EFFECTS OF STORM RUNOFF ON WATER QUALITY IN THE WHITE RIVER AND FALL CREEK, INDIANAPOLIS, INDIANA, JUNE THROUGH OCTOBER 1986 AND 1987

By Jeffrey D. Martin and Richard A. Craig

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 89-4185

Prepared in cooperation with the

INDIANAPOLIS DEPARTMENT OF PUBLIC WORKS

Indianapolis, Indiana

1990

DEPARTMENT OF THE INTERIOR

MANUEL L. LUJAN, JR., Secretary

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information
write to:

District Chief
U.S. Geological Survey
5957 Lakeside Boulevard
Indianapolis, IN 46278-1996

Copies of this report
can be purchased from:

U.S. Geological Survey
Books and Open-File Reports
Federal Center, Building 810
Box 25425
Denver, CO 80225-0425

CONTENTS

FIGURES

TABLES

CONVERSION FACTORS

Inch-pound units in this report may be converted to metric (International System) units by using the following conversion factors:

Multiply inch-pound units	By	To obtain metric units
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
gallon per minute (gal/min)	0.06309	liters per second (L/s)

To convert degree Fahrenheit (°F) to degree Celsius (°C)

$$5/9 \times (°F - 32) = °C$$

To convert degree Celsius (°C) to degree Fahrenheit (°F)

$$(1.8 \times °C) + 32 = °F$$

ABBREVIATIONS AND SYMBOLS

AWT	Advanced wastewater treatment
°C	Degree Celsius
CSO	Combined sewer overflow
DPW	Indianapolis Department of Public Works
°F	Degree Fahrenheit
ft	Foot
ft^3/s	Cubic foot per second
gal/min	Gallon per minute
HNTB	Howard Needles Tammen & Bergendoff
in.	Inch
mg/L	Milligram per liter
mi	Mile
mi^2	Square mile
mL	Milliliter
μS/cm	Microsiemen per centimeter at 25 degrees Celsius
---	No data

EFFECTS OF STORM RUNOFF ON WATER QUALITY IN THE WHITE RIVER AND FALL CREEK, INDIANAPOLIS, INDIANA, JUNE THROUGH OCTOBER 1986 AND 1987

By Jeffrey D. Martin and Richard A. Craig

ABSTRACT

Four continuous, flow-through water-quality monitors were installed upstream from, in, and downstream from Indianapolis on the White River and near the mouth of Fall Creek in Indianapolis to monitor water quality, especially dissolved oxygen, during periods of base flow and storm runoff. The sites are White River near Nora (upstream from Indianapolis, referred to as Nora), White River at Indianapolis (in Indianapolis, referred to as Indianapolis), White River at Waverly (downstream from Indianapolis, referred to as Waverly), and Fall Creek at 16th Street at Indianapolis (in Indianapolis, referred to as Fall Creek at Indianapolis). Streamflow, dissolved-oxygen concentration, specific conductance, pH, and water temperature were measured at 15-minute intervals from June through October 1986 at Nora, Indianapolis, Waverly, and Fall Creek at Indianapolis, and from June through October 1987 at Waverly and Fall Creek at Indianapolis. Concentrations of dissolved oxygen ranged from 1.0 to 20.4 milligrams per liter, specific conductance ranged from 161 to 1,400 microsiemens per centimeter at 25 degrees Celsius, pH ranged from 6.6 to 8.9, and temperature ranged from 9.8 to 30.4 degrees Celsius during the study period.

Daily cycles of dissolved oxygen, pH, and temperature are typical features of water quality during base flow during the summer. Dissolved oxygen, pH, and temperature cycled in phase. Daily fluctuations of temperature of 2 to 3 degrees Celsius were common. Daily mean water temperature typically was greater at Indianapolis and Waverly than at Nora and Fall Creek at Indianapolis. Daily fluctuations of dissolved oxygen in the White River often were greater than 6 milligrams per liter, and fluctuations greater than 13 milligrams per liter were measured. Daily fluctuations of dissolved oxygen in Fall Creek were less than 6 milligrams per liter. Daily mean concentrations of dissolved oxygen in the White River generally were higher than those in Fall Creek. Supersaturation of dissolved oxygen greater than 200 percent commonly occurred in the White River, but rarely exceeded 150 percent in Fall Creek. Continuous supersaturation occurred for 12 consecutive days at Nora during base flow. Supersaturation greater than 260 percent occurred at Waverly on August 14, 1987. Photosynthesis caused the large fluctuations and supersaturation of dissolved oxygen, and indicates that the White River is more productive than Fall Creek. Daily fluctuations of pH of one-half unit or more were common during periods of intense photosynthesis. Daily mean pH often was more than one-half unit less at Waverly than at the upstream monitoring stations.

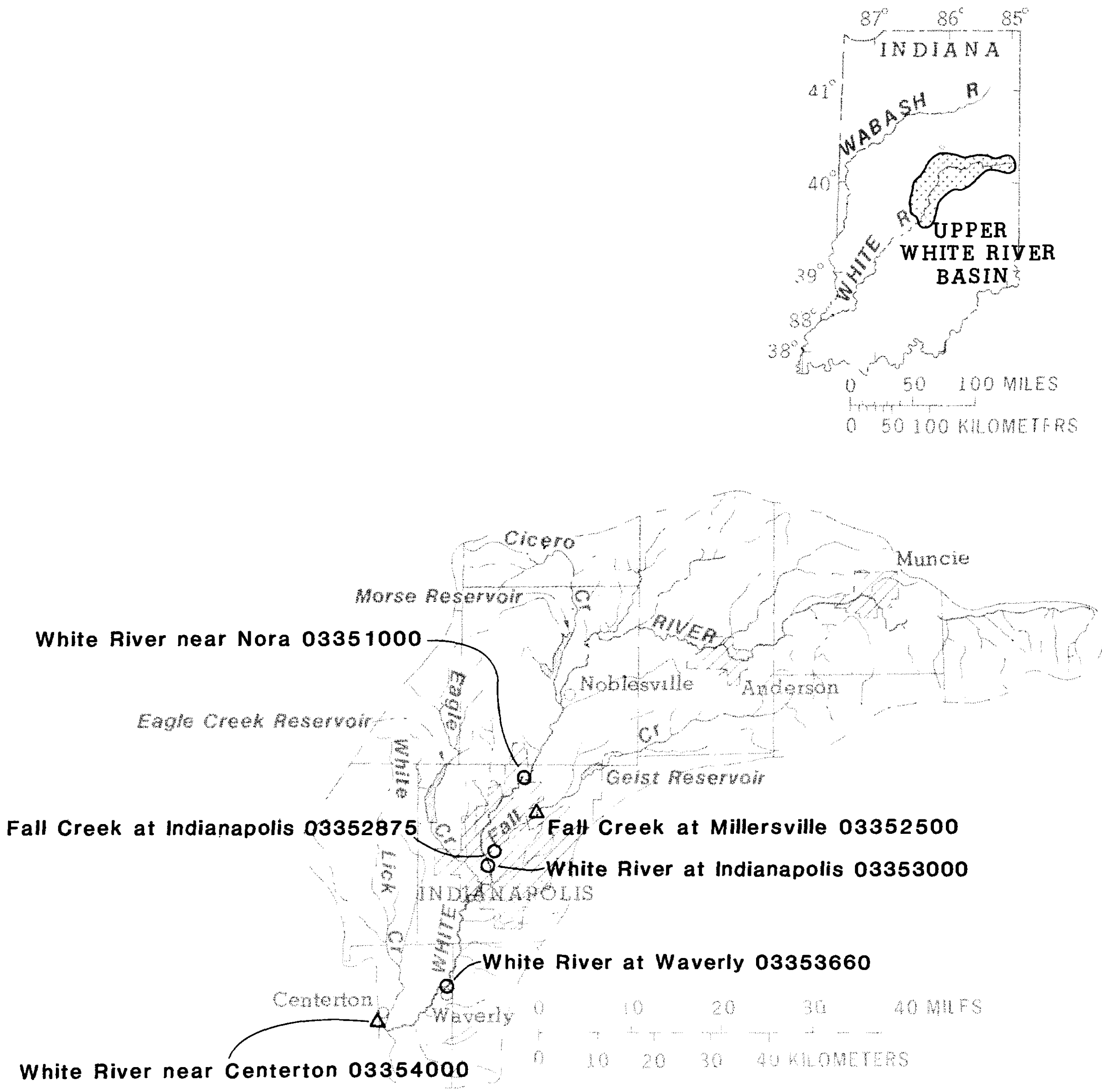
Water quality during base flow is the typical condition against which water quality during storm runoff is compared. A rapid increase in streamflow indicates the beginning of a period of storm runoff and is associated with a decrease in specific conductance and pH and, sometimes, dissolved oxygen or temperature. Concentrations of dissolved oxygen often decreased during storm runoff, especially during the initial rise in the hydrograph. The occurrence and magnitude of the decrease in dissolved oxygen varied among periods of storm runoff and were not related consistently to the magnitude of storm runoff. Storm runoff consistently diminished or eliminated daily cycles of dissolved oxygen.

Periods of low dissolved-oxygen concentrations are defined as the periods of time when concentrations of dissolved oxygen are less than 4.0 milligrams per liter (the Indiana instantaneous dissolved-oxygen standard). Twenty-one periods of low dissolved-oxygen concentrations were measured during the study period. Four periods of low dissolved-oxygen concentrations occurred at Nora on four consecutive days during base flow. All of the low dissolved-oxygen concentrations at Waverly and Fall Creek at Indianapolis occurred during periods of storm runoff. Minimum concentrations during 12 low dissolved-oxygen periods at Waverly ranged from 1.0 to 3.9 milligrams per liter and had a median concentration of 2.8 milligrams per liter. Duration of low dissolved-oxygen concentrations ranged from 0.75 to 83.75 hours and had a median duration of 5 hours. Minimum concentrations during five low dissolved-oxygen periods at Fall Creek at Indianapolis ranged from 2.0 to 3.4 milligrams per liter and had a median concentration of 2.7 milligrams per liter. Duration of low dissolved-oxygen concentrations ranged from 1.75 to 33.75 hours and had a median duration of 7 hours.

INTRODUCTION

The White River is the principal river draining central Indiana and the cities of Muncie, Anderson, and Indianapolis (fig. 1). Water quality of the upper White River during base flow has improved markedly in recent years, largely because of improvements in municipal and industrial wastewater treatment (Indiana Department of Environmental Management, undated, p. 98, 104, 129). Consequently, concern about water quality in the White River has shifted from point to nonpoint sources of pollution.

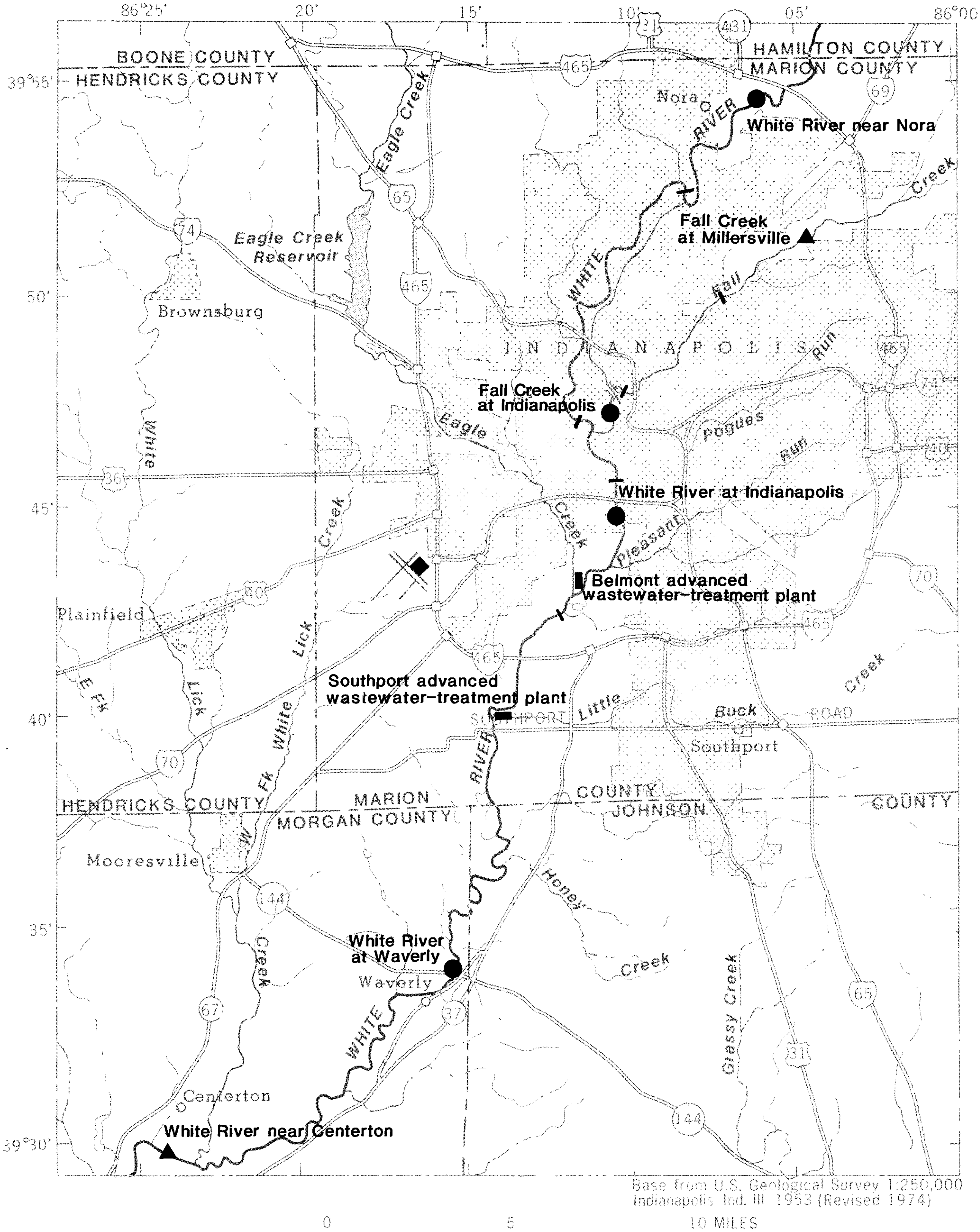
The U.S. Geological Survey, in cooperation with the Indianapolis Department of Public Works, began a program in 1985 to monitor concentrations of dissolved oxygen in the White River and Fall Creek continuously during the summer low-flow season. Continuous, flow-through water-quality monitors were installed at three locations on the White River and near the mouth of Fall Creek, the largest tributary to the White River in Indianapolis (fig. 2). The purpose of this monitoring program was to document the frequency and duration of low dissolved-oxygen concentrations associated with storm runoff and to provide a data base of dissolved-oxygen concentrations in the White River and Fall Creek.



EXPLANATION

O	*Streamflow and water-quality monitoring station*
Δ	Selected streamflow-gaging station
03354000	Station number

Figure 1.-- The upper White River basin in east-central Indiana.



EXPLANATION

● Streamflow and water-quality monitoring station

▲ Selected streamflow-gaging station

◆ Indianapolis International Airport climatological station

— Low-head dam

Figure 2.-- Locations of water-quality monitoring stations in and near Indianapolis.

Previous Studies

The effects of municipal sewage effluent and other sources of pollution on the chmical and biological characteristics of the White River have been studied by a variety of investigators for more than 50 years. Denham (1938, p. 19, 58) noted that black sludge deposits were common for a few miles downstream from the Indianapolis sewage treatment plant and that the polluted area was characterized by a great abundance of tolerant organisms. Minimum diel (24-hour) dissolved-oxygen concentrations during July 1933 were 0.0 mg/L (milligrams per liter) for 14 mi (miles) downstream from the effluent. Maximum diel dissolved-oxygen concentrations were 0.0 mg/L from 2.5 to 6.5 mi downstream from the effluent (Denham, 1938, p. 52). Maximum phytoplankton concentrations of 15,265 cells/mL (cells per milliliter) were measured about 61 mi downstream from the effluent (17 mi downstream from Centerton) and correlated with maximum dissolved-oxygen concentrations (21.8 mg/L, 310-percent saturation) (Denham, 1938, p. 60, 70).

Brinley (1942, p. 138-139) studied the White River during low flow in August and September 1940 and determined that the phytoplankton community was almost totally destroyed by sewage from Muncie. Five-day biochemical oxygen demand and coliform bacteria downstream from Muncie were as high as 57.6 mg/L and 460,000 organisms/mL (organisms per milliliter). Concentrations of dissolved oxygen downstream from Muncie were 0.0 mg/L for at least 1 mi. Phytoplankton increased to a maximum concentration of 35,700 cells/mL at Noblesville (Brinley, 1942, p. 141). A similar algal bloom was observed downstream from Indianapolis, starting about 7 mi downstream from Centerton and extending for about 60 mi. In this reach, phytoplankton, primarily diatoms, ranged from 28,800 to 44,300 cells/mL and were associated with high dissolved-oxygen concentrations (8.0 to 15.7 mg/L) and low concentrations of biochemical oxygen demand (5.7 to 7.5 mg/L) and coliform bacteria (15 to 93 organisms/mL) (Brinley, 1942, p. 137, 140).

Shampine (1975, p. 64) assessed the water quality of the upper White River basin and concluded that the most severe water-quality problems occurred in the Indianapolis area. Oxygen-demanding wastes discharged by the Indianapolis sewage-treatment plant decreased dissolved-oxygen concentrations at least 28 mi downstream to the town of Centerton (Shampine, 1975, p. 36, 64). Dissolved-oxygen concentrations in the White River at Centerton were 1.0 mg/L or less at least 1 day per month, 6 months out of each year during 1965-69 (Shampine, 1975, p. 35, 37).

Wangsness and others (1981) studied the White River at nine sites in Indianapolis upstream from the sewage treatment plants for 24 hours during low flow on August 4-5, 1980. The minimum dissolved-oxygen concentration was 6.5 mg/L (81-percent saturation) and the maximum was 19.0 mg/L (250-percent saturation) (Wangsness and others, 1981, p. 22). Concentrations of dissolved oxygen were greatest where the velocity of streamflow was slowed by small dams. Concentrations of 5-day biochemical oxygen demand ranged from 2.2 to 5.0 mg/L. Concentrations of phytoplankton ranged from 38,945 to 80,990 cells/mL. Most of the phytoplankton were diatoms, primarily *Cyclotella sp.* (Wangsness and others, 1981, p. 34-39). Fecal coliform and fecal streptococci bacteria ranged from 50 to 900 organisms/100mL (organisms per 100 milliliters) and 10 to 840 organisms/100mL. Ratios of fecal coliform to fecal streptococci bacteria indicate that wastes were of human origin (Wangsness and others, 1981, p. 43). The authors suggested that the high concentrations of fecal coliform bacteria that have been measured on other dates likely are caused by combined sewer overflows (CSO's).

The U.S. Geological Survey, in cooperation with the Indianapolis Department of Public Works, began studying the water quality of the White River in 1981 to determine the effects of enlarging and improving the Indianapolis sewage-treatment plants. The two plants were upgraded to advanced wastewater treatment (AWT) including oxygen nitrification and ozone disinfection and were operational in 1983. Trend analysis of fixed-station monitoring data showed statistically significant decreases in downstream concentrations of ammonia, phosphate, solids, fecal coliform bacteria, and biochemical oxygen demand and statistically significant increases in nitrate and dissolved oxygen that were attributed to implementation of AWT (D.J. Wangsness and C.G. Crawford, U.S. Geological Survey, written commun., 1987). Analysis of synoptic, low-flow, 24-hour water-quality surveys made during the summers of 1981-84 at 15 to 17 sites on the White River showed dramatic improvements in water quality after AWT was implemented. Carbonaceous biochemical oxygen demand ranged from 3.5 to 22.0 mg/L before implementation of AWT but ranged from 0.8 to 7.5 mg/L after AWT. Ammonia ranged from 0.06 to 10.0 mg/L before AWT but ranged from 0.01 to 1.6 mg/L after AWT. Dissolved oxygen ranged from 2.2 to 11.1 mg/L before AWT but ranged from 5.6 to 17.4 mg/L after AWT (D.J. Wangsness, U.S. Geological Survey, written commun., 1987) Analysis of benthic invertebrate samples collected downstream from the wastewater treatment plants before and after AWT showed that the benthic invertebrate communities changed from those characteristic of organically enriched streams (dominated by midges, aquatic worms, and leeches) to those found in unpolluted streams (dominated by caddisflies and mayflies) (D.J. Wangsness, U.S. Geological Survey, written commun., 1987).

Kennedy and Bell (1986) measured dissolved-oxygen profiles downstream from the sewage treatment plants on summer mornings during low flow for 3 days in 1982 and 4 days in 1983. Dissolved-oxygen concentrations were less than 3.0 mg/L at every site during the 1982 surveys, but were greater than 3.0 mg/L at every site during the 1983 surveys (after the AWT plants became operational) (Kennedy and Bell, 1986, p. 1142).

Results of the studies by Kennedy and Bell (1986), D.J. Wangsness and C.G. Crawford, U.S. Geological Survey, written commun., 1987, and D.J. Wangsness, U.S. Geological Survey, written commun., 1987, have shown that the base-flow water quality of the White River downstream from Indianapolis has markedly improved, largely because of the implementation of advanced wastewater treatment. Point-source discharges largely have been brought under control, and improvements in the water quality of the White River upstream and downstream from Indianapolis are the result of new or upgraded wastewater-treatment facilities built in the past few years (Indiana Department of Environmental Management, undated, p. 98, 104, 129).

Nonpoint sources of pollution, which include combined sewer overflows and urban runoff, have become a prominent water-quality issue for Indiana (Indiana Department of Environmental Management, undated, p. 101, 104, 108, 129, 131). About 30 percent of the stream miles with impaired water quality in Indiana during 1984-85 were caused by CSO's. Nonpoint sources, primarily urban and agricultural runoff, were responsible for about 10 percent of the stream miles with impaired water quality (Indiana Department of Environmental Management, undated, fig. 3, p. 6-11).

The Indianapolis Department of Public Works hired the firm of Howard Needles Tammen & Bergendoff (HNTB) in 1975 to inventory and monitor combined sewer overflow structures in Indianapolis. The study identified 129 CSO structures, and 124 of these were instrumented to determine the frequency and duration of overflows (Howard Needles Tammen & Bergendoff, 1983, p. 2-2). Frequent dry-weather overflows were observed. Increased sewer maintenance decreased the average number of dry-weather overflow days per month from 63 in 1980 to 8.9 in 1982 (Morse and Eckrich, 1984, p. 69-70).

In 1980, the Indianapolis Department of Public Works hired HNTB to evaluate the effect of CSO's on the water quality of the White River and to propose control measures. Water-quality samples were collected from 5 land use areas, 30 CSO structures, and 18 stream sites on the White River and its tributaries in and downstream from Indianapolis. Diel (24-hour), dry-weather samples were collected on July 9-10, 1981. Dissolved-oxygen concentrations in the White River ranged from 5.8 to 11.3 mg/L in Indianapolis, upstream from the wastewater-treatment plants, but ranged from 3.1 to 5.5 mg/L downstream from the plants (Howard Needles Tammen & Bergendoff, 1983, p. 5-26). Downstream concentrations of dissolved oxygen measured during and after storms were related to the volume of overflow and the load (mass) of pollutants discharged from CSO's. Large overflow volumes and loads of pollutants were associated with concentrations of dissolved oxygen that generally were less than those measured during dry weather. Small volumes and loads were associated with concentrations of dissolved oxygen that generally were greater than those measured during dry weather (Howard Needles Tammen & Bergendoff, 1983, p. 5-29). Generally, concentrations of 5-day biochemical oxygen demand, suspended solids, ammonia, fecal coliform bacteria, lead, and zinc increased during wet weather, whereas total phosphorus, nitrate, and total Kjeldahl nitrogen decreased during wet weather (Howard Needles Tammen & Bergendoff, 1983, p. 5-30).

Water-quality data were used to calibrate computer models. STORM was used to estimate flow and pollutant loadings from surface runoff and combined sewer overflows. RECEIV-II was used to simulate water quality in the White River. Simulations of a variety of scenarios involving stream temperature, base-flow rate, precipitation volume, and effluent quality from AWT plants predicted that 3 to 49 mi of the White River would be expected to have concentrations of dissolved oxygen less than the Indiana standard of 4.0 mg/L (Howard Needles Tammen & Bergendoff, 1983, p. 7-30). Storms with recurrence intervals of 1 month (0.89 in. [inches]), 3 months (1.56 in.), 6 months (2.01 in.), and 1 year (2.50 in.), and durations of 6 hours were modeled. The 3-month design storm had the most adverse effect on dissolved-oxygen concentrations.

HNTB estimated that an average of 12 storms per year would result in concentrations of dissolved oxygen in the White River less than 4.0 mg/L (Howard Needles Tammen & Bergendoff, 1983, p. 9-10, 9-11). The most cost-effective control alternative would be construction of a 10-foot deep by 40-acre pond at the Belmont wastewater-treatment plant to store runoff and wastewater that would otherwise overflow from CSO's. Construction of the pond would eliminate 4 of the 12 wet-weather dissolved-oxygen violations at a capital cost of $29,000,000 and an annual operation and maintenance cost of $47,000 (Howard Needles Tammen & Bergendoff, 1983, p. 8-34, 9-14). HNTB estimated that 5 of the 12 annual violations of the 4.0 mg/L dissolved-oxygen standard were attributed to nonpoint pollution sources other than CSO's, and recommended that the Indianapolis Department of Public Works monitor the quality of the White River during wet weather before initiating control measures (Howard Needles Tammen & Bergendoff, 1983, p. 10-1, 10-3).

Sweeney and Wukash (1982) investigated the water quality of the White River using STORM and LEV3REC computer models. Modeling scenarios included dry- and wet-weather conditions, implementation of AWT, and combined sewer separation. The 1976 water year[1] was used to determine the number of wet-weather days. STORM determined that precipitation on 63 of 72 wet-weather days would cause combined sewers to overflow. With AWT, 47 percent of the storms resulted in concentrations of dissolved oxygen less than 5.0 mg/L (Sweeney and Wukash, 1982, p. 54, 59). Simulation of combined sewer separation decreased the percentage of storms that resulted in concentrations of dissolved oxygen less than 5.0 mg/L from 47 to 45 percent. The authors concluded that urban runoff rather than CSO's is the limiting factor controlling dissolved oxygen during storms (Sweeney and Wukash, 1982, p. 58, 60).

Analysis of the model results showed that, on an annual basis (including both wet-weather and fair-weather days), AWT results in concentrations of dissolved oxygen less than 5.0 mg/L only 5 percent of the year compared to 48 percent of the year without AWT, but the authors concluded that the effect of CSO's and urban runoff are still severe (Sweeney and Wukash, 1982, p. 58-59). Sweeney and Wukash recommended that additional field data be collected to calibrate and verify water-quality models, especially during the summer low-flow season (Sweeney and Wukash, 1982, p. 60).

Purpose and Scope

This report discusses the relation of water quality, especially dissolved oxygen, in the White River and Fall Creek near Indianapolis, to base flow, storm runoff, and Indiana water-quality standards, and it documents the frequency and duration of low dissolved-oxygen concentrations.

Four continuous, flow-through water-quality monitors were installed upstream, in, and downstream from Indianapolis on the White River and near the mouth of Fall Creek in Indianapolis (fig. 2). The sites are: White River near Nora (station 03351000, hereafter referred to as Nora), White River at

[1]A water year is a 12-month period that begins October 1 and ends September 30 and is named for the calendar year in which it ends. For example, the 1976 water year is the period October 1, 1975, through September 30, 1976.

Indianapolis (station 03353000, hereafter referred to as Indianapolis), White River at Waverly (station 03353660, hereafter referred to as Waverly), and Fall Creek at 16th Street at Indianapolis (station 03352875, hereafter referred to as Fall Creek at Indianapolis). Nora and Indianapolis are existing streamflow-gaging stations with relatively long periods of record. Waverly and Fall Creek at Indianapolis were established for this study and lack historic streamflow information. Waverly was established in a reach of the White River that exhibited a dissolved-oxygen sag (area of relatively low concentrations of dissolved oxygen) during base flow (D.J. Wangsness, U.S. Geological Survey, written commun., 1987), and in an area predicted to be in the sag during storm runoff (Howard Needles Tammen & Bergendoff, 1983, p. 7-14, 7-15, 7-16, 7-19, 7-20, 7-32). Fall Creek at Indianapolis was established near the mouth of Fall Creek, a creek generally considered a major source of pollutants to the White River.

Streamflow, dissolved-oxygen concentration, specific conductance, pH, and water temperature were measured at 15-minute intervals from June through October 1986 at Nora, Indianapolis, Waverly, and Fall Creek at Indianapolis, and from June through October 1987 at Waverly and Fall Creek at Indianapolis. Precipitation was measured at the Indianapolis International Airport climatological station. Approximately 352,000 measurements of water quality and 88,000 measurements of streamflow were made during the study period.

Methods used to collect and process streamflow and water-quality data are explained. Precipitation and streamflow data collected during the summers of 1986 and 1987 are compared with long-term normal precipitation and streamflow. Intensity and duration of selected storms during the study period are compared with rainfall frequency for Indianapolis. Ranges of measured water quality and the accuracy of the data are discussed. Daily values of streamflow and water quality are given in 30 tables at the back of the report.

Processes controlling dissolved oxygen during base flow and periods of storm runoff are discussed. Streamflow and dissolved-oxygen concentration and saturation are plotted by month. Water quality typical of base flow is described and compared with water quality during storm runoff. Anomalous patterns of water quality are described. Indiana water-quality standards for dissolved oxygen, specific conductance, pH, and temperature are given, and standards for dissolved oxygen are used to define low concentrations of dissolved oxygen. Frequency and duration of low dissolved-oxygen concentrations are described.

Physical Setting and Hydrologic Conditions

The study area consists of 2,444 mi^2 (square miles) of predominantly agricultural land upstream from the U.S. Geological Survey streamflow-gaging station at White River near Centerton (fig. 1). Corn and soybeans are the principal row crops, but hay production, pasture, small woodlots, and livestock production also are common agricultural land uses. The Miami-Crosby silt loams association are the principal soils in the study area and have developed in a thin silt mantle overlying a clay-loam till (Ulrich, 1966, p. 88-89).

All the land in the study area is located in the Tipton Till Plain physiographic province, a virtually featureless, flat to gently rolling plain composed of Pleistocene drift (Schneider, 1966, p. 49). The drift ranges from less than 50 to more than 250 ft (feet) in thickness (Geosciences Research Associates, Inc., 1982, plate 4) and overlies Mississippian, Devonian, Silurian, and Ordovician bedrock (Gutschick, 1966, p. 5). The bedrock units dip to the southwest and are composed of shale, siltstone, limestone, and dolomite (Indiana Department of Natural Resources, 1970, map 16). The most productive aquifers in the area are Silurian and Devonian carbonate rocks and the glaciofluvial aquifer beneath the floodplain of the White River (Banaszak, 1985, p. 205-206).

Muncie, Anderson, and Indianapolis are the major urban areas in the watershed, and parts of each urban area are served by combined sewers. In Indianapolis, approximately 40 mi^2 of the urban area is served by combined sewers; much of the area served is north and east of downtown Indianapolis (Howard Needles Tammen & Bergendoff, 1983, p. 1-1, exhibit A). The combined sewer system has 129 CSO structures that actively overflow during storms (Howard Needles Tammen & Bergendoff, 1983, p. 1-1). Of the 129 CSO structures, 45 discharge to Pleasant Run; 28 discharge to Fall Creek; 25 discharge directly to the White River; 23 discharge to Pogues Run; 4 discharge to Bean Creek, a tributary to Pleasant Run; 3 discharge to Eagle Creek; and 1 discharges to Little Buck Creek (fig. 2). The Indianapolis monitoring station is downstream from 19 of the CSO's that discharge directly to the White River and all of the CSO's that discharge to Fall Creek and Pogues Run (Howard Needles Tammen & Bergendoff, 1983, exhibit B). The Fall Creek at Indianapolis monitoring station is downstream from 27 of the 28 CSO's that discharge to Fall Creek. The Waverly monitoring station is downstream from all the CSO's in the Indianapolis area, whereas the Nora monitoring station is upstream from all CSO structures in the Indianapolis area.

The study area has a continental climate characterized by hot, humid summers and cold winters. Normal precipitation at the Indianapolis International Airport climatological station is 39.12 in., 17.02 in. of which falls during June through October (National Oceanic and Atmospheric Administration, 1986). Precipitation during the 1986 study period (June through October) was about 6 in. greater than normal, whereas precipitation during the 1987 study period was about normal (table 1). September and October 1986 and July 1987 were much wetter than normal, whereas August 1986 and August, September, and October 1987 were drier than normal (table 1). Daily mean air temperature during the 1986 study period was 69.2 °F (degrees Fahrenheit), 0.9 °F above normal but was 0.3 °F below normal during the 1987 study period. August 1986 and October 1987 were cooler than normal; departures from normal were −3.1 °F and −6.2 °F. The other months were warmer than normal; departures from normal ranged from 0.4 °F in August 1987 to 3.2 °F in September 1986 (National Oceanic and Atmospheric Administration, 1986-87).

The White River generally flows to the west in the upper half of the study area and to the southwest in the lower half of the study area (fig. 1) to its confluence with the Wabash River in southwestern Indiana. The major tributaries to the White River in the study area (those draining more than 200 mi^2) are Fall Creek, White Lick Creek, Cicero Creek, and Eagle Creek (fig. 1). Three major reservoirs regulate streamflow in the vicinity of

Table 1.--Relation of monthly precipitation and streamflow measured in 1986 and 1987 to normal (long-term) monthly precipitation and streamflow

[Data from National Oceanic and Atmospheric Administration, 1986-87; Arvin, 1989; ---, no data]

Station[1]	Year or statistic	Monthly precipitation (inches) June	July	August	September	October	Total
Indianapolis International Airport climatological station	1986	3.58	4.88	1.18	5.68	7.84	23.16
	1987	4.11	9.22	.86	1.41	1.36	16.96
		Normal monthly precipitation					
	Mean	3.99	4.32	3.46	2.74	2.51	17.02

Station[2]	Year or statistic	Monthly mean streamflow (cubic feet per second) June	July	August	September	October
White River near Nora (03351000)	1986	1,670	1,214	306	350	1,150
	1987	1,006	866	295	179	181
		Normal monthly streamflow				
	Mean	1,055	631	434	302	325
	Minimum	200	102	82.5	72.3	108
	25th percentile	485	252	199	158	155
	50th percentile	703	566	301	233	245
	75th percentile	1,219	920	435	413	405
	Maximum	6,093	2,538	2,612	856	1,351
White River at Indianapolis (03353000)	1986	2,133	1,375	228	351	1,981
	1987	976	1,302	249	113	105
		Normal monthly streamflow				
	Mean	1,335	794	522	352	380
	Minimum	216	90.3	42.5	31.5	70.1
	25th percentile	609	333	228	147	173
	50th percentile	1,001	681	348	284	270
	75th percentile	1,561	1,053	550	519	457
	Maximum	7,910	3,149	3,399	1,490	1,819
White River near Centerton (03354000)	1986	3,317	2,362	638	804	3,709
	1987	1,603	2,668	684	396	416
		Normal monthly streamflow				
	Mean	2,302	1,670	1,093	701	702
	Minimum	597	344	327	213	281
	25th percentile	1,241	878	533	435	423
	50th percentile	1,577	1,242	721	588	584
	75th percentile	2,785	1,955	1,148	899	844
	Maximum	10,280	6,629	6,001	1,726	2,215
Fall Creek at Millersville (03352500)	1986	402	256	68.5	72.8	713
	1987	133	328	86.5	59.3	41.9
		Normal monthly streamflow				
	Mean	313	196	137	85.4	90.8
	Minimum	63.0	56.5	46.1	44.1	38.3
	25th percentile	131	90.3	68.1	63.7	57.5
	50th percentile	254	128	76.2	72.3	72.3
	75th percentile	365	252	130	89.3	88.1
	Maximum	1,449	796	739	204	385

[1]Period of record for normal monthly precipitation is 1951-80.
[2]Period of record for normal monthly streamflow is the same as that given in table 2 for mean streamflow.

Indianapolis: Morse, Geist, and Eagle Creek Reservoirs (fig. 1). Morse Reservoir is located on Cicero Creek, Geist Reservoir is located on Fall Creek, and Eagle Creek Reservoir is located on Eagle Creek. Water in Eagle Creek Reservoir and water released from Morse and Geist Reservoirs are used for public supply for Indianapolis. About 30 to 60 ft^3/s (cubic feet per second) is withdrawn from Fall Creek downstream from Fall Creek at Millersville but upstream from Fall Creek at Indianapolis (fig. 2). About 110 to 180 ft^3/s is withdrawn from the White River downstream from Nora but upstream from Indianapolis. Several low-head dams are located on the White River and Fall Creek (fig. 2). The dams pool water upstream from the dam, decrease streamflow velocity, and increase traveltime through the pooled reaches.

Streamflow during June through October largely is controlled by precipitation and evapotranspiration but also is affected by regulation of flow through reservoirs, withdrawals for water supply, and discharge of municipal and industrial effluent. Generally, streamflow is positively associated with the size of the drainage area. Most of the statistics for long-term streamflow-gaging stations on the White River (fig. 1) show that streamflow increases downstream (table 2). During low flow, however, streamflow at Indianapolis is less than that at Nora, 17.6 mi upstream, and shows the effect of withdrawing water for public water supply between these stations (tables 1, 2).

Mean monthly streamflow[1] and other statistics of normal monthly streamflow usually are greatest in June and least in September or October (table 1). Monthly mean streamflow[1] for long-term streamflow-gaging stations near Indianapolis exceeded the 75th percentile for normal monthly flow in June and July 1986, but was near the median for August and September 1986 (table 1). The largest October mean streamflow of record was measured at three of the four long-term stations in October 1986. Monthly mean streamflow for long-term stations was near the median for June and August 1987, was near or greater than the 75th percentile for July 1987, and was near or less than the 25th percentile for September and October 1987 (table 1). Monthly mean streamflow substantially different from normal generally was associated with monthly precipitation that was different from normal.

Two Indianapolis AWT plants discharge large volumes of effluent to the White River (fig. 2). Daily mean discharge of combined effluent from both plants during the study period ranged from 150 to 545 ft^3/s; the median discharge was 230 ft^3/s. The rate of effluent discharged was positively associated with streamflow to the extent that the discharge of effluent generally increased markedly during periods of storm runoff. Treated municipal effluent constituted 4 to 75 percent of the streamflow measured at Waverly during the study period. The median proportion of effluent in streamflow at Waverly was 32 percent. The greatest proportion of effluent occurs during periods of low flow, whereas the least occurs during high flow.

---

[1]The monthly mean streamflow is the arithmetic mean of all daily mean streamflows for a particular month in a particular year. For example, the monthly mean streamflow for October 1986 is the mean of the 31 daily mean streamflows computed for that month. The mean monthly streamflow is a long-term or normal statistic of streamflow. For example, the mean monthly streamflow for October is the arithmetic mean of all October monthly mean streamflows for the period of record.

Table 2.--Daily mean streamflow at selected long-term gaging stations in and near Indianapolis

[Data from Arvin, 1989, and unpublished WATSTORE data; mi^2, square miles; ft^3/s, cubic feet per second]

Station	Drainage area (mi^2)	Period of record	Minimum daily streamflow (ft^3/s)	Daily mean streamflow for June 1 through October 31: Percentage of time daily mean streamflow equaled or exceeded (percent) / Daily mean streamflow equaled or exceeded (ft^3/s) 95	75	50	25	5	Maximum daily streamflow (ft^3/s)
White River near Nora (03351000)[1]	1,219	1929-86	49	109	182	288	514	1,730	28,400
White River at Indianapolis (03353000)[2]	1,635	1904-06 1930-86	8	86	189	338	679	2,160	29,400
White River near Centerton (03354000)[3]	2,444	1930-32 1946-86	138	308	473	748	1,300	3,870	35,000
Fall Creek at Millersville (03352500)[4]	298	1944-86	34	49	65	81	131	517	6,740

[1]Flow slightly regulated by Morse Reservoir.
[2]Flow affected by regulation of Morse Reservoir and Geist Reservoir and by diversion of municipal water supply. Stage-discharge relation affected at times by releases from Eagle Creek Reservoir.
[3]Flow slightly regulated by upstream reservoirs.
[4]Flow regulated by Geist Reservoir.

Acknowledgments

The authors express sincere appreciation to the people who assisted in this study. Vicky Keramida of the Indianapolis Department of Public Works was instrumental in planning the study. Mike Sweeney and Rick Farnham of the Indianapolis Department of Public Works provided information about the processes and discharges from the AWT plants. Tim Bumgardner of the Indianapolis Water Company provided information about the rates of water withdrawn for public supply in the White River and Fall Creek. Beth LeaMond of Indiana University and Roger Letterman of Indiana University-Purdue University at Indianapolis processed much of the 1987 water-quality data. Roger Letterman prepared the data tables for the report. Without the valuable information and assistance provided, the scope of the study would have been diminished greatly.

METHODS

Measurement of Stage and Computation of Streamflow

A continuous record of streamflow at each of the four water-quality monitoring stations was computed by applying a stage-streamflow rating curve to a stage record obtained at 15-minute intervals. The stage of the river was measured by a float or a pressure-sensing device called a manometer and was digitally recorded on paper tape. The stage-streamflow rating curves were developed by a graphical analysis of current-meter streamflow measurements made at various stages. Methods used to measure and compute streamflow are given in Rantz and others (1982a, 1982b).

Measurement of Water Quality

Flow-through monitors were used to measure water quality (Gordon and Katzenbach, 1983). The flow-through monitor consists of three integrated systems that provide a continuous flow of water; an instrument for measuring dissolved-oxygen concentration, specific conductance, pH, and temperature; and a timer and paper-punch recorder for digitally recording water-quality measurements at 15-minute intervals.

The pump system consists of a submersible pump capable of pumping a minimum of 5 gal/min (gallons per minute) from the river to a sensor tank located in the shelter house. Water in the sensor tank swirls past the water-quality sensors and is returned to the river via a discharge line. Approximately 8 mL of chlorine bleach were added to the intake line at the pump after water-quality measurements were made to inhibit biological growth in the lines that could affect water quality. The monitor consists of four signal conditioners, a digital readout, and a programmer. Signal conditioners are used to calibrate the water-quality sensors and to output a voltage that is proportional to the value of the water-quality variable being measured. The digital readout converts the analog voltage signal to the numeral value of the water-quality variable and places this value in a buffer for output to the recorder. The programmer scans the signal conditioners in sequence and causes the recorder to punch the value in the buffer onto paper tape. The timer causes the programmer to scan and record water-quality data at 15-minute intervals.

Initially, pumps were installed in stilling wells that contained the stage-sensing equipment. However, sediment would accumulate in the stilling well, particularly during periods of storm runoff, and would cause the pump to pump at a slow rate, overheat, or shut off. Pumps were placed directly in the stream, and problems associated with pumping sediment-laden water were decreased. Timers were installed in May 1987 that stopped the pump at 6-hour intervals, allowing water in the sensor tank to back-flush sediment from the intake lines and pump. Back-flushing further decreased problems associated with pumping sediment-laden water. Water-quality measurements made when the pump was pumping at a slow rate, overheating, or inoperable were deleted from the record.

Flow-through monitors were calibrated and operated according to the guidelines given in Gordon and Katzenbach (1983, p. 44-89). A Hydrolab[1] model 4041 multiparameter field monitor was used to check the accuracy of data being recorded by the flow-through monitors. The field monitor was calibrated according to the manufacturer's instructions in the office laboratory on the day inspections were made and was used to measure water quality in the river and the sensor tank before and after cleaning or recalibrating the flow-through monitor. During an inspection, if readings from the flow-through monitor and field monitor did not agree within acceptable limits (table 3), the flow-through sensors were cleaned and serviced and readings taken again. If subsequent readings were within limits, the discrepancy between the flow-through monitor and field monitor was attributed to fouling of the flow-through sensor, either by biological growth or adsorption of clay particles. If subsequent readings were not within limits, the flow-through monitor was recalibrated and the discrepancy was attributed to drift in calibration of the monitor. Flow-through monitors were inspected an average of every 5 days at Nora, 8 days at Indianapolis, 9 days at Waverly, and every 7 days at Fall Creek at Indianapolis.

Water-quality measurements recorded on punched paper tape were removed from the recorder and brought to the office for processing at approximately 3-week intervals. Paper tapes were interpreted by a machine that converted punches to numeric values of water-quality variables and stored them and the times of measurement in computer files. Water-quality data were plotted by month and checked for missing punches or other errors. Water-quality data

---

[1]Use of trade names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

Table 3.--Acceptable limits for differences between flow-through monitor values and field monitor values.

[Data from Gordon and Katzenbach, 1983, p. 87; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius]

Water-quality variable	Acceptable limit
Dissolved oxygen	The greater of ±0.3 mg/L or ±5 percent of the measured value
Specific conductance	The greater of ±5 µS/cm or ±5 percent of the measured value
pH	±0.2 pH units
Water temperature	±0.3 °C

collected during periods of fouling or drift in calibration were corrected (Gordon and Katzenbach, 1983, p. 89-93), provided the corrections did not exceed certain magnitudes. Unless evidence was determined to the contrary, the rate of change in the error caused by fouling or drift was assumed to be constant between inspections and to have begun at the last inspection. Data requiring corrections greater than 2.0 mg/L dissolved oxygen, 100 µS/cm (microsiemens per centimeter at 25 degrees Celsius) specific conductance, 0.6 units pH, or 5 °C (degrees Celsius) water temperature were considered too large to be applied and were deleted from the record.

Percent saturation of dissolved oxygen was calculated as the measured concentration of dissolved oxygen divided by the saturation concentration of dissolved oxygen times 100 percent. Saturation concentration of dissolved oxygen was calculated as presented in Bowie and others (1985, p. 91, eq. 3-5):

$$Cs = (14.652-(0.41022\ T)+(0.007991\ T^2)-(0.000077774\ T^3))\ (LP/29.92) \quad (1)$$

where Cs = saturation concentration of dissolved oxygen (milligram per liter),
T = water temperature (degree Celsius), and
LP = local barometric pressure (inch of mercury).

The mean daily local barometric pressure for the study period was 28.34 in. of mercury and was used for all calculation of dissolved-oxygen saturation.

STORM-RUNOFF AND WATER-QUALITY DATA

Daily mean streamflow and daily mean, maximum, and minimum dissolved-oxygen concentration, specific conductance, pH, and water temperature are given by station and year in tables 4-33 in the appendix at the back of the report. Daily precipitation and continuous (15-minute) streamflow, dissolved-oxygen concentration, and dissolved-oxygen saturation are shown by station and month in figures 3a-8e in the appendix at the back of the report. Station descriptions, daily mean and other statistics of streamflow, and related information for the monitoring stations and long-term stations used in this report are published annually in "U.S. Geological Survey Water-Data Reports" (Glatfelter and others, 1987). Statistical summaries of streamflow are published in Stewart (1983) and Arvin (1989). Daily and hourly precipitation for the Indianapolis International Airport climatological station are published monthly (National Oceanic and Atmospheric Administation, 1986-87) and annually (National Oceanic and Atmospheric Administration, 1986).

