# QUALITY OF STORMWATER RUNOFF IN THE BLUE RIVER BASIN, MISSOURI AND KANSAS, JULY-OCTOBER 1981 AND APRIL-JULY 1982

By Dale W. Blevins

---

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 84-4226

Prepared in cooperation with the

MISSOURI DEPARTMENT OF NATURAL RESOURCES,

DIVISION OF ENVIRONMENTAL QUALITY

Rolla, Missouri

1986

UNITED STATES DEPARTMENT OF THE INTERIOR

DONALD PAUL HODEL, Secretary

GEOLOGICAL SURVEY

Dallas L. Peck, Director

---

For additional information write to:

District Chief
U.S. Geological Survey
1400 Independence Road
Mail Stop 200
Rolla, Missouri 65401

Copies of this report can be purchased from:

Open-File Services Section
Western Distribution Branch
U.S. Geological Survey
Box 25425, Federal Center
Denver, Colorado 80225
(Telephone: (303) 236-7476)

CONTENTS

## ILLUSTRATIONS

TABLES

Page

TABLES--Continued

## CONVERSION FACTORS

For readers who prefer to use the International System of Units (SI) rather than inch-pound units, the conversion factors for the terms used in this report are listed below.

| Multiply inch-pound unit | By | To obtain SI unit |
|---|---|---|
| foot | 0.3048 | meter |
| inch per hour | 0.007056 | millimeter per second |
| foot per mile | 0.1896 | meter per kilometer |
| foot per second | 0.3048 | meter per second |
| cubic foot per second | 0.02832 | cubic meter per second |
| mile | 1.609 | kilometer |
| square mile | 2.590 | square kilometer |
| acre | 0.4047 | hectare |
| ton | 907.2 | kilogram |
| inch | 25.4 | millimeter |

To convert temperature in °C (degrees Celsius) to °F (degrees Fahrenheit), multiply by 1.8 and add 32.

# QUALITY OF STORMWATER RUNOFF IN THE BLUE RIVER BASIN, MISSOURI AND KANSAS, JULY-OCTOBER 1981 AND APRIL-JULY 1982

By Dale W. Blevins

## ABSTRACT

Stormwater-runoff sampling was done at three stations on the Blue River in Kansas City, Missouri, to describe the quality of stormwater runoff in a combined urban and rural setting. Urban land use upstream from the mainstem stations increased from 17 percent of the basin (46 square miles) at the most upstream station to 33 percent (88 square miles) at the most downstream station. Stormwater-runoff sampling also was done at three stations on urban tributaries (Brush Creek, Blue Ridge Mall storm sewer, and an unnamed tributary of Blue River) that drain areas of residential, commercial, and mixed-urban land uses. Samples were analyzed for chemical and biochemical-oxygen demands, dissolved solids, suspended sediment, dissolved and total nutrients, dissolved and total metals, and total organic carbon. Discharge also was measured at the six stations.

Total concentrations of copper, iron, lead, and zinc exceeded the numeric aquatic-life criteria values listed in Missouri's water quality standards. However, the state's criteria implementation policy applies only to dissolved concentrations of these metals. Most constituents, except lead and zinc, were associated with concentrations of suspended sediment of as much as 3,100 milligrams per liter from the predominately agricultural areas in the upstream part of the basin. Regression equations with correlation coefficients greater than 0.70 indicated a significant relationship between suspended-sediment concentrations and the total concentrations of a number of constituents in stormwater runoff from the basin.

The large number of impervious surfaces and lined channels in urban areas caused increased volumes of stormwater runoff per unit drainage area as much as three times that from nonurban areas and limited the availability of sediment to streams. Consequently, concentrations of most constituents were small, but the loads per unit drainage area were large when compared with those in the Blue River. When stormwater runoff from Brush Creek reached unlined channels it picked up sediment, and loads for most constituents increased by factors as much as 4 in the Blue River after receiving runoff from Brush Creek.

Combined sewer overflows along Brush Creek caused large concentrations of 5-day biochemical-oxygen demand, dissolved solids, suspended sediment, nutrients, and metals in the initial storm runoff. Concentrations of 5-day biochemical-oxygen demand were as much as 380 milligrams per liter at a discharge of 458 cubic feet per second. However, the sewers were quickly flushed and the total volume of water discharged by combined sewers was a small fraction of that in the Blue River. Consequently, the mean 5-day biochemical-oxygen demand was only slightly increased from 0 to 23 percent in the Blue River.

After extended dry periods, concentrations of lead and zinc, as much as 1,100 and 1,000 micrograms per liter, were larger during the leading edge of stormwater runoff than during later runoff in all three urban tributaries. Concentrations of most constituents in the leading edge of stormwater runoff were not large or consistent at the downstream Blue River station (Coalmine Road and St. John Avenue) when compared to later runoff due to mixing and timing of tributary runoff. However, concentrations of 5-day biochemical-oxygen demand, suspended sediment, dissolved phosphorus, and lead that occured upstream in the Blue River near Gregory Boulevard, were 0 to 300 percent larger in the leading edge of stormwater runoff if dry antecedent conditions and sufficient stormwater runoff occured.

Concentrations of total lead and total zinc were significantly increased in stormwater runoff from the urban area. During the storm of July 27-28, 1981, urban areas contributed 3.4 tons of lead and 7.4 tons of zinc to the Blue River.

Two low-head dams upstream from the St. John Avenue sampling station on the Blue River caused suspended-sediment concentrations to be as much as 30 percent smaller and concentrations of dissolved solids to be as much as 85 percent larger during the first part of runoff from small storms. This was due to sediment trapping and the flushing of impounded water from behind the dams. These dams also decreased the total storm load of suspended sediment 10 and 39 percent in two small storms.

# INTRODUCTION

Stormwater quality is of concern to water planners and managers, as well as to the public, to assure that water-quality standards are being met and for water-resource management for water supply, recreation, waste disposal, and other purposes. Of particular concern is the water quality of streams draining urban areas where accumulations of street litter, pesticides, fertilizers, chemicals and abrasives used in ice control, animal wastes, and automobile and stack emissions may be significant sources of pollution. Although the quality of streamflow generally is characterized by periodic, discrete sampling, the actual water quality is quite variable depending on areal and temporal conditions of precipitation, streamflow, land use, and other factors. A potentially significant contribution of pollutants to urban streams is the initial runoff from spring and summer storms that flush pollutants accumulated since previous storms into receiving waters. The study was done in cooperation with the Missouri Department of Natural Resources to assist the U.S. Environmental Protection Agency in determining the quality of stormwater runoff in the Blue River basin.

The purpose of this report is to describe the quality of stormwater runoff entering the Blue River and several of its tributaries as determined from both composite and discrete samples collected at selected sites chosen to represent both urbanized and non-urbanized areas of the Blue River basin. Samples were collected during runoff resulting from a number of storms in the basin during July-October 1981, and April-July 1982.

## Description of Study Area

The Blue River basin is on the Missouri-Kansas border and has an area of 269 square miles (fig. 1). A large part of the Kansas City metropolitan area is drained by the downstream one-half of the Blue River Basin. As of 1978, 88 square miles (33 percent) of the Blue River basin had been urbanized and the remaining 181 square miles (67 percent) was chiefly agricultural use (Mid-America Regional Council, 1981). These conditions are relatively unchanged at present (1983). Much of the agricultural area is used for row crops, although hay crops, pasture and woodlands cover a significant part of the area. Several small towns are located in the relatively undeveloped upstream part of the basin. Part of the city of Olathe, Kansas, approximately 2 square miles, is within the basin, but the area covered by other small towns total less than 1 square mile. A summary of land use within the basin during 1978 is shown in table 1. The corporate boundaries in figure 1 delineate the approximate limit of urbanization in the Kansas City area.

More than 75 percent of the soils in the upstream, agricultural areas have saturated hydraulic conductivity ranging from 0.016 to 0.04 inch per hour, and erodibility factors (K) ranging from 0.28 to 0.43 (Mausel and others, 1976). Although the natural susceptibility to erosion is moderate, most soils in the agricultural areas are cultivated. In combination with the minimal hydraulic conductivities that increase runoff, cultivation creates the potential for large sediment yields from overland and channel erosion.

The Kansas City area receives an average of 37 inches of precipitation per year, which includes an average annual snowfall of 19 inches. Although precipitation is distributed throughout the year, May, June, and September receive the most precipitation. Precipitation generally is associated with frontal movement, although localized convectional storms are common during the summer. The average daily mean temperature is 28.6 °C during July and 0.4 °C during January (National Oceanic and Atmospheric Administration, 1982).

A combined sanitary and stormwater sewage system typically increases biochemical-oxygen demand, suspended solids, and total phosphorus two to four times more than stormwater runoff alone (Gehm and Bergman, 1976). About 56 square miles of the downstream end of the Blue River basin (21 percent of the entire basin) are served by a combined system that carries both sanitary sewage and stormwater runoff (fig. 2). The Big Blue interceptor sewer is located along the downstream 16-mile reach of the Blue River, and during dry conditions routes all sanitary sewage to a large wastewater-treatment facility near the mouth of the Blue River. However, during periods of significant rainfall, runoff mixes with sanitary sewage until the interceptor can no longer accommodate all the inflow, and the excess is discharged directly into the river (fig. 2). Newer developments in the southern parts of Kansas City have separate sanitary and stormwater sewage systems. The point where effluent from the Big Blue Sewage Treatment Plant enters into the Blue River is located downstream from the reach sampled in this study.

## Data-Collection Methods

Rainfall data were compiled from three National Weather Service sites and collected at four U.S. Geological Survey sites (fig. 1). Rainfall data-collection sites were chosen or established to show relative depths of rainfall for the major tributaries contributing flow at the sampling sites. Data from Stillwell, Kansas, represent rainfall on the upper Blue River basin. Data from Morse and Olathe, Kansas, represent rainfall on the Indian and Tomahawk Creek basins. Rainfall data from Prairie Village, Kansas, represent the Brush Creek basin. Data collected at Gregory Boulevard represent rainfall on

Table 1.--Land use upstream from sampling stations during 1978

[Compiled from Mid-America Regional Council, 1981]

| Station number (fig.1) | Drainage basin | Land use, in acres and percentage of total drainage basin | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Single-family residential | | Multi-family residential | | Commercial | | Industrial | | Agricultural and vacant | | Other | | Total | |
| | | Acres | Percent | Acres | Percent | Acres | Percent | Acres | Percent | Acres | Percent | Acres | Percent | Acres | Percent |
| 2 | Blue River tributary at Virginia Avenue | 303 | 96 | 0 | 0 | 10 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 313 | 100 |
| 4 | Blue River near Gregory Boulevard | 22,700 | 17 | 1,900 | 1 | 2,500 | 2 | 2,200 | 2 | 95,200 | 71 | 9,500 | 7 | 134,000 | 100 |
| 6 | Brush Creek at Elmwood Avenue | 13,260 | 71 | 760 | 4 | 1,320 | 7 | 130 | 1 | 2,580 | 14 | 490 | 3 | 18,540 | 100 |
| 7 | Blue River at Coalmine Road | 38,000 | 24 | 2,700 | 2 | 4,000 | 2 | 2,500 | 2 | 97,800 | 62 | 13,100 | 8 | 158,100 | 100 |
| 8 | Blue Ridge Mall storm sewer | 0 | 0 | 0 | 0 | 50 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 100 |
| 11 | Blue River near St. John Avenue | 44,400 | 26 | 3,300 | 2 | 4,500 | 3 | 4,100 | 2 | 101,500 | 59 | 14,600 | 8 | 172,400 | 100 |

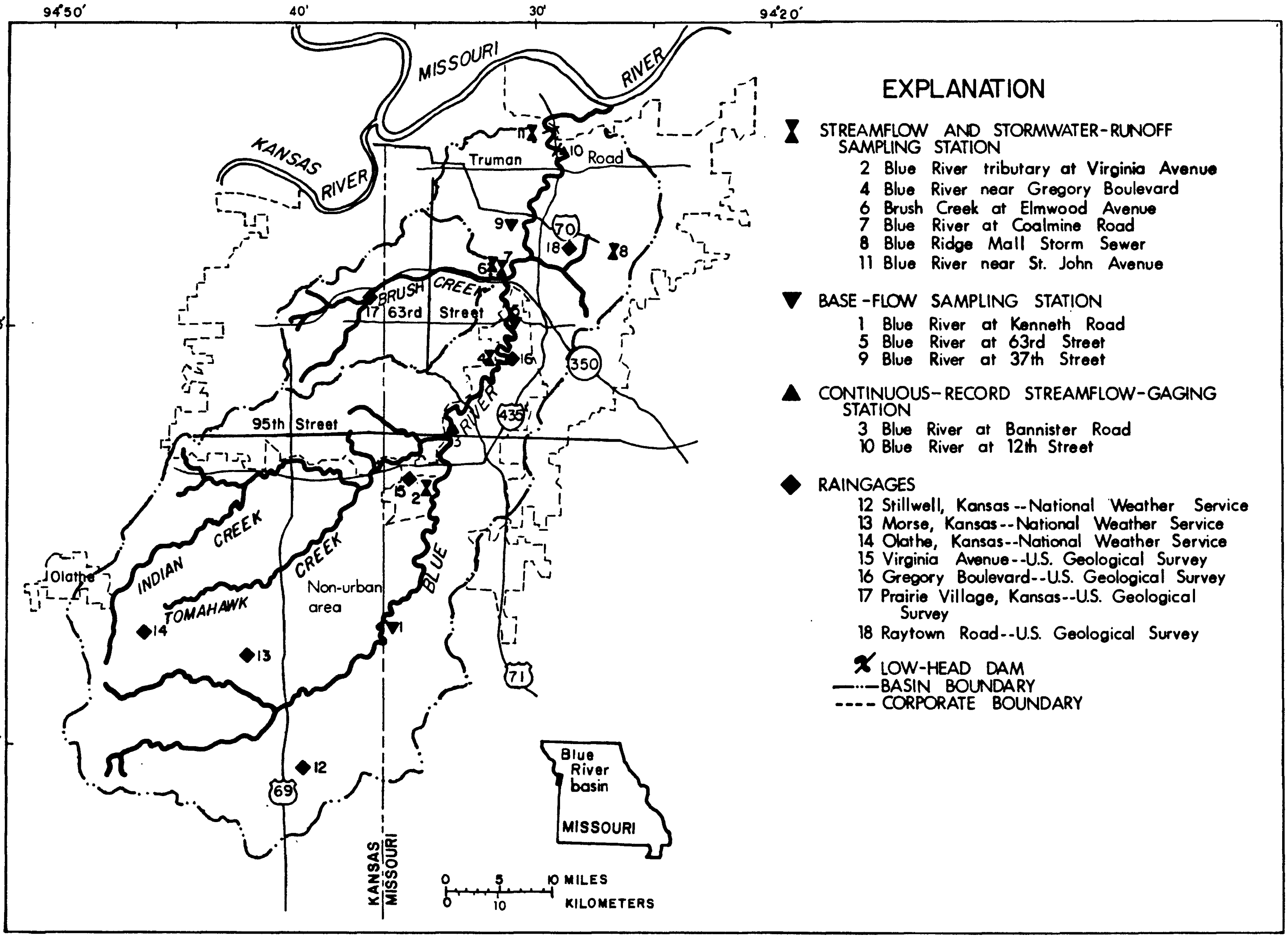



Figure 1.--Location of the Blue River basin, data-collection sites, non-urban area, and corporate boundaries of the southern Kansas City metropolitan area, Missouri and Kansas.

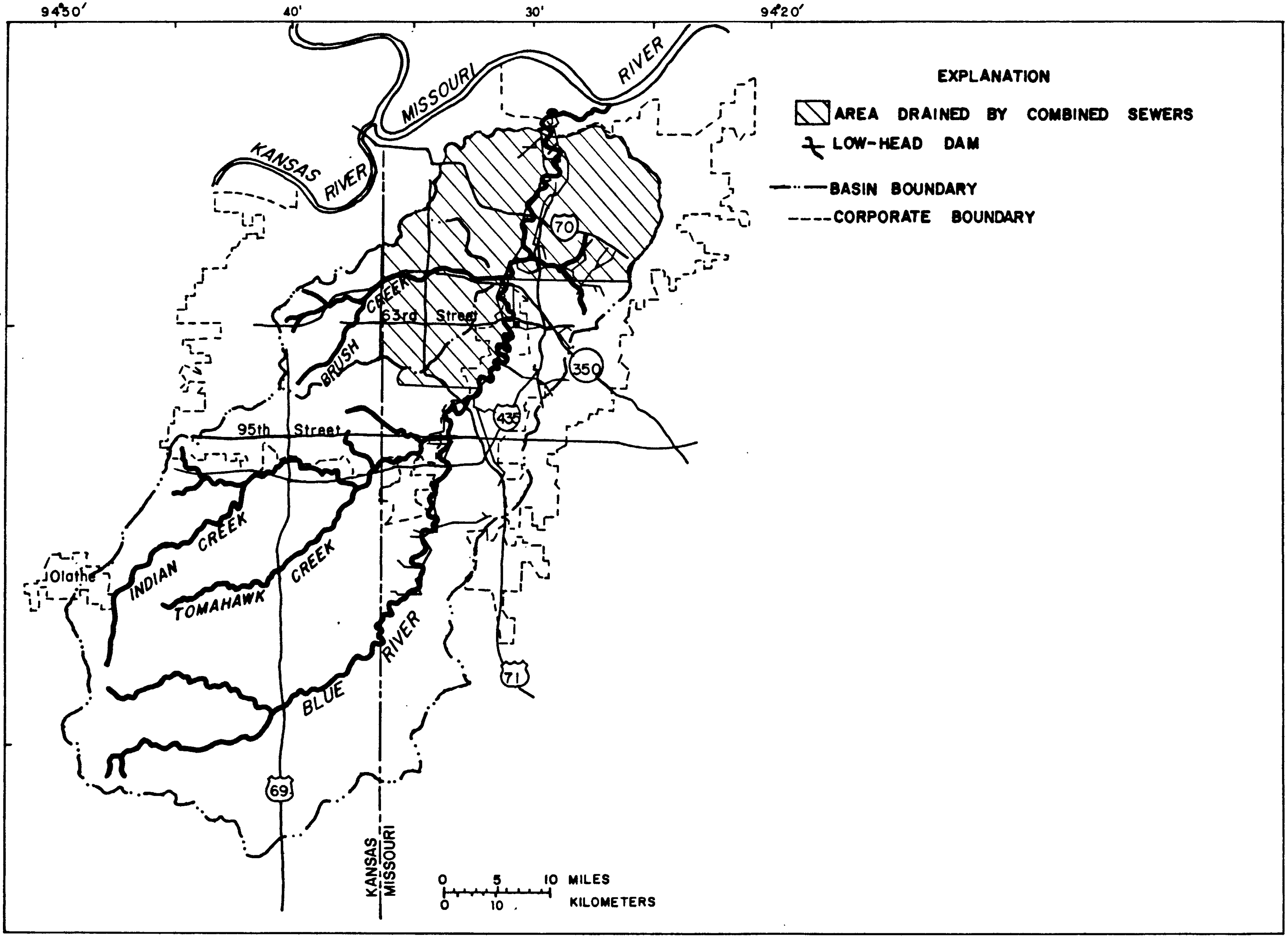



Figure 2.--Area of the Blue River basin drained by combined sewers (modified from Mid-America Regional Council, 1974).

the lower Blue River basin, and rainfall data from Virginia Avenue and Raytown Road represent small land-use areas as well as the middle and lower Blue River basin. Precipitation data for Stillwell, Morse, and Olathe, Kansas, are from National Weather Service records. Rainfall data for Gregory Boulevard and Virginia Avenue were collected as a part of this study. Precipitation data at Raytown Road and Prairie Village, Kansas, were collected by the U.S. Geological Survey for a separate rainfall-runoff study.

Continuous-record, streamflow information was collected at all six stormwater-runoff sampling stations--Blue River tributary at Virginia Avenue (station 2), Blue River near Gregory Boulevard (station 4), Brush Creek at Elmwood Avenue (station 6), Blue River at Coalmine Road (station 7), Blue Ridge Mall storm sewer (station 8), and Blue River near St. John Avenue (station 11) (fig. 1). For the Blue River stations, stage-discharge rating curves were developed from 10 to 12 discharge measurements at each station, from comparison with the long-term streamflow-gaging station on the Blue River at Bannister Road (station 3), from a streamflow-gaging station on the Blue River at 12th Street (station 10), and from comparisons between the study stations. Although the rating curve for Brush Creek at Elmwood Avenue was affected by backwater from the Blue River, a satisfactory relationship was developed between the mean velocity at Elmwood Avenue and the change in water-surface elevation between this station and the Blue River at Coalmine Road for various stages (coefficient of determination $r^2$=0.98). Stream-depth measurements made at Elmwood Avenue were used to develop the relationship between gage height and cross-sectional area. Discharge for a given gage height was computed by multiplying the computed mean velocity by the cross-sectional area from the curve developed at Elmwood Avenue. A stage-discharge rating curve for the Blue River tributary at Virginia Avenue was based on five discharge measurements. At the Blue Ridge Mall storm sewer, more than 30 velocity measurements at various stages in the center of a 5-foot diameter pipe and theoretical velocity distributions were used with the Prandtl-VonKarman universal-velocity-distribution equation (Chow, 1964) to compute discharges for a stage-discharge rating curve. The rating curves were used to composite water-quality samples and obtain discharge hydrographs.

Six water-quality sampling stations were established; three on the Blue River and three on urban tributaries of the Blue River. Stations on the Blue River are located: (1) Near the mouth, near St. John Avenue; (2) just downstream from the confluence with Brush Creek at Coalmine Road; and (3) Swope Park near Gregory Boulevard, upstream from most urban development and downstream from agricultural land. The three sampling stations on urban tributaries are located: (1) Downstream from a mixed-urban land-use area on Brush Creek near its mouth at Elmwood Avenue; (2) downstream from a small, commercial land-use area at the Blue Ridge Mall storm sewer; and (3) downstream from a small, residential land-use area at Virginia Avenue in southern Kansas City (fig. 1). Samples were collected with automatic samplers at five stations and manually at the station on the Blue Ridge Mall storm sewer.

During July-October 1981, consecutive discrete samples collected at equal time increments were composited into one to four samples for each storm based on values of discharge. These composite samples were used to compute mean constituent concentrations during storms and to show general trends in water quality during periods of stormwater runoff. During April-July 1982, discrete samples were collected at the Blue River and Brush Creek stations at the start of stormwater runoff and during increased discharge to determine the effects of flushing of material accumulated in combined sewers and on land surfaces. All samples collected from the commercial and residential land-use areas were discharge-weighted composites. Sampling intervals were 7½ minutes to 1 hour depending on the size of the basin. Samples were collected from July 25 to October 17, 1981; and April 28 to July 6, 1982.

Although samples were not collected during the winter for this study, the analysis of a sample collected from Brush Creek during January for a study of combined sewer overflows indicated the concentrations of dissolved-solids to be more than 1,100 milligrams per liter. This large concentration of dissolved solids was related to washoff of deicing salts (Lamb, 1983).

Chemical analyses of water samples were made by the U.S. Geological Survey laboratory in Arvada, Colorado, for metals (total and dissolved), chemical-oxygen demand, total organic carbon, and dissolved solids, in accordance with procedures outlined by Skougstad and others (1979). Chemical analyses of water samples for nutrients (total and dissolved), turbidity, and 5-day biochemical-oxygen demand ($BOD_5$) were made according to procedures outlined by the U.S. Environmental Protection Agency (1979) at the agency's laboratory in Kansas City, Kansas. Analyses for suspended sediment and particle size were made in the U.S. Geological Survey Laboratory in Rolla, Missouri, according to procedures outlined by Guy (1969).

For this report, chemical constituents referred to as "total" or "total recoverable" were determined from unfiltered samples that were digested by a method that results in dissolution of readily soluble substances. "Dissolved" constituents were determined from samples that passed through 0.45 micrometer filters. Four reconnaissance samples were collected on April 15, 1981, on Blue River and Brush Creek near the end of a streamflow recession were analyzed for common contaminants usually present in runoff from urban areas. The resluts were used to guide the selection of constituents and properties to be determined for stormwater-runoff samples. Chemical- and biochemical-oxygen demands, dissolved solids, suspended-sediment, nutrients, metals, and total organic carbon were chosen as practical and acceptable for general water-quality characterization. This selection was supported by four high-flow samples that were analyzed for 103 of the U.S. Environmental Protection Agency's (1979) priortiy pollutants. Concentrations of analyzed constituents were less than detectable limits except certain metals, calcium, magnesium and 1, 1, 2, 2 tetrachloroethane. The priority-pollutant data are shown in the "Supplemental Information" section at the back of this report.

Two sets of depth-integrated, equal-discharge-increment samples from Blue River near Gregory Boulevard, one set from Blue River at Coalmine Road, and two sets from Brush Creek at Elmwood Avenue were collected concurrently with pumped samples collected from the automatic samplers. A comparison of suspended-sediment and dissolved-solids concentrations collected manually and automatically is shown in table 2. Total-iron analyses were included where suspended-sediment samples had been destroyed in transport. Concentrations for the automatically collected samples generally were typical of constituent concentrations representative of the entire stream cross section. This probably is the result of the natural mixing characteristics of the Blue River caused by large sinuosity, small width-to-height cross-section ratios, and increased velocities during high flows.

Table 2.--Comparison of suspended-sediment, dissolved-solids, and total-iron concentrations in manually and automatically collected samples

| Station number (fig. 1) | Station name | Discharge, at time of sample, in cubic feet per second | Suspended sediment, in milligrams per liter | | Percent[1] difference | Dissolved-solids, in milligrams per liter | | Percent[1] difference | Total iron, in micrograms per liter | | Percent[1] difference |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Manual | Automatic | | Manual | Automatic | | Manual | Automatic | |
| 4 | Blue River near Gregory Boulevard | 390 | ([2]) | ([2]) | ([2]) | 241 | 227 | -6 | 46,000 | 51,000 | +11 |
| | | 1,090 | 2,590 | 2,870 | +11 | 210 | 166 | -21 | --- | --- | --- |
| 6 | Brush Creek at Elmwood Avenue | 450 | 2,670 | 2,390 | 10 | 129 | 122 | -5 | --- | --- | --- |
| | | 1,990 | 323 | 251 | 22 | 98 | 94 | -4 | --- | --- | --- |
| 7 | Blue River at Coalmine Road | 745 | ([2]) | ([2]) | ([2]) | 346 | 317 | -8 | 28,000 | 20,000 | -29 |

[1]Percentage that the concentration for the automatically collected sample varies from the concentration for the manually collected sample.
[2]Suspended-sediment samples destroyed in transport. Total-iron concentrations substituted.

Although manually collected samples were not obtainable near St. John Avenue, adequate mixing at the low-head dam just upstream and average high-flow velocities between 6 and 8 feet per second in the vicinity of the sampler probably sustained a well-mixed flow. Therefore, it was assumed that automatically collected samples at this station were representative of the entire cross section.

## RAINFALL

Data for storm and antecedent rainfall for sampled storms collected at the seven raingages in the study area are presented in table 3. Rainfall for days with no corresponding runoff data is indicated by dashes.

## STREAMFLOW

The flow regime present during sampled storms was summarized with flow-duration information from a long-term station. The mean discharge and duration of runoff for the Blue River near Gregory Boulevard (drainage area, 203 square miles) and a mean daily flow-duration table for the Blue River at Bannister Road (drainage area, 188 square miles) were used to approximate the percentages of time flow in the Blue River exceeds the mean discharge of each storm sampled and are shown in table 4. The discharge and approximate flow duration at which sampling was begun on streamflow rises near Gregory Boulevard also are shown. Sampling began at the Blue River and Brush Creek stations when the stage reached approximately 2 feet more than the base-flow (sustained or fair-weather flow) gage height. All flows sampled are exceeded 10 percent of the time or less.

## QUALITY OF STORMWATER RUNOFF DETERMINED FROM COMPOSITE SAMPLES, JULY-OCTOBER 1981

Values of properties and concentrations of constituents in runoff are significantly affected by storm-specific conditions such as antecedent rainfall, rainfall distribution, quantity of runoff, and the time since the beginning of runoff. Therefore, storm-specific conditions are described for all stormwater runoff characterized by composite samples. When possible, water-quality data are interpreted in consideration of these conditions.

Mean values of selected properties and mean concentrations of selected constituents are plotted for each Blue River station in downstream order and connected by a straight line for each storm (numbered chronologically 1 through 5) in figure 3 and the data are summarized in table 5. The graphs in figure 3 show downstream changes in water quality caused by increasing quantities of urban runoff. Storm hydrographs and concurrent values for selected properties and concentrations for selected constituents are shown in figures 4 through 9 stations on the Blue River and Brush Creek. The values and concentrations shown are from composite samples collected during periods separated by the dashed vertical lines below the hydrographs. These lines divide the total volume of runoff into approximately equal fractions at a given site (that is, one-half, one-third, one-fourth). General variations of water quality with flow and time are shown in figures 4 through 9. Periods of missed samples are indicated by hatchured lines. Properties and constituents included in these figures were selected to indicate as much about the total water quality as possible. For example, because most total metals concentrations were significantly correlated

Table 3.--Storm and antecedent rainfall, in inches, for sampled storms

| Date of storm | Raytown Road (Commercial area and lower Blue River) (station 18, fig. 1) Storm total | Days previous 1 | 3 | 7 | 14 | Prairie Village, Kansas (Brush Creek) (station 17, fig. 1) Storm total | Days previous 1 | 3 | 7 | 14 | Gregory Boulevard (Lower Blue River) (station 16, fig. 1) Storm total | Days previous 1 | 3 | 7 | 14 | Morse, Kansas (Indian Creek) (station 13, fig. 1) Storm total | Days previous 1 | 3 | 7 | 14 | Stillwell, Kansas (Upper Blue River) (station 12, fig. 1) Storm total | Days previous 1 | 3 | 7 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| July 25, 1981 | 0 | 0 | 0 | -- | -- | 0.4 | 0 | 0 | 0 | -- | 0.9 | -- | -- | 1.4[a] | 2.1[a] | 1.1 | 0 | .1 | 1.1 | 2.6 | 2.0 | 0 | 0 | 0.2 | 4.6 |
| July 27-28, 1981 | 2.0 | 0 | 0 | 0 | -- | 3.4 | 0 | 0 | .4 | .4[a] | 1.9 | 0 | .9 | -- | -- | 2.2 | 0 | 1.2 | 1.3 | 3.8 | 1.3 | 0 | 2.0 | 2.0 | 6.6 |
| Sept. 1, 1981 | -- | -- | -- | -- | -- | .5 | 0 | 0 | 1.1 | 1.1 | .1 | 0 | 0 | .7 | .7 | .5 | .1 | .1 | 1.1 | 1.1 | 1.7 | -- | -- | -- | .9[a] |
| Oct. 13-14, 1981 | 1.2 | 0 | 0 | -- | -- | 2.1 | 0 | 0 | 0 | 0 | 2.5 | 0 | 0 | 0 | .6 | 2.4 | 0 | 0 | 0 | 1.0 | 2.3 | 0 | 0 | 0 | .4 |
| Oct. 17, 1981 | 1.1 | 0 | 0 | 1.2 | -- | .9 | 0 | 0 | 2.1 | 2.1 | .8 | 0 | .5 | 2.6 | 3.0 | .4 | 0 | .3 | 2.4 | 3.1 | .4 | 0 | 2.2 | 2.5 | 2.5 |

| Date of storm | Raytown Road (Commercial area and lower Blue River) (station 18, fig. 1) Storm total | Days previous 1 | 3 | 7 | 14 | Prairie Village, Kansas (Brush Creek) (station 17, fig. 1) Storm total | Days previous 1 | 3 | 7 | 14 | Virginia Avenue (Residential site) (station 15, fig. 1) Storm total | Days previous 1 | 3 | 7 | 14 | Olathe, Kansas (Indian Creek) (station 14, fig. 1) Storm total | Days previous 1 | 3 | 7 | 14 | Stillwell, Kansas (Upper Blue River) (station 12, fig. 1) Storm total | Days previous 1 | 3 | 7 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| April 28, 1982 | -- | 0 | -- | -- | -- | 1.3 | 0 | 0 | 0 | 0 | 1.5 | 0 | .3 | .3 | .5 | 0 | 0 | .4 | .4 | .8 | 0 | 0 | .3 | .3 | .8 |
| May 12, 1982 | .2 | .2 | .2 | .2 | -- | .5 | .2 | .2 | 1.1 | 2.4 | .4 | .6 | .6 | 1.1 | 1.1 | 1.5 | 0 | 0 | .6 | 2.3 | .5 | 0 | 0 | .8 | 2.4 |
| May 13, 1982 | .1 | .2 | .4 | .4 | -- | .1 | .5 | .7 | 1.0 | 1.5 | .1 | .4 | .9 | 1.1 | 1.5 | .5 | 1.5 | 1.5 | 2.2 | 3.9 | .3 | .5 | .5 | 1.3 | 2.8 |
| May 14, 1982 | 1.8 | .1 | .5 | .5 | -- | .8 | .1 | .8 | .8 | 1.7 | 1.0 | .1 | 1.0 | 1.0 | 1.6 | .5 | .5 | 2.0 | 2.1 | 2.1 | .7 | .3 | .8 | .9 | 1.6 |
| May 29, 1982 | .7 | 0 | .1 | .7 | 3.3 | .6 | 0 | 0 | -- | -- | .7 | 0 | 0 | .6 | 4.1 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| June 7, 1982 | -- | -- | -- | -- | -- | 1.3 | -- | -- | -- | 1.3 | .9 | 0 | 0 | .6 | 2.7 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| June 14-15, 1982 | .5 | 0 | .1 | 1.0 | 1.1 | -- | -- | -- | 1.2[a] | 2.5[a] | .5 | 0 | .2 | 1.1 | 2.3 | 0 | 0 | .2 | 1.8 | 3.5 | 0 | 0 | .2 | 2.7 | 4.8 |
| June 25, 1982 | .1 | 0 | 0 | .2 | .7 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| July 6, 1982 | -- | -- | -- | -- | -- | .3 | 0 | 0 | .1 | .1 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

[a]Value was at least as much as value shown.

Table 4.--Daily flow duration for the mean-storm discharge of sampled runoff in the Blue River near Gregory Boulevard

| Date of storm | Mean-storm[1] discharge, in cubic feet per second | Runoff duration, in hours | Flow duration for the Blue River at Bannister Road, in percent exceedence |
|---|---|---|---|
| July 25, 1981 | 917 | 19 | 2.8 |
| July 27-28, 1981 | 2,170 | 42 | 1.1 |
| Sept. 1, 1981 | 550 | 17 | 4.6 |
| Oct. 13-14, 1981 | 672 | 40 | 3.8 |
| Oct. 17, 1981 | 472 | 18 | 5.2 |
| Smallest discharge sampled | 245 | -- | 10.0 |

[1]Mean of discharge during entire period of runoff.

Table 5.--Mean values of properties and mean concentrations of constituents collected from the Blue River and Brush Creek for storms during 1981

[Results in milligrams per liter, except as indicated; µg/L, micrograms per liter; NTU, nephlometric turbidity units]

| Property or Constituent | Blue River near Gregory Boulevard (station 4, fig. 1) | | | | | Blue River at Coalmine Road (station 7, fig. 1) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Storm number[1] | | | | | Storm number[1] | | | | |
| | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| Specific conductance (micromhos per centimeter at 25 °Celsius) | 313 | 253 | 401 | 380 | 355 | 351 | 234 | 400 | 349 | 333 |
| pH (units) | 7.2 | 7.5 | 7.9 | 7.4 | 7.5 | 7.6 | 7.4 | 7.7 | 7.1 | 7.8 |
| Turbidity (NTU) | 133 | 288 | 158 | 157 | 157 | 141 | 171 | 175 | 162 | 150 |
| Chemical-oxygen demand | 196 | 109 | 115 | 91 | 101 | 150 | 94 | 135 | 69 | 114 |
| 5-day biochemical-oxygen demand | 9.7 | 5.1 | 6.9 | 11.3 | 13.4 | 5.0 | 6.3 | 7.9 | 11.8 | 13.2 |
| Dissolved solids | 244 | 159 | 241 | 217 | 217 | 222 | 146 | 234 | 189 | 189 |
| Suspended sediment | 3,110 | 2,450 | 1,380 | 897 | 1,050 | 2,810 | 1,850 | 1,390 | 838 | 1,070 |
| Total nitrite and nitrate as nitrogen | 1.3 | .79 | -- | .85 | .97 | 1.4 | .77 | -- | .78 | .72 |
| Dissolved nitrite and nitrate as nitrogen | 1.29 | .96 | 1.19 | -- | -- | 1.49 | 1.03 | 1.09 | -- | -- |
| Total ammonia as nitrogen | .56 | .23 | -- | .57 | .62 | .43 | .24 | -- | .58 | .44 |
| Dissolved ammonia as nitrogen | .32 | .08 | .18 | .47 | .49 | .28 | .02 | .29 | .31 | .33 |
| Total organic nitrogen | 6.1 | 4.8 | -- | 2.7 | 3.3 | 4.4 | 4.0 | -- | 2.7 | 3.3 |
| Dissolved organic nitrogen | 1.66 | .72 | 1.09 | .70 | .64 | .39 | .14 | .80 | .93 | .74 |

Table 5.--Mean values of properties and mean concentrations of constituents collected from the Blue River and Brush Creek for storms during 1981--Continued

| Property or constituent | Blue River near St. John Avenue (station 11, fig. 1) | | | | Brush Creek at Elmwood Avenue (station 6, fig. 1) | | | |
|---|---|---|---|---|---|---|---|---|
| | Storm number[1] | | | | Storm number[1] | | | |
| | 1 | 2 | 4 | 5 | 2 | 3 | 4 | 5 |
| Specific conductance (micromhos per centimeter at 25 °Celsius) | 484 | 246 | 439 | 403 | 180 | 216 | 152 | 150 |
| pH (units) | 7.6 | 7.5 | 6.8 | 7.7 | 6.9 | 7.6 | 7.0 | 7.5 |
| Turbidity (NTU) | 200 | 155 | 161 | 153 | 125 | 32 | 104 | 112 |
| Chemical-oxygen demand | -- | 139 | 111 | 94 | 180 | 140 | 129 | 117 |
| 5-day biochemical-oxygen demand | -- | 7.6 | 11.5 | 9.8 | .3 | 23 | 32 | 13 |
| Dissolved solids | 293 | 152 | 239 | 241 | 148 | 110 | 93 | 83 |
| Suspended sediment | 1,710 | 2,280 | 891 | 944 | 1,620 | 402 | 954 | 797 |
| Total nitrite and nitrate as nitrogen | 1.8 | .66 | .68 | .66 | .43 | .54 | .27 | .39 |
| Dissolved nitrite and nitrate as nitrogen | 1.83 | .91 | -- | -- | .45 | .54 | -- | -- |
| Total ammonia as nitrogen | .67 | .29 | .83 | .32 | .22 | -- | .39 | .11 |
| Dissolved ammonia as nitrogen | .39 | .13 | .66 | .25 | .17 | .04 | .28 | .90 |
| Total organic nitrogen | 2.8 | 4.4 | 3.0 | 2.4 | 5.6 | -- | 5.6 | -- |
| Dissolved organic nitrogen | .61 | .82 | .72 | .45 | 1.2 | -- | .73 | -- |

Table 5.--Mean values of properties and mean concentrations of constituents collected from the Blue River and Brush Creek for storms during 1981--Continued

| Property or constituent | Blue River near Gregory Boulevard (station 4, fig. 1) | | | | | Blue River at Coalmine Road (station 7, fig. 1) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Storm number[1] | | | | | Storm number[1] | | | | |
| | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| Total organic and ammonia nitrogen | 6.61 | 5.03 | 4.45 | 3.20 | 3.66 | 4.58 | 4.26 | 2.67 | 3.33 | 3.82 |
| Dissolved organic and ammonia nitrogen | 2.0 | .8 | 1.7 | 1.2 | 1.1 | 1.0 | .6 | 1.6 | 1.2 | 1.1 |
| Total nitrogen | 7.9 | 5.8 | -- | 4.1 | 4.9 | 6.2 | 5.0 | -- | 4.1 | 4.5 |
| Total phosphorus | 2.85 | 2.21 | 2.15 | 1.89 | 1.80 | 2.48 | 1.91 | 2.20 | 2.11 | 1.74 |
| Dissolved phosphorus | .59 | .16 | .61 | .54 | .47 | .28 | .11 | .51 | .54 | .35 |
| Total arsenic (µg/L) | 15 | 14 | 5 | 7 | 8 | 14 | 11 | 8 | 8 | 10 |
| Dissolved arsenic (µg/L) | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 |
| Total cadmium (µg/L) | 1 | 1 | 5 | 1 | 0 | 1 | 1 | 0 | 1 | 1 |
| Total chromium (µg/L) | 60 | 50 | 20 | 30 | 30 | 60 | 40 | 20 | 20 | 40 |
| Total copper (µg/L) | 80 | 53 | 31 | 29 | 50 | 68 | 51 | 38 | 31 | 37 |
| Dissolved copper (µg/L) | 10 | 6 | 4 | 3 | 3 | 6 | 4 | 4 | 3 | 2 |
| Total iron (µg/L) | 51,000 | 44,000 | 21,000 | 20,000 | 25,000 | 47,000 | 36,000 | 28,000 | 16,000 | 23,000 |
| Dissolved iron (µg/L) | 1,380 | 116 | 62 | 90 | 110 | 126 | 66 | 55 | 85 | 74 |
| Total lead (µg/L) | 64 | 38 | 26 | 38 | 62 | 77 | 100 | 39 | 66 | 109 |
| Total manganese (µg/L) | 1,830 | 1,460 | 930 | 800 | 1,060 | 1,840 | 1,190 | 1,200 | 690 | 940 |
| Total mercury (µg/L) | .3 | .2 | .1 | .1 | .1 | .2 | .2 | .0 | .6 | .3 |
| Total selenium (µg/L) | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total zinc (µg/L) | 250 | 200 | 110 | 120 | 180 | 240 | 210 | 170 | 140 | 200 |
| Dissolved zinc (µg/L) | 28 | 32 | 18 | 40 | 52 | 15 | 26 | 23 | 31 | 33 |
| Total organic carbon | 43 | 39 | -- | 25 | -- | 36 | 33 | -- | 28 | -- |

