SURFACE-WATER HYDROLOGY OF THE LITTLE BLACK RIVER BASIN, MISSOURI AND ARKANSAS, BEFORE WATER-LAND IMPROVEMENT PRACTICES

By

Wayne R. Berkas, Suzanne R. Femmer, Thomas O. Mesko, and Bruce W. Thompson

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CONVERSION FACTORS

For readers who prefer to use metric (International System) units, conversion factors for inch-pound units used in this report are listed below:

Multiply inch-pound unit	By	To obtain metric unit
inch	25.40	millimeter
foot	0.3048	meter
mile	1.609	kilometer
square mile	2.590	square kilometer
	259.0	hectare
foot squared per day	0.9290	meter squared per day
cubic foot per second	0.02832	cubic meter per second
foot per mile	0.1894	meter per kilometer
gallon per minute	3.785	liter per minute
	0.003785	cubic meter per minute
gallons per day	3.785	liter per day
million gallons	3,785	cubic meter
million gallons per day	0.04381	cubic meter per second
acre	0.4047	hectare
ton	0.9072	metric ton
ton per square mile	0.003503	metric ton per hectare

Temperature in degree Celsius (°C) can be converted to degree Fahrenheit (°F) as follows: °F = 9/5 °C + 32.

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "Mean Sea Level of 1929."

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ABSTRACT

The U.S. Department of Agriculture, Soil Conservation Service, in accordance with Public Law 566, is implementing various types of water-land improvement practices in the Little Black River basin in southeastern Missouri. These practices are designed, in part, to decrease the suspended-sediment transport in the basin, decrease flood damage in the basin, and improve drainage in the agricultural area. The purpose of this report is to describe the surface-water hydrology in the basin before water-land improvement practices. The general features of the basin, such as geology, ground-water hydrology, soils, land use, water use, and precipitation are described; surface-water quantity, quality, and suspended-sediment discharge also are described.

Dolomitic rock, sand, clay, and loess are the surficial materials in the basin; dolomitic rock forms the bedrock, and granitic rock forms the basal unit. The aquifers are the Mississippi River valley alluvial aquifer, which can yield about 3,500 gallons per minute to properly constructed wells, and the Ozark and St. Francois aquifers, which can yield from about 30 to about 500 gallons per minute to properly constructed wells. Soils in the area have formed in loess and cherty residuum in the uplands or have formed in alluvial sediment in the lowlands. Forestry and agriculture are the main land uses. About 93 percent of the estimated 3 billion gallons per year of water used in the basin is for crop irrigation. The average monthly precipitation varies slightly throughout the year, with an average annual precipitation of about 47 inches.

Daily discharge data were collected at six stations. The smallest average monthly flows occurred from June to October. Estimates of low flows for the 2-, 5-, and 10-year recurrence intervals were made at the six stations. Estimates of flood magnitude and frequency were by made using statewide equations and were compared to the measured peak flows. At many locations, the flood peaks of December 3, 1982, exceeded the estimated peak flows for the 100-year recurrence interval.

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[1] U.S. Geological Survey
[2] U.S. Soil Conservation Service

Water-quality data were collected at seven stations. Specific-conductance values ranged from 50 to 400 microsiemens per centimeter at 25 °Celsius. Water temperatures ranged from 0.0 °Celsius in the winter to 33.5 °Celsius in the summer. pH values ranged from 6.4 to 8.5 units. Dissolved-oxygen concentrations ranged from 2.2 to 12.8 milligrams per liter. Total nitrogen concentrations ranged from 0.13 to 2.20 milligrams per liter as nitrogen, with organic nitrogen as the most abundant form. Phosphorus concentrations ranged from zero to 0.29 milligram per liter as phosphorus. Bacteria counts were largest during storm runoff in the basin; livestock waste was the significant contributor.

Suspended-sediment discharge data were collected at four stations. For the period from October 1, 1980, to September 30, 1984, the average annual suspended-sediment discharge ranged from 2,230 tons per year in the headwater areas to 27,800 tons per year at the most downstream station. The average annual suspended-sediment yield ranged from 59.6 to 85.9 tons per square mile.

1.0 INTRODUCTION

REPORT SUMMARIZES AVAILABLE HYDROLOGIC DATA

Hydrologic data collected before the completion of the U.S. Soil Conservation Service water-land improvement practices in the Little Black River basin are summarized for comparison with future data.

Public Law 566 authorizes the U.S. Department of Agriculture, Soil Conservation Service to implement various types of water-land improvement practices in the Little Black River basin, which has a drainage area of 386 square miles. The purposes of these practices are watershed protection, flood prevention, recreation, and drainage improvement. Watershed protection practices will be implemented on about 66,130 acres of forestland, 18,000 acres of pasture land, and 37,500 acres of cropland. Construction planned for the basin includes 24 floodwater-retarding structures, 1 multiple-purpose structure, and 85 miles of channel improvement. The construction is expected to be completed by 1995. The location of the study area, the floodwater-retarding structures, the multiple-purpose structure, and the areas of channel improvements are shown in figure 1.0-1.

The water-land improvement practices to be implemented in the basin are designed, in part, to decrease suspended-sediment transport in the streams, decrease flood damage, and to improve drainage in the agricultural areas. To determine if these practices are successful, the hydrology in the basin before the improvements needs to be appraised. This report contains a summary of the geohydrologic data, with special emphasis on the surface-water data, collected in the basin before the water-land improvements. The general features described include the geology, ground-water hydrology, soils, land use, water use, and precipitation in the basin. Surface-water quantity characteristics include descriptions of daily and average annual streamflow, low flow, and floodflow. The surface-water quality characteristics described include specific conductance, water temperature, pH, dissolved oxygen, nitrogen, phosphorus, and bacteria. The description of sediment characteristics includes suspended-sediment discharge from the basin.

Most of this report is based on data collected by the U.S. Geological Survey in cooperation with the U.S. Soil Conservation Service from August 1980 to September 1984.