Storm Runoff

Periods of storm runoff can be determined from figures 3a-8e by examining graphs of precipitation and streamflow. A rapid increase in streamflow associated with precipitation marks the beginning of a period of storm runoff. Storm runoff is assumed to have ended when streamflow returns to approximately the same magnitude as when storm runoff began. Streamflow after this point is called base flow and is fair-weather streamflow composed largely of ground water (Langbein and Iseri, 1960, p. 5), effluent from municipal wastewater treatment or industry, and reservoir releases. Storm runoff is surface runoff or direct runoff (Langbein and Iseri, 1960, p. 7, 18, 20) and is the runoff from rural and urban land, combined sewer overflows, and treatment-plant bypass. Both surface runoff and base flow compose the volume of flood waters during a period of storm runoff, although the proportion of base flow typically is small.

Not all periods of storm runoff are associated with precipitation measured at the Indianapolis International Airport climatological station. For example, storm runoff at Nora on June 21-26, 1986, likely was caused by precipitation during a storm located north of Indianapolis, because no precipitation was measured at the airport (fig. 3a).

Rainfall intensity for selected storms during June through October, 1986 and 1987, is shown in table 34. Storms were selected on the basis of published data for monthly maximum short-duration precipitation (National Oceanic and Atmospheric Administration, 1986-87). Analysis of rainfall intensity shows that some of the storms during the study period were large and infrequent (table 35). Rainfall intensity did not exceed the 2-year recurrence interval for durations of 5 or 15 minutes for any of the storms (tables 34, 35). Rainfall intensity for the storm on October 1, 1986,

Table 34.--Rainfall intensity measured at Indianapolis International Airport climatological station for selected storms during June through October 1986 and 1987

[Data from National Oceanic and Atmospheric Administration, 1986-87; ---, no data]

Date	Duration (minutes)					
	5	15	60	120	180	360
	Maximum rainfall during indicated duration (inches)					
June 16, 1986	0.15	0.41	1.21	1.26	1.26	1.26
July 11, 1986	.13	.34	.99	1.04	1.11	1.16
August 15, 1986	.05	.12	.41	.44	.44	.49
September 20, 1986	---	---	.99	1.20	1.26	1.27
September 26, 1986	.15	.40	---	.75	.75	.75
October 1, 1986	.19	.46	1.05	1.80	1.82	2.69
October 3-4, 1986	---	---	1.70	2.15	2.60	2.79
June 2, 1987	.36	.69	1.37	1.60	1.77	1.92
June 21, 1987	---	---	1.02	1.02	1.02	1.02
July 1, 1987	.15	.38	1.25	2.00	2.62	3.58
July 12, 1987	---	---	.67	.82	.82	.82
August 17, 1987	.10	.16	.28	.32	.32	.32
September 29, 1987	.03	.07	.14	.28	.41	.47
October 26-27, 1987	.04	.09	.19	.31	.38	.62

Table 35.--Rainfall intensity for selected durations and recurrence intervals for Indianapolis

[Data from Indiana Department of Natural Resources, 1982; ---, no data]

Duration (minutes)	Recurrence inverval			
	1 year	2 years	5 years	10 years
	Rainfall (inches)			
5	---	0.45	0.52	0.58
15	---	.86	1.04	1.17
60	---	1.43	1.83	2.11
120	1.49	1.73	2.13	2.40
180	1.55	1.86	2.31	2.67
360	1.90	2.23	2.75	3.17

exceeded the 2-year recurrence interval for durations of 120 and 360 minutes. Rainfall intensity for the storm on October 3-4, 1986, exceeded the 2-year recurrence interval for a duration of 60 minutes and the 5-year recurrence interval for durations of 120, 180, and 360 minutes. Rainfall intensity for the storm on July 1, 1987, exceeded the 2-year recurrence interval for a durations of 120 minutes, the 5-year recurrence interval for a duration of 180 minutes, and exceeded the 10-year recurrence interval for a duration of 360 minutes (tables 34, 35).

Daily mean streamflow during June through October 1986 ranged from 190 to 5,600 ft^3/s at Nora (table 4), 115 to 10,400 ft^3/s at Indianapolis (table 9), 388 to 12,900 ft^3/s at Waverly (table 14), and from 30 to 4,970 ft^3/s at Fall Creek at Indianapolis (table 19). Daily mean streamflow during June through October 1987 ranged from 277 to 5,270 ft^3/s at Waverly (table 24), and from 19 to 1,310 ft^3/s at Fall Creek at Indianapolis (table 29).

Water Quality

Ranges and Missing Record

Concentrations of dissolved oxygen during June through October 1986 ranged from 2.9 to 18.5 mg/L at Nora (table 5), 4.5 to 16.8 mg/L at Indianapolis (table 10), 1.1 to 14.3 mg/L at Waverly (table 15), and from 4.0 to 11.2 mg/L at Fall Creek at Indianapolis (table 20). Concentrations of dissolved oxygen during June through October 1987 ranged from 1.0 to 20.4 mg/L at Waverly (table 25) and from 2.0 to 12.3 mg/L at Fall Creek at Indianapolis (table 30). Approximately 16 percent of the dissolved-oxygen record during 1986 was missing at Nora (table 5, figs. 3a-3e), 6 percent at Indianapolis (table 10, figs. 4a-4e), 35 percent at Waverly (table 15, figs. 5a-5d), and 1 percent was missing at Fall Creek at Indianapolis (table 20, figs. 6a-6e). Approximately 22 percent of the dissolved-oxygen record during 1987 was missing at Waverly (table 25, figs. 7a-7e) and 3 percent was missing at Fall Creek at Indianapolis (table 30, figs. 8a-8e).

Specific conductance during June through Octber 1986 ranged from 305 to 882 µS/cm at Nora (table 6), 265 to 812 µS/cm at Indianapolis (table 11), 292 to 1,150 µS/cm at Waverly (table 16), and from 161 to 955 µS/cm at Fall Creek at Indianapolis, (table 21). Specific conductance during June through October 1987 ranged from 259 to 1,400 µS/cm at Waverly (table 26), and from 194 to 945 µS/cm at Fall Creek at Indianapolis (table 31). Approximately 9 percent of the specific-conductance record during 1986 was missing at Nora (table 6), 5 percent at Indianapolis (table 11), 29 percent at Waverly (table 16), and 50 percent was missing at Fall Creek at Indianapolis (table 21). Approximately 22 percent of the specific-conductance record during 1987 was missing at Waverly (table 26), and 3 percent was missing at Fall Creek at Indianapolis (table 31).

Measurements of pH during June through October 1986 ranged from 6.9 to 8.9 at Nora (table 7), 7.1 to 8.7 at Indianapolis (table 12), 6.7 to 7.9 at Waverly (table 17), and from 6.6 to 8.3 at Fall Creek at Indianapolis (table 22). Measurements of pH during June through October 1987 ranged from 6.9 to 8.2 at Waverly (table 27) and from 7.3 to 8.5 at Fall Creek at Indianapolis (table 32). Approximately 9 percent of the pH record durng 1986 was missing at Nora (table 7), 5 percent at Indianapolis (table 12), 42 percent at Waverly (table 17), and 1 percent was missing at Fall Creek at Indianapolis (table 22). None of the pH record during 1987 was missing at Waverly (table 27), but approximately 3 percent was missing at Fall Creek at Indianapolis (table 32).

Water temperature during June through October 1986 ranged from 10.5 to 29.4 °C at Nora (table 8), 11.8 to 29.7 °C at Indianapolis (table 13), 11.9 to 28.8 °C at Waverly (table 18), and from 12.1 to 28.1 °C at Fall Creek at Indianapolis (table 23). Water temperature during June to October 1987 ranged from 12.3 to 30.4 °C at Waverly (table 28) and from 9.8 to 29.8 °C at Fall Creek at Indianapolis (table 33). Approximately 16 percent of the water-temperature record during 1986 was missing at Nora (table 8), 5 percent at Indianapolis (table 13), 29 percent at Waverly (table 18), 1 percent was missing at Fall Creek at Indianapolis (table 23). None of the water-temperature record during 1987 was missing at Waverly (table 28), but approximately 3 percent was missing at Fall Creek at Indianapolis (table 33).

Accuracy of Water-Quality Data

Gordon and Katzenbach (1983, p. 6) provide information about the measurement accuracy of the flow-through monitor. Accuracy is defined as a epercentage of the full measurement scale or a numerical value. For measurment scales used in this study, the expected accuracy is plus or minus 0.2 mg/L for concentrations of dissolved oxygen, 30 µS/cm for specific conductance, 0.1 for pH, and 0.5 °C for temperature.

Measurement accuracy attained during this study was not as good as that given in Gordon and Katzenbach (1983, p.6). Accuracy is defined in this study as the difference between water quality measured in the river near the pump with a field monitor and water quality measured in the sensor tank by the flow-through monitor, before the flow-through monitor was serviced. Differences (water quality measured by the field monitor minus water quality measured by the flow-through monitor) show considerable scatter and do not appear to be symmetrically distributed about zero, the point of no diffference (figs. 9-12, table 36). Generally, dissolved-oxygen concentration, specific conductance, and pH measured by the flow-through monitor were less than those measured by the field monitor (figs. 9-11), whereas water temperature measured by the flow-through monitor generally was greater than that measured by the field monitor (fig. 12). Differences shown in figures 9-12 and table 36 are for water-quality data presented in this report. Differences for missing or deleted periods of record are not shown.

Fouling of flow-through water-quality sensors by biological growth or adsorption of clay particles is a likely cause of some of the differnces in measured water quality. Cleaning the sensors during an inspection usually improved agreement in measured water quality. Drift in calibration of the flow-through monitor is another likely cause of differences in measured water quality. Other sources of variation include changes in water quality caused by pumping water from the river to the sensor tank and malfunction of electrical or mechanical components of the flow-through monitor.

Differences in water quality measured before the flow-through monitor was serviced were used to correct water-quality record from the flow-through monitor to measured values in the river. Unless evidence was determined to the contrary, the rate of fouling, drift, and other causes of differences in measured water quality was assumed to be constant and to have begun following the last inspection. On the basis of these assumptions, a prorated correction based on time was applied to data collected between inspections. All water-quality data were corrected using the procedure given for the first type of nonuniform error discussed in Gordon and Katzenbach (1983, p. 90-91). Water-quality data requiring corrections greater than plus or minus 2.0 mg/L dissolved oxygen 100 µS/cm specific conductance, 0.6 pH, or 5.0 °C temperature were considered too large to be applied and were deleted from the record.

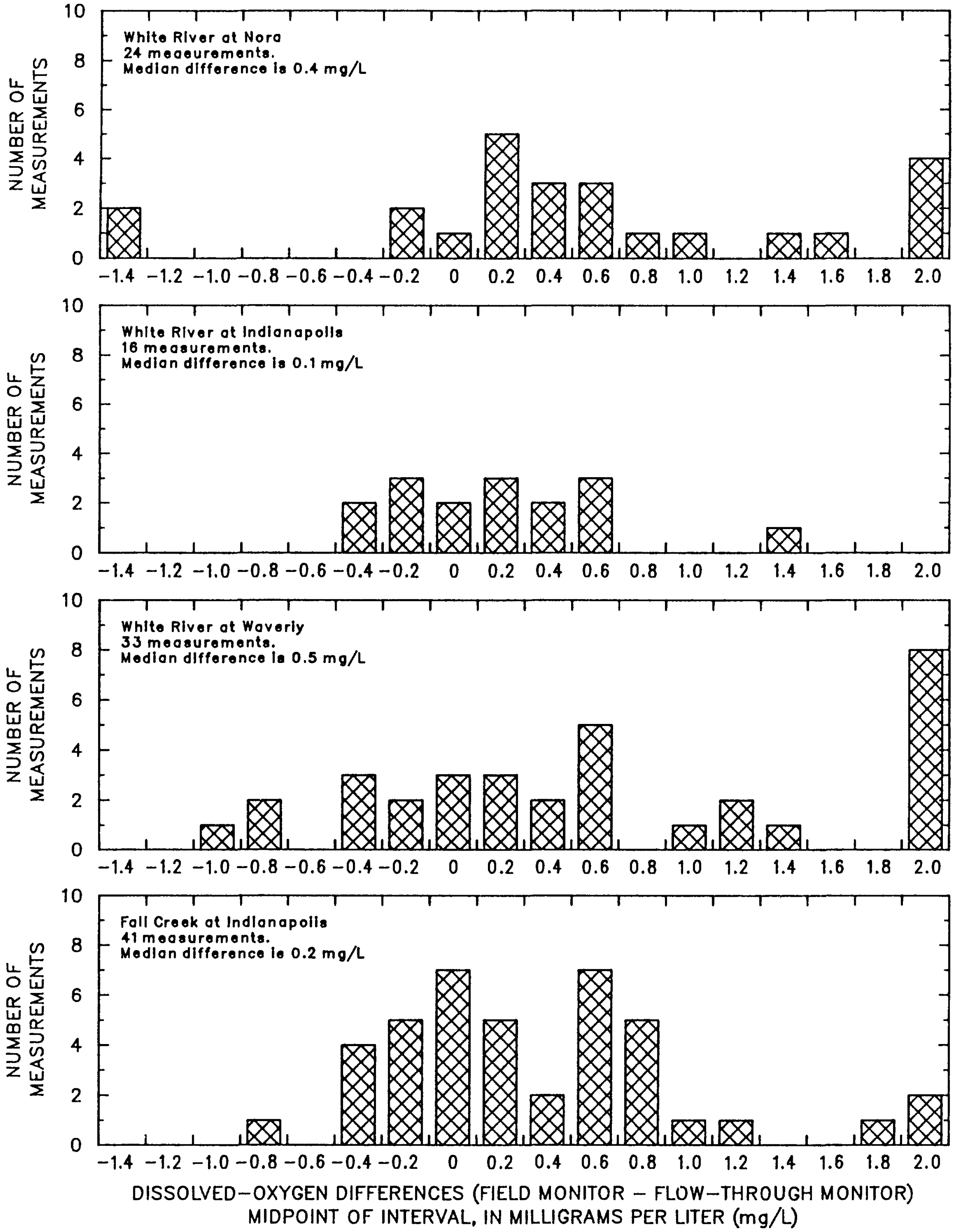


Figure 9. −− Histograms of differences between dissolved−oxygen concentration measured with the field monitor and dissolved−oxygen concentration measured with the flow−through monitor, before the flow−through monitor was serviced.

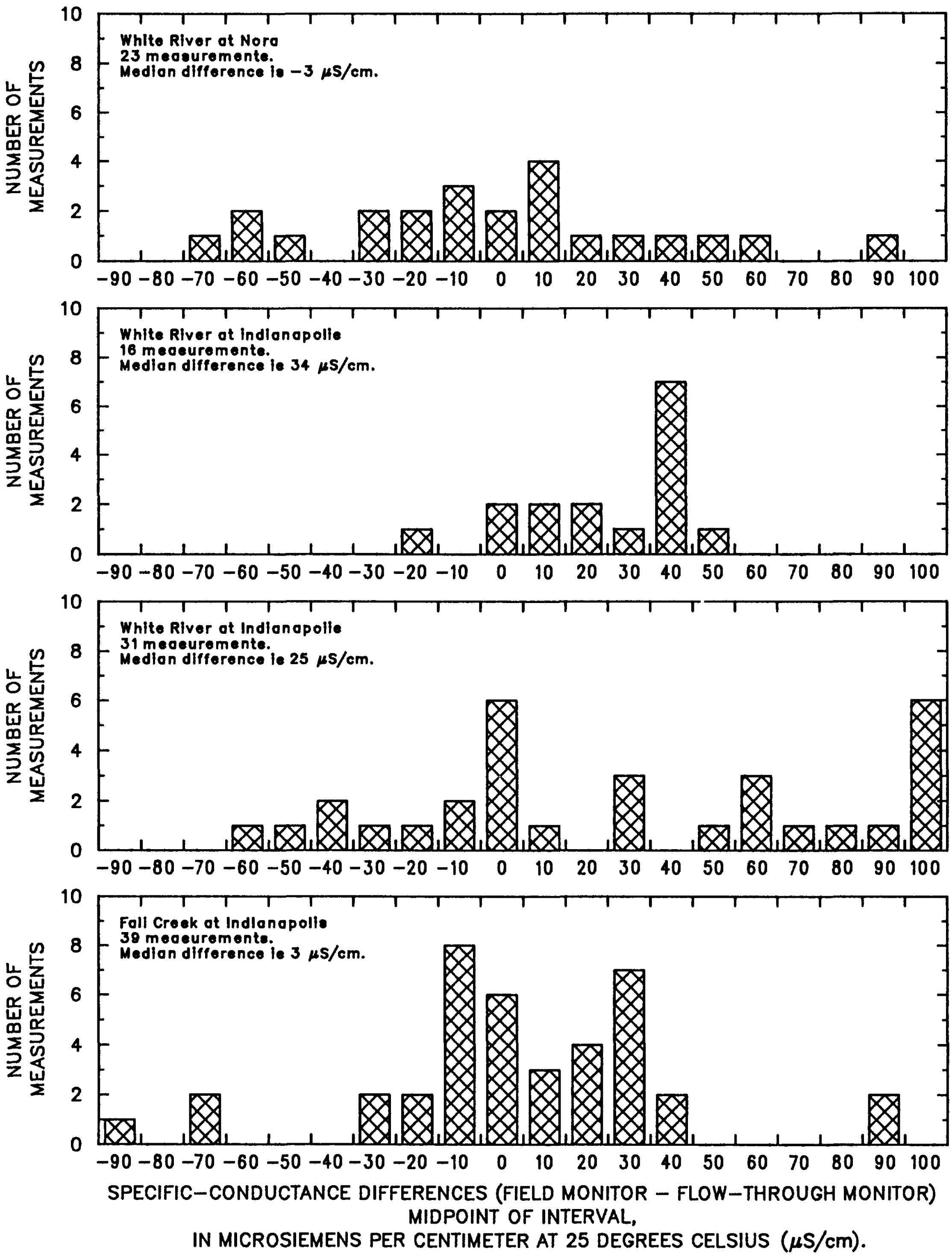


Figure 10. —— Histograms of differences between specific conductance measured with the field monitor and specific conductance measured with the flow−through monitor, before the flow−through monitor was serviced.

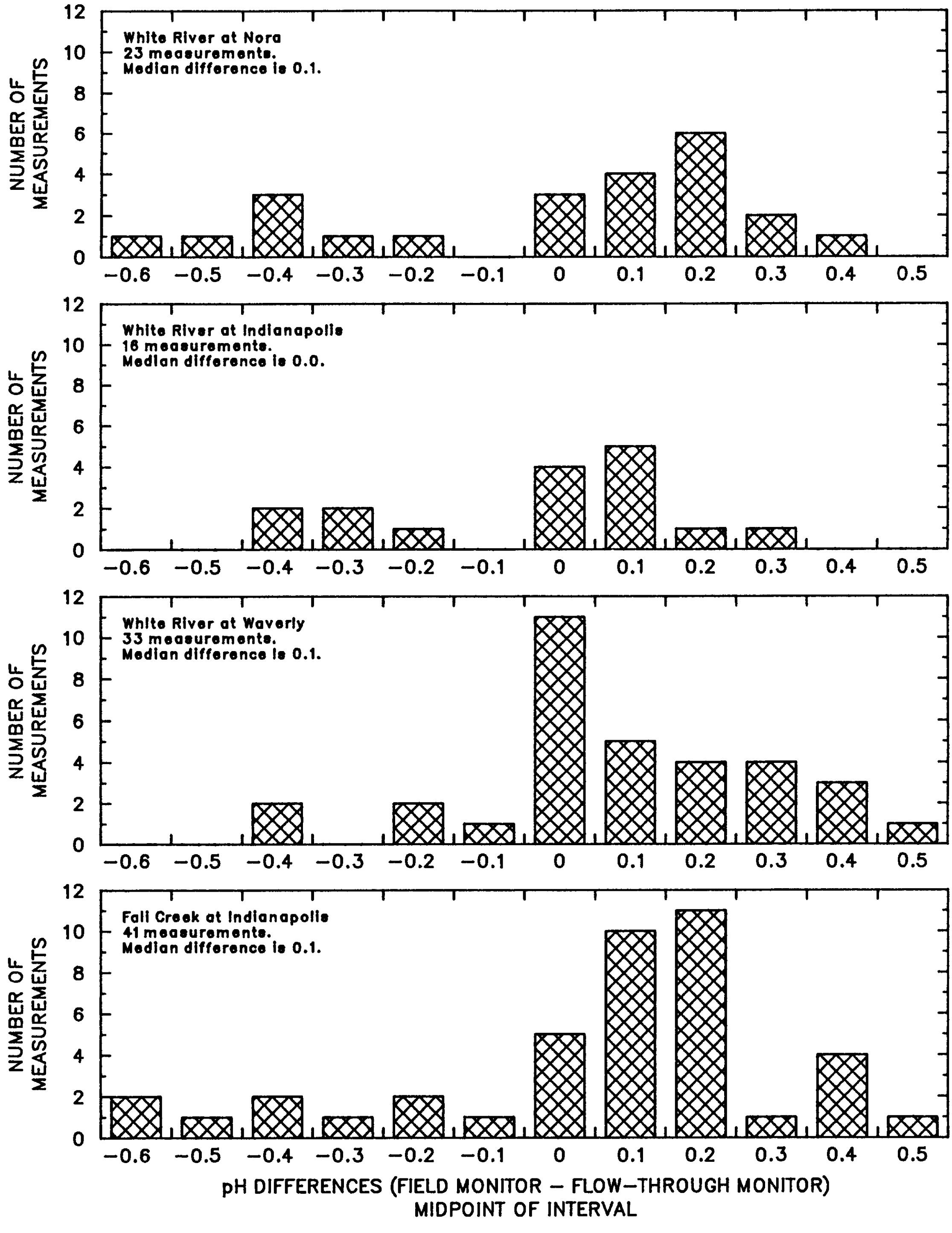


Figure 11. —— Histograms of differences between pH measured with the field monitor and pH measured with the flow–through monitor, before the flow–through monitor was serviced.

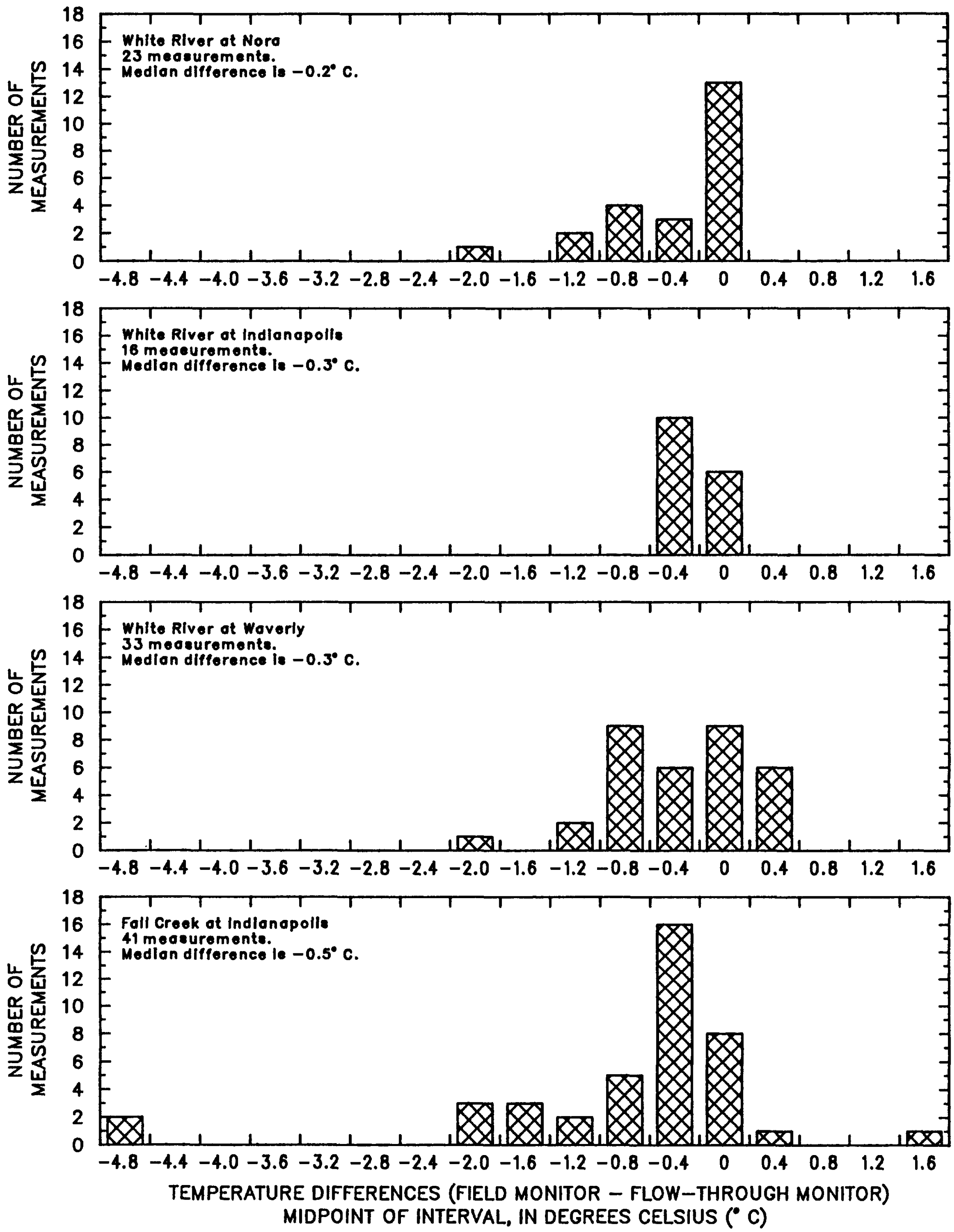


Figure 12. —— Histograms of differences between water temperature measured with the field monitor and water temperature measured with the flow–through monitor, before the flow–through monitor was serviced.

Table 36.--Distribution of differences between water quality measured with the field monitor and water quality measured with the flow-through monitor, before the flow-through monitor was serviced. Differences are corrections applied to the water-quality record

[mg/L, milligrams per liter; μS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius]

Station	Number of measurements	Minimum	25th Percentile	Median	75th Percentile	Maximum
		Dissolved-oxygen concentration (mg/L)				
Nora	24	-1.4	0.1	0.4	1.2	2.0
Indianapolis	16	- .4	-.2	.1	.6	1.5
Waverly	33	-1.1	-.1	.5	1.7	2.0
Fall Creek	41	- .8	-.1	.2	.7	2.0
All data	114	-1.4	-.1	.3	.8	2.0
		Specific conductance (μS/cm)				
Nora	23	-72	-26	-3	24	88
Indianapolis	16	-18	9	34	40	46
Waverly	31	-60	- 8	25	77	100
Fall Creek	39	-88	-13	3	27	90
All data	109	-88	-13	8	36	100
		pH				
Nora	23	-0.6	-0.3	0.1	0.2	0.4
Indianapolis	16	- .4	- .3	.0	.1	.3
Waverly	33	- .4	.0	.1	.3	.5
Fall Creek	41	- .6	.0	.1	.2	.5
All data	113	- .6	.0	.1	.2	.5
		Water temperature (°C)				
Nora	23	-2.1	-0.7	-0.2	-0.1	0.1
Indianapolis	16	- .6	- .4	- .3	- .1	.0
Waverly	33	-2.2	- .8	- .3	.1	.4
Fall Creek	41	-5.0	-1.1	- .5	- .2	1.4
All data	113	-5.0	- .7	- .3	- .1	1.4

On the basis of criteria for deleting record and on differences in measured water quality, the maximum error for all of the uncorrected water-quality data probably ranges from -1.4 to 2.0 mg/L for dissolved oxygen, -88 to 100 μS/cm for specific conductance, -0.6 to 0.5 for pH, and -5.0 to 1.4 °C for temperature (table 36). The maximum error for approximately one-half of the uncorrected data probably ranges from -0.1 to 0.8 mg/L for dissolved oxygen, -13 to 36 μS/cm for specific conductance, 0.0 to to 0.2 for pH, and -0.7 to -0.1 °C for temperature (25th and 75th percentiles, table 36). Moreover, the maximum errors are for water-quality measurements made immediately before an inspection. Water-quality measurements made immediately after an inspection, after the flow-through monitor has been serviced and recalibrated, have the minimum errors given in Gordon and Katzenbach (1983, p. 6). Errors for measurements made between inspections are unknown, but are assumed to be between the maximum and minimum errors determined.

Applying corrections to water-quality measurements made immediately before an inspection decreased the error of these measurements to the minimum errors given in Gordon and Katzenbach (1983, p. 6). The effect of applying corrections to water-quality measurements made in between inspections is not known, but is assumed to have decreased the error of these measurements if the assumptions concerning the start and rate of fouling or drift are valid. If these assumptions are valid, the maximum error for corrected water-quality data probably is less than that for uncorrected data.

The error structure of the data is unknown and unknowable unless one is willing to continuously take measurements, evaluate the data, and service and recalibrate the instrument, which, of course, would defeat the purpose of unmanned, continuous water-quality monitors. It is important, however, to realize that water-quality data are measured with error and that measurement error needs to be assessed in interpreting water-quality data. Moreover, measurement error in this report relates more to the specific numerical value of a particular measurement than to the relative difference between consecutive measurements.

EFFECTS OF STORM RUNOFF ON WATER QUALITY

In order to describe the effects of storm runoff on water quality, it is necessary to describe water quality during base flow prior to periods of storm runoff. Base-flow water quality is the typical condition against which water quality during periods of storm runoff is compared. Dissolved oxygen, specific conductance, pH, and temperature are measures of water quality that are controlled or affected by physical, chemical, and biological processes and their interactions. Most of the processes that affect water quality during periods of base flow also affect water quality during periods of storm runoff, but rates or importance of the processes usually differ.

Processes Controlling Dissolved Oxygen

Oxygen is necessary for sustaining the higher forms of aquatic life and for the self-purification process of streams. Concentrations of dissolved oxygen in aquatic systems are the result of processes that add oxygen to the water and those that remove oxygen. The major sources of oxygen in aquatic systems are the atmosphere and photosynthesis by aquatic plants. The major consumers of oxygen are aerobic respiration by aquatic plants and animals and decomposition (biochemical oxidation) of organic material by bacteria. Biochemical oxidation of inorganic compounds, such as the oxidation of ammonia to nitrate, also consumes oxygen.

The solubility of oxygen in water is controlled by the temperature of the water and the partial pressure of oxygen in the atmosphere. Oxygen from the atmosphere is added to the water by a process called reaeration. When the concentration of oxygen in the water is in equalibrium with the atmosphere, the water is saturated with respect to oxygen (100-percent saturation) and reaeration ceases. The partial pressure of oxygen in the atmosphere, as with barometric pressure, changes with weather conditions, but largely is controlled by altitude. Local pressure (not corrected to sea level) averaged 28.34 in. of mercury during the study period. Dissolved-oxygen saturation is controlled primarily by water temperature. For example, dissolved-oxygen saturation at 28.34 in. of mercury is 13.8 mg/L at 0 °C, 10.7 mg/L at 10 °C, 8.6 mg/L at 20 °C, and 7.1 mg/L at 30 °C (Gordon and Katzenbach, 1983, p. 4).

Photosynthesis by aquatic plants (attached algae, plankton, submerged vascular plants) is an important source of oxygen in productive aquatic systems. Carbon dioxide is used by plants in the presence of sunlight to produce carbohydrates and oxygen as shown in the following formula (Ruttner, 1963, p. 67):

$$6\ H_2O + 6\ CO_2 \implies C_6H_{12}O_6 + 6\ O_2. \qquad (2)$$

Photosynthesis can produce concentrations of dissolved oxygen in excess of the saturation concentration (supersaturation). Dissolved-oxygen concentrations of nearly 36 mg/L and 400-percent saturation have been reported (Wetzel, 1975, p. 130).

Algae, plankton, and the higher aquatic plants produce oxygen by photosnythesis but also consume oxygen by respiration. Respiration is the metabolic process that sustains life and a formula that expresses the process is essentially the opposite of photosynthesis. Oxygen and carbohydrate are reacted in living cells to produce energy for cell metabolism and carbon dioxide and water as products. Because the products of photosynthesis are the reactants for respiration, concentrations of dissolved oxygen and carbon dioxide are related inversely.

Biochemical oxidation (decomposition) of organic compounds is a major consumer of dissolved oxygen in aquatic systems. Bacteria consume oxygen and produce carbon dioxide in the process of decomposing organic detritus (some of which is produced *in situ* by photosynthesis) or organic waste. Decomposition is a biological process that requires time for bacterial populations to grow in response to inputs of organic waste and exert an oxygen demand. A dissolved-oxygen sag (area of low concentration) commonly occurs downstream from a source of organic waste (Lazaro, 1979, p. 45-47; Metcalf & Eddy, Inc., 1979, p. 836-843). The sag is caused by an increasing consumption of dissolved oxygen as a growing population of bacteria begins to decompose the waste. The amount of waste eventually decreases, which causes a decrease in the number of bacteria that use the waste as food. As the number of bacteria decrease, oxygen consumption decreases, and the concentration of dissolved oxygen increases to that occurring upstream from the source of waste. Bacteria are suspended in the water column or accumulate on the stream bottom. Biochemical oxygen demand is a measure of the amount of oxygen used by suspended bacteria to decompose organic material in a specific amount of time (usually 5 days). Sediment oxygen demand is a measure of the amount of oxygen used by bacteria on the stream bottom.

Processes that consume oxygen, respiration and oxidation of organic material or other compounds, do so continually, although rates of consumption and the importance of the processes change. Important variables affecting respiration and decomposition are the amount of oxygen-demanding material, dissolved-oxygen concentration, temperature, time of day, size and composition of the biologic community, and velocity of streamflow (Ruttner, 1963, p. 169; Hynes, 1970, p. 64-65, 161-164; Wetzel, 1975, p. 303, 595-596). Processes that supply oxygen, reaeration and photosynthesis, do so intermittantly. Photosynthesis only occurs during daylight and is affected by the intensity and duration of sunshine, temperature, and concentrations of nutrients (Ruttner, 1963, p. 99-100). The rate of reaeration is affected by temperature, water quality, channel morphology, stream velocity and depth, turbulence, and the degree of undersaturation with respect to dissolved oxygen (Langbein and Durum, 1967, p. 1-2). The rate of reaeration is greatest where undersaturation is greatest, and ceases when water is saturated or supersaturated with dissolved oxygen. Deaeration, or degassing, occurs during supersaturation, the rate positively associated with the degree of supersaturation (Butts and Evans, 1978, p. 2).

Water Quality During Base Flow

Daily (diurnal) cycles of dissolved oxygen, pH, and temperature are typical features of water quality during base flow during summer (figs. 13-16). Increased water temperature during the daytime is caused by solar radiation that heats the water and air and soil in contact with the water. In the absence of solar radiation in the evening, heat is lost from the water and temperatures decrease. Daily fluctuations of temperature of 2 to 3 °C were common (tables 8, 13, 18, 23, 28, 33). Maximum temperature usually occurred from 1500 to 1800 hours, and minimum temperature usually occurred from 0500 to 0800 hours. Daily mean water temperature typically was greater at Indianapolis and Waverly than at Nora and Fall Creek at Indianapolis (tables 8, 13, 18, 23, 28, 33).

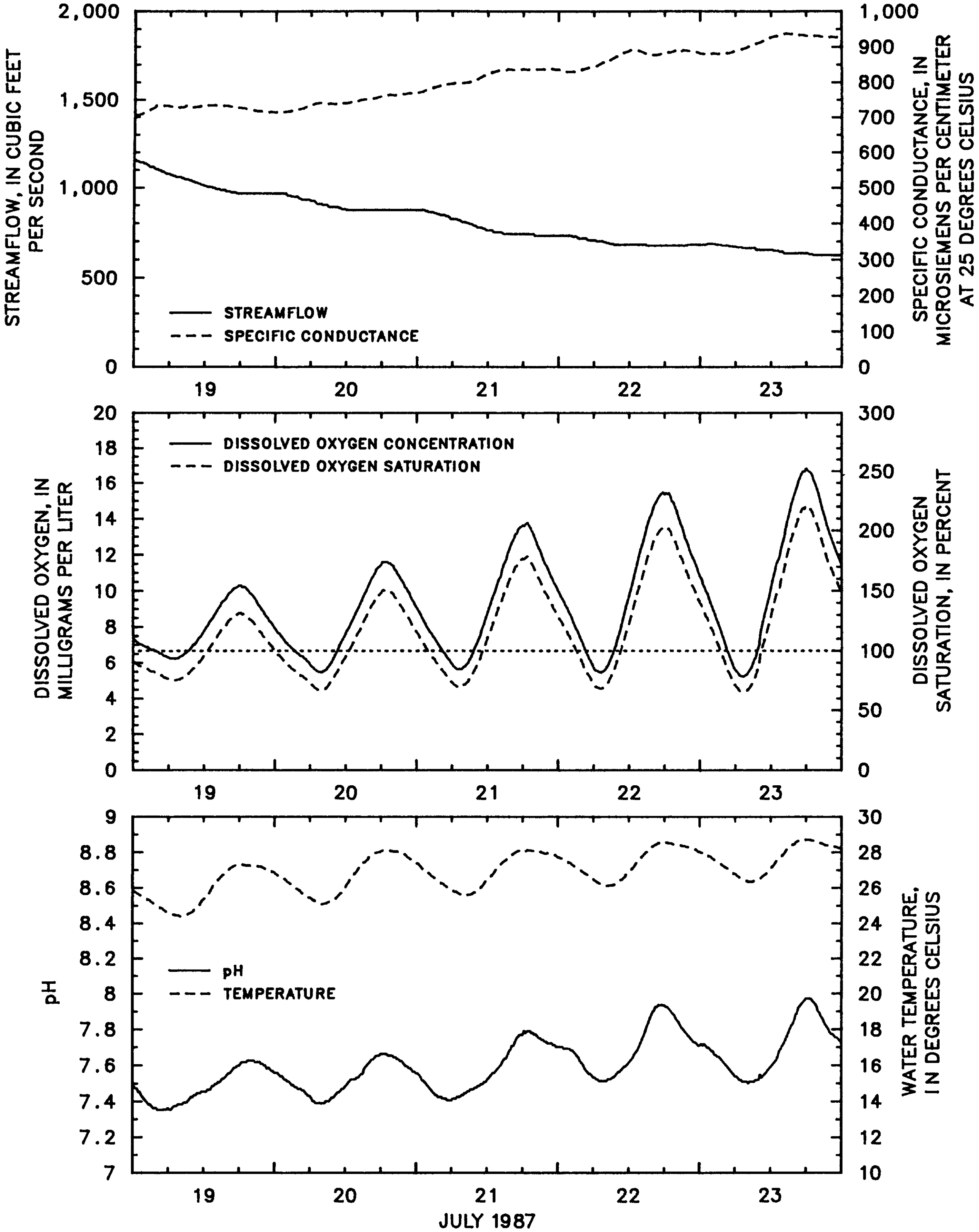


Figure 13. -- Streamflow and selected water-quality characteristics during base flow at White River at Waverly, July 19-23, 1987.

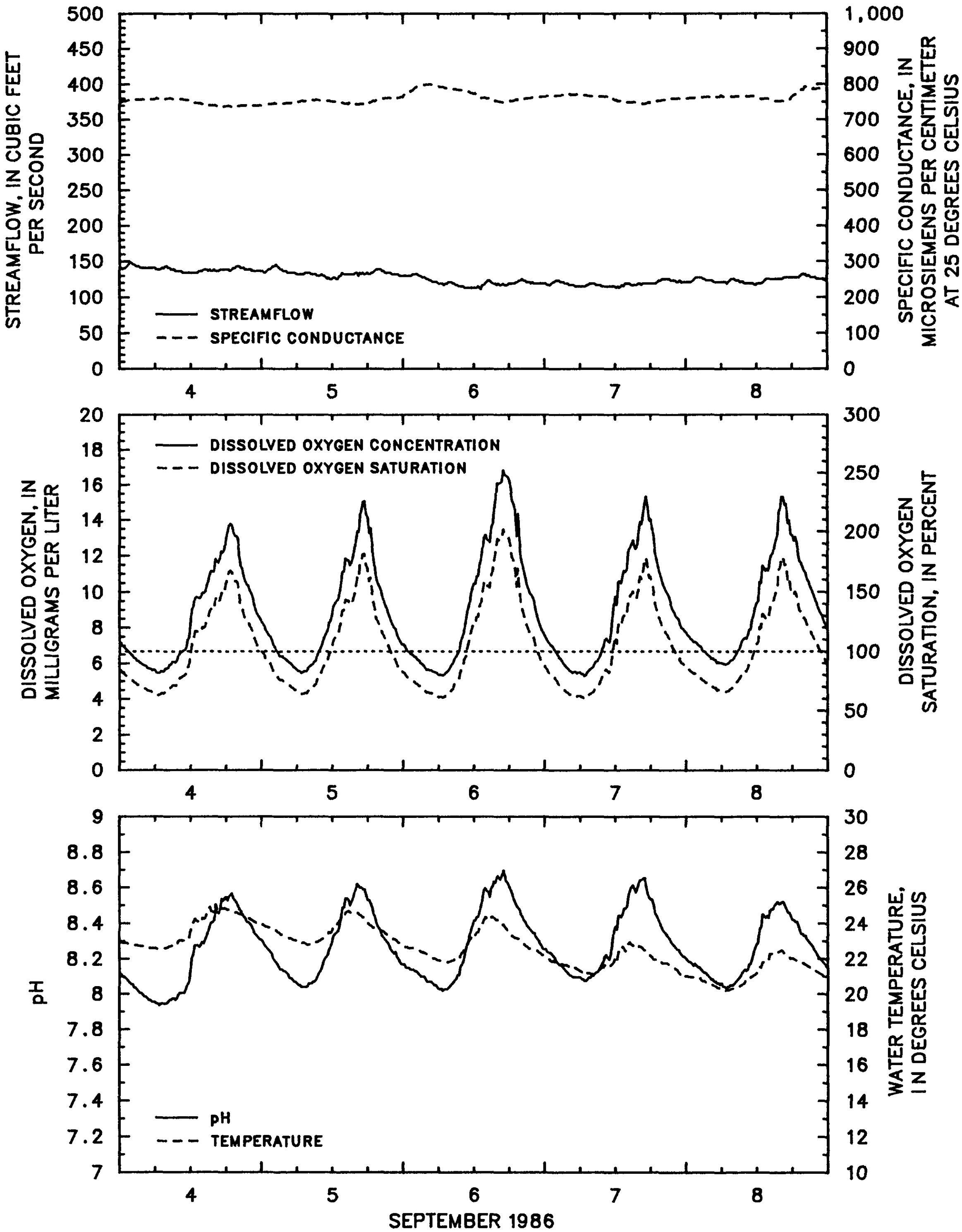


Figure 14. -- Streamflow and selected water-quality characteristics during base flow at White River at Indianapolis, September 4-8, 1986.

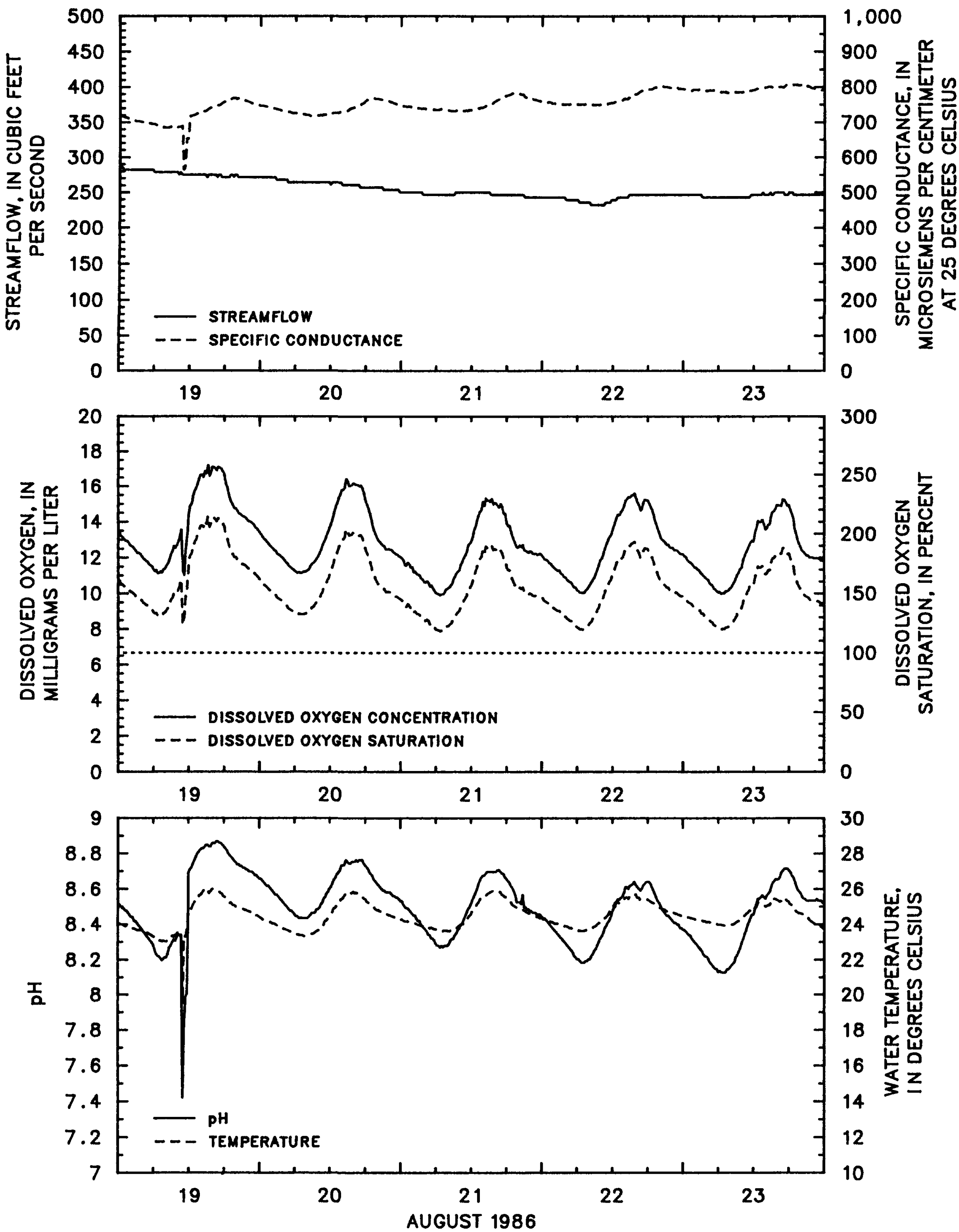


Figure 15. —— Streamflow and selected water–quality characteristics during base flow at White River near Nora, August 19–23, 1986.