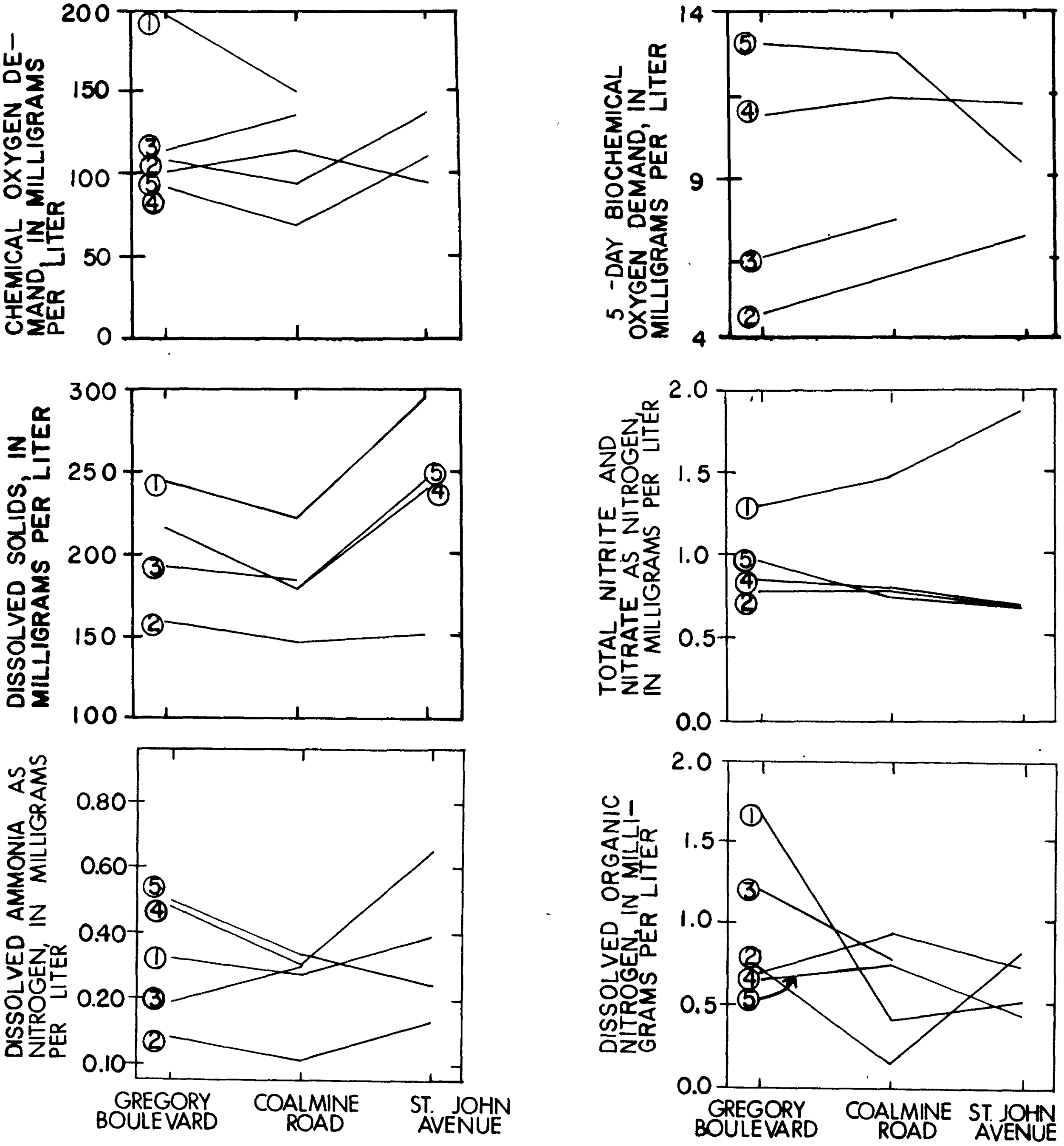
Table 5.--Mean values of properties and mean concentrations of constituents collected from the Blue River and Brush Creek for storms during 1981--continued

| Property or constituent | Blue River near St. John Avenue (station 11, fig. 1) | | | | Brush Creek at Elmwood Avenue (station 6, fig. 1) | | | |
|---|---|---|---|---|---|---|---|---|
| | Storm number[1] | | | | Storm number[1] | | | |
| | 1 | 2 | 4 | 5 | 2 | 3 | 4 | 5 |
| Total organic and ammonia nitrogen | 3.5 | 4.9 | 3.9 | 2.8 | 5.6 | 3.8 | 6.0 | 3.9 |
| Dissolved organic and ammonia nitrogen | 1.0 | 1.0 | 1.3 | .7 | 1.4 | .7 | 1.0 | .77 |
| Total nitrogen | 5.5 | 4.5 | 3.4 | 6.3 | -- | -- | 6.3 | 4.3 |
| Total phosphorus | 2.13 | 2.10 | 2.18 | 1.42 | 2.28 | 1.08 | 1.75 | 1.26 |
| Dissolved phosphorus | .33 | .09 | .52 | .28 | .22 | .12 | .24 | .18 |
| Total arsenic (μg/L) | 9 | 13 | 10 | 7 | 21 | 5 | 9 | 10 |
| Dissolved arsenic (μg/L) | 3 | 3 | 3 | 2 | 3 | 3 | 2 | 3 |
| Total copper (μg/L) | 51 | 62 | 45 | 47 | 100 | 46 | 58 | 43 |
| Dissolved copper (μg/L) | 3 | 3 | 2 | 2 | 8 | 6 | 3 | 3 |
| Total cadium (μg/L) | 1 | 1 | 2 | 3 | 2 | 3 | 3 | 2 |
| Total chromium | 50 | 50 | 30 | 30 | 70 | 30 | 50 | 20 |
| Total iron (μg/L) | 37,000 | 39,000 | 19,000 | 18,000 | 31,000 | 8,600 | 18,000 | 15,000 |
| Dissolved iron (μg/L) | 26 | 93 | 45 | 66 | 230 | 76 | 117 | 142 |
| Total lead (μg/L) | 82 | 114 | 93 | 94 | 480 | 300 | 345 | 226 |
| Total manganese (μg/L) | 1,500 | 1,320 | 760 | 760 | 1,600 | 490 | 979 | 667 |
| Total mercury (μg/L) | .2 | .2 | .1 | .2 | .5 | .2 | .4 | .2 |
| Total selenium (μg/L) | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |

Table 5.--Mean values of properties and mean concentrations of constituents collected from the Blue River and Brush Creek for storms during 1981--Continued

| Property or constituent | Blue River near St. John Avenue (station 11, fig. 1) | | | | Brush Creek at Elmwood Avenue (station 6, fig. 1) | | | |
|---|---|---|---|---|---|---|---|---|
| | Storm number[1] | | | | Storm number[1] | | | |
| | 1 | 2 | 4 | 5 | 2 | 3 | 4 | 5 |
| Total zinc (μg/L) | 230 | 310 | 240 | 270 | 540 | 720 | 380 | 260 |
| Dissolved zinc (μg/L) | 20 | 26 | 28 | 42 | 12 | 34 | 44 | 41 |
| Total organic carbon | -- | 34 | 30 | 26 | 37 | -- | 46 | 31 |

[1]Storm 1, July 25, 1981; storm 2, July 27-28, 1981; storm 3, September 1, 1981; storm 4, October 13-14, 1981; storm 5, October 17, 1981.




**EXPLANATION**

| STORM NUMBER | STORM DATE |
|---|---|
| ① | July 25, 1981 |
| ② | July 27-28, 1981 |
| ③ | September 1, 1981 |
| ④ | October 13-14, 1981 |
| ⑤ | October 17, 1981 |

(See figure 1 for location of stations)

Figure 3.--Downstream changes in mean values of selected properties and mean concentrations of selected constituents in stormwater runoff in the Blue River.

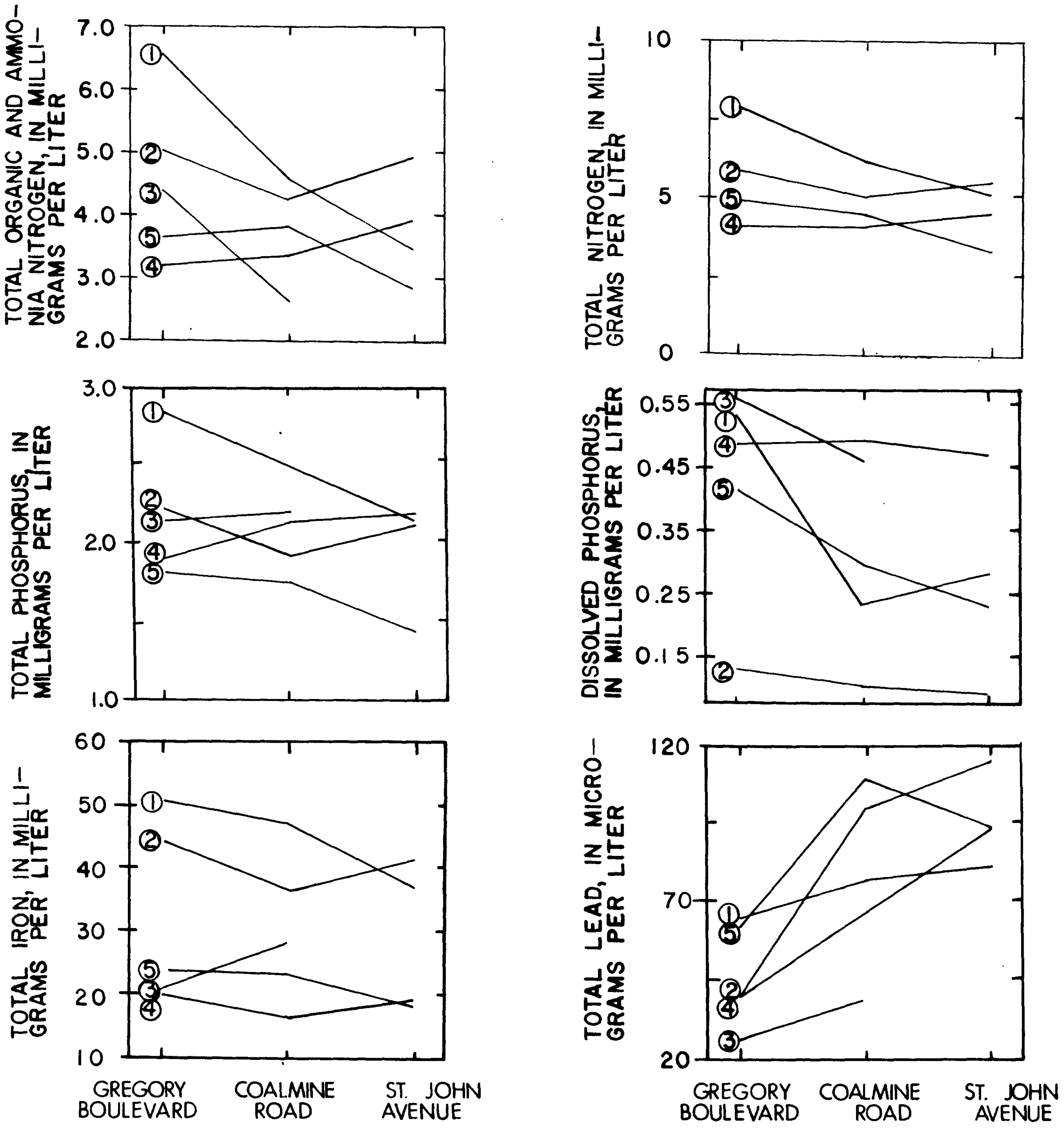



Figure 3.--Downstream changes in mean values of selected properties and mean concentrations of selected constituents in stormwater runoff in the Blue River--Continued.

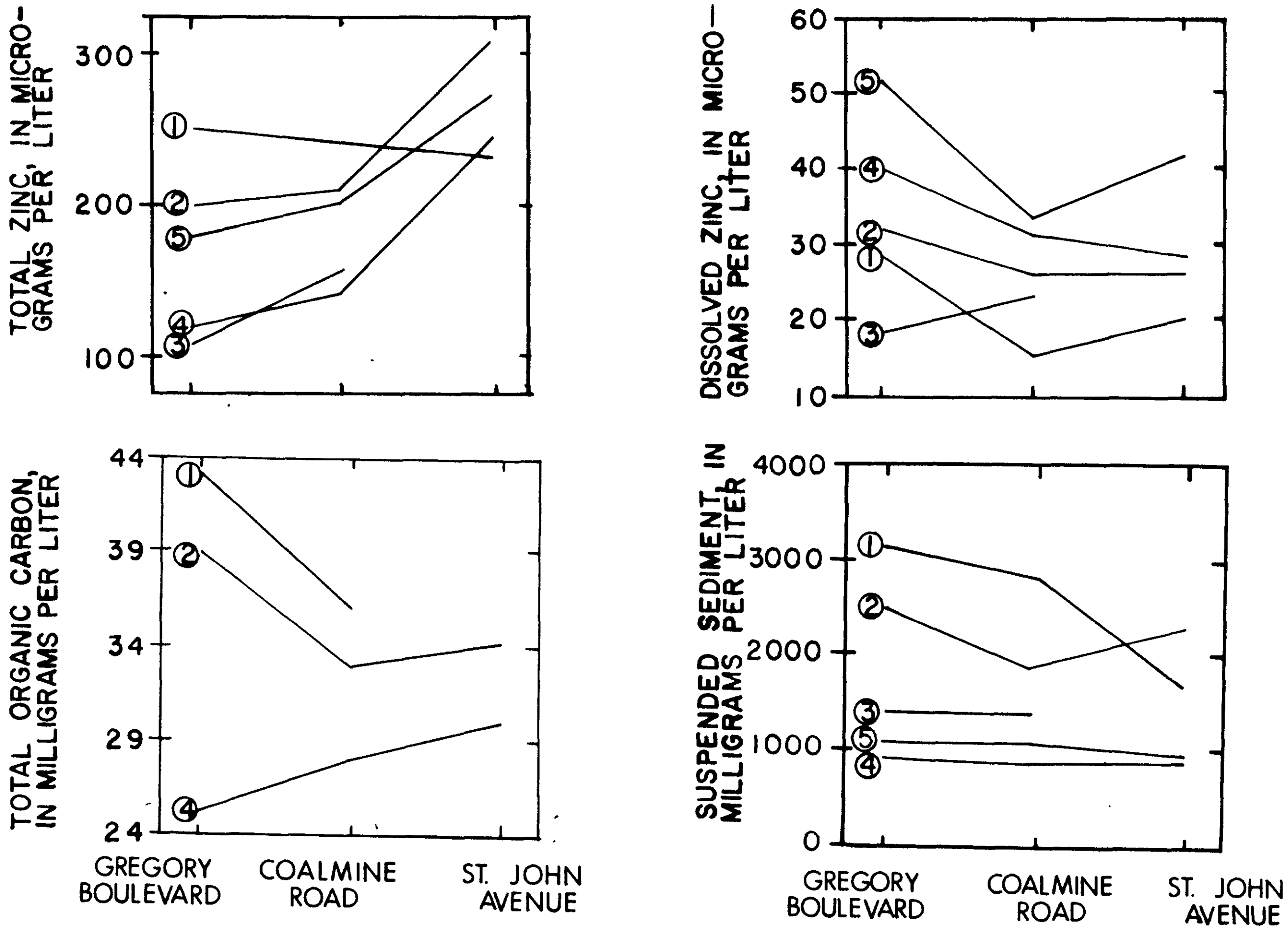



Figure 3.--Downstream changes in mean values of selected properties and mean concentrations of selected constituents in stormwater runoff in the Blue River--Continued.

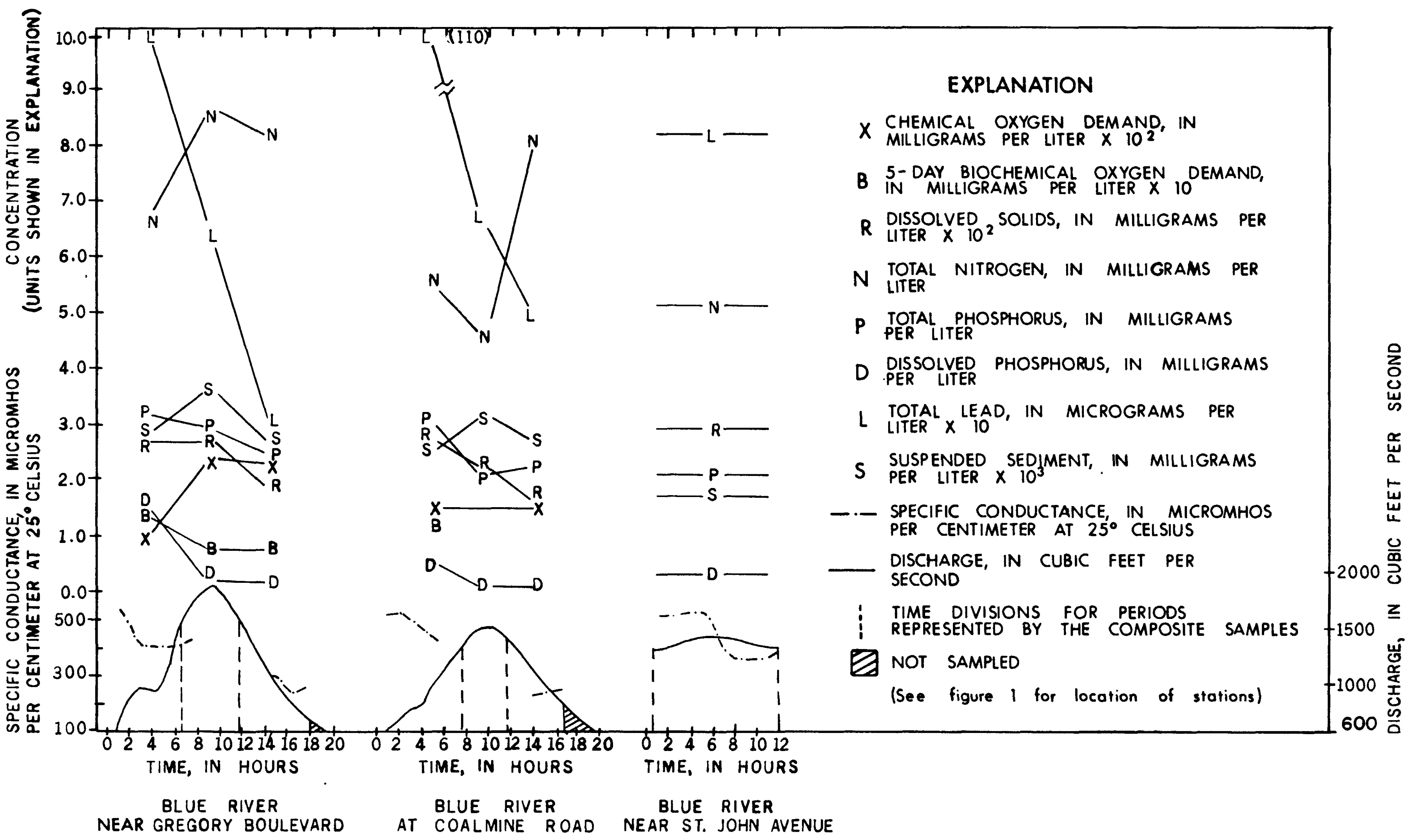



Figure 4.--Values of selected properties and concentrations of selected constituents in composite samples collected during stormwater runoff at selected stations on the Blue River for the storm of July 25, 1981.

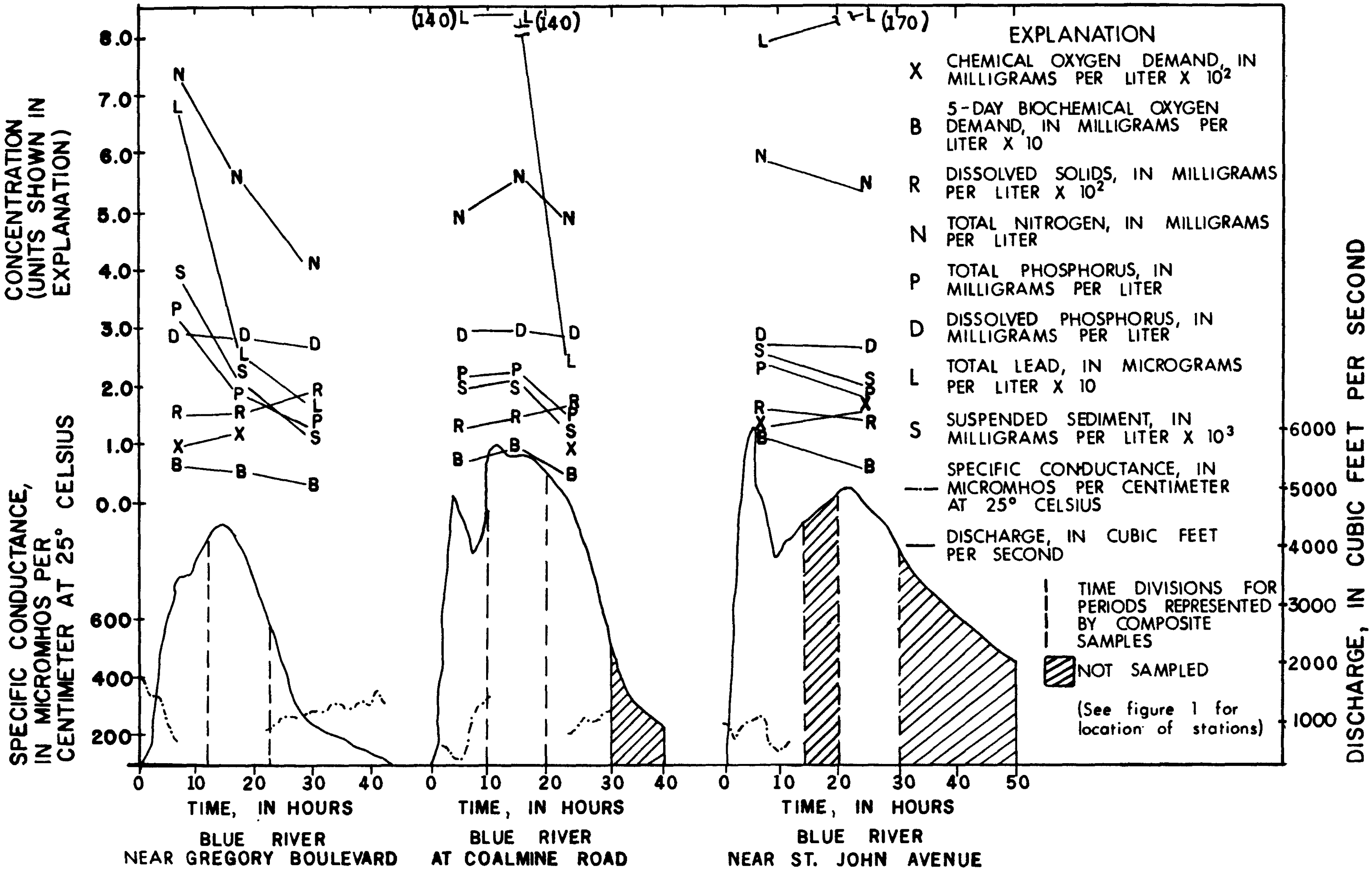



Figure 5.--Values of selected properties and concentrations of selected constituents in composite samples collected during stormwater runoff at all stations on the Blue River for the storm of July 27 - 28, 1981.

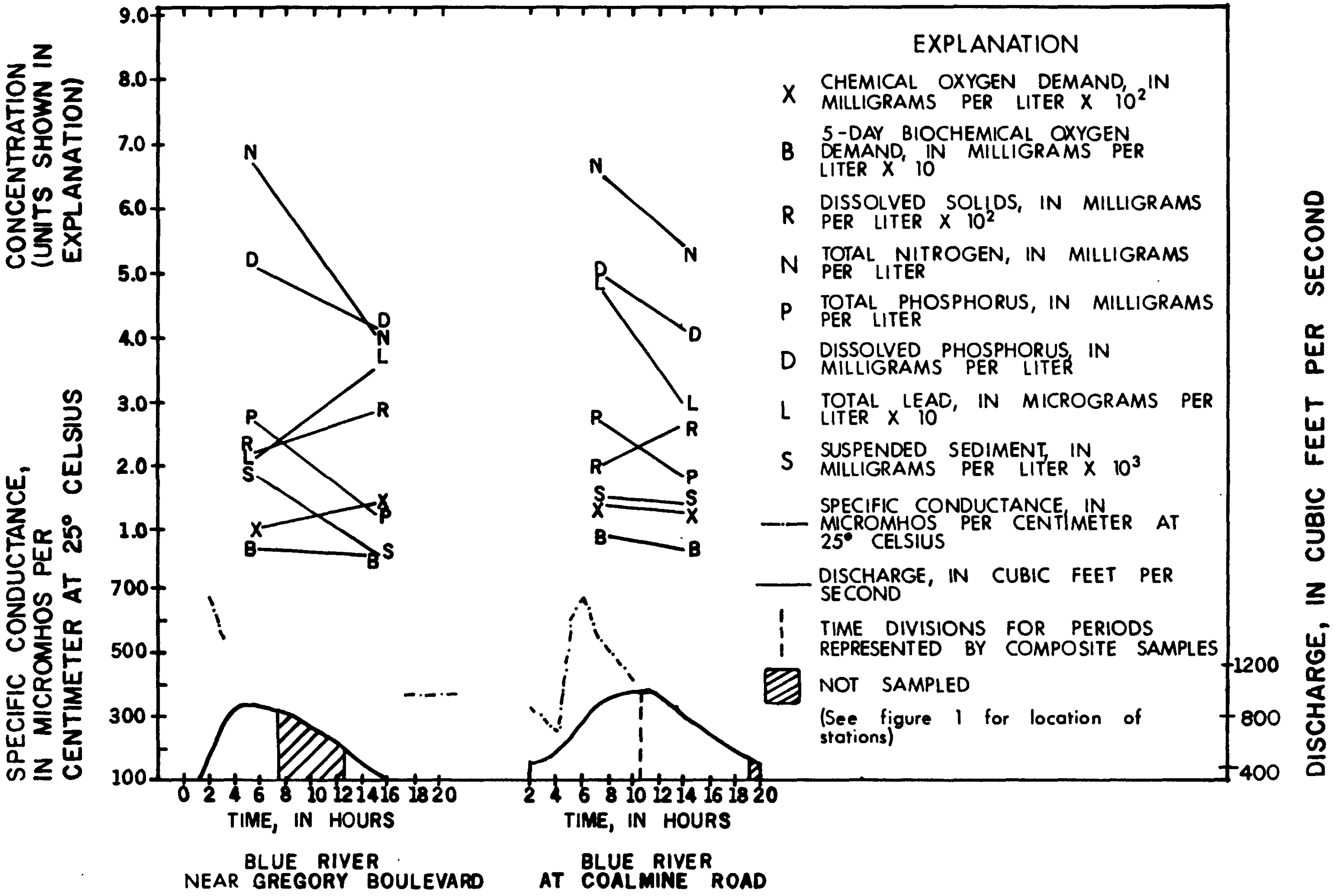



Figure 6.--Values of selected properties and concentrations of selected constituents in composite samples collected during stormwater runoff at selected stations on the Blue River for the storm of September 1, 1981.

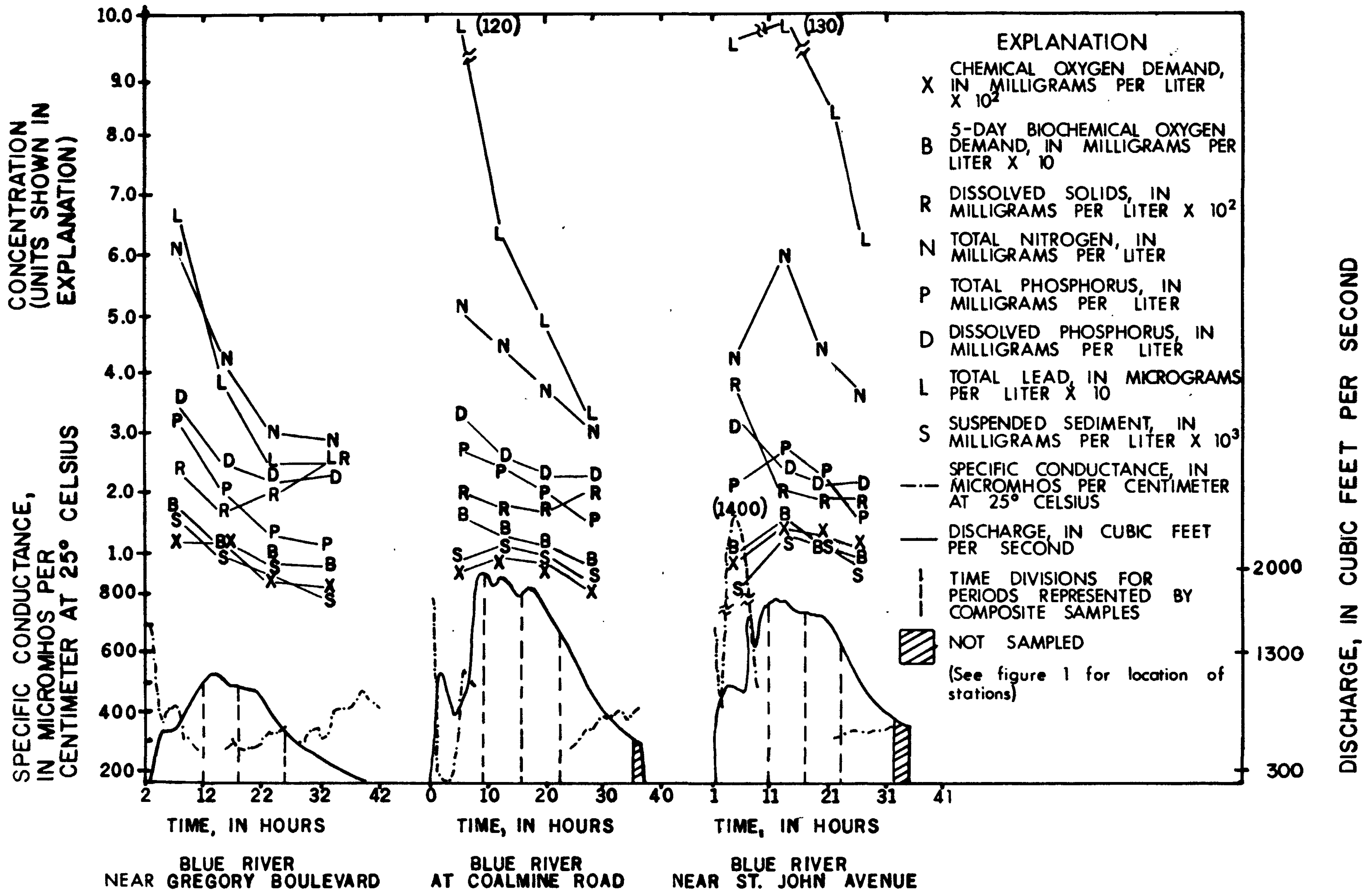



Figure 7.--Values of selected properties and concentrations of selected constituents in composite samples collected during stormwater runoff at all stations on the Blue River for the storm of October 13-14, 1981.

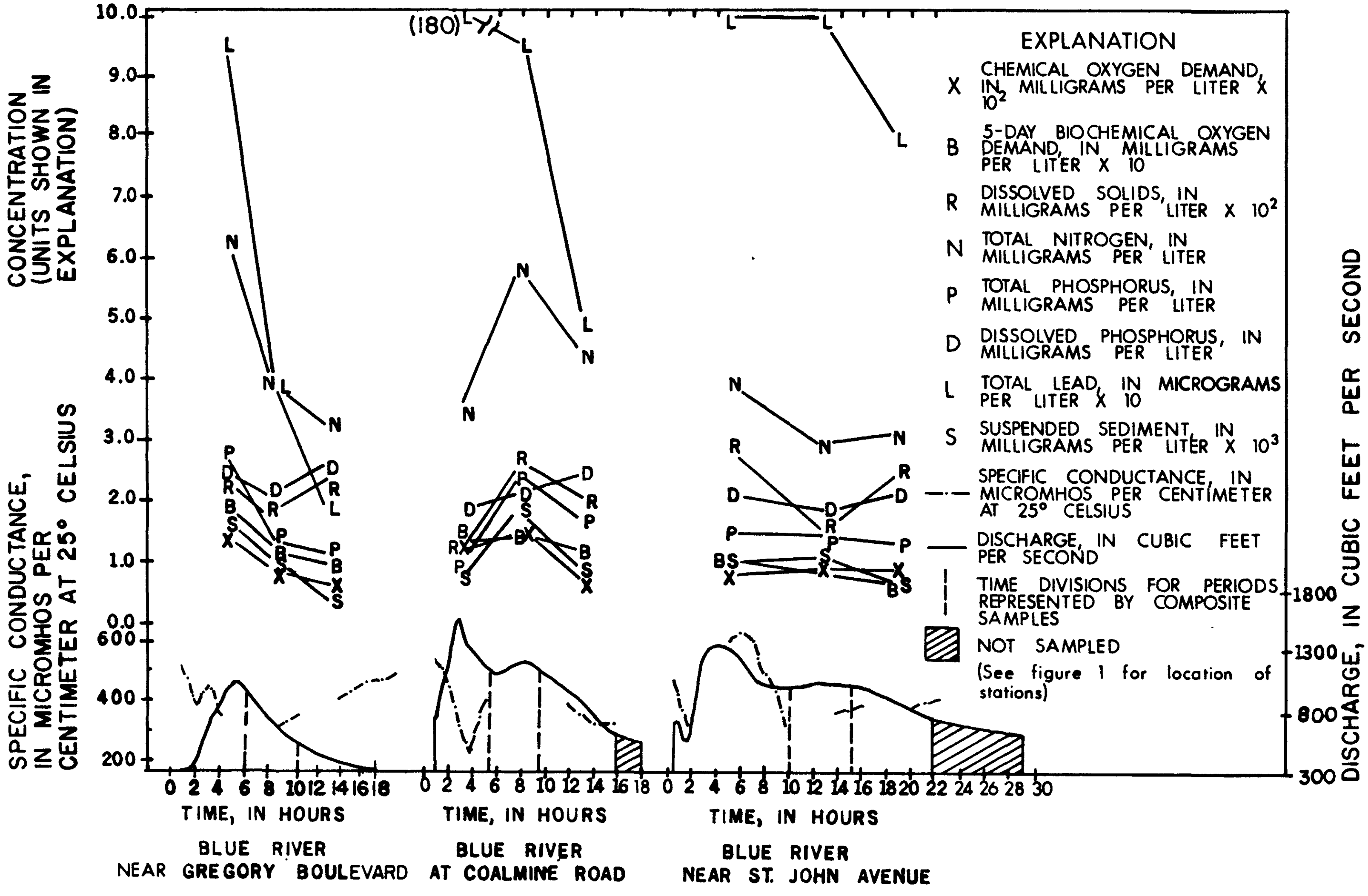



Figure 8.--Values of selected properties and concentrations of selected constituents in composite samples collected during stormwater runoff at all stations on the Blue River for the storm of October 17, 1981.

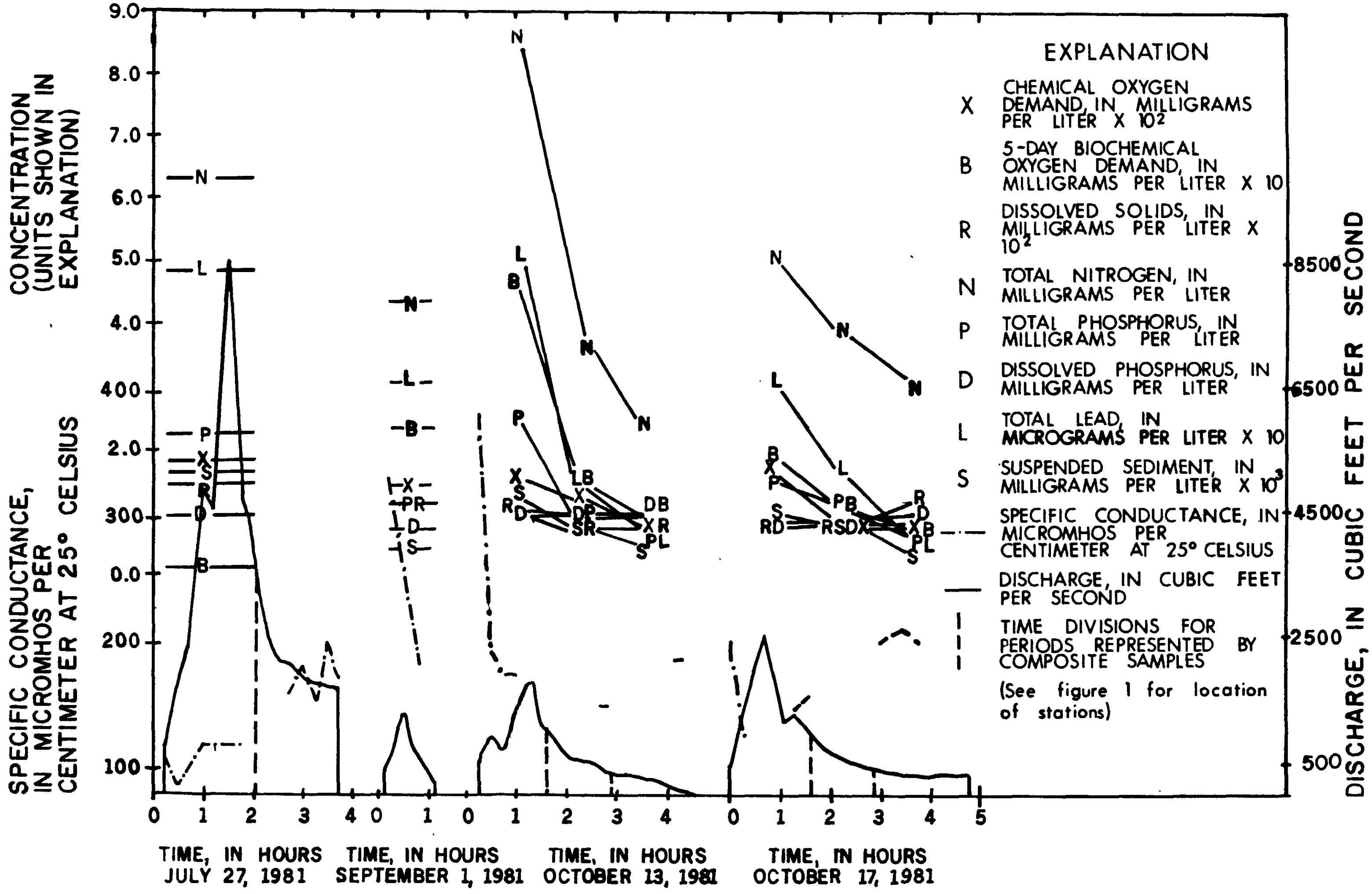



Figure 9.--Values of selected properties and concentrations of selected constituents in composite samples collected during stormwater runoff on Brush Creek at Elmwood Avenue for the storms of July 27-28, September 1, October 13-14, and October 17, 1981.

with suspended-sediment concentrations, (see "Relationship Between Concentrations of Constituents in the Suspended and Dissolved Phases and Sediment" section) only suspended sediment is shown. Trends detected for suspended sediment can be expected for most metals. Total nitrogen, total phosphorus, and dissolved phosphorus are plotted to indicate trends in nutrient concentrations. Total lead is plotted because it is an element related to vehicle exhaust and deposits on urban surfaces and is not well correlated with suspended sediment. Five-day biochemical-oxygen demand, chemical-oxygen demand, and to some extent suspended sediment, are plotted to represent major oxygen-demanding substances. Specific-conductance values were determined for all composite samples and any discrete samples with water remaining in the sample bottle after water for the composites were removed. Where specific-conductance values are available, they are shown as a dashed line on the hydrograph. Concentrations of constituents not plotted in figures 4-9 can be found in the "Supplemental Information" section at the back of this report.

Stormwater-runoff volumes and loads of 5-day biochemical-oxygen demand and selected dissolved and total constituents for all storms sampled during 1981 are shown in table 6 for the Blue River stations near Gregory Boulevard, at Coalmine Road, near St. John Avenue, and for Brush Creek at Elmwood Avenue. The volumes and loads represented by each composite sample are expressed as a percentage of total storm volumes and loads for the same storms and stations and are shown in tables 7-10.

## Storm 1, July 25, 1981

Most of this storm rainfall occurred on the rural, upstream areas of Blue River and Indian Creek. Antecedent rainfall quantities were minimal throughout most of the basin for the week preceding the storm; however, a large rainstorm occurred about 10 days earlier (table 3).

Runoff quality near Gregory Boulevard and at Coalmine Road was represented by three composite samples for storm 1 (fig. 4). Because of the extreme flatness of the hydrograph and an underestimation of discharge at lower gage heights at St. John Avenue, 60 percent of the storm runoff passed the gage in the rising and receding parts of the hydrograph below the gage height of sample activation. Consequently, there were not enough samples to make more than one composite (fig. 4). Brush Creek did not rise enough to allow thorough sampling.

Specific conductance values decreased initially during the runoff at each station as the more mineralized base flow was replaced with less mineralized runoff (fig. 4). The specific-conductance trace for runoff at St. John Avenue shows an abrupt break, indicating the time when base-flow water impounded behind the low-head dams (fig. 1) was replaced by upstream runoff. The $BOD_5$ also was largest in the first composite and generally decreased in subsequent samples.

Although this storm produced little runoff from urban areas, it produced the largest concentrations of suspended sediment in the Blue River of the five storms. This indicates that the upstream agricultural area is the source for most of the suspended sediment and associated nutrients and metals.

