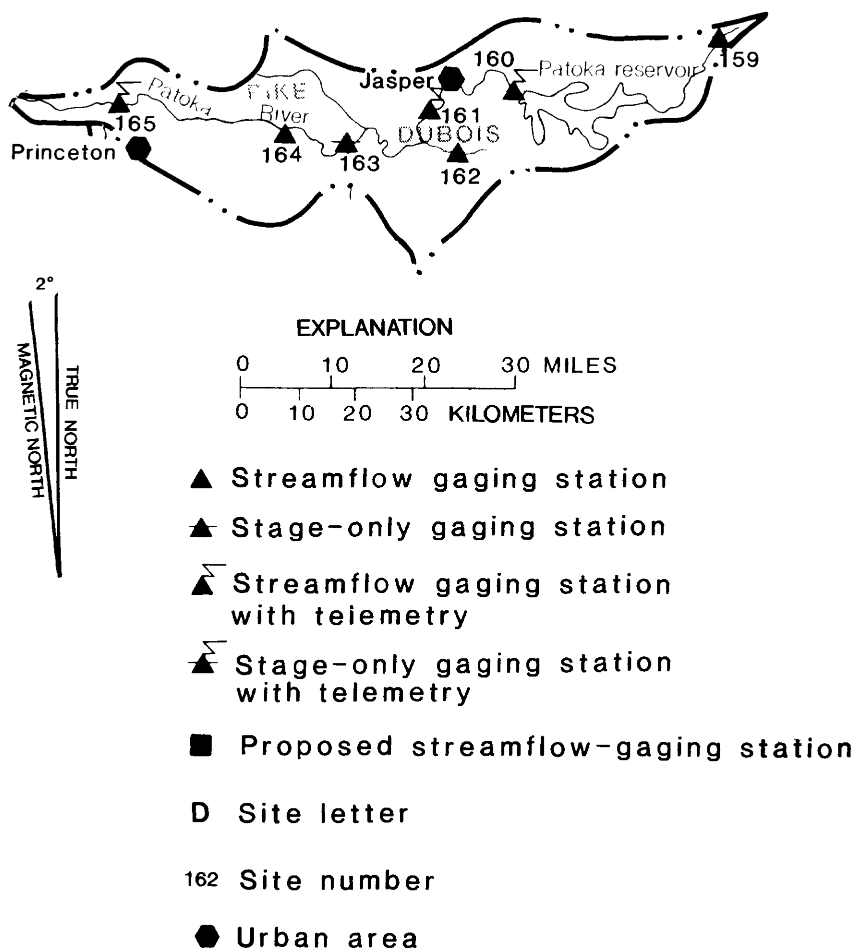


Figure 28.-- Patoka River basin.

The stations are used primarily for flood-warning management and reservoir operations. The outflow station at Patoka Reservoir is Patoka River near Cuzco (site 160). The inflow station is Patoka River near Hardinsburg (site 159).

Analysis of the telemetry-guidelines table (table 6) indicated a need for telemetry at the station on the Patoka River near Hardinsburg (site 159, figs. 17 and 28) to monitor Patoka Reservoir inflow. Patoka River near Hardinsburg accounts for only 8 percent of the inflow. Little improvement would result from relocating the station downstream or adding another station because of backwater from Patoka Reservoir.

There are two rain gages with telemetry in the basin. Rain gages with telemetry outside the basin at Mount Carmel (site 166, fig. 25) and Petersburg (site 157, fig. 26) provide additional information about rainfall moving into the basin. A rain gage with telemetry would be beneficial in the headwaters of the Patoka River basin because of the rapid runoff characteristics in that part of the basin.

St. Joseph River Basin

The St. Joseph River basin (fig. 29) has a drainage area of 3,459 mi^2, including 1,761 mi^2 in Michigan. Michigan drainage area downstream from where the St. Joseph River re-enters Michigan is excluded from this analysis. The two major tributaries in Indiana are the Elkhart River (699 mi^2) and the Pigeon River (361 mi^2 at Michigan line). Major urban areas in the Indiana part of the basin include South Bend (population 109,727), Elkhart (population 41,305), Mishawaka (population 40,201), and Goshen (population 19,665).

Glatfelter (1984) reported drainage area, storage, and 1941–70 mean annual precipitation (fig. 18) to be significant basin characteristics for estimating flood magnitudes in the Indiana part of the basin. Channel slopes on tributary drainages of less than 100 mi^2 are 10 ft/mi or less, and 3 to 6 ft/mi on larger tributaries. The channel slope of the St. Joseph River is about 2 ft/mi. In Indiana, the rainfall-runoff coefficient (fig. 20) is generally 0.50.

The basin has 20 streamflow-gaging stations, 3 of which have telemetry. The Indiana part of the basin has 11 stations, 2 of which have telemetry. Three stations are used by the NWS for flood forecasting.

Runoff from Michigan is monitored adequately by a station with telemetry on the St. Joseph River at Mottville, Mich. (site 184). Analysis of the telemetry-guidelines table (table 6) indicated a need for telemetry at the station on the St. Joseph River at South Bend (site 195) because of flood-warning management use of the data. The NWS can obtain river levels 24 hrs/day from the South Bend sewage-treatment plant; therefore, no telemetry is needed. Analysis also indicated a need for telemetry at the station on the Pigeon River near Scott (site 186, figs. 17 and 29). Telemetry at this site would be beneficial to the NWS North Central River Forecast Center.

The basin has no rain gages with telemetry. Generally, spring snowmelt is the cause of most floods. Rain gages with telemetry would provide beneficial information, especially along the Elkhart River and Pigeon River.

Maumee River Basin

The Maumee River basin (fig. 30) covers 2,120 mi^2, including 939 mi^2 in Ohio and Michigan. The Maumee River begins at the confluence of the St. Joseph River (1,086 mi^2) and the St. Marys River (839 mi^2) in Fort Wayne. The largest urban areas in the Indiana part of the basin are Fort Wayne (population 172,196), Decatur (population 8,649), and Auburn (population 8,122).

Interbasin flow from the Maumee River basin into the upper Wabash River basin can occur during exceptionally high stages on the St. Marys River in Fort Wayne. For example, in March 1982,