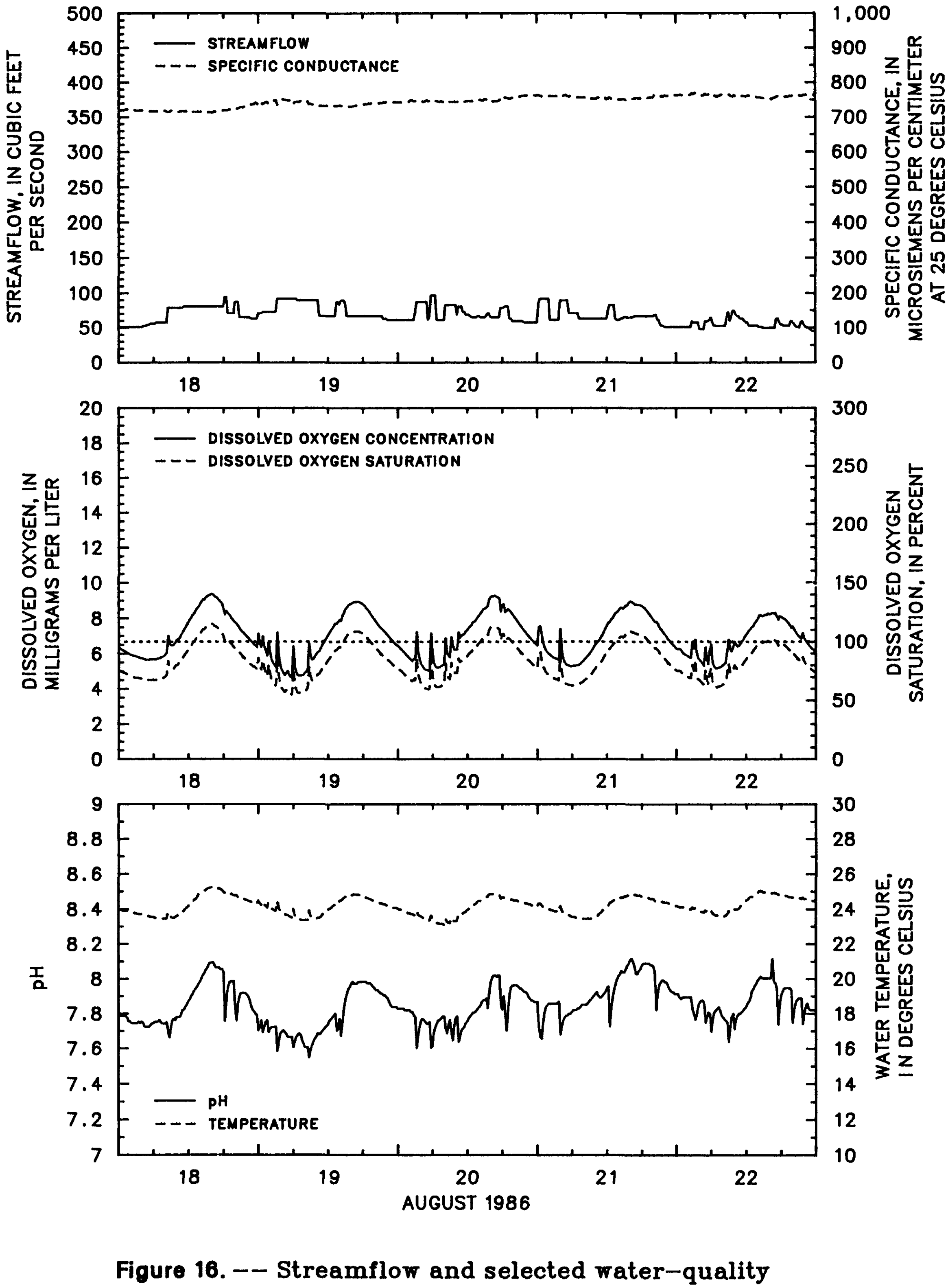


Figure 16. —— Streamflow and selected water–quality characteristics during base flow at Fall Creek at Indianapolis, August 18–22, 1986.

In phase with temperature is the daily cycle of dissolved oxygen (figs. 13-16). As with temperature, fluctuations of dissolved oxygen are caused by solar radiation. During the daytime, production of oxygen by photosynthesis exceeds consumption of oxygen by respiration and biochemical oxidation, which causes concentrations of dissolved oxygen to increase. In the evening, photosynthesis ceases and respiration and oxidation of organic matter consume oxygen, which causes concentrations to decrease. Times of maximum and minimum concentrations correspond to those of temperature.

Daily maximum dissolved-oxygen concentration and percent saturation were much higher in the White River than in Fall Creek (figs. 3a-8e, tables 5, 10, 15, 20, 25, 30). Daily fluctuations of dissolved oxygen in the White River often were greater than 6 mg/L, and fluctuations greater than 13 mg/L were measured (fig. 7c). Daily fluctuations of dissolved oxygen in Fall Creek were less than 6 mg/L. Daily mean concentrations of dissolved oxygen generally were higher in the White River than Fall Creek, especially during low flow (tables 5, 10, 15, 20, 25, 30). Supersaturation of dissolved oxygen greater than 200 percent commonly occurred in the White River, but rarely exceeded 150 percent in Fall Creek (figs. 3a-8e). Continuous supersaturation occurred for 12 consecutive days at Nora during base flow (figs. 3c, 3d). Supersaturation greater than 260 percent occurred at Waverly on August 14, 1987 (fig. 7c). Photosynthesis caused the large fluctuations and supersaturation of dissolved oxygen and indicates that the White River is more productive than Fall Creek. Daily cycles of dissolved oxygen usually are greatly diminished during October (figs. 3e, 4e, 5d, 6e, 8e) and may indicate the effect of cooler water temperature on photosynthesis and the senescence of aquatic vegetation. Hynes (1970, p. 107) reports that temperature must exceed 12 °C for active development of most of the plankton community. Temperatures were at or near 12 °C for many of the days in October (tables 8, 13, 18, 23, 28, 33).

Anomalous daily cycles of dissolved oxygen were observed during base flow at Nora during August and September 1986, and at Waverly during September and especially October 1987. Generally, dissolved oxygen followed a sinusoidal, daily pattern. Although the rising limb often was steeper then the falling limb, the rates of change were relatively constant for each limb. During August and September 1986 at Nora and September and October 1987 at Waverly, the falling limb of the daily dissolved-oxygen cycle showed a distinct change (decrease) in the rate of oxygen loss (figs. 3c, 3d, 7d, 7e, 15). The rate of oxygen loss decreased at approximately midnight at Waverly, but earlier at Nora. During October 15-16 and 22-23, 1987, at Waverly, the concentration of dissolved oxygen actually increased slightly during the falling limb (fig. 7e). The cause of the change in the rate of oxygen loss during the falling limb is not known but may be associated with cyclic changes in the amount or quality of discharges upstream.

In phase with the daily cycles of temperature and dissolved oxygen is pH (figs. 13-16), a measure of the effective concentration (activity) of hydrogen ions. A decrease in pH of 1 unit corresponds to a tenfold increase in the concentration of hydrogen ions because pH is the negative base-10 logarithm of the hydrogen-ion concentration in moles per liter (Hem, 1985, p. 61). Changes in pH are primarily the result of changes in carbon dioxide caused by photosynthesis, respiration, and decomposition. Respiration and decomposition of organic material produce carbon dioxide. Carbon dioxide reacts with water to form carbonic acid, a weak acid that dissociates to form a hydrogen ion and a bicarbonate ion as shown in the following formula (Wetzel and Likens, 1979, p. 110):

$$CO_2 + H_2O \Longleftrightarrow H_2CO_3 \Longleftrightarrow H^+ + HCO_3^-. \qquad (3)$$

As carbon dioxide is produced, equalibrium shifts to the right, which favors reactions that produce hydrogen ions and decrease the pH. Photosynthesis consumes carbon dioxide, which shifts equalibrium to the left, which favors reactions that consume hydrogen ions and increase the pH. Daily fluctuations of one-half a pH unit or more were common during periods of intense photosynthesis (tables 7, 12, 17, 22, 27, 32, figs. 13-16). Daily mean pH generally was highest at Nora and Indianapolis, intermediate at Fall Creek at Indianapolis, and lowest at Waverly (tables 7, 12, 17, 22, 27, 32). Daily mean pH often was more than one-half unit less at Waverly than at the monitoring stations upstream.

Specific conductance was more variable with respect to the presence or absence of daily cycles than temperature, dissolved oxygen, or pH (figs. 13-16). Specific conductance is a measure of the ability of water to conduct an electrical current, and it indicates the concentrations of ions and dissolved solids (ions and uncharged species) in solution (Hem, 1985, p. 66-68). Daily mean specific conductance was lowest at Indianapolis, intermediate at Nora, highest at Waverly, and, with respect to stations on the White River, variable at Fall Creek at Indianapolis (tables 6, 11, 16, 21, 26, 31). Two different daily cycles were apparent. At Indianapolis and Fall Creek at Indianapolis, specific conductance was affected by photosynthesis. Daily minimum specific conductance was associated with daily maximum dissolved-oxygen concentration, pH, and temperature (figs. 14, 16). Photosynthesis consumes carbon dioxide and can cause a decrease in bicarbonate (eq. 3) and, therefore, specific conductance (Ruttner, 1963, p. 61-73; Hynes, 1970, p. 43, 44, 51). Daily fluctuations of specific conductance caused by photosynthesis were small, generally less than 20 µS/cm Indianapolis and 10 µS/cm at Fall Creek at Indianapolis.

Daily cycles of specific conductance at Waverly and Nora generally were less than 75 µS/cm and were in phase with dissolved oxygen, pH, and temperature (opposite of those measured at Indianapolis and Fall Creek at Indianapolis) (figs. 13, 15). Initially, the authors suspected that the temperature compensators for the specific-conductance sensors had malfunctioned and that fluctuations of specific conductance were caused by fluctuations of temperature. Subsequent tests showed that the compensators were working at the times of the tests. The magnitude of the fluctuations of specific conductance was two to three times greater than that expected on the basis of a 2-percent increase in specific conductance for every 1 °C increase in temperature (Hem, 1985, p. 66-67). Although the daily cycles of temperature and specific conductance during base flow usually followed similar patterns, approximately one-fourth of the time variations in temperature were not observed in specific conductance. Daily cycles of temperature and specific conductance usually were in phase; however, at Nora, cycles of specific conductance sometimes lagged cycles of temperature by about 3 to 4 hours (fig. 15). On the basis of this information, the authors believe that daily fluctuations of specific conductance truly occur at Nora and Waverly, although the mechanism causing the fluctuations is not known.

Transient changes in water quality often were superimposed upon daily cycles of water quality during base flow. Water quality on August 19, 1986, at Nora was affected by a slug of water that disturbed the normal daily cycle of water quality for approximately 1 hour (fig. 15). The cause of the disturbance is not known and was not associated with a change in streamflow. A similar disturbance was observed on June 20, 1986, at Nora. A more persistent transient change in water quality was observed during base flow on September 16-18, 1986, at Indianapolis where concentrations of dissolved oxygen rapidly increased on the falling limb of the dissolved-oxygen cycle (fig. 4d). Concentrations of dissolved oxygen remained in excess of 12 mg/L for 42 consecutive hours before rapidly decreasing in response to storm runoff. Associated changes in specific conductance, pH, or temperature were not measured, yet the dissolved-oxygen sensor was functioning well when inspected. The cause of the sustained high concentrations of dissolved oxygen is not known.

More frequent transient changes were observed during low streamflow at Fall Creek at Indianapolis (figs. 6c, 6d, 8c, 8d, 8e, 16). Discharge of filter backwash from the purification plant of a water-supply utility approximately 500 ft upstream from the monitoring station caused measurable changes in water quality. Backwash discharge increased streamflow by 10 to 50 ft^3/s and increased dissolved oxygen when ambient concentrations were low but decreased dissolved oxygen when ambient concentrations were high (fig. 16).

Water Quality During Storm Runoff

Storm runoff can obliterate, diminish, or distort the daily cycles of water quality that are typically observed during base flow. Moreover, storm runoff can change the concentration or magnitude of water-quality constituents or properties from those that are typically observed during base flow. Some of the rain that falls during a storm runs off the surface of pavement and other impervious areas, or flows over or through soils in pervious areas as it moves by the force of gravity to streams. Rain contains substantial quantities of particulate and dissolved material (Ebbert and Wagner, 1987, p. 869) and has a great potential to accumulate additional material as it runs off the surface of the land or flows through soils. Runoff in areas served by combined sewers may exceed the capacity of the interceptor sewer and overflow, discharging sewage and urban runoff into receiving streams.

Bypassing raw wastewater or wastewater that has received only primary treatment at the advanced wastewater treatment plants may occur during periods of storm runoff when plant capacities are exceeded. Bypassing occurred on 36 days during the 1986 study period and on 19 days during the 1987 study period (Indianapolis Department of Public Works, written commun., 1986-87). Wastewater bypass is a potential source of oxygen-demanding materials to the White River during periods of storm runoff.

A rapid increase in streamflow indicates the beginning of a period of storm runoff and is associated with a decrease in specific conductance and pH, and sometimes dissolved oxygen or temperature (figs. 17-19). Specific conductance decreases because surface runoff has lower concentrations of ions and dissolved solids than base flow and provides dilution (Hem, 1985, p. 180-182). The pH decreases during periods of surface runoff because rain is acidic, ranging from 3.5 to 5.5 in Indiana (Banaszak, 1984, p. 80). The pH of rain increases as it flows over land surfaces and through vegetation (Halverson and others, 1984, p. 862), but is still less than that of base flow. Temperature may decrease if rain is cooler than base flow and if it is not warmed sufficiently by overland flow or movement through the soil.

Dissolved-oxygen concentration and percent saturation often decreased during storm runoff, especially during the initial rise in the storm hydrograph (figs. 3a-8e, 17-19). During periods of storm runoff, oxygen-demanding material may be washed off urban and rural land by surface runoff or discharged by CSO's. Oxygen-demanding sediment may be scoured and resuspended during periods of storm runoff. Bacteria grow in response to the influx of oxygen-demanding material and, in the process of decomposing (oxidizing) this material, consume dissolved oxygen. Decomposition, rather than respiration, is the principal process consuming dissolved oxygen during periods of storm runoff.

Decreased dissolved oxygen during the initial rise in the storm hydrograph may be caused by the first-flush effect observed during many urban-runoff studies (Lazaro, 1979, p. 57-58; Howard Needles Tammen & Bergendoff, 1983, p. 5-18; Karaca, 1984, p. 239-243; Mustard and others, 1987, p. 13; Striegl and Cowan, 1987, p. 7). The first flush occurs when the majority of pollutants that have accumulated on land surfaces are transported to the stream during the initial periods of surface runoff. Concentrations of pollutants initially are high but decrease as runoff that occurs later during the storm flows over relatively pollutant-free surfaces. River sediment can be resuspended as streamflow increases, and pollutants associated with the sediment also may cause high concentrations during the initial rise in the storm hydrograph. The relative importance of the first-flush effect versus resuspension of river sediment cannot be determined on the basis of data collected during this study.

The occurrence and magnitude of the decrease in dissolved oxygen varied among periods of storm runoff and were not consistently related to the magnitude of storm runoff (figs. 3a-8e). For example, storm hydrographs for July 10-19, 1986 (fig. 6b), and July 13-20, 1987 (fig. 8b), at Fall Creek at Indianapolis are somewhat similar, yet concentrations of dissolved oxygen decreased to a greater degree in 1987 than in 1986. Similarly, storm hydrographs for October 1-10, 1986 (fig. 5d), and July 1-10, 1987 (fig. 7b), show the largest volumes of storm runoff measured at Waverly during the study period. Concentrations of dissolved oxygen decreased to a much greater degree during the storm in 1987 than the storm in 1986. The lack of a consistent relation between the decrease in dissolved oxygen and the magnitude of storm runoff is a consequence of the number and complexity of the variables and their interactions that affect dissolved oxygen during storm runoff, especially in large river systems like the White River and Fall Creek.

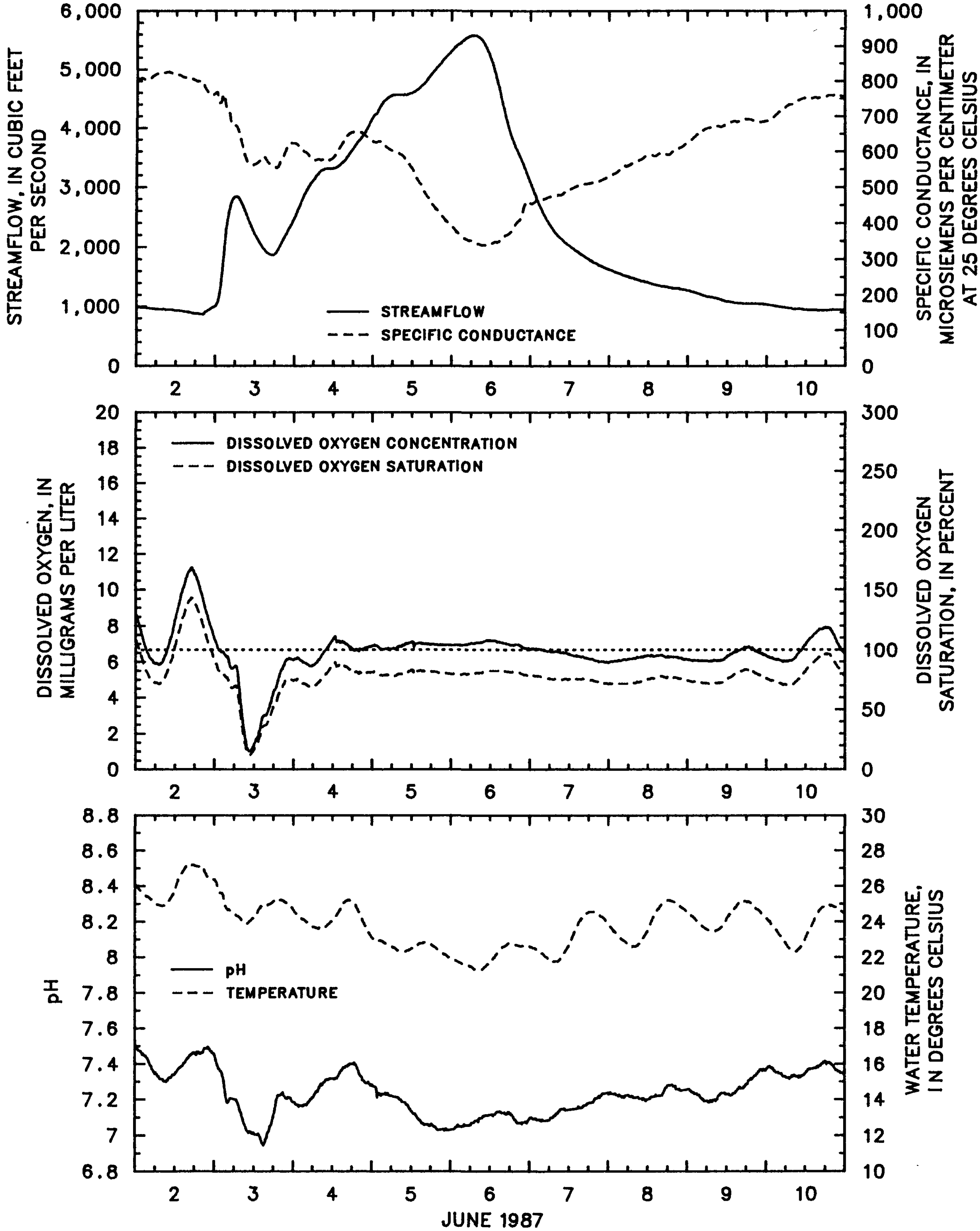


Figure 17. -- Streamflow and selected water-quality characteristics during storm runoff at White River at Waverly, June 2-10, 1987.

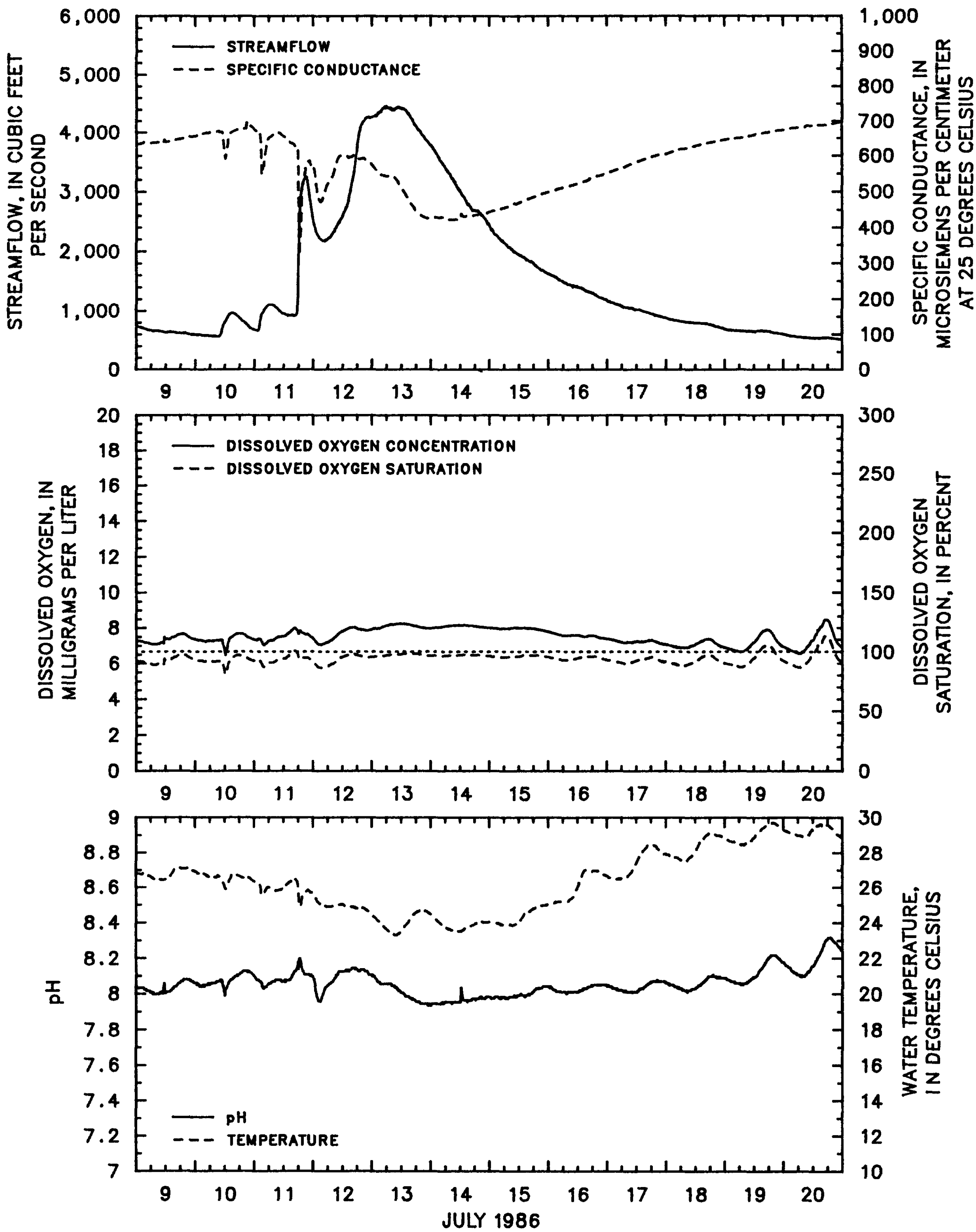


Figure 18. -- Streamflow and selected water-quality characteristics during storm runoff at White River at Indianapolis, July 9-20, 1986.

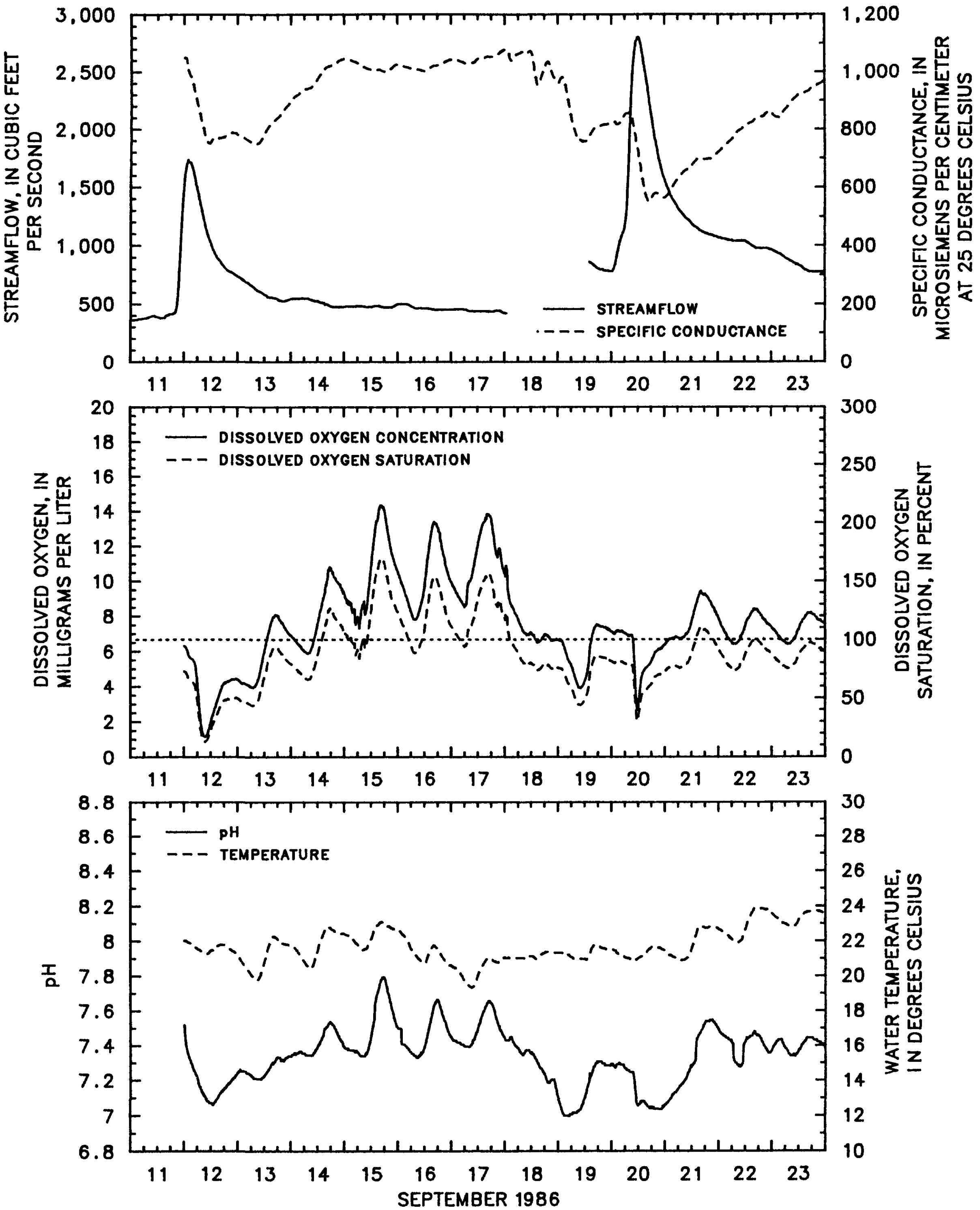


Figure 19. -- Streamflow and selected water-quality characteristics during storm runoff at White River at Waverly, September 11-23, 1986.

Storm runoff consistently diminished or eliminated daily cycles of dissolved oxygen (figs. 3a-8e). For example, storm runoff on June 3-9, 1987 (fig. 7a), at Waverly caused concentrations of dissolved oxygen to decrease as a slug of water with, presumably, high concentrations of oxygen-demanding material and low concentrations of dissolved oxygen flowed past the monitoring station. Daily cycles of dissolved oxygen were eliminated as the storm runoff passed the station, but gradually returned to normal as streamflow returned to base flow. Keefer and others (1979, p. 78) observed similar disruptions in the daily cycle of dissolved oxygen and determined that the daily cycle typically recovered within 3 to 5 days following a single peak of storm runoff. Storm runoff on June 20-23, 1987, at Waverly did not eliminate daily cycles of dissolved oxygen, but did diminish the magnitude of daily fluctuations (fig. 7a).

Diminution or elimination of the daily cycles of dissolved oxygen may be caused by several factors that adversely affect photosynthesis. Sediment brought to the stream or resuspended during storm runoff may increase turbidity and inhibit light penetration and photosynthesis. Increased streamflow may flush out plankton or remove attached algae by scouring. Decreasing streamflow during the falling limb of a hydrograph may cause sediment deposition and bury attached algae and submerged aquatic plants. Further, storm runoff may dilute the concentrations of dissolved oxygen produced by plankton and attached algae (Hynes, 1970, p. 106-107).

RELATION OF WATER QUALITY TO INDIANA WATER-QUALITY STANDARDS

Indiana water-quality standards are designed to protect water for its intended use. Standards for dissolved oxygen, pH, and temperature are established to ensure maintenance of a well-balanced, warm-water fish community. Standards for specific conductance, considered a measure of dissolved-solids concentration, are established to ensure protection of water quality for industrial water supply. Numerical standards that are applicable to this study follow.

Concentrations of dissolved oxygen must average at least 5.0 mg/L per calendar day and must not be less than 4.0 mg/L at any time [Indiana Administrative Code, Title 327, section 2-1-6 (c)(1)]. No pH values less than 6.0 nor more than 9.0, except those more than 9.0 that are associated with photosynthetic activity will be permitted [Indiana Administrative Code, Title 327, section 2-1-6 (b)(3)]. Water temperature must not exceed 33.9 °C at any time during June through September and must not exceed 27.2 °C at any time in October [Indiana Administrative Code, Title 327, section 2-1-6 (c)(2)(D)]. Specific conductance must not exceed 1,200 µS/cm as a monthly average nor exceed 1,600 µS/cm at any time [Indiana Administrative Code, Title 327, section 2-1-6 (g)].

None of the measurements of pH or water temperature exceeded water-quality standards during the study period. Specific conductance at Waverly exceeded the monthly mean standard of 1,200 µS/cm by 83 µS/cm during October 1987 (table 26).

Concentrations of dissolved oxygen were less than Indiana standards at Nora and Waverly during the 1986 study period and at Waverly and Fall Creek during the 1987 study period (table 37). None of the concentrations of dissolved oxygen measured at Indianapolis or Fall Creek at Indianapolis during the 1986 study period were less than Indiana water-quality standards. Concentrations at Nora failed to meet standards on five consecutive days during base flow following a period of storm runoff during July 1986 (fig. 3b, table 37). Except at Nora, all of the concentrations that failed to meet dissolved-oxygen standards occurred during periods of storm runoff.

Concentrations of dissolved oxygen were less than the instantaneous standard (less than 4.0 mg/L at any time) on 27 days but were less than the daily mean standard (less than 5.0 mg/L) on only 15 days (table 37). On the basis of the number of days when concentrations of dissolved oxygen were less than Indiana standards, the instantaneous standard is more stringent than the daily mean standard.

Table 37.--Relation of dissolved oxygen to Indiana water-quality standards

[mg/L, milligrams per liter; NA, not applicable]

Station	Daily mean dissolved-oxygen concentrations less than 5.0 mg/L[1]		Instantaneous dissolved-oxygen concentrations less than 4.0 mg/L[1]	
	Date	Daily mean (mg/L)	Date	Daily minimum (mg/L)
	JUNE 1 THROUGH OCTOBER 31, 1986			
White River at Nora	July 17	4.6		
	July 18	4.0	July 18	3.6
	July 19	3.7	July 19	3.1
	July 20	4.3	July 20	2.9
			July 21	3.5
White River at Indianapolis	None	NA	None	NA
White River at Waverly			July 12	3.3
	Sept 12	3.7	Sept 12	1.1
			Sept 13	3.9
			Sept 19	3.9
			Sept 20	2.7
Fall Creek at Indianapolis	None	NA	None	NA
	JUNE 1 THROUGH OCTOBER 31, 1987			
White River at Waverly	June 3	4.4	June 3	1.0
			June 20	3.9
	July 1	2.4	July 1	1.2
	July 2	2.8	July 2	1.6
	July 3	3.5	July 3	2.7
	July 4	3.9	July 4	2.7
			July 27	3.7
	July 28	4.7	July 28	1.5
			July 29	2.9
			Oct 27	3.1
	Oct 28	4.8	Oct 28	1.8
Fall Creek at Indianapolis			June 2	3.7
	June 3	4.5	June 3	2.0
			June 29	3.6
	June 30	3.2	June 30	2.4
	July 1	4.9	July 1	2.6
			July 13	2.7
			July 27	3.4

[1]Indiana water-quality standards for maintenance of warm-water fish communities state that concentrations of dissolved oxygen must average at least 5.0 mg/L per calendar day and must not be less than 4.0 mg/L at any time.

The instantaneous dissolved-oxygen standard was used to identify periods of low dissolved-oxygen concentrations in the White River and Fall Creek during base flow and storm runoff. Periods of low dissolved-oxygen concentrations are defined in this study as the periods of time when concentrations of dissolved oxygen are less than 4.0 mg/L. Periods of low dissolved-oxygen concentrations may include short periods of time (less than 5 hours) when concentrations of dissolved oxygen rise to 4.0 mg/L or slightly higher (less than 4.2 mg/L, except for one measurement of 4.5 that was caused by filter backwash). On the basis of these criteria, 21 periods of low dissolved-oxygen concentrations were measured during the study period (table 38). Most of these periods were clearly defined (figs. 3b, 5a, 5c, 7a, 7b, 7e, 8a, 8b). The most poorly defined period occurred on September 13, 1986, at Waverly (fig. 5c).

Four low dissolved-oxygen periods occurred at Nora on four consecutive days (July 18-21) during base flow following a period of storm runoff during July 1986 (fig. 3b). Minimum concentrations of dissolved oxygen during these periods ranged from 2.9 to 3.8 mg/L and duration ranged from 2.75 to 16 hours (table 38). Concentrations of dissolved oxygen steadily decreased during the falling limb of the storm hydrograph and decreased to less than 4.0 mg/L as streamflow reached base flow. This period is the only time during the study that concentrations of dissolved oxygen less than 4.0 mg/L were measured during base flow.

The cause of the low dissolved-oxygen concentrations is not known, but may have resulted from a temporary, point-source input of oxygen-demanding material. Possible sources would include a malfunctioning treatment plant forced to bypass effluent during and after a storm or a sewer that becomes clogged with debris and continues to overflow during fair weather. A decrease in storm runoff available for dilution of a point source would cause a decrease in the concentrations of dissolved oxygen as streamflow returned to base flow and would result in a pattern of streamflow and dissolved oxygen similar to that measured on July 14-19, 1986 (fig. 3b). If this hypothesis is correct, the input of material must have started during the period of storm runoff and must have ceased on July 20, which would allow concentrations of dissolved oxygen to increase to those typical of base flow.

All of the periods of low dissolved-oxygen concentrations at Waverly and Fall Creek at Indianapolis occurred during periods of storm runoff. Minimum concentrations during 12 low dissolved-oxygen periods at Waverly ranged from 1.0 to 3.9 mg/L (table 38) and had a median concentration of 2.8 mg/L. Duration of low dissolved-oxygen concentrations ranged from 0.75 to 83.75 hours and had a median duration of 5 hours. Minimum concentrations during five low dissolved-oxygen periods at Fall Creek at Indianapolis ranged from 2.0 to 3.4 mg/L (table 38) and had a median concentration of 2.7 mg/L. Duration of low dissolved-oxygen concentrations ranged from 1.75 hours to 33.75 hours and had a median duration of 7 hours.

The lack of low dissolved-oxygen concentrations during periods of storm runoff does not necessarily mean that concentrations of oxygen-demanding

Table 38.--Frequency and duration of low dissolved-oxygen concentrations

[mg/L, milligrams per liter; NA, not applicable]

Station	Periods of low dissolved-oxygen concentrations[1]		
	Date	Minimum concentration (milligrams per liter)	Duration (hours)
	JUNE 1 THROUGH OCTOBER 31, 1986		
White River at Nora	July 18	3.8	7
	July 18-19	3.1	16
	July 19-20	2.9	14
	July 21	3.5	2.75
White River at Indianapolis	None	NA	NA
White River at Waverly	July 12	3.3	3.75
	Sept 12	1.1	10.75
	Sept 13	3.9	[2]1.25
	Sept 19	3.9	[2]1.5
	Sept 20	2.7	2
Fall Creek at Indianapolis	None	NA	NA
	JUNE 1 THROUGH OCTOBER 31, 1987		
White River at Waverly	June 3	1.0	9.5
	June 20	3.9	[2]1.75
	July 1-4	1.2	[3]83.75
	July 27	3.9	.75
	July 27-28	1.5	[4]12.5
	July 29	2.9	6.25
	Oct 27-28	1.8	11
Fall Creek at Indianapolis	June 2-3	2.0	[5]10.75
	June 29-July 1	2.4	[6]33.75
	July 1	3.1	1.75
	July 13	2.7	7
	July 27	3.4	[7]2.5

[1]Periods of low dissolved-oxygen concentrations are defined in this study as the periods of time when concentrations of dissolved-oxygen are less than 4.0 mg/L. Duration is reported to the nearest quarter hour. Periods of low dissolved-oxygen concentrations may contain short periods of time when concentrations of dissolved oxygen increase to 4.0 mg/L or slightly higher. Duration of the short time period and the maximum concentration are reported in footnotes and are shown in figures 3a-8e.

[2]Includes one measurement (0.25 hour) of 4.0 mg/L.

[3]Includes 5 hours with a maximum concentration of 4.2 mg/L and 4 hours with a maximum concentration of 4.1 mg/L.

[4]Includes two measurements (0.5 hour) of 4.0 mg/L.

[5]Includes 1 hour with a maximum concentration of 4.1 mg/L.

[6]Includes 2.5 hours with a maximum concentration of 4.2 mg/L and one measurement (0.25 hour) of 4.5 mg/L (caused by filter backwash).

[7]Includes 0.75 hour with a maximum concentration of 4.1 mg/L.

material are low or that storm runoff will not cause low concentrations of dissolved oxygen upstream or downstream from the monitoring station. Time is required for bacteria to grow in response to an influx of organic material and exert an oxygen demand. Low dissolved-oxygen concentrations commonly occur downstream from the sources of oxygen-demanding material and after precipitation has stopped (Pitt, 1984, p. 85-86). Location and magnitude of the dissolved-oxygen sag is affected by numerous factors, including the composition, quantity, and timing of waste inputs, the temperature and water quality of the receiving stream, and the hydrologic characteristics of the receiving stream such as amount of base flow, volume and timing of storm runoff, and traveltime. Location and magnitude of the dissolved-oxygen sag may change from storm to storm as conditions change and need to be considered in interpreting the effects of storm runoff on river quality on the basis of data from fixed monitoring stations. Longer traveltimes from upstream sources of oxygen-demanding material and more upstream sources are likely reasons why low dissolved-oxygen concentrations occur more frequently at Waverly than at the other stations.

SUMMARY

The White River is the principal river draining central Indiana and the cities of Muncie, Anderson, and Indianapolis. Water quality during base flow has improved markedly, largely because of the implementation of advanced wastewater treatment in Indianapolis and improved wastewater treatment upstream from Indianapolis.

Four continuous, flow-through water-quality monitors were installed upstream, in, and downstream from Indianapolis on the White River and near the mouth of Fall Creek in Indianapolis to monitor water quality during base flow and storm runoff during the summer low-flow season. The sites are White River near Nora (upstream from Indianapolis, referred to as Nora), White River at Indianapolis (in Indianapolis, referred to as Indianapolis), White River at Waverly (downstream from Indianapolis, referred to as Waverly), and Fall Creek at 16th Street at Indianapolis (in Indianapolis, referred to as Fall Creek at Indianapolis). Streamflow, dissolved-oxygen concentration, specific conductance, pH, and water temperature were measured at 15-minute intervals from June through October 1986 at Nora, Indianapolis, Waverly, and Fall Creek at Indianapolis, and from June through October 1987 at Waverly and Fall Creek at Indianapolis.

Concentrations of dissolved oxygen during June through October 1986 ranged from 2.9 to 18.5 mg/L at Nora, 4.5 to 16.8 mg/L at Indianapolis, 1.1 to 14.3 mg/L at Waverly, and from 4.0 to 11.2 mg/L at Fall Creek at Indianapolis. Concentrations of dissolved oxygen during June through October 1987 ranged from 1.0 to 20.4 mg/L at Waverly and from 2.0 to 12.3 mg/L at Fall Creek at Indianapolis.

Specific conductance during June through October 1986 ranged from 305 to 882 μS/cm at Nora, 265 to 812 μS/cm at Indianapolis, 292 to 1,150 μS/cm at Waverly, and from 161 to 955 μS/cm at Fall Creek at Indianapolis. Specific conductance during June through October 1987 ranged from 259 to 1,400 μS/cm at Waverly and from 194 to 945 μS/cm at Fall Creek at Indianapolis.

Measurements of pH during June through October 1986 ranged from 6.9 to 8.9 at Nora, 7.1 to 8.7 at Indianapolis, 6.7 to 7.9 at Waverly, and from 6.6 to 8.3 at Fall Creek at Indianapolis. Measurements of pH during June through October 1987 ranged from 6.9 to 8.2 at Waverly and from 7.3 to 8.5 at Fall Creek at Indianapolis.

Water temperature during June through October 1986 ranged from 10.5 to 29.4 °C at Nora, 11.8 to 29.7 °C at Indianapolis, 11.9 to 28.8 °C at Waverly, and from 12.1 to 28.1 °C at Fall Creek at Indianapolis. Water temperature during June to October 1987 ranged from 12.3 to 30.4 °C at Waverly and from 9.8 to 29.8 °C at Fall Creek at Indianapolis.

Daily (diurnal) cycles of dissolved oxygen, pH, and temperature are typical features of water quality during base flow during summer. Daily cycles of solar radiation and photosynthesis by aquatic plants were the primary processes controlling the daily cycles of water quality. Dissolved oxygen, pH, and temperature cycled in phase; maxima usually occurred from 1500

to 1800 hours and minima usually occurred from 0500 to 0800 hours. Daily fluctuations of temperature of 2 to 3 °C were common. Daily mean water temperature typically was greater at Indianapolis and Waverly than at Nora and Fall Creek at Indianapolis. Daily fluctuations of dissolved oxygen in the White River often were greater than 6 mg/L, and fluctuations greater than 13 mg/L were measured. Daily fluctuations of dissolved oxygen in Fall Creek were less than 6 mg/L. Daily mean concentrations of dissolved oxygen in the White River generally were higher than those in Fall Creek. Supersaturation greater than 200 percent commonly occurred in the White River, but rarely exceeded 150 percent in Fall Creek. Continuous supersaturation occurred for 12 consecutive days at Nora during base flow. Supersaturation greater than 260 percent occurred at Waverly on August 14, 1987. Photosynthesis caused the large fluctuations and supersaturation of dissolved oxygen and indicates that the White River is more productive than Fall Creek. Daily fluctuations of pH of one-half unit or more were common during periods of intense photosynthesis. Daily mean pH often was more than one-half unit less at Waverly than at the monitoring stations upstream.

Water quality during base flow is the typical condition against which water quality during storm runoff is compared. A rapid increase in streamflow indicates the beginning of a period of storm runoff and is associated with a decrease in specific conductance and pH, and sometimes dissolved oxygen or temperature. Concentrations of dissolved oxygen often decreased during storm runoff, especially during the initial rise in the hydrograph. The occurrence and magnitude of the decrease in dissolved oxygen varied among periods of storm runoff and were not related consistently to the magnitude of storm runoff. Storm runoff consistently diminished or eliminated daily cycles of dissolved oxygen.

Indiana water-quality standards for dissolved oxygen are established to ensure maintenance of a well-balanced, warm-water fish community. Concentrations of dissolved oxygen must average 5.0 mg/L per calendar day and must not be less than 4.0 mg/L at any time. Concentrations of dissolved oxygen were less than Indiana standards at Nora and Waverly during 1986 and at Waverly and Fall Creek at Indianapolis during 1987. Dissolved oxygen was less than the instantaneous standard on 27 days but was less than the daily mean standard on only 15 days. Except for Nora, all of the concentrations that failed to meet dissolved-oxygen standards occurred during periods of storm runoff.

Periods of low dissolved-oxygen concentrations are defined in this study as the periods of time when concentrations of dissolved oxygen are less than 4.0 mg/L. Twenty-one periods of low dissolved-oxygen concentrations were measured during the study period. Four of the periods of low dissolved-oxygen concentrations occurred at Nora on four consecutive days during base flow. All of the low dissolved-oxygen concentrations at Waverly and Fall Creek at Indianapolis occurred during periods of storm runoff. Minimum concentrations during 12 low dissolved-oxygen periods at Waverly ranged from 1.0 to 3.9 mg/L and had a median concentration of 2.8 mg/L. Duration of low dissolved-oxygen concentrations ranged from 0.75 to 83.75 hours and had a median duration of 5 hours. Minimum concentrations during five low dissolved-oxygen periods at Fall Creek at Indianapolis ranged from 2.0 to 3.4 mg/L and had a median concentration of 2.7 mg/L. Duration of low dissolved-oxygen concentrations ranged from 1.75 hours to 33.75 hours and had a median duration of 7 hours.

The lack of low dissolved-oxygen concentrations during periods of storm runoff does not necessarily mean that concentrations of oxygen-demanding material are low or that storm runoff will not cause low concentrations of dissolved oxygen upstream or downstream from the monitoring station. Location and magnitude of the dissolved-oxygen sag is affected by numerous factors, including the composition, quantity, and timing of waste inputs, the temperature and water quality of the receiving stream, and the hydrologic characteristics of the receiving stream, such as amount of base flow, volume and timing of storm runoff, and traveltime. Location and magnitude of the dissolved-oxygen sag may change from storm to storm as conditions change and need to be considered in interpreting the effects of storm runoff on river quality on the basis of data from fixed monitoring stations. Longer traveltimes from upstream sources of oxygen-demanding material and more upstream sources are likely reasons why low dissolved-oxygen concentrations occur more frequently at Waverly than at the other stations.

(PAGE 51 FOLLOWS)

REFERENCES CITED

Arvin, D.V., 1989, Statistical summary of streamflow data for Indiana: U.S. Geological Survey Open-File Report 89-62, 968 p.

Banaszak, K.J., 1984, Acid rain -- what we know even in Indiana [abs.], in Martin, J.D., ed., Proceedings of the fifth annual water resources symposium, June 20-22, 1984, Shawnee Bluffs, Bloomington, Indiana: Indiana Water Resources Association, p. 80.

______ 1985, Indiana ground-water resources, in National Water Summary 1984. Hydrologic events, selected water-quality trends, and ground-water resources: U.S. Geological Survey Water-Supply Paper 2275, p. 205-210.

Bowie, G.L., Mills, W.B., Porcella, D.B., Campbell, C.L., Pagenkoph, J.R., Rupp, G.L., Johnson, K.M., Chan, P.W.H., Gherini, S.A., and Chamberlin, C.E., 1985, Rates, constants, and kinetics formulations in surface water quality modeling (2nd ed.): U.S. Environmental Protection Agency, Environmental Research Laboratory, EPA/600/3-85/040, 455 p.

Brinley, F.J., 1942, The effect of pollution upon the plankton population of the White River, Indiana: Indiana Department of Conservation, Investigations of Indiana Lakes and Streams, v. 2, no. 9, p. 137-143.

Butts, T.A., and Evans, R.L., 1978, Effects of channel dams on dissolved oxygen concentrations in northeastern Illinois streams: Illinois State Water Survey Circular 132, 153 p.

Denham, S.C., 1938, A limnological investigation of the West Fork and Common Branch of White River: Indiana Department of Conservation, Investigations of Indiana Lakes and Streams, v. 1, no. 5, p. 17-71.

Ebbert, J.C., and Wagner, R.J., 1987, Contributions of rainfall to constituent loads in storm runoff from urban catchments: Water Resources Bulletin, v. 23, no. 5, p. 867-871.

Geosciences Research Associates, Inc., 1982, Hydrogeologic atlas of Indiana: Bloomington, Ind., Fine Print, 31 plates, scale approximately 1:1,009,000.

Glatfelter, D.R., Thompson, R.E., Jr., and Nell, G.E., 1987, Water resources data, Indiana, Water year 1986: U.S. Geological Survey Water-Data Report IN-86-1, 441 p.