Table 6.--Stormwater-runoff volume and loads of 5-day biochemical-oxygen demand and selected dissolved and total constituents at the Blue River and Brush Creek stations for storms during 1981

[Station number (figure 1): 4, Blue River near Gregory Boulevard; 7, Blue River at Coalmine Road; 11, Blue River near St. John Avenue; 6, Brush Creek at Elmwood Avenue]

| Date of storm | Station number | Stormwater-runoff volume (cubic feet x $10^6$) | 5-day biochemical oxygen demand (tons) | Dissolved solids (tons) | Suspended sediment (tons) | Total nitrogen (tons) |
|---|---|---|---|---|---|---|
| July 25, 1981 | 4 | 71.9 | 22 | 541 | 6,940 | 18 |
| | 7 | 81.0 | -- | 554 | 7,030 | 16 |
| | 11 | 81.1 | -- | 742 | 4,330 | 13 |
| | 6 | -- | -- | -- | -- | -- |
| July 27-28, 1981 | 4 | 329 | 52 | 1,630 | 25,200 | 60 |
| | 7 | 554 | 105 | 2,570 | 31,000 | 86 |
| | 11 | 845 | 108 | 3,900 | 55,900 | 145 |
| | 6 | -- | -- | -- | -- | -- |
| Sept. 1, 1981 | 4 | 38.8 | 8.3 | 293 | 1,670 | -- |
| | 7 | 51.9 | 13 | 384 | 2,250 | -- |
| | 11 | -- | -- | -- | -- | -- |
| | 6 | 3.74 | 3.8 | 12.8 | 46.9 | -- |
| Oct. 13-14, 1981 | 4 | 94.5 | 34 | 628 | 2,770 | 12 |
| | 7 | 170 | 62 | 1,010 | 4,420 | 22 |
| | 11 | 176 | 62 | 1,280 | 4,850 | 25 |
| | 6 | 10.9 | 11 | 31.8 | 325 | .21 |
| Oct. 17, 1981 | 4 | 30.6 | 14 | 210 | 1,120 | 4.7 |
| | 7 | 60.8 | 25 | 362 | 1,990 | 8.6 |
| | 11 | 65.3 | 36 | 499 | 1,820 | 7.0 |
| | 6 | 13.4 | 5.7 | 35.3 | 333 | 1.8 |

Table 6.--Stormwater-runoff volume and loads of 5-day biochemical-oxygen demand and selected dissolved and total constituents at the Blue River and Brush Creek stations for storms during 1981--Continued

| Date of storm | Station number | Total phosphorus (tons) | Dissolved phosphorus (tons) | Total lead (tons) | Total zinc (tons) |
|---|---|---|---|---|---|
| July 25, 1981 | 4 | 6.38 | 1.3 | 0.14 | 0.534 |
| | 7 | 6.27 | .70 | 0.19 | 0.490 |
| | 11 | 5.39 | .84 | 0.21 | 0.216 |
| | 6 | -- | -- | -- | -- |
| July 27-28, 1981 | 4 | 22.7 | 1.7 | .40 | 2.10 |
| | 7 | 31.8 | 2.0 | 1.6 | 3.15 |
| | 11 | 51.7 | 2.3 | 3.8 | 9.53 |
| | 6 | -- | -- | -- | -- |
| Sept. 1, 1981 | 4 | 2.59 | .74 | .032 | .093 |
| | 7 | 3.50 | .79 | .061 | .253 |
| | 11 | -- | -- | -- | -- |
| | 6 | .126 | .014 | .035 | .023 |
| Oct. 13-14, 1981 | 4 | 5.69 | 1.6 | .11 | .468 |
| | 7 | 11.1 | 2.8 | .35 | .745 |
| | 11 | 11.5 | 2.7 | .49 | 1.15 |
| | 6 | .596 | .083 | .12 | .131 |
| Oct. 17, 1981 | 4 | 1.87 | .46 | .059 | .177 |
| | 7 | 3.30 | .69 | .20 | .350 |
| | 11 | 2.83 | .58 | .19 | .397 |
| | 6 | .527 | .073 | .096 | .110 |

Table 7.--Percentages of total stormwater-runoff volume and loads of 5-day biochemical-oxygen demand and selected dissolved and total constituents represented by each composite sample collected for each storm during 1981 at the Blue River near Gregory Boulevard station

[NS, not sampled; loads from unsampled periods of runoff were estimated from concentrations in samples collected immediately before and after the unsampled period]

| Date of storm | Composite-sample number | Percent of total storm-water runoff volume | Percent of total loads: 5-day biochemical oxygen demand | Dissolved solids | Suspended sediment | Total nitrogen | Total phosphorus | Dissolved phosphorus | Total lead | Total zinc |
|---|---|---|---|---|---|---|---|---|---|---|
| July 25, 1981 | 1 | 28 | 40 | 31 | 26 | 23 | 31 | 72 | 44 | 31 |
| | 2 | 38 | 31 | 43 | 45 | 42 | 39 | 16 | 39 | 42 |
| | 3 | 30 | 25 | 23 | 25 | 31 | 26 | 10 | 15 | 24 |
| | NS | 4 | 4 | 3 | 4 | 4 | 4 | 2 | 2 | 3 |
| July 27-28, 1981 | 1 | 36 | 45 | 33 | 56 | 44 | 51 | 39 | 63 | 53 |
| | 2 | 41 | 42 | 40 | 34 | 40 | 36 | 41 | 27 | 34 |
| | 3 | 23 | 13 | 27 | 10 | 16 | 13 | 20 | 10 | 13 |
| Sept. 1, 1981 | 1 | 46 | 48 | 40 | 64 | -- | 59 | 62 | 35 | 29 |
| | NS | 28 | 27 | 29 | 25 | -- | 26 | 25 | 29 | 31 |
| | 2 | 26 | 25 | 31 | 11 | -- | 15 | 13 | 36 | 40 |
| Oct. 13-14, 1981 | 1 | 27 | 40 | 30 | 49 | 41 | 46 | 48 | 48 | 47 |
| | 2 | 25 | 26 | 20 | 26 | 24 | 25 | 21 | 25 | 28 |
| | 3 | 28 | 20 | 26 | 18 | 21 | 18 | 17 | 19 | 17 |
| | 4 | 20 | 14 | 24 | 7 | 14 | 11 | 14 | 8 | 8 |
| Oct. 17, 1981 | 1 | 50 | 63 | 53 | 73 | 63 | 69 | 56 | 77 | 64 |
| | 2 | 26 | 20 | 21 | 19 | 20 | 18 | 17 | 16 | 27 |
| | 3 | 24 | 17 | 26 | 8 | 17 | 13 | 27 | 7 | 9 |

Table 8.--Percentages of total stormwater-runoff volume and loads of 5-day biochemical-oxygen demand and selected dissolved and total constituents represented by each composite sample collected for each storm during 1981 at the Blue River at Coalmine Road station

[NS, not sampled; loads from unsampled periods of runoff were estimated from concentrations in samples collected immediately before and after the unsampled period]

| Date of storm | Composite-sample number | Percent of total storm-water runoff volume | Percent of total loads | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 5-day biochemical oxygen demand | Dissolved solids | Suspended sediment | Total nitrogen | Total phosphorus | Dissolved phosphorus | Total lead | Total zinc |
| July 25, 1981 | 1 | 35 | -- | 48 | 35 | 33 | 47 | 77 | 55 | 39 |
| | 2 | 27 | -- | 27 | 31 | 20 | 23 | 14 | 24 | 28 |
| | 3 | 26 | -- | 19 | 25 | 33 | 23 | 9 | 17 | 23 |
| | NS | 12 | -- | 6 | 9 | 14 | 7 | 0 | 4 | 10 |
| July 27-28, 1981 | 1 | 28 | 32 | 25 | 32 | 28 | 33 | 30 | 43 | 36 |
| | 2 | 29 | 39 | 28 | 35 | 32 | 35 | 25 | 45 | 33 |
| | 3 | 30 | 20 | 33 | 23 | 28 | 23 | 32 | 8 | 22 |
| | NS | 13 | 9 | 14 | 10 | 12 | 9 | 13 | 4 | 9 |
| Sept. 1, 1981 | 1 | 46 | 53 | 39 | 48 | -- | 58 | 70 | 59 | 55 |
| | 2 | 46 | 40 | 52 | 44 | -- | 36 | 25 | 35 | 38 |
| | NS | 8 | 7 | 9 | 8 | -- | 6 | 5 | 6 | 6 |
| Oct. 13-14, 1981 | 1 | 24 | 33 | 26 | 25 | 31 | 31 | 41 | 45 | 32 |
| | 2 | 24 | 24 | 22 | 31 | 26 | 28 | 23 | 24 | 24 |
| | 3 | 22 | 21 | 19 | 23 | 20 | 21 | 17 | 16 | 19 |
| | 4 | 27 | 20 | 30 | 19 | 21 | 19 | 17 | 14 | 23 |
| | NS | 3 | 2 | 3 | 2 | 2 | 1 | 2 | 1 | 2 |
| Oct. 17, 1981 | 1 | 32 | 32 | 20 | 21 | 25 | 21 | 16 | 55 | 36 |
| | 2 | 25 | 29 | 34 | 44 | 33 | 37 | 24 | 24 | 34 |
| | 3 | 33 | 30 | 35 | 27 | 32 | 32 | 46 | 16 | 23 |
| | NS | 10 | 9 | 11 | 8 | 10 | 10 | 14 | 5 | 7 |



5/8"

5/8"

Table 9.--Percentages of total stormwater-runoff volume and loads of 5-day biochemical-oxygen demand and selected dissolved and total constituents represented by each composite sample collected for each storm during 1981 at the Blue River at St. John Avenue station

[NS, not sampled; loads from unsampled periods of runoff were estimated from concentrations in samples collected immediately before and after the unsampled period]

| Date of storm | Composite-sample number | Percent of total stormwater runoff volume | Percent of total loads: 5-day biochemical oxygen demand | Dissolved solids | Suspended sediment | Total nitrogen | Total phosphorus | Dissolved phosphorus | Total lead | Total zinc |
|---|---|---|---|---|---|---|---|---|---|---|
| July 27-28, 1981 | 1 | 24 | 32 | 26 | 29 | 26 | 29 | 28 | 13 | 14 |
| | NS | 12 | 12 | 11 | 13 | 12 | 13 | 13 | 11 | 10 |
| | 2 | 20 | 18 | 20 | 18 | 20 | 18 | 19 | 24 | 24 |
| | NS | 44 | 38 | 43 | 40 | 42 | 40 | 40 | 52 | 52 |
| Oct. 13-14, 1981 | 1 | 23 | 19 | 34 | 7 | 21 | 22 | 39 | 23 | 27 |
| | 2 | 21 | 28 | 19 | 31 | 28 | 28 | 19 | 31 | 26 |
| | 3 | 20 | 21 | 16 | 26 | 20 | 21 | 15 | 19 | 18 |
| | 4 | 25 | 21 | 20 | 24 | 20 | 19 | 17 | 17 | 20 |
| | NS | 11 | 11 | 11 | 12 | 11 | 10 | 10 | 10 | 9 |
| Oct. 17, 1981 | 1 | 41 | 25 | 46 | 45 | 45 | 44 | 44 | 44 | 51 |
| | 2 | 14 | 56 | 9 | 16 | 2 | 14 | 9 | 16 | 16 |
| | 3 | 18 | 7 | 17 | 15 | 16 | 16 | 18 | 15 | 13 |
| | NS | 27 | 12 | 28 | 24 | 37 | 26 | 29 | 25 | 20 |

13/16"

9/16"

Table 10.--Percentages of total stormwater-runoff volume and loads of 5-day biochemical-oxygen demand and selected dissolved and total constituents represented by each composite sample collected for each storm during 1981 at the Brush Creek at Elmwood Avenue station

| Date of storm | Composite-sample number | Percent of total storm-water runoff volume | Percent of total loads | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 5-day biochemical oxygen demand | Dissolved solids | Suspended sediment | Total nitrogen | Total phosphorus | Dissolved phosphorus | Total lead | Total zinc |
| Oct. 13-14, 1981 | 1 | 57 | 83 | 66 | 73 | 79 | 80 | 59 | 85 | 81 |
| | 2 | 26 | 12 | 20 | 19 | 15 | 14 | 25 | 12 | 15 |
| | 3 | 17 | 5 | 14 | 8 | 6 | 6 | 16 | 3 | 4 |
| Oct. 17, 1981 | 1 | 59 | 73 | 52 | 68 | 68 | 69 | 55 | 79 | 74 |
| | 2 | 23 | 17 | 22 | 25 | 20 | 21 | 21 | 16 | 20 |
| | 3 | 18 | 10 | 26 | 7 | 12 | 10 | 24 | 5 | 6 |

3/4"

Both suspended-sediment concentrations and loads show the effects of small runoff contributions from the downstream, urbanized part of the basin (table 6). Runoff entered the sampled reach at Gregory Boulevard with the largest concentrations of suspended sediment because the sediment-carrying capacity of the stream decreased with attenuation of the hydrograph in a downstream direction. The total storm load of suspended-sediment was nearly constant between Gregory Boulevard and Coalmine Road and decreased between Coalmine Road and St. John Avenue. Most of the suspended sediment in the downstream reach probably was deposited behind two low-head dams just upstream from the St. John Avenue site (fig. 1).

Total nutrient and metals concentrations, which are closely associated with suspended sediment, were larger for this storm than any other near Gregory Boulevard and at Coalmine Road (fig. 3, table 5). Distribution of concentrations and loads show suspended-sediment concentrations peaking during the middle part of the runoff at both stations, indicating discharge as the controlling factor (fig. 4, tables 7-8).

Nitrification is apparent because of the small volume of runoff downstream. Downstream, ammonia and organic nitrogen decreased by almost 50 percent, whereas nitrite and nitrate nitrogen increased by more than 40 percent. Although some unoxidized nitrogen probably was deposited with the sediment between Coalmine Road and St. John Avenue, it appears that nitrification occurred during the movement downstream.

Dissolved phosphorus and total lead were the only constituents that could be described as being flushed by initial runoff. About 75 percent of the dissolved-phosphorus and slightly more than 50 percent of the total-lead loads were in the first one-third of the volume at both the Gregory Boulevard and Coalmine Road stations (tables 7 and 8).

## Storm 2, July 27-28, 1981

The volume of runoff for storm 2 was greater than that for the other four 1981 storms combined because 1.3 to 3.4 inches of rain fell on the Blue River basin after receiving significant rainfall 2 days earlier (table 3). The largest rainfall occurred on the Brush Creek basin in contrast with storm 1, which primarily occurred in the upstream agricultural areas.

Most concentrations of $BOD_5$ and dissolved constituents were smaller for this storm than any other because of dilution (fig. 3, table 5). However, the large volume of runoff from this storm caused the total loads of most constituents in Blue River to be larger than the total of the other four storms (table 6).

The distribution of concentrations and loads during runoff had different patterns at each station (fig. 5, tables 7-9). At Gregory Boulevard more than one-half the suspended-sediment load was transported during the first one-third of the volume. Total lead showed an even more notable flushing pattern, and $BOD_5$ showed a gradual decrease during runoff.

At Coalmine Road, inflows from Brush Creek diluted concentrations of most constituents in the first composite sample, decreasing the effects of upstream flushing (fig. 5). Concentrations of most constituents in the remaining composite samples were similar to concentrations in the last two composite samples collected at Gregory Boulevard. Specific conductance values at Coalmine Road (fig. 5) show a significant initial decrease, resulting from dilution by less mineralized water from Brush Creek. Although concentration and loads of suspended sediment from Brush Creek were larger for this storm than for any other, they were still less than those in the Blue River. A sampler malfunction prevented the collection of a composite sample representing the last part of stormwater runoff at Coalmine Road.

At St. John Avenue, malfunction of the automatic sampler prevented sampling of parts of the stormwater runoff and only two composite samples could be obtained. Loads for missing periods were estimated by interpolation or extrapolation of concentrations nearest the missing period. The discharge hydrograph (fig. 5) shows a rapid rise and decline from local urban runoff and show little trend in loads or concentrations during runoff.

Flow volume and total loadings of six constituents per unit area for three parts of the Blue River basin are shown in figure 10: (1) Blue River upstream from Gregory Boulevard, (2) the intervening drainage area between Gregory Boulevard and Coalmine Road, and (3) the intervening drainage area between Coalmine Road and St. John Avenue. These bar charts indicate loadings for suspended sediment, total nitrogen, total phosphorus, dissolved solids, total lead, and total zinc were greater for the urban areas than for the upstream agricultural areas. The primary cause for the downstream increase in loads was the increase in runoff per unit drainage area (fig. 10) that resulted from larger quantities of rain and larger percentages of impervious surfaces in the urban areas.

Suspended-sediment loads nearly doubled between Coalmine Road and St. John Avenue with only a 9 percent increase in drainage area, which indicates the unlined channel in lower Brush Creek and Blue River between Coalmine Road and St. John Avenue was the main source of sediment (table 6). Similar increases occurred for the nutrients and metals associated with sediment. Concentrations of total lead and total zinc increased downstream through the urban reach of the Blue River (fig. 3). Despite the large volume of runoff, Brush Creek had the largest lead and zinc concentrations in storm 2 of all those sampled (table 5), probably from resuspension of lead-laden sediment in the unlined channel of lower Brush Creek. The total-lead load quadrupled and the total-zinc load increased 50 percent in Blue River between Gregory Boulevard and Coalmine Road (table 6) with only an 18 percent increase in drainage area.

### Storm 3, September 1, 1981

Storm 3 was relatively small, with rainfall being largest in the upstream part of the Blue River basin (table 3). Only minor rainfall was recorded during the perevious 3 days; however, more than 1 inch of rainfall was recorded in large parts of the basin from 3 to 7 days before this storm. One-half inch of rainfall was enough to produce a small rise at the gage on Brush Creek, but Blue River was not high enough to sample at St. John Avenue, the farthest downstream site. At Gregory Boulevard and Coalmine Road the storm was of such short duration that only two composites could be made at each site. Twenty-seven percent of the hydrograph at Gregory Boulevard was missed because of sampler malfunction. Loads for this period were interpolated from composite concentrations on either side of the missing period.

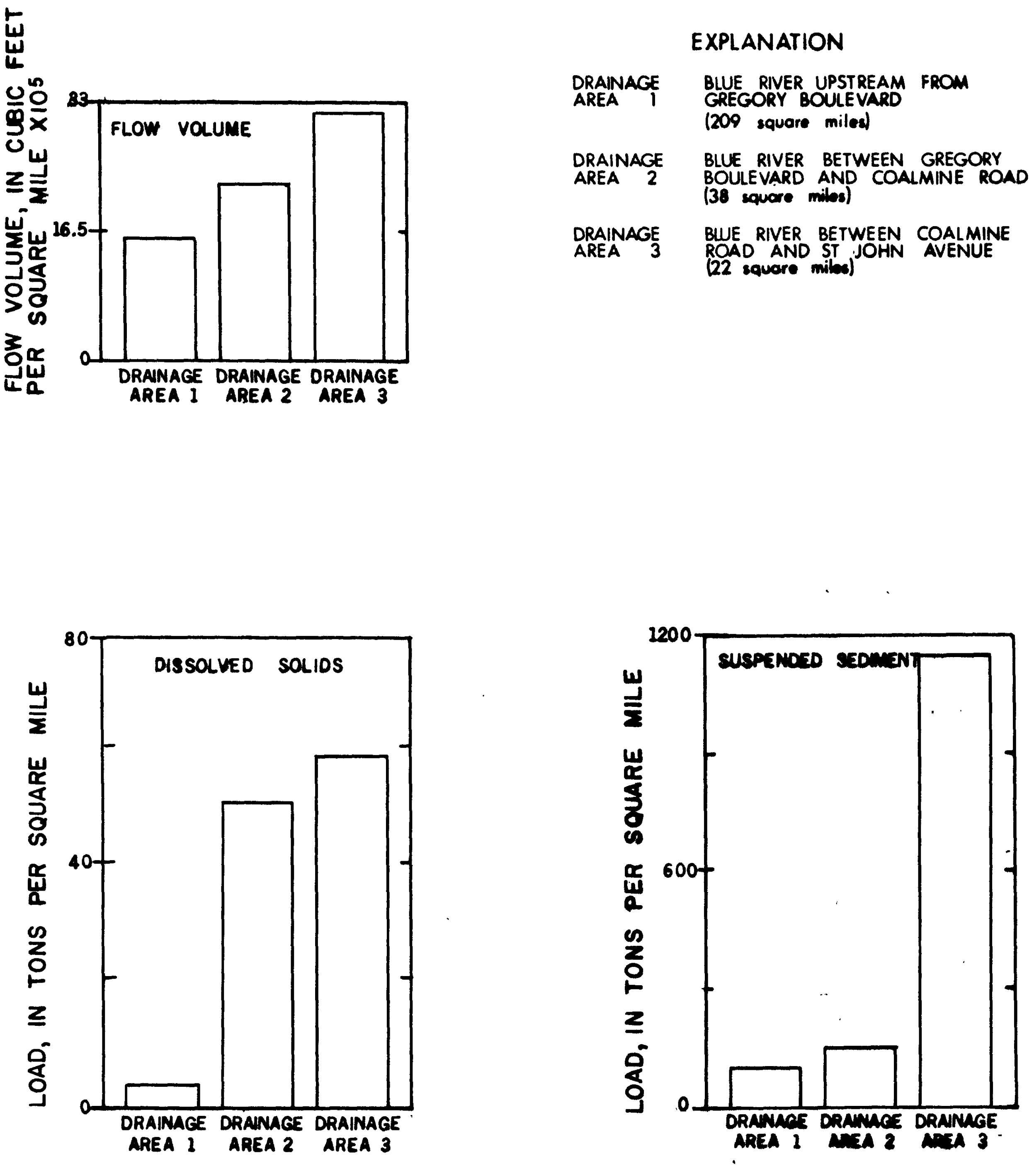



Figure 10.--Flow volume and loads for six constituents in stormwater runoff for the storm of July 27-28, 1981, for three incremental drainage areas in the Blue River basin.

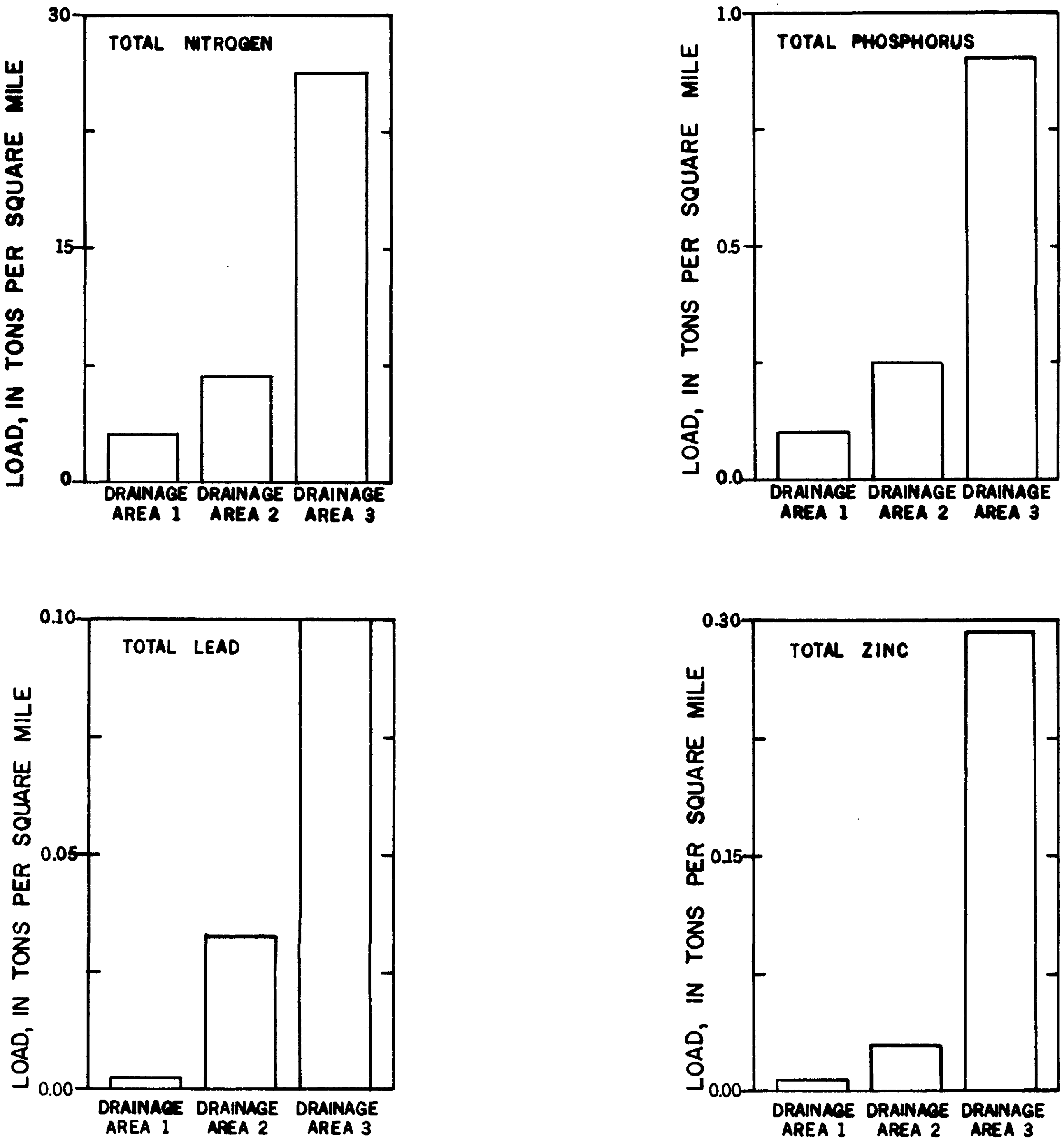



Figure 10.--Flow volume and loads for six constituents in stormwater runoff for the storm of July 27-28, 1981, for three incremental drainage areas in the Blue River basin --Continued.

The average $BOD_5$ from Brush Creek was three times that found in Blue River and was more than 75 times that from Brush Creek in the previous storm (table 5). This large concentration can be attributed to combined sewer overflows diluted by only small volumes of runoff.

Although concentrations of suspended sediment and most dissolved constituents were smaller in runoff coming from Brush Creek than Blue River (table 5), the effects were not discernible at Coalmine Road (fig. 3), because the volume of runoff in Blue River was more than 13 times that from Brush Creek (table 6). Concentration and load of suspended sediment were larger during the first one-half of the flow volume than the second one-half at Gregory Boulevard (fig. 6, table 7). Concentrations of most constituents decreased in the second one-half of the flow volume at both Gregory Boulevard and Coalmine Road.

Lead concentrations from Brush Creek were more than 11 times the concentrations at Gregory Boulevard (table 5). Large concentrations of lead in the small volume of runoff from Brush Creek increased the average lead concentrations at Coalmine Road 50 percent and contributed one-half of the total lead load. Zinc concentrations increased 50 percent as the total storm load increased 270 percent between Gregory Boulevard and Coalmine Road, indicating zinc is another constituent significantly associated with urban runofff in Blue River.

Storm 4, October 13-14, 1981

Storm 4 was of moderate intensity and produced 2 inches of rainfall throughout the basin (table 3). The peak discharge was limited by the lack of antecedent moisture and the relatively long period in which the rain fell. No rainfall had occured in the basin during the week before the storm, and 1 inch or less of rain had fallen during the previous 2 weeks. Four composite samples were prepared for each Blue River station and three for Brush Creek, which allowed the best definition of concentration distribution for any of the storms.

The relatively long dry period before this storm allowed materials to build up in the sewers on the Brush Creek basin. The flushing of this buildup was reflected in large $BOD_5$ levels, which were almost three times those found in Blue River (table 5). Sewage materials also caused the average concentrations of organic nitrogen in Brush Creek runoff to be almost twice that found in Blue River (table 5). The average concentration of dissolved solids showed the familiar decrease at Coalmine Road due to Brush Creeek and a strong recovery at St. John Avenue.

Despite a dry basin, concentrations of suspended sediment were smaller for this storm than any other (fig. 3), probably because of low-intensity, less-erosive rainfall, and the consequent lower peak discharge. Concentrations of suspended sediment and associated nutrients and metals were similar throughout the sampled reach of Blue River (fig. 3, table 5).

Once again, concentrations of lead and zinc steadily increased downstream (fig. 3). Lead concentrations from Brush Creek were about 10 times those found in Blue River near Gregory Boulevard (table 5). More than one-third of the total lead load in Blue River at Coalmine Road came from Brush Creek, which represents only 12 percent of the drainage area (table 1 and 6). Zinc concentrations doubled between Gregory Boulevard and St. John Avenue.

At Gregory Boulevard, specific-conductance values decreased during initial flows and slowly recovered as runoff decreased. Also, 46 to 49 percent of the suspended-sediment, dissolved-phosphorus, and total-lead loads occurred in the first 27 percent of the flow volume at this station (fig. 7). These figures and trends indicate that buildups of soluble, loose particulate, and oxygen-demanding substances occur in agricultural areas during dry periods of 1 week or more. These materials tend to be readily removed during the first part of a hydrograph if runoff is sufficient to carry the material to the channel.

At Coalmine Road the same basin patterns existed, except the first composite sample was affected by inflows from Brush Creek as shown by the decrease in specific conductance during the first part of the hydrograph (fig. 6). Brush Creek runoff caused the first composite sample at Coalmine Road to have concentrations of dissolved solids and suspended sediment less than, and lead concentrations larger than, the first composite sample at Gregory Boulevard.

At St. John Avenue the distribution of $BOD_5$, suspended sediment, lead, and other constituents are similar to those found at Gregory Boulevard after the first composite sample (fig. 6). A significant increase in specific-conductance values, a large concentration of dissolved-solids and nutrients, and smaller concentrations of $BOD_5$, suspended sediment, total nitrogen, and lead in the first sample probably were caused by a mixture of initial urban runoff, combined-sewer overflow, and previously impounded water from behind the two low-head dams.

At Brush Creek the large initial concentrations of $BOD_5$, phosphorus, total nitrogen, and lead and their rapid decrease show a significant flush of street surfaces and combined sewers (fig. 9). Concentrations of suspended sediment and dissolved solids also decreased throughout the hydrograph. The first composite sample represents more than one-half the total flow volume (table 10) and probably had been diluted by relatively clean runoff following the initial flush. Therefore, the concentrations of most constituents in this sample do not represent the maximum concentrations present during the initial 10 to 30 percent of runoff from sewers and urban surfaces. The significant decrease in specific conductance values at the beginning of the hydrograph probably defines the end of the flush.

### Storm 5, October 17, 1981

Storm 5 occurred 3 days after storm 4; therefore, storm 5 typifies low build-up conditions on the basin and in the sewers. The storm produced only 0.4 to 1.1 inches of rain, which fell on moist soils (table 3). The smallest quantities of rainfall occurred in the upstream part of the basin and the largest quantities in the middle of the basin.

Mean values of $BOD_5$ during runoff from storm 5 were relatively large. $BOD_5$ levels were 13 milligrams per liter in Blue River near Gregory Boulevard, Coalmine Road, and Brush Creek at Elmwood Avenue (table 5). Large quantities of diluted runoff from Brush Creek caused the concentration of dissolved solids to decrease at Coalmine Road, followed by recovery at St. John Avenue.

Table 11.--Percentage of total concentrations of selected constituents in the suspended phase in stormwater runoff at Blue River stations for storms during 1981

| Constituent | Number of samples | Blue River near Gregory Boulevard (station 4, fig. 1) Percent | | Number of samples | Blue River at Coalmine Road (station 7, fig. 1) Percent | | Number of samples | Blue River near St. John Avenue (station 11, fig. 1) Percent | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Range | | Mean | Range | | Mean | Range |
| Nitrite and nitrate | 6 | 2 | 1-8 | 6 | 1 | 0-6 | 3 | 0 | 0-0 |
| Ammonia | 13 | 33 | 0-72 | 13 | 64 | 6-100 | 10 | 55 | 10-73 |
| Organic nitrogen | 13 | 79 | 58-84 | 9 | 75 | 54-89 | 10 | 79 | 61-86 |
| Phosphorus | 15 | 85 | 51-94 | 15 | 85 | 66-96 | 10 | 91 | 58-96 |
| Arsenic | 15 | 73 | 0-89 | 15 | 74 | 50-93 | 10 | 79 | 50-88 |
| Chromium | 15 | 93 | 0-100 | 15 | 87 | 50-100 | 10 | 86 | 67-100 |
| Copper | 15 | 87 | 79-97 | 15 | 91 | 79-97 | 10 | 96 | 93-98 |
| Iron | 15 | 99 | 79-100 | 15 | 100 | 100-100 | 10 | 100 | 100-100 |
| Lead | 15 | 91 | 73-100 | 15 | 93 | 84-100 | 10 | 97 | 92-100 |
| Manganese | 15 | 99 | 95-100 | 14 | 99 | 94-100 | 10 | 98 | 81-100 |
| Zinc | 15 | 78 | 18-93 | 15 | 83 | 67-96 | 10 | 91 | 78-93 |
| Percentage of sediment finer than 0.062 millimeter | 15 | 85 | 58-94 | 15 | 83 | 68-90 | 10 | 79 | 56-89 |

Concentrations of suspended sediment were small and constant throughout the sampled reach of Blue River, resulting from a small storm on a well-washed surface (fig. 3, table 5). A small decrease in suspended-sediment load occurred between Coalmine Road and St. John Avenue (table 6). As in storm 1, sediments probably were trapped behind the two low-head dams.

Nutrient concentrations, both dissolved and suspended, were small and decreased throughout the reach because of small concentrations of suspended sediments, the deposition of suspended sediment, and low build-up conditions (fig. 3, tables 5, 6). Although lead showed a typical large increase in concentration at Coalmine Road from Brush Creek runoff, a small decrease in lead concentration between Coalmine Road and St. John Avenue occurred for the first and only time. This decrease was caused by the loss of suspended sediment. Zinc, however, repeated the pattern of increasing concentration downstream through the sampled reach. Relatively large $BOD_5$ levels of 13 milligrams per liter were detected on Blue River near Gregory Boulevard, Coalmine Road, and Brush Creek at Elmwood Avenue.

At Gregory Boulevard, concentrations for the first composite sample were the largest for nearly all constituents and properties with decreases throughout the period of runoff (fig. 8). Specific-conductance values decreased to a minimum near the peak discharge and slowly recovered as flow receded. Seventy-three percent of the suspended-sediment load occurred during the first one-half of the volume at Gregory Boulevard (table 7).

The same patterns described at Gregory Boulevard probably would have appeared at Coalmine Road, but the first sample was affected by Brush Creek inflow. These effects include smaller concentrations of dissolved nutrients, suspended sediment and associated nutrients and metals, and larger concentrations of lead. The strong effect of Brush Creek is shown on the discharge hydrograph and specific-conductance trace from Coalmine Road (fig. 8).

Most sampled constituents at St. John Avenue show less fluctuation during the period of runoff than at the other Blue River stations. This moderation resulted from the low build-up conditions on the basin and the recent flushing of base-flow water from behind the two low-head dams. Specific-conductance values displayed several fluctuations apparently related to discharge. The initial pulse of runoff from the local urban areas caused an initial decrease in specific conductance similar to that found at Coalmine Road just downstream from Brush Creek. However, an increase in specific conductance during the second, larger pulse of runoff was not typical of urban runoff and is attributed to combined-sewer overflows of some other source. Lead concentrations were large in the first 55 percent of the volume at St. John Avenue, indicating that most of the the rain fell on the downstream, urban parts of the basin.

Concentrations of constituents in Brush Creek runoff showed a typical decrease throughout the hydrograph, although the initial flush was less pronounced due to low build-up conditions (fig. 9).

## Summary of Composite-Sampling Data for 1981

The different watershed conditions and different storm patterns that occurred during 1981 caused differences in the quality of storm water runoff in the Blue River. However, several trends were repeated in all or nearly all five storms, and several phenomena were identified as the result of the shape of the Blue River basin or the special characteristics of an individual storm.

The differences in values of several properties and in concentrations of several constituents during runoff at a given station was partially controlled by the long, narrow shape of the Blue River basin (fig. 1). This shape usually causes runoff from the farthest downstream tributaries to pass a gage on the mainstem before runoff from upstream tributaries arrives. Consequently, during the first part of stormwater runoff at Coalmine Road and St. John Avenue, discharge, specific conductance, and several constituent concentrations fluctuated as runoff from different urban tributaries, combined-sewer overflows, and the upstream agricultural areas passed these stations at different times. For example, at Coalmine Road, the first composite samples were mostly stormwater runoff from Brush Creek and, therefore, were of a different character than the later samples of stormwater runoff from the upstream agricultural areas.

The type of stormwater runoff from Brush Creek was considerably different from that in Blue River. Generally, mean values of turbidity and mean concentrations of dissolved solids, nitrite and nitrate, suspended sediment, and most total metals, were smaller than those in the Blue River, whereas mean concentrations of total lead and zinc were larger than those in Blue River. Concentrations and loads of constituents in stormwater runoff from Brush Creek were primarily affected by the quantity of materials accumulated on the surface and in the combined sewers before the storm and the quantity of flow available for dilution. The large areas of impervious surfaces and concrete-lined channels limited the quantity of material that could be washed away, but increased runoff volumes resulted in larger loads per unit drainage area from Brush Creek than from the undeveloped areas during some storms. Five-day biochemical-oxygen demand, dissolved solids, total nitrogen, total phosphorus, and total lead all showed flushing characteristics in Brush Creek.

Specific-conductance values and dissolved-solids concentrations were smaller in the Blue River when urban contributions of stormwater runoff were significant or when the discharge was large. Runoff from Brush Creek decreased the mean concentration of dissolved solids in Blue River at Coalmine Road during every storm. However, mean concentrations of dissolved solids were larger downstream at St. John Avenue during almost every storm because of the two low-head dams that trap base flow. Water from behind these dams is flushed out by upstream runoff and causes a slightly larger mean concentration of dissolved solids.

The primary source of suspended sediment (and several associated nutrients and metals) was the agricultural areas in the upstream part of the Blue River basin. However, sediment deposits in the channel, banks, and small impoundments of the downstream reaches were readily available for resuspension by more dilute urban runoff entering the mainstem of the Blue River (storm 2). Mean concentrations and total loads of suspended sediment were greater for storms of larger peak discharge if the total volume of flow was comparable (storms 1 and 4). At Gregory Boulevard, upstream from most urbanization, suspended sediment, dissolved phosphorus, and several constituents associated with sediment usually were concentrated in the first one-fourth to one-half of the flow volume.

Total-lead concentrations and loads increased significantly during almost every storm throughout the urban reaches of Blue River. Contributions of lead to Blue River from Brush Creek were disproportionately large relative to their respective drainage areas. This characteristic is caused by engine exhausts from the large volume of automobile traffic in the Brush Creek basin. Total-zinc concentrations and loads also increased throughout the downstream, urban reaches of the Blue River in four out of five storms, although no source can be positively identified.

### Relationship Between Concentrations of Constituents in the Suspended and Dissolved Phases and Sediment

Concentrations of constituents in the suspended phase, computed as a percentage of the total concentrations for each sample, show that all metals were significantly associated with suspended-sediment (tables 11 and 12). Mean percentages of metals in the suspended phase generally were greater than 80 percent for all stations on the Blue River and Brush Creek. Most nutrients also were in the suspended phase with the major exception of nitrite and nitrate, which were nearly all dissolved. A significant part of total ammonia was in the dissolved phase, but the mean percentage of organic nitrogen and phosphorus in the suspended phase always was more than 75 percent. Therefore, decreasing the quantity of suspended sediments could be expected to decrease total concentrations of nutrients and metals in storm runoff as well as decrease the exposure of base-flow water to the pollutant-laden sediments deposited in the channel.

Concentrations of all properties and constituents in composite samples collected on Blue River were plotted and correlated with one another. Regression equations and coefficients of determination ($r^2$) are shown in table 13 for all relationships that had correlation coefficients larger than 0.70 and were not related through a third variable (such as iron and manganese, which are both related to sediment). The scatter of data around these regression lines is shown in figure 11. Correlation coefficients ($r$) for all relationships with $r$ between 0.50 and 0.70 are shown in table 14.

These tables and graphs show that concentrations of several metals, several nutrients, and dissolved solids can be estimated from relationships with specific conductance and suspended sediment. Specific conductance was well correlated with concentrations of dissolved solids, dissolved nitrite and nitrate, total ammonia, and dissolved ammonia. Suspended sediment was well correlated with total organic nitrogen, total nitrogen, total phosphorus, and total organic carbon concentrations. The relationships between suspended sediment and all metals, except lead and zinc, had coefficients of determination larger than 0.54. The relationships between suspended sediment and lead and zinc were less significnat because of the increased quantities of lead and zinc on sediments in the reaches of Blue River that received larger volumes of urban runoff.

### Comparison of Stormwater-Runoff Quality with Water-Quality Standards and with Base-Flow Water Quality

Volume-weighted, mean concentrations of selected trace elements in the stormwater runoff at the Blue River and Brush Creek stations for each sampled storm during 1981 are compared in table 15 with numeric aquatic-life criteria

Table 12.--Percentage of total concentrations of selected constituents in the suspended phase in stormwater runoff from Brush Creek and the land-use sites for storms during 1981

| Constituent | Number of samples | Brush Creek at Elmwood Avenue (station 6, fig. 1) Percent Mean | Range | Number of samples | Blue River trib. at Virginia Avenue (station 2, fig. 1) Percent Mean | Range | Number of samples | Blue Ridge Mall storm sewer (station 8, fig. 1) Percent Mean | Range |
|---|---|---|---|---|---|---|---|---|---|
| Nitrite and nitrate | 1 | 0 | 0-0 | -- | -- | -- | -- | -- | -- |
| Ammonia | 6 | 43 | 12-50 | -- | -- | -- | -- | -- | -- |
| Organic nitrogen | 6 | 78 | 52-92 | -- | -- | -- | -- | -- | -- |
| Phosphorus | 8 | 88 | 60-90 | 11 | 40 | 9-67 | 13 | 66 | 25-100 |
| Arsenic | 8 | 79 | 29-86 | 12 | 22 | 0-62 | 12 | (a) | (a) |
| Chromium | 8 | 90 | 86-100 | 6 | 50 | 11-100 | 2 | (a) | (a) |
| Copper | 8 | 92 | 65-97 | 13 | 73 | 44-97 | 17 | 66 | 5-83 |
| Iron | 8 | 99 | 97-100 | 13 | 95 | 64-100 | 17 | 95 | 76-100 |
| Lead | 8 | 99 | 95-100 | 12 | 91 | 33-100 | 14 | 94 | 73-100 |
| Manganese | 8 | 84 | 71-100 | 11 | 95 | 66-100 | 17 | 82 | 11-92 |
| Zinc | 8 | 93 | 56-98 | 11 | 53 | 0-84 | 17 | 62 | 2-90 |
| Percentage of solids finer than 0.062 millimeter | 8 | 42 | 30-88 | 5 | 58 | 47-73 | 12 | 74 | 20-87 |

[a]Concentrations too small to calculate meaningful percentages.