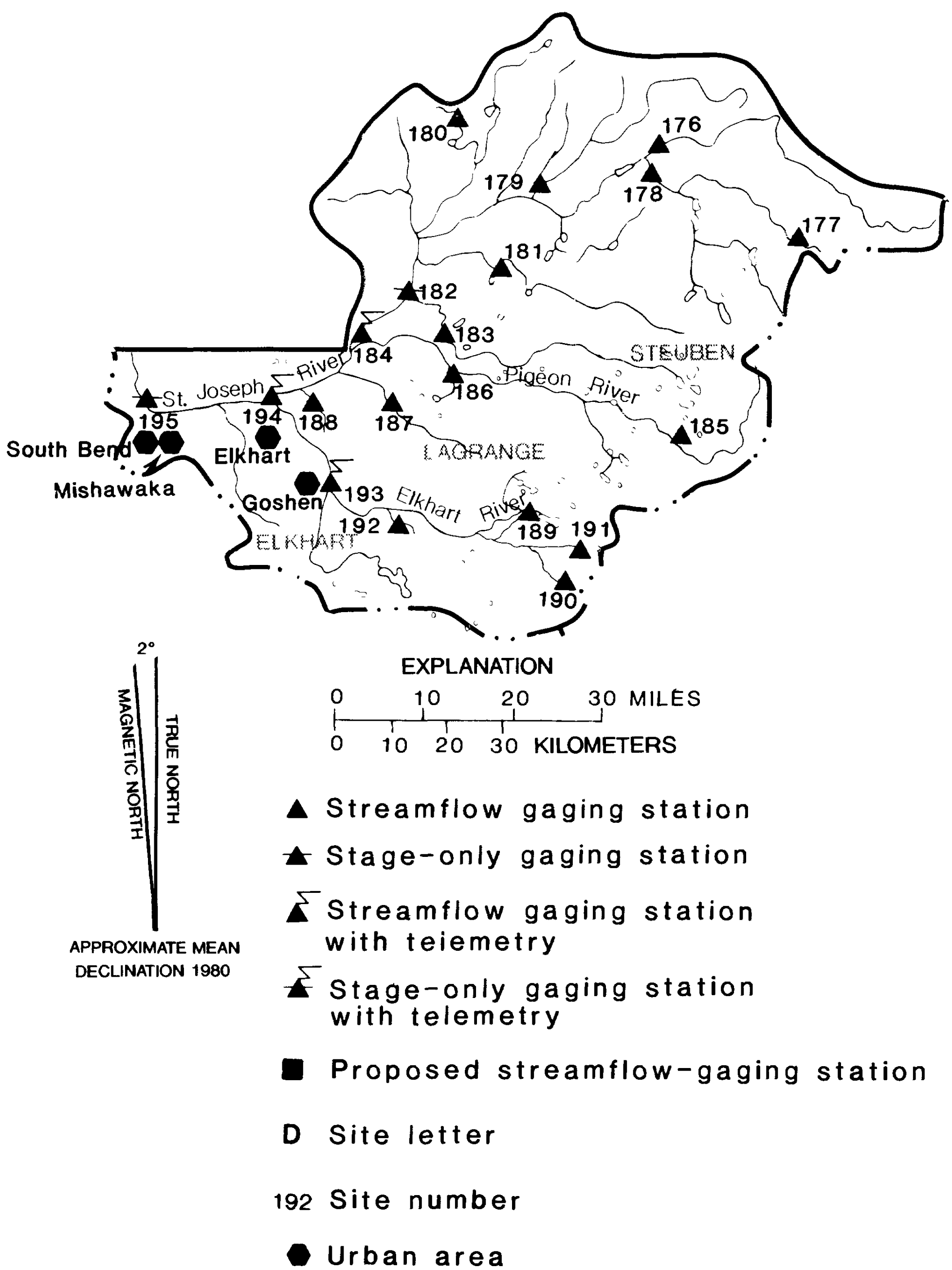


Figure 29.-- St. Joseph River basin.

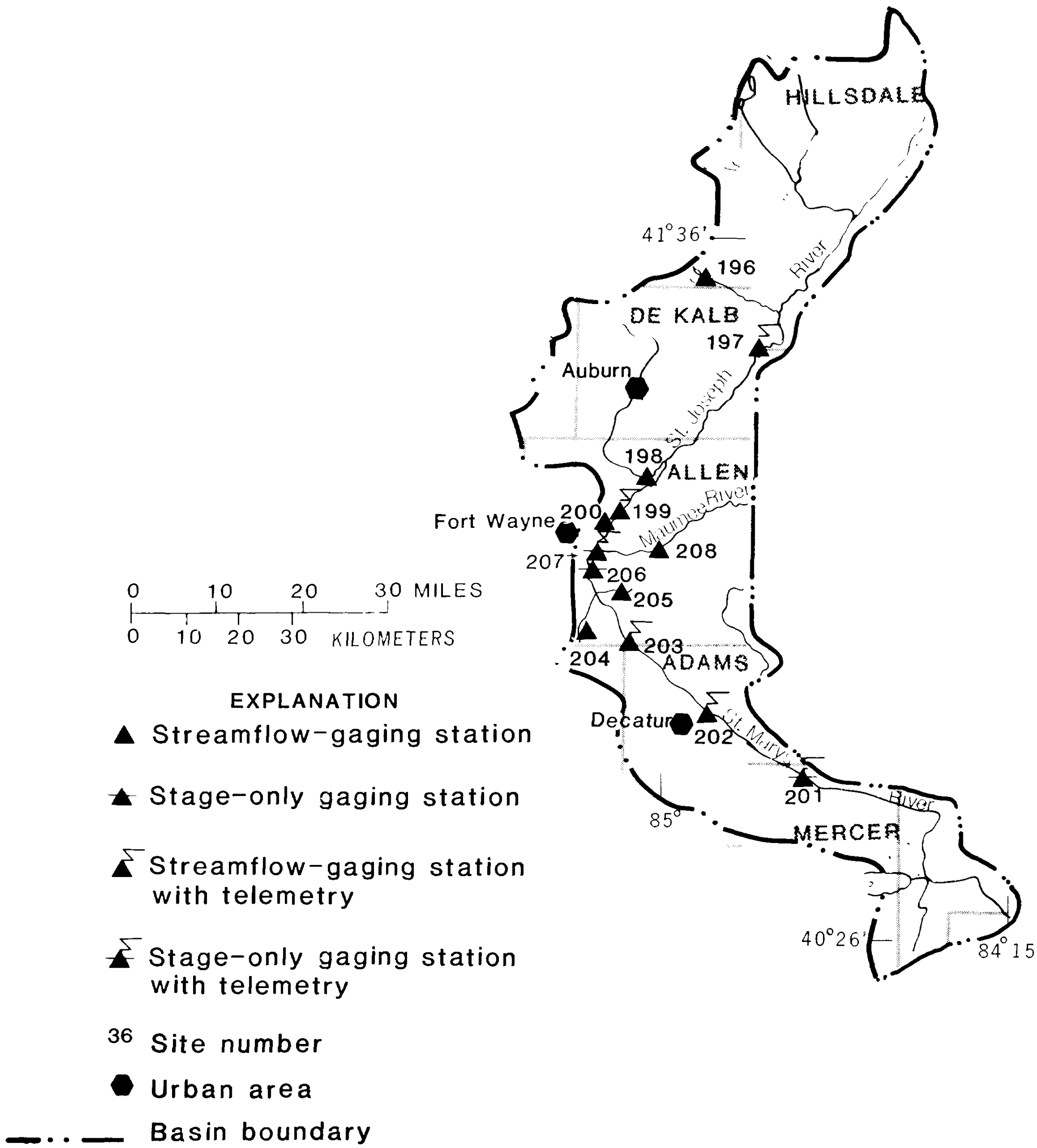


Figure 30.-- Maumee River basin.

525 ft^3/s was measured flowing out of the Maumee River basin. The maximum interbasin flow is unknown.

Glatfelter (1984) reported that drainage area, storage, rainfall-runoff coefficient (fig. 20), and 1941–70 mean annual precipitation (fig. 18) are significant basin characteristics for estimating flood magnitudes in the basin. Generally, channel slopes are flat throughout the basin. Tributary slopes range from 5 to 10 ft/mi and main-stem Maumee River slopes are about 2 ft/mi. In Indiana, the rainfall-runoff coefficient is 1.00 downstream from Fort Wayne, 0.80 in the St. Marys River basin, and 0.50 in the St. Joseph River basin.

The basin has 13 streamflow-gaging stations, 6 of which have telemetry. Three stations are used by the NWS for flood forecasting. The NWS collects stage from six stations (includes the three used for flood forecasting) in the ALERT network (table 5) to monitor flooding in Fort Wayne.

Runoff from Ohio and Michigan is monitored adequately by two stations with telemetry on the St. Joseph River near Newville (site 197) and the St. Marys River at Rockford (site 201). Analysis of the telemetry-guidelines table (table 6) indicated a need for telemetry at the stations on Cedar Creek near Cedarville (site 198, figs. 17 and 30) and the Maumee River near New Haven (site 208, figs. 17 and 30). Telemetry would be beneficial on Cedar Creek because the Creek accounts for 26 percent of the St. Joseph River drainage area at the confluence with the St. Marys River and because of the Creek's proximity to Fort Wayne. Telemetry at New Haven would assist flood monitoring on the east side of Fort Wayne.

The basin has 11 rain gages with telemetry. Rain gages with telemetry outside the basin near Huntington (site 31, fig. 23) and Bluffton (site 29, fig. 23) provide additional information about rainfall entering the southwestern part of the basin. Additional telemetry would be beneficial (but not necessary) in this basin.

Kankakee River Basin

The Kankakee River basin (fig. 31) includes 2,960 mi^2 in Indiana. Major tributaries are the Iroquois River (661 mi^2) and the Yellow River (439 mi^2). Cedar Lake (population 8,754) and Plymouth (population 7,693) are the two largest urban areas in the basin.

Glatfelter (1984) reported drainage area, channel slope, channel length, and rainfall-runoff coefficient (fig. 20) to be significant basin characteristics for estimating flood magnitudes in the basin. Generally, slopes are flat throughout the basin, varying from 5 to 10 ft/mi in tributaries with drainage areas less than 100 mi^2 to 2 to 3 ft/mi on larger tributaries. The channel slopes for the Kankakee River at Shelby (site 217) and at Dunns Bridge (site 213) are 0.9 ft/mi, which results in extended periods of flooding. For example, in 1982 the Kankakee River at Shelby remained above flood stage (15.0 ft) from March 12 to May 6. The rainfall-runoff coefficient is 0.70 in the Iroquois River basin, 0.50 in the headwaters of the Yellow River, and 0.30 in the remainder of the basin.