Gordon, A.B., and Katzenbach, Max, 1983, Guidelines for use of water quality monitors: U.S. Geological Survey Open-File Report 83-681, 94 p.

Gutschick, R.C., 1966, Bedrock geology, in Lindsey, A.A., ed., Natural features of Indiana: Indianapolis, Indiana Academy of Science and Indiana State Library, p. 1-20.

Halverson, H.G., DeWalle, D.R., and Sharpe, W.E., 1984, Contribution of precipitation to quality of urban storm runoff: Water Resources Bulletin, v. 20, no. 6, p. 859-864.

Hem, J.D., 1985, Study and interpretation of the chemical characteristics of natural water (3rd ed.): U.S. Geological Survey Water-Supply Paper 2254, 263 p.

Howard Needles Tammen & Bergendoff, 1983, Combined sewer overflow water quality impact analysis, City of Indianapolis, Indiana: Indianapolis, Howard Needles Tammen & Bergendoff, U.S. EPA Grant No. C180885 01, variable pagination.

Hynes, H.B.N., 1970, The ecology of running waters: Toronto, Ont., University of Toronto Press, 555 p.

Indiana Administrative Code, 1989, 1989 supplement containing all amendments, additions, and repeals to the Indiana Administrative Code filed with the Secretary of State after August 12, 1987 and before August 12, 1988 -- Volume 1: Cleveland, Banks-Baldwin, 825 p.

Indiana Department of Environmental Management, undated, 1984-85 305(b) report: Indiana Department of Environmental Management, 172 p.

Indiana Department of Natural Resources, 1970, Map of Indiana showing bedrock geology: Indiana Department of Natural Resources, Geological Survey Miscellaneous Map No. 16, scale approximately 1:1,810,000.

_____ 1982, Rainfall frequency for Indiana (revised): Indiana Department of Natural Resources, Division of Water, variable pagination.

Karaca, A., 1984, Combined sewer overflow and urban runoff study in Belleville, Illinois, in Blake-Coleman, Wendy, ed., Urban effects on water quality and quantity, Conference proceedings of October 20 and 21, 1983, Jumer's Castle Lodge, Urbana, Illinois: Illinois Department of Energy and Natural Resources, p. 239-245.

Keefer, T.N., Simons, R.K., and McQuivey, R.S., 1979, Dissolved oxygen impact from urban storm runoff: U.S. Environmental Protection Agency, Municipal Environmental Research Laboratory, EPA-600/2-79-156, 238 p.

Kennedy, M.S., and Bell, J.M., 1986, The effects of advanced wastewater treatment on river water quality: Journal of the Water Pollution Control Federation, v. 58, no. 12, p. 1138-1144.

Langbein, W.B., and Durum, W.H., 1967, The aeration capacity of streams: U.S. Geological Survey Circular 542, 6 p.

Langbien, W.B., and Iseri, K.T., 1960, General introduction and hydrologic definitions, Chapter A in Manual of hydrology--Part 1, General surface-water techniques: U.S. Geological Survey Water-Supply Paper 1541, p. 1-29.

Lazaro, T.R., 1979, Urban hydrology--A multidisciplinary perspective: Ann Arbor, Mich., Ann Arbor Science, 249 p.

Metcalf & Eddy, Inc., 1979, Wastewater engineering--Treatment, disposal, reuse (2nd ed.): New York, McGraw-Hill, 920 p.

Morse, R.S., and Eckrich, H.M., 1984, Polluting sewers brought under control: Journal of Environmental Health, v. 47, no. 2, p. 68-70.

Mustard, M.H., Ellis, S.R., and Gibbs, J.W., 1987, Runoff characteristics and washoff loads from rainfall-simulation experiments on a street surface and a native pasture in the Denver metropolitan area, Colorado: U.S. Geological Survey Professional Paper 1441, 30 p.

National Oceanic and Atmospheric Administration, 1986, Local climatological data, Annual summary with comparative data, Indianapolis, Indiana: Asheville, N.C., National Climatic Data Center, v. 91, no. 13, 8 p.

_____ 1986-87, Local climatological data, Monthly summaries, Indianapolis, Indiana, June 1986 through October 1987: Asheville, N.C., National Climatic Data Center, v. 91, no. 6-12, and v. 92, no. 1-10.

Pitt, Robert, 1984, Effects of urbanization on receiving waters, in Blake-Coleman, Wendy, ed., Urban effects on water quality and quantity, Conference proceedings of October 20 and 21, 1983, Jumer's Castle Lodge, Urbana, Illinois: Illinois Department of Energy and Natural Resources, p. 84-98.

Rantz, S.E., and others, 1982a, Measurement and computation of streamflow--Volume 1, Measurement of stage and discharge: U.S. Geological Survey Water-Supply Paper 2175, p. 1-284. , p. 1-284.

_____ 1982b, Measurement and computation of streamflow--Volume 2, Computation of discharge: U.S. Geological Survey Water-Supply Paper 2175, p. 285-631. p. 285-631.

Ruttner, Frantz, 1963, Fundamentals of Limnology (3rd ed.): Toronto, Ont., University of Toronto Press, 295 p. ess, 295 p.

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

Shampine, W.J., 1975, A river-quality assessment of the upper White River, Indiana: U.S. Geological Survey Water-Resources Investigations 75-10, 68 p.

Stewart, J.A., 1983, Low-flow characteristics of Indiana streams: U.S. Geological Survey Open-File Report 82-1007, 277 p. 007, 277 p.

Striegl, R.G., and Cowan, E.A., 1987, Relations between quality of urban runoff and quality of Lake Ellyn at Glen Ellyn, Illinois: U.S. Geological Survey Water-Supply Paper 2301, 59 p.

Sweeney, M.W., and Wukash, R.F., 1982, Prediction of water quality during wet weather events, in Delleur, J.W., ed., Proceedings of a symposium on water - Indiana's abundant resource, June 9-11, 1982, Century Center, South Bend, Indiana: Indiana Water Resources Association, p. 49-60.

Ulrich, H.P., 1966, Soils, in Lindsey, A.A., ed., Natural features of Indiana: Indianapolis, Indiana Academy of Science and Indiana State Library, p. 57-90.

Wangsness, D.J., Eikenberry, S.E., Wilber, W.G., and Crawford, C.G., 1981, Preliminary water-quality assessment of the upper White River near Indianapolis, Marion County, Indiana: U.S. Geological Survey Open-File Report 81-408, 50 p.

Wetzel, R.G., 1975, Limnology: Philadelphia, Saunders, 743 p.

Wetzel, R.G., and Likens, G.E., 1979, Limnological analyses: Philadelphia, Saunders, 357 p.

APPENDIX: Streamflow and
Water-quality information

Table 4.--Daily mean streamflow at White River near Nora, June through October 1986

	Daily mean streamflow (cubic feet per second)				
Day	June	July	August	September	October
1	1,150	1,400	400	231	1,660
2	991	2,990	379	225	1,910
3	840	4,010	352	217	2,490
4	808	2,630	339	221	3,450
5	825	1,500	317	212	3,940
6	1,630	1,100	303	204	4,100
7	4,020	881	310	201	2,330
8	5,600	749	307	194	1,420
9	3,900	662	309	190	1,030
10	2,220	622	349	191	837
11	1,660	788	406	220	708
12	2,640	2,650	395	271	657
13	3,670	3,610	338	277	661
14	2,290	2,260	307	244	715
15	1,580	1,430	295	232	750
16	1,280	1,080	291	210	754
17	1,190	876	305	198	646
18	1,150	737	311	292	571
19	1,020	646	275	414	512
20	856	582	259	682	473
21	821	530	244	697	444
22	1,130	478	239	547	426
23	1,140	450	243	420	408
24	1,540	422	242	473	399
25	1,150	405	232	448	458
26	849	731	243	427	593
27	710	1,110	315	542	701
28	849	782	371	670	769
29	1,200	597	290	608	689
30	1,380	487	263	533	616
31		432	243		542
Mean	1,670	1,214	306	350	1,150
Minimum	710	405	232	190	399
Maximum	5,600	4,010	406	697	4,100

Table 5.--Daily mean, minimum, and maximum dissolved-oxygen concentration at White River near Nora, June through October 1986

[Min, minimum; Max, maximum; p, partial day; ---, no data]

	Mean, minimum, and maximum dissolved-oxygen concentration (milligrams per liter)														
	June			July			August			September			October		
Day	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
1	6.9	6.5	7.5	6.9	6.4	8.9	9.2	7.0	12.2	12.8	10.3	16.3	6.5	6.0	7.0
2	p 7.2	6.9	8.1	8.6	6.9	11.1	9.4	7.6	11.6	12.6	10.0	16.3	6.1	5.9	6.3
3	p 8.7	7.9	9.0	---	---	---	9.6	7.6	12.2	13.5	10.3	18.5	6.1	5.9	6.5
4	p 9.1	8.1	10.8	---	---	---	9.8	8.1	12.0	12.7	9.8	16.9	6.2	5.8	6.7
5	p 8.7	8.3	9.4	p 7.0	6.8	7.2	p 8.6	8.0	9.4	12.8	10.2	17.1	5.8	5.7	6.0
6	---	---	---	6.7	6.5	6.8	---	---	---	12.8	9.8	16.9	6.3	5.8	6.6
7	---	---	---	6.4	6.3	6.5	---	---	---	13.0	9.9	17.2	7.2	6.5	7.6
8	---	---	---	6.0	5.5	7.2	p 8.5	8.1	8.8	13.6	10.2	18.3	7.7	7.6	7.9
9	---	---	---	p 5.9	5.7	6.1	9.0	7.5	10.8	13.9	10.8	18.3	7.6	7.6	7.7
10	---	---	---	p 6.0	5.3	6.9	8.7	7.9	9.6	12.9	11.0	16.2	7.8	7.6	7.9
11	---	---	---	6.0	5.3	7.2	8.5	7.4	9.6	9.4	7.8	11.0	7.7	7.5	7.9
12	---	---	---	---	---	---	9.5	7.9	11.5	8.8	6.8	11.4	7.5	7.3	7.6
13	---	---	---	---	---	---	11.6	9.0	14.9	10.4	7.8	14.3	7.3	7.3	7.5
14	---	---	---	p 6.7	6.4	6.9	---	---	---	10.7	8.8	13.4	7.7	7.5	8.0
15	---	---	---	6.2	5.9	6.4	---	---	---	11.0	8.7	14.2	8.1	7.8	8.4
16	---	---	---	5.5	5.0	5.9	---	---	---	11.0	8.7	14.7	8.4	8.1	8.6
17	p 7.3	7.0	7.5	4.6	4.1	5.0	---	---	---	10.6	8.3	14.3	8.5	8.4	8.7
18	7.3	7.0	7.6	4.0	3.6	4.4	p 15.4	12.6	17.8	7.8	7.0	9.1	8.6	8.5	8.7
19	7.5	7.3	7.7	3.7	3.1	4.4	13.8	11.0	17.2	7.3	6.6	8.2	8.5	8.4	8.6
20	7.0	6.7	7.2	4.3	2.9	6.3	13.2	11.1	16.4	6.7	6.1	7.2	8.4	8.3	8.6
21	7.2	6.8	7.6	6.2	3.5	9.3	12.3	9.9	15.3	6.5	6.1	7.2	8.3	8.2	8.6
22	7.3	7.1	7.5	7.5	5.1	9.6	12.6	10.0	15.6	6.3	5.9	6.8	8.2	8.0	8.4
23	7.0	6.7	7.2	9.2	7.4	11.5	12.3	10.0	15.2	6.6	6.0	7.1	7.9	7.8	8.1
24	6.8	6.6	7.0	10.6	7.9	13.5	12.0	9.4	15.5	6.3	6.0	6.6	7.7	7.6	7.9
25	7.0	6.9	7.1	12.8	10.1	16.9	---	---	---	6.1	5.8	6.6	7.5	7.5	7.6
26	7.0	6.9	7.1	8.7	6.5	11.0	---	---	---	6.4	5.9	7.2	7.5	7.4	7.6
27	6.8	6.6	6.9	6.5	5.7	7.3	---	---	---	6.5	6.0	7.0	7.6	7.4	7.7
28	6.5	6.3	6.6	6.8	6.0	7.7	11.1	8.6	14.8	6.9	6.0	7.9	7.8	7.5	8.0
29	6.4	6.2	6.7	6.5	5.9	7.3	11.9	9.0	15.5	7.2	6.3	8.1	8.0	7.9	8.2
30	6.4	6.3	6.6	6.8	5.9	7.7	12.8	10.2	16.6	6.9	6.2	7.6	8.0	7.8	8.3
31				6.8	5.9	7.7	12.6	10.2	16.1				8.2	8.0	8.4
Mean	7.3	7.0	7.6	6.8	5.8	8.0	11.0	9.0	13.6	9.7	8.0	12.1	7.6	7.4	7.8
Minimum	6.4	6.2	6.6	3.7	2.9	4.4	8.5	7.0	8.8	6.1	5.8	6.6	5.8	5.7	6.0
Maximum	9.1	8.3	10.8	12.8	10.1	16.9	15.4	12.6	17.8	13.9	11.0	18.5	8.6	8.5	8.7

Table 6.--Daily mean, minimum, and maximum specific conductance at White River near Nora, June through October 1986

[Min, minimum; Max, maximum; p, partial day; ---, no data]

Day	Mean, minimum, and maximum specific conductance (microsiemens per centimeter at 25 degrees Celsius)														
	June			July			August			September			October		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
1	677	655	704	538	513	561	698	681	724	810	799	827	435	305	594
2	p 663	649	680	523	456	550	719	709	739	818	808	834	478	384	536
3	p 718	677	740	427	405	461	724	712	741	821	805	846	451	401	496
4	p 706	678	725	444	404	499	745	724	781	841	830	861	398	330	444
5	p 696	681	709	535	501	574	p 745	742	754	820	806	847	395	332	441
6	---	---	---	610	572	657	---	---	---	810	796	824	329	317	350
7	---	---	---	677	647	722	---	---	---	807	794	827	400	351	439
8	---	---	---	705	690	720	p 773	764	782	812	795	839	469	432	511
9	---	---	---	712	694	738	758	738	783	819	804	843	537	511	557
10	---	---	---	717	693	747	741	716	769	837	826	856	590	558	623
11	---	---	---	725	686	765	727	713	745	823	758	844	642	618	675
12	---	---	---	609	510	686	727	715	749	798	781	813	676	670	682
13	---	---	---	434	411	500	720	706	743	799	772	842	681	668	691
14	---	---	---	477	434	524	700	683	724	843	824	873	673	668	683
15	---	---	---	556	515	608	685	667	704	862	848	881	692	680	709
16	---	---	---	640	607	686	684	660	723	830	813	860	706	698	714
17	p 651	635	661	698	668	741	717	697	753	825	803	864	712	703	727
18	667	638	706	732	703	770	721	682	750	822	780	861	715	698	740
19	689	674	706	756	728	784	719	564	769	754	741	779	738	713	773
20	659	626	683	762	750	775	739	718	769	736	693	759	759	737	791
21	673	633	733	750	734	774	750	732	783	642	577	692	783	764	807
22	729	698	773	770	742	808	769	749	802	565	550	578	796	778	817
23	627	585	713	778	757	810	794	783	807	579	564	605	802	792	808
24	545	509	582	767	741	798	785	769	808	592	555	605	804	799	809
25	568	546	598	741	718	775	786	767	813	618	589	658	792	779	808
26	600	570	638	695	615	750	811	793	842	678	656	718	756	742	781
27	667	633	710	615	583	734	783	765	807	667	640	685	749	741	757
28	693	679	705	619	590	635	794	766	832	663	648	681	756	744	769
29	715	702	743	561	534	587	845	824	882	634	616	665	750	743	758
30	633	526	714	606	573	657	816	772	858	607	592	616	745	733	764
31				664	630	713	783	756	827				757	735	789
Mean	662	631	696	640	607	681	750	726	778	751	729	776	644	617	672
Minimum	545	509	582	427	404	461	684	564	704	565	550	578	329	305	350
Maximum	729	702	773	778	757	810	845	824	882	862	848	881	804	799	817

Table 7.--Daily mean, minimum, and maximum pH at White River near Nora, June through October 1986

[Min, minimum; Max, maximum; p, partial day; ---, no data]

Day	June			July			August			September			October		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
1	7.7	7.7	7.7	7.8	7.8	7.9	8.3	8.2	8.5	8.6	8.5	8.8	7.3	7.2	7.5
2	p 7.7	7.7	7.8	7.8	7.7	7.9	8.4	8.2	8.5	8.6	8.5	8.8	7.3	7.2	7.4
3	p 7.7	7.7	7.8	7.7	7.7	7.7	8.4	8.3	8.6	8.6	8.5	8.9	7.4	7.3	7.4
4	p 7.6	7.4	7.7	7.8	7.7	7.9	8.4	8.3	8.5	8.5	8.4	8.7	7.4	7.3	7.5
5	p 7.4	7.3	7.5	7.9	7.8	7.9	p 8.4	8.3	8.4	8.4	8.1	8.6	7.4	7.4	7.5
6	---	---	---	8.0	7.9	8.0	---	---	---	8.3	8.1	8.6	7.5	7.4	7.6
7	---	---	---	8.0	8.0	8.0	---	---	---	8.4	8.1	8.7	7.7	7.6	7.8
8	---	---	---	8.0	8.0	8.1	p 8.3	8.3	8.3	8.5	8.3	8.8	7.8	7.8	7.9
9	---	---	---	8.1	8.0	8.1	8.4	8.3	8.5	8.5	8.3	8.8	7.9	7.8	7.9
10	---	---	---	8.1	8.0	8.1	8.4	8.3	8.5	8.5	8.4	8.7	7.9	7.9	7.9
11	---	---	---	8.1	8.0	8.2	8.4	8.3	8.4	8.4	8.3	8.5	7.9	7.9	8.0
12	---	---	---	8.0	7.8	8.1	8.5	8.3	8.6	8.4	8.2	8.5	8.0	7.9	8.0
13	---	---	---	7.8	7.7	7.8	8.6	8.5	8.8	8.4	8.3	8.6	8.0	8.0	8.0
14	---	---	---	7.9	7.8	7.9	8.7	8.5	8.8	8.4	8.3	8.5	8.0	8.0	8.1
15	---	---	---	7.9	7.9	8.0	8.6	8.3	8.8	8.4	8.3	8.5	8.1	8.0	8.1
16	---	---	---	8.0	8.0	8.0	8.6	8.3	8.8	8.4	8.3	8.6	8.1	8.1	8.1
17	p 7.5	7.4	7.5	8.0	8.0	8.0	8.6	8.4	8.8	8.3	8.2	8.5	8.1	8.1	8.1
18	7.5	7.4	7.5	7.9	7.9	8.0	8.6	8.4	8.9	8.1	8.0	8.2	8.1	8.1	8.1
19	7.4	7.4	7.5	7.9	7.8	7.9	8.5	7.4	8.9	8.0	7.9	8.1	8.1	8.1	8.1
20	7.3	6.9	7.4	7.9	7.9	8.0	8.6	8.4	8.8	7.9	7.8	8.0	8.1	8.1	8.1
21	7.4	7.3	7.5	8.1	7.9	8.3	8.5	8.3	8.7	7.8	7.7	7.8	8.1	8.1	8.2
22	7.6	7.5	7.6	8.2	8.1	8.3	8.4	8.2	8.6	7.6	7.6	7.7	8.2	8.1	8.2
23	7.6	7.5	7.6	8.3	8.2	8.4	8.4	8.1	8.7	7.7	7.6	7.7	8.2	8.1	8.2
24	7.6	7.5	7.6	8.4	8.3	8.6	8.5	8.3	8.8	7.6	7.6	7.7	8.2	8.1	8.2
25	7.7	7.6	7.7	8.3	8.1	8.6	8.5	8.3	8.8	7.6	7.5	7.6	8.2	8.1	8.2
26	7.7	7.7	7.7	8.3	8.2	8.4	8.5	8.3	8.8	7.6	7.6	7.7	8.2	8.1	8.2
27	7.7	7.7	7.7	8.1	8.0	8.3	8.5	8.3	8.8	7.6	7.6	7.7	8.2	8.2	8.2
28	7.8	7.7	7.8	8.1	8.0	8.2	8.7	8.5	8.8	7.6	7.5	7.7	8.2	8.2	8.3
29	7.8	7.8	7.9	8.0	7.9	8.1	8.7	8.5	8.8	7.6	7.5	7.7	8.3	8.3	8.3
30	7.8	7.8	7.9	8.0	7.9	8.1	8.7	8.6	8.8	7.5	7.5	7.6	8.3	8.3	8.3
31				8.0	8.0	8.2	8.7	8.6	8.8				8.3	8.3	8.3
Mean	7.6	7.5	7.7	8.0	7.9	8.1	8.5	8.3	8.7	8.1	8.0	8.3	8.0	7.9	8.0
Minimum	7.3	6.9	7.4	7.7	7.7	7.7	8.3	7.4	8.3	7.5	7.5	7.6	7.3	7.2	7.4
Maximum	7.8	7.8	7.9	8.4	8.3	8.6	8.7	8.6	8.9	8.6	8.5	8.9	8.3	8.3	8.3

Table 8.--Daily mean, minimum, and maximum water temperature at White River near Nora, June through October 1986

[Min, minimum; Max, maximum; p, partial day; ---, no data]

Day	Mean, minimum, and maximum water temperature (degrees Celsiua)														
	June			July			August			September			October		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
1	21.8	21.0	22.8	21.7	21.4	22.2	25.7	24.9	26.8	20.0	19.3	20.7	21.2	20.3	22.0
2	p 21.4	20.6	22.1	21.4	20.6	22.8	25.5	24.9	26.2	20.8	19.7	22.5	20.9	20.5	21.2
3	p 20.7	19.7	21.1	---	---	---	24.8	23.9	25.9	21.9	20.6	23.6	20.6	20.4	20.7
4	p 20.3	19.7	20.8	---	---	---	24.4	23.6	25.4	22.9	22.1	24.2	21.5	20.5	22.3
5	p 20.7	20.5	21.3	p 22.4	21.0	23.1	p 23.5	23.2	24.0	22.5	21.1	24.3	20.6	19.8	21.9
6	---	---	---	23.7	22.6	25.0	---	---	---	22.2	21.3	23.7	18.7	18.2	20.0
7	---	---	---	25.3	24.4	26.4	---	---	---	21.3	20.3	22.6	17.0	16.3	18.1
8	---	---	---	26.1	25.4	26.9	p 23.7	23.3	24.1	20.1	19.1	21.5	15.9	15.3	16.4
9	---	---	---	26.2	25.7	26.6	23.6	22.7	24.7	19.3	18.0	21.1	15.7	15.2	16.1
10	---	---	---	25.3	24.8	25.9	23.6	23.1	24.1	20.2	18.8	21.8	14.9	14.3	15.4
11	---	---	---	24.7	24.1	25.4	23.2	22.4	24.2	21.7	20.5	23.4	14.6	13.9	15.1
12	---	---	---	---	---	---	23.2	22.3	24.3	20.1	19.5	20.6	15.2	15.0	15.5
13	---	---	---	---	---	---	23.1	22.0	24.4	19.7	18.7	21.0	14.4	13.7	15.0
14	---	---	---	p 23.4	23.0	23.6	---	---	---	20.2	19.2	21.7	12.8	12.0	13.7
15	---	---	---	24.3	23.5	25.3	---	---	---	20.8	19.8	21.7	11.8	11.2	12.3
16	---	---	---	25.7	24.8	26.9	---	---	---	20.1	19.1	21.6	11.2	11.0	11.7
17	p 22.9	22.3	23.2	27.1	25.9	28.4	---	---	---	19.4	18.4	20.8	11.1	10.6	11.8
18	21.7	21.1	22.3	27.9	26.9	28.8	p 24.8	24.0	25.7	19.7	19.4	20.0	11.2	10.5	12.0
19	21.7	20.6	22.9	28.4	27.3	29.4	24.4	19.5	26.0	20.1	19.6	20.8	11.3	10.6	12.2
20	23.1	22.1	24.2	28.5	27.8	29.3	24.4	23.3	25.9	20.1	19.7	20.6	11.5	10.8	12.3
21	24.0	22.9	25.1	26.9	26.1	27.9	24.6	23.6	25.9	20.5	19.7	21.3	12.4	11.5	13.3
22	24.8	24.1	25.6	25.9	25.1	26.7	24.6	23.6	25.8	21.3	20.6	22.1	13.3	12.7	13.9
23	24.5	24.1	24.9	25.9	24.9	27.1	24.5	23.8	25.5	21.8	21.4	22.1	13.8	13.6	14.0
24	23.5	22.9	24.1	26.0	25.0	27.0	23.9	22.7	25.5	21.4	21.2	21.6	14.0	13.9	14.2
25	22.3	21.4	23.0	26.6	25.6	27.7	---	---	---	21.9	20.9	22.9	14.1	13.9	14.1
26	22.2	21.2	23.0	26.8	26.2	27.5	---	---	---	22.7	22.1	23.7	14.1	13.9	14.3
27	23.4	22.4	24.4	26.2	25.4	26.9	---	---	---	22.6	21.9	23.1	13.7	13.3	14.0
28	24.3	23.7	25.1	26.5	25.6	27.3	20.2	19.5	21.0	22.7	22.0	23.4	13.3	12.8	13.8
29	24.5	23.8	25.1	26.6	25.7	27.5	19.6	18.6	20.9	23.0	22.6	23.5	13.5	13.1	13.9
30	23.3	22.2	24.3	26.3	25.4	27.2	19.5	18.3	21.1	22.5	22.0	22.9	13.1	12.5	13.6
31				25.6	24.5	26.6	19.9	18.4	21.7				12.4	11.8	13.1
Mean	22.7	21.9	23.4	25.6	24.8	26.5	23.4	22.3	24.5	21.1	20.3	22.2	14.8	14.3	15.4
Minimum	20.3	19.7	20.8	21.4	20.6	22.2	19.5	18.3	20.9	19.3	18.0	20.0	11.1	10.5	11.7
Maximum	24.8	24.1	25.6	28.5	27.8	29.4	25.7	24.9	26.8	23.0	22.6	24.3	21.5	20.5	22.3

Table 9.--Daily mean streamflow at White River at Indianapolis, June through October 1986

Day	Daily mean streamflow (cubic feet per second) June	July	August	September	October
1	1,680	1,780	373	162	5,790
2	1,420	3,210	319	161	3,720
3	1,130	3,890	303	149	3,690
4	1,710	3,080	272	139	10,400
5	1,500	1,860	255	133	7,120
6	1,930	1,300	247	120	6,500
7	4,320	955	269	119	3,710
8	6,590	778	262	124	2,190
9	4,910	652	253	119	1,540
10	3,030	721	327	115	1,160
11	2,370	1,450	333	352	902
12	3,500	2,950	292	349	841
13	4,430	4,250	242	193	923
14	3,200	3,050	216	178	1,040
15	2,380	1,970	203	161	921
16	1,800	1,400	229	143	923
17	1,620	1,040	213	133	780
18	1,450	836	213	382	643
19	1,380	705	198	388	567
20	1,110	607	174	1,120	527
21	963	551	168	652	491
22	1,220	456	155	526	466
23	1,350	403	142	339	439
24	1,620	366	140	603	435
25	1,450	358	146	508	672
26	1,040	568	144	441	948
27	809	1,030	186	746	936
28	1,080	879	218	735	976
29	1,240	611	225	642	829
30	1,750	466	175	590	746
31		453	169		596
Mean	2,133	1,375	228	351	1,981
Minimum	809	358	140	115	435
Maximum	6,590	4,250	373	1,120	10,400

Table 10.--Daily mean, minimum, and maximum dissolved-oxygen concentration at White River at Indianapolis, June through October 1986

[Min, minimum; Max, maximum; p, partial day; ---, no data]

Day	June Mean	June Min	June Max	July Mean	July Min	July Max	August Mean	August Min	August Max	September Mean	September Min	September Max	October Mean	October Min	October Max
1	7.2	7.1	7.4	7.3	7.2	7.6	7.1	5.8	10.9	8.8	6.8	11.8	6.7	5.4	7.5
2	7.4	7.0	7.8	8.0	7.5	8.4	7.2	5.7	11.0	8.7	7.0	12.1	7.2	6.1	7.8
3	7.6	7.3	8.1	8.6	8.2	9.0	7.9	5.9	12.6	8.3	6.1	11.4	7.6	7.5	7.7
4	7.3	6.5	7.8	8.5	8.2	8.8	8.5	6.1	12.8	8.6	5.4	13.8	---	---	---
5	6.9	6.6	7.3	8.1	7.8	8.3	9.0	6.9	13.7	8.7	5.4	15.0	---	---	---
6	7.4	7.0	8.0	7.7	7.6	7.8	7.1	6.2	7.8	9.5	5.3	16.8	8.4	8.3	8.7
7	7.4	7.3	7.5	7.5	7.4	7.6	6.3	5.7	7.4	8.8	5.3	15.3	8.4	8.0	8.8
8	7.5	7.3	7.7	7.4	7.3	7.5	6.1	5.5	7.0	9.2	5.9	15.3	8.5	8.3	8.8
9	7.6	7.5	7.7	7.3	7.1	7.7	6.1	5.3	7.3	8.6	6.0	12.4	8.5	8.3	8.7
10	7.6	7.4	7.7	7.3	6.5	7.7	6.0	5.5	6.7	7.0	5.6	8.6	8.8	8.6	9.0
11	p 7.4	7.3	7.5	7.5	7.0	8.0	6.8	5.7	8.3	5.8	4.9	6.7	8.7	8.5	8.9
12	p 7.9	7.7	8.0	7.6	7.0	8.0	7.6	6.4	9.3	6.3	5.2	6.9	8.4	8.2	8.5
13	8.1	7.9	8.2	8.1	7.9	8.2	7.9	6.6	10.3	6.4	4.8	8.3	8.3	8.1	8.7
14	8.0	7.7	8.1	8.1	8.0	8.2	7.8	6.3	9.9	8.0	6.1	10.6	8.8	8.4	9.1
15	7.7	7.7	7.8	8.0	7.8	8.0	7.1	6.0	8.4	8.0	6.2	10.3	9.2	9.0	9.7
16	7.6	7.5	7.7	7.6	7.4	7.8	6.6	5.8	7.8	11.2	7.0	13.9	9.5	9.2	9.8
17	7.8	7.5	8.0	7.2	7.1	7.4	7.4	6.0	9.5	13.4	12.5	14.3	9.6	9.5	9.7
18	7.9	7.8	8.1	7.1	6.8	7.4	7.5	6.0	9.4	7.7	5.3	14.2	9.6	9.5	9.8
19	7.9	7.8	8.1	7.1	6.6	7.9	8.2	6.2	11.4	6.5	5.6	7.0	9.6	9.4	9.8
20	7.8	7.7	8.0	7.3	6.5	8.5	9.1	5.8	15.8	7.4	6.5	8.0	9.4	9.2	9.6
21	7.9	7.6	8.6	7.4	6.6	8.6	9.6	6.2	15.9	7.5	7.2	7.7	9.3	9.0	9.5
22	7.7	7.5	8.0	7.7	6.7	9.1	8.0	5.7	10.7	7.5	7.2	8.0	9.0	8.8	9.3
23	7.8	7.4	8.6	8.1	6.6	11.6	6.7	5.6	8.6	7.4	6.8	8.2	8.8	8.6	8.9
24	7.9	7.4	8.4	9.0	7.1	12.4	6.4	4.8	9.1	7.1	6.4	7.7	8.6	8.5	8.9
25	8.1	7.9	8.4	7.5	4.5	11.5	6.0	4.8	7.7	7.2	6.6	8.0	8.5	8.3	8.7
26	7.9	7.6	8.1	5.8	4.5	7.0	6.3	5.3	7.8	p 6.9	6.3	7.9	8.4	8.4	8.5
27	7.6	6.9	7.9	7.2	5.9	10.6	5.8	4.7	7.2	---	---	---	8.5	8.3	8.7
28	7.1	6.9	7.3	8.0	6.3	11.5	6.5	5.8	7.3	---	---	---	p 8.8	8.7	9.1
29	7.1	6.9	7.3	7.1	5.8	10.1	7.6	6.4	9.4	---	---	---	---	---	---
30	7.3	7.0	7.5	6.7	6.0	9.1	8.5	6.4	11.9	---	---	---	---	---	---
31				6.3	5.6	7.2	9.3	6.9	13.6				---	---	---
Mean	7.6	7.4	7.9	7.6	6.9	8.7	7.4	5.9	9.9	8.1	6.3	10.8	8.7	8.4	8.9
Minimum	6.9	6.5	7.3	5.8	4.5	7.0	5.8	4.7	6.7	5.8	4.8	6.7	6.7	5.4	7.5
Maximum	8.1	7.9	8.6	9.0	8.2	12.4	9.6	6.9	15.9	13.4	12.5	16.8	9.6	9.5	9.8

Mean, minimum, and maximum dissolved-oxygen concentration (milligrams per liter)

Table 11.--Daily mean, minimum, and maximum specific conductance at White River at Indianapolis, June through October 1986

[Min, minimum; Max, maximum; p, partial day; ---, no data]

Day	Mean, minimum, and maximum specific conductance (microsiemens per centimeter at 25 degrees Celsius)														
	June			July			August			September			October		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
1	650	632	667	649	592	678	637	630	643	762	748	787	348	265	481
2	671	665	675	516	482	587	645	636	652	748	738	754	321	317	323
3	671	669	676	497	457	532	662	651	670	749	733	756	465	350	485
4	654	534	682	430	420	456	670	655	676	749	735	761	321	287	388
5	568	544	603	467	438	500	664	650	680	751	741	765	403	346	427
6	655	603	681	528	500	551	667	656	682	773	748	799	382	360	423
7	602	523	662	575	552	597	701	682	726	760	744	773	381	355	421
8	475	455	522	616	596	633	739	727	744	767	752	793	441	422	458
9	466	454	484	643	632	656	740	736	744	774	762	784	477	458	495
10	517	484	545	666	590	699	735	713	744	796	777	812	518	497	541
11	p 562	546	579	612	320	675	752	743	774	719	364	811	559	541	574
12	p 553	529	564	564	472	602	748	730	756	742	702	765	588	575	600
13	545	533	562	500	427	572	733	726	738	688	676	711	603	590	611
14	539	531	548	431	422	444	739	731	750	701	685	708	608	597	618
15	550	538	564	471	445	498	743	737	753	710	706	716	620	613	628
16	585	565	610	525	499	552	750	745	754	728	715	739	635	628	643
17	620	605	630	581	553	605	735	724	751	754	737	768	648	643	651
18	628	623	633	627	606	646	723	710	731	744	622	786	654	651	658
19	642	626	661	659	645	674	708	699	731	714	570	793	662	657	668
20	680	662	694	685	674	698	702	686	711	616	422	675	672	667	677
21	694	690	699	704	698	725	701	686	722	663	642	686	680	677	684
22	678	670	691	714	704	731	724	707	746	717	676	759	686	681	692
23	681	671	697	722	713	726	721	715	727	724	705	741	699	691	705
24	677	615	704	713	684	746	734	723	744	651	528	705	711	705	715
25	576	558	613	694	624	719	748	744	754	614	576	632	710	689	731
26	578	565	591	703	634	713	745	733	750	p 563	557	576	691	679	701
27	600	591	615	683	669	700	743	734	748	---	---	---	662	654	678
28	613	601	623	657	637	685	750	746	756	---	---	---	p 673	666	676
29	629	602	667	643	639	661	751	741	775	---	---	---	---	---	---
30	676	664	685	651	644	659	768	762	774	---	---	---	---	---	---
31				657	633	679	763	748	773				---	---	---
Mean	608	585	628	606	568	632	721	710	732	718	668	744	565	545	584
Minimum	466	454	484	430	320	444	637	630	643	563	364	576	321	265	323
Maximum	694	690	704	722	713	746	768	762	775	796	777	812	711	705	731

Table 12.--Daily mean, minimum, and maximum pH at White River at Indianapolis, June through October 1986

[Min, minimum; Max, maximum; p, partial day; ---, no data]

Day	Mean, minimum, and maximum pH														
	June			July			August			September			October		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
1	7.8	7.8	7.8	7.9	7.9	8.0	8.1	8.0	8.3	8.2	8.0	8.5	7.4	7.1	7.7
2	7.8	7.8	7.8	7.9	7.9	8.0	8.2	8.1	8.3	8.2	8.0	8.5	7.4	7.4	7.5
3	7.8	7.8	7.9	7.9	7.9	8.0	8.2	8.1	8.4	8.2	8.0	8.4	7.7	7.6	7.7
4	7.8	7.7	7.9	7.9	7.9	8.0	8.3	8.2	8.5	8.2	7.9	8.6	7.6	7.5	7.7
5	7.7	7.7	7.7	8.0	8.0	8.0	8.2	8.1	8.3	8.3	8.0	8.6	7.7	7.6	7.8
6	7.7	7.7	7.9	8.0	8.0	8.0	8.0	8.0	8.2	8.3	8.0	8.7	7.8	7.8	7.8
7	7.7	7.5	7.8	8.0	8.0	8.0	8.0	7.9	8.1	8.3	8.1	8.7	7.8	7.8	7.9
8	7.5	7.4	7.5	8.0	8.0	8.1	8.1	8.1	8.2	8.2	8.0	8.5	7.9	7.8	7.9
9	7.5	7.4	7.5	8.0	8.0	8.1	8.2	8.1	8.2	8.2	8.0	8.4	7.9	7.9	7.9
10	7.5	7.5	7.6	8.1	8.0	8.1	8.2	8.1	8.2	8.0	7.9	8.1	7.9	7.9	8.0
11	p 7.6	7.6	7.6	8.1	8.0	8.2	8.2	8.1	8.3	7.8	7.5	7.9	8.0	7.9	8.0
12	p 7.6	7.5	7.6	8.1	8.0	8.1	8.3	8.3	8.5	7.8	7.6	7.9	8.0	8.0	8.0
13	7.6	7.6	7.6	8.0	7.9	8.1	8.3	8.2	8.4	7.7	7.6	7.8	7.9	7.9	8.0
14	7.6	7.6	7.6	8.0	7.9	8.0	8.3	8.2	8.3	7.9	7.8	8.1	8.0	8.0	8.0
15	7.6	7.6	7.6	8.0	8.0	8.0	8.2	8.1	8.3	7.9	7.8	8.1	8.0	8.0	8.1
16	7.6	7.6	7.7	8.0	8.0	8.1	8.1	8.1	8.2	8.0	7.9	8.1	8.1	8.0	8.1
17	7.6	7.6	7.7	8.0	8.0	8.1	8.2	8.0	8.3	7.9	7.8	7.9	8.1	8.1	8.1
18	7.7	7.7	7.7	8.0	8.0	8.1	8.2	8.1	8.3	7.8	7.8	8.0	8.1	8.1	8.1
19	7.7	7.7	7.7	8.1	8.0	8.2	8.2	8.0	8.4	7.7	7.6	7.9	8.1	8.0	8.1
20	7.7	7.7	7.8	8.2	8.1	8.3	8.2	8.0	8.6	7.9	7.7	8.0	8.0	8.0	8.1
21	7.7	7.7	7.8	8.2	8.2	8.3	8.2	8.0	8.6	8.0	7.5	8.0	8.0	8.0	8.1
22	7.8	7.7	7.8	8.3	8.2	8.4	8.2	8.0	8.3	8.1	8.0	8.2	8.0	8.0	8.0
23	7.8	7.7	7.9	8.3	8.2	8.4	8.0	7.9	8.1	8.0	8.0	8.1	8.0	8.0	8.0
24	7.8	7.7	7.9	8.2	8.1	8.4	8.0	7.8	8.2	7.9	7.8	8.0	8.0	8.0	8.0
25	7.8	7.7	7.8	8.1	7.9	8.2	7.9	7.8	8.0	7.8	7.6	8.0	8.0	8.0	8.0
26	7.8	7.8	7.8	8.0	8.0	8.1	8.0	7.9	8.1	p 7.8	7.7	8.0	8.0	8.0	8.0
27	7.8	7.8	7.9	8.1	7.9	8.4	7.9	7.8	8.0	---	---	---	8.1	8.0	8.1
28	7.8	7.7	7.8	8.4	8.3	8.6	7.9	7.9	8.0	---	---	---	p 8.1	8.1	8.1
29	7.8	7.8	7.9	8.3	8.2	8.4	8.1	7.9	8.3	---	---	---	---	---	---
30	7.9	7.9	8.0	8.3	8.2	8.3	8.3	8.1	8.5	---	---	---	---	---	---
31				8.1	8.0	8.2	8.3	8.1	8.6				---	---	---
Mean	7.7	7.7	7.8	8.1	8.0	8.2	8.1	8.0	8.3	8.0	7.8	8.2	7.9	7.9	8.0
Minimum	7.5	7.4	7.5	7.9	7.9	8.0	7.9	7.8	8.0	7.7	7.5	7.8	7.4	7.1	7.5
Maximum	7.9	7.9	8.0	8.4	8.3	8.6	8.3	8.3	8.6	8.3	8.1	8.7	8.1	8.1	8.1

Table 13.--Daily mean, minimum, and maximum water temperature at White River at Indianapolis, June through October 1986

[Min, minimum; Max, maximum; p, partial day; ---, no data]

	Mean, minimum, and maximum water temperature (degrees Celsius)														
	June			July			August			September			October		
Day	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
1	22.6	22.1	23.2	23.8	22.9	24.5	27.3	26.6	28.0	21.2	20.5	21.9	21.9	21.5	22.8
2	22.5	21.9	23.0	22.1	21.8	22.9	27.0	26.4	27.6	22.0	21.2	23.1	21.6	21.6	21.7
3	21.4	20.5	22.1	21.1	20.3	21.7	26.3	25.6	27.0	22.6	21.6	23.8	21.7	21.5	21.8
4	22.1	21.3	23.2	21.2	20.3	22.2	25.8	25.1	26.4	23.6	22.6	25.1	21.4	21.0	21.9
5	22.1	21.8	22.3	22.3	21.6	23.2	25.7	25.1	26.5	23.6	22.7	24.7	20.8	20.2	21.3
6	22.1	21.8	22.6	23.9	23.1	24.7	25.2	24.7	25.7	22.8	21.8	24.3	19.3	18.6	20.2
7	22.3	21.9	22.7	25.6	24.6	27.1	24.6	24.2	25.1	21.8	20.9	22.9	17.9	17.3	18.6
8	22.1	21.3	23.1	26.6	25.6	27.6	24.6	24.1	25.4	21.2	20.2	22.5	17.2	16.8	17.7
9	22.5	22.1	23.0	26.8	26.4	27.1	25.1	24.3	25.9	21.0	20.0	22.1	16.9	16.1	17.2
10	22.8	22.2	23.4	26.6	25.9	26.9	24.8	24.4	25.4	21.2	20.2	22.1	15.8	15.4	16.1
11	p 23.1	22.8	23.3	25.9	24.9	26.6	24.4	23.6	25.2	21.5	21.1	22.5	15.7	15.1	16.1
12	p 21.6	21.3	21.8	24.9	24.5	25.6	24.0	23.4	24.6	20.9	20.4	21.2	16.0	15.9	16.2
13	21.4	20.6	22.3	24.0	23.3	24.7	23.6	22.9	24.3	20.9	19.9	22.0	15.5	14.8	16.0
14	22.0	21.2	22.9	23.8	23.5	24.4	24.2	23.3	25.2	21.6	20.9	22.3	13.9	13.2	14.8
15	22.6	22.2	22.9	24.3	23.8	25.0	24.8	24.3	25.1	21.5	21.0	22.1	12.9	12.5	13.2
16	23.3	22.7	24.1	26.0	25.0	27.0	24.5	24.1	24.9	20.9	20.1	21.6	12.6	12.3	12.9
17	23.5	23.1	23.8	27.4	26.5	28.5	25.2	24.3	26.2	19.7	18.8	20.3	12.2	11.9	12.5
18	23.0	22.5	23.4	28.3	27.5	29.1	25.5	24.7	26.4	20.0	19.8	20.5	12.2	11.8	12.5
19	23.3	22.3	24.3	29.0	28.4	29.7	25.7	24.8	26.5	20.2	19.8	21.0	12.4	12.0	12.9
20	24.4	23.1	26.0	29.2	28.9	29.7	25.9	24.9	27.6	20.6	20.1	21.0	12.7	12.2	13.1
21	24.8	23.9	25.8	28.6	28.2	29.0	25.4	24.6	26.6	21.2	20.7	22.7	13.2	12.4	13.8
22	25.6	24.9	26.5	28.1	27.6	28.8	25.4	24.4	26.4	22.1	21.4	22.8	13.9	13.2	14.4
23	25.9	25.4	26.4	27.8	27.1	28.6	25.7	24.8	26.7	22.8	22.2	23.3	14.3	14.1	14.6
24	25.1	24.2	25.8	27.9	27.0	28.6	24.6	23.6	25.9	22.7	22.5	23.0	14.5	14.3	14.7
25	23.5	23.2	24.1	28.2	27.6	28.9	24.1	23.2	25.0	22.9	22.2	23.6	14.4	14.3	14.6
26	23.6	22.8	24.4	28.0	27.4	28.7	24.6	23.9	25.3	p 23.4	22.9	24.3	14.3	14.2	14.4
27	24.2	23.2	25.2	28.0	27.5	28.5	24.0	22.7	24.6	---	---	---	14.2	14.1	14.3
28	25.1	24.4	26.1	28.2	27.4	29.0	22.0	21.4	22.7	---	---	---	p 13.9	13.6	14.1
29	25.7	25.1	26.0	27.8	26.9	28.5	21.4	20.6	22.3	---	---	---	---	---	---
30	25.2	24.5	25.8	27.9	27.4	28.7	21.3	20.2	22.5	---	---	---	---	---	---
31				27.2	26.5	27.9	21.4	20.2	23.0				---	---	---
Mean	23.3	22.7	24.0	26.1	25.5	26.9	24.6	23.9	25.5	21.7	21.0	22.6	15.8	15.4	16.2
Minimum	21.4	20.5	21.8	21.1	20.3	21.7	21.3	20.2	22.3	19.7	18.8	20.3	12.2	11.8	12.5
Maximum	25.9	25.4	26.5	29.2	28.9	29.7	27.3	26.6	28.0	23.6	22.9	25.1	21.9	21.6	22.8

Table 14.--Daily mean streamflow at White River at Waverly, June through October 1986

[---, no data]

Day	Daily mean streamflow (cubic feet per second)				
	June	July	August	September	October
1	---	---	809	444	5,120
2	---	---	691	462	6,910
3	---	---	664	467	4,730
4	---	---	609	441	12,900
5	---	---	602	434	11,100
6	---	---	563	416	6,400
7	---	---	603	388	4,300
8	---	---	589	391	2,770
9	---	---	574	409	2,380
10	---	---	599	398	1,940
11	---	---	773	476	1,600
12	---	---	711	1,130	1,450
13	---	---	659	618	1,550
14	---	---	604	536	1,730
15	---	---	577	500	1,480
16	---	---	652	489	1,510
17	---	---	597	463	1,420
18	---	---	595	441	1,220
19	---	---	590	812	1,090
20	---	---	549	1,800	1,020
21	---	---	522	1,230	982
22	---	---	510	1,010	945
23	---	---	472	846	904
24	---	---	476	1,020	892
25	---	---	---	1,120	1,130
26	---	---	---	824	1,640
27	---	---	---	1,280	1,600
28	---	---	---	1,200	1,510
29	---	991	598	1,060	1,400
30	---	871	513	973	1,300
31		846	459		1,110
Mean	---	903	599	736	2,775
Minimum	---	846	459	388	892
Maximum	---	991	809	1,800	12,900