Table 13.--Regression equations having correlation coefficients (r) more than 0.70 for properties and constituents in stormwater runoff at Blue River stations for storms during 1981

[units are in milligrams per liter, except as indicated; $r^2$, coefficient of determination]

| Number of samples | Independent variable (X) | Dependent variable (Y) | Equation | $r^2$ | Standard error of estimate (units same as Y) |
|---|---|---|---|---|---|
| 40 | Specific conductance (micromhos per centimeter at 25 °C) | Dissolved solids | $Y = 0.475X + 42.7$ | 0.77 | 27 |
| 19 | Specific conductance (micromhos per centimeter at 25 °C) | Dissolved nitrite and nitrate (as nitrogen) | $Y = 0.00216X + 0.491$ | .52 | .20 |
| 16 | 5-day biochemical-oxygen demand | Dissolved nitrite and nitrate (as nitrogen) | $Y = 0.0568X + 0.679$ | .53 | .16 |
| 38 | Suspended sediment | Suspended solids | $Y = 0.619X + 207$ | .76 | 329 |
| 36 | Suspended sediment | Total organic nitrogen | $Y = 0.00121X + 1.70$ | 0.65 | 0.86 |
| 40 | Suspended sediment | Total organic and ammonia nitrogen | $Y = 0.00117X + 2.31$ | .59 | .91 |
| 36 | Suspended sediment | Total nitrogen | $Y = 0.00132X + 2.89$ | .68 | .87 |
| 40 | Suspended sediment | Total arsenic (micrograms per liter) | $Y = 0.00319X + 5.16$ | .62 | 2.3 |
| 40 | Suspended sediment | Total chromium (micrograms per liter) | $Y = 0.0160X + 12.7$ | .70 | 9.8 |
| 40 | Suspended sediment | Total copper (micrograms per liter) | $Y = 0.0166X + 21.7$ | .54 | 14 |



5/8"

Table 13.--Regression equations having correlation coefficients (r) more than 0.70 for properties and constituents in stormwater runoff at Blue River stations for storms during 1981--Continued

| Number of samples | Independent variable (X) | Dependent variable (Y) | Equation | $r^2$ | Standard error of estimate (units same as Y) |
|---|---|---|---|---|---|
| 40 | Suspended sediment | Total iron (micrograms per liter) | Y = 14.8X + 6560 | 0.84 | 5,900 |
| 40 | Suspended sediment | Total manganese (micrograms per liter) | Y = 0.485X + 364 | .73 | 270 |
| 24 | Suspended sediment | Total organic carbon | Y = 0.00651X + 21.2 | .67 | 4.8 |
| 15 | Total nitrite and nitrate (as nitrogen) | Dissolved nitrite and nitrate (as nitrogen) | Y = 0.811X + 0.334 | .90 | .10 |
| 36 | Total ammonia (as nitrogen) | Dissolved ammonia (as nitrogen) | Y = 0.790X - 0.0623 | .73 | .15 |
| 40 | Dissolved ammonia (as nitrogen) | Dissolved phosphorus | Y = 0.773X + 0.149 | .75 | .20 |
| 36 | Total organic nitrogen | Total nitrogen | Y = 1.01X + 1.35 | .89 | .51 |
| 36 | Total organic and ammonia nitrogen | Total organic nitrogen | Y = 0.979X - 0.406 | .95 | .32 |
| 24 | Total organic and ammonia nitrogen | Total organic carbon | Y = 4.53X + 12.4 | .79 | 3.8 |
| 40 | Total lead (micrograms per liter) | Total zinc (micrograms per liter) | Y = 1.41X + 102 | .58 | 52 |

Table 14.--Correlation coefficients (r) between 0.50 and 0.70 for selected properties and constituents in stormwater runoff at the Blue River stations for storms during 1981

| Variable | Variable | Number of samples | r |
| --- | --- | --- | --- |
| Specific conductance | Total ammonia | 36 | 0.68 |
| Specific conductance | Dissolved ammonia | 40 | .68 |
| Dissolved solids | Dissolved nitrite and nitrate | 19 | .66 |
| Dissolved solids | Total ammonia | 36 | .61 |
| Dissolved solids | Dissolved ammonia | 40 | .53 |
| Suspended solids | Total zinc | 38 | .51 |
| Suspended sediment | Chemical-oxygen demand | 35 | .64 |
| Suspended sediment | Total phosphorus | 40 | .67 |
| Dissolved nitrite and nitrate | Dissolved ammonia | 19 | .60 |
| Total ammonia | Total phosphorus | 36 | .55 |
| Total organic nitrogen | Dissolved organic nitrogen | 32 | .51 |
| Dissolved organic nitrogen | Total organic and ammonia nitrogen | 34 | .61 |
| Dissolved ammonia and organic nitrogen | Dissolved ammonia nitrogen | 40 | .65 |
| Dissolved copper | Total copper | 40 | .51 |
| Total organic carbon | Dissolved organic nitrogen | 22 | .55 |

Table 15.--Comparison of Missouri water-quality standards for aquatic life with mean total concentrations of selected trace elements in samples from the Blue River and Brush Creek for storms during 1981

[Results in micrograms per liter, except where indicated as milligrams per liter (mg/L); EPA, U.S. Environmental Protection Agency]

| Trace element | Missouri water-quality standards for aquatic life[1] | Blue River near Gregory Boulevard (station 4, fig. 1) Storm number[2] | | | | | Blue River at Coalmine Road (station 7, fig. 1) Storm number[2] | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| Arsenic | 20 | 15 | 14 | 5 | 7 | 8 | 14 | 11 | 8 | 8 | 10 |
| Cadmium | 12 | 1 | 1 | 5 | 1 | 0 | 1 | 1 | 0 | 1 | 1 |
| Chromium | 50 | 60 | 50 | 20 | 30 | 30 | 60 | 40 | 20 | 20 | 40 |
| Copper | 20 | 80 | 53 | 31 | 29 | 50 | 68 | 51 | 38 | 31 | 37 |
| Iron (mg/L) | 1 | 51 | 44 | 21 | 20 | 25 | 47 | 36 | 28 | 16 | 23 |
| Lead | 50 | 64 | 38 | 26 | 38 | 62 | 77 | 100 | 39 | 66 | 109 |
| Mercury | 2 | .3 | .2 | .1 | .1 | .1 | .2 | .2 | .0 | .6 | .3 |
| Zinc | 100 | 250 | 200 | 110 | 120 | 180 | 240 | 210 | 170 | 140 | 200 |

Table 15.--Comparison of Missouri water-quality standards for aquatic life with mean total concentrations of selected trace elements in samples from the Blue River and Brush Creek for storms during 1981--Continued

| Trace element | Missouri water-quality standards for aquatic life[1] | Blue River near St. John Avenue (station 11, fig. 1) Storm number[2] | | | | Brush Creek at Elmwood Avenue (station 6, fig. 1) Storm number[2] | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 4 | 5 | 2 | 3 | 4 | 5 |
| Arsenic | 20 | 9 | 13 | 10 | 7 | 21 | 5 | 9 | 10 |
| Cadmium | 12 | 1 | 1 | 2 | 3 | 2 | 3 | 3 | 2 |
| Chromium | 50 | 50 | 50 | 30 | 30 | 70 | 30 | 50 | 20 |
| Copper | 20 | 51 | 62 | 45 | 47 | 100 | 46 | 58 | 43 |
| Iron (mg/L) | 1 | 37 | 39 | 19 | 18 | 31 | 8.6 | 18 | 15 |
| Lead | 50 | 82 | 114 | 93 | 94 | 480 | 300 | 345 | 226 |
| Mercury | 2 | .2 | .2 | .1 | .2 | .5 | .2 | .4 | .2 |
| Zinc | 100 | 230 | 310 | 240 | 270 | 540 | 270 | 380 | 260 |

[1]Missouri Department of Natural Resources, 1984.

[2]Storm 1, July 25, 1981; storm 2, July 27-28, 1981; storm 3, September 1, 1981; storm 4, October 13-14, 1981; storm 5, October 17, 1981.

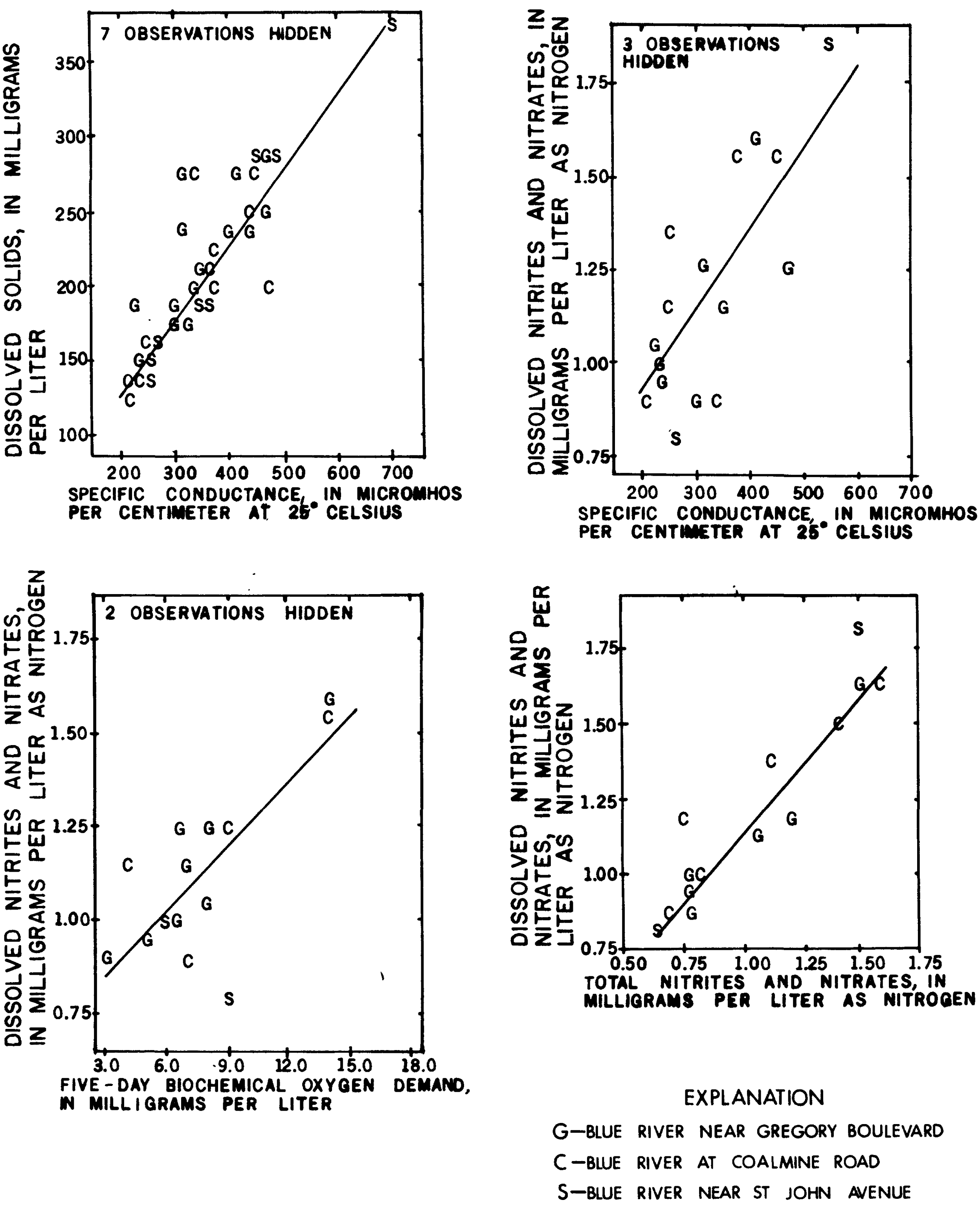



Figure 11.--Relationships between selected properties and constituents in stormwater runoff at Blue River stations for storms during 1981.

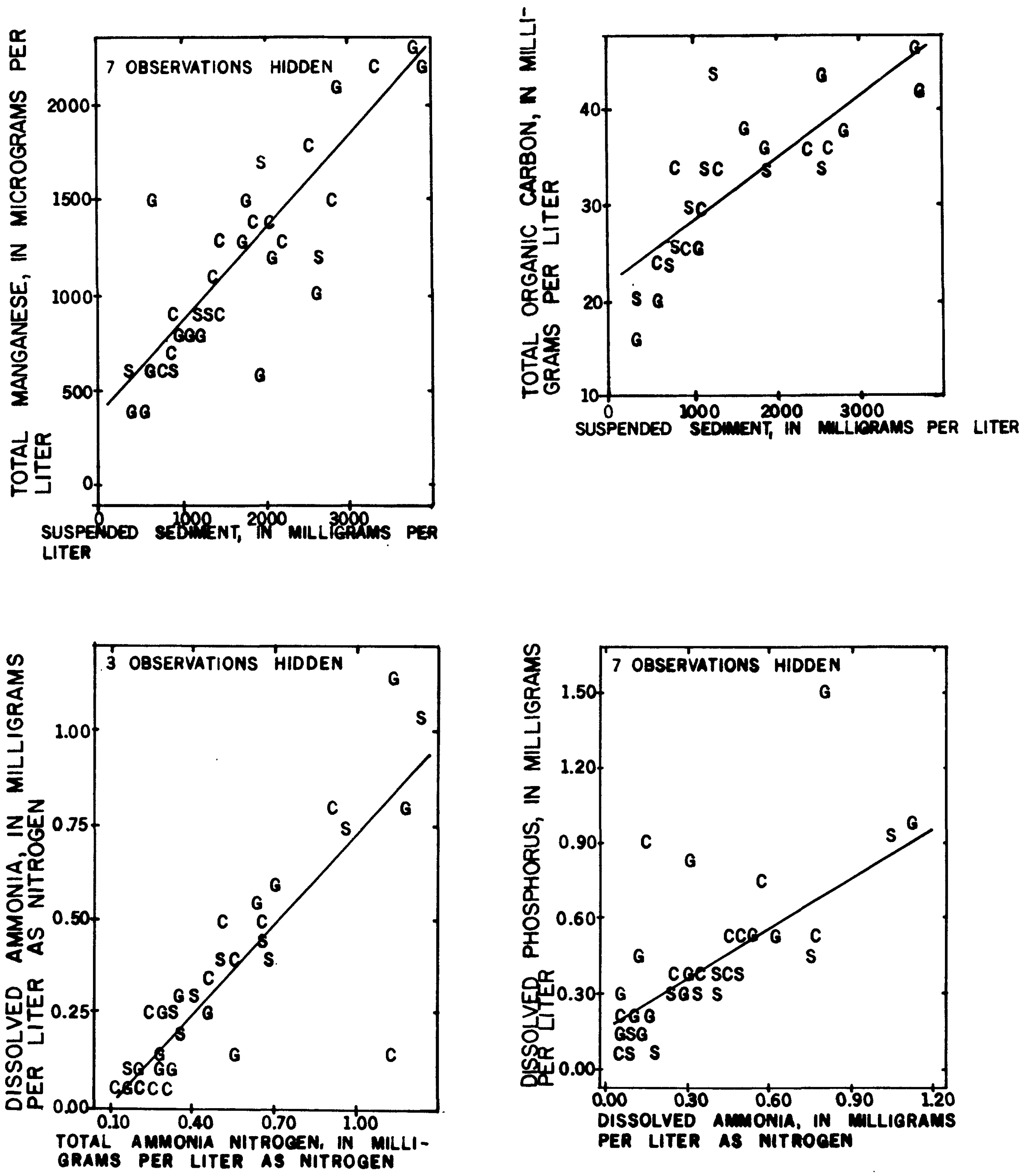



Figure 11--Relationships between selected properties and constituents in stormwater runoff at Blue River stations for storms during 1981--Continued.

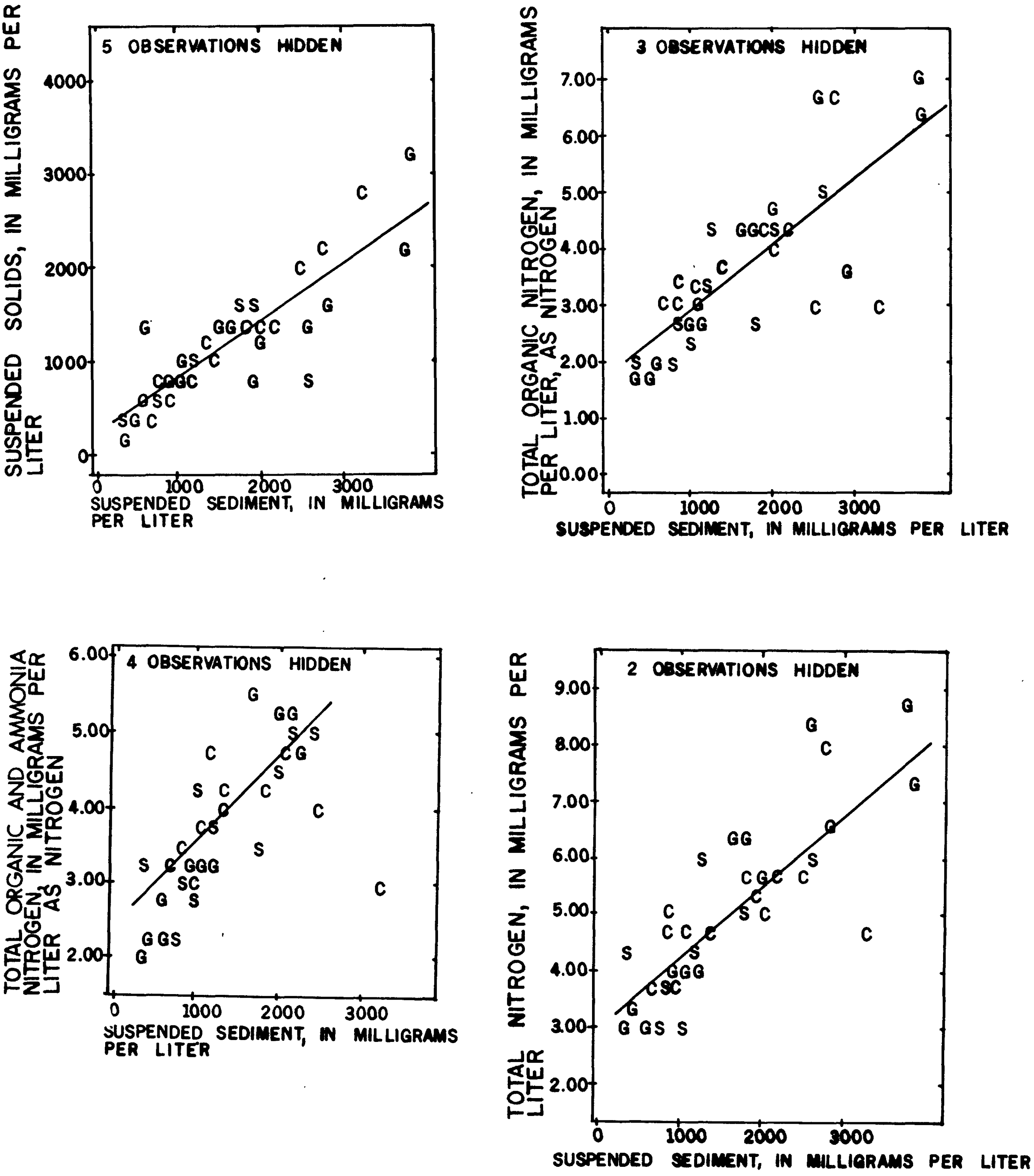



Figure 11.--Relationships between selected properties and constituents in stormwater runoff at Blue River stations for storms during 1981--Continued.

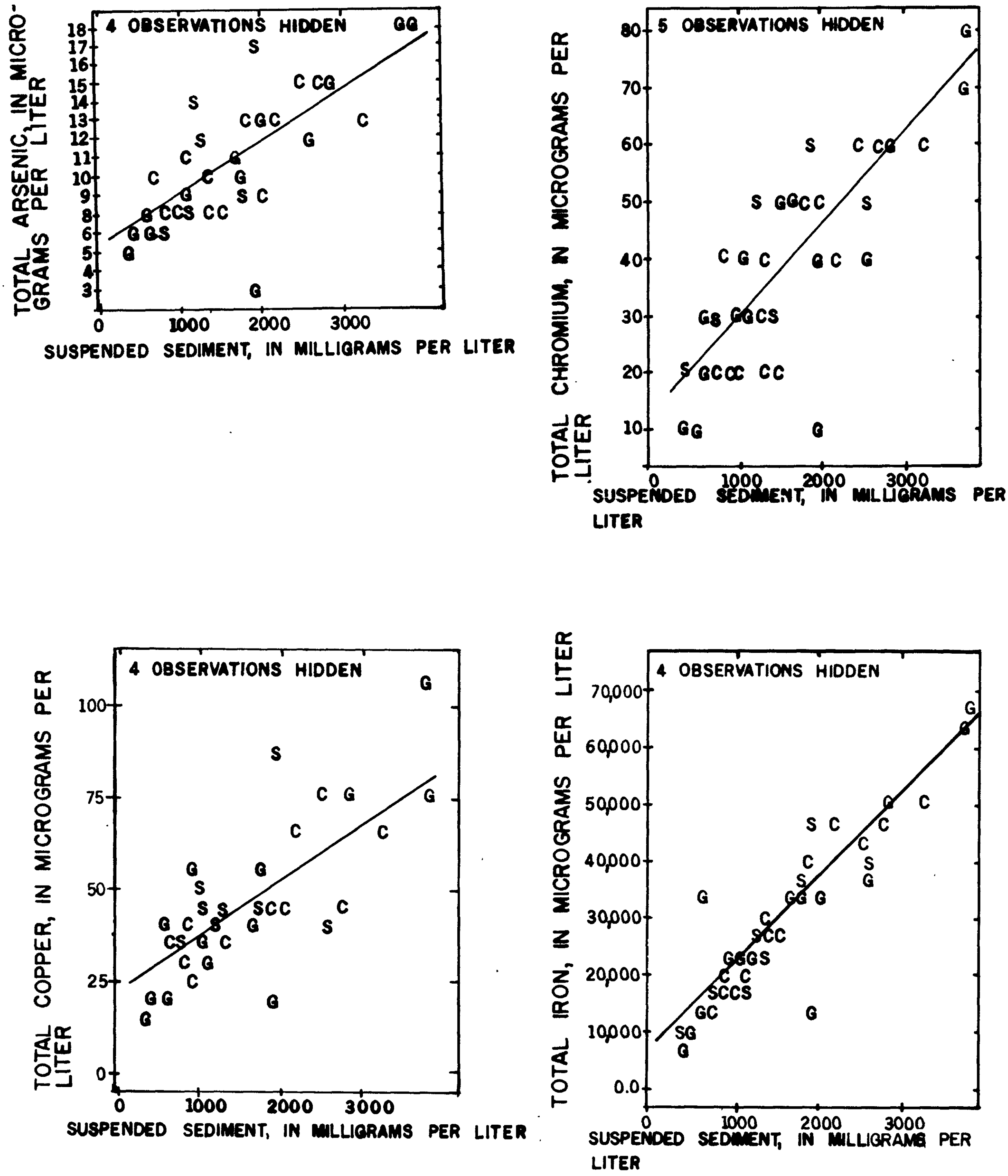



Figure 11.--Relationships between selected properties and constituents in stormwater runoff at Blue River stations for storms during 1981--Continued.

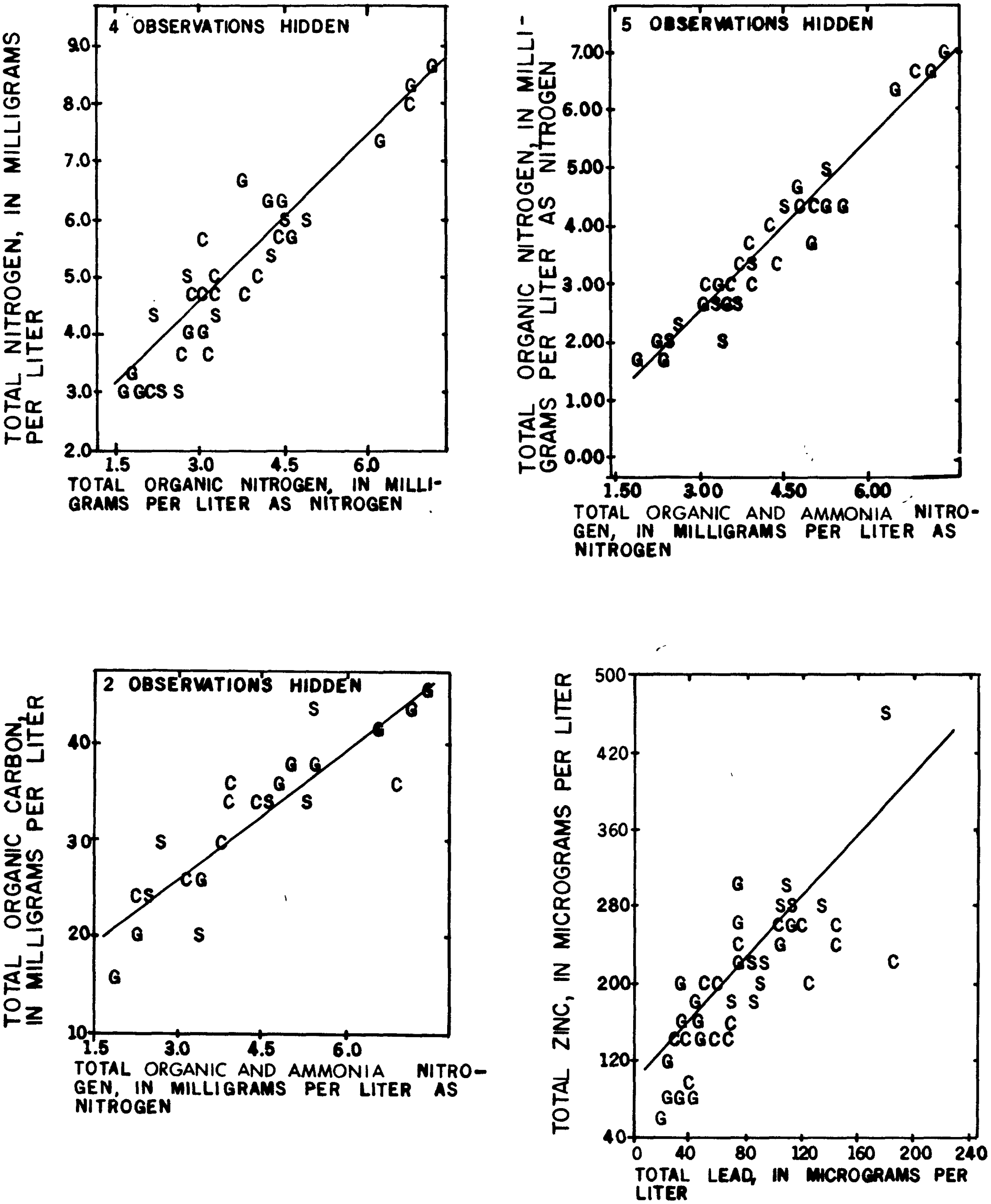



Figure 11.--Relationships between selected properties and constituents in stormwater runoff at Blue River stations for storms during 1981--Continued.

values listed in Missouri's water-quality standards (Missouri Department of Natural Resources, 1984). Total concentrations of copper, iron, lead, and zinc exceeded the criteria. However, the state's criteria implementation policy applies only to dissolved concentrations of these metals (John R. Howland, Missouri Department of Natural Resources, written commun., 1986).

Water-quality data collected monthly using manual methods by the Missouri Department of Natural Resources at three Blue River stations at Kenneth Road (station 1), at 63rd Street (station 5), and at 37th Street (station 9) (fig. 1) during base-flow conditions from 1973 to 1978 are summarized in table 16 (Lee Muschler, Missouri Department of Natural Resources, written commun., 1981). The data (designated as base-flow data) used in this table were selected by excluding all samples collected when the average daily discharge for Blue River at Bannister Road (station 3, fig. 1) was more than 98 cubic feet per second (U.S. Geological Survey records show that the mean daily flow exceeds 98.5 cubic feet per second 25 percent of the time at Bannister Road). The Kenneth Road station is upstream from the urbanized part of the basin and near the Missouri-Kansas State line. The 63rd Street station is between the Gregory Boulevard and Coalmine Road stations, and the 37th Street station is between the Coalmine Road and St. John Avenue stations (fig. 1). Although metals were not obtained in the base-flow data, specific conductance and pH values and nutrient concentrations can be compared to data in tables 5 and 15.

A distinct degradation of water quality during base flow between Kenneth Road and 63rd Street is shown in table 16. The increased nutrient concentrations were caused by sewage-treatment effluents and possibly other urban contributions entering the Blue River primarily from Indian Creek (fig. 1). The large concentrations in the Blue River mainstem during base flow mask variations in concentrations caused by initial flushing of urban areas and make comparisons of large-flow concentrations to small-flow concentration deceiving. Concentrations of constituents that were larger during storms were partly caused by suspension of bottom sediments containing large concentrations of pollutants that were deposited during base-flow conditions. Therefore, the site at Kenneth Road is used to compare stormwater quality to nonurbainized base-flow quality.

The specific conductance of stormwater downstream from Indian Creek generally was one-half of that measured during base flow because of dilution with runoff (table 5). However, specific-conductance values of stormwater runoff were slightly more than one-half the base-flow value at the rural Kenneth Road station. No significant difference in pH was determined between stations or flow regimes. Total ammonia nitrogen concentrations in stormwater runoff downstream from Indian Creek were less than one-half the concentrations in base flows at 63rd and 37th Streets, but generally more than four times the concentrations at Kenneth Road. Concentrations of nitrite and nitrate in stormwater runoff downstream from Indian Creek generally were less than one-half the concentrations in base-flow samples at 63rd and 37th Streets, but were about 50 percent more than in base-flow samples at Kenneth Road. Although concentrations of total phosphorus in stormwater runoff were similar to

Table 16.--Statistical summary of discharge and selected water-quality data collected monthly from 1973 to 1978 using manual methods at three stations on the Blue River during base-flow conditions

[Unpublished data provided by Lee Muschler, Missouri Department of Natural Resources, Jefferson City, Missouri (December, 1981); $ft^3/s$, cubic feet per second; mg/L, milligrams per liter; µmho/cm at 25 °C, micromhos per centimeter at 25 °Celsius]

| Property or constituent | Units | Blue River at Kenneth Road (station 1, fig. 1) | | | Blue River at 63rd Street (station 5, fig. 1) | | | Blue River at 37th Street (station 9, fig. 1) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Standard deviation | Number of samples | Mean | Standard deviation | Number of samples | Mean | Standard deviation | Number of samples |
| Discharge[1] | $ft^3/s$ | 36 | 22 | 32 | 37 | 24 | 38 | 37 | 24 | 37 |
| Specific conductance | µmho/cm at 25°C | 558 | 137 | 30 | 828 | 232 | 35 | 830 | 221 | 35 |
| pH | units | 7.5 | .4 | 30 | 7.6 | 0.4 | 36 | 7.5 | .3 | 35 |
| Total nitrite and nitrate as nitrogen | mg/L | .63 | .68 | 28 | 2.59 | 1.21 | 35 | 1.93 | .94 | 35 |
| Total ammonia as nitrogen | mg/L | .12 | .07 | 29 | 1.73 | 2.10 | 37 | 1.52 | 1.75 | 36 |
| Total phosphorus | mg/L | .14 | .07 | 30 | 2.56 | 1.45 | 38 | 1.82 | 1.10 | 37 |

[1]Flow values are daily mean discharges from records for the Blue River at Bannister Road (station 3, fig. 1)

11/16"

concentrations in base flows at 63rd and 37th Streets, they were more than an order of magnitude greater than concentrations in base flows at Kenneth Road. Minimum metals data are available at low flow for the downstream reaches of Blue River, and the affinity of metals for sediment particles causes much larger metals concentrations during runoff.

## QUALITY OF INITIAL STORMWATER RUNOFF DETERMINED FROM DISCRETE SAMPLES, APRIL - JULY 1982

During April-July 1982, discrete sampling was done during initial stormwater-runoff at the four Blue River and Brush Creek stations to determine the presence and significance of a first-flush phenomenon. The discrete samples were used to give a better portrayal of the water-quality characteristics of initial stormwater runoff than shown by the earlier composite-sampling methods. These results are described by station.

Concentrations of all analyzed properties and constituents could not be plotted in figures 12-16. However, trends and fluctuations for the plotted properties and constituents generally are true for several other closely related constituents. The values for all properties and the concentrations for all analyzed constituents for all samples are given in the "Supplemental Information" section at the back of this report.

### Blue River near Gregory Boulevard

Discharge and values of selected properties and concentrations of selected constituents in the initial runoff from three storm sampled at Gregory Boulevard are shown in figure 12. Concentrations of most constituents in the initial runoff near Gregory Boulevard show distinctively different patterns that were caused by individual storm and basin characteristics. The storms of April 28 and June 14, 1982, occurred mainly on the urban areas immediately upstream from Gregory Boulevard after 3 to 14 days of little or no rainfall (table 3). The initial runoff from these two storms contained concentrations of total nitrogen, total phosphorus, total lead, and total zinc that were larger than the mean concentrations of the same constituents in samples collected the year before (tables 5 and 15). These constituents also tended to be flushed from the urban areas during this study. A peak in specific conductance occurred after the four samples of initial runoff were collected on April 28. This peak and other similar fluctuations in the chemical data occurred when initial runoff from different tributaries passed the gage at different times. The long, narrow shape of the Blue River basin allows runoff from downstream tributaries to pass before runoff arrives from farther upstream.

The initial runoff for the storm of May 12 occurred after 0.5 inch of rain the day before. Consequently, the magnitude and fluctuations of most properties and constituents were much smaller than those for the other two storms.

### Blue River at Coalmine Road

Discharge of and values of specific conductance and concentration of selected constituents in the initial runoff from two storms sampled at Coalmine Road are shown in figure 13. Initial runoff at this station primarily was from Brush Creek. This water has a distinctly different character from the stormwater runoff from farther upstream. As shown in the composite sampling for

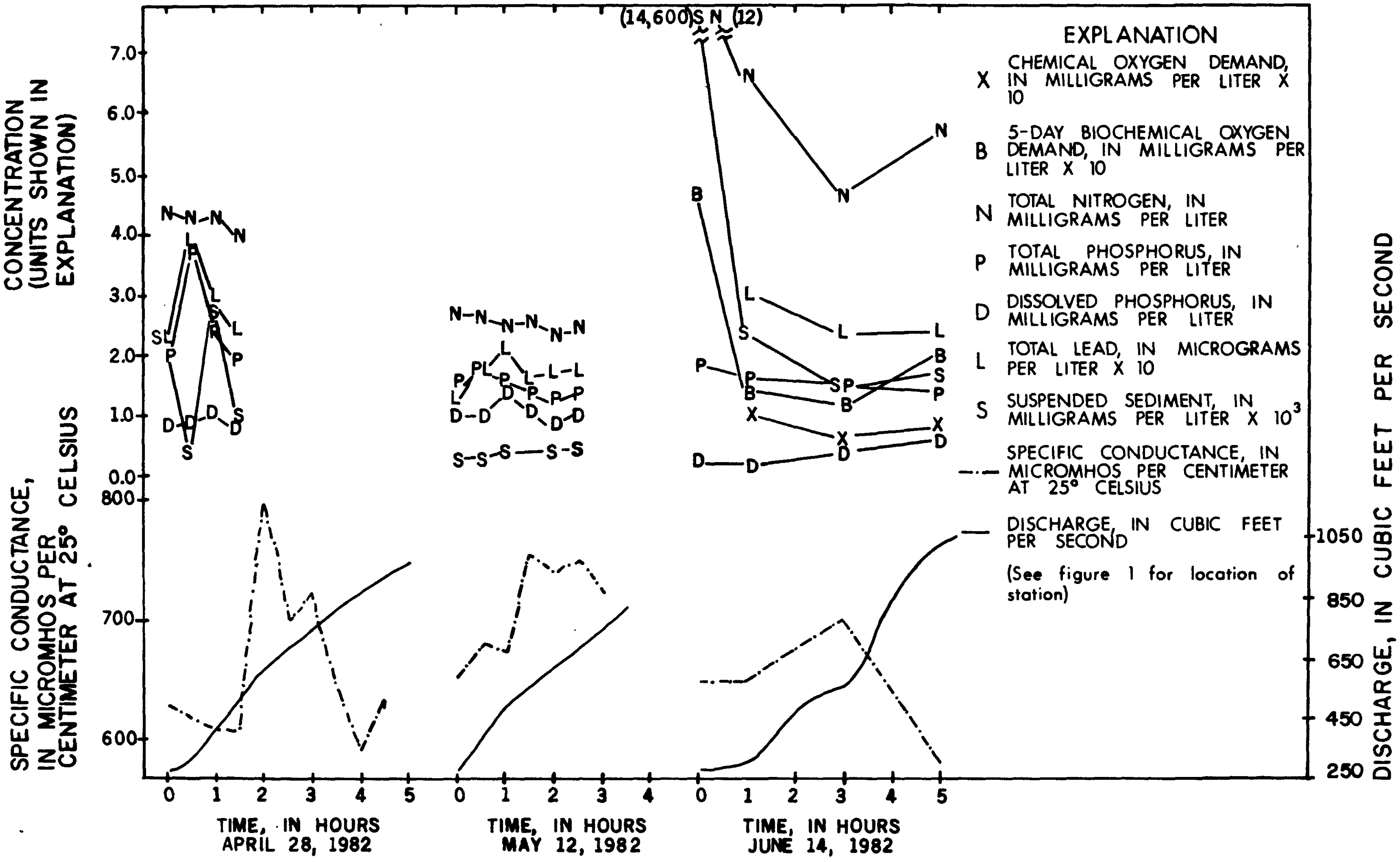



Figure 12.--Values of selected properties and concentrations of selected constituents in discrete samples collected during initial stormwater runoff, Blue River near Gregory Boulevard for the storms of April 28, May 12, and June 14, 1982.

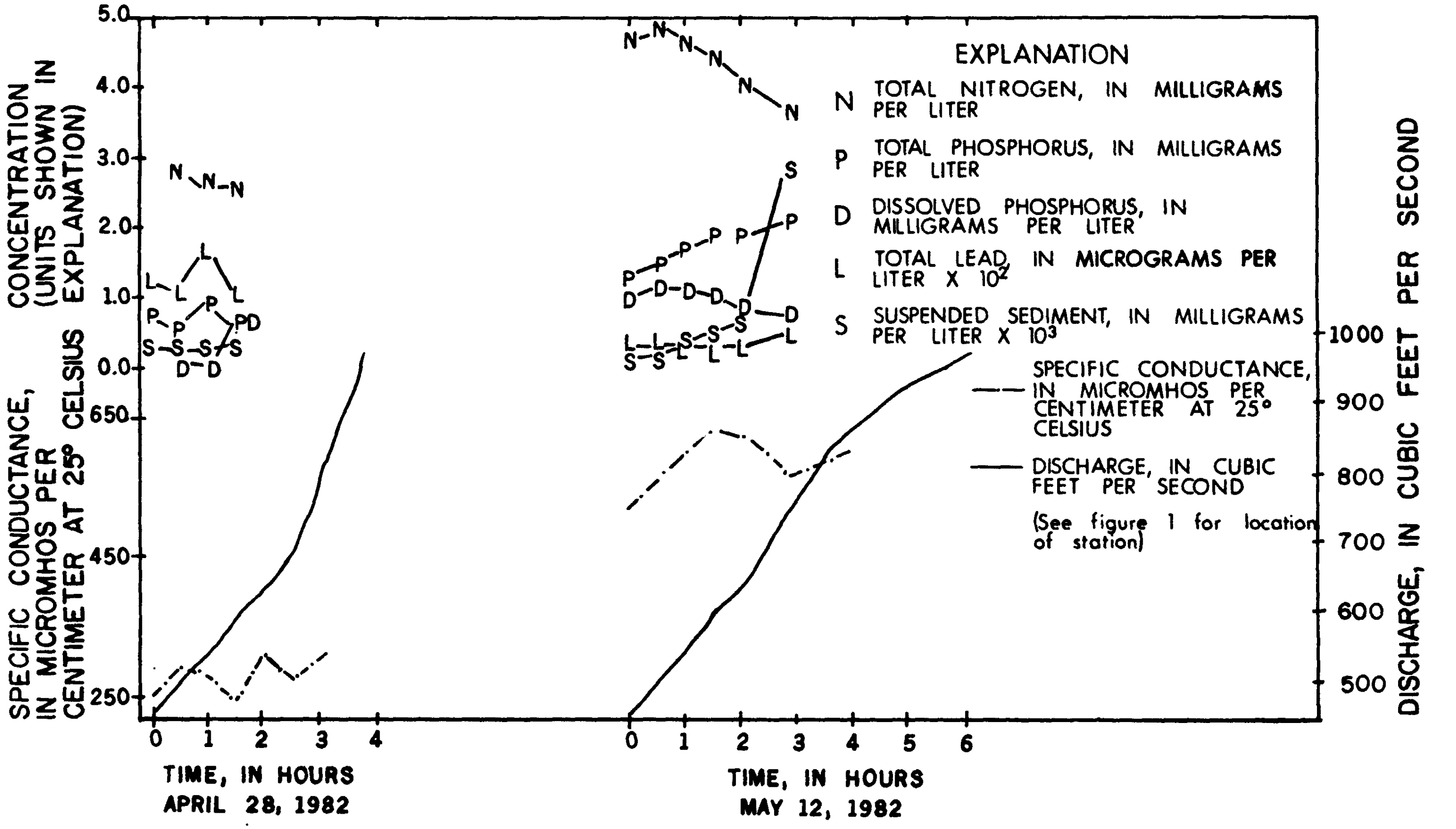



**Figure 13.**--Values of selected properties and concentrations of selected constituents in discrete samples collected during initial stormwater runoff, Blue River at Coalmine Road for the storms of April 28 and May 12, 1982.

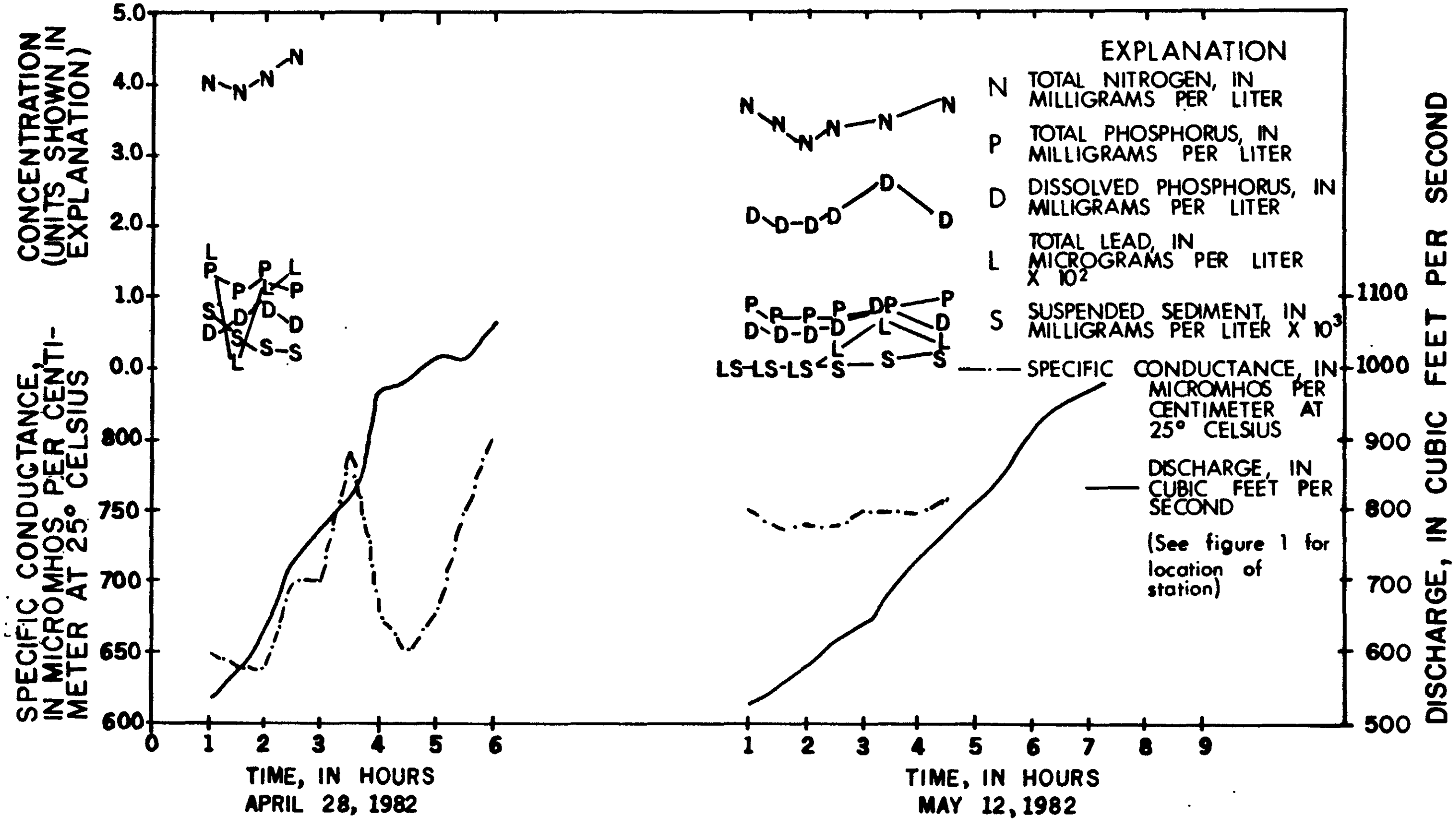



Figure 14.--Values of selected properties and concentrations of selected constituents in discrete samples collected during initial stormwater runoff, Blue River near St. John Avenue for the storms of April 28 and May 12, 1982.