The basin has 15 streamflow-gaging stations, 6 of which have telemetry. Six of the stations are on the Kankakee River, four are on the Iroquois River, and two are on the Yellow River. Six stations are used by the NWS for flood forecasting.

The Iroquois River basin is the largest drainage area in Indiana without telemetry. Analysis of the telemetry-guidelines table (table 6) indicated a need for telemetry at the station on the Iroquois River near Foresman (site 223, figs. 17 and 31). This station also would be useful to the NWS North Central River Forecast Center. Telemetry at a station on the Kankakee River downstream from the confluence with the Yellow River near English Lake (site O, figs. 17 and 31) would provide beneficial flood information to the NWS.

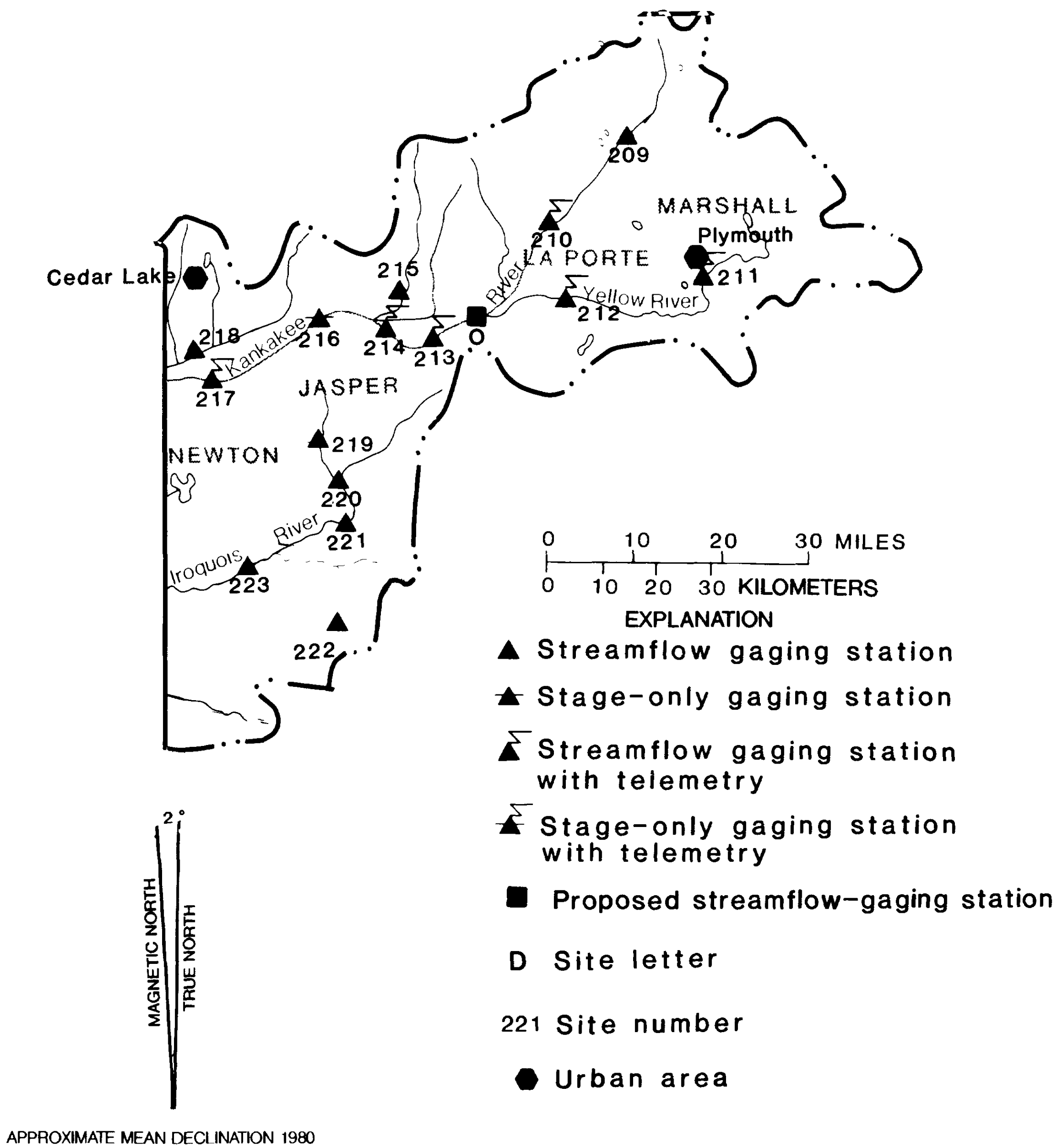


Figure 31.-- Kankakee River basin.

The basin has two rain gages with telemetry. A rain gage with telemetry at a station on the Kankakee River 20 mi downstream from Shelby at Momence, Ill., can provide information about rainfall moving into the basin. Additional rain gages with telemetry along the Iroquois, the Yellow, and the upper Kankakee Rivers would be beneficial.

Calumet River Basin

The Calumet River basin (fig. 32) has a drainage area of approximately 550 mi^2, including 324 mi^2 in Illinois. The basin is primarily a series of dredged drainage channels that have been altered by the urbanization and the industrialization of the area. The major stream in the basin is Burns ditch (331 mi^2). Deep River (151 mi^2) and the East Arm Little Calumet River (151 mi^2) are major tributaries to Burns ditch. The West Arm Little Calumet River has split flow—part flows eastward into Burns ditch and part flows westward into Illinois.

Glatfelter (1984) reported drainage area, storage, and 1941–70 mean annual precipitation (fig. 18) to be significant basin characteristics for estimating flood magnitude in nonurban areas of the basin. Slopes are flat throughout the basin. The slope of the West Arm Little Calumet River between Munster and Hobart is only 0.06 ft/mi. The rainfall-runoff coefficient (fig. 20) for nonurban areas in the basin is 0.30 to 0.50. Rapid runoff in urban areas combined with flat channel slopes causes serious ponding of water in many areas. A separate analysis of urban areas follows the basin analyses.

The basin has 10 streamflow-gaging stations, 5 of which have telemetry. Analysis of the telemetry-guidelines table (table 6) indicated telemetry would be beneficial at the station on the Little Calumet River at Porter (site 172, figs. 17 and 32).

The basin has one rain gage with telemetry. A rain gage at any other site with telemetry would be beneficial, especially on Deep River and the Little Calumet River.

Urban Areas

Urban areas create special flood problems because of rapid runoff from rainfall on impervious surfaces. Storm sewers direct the runoff into streams but ponding can occur if the sewer, the stream, or both are unable to transport the runoff. Telemetry at index stations will not eliminate a flood problem but telemetry can help determine the extent of flooding. The two largest urban areas in Indiana where local flooding is a recurring problem are the Calumet River basin and the Indianapolis area.

The Calumet River basin (fig. 32) includes approximately 550 mi^2 and has a population of more than 500,000. According to the Indiana Department of Natural Resources, flooding along the Little Calumet River is the worst urban flooding problem in the State, annually resulting in more than $12 million in damage (Little Calumet River Basin Development Commission, 1984). This area is characterized by flat terrain, which slows the downstream movement of water. The Calumet River basin analysis determined that telemetry at the station on the Little Calumet River at Porter (site 172) would be beneficial. Additional telemetry at the stations on Salt Creek near McCool (site 173, figs. 17 and 32) and Trail Creek at Michigan City (site 174, figs. 17 and 32) would assist in flood monitoring. No telemetry is necessary along the Grand Calumet River because streamflow is primarily controlled by industrial pumpage.