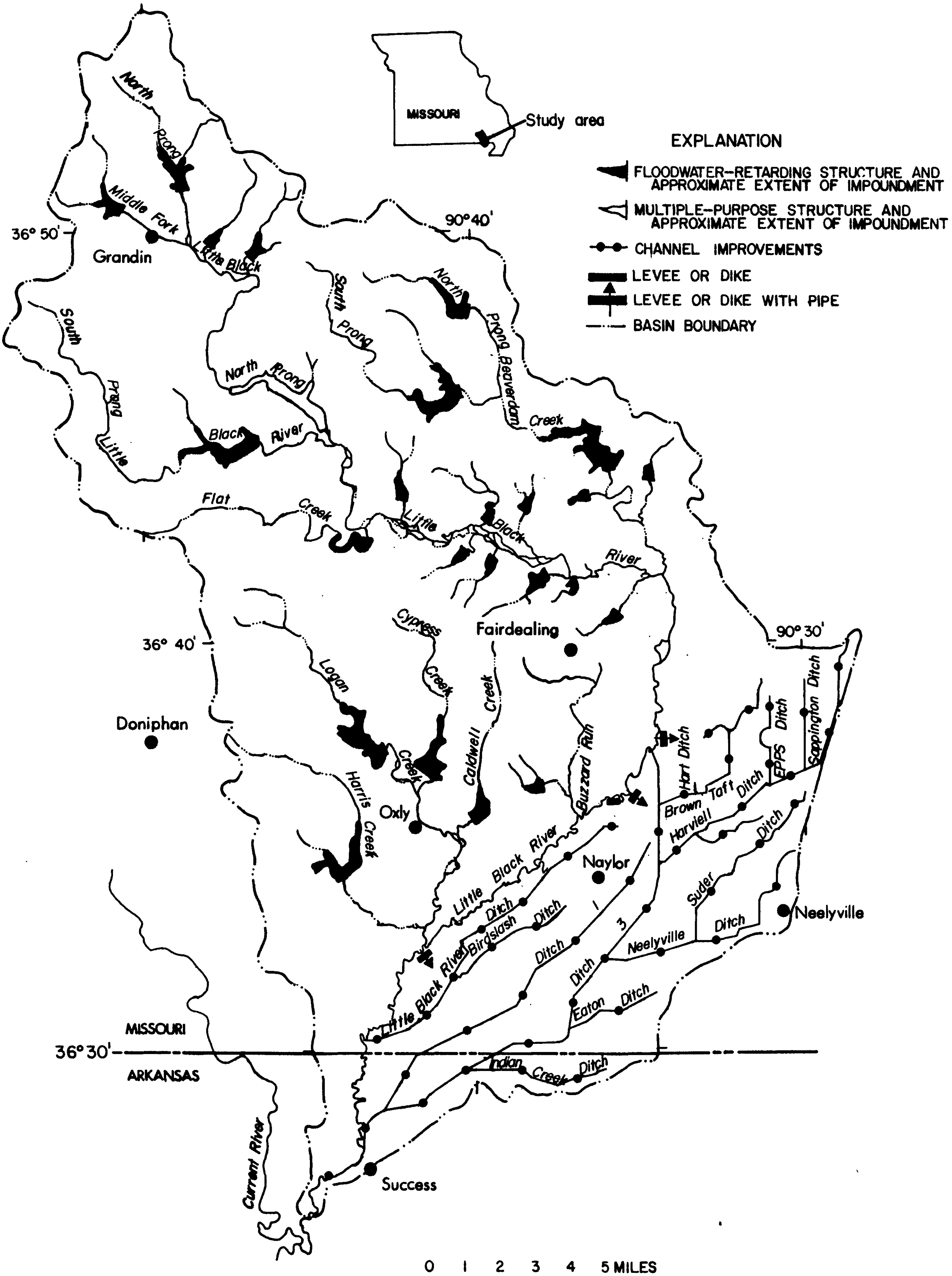


Figure 1.0-1.--Location of floodwater-retarding and multiple-purpose structures, and types of channel improvements planned for the Little Black River basin by the Soil Conservation Service (from U.S. Department of Agriculture, 1974a, 1974b).

2.0 GENERAL FEATURES

2.1 Geology and Physiography

QUATERNARY, ORDOVICIAN, AND CAMBRIAN SYSTEMS AND PRECAMBRIAN ROCKS ARE PRESENT IN THE BASIN

Dolomitic rock, sand, clay, and loess are the surficial materials in the basin; dolomitic rock forms the consolidated strata and granitic rock forms the regional basal unit.

Geologic systems and formations in the basin (fig. 2.1-1) are the Quaternary System (less than 1.8 million years old), which includes Holocene alluvium mixed with Pleistocene glacial outwash and loess; the Ordovician System (435 to 500 million years old), which includes the Jefferson City Dolomite, Roubidoux Formation, and Gasconade Dolomite in the Ozark aquifer; the Cambrian System (500 to 570 million years old), which includes formations in the St. Francois aquifer not discussed in this report; and the Precambrian rocks (more than 570 million years old; U.S. Geological Survey, 1984).