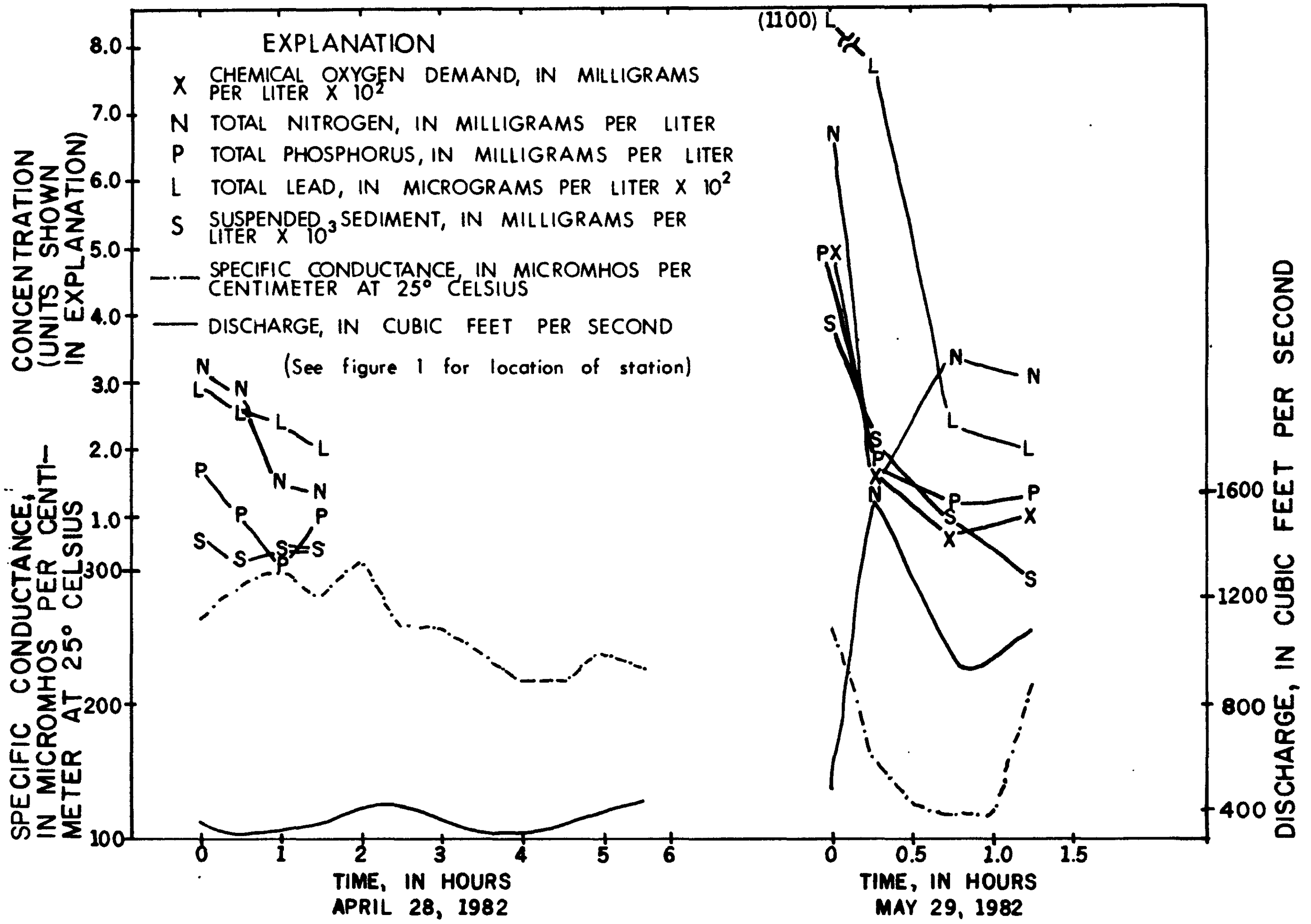



Figure 15.--Values of selected properties and concentrations of selected constituents in discrete samples collected during initial stormwater runoff, Brush Creek at Elmwood Avenue for the storms of April 28 and May 29, 1982.

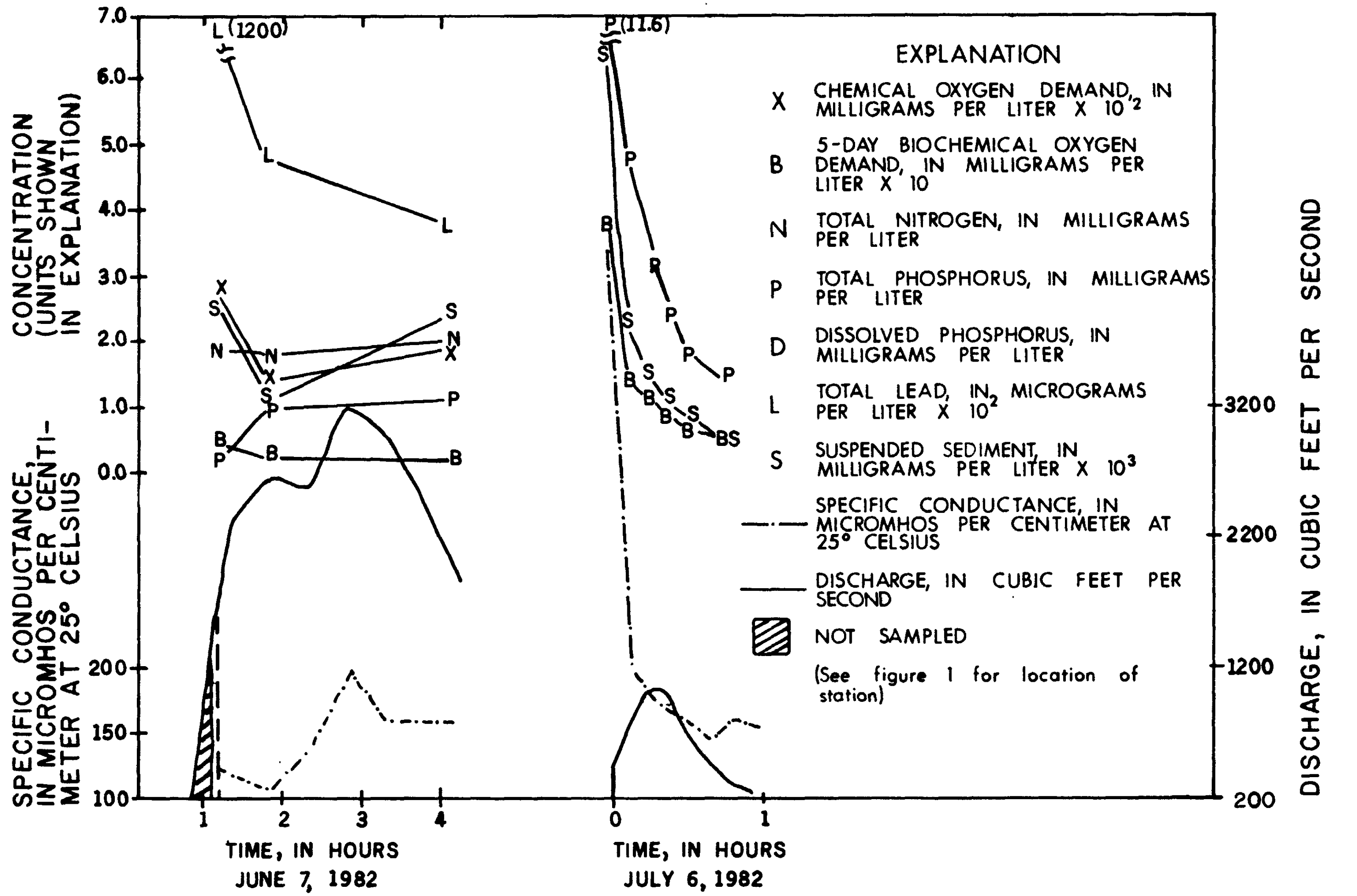



**Figure 16.**--Values of selected properties and concentrations of selected constituents in discrete samples collected during initial stormwater runoff, Brush Creek at Elmwood Avenue for the storms of June 7 and July 6, 1982.

January 1981, Brush Creek runoff causes smaller concentrations of suspended sediment, total nitrite and nitrate, total nitrogen, total phosphorous, and most total metals, and larger concentrations of dissolved ammonia, total lead, and total zinc than those in Blue River (tables 5 and 15). This pattern remained constant for the initial runoff of the two storms sampled at Coalmine Road during 1982. The major difference between these two storms was the antecedent conditions (table 3). The storm of April 28 occurred during relatively dry conditions, and the storm of May 12 occurred after 0.6 inch of rainfall May 11. Although few large fluctuations were found in the concentrations of most constituents in the initial runoff from either storm, larger concentrations of total lead and total zinc were present in the initial runoff from the storm of April 28 (see "Supplemental Information" section). Replacement of Brush Creek runoff with Blue River became apparent in the last sample collected on May 28 as suspended sediment began to increase.

### Blue River near St. John Avenue

Discharge values of specific conductance and concentrations of selected constituents in the initial runoff from two storms sampled near St. John Avenue are shown in figure 14. The largest volume of rainfall for the storm of April 28 occurred on the downstream, urban parts of the basin after dry, antecedent conditions (table 3). Specific conductance, which reflects dissolved-solids concentrations, rapidly increased to 780 micromhos per centimeter, rapidly decreased to 650 micromhos per centimeter, and again rapidly increased to more than 800 micromhos per centimeter. Evidently, pulses of runoff from either pulses of rain or from different urban tributaries were passing the sampler at different times. Large concentrations of dissolved solids probably were caused by the flushing of base-flow water impounded behind the two low-head dams and the large sewer just upstream from the downstream dam. Small concentrations of suspended sediment and large concentrations of total lead and total zinc indicated that the water in the four samples originated in urban areas.

The runoff on May 12 was caused by rainfall that was greater in the upstream part of the basin. Only 0.2 inch of rainfall was recorded at Raytown Road. Consequently, the first five samples represent impounded water being flushed from behind the two upstream dams pushed out by runoff from upstream. Specific-conductance values were larger (more than 740 micromhos per centimeter) and concentrations of suspended sediment were smaller (less than 56 milligrams per liter) with little fluctuation during the first 4 hours of runoff. The data for the sixth sample begins to show the effects of runoff as the concentration of suspended sediment begins to increase.

### Brush Creek at Elmwood Avenue

The plots in figures 15 and 16 show that initial runoff from storms in Brush Creek were largely raw sewage if combined sewers had not been recently flushed (table 3). Extremely large concentrations of $BOD_5$ (as much as 380 milligrams per liter) and suspended sediment (as much as 6,450 milligrams per liter) occurred in the first samples of storms on May 29 and July 6. Large concentrations of total lead (as much as 1,200 micrograms per liter) and total zinc (as much as 1,000 micrograms per liter) indicate that runoff from urban areas also was present in initial flows. Less intense flushes were recorded on:

(1) April 28, because moderate-intensity rainfall caused a large percentage of the volume to pass the gage before the stage was high enough to activate the sampler; and (2) June 7, because the automatic sampler malfunctioned and didn't collect the first sample, which would have contained the largest concentrations of constituents.

### Summary of Discrete-Sampling Data for 1982

The long, narrow shape and large size of the Blue River basin and the rainfall distribution usually caused initial stormwater runoff at stations on the mainstem to come from the areas immediately upstream. Consequently, constituent concentrations show different patterns at all three Blue River stations. Near Gregory Boulevard concentrations of most constituents associated with runoff from urban areas generally were larger during initial runoff than the mean concentrations at this station during 1981. However, fluctuations in specific-conductance values indicate that pulses of runoff from different tributaries passed Gregory Boulevard at different times. At Coalmine Road initial runoff usually is from the Brush Creek basin and contains constituents concentrations similar to those in the composite samples collected from Brush Creek during 1981. Near St. John Avenue water from behind two low-head dams was flushed out by initial volumes of runoff, followed by pulses of runoff from different urban tributaries and sewers, which caused specific-conductance values to fluctuate. On Brush Creek at Elmwood Avenue, discharges from combined sewers and runoff from areas with large volumes of automobile traffic produced storm flushes of $BOD_5$, suspended sediment, total lead, and total zinc when runoff was preceded by dry periods.

## QUALITY OF STORMWATER RUNOFF FROM TWO SINGLE LAND-USE AREAS DETERMINED FROM COMPOSITE SAMPLES, APRIL-JUNE 1982

Residential and commercial land use are the two most prevalent types of urban land use in the Blue River basin (table 1). For this study, two tributaries were selected as typical of the residential and commercial land use for the area. The Blue River tributary at Virginia Avenue (station 2, fig. 1) was used to sample stormwater runoff from an area of residential land use and the Blue Ridge Mall storm sewer (station 8, fig. 1) was used to sample stormwater runoff from an area of commercial land use.

Residential development during 1981 in the Blue River tributary at Virginia Avenue was predominantly single-family homes built since 1960. Housing density was 1.7 units per acre (planimetered from aerial photographs). The subbasin has an area of 313 acres, has separate storm-drainage and sanitary-sewage systems, and has street curbs. Short parts of the main channel are lined. Impervious areas covered 16 percent of the subbasin during 1981, although continuous impervious areas covered only 9 percent. Continuous impervious areas refer to impervious surfaces not separated from the channel by pervious surfaces.

Land use during 1981 for the storm sewer draining the commercial site can be classified as follows: Blue Ridge Mall rooftop, 15 percent; other rooftops, 3 percent; freeway, streets, median strip, and right-of-ways, 27 percent; and paved parking lots, 55 percent (planimetered from aerial photographs). Less than 10 percent of the main drainage paths were unlined.

Data for stormwater runoff from the residential and commercial tributaries indicate many of the same trends in runoff from urban areas in Brush Creek at Elmwood Avenue. Mean values of selected properties and mean concentrations of selected constiutuents in samples from the Blue River tributary at Virginia Avenue and the Blue Ridge Mall storm sewer are shown in tables 17 and 18. Larger impervious areas and lined channels caused much smaller sediment concentrations in stormwater runoff from the urban areas than those in the mainstem of the Blue River. Consequently, the percentage of all constituents in the suspended phase was less in stormwater runoff from the urban areas than in the mainstem of the Blue River (tables 11 and 12). The range of mean concentrations of suspended sediment in runoff from four storms during 1982 at the Blue Ridge Mall storm sewer was 81 to 642 milligrams per liter, and the range of mean concentrations of suspended sediment in stormwater runoff at all three mainstem Blue River stations was 838 to 3,110 milligrams per liter (tables 5 and 18). Consequently, concentrations of most nutrients and metals associated with sediment were considerably smaller in stormwater runoff from the residential and commercial land-use areas (tables 5, 15, 17, and 18). The range of mean concentrations for total organic and ammonia nitrogen as nitrogen in runoff from four storms at both the Blue River tributary at Virginia Avenue and the Blue Ridge Mall storm sewer during 1982 was 0.28 to 2.1 milligrams per liter. The range of mean concentrations of this same constituent in stormwater runoff at all mainstem Blue River stations during 1981 ranged from 2.7 to 6.6 milligrams per liter as nitrogen. Concentrations of total organic and ammonia nitrogen in stormwater runoff in Brush Creek at Elmwood Avenue were larger than at the other two urban stations and more comparable to concentrations in the Blue River because of the large volume of combined-sewer-overflows in the runoff. Total lead and total zinc concentrations in stormwater runoff from all three urban subbasins were large despite smaller suspended-sediment concentrations. The range of mean concentrations of total lead from the Blue Ridge Mall storm sewer during 1982 was 48 to 200 micrograms per liter. The range of mean concentrations of total lead in samples collected from the Blue River near Gregory Boulevard (primarily agricultural land use) during 1981 was 26 to 64 micrograms per liter.

Concentrations of dissolved constituents were less in stormwater runoff from urban areas than in stormwater runoff at the Blue River stations. The range in mean concentrations of dissolved solids in runoff from nine storms at both the Blue River tributary at Virginia Avenue and Blue Ridge Mall storm sewer was 66 to 175 milligrams per liter. The range of mean concentrations of dissolved solids in stormwater runoff at all three of the stations on the mainstem of the Blue River was 146 to 293 milligrams per liter. The smaller concentrations of dissolved solids probably were caused by dilution from the larger volumes of runoff per unit drainage area coming from the urban subbasins, which have larger percentages of impervious areas (table 1). Concentrations of dissolved nutrients also were diluted in stormwater runoff from urban areas, but may have been enriched in the mainstem of the Blue River from agricultural fertilizers used in the upstream part of the basin.

Comparison of mean concentrations in stormwater runoff at the Blue River tributary at Virginia Avenue and the Blue Ridge Mall storm sewer showed only total phosphorous and total lead concentrations as being significantly different. Mean concentrations of total phosphorous ranged from 0.14 to 1.0 milligrams per liter at the Blue Ridge Mall storm sewer. This difference

Table 17.--Mean values of selected properties and mean concentrations of selected constituents in runoff from four storms during May to June, 1982, Blue River tributary at Virginia Avenue (station 2, fig. 1)

[Results in milligrams per liter, except as indicated; <, less than; $ft^3/s$, cubic feet per second; µg/L, micrograms per liter; µmho/cm at 25 °C, micromhos per centimeter at 25 °Celsius; NTU, nephelometric units]

| Property or constituent | Date of storm | | | |
|---|---|---|---|---|
| | May 14, 1982 | May 29, 1982 | June 7, 1982 | June 14, 1982 |
| Peak discharge ($ft^3/s$) | 20 | 20 | 60 | 27 |
| Total runoff volume (cubic feet X 1,000) | 91 | 114 | 126 | 66 |
| Specific conductance (µmho/cm at 25 °C) | 191 | 153 | 124 | 151 |
| Turbidity (NTU) | -- | -- | 283 | 85 |
| Chemical-oxygen demand | -- | 53 | 115 | 59 |
| 5-day biochemical-oxygen demand | -- | -- | 18 | 8.1 |
| Dissolved solids | 120 | 109 | 103 | 101 |
| Suspended sediment | -- | 190 | -- | -- |
| Dissolved nitrite and nitrate as nitrogen | .37 | .45 | .56 | .46 |
| Dissolved ammonia as nitrogen | .40 | <.40 | <.40 | <.40 |
| Total organic and ammonia nitrogen as nitrogen | .70 | 1.8 | 1.3 | 2.1 |
| Dissolved organic and ammonia nitrogen as nitrogen | .61 | 1.4 | 1.9 | 1.2 |
| Total phosphorus | .14 | .42 | 1.0 | .43 |
| Dissolved phosphorus | .10 | .33 | .49 | .17 |
| Total arsenic (µg/L) | 5 | 10 | -- | 7 |
| Total cadmium (µg/L) | 2 | 1 | 1 | 1 |
| Total chromium (µg/L) | 70 | 20 | 40 | 20 |
| Total copper (µg/L) | 17 | 12 | 46 | 10 |
| Total iron (µg/L) | 2,900 | 3,900 | 32,000 | 2,500 |

Table 17.--Mean values of selected properties and mean concentrations of selected constituents in runoff from four storms during May-June, 1982, Blue River tributary at Virginia Avenue (station 2, fig. 1)--Continued

| Constituent or property | Date of storm | | | |
|---|---|---|---|---|
| | May 14, 1982 | May 29, 1982 | June 7, 1982 | June 14, 1982 |
| Total lead (μg/L) | 54 | 41 | 80 | 17 |
| Total manganese (μg/L) | 230 | 300 | 3,400 | 160 |
| Total zinc (μg/L) | 80 | 60 | 280 | 110 |
| Total organic carbon | -- | 17 | 30 | 15 |

Table 18.--Mean values of selected properties and mean concentrations of selected constituents in runoff from five storms during April-June, 1982, Blue Ridge Mall storm sewer (station 8, fig. 1)

[Results in milligrams per liter, except as indicated; <, less than; $ft^3/s$, cubic feet per second; µg/L, micrograms per liter; µmho/cm at 25 °C, micromhos per centimeter at 25 °Celsius; NTU, nephelometric units]

| Property or constituent | Date of storm | | | | |
|---|---|---|---|---|---|
| | April 28, 1982 | May 11-14, 1982 | May 28-29, 1982 | June 14-15, 1982 | June 25, 1982 |
| Peak discharge ($ft^3/s$) | 12 | 100 | 39 | 48 | 49 |
| Total runoff volume (cubic feet X 1,000) | 142 | 246 | 169 | 131 | 104 |
| Specific conductance (µmho/cm at 25 °C) | 204 | 126 | 118 | 165 | 141 |
| Turbidity (NTU) | 19 | -- | -- | 23 | -- |
| Chemical-oxygen demand | -- | -- | 40 | -- | 103 |
| 5-day biochemical-oxygen demand | -- | -- | -- | 10.3 | -- |
| Dissolved solids | 124 | 74 | 66 | 67 | 175 |
| Suspended sediment | 119 | 642 | 81 | -- | 184 |
| Dissolved nitrite and nitrate as nitrogen | .47 | .27 | .35 | .45 | -- |
| Dissolved ammonia as nitrogen | .52 | <.40 | <.40 | <.40 | -- |
| Total organic and ammonia nitrogen as nitrogen | 1.4 | .28 | 1.3 | 1.2 | -- |
| Dissolved organic and ammonia nitrogen as nitrogen | 1.3 | .13 | .87 | 1.2 | -- |
| Total phosphorus | .18 | .39 | .17 | .32 | -- |
| Dissolved phosphorus | .12 | .12 | .10 | <.10 | -- |
| Total arsenic (µg/L) | 1 | 1 | 2 | -- | 2 |
| Total cadmium (µg/L) | -- | 2 | 2 | 1 | 2 |
| Total chromium (µg/L) | 10 | 30 | -- | 20 | 20 |
| Total copper (µg/L) | 19 | 28 | 13 | 14 | 24 |
| Total iron (µg/L) | 2,200 | 9,100 | 1,700 | 2,500 | 3,900 |

Table 18.--Mean values of selected properties and mean concentrations of selected constituents in runoff from five storms during April-June, 1982, Blue Ridge Mall storm sewer (station 8, fig. 1)--Continued

| Property or constituent | Date of storm | | | | |
| --- | --- | --- | --- | --- | --- |
| | April 28, 1982 | May 11-14, 1982 | May 28-29, 1982 | June 14-15, 1982 | June 25, 1982 |
| Total lead (μg/L) | 67 | 200 | 48 | 85 | 147 |
| Total manganese (μg/L) | 131 | 490 | 181 | 255 | 626 |
| Total zinc (μg/L) | 150 | 280 | 110 | 170 | 270 |
| Total organic carbon | 10 | -- | 8.6 | 13 | 24 |

is expected from fertilizer commonly used on lawns in residential areas. Mean concentrations of total lead ranged from 17 to 80 micrograms per liter at Blue River tributary at Virginia Avenue and from 48 to 200 micrograms per liter at the Blue Ridge Mall storm sewer (tables 17 and 18). This difference can be explained by the large volume of automobile traffic using the parking lots at the Blue Ridge Mall.

Discharge and values of selected properties and concentrations of selected constituents in composite samples of stormwater runoff from the urban land-use stations are plotted in figures 17 and 18. Specific-conductance values at both stations generally were controlled by the volume of discharge diluting the sample. Total lead concentrations were large in the first composite samples collected during stormwater runoff at both the Blue River tributary at Virginia Avenue and the Blue Ridge Mall storm sewer only if there was enough runoff to thoroughly flush the subbasins. However, after initial flushing, concentrations of total lead decreased to concentrations much less than those in the Blue River (tables 5 and 15). Total zinc also showed large flushes at the Blue Ridge Mall storm sewer, but no consistent pattern could be detected at the Blue River tributary at Virginia Avenue. Trends for other properties or constituents were not apparent or consistent at the commercial and residential land-use stations.

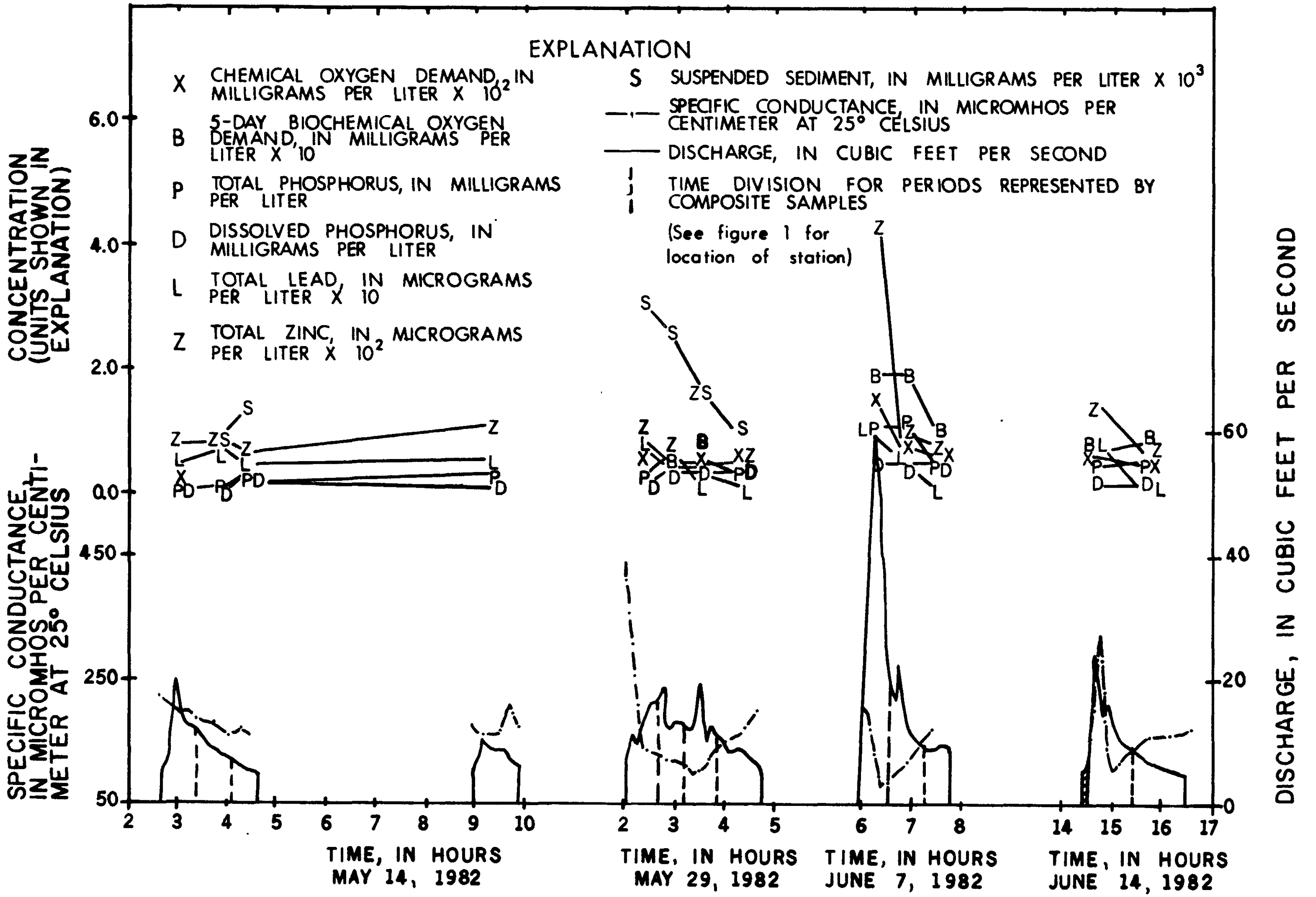



Figure 17.--Values of selected properties and concentrations of selected constituents in composite samples collected during stormwater runoff at the residential land-use site (Blue River tributary at Virginia Avenue) for four storms during May-June 1982.

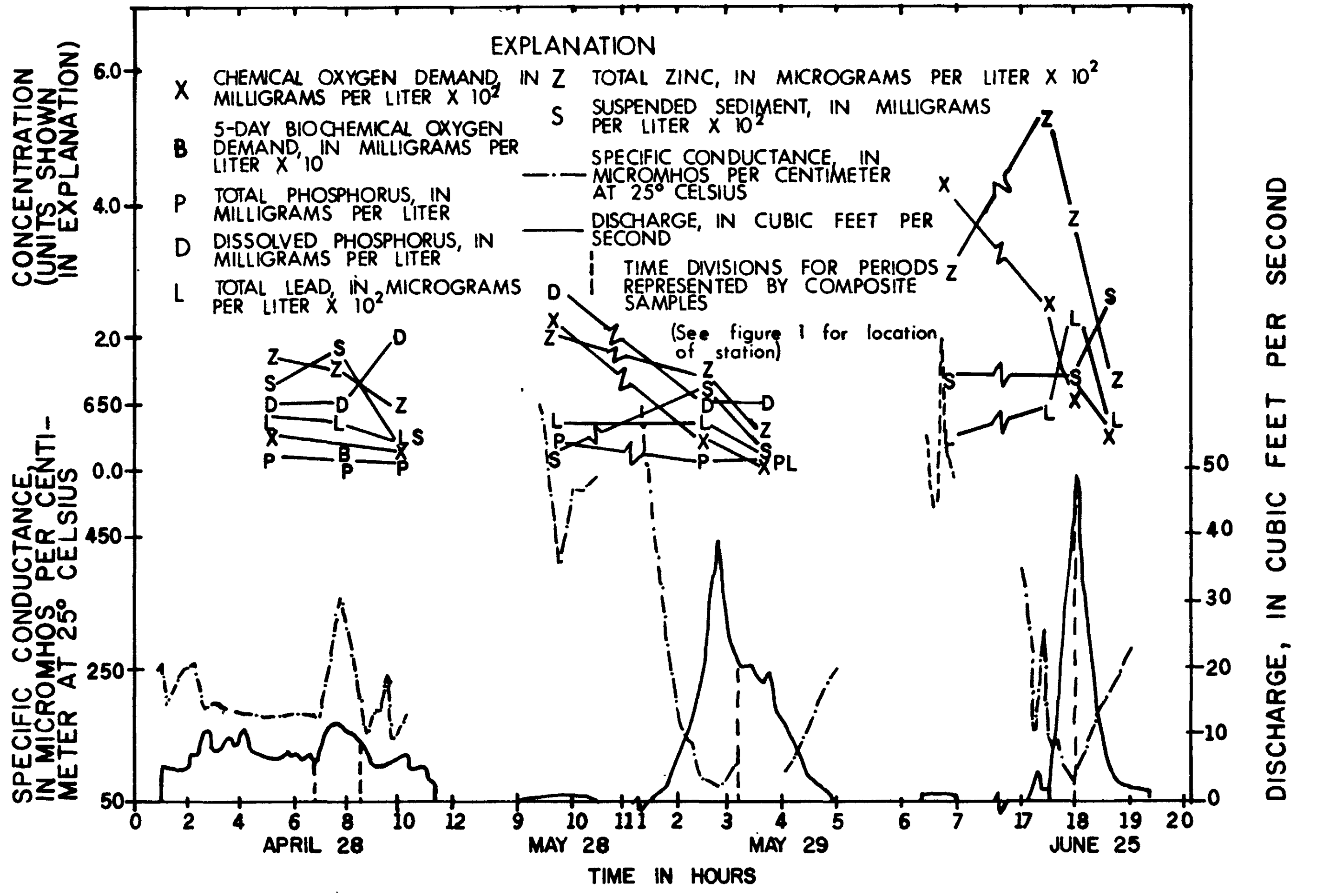



Figure 18.--Values of selected properties and concentrations of selected constituents in composite samples collected during stormwater runoff at the commercial land-use site (Blue Ridge Mall storm sewer), for five storms during April - June 1982.

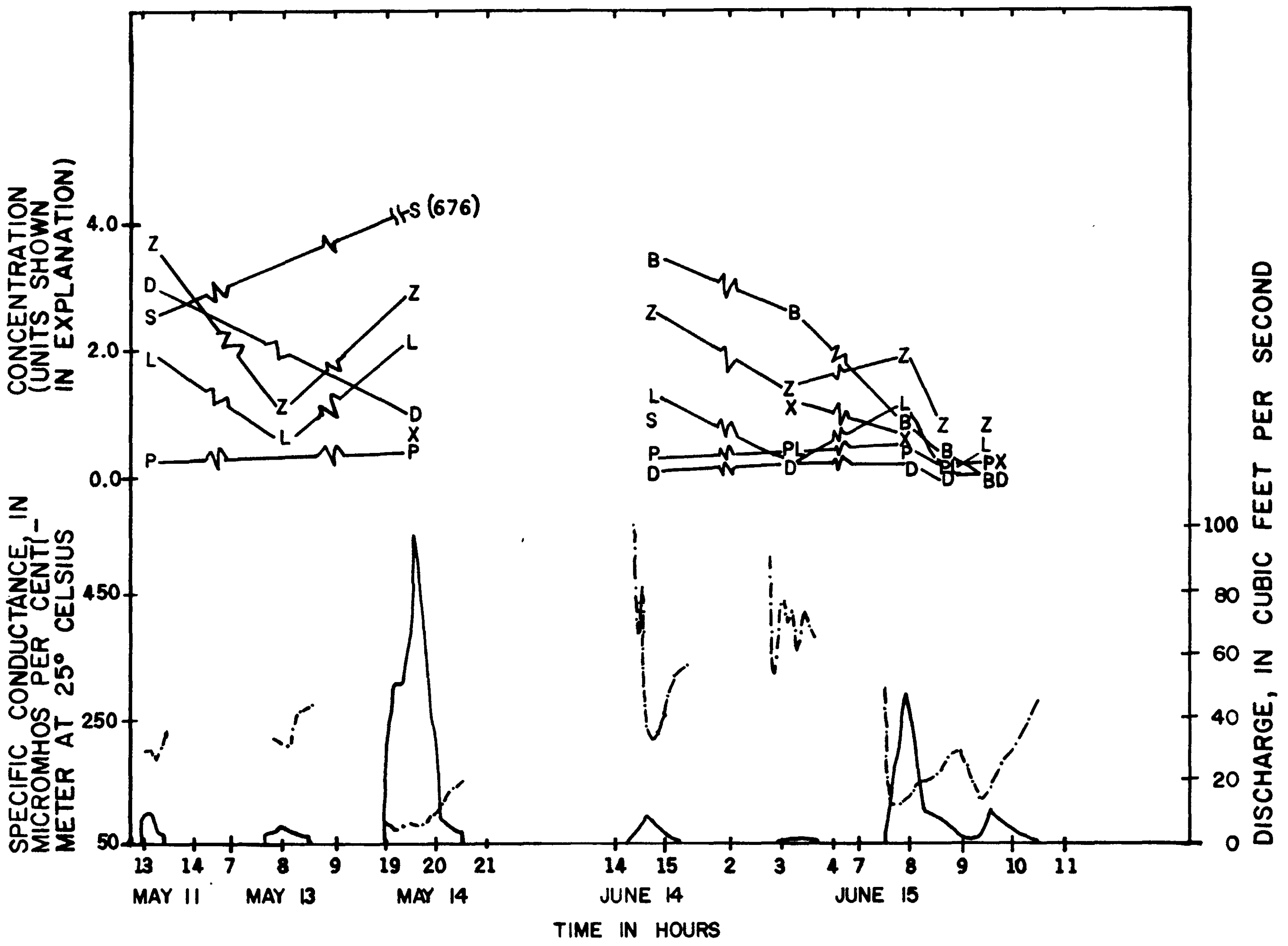



Figure 18.--Values of selected properties and concentrations of selected constituents in composite samples collected during stormwater runoff at the commercial land-use site (Blue Ridge Mall storm sewer), for five storms during April - June 1982--Continued.

## SUMMARY AND CONCLUSIONS

Although the Blue River basin contains a large part of the Kansas City metropolitan area, agricultural and vacant areas comprise about 67 percent of the land in the basin during 1981. The large concentrations of most sampled constituents were associated with the large concentrations of suspended sediment. Seventy-five percent of the nitrogen and phosphorus concentrations and more than 90 percent of most metals concentrations were associated with suspended sediment in the Blue River. The close relationships between suspended sediment and copper, iron and manganese; and the lack of increase in the concentrations of these three constituents through the urban reaches of the Blue River indicate that these metals are a part of the sediment entering the Kansas City metropolitan area from upstream agricultural lands.

The presence of large impervious areas and lined drainageways in urban areas increased the quantity of storm runoff in the Blue River and limited the quantity of soil and sediment available for detachment. Generally, mean concentrations in stormwater runoff for most constituents at all three urban stations were smaller than those in the Blue River, but because the volume of runoff in the Blue River was so much larger, loads per square mile from urban areas were sometimes larger than those from undeveloped areas. Once urban runoff leaves unlined drainageways, the readily available sediments are picked up from the silt banks of the Blue River.

The two low-head dams on the downstream reach of the Blue River affected concentrations of dissolved solids and suspended sediment. Also, after several days without runoff, water behind the impoundments was replaced with base-flow water. Runoff from small storms pushed this volume of stored, base-flow water out tending to increase mean concentrations of dissolved solids, and decrease mean concentrations of suspended sediment. During small storms, suspended sediment and associated metals and nutrients were trapped behind the dams decreasing loads. However, during large storms, the effect on dissolved solids became indistinguisable and sediments were removed from storage behind these small dams.

Concentrations of most nutrients in runoff from the land-use sites were smaller than concentrations in the mainstem of the Blue River. These findings indicate the principal quantities of ammonia nitrogen are coming from the fertilized, agricultural lands upstream in the Blue River Basin.

Total concentrations of copper, iron, lead, and zinc exceeded the numeric aquatic-life criteria values listed in Missouri's water quality standards. However, the state's criteria implementation policy applies only to dissolved concentrations of these metals. Concentrations of lead and zinc were significantly associated with urban runoff from Brush Creek, the Blue Ridge Mall storm sewer, and Blue River between Gregory Boulevard and St. John Avenue. Lead loads increased from 0.4 to 3.8 tons and zinc loads increased from 2.1 to 9.5 tons between Gregory Boulevard and St. John Avenue during the storm of July 27-28, 1981. Lead is associated with vehicle exhausts and is commonly present in large concentrations in urban runoff. A specific source of zinc was not identified. The largest increases of lead concentrations in Blue River were between Gregory Boulevard and Coalmine Road, whereas the increases in zinc concentrations primarily were between Coalmine Road and St. John Avenue, indicating different sources for these two metals.

Characteristics of runoff quality in the Blue River were affected by the shape of the basin and the location of urban areas in the downstream end of the basin. The long, narrow shape promoted noncoincidental timing of runoff, allowing runoff from the downstream tributaries to enter the mainstream reach before upstream runoff arrived. Consequently, urban runoff dominated the first part of runoff for streamflow-gaging stations at Coalmine Road and St. John Avenue, but water quality fluctuated widely during initial rises as runoff from different sources passed these sites at different times. Generally, urban runoff was soon replaced by upstream, agricultural runoff, which constituted the larger part of the total flow volume at the Blue River stations.

Water-quality problems from urban runoff primarily occurred on the initial rise of a stream after a dry antecedent period. The flushing of combined sewers in the Brush Creek basin caused large concentrations of $BOD_5$, dissolved solids, suspended sediment, nutrients and metals. Concentrations of $BOD_5$ were as much as 380 milligrams per liter at a discharge of 458 cubic feet per second. These conditions rapidly improved as the sewers were flushed and water discharged from them was diluted by the later and larger flows in Brush Creek and especially Blue River. Consequently, average $BOD_5$ concentrations in runoff in the Blue River at Coalmine Road just downstream from Brush Creek were only slightly larger than those near Gregory Boulevard. Lead (and at times $BOD_5$, suspended sediment, dissolved phosphorus, and zinc) showed significant flushes at the Blue River tributary at Virginia Avenue, Blue Ridge Mall storm sewer, Brush Creek at Elmwood Avenue, and moderate flushes during the first one-third or one-fourth of hydrographs on Blue River near Gregory Boulevard. Flushes at Coalmine Road and St. John Avenue were masked by Brush Creek inflow and impounded water.

## REFERENCES

Chow, V.T., (ed.), 1964, Handbook of applied hydrology: New York, McGraw Hill, 1418 p.

Gehm, H.W., and Bregman, J.I., 1976, Handbook of water resources and pollution control: New York, Van Nostrand Reinhold, 840 p.

Guy, H.P., 1969, Laboratory theory and methods for sediment analysis: U.S. Geological Survey Techniques of Water Resources Investigations, Book 3, Chapter C2, 59 p.

Lamb, Frank, 1983, The combined sewer overflow study for Kansas City, Missouri, Phase I: Kansas City, Mo., Howard Needles Tammen & Bergendoff (in press).

Mausel, P.W., and others, 1976, Regional soils guide, metropolitan region of Kansas City, Missouri and Kansas: Kansas City, Mo., Mid-American Regional Council, 120 p.

Mid-America Regional Council, 1974, Water--A report on quality: Kansas City, Mo., 100 p.

_____1981, 1978 Land use acreage by census tract: Kansas City, Mo., 14 p.

Missouri Department of Natural Resources, 1984, Missouri water-quality report 1984: Jefferson City, Mo., Division of Environmental Quality, 55 p.