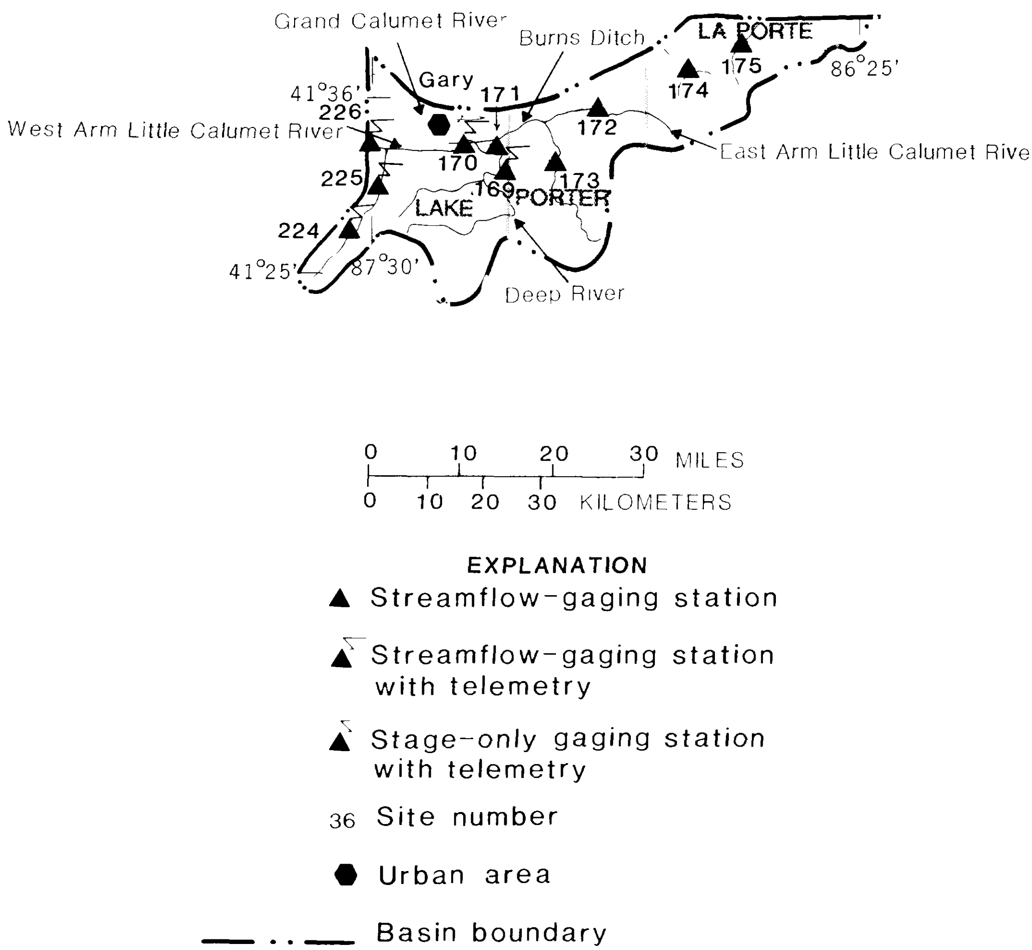


Figure 32.-- Calumet River basin.

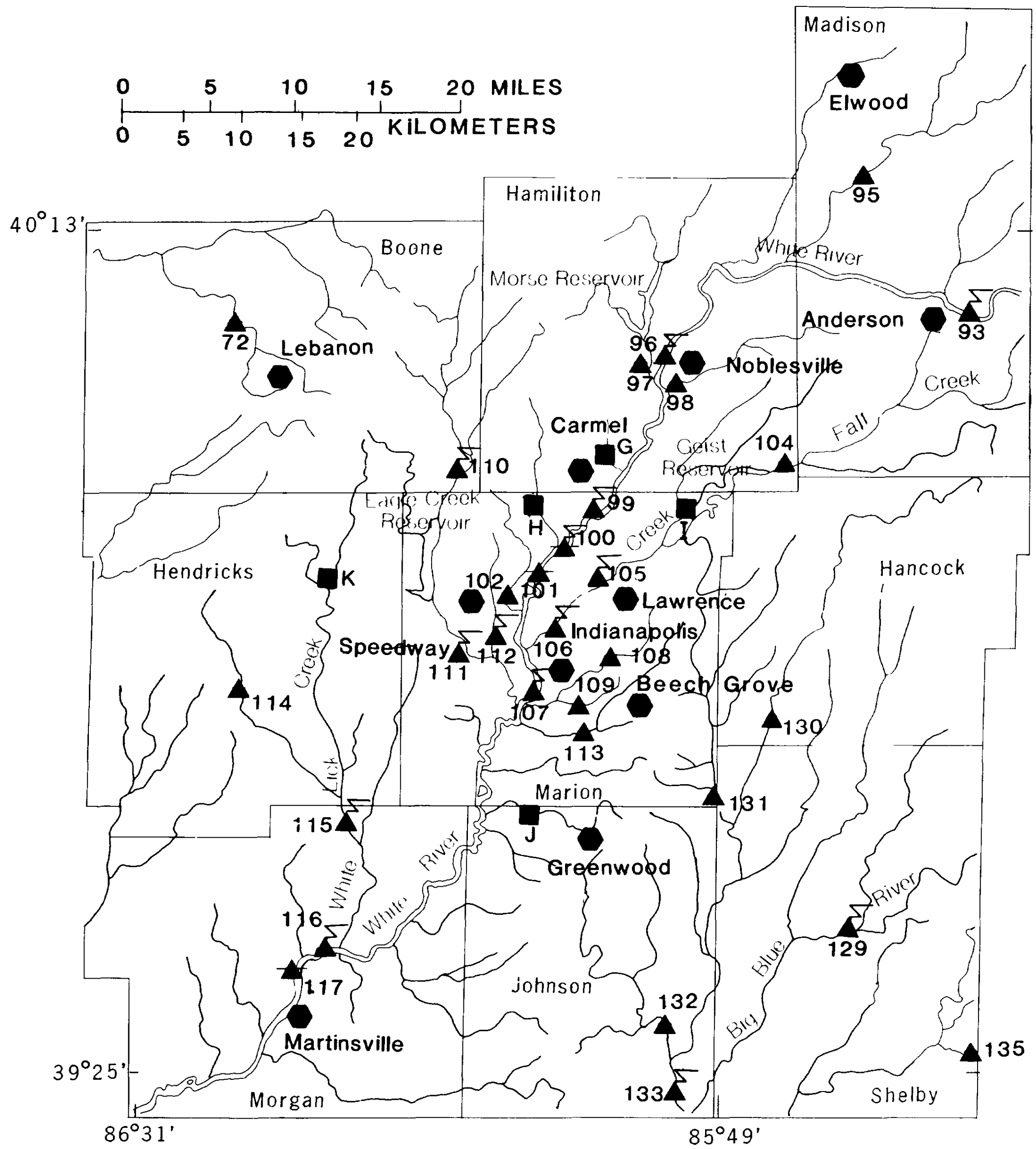
The Indianapolis area includes nine counties in central Indiana, covers 392 mi^2, and has a population of approximately 800,000. Runoff is more rapid in this area than in the Calumet River basin because of steeper channel slopes. Sites where stage is measured on a routine basis in the Indianapolis area are shown in figure 33. The basin analysis for the East Fork White River and the White River determined telemetry at the station on Buck Creek at Acton (site 131, figs. 17 and 33) and Fall Creek near Fortville (site 104, figs. 17 and 33) would be beneficial. Additional telemetry at the existing stations on Crooked Creek at Indianapolis (site 102, figs. 17 and 33) and Lick Creek at Indianapolis (site 113, figs. 17 and 33), and the establishment of new stations with telemetry on Mud Creek at Indianapolis (site I, figs. 17 and 33) and Williams Creek at Indianapolis (site H, figs. 17 and 33) would assist in flood monitoring. Stations with telemetry on Pleasant Run Creek near Greenwood (site J, figs. 17 and 33), Cool Creek near Carmel (site G, figs. 17 and 33), and White Lick Creek near Brownsburg (site K, figs. 17 and 33) also would be beneficial.

FUTURE APPLICATIONS

Although the thrust of the analyses discussed in this report is towards flood-data collection and transmission, the concept of obtaining accurate, timely data can be extended into other areas—such as monitoring droughts, water quality, and ground water. For example, during the summer of 1988 many operational and economic decisions were made in Indiana and elsewhere based on streamflow and ground-water data. A baseline network that supplied these data for a limited number of locations in Indiana was developed and operated to meet the needs of government officials and the general public. Telemetry installed to provide flood information on streams also can provide information during droughts or chemical spills. In the future, most streamflow-gaging stations will be equipped with some form of telemetry to quickly relay data for making management decisions.