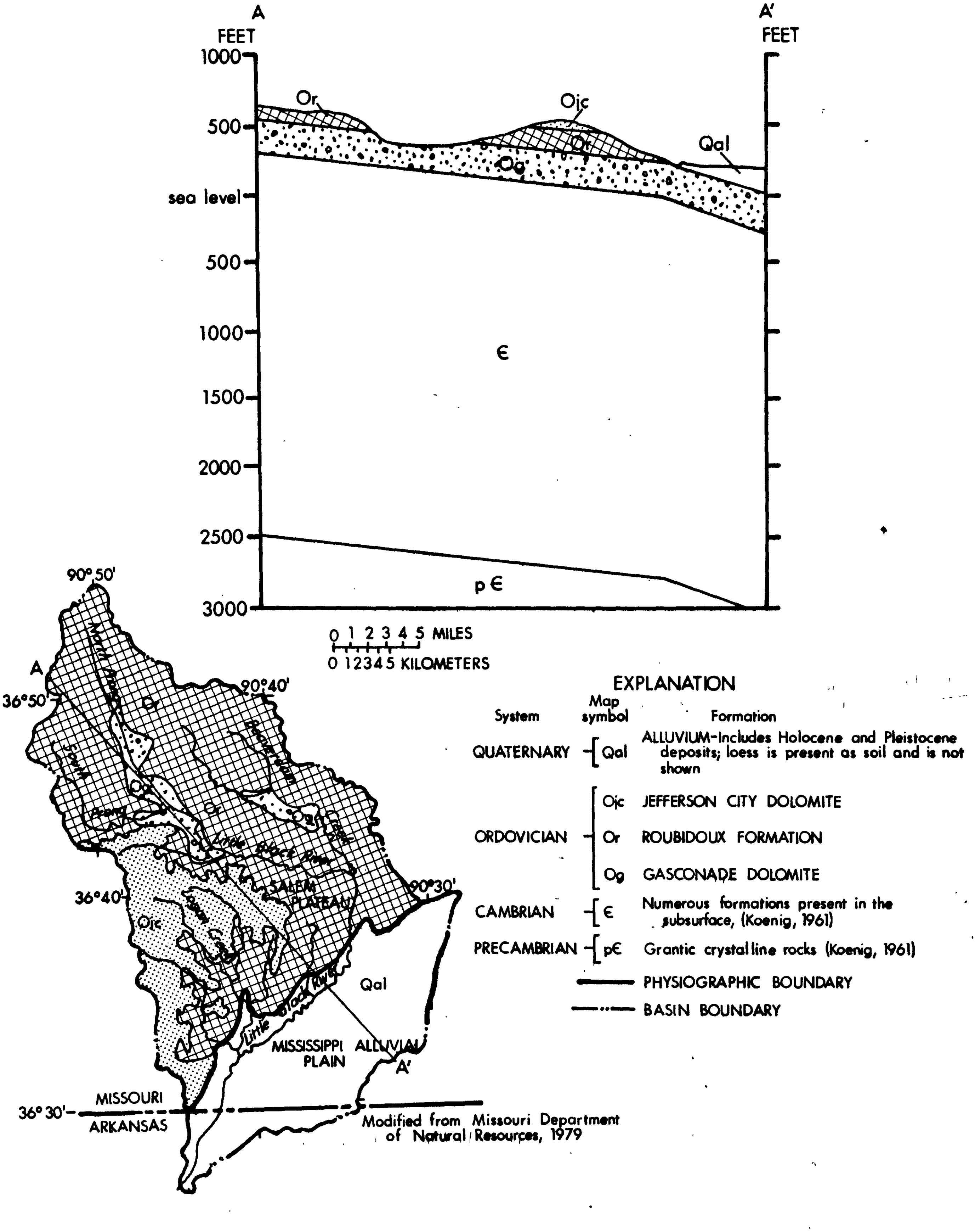
The Quaternary alluvium consists of Holocene sand, gravel, and clay that has been eroded from the upland bedrock areas and mixed with Pleistocene glacial material from sources outside the basin. These materials were deposited as sediment by area streams. The thickness of the alluvium in the basin ranges from 0 to 150 feet. Outside the basin to the east, the thickness may exceed 250 feet. Upland river valleys generally contain alluvial material eroded from streambanks; however, the thickness usually is minimal. Loess covers about 75 percent of the area. It consists of fine-grained wind-blown particles generally mixed with cherty residuum and forms the soil in upland areas.

Ordovician strata have been partly eroded throughout the basin. The youngest exposed strata from this system, the Jefferson City Dolomite, is found in hills and knobs. It is a dolomitic rock with interbedded chert. The formation generally is less than 50 feet thick and dips in a southeasterly direction. The Roubidoux Formation underlies the Jefferson City Dolomite and consists of sand, dolomitic sandstone, and cherty dolomite. The Roubidoux crops out throughout most of the basin, ranges in thickness from 0 to 350 feet, and dips to the south and southeast. The Gasconade Dolomite underlies the Roubidoux Formation and consists of cherty dolomite and a basal sandstone unit. The Gasconade Dolomite crops out along the Little Black River and Beaverdam Creek where the streams have eroded the overlying beds and exposed this formation. The Gasconade Dolomite may be more than 600 feet thick in the subsurface of the basin.

The Cambrian System does not crop out in the area. It is composed of numerous formations consisting of dolomite, sandstone, and shale. The system is estimated to be about 2,000 feet thick in the subsurface area of the basin. A description of the Cambrian System is given by Koenig (1961).

Precambrian rocks, described by Koenig (1961), are composed of granitic crystalline rocks. The estimated depth of this granitic "basement" is about 3,000 feet below land surface, and the total thickness of the unit is unknown.

The basin is located in two physiographic sections (Fenneman, 1938; fig. 2.1-1). The upland area is in the Salem Plateau section, which is a part of the Ozark Plateaus province, and the lowland area is in the Mississippi Alluvial Plain section of the Costal Plain province.



Modified from Missouri Department of Natural Resources, 1979

Figure 2.1-1.--Generalized geologic section and surficial geology.

2.2 Ground-water Hydrology

THREE PRINCIPAL AQUIFERS UNDERLIE THE LITTLE BLACK RIVER BASIN

Properly constructed wells completed in the Mississippi River valley alluvial aquifer can yield about 3,500 gallons per minute; properly constructed wells completed in the Ozark and St. Francois aquifers can yield from about 30 to about 500 gallons per minute.

The Mississippi River valley alluvial aquifer, the Ozark aquifer, and the St. Francois aquifer are the three principal aquifers underlying in the Little Black River basin. All seem to be hydraulically connected. The significant difference among the geologic units comprising the aquifers are lithology and hydraulic characteristics, such as yield, storage, and transmissivity. The basal unit in the area is Precambrian granitic rock that yields small quantities of water in areas of localized fractures. The water-table map (fig. 2.2-1) presents water-level data for all three aquifers. The topography in the basin controls the direction of shallow ground-water movement, and the direction of dip of the underlying strata controls the regional movement. Water-level altitudes indicate the maximum gradient is in the upland area and the minimum gradient is in the lowlands area.