Table 15.--Daily mean, minimum, and maximum dissolved-oxygen concentration at White River at Waverly, June through October 1986

[Min, minimum; Max, maximum; p, partial day; ---, no data]

Day	June			July			August			September			October		
	Mean, minimum, and maximum dissolved-oxygen concentration (milligrams per liter)														
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
1	---	---	---	6.9	6.2	7.4	6.9	4.9	9.1	9.0	7.9	10.3	p 5.6	4.6	6.5
2	---	---	---	7.0	5.4	7.8	7.8	5.6	9.9	10.9	8.9	13.7	6.6	6.3	6.9
3	---	---	---	8.1	7.7	8.3	8.9	6.3	11.7	10.0	7.8	12.1	6.9	5.8	8.0
4	---	---	---	8.1	7.8	8.3	9.3	6.8	11.9	8.8	7.0	10.7	p 6.3	6.2	6.4
5	---	---	---	7.7	7.4	8.0	9.7	7.0	13.0	8.8	7.8	9.8	p 6.3	6.1	6.7
6	---	---	---	7.5	7.0	7.7	8.0	6.5	9.8	---	---	---	---	---	---
7	---	---	---	7.2	6.9	7.5	7.5	5.8	9.6	---	---	---	p 8.3	8.2	8.4
8	---	---	---	7.3	7.0	7.6	7.0	5.9	8.4	---	---	---	7.8	7.4	8.2
9	---	---	---	6.9	6.1	7.5	7.0	5.8	8.4	---	---	---	7.4	6.9	7.7
10	---	---	---	6.9	6.5	7.7	6.7	5.8	7.9	---	---	---	7.7	7.1	7.9
11	---	---	---	5.9	4.8	7.4	7.5	6.2	9.2	---	---	---	---	---	---
12	---	---	---	5.3	3.3	6.6	8.2	5.7	10.7	3.7	1.1	6.3	---	---	---
13	---	---	---	p 5.9	5.9	5.9	9.2	6.4	12.1	5.9	3.9	8.1	---	---	---
14	---	---	---	---	---	---	10.1	7.0	13.5	8.0	5.9	10.8	---	---	---
15	---	---	---	---	---	---	9.4	6.6	12.8	10.6	7.3	14.3	---	---	---
16	---	---	---	---	---	---	7.0	5.4	8.5	10.3	7.8	13.4	---	---	---
17	---	---	---	---	---	---	7.6	5.8	10.0	11.1	8.5	13.8	8.9	8.7	9.0
18	---	---	---	---	---	---	7.9	5.6	10.8	7.4	6.5	10.9	8.8	8.6	8.9
19	---	---	---	---	---	---	7.7	5.7	9.9	6.0	3.9	7.5	8.8	8.6	9.0
20	---	---	---	---	---	---	7.8	5.6	10.7	5.9	2.7	7.2	8.8	8.5	9.1
21	---	---	---	---	---	---	8.1	5.2	11.2	7.8	6.4	9.4	8.8	8.4	9.2
22	---	---	---	---	---	---	9.3	6.0	13.0	7.4	6.4	8.4	8.9	8.4	9.3
23	---	---	---	p 10.8	9.2	11.7	8.8	6.8	10.4	7.3	6.4	8.2	8.6	8.1	8.9
24	---	---	---	9.2	6.4	12.0	7.8	6.6	9.1	6.9	6.3	7.6	8.4	8.0	8.7
25	---	---	---	9.3	6.5	12.4	8.7	6.8	10.4	7.0	4.1	10.1	8.2	7.8	8.5
26	---	---	---	6.7	4.5	8.6	8.2	6.2	9.5	8.2	6.1	11.1	8.5	7.7	8.9
27	---	---	---	6.1	4.5	8.4	7.6	5.7	9.6	7.1	5.7	8.9	8.9	8.6	9.0
28	---	---	---	5.8	5.0	6.7	8.5	6.4	10.9	7.2	4.9	9.6	9.2	8.8	9.7
29	---	---	---	6.3	5.1	7.8	8.9	6.8	11.3	---	---	---	8.9	8.6	9.3
30	p 7.2	6.3	7.5	6.9	5.5	8.5	8.8	6.4	11.5	---	---	---	8.9	8.4	9.4
31				7.1	5.8	8.6	9.5	8.0	11.0				9.1	8.4	9.7
Mean	7.2	6.3	7.5	7.2	6.1	8.3	8.2	6.2	10.5	8.0	6.1	10.1	8.1	7.7	8.5
Minimum	7.2	6.3	7.5	5.3	3.3	5.9	6.7	4.9	7.9	3.7	1.1	6.3	5.6	4.6	6.4
Maximum	7.2	6.3	7.5	10.8	9.2	12.4	10.1	8.0	13.5	11.1	8.9	14.3	9.2	8.8	9.7

Table 16.--Daily mean, minimum, and maximum specific conductance at White River at Waverly, June through October 1986

[Min, minimum; Max, maximum; p, partial day; ---, no data]

	Mean, minimum, and maximum specific conductance (microsiemens per centimeter at 25 degrees Celsius)														
	June			July			August			September			October		
Day	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
1	---	---	---	708	669	752	835	813	862	1,030	1,010	1,070	578	311	841
2	---	---	---	581	524	707	844	812	873	1,040	1,030	1,070	383	329	429
3	---	---	---	546	524	567	856	833	876	1,050	1,020	1,070	473	430	542
4	---	---	---	510	494	526	835	810	860	1,090	1,050	1,140	p 318	292	345
5	---	---	---	529	500	564	888	843	927	1,130	1,090	1,150	p 364	346	390
6	---	---	---	599	566	636	922	883	950	---	---	---	---	---	---
7	---	---	---	660	621	696	945	901	991	---	---	---	p 445	423	470
8	---	---	---	727	675	757	939	909	967	---	---	---	501	470	543
9	---	---	---	753	702	800	968	938	1,000	---	---	---	557	537	588
10	---	---	---	771	732	796	971	955	991	---	---	---	592	570	616
11	---	---	---	748	688	767	888	806	971	---	---	---	651	616	679
12	---	---	---	543	446	683	856	806	921	833	750	1,050	683	661	707
13	---	---	---	p 602	602	602	924	885	975	803	747	897	659	621	690
14	---	---	---	---	---	---	972	924	1,010	978	900	1,050	610	569	649
15	---	---	---	---	---	---	1,030	982	1,090	1,020	1,000	1,050	655	620	684
16	---	---	---	---	---	---	1,060	986	1,080	1,020	1,000	1,040	683	659	722
17	---	---	---	---	---	---	951	925	983	1,050	1,030	1,080	718	651	770
18	---	---	---	---	---	---	945	908	986	1,030	954	1,080	795	770	816
19	---	---	---	---	---	---	978	946	1,010	828	756	982	804	774	835
20	---	---	---	---	---	---	1,010	974	1,030	705	550	858	829	787	869
21	---	---	---	---	---	---	1,060	1,020	1,110	661	564	721	894	844	923
22	---	---	---	---	---	---	1,110	1,070	1,140	803	722	863	934	905	957
23	---	---	---	p 899	889	906	1,100	1,090	1,130	907	840	969	963	942	979
24	---	---	---	898	873	920	1,090	1,070	1,110	941	875	988	986	953	1,010
25	---	---	---	911	884	939	1,060	1,050	1,080	800	767	949	1,000	989	1,020
26	---	---	---	862	785	912	1,080	1,050	1,110	846	786	882	776	664	988
27	---	---	---	771	749	797	1,110	1,100	1,120	779	651	878	762	678	803
28	---	---	---	756	737	777	1,040	999	1,100	699	677	719	815	782	830
29	---	---	---	784	770	798	993	952	1,030	737	700	766	837	782	870
30	p 739	715	754	812	783	846	989	941	1,040	798	752	829	850	800	879
31				831	818	854	1,020	1,000	1,060				890	847	919
Mean	739	715	754	718	683	755	976	941	1,012	899	843	965	700	654	745
Minimum	739	715	754	510	446	526	835	806	860	661	550	719	318	292	345
Maximum	739	715	754	911	889	939	1,110	1,100	1,140	1,130	1,090	1,150	1,000	989	1,020

Table 17.--Daily mean, minimum, and maximum pH at White River at Waverly, June through October 1986

[Min, minimum; Max, maximum; p, partial day; ---, no data]

Day	June Mean	June Min	June Max	July Mean	July Min	July Max	August Mean	August Min	August Max	September Mean	September Min	September Max	October Mean	October Min	October Max
1	---	---	---	7.4	7.3	7.5	---	---	---	7.6	7.5	7.8	6.9	6.8	7.0
2	---	---	---	7.4	7.2	7.6	---	---	---	7.7	7.5	7.9	6.9	6.8	7.1
3	---	---	---	7.6	7.5	7.7	---	---	---	7.6	7.4	7.7	7.5	7.1	7.6
4	---	---	---	7.6	7.5	7.6	---	---	---	7.6	7.5	7.7	p 7.5	7.4	7.5
5	---	---	---	7.5	7.5	7.6	---	---	---	7.5	7.4	7.7	p 7.4	7.4	7.5
6	---	---	---	7.5	7.5	7.6	---	---	---	---	---	---	---	---	---
7	---	---	---	7.6	7.5	7.6	---	---	---	---	---	---	p 7.6	7.5	7.7
8	---	---	---	7.6	7.5	7.7	---	---	---	---	---	---	7.6	7.5	7.6
9	---	---	---	7.6	7.4	7.7	---	---	---	---	---	---	7.6	7.5	7.7
10	---	---	---	7.6	7.6	7.7	---	---	---	---	---	---	7.6	7.6	7.7
11	---	---	---	7.5	7.4	7.6	p 7.1	7.1	7.2	---	---	---	7.6	7.6	7.6
12	---	---	---	7.5	7.3	7.8	7.1	6.9	7.2	7.2	7.1	7.5	7.6	7.5	7.7
13	---	---	---	p 7.7	7.7	7.7	7.2	7.1	7.3	7.3	7.2	7.3	7.5	7.4	7.7
14	---	---	---	---	---	---	7.3	7.2	7.5	7.4	7.3	7.5	7.6	7.4	7.7
15	---	---	---	---	---	---	7.3	7.2	7.4	7.5	7.3	7.8	7.6	7.6	7.7
16	---	---	---	---	---	---	7.1	7.1	7.2	7.5	7.3	7.7	7.7	7.6	7.7
17	---	---	---	---	---	---	7.2	7.1	7.3	7.5	7.4	7.7	7.6	7.6	7.7
18	---	---	---	---	---	---	7.4	7.3	7.5	7.3	7.1	7.4	7.6	7.6	7.7
19	---	---	---	---	---	---	7.4	7.3	7.6	7.1	7.0	7.3	7.6	7.6	7.7
20	---	---	---	---	---	---	7.5	7.4	7.7	7.1	7.0	7.3	7.6	7.5	7.6
21	---	---	---	---	---	---	7.5	7.4	7.7	7.3	7.1	7.5	7.5	7.5	7.5
22	---	---	---	---	---	---	7.5	7.4	7.7	7.4	7.3	7.5	7.5	7.4	7.5
23	---	---	---	---	---	---	7.5	7.3	7.7	7.4	7.3	7.4	7.5	7.4	7.5
24	---	---	---	---	---	---	7.5	7.4	7.6	7.3	7.1	7.4	7.4	7.4	7.5
25	---	---	---	---	---	---	7.5	7.4	7.6	7.2	7.1	7.3	7.4	7.2	7.4
26	---	---	---	---	---	---	7.5	7.4	7.6	7.1	7.0	7.2	7.4	7.2	7.5
27	---	---	---	---	---	---	7.5	7.4	7.6	7.0	6.8	7.1	7.5	7.4	7.5
28	---	---	---	---	---	---	7.6	7.5	7.7	6.9	6.7	7.2	7.5	7.4	7.5
29	---	---	---	---	---	---	7.6	7.5	7.7	7.0	6.8	7.1	7.5	7.4	7.6
30	p 7.5	7.3	7.6	---	---	---	7.6	7.5	7.7	6.9	6.8	7.0	7.5	7.4	7.6
31				---	---	---	7.6	7.5	7.8				7.5	7.5	7.6
Mean	7.5	7.3	7.6	7.5	7.5	7.6	7.4	7.3	7.5	7.3	7.2	7.5	7.5	7.4	7.6
Minimum	7.5	7.3	7.6	7.4	7.2	7.5	7.1	6.9	7.2	6.9	6.7	7.0	6.9	6.8	7.0
Maximum	7.5	7.3	7.6	7.7	7.7	7.8	7.6	7.5	7.8	7.7	7.5	7.9	7.7	7.6	7.7

Table 18.--Daily mean, minimum, and maximum water temperature at White River at Waverly, June through October 1986

[Min, minimum; Max, maximum; p, partial day; ---, no data]

Day	June			July			August			September			October		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
1	---	---	---	24.5	23.9	25.2	26.3	25.1	27.3	22.1	21.6	22.7	21.6	21.6	24.2
2	---	---	---	23.3	22.8	23.9	25.8	24.9	26.5	22.6	21.7	23.9	21.4	21.4	21.9
3	---	---	---	22.4	21.9	22.8	25.1	24.1	26.0	23.3	22.2	24.5	21.8	21.8	22.4
4	---	---	---	22.1	21.4	22.8	24.5	23.3	25.2	24.3	23.3	25.5	p 21.4	21.4	21.7
5	---	---	---	23.1	21.9	24.5	24.6	23.2	25.7	23.9	23.0	24.9	p 20.6	20.6	21.5
6	---	---	---	24.2	22.9	25.7	24.2	23.7	25.1	---	---	---	---	---	---
7	---	---	---	25.8	24.6	26.9	24.1	23.2	25.1	---	---	---	p 17.7	17.7	18.4
8	---	---	---	26.5	25.2	27.6	24.5	23.6	25.6	---	---	---	17.0	17.0	18.7
9	---	---	---	26.4	25.7	27.2	24.7	23.5	25.6	---	---	---	17.0	17.0	17.9
10	---	---	---	26.4	25.5	26.9	24.6	24.1	25.3	---	---	---	16.2	16.2	17.2
11	---	---	---	26.3	25.4	27.3	24.4	23.5	25.5	---	---	---	15.2	15.2	18.9
12	---	---	---	24.9	24.0	25.8	24.2	23.0	25.1	21.6	21.2	22.0	16.3	16.3	18.5
13	---	---	---	p 25.0	25.0	25.0	24.0	22.7	24.9	21.1	19.8	22.3	13.7	13.7	16.4
14	---	---	---	---	---	---	24.7	23.4	26.0	21.7	20.4	22.8	12.3	12.3	16.5
15	---	---	---	---	---	---	25.6	24.8	26.6	22.4	21.5	23.1	12.9	12.9	15.7
16	---	---	---	---	---	---	25.1	24.6	25.7	21.4	20.6	22.6	11.9	11.9	16.0
17	---	---	---	---	---	---	25.1	23.9	26.3	20.3	19.3	21.1	12.7	12.7	14.6
18	---	---	---	---	---	---	25.5	24.3	26.6	21.1	21.0	21.4	13.1	13.1	14.8
19	---	---	---	---	---	---	25.4	24.4	26.6	21.3	20.9	21.8	13.0	13.0	14.8
20	---	---	---	---	---	---	25.0	23.7	26.1	21.3	20.8	21.6	12.9	12.9	15.1
21	---	---	---	---	---	---	25.1	24.1	25.9	21.9	20.9	22.9	14.4	14.4	16.3
22	---	---	---	---	---	---	25.2	24.1	26.3	23.0	21.9	23.9	15.2	15.2	16.5
23	---	---	---	p 26.8	26.4	26.9	25.4	24.6	26.3	23.3	22.8	23.7	16.1	16.1	16.4
24	---	---	---	25.9	24.5	26.8	24.8	22.9	26.9	23.4	22.9	24.1	16.0	16.0	16.5
25	---	---	---	26.4	25.2	27.3	24.8	23.3	25.9	24.2	23.2	25.2	15.9	15.9	16.3
26	---	---	---	26.1	25.3	26.8	25.5	24.3	26.8	24.6	24.1	25.8	14.9	14.9	16.3
27	---	---	---	26.7	25.3	28.2	25.1	24.0	26.0	23.7	23.2	24.2	14.3	14.3	14.9
28	---	---	---	27.6	26.4	28.8	22.7	21.7	24.0	24.0	23.0	25.0	13.9	13.9	15.3
29	---	---	---	27.1	25.9	28.0	21.8	20.5	23.0	24.7	23.9	25.3	14.5	14.5	15.9
30	p 25.5	25.2	25.6	26.4	25.0	27.4	21.8	20.4	23.1	24.4	23.9	24.8	14.3	14.3	15.4
31				25.9	24.4	26.9	22.2	20.7	23.6				13.7	13.7	15.4
Mean	25.5	25.2	25.6	25.4	24.5	26.3	24.6	23.5	25.6	22.7	22.0	23.5	15.7	15.7	17.3
Minimum	25.5	25.2	25.6	22.1	21.4	22.8	21.8	20.4	23.0	20.3	19.3	21.1	11.9	11.9	14.6
Maximum	25.5	25.2	25.6	27.6	26.4	28.8	26.3	25.1	27.3	24.7	24.1	25.8	21.8	21.8	24.2

Table 19.--Daily mean streamflow at Fall Creek at Indianapolis, June through October 1986

Day	Daily mean streamflow (cubic feet per second)				
	June	July	August	September	October
1	321	317	56	51	2,060
2	301	514	76	40	1,580
3	217	396	67	35	1,280
4	220	253	57	41	4,970
5	230	210	57	34	4,490
6	500	170	67	39	3,220
7	1,400	155	92	50	1,150
8	1,300	135	71	47	671
9	734	125	69	41	493
10	470	160	113	39	378
11	431	463	93	113	292
12	820	754	62	75	263
13	982	938	61	49	290
14	679	651	54	36	328
15	469	432	59	33	316
16	363	308	90	35	279
17	366	231	74	42	241
18	305	202	69	150	209
19	252	163	76	88	186
20	220	147	70	156	162
21	212	140	68	53	153
22	200	98	55	30	147
23	190	104	45	30	136
24	160	85	48	106	132
25	133	82	43	72	191
26	107	152	42	73	256
27	96	180	57	147	285
28	228	115	49	89	254
29	197	88	50	66	220
30	186	73	44	98	214
31		88	55		171
Mean	410	256	64.2	65.3	807
Minimum	96	73	42	30	132
Maximum	1,400	938	113	156	4,970

Table 20.--Daily mean, minimum, and maximum dissolved-oxygen concentration at Fall Creek at Indianapolis, June through October 1986

[Min, minimum; Max, maximum; p, partial day; ---, no data]

	Mean, minimum, and maximum dissolved-oxygen concentration (milligrams per liter)														
	June			July			August			September			October		
Day	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
1	7.4	7.0	7.9	7.1	6.1	7.7	5.4	4.3	6.7	8.1	6.9	9.4	6.1	4.0	7.1
2	7.6	7.1	8.1	7.6	6.2	7.9	6.0	4.3	7.8	8.1	6.9	9.7	7.5	7.1	7.6
3	7.8	7.4	8.2	7.9	7.6	8.1	6.6	5.2	8.8	8.0	6.1	10.4	7.7	7.0	7.9
4	p 7.6	7.4	8.1	7.8	7.5	8.2	6.6	5.3	8.3	8.6	6.6	11.2	7.2	6.9	7.7
5	---	---	---	7.7	7.3	8.3	6.5	5.0	8.5	8.1	6.2	10.6	7.6	7.1	7.9
6	p 8.3	8.3	8.4	7.5	7.1	8.1	6.0	4.7	7.2	8.6	7.0	11.2	8.0	7.6	8.2
7	8.4	7.7	8.5	7.3	6.9	7.9	6.4	5.4	7.8	8.4	7.3	9.9	8.3	8.1	8.4
8	8.2	7.9	8.5	6.8	5.6	7.7	6.1	4.9	7.4	8.4	7.6	9.9	8.4	8.2	8.6
9	8.0	7.7	8.3	6.5	5.5	7.5	6.6	5.2	8.2	8.0	7.2	9.1	8.4	8.2	8.5
10	7.7	7.5	8.1	6.3	4.8	6.9	6.0	5.1	6.8	7.8	6.9	9.0	8.6	8.5	8.7
11	7.3	6.0	7.7	6.0	4.8	7.1	6.0	5.4	6.8	6.6	4.9	7.7	8.6	8.5	8.8
12	7.3	5.9	7.7	6.6	5.8	7.2	6.3	4.9	8.1	5.3	4.5	7.3	8.0	7.1	8.5
13	7.7	7.4	7.8	7.0	6.5	7.2	6.7	5.2	8.4	6.9	5.4	8.7	8.1	7.5	8.5
14	7.6	7.3	8.0	6.7	6.5	6.9	6.9	5.4	8.7	7.9	6.2	10.5	8.6	7.6	9.0
15	7.5	7.1	7.9	6.3	5.8	6.8	6.6	5.2	8.0	8.1	6.4	10.2	9.0	8.9	9.2
16	7.3	7.0	7.7	7.1	6.4	7.8	6.7	5.7	8.1	7.2	5.9	8.9	9.0	8.8	9.1
17	7.3	6.9	7.7	6.9	6.4	7.7	7.0	5.9	8.3	7.6	6.3	9.4	9.0	8.7	9.2
18	7.4	7.1	7.7	7.0	6.4	7.8	7.1	5.6	9.4	6.2	5.4	8.2	9.1	8.9	9.3
19	7.7	7.3	8.1	6.8	6.2	7.7	6.8	4.6	8.9	6.0	5.6	6.7	9.1	8.9	9.4
20	7.5	7.1	7.9	6.8	6.1	8.0	7.0	5.0	9.2	6.3	5.6	6.6	9.1	8.9	9.3
21	7.6	7.2	8.2	6.9	6.3	8.2	7.0	5.3	8.9	6.8	6.3	7.6	8.9	8.6	9.2
22	7.6	7.3	8.2	7.1	6.2	8.4	6.8	5.2	8.3	6.5	5.5	7.6	8.7	8.5	8.9
23	6.6	5.3	7.4	7.2	6.3	8.9	6.5	4.6	8.1	6.3	5.5	7.4	8.5	8.4	8.7
24	7.2	6.6	7.9	7.3	6.2	9.3	7.0	5.2	9.1	5.6	5.0	6.6	8.5	8.3	8.7
25	7.6	7.1	8.3	7.2	5.0	9.5	6.5	5.3	7.7	6.2	5.7	6.7	8.2	7.9	8.4
26	7.7	7.1	8.4	6.0	4.3	7.7	6.7	5.6	7.5	5.7	4.8	6.7	8.5	8.1	8.8
27	7.4	6.4	8.0	7.0	5.8	9.0	6.9	6.1	7.8	5.2	4.5	6.4	8.8	8.4	9.0
28	6.6	5.4	7.6	6.5	5.6	8.1	7.2	6.2	8.2	5.8	5.2	6.8	9.0	8.9	9.2
29	7.4	6.8	8.1	6.3	5.3	8.4	7.9	6.8	9.2	5.8	5.2	6.8	8.9	8.8	9.1
30	6.9	6.6	7.3	6.1	4.7	8.1	8.3	7.0	10.1	5.7	5.0	6.5	9.0	8.6	9.2
31				5.7	4.7	7.1	8.4	7.2	10.0				9.2	9.0	9.4
Mean	7.5	7.0	8.0	6.9	6.0	7.9	6.7	5.4	8.3	7.0	5.9	8.5	8.4	8.1	8.7
Minimum	6.6	5.3	7.3	5.7	4.3	6.8	5.4	4.3	6.7	5.2	4.5	6.4	6.1	4.0	7.1
Maximum	8.4	8.3	8.5	7.9	7.6	9.5	8.4	7.2	10.1	8.6	7.6	11.2	9.2	9.0	9.4

Table 21.--Daily mean, minimum, and maximum specific conductance at Fall Creek at Indianapolis, June through October 1986

[Min, minimum; Max, maximum; p, partial day; ---, no data]

Day	Mean, minimum, and maximum specific conductance (microsiemens per centimeter at 25 degrees Celsius)														
	June			July			August			September			October		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
1	595	583	620	---	---	---	---	---	---	774	757	805	349	161	669
2	611	607	627	---	---	---	---	---	---	753	735	775	375	257	450
3	631	614	651	---	---	---	---	---	---	745	734	763	430	298	462
4	p 656	649	670	---	---	---	---	---	---	760	752	770	298	184	445
5	---	---	---	---	---	---	---	---	---	771	760	785	---	---	---
6	p 505	487	522	---	---	---	---	---	---	776	766	783	---	---	---
7	508	471	532	---	---	---	---	---	---	783	773	795	---	---	---
8	497	432	521	---	---	---	---	---	---	798	786	811	---	---	---
9	529	516	543	---	---	---	---	---	---	812	794	866	---	---	---
10	552	543	562	---	---	---	---	---	---	807	801	814	---	---	---
11	564	457	581	---	---	---	---	---	---	738	567	816	---	---	---
12	486	418	509	---	---	---	p 721	710	737	551	516	741	---	---	---
13	512	496	533	---	---	---	747	736	760	663	601	756	---	---	---
14	534	525	547	---	---	---	767	761	780	731	687	766	---	---	---
15	556	547	567	---	---	---	774	753	789	777	748	819	---	---	---
16	581	565	598	---	---	---	751	739	765	855	792	904	---	---	---
17	587	570	606	---	---	---	729	721	742	900	858	955	---	---	---
18	571	555	601	---	---	---	720	713	742	729	482	905	---	---	---
19	601	585	613	---	---	---	739	729	752	561	473	637	---	---	---
20	621	603	651	---	---	---	749	743	763	471	417	646	---	---	---
21	633	630	660	---	---	---	757	748	764	590	514	640	---	---	---
22	640	632	657	---	---	---	761	751	770	661	628	709	---	---	---
23	p 608	572	636	---	---	---	765	758	772	686	658	714	---	---	---
24	---	---	---	---	---	---	773	763	784	683	512	768	---	---	---
25	---	---	---	---	---	---	796	774	811	535	507	593	---	---	---
26	---	---	---	---	---	---	808	794	817	562	487	615	---	---	---
27	---	---	---	---	---	---	804	779	814	497	420	593	---	---	---
28	---	---	---	---	---	---	802	787	813	490	431	555	---	---	---
29	---	---	---	---	---	---	764	744	790	590	546	643	---	---	---
30	---	---	---	---	---	---	755	744	771	659	602	705	---	---	---
31				---	---	---	767	759	787				---	---	---
Mean	572	548	591	---	---	---	762	750	776	690	637	748	363	225	507
Minimum	486	418	509	---	---	---	720	710	737	471	417	555	298	161	445
Maximum	656	649	670	---	---	---	808	794	817	900	858	955	430	298	669

Table 22.--Daily mean, minimum, and maximum pH at Fall Creek at Indianapolis, June through October 1986

[Min, minimum; Max, maximum; p, partial day; ---, no data]

	Mean, minimum, and maximum pH														
	June			July			August			September			October		
Day	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
1	7.6	7.5	7.7	7.6	7.3	7.7	7.7	7.6	7.7	8.1	7.9	8.3	7.1	6.6	7.2
2	7.6	7.5	7.7	7.6	7.4	7.7	7.8	7.6	8.1	8.0	7.9	8.2	7.3	7.2	7.4
3	7.5	7.5	7.7	7.7	7.6	7.8	8.0	7.8	8.1	8.0	7.8	8.1	7.4	7.1	7.5
4	p 7.5	7.4	7.5	7.7	7.5	7.8	7.9	7.8	8.0	8.0	7.7	8.2	7.3	7.1	7.4
5	---	---	---	7.7	7.4	7.8	7.9	7.8	8.1	7.9	7.5	8.1	7.5	7.3	7.6
6	p 7.5	7.5	7.6	7.7	7.6	7.8	7.9	7.8	8.0	8.1	7.8	8.3	7.6	7.5	7.6
7	7.6	7.5	7.7	7.7	7.5	7.8	7.9	7.8	8.0	8.1	7.9	8.2	7.6	7.4	7.6
8	7.5	7.3	7.6	7.7	7.5	7.8	8.0	7.9	8.1	8.0	7.5	8.1	7.6	7.3	7.6
9	7.6	7.2	7.6	7.7	7.6	7.8	8.0	7.9	8.1	7.9	7.4	8.0	7.6	7.4	7.7
10	7.5	7.2	7.6	7.7	7.5	7.8	7.9	7.8	7.9	7.9	7.6	8.0	7.7	7.6	7.7
11	7.4	7.2	7.5	7.7	7.5	7.9	7.9	7.8	7.9	7.7	7.5	7.9	7.7	7.7	7.8
12	7.4	7.1	7.5	7.8	7.5	7.9	7.9	7.8	8.1	7.5	7.3	7.6	7.7	7.6	7.8
13	7.5	7.3	7.5	7.9	7.7	7.9	8.0	7.9	8.1	7.8	7.6	8.0	7.8	7.7	7.9
14	7.5	7.3	7.5	7.9	7.8	7.9	8.0	7.9	8.1	8.0	7.8	8.2	7.9	7.8	8.0
15	7.4	7.3	7.5	7.8	7.7	7.9	7.9	7.8	8.0	8.0	7.8	8.1	8.0	7.9	8.0
16	7.3	7.1	7.4	7.8	7.7	7.9	7.9	7.7	8.0	7.9	7.7	8.0	7.9	7.9	8.0
17	7.3	7.1	7.4	7.8	7.7	7.8	7.8	7.7	7.9	8.1	8.0	8.2	7.9	7.8	8.0
18	7.3	7.1	7.4	7.8	7.6	7.9	7.8	7.7	8.1	7.8	7.6	8.0	7.9	7.9	7.9
19	7.4	7.2	7.5	7.8	7.7	7.9	7.8	7.5	8.0	7.7	7.7	7.8	7.9	7.9	7.9
20	7.3	7.2	7.5	7.8	7.8	7.9	7.8	7.6	8.0	7.7	7.6	7.7	7.9	7.8	7.9
21	7.4	7.3	7.4	7.9	7.8	8.1	7.9	7.7	8.1	7.8	7.7	7.8	7.9	7.8	7.9
22	7.4	7.3	7.5	7.9	7.8	8.0	7.9	7.6	8.1	7.8	7.8	7.9	7.9	7.8	7.9
23	7.3	7.1	7.5	8.0	7.9	8.2	7.8	7.6	7.9	7.7	7.6	7.8	7.9	7.8	7.9
24	7.6	7.4	7.8	8.1	8.0	8.2	7.9	7.7	8.1	7.6	7.5	7.7	7.9	7.8	7.9
25	7.7	7.6	7.8	8.0	7.8	8.2	7.8	7.7	7.9	7.6	7.5	7.6	7.8	7.8	7.9
26	7.7	7.5	7.7	7.8	7.7	7.9	7.8	7.7	8.0	7.5	7.4	7.7	7.9	7.9	8.0
27	7.6	7.5	7.6	8.0	7.9	8.3	7.9	7.7	8.1	7.4	7.4	7.5	8.0	7.9	8.1
28	7.5	7.3	7.7	7.9	7.8	8.0	7.9	7.8	8.0	7.5	7.4	7.5	8.0	7.9	8.1
29	7.7	7.5	7.8	7.9	7.6	8.0	8.0	7.8	8.1	7.5	7.4	7.5	8.0	7.9	8.0
30	7.6	7.5	7.7	7.8	7.6	8.0	8.1	7.9	8.3	7.2	7.1	7.4	8.0	7.8	8.0
31				7.8	7.6	7.8	8.1	7.9	8.2				8.0	7.9	8.0
Mean	7.5	7.3	7.6	7.8	7.6	7.9	7.9	7.8	8.0	7.8	7.6	7.9	7.8	7.6	7.8
Minimum	7.3	7.1	7.4	7.6	7.3	7.7	7.7	7.5	7.7	7.2	7.1	7.4	7.1	6.6	7.2
Maximum	7.7	7.6	7.8	8.1	8.0	8.3	8.1	7.9	8.3	8.1	8.0	8.3	8.0	7.9	8.1

Table 23.--Daily mean, minimum, and maximum water temperature at Fall Creek at Indianapolis, June through October 1986

[Min, minimum; Max, maximum; p, partial day; ---, no data]

	Mean, minimum, and maximum water temperature (degrees Celsius)														
	June			July			August			September			October		
Day	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
1	22.2	21.1	23.3	23.0	22.8	23.4	25.5	24.7	26.4	20.8	20.3	21.2	21.4	20.9	22.4
2	21.3	20.2	22.2	22.8	22.3	23.2	25.2	24.6	25.9	21.4	20.7	22.3	21.3	20.9	21.6
3	20.2	18.8	21.6	22.9	22.1	23.6	24.6	23.9	25.5	21.9	21.1	22.9	21.3	21.0	21.5
4	p 20.3	19.6	21.4	23.3	22.5	24.1	24.1	23.4	24.7	22.4	21.7	23.3	20.7	20.5	21.0
5	---	---	---	24.0	22.9	25.0	24.1	23.3	24.8	22.2	21.5	23.2	20.2	19.8	20.5
6	p 22.0	21.9	22.0	24.7	23.7	25.6	23.6	23.4	24.1	21.7	20.9	22.6	19.2	18.7	19.8
7	22.1	21.8	22.5	25.3	24.4	25.9	23.2	22.7	23.8	21.0	20.4	21.5	18.3	17.9	18.7
8	22.3	21.6	23.0	25.7	25.1	26.1	23.3	22.6	24.0	20.4	19.6	21.3	17.5	17.0	17.9
9	22.6	22.4	22.8	25.6	25.3	26.1	23.4	22.7	24.2	20.2	19.2	21.0	17.0	16.3	17.6
10	22.6	22.2	23.0	25.3	24.8	25.8	23.2	23.0	23.6	20.5	19.8	21.2	16.1	15.7	16.4
11	22.4	22.2	22.7	25.0	24.6	25.8	23.2	22.5	24.1	20.9	20.7	21.1	15.8	15.2	16.1
12	21.7	21.2	22.2	24.8	24.5	25.1	23.0	22.3	24.0	20.5	20.1	21.0	15.9	15.7	16.1
13	21.8	21.2	22.5	25.1	24.5	25.8	22.9	22.0	23.8	20.3	19.4	21.3	14.9	14.2	15.6
14	22.2	21.7	22.6	25.1	24.8	25.5	23.3	22.2	24.2	20.6	19.8	21.5	13.7	13.4	14.2
15	22.1	21.8	22.4	25.6	24.9	26.5	23.7	23.1	24.2	20.9	20.4	21.4	13.2	12.9	13.5
16	22.3	21.9	22.8	26.3	25.6	27.2	23.6	23.1	24.0	20.3	19.7	21.0	12.9	12.6	13.0
17	21.9	21.6	22.2	26.7	25.9	27.6	23.8	23.1	24.6	19.7	19.1	20.2	12.8	12.3	13.2
18	21.6	21.1	22.1	27.0	26.1	27.7	24.2	23.4	25.2	20.0	19.7	20.4	12.8	12.5	13.2
19	22.2	21.4	23.1	27.4	26.5	28.1	24.1	23.4	24.8	20.5	20.3	21.0	12.8	12.3	13.2
20	23.3	22.5	24.2	27.5	26.8	28.1	24.0	23.1	24.9	20.5	20.2	20.9	12.8	12.3	13.2
21	23.9	23.0	24.6	26.7	26.1	27.6	24.2	23.4	24.8	21.1	20.3	21.9	13.3	12.7	13.8
22	24.8	24.2	25.4	26.1	25.5	26.5	24.3	23.6	25.0	21.7	21.0	22.4	13.6	13.2	14.1
23	25.1	24.6	25.6	26.2	25.4	27.1	24.3	23.5	25.0	21.8	21.5	22.2	13.7	13.5	13.8
24	24.1	23.5	24.8	26.1	25.2	27.1	23.4	22.6	24.4	21.5	21.2	21.7	13.6	13.5	13.7
25	23.1	22.2	23.8	26.4	25.5	27.3	23.2	22.3	24.2	22.3	21.6	23.2	13.5	13.5	13.6
26	23.1	22.4	23.8	26.1	25.5	26.9	23.5	22.8	24.2	22.9	22.2	23.9	13.6	13.4	13.6
27	23.7	23.1	24.4	26.3	25.5	27.2	22.9	22.0	23.4	22.9	22.4	23.4	13.2	12.8	13.6
28	24.3	23.6	25.0	26.4	25.7	27.3	21.4	20.7	22.1	23.2	22.6	24.0	12.9	12.6	13.3
29	24.4	23.7	24.9	26.3	25.6	27.2	20.8	20.0	21.7	23.6	23.2	24.4	13.2	12.9	13.6
30	23.8	23.4	24.4	25.9	25.1	26.8	20.8	19.8	21.9	22.8	22.4	23.2	12.9	12.7	13.3
31				25.6	24.6	26.5	20.9	19.9	21.9				12.5	12.1	12.8
Mean	22.7	22.1	23.3	25.5	24.8	26.2	23.4	22.7	24.2	21.3	20.8	22.0	15.4	15.0	15.7
Minimum	20.2	18.8	21.4	22.8	22.1	23.2	20.8	19.8	21.7	19.7	19.1	20.2	12.5	12.1	12.8
Maximum	25.1	24.6	25.6	27.5	26.8	28.1	25.5	24.7	26.4	23.6	23.2	24.4	21.4	21.0	22.4

Table 24.--Daily mean streamflow at White River at Waverly, June through October 1987

Day	Daily mean streamflow (cubic feet per second) June	July	August	September	October
1	1,040	3,630	905	393	336
2	939	5,270	780	379	321
3	2,170	3,800	787	381	301
4	3,360	4,040	766	368	277
5	4,700	2,710	903	354	280
6	4,750	2,720	804	334	303
7	2,120	2,060	679	327	301
8	1,420	1,490	573	340	312
9	1,120	1,190	531	353	316
10	965	1,040	513	341	324
11	848	913	539	400	394
12	826	832	529	403	372
13	757	2,280	478	368	359
14	841	2,770	438	358	350
15	792	2,630	433	356	336
16	820	2,420	390	398	340
17	799	1,710	412	436	338
18	841	1,270	428	415	327
19	779	1,030	393	361	336
20	879	899	360	342	350
21	1,060	783	349	329	330
22	1,440	692	350	341	320
23	1,040	652	347	324	310
24	814	626	324	324	320
25	693	575	339	333	320
26	618	521	360	302	370
27	529	810	486	298	580
28	458	932	484	292	540
29	474	663	486	365	430
30	725	1,040	436	380	410
31		1,210	412		380
Mean	1,287	1,716	517	357	351
Minimum	458	521	324	292	277
Maximum	4,750	5,270	905	436	580

Table 25.--Daily mean, minimum, and maximum dissolved-oxygen concentration at White River at Waverly, June through October 1987

[Min, minimum; Max, maximum; p, partial day; ---, no data]

	Mean, minimum, and maximum dissolved-oxygen concentration (milligrams per liter)														
	June			July			August			September			October		
Day	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
1	9.2	6.0	13.1	2.4	1.2	4.2	---	---	---	10.1	6.3	15.0	8.0	5.8	10.8
2	8.2	5.8	11.2	2.8	1.6	4.2	---	---	---	11.9	6.9	17.8	8.4	7.2	9.9
3	4.4	1.0	7.2	3.5	2.7	4.1	---	---	---	11.5	6.7	16.9	8.6	6.8	10.9
4	6.5	5.7	7.4	3.9	2.7	5.5	---	---	---	11.2	6.6	16.6	8.9	7.5	11.2
5	6.9	6.7	7.1	5.9	5.5	6.0	p 9.0	6.2	11.1	10.9	6.7	16.6	8.9	7.7	10.8
6	7.0	6.7	7.2	---	---	---	7.6	4.5	11.0	9.6	6.2	14.4	8.8	7.7	10.2
7	6.4	5.9	6.7	---	---	---	7.8	4.6	11.5	8.9	5.7	13.1	8.8	7.7	10.4
8	6.2	6.0	6.4	---	---	---	7.8	4.9	10.5	---	---	---	9.6	7.9	12.3
9	6.3	6.0	6.8	---	---	---	8.1	5.1	12.2	---	---	---	9.9	8.4	12.0
10	6.8	6.0	7.9	---	---	---	8.3	5.0	12.2	---	---	---	8.2	6.6	9.1
11	7.4	6.1	9.1	---	---	---	9.4	6.0	13.9	---	---	---	8.4	6.6	10.7
12	7.5	6.5	8.5	---	---	---	11.3	5.7	17.3	---	---	---	8.7	6.9	11.1
13	8.3	6.2	10.8	---	---	---	12.7	7.2	18.8	---	---	---	9.0	7.3	11.1
14	8.2	6.0	10.9	---	---	---	13.8	7.1	20.4	---	---	---	9.0	7.3	11.3
15	8.7	5.8	11.8	p 8.0	7.2	8.6	12.0	7.4	16.9	---	---	---	9.3	7.5	11.9
16	9.0	5.8	12.6	8.0	7.4	8.9	9.2	5.8	13.7	p 7.9	5.8	9.0	10.5	8.4	13.7
17	9.1	5.6	13.1	7.8	7.3	8.5	9.2	5.2	14.1	5.9	4.6	7.6	11.0	8.7	14.6
18	9.1	5.4	13.6	7.6	6.6	9.0	10.7	6.1	16.3	5.2	4.4	6.2	11.0	8.5	14.9
19	7.5	5.0	10.8	8.0	6.2	10.3	12.3	6.6	19.5	6.2	4.9	8.3	10.1	8.6	12.4
20	5.3	3.9	6.7	8.3	5.4	11.6	12.3	6.8	18.9	6.7	5.2	8.5	9.3	7.7	11.8
21	5.8	4.3	7.7	9.4	5.6	13.8	9.0	6.0	13.6	7.6	6.0	9.6	10.1	8.2	13.2
22	6.0	4.8	7.5	10.3	5.4	15.5	---	---	---	7.5	6.2	9.3	10.5	8.9	13.3
23	6.4	4.0	9.5	10.8	5.2	16.8	---	---	---	8.0	6.5	10.3	11.2	9.3	14.3
24	---	---	---	11.2	6.1	16.7	---	---	---	8.2	6.3	10.8	9.0	7.4	10.6
25	---	---	---	10.4	5.3	15.9	---	---	---	8.8	6.6	11.9	9.0	6.5	12.4
26	p 9.3	7.8	10.0	8.6	5.5	13.0	---	---	---	9.6	7.1	13.5	9.7	8.1	12.4
27	10.2	6.7	15.0	6.0	3.7	8.8	---	---	---	10.2	7.1	14.4	7.7	3.1	9.1
28	10.9	6.7	17.4	4.7	1.5	8.2	---	---	---	9.9	7.6	13.3	4.8	1.8	7.7
29	9.9	6.6	14.0	6.2	2.9	10.1	---	---	---	8.4	6.8	10.2	7.1	5.7	8.4
30	7.2	4.4	10.7	---	---	---	7.4	5.1	10.1	7.8	6.1	9.7	7.9	5.9	10.5
31				---	---	---	8.4	5.8	12.1				7.1	5.3	9.4
Mean	7.6	5.6	10.0	7.2	4.7	10.0	9.8	5.8	14.4	8.7	6.2	12.0	9.0	7.1	11.4
Minimum	4.4	1.0	6.4	2.4	1.2	4.1	7.4	4.5	10.1	5.2	4.4	6.2	4.8	1.8	7.7
Maximum	10.9	7.8	17.4	11.2	7.4	16.8	13.8	7.4	20.4	11.9	7.6	17.8	11.2	9.3	14.9

Table 26.--Daily mean, minimum, and maximum specific conductance at White River at Waverly, June through October 1987

[Min, minimum; Max, maximum; p, partial day; ---, no data]

Day	Mean, minimum, and maximum specific conductance (microsiemens per centimeter at 25 degrees Celsius)														
	June			July			August			September			October		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
1	802	790	837	581	259	795	752	720	793	---	---	---	---	---	---
2	806	761	827	382	277	499	849	791	882	---	---	---	p 1,270	1,260	1,290
3	623	554	768	552	502	606	871	845	890	---	---	---	1,300	1,280	1,310
4	613	575	656	505	458	601	858	846	869	---	---	---	1,310	1,280	1,340
5	531	391	628	491	470	520	857	820	876	---	---	---	1,340	1,330	1,350
6	371	338	461	519	443	561	843	820	863	---	---	---	1,340	1,310	1,370
7	493	454	531	584	545	619	884	859	906	---	---	---	1,350	1,320	1,360
8	581	532	625	643	613	675	914	883	941	---	---	---	1,300	1,280	1,330
9	673	627	693	717	676	733	958	938	991	---	---	---	1,390	1,340	1,400
10	740	687	760	759	725	776	979	939	1,010	---	---	---	1,380	1,330	1,400
11	795	758	824	804	762	843	974	957	1,000	---	---	---	1,370	1,290	1,390
12	853	823	907	836	799	857	987	958	1,030	---	---	---	1,240	1,160	1,290
13	861	843	913	605	512	809	1,020	979	1,060	---	---	---	1,200	1,160	1,240
14	869	844	892	606	568	651	1,040	1,010	1,070	---	---	---	1,260	1,230	1,290
15	866	835	894	657	626	682	1,070	1,040	1,090	---	---	---	1,320	1,260	1,370
16	937	893	977	656	640	684	1,080	1,060	1,100	---	---	---	1,370	1,280	1,390
17	922	895	937	668	656	689	1,090	1,080	1,110	---	---	---	1,380	1,360	1,390
18	909	864	929	711	689	728	1,100	1,080	1,120	---	---	---	1,380	1,350	1,400
19	886	864	899	726	706	735	1,080	1,050	1,140	---	---	---	1,330	1,310	1,350
20	830	734	898	744	713	769	1,130	1,100	1,160	---	---	---	1,300	1,280	1,310
21	840	768	893	815	770	838	1,220	1,170	1,240	---	---	---	1,310	1,280	1,340
22	759	686	808	868	830	893	1,220	1,200	1,260	---	---	---	1,300	1,270	1,310
23	745	716	761	913	879	937	1,250	1,230	1,270	---	---	---	1,360	1,280	1,400
24	801	762	825	945	912	971	1,270	1,240	1,300	---	---	---	1,330	1,260	1,370
25	862	827	887	954	939	969	1,270	1,250	1,290	---	---	---	1,300	1,260	1,330
26	893	868	906	994	972	1,020	1,280	1,250	1,310	---	---	---	1,290	1,230	1,330
27	899	883	909	903	772	980	1,330	1,290	1,390	---	---	---	1,200	1,050	1,250
28	931	902	943	744	720	777	1,230	1,170	1,320	---	---	---	900	871	1,040
29	946	934	957	842	733	900	---	---	---	---	---	---	1,010	906	1,130
30	921	797	1,020	858	722	905	---	---	---	---	---	---	1,150	1,120	1,180
31				679	641	723	---	---	---				1,200	1,160	1,290
Mean	785	740	826	718	662	766	1,050	1,021	1,082	---	---	---	1,283	1,237	1,318
Minimum	371	338	461	382	259	499	752	720	793	---	---	---	900	871	1,040
Maximum	946	934	1,020	994	972	1,020	1,330	1,290	1,390	---	---	---	1,390	1,360	1,400

Table 27.--Daily mean, minimum, and maximum pH at White River at Waverly, June through October 1987

[Min, minimum; Max, maximum]