SUMMARY

Flooding can occur at any time and place in Indiana. The degree of flooding can vary from a minor inconvenience to major flooding that results in loss of life and extensive damage. In this study, the existing streamflow-gaging network in Indiana was evaluated based on meeting flood-data needs of various governmental agencies. Each of 12 basins and the Indianapolis area were analyzed on the basis of hydrologic characteristics, flood potential, and availability and benefits of real-time data. A set of guidelines for evaluating an existing streamflow-gaging station without telemetry was developed so that quantitative comparisons could be made between stations. Determinations were made of what modifications or additions to the networks would improve flood-data collection and transmission. These modifications or additions were discussed at interagency meetings to ensure agreement among those agencies collecting and using the data. The study indicates that 15 locations at which no stage data are collected could be gaged and that these 15—plus 26 existing streamflow-gaging stations—could be equipped with telemetry. This telemetry preferably would be data-collection platforms with satellite transmitters which allow access to data by automated computer interrogation programs.



EXPLANATION

- ▲ Streamflow-gaging station
- Stage-only gaging station
- Streamflow-gaging station with telemetry
- Stage-only gaging station with telemetry
- ■ Proposed streamflow-gaging station
- D Site letter
- 36 Site number
- ● Urban area

Figure 33.--Indianapolis area.

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SUPPLEMENTAL DATA

Table 1. Streamflow-gaging stations without telemetry
[ft^3/s, cubic feet per second; $[ft^3/s]/mi^2$, cubic feet per second per square mile; mi^2, square mile; --, no data]

Site number	Station number	Station name	Drainage area (mi^2)	Peak discharge (ft^3/s)	Peak discharge ($[ft^3/s]/mi^2$)
1	03274650	Whitewater River near Economy	10.4	1,100	106
2	03274750	Whitewater River near Hagerstown	58.7	2,300	39
3	03274950	Little Williams Creek at Connersville	9.16	3,560	389
5	03275600	East Fork Whitewater River at Abington	200	13,400	67
8	03276700	South Hogan Creek near Dillsboro	38.1	16,300	428
10	03291780	Indian-Kentuck Creek near Canaan	27.5	7,240	263
11	03294000	Silver Creek near Sellersburg	189	19,600	104
14	03302220	Buck Creek near New Middletown	65.2 [a]	12,700	195
15	03302300	Little Indian Creek near Galena	16.1	5,500	342
16	03302500	Indian Creek near Corydon	129 [b]	26,700	207
17	03302680	West Fork Blue River at Salem	19	5,400	284
18	03302800	Blue River at Fredericksburg	283 [c]	13,500	48
20	03303000	Blue River near White Cloud	476 [d]	28,500	60
22	03303300	Middle Fork Anderson River at Bristow	39.8	15,000	377
23	03303400	Crooked Creek near Santa Claus	7.86	4,100	522
26	03322011	Pigeon Creek near Fort Branch	35.4	--	--
32	03324200	Salamonie River at Portland	85.6	3,460	40
36	03325311	Little Mississinewa River at Union City	9.67	241	25
37	03325500	Mississinewa River near Ridgeville	133	13,900	105
38	03326070	Big Lick Creek near Hartford City	29.2	1,940	66
42	03327520	Pipe Creek near Bunker Hill	159	4,390	28
44	03328430	Weesau Creek near Deedsville	8.87	471	53
47	03329400	Rattlesnake Creek near Patton	6.83	456	67
48	03329700	Deer Creek near Delphi	274	14,400	53
49	03330241	Tippecanoe River at North Webster	49.3	294	6

Table 1. Streamflow-gaging stations without telemetry--Continued

Site number	Station number	Station name	Drainage area (mi^2)	Peak discharge (ft^3/s)	($[ft^3/s]/mi^2$)
50	03330500	Tippecanoe River at Oswego	113	950	8
51	03331110	Walnut Creek near Warsaw	19.6	561	29
52	--	Tippecanoe River at Talma	483	--	--
53	--	Tippecanoe River at Leiters Ford	639	--	--
55	--	Tippecanoe River at Winamac	941	--	--
58	03333450	Wildcat Creek near Jerome	146	6,140	42
59	03333600	Kokomo Creek near Kokomo	24.7	1,040	42
61	03334000	Wildcat Creek at Owasco	396	--	--
62	03334500	South Fork Wildcat Creek near Lafayette	243	15,100	62
65	03335690	Mud Pine Creek near Oxford	39.4	3,420	87
67	03336645	Middle Fork Vermilion River at Oakwood, Ill.	432	10,600	25
68	03336900	Salt Fork near St. Joseph, Ill.	134	6,860	51
69	03337000	Boneyard Creek at Urbana, Ill.	4.46[e]	982	220
71	03339108	East Fork Coal Creek near Hillsboro	33.4	2,680	80
72	03339280	Prairie Creek near Lebanon	33.2	--	--
78	--	Wabash River at Clinton	11,715	--	--
80	--	Wabash River at Hutsonville, Ill.	12,959	--	--
82	03342100	Busseron Creek near Hymera	16.7	1,890	113
83	03342244	Mud Creek near Cass	9.16	458	50
84	03342500	Busseron Creek near Carlisle	228	8,800	39
85	--	Wabash River at Vincennes	13,732	--	--
87	03343400	Embarras River near Camargo, Ill.	186	6,240	34
89	03346000	North Fork Embarras River near Oblong, Ill.	318	27,100	85
90	--	Embarras River at Lawrenceville, Ill.	2,260	--	--
92	03347500	Buck Creek near Muncie	35.5	1,780	50

Table 1. Streamflow-gaging stations without telemetry--Continued

Site number	Station number	Station name	Drainage area (mi²)	Peak discharge	
				(ft³/s)	([ft³/s]/mi²)
94	03348020	Killbuck Creek near Gaston	25.5	1,200	47
95	03348350	Pipe Creek at Frankton	113	4,900	43
97	03350500	Cicero Creek at Noblesville	216	9,800	45
98	03350700	Stony Creek near Noblesville	50.8	1,640	32
101	--	White River at Ravenswood	1,226	--	--
102	03351310	Crooked Creek at Indianapolis	17.9	5,500	307
103	03351400	Sugar Creek near Middletown	5.80	1,100	190
104	03351500	Fall Creek near Fortville	169	8,750	52
108	03353120	Pleasant Run at Arlington Avenue at Indianapolis	7.58	2,600	343
109	03353180	Bean Creek at Indianapolis	4.40	770	175
113	03353620	Lick Creek at Indianapolis	15.6	2,500	160
114	03353700	West Fork White Lick Creek at Danville	28.8	3,330	116
117	--	White River at Centerton	2,449	--	--
118	03354500	Beanblossom Creek at Beanblossom	14.6	8,140	558
120	03357350	Plum Creek near Bainbridge	3.00	744	248
122	03358000	Mill Creek near Cataract	245	11,400	47
125	--	White River at Elliston	4,468	--	--
127	--	White River at Edwardsport	5,012	--	--
130	03361650	Sugar Creek at New Palestine	93.9	1,880	20
131	03361850	Buck Creek at Acton	78.8	7,140	91
132	03362000	Youngs Creek near Edinburgh	107	10,700	100
134	03363000	Driftwood River near Edinburgh	1,060	40,500	38
135	03363500	Flatrock River at St. Paul	303	18,500	61
136	03363900	Flatrock River at Columbus	534	20,000	37
138	03364200	Haw Creek near Clifford	47.5	2,560	54