The Mississippi River valley alluvial aquifer, which lies directly on the Ozark aquifer, is located in the lowlands and river valleys and is composed of unconsolidated gravel, sand, and clay that allow rapid movement and storage of large quantities of water. The total thickness of the aquifer is 150 feet or more in the basin and more than 250 feet east of the basin. Test data for wells completed in the alluvium outside the basin indicate values of transmissivity range from about 15,500 to about 50,000 feet squared per day. Recharge to the alluvium occurs from several sources. Precipitation falling on the outcrop area is the primary source of recharge, which averages about 45 inches per year in the lowlands area. A secondary source of recharge is from stream overflow during rainstorms or regional flooding. Impounded surface water also may infiltrate into the aquifer as recharge. The alluvium may be recharged by water from the underlying Ozark aquifer. Comparison of water-level data indicates that water levels are much higher in the outcrop areas of the Ozark aquifer than in the alluvial aquifer. The hydraulic-head differential may direct water upward into the alluvium.

The Ozark and St. Francois aquifers include the Cambrian and Ordovician rocks in the area (Imes, in press). The aquifers underlie all of the basin and are discussed as a single unit because they have similar water levels and seem to be hydraulically connected. Water moves through and is stored in fractures and solution cavities in the rocks. The total combined thickness of both aquifers may be more than 2,000 feet. Test data from wells outside the basin indicate that the calculated hydraulic conductivity is about 0.00001 ($1X10^{-5}$) feet per second (J.L. Imes, U.S. Geological Survey, oral commun., 1985). Well yields range from about 30 to about 500 gallons per minute. A value of transmissivity, calculated from an aquifer test outside of the basin, was 2,600 feet squared per day. The source of recharge to the Ozark and St. Francois aquifers is from precipitation falling on outcrop areas and infiltrating into the ground-water system.

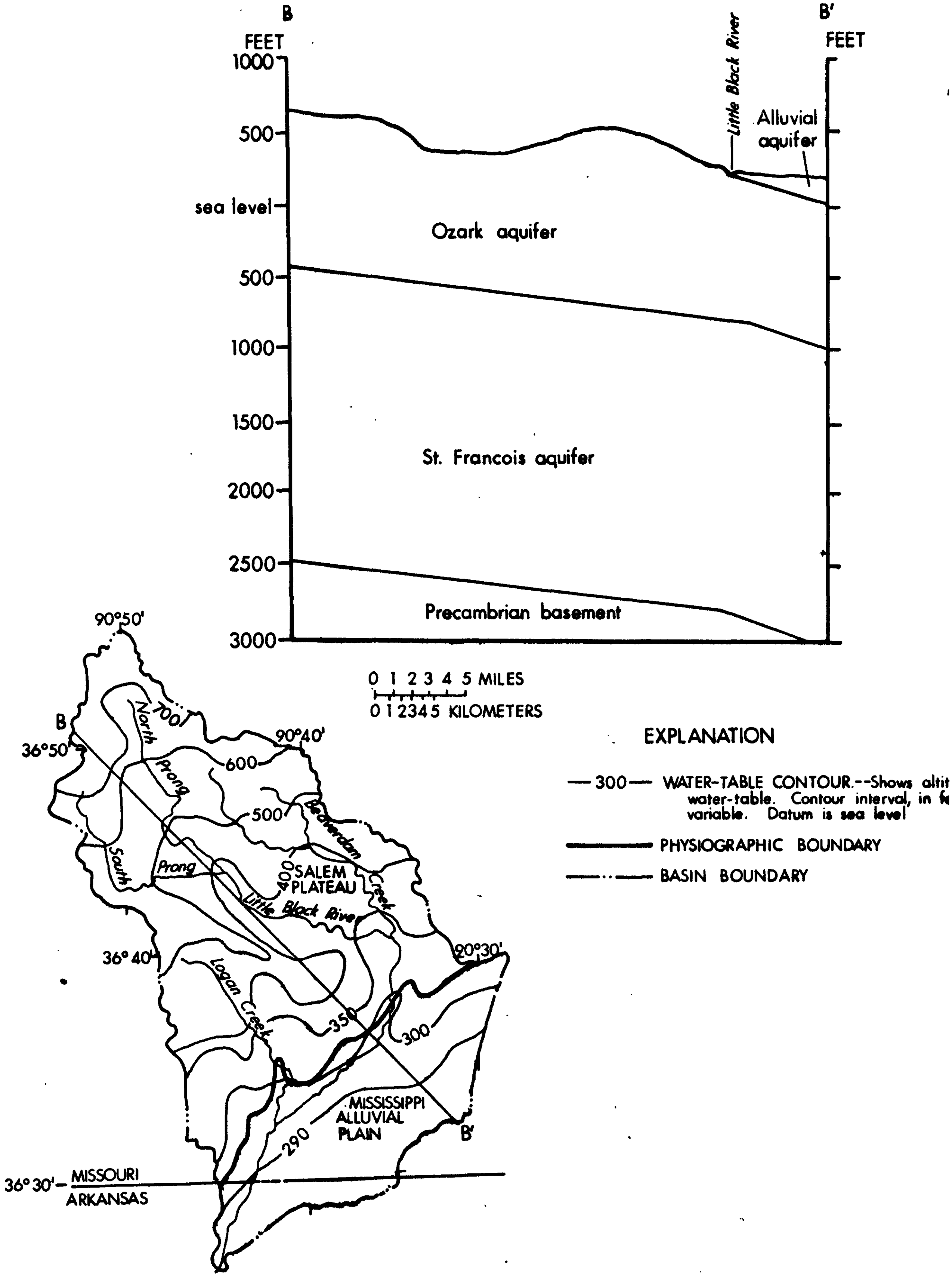


Figure 2.2-1.--Generalized geohydrologic section and water-table map.