	Mean, minimum, and maximum pH														
	June			July			August			September			October		
Day	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
1	7.6	7.5	7.7	7.4	7.3	7.5	7.3	7.2	7.4	7.4	7.4	7.6	7.2	7.2	7.3
2	7.4	7.3	7.5	7.5	7.4	7.6	7.3	7.3	7.4	7.6	7.4	7.9	7.2	7.2	7.3
3	7.1	6.9	7.4	7.7	7.5	7.9	7.3	7.3	7.4	7.5	7.3	7.7	7.2	7.2	7.3
4	7.3	7.2	7.4	7.6	7.6	7.7	7.3	7.3	7.4	7.5	7.4	7.5	7.2	7.2	7.3
5	7.1	7.0	7.3	7.6	7.6	7.6	7.4	7.3	7.5	7.5	7.3	7.7	7.3	7.2	7.4
6	7.1	7.0	7.1	7.5	7.4	7.6	7.4	7.3	7.5	7.4	7.3	7.5	7.3	7.2	7.3
7	7.1	7.1	7.2	7.5	7.5	7.6	7.4	7.3	7.5	7.4	7.3	7.6	7.3	7.3	7.4
8	7.2	7.2	7.3	7.6	7.5	7.7	7.4	7.4	7.5	7.4	7.2	7.6	7.4	7.4	7.6
9	7.3	7.2	7.4	7.6	7.5	7.6	7.3	7.3	7.4	7.4	7.2	7.6	7.4	7.3	7.5
10	7.4	7.3	7.4	7.5	7.4	7.7	7.2	7.2	7.4	7.3	7.2	7.5	7.3	7.3	7.5
11	7.4	7.3	7.5	7.5	7.5	7.6	7.2	7.0	7.3	7.3	7.2	7.4	7.2	7.1	7.4
12	7.4	7.4	7.5	7.6	7.4	7.7	7.3	7.2	7.5	7.2	7.2	7.3	7.3	7.3	7.4
13	7.5	7.3	7.6	7.5	7.3	7.7	7.3	7.3	7.4	7.3	7.2	7.4	7.3	7.3	7.4
14	7.5	7.4	7.6	7.6	7.4	7.8	7.4	7.3	7.6	7.3	7.2	7.4	7.3	7.2	7.4
15	7.6	7.5	7.7	7.7	7.6	7.8	7.4	7.3	7.5	7.3	7.2	7.4	7.2	7.2	7.4
16	7.5	7.4	7.8	7.6	7.5	7.7	7.3	7.3	7.4	7.2	7.1	7.3	7.3	7.3	7.4
17	7.6	7.5	7.7	7.5	7.4	7.6	7.4	7.3	7.6	7.3	7.2	7.4	7.4	7.4	7.5
18	7.6	7.4	7.8	7.5	7.4	7.6	7.4	7.3	7.6	7.2	7.1	7.4	7.4	7.3	7.5
19	7.5	7.4	7.7	7.5	7.3	7.6	7.6	7.4	7.9	7.3	7.2	7.4	7.3	7.3	7.4
20	7.4	7.2	7.6	7.5	7.4	7.7	7.7	7.3	8.2	7.3	7.2	7.4	7.2	7.2	7.3
21	7.5	7.3	7.6	7.6	7.4	7.8	7.4	7.3	7.8	7.4	7.2	7.4	7.3	7.2	7.5
22	7.5	7.3	7.7	7.7	7.5	7.9	7.3	7.2	7.4	7.3	7.3	7.4	7.3	7.3	7.4
23	7.5	7.3	7.8	7.7	7.5	8.0	7.3	7.2	7.4	7.3	7.3	7.4	7.3	7.2	7.3
24	7.5	7.3	7.6	7.7	7.5	7.9	7.3	7.3	7.4	7.3	7.3	7.5	7.3	7.3	7.4
25	7.4	7.3	7.5	7.6	7.4	7.9	7.2	7.1	7.3	7.3	7.2	7.4	7.3	7.2	7.3
26	7.5	7.3	7.6	7.5	7.5	7.7	7.3	7.1	7.5	7.3	7.2	7.5	7.3	7.3	7.4
27	7.6	7.4	7.8	7.3	7.3	7.5	7.3	7.2	7.5	7.3	7.2	7.4	7.2	7.1	7.3
28	7.6	7.4	7.9	7.3	7.2	7.5	7.3	7.2	7.4	7.3	7.2	7.4	7.2	7.2	7.4
29	7.5	7.4	7.6	7.4	7.3	7.7	7.4	7.2	7.5	7.2	7.1	7.3	7.3	7.3	7.5
30	7.4	7.2	7.7	7.2	7.2	7.4	7.4	7.4	7.5	7.1	7.0	7.2	7.4	7.3	7.6
31				7.2	7.1	7.4	7.5	7.4	7.6				7.4	7.3	7.6
Mean	7.4	7.3	7.6	7.5	7.4	7.7	7.4	7.3	7.5	7.3	7.2	7.5	7.3	7.3	7.4
Minimum	7.1	6.9	7.1	7.2	7.1	7.4	7.2	7.0	7.3	7.1	7.0	7.2	7.2	7.1	7.3
Maximum	7.6	7.5	7.9	7.7	7.6	8.0	7.7	7.4	8.2	7.6	7.4	7.9	7.4	7.4	7.6

Table 28.--Daily mean, minimum, and maximum water temperature at White River at Waverly, June through October 1987

[Min, minimum; Max, maximum]

Day	Mean, minimum, and maximum water temperature (degrees Celsius)														
	June			July			August			September			October		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
1	26.0	24.9	26.7	23.9	21.4	26.5	26.9	25.9	27.6	22.4	21.0	23.6	19.2	18.2	20.0
2	26.1	24.9	27.3	22.2	21.1	23.6	28.0	25.9	29.7	22.2	20.9	23.3	17.8	16.5	18.5
3	24.8	23.9	26.4	23.8	22.9	24.8	29.4	28.2	30.4	22.6	21.4	23.7	16.3	15.6	17.0
4	24.2	23.2	25.2	23.9	23.5	24.3	28.4	27.6	29.5	22.9	21.8	24.1	16.1	14.8	17.5
5	22.6	21.9	23.1	23.8	23.2	24.7	27.7	27.1	28.4	23.5	22.3	24.6	16.2	15.5	16.9
6	22.0	21.3	22.8	23.4	22.7	24.1	27.4	26.2	28.3	23.9	22.5	25.3	16.2	15.5	16.8
7	23.1	21.8	24.6	24.3	23.1	25.9	27.4	26.1	28.5	24.2	23.2	25.3	15.4	14.5	16.0
8	23.9	22.6	25.2	25.3	24.4	26.3	27.2	26.3	27.9	24.0	23.2	24.6	14.6	13.5	15.9
9	24.3	23.5	25.1	25.6	24.9	26.3	27.0	26.4	27.8	23.8	22.6	25.2	15.5	14.7	16.5
10	23.7	22.3	24.9	25.5	24.4	26.8	25.8	25.3	26.4	24.0	23.2	24.8	15.8	14.9	16.5
11	23.9	22.7	24.9	26.3	25.3	27.2	25.1	23.9	26.2	24.1	23.6	24.7	15.5	14.7	16.1
12	24.0	23.5	24.8	26.9	25.7	28.0	25.6	24.1	26.9	24.4	23.7	25.3	14.7	13.9	15.8
13	24.4	22.9	25.9	25.4	24.6	27.1	25.9	24.9	26.7	23.9	22.8	24.6	14.6	13.6	15.7
14	25.7	24.0	27.3	25.2	24.3	26.2	26.7	25.5	28.2	23.7	22.4	24.8	14.9	13.9	16.0
15	26.6	25.3	27.4	24.2	23.5	25.1	27.2	25.8	28.2	23.8	23.2	24.2	15.7	14.9	17.0
16	26.3	25.4	27.1	23.2	22.3	24.1	27.4	26.4	28.6	23.6	23.3	24.0	16.2	15.3	17.4
17	26.3	24.7	27.7	23.7	22.4	25.1	27.3	26.5	28.2	23.2	22.3	23.6	16.9	16.2	17.5
18	26.7	25.2	28.0	25.0	23.6	26.4	26.5	25.2	27.6	22.6	22.2	23.3	16.0	14.9	17.0
19	25.9	25.4	27.4	25.9	24.4	27.3	26.4	25.2	27.5	22.4	21.4	23.7	15.6	15.2	15.9
20	24.9	23.8	25.6	26.7	25.1	28.1	26.0	24.6	27.3	21.5	20.5	22.2	15.6	15.0	15.9
21	25.5	24.6	26.7	27.0	25.6	28.1	25.4	25.0	26.2	20.4	19.6	21.1	13.9	13.0	14.9
22	25.4	24.5	26.2	27.4	26.1	28.5	25.5	24.9	26.5	20.1	19.5	20.7	12.9	12.4	13.4
23	25.4	24.1	26.7	27.6	26.3	28.7	24.3	23.2	25.5	20.1	19.3	21.4	13.7	12.3	15.2
24	26.0	24.6	27.4	28.2	26.9	29.4	23.4	22.2	24.5	20.8	19.5	22.2	14.5	13.9	14.8
25	26.4	24.4	28.4	28.4	27.1	29.4	22.4	21.3	23.3	21.3	20.3	22.4	13.9	13.0	14.7
26	26.8	25.7	27.8	27.7	27.1	28.3	22.5	21.1	24.3	20.6	19.4	21.9	13.8	13.4	14.4
27	25.1	24.1	26.5	26.9	26.5	27.2	23.6	23.4	23.9	21.1	19.9	22.5	14.9	14.2	15.7
28	24.4	22.8	25.9	27.1	25.7	28.1	22.9	22.3	23.6	21.6	20.7	22.5	13.5	12.5	15.1
29	25.8	24.3	27.3	27.6	26.4	28.5	22.8	21.6	24.3	21.6	21.2	22.0	12.9	12.3	13.4
30	26.3	25.1	27.4	27.2	26.0	28.1	23.2	22.2	24.3	20.9	19.7	21.9	13.5	12.4	14.4
31				26.6	26.0	27.3	23.3	22.6	24.2				14.7	13.4	15.7
Mean	25.1	23.9	26.3	25.7	24.6	26.8	25.8	24.7	26.8	22.5	21.6	23.4	15.2	14.3	16.1
Minimum	22.0	21.3	22.8	22.2	21.1	23.6	22.4	21.1	23.3	20.1	19.3	20.7	12.9	12.3	13.4
Maximum	26.8	25.7	28.4	28.4	27.1	29.4	29.4	28.2	30.4	24.4	23.7	25.3	19.2	18.2	20.0

Table 29.--Daily mean streamflow at Fall Creek at Indianapolis, June through October 1987

	Daily mean streamflow (cubic feet per second)				
Day	June	July	August	September	October
1	144	815	178	43	51
2	186	1070	161	23	29
3	480	1310	163	19	26
4	350	916	195	26	25
5	260	535	205	39	24
6	190	396	141	36	27
7	130	315	102	41	43
8	98	241	87	28	32
9	82	177	83	35	31
10	71	127	66	29	35
11	62	100	66	46	36
12	59	113	57	54	33
13	79	491	42	52	32
14	73	625	60	40	35
15	74	607	48	50	31
16	189	404	45	59	29
17	148	277	61	57	35
18	116	213	45	39	48
19	94	176	47	32	42
20	82	130	42	24	51
21	157	110	47	26	33
22	163	98	44	26	30
23	110	96	40	33	30
24	90	93	36	30	33
25	82	91	37	24	37
26	59	97	44	35	34
27	53	175	59	27	97
28	61	114	48	25	53
29	84	84	33	54	51
30	141	241	39	46	52
31		224	40		59
Mean	132	337	76.2	36.6	38.8
Minimum	53	84	33	19	24
Maximum	480	1310	205	59	97

Table 30.--Daily mean, minimum, and maximum dissolved-oxygen concentration at Fall Creek at Indianapolis, June through October 1987

[Min, minimum; Max, maximum; p, partial day; ---, no data]

	Mean, minimum, and maximum dissolved-oxygen concentration (milligrams per liter)														
	June			July			August			September			October		
Day	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
1	5.2	4.8	5.8	4.9	2.6	7.3	7.1	6.3	8.2	7.5	6.4	8.9	6.8	6.0	7.8
2	5.0	3.7	5.8	7.4	7.0	7.8	7.1	5.7	8.9	7.0	5.7	8.6	6.9	6.4	7.3
3	4.5	2.0	6.0	7.1	6.9	7.3	6.4	5.1	7.5	8.2	6.5	10.8	7.7	6.6	8.9
4	6.4	5.9	6.7	7.2	6.8	7.6	6.7	5.7	8.1	p 7.7	6.3	9.9	8.3	7.9	8.8
5	6.2	5.7	6.7	7.2	6.5	8.1	7.2	6.0	8.7	---	---	---	8.4	8.0	9.0
6	5.8	5.3	6.5	6.8	6.0	7.8	7.6	6.5	9.2	---	---	---	8.2	7.8	8.7
7	5.5	5.0	6.2	7.2	5.9	8.4	7.8	6.6	9.6	---	---	---	8.4	8.0	9.0
8	5.6	4.7	7.0	7.4	6.3	8.8	7.5	6.3	8.9	p 7.5	7.1	8.0	8.7	8.4	9.1
9	5.2	4.2	6.5	7.3	6.4	8.6	7.3	6.2	8.9	7.4	6.0	8.9	8.9	8.6	9.3
10	5.4	4.4	6.6	7.5	6.4	9.0	7.5	6.1	9.1	7.8	6.0	10.3	8.8	8.6	9.2
11	6.2	4.4	8.5	7.6	6.3	9.2	7.7	6.4	9.7	7.6	6.3	9.7	8.6	8.3	9.3
12	6.4	5.7	6.8	7.4	5.4	9.4	7.6	6.2	9.5	7.0	6.0	8.3	8.6	8.3	9.2
13	6.6	5.7	8.3	5.0	2.7	7.5	7.6	6.0	9.8	7.3	6.0	9.2	8.5	8.2	9.0
14	6.7	5.6	8.4	6.8	5.7	7.2	7.4	6.0	9.4	7.5	6.1	9.1	9.3	8.7	9.9
15	7.1	5.3	9.6	7.2	6.7	7.8	7.1	5.8	8.7	7.2	6.3	8.1	9.2	8.8	9.8
16	6.2	4.2	7.9	7.7	6.9	8.7	6.9	5.5	8.7	6.7	6.2	7.2	9.1	8.7	9.7
17	6.7	5.4	8.4	7.8	6.8	9.1	6.6	4.9	8.8	5.8	4.1	6.5	9.1	8.7	9.9
18	7.2	5.7	9.5	7.7	6.6	9.1	6.0	4.6	8.1	5.2	4.6	5.8	9.4	8.9	10.2
19	6.9	5.4	9.2	7.5	6.7	8.7	6.1	4.3	8.4	5.0	4.1	6.2	9.3	8.9	9.9
20	6.7	5.5	8.8	7.6	6.2	9.3	6.8	5.0	8.9	5.8	4.9	7.0	9.3	8.9	9.8
21	6.8	5.5	8.3	7.7	5.9	9.8	5.9	4.7	7.2	6.7	5.6	7.8	9.4	8.9	10.1
22	6.6	5.2	8.1	7.9	6.4	9.7	5.9	4.9	6.9	6.8	6.2	7.5	9.9	9.3	10.7
23	7.2	5.6	9.4	8.0	6.3	10.4	6.1	4.6	7.7	7.4	6.6	8.3	9.8	9.3	10.5
24	7.3	5.5	9.5	7.8	6.1	10.2	6.6	5.0	8.5	7.3	6.7	8.2	9.6	9.2	10.0
25	7.0	5.3	9.1	7.9	5.9	10.8	6.2	5.1	7.0	7.0	6.6	7.7	9.4	9.1	9.9
26	7.2	5.3	9.9	7.1	5.9	8.8	7.4	5.2	9.6	7.9	7.1	9.2	9.7	9.1	10.8
27	7.8	5.6	10.1	5.5	3.4	6.8	6.8	5.5	8.1	7.7	6.9	9.0	8.3	6.3	9.8
28	9.0	6.6	12.3	p 4.3	4.0	5.7	5.8	5.0	6.6	7.6	6.8	8.7	7.0	6.3	7.8
29	6.7	3.6	8.4	---	---	---	6.0	4.6	7.7	7.1	6.3	7.6	8.6	7.6	9.6
30	3.2	2.4	4.5	p 6.2	5.1	6.5	7.5	6.0	9.5	7.0	6.4	8.1	9.9	9.6	10.4
31				6.8	6.3	7.6	7.4	5.8	9.3				10.2	9.6	10.8
Mean	6.3	5.0	8.0	7.0	5.9	8.4	6.9	5.5	8.6	7.1	6.1	8.3	8.8	8.3	9.5
Minimum	3.2	2.0	4.5	4.3	2.6	5.7	5.8	4.3	6.6	5.0	4.1	5.8	6.8	6.0	7.3
Maximum	9.0	6.6	12.3	8.0	7.0	10.8	7.8	6.6	9.8	8.2	7.1	10.8	10.2	9.6	10.8

Table 31.--Daily mean, minimum, and maximum specific conductance at Fall Creek at Indianapolis, June through October 1987

[Min, minimum; Max, maximum; p, partial day; ---, no data]

Day	Mean, minimum, and maximum specific conductance (microsiemens per centimeter at 25 degrees Celsius)														
	June			July			August			September			October		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
1	602	575	624	383	194	567	479	429	567	777	745	798	795	780	869
2	578	421	613	417	323	463	511	501	567	747	741	783	775	753	796
3	461	325	529	480	464	491	517	499	593	769	755	805	765	753	821
4	529	498	553	488	483	502	517	504	527	p 785	761	810	780	765	848
5	552	548	575	492	474	502	500	492	564	---	---	---	787	775	849
6	568	538	582	491	465	503	516	501	557	---	---	---	806	794	844
7	568	544	582	499	493	508	556	540	619	---	---	---	837	805	877
8	597	580	618	516	507	527	581	560	613	p 709	706	712	859	837	945
9	626	617	644	531	526	547	610	596	630	726	710	785	856	846	896
10	654	636	660	554	541	595	637	629	670	755	727	804	860	840	892
11	658	650	663	573	560	621	667	650	692	743	732	770	819	803	861
12	680	660	697	584	468	633	696	678	725	738	732	749	820	804	866
13	721	698	741	433	348	508	723	707	740	721	681	786	824	810	875
14	694	681	728	419	358	454	740	726	760	704	676	783	844	819	886
15	692	682	710	459	447	468	755	743	769	715	679	793	825	794	876
16	603	533	696	475	466	484	745	719	767	784	751	848	804	792	814
17	586	568	634	493	482	503	710	698	728	690	606	749	825	804	882
18	629	599	662	516	502	531	716	706	731	707	659	774	834	818	852
19	666	637	717	546	531	566	706	694	719	680	655	778	828	808	885
20	681	675	707	570	556	588	726	719	737	741	688	829	832	802	887
21	626	548	676	601	579	625	763	738	782	791	769	865	824	807	889
22	544	522	591	639	624	655	775	759	785	804	785	840	831	796	892
23	559	547	566	675	654	692	765	732	789	831	810	880	814	804	831
24	572	561	586	683	659	709	756	743	787	841	832	883	796	788	814
25	590	558	610	687	678	702	765	745	797	827	806	883	796	791	802
26	637	612	662	702	691	713	761	728	783	857	820	903	810	772	878
27	677	664	691	601	443	716	746	706	798	848	836	882	657	585	788
28	698	691	710	p 416	384	537	727	686	760	842	827	893	625	586	723
29	692	594	734	---	---	---	717	691	777	832	805	866	729	645	788
30	587	524	659	p 399	368	441	734	709	815	827	788	896	779	761	822
31				432	397	497	765	730	803				818	790	885
Mean	618	583	647	525	489	562	674	653	708	770	744	820	802	778	853
Minimum	461	325	529	383	194	441	479	429	527	680	606	712	625	585	723
Maximum	721	698	741	702	691	716	775	759	815	857	836	903	860	846	945

Table 32.--Daily mean, minimum, and maximum pH at Fall Creek at Indianapolis, June through October 1987

[Min, minimum; Max, maximum; p, partial day; ---, no data]

	Mean, minimum, and maximum pH														
	June			July			August			September			October		
Day	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
1	7.6	7.5	7.7	7.6	7.5	7.7	7.9	7.7	8.1	7.8	7.7	7.8	7.8	7.7	7.9
2	7.6	7.4	7.7	7.9	7.6	8.0	8.0	7.8	8.2	7.7	7.6	7.8	7.8	7.7	7.8
3	7.5	7.3	7.7	8.0	7.9	8.1	7.9	7.8	8.0	7.8	7.7	8.0	7.8	7.7	7.9
4	7.8	7.7	7.9	8.1	7.8	8.2	8.0	7.8	8.3	p 7.8	7.7	8.0	7.9	7.8	7.9
5	7.7	7.5	7.8	8.2	7.8	8.4	8.1	7.9	8.4	---	---	---	7.9	7.8	7.9
6	7.6	7.4	7.8	8.0	7.8	8.3	8.1	7.9	8.3	---	---	---	7.9	7.8	7.9
7	7.6	7.4	7.7	8.0	7.7	8.2	8.0	7.8	8.2	---	---	---	7.9	7.8	8.0
8	7.7	7.4	7.8	8.1	7.9	8.3	8.0	7.8	8.1	p 7.8	7.8	7.9	7.9	7.8	8.0
9	7.7	7.5	7.8	8.1	7.9	8.3	8.0	7.9	8.1	7.9	7.8	8.0	7.9	7.8	8.0
10	7.8	7.6	7.9	8.1	7.9	8.3	8.0	7.8	8.1	7.9	7.8	8.1	8.0	7.9	8.0
11	7.8	7.6	8.0	8.1	7.9	8.3	8.0	7.8	8.1	7.9	7.7	8.1	7.9	7.8	7.9
12	7.8	7.7	7.9	8.2	8.0	8.3	8.0	7.9	8.2	7.9	7.8	7.9	7.8	7.8	7.9
13	7.8	7.7	7.9	7.8	7.5	8.1	8.0	7.8	8.2	7.9	7.7	8.1	7.8	7.7	7.8
14	7.8	7.7	8.0	8.0	7.8	8.2	8.0	7.8	8.1	7.9	7.8	8.0	7.9	7.8	8.0
15	7.9	7.7	8.1	8.3	8.2	8.4	7.9	7.7	8.0	7.9	7.6	8.0	7.8	7.8	7.9
16	7.8	7.6	8.0	8.3	8.1	8.4	7.9	7.7	8.1	7.9	7.8	8.0	7.8	7.7	7.9
17	7.9	7.7	8.1	8.2	7.9	8.4	7.9	7.6	8.1	7.7	7.6	7.8	7.8	7.8	7.9
18	8.0	7.8	8.2	8.1	7.8	8.3	7.8	7.5	7.9	7.7	7.6	7.7	7.9	7.8	8.0
19	8.0	7.8	8.2	8.1	7.9	8.2	7.8	7.6	8.0	7.6	7.6	7.7	7.9	7.8	7.9
20	7.9	7.8	8.1	8.0	7.8	8.2	7.8	7.6	8.1	7.7	7.6	7.8	7.8	7.7	7.9
21	7.7	7.6	7.9	8.0	7.8	8.2	7.8	7.6	8.0	7.8	7.7	7.9	7.9	7.8	7.9
22	7.7	7.5	7.8	8.0	7.9	8.2	7.8	7.7	7.9	7.8	7.7	7.9	8.0	7.9	8.0
23	7.7	7.5	7.9	8.0	7.9	8.2	7.8	7.8	7.9	7.9	7.9	8.0	7.9	7.8	8.0
24	7.7	7.5	7.9	8.1	7.8	8.3	7.9	7.7	8.0	7.9	7.9	8.0	7.9	7.8	8.0
25	7.8	7.4	8.0	8.1	7.9	8.3	7.8	7.7	7.9	7.8	7.8	7.9	7.8	7.8	7.8
26	7.8	7.6	8.0	8.0	7.8	8.1	7.8	7.7	7.9	8.0	7.9	8.1	7.8	7.8	7.9
27	7.9	7.6	8.1	7.8	7.5	8.0	7.7	7.6	7.7	7.9	7.9	8.0	7.7	7.6	7.9
28	8.2	7.9	8.5	p 7.6	7.5	7.7	7.6	7.5	7.7	7.8	7.8	7.9	7.6	7.6	7.7
29	7.9	7.6	8.2	---	---	---	7.5	7.5	7.6	7.8	7.7	7.9	7.8	7.7	7.9
30	7.5	7.4	7.7	p 7.8	7.6	7.9	7.6	7.5	7.8	7.8	7.7	7.9	7.9	7.9	7.9
31				7.9	7.7	8.0	7.7	7.6	7.9				7.9	7.9	8.1
Mean	7.8	7.6	7.9	8.0	7.8	8.2	7.9	7.7	8.0	7.8	7.7	7.9	7.9	7.8	7.9
Minimum	7.5	7.3	7.7	7.6	7.5	7.7	7.5	7.5	7.6	7.6	7.6	7.7	7.6	7.6	7.7
Maximum	8.2	7.9	8.5	8.3	8.2	8.4	8.1	7.9	8.4	8.0	7.9	8.1	8.0	7.9	8.1

Table 33.--Daily mean, minimum, and maximum water temperature at Fall Creek at Indianapolis, June through October 1987

[Min, minimum; Max, maximum; p, partial day; ---, no data]

	Mean, minimum, and maximum water temperature (degrees Celsius)														
	June			July			August			September			October		
Day	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
1	24.6	23.9	25.3	22.5	21.2	23.9	26.0	25.3	26.5	21.4	20.3	22.9	17.6	16.7	18.8
2	24.5	23.6	25.6	23.2	21.4	24.4	26.7	25.2	28.1	21.0	19.8	22.2	16.2	14.7	17.0
3	23.5	22.4	24.4	24.5	23.6	25.4	28.0	26.8	29.0	21.2	19.6	23.1	14.4	13.5	15.7
4	23.0	21.9	23.9	24.9	23.9	25.7	27.7	27.2	28.4	p 21.3	20.0	22.8	14.2	12.9	16.1
5	23.2	21.9	24.4	25.5	24.9	26.0	26.6	26.2	27.1	---	---	---	14.0	13.3	14.9
6	23.8	22.0	25.2	24.6	24.0	25.4	26.1	25.1	27.0	---	---	---	13.9	13.4	14.5
7	24.0	22.6	25.2	24.9	23.7	26.1	26.3	25.3	27.4	---	---	---	12.9	12.1	13.4
8	24.5	23.2	25.9	25.9	25.0	26.9	26.4	25.8	27.0	p 23.0	22.6	23.3	12.4	11.1	14.1
9	24.6	23.9	25.9	25.7	25.1	26.3	26.0	25.4	26.6	22.8	21.8	23.8	12.9	12.0	14.2
10	23.5	22.2	24.8	25.3	24.3	26.3	25.0	24.6	25.5	22.9	21.8	24.2	12.8	12.4	13.1
11	23.0	21.8	24.2	26.2	25.3	26.9	24.6	23.3	25.9	23.0	22.2	23.8	12.5	12.1	13.1
12	23.1	22.7	24.0	26.6	25.7	27.6	24.8	23.4	26.0	23.1	22.3	24.1	12.1	11.0	13.7
13	23.4	22.1	25.3	25.7	24.7	26.5	25.3	24.3	26.2	22.8	21.6	24.1	12.0	10.8	13.8
14	24.8	23.1	26.8	24.8	23.8	25.7	25.9	24.9	26.8	22.7	21.3	23.9	12.3	11.1	13.9
15	26.4	24.9	28.2	23.9	23.5	24.7	26.3	24.9	27.5	22.8	22.1	23.3	13.1	11.9	14.9
16	26.4	25.3	27.4	23.7	22.7	24.8	27.0	25.9	28.1	22.6	22.3	23.1	13.6	12.3	15.3
17	26.6	25.1	27.8	24.8	23.2	26.3	26.9	25.9	28.0	21.8	21.3	22.3	13.9	13.3	14.6
18	27.0	25.8	28.3	25.7	24.6	26.7	26.4	25.1	27.6	21.0	20.7	21.6	13.5	12.3	15.0
19	26.9	26.2	27.8	26.0	24.8	27.0	26.3	25.1	27.7	21.0	19.9	22.7	13.5	12.8	14.0
20	25.9	25.4	26.6	26.5	25.4	27.7	26.1	24.8	27.5	20.0	19.2	20.9	13.4	12.2	14.2
21	25.7	24.9	26.5	27.1	26.1	28.2	25.3	24.6	26.1	19.2	18.4	20.2	11.5	10.5	12.5
22	26.0	25.1	26.9	27.3	26.4	28.2	25.0	23.6	25.8	18.7	18.2	19.7	10.5	9.8	11.6
23	26.2	25.2	27.4	27.2	26.1	28.3	23.5	22.4	24.7	18.6	17.5	20.0	11.4	10.3	13.0
24	26.7	25.7	28.1	27.7	26.2	29.2	22.5	21.1	23.9	18.8	17.4	20.6	11.3	10.8	11.6
25	26.5	25.5	28.0	28.3	26.9	29.8	21.4	20.6	22.4	18.9	17.6	20.7	11.2	10.1	12.7
26	25.5	24.4	26.8	28.3	27.4	29.4	21.3	20.0	22.6	18.9	17.5	20.7	11.0	10.1	11.8
27	24.1	23.0	25.5	26.8	26.1	28.0	21.7	21.3	22.2	19.3	18.1	21.0	12.6	11.3	14.2
28	23.9	22.4	25.7	p 25.9	25.4	27.0	21.3	20.5	21.7	20.0	18.9	21.5	12.2	11.1	13.1
29	24.2	22.9	25.6	---	---	---	21.2	19.7	23.1	20.0	19.5	20.6	11.6	10.3	12.9
30	23.9	23.2	24.7	p 26.2	25.4	26.5	21.7	20.5	23.0	19.0	18.1	20.2	10.9	9.8	12.4
31				26.2	25.9	26.6	22.0	21.2	23.1				11.8	10.7	13.0
Mean	24.8	23.7	26.1	25.7	24.8	26.7	24.9	23.9	25.9	21.0	20.0	22.1	12.8	11.8	14.0
Minimum	23.0	21.8	23.9	22.5	21.2	23.9	21.2	19.7	21.7	18.6	17.4	19.7	10.5	9.8	11.6
Maximum	27.0	26.2	28.3	28.3	27.4	29.8	28.0	27.2	29.0	23.1	22.6	24.2	17.6	16.7	18.8

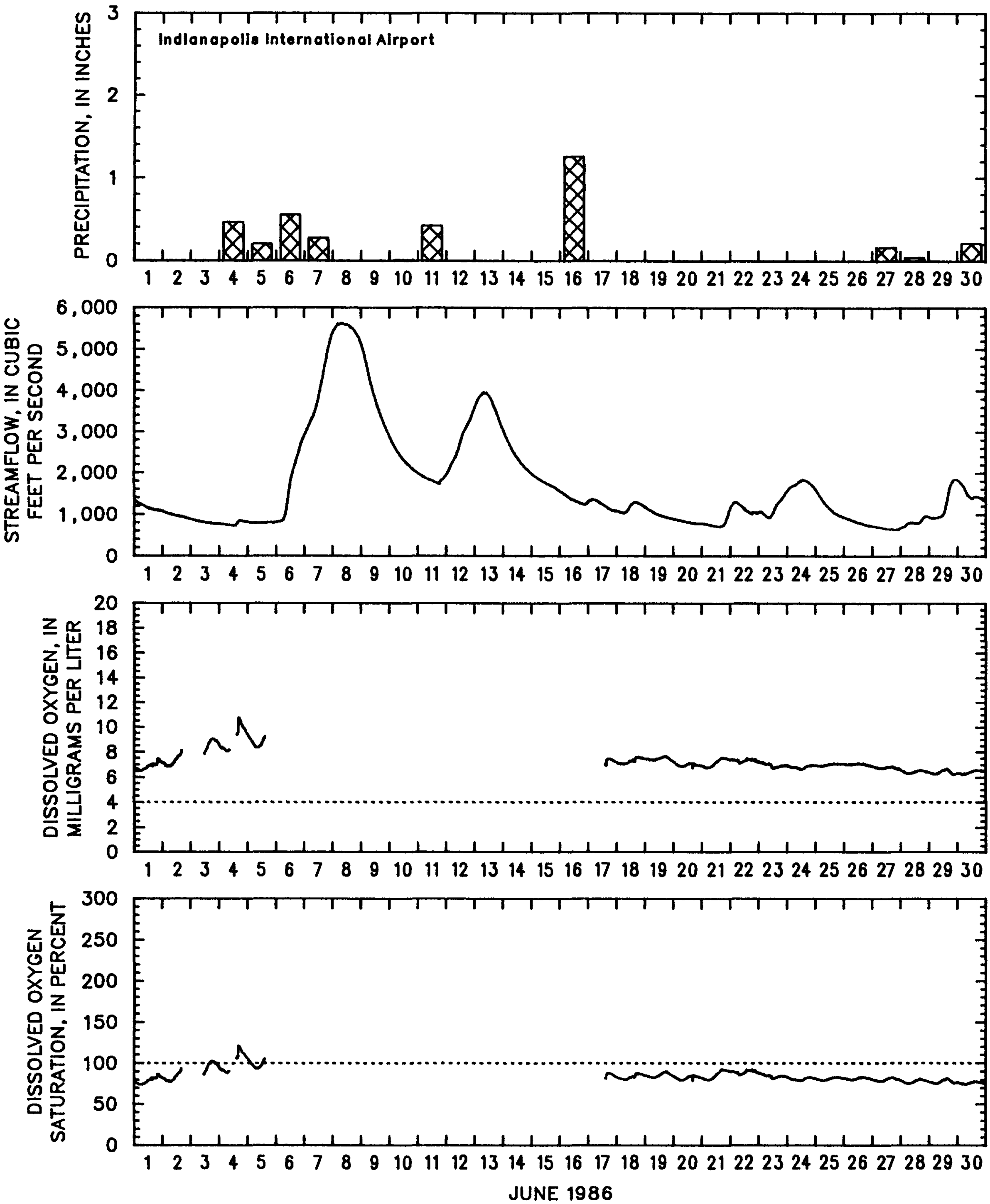


Figure 3a. —— **Streamflow and dissolved–oxygen concentration and saturation at White River near Nora, June 1986.**

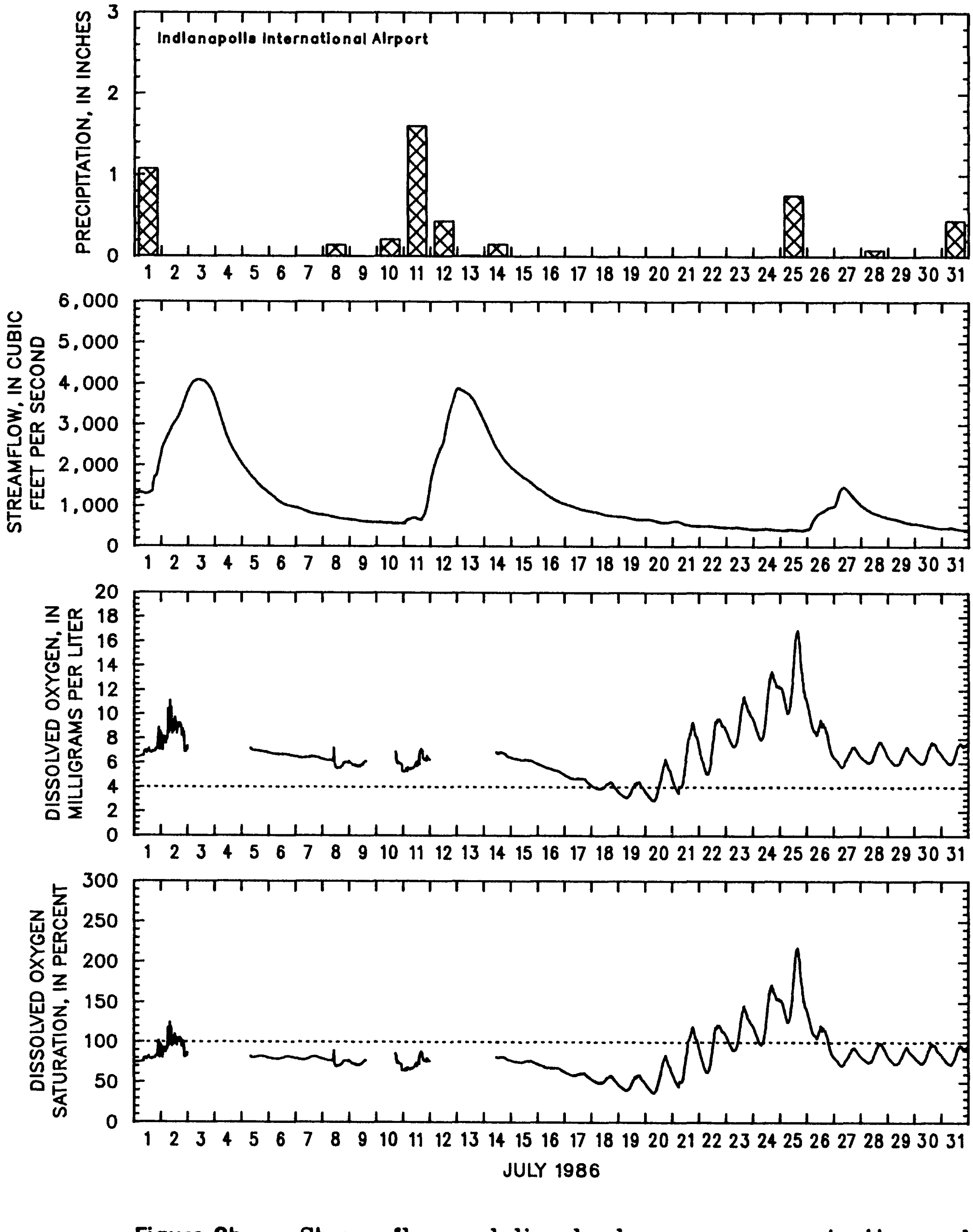


Figure 3b. — Streamflow and dissolved-oxygen concentration and saturation at White River near Nora, July 1986.

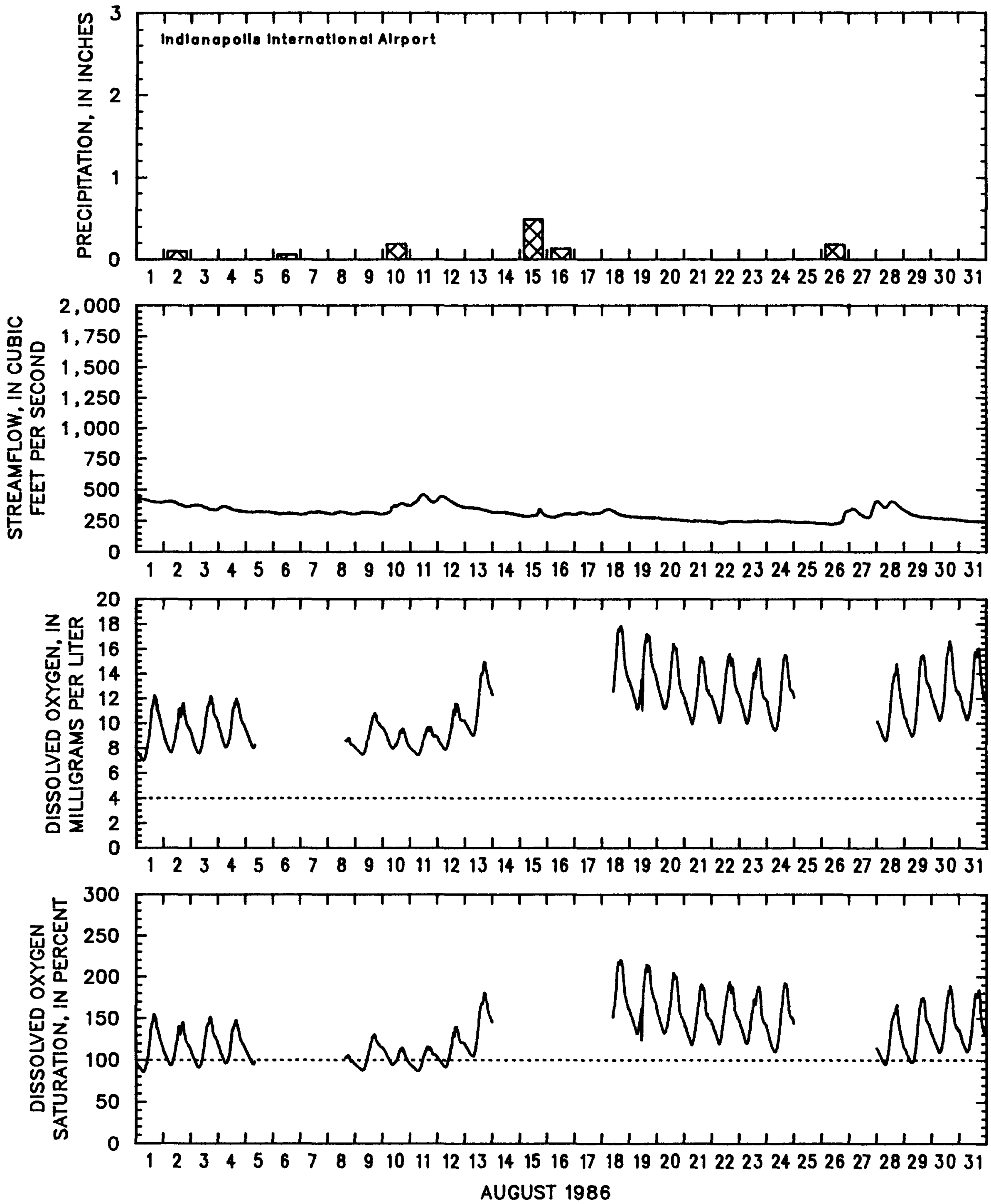


Figure 3c. -- Streamflow and dissolved-oxygen concentration and saturation at White River near Nora, August 1986.

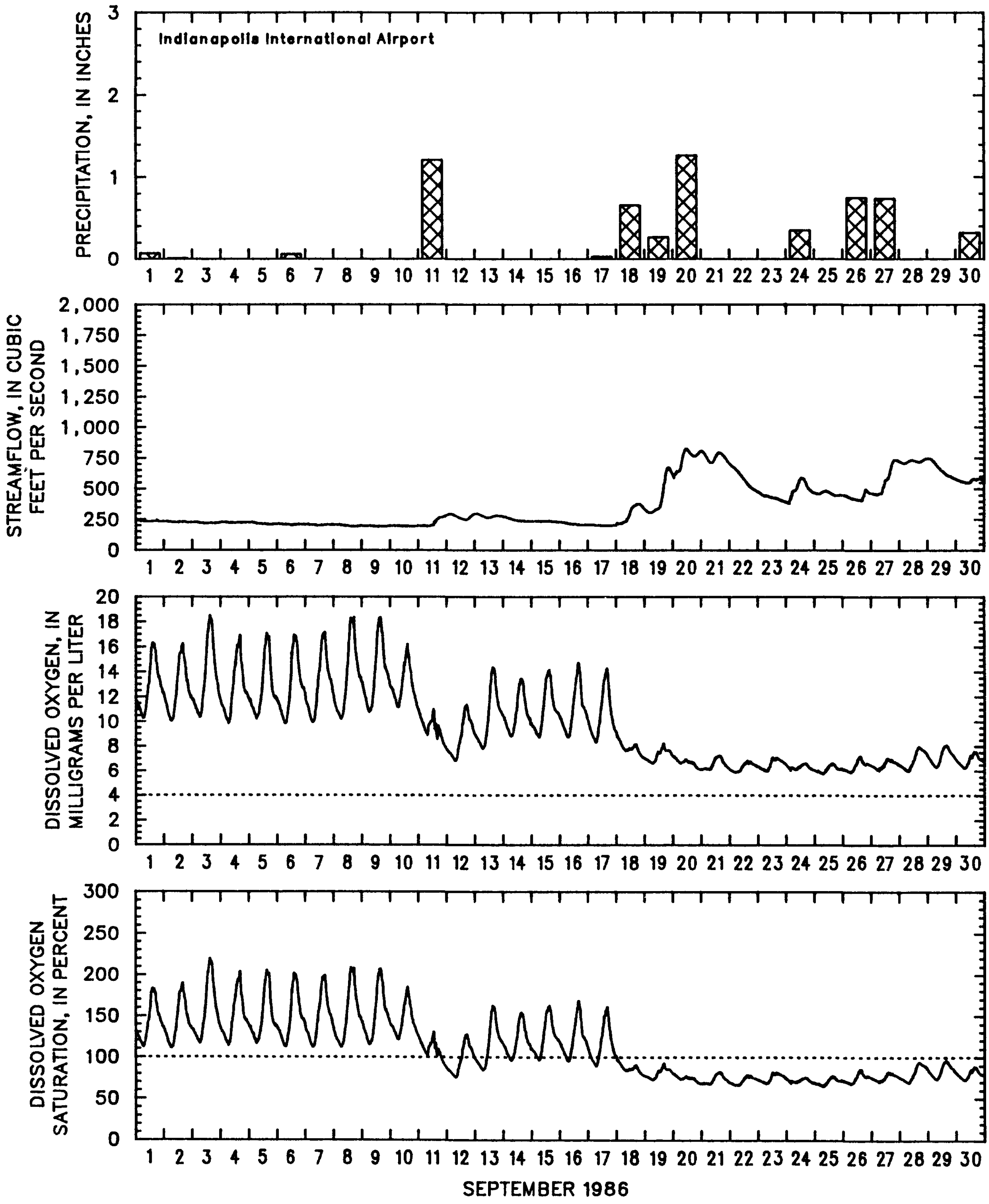


Figure 3d. -- Streamflow and dissolved-oxygen concentration and saturation at White River near Nora, September 1986.