Table 1. Streamflow-gaging stations without telemetry--Continued

Site number	Station number	Station name	Drainage area (mi^2)	Peak discharge (ft^3/s)	($[ft^3/s]/mi^2$)
139	03364500	Clifty Creek at Hartsville	91.4	11,300	124
141	03366200	Harberts Creek near Madison	9.31	1,540	165
143	03368000	Brush Creek near Nebraska	11.4	9,360	821
144	03369000	Vernon Fork Muscatatuck River near Butlerville	85.9	26,200	305
146	--	Muscatatuck River at Milport	1,134	--	--
148	03371520	Back Creek at Leesville	24.1	15,300	635
149	--	East Fork White River at Bedford	4,049	--	--
150	03372300	Stephens Creek near Bloomington	10.9	5,400	495
152	--	Salt Creek near Peerless	573	--	--
153	--	East Fork White River at Williams	4,720	--	--
155	03373700	Lost River near West Baden Springs	287	11,100	39
158	--	White River at Hazleton	11,295	--	--
159	03374455	Patoka River near Hardinsburg	12.8	9,270	724
162	03375800	Hall Creek near St. Anthony	21.8	11,500	528
163	--	Patoka River at Pike-Dubois County line	538	--	--
164	03376300	Patoka River at Winslow	603	15,500	26
168	03378550	Big Creek near Wadesville	104	7,880	76
171	04093500	Burns ditch at Gary	160	3,430	21
172	04094000	Little Calumet River at Porter	66.2	3,110	47
173	04094500	Salt Creek near McCool	74.6	3,180	43
174	04095300	Trail Creek at Michigan City	54.1	2,430	45
175	04096100	Galena River near LaPorte	17.2[f]	650	38
176	04096400	St. Joseph River near Burlington, Mich.	201	1,340	7
177	04096515	Hog Creek near Allen, Mich.	48.7	664	14
178	04096600	Coldwater River near Hodunk, Mich.	293	2,280	8

Table 1. Streamflow-gaging stations without telemetry--Continued

Site number	Station number	Station name	Drainage area (mi²)	Peak discharge (ft³/s)	Peak discharge ([ft³/s]/mi²)
179	04096900	Nottawa Creek near Athens, Mich.	162	1,340	8
180	04097195	Gourdneck Canal near Schoolcraft, Mich.	g	16	--
181	04097540	Prairie River near Nottawa, Mich.	106	797	8
182	--	St. Joseph River at Three Rivers, Mich.	1,350	8,180	6
183	--	Fawn River near White Pigeon, Mich.	192	725	4
185	04099510	Pigeon Creek near Angola	106 [h]	795	8
186	04099750	Pigeon River near Scott	361 [i]	2,370	7
187	04099808	Little Elkhart River at Middlebury	97.6 [j]	2,470	25
188	04099850	Pine Creek near Elkhart	31.0 [k]	577	19
189	04100222	North Branch Elkhart River at Cosperville	142	919	6
190	04100252	Forker Creek near Burr Oak	19.2	480	25
191	04100295	Rimmel Branch near Albion	10.7	418	39
192	04100377	Solomon Creek near Syracuse	36.1	--	--
195	--	St. Joseph River at South Bend	3,609	--	--
196	04177720	Fish Creek at Hamilton	37.5	654	17
198	04180000	Cedar Creek near Cedarville	270	5,340	20
200	--	St. Joseph River at Fort Wayne	1,080	--	--
204	04182590	Harber ditch at Fort Wayne	21.9	1,010	46
205	04182810	Spy Run Creek at Fort Wayne	14.0	1,270	91
206	--	St. Marys River at Fort Wayne	815	--	--
208	04183000	Maumee River at New Haven	1,967	26,600	14
209	05515000	Kankakee River near North Liberty	174 [l]	908	5
215	05517890	Cobb ditch near Kouts	30.3	1,070	35
216	--	Kankakee River at Hebron	1,650	--	--
218	05519000	Singleton ditch at Schneider	123	3,550	29

Table 1. Streamflow-gaging stations without telemetry--Continued

Site number	Station number	Station name	Drainage area (mi^2)	Peak discharge (ft^3/s)	($[ft^3/s]/mi^2$)
219	05521000	Iroquois River at Rosebud	35.6	475	13
220	05522000	Iroquois River near North Marion	144	2,040	14
221	05522500	Iroquois River at Rensselaer	203	2,550	13
222	05523000	Bice ditch near South Marion	21.8	1,080	50
223	05524500	Iroquois River near Foresman	449	5,930	13

[a]Includes 28.1 mi^2 non-contributing drainage.
[b]Includes 10.6 mi^2 non-contributing drainage.
[c]Includes 76.9 mi^2 non-contributing drainage.
[d]Includes 192 mi^2 non-contributing drainage.
[e]Includes 0.88 mi^2 non-contributing drainage.
[f]Includes 2.30 mi^2 non-contributing drainage.
[g]Indeterminate drainage.
[h]Includes 22.5 mi^2 non-contributing drainage.
[i]Includes 53.9 mi^2 non-contributing drainage.
[j]Includes 5.89 mi^2 non-contributing drainage.
[k]Includes 8.75 mi^2 non-contributing drainage.
[l]Includes 58.2 mi^2 non-contributing drainage.

Table 2. Streamflow-gaging stations with Telemark equipment
[ft^3/s, cubic feet per second; $[ft^3/s]/mi^2$, cubic feet per second per square mile; mi^2, square mile; --, no data]

Site number	Station number	Station name	Drainage area (mi^2)	Peak discharge (ft^3/s)	($[ft^3/s]/mi^2$)
60	03333700	Wildcat Creek at Kokomo	242	8,100	33
91	03347000	White River at Muncie	241	20,000	83
96	03349000	White River at Noblesville	858	26,800	31
100	03351060	White River at Broad Ripple	1,238	--	--
112	03353600	Little Eagle Creek at Speedway	23.9	3,330	139
128	03361000	Big Blue River at Carthage	184	12,900	70
170	04093200	Little Calumet River at Gary	5.8	--	--
206	04182900	Maumee River at Fort Wayne	1,926	--	--
212	05517000	Yellow River at Knox	435 [a]	5,660	13
213	05517500	Kankakee River at Dunns Bridge	1,352 [b]	5,870	4
214	05517530	Kankakee River at Kouts	1,376 [c]	6,420	5

[a]Includes 51.0 mi^2 non-contributing drainage.
[b]Includes 192 mi^2 non-contributing drainage.
[c]Includes 194 mi^2 non-contributing drainage.

Table 3. Streamflow-gaging stations with data-collection platform and telephone line
[ft^3/s, cubic feet per second; $[ft^3/s]/mi^2$, cubic feet per second per square mile; mi^2, square mile; --, no data]

Site number	Station number	Station name	Drainage area (mi^2)	Peak discharge (ft^3/s)	Peak discharge ($[ft^3/s]/mi^2$)
4	03275000	Whitewater River near Alpine	522	37,100	71
6	03276000	East Fork Whitewater River at Brookville	380	36,100	95
7	03276500	Whitewater River at Brookville	1,224	81,800	67
19	03302849	Whiskey Run at Marengo	7.02	--	--
28	03322900	Wabash River at Linn Grove	453	9,560	21
30	03323500	Wabash River at Huntington	721	14,900	21
31	03324000	Little River near Huntington	263	5,990	23
33	03324300	Salamonie River near Warren	425	13,200	31
34	03324500	Salamonie River at Dora	557	16,500	30
35	03325000	Wabash River at Wabash	1,768	90,000	51
39	03326500	Mississinewa River at Marion	682	25,000	37
40	03327000	Mississinewa River at Peoria	808	28,000	35
41	03327500	Wabash River at Peru	2,686	115,000	43
43	03328000	Eel River at North Manchester	417	8,240	20
46	03329000	Wabash River at Logansport	3,779	140,000	37
54	0331500	Tippecanoe River near Ora	856	8,660	10
64	03335500	Wabash River at Lafayette	7,267	190,000	26
74	03340500	Wabash River at Montezuma	11,118	230,000	21
75	03340800	Big Raccoon Creek near Fincastle	139	39,900	287
76	03340900	Big Raccoon Creek at Ferndale	217	40,500	187
77	03341300	Big Raccoon Creek at Coxville	448	108,000	241
79	03341500	Wabash River at Terre Haute	12,263	245,000	20
93	03348000	White River at Anderson	406	28,000	69
99	03351000	White River near Nora	1,219	58,500	48
105	03352500	Fall Creek at Millersville	298	22,000	74

Table 3. Streamflow-gaging stations with data-collection platform and telephone line--Continued