2.3 Soils

SOILS IN THE SALEM PLATEAU AND MISSISSIPPI ALLUVIAL PLAIN ARE DISTINCTLY DIFFERENT

Soils in the Salem Plateau usually are well-drained and have formed in loess and cherty residuum; soils in the Mississippi Alluvial Plain usually are poorly drained and have formed in alluvial sediments.

Two distinct groups of soil associations are present in the Little Black River basin (fig. 2.3-1). The soils in the Salem Plateau are upland soils that have formed in loess and cherty residuum. The soils in the Mississippi Alluvial Plain are lowland soils that have formed in alluvial sediment.

The Captina-Clarksville-Macedonia soil association occurs in the northwestern part of the basin in the Salem Plateau. The soils in this association are moderately to steeply sloping, well drained, and have formed in loess and cherty residuum. They have a surface layer of silty loam and a subsoil of silt or silty clay loam. A cherty fragipan layer is about 17 to 30 inches from the land surface in the Captina soils. Chert is present throughout the Clarksville soil and in the subsoil of the Macedonia soil. This soil association occupies the ridge tops and side slopes in the basin.

The Clarksville-Captina soil association occurs in the northern part of the basin in the Salem Plateau. The soils in this association are moderately to steeply sloping, well drained, and have formed in loess over cherty residuum or in a mixture of loess and cherty residuum. They have a surface layer of silty loam and a subsoil that changes with depth from silty loam to clay. Chert is present throughout the Clarksville soil and in the subsoil of the Captina soil. This soil association occupies ridge tops and side and foot slopes.

The Loring-Captina-Clarksville soil association occurs in the central and north-central parts of the basin in the Salem Plateau. The soils in this association are moderately to steeply sloping, well drained, and have formed in loess over cherty residuum or in a mixture of loess and cherty residuum. They have a surface layer of silty loam and the subsoil is a silty clay loam. A fragipan is present in the Loring and Captina soils. Chert is present in the subsoil of the Captina soils and throughout the Clarksville soil. This association is on ridge tops and side and foot slopes.

The Calhoun-Amagon soil association occurs in the southeastern part of the basin in the Mississippi Alluvial Plain adjacent to the upland and on either side of the Little Black River. The nearly level, poorly drained soils were formed in silty alluvial sediment. They have a surface layer of silty loam and a subsoil of silty loam or silty clay loam.

The Tuckerman-Bosket soil association occurs in the southeastern part of the basin in the Mississippi Alluvial Plain. The soils in this association are nearly level to moderately sloping, poorly and well drained, and have formed in loamy alluvial sediment. The surface layer is a fine sandy loam and the subsoils are fine sandy loam and sandy clay loam. This association occupies low terraces and ridges of natural levees.

2.0 GENERAL FEATURES--Continued

2.3 Soils--Continued

The Wardell-Foley soil association occurs in the southern part of the basin in the Mississippi Alluvial Plain. The soils in the association are nearly level, poorly drained, and have formed in loamy alluvial sediment. The Wardell soil has a surface layer and subsoil of fine sandy loam, and the Foley soil has a surface layer and subsoil of silty loam. This association occupies the broad, flat natural levees and old flood plains.

The Bosket-Dexter-Beulah soil association occurs in the southern part of the basin in the Mississippi Alluvial Plain. The soils in the association are undulating, well drained, and have formed in loamy alluvial sediment. The surface layer is a fine sand-to-silt loam and the subsoil is a fine sand-to-clay loam. This soil association occupies the natural levees.

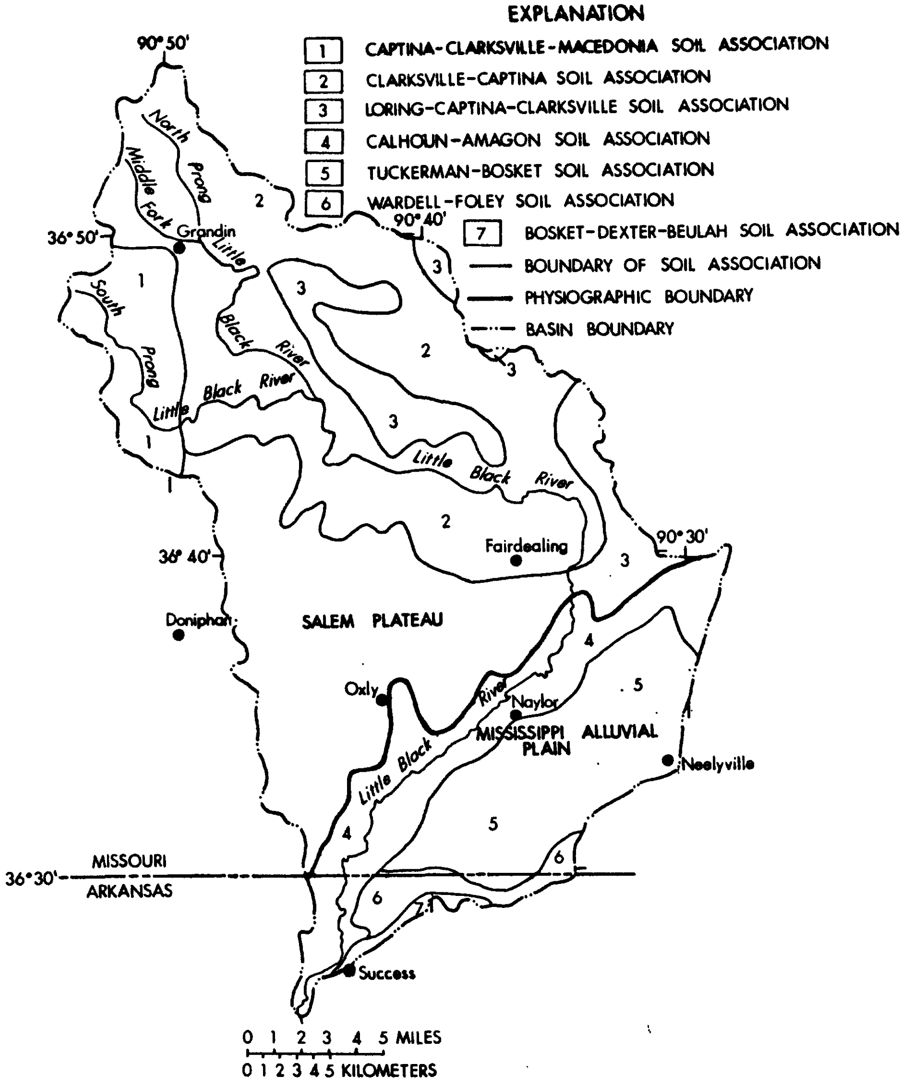


Figure 2.3-1--General soil map (modified from U.S. Department of Agriculture, 1985.)