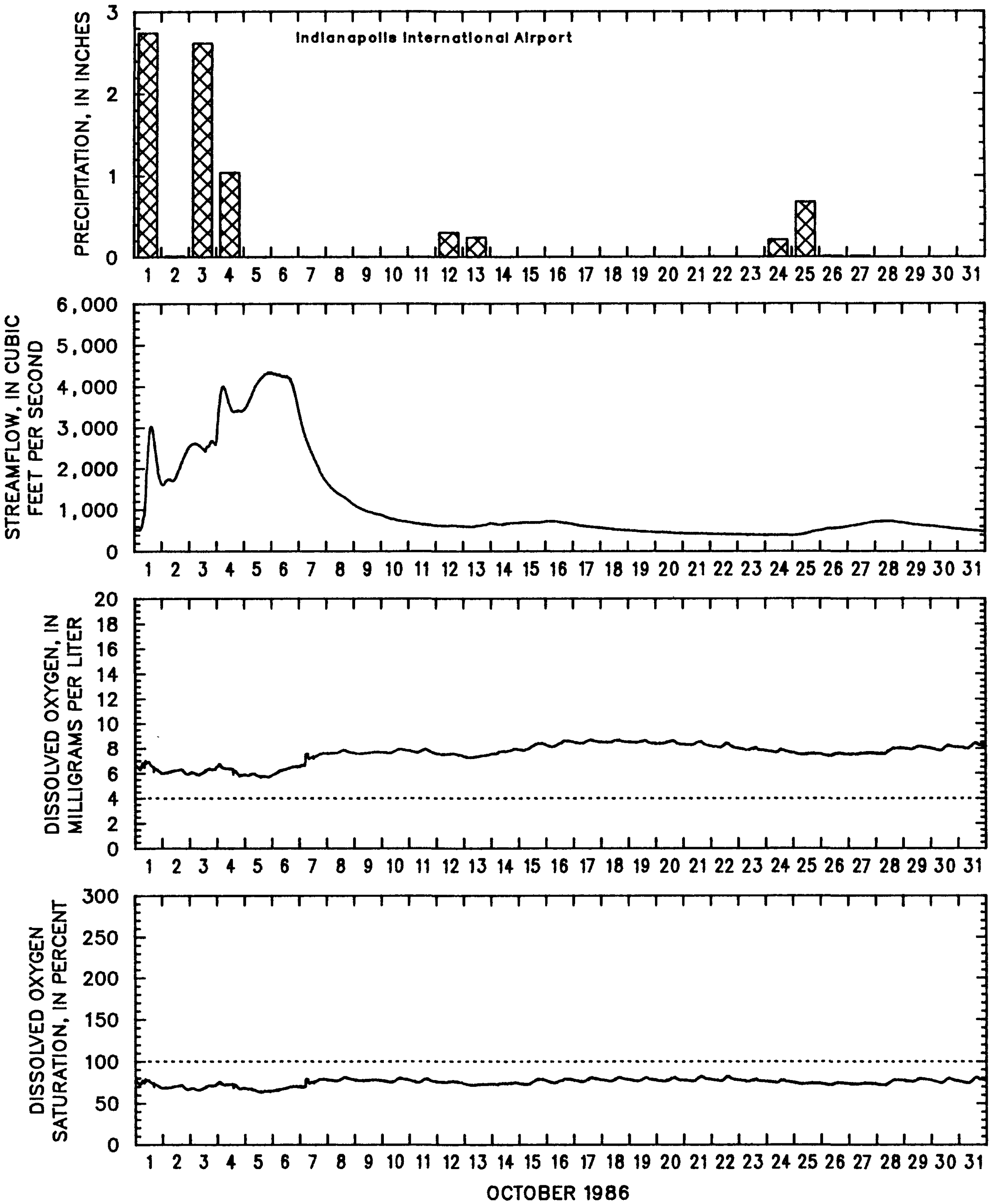


Figure 3e. —— Streamflow and dissolved-oxygen concentration and saturation at White River near Nora, October 1986.

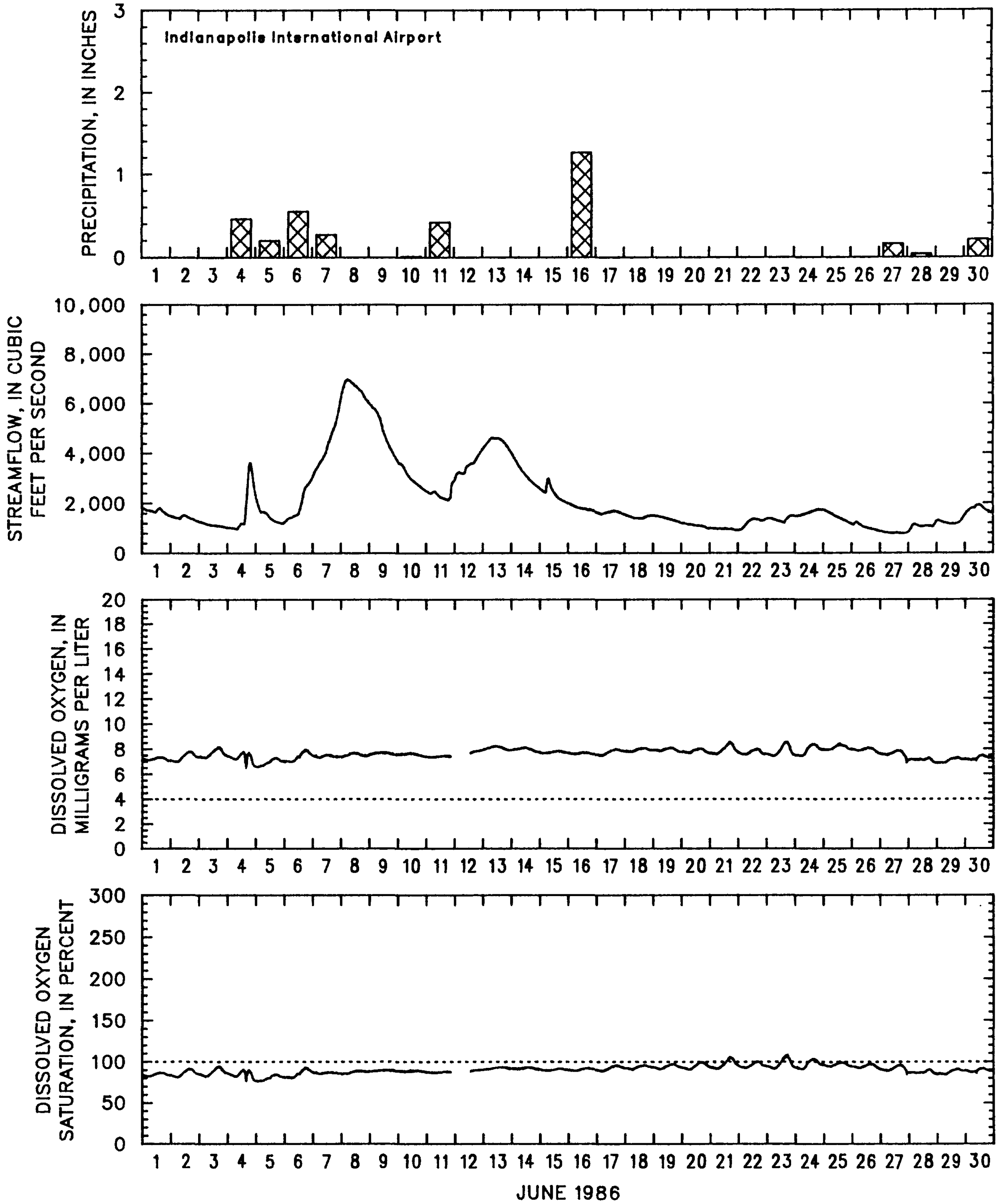


Figure 4a. -- Streamflow and dissolved-oxygen concentration and saturation at White River at Indianapolis, June 1986.

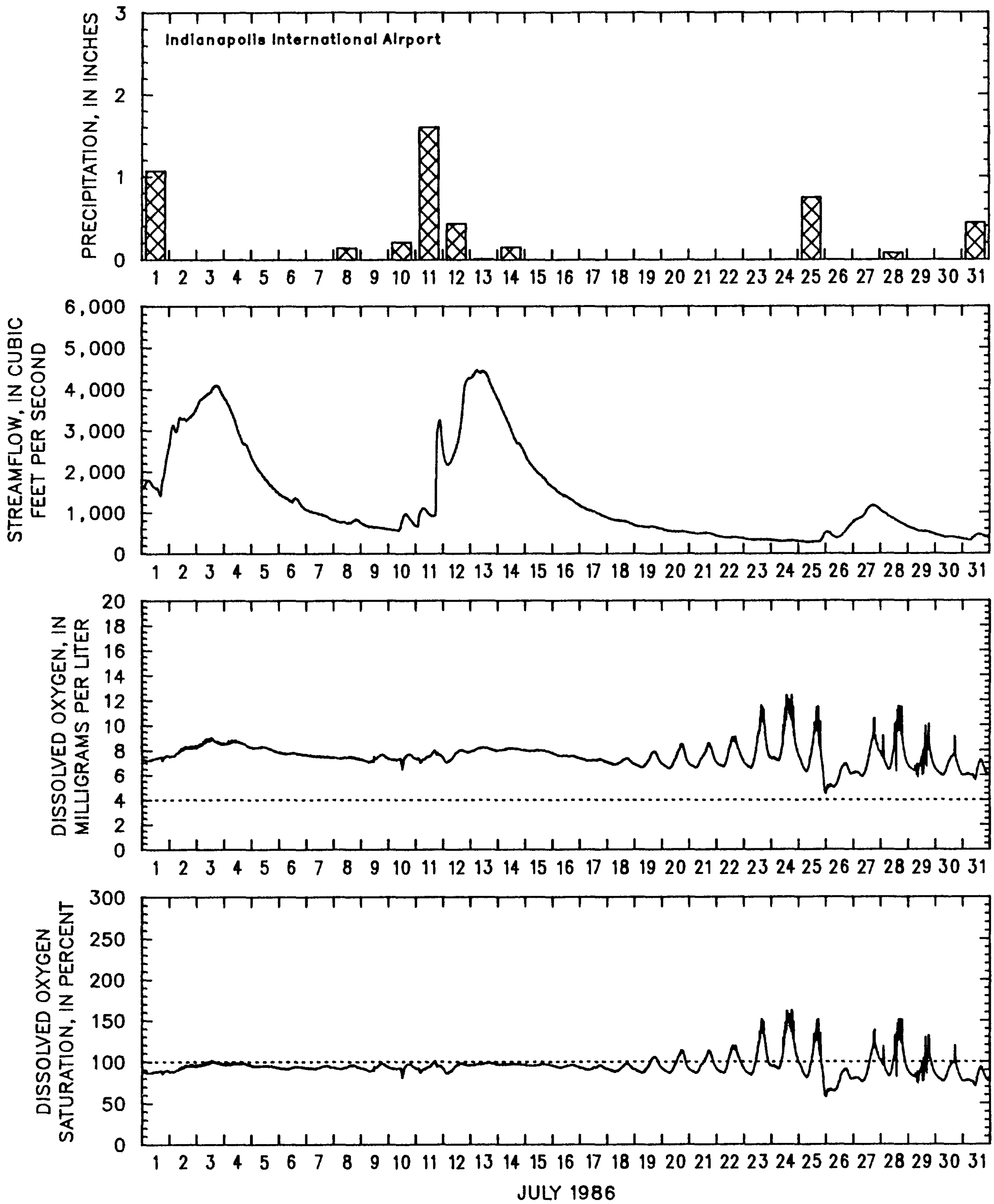


Figure 4b. —— Streamflow and dissolved–oxygen concentration and saturation at White River at Indianapolis, July 1986.

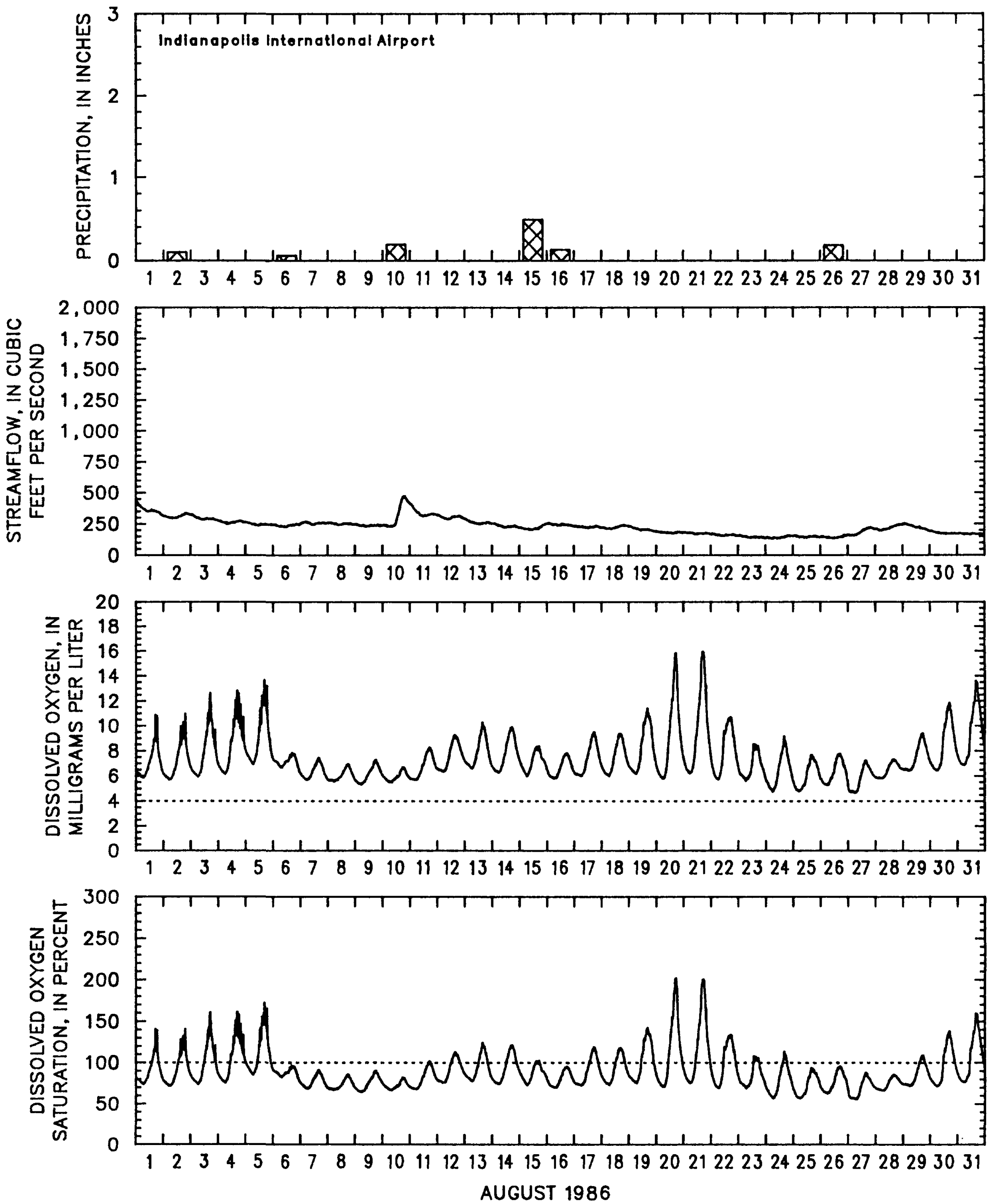


Figure 4c. -- Streamflow and dissolved-oxygen concentration and saturation at White River at Indianapolis, August 1986.

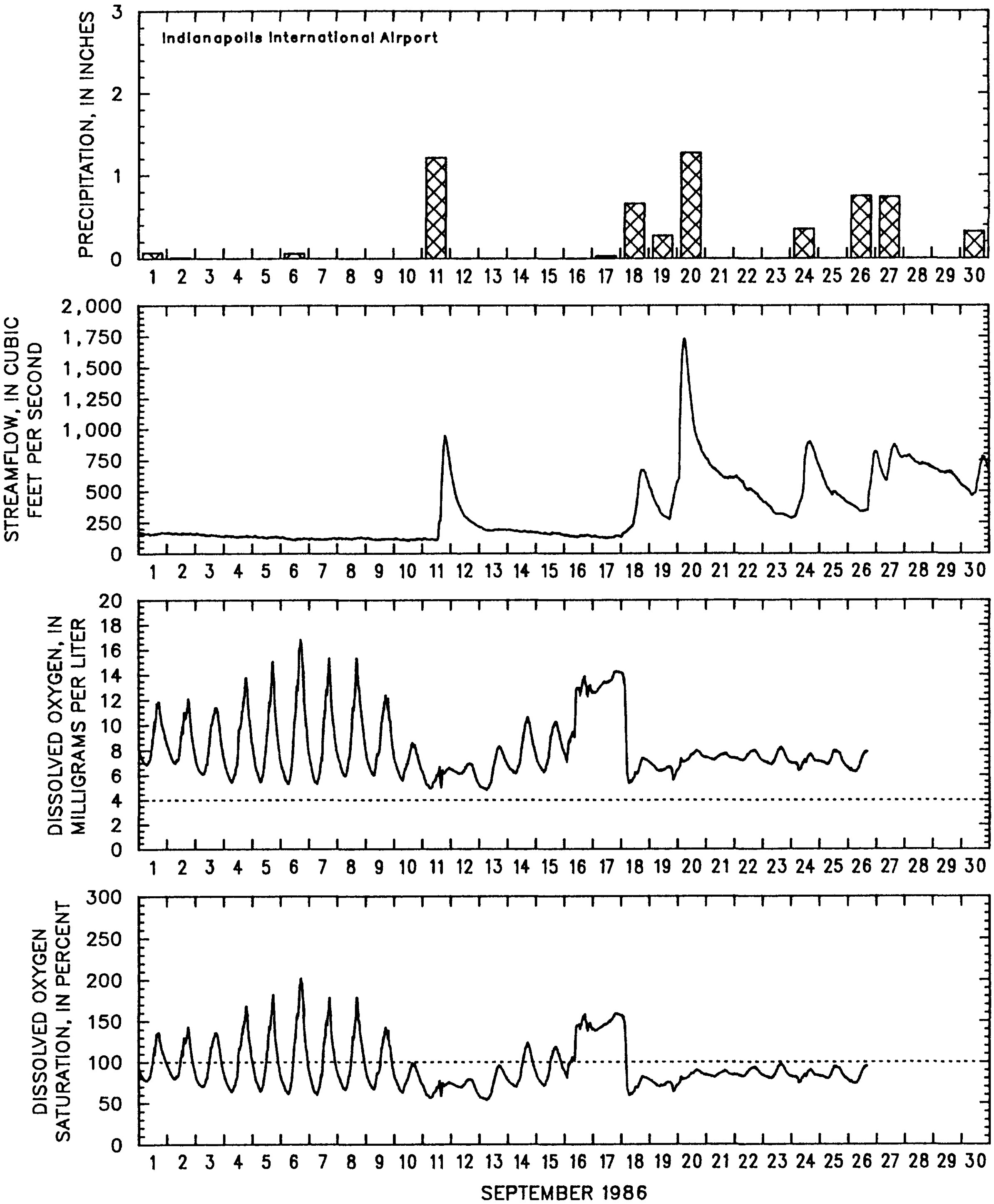


Figure 4d. -- Streamflow and dissolved-oxygen concentration and saturation at White River at Indianapolis, September 1986.

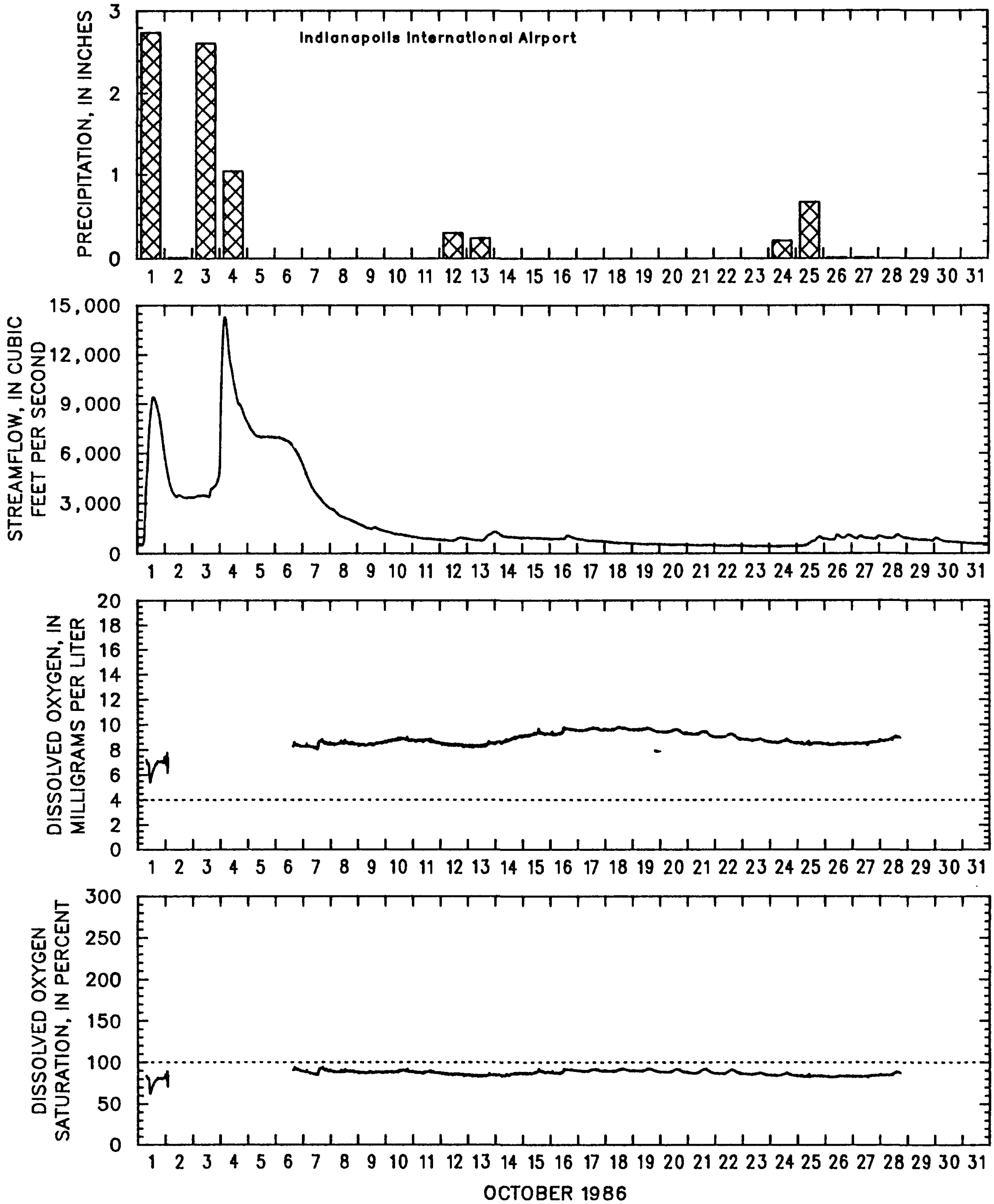


Figure 4e. -- Streamflow and dissolved-oxygen concentration and saturation at White River at Indianapolis, October 1986.

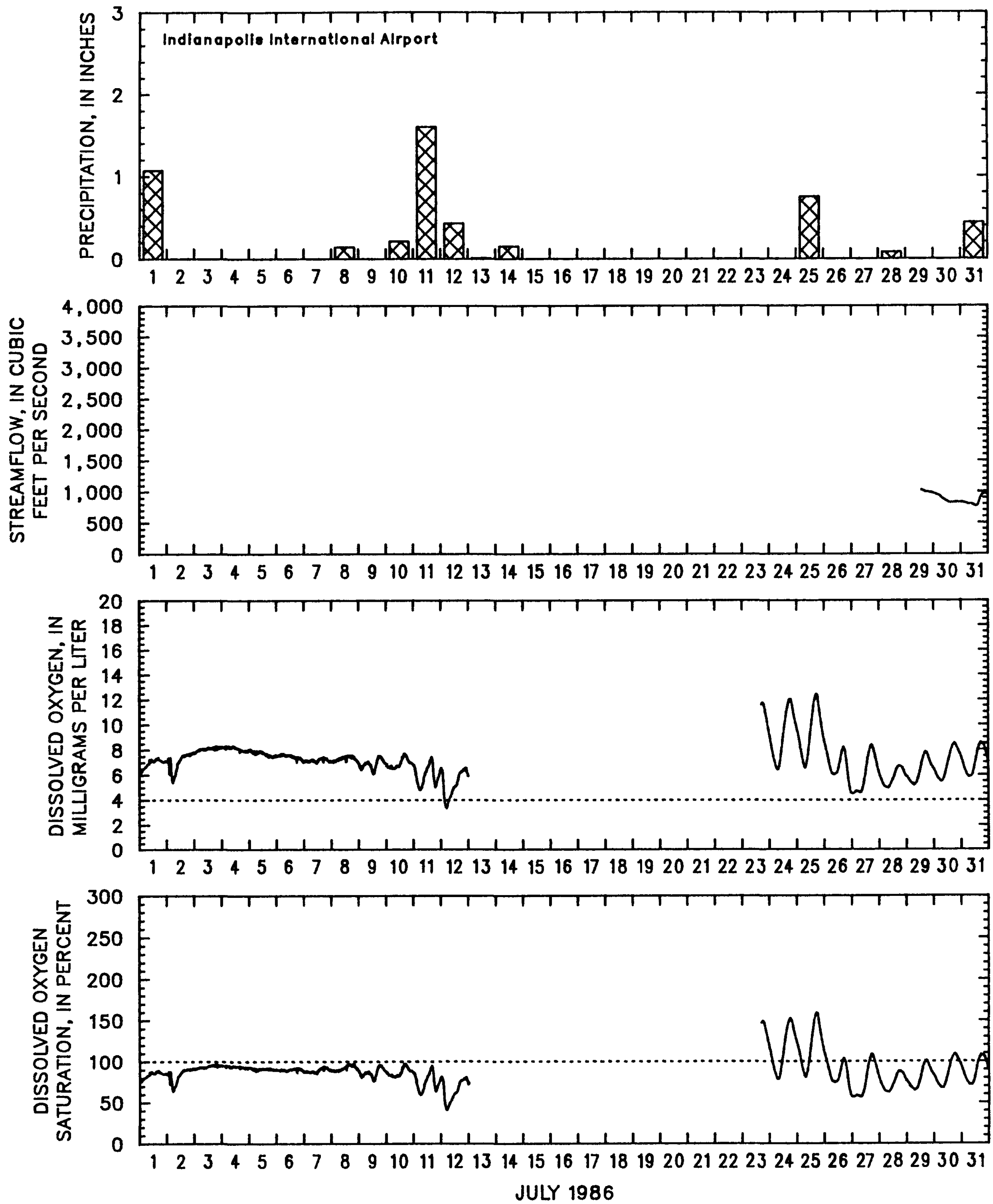


Figure 5a. -- Streamflow and dissolved-oxygen concentration and saturation at White River at Waverly, July 1986.

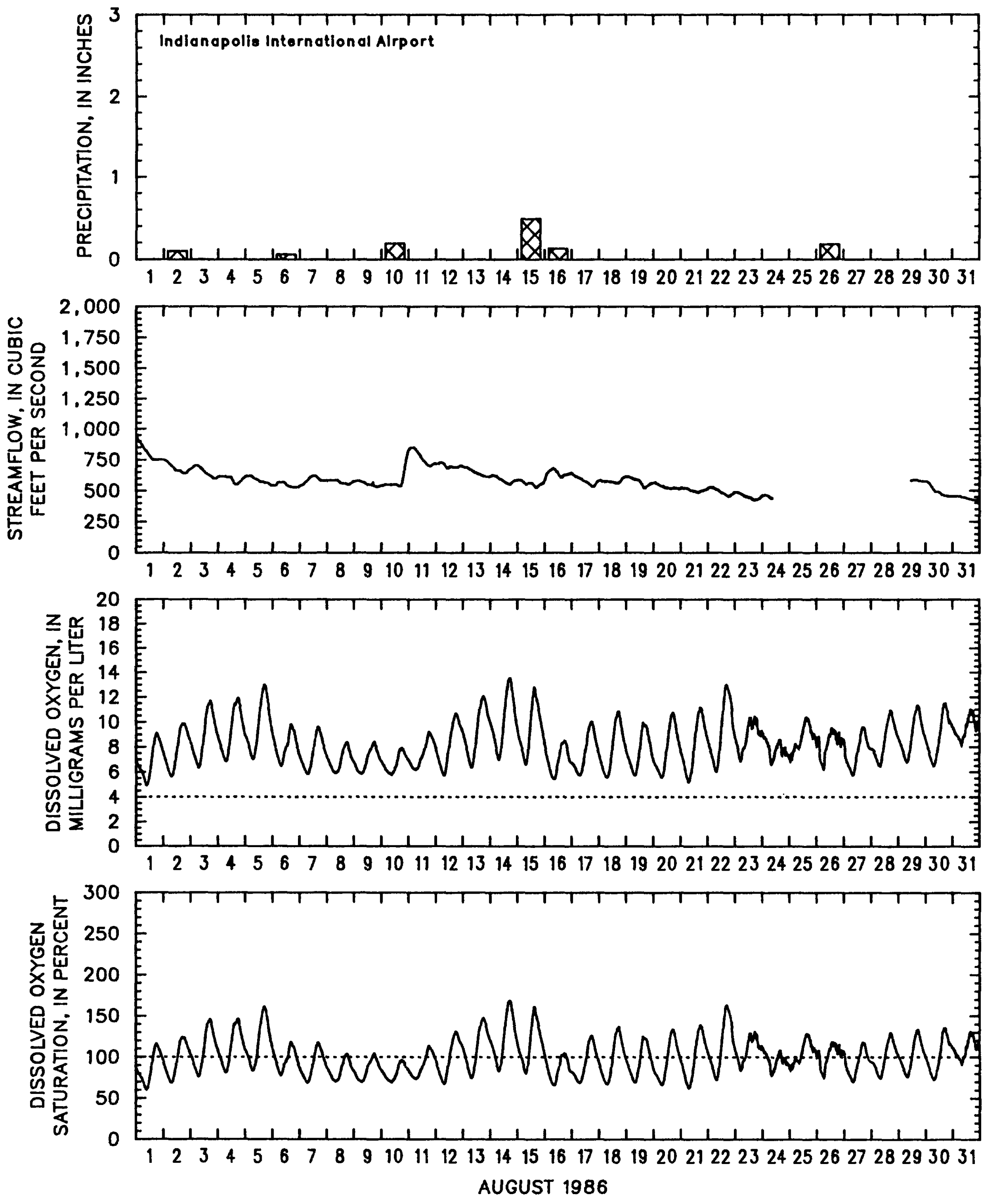


Figure 5b. -- Streamflow and dissolved-oxygen concentration and saturation at White River at Waverly, August 1986.

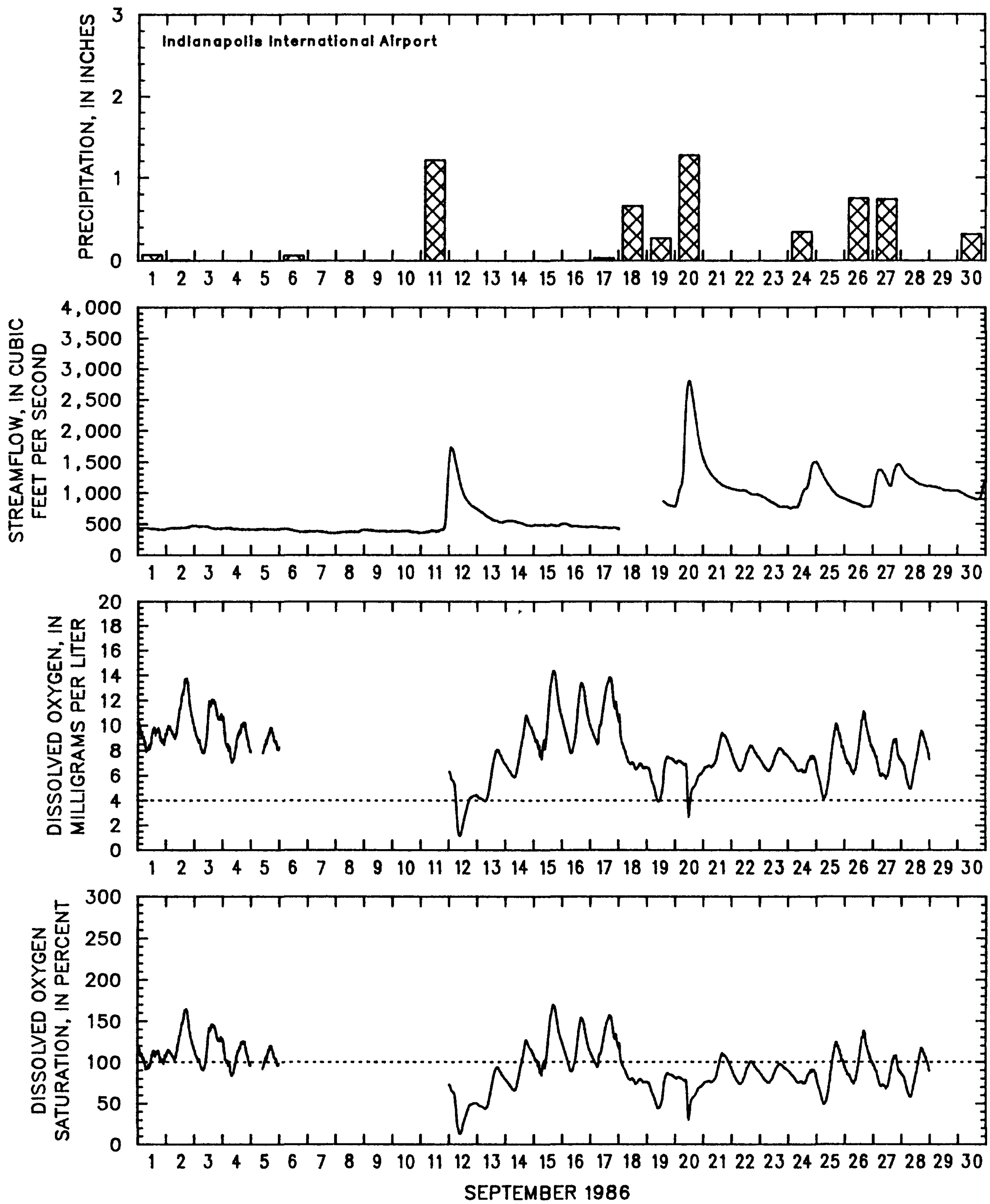


Figure 5c. — Streamflow and dissolved-oxygen concentration and saturation at White River at Waverly, September 1986.

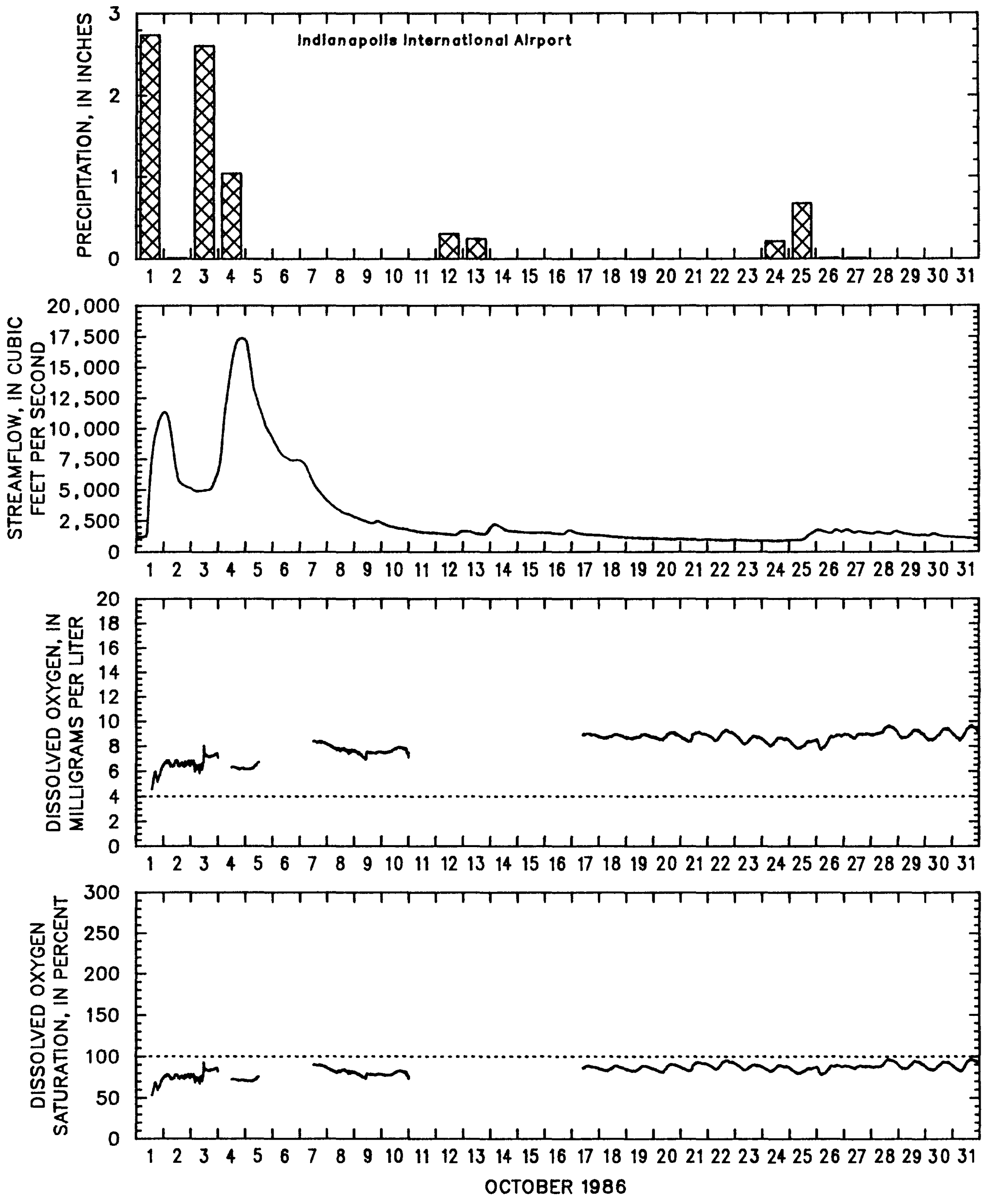


Figure 5d. -- Streamflow and dissolved-oxygen concentration and saturation at White River near Waverly, October 1986.

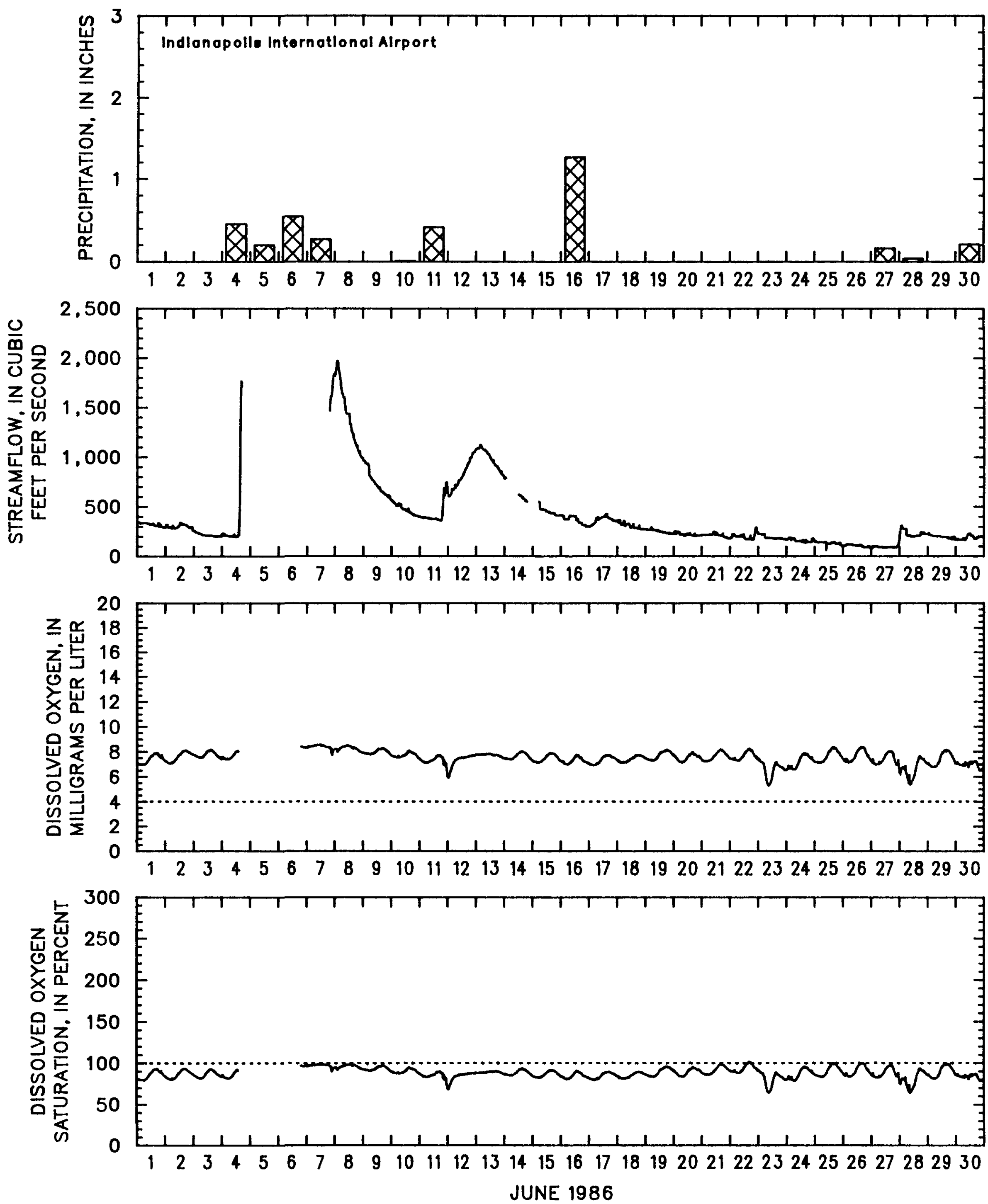


Figure 6a. — Streamflow and dissolved-oxygen concentration and saturation at Fall Creek at Indianapolis, June 1986.

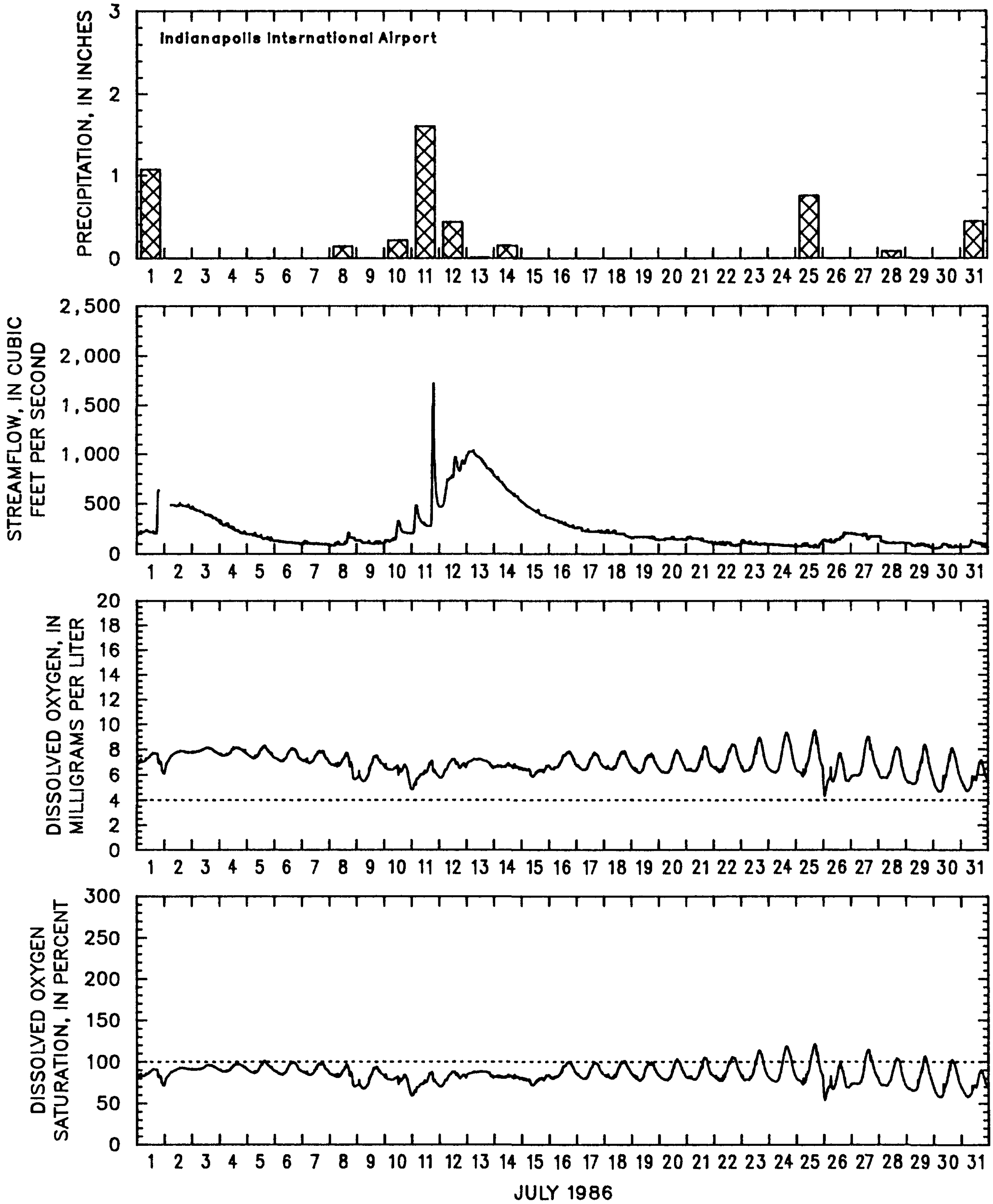


Figure 6b. —— Streamflow and dissolved–oxygen concentration and saturation at Fall Creek at Indianapolis, July 1986.

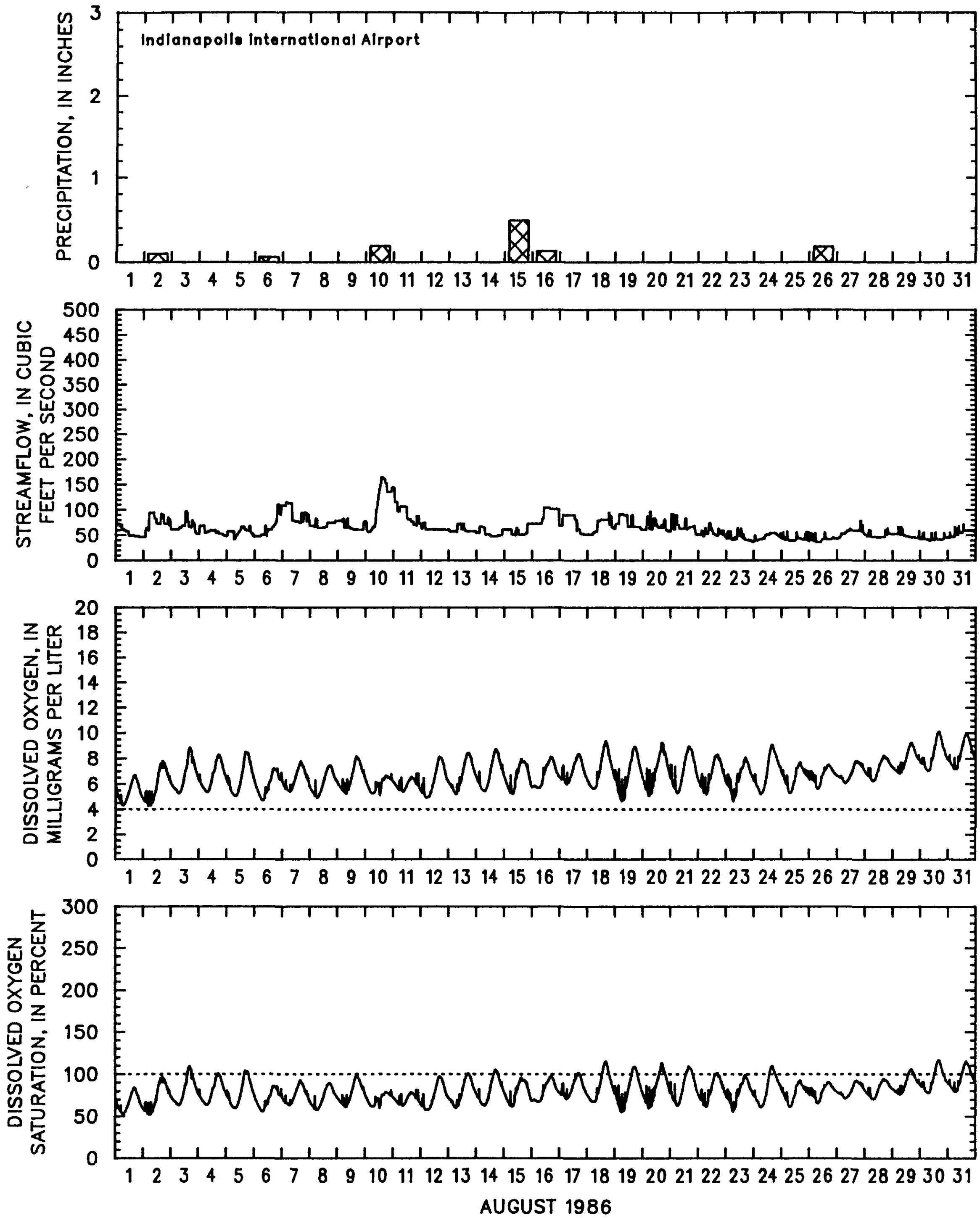


Figure 6c. —— Streamflow and dissolved–oxygen concentration and saturation at Fall Creek at Indianapolis, August 1986.