National Oceanic and Atmospheric Administration, 1982, Climatological Data, Annual Summary, Missouri, 1981: Asheville, N.C., 19 p.

Skougstad, M.W., Fishman, M.J., Friedman, L.C., Erdmann, D.E., Duncan, S.S., editors, 1979, Methods for determination of inorganic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water Resources Investigations, Book 5, Chapter A1, 626 p.

U.S. Environmental Protection Agency, 1979, Methods for chemical analysis of water and wastes: Cincinnati, U.S. Environmental Protection Agency USEPA 600/4-79-020, 490 p.

_____1979, Water related, environmental fate of 129 priority pollutants: Washington, D.C., U.S. Environmental Protection Agency, USEPA 440/4-79-029, 514 p.

## SUPPEMENTAL INFORMATION

Table 19.--U.S. Environmental Protection Agency priority-pollutant concentrations from manually collected samples July 25-27, 1981

[Results in micrograms per liter, except as noted; <, less than]

| Constituent | Blue River near Gregory Boulevard (station 4, fig. 1) | Blue River at Coalmine Road (station 7, fig. 1) | Blue River near St. John Avenue (station 11, fig. 1) | Brush Creek at Elmwood Avenue (station 6, fig. 1) |
|---|---|---|---|---|
| Phenol | <1.3 | <1.3 | <1.3 | <1.3 |
| 2-Chlorophenol | <2.3 | <2.3 | <2.3 | <2.3 |
| 2-Nitrophenol | <8.4 | <8.4 | <8.4 | <8.4 |
| 2,4-Dimethyphenol | <1.6 | <1.6 | <1.6 | <1.6 |
| 2,4-Dichlorophenol | <5.2 | <5.2 | <5.2 | <5.2 |
| P-Chloro-M-Cresol | <2.7 | <2.7 | <2.7 | <2.7 |
| 2,4,6-Trichlorophenol | <3.3 | <3.3 | <3.3 | <3.3 |
| 2,4-Dinitrophenol | <33 | <33 | <33 | <33 |
| 4-Nitrophenol | <15 | <15 | <15 | <15 |
| 4, 6-Dinitro-O-Cresol | <17 | <17 | <17 | <17 |
| Pentachlorophenol | <14 | <14 | <14 | <14 |
| Dibenzo(A,H)-Anthracene | <2.2 | <2.2 | <2.2 | <2.2 |
| Benzo (G,H,I)Perylene | <2.4 | <2.4 | <2.4 | <2.4 |
| Diethylphthalalate | <1.4 | <1.4 | <1.4 | <1.4 |
| N-Nitrosodiphenylamine | <3.2 | <3.2 | <3.2 | <3.2 |
| Hexachlorobenzene | <2.3 | <2.3 | <2.3 | <2.3 |
| 4-Boromophenyl Phenyl Ether | <2.2 | <2.2 | <2.2 | <2.2 |
| Phenanthrene | <12 | <12 | <12 | <12 |
| Di-N-Butyl-Phthalate | <2.8 | <2.8 | <2.8 | <2.8 |
| Fluoranthene | <2.3 | <2.3 | <2.3 | <2.3 |
| Pyrene | <2.3 | <2.3 | <2.3 | <2.3 |
| Benzidine | <25 | <25 | <25 | <25 |

Table 19.--U.S. Environmental Protection Agency priority-pollutant concentrations from manually collected samples collected July 25-27, 1981--Continued

| Constituent | Blue River near Gregory Boulevard (station 4, fig. 1) | Blue River at Coalmine Road (station 7, fig. 1) | Blue River near St. John Avenue (station 11, fig. 1) | Brush Creek at Elmwood Avenue (station 6, fig. 1) |
|---|---|---|---|---|
| Butyl-Benzyl-Phthalate | <3.0 | <3.0 | <3.0 | <3.0 |
| Bis (2 Ethylhexyl) Phthalate | <9.3 | <9.3 | <9.3 | <9.3 |
| Chrysene | <18 | <18 | <18 | <18 |
| Benzo(B)Fluoranthene | <20 | <20 | <20 | <20 |
| 3,3'-Dichlorobenzidine | <25 | <25 | <25 | <25 |
| Di-N-Octyl Phthalate | <2.6 | <2.6 | <2.6 | <2.6 |
| Benzo(A)Pyrene | <10 | <10 | <10 | <10 |
| Indeno(1,2,3,-CD)Pyrene | <2.5 | <2.5 | <2.5 | <2.5 |
| Hexachloroethane | <1.3 | <1.3 | <1.3 | <1.3 |
| Bis-(2-Chloroethyl Ether) | <10 | <10 | <10 | <10 |
| Bis-(2-Chloroisopropyl)Ether | <32 | 32 | <32 | <32 |
| N-Nitrosodi-N-Propylamine | <8.2 | <8.2 | <8.2 | <8.2 |
| Isophorone | <2.5 | <2.5 | <2.5 | <2.5 |
| Nitrobenzene | <3.1 | <3.1 | <3.1 | <3.1 |
| Hexachlorobutadiene | <.0920 | <.0920 | <.0920 | <.0920 |
| 1,2,4,Trichlorobenzene | <1.8 | <1.8 | <1.8 | <1.8 |
| Napthalene | <2.1 | <2.1 | <2.1 | <2.1 |
| Bis-(2-Chloroethoxy)Methane | <8.2 | <8.2 | <8.2 | <8.2 |
| Hexachlorocyclopentadiene | <2.2 | <2.2 | <2.2 | <2.2 |
| 2-Chloronapthalene | <2.2 | <2.2 | <2.2 | <2.2 |
| Acenapthylene | <2.3 | <2.3 | <2.3 | <2.3 |
| 2,6-Dinitrotoluene | <1.9 | <1.9 | <1.9 | <1.9 |
| Acenapthene | <2.2 | <2.2 | <2.2 | <2.2 |

Table 19.--U.S. Environmental Protection Agency priority-pollutant concentrations from manually collected samples collected July 25-27, 1981--Continued

| Constituent | Blue River near Gregory Boulevard (station 4, fig. 1) | Blue River at Coalmine Road (station 7, fig. 1) | Blue River near St. John Avenue (station 11, fig. 1) | Brush Creek at Elmwood Avenue (station 6, fig. 1) |
|---|---|---|---|---|
| Dimethylphtalate | <0.700 | <0.700 | <0.700 | <0.700 |
| Fluorene | <1.9 | <1.9 | <1.9 | <1.9 |
| 4-Chloro-Phenyl Phenyl Ether | <10 | <10 | <10 | <10 |
| 2,4-Dinitrotoluene | <2.2 | <2.2 | <2.2 | <2.2 |
| 1,2-Diphenylhydrazine | <12 | <12 | <12 | <12 |
| CIS-1,3-Dichloropropene | <0.300 | <0.300 | <0.300 | <0.300 |
| Dibromocloromethane | <0.400 | <0.400 | <0.400 | <0.400 |
| 1,1,2-Trichloroethane | <0.400 | <0.400 | <0.400 | <0.400 |
| 2-Chloroethyvinl Ether | <1.8 | <1.8 | <1.8 | <1.8 |
| Bromoform | <0.500 | <0.500 | <0.500 | <0.500 |
| 1,1,2,2,-Tetrachloroethene | <0.400 | <0.400 | <0.400 | <0.400 |
| Toluene | <0.200 | <0.200 | <0.200 | <0.200 |
| 1,1,2,2,-Tetrachloroethane | <0.300 | 1.6 | 1.6 | 3.5 |
| Chlorobenzene | <0.200 | <0.200 | <0.200 | <0.200 |
| Ethyl Benzene | <0.300 | <0.300 | <0.300 | <0.300 |
| 1,3-Dichlorobenzene | <1.0 | <1.0 | <1.0 | <1.0 |
| 1,2-Dichlorobenzene | <1.0 | <1.0 | <1.0 | <1.0 |
| 1,4-Dichlorbenzene | <1.0 | <1.0 | <1.0 | <1.0 |
| Acrolein | <12 | <12 | <12 | <12 |
| Acrylonitile | <19 | <19 | <19 | <19 |
| Chloromethane | <1.2 | <1.2 | <1.2 | <1.2 |
| Dichlorodifluoromethane | <2.4 | <2.4 | <2.4 | <2.4 |
| Bromomethane | <2.2 | <2.2 | <2.2 | <2.2 |

Table 19.--U.S. Environmental Protection Agency priority-pollutant concentrations from manually collected samples collected July 25-27, 1981--Continued

| Constituent | Blue River near Gregory Boulevard (station 4, fig. 1) | Blue River at Coalmine Road (station 7, fig. 1) | Blue River near St. John Avenue (station 11, fig. 1) | Brush Creek at Elmwood Avenue (station 6, fig. 1) |
|---|---|---|---|---|
| Vinyl Chloride | <1.4 | <1.4 | <1.4 | <1.4 |
| Chloroethane | <1.4 | <1.4 | <1.4 | <1.4 |
| Methlene Chloride | <0.300 | <0.300 | <0.300 | <0.300 |
| Trichorofluoromethane | <0.300 | <0.300 | <0.300 | <0.300 |
| 1,1-Dichloroethylene | <0.200 | <0.200 | <0.200 | <0.200 |
| 1,1-Dichloroetane | <0.300 | <0.300 | <0.300 | <0.300 |
| Trans-1,2-Dichloroethylene | <0.400 | <0.400 | <0.400 | <0.400 |
| Chloroform | <0.200 | <0.200 | <0.200 | <0.200 |
| 1,2-Dichloroethane | <0.300 | <0.300 | <0.300 | <0.300 |
| 1,1,1-Trichloroethane | <0.500 | <0.500 | <0.500 | <0.500 |
| Carbon Tetrachloride | <0.400 | <0.400 | <0.400 | <0.400 |
| Bromodichloromethane | <0.200 | <0.200 | <0.200 | <0.200 |
| 1,2-Dichloropropane | <0.200 | <0.200 | <0.200 | <0.200 |
| Benzene | <0.200 | <0.200 | <0.200 | <0.200 |
| Trans-1,3-Dichloropropene | <0.400 | <0.400 | <0.400 | <0.400 |
| Trichloroetylene | <0.300 | <0.300 | <0.300 | <0.300 |
| Silver | <1 | <1 | <1 | <1 |
| Aluminum | 79,200 | 79,200 | 79,200 | 79,200 |
| Arsenic | <116 | <100 | <20 | <20 |
| Barium | <866 | <470 | <185 | <103 |
| Beryllium | 3 | <1 | <1 | <1 |
| Cadmium | <4 | <4 | <1 | <1 |
| Chromium | 84 | 45 | 10 | 10 |

Table 19.--U.S. Environmental Protection Agency priority-pollutant concentrations from manually collected samples collected July 25-27, 1981--Continued

| Constituent | Blue River near Gregory Boulevard (station 4, fig. 1) | Blue River at Coalmine Road (station 7, fig. 1) | Blue River near St. John Avenue (station 11, fig. 1) | Brush Creek at Elmwood Avenue (station 6, fig. 1) |
|---|---|---|---|---|
| Copper | 60 | 37 | 6 | 10 |
| Iron | 67,400 | 36,600 | 6,100 | 6,620 |
| Manganese | 1,734 | 1,100 | 646 | 188 |
| Nickel | 74 | 40 | 8 | 8 |
| Lead | <5 | 8 | 14 | <23 |
| Antimony | <20 | <20 | <20 | <20 |
| Selenium | <100 | <100 | <20 | <20 |
| Zinc | 236 | 163 | 48 | 73 |
| Calcium (milligrams per liter) | 82 | 59 | 67 | 28 |
| Magnesium (milligrams per liter) | 16 | 11 | 8 | 4 |
| Sodium (milligrams per liter) | 8 | 16 | 34 | 10 |
| Mercury | <0.2 | <0.2 | <0.2 | <0.2 |

11/16"

Table 20.--Water-quality data for storm runoff in Blue River tributary at Virginia Avenue (station 2, fig. 1) for four storms during May-June, 1982

[units are in micrograms per liter, except as indicated; µmho/cm at 25 °C, micromhos per centimeter at 25 °C; NTU, nephelometric turbidity units; mg/L, milligrams per liter; $NO_2$, nitrite; $NO_3$, nitrate; N, nitrogen; P, phosphorus; tons/d, tons per day; mm, millimeter]

| Date | Starting time (2400 hours) | Ending time (2400 hours) | Discharge (cubic feet per second) | Specific conductance (µmho/cm at 25°C) | pH (units) | Turbidity (NTU) | Chemical oxygen demand (mg/L) | 5-day biochemical oxygen demand (mg/L) | Solids, residue at 180 °C dissolved (mg/L) | Solids, residue at 105 °C suspended (mg/L) | Nitrogen, $NO_2 + NO_3$ dissolved (mg/l as N) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| May 1982 | | | | | | | | | | | |
| 14 | 0240 | 0312 | 12 | 210 | 7.5 | -- | -- | -- | 123 | 124 | 0.43 |
| 14 | 0320 | 0352 | 9.5 | 185 | 7.8 | -- | 21 | -- | 121 | 146 | .38 |
| 14 | 0400 | 0432 | 6.2 | 170 | 7.7 | -- | -- | -- | 109 | 159 | .29 |
| 14 | 0855 | 0950 | 25 | 185 | 7.1 | -- | -- | -- | 119 | 101 | .33 |
| 29 | 0200 | 0230 | 12 | 200 | 7.1 | -- | 70 | -- | 124 | 164 | .41 |
| 29 | 0245 | 0308 | 14 | 115 | 7.2 | -- | 47 | -- | 83 | -- | .36 |
| 29 | 0315 | 0345 | 13 | 120 | 7.2 | -- | 45 | -- | 93 | 127 | .41 |
| 29 | 0352 | 0445 | 8.1 | 180 | 7.3 | -- | 51 | -- | 138 | 37 | .64 |
| June | | | | | | | | | | | |
| 07 | 0605 | 0635 | 34 | 115 | 7.2 | 320 | 150 | 19 | 95 | -- | .53 |
| 07 | 0642 | 0712 | 15 | 120 | 7.1 | 320 | 73 | 19 | 101 | -- | .53 |
| 07 | 0720 | 0742 | 9.2 | 170 | 7.3 | 55 | 62 | 10 | 141 | -- | .73 |
| 14 | 1420 | 1520 | 13 | 140 | 7.5 | 100 | 61 | 7.6 | 91 | 206 | .40 |
| 14 | 1530 | 1630 | 6.4 | 170 | 7.5 | 57 | 56 | 8.8 | 118 | 41 | .57 |

Table 20.--Water-quality data for storm runoff in Blue River tributary at Virginia Avenue (station 2, fig. 1) for four storms during May-June, 1982--Continued

| Date | Nitrogen, ammonia dissolved (mg/L as N) | Nitrogen, ammonia + organic total (mg/L as N) | Nitrogen, ammonia + organic dissolved (mg/L as N) | Phosphorus, total (mg/L as N) | Phosphorus, dissolved (mg/L as N) | Arsenic, total | Arsenic, suspended total | Arsenic, dissolved | Cadmium, total recoverable | Cadmium, dissolved | Chromium, total recoverable | Chromium, suspended recoverable |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| May 1982 | | | | | | | | | | | | |
| 14 | <0.40 | 0.90 | 0.73 | <0.10 | 0.10 | 4 | 1 | 3 | 1 | <3 | 90 | 10 |
| 14 | <.40 | 1.0 | .87 | <.10 | .10 | 5 | 2 | 3 | 1 | <3 | 60 | 10 |
| 14 | <.40 | 1.1 | 1.1 | .30 | .28 | 4 | 0 | 4 | 1 | <3 | 50 | 10 |
| 14 | <.40 | <.10 | <.10 | .20 | .13 | 6 | 1 | 5 | 4 | 1 | 50 | 20 |
| 29 | <.40 | 1.6 | 1.3 | .28 | .20 | 8 | 5 | 3 | 1 | <3 | 30 | 10 |
| 29 | <.40 | 1.7 | 1.2 | .46 | .35 | 8 | 0 | 8 | 2 | <3 | 10 | -- |
| 29 | <.40 | 1.8 | 1.3 | .48 | .37 | 11 | 0 | 12 | 1 | <3 | <10 | -- |
| 29 | <.40 | 2.0 | 1.7 | .46 | .42 | 15 | 0 | 15 | 1 | <3 | <10 | -- |
| June | | | | | | | | | | | | |
| 07 | <.40 | 1.3 | .96 | 1.1 | .48 | -- | -- | 4 | <1 | <1 | 80 | -- |
| 07 | <.40 | 1.3 | .96 | 1.1 | .48 | 10 | 2 | 8 | 1 | <1 | 10 | -- |
| 07 | <.40 | 1.4 | 1.3 | .52 | .52 | 10 | 1 | 9 | 1 | <1 | <10 | -- |
| 14 | <.40 | 2.1 | 1.0 | .40 | .18 | 5 | 2 | 3 | 1 | <1 | 20 | -- |
| 14 | <.40 | 2.0 | 1.5 | .48 | .16 | 10 | 2 | 8 | 1 | <1 | 10 | -- |

Table 20.--Water-quality data for storm runoff in Blue River tributary at Virginia Avenue (station 2, fig. 1) for four storms during May-June, 1982--Continued

| Date | Chromium, dissolved | Copper, total recoverable | Copper, suspended recoverable | Copper, dissolved | Iron, total recoverable | Iron, suspended recoverable | Iron, dissolved | Lead, total recoverable | Lead, suspended recoverable | Lead, dissolved | Manganese, total recoverable | Manganese, suspended recoverable |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| May 1982 | | | | | | | | | | | | |
| 14 | 80 | 23 | 16 | 7 | 2,600 | 2,500 | 75 | 53 | 49 | 4 | 240 | 240 |
| 14 | 50 | 17 | 11 | 6 | 3,400 | 3,400 | 35 | 64 | 61 | 3 | 270 | -- |
| 14 | 40 | 17 | 11 | 6 | 3,400 | 3,300 | 97 | 52 | 44 | 8 | 220 | 220 |
| 14 | 30 | 12 | 6 | 6 | 2,500 | 2,500 | 20 | 49 | 47 | 2 | 190 | -- |
| 29 | 20 | 15 | 13 | 2 | 5,800 | 5,700 | 110 | 83 | 82 | 1 | 570 | 520 |
| 29 | <10 | 12 | 9 | 3 | 5,300 | 5,100 | 190 | 52 | 50 | 2 | 340 | 330 |
| 29 | <10 | 11 | 8 | 3 | 3,200 | 2,900 | 260 | 22 | 21 | 1 | 190 | 180 |
| 29 | <10 | 9 | 6 | 3 | 1,200 | 770 | 430 | 8 | 7 | 1 | 110 | 90 |
| June | | | | | | | | | | | | |
| 07 | <10 | 70 | 68 | 2 | 51,000 | 51,000 | 250 | 110 | 110 | 1 | 5,500 | 5,500 |
| 07 | <10 | 19 | 15 | 4 | 10,000 | 9,600 | 360 | 58 | 56 | 2 | 1,000 | 980 |
| 07 | <10 | 9 | 5 | 4 | 1,800 | 1,400 | 450 | 10 | 8 | 2 | 150 | 100 |
| 14 | <10 | 15 | 10 | 5 | 6,600 | 6,500 | 130 | 78 | -- | <1 | 480 | 460 |
| 14 | <10 | 9 | 4 | 5 | 2,500 | 2,400 | 150 | 9 | 3 | 6 | 120 | 120 |

Table 20.--Water-quality data for storm runoff in Blue River tributary at Virginia Avenue (station 2, fig. 1) for four storms during May-June, 1982--Continued

| Date | Manganese, dissolved | Mercury, total recoverable | Mercury, dissolved | Selenium, total | Selenium, dissolved | Zinc, total recoverable | Zinc, suspended recoverable | Zinc, dissolved | Carbon, organic total (mg/L) | Sediment, suspended (mg/L) | Sediment, discharge suspended (tons/d) | Sediment, suspended, percent finer than 0.062 mm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| May 1982 | | | | | | | | | | | | |
| 14 | 3 | <0.1 | <0.1 | <1 | <1 | 80 | 60 | 19 | 16 | -- | -- | -- |
| 14 | 3 | .1 | <.1 | <1 | <1 | 80 | -- | <12 | -- | 83 | 2.1 | -- |
| 14 | 3 | .1 | <.1 | <1 | <1 | 70 | -- | <12 | -- | 131 | 2.2 | 65 |
| 14 | 10 | .1 | <.1 | <1 | <1 | 100 | 80 | 20 | -- | -- | -- | -- |
| 29 | 51 | <.1 | <.1 | <1 | <1 | 100 | 60 | 45 | 26 | 299 | 9.8 | 47 |
| 29 | 12 | .1 | <.1 | <1 | <1 | 70 | 30 | 40 | 14 | 253 | 9.8 | 73 |
| 29 | 11 | .1 | <.1 | <1 | <1 | 160 | 80 | 82 | 15 | 156 | 5.6 | 64 |
| 29 | 17 | .1 | <.1 | <1 | <1 | 50 | 0 | 50 | 12 | 52 | 1.1 | 47 |
| June | | | | | | | | | | | | |
| 07 | 14 | -- | <.1 | -- | <1 | 430 | 360 | 66 | 41 | -- | -- | -- |
| 07 | 20 | .1 | <.1 | <1 | <1 | 90 | 50 | 43 | 17 | -- | -- | -- |
| 07 | 51 | <.1 | <.1 | <1 | <1 | 70 | 30 | 41 | 15 | -- | -- | -- |
| 14 | 17 | .2 | <.1 | <1 | <1 | 140 | 50 | 88 | 18 | -- | -- | -- |
| 14 | 1 | .1 | <.1 | <1 | <1 | 60 | 9 | 51 | 8.0 | -- | -- | -- |

Table 21.--Water-quality data for storm runoff in Blue River near Gregory Boulevard (station 4, fig. 1) for selected storms during 1981 and 1982

[units are in micrograms per liter, except as indicated; µmho/cm at 25 °C; micromhos per centimeter at 25 °C; NTU: nephelometric turbidity units; mg/L; milligrams per liter; $NO_2$, nitrite; $NO_3$, nitrate; N, nitrogen; P, phosphorus; tons/d, tons per day; $mm^2$, millimeter]

| Date | Starting time (2400 hours) | Ending time (2400 hours) | Discharge, (cubic feet per second) | Streamflow, instantaneous (cubic feet per second) | Specific conductance (µmho at 25 °C) | Specific conductance lab (µmho at 25 °C) | pH (units) | Turbidity (NTU) | Chemical oxygen demand (mg/L) | 5-day biochemical oxygen demand (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| July 1981 | | | | | | | | | | |
| 25 | 0250 | 0750 | 694 | -- | -- | 418 | 7.1 | 200 | 100 | 14 |
| 25 | 0850 | 1250 | 1,260 | -- | -- | 315 | 7.3 | 105 | 240 | 8.0 |
| 25 | 1350 | 1950 | 865 | -- | -- | 227 | 7.1 | 110 | 230 | 8.0 |
| 27 | 0240 | 1340 | 2,710 | -- | -- | 243 | 7.5 | 140 | 96 | 6.4 |
| 27 | 1440 | 2340 | 3,800 | -- | -- | 239 | 7.4 | 160 | 120 | 5.1 |
| 28 | 0040 | 1940 | 1,040 | -- | -- | 294 | 7.6 | 170 | -- | 3.0 |
| September | | | | | | | | | | |
| 01 | 0455 | 1100 | 710 | -- | -- | 355 | 7.9 | 170 | 98 | 7.1 |
| 01 | 1710 | 0012 | 354 | -- | -- | 469 | 7.8 | 140 | 140 | 6.5 |
| October | | | | | | | | | | |
| 13 | 1330 | 2230 | 717 | -- | 440 | 415 | 7.3 | 200 | 120 | 17 |
| 13 | 2330 | 0425 | 1,070 | -- | 300 | 312 | 8.1 | 170 | 110 | 12 |
| 14 | 0525 | 1330 | 827 | -- | -- | 336 | 7.3 | 145 | 74 | 8.0 |
| 14 | 1430 | 0425 | 346 | -- | 460 | 413 | 7.3 | 100 | 63 | 7.9 |
| 17 | 0630 | 1130 | 708 | -- | 400 | 390 | 7.4 | 160 | 140 | 18 |
| 17 | 1230 | 1530 | 542 | -- | 310 | 298 | 7.6 | 185 | 86 | 11 |
| 17 | 1630 | 2330 | 260 | -- | 310 | 374 | 7.7 | 120 | 67 | 10 |

7/16"

Table 21.--Water-quality data for storm runoff in Blue River near Gregory Boulevard (station 4, fig. 1) for selected storms during 1981 and 1982--Continued

| Date | Starting time (2400 hours) | Ending time (2400 hours) | Discharge, (cubic feet per second) | Streamflow, instantaneous (cubic feet per second) | Specific conductance (μmho at 25 °C) | Specific conductance lab (μmho at 25 °C) | pH (units) | Turbidity (NTU) | Chemical oxygen demand (mg/L) | 5-day biochemical oxygen demand (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| April 1982 | | | | | | | | | | |
| 28 | -- | -- | -- | 274 | -- | 630 | 8.0 | 132 | -- | -- |
| 28 | -- | -- | -- | 333 | 620 | 650 | 7.5 | 152 | -- | -- |
| 28 | -- | -- | -- | 410 | 610 | 685 | 7.4 | 264 | -- | -- |
| 28 | -- | -- | -- | 509 | 610 | 660 | 7.6 | 115 | -- | -- |
| May | | | | | | | | | | |
| 12 | -- | -- | -- | 270 | 650 | 714 | 7.8 | 70 | -- | -- |
| 12 | -- | -- | -- | 388 | 680 | 713 | 7.9 | 76 | -- | -- |
| 12 | -- | -- | -- | 492 | 675 | 693 | 8.0 | 79 | -- | -- |
| 12 | -- | -- | -- | 560 | -- | 754 | 7.9 | 80 | -- | -- |
| 12 | -- | -- | -- | 615 | 740 | 759 | 8.0 | 135 | -- | -- |
| 12 | -- | -- | -- | 675 | 750 | 750 | 7.9 | 130 | -- | -- |
| June | | | | | | | | | | |
| 14 | -- | -- | -- | 278 | 650 | 621 | 8.3 | 1,330 | 1,400 | 47 |
| 14 | -- | -- | -- | 308 | 650 | 637 | 8.1 | 450 | 100 | 14 |
| 14 | -- | -- | -- | 559 | 700 | 674 | 8.2 | 338 | 75 | 12 |
| 14 | -- | -- | -- | 1,020 | 580 | 507 | 8.0 | 320 | 80 | 20 |

3/16"

Table 21.--Water-quality data for storm runoff in Blue River near Gregory Boulevard (station 4, fig. 1) for selected storms during 1981 and 1982--Continued

| Date | Solids, residue at 180 °C dissolved (mg/L) | Solids, residue at 105 °C suspended (mg/L) | Nitrogen, $NO_2 + NO_3$ total (mg/L as N) | Nitrogen, $NO_2 + NO_3$ dissolved (mg/L as N) | Nitrogen, ammonia total (mg/L as N) | Nitrogen, ammonia dissolved (mg/L as N) | Nitrogen, organic total (mg/L as N) | Nitrogen, ammonia and organic total (mg/L as N) | Nitrogen, ammonia and organic dissolved (mg/L as N) | Nitrogen, organic dissolved (mg/L as N) | Nitrogen, total (mg/L) | Phosphorus, total (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| July 1981 | | | | | | | | | | | | |
| 25 | 270 | 1,160 | 1.6 | 1.6 | 1.2 | .81 | 3.8 | 5.0 | 2.4 | 1.6 | 6.6 | 3.2 |
| 25 | 272 | 2,180 | 1.3 | 1.2 | .33 | .10 | 7.1 | 7.4 | 1.7 | 1.6 | 8.7 | 2.9 |
| 25 | 185 | 1,400 | 1.1 | 1.1 | .28 | .14 | 6.8 | 7.1 | 1.9 | 1.8 | 8.2 | 2.4 |
| 27 | 148 | 3,240 | .79 | 1.0 | .31 | .10 | 6.2 | 6.5 | .80 | .70 | 7.3 | 3.2 |
| 27 | 155 | 1,300 | .78 | .96 | .18 | .05 | 4.6 | 4.8 | .80 | .75 | 5.6 | 1.9 |
| 28 | 185 | 990 | .79 | .90 | .20 | .09 | 3.0 | 3.2 | .80 | .71 | 4.0 | 1.2 |
| September | | | | | | | | | | | | |
| 01 | 213 | 812 | -- | 1.2 | -- | .30 | -- | 5.6 | 2.1 | 1.8 | -- | 2.8 |
| 01 | 284 | 1,360 | -- | 1.3 | -- | <.04 | -- | 2.7 | 1.1 | -- | -- | 1.2 |
| October | | | | | | | | | | | | |
| 13 | 235 | 1,470 | .85 | -- | 1.1 | 1.1 | 4.2 | 5.4 | 1.8 | .70 | 6.2 | 3.2 |
| 13 | 175 | 896 | .73 | -- | .54 | .13 | 2.8 | 3.3 | 1.0 | .90 | 4.1 | 2.0 |
| 14 | 196 | 523 | .77 | -- | .27 | .27 | 1.9 | 2.2 | .90 | .63 | 3.0 | 1.2 |
| 14 | 252 | 292 | 1.0 | -- | .34 | .30 | 1.6 | 1.9 | .87 | .57 | 2.9 | 1.1 |
| 17 | 233 | 1,320 | 1.1 | -- | .71 | .62 | 4.4 | 5.1 | 1.2 | .54 | 6.2 | 2.7 |
| 17 | 178 | 738 | .76 | -- | .44 | .27 | 2.7 | 3.1 | .98 | .71 | 3.9 | 1.4 |
| 17 | 235 | 332 | .95 | -- | .63 | .53 | 1.7 | 2.4 | 1.2 | .69 | 3.3 | 1.1 |

Table 21.--Water-quality data for storm runoff in Blue River near Gregory Boulevard (station 4, fig. 1) for selected storms during 1981 and 1982--Continued

| Date | Solids, residue at 180 °C dissolved (mg/L) | Solids, residue at 105 °C suspended (mg/L) | Nitrogen, $NO_2 + NO_3$ total (mg/L as N) | Nitrogen, $NO_2 + NO_3$ dissolved (mg/L as N) | Nitrogen, ammonia total (mg/L as N) | Nitrogen, ammonia dissolved (mg/L as N) | Nitrogen, organic total (mg/L as N) | Nitrogen, ammonia and organic total (mg/L as N) | Nitrogen, ammonia and organic dissolved (mg/L as N) | Nitrogen, organic dissolved (mg/L as N) | Nitrogen, total (mg/L) | Phosphorus, total (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| April 1982 | | | | | | | | | | | | |
| 28 | 376 | -- | -- | 1.2 | -- | 1.4 | -- | 3.2 | 2.4 | 1.0 | -- | 2.0 |
| 28 | 416 | -- | -- | 1.3 | -- | 2.0 | -- | 3.0 | 2.6 | .60 | -- | 3.7 |
| 28 | 415 | -- | -- | 1.3 | -- | 2.3 | -- | 3.0 | 2.6 | .30 | -- | 2.4 |
| 28 | 395 | -- | -- | 1.0 | -- | 1.4 | -- | 3.0 | 1.9 | .50 | -- | 1.9 |
| May | | | | | | | | | | | | |
| 12 | 416 | -- | -- | 2.4 | -- | 1.3 | -- | 2.7 | 2.1 | .80 | -- | 1.4 |
| 12 | 415 | 274 | -- | 2.5 | -- | 1.4 | -- | 2.7 | 2.1 | .70 | -- | 1.8 |
| 12 | 399 | 342 | -- | 2.5 | -- | 1.2 | -- | 2.0 | 1.9 | .70 | -- | 1.6 |
| 12 | 439 | 354 | -- | 2.5 | -- | 1.1 | -- | 1.7 | 1.7 | .60 | -- | 1.4 |
| 12 | 441 | -- | -- | 2.2 | -- | .80 | -- | 1.5 | 1.5 | .70 | -- | 1.3 |
| 12 | 446 | 472 | -- | 2.2 | -- | 1.0 | -- | 1.8 | 1.8 | .80 | -- | 1.4 |
| June | | | | | | | | | | | | |
| 14 | 368 | 902 | -- | 1.8 | -- | 1.2 | -- | 10.6 | 1.9 | .70 | -- | 8.3 |
| 14 | 386 | 838 | -- | 1.6 | -- | .90 | -- | 5.0 | 2.3 | 1.4 | -- | 2.7 |
| 14 | 416 | 551 | -- | 1.5 | -- | 1.0 | -- | 3.2 | 1.4 | .40 | -- | 1.3 |
| 14 | 294 | 702 | -- | 1.5 | -- | 1.5 | -- | 4.2 | 2.0 | .50 | -- | 2.2 |

Table 21.--Water-quality data for storm runoff in Blue River near Gregory Boulevard (station 4, fig. 1) for selected storms during 1981 and 1982--Continued

| Date | Phosphorus, dissolved (mg/L) | Arsenic, total | Arsenic, suspended total | Arsenic, dissolved | Cadmium, total recoverable | Cadmium, dissolved | Chromium, total recoverable | Chromium, suspended recoverable | Chromium, dissolved | Copper, total recoverable | Copper, suspended recoverable | Copper, dissolved |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| July 1981 | | | | | | | | | | | | |
| 25 | 1.5 | 15 | 11 | 4 | 1 | 2 | 60 | 50 | 10 | 80 | 70 | 10 |
| 25 | .24 | 18 | 15 | 3 | 1 | 2 | 70 | 60 | 10 | 110 | 100 | 10 |
| 25 | .19 | 12 | 10 | 2 | 1 | <1 | 40 | 30 | 10 | 42 | 33 | 9 |
| 27 | .18 | 18 | 16 | 2 | 2 | <1 | 80 | 80 | 0 | 80 | 72 | 8 |
| 27 | .16 | 13 | 11 | 2 | 1 | <1 | 40 | 40 | 0 | 42 | 37 | 5 |
| 28 | .14 | 9 | 7 | 2 | 1 | <1 | 40 | 30 | 10 | 30 | 24 | 6 |
| September | | | | | | | | | | | | |
| 1 | .82 | 3 | 0 | 3 | 8 | <1 | 10 | 10 | 0 | 22 | 19 | 3 |
| 1 | .29 | 8 | 5 | 3 | 0 | <1 | 30 | 20 | 10 | 46 | 41 | 5 |
| October | | | | | | | | | | | | |
| 13 | .96 | 11 | 8 | 3 | 1 | <1 | 50 | 50 | 0 | 47 | 44 | 3 |
| 13 | .47 | 7 | 4 | 3 | 1 | <1 | 30 | 30 | 0 | 37 | 33 | 4 |
| 14 | .33 | 6 | 3 | 3 | 1 | 0 | 20 | 20 | 0 | 21 | 19 | 2 |
| 14 | .37 | 5 | 3 | 2 | 1 | <1 | 10 | 0 | 10 | 13 | 11 | 2 |
| 17 | .54 | 10 | 7 | 3 | 0 | <1 | 50 | 50 | 0 | 60 | 58 | 2 |
| 17 | .32 | 7 | 4 | 3 | 1 | <1 | 30 | 30 | 0 | 60 | 57 | 3 |
| 17 | .53 | 6 | 3 | 3 | 1 | <1 | 10 | 10 | 0 | 18 | 15 | 3 |
| April 1982 | | | | | | | | | | | | |
| 28 | .80 | 9 | -- | -- | <10 | -- | 30 | -- | -- | 53 | -- | -- |
| 28 | .90 | 11 | -- | -- | <10 | -- | 80 | -- | -- | 90 | -- | -- |
| 28 | 1.0 | 9 | -- | -- | <5 | -- | 40 | -- | -- | 47 | -- | -- |
| 28 | .80 | 5 | -- | -- | <5 | -- | 20 | -- | -- | 29 | -- | -- |

Table 21.--Water-quality data for storm runoff in Blue River near Gregory Boulevard (station 4, fig. 1) for selected storms during 1981 and 1982--Continued

| Date | Phosphorus, dissolved (mg/L) | Arsenic, total | Arsenic, suspended total | Arsenic, dissolved | Cadmium, total recoverable | Cadmium, dissolved | Chromium, total recoverable | Chromium, suspended recoverable | Chromium, dissolved | Copper, total recoverable | Copper, suspended recoverable | Copper, dissolved |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| May 1982 | | | | | | | | | | | | |
| 12 | 1.0 | -- | -- | -- | 1 | -- | 20 | -- | -- | 16 | -- | -- |
| 12 | 1.0 | -- | -- | 3 | 1 | <3 | 20 | -- | <10 | 23 | 17 | 6 |
| 12 | 1.3 | -- | -- | 3 | <1 | <3 | 20 | -- | <10 | 18 | 14 | 4 |
| 12 | 1.1 | -- | -- | 3 | 1 | <3 | 20 | -- | <10 | 16 | 12 | 4 |
| 12 | .80 | -- | -- | 2 | 1 | <3 | 20 | -- | <10 | 24 | 19 | 5 |
| 12 | 1.0 | -- | -- | 3 | 5 | <3 | 20 | -- | <10 | 34 | 28 | 6 |
| June | | | | | | | | | | | | |
| 14 | .22 | 12 | 11 | 1 | 2 | <1 | 200 | -- | <10 | 220 | 210 | 8 |
| 14 | .16 | 6 | 4 | 2 | <1 | <1 | 50 | -- | <10 | 44 | 40 | 4 |
| 14 | .35 | 6 | 5 | 1 | 3 | <1 | 40 | -- | <10 | 30 | 23 | 7 |
| 14 | .60 | 7 | 4 | 3 | 4 | <1 | 40 | -- | <10 | 32 | 27 | 5 |

Table 21.--Water-quality data for storm runoff in Blue River near Gregory Boulevard (station 4, fig. 1) for selected storms during 1981 and 1982--Continued

| Date | Iron, total recoverable | Iron, suspended recoverable | Iron, dissolved | Lead, total recoverable | Lead, suspended recoverable | Lead, dissolved | Manganese, total recoverable | Manganese, suspended recoverable | Manganese, dissolved | Mercury, total recoverable | Mercury, suspended recoverable |
|---|---|---|---|---|---|---|---|---|---|---|---|
| July 1981 | | | | | | | | | | | |
| 25 | 49,000 | 48,000 | 1,400 | 100 | 90 | 10 | 2,100 | 2,000 | 120 | 0.5 | 0.5 |
| 25 | 64,000 | 62,000 | 1,900 | 65 | 58 | 7 | 2,300 | 2,200 | 130 | .2 | .1 |
| 25 | 37,000 | 36,000 | 720 | 30 | 22 | 8 | 1,000 | 960 | 40 | .2 | .2 |
| 27 | 66,000 | 66,000 | 160 | 68 | 64 | 4 | 2,200 | 2,200 | 6 | .3 | .3 |
| 27 | 35,000 | 35,000 | 75 | 25 | 23 | 2 | 1,200 | 1,200 | 2 | .2 | .2 |
| 28 | 25,000 | 25,000 | 120 | 17 | 14 | 3 | 790 | 790 | 3 | .1 | .1 |
| September | | | | | | | | | | | |
| 1 | 13,000 | 13,000 | 65 | 20 | 17 | 3 | 560 | 560 | 2 | .1 | .1 |
| 1 | 34,000 | 34,000 | 57 | 36 | 32 | 4 | 1,500 | 1,500 | 6 | .1 | .1 |
| October | | | | | | | | | | | |
| 13 | 35,000 | 35,000 | 39 | 67 | 65 | 2 | 1,300 | 1,300 | 20 | .2 | .2 |
| 13 | 23,000 | 23,000 | 140 | 39 | 39 | 0 | 830 | 830 | 2 | .1 | .1 |
| 14 | 14,000 | 14,000 | 90 | 25 | 22 | 3 | 570 | 570 | 0 | .1 | .1 |
| 14 | 7,100 | 7,000 | 94 | 15 | 14 | 1 | 380 | 380 | 4 | .1 | .1 |
| 17 | 34,000 | 34,000 | 89 | 95 | 94 | 1 | 1,500 | 1,500 | 22 | .2 | .2 |
| 17 | 24,000 | 24,000 | 150 | 39 | 39 | 0 | 810 | 810 | 5 | .1 | .1 |
| 17 | 9,300 | 9,200 | 100 | 19 | 19 | 0 | 410 | 400 | 7 | .0 | .0 |
| April 1982 | | | | | | | | | | | |
| 28 | 33,000 | -- | -- | 30 | -- | -- | 1,600 | -- | -- | .1 | -- |
| 28 | 73,000 | -- | -- | 120 | -- | -- | 3,100 | -- | -- | .2 | -- |
| 28 | 41,000 | -- | -- | 65 | -- | -- | 1,800 | -- | -- | .1 | -- |
| 28 | 17,000 | -- | -- | 40 | -- | -- | 1,100 | -- | -- | .1 | -- |

Table 21.--Water-quality data for storm runoff in Blue River near Gregory Boulevard (station 4, fig. 1) for selected storms during 1981 and 1982--Continued

| Date | Iron, total recoverable | Iron, suspended recoverable | Iron, dissolved | Lead, total recoverable | Lead, suspended recoverable | Lead, dissolved | Manganese, total recoverable | Manganese, suspended recoverable | Manganese, dissolved | Mercury, total recoverable | Mercury, suspended recoverable |
|---|---|---|---|---|---|---|---|---|---|---|---|
| May 1982 | | | | | | | | | | | |
| 12 | 7,900 | -- | -- | 13 | -- | -- | 610 | -- | -- | -- | -- |
| 12 | 7,200 | 7,200 | 21 | 18 | 15 | 3 | 600 | -- | <3 | -- | -- |
| 12 | 8,000 | 8,000 | 14 | 21 | 19 | 2 | 620 | -- | <3 | -- | -- |
| 12 | 7,000 | 7,000 | 10 | 16 | 14 | 2 | 590 | -- | <3 | -- | -- |
| 12 | 10,000 | -- | <9 | 17 | 16 | 1 | 580 | -- | <3 | -- | -- |
| 12 | 9,500 | -- | <9 | 18 | 15 | 3 | 540 | -- | <3 | -- | -- |
| June | | | | | | | | | | | |
| 14 | 180,000 | 180,000 | 27 | <1 | -- | 2 | 8,100 | 7,000 | 1,100 | .6 | -- |
| 14 | 34,000 | 34,000 | 7 | 30 | -- | <1 | 1,500 | 1,300 | 250 | .2 | -- |
| 14 | 23,000 | 23,000 | 54 | 24 | -- | <1 | 1,100 | 1,000 | 91 | .1 | -- |
| 14 | 24,000 | 24,000 | 8 | 24 | -- | <1 | 1,200 | 1,200 | 7 | .2 | -- |