2.4 Land Use

FORESTRY AND AGRICULTURE ARE THE PRINCIPAL LAND USES

In the Salem Plateau part of the basin, most of the land is covered by forests; in the Mississippi Alluvial Plain part of the basin, most of the land is used for row-crop agriculture.

The Little Black River basin consists of about 247,000 acres and is in two distinct physiographic sections, the Salem Plateau and the Mississippi Alluvial Plain. The Salem Plateau is mostly well-drained with moderately sloping-to-steep terrain. Timber production is a major economic activity in the Salem Plateau. The U.S. Forest Service manages timber on about 9,700 acres in the Little Black River basin. White oak, black oak, red oak, blackjack oak, post oak, hickory, shortleaf pine, and sweet gum are the principal native tree species. About 25 percent of the basin in the Salem Plateau has been cleared (fig. 2.4-1).

The cleared acreage primarily is used for pasture with small patches of wheat and row crops. The pasture areas are subject to overgrazing, which enhances erosion conditions. The remaining land is used for raising livestock, primarily pigs, and growing timber.

The part of the Little Black River basin in the Mississippi Alluvial Plain generally is poorly drained and has a high seasonal water table, which limits the land use. The land has a large potential for woodland growth, but water logging limits using the area for marketable forest products. Row-crop agriculture is the principal activity (fig. 2.4-1) and the principal crops are corn, cotton, grain-sorghum, rice, soybeans, and wheat. As shown by data for Arkansas, the acreage planted in grain-sorghum, rice, and wheat has increased substantially since 1969 (table 2.4-1), whereas the acreage planted in corn, cotton, and soybeans has decreased.

The Little Black River basin is sparsely populated with a few small towns of less than 500 people. Much of the land is unsuitable for building sites because of water logging, flooding, clay, soil, and cutbank instability. Water logging, flooding, and steep slopes make most sites impractical for sewage-lagoon construction.

Table 2.4-1.--Acreage of selected crops planted in Clay County, Arkansas

[1969 data from U.S. Department of Agriculture, 1978; 1984 data from Arkansas State Extension Office, oral commun., 1985]

Crop	Acreage 1969	 1984
Corn......................	5,567	3,534
Cotton....................	35,558	11,156
Grain-sorghum............	15,246	61,358
Rice......................	9,500	61,664
Soybeans..................	162,642	98,589
Wheat.....................	16,821	47,944