Site number	Station number	Station name	Drainage area (mi^2)	Peak discharge (ft^3/s)	($[ft^3/s]/mi^2$)
107	03353000	White River at Indianapolis	1,635	70,000	43
110	03353200	Eagle Creek at Zionsville	103	12,400	120
111	03353500	Eagle Creek at Indianapolis	174	28,800	166
115	03353800	White Lick Creek at Mooresville	212	19,000	90
116	03354000	White River near Centerton	2,444	90,000	37
119	03357000	White River at Spencer	2,988	100,000	33
121	03357500	Big Walnut Creek near Reelsville	326	27,400	84
123	03359000	Mill Creek near Manhattan	294	8,960	30
124	03360000	Eel River at Bowling Green	830	34,000	41
129	03361500	Big Blue River at Shelbyville	421	15,800	38
133	03362500	Sugar Creek near Edinburgh	474	27,600	58
137	03364000	East Fork White River at Columbus	1,707	52,300	31
140	03365500	East Fork White River at Seymour	2,341	120,000	51
142	03366500	Muscatatuck River near Deputy	293	52,200	178
145	03369500	Vernon Fork Muscatatuck River at Vernon	198	56,800	287
147	03371500	East Fork White River near Bedford	3,861	155,000	40
151	03372500	Salt Creek near Harrodsburg	432	22,000	51
154	03373500	East Fork White River at Shoals	4,927	160,000	32
156	03373980	White River above Petersburg	11,123	235,000	21
157	03374000	White River at Petersburg	11,125	235,000	21
160	03374500	Patoka River near Cuzco	170	14,700	86
161	03375500	Patoka River at Jasper	262	16,000	61
166	03377500	Wabash River at Mount Carmel, Ill.	28,635	428,000	15
169	04093000	Deep River at Lake George outlet at Hobart	124	4,000	32
184	04099000	St. Joseph River at Mottville, Mich.	1,866	10,700	6

Table 3. Streamflow-gaging stations with data-collection platform and telephone line--Continued

Site number	Station number	Station name	Drainage area (mi^2)	Peak discharge (ft^3/s)	Peak discharge ($[ft^3/s]/mi^2$)
193	04100500	Elkhart River at Goshen	594	6,360	11
194	04101000	St. Joseph River at Elkhart	3,370	18,800	6
197	04178000	St. Joseph River near Newville	610	9,710	16
202	04181500	St. Marys River at Decatur	621	11,300	18
210	05515500	Kankakee River at Davis	537 [a]	1,920	4
211	05516500	Yellow River at Plymouth	294 [b]	5,390	18
224	05536179	Hart ditch at Dyer	37.6	--	--
225	05536190	Hart ditch at Munster	70.7	2,670	38
226	05536195	Little Calumet River at Munster	90.0	1,510	17

[a]Includes 137 mi^2 non-contributing drainage.
[b]Includes 22.0 mi^2 non-contributing drainage.

Table 4. Streamflow-gaging stations with data-collection platform and satellite transmitter
[ft^3/s, cubic feet per second; $[ft^3/s]/mi^2$, cubic feet per second per square mile; mi^2, square mile; --, no data]

Site number	Station number	Station name	Drainage area (mi^2)	Peak discharge (ft^3/s)	Peak discharge ($[ft^3/s]/mi^2$)
4	03275000	Whitewater River near Alpine	522	37,100	71
6	03276000	East Fork Whitewater River at Brookville	380	36,100	95
7	03276500	Whitewater River at Brookville	1,224	81,800	67
9	03277200	Ohio River at Markland Dam, Ky.	83,170	542,000	7
12	03294500	Ohio River at Louisville, Ky.	91,170	1,110,000	12
13	03294600	Ohio River at Kosmosdale, Ky.	91,440	--	--
21	03303280	Ohio River at Cannelton Dam, Ky.	97,000	617,000	6
24	03304300	Ohio River at Newburgh	--	--	--
25	03322000	Ohio River at Evansville	107,000	1,410,000	13
27	03322420	Ohio River at Uniontown Dam, Ky.	108,000	--	--
28	03322900	Wabash River at Linn Grove	453	9,560	21
29	03323000	Wabash River at Bluffton	532	25,000	47
30	03323500	Wabash River at Huntington	721	14,900	21
31	03324000	Little River near Huntington	263	5,990	23
33	03324300	Salamonie River near Warren	425	13,200	31
34	03324500	Salamonie River at Dora	557	16,500	30
35	03325000	Wabash River at Wabash	1,768	90,000	51
39	03326500	Mississinewa River at Marion	682	25,000	37
40	03327000	Mississinewa River at Peoria	808	28,000	35
41	03327500	Wabash River at Peru	2,686	115,000	43
45	03328500	Eel River at Logansport	789	17,700	22
46	03329000	Wabash River at Logansport	3,779	140,000	37
56	03332345	Tippecanoe River at Buffalo	1,284	--	--
57	03333050	Tippecanoe River near Delphi	1,869	22,600	12
63	03335000	Wildcat Creek near Lafayette	794	25,000	31

Table 4. Streamflow-gaging stations with data-collection platform and satellite transmitter--Continued

Site number	Station number	Station name	Drainage area (mi^2)	Peak discharge	
				(ft^3/s)	($[ft^3/s]/mi^2$)
64	03335500	Wabash River at Lafayette	7,267	190,000	26
66	03336000	Wabash River at Covington	8,218	200,000	24
70	03339000	Vermilion River near Danville, Ill.	1,290	48,700	38
73	03339500	Sugar Creek at Crawfordsville	509	36,000	71
74	03340500	Wabash River at Montezuma	11,118	230,000	21
75	03340800	Big Raccoon Creek near Fincastle	139	39,900	287
76	03340900	Big Raccoon Creek at Ferndale	217	40,500	187
77	03341300	Big Raccoon Creek at Coxville	448	108,000	241
79	03341500	Wabash River at Terre Haute	12,263	245,000	20
81	03342000	Wabash River at Riverton	13,161	250,000	19
86	03343000	Wabash River at Vincennes	13,706	255,000	19
88	03345500	Embarras River at Ste. Marie, Ill.	1,516	44,800	30
106	03352875	Fall Creek at 16th Street at Indianapolis	317	--	--
116	03354000	White River near Centerton	2,444	90,000	37
119	03357000	White River at Spencer	2,988	100,000	33
121	03357500	Big Walnut Creek near Reelsville	326	27,400	84
123	03359000	Mill Creek near Manhattan	294	8,960	30
124	03360000	Eel River at Bowling Green	830	34,000	41
126	03360500	White River at Newberry	4,688	130,000	28
140	03365500	East Fork White River at Seymour	2,341	120,000	51
151	03372500	Salt Creek near Harrodsburg	432	22,000	51
154	03373500	East Fork White River at Shoals	4,927	160,000	32
156	03373980	White River above Petersburg	11,123	235,000	21
157	03374000	White River at Petersburg	11,125	235,000	21
160	03374500	Patoka River near Cuzco	170	14,700	86

Table 4. Streamflow-gaging stations with data-collection platform and satellite transmitter--Continued

Site number	Station number	Station name	Drainage area (mi^2)	Peak discharge	
				(ft^3/s)	($[ft^3/s]/mi^2$)
161	03375500	Patoka River at Jasper	262	16,000	61
165	03376500	Patoka River near Princeton	822	18,700	23
166	03377500	Wabash River at Mount Carmel, Ill.	28,635	428,000	15
167	03378500	Wabash River at New Harmony	29,234	--	--
217	05518000	Kankakee River at Shelby	1,779 [a]	7,650	4
224	05536179	Hart ditch at Dyer	37.6	--	--

[a]Includes 201 mi^2 non-contributing drainage.