Table 21.--Water-quality data for storm runoff in Blue River near Gregory Boulevard (station 4, fig. 1) for selected storms during 1981 and 1982--Continued

| Date | Mercury, dissolved | Selenium, total | Selemium, suspended total | Selenium, dissolved | Zinc, total recoverable | Zinc, suspended recoverable | Zinc, dissolved | Carbon, organic total (mg/L) | Sediment, suspended (mg/L) | Sediment, discharge suspended (tons/d) | Sediment, suspended, percent finer than 0.062 mm |
|---|---|---|---|---|---|---|---|---|---|---|---|
| July 1981 | | | | | | | | | | | |
| 25 | 0.0 | 0 | 0 | 0 | 270 | 250 | 24 | 38 | 2,860 | 5,360 | 73 |
| 25 | .1 | 0 | 0 | 0 | 270 | 240 | 35 | 45 | 3,710 | 12,600 | 84 |
| 25 | .0 | 0 | 0 | 0 | 200 | 180 | 23 | 44 | 2,580 | 6,030 | 89 |
| 27 | .0 | 0 | 0 | 0 | 300 | 270 | 35 | 42 | 3,850 | 28,200 | 88 |
| 27 | .0 | 0 | 0 | 0 | 170 | 140 | 30 | 36 | 1,990 | 20,400 | 91 |
| 28 | .0 | 0 | 0 | 0 | 120 | 90 | 31 | -- | 1,120 | 3,150 | 94 |
| September | | | | | | | | | | | |
| 01 | .0 | 1 | 1 | 0 | 70 | 50 | 18 | -- | 1,900 | 3,640 | 70 |
| 01 | .0 | 0 | 0 | 0 | 170 | 150 | 17 | -- | 593 | 567 | 58 |
| October | | | | | | | | | | | |
| 13 | .0 | 1 | 1 | 0 | 220 | 170 | 47 | 38 | 1,680 | 3,250 | 67 |
| 13 | .0 | 0 | 0 | 0 | 140 | 100 | 40 | 25 | 1,010 | 2,930 | 76 |
| 14 | .0 | 0 | 0 | 0 | 80 | 50 | 30 | 19 | 606 | 1,350 | 88 |
| 14 | .0 | 0 | 0 | 0 | 50 | 9 | 41 | 16 | 306 | 286 | 78 |
| 17 | .0 | 0 | 0 | 0 | 240 | 180 | 58 | -- | 1,710 | 3,270 | 80 |
| 17 | .0 | 0 | 0 | 0 | 190 | 140 | 48 | -- | 876 | 1,280 | 84 |
| 17 | .0 | 0 | 0 | 0 | 70 | 20 | 48 | -- | 384 | 270 | 84 |

5/16"

Table 21.--Water-quality data for storm runoff in Blue River near Gregory Boulevard (station 4, fig. 1) for selected storms during 1981 and 1982--Continued

| Date | Mercury, dissolved | Selenium, total | Selemium, suspended total | Selenium, dissolved | Zinc, total recoverable | Zinc, suspended recoverable | Zinc, dissolved | Carbon, organic total (mg/L) | Sediment, suspended (mg/L) | Sediment, discharge suspended (tons/d) | Sediment, suspended, percent finer than 0.062 mm |
|---|---|---|---|---|---|---|---|---|---|---|---|
| April 1982 | | | | | | | | | | | |
| 28 | -- | 1 | -- | -- | 210 | -- | -- | -- | 1,570 | 1,160 | 68 |
| 28 | -- | 1 | -- | -- | 430 | -- | -- | -- | 450 | 405 | 61 |
| 28 | -- | 3 | -- | -- | 260 | -- | -- | -- | 2,860 | 3,170 | 65 |
| 28 | -- | 1 | -- | -- | 150 | -- | -- | -- | 984 | 1,350 | 71 |
| May | | | | | | | | | | | |
| 12 | -- | -- | -- | -- | 80 | -- | -- | 42 | 313 | 228 | 80 |
| 12 | <.1 | -- | -- | <1 | 90 | 70 | 20 | 13 | 319 | 334 | 76 |
| 12 | <.1 | -- | -- | <1 | 80 | 70 | 12 | 13 | 414 | 550 | 92 |
| 12 | <.1 | -- | -- | <1 | 60 | -- | <12 | 10 | -- | -- | 93 |
| 12 | <.1 | -- | -- | 1 | 80 | 70 | 12 | 12 | 421 | 699 | 81 |
| 12 | <.1 | -- | -- | <1 | 100 | -- | <12 | 12 | 513 | 935 | 88 |
| June | | | | | | | | | | | |
| 14 | <.1 | 1 | -- | <1 | 1,000 | 840 | 160 | 200 | 14,600 | 11,000 | 71 |
| 14 | <.1 | 1 | 0 | 1 | 220 | 160 | 63 | 36 | 2,390 | 1,990 | 81 |
| 14 | <.1 | 1 | 0 | 1 | 130 | 10 | 120 | 23 | 1,500 | 2,260 | 85 |
| 14 | <.1 | 1 | -- | <1 | 140 | 100 | 38 | 31 | 1,700 | 4,680 | 90 |

5/16"

Table 22.--Water-quality data for storm runoff in Brush Creek at Elmwood Avenue (station 6, fig. 1) for selected storms during 1981 and 1982

[units are in micrograms per liter, except as indicated; µmho/cm at 25 °C; micromhos per centimeter at 25 °C; NTU: nephelometric turbidity units; mg/L; milligrams per liter; $NO_2$, nitrite; $NO_3$, nitrate; N, nitrogen; P, phosphorus; tons/d, tons per day; mm, millimeter]

| Date | Starting time (2400 hours) | Ending time (2400 hours) | Discharge, (cubic feet per second) | Streamflow, instantaneous (cubic feet per second) | Specific conductance (µmho at 25°C) | Specific conductance lab (µmho at 25°C) | pH (units) | Turbidity (NTU) | Chemical oxygen demand (mg/L) | 5-day biochemical oxygen demand (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| July 1981 | | | | | | | | | | |
| 27 | 0115 | 0445 | 3,980 | -- | -- | 180 | 6.9 | 125 | 180 | 0.3 |
| September | | | | | | | | | | |
| 01 | 0450 | 0535 | 772 | -- | -- | 216 | 7.6 | 32 | 140 | 23 |
| October | | | | | | | | | | |
| 13 | 1050 | 1210 | 1,160 | -- | 170 | 174 | 7.5 | 110 | 150 | 47 |
| 13 | 1220 | 1320 | 629 | -- | 120 | 185 | 6.9 | 110 | 120 | 15 |
| 13 | 1340 | 1510 | 294 | -- | 140 | 163 | 6.9 | 75 | 72 | 9.4 |
| 17 | 0555 | 0710 | 1,450 | -- | 140 | 129 | 7.4 | 110 | 160 | 17 |
| 17 | 0725 | 0825 | 682 | -- | 150 | 138 | 7.5 | 130 | 79 | 9.9 |
| 17 | 0840 | 1030 | 386 | -- | 180 | 178 | 7.6 | 94 | 69 | 6.8 |
| April 1982 | | | | | | | | | | |
| 28 | -- | -- | -- | 365 | 270 | 237 | 6.9 | 90 | -- | -- |
| 28 | -- | -- | -- | 343 | 290 | 265 | 7.0 | 87 | -- | -- |
| 28 | -- | -- | -- | 351 | 305 | 290 | 7.2 | 60 | -- | -- |
| 28 | -- | -- | -- | 368 | 280 | 297 | 6.9 | 54 | -- | -- |

9/16"

Table 22.--Water-quality data for storm runoff in Brush Creek at Elmwood Avenue (station 6, fig. 1) for selected storms during 1981 and 1982--Continued

| Date | Starting time (2400 hours) | Ending time (2400 hours) | Discharge, (cubic feet per second) | Streamflow, instantaneous (cubic feet per second) | Specific conductance (μmho at 25°C) | Specific conductance lab (μmho at 25°C) | pH (units) | Turbidity (NTU) | Chemical oxygen demand (mg/l) | 5-day biochemical oxygen demand (mg/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| May 1982 | | | | | | | | | | |
| 29 | -- | -- | -- | 480 | 260 | 241 | 7.2 | -- | 500 | -- |
| 29 | -- | -- | -- | 1,570 | 160 | 164 | 7.1 | -- | 260 | -- |
| 29 | -- | -- | -- | 960 | 120 | 120 | 7.2 | -- | 76 | -- |
| 29 | -- | -- | -- | 1,100 | 220 | 224 | 7.4 | -- | 100 | -- |
| June | | | | | | | | | | |
| 07 | -- | -- | -- | 2,290 | 120 | 124 | 7.3 | 280 | 280 | 40 |
| 07 | -- | -- | -- | 1,860 | 110 | 111 | 7.3 | 180 | 180 | 24 |
| 07 | -- | -- | -- | 8,600 | 160 | 154 | 7.3 | 370 | 190 | 20 |
| July | | | | | | | | | | |
| 06 | -- | -- | -- | 458 | 520 | -- | -- | 800 | -- | 380 |
| 06 | -- | -- | -- | 826 | 200 | -- | -- | 400 | -- | 140 |
| 06 | -- | -- | -- | 1,070 | 180 | -- | -- | 320 | -- | 120 |
| 06 | -- | -- | -- | 970 | 165 | -- | -- | 230 | -- | 95 |
| 06 | -- | -- | -- | 626 | 160 | -- | -- | 190 | -- | 71 |
| 06 | -- | -- | -- | 303 | 160 | -- | -- | 160 | -- | 54 |



318"

Table 22.--Water-quality data for storm runoff in Brush Creek at Elmwood Avenue (station 6, fig. 1) for selected storms during 1981 and 1982--Continued

| Date | Solids, residue at 180 °C dissolved (mg/L) | Solids, residue at 105 °C suspended (mg/L) | Nitrogen, $NO_2 + NO_3$ total (mg/L as N) | Nitrogen, $NO_2 + NO_3$ dissolved (mg/L as N) | Nitrogen, ammonia total (mg/L as N) | Nitrogen, ammonia dissolved (mg/L as N) | Nitrogen, organic total (mg/L as N) | Nitrogen, ammonia and organic total (mg/L as N) | Nitrogen, ammonia and organic dissolved (mg/L as N) | Nitrogen, organic dissolved (mg/L as N) | Nitrogen, total (mg/L) | Phosphorus total (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| July 1981 | | | | | | | | | | | | |
| 27 | 148 | 1,430 | 0.43 | 0.45 | 0.34 | 0.17 | 5.6 | 5.9 | 1.4 | 1.2 | 6.3 | 2.3 |
| September | | | | | | | | | | | | |
| 01 | 110 | 46 | -- | .54 | -- | <.04 | -- | 3.8 | .70 | -- | -- | 1.1 |
| October | | | | | | | | | | | | |
| 13 | 107 | 854 | .23 | -- | .51 | .37 | 7.9 | 8.4 | 1.0 | .63 | 8.6 | 2.5 |
| 13 | 71 | 540 | .26 | -- | .22 | .15 | 3.2 | 3.4 | 1.1 | .95 | 3.7 | .96 |
| 13 | 80 | 225 | .42 | -- | .22 | .15 | 1.8 | 2.0 | .90 | .75 | 2.4 | .58 |
| 17 | 75 | 630 | .30 | -- | .14 | .09 | 4.5 | 4.7 | .54 | .45 | 5.0 | 1.5 |
| 17 | 83 | 742 | .36 | -- | <.04 | <.04 | -- | 3.4 | .68 | -- | 3.8 | 1.2 |
| 17 | 107 | 224 | .66 | -- | .17 | .15 | 1.8 | 2.0 | 1.0 | .86 | 2.6 | .63 |
| April 1982 | | | | | | | | | | | | |
| 28 | 146 | -- | -- | .54 | -- | .70 | -- | 2.7 | 1.9 | 1.2 | -- | 1.7 |
| 28 | 153 | -- | -- | .44 | -- | .50 | -- | 2.4 | 1.6 | 1.1 | -- | 1.1 |
| 28 | 182 | -- | -- | .56 | -- | .50 | -- | .9 | 1.3 | .80 | -- | 1.3 |
| 28 | 188 | -- | -- | .48 | -- | .40 | -- | .9 | 1.6 | 1.2 | -- | 1.0 |
| May | | | | | | | | | | | | |
| 29 | 148 | 3,110 | -- | .35 | -- | <.40 | -- | 6.5 | 1.7 | -- | -- | 5.0 |
| 29 | 110 | 702 | -- | .32 | -- | <.40 | -- | 1.2 | 1.1 | -- | -- | 1.7 |
| 29 | 84 | 687 | -- | .31 | -- | <.40 | -- | 3.1 | 1.1 | -- | -- | 1.2 |
| 29 | 128 | 782 | -- | .41 | -- | <.40 | -- | 2.7 | 1.2 | -- | -- | 1.3 |

Table 22.--Water-quality data for storm runoff in Brush Creek at Elmwood Avenue (station 6, fig. 1) for selected storms during 1981 and 1982--Continued

| Date | Solids, residue at 180 °C dissolved (mg/L) | Solids, residue at 105 °C suspended (mg/L) | Nitrogen, $NO_2 + NO_3$ total (mg/L as N) | Nitrogen, $NO_2 + NO_3$ dissolved (mg/L as N) | Nitrogen, ammonia total (mg/L as N) | Nitrogen, ammonia dissolved (mg/L as N) | Nitrogen, organic total (mg/L as N) | Nitrogen, ammonia and organic total (mg/L as N) | Nitrogen, ammonia and organic dissolved (mg/L as N) | Nitrogen, organic dissolved (mg/L as N) | Nitrogen, total (mg/L) | Phosphorus total (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| June 1982 | | | | | | | | | | | | |
| 07 | 87 | 1,540 | -- | 0.49 | -- | <0.40 | -- | 1.4 | 1.3 | -- | -- | 0.23 |
| 07 | 78 | 901 | -- | .53 | -- | <.40 | -- | 1.2 | .93 | -- | -- | 1.0 |
| 07 | 94 | 1,740 | -- | .68 | -- | <.40 | -- | 1.2 | .93 | -- | -- | 1.1 |
| July | | | | | | | | | | | | |
| 06 | -- | -- | -- | -- | -- | -- | -- | 34.0 | -- | -- | -- | 11.6 |
| 06 | -- | -- | -- | -- | -- | -- | -- | 17.6 | -- | -- | -- | 4.8 |
| 06 | -- | -- | -- | -- | -- | -- | -- | 10.0 | -- | -- | -- | 3.2 |
| 06 | -- | -- | -- | -- | -- | -- | -- | 9.2 | -- | -- | -- | 2.4 |
| 06 | -- | -- | -- | -- | -- | -- | -- | 6.8 | -- | -- | -- | 1.8 |
| 06 | -- | -- | -- | -- | -- | -- | -- | 6.8 | -- | -- | -- | 1.4 |

Table 22.--Water-quality data for storm runoff in Brush Creek at Elmwood Avenue (station 6, fig. 1) for selected storms during 1981 and 1982--Continued

| Date | Phosphorus, dissolved (mg/L) | Arsenic, total | Arsenic, suspended total | Arsenic, dissolved | Cadmium, total recoverable | Cadmium, dissolved | Chromium, total recoverable | Chromium, suspended recoverable | Chromium, dissolved | Copper, total recoverable | Copper, suspended recoverable | Copper, dissolved |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| July 1981 | | | | | | | | | | | | |
| 27 | 0.22 | 21 | 18 | 3 | 2 | <1 | 70 | 60 | 10 | 100 | 92 | 8 |
| September | | | | | | | | | | | | |
| 01 | .12 | 5 | 2 | 3 | 3 | <1 | 30 | 30 | 0 | 46 | 40 | 6 |
| October | | | | | | | | | | | | |
| 13 | .25 | 11 | 9 | 2 | 3 | <1 | 70 | 70 | 0 | 80 | 75 | 5 |
| 13 | .24 | 7 | 5 | 2 | 2 | <1 | 20 | 20 | 0 | 35 | 34 | 1 |
| 13 | .23 | 5 | 2 | 3 | 2 | <1 | 10 | 10 | 0 | 21 | 19 | 2 |
| 17 | .17 | 12 | 10 | 2 | 2 | <1 | 20 | 20 | 0 | 54 | 51 | 3 |
| 17 | .16 | 8 | 4 | 4 | 1 | <1 | 20 | 20 | 0 | 40 | 38 | 2 |
| 17 | .21 | 7 | 2 | 5 | 1 | <1 | 10 | 10 | 0 | 17 | 11 | 6 |
| April 1982 | | | | | | | | | | | | |
| 28 | .40 | 8 | -- | -- | 5 | -- | 30 | -- | -- | 50 | -- | -- |
| 28 | .30 | 6 | -- | -- | <10 | -- | 30 | -- | -- | 51 | -- | -- |
| 28 | .40 | 3 | -- | -- | <20 | -- | 20 | -- | -- | 37 | -- | -- |
| 28 | .30 | 5 | -- | -- | <10 | -- | 20 | -- | -- | 31 | -- | -- |
| May | | | | | | | | | | | | |
| 29 | .22 | 18 | 15 | 3 | <1 | <3 | 90 | -- | <10 | 160 | 160 | 2 |
| 29 | .33 | 11 | 9 | 2 | <1 | <3 | 50 | -- | <10 | 90 | 88 | 2 |
| 29 | .17 | 6 | 4 | 2 | 1 | <3 | 20 | -- | <10 | 35 | 31 | 4 |
| 29 | .13 | 9 | 7 | 2 | <1 | <3 | 40 | -- | <10 | 43 | 38 | 5 |

Table 22.--Water-quality data for storm runoff in Brush Creek at Elmwood Avenue (station 6, fig. 1) for selected storms during 1981 and 1982--Continued

| Date | Phosphorus, dissolved (mg/L) | Arsenic, total | Arsenic, suspended total | Arsenic, dissolved | Cadmium, total recoverable | Cadmium, dissolved | Chromium, total recoverable | Chromium, suspended recoverable | Chromium, dissolved | Copper, total recoverable | Copper, suspended recoverable | Copper, dissolved |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| June, 1982 | | | | | | | | | | | | |
| 07 | 0.40 | 10 | 8 | 2 | 1 | <1 | 60 | -- | <10 | 140 | -- | <1 |
| 07 | .23 | 7 | 5 | 2 | 5 | <1 | 30 | -- | <10 | 80 | 78 | 2 |
| 07 | .23 | 14 | 10 | 4 | <1 | <1 | 50 | 40 | 10 | 80 | -- | <1 |
| July | | | | | | | | | | | | |
| 06 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 06 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 06 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 06 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 06 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 06 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

3/8"

Table 22.--Water-quality data for storm runoff in Brush Creek at Elmwood Avenue (station 6, fig. 1) for selected storms during 1981 and 1982--Continued

| Date | Iron, total recoverable | Iron, suspended recoverable | Iron, dissolved | Lead, total recoverable | Lead, suspended recoverable | Lead, dissolved | Manganese, total recoverable | Manganese, suspended recoverable | Manganese, dissolved | Mercury, total recoverable | Mercury, suspended recoverable |
|---|---|---|---|---|---|---|---|---|---|---|---|
| July 1981 | | | | | | | | | | | |
| 27 | 31,000 | 31,000 | 230 | 480 | 470 | 7 | 1,600 | 1,300 | 300 | 0.5 | 0.5 |
| September | | | | | | | | | | | |
| 01 | 8,600 | 8,500 | 76 | 300 | 290 | 8 | 490 | 350 | 140 | .2 | .2 |
| October | | | | | | | | | | | |
| 13 | 23,000 | 23,000 | 130 | 510 | 510 | 2 | 1,300 | 1,100 | 180 | .5 | .5 |
| 13 | 14,000 | 14,000 | 79 | 160 | 160 | 3 | 710 | 690 | 16 | .2 | .2 |
| 13 | 6,300 | 6,200 | 130 | 73 | 69 | 4 | 310 | 300 | 14 | .1 | .1 |
| 17 | 16,000 | 16,000 | 130 | 310 | 310 | 1 | 730 | 690 | 36 | .3 | .3 |
| 17 | 20,000 | 20,000 | 150 | 160 | 160 | 0 | 840 | 830 | 9 | .2 | .2 |
| 17 | 7,900 | 7,700 | 170 | 60 | 58 | 2 | 300 | 300 | 4 | .1 | .1 |
| April 1982 | | | | | | | | | | | |
| 28 | 11,000 | -- | -- | 300 | -- | -- | 610 | -- | -- | .5 | -- |
| 28 | 10,000 | -- | -- | 260 | -- | -- | 740 | -- | -- | .2 | -- |
| 28 | 7,600 | -- | -- | 240 | -- | -- | 640 | -- | -- | .2 | -- |
| 28 | 9,800 | -- | -- | 210 | -- | -- | 740 | -- | -- | .2 | -- |
| May | | | | | | | | | | | |
| 29 | 58,000 | 58,000 | 120 | 1100 | -- | <1 | 2,500 | 1,800 | 670 | .6 | -- |
| 29 | 32,000 | 32,000 | 120 | 780 | -- | <1 | 1,400 | 1,100 | 310 | .8 | -- |
| 29 | 10,000 | 9,900 | 120 | 240 | 230 | 7 | 450 | 400 | 48 | .3 | -- |
| 29 | 13,000 | 13,000 | 100 | 200 | 200 | 3 | 870 | 850 | 22 | .3 | -- |

Table 22.--Water-quality data for storm runoff in Brush Creek at Elmwood Avenue (station 6, fig. 1) for selected storms during 1981 and 1982--Continued

| Date | Iron, total recoverable | Iron, suspended recoverable | Iron, dissolved | Lead, total recoverable | Lead, suspended recoverable | Lead, dissolved | Manganese, total recoverable | Manganese, suspended recoverable | Manganese, dissolved | Mercury, total recoverable | Mercury, suspended recoverable |
|---|---|---|---|---|---|---|---|---|---|---|---|
| June 1982 | | | | | | | | | | | |
| 07 | 36,000 | 36,000 | 210 | 1200 | -- | <1 | 1,700 | 1,600 | 100 | 0.5 | -- |
| 07 | 19,000 | 19,000 | 200 | 480 | 470 | 6 | 880 | 840 | 45 | .4 | -- |
| 07 | 45,000 | 45,000 | 370 | 380 | -- | <1 | 2,200 | 2,200 | 51 | .3 | -- |
| July | | | | | | | | | | | |
| 06 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 06 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 06 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 06 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 06 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 06 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

Table 22.--Water-quality data for storm runoff in Brush Creek at Elmwood Avenue (station 6, fig. 1) for selected storms during 1981 and 1982--Continued

| Date | Mercury, dissolved | Selenium, total | Selemium, suspended total | Selenium, dissolved | Zinc, total recoverable | Zinc, suspended recoverable | Zinc, dissolved | Carbon, organic total (mg/L) | Sediment, suspended (mg/L) | Sediment, discharge suspended (tons/d) | Sediment, suspended, percent finer than 0.062 mm |
|---|---|---|---|---|---|---|---|---|---|---|---|
| July 1981 | | | | | | | | | | | |
| 27 | 0.0 | 0 | 0 | 0 | 540 | 530 | 12 | 37 | 1,620 | 17,400 | 38 |
| September | | | | | | | | | | | |
| 01 | .0 | 0 | 0 | 0 | 270 | 240 | 34 | -- | 402 | 838 | 56 |
| October | | | | | | | | | | | |
| 13 | .0 | 1 | 1 | 0 | 540 | 480 | 63 | 63 | 1,210 | 3,790 | 30 |
| 13 | .0 | 0 | 0 | 0 | 220 | 200 | 21 | 30 | 706 | 1,200 | 61 |
| 13 | .0 | 0 | 0 | 0 | 100 | 80 | 16 | 16 | 475 | 377 | 37 |
| 17 | .0 | 0 | 0 | 0 | 330 | 290 | 44 | 34 | 937 | 3,670 | 46 |
| 17 | .0 | 1 | 1 | 0 | 220 | 190 | 33 | 33 | 865 | 1,590 | 69 |
| 17 | .0 | 0 | 0 | 0 | 90 | 50 | 41 | 17 | 268 | 279 | 88 |
| April 1982 | | | | | | | | | | | |
| 28 | -- | 1 | -- | -- | 380 | -- | -- | -- | 720 | 710 | 27 |
| 28 | -- | 1 | -- | -- | 340 | -- | -- | -- | 401 | 371 | 7 |
| 28 | -- | 1 | -- | -- | 230 | -- | -- | -- | 510 | 483 | 47 |
| 28 | -- | 1 | -- | -- | 250 | -- | -- | -- | 533 | 530 | 42 |
| May | | | | | | | | | | | |
| 29 | <.1 | 2 | -- | <1 | 1000 | 950 | 53 | 120 | 4,010 | 5,200 | 48 |
| 29 | <.1 | 1 | -- | <1 | 660 | 560 | 100 | 67 | 2,170 | 9,200 | 56 |
| 29 | <.1 | 1 | -- | <1 | 230 | 180 | 48 | 19 | 917 | 2,380 | 61 |
| 29 | <.1 | 1 | -- | <1 | 240 | 160 | 78 | 23 | 567 | 1,680 | 60 |

3/8"

Table 22.--Water-quality data for storm runoff in Brush Creek at Elmwood Avenue (station 6, fig. 1) for selected storms during 1981 and 1982--Continued

| Date | Mercury, dissolved | Selenium, total | Selemium, suspended total | Selenium, dissolved | Zinc, total recoverable | Zinc, suspended recoverable | Zinc, dissolved | Carbon, organic total (mg/L) | Sediment, suspended (mg/L) | Sediment, discharge suspended (tons/d) | Sediment, suspended, percent finer than 0.062 mm |
|---|---|---|---|---|---|---|---|---|---|---|---|
| June 1982 | | | | | | | | | | | |
| 07 | <0.1 | 1 | -- | <1 | 910 | 860 | 49 | 55 | 2,730 | 16,900 | 39 |
| 07 | <.1 | 1 | -- | <1 | 550 | 490 | 59 | 34 | 1,180 | 5,930 | 57 |
| 07 | <.1 | -- | -- | <1 | 480 | 300 | 180 | 43 | 2,670 | 62,000 | 86 |
| July | | | | | | | | | | | |
| 06 | -- | -- | -- | -- | -- | -- | -- | -- | 6,450 | 7,980 | 21 |
| 06 | -- | -- | -- | -- | -- | -- | -- | -- | 2,290 | 5,110 | 12 |
| 06 | -- | -- | -- | -- | -- | -- | -- | -- | 1,530 | 4,420 | 26 |
| 06 | -- | -- | -- | -- | -- | -- | -- | -- | 1,100 | 2,880 | 33 |
| 06 | -- | -- | -- | -- | -- | -- | -- | -- | 819 | 1,380 | 42 |
| 06 | -- | -- | -- | -- | -- | -- | -- | -- | 436 | 357 | 45 |

3/8"

Table 23.--Water-quality data for storm runoff in Blue River at Coalmine Road (station 7, fig. 1) for selected storms during 1981 and 1982

[units are in micrograms per liter, except as indicated; µmho/cm at 25 °C; micromhos per centimeter at 25 °C; NTU: nephelometric turbidity units; mg/L; milligrams per liter; $NO_2$, nitrite; $NO_3$, nitrate; N, nitrogen; P, phosphorus; tons/d, tons per day; mm, millimeter]

| Date | Starting time (2400 hours) | Ending time (2400 hours) | Discharge, (cubic feet per second) | Streamflow, instantaneous (cubic feet per second | Specific conductance (µmhos) | Specific conductance lab (µmhos) | pH (units) | Turbidity (NTU) | Chemical oxygen demand (mg/L) | 5-day biochemical oxygen demand (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| July 1981 | | | | | | | | | | |
| 25 | 0530 | 1130 | 929 | -- | -- | 446 | 7.3 | 160 | 150 | 14 |
| 25 | 1230 | 1630 | 1,510 | -- | -- | 369 | 7.9 | 140 | -- | -- |
| 25 | 1730 | 2030 | 1,160 | -- | -- | 247 | 7.7 | 120 | 150 | -- |
| 27 | 0150 | 1150 | 3,940 | -- | -- | 214 | 7.4 | 180 | -- | 6.9 |
| 27 | 1250 | 1950 | 5,560 | -- | -- | 228 | 7.4 | 160 | -- | 8.1 |
| 27 | 2050 | 650 | 4,220 | -- | -- | 251 | 7.5 | 175 | 94 | 4.1 |
| September | | | | | | | | | | |
| 01 | 0550 | 1350 | 667 | -- | -- | 476 | 7.7 | 170 | 140 | 8.9 |
| 01 | 1450 | 2250 | 658 | -- | -- | 334 | 7.8 | 180 | 130 | 6.9 |
| October | | | | | | | | | | |
| 13 | 1130 | 2030 | 1,150 | -- | 380 | 382 | 7.1 | 160 | 74 | 16 |
| 13 | 2130 | 225 | 1,880 | -- | 310 | 325 | 7.3 | 180 | 89 | 12 |
| 14 | 0325 | 825 | 1,710 | -- | 310 | 305 | 6.9 | 160 | 89 | 11 |
| 14 | 0925 | 2240 | 922 | -- | 380 | 341 | 7.2 | 150 | 31 | 8.4 |
| 17 | 0610 | 1010 | 1,070 | -- | 210 | 183 | 7.6 | 115 | 110 | 13 |
| 17 | 1110 | 1410 | 1,080 | -- | 440 | 373 | 8.8 | 170 | 150 | 15 |
| 17 | 1510 | 2110 | 786 | -- | 360 | 331 | 7.8 | 170 | 89 | 12 |

13/16"

Table 23.--Water-quality data for storm runoff in Blue River at Coalmine Road (station 7, fig. 1) for selected storms during 1981 and 1982--Continued

| Date | Starting time (2400 hours) | Ending time (2400 hours) | Discharge, (cubic feet per second) | Streamflow, instantaneous (cubic feet per second | Specific conductance (μmhos) | Specific conductance lab (μmhos) | pH (units) | Turbidity (NTU) | Chemical oxygen demand (mg/L) | 5-day biochemical oxygen demand (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| April 1982 | | | | | | | | | | |
| 28 | -- | -- | -- | 456 | 250 | 255 | 7.1 | 70 | -- | -- |
| 28 | -- | -- | -- | 510 | 290 | 298 | 7.0 | 46 | -- | -- |
| 28 | -- | -- | -- | 540 | 280 | 295 | 6.9 | 60 | -- | -- |
| 28 | -- | -- | -- | 600 | 240 | 284 | 7.3 | 90 | -- | -- |
| May | | | | | | | | | | |
| 12 | -- | -- | -- | 455 | 520 | 530 | 7.9 | 52 | -- | -- |
| 12 | -- | -- | -- | 500 | 560 | 576 | 7.8 | 46 | -- | -- |
| 12 | -- | -- | -- | 545 | 600 | 618 | 7.9 | 64 | -- | -- |
| 12 | -- | -- | -- | 597 | 630 | 648 | 7.8 | 82 | -- | -- |
| 12 | -- | -- | -- | 633 | 620 | 622 | 7.8 | 150 | -- | -- |
| 12 | -- | -- | -- | 745 | 560 | 533 | 7.7 | 200 | -- | -- |

Table 23.--Water-quality data for storm runoff in Blue River at Coalmine Road (station 7, fig. 1) for selected storms during 1981 and 1982--Continued

| Date | Solids, residue at 180 °C dissolved (mg/L) | Solids, residue at 105 °C suspended (mg/L) | Nitrogen, $NO_2 + NO_3$ total (mg/L as N) | Nitrogen, $NO_2 + NO_3$ dissolved (mg/L as N) | Nitrogen, ammonia total (mg/L as N) | Nitrogen, ammonia dissolved (mg/L as N) | Nitrogen, organic total (mg/L as N) | Nitrogen, ammonia and organic total (mg/L as N) | Nitrogen, ammonia and organic dissolved (mg/L as N) | Nitrogen, organic dissolved (mg/L as N) | Nitrogen, total (mg/L) | Phosphorus, total (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| July 1981 | | | | | | | | | | | | |
| 25 | 276 | 2,050 | 1.7 | 1.6 | 0.91 | .78 | 3.0 | 3.9 | 1.9 | 1.1 | 5.5 | 3.1 |
| 25 | 220 | 2,810 | 1.5 | 1.5 | .14 | <.04 | 3.0 | 3.1 | .30 | -- | 4.6 | 2.1 |
| 25 | 164 | 2,240 | 1.2 | 1.4 | .20 | <.04 | 6.7 | 6.9 | .60 | -- | 8.1 | 2.2 |
| 27 | 132 | 1,410 | .71 | .88 | .24 | .06 | 4.0 | 4.2 | .50 | .44 | 4.9 | 2.1 |
| 27 | 143 | 1,330 | .82 | 1.0 | .32 | <.04 | 4.4 | 4.7 | .60 | -- | 5.5 | 2.2 |
| 27 | 163 | -- | .78 | 1.2 | .17 | <.04 | 3.7 | 3.9 | .80 | -- | 4.7 | 1.4 |
| September | | | | | | | | | | | | |
| 01 | 198 | 928 | -- | 1.3 | -- | .57 | -- | 5.3 | 2.2 | 1.6 | -- | 2.7 |
| 01 | 271 | 1,130 | -- | .90 | -- | <.04 | -- | 4.5 | 1.0 | -- | -- | 1.7 |
| October | | | | | | | | | | | | |
| 13 | 203 | 780 | .74 | -- | 1.1 | .16 | 3.3 | 4.4 | 1.6 | 1.5 | 5.1 | 2.7 |
| 13 | 177 | 868 | .79 | -- | .51 | .48 | 3.2 | 3.7 | 1.1 | .62 | 4.5 | 2.5 |
| 14 | 170 | 778 | .75 | -- | .46 | .36 | 2.6 | 3.1 | 1.1 | .74 | 3.8 | 2.0 |
| 14 | 203 | 542 | .82 | -- | .26 | .24 | 2.0 | 2.2 | 1.1 | .83 | 3.1 | 1.4 |
| 17 | 120 | 388 | .41 | -- | .14 | .06 | 3.1 | 3.2 | .79 | .73 | 3.6 | 1.2 |
| 17 | 252 | 1,450 | .77 | -- | .56 | .42 | 4.4 | 5.0 | 1.1 | .70 | 5.8 | 2.5 |
| 17 | 207 | 672 | 1.0 | -- | .65 | .51 | 2.9 | 3.5 | 1.3 | .79 | 4.5 | 1.7 |

Table 23.--Water-quality data for storm runoff in Blue River at Coalmine Road (station 7, fig. 1) for selected storms during 1981 and 1982--Continued

| Date | Solids, residue at 180 °C dissolved (mg/L) | Solids, residue at 105 °C suspended (mg/L) | Nitrogen, $NO_2 + NO_3$ total (mg/L as N) | Nitrogen, $NO_2 + NO_3$ dissolved (mg/L as N) | Nitrogen, ammonia total (mg/L as N) | Nitrogen, ammonia dissolved (mg/L as N) | Nitrogen, organic total (mg/L as N) | Nitrogen, ammonia and organic total (mg/L as N) | Nitrogen, ammonia and organic dissolved (mg/L as N) | Nitrogen, organic dissolved (mg/L as N) | Nitrogen, total (mg/L) | Phosphorus, total (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| April 1982 | | | | | | | | | | | | |
| 28 | 172 | -- | -- | -- | -- | -- | -- | 2.4 | -- | -- | -- | 0.80 |
| 28 | 189 | -- | -- | 0.61 | -- | 0.60 | -- | 2.2 | 1.9 | 1.3 | -- | .60 |
| 28 | 185 | -- | -- | .47 | -- | .80 | -- | 2.1 | 1.5 | .70 | -- | .90 |
| 28 | 123 | -- | -- | .54 | -- | 1.1 | -- | 2.0 | 1.7 | .60 | -- | .60 |
| May | | | | | | | | | | | | |
| 12 | 294 | 109 | -- | 1.8 | -- | 1.7 | -- | 2.9 | 2.8 | 1.1 | -- | 1.3 |
| 12 | 328 | 170 | -- | 2.0 | -- | 1.7 | -- | 2.8 | 2.8 | 1.1 | -- | 1.5 |
| 12 | 351 | 262 | -- | 2.1 | -- | 1.3 | -- | 2.5 | 2.5 | 1.2 | -- | 1.6 |
| 12 | 376 | 304 | -- | 2.5 | -- | .90 | -- | 1.9 | 1.9 | 1.0 | -- | 1.7 |
| 12 | 358 | -- | -- | 2.5 | -- | .60 | -- | 1.5 | 1.5 | .90 | -- | 1.7 |
| 12 | 317 | 956 | -- | 2.1 | -- | .60 | -- | 1.5 | 1.5 | .90 | -- | 2.0 |

Table 23.--Water-quality data for storm runoff in Blue River at Coalmine Road (station 7, fig. 1) for selected storms during 1981 and 1982--Continued

| Date | Phosphorus, dissolved (mg/L) | Arsenic, total | Arsenic, suspended total | Arsenic, dissolved | Cadmium, total recoverable | Cadmium, dissolved | Chromium, total recoverable | Chromium, suspended recoverable | Chromium, dissolved | Copper, total recoverable | Copper, suspended recoverable | Copper, dissolved |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| July 1981 | | | | | | | | | | | | |
| 25 | 0.56 | 15 | 12 | 3 | 1 | 1 | 60 | 50 | 10 | 80 | 71 | 9 |
| 25 | .14 | 13 | 11 | 2 | 1 | <1 | 60 | 50 | 10 | 70 | 65 | 5 |
| 25 | .10 | 15 | 14 | 1 | 1 | <1 | 60 | 50 | 10 | 52 | 49 | 3 |
| 27 | .12 | 9 | 6 | 3 | 1 | <1 | 50 | 40 | 10 | 50 | 45 | 5 |
| 27 | .10 | 13 | 11 | 2 | 1 | <1 | 40 | 40 | 0 | 70 | 68 | 2 |
| 27 | .12 | 10 | 8 | 2 | 1 | <1 | 40 | 30 | 10 | 34 | 29 | 5 |
| September | | | | | | | | | | | | |
| 01 | .74 | 8 | 4 | 4 | 0 | <1 | 20 | 20 | 0 | 41 | 39 | 2 |
| 01 | .27 | 8 | 6 | 2 | 0 | <1 | 20 | 10 | 10 | 34 | 27 | 7 |
| October | | | | | | | | | | | | |
| 13 | .90 | 8 | 5 | 3 | 1 | <1 | 20 | 20 | 0 | 46 | 43 | 3 |
| 13 | .51 | 11 | 8 | 3 | 0 | <1 | 30 | 30 | 0 | 31 | 28 | 3 |
| 14 | .41 | 8 | 5 | 3 | 1 | <1 | 20 | 20 | 0 | 27 | 25 | 2 |
| 14 | .34 | 6 | 3 | 3 | 2 | <1 | 20 | 20 | 0 | 22 | 20 | 2 |
| 17 | .19 | 10 | 7 | 3 | 1 | <1 | 20 | 20 | 0 | 34 | 32 | 2 |
| 17 | .34 | 13 | 11 | 2 | 1 | <1 | 50 | 50 | 0 | 50 | 48 | 2 |
| 17 | .51 | 8 | 4 | 4 | 0 | <1 | 40 | 40 | 0 | 31 | 28 | 3 |

Table 23.--Water-quality data for storm runoff in Blue River at Coalmine Road (station 7, fig. 1) for selected storms during 1981 and 1982--Continued

| Date | Phosphorus, dissolved (mg/L) | Arsenic, total | Arsenic, suspended total | Arsenic, dissolved | Cadmium, total recoverable | Cadmium, dissolved | Chromium, total recoverable | Chromium, suspended recoverable | Chromium, dissolved | Copper, total recoverable | Copper, suspended recoverable | Copper, dissolved |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| April 1982 | | | | | | | | | | | | |
| 28 | -- | 4 | -- | -- | <5 | -- | 10 | -- | -- | 25 | -- | -- |
| 28 | 0.10 | 4 | -- | -- | <10 | -- | 10 | -- | -- | 39 | -- | -- |
| 28 | <.10 | 5 | -- | -- | <5 | -- | 10 | -- | -- | 24 | -- | -- |
| 28 | .60 | 5 | -- | -- | 10 | -- | 10 | -- | -- | 31 | -- | -- |
| May | | | | | | | | | | | | |
| 12 | 1.0 | -- | -- | 2 | 1 | <3 | 10 | -- | <10 | 12 | 4 | 8 |
| 12 | 1.1 | -- | -- | 3 | 1 | <3 | 10 | -- | <10 | 17 | 11 | 6 |
| 12 | 1.1 | -- | -- | 3 | 1 | <3 | 20 | -- | <10 | 24 | 18 | 6 |
| 12 | 1.0 | 4 | 1 | 3 | 1 | <3 | 20 | -- | <10 | 21 | 16 | 5 |
| 12 | .80 | -- | -- | -- | 2 | -- | 30 | -- | -- | 27 | -- | -- |
| 12 | .70 | -- | -- | -- | 1 | -- | 30 | -- | -- | 37 | -- | -- |

Table 23.--Water-quality data for storm runoff in Blue River at Coalmine Road (station 7, fig. 1) for selected storms during 1981 and 1982--Continued

| Date | Iron, total recoverable | Iron, suspended recoverable | Iron, dissolved | Lead, total recoverable | Lead, suspended recoverable | Lead, dissolved | Manganese, total recoverable | Manganese, suspended recoverable | Manganese, dissolved | Mercury, total recoverable | Mercury, suspended recoverable |
|---|---|---|---|---|---|---|---|---|---|---|---|
| July 1981 | | | | | | | | | | | |
| 25 | 43,000 | 43,000 | 260 | 110 | 100 | 7 | 1,800 | 1,800 | 28 | 0.3 | 0.3 |
| 25 | 51,000 | 51,000 | 28 | 67 | 60 | 7 | 2,200 | 2,200 | 1 | .2 | .1 |
| 25 | 48,000 | 48,000 | 77 | 50 | 43 | 7 | 1,500 | 1,500 | 1 | .2 | .2 |
| 27 | 35,000 | 35,000 | 62 | 140 | 140 | 3 | 1,400 | 1,400 | 1 | .2 | .2 |
| 27 | 46,000 | 46,000 | 78 | 140 | 140 | 4 | 1,300 | 1,300 | 1 | .2 | .2 |
| 27 | 28,000 | 28,000 | 57 | 25 | 21 | 4 | 880 | 880 | 2 | .1 | .1 |
| September | | | | | | | | | | | |
| 01 | 28,000 | 28,000 | 56 | 48 | 44 | 4 | 1,300 | 1,200 | 63 | .1 | .1 |
| 01 | 29,000 | 29,000 | 53 | 29 | 25 | 4 | 1,100 | -- | <1 | .0 | .0 |
| October | | | | | | | | | | | |
| 13 | 17,000 | 17,000 | 65 | 120 | 120 | 0 | 700 | 660 | 40 | .3 | .3 |
| 13 | 20,000 | 20,000 | 92 | 64 | 63 | 1 | 770 | 760 | 13 | 2.1 | 2.1 |
| 14 | 17,000 | 17,000 | 83 | 49 | 49 | 0 | 750 | 740 | 7 | .1 | .1 |
| 14 | 12,000 | 12,000 | 93 | 33 | 32 | 1 | 550 | 550 | 3 | .1 | .1 |
| 17 | 13,000 | 13,000 | 98 | 180 | 180 | 2 | 630 | 620 | 13 | .3 | .3 |
| 17 | 40,000 | 40,000 | 56 | 96 | 95 | 1 | 1,400 | 1,400 | 11 | .5 | .5 |
| 17 | 19,000 | 19,000 | 66 | 50 | 48 | 2 | 890 | 890 | 2 | .2 | .2 |