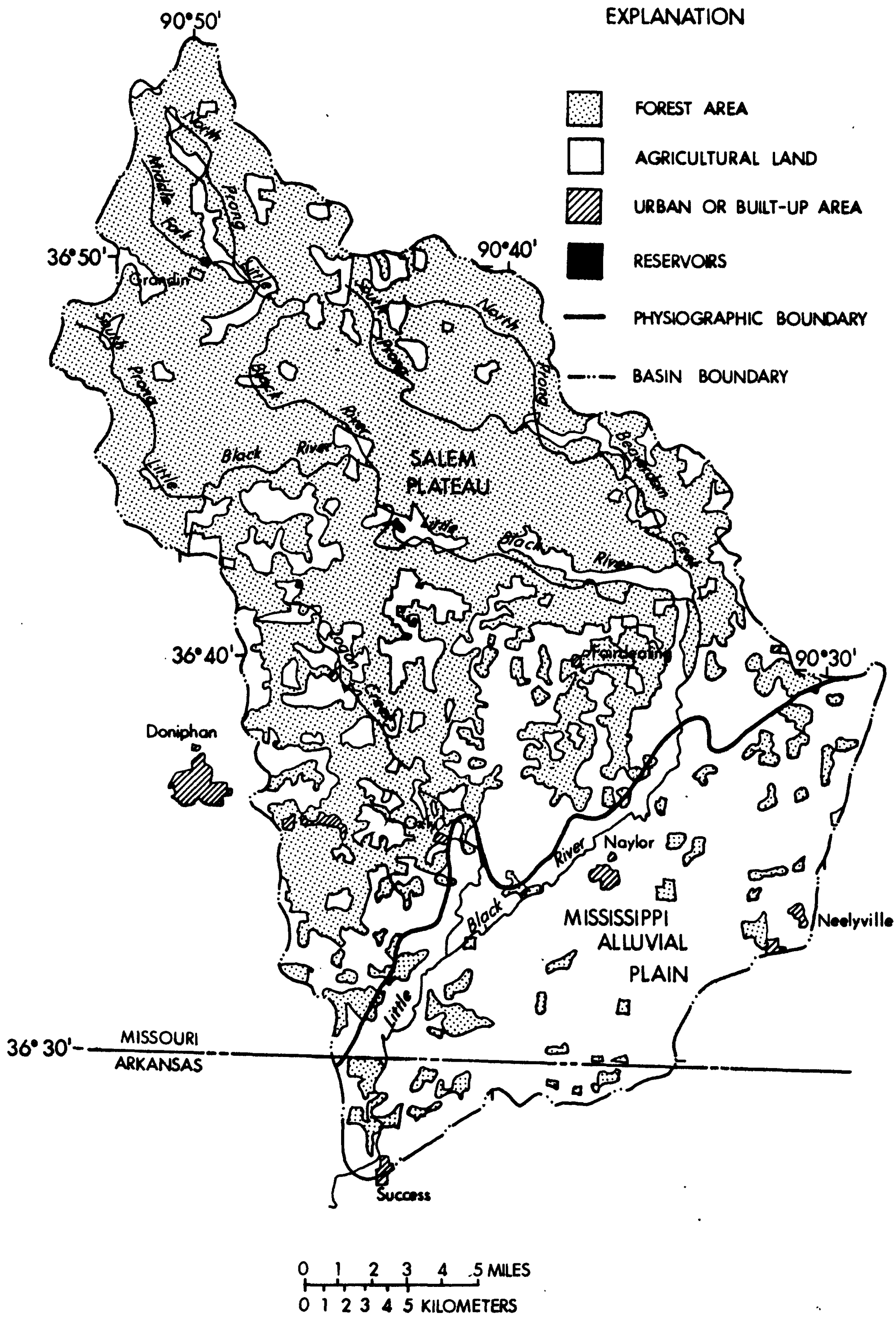


Figure 2.4-1.--Land use and land cover, 1976.

2.5 Water Use

ABOUT 93 PERCENT OF ALL WATER USED IN THE BASIN IS FOR CROP IRRIGATION

Irrigation during 1984 used about 2.8 billion gallons
of the estimated 3 billion gallons of water used in
the Little Black River basin.

Annual water use is estimated at 8.2 million gallons per day; the water primarily is obtained from ground-water sources. Of the water used in the basin 92.7 percent is used for irrigation, 5.7 percent for rural-domestic supplies, and 1.6 percent for public supplies in urban areas (fig. 2.5-1).

The largest quantity of water is used for irrigation, an average of 7.6 million gallons per day or a total of 2.8 billion gallons during 1984 (Missouri Division of Geology and Land Survey, written commun., 1984). Almost all water used for irrigation is withdrawn from ground-water sources. About 0.12 million gallons per day is diverted and pumped from a surface-water source, the Little Black River. The information on surface-water use is not accurate because the pumping sites are moved frequently.

Water for domestic use in rural areas is supplied by the Ripley County Public Water-Supply Districts 1 and 2 and individual sources. The water-supply districts provided an estimated 2,060 people in the basin with about 0.17 million gallons per day during 1984. Domestic water use by an estimated 5,000 people in the remainder of the basin was about 0.30 million gallons per day during 1984. This was determined by estimating the rural population and multiplying by 60 gallons per day per person (Donald Hammer, Missouri Division of Geology and Land Survey, oral commun., 1985). The total quantity of water used in rural areas during 1984 was about 0.47 million gallons per day or a total of 170 million gallons. Ground water is the source for the Ripley County Public Water-Supply Districts 1 and 2, and is assumed to be the primary source for individual domestic use.

There are four city-owned public-water suppliers in the Little Black River basin. During 1984, the city of Naylor, Mo., used 0.055 million gallons per day, the city of Grandin, Mo., used 0.033 million gallons per day, and the city of Neelyville, Mo., used 0.0343 million gallons per day (Missouri Department of Natural Resources, 1985). Success, Ark., used 0.012 million gallons per day (C.T. Bryant, U.S. Geological Survey, oral commun., 1985) for a total of 0.134 million gallons per day or a total of 49 million gallons per year of city-supplied water. All the cities pump from a total of five wells to supply about 1,540 people.

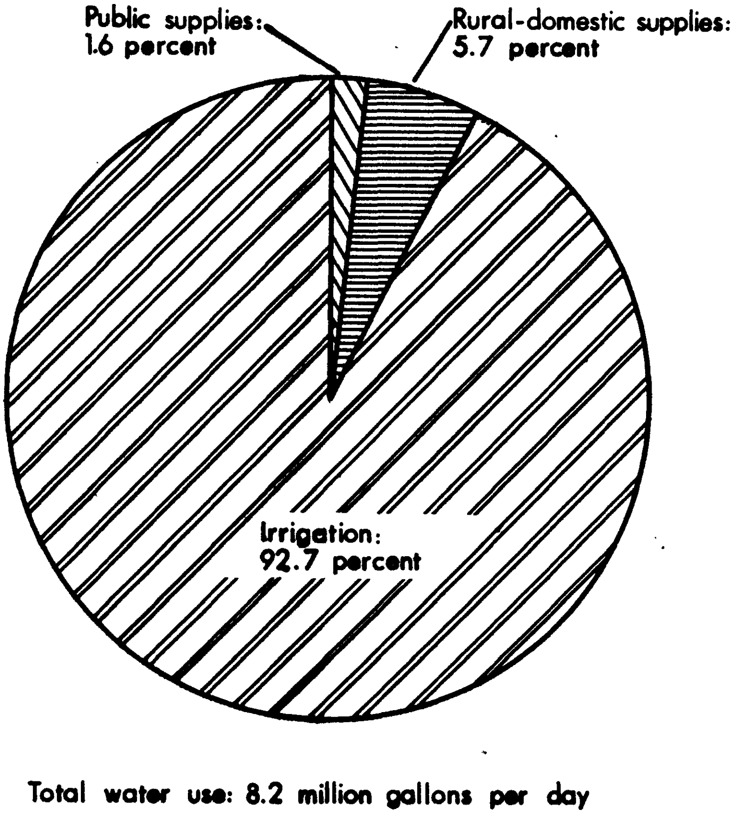


Figure 2.5-1.--Water use, 1984.

2.6 Precipitation

AVERAGE MONTHLY PRECIPITATION VARIES SLIGHTLY THROUGHOUT THE YEAR

Monthly precipitation was variable during 1980 through 1984.

At Doniphan, Mo., which is slightly west of the basin (fig. 1.0-1), the average annual precipitation is 47.08 inches (National Oceanic and Atmospheric Administration, 1984). Snow usually melts within 1 to 2 weeks. Monthly precipitation data for 1980 through 1984 are shown in figures 2.6-1 to 2.6-5. The average monthly precipitation data are shown in figure 2.6-6.