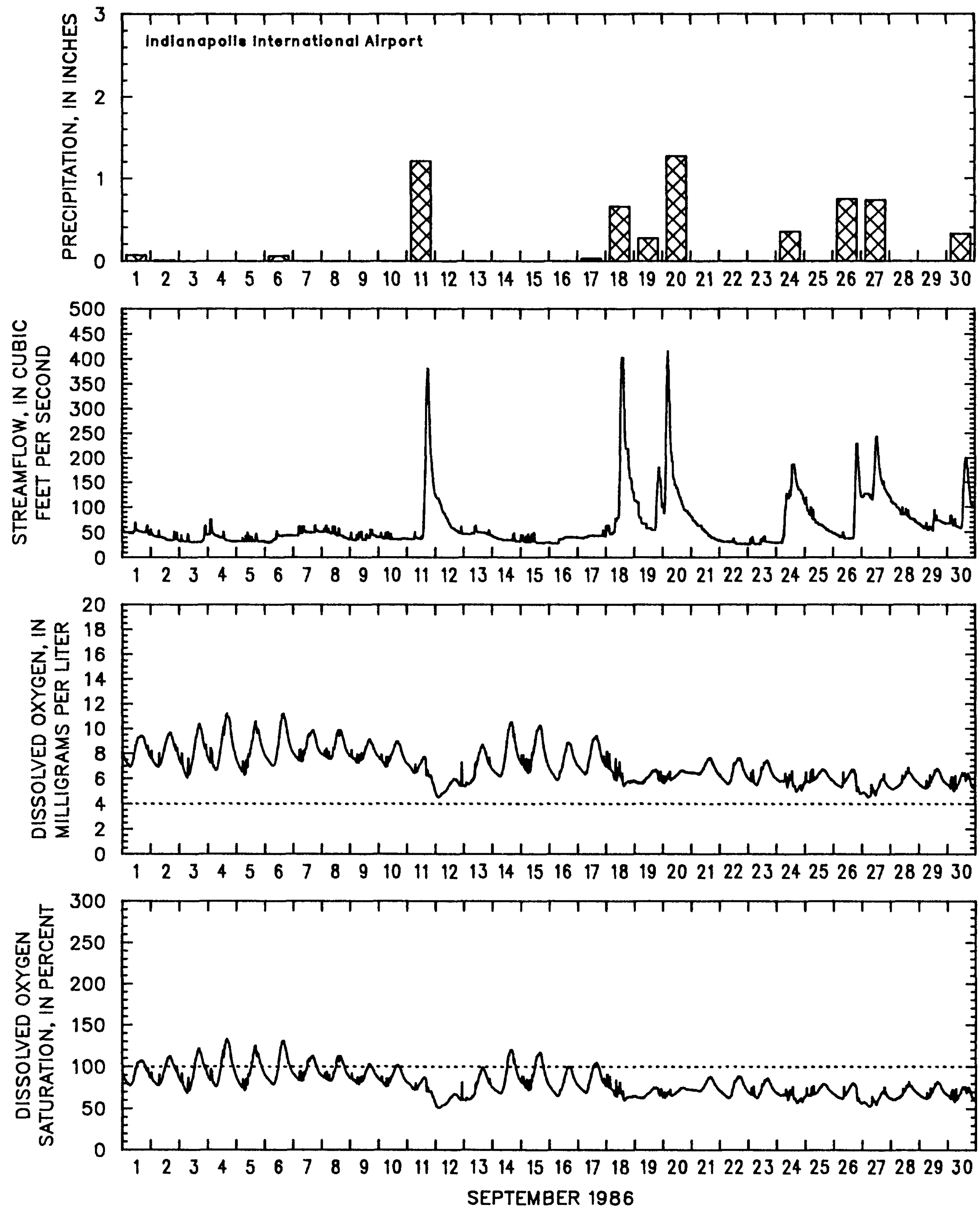


Figure 6d. -- Streamflow and dissolved-oxygen concentration and saturation at Fall Creek at Indianapolis, September 1986.

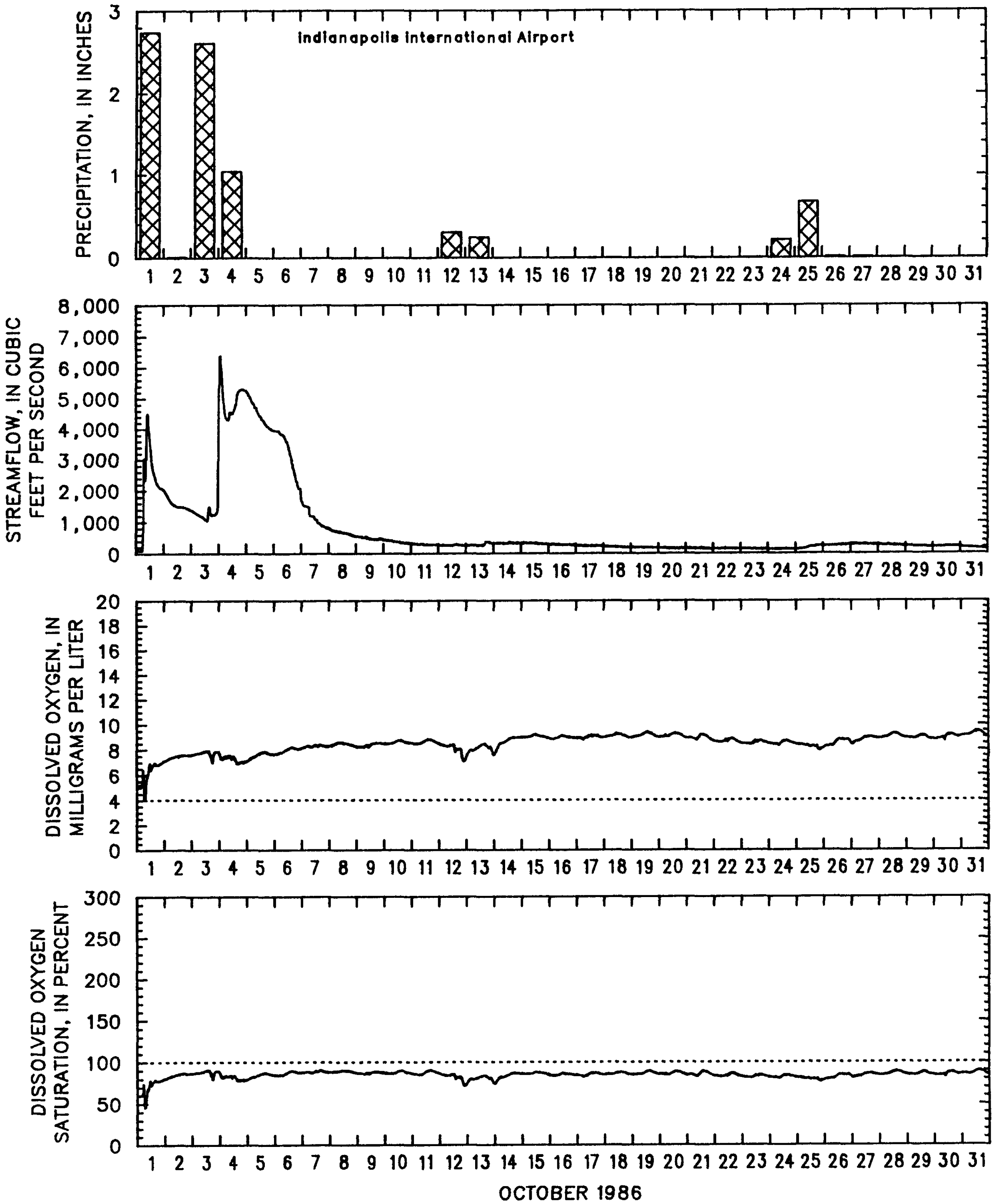


Figure 6e. -- Streamflow and dissolved-oxygen concentration and saturation at Fall Creek at Indianapolis, October 1986.

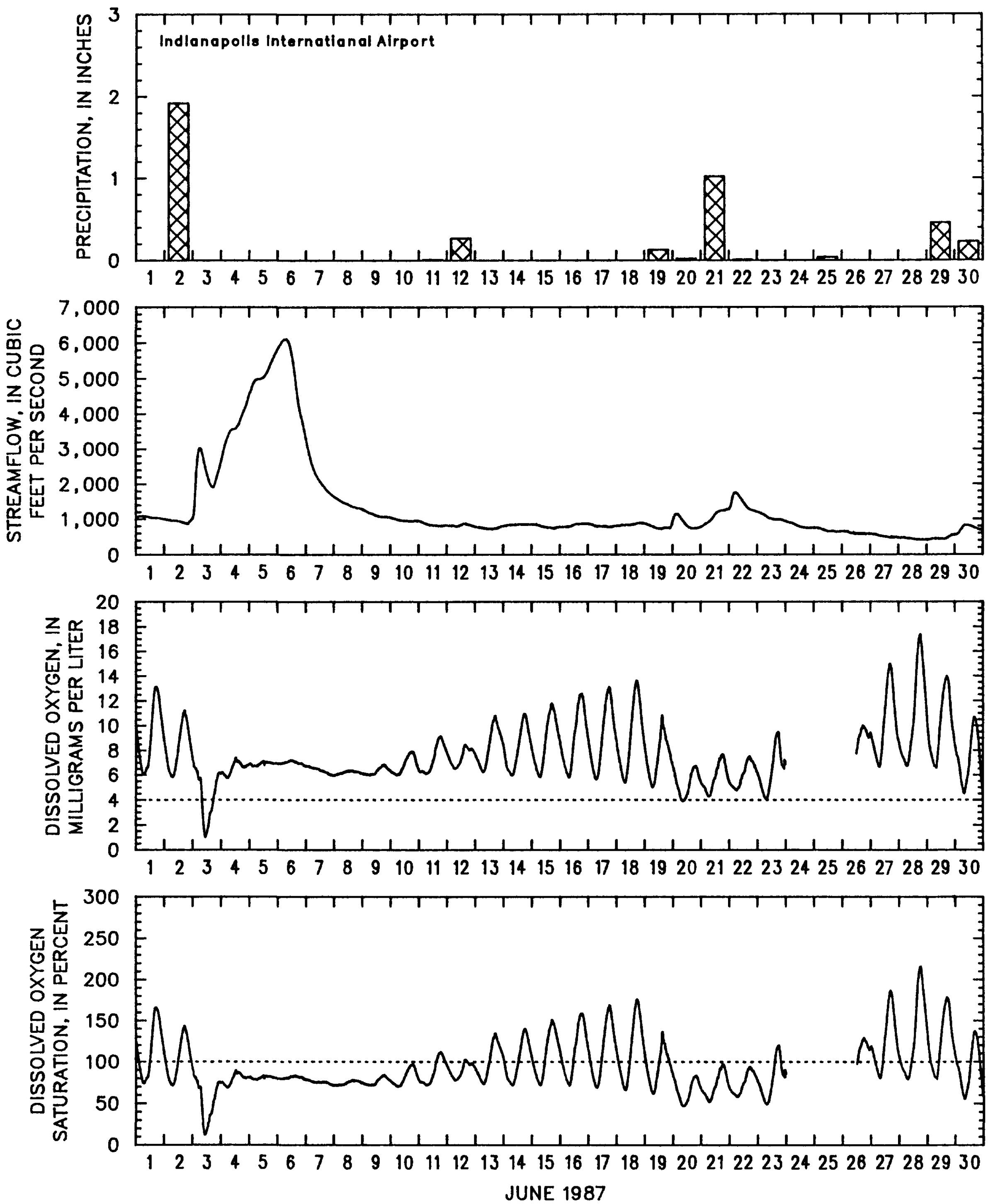


Figure 7a. -- Streamflow and dissolved-oxygen concentration and saturation at White River at Waverly, June 1987.

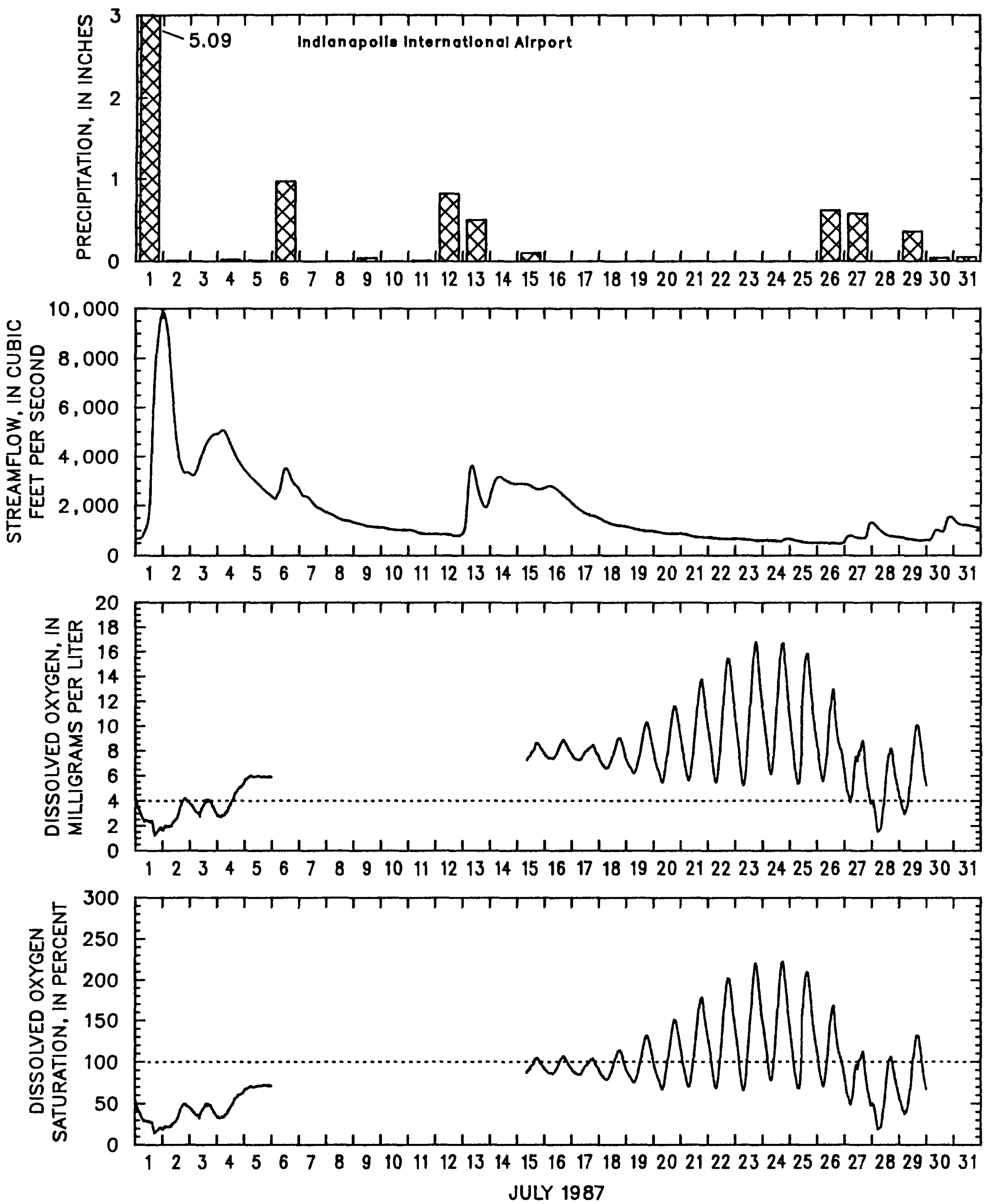


Figure 7b. -- Streamflow and dissolved-oxygen concentration and saturation at White River at Waverly, July 1987.

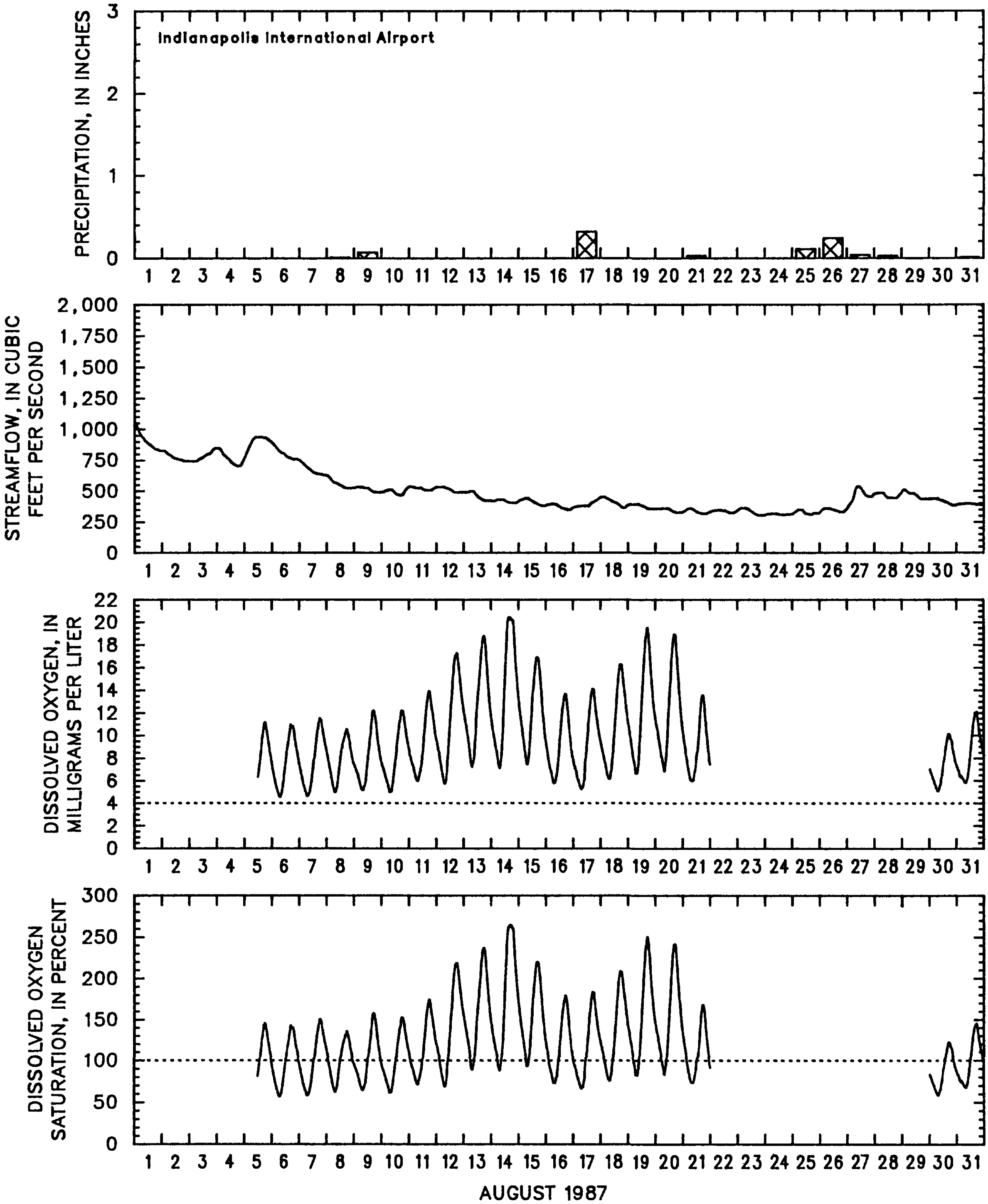


Figure 7c. —— **Streamflow and dissolved–oxygen concentration and saturation at White River at Waverly, August 1987.**

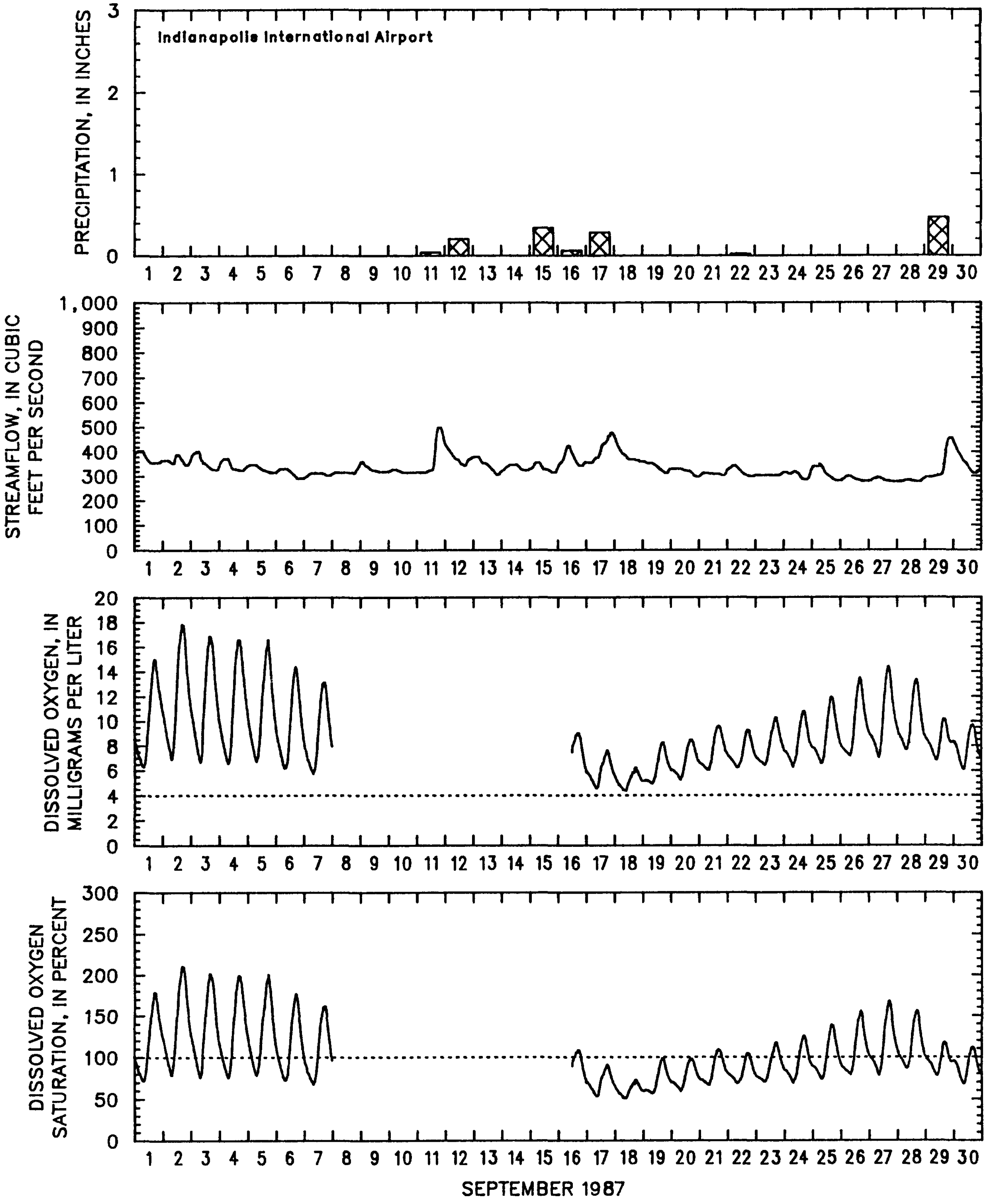


Figure 7d. — Streamflow and dissolved-oxygen concentration and saturation at White River at Waverly, September 1987.

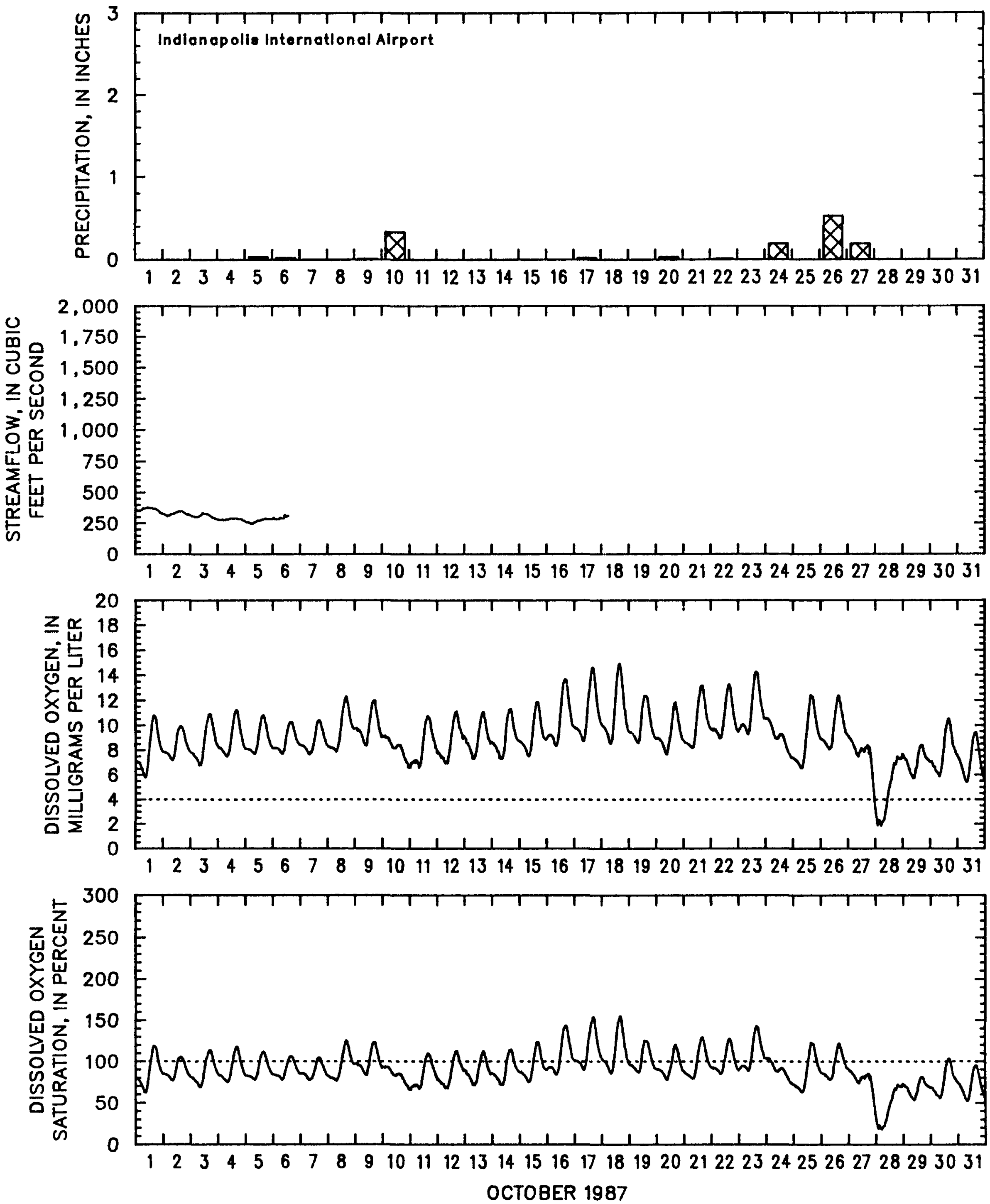


Figure 7e. -- Streamflow and dissolved-oxygen concentration and saturation at White River near Waverly, October 1987.

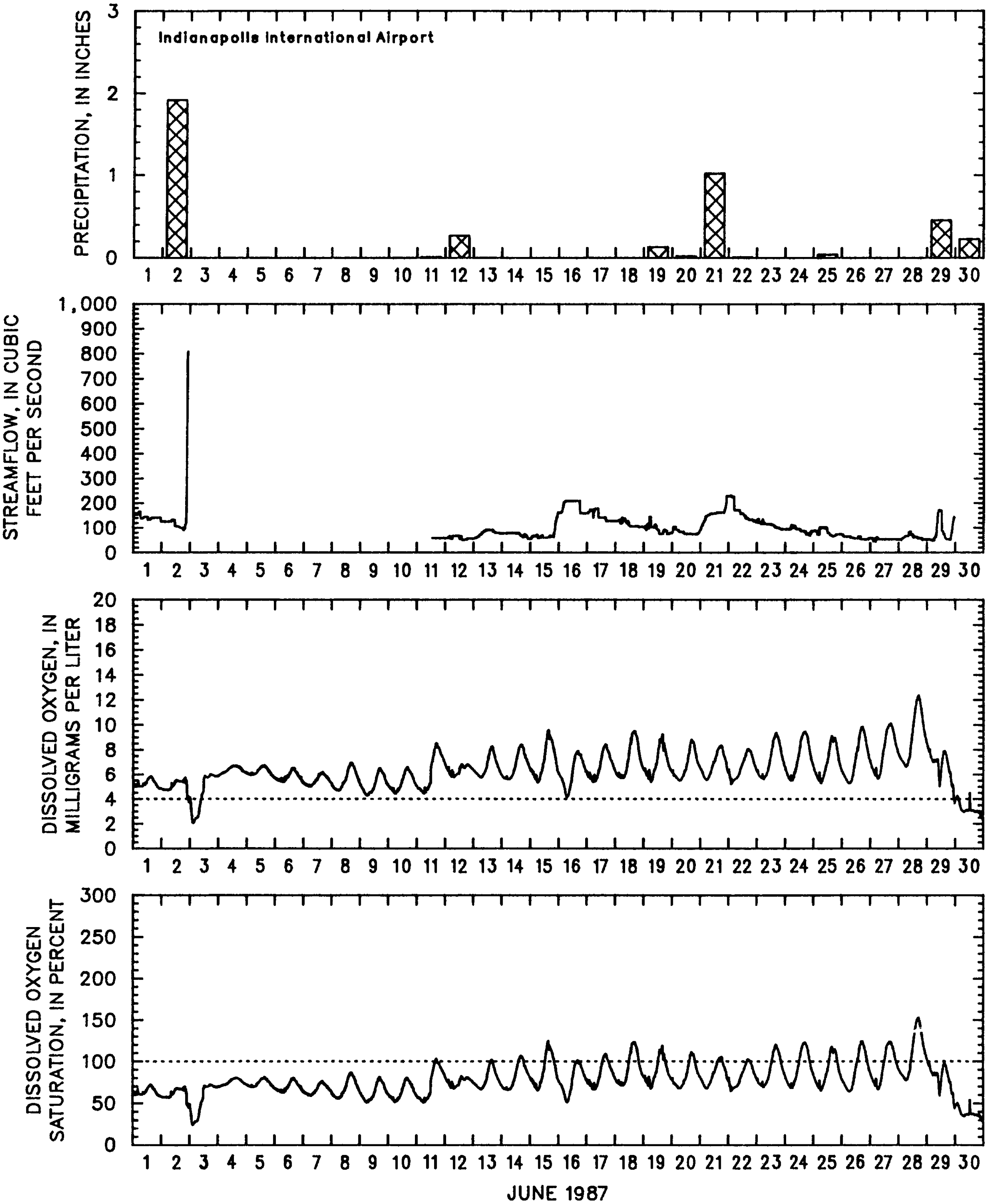


Figure 8a. —— Streamflow and dissolved–oxygen concentration and saturation at Fall Creek at Indianapolis, June 1987.

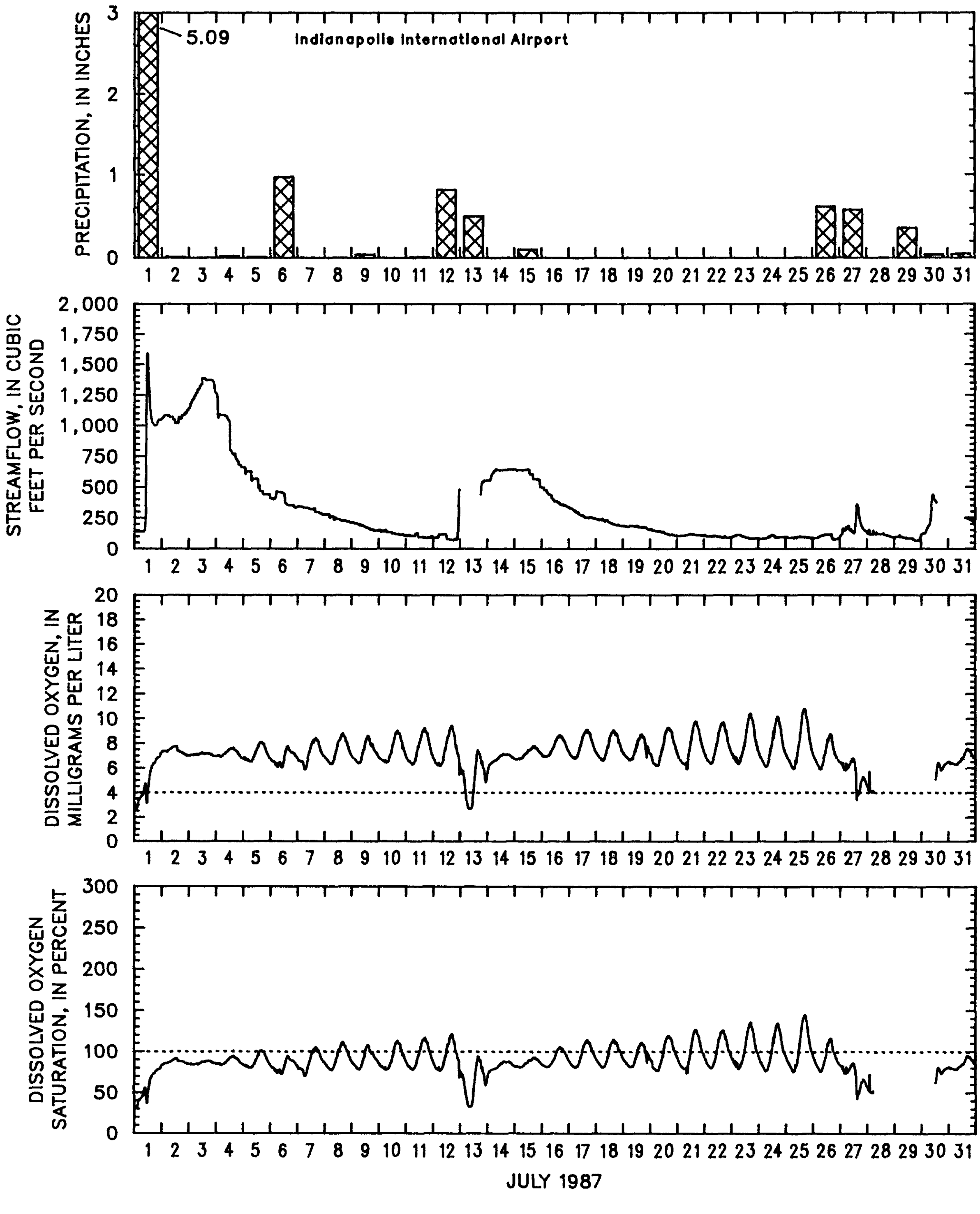


Figure 8b. —— **Streamflow and dissolved–oxygen concentration and saturation at Fall Creek at Indianapolis, July 1987.**

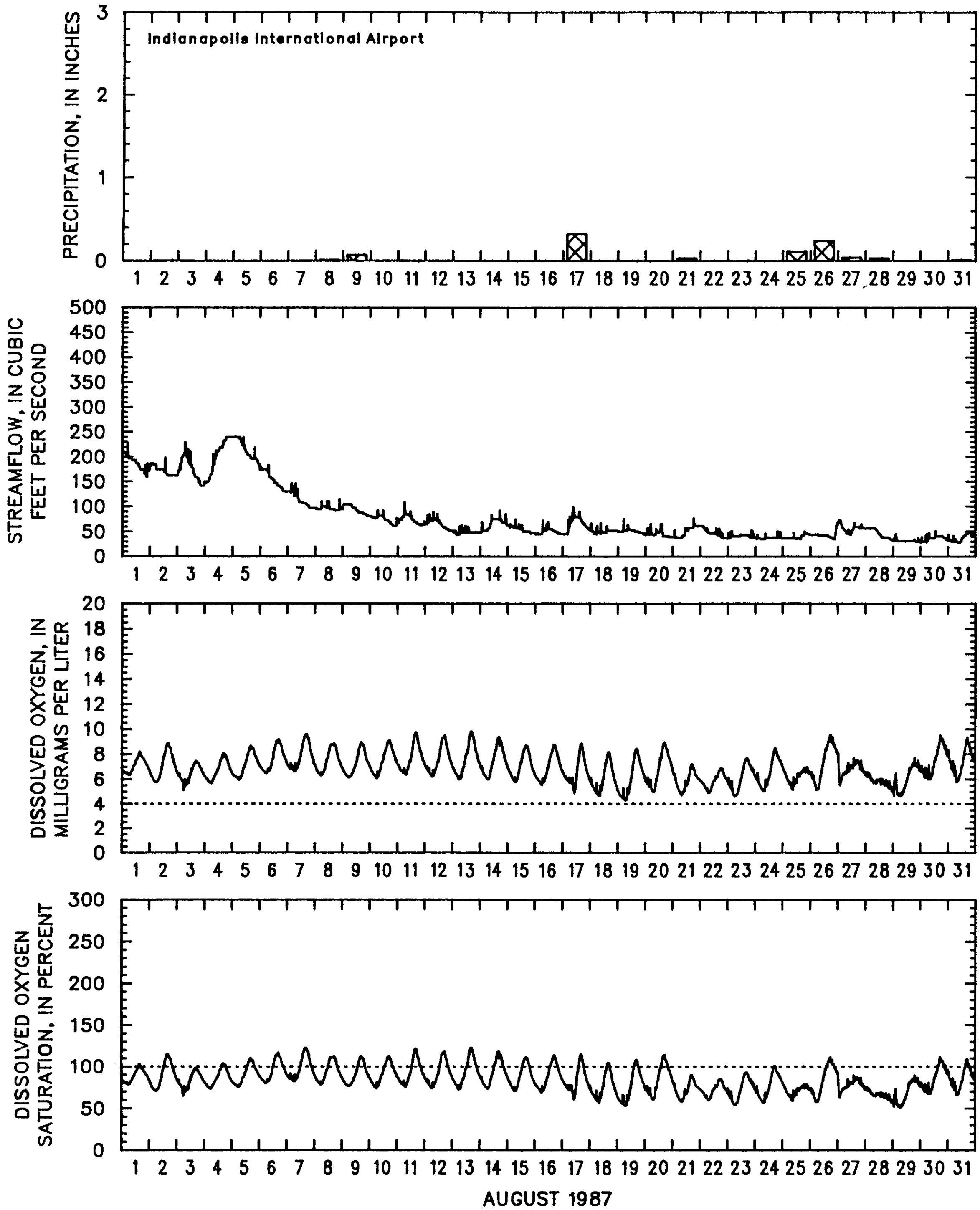


Figure 8c. -- **Streamflow and dissolved-oxygen concentration and saturation at Fall Creek at Indianapolis, August 1987.**

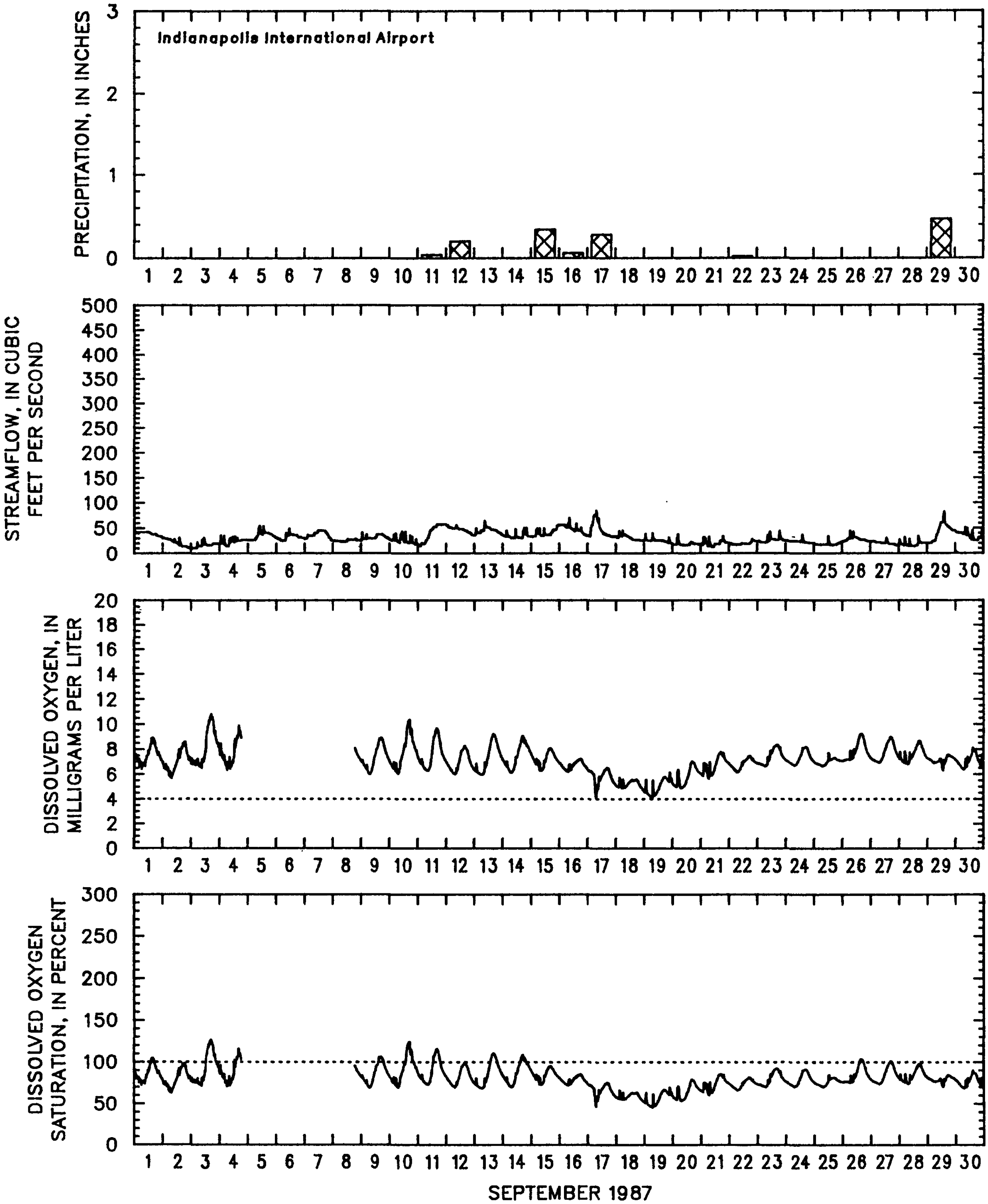


Figure 8d. — Streamflow and dissolved–oxygen concentration and saturation at Fall Creek at Indianapolis, September 1987.

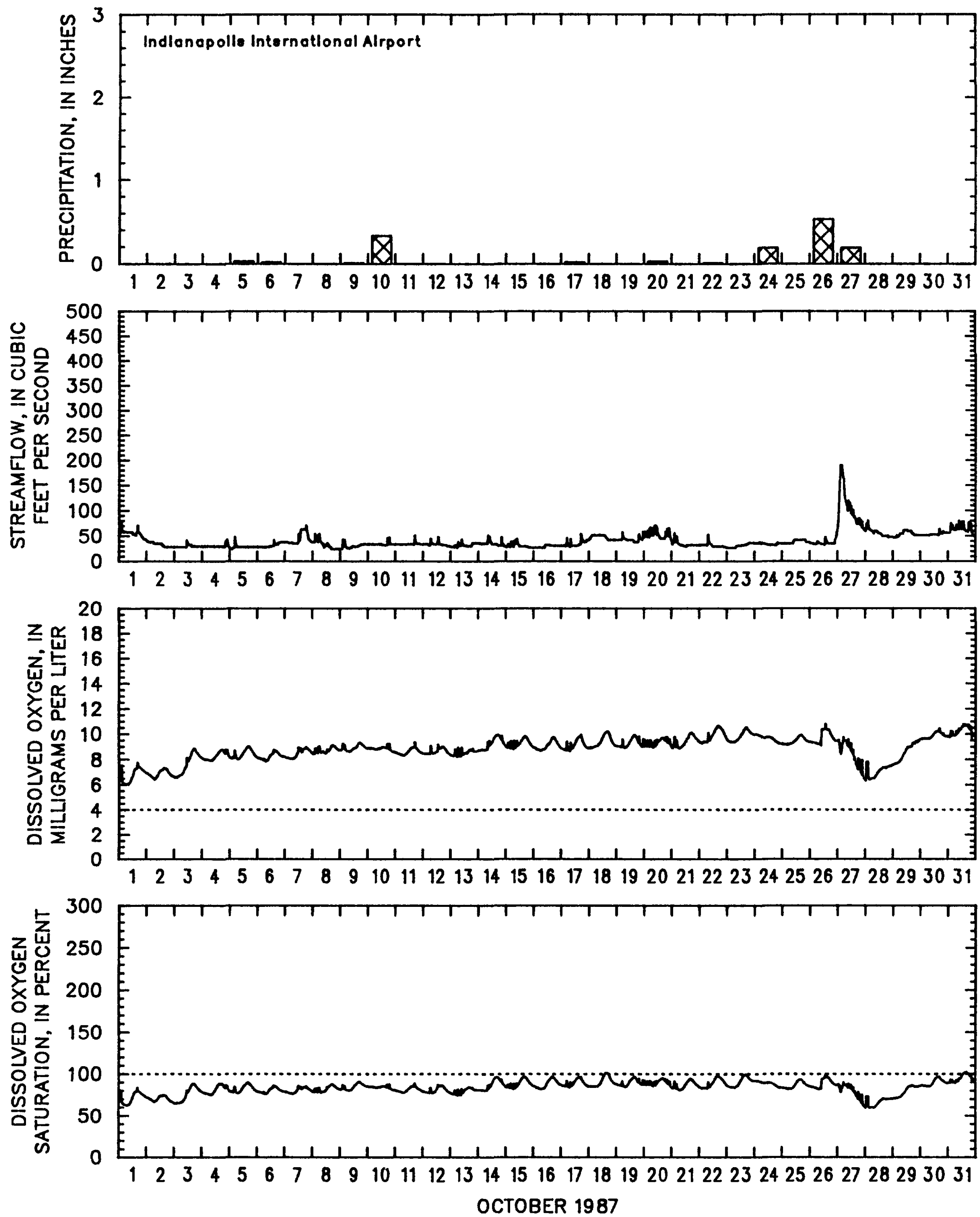


Figure 8e. —— Streamflow and dissolved–oxygen concentration and saturation at Fall Creek at Indianapolis, October 1987.