Table 23.--Water-quality data for storm runoff in Blue River at Coalmine Road (station 7, fig. 1) for selected storms during 1981 and 1982--Continued

| Date | Iron, total recoverable | Iron, suspended recoverable | Iron, dissolved | Lead, total recoverable | Lead, suspended recoverable | Lead, dissolved | Manganese, total recoverable | Manganese, suspended recoverable | Manganese, dissolved | Mercury, total recoverable | Mercury, suspended recoverable |
|---|---|---|---|---|---|---|---|---|---|---|---|
| April 1982 | | | | | | | | | | | |
| 28 | 6,900 | -- | -- | 120 | -- | -- | 450 | -- | -- | 0.1 | -- |
| 28 | 6,600 | -- | -- | 110 | -- | -- | 450 | -- | -- | .2 | -- |
| 28 | 7,600 | -- | -- | 170 | -- | -- | 500 | -- | -- | .1 | -- |
| 28 | 7,700 | -- | -- | 100 | -- | -- | 490 | -- | -- | .2 | -- |
| May | | | | | | | | | | | |
| 12 | 3,300 | 3,300 | 35 | 31 | 29 | 2 | 290 | 280 | 14 | -- | -- |
| 12 | 4,000 | 4,000 | 28 | 28 | 27 | 1 | 320 | 320 | 4 | -- | -- |
| 12 | 6,200 | 6,200 | 21 | 34 | 33 | 1 | 440 | 440 | 3 | -- | -- |
| 12 | 8,800 | 8,800 | 17 | 33 | 31 | 2 | 590 | 580 | 6 | .1 | -- |
| 12 | 1,100 | -- | -- | 34 | -- | -- | 680 | -- | -- | -- | -- |
| 12 | 20,000 | -- | -- | 47 | -- | -- | 990 | -- | -- | -- | -- |

Table 23.--Water-quality data for storm runoff in Blue River at Coalmine Road (station 7, fig. 1) for selected storms during 1981 and 1982--Continued

| Date | Mercury, dissolved | Selenium, total | Selemium, suspended total | Selenium, dissolved | Zinc, total recoverable | Zinc, suspended recoverable | Zinc, dissolved | Carbon, organic total (mg/L) | Sediment, suspended (mg/L) | Sediment, discharge suspended (tons/d) | Sediment, suspended, percent finer than 0.062 mm |
|---|---|---|---|---|---|---|---|---|---|---|---|
| July 1981 | | | | | | | | | | | |
| 25 | 0.0 | 0 | 0 | 1 | 260 | 250 | 11 | 36 | 2,500 | 6,720 | 88 |
| 25 | .1 | 0 | 0 | 0 | 240 | 220 | 17 | -- | 3,210 | 13,100 | 90 |
| 25 | .0 | 0 | 0 | 0 | 210 | 190 | 18 | 36 | 2,740 | 8,580 | 87 |
| 27 | .0 | 0 | 0 | 0 | 260 | 240 | 17 | -- | 2,030 | 21,600 | 75 |
| 27 | .0 | 0 | 0 | 0 | 230 | 220 | 15 | -- | 2,200 | 33,000 | 90 |
| 27 | .0 | 0 | 0 | 0 | 140 | 100 | 44 | 33 | 1,360 | 15,500 | 86 |
| September | | | | | | | | | | | |
| 01 | .0 | 0 | 0 | 0 | 200 | 180 | 25 | -- | 1,450 | 2,610 | 79 |
| 01 | .0 | 0 | 0 | 0 | 140 | 120 | 21 | -- | 1,330 | 2,360 | 90 |
| October | | | | | | | | | | | |
| 13 | .0 | 0 | 0 | 0 | 200 | 170 | 30 | 33 | 841 | 2,610 | 68 |
| 13 | .0 | 0 | 0 | 0 | 150 | 100 | 47 | 30 | 1,100 | 5,580 | 80 |
| 14 | .0 | 0 | 0 | 0 | 130 | 110 | 21 | 25 | 879 | 4,060 | 77 |
| 14 | .0 | 0 | 0 | 0 | 100 | 70 | 27 | 24 | 574 | 1,430 | 89 |
| 17 | .0 | 0 | 0 | 0 | 220 | 200 | 24 | -- | 683 | 1,970 | 75 |
| 17 | .0 | 1 | 1 | 0 | 270 | 220 | 52 | -- | 1,810 | 5,280 | 89 |
| 17 | .0 | 0 | 0 | 0 | 140 | 110 | 28 | -- | 865 | 1,840 | 84 |

9/14 "

Table 23.--Water-quality data for storm runoff in Blue River at Coalmine Road (station 7, fig. 1) for selected storms during 1981 and 1982--Continued

| Date | Mercury, dissolved | Selenium, total | Selemium, suspended total | Selenium, dissolved | Zinc, total recoverable | Zinc, suspended recoverable | Zinc, dissolved | Carbon, organic total (mg/L) | Sediment, suspended (mg/L) | Sediment, discharge suspended (tons/d) | Sediment, suspended, percent finer than 0.062 mm |
|---|---|---|---|---|---|---|---|---|---|---|---|
| April 1982 | | | | | | | | | | | |
| 28 | -- | 1 | -- | -- | 170 | -- | -- | -- | 314 | 387 | 81 |
| 28 | -- | 1 | -- | -- | 190 | -- | -- | -- | 276 | 380 | 74 |
| 28 | -- | 1 | -- | -- | 180 | -- | -- | -- | 315 | 459 | 73 |
| 28 | -- | 1 | -- | -- | 170 | -- | -- | -- | 349 | 565 | 74 |
| May | | | | | | | | | | | |
| 12 | <.1 | -- | -- | <1 | 70 | 40 | 35 | 13 | 121 | 149 | 82 |
| 12 | <.1 | -- | -- | <1 | 70 | 50 | 19 | 12 | 171 | 231 | 86 |
| 12 | <.1 | -- | -- | <1 | 90 | 70 | 17 | 13 | 292 | 430 | 84 |
| 12 | <.1 | <1 | -- | <1 | 100 | 80 | 23 | 15 | 486 | 783 | 78 |
| 12 | -- | -- | -- | -- | 110 | -- | -- | -- | 658 | 1,130 | 81 |
| 12 | -- | -- | -- | -- | 160 | -- | -- | 23 | 2,850 | 5,730 | 91 |

Table 24.--Water-quality data for storm runoff in the Blue Ridge Mall storm sewer (station 8, fig. 1) for storms during April-June, 1982

[units are in micrograms per liter, except as indicated; µmho/cm at 25 °C; micromhos per centimeter at 25 °C; NTU: nephelometric turbidity units; mg/L; milligrams per liter; $NO_2$, nitrite; $NO_3$, nitrate; N, nitrogen; P, phosphorus; tons/d, tons per day; mm, millimeter]

| Date | Starting time (2400) hours | Ending time (2400) hours | Discharge, (cubic feet per second) | Specific conductance (umhos/cm at 25 °C) | Specific conductance lab (umhos/cm at 25 °C) | pH (units) | Turbidity (NTU) | Chemical oxygen demand (mg/L) | 5-day biochemical oxygen demand (mg/L) |
|---|---|---|---|---|---|---|---|---|---|
| April 1982 | | | | | | | | | |
| 28 | 1220 | 1800 | 7.1 | 215 | 215 | 7.4 | 19 | 52 | -- |
| 28 | 1820 | 1950 | 10 | 175 | 165 | 7.0 | 23 | -- | -- |
| 28 | 2000 | 2300 | 5.9 | 205 | 208 | 7.1 | 14 | 31 | -- |
| May | | | | | | | | | |
| 11 | 1310 | 1340 | 6.9 | -- | 228 | 6.8 | -- | -- | -- |
| 13 | 0736 | 0838 | 3.1 | -- | 275 | 7.0 | -- | -- | -- |
| 14 | 1900 | 2030 | 56 | -- | 110 | 7.1 | -- | 66 | -- |
| 28 | 0900 | 1030 | .48 | 580 | -- | -- | -- | 220 | -- |
| 29 | 0130 | 0310 | 14 | 115 | 119 | 6.8 | -- | 54 | -- |
| 29 | 0320 | 0500 | 10 | 100 | 108 | 7.2 | -- | 13 | -- |
| June | | | | | | | | | |
| 14 | 1340 | 1520 | 3.1 | 300 | 280 | 7.1 | 30 | -- | 35 |
| 15 | 0240 | 0335 | .62 | 380 | 387 | 7.2 | 12 | 120 | 27 |
| 15 | 0725 | 0810 | 18 | 120 | -- | -- | 28 | 71 | 7.5 |
| 15 | 0815 | 0855 | 3.9 | 170 | 164 | 7.7 | 12 | -- | 3.3 |
| 15 | 0905 | 1030 | 6.3 | 160 | 163 | 7.5 | 12 | 37 | <1.0 |

Table 24.--Water-quality data for storm for runoff in the Blue Ridge Mall storm sewer (station 8, fig. 1) for storms during April-June, 1982--Continued

| Date | Starting time (2400 hours) | Ending time (2400 hours) | Discharge, (cubic feet per second) | Specific conductance (µmhos/cm at 25 °C) | Specific conductance lab (µmhos/cm at 25 °C) | pH (units) | Turbidity (NTU) | Chemical oxygen demand (mg/L) | 5-day biochemical oxygen demand (mg/L) |
|---|---|---|---|---|---|---|---|---|---|
| June 1982--continued | | | | | | | | | |
| 25 | 0619 | 0654 | 0.66 | -- | 566 | 6.2 | -- | 420 | -- |
| 25 | 1710 | 1730 | 2.3 | -- | 232 | 6.3 | -- | 240 | -- |
| 25 | 1730 | 1750 | 32 | -- | 126 | 6.7 | -- | 120 | -- |
| 25 | 1750 | 1910 | 8.6 | -- | 131 | 7.1 | -- | 60 | -- |

| Date | Solids, residue at 180 °C dissolved (mg/L) | Solids, residue at 105 °C suspended (mg/L) | Nitrogen, $NO_2 + NO_3$ dissolved (mg/L as N) | Nitrogen, ammonia dissolved (mg/L as N) | Nitrogen, ammonia and organic total (mg/L as N) | Nitrogen, ammonia and organic dissolved (mg/L as N) | Nitrogen, organic dissolved (mg/L as N) | Phosphorus, total (mg/L) | Phosphorus, dissolved (mg/l) | Arsenic, total |
|---|---|---|---|---|---|---|---|---|---|---|
| April 1982 | | | | | | | | | | |
| 28 | 132 | 96 | 0.49 | 0.80 | 1.5 | 1.3 | 0.50 | 0.20 | 0.10 | 1 |
| 28 | 102 | -- | .43 | .10 | 1.2 | 1.5 | 1.4 | .20 | .10 | 2 |
| 28 | 123 | -- | .49 | .20 | 1.2 | 1.3 | 1.1 | .10 | .20 | 1 |
| May | | | | | | | | | | |
| 11 | 146 | -- | .45 | <.40 | 1.7 | 1.0 | -- | .30 | .30 | -- |
| 13 | 164 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 14 | 64 | 372 | .25 | <.40 | <.10 | <.10 | -- | .40 | .10 | -- |
| 28 | -- | -- | 1.2 | <.40 | 3.3 | 2.8 | -- | .47 | .27 | 2 |
| 29 | 66 | -- | .24 | <.40 | .12 | .87 | -- | .17 | .10 | 2 |
| 29 | 66 | -- | .45 | <.40 | 1.4 | .76 | -- | .16 | .10 | 1 |

Table 24.--Water-quality data for storm for runoff in the Blue Ridge Mall storm sewer (station 8, fig. 1) for storms during April-June, 1982--Continued

| Date | Solids, residue at 180 °C dissolved (mg/L) | Solids, residue at 105 °C suspended (mg/L) | Nitrogen, $NO_2 + NO_3$ dissolved (mg/L as N) | Nitrogen, ammonia dissolved (mg/L as N) | Nitrogen, ammonia and organic total (mg/L as N) | Nitrogen, ammonia and organic dissolved (mg/L as N) | Nitrogen, organic dissolved (mg/L as N) | Phosphorus, total (mg/L) | Phosphorus, dissolved (mg/l) | Arsenic, total |
|---|---|---|---|---|---|---|---|---|---|---|
| June 1982 | | | | | | | | | | |
| 14 | 201 | -- | 0.89 | <0.40 | 2.5 | 2.3 | -- | 0.23 | <0.10 | -- |
| 15 | 259 | 36 | .61 | <.40 | 1.7 | 1.7 | -- | .32 | .24 | 1 |
| 15 | 5 | -- | .40 | <.40 | 1.2 | .80 | -- | .41 | .10 | 1 |
| 15 | 101 | -- | .44 | <.40 | .63 | 1.8 | -- | .11 | <.10 | -- |
| 15 | 98 | 21 | .21 | <.40 | .63 | .80 | -- | .18 | <.10 | 1 |
| 25 | 479 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 25 | 190 | -- | -- | -- | -- | -- | -- | -- | -- | 1 |
| 25 | 86 | 263 | -- | -- | -- | -- | -- | -- | -- | 2 |
| 25 | 79 | 110 | -- | -- | -- | -- | -- | -- | -- | 2 |

| Date | Arsenic, suspended total | Arsenic, dissolved | Cadmium, total recoverable | Cadmium, dissolved | Chromium, total recoverable | Chromium, suspended recoverable | Chromium, dissolved | Copper, total recoverable | Copper, suspended recoverable | Copper, dissolved |
|---|---|---|---|---|---|---|---|---|---|---|
| April 1982 | | | | | | | | | | |
| 28 | 0 | 1 | <1 | <3 | 10 | -- | <10 | 23 | 19 | 4 |
| 28 | 1 | 1 | <10 | <3 | 10 | -- | <10 | 16 | 12 | 4 |
| 28 | 0 | 1 | <5 | <3 | 10 | -- | <10 | 10 | 6 | 4 |

Table 24.--Water-quality data for storm for runoff in the Blue Ridge Mall storm sewer (station 8, fig. 1) for storms during April-June, 1982--Continued

| Date | Arsenic, suspended total | Arsenic, dissolved | Cadmium, total recoverable | Cadmium, dissolved | Chromium, total recoverable | Chromium, suspended recoverable | Chromium, dissolved | Copper, total recoverable | Copper, suspended recoverable | Copper, dissolved |
|---|---|---|---|---|---|---|---|---|---|---|
| May 1982 | | | | | | | | | | |
| 11 | -- | 1 | 2 | 1 | 20 | 10 | 10 | 32 | 22 | 10 |
| 13 | -- | -- | 1 | -- | <10 | -- | -- | 14 | -- | -- |
| 14 | -- | 1 | 2 | <3 | 30 | -- | <10 | 29 | 22 | 7 |
| 28 | 1 | 1 | 1 | 3 | 10 | 0 | 10 | 28 | 11 | 17 |
| 29 | 1 | 1 | 2 | <3 | 10 | -- | <10 | 15 | 10 | 5 |
| 29 | 0 | 1 | 2 | <3 | 10 | -- | <10 | 9 | 5 | 4 |
| June | | | | | | | | | | |
| 14 | -- | 1 | 1 | <1 | 20 | -- | <10 | 20 | 10 | 10 |
| 15 | 0 | 1 | 1 | <1 | 10 | -- | <10 | 14 | 4 | 10 |
| 15 | 0 | 1 | 2 | <1 | 20 | -- | <10 | 15 | 9 | 6 |
| 15 | -- | 1 | 1 | <1 | 10 | -- | <10 | 8 | 3 | 5 |
| 15 | 0 | 1 | <1 | <1 | 10 | -- | <10 | 8 | 3 | 5 |
| 25 | -- | 2 | 2 | 2 | 10 | -- | <10 | 35 | 11 | 24 |
| 25 | 0 | 1 | 2 | 1 | 20 | -- | <10 | 19 | 1 | 18 |
| 25 | 1 | 1 | 3 | <1 | 20 | -- | <10 | 34 | 21 | 13 |
| 25 | 1 | 1 | 1 | <1 | 10 | -- | <10 | 14 | 5 | 9 |

7/16"

Table 24.--Water-quality data for storm for runoff in the Blue Ridge Mall storm sewer (station 8, fig. 1) for storms during April-June, 1982--Continued

| Date | Iron, total recoverable | Iron, suspended recoverable | Iron, dissolved | Lead, total recoverable | Lead, suspended recoverable | Lead, dissolved | Manganese, total recoverable | Manganese, suspended recoverable | Manganese, dissolved | Mercury, total recoverable |
|---|---|---|---|---|---|---|---|---|---|---|
| April 1982 | | | | | | | | | | |
| 28 | 2,300 | 2,200 | 82 | 78 | 71 | 7 | 130 | 90 | 40 | 0.1 |
| 28 | 3,100 | 3,000 | 53 | 70 | 64 | 6 | 180 | 160 | 22 | <.1 |
| 28 | 870 | 830 | 36 | 35 | 31 | 4 | 80 | 50 | 26 | <.1 |
| May | | | | | | | | | | |
| 11 | 4,700 | 4,600 | 100 | 200 | 190 | 8 | 420 | 300 | 120 | -- |
| 13 | 790 | -- | -- | 60 | -- | -- | 130 | -- | -- | -- |
| 14 | 9,900 | 9,700 | 250 | 210 | 200 | 11 | 520 | 480 | 38 | -- |
| 28 | 1,400 | 1,300 | 82 | 72 | 64 | 8 | 480 | 60 | 420 | .1 |
| 29 | 2,300 | 2,200 | 89 | 70 | 66 | 4 | 240 | 220 | 22 | .1 |
| 29 | 1,000 | 890 | 110 | 18 | 17 | 1 | 90 | 80 | 12 | <.1 |
| June | | | | | | | | | | |
| 14 | 3,100 | 3,000 | 88 | 130 | 130 | 4 | 370 | 170 | 200 | -- |
| 15 | 640 | 480 | 160 | 34 | -- | <10 | 360 | 40 | 320 | .1 |
| 15 | 3,400 | 3,300 | 76 | 110 | 110 | 2 | 310 | 270 | 38 | .1 |
| 15 | 550 | 500 | 46 | 16 | -- | <5 | 80 | 30 | 53 | -- |
| 15 | 770 | 720 | 51 | 26 | 23 | 3 | 80 | 40 | 41 | .1 |
| 25 | 2,000 | 1,800 | 220 | 55 | 40 | 15 | 870 | 370 | 500 | -- |
| 25 | 3,300 | 3,100 | 180 | 92 | 78 | 14 | 300 | 60 | 240 | .6 |
| 25 | 5,300 | 5,200 | 52 | 230 | 220 | 7 | 980 | 840 | 140 | .4 |
| 25 | 2,600 | 2,600 | 37 | 72 | -- | <1 | 290 | 220 | 66 | .3 |

Table 24.--Water-quality data for storm for runoff in the Blue Ridge Mall storm sewer (station 8, fig. 1) for storms during April-June, 1982--Continued

| Date | Mercury, dissolved | Selenium, total | Selenium, dissolved | Zinc, total recoverable | Zinc, suspended recoverable | Zinc, dissolved | Carbon, organic total (mg/L) | Sediment, suspended (mg/L) | Sediment, discharge suspended (tons/d) | Sediment, suspended, percent finer than 0.062 mm |
|---|---|---|---|---|---|---|---|---|---|---|
| April 1982 | | | | | | | | | | |
| 28 | <0.1 | <1 | <1 | 170 | 130 | 45 | 12 | 122 | 2.4 | 77 |
| 28 | <.1 | <1 | <1 | 160 | 120 | 43 | 9.1 | 178 | 4.8 | 81 |
| 28 | <.1 | <1 | <1 | 100 | 50 | 49 | 6.8 | 45 | .72 | 81 |
| May | | | | | | | | | | |
| 11 | <.1 | -- | <1 | 370 | 300 | 70 | -- | 249 | 4.7 | 58 |
| 13 | -- | -- | -- | 110 | -- | -- | -- | -- | -- | -- |
| 14 | <.1 | -- | <1 | 290 | 260 | 31 | 13 | 676 | 101 | 76 |
| 28 | <.1 | -- | <1 | 210 | 90 | 120 | -- | 30 | .04 | 58 |
| 29 | <.1 | -- | <1 | 140 | 90 | 48 | 11 | 119 | 4.6 | 80 |
| 29 | <.1 | <1 | <1 | 60 | 20 | 44 | 5.5 | 33 | .91 | 87 |
| June | | | | | | | | | | |
| 14 | <.1 | -- | <1 | 260 | 150 | 110 | -- | 90 | .76 | 60 |
| 15 | <.1 | <1 | <1 | 140 | 20 | 120 | 15 | -- | -- | -- |
| 15 | <.1 | <1 | <1 | 190 | 70 | 120 | 15 | -- | -- | -- |
| 15 | <.1 | -- | <1 | 80 | 2 | 78 | 9.4 | -- | -- | -- |
| 15 | <.1 | <1 | <1 | 80 | 6 | 74 | 9.3 | -- | -- | -- |
| 25 | <.1 | -- | <1 | 290 | 60 | 230 | 130 | 145 | .26 | 69 |
| 25 | <.1 | <1 | <1 | 520 | 200 | 320 | 48 | -- | -- | -- |
| 25 | <.1 | <1 | <1 | 380 | 230 | 150 | 28 | 124 | 11 | 20 |
| 25 | <.1 | <1 | <1 | 140 | 10 | 130 | 12 | 246 | 5.7 | 58 |

Table 25.--Water-quality data for storm runoff in Blue River near St. John Avenue (station 11, fig. 1) for selected storms during 1981 and 1982

[units are in micrograms per liter, except as indicated; µmho/cm at 25 °C; micromhos per centimeter at 25 °C; NTU: nephelometric turbidity units; mg/L; milligrams per liter; $NO_2$, nitrite; $NO_3$, nitrate; N, nitrogen; P, phosphorus; tons/d, tons per day; mm, millimeter]

| Date | Starting time (2400 hours) | Ending time (2400 hours) | Discharge, (cubic feet per second) | Streamflow instantaneous, (cubic feet per second) | Specific conductance (µmhos/cm at 25 °C) | Specific conductance lab (µmhos/cm at 25 °C) | pH (units) | Turbidity (NTU) | Chemical oxygen demand (mg/L) | 5-day biochemical oxygen demand (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| July 1981 | | | | | | | | | | |
| 25 | 1400 | 1900 | 1,390 | -- | -- | 484 | 7.6 | 200 | -- | -- |
| 27 | 0140 | 1340 | 4,320 | -- | -- | 262 | 7.5 | 150 | 130 | 9.0 |
| 27 | 2100 | 0600 | 4,780 | -- | -- | 240 | 7.5 | 160 | 150 | 5.9 |
| October | | | | | | | | | | |
| 13 | 1220 | 2020 | 1,160 | -- | 700 | 640 | 6.3 | 96 | 87 | 9.7 |
| 13 | 2120 | 0220 | 1,720 | -- | 380 | 343 | 7.4 | 180 | 140 | 15 |
| 14 | 0320 | 0820 | 1,620 | -- | 350 | 350 | 7.4 | 200 | 120 | 12 |
| 14 | 0925 | 1940 | 982 | -- | 360 | 335 | 7.2 | 170 | 99 | 9.6 |
| 17 | 5550 | 1320 | 3,560 | -- | 460 | 451 | 7.6 | 150 | 99 | 11 |
| 17 | 1350 | 1550 | 577 | -- | 250 | 222 | 7.7 | 155 | 89 | -- |
| 17 | 1620 | 1920 | 509 | -- | 400 | 373 | 7.7 | 155 | 87 | 6.9 |
| April 1982 | | | | | | | | | | |
| 28 | -- | -- | -- | 540 | 650 | 657 | 7.4 | 68 | -- | -- |
| 28 | -- | -- | -- | 566 | 640 | 640 | 7.6 | 50 | -- | -- |
| 28 | -- | -- | -- | 627 | 640 | 670 | 7.8 | 34 | -- | -- |
| 28 | -- | -- | -- | 723 | 700 | 640 | 7.3 | 42 | -- | -- |

5/16"

Table 25.--Water-quality data for storm runoff in Blue River near St. John Avenue (station 11, fig. 1) for selected storms during 1981 and 1982--Continued

| Date | Starting time (2400 hours) | Ending time (2400 hours) | Discharge, (cubic feet per second) | Streamflow instantaneous, (cubic feet per second) | Specific conductance (μmhos/cm at 25 °C) | Specific conductance lab (μmhos/cm at 25 °C) | pH (units) | Turbidity (NTU) | Chemical oxygen demand (mg/L) | 5-day biochemical oxygen demand (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| May 1982 | | | | | | | | | | |
| 12 | -- | -- | -- | 530 | 750 | 767 | 7.8 | -- | -- | -- |
| 12 | -- | -- | -- | 550 | 740 | 734 | 8.0 | -- | -- | -- |
| 12 | -- | -- | -- | 580 | 740 | 744 | 8.2 | -- | -- | -- |
| 12 | -- | -- | -- | 618 | 740 | 744 | 8.2 | -- | -- | -- |
| 12 | -- | -- | -- | 694 | 750 | 751 | 8.0 | -- | -- | -- |
| 12 | -- | -- | -- | 764 | 760 | 771 | 8.0 | -- | -- | -- |

| Date | Solids, residue at 180 °C dissolved (mg/L) | Solids, residue at 105 °C suspended (mg/L) | Nitrogen, $NO_2 + NO_3$ total (mg/L as N) | Nitrogen, $NO_2 + NO_3$ dissolved (mg/L as N) | Nitrogen, ammonia total (mg/L as N) | Nitrogen, ammonia dissolved (mg/L as N) | Nitrogen, organic total (mg/L as N) | Nitrogen, ammonia and organic total (mg/L as N) | Nitrogen, ammonia and organic dissolved (mg/L as N) | Nitrogen, organic dissolved (mg/L as N) | Nitrogen, total (mg/L) | Phosphorus, total (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| July 1981 | | | | | | | | | | | | |
| 25 | 293 | 1,520 | 1.6 | 1.8 | 0.67 | 0.39 | 2.8 | 3.5 | 1.0 | 0.61 | 5.1 | 2.1 |
| 27 | 159 | 760 | .65 | .82 | .36 | .18 | 4.9 | 5.3 | .90 | .72 | 5.9 | 2.4 |
| 27 | 143 | 1,670 | .81 | 1.0 | .26 | .07 | 4.2 | 4.5 | 1.0 | .93 | 5.3 | 1.8 |

Table 25.--Water-quality data for storm runoff in Blue River near St. John Avenue (station 11, fig. 1) for selected storms during 1981 and 1982--Continued

| Date | Solids, residue at 180 °C dissolved (mg/L) | Solids, residue at 105 °C suspended (mg/L) | Nitrogen, $NO_2 + NO_3$ total (mg/L as N) | Nitrogen, $NO_2 + NO_3$ dissolved (mg/L as N) | Nitrogen, ammonia total (mg/L as N) | Nitrogen, ammonia dissolved (mg/L as N) | Nitrogen, organic total (mg/L as N) | Nitrogen, ammonia and organic total (mg/L as N) | Nitrogen, ammonia and organic dissolved (mg/L as N) | Nitrogen, organic dissolved (mg/L as N) | Nitrogen, total (mg/L) | Phosphorus, total (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| October 1981 | | | | | | | | | | | | |
| 13 | 373 | 354 | 0.95 | -- | 1.2 | 1.0 | 2.1 | 3.4 | 1.9 | 0.82 | 4.3 | 2.2 |
| 13 | 203 | -- | .59 | -- | .94 | .75 | 4.5 | 5.4 | 1.5 | .74 | 6.0 | 2.8 |
| 14 | 189 | 1,040 | .58 | -- | .64 | .46 | 3.2 | 3.8 | 1.2 | .73 | 4.4 | 2.2 |
| 14 | 188 | 770 | .60 | -- | .49 | .39 | 2.6 | 3.1 | .98 | .59 | 3.7 | 1.6 |
| 17 | 286 | 812 | .70 | -- | .40 | .32 | 2.8 | 3.2 | .83 | .51 | 3.9 | 1.5 |
| 17 | 149 | 784 | .42 | -- | .18 | .08 | 2.4 | 2.6 | .42 | .34 | 3.0 | 1.4 |
| 17 | 239 | 692 | .77 | -- | .29 | .26 | 2.1 | 2.4 | .69 | .43 | 3.1 | 1.3 |
| April 1982 | | | | | | | | | | | | |
| 28 | 413 | -- | -- | 1.6 | -- | 2.4 | -- | 2.4 | 2.5 | .10 | -- | 1.3 |
| 28 | 394 | -- | -- | 1.7 | -- | 1.4 | -- | 2.2 | 2.5 | 1.1 | -- | 1.1 |
| 28 | 409 | -- | -- | 1.7 | -- | 1.3 | -- | 2.4 | 2.6 | 1.3 | -- | 1.2 |
| 28 | 401 | -- | -- | 1.4 | -- | 2.5 | -- | 3.0 | 2.3 | -- | -- | 1.1 |

Table 25.--Water-quality data for storm runoff in Blue River near St. John Avenue (station 11, fig. 1) for selected storms during 1981 and 1982--Continued

| Date | Solids, residue at 180 °C dissolved (mg/L) | Solids, residue at 105 °C suspended (mg/L) | Nitrogen, $NO_2 + NO_3$ total (mg/L as N) | Nitrogen, $NO_2 + NO_3$ dissolved (mg/L as N) | Nitrogen, ammonia total (mg/L as N) | Nitrogen, ammonia dissolved (mg/L as N) | Nitrogen, organic total (mg/L as N) | Nitrogen, ammonia and organic total (mg/L as N) | Nitrogen, ammonia and organic dissolved (mg/L as N) | Nitrogen, organic dissolved (mg/L as N) | Nitrogen, total (mg/L) | Phosphorus, total (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| May 1982 | | | | | | | | | | | | |
| 12 | 326 | 65 | -- | 2.2 | -- | 0.60 | -- | 1.5 | 1.5 | 0.90 | -- | 0.90 |
| 12 | 445 | 39 | -- | 1.9 | -- | .50 | -- | 1.5 | 1.5 | 1.0 | -- | .70 |
| 12 | 447 | 33 | -- | 1.8 | -- | .60 | -- | 1.4 | 1.4 | .80 | -- | .70 |
| 12 | 447 | 29 | -- | 1.8 | -- | .70 | -- | 1.6 | 1.6 | .90 | -- | .70 |
| 12 | 444 | 73 | -- | 2.0 | -- | .50 | -- | 1.5 | 1.5 | 1.0 | -- | .80 |
| 12 | 469 | 170 | -- | 2.2 | -- | .70 | -- | 1.6 | 1.6 | .90 | -- | 1.0 |

| Date | Phosphorus, dissolved (mg/L) | Arsenic, total | Arsenic, suspended total | Arsenic, dissolved | Cadmium, total recoverable | Cadmium, dissolved | Chromium, total recoverable | Chromium, suspended recoverable | Chromium, dissolved | Copper, total recoverable | Copper, suspended recoverable | Copper, dissolved |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| July 1981 | | | | | | | | | | | | |
| 25 | 0.33 | 9 | 6 | 3 | 1 | <1 | 50 | 50 | 0 | 51 | 48 | 3 |
| 27 | .10 | 12 | 9 | 3 | 1 | <1 | 50 | 40 | 10 | 46 | 43 | 3 |
| 27 | .08 | 17 | 15 | 2 | 2 | <1 | 60 | 50 | 10 | 90 | 87 | 3 |

5/16

Table 25.--Water-quality data for storm runoff in Blue River near St. John Avenue (station 11, fig. 1) for selected storms during 1981 and 1982--Continued

| Date | Phosphorus, dissolved (mg/L) | Arsenic, total | Arsenic, suspended total | Arsenic, dissolved | Cadmium, total recoverable | Cadmium, dissolved | Chromium, total recoverable | Chromium, suspended recoverable | Chromium, dissolved | Copper, total recoverable | Copper, suspended recoverable | Copper, dissolved |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| October 1981 | | | | | | | | | | | | |
| 13 | 0.91 | 7 | 4 | 3 | 2 | <1 | 20 | 20 | 0 | 40 | 38 | 2 |
| 13 | .44 | 12 | 10 | 2 | 1 | <1 | 50 | 50 | 0 | 50 | 48 | 2 |
| 14 | .36 | 14 | 11 | 3 | 1 | <1 | 30 | 30 | 0 | 44 | 43 | 1 |
| 14 | .35 | 7 | 4 | 3 | 2 | <1 | 20 | 20 | 0 | 45 | 44 | 1 |
| 17 | .32 | 7 | 5 | 2 | 1 | <1 | 30 | 20 | 10 | 50 | 47 | 3 |
| 17 | .18 | 8 | 6 | 2 | 2 | <1 | 30 | 30 | 0 | 54 | 52 | 2 |
| 17 | .29 | 6 | 3 | 3 | 6 | <1 | 30 | 30 | 0 | 36 | 34 | 2 |
| April 1982 | | | | | | | | | | | | |
| 28 | .60 | 5 | -- | -- | <20 | -- | 20 | -- | -- | 53 | -- | -- |
| 28 | .60 | 5 | -- | -- | <10 | -- | 20 | -- | -- | 80 | -- | -- |
| 28 | .90 | 5 | -- | -- | <10 | -- | 10 | -- | -- | 41 | -- | -- |
| 28 | .60 | 5 | -- | -- | <10 | -- | 20 | -- | -- | 53 | -- | -- |

Table 25.--Water-quality data for storm runoff in Blue River near St. John Avenue (station 11, fig. 1) for selected storms during 1981 and 1982--Continued

| Date | Phosphorus, dissolved (mg/L) | Arsenic, total | Arsenic, suspended total | Arsenic, dissolved | Cadmium, total recoverable | Cadmium, dissolved | Chromium, total recoverable | Chromium, suspended recoverable | Chromium, dissolved | Copper, total recoverable | Copper, suspended recoverable | Copper, dissolved |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| May 1982 | | | | | | | | | | | | |
| 12 | 0.60 | 4 | 1 | 3 | 5 | 10 | 10 | -- | <10 | 9 | 2 | 7 |
| 12 | .50 | 3 | 0 | 3 | 1 | <3 | 10 | -- | <10 | 17 | 11 | 6 |
| 12 | .50 | 3 | 0 | 3 | 2 | <3 | 10 | -- | <10 | 11 | 4 | 7 |
| 12 | .60 | 3 | 0 | 3 | 1 | <3 | 10 | -- | <10 | 14 | 7 | 7 |
| 12 | .80 | 4 | 1 | 3 | 1 | <3 | 10 | -- | <10 | 15 | 8 | 7 |
| 12 | .50 | 4 | 1 | 3 | 4 | 4 | 10 | -- | <10 | 28 | 20 | 8 |

| Date | Iron, total recoverable | Iron, suspended recoverable | Iron, dissolved | Lead, total recoverable | Lead, suspended recoverable | Lead, dissolved | Manganese, total recoverable | Manganese, suspended recoverable | Manganese, dissolved | Mercury, total recoverable | Mercury, suspended recoverable |
|---|---|---|---|---|---|---|---|---|---|---|---|
| July 1981 | | | | | | | | | | | |
| 25 | 37,000 | 37,000 | 26 | 82 | 76 | 6 | 1,500 | 1,500 | 3 | 0.2 | 0.2 |
| 27 | 40,000 | 40,000 | 110 | 79 | 73 | 6 | 1,200 | 1,200 | 2 | .2 | .2 |
| 27 | 46,000 | 46,000 | 73 | 170 | 170 | 3 | 1,700 | 1,700 | 18 | .3 | .3 |

Table 25.--Water-quality data for storm runoff in Blue River near St. John Avenue (station 11, fig. 1) for selected storms during 1981 and 1982--Continued

| Date | Iron, total recoverable | Iron, suspended recoverable | Iron, dissolved | Lead, total recoverable | Lead, suspended recoverable | Lead, dissolved | Manganese, total recoverable | Manganese, suspended recoverable | Manganese, dissolved | Mercury, total recoverable | Mercury, suspended recoverable |
|---|---|---|---|---|---|---|---|---|---|---|---|
| October 1981 | | | | | | | | | | | |
| 13 | 9,300 | 9,300 | 26 | 97 | 97 | 0 | 590 | 480 | 110 | 0.1 | 0.1 |
| 13 | 26,000 | 26,000 | 34 | 130 | 130 | 1 | 910 | 850 | 58 | .2 | .2 |
| 14 | 24,000 | 24,000 | 48 | 84 | 84 | 0 | 890 | 880 | 10 | .1 | .1 |
| 14 | 18,000 | 18,000 | 73 | 63 | 63 | 0 | 650 | 650 | 1 | .1 | .1 |
| 17 | 17,000 | 17,000 | 50 | 100 | 99 | 1 | 810 | 770 | 41 | .2 | .2 |
| 17 | 22,000 | 22,000 | 97 | 100 | 97 | 3 | 800 | 800 | 4 | .3 | .3 |
| 17 | 16,000 | 16,000 | 68 | 80 | 79 | 1 | 630 | 620 | 8 | .2 | .2 |
| April 1982 | | | | | | | | | | | |
| 28 | 13,000 | -- | -- | 140 | -- | -- | 970 | -- | -- | .2 | -- |
| 28 | 8,800 | -- | -- | 12 | -- | -- | 850 | -- | -- | .1 | -- |
| 28 | 6,400 | -- | -- | 110 | -- | -- | 880 | -- | -- | .1 | -- |
| 28 | 9,600 | -- | -- | 130 | -- | -- | 940 | -- | -- | .1 | -- |
| May | | | | | | | | | | | |
| 12 | 1,700 | 1,700 | 33 | 6 | 4 | 2 | 560 | 380 | 180 | .1 | -- |
| 12 | 1,100 | 1,100 | 9 | 12 | 11 | 1 | 540 | 350 | 190 | .2 | -- |
| 12 | 1,000 | -- | <9 | 12 | 11 | 1 | 530 | 340 | 190 | .1 | -- |
| 12 | 920 | -- | <9 | 18 | 17 | 1 | 550 | 200 | 350 | .2 | -- |
| 12 | 2,000 | -- | <9 | 64 | -- | <1 | 580 | 330 | 250 | .1 | -- |
| 12 | 4,700 | 4,700 | 17 | 36 | 35 | 1 | 670 | 580 | 88 | .1 | -- |

3/8"

Table 25.--Water-quality data for storm runoff in Blue River near St. John Avenue (station 11, fig. 1) for selected storms during 1981 and 1982--Continued

| Date | Mercury, dissolved | Selenium, total | Selemium, suspended total | Selenium, dissolved | Zinc, total recoverable | Zinc, suspended recoverable | Zinc, dissolved | Carbon, organic total (mg/L) | Sediment, suspended (mg/L) | Sediment, discharge suspended (tons/d) | Sediment, suspended, percent finer than 0.062 mm |
|---|---|---|---|---|---|---|---|---|---|---|---|
| July 1981 | | | | | | | | | | | |
| 25 | 0.0 | 0 | 0 | 0 | 230 | 210 | 20 | -- | 1,710 | 6,420 | 89 |
| 27 | .0 | 0 | 0 | 0 | 220 | 200 | 25 | 34 | 2,590 | 30,200 | 78 |
| 27 | .0 | 0 | 0 | 0 | 450 | 420 | 28 | 33 | 1,920 | 24,800 | 82 |
| October | | | | | | | | | | | |
| 13 | .0 | 0 | 0 | 0 | 280 | 250 | 33 | 19 | 297 | 930 | 56 |
| 13 | .0 | 0 | 0 | 0 | 290 | 260 | 27 | 43 | 1,270 | 5,900 | 77 |
| 14 | .0 | 0 | 0 | 0 | 210 | 180 | 27 | 33 | 1,150 | 5,030 | 85 |
| 14 | .0 | 0 | 0 | 0 | 190 | 170 | 25 | 25 | 872 | 2,310 | 86 |
| 17 | .0 | 1 | 1 | 0 | 310 | 270 | 42 | -- | 1,030 | 9,900 | 76 |
| 17 | .0 | 0 | 0 | 0 | 280 | 240 | 40 | 29 | 1,030 | 1,610 | 78 |
| 17 | .0 | 1 | 1 | 0 | 180 | 140 | 44 | 24 | 726 | 998 | 79 |
| April 1982 | | | | | | | | | | | |
| 28 | -- | 1 | -- | -- | 290 | -- | -- | -- | 812 | 1,180 | 40 |
| 28 | -- | 1 | -- | -- | 260 | -- | -- | -- | 587 | 897 | 58 |
| 28 | -- | 1 | -- | -- | 230 | -- | -- | -- | 361 | 611 | 54 |
| 28 | -- | 1 | -- | -- | 280 | -- | -- | -- | 355 | 693 | 48 |

5/16"

Table 25.--Water-quality data for storm runoff in Blue River near St. John Avenue (station 11, fig. 1) for selected storms during 1981 and 1982--Continued

| Date | Mercury, dissolved | Selenium, total | Selemium, suspended total | Selenium, dissolved | Zinc, total recoverable | Zinc, suspended recoverable | Zinc, dissolved | Carbon, organic total (mg/L) | Sediment, suspended (mg/L) | Sediment, discharge suspended (tons/d) | Sediment, suspended percent finer than 0.062 mm |
|---|---|---|---|---|---|---|---|---|---|---|---|
| May, 1982 | | | | | | | | | | | |
| 12 | <0.1 | <1 | -- | <1 | 70 | 40 | 32 | 11 | 29 | 42 | 4 |
| 12 | <.1 | <1 | -- | <1 | 60 | 30 | 27 | 7.3 | 17 | 25 | 30 |
| 12 | <.1 | 1 | -- | <1 | 60 | 0 | 72 | 7.6 | 7 | 11 | 52 |
| 12 | <.1 | <1 | -- | <1 | 60 | 40 | 24 | 6.9 | 4 | 6.7 | 42 |
| 12 | <.1 | 1 | -- | <1 | 60 | 40 | 21 | 6.7 | 56 | 106 | 62 |
| 12 | <.1 | <1 | -- | <1 | 100 | 80 | 19 | -- | 260 | 536 | 65 |