Table 5. Streamflow-gaging stations in the National Weather Service Automated Local Evaluation in Real Time (ALERT) network in the Maumee River basin
[ft^3/s, cubic feet per second; [ft3/s]/mi^2, cubic feet per second per square mile; mi^2, square mile; --, no data]

Site number	Station number	Station name	Drainage area (mi^2)	Peak discharge	
				(ft^3/s)	($[ft^3/s]/mi^2$)
197	04178000	St. Joseph River near Newville	610	9,710	16
199	04180500	St. Joseph River near Fort Wayne	1,060	13,200	12
201	--	St. Marys River at Rockford, Oh.	--	--	--
202	04181500	St. Marys River at Decatur	621	11,300	18
203	04182000	St. Marys River near Fort Wayne	762	13,600	18
207	04182900	Maumee River at Fort Wayne	1,926	--	--

Table 6. Guidelines for evaluation of a streamflow-gaging station without telemetry

[ft^3/s, cubic feet per second; $(ft^3/s)/mi^2$, cubic feet per second per square mile; mi^2, square mile; NWS, National Weather Service; >, greater than; <, less than]

Station factors	Points
A. Characteristic of the site	
1. Drainage area, DA in mi^2	
a. DA > 300 and no upstream site	10
2. Peak discharge, Q in ft^3/s and q in $(ft^3/s)/mi^2$	
a. Q > 10,000 and q > 100	10
b. Q > 10,000 and q < 100	5
c. Q < 10,000 and q > 100	5
3. Population of the nearby area	
a. > 100,000	10
b. 10,000 – 100,000	5
B. Flood management and planning use of the data	
1. NWS flood forecast point and no nearby telemetry	20
2. Major reservoir inflow/outflow	20
3. Regional applications (subjective)	10

Table 7. Daily or flood forecast points as supplied by the National Weather Service River Forecast Centers
[mi^2, square mile; --, no data]

Site number	Station number	Station name	Drainage area (mi^2)	River basin
7	03276500	Whitewater River at Brookville	1,224	Whitewater
29	03323000	Wabash River at Bluffton	532	Upper Wabash
35	03325000	Wabash River at Wabash	1,768	Upper Wabash
39	03326500	Mississinewa River at Marion	682	Upper Wabash
41	03327500	Wabash River at Peru	2,686	Upper Wabash
46	03329000	Wabash River at Logansport	3,779	Upper Wabash
54	03331500	Tippecanoe River near Ora	856	Upper Wabash
55	--	Tippecanoe River at Winamac	--	Upper Wabash
64	03335500	Wabash River at Lafayette	7,267	Upper Wabash
66	03336000	Wabash River at Covington	8,218	Middle Wabash
70	03339000	Vermilion River near Danville, Ill.	1,290	Middle Wabash
73	03339500	Sugar Creek at Crawfordsville	509	Middle Wabash
74	03340500	Wabash River at Montezuma	11,118	Middle Wabash
78	--	Wabash River at Clinton	--	Middle Wabash
79	03341500	Wabash River at Terre Haute	12,263	Lower Wabash
80	--	Wabash River at Hutsonville, Ill.	--	Lower Wabash
81	03342000	Wabash River at Riverton	13,161	Lower Wabash
86	03343000	Wabash River at Vincennes	13,706	Lower Wabash
91	03347000	White River at Muncie	241	White
93	03348000	White River at Anderson	406	White
96	03349000	White River at Noblesville	858	White
99	03351000	White River near Nora	1,219	White
101	--	White River at Ravenswood	--	White
107	03353000	White River at Indianapolis	1,635	White
117	--	White River at Centerton	--	White

Table 7. Daily or flood forecast points as supplied by the National Weather Service River Forecast Centers--Continued

Site number	Station number	Station name	Drainage area (mi^2)	River basin
119	03357000	White River at Spencer	2,988	White
124	03360000	Eel River at Bowling Green	830	White
125	--	White River at Elliston	--	White
126	03360500	White River at Newberry	4,688	White
127	--	White River at Edwardsport	--	White
137	03364000	East Fork White River at Columbus	1,707	East Fork White
140	03365500	East Fork White River at Seymour	2,341	East Fork White
149	--	East Fork White River at Bedford	--	East Fork White
153	--	East Fork White River at Williams	--	East Fork White
154	03373500	East Fork White River at Shoals	4,927	East Fork White
157	03374000	White River at Petersburg	11,125	White
158	--	White River at Hazleton	--	White
166	03377500	Wabash River at Mount Carmel, Ill.	28,635	Lower Wabash
167	03378500	Wabash River at New Harmony	29,234	Lower Wabash
184	04099000	St. Joseph River at Mottville, Mich.	1,866	St. Joseph
193	04100500	Elkhart River at Goshen	594	St. Joseph
194	04101000	St. Joseph River at Elkhart	3,370	St. Joseph
197	04178000	St. Joseph River near Newville	610	Maumee
202	04181500	St. Marys River at Decatur	621	Maumee
207	04182900	Maumee River at Fort Wayne	1,926	Maumee
210	05515500	Kankakee River at Davis	537 [a]	Kankakee
211	05516500	Yellow River at Plymouth	294 [b]	Kankakee
212	05517000	Yellow River at Knox	435 [c]	Kankakee
213	05517500	Kankakee River at Dunns Bridge	1,352 [d]	Kankakee
214	05517530	Kankakee River near Kouts	1,376 [e]	Kankakee
217	05518000	Kankakee River at Shelby	1,779 [f]	Kankakee

[a]Includes 137 mi^2 non-contributing drainage.
[b]Includes 22.0 mi^2 non-contributing drainage.
[c]Includes 51.0 mi^2 non-contributing drainage.
[d]Includes 192 mi^2 non-contributing drainage.
[e]Includes 194 mi^2 non-contributing drainage.
[f]Includes 201 mi^2 non-contributing drainage.

Table 8. Major flood-control reservoirs in Indiana
[mi^2, square mile]

Station number	Station name	Drainage area (mi^2)	Storage (acre-feet)	River basin
03275990	Brookville Reservoir	379	360,000	Whitewater
03323450	Huntington Reservoir	717	153,000	Upper Wabash
03324450	Salamonie Reservoir	553	263,000	Upper Wabash
03326950	Mississinewa Reservoir	807	368,000	Upper Wabash
03340870	Cecil M. Harden Reservoir	216	133,000	Middle Wabash
03353450	Eagle Creek Reservoir	162	24,000	White
03358900	Cagles Mill Reservoir	293	228,000	White
03372400	Monroe Reservoir	432	446,000	East Fork White
03374498	Patoka Reservoir	168	298,000	Patoka

Table 9. Locations indicated for installation of telemetry
[mi^2, square mile]

Existing streamflow-gaging stations:

Site number	Station number	Station name	Drainage area (mi^2)	River basin
2	03274750	Whitewater River near Hagerstown	58.7	Whitewater
5	03275600	East Fork Whitewater River at Abington	200	Whitewater
8	03276700	South Hogan Creek near Dillsboro	38.1	Ohio
11	03294000	Silver Creek near Sellersburg	189	Ohio
18	03302800	Blue River at Fredericksburg	283	Ohio
37	03325500	Mississinewa River near Ridgeville	133	Upper Wabash
48	03329700	Deer Creek near Delphi	274	Upper Wabash
52	--	Tippecanoe River at Talma	483	Upper Wabash
58	03333450	Wildcat Creek near Jerome	146	Upper Wabash
62	03334500	South Fork Wildcat Creek near Lafayette	243	Upper Wabash
102	03351310	Crooked Creek at Indianapolis	17.9	White
104	03351500	Fall Creek near Fortville	169	White
113	03353620	Lick Creek at Indianapolis	15.6	White
122	03358000	Mill Creek near Cataract	245	White
131	03361850	Buck Creek at Acton	78.8	East Fork White
132	03362000	Youngs Creek near Edinburgh	107	East Fork White
135	03363500	Flatrock River at St. Paul	303	East Fork White
155	03373700	Lost River near West Baden Springs	287	East Fork White
159	03374455	Patoka River near Hardinsburg	12.8	Patoka
172	04094000	Little Calumet River at Porter	66.2	Calumet
173	04094500	Salt Creek near McCool	74.6	Calumet
174	04095300	Trail Creek at Michigan City	54.1	Calumet
186	04099750	Pigeon River near Scott	361	St. Joseph
198	04180000	Cedar Creek near Cedarville	270	Maumee
208	04183000	Maumee River at New Haven	1,967	Maumee
223	05524500	Iroquois River near Foresman	449	Kankakee

Table 9. Locations indicated for installation of telemetry--Continued

Proposed streamflow-gaging stations:

Site letter	Station name	River basin
A	Anderson River near Fulda	Ohio
B	Big Walnut Creek near Barnard	White
C	Cool Creek near Carmel	White
D	East Fork White River at Sparksville	East Fork White
E	Honey Creek near Terre Haute	Lower Wabash
F	Kankakee River near English Lake	Kankakee
G	Laughery Creek near Friendship	Ohio
H	Little Blue River at English	Ohio
I	Mud Creek at Indianapolis	White
J	North Fork Salt Creek near Nashville	East Fork White
K	Pleasant Run Creek near Greenwood	White
L	Sugar Creek near Lebanon	Middle Wabash
M	White Lick Creek near Brownsburg	White
N	White River near Windsor	White
O	Williams Creek at Indianapolis	White