During 1980 to 1984 the least quantity of precipitation occurred during 1980 and 1981. Data for these 2 years also indicated the least variability between monthly precipitations. The largest quantity and variability of precipitation occurred during 1982 and 1983. For those months in 1982 and 1983 with large quantities of monthly precipitation, 1 or 2 storms contributed most of the precipitation in that month (National Oceanic and Atmospheric Administration, 1982 and 1983). During 1984 the precipitation was larger than average with some variability between months.

The average monthly precipitation varies slightly between months (fig. 2.6-6) with no wet or dry months. The monthly precipitation data from 1980 to 1984 also indicate that large variations in precipitation can occur in any month.

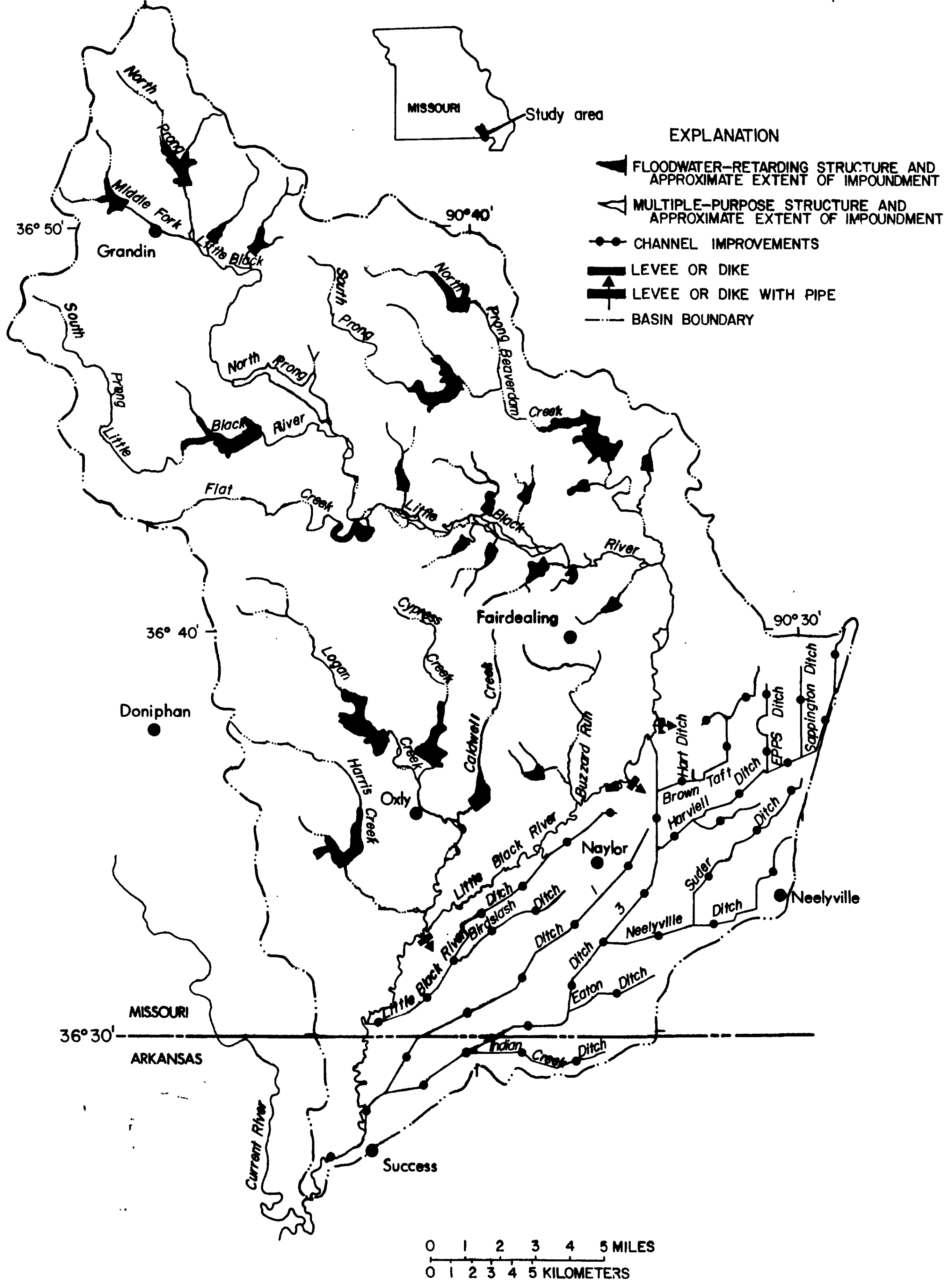


Figure 1.0-1.--Location of floodwater-retarding and multiple-purpose structures, and types of channel improvements planned for the Little Black River basin by the Soil Conservation Service (from U.S. Department of Agriculture, 1974a, 1974b).

3.0 SURFACE-WATER QUANTITY

3.1 Average Monthly and Annual Streamflow

STREAMFLOW VARIES SEASONALLY AND ANNUALLY

During 1980-84, the smallest average monthly flows occurred from June through November.

Six continuous-record streamflow-gaging stations were operated in the Little Black River basin during the study (fig. 3.1-1). Five stations were in the Salem Plateau and one station, Little Black River at Success, Ark. was in the Mississippi Alluvial Plain. The channel slope of the Little Black River in the Salem Plateau is fairly steep, but in the Mississippi Alluvial Plain the channel slope flattens (fig. 3.1-2). Generally, steeper slopes cause the stage of a river to rise and to recede more rapidly.

Average monthly and annual flows at the six streamflow-gaging stations in the basin were calculated for 1980-84 using daily records and are shown in figure 3.1-3. Large average flows occurred from December through May. In these months, soil moisture was plentiful, contributing to large base flows. When precipitation occurs in these months, the soil is almost saturated; therefore, only small quantities of water infiltrate into the soil and most of the water flows off the land into the streams. From June through November, the average flows were minimal; this is during the growing season and substantial quantities of soil moisture are lost to evaporation and transpiration. The precipitation data presented in section 2.6 indicate that during 1980-84 precipitation from June through November was only slightly less than the precipitation in other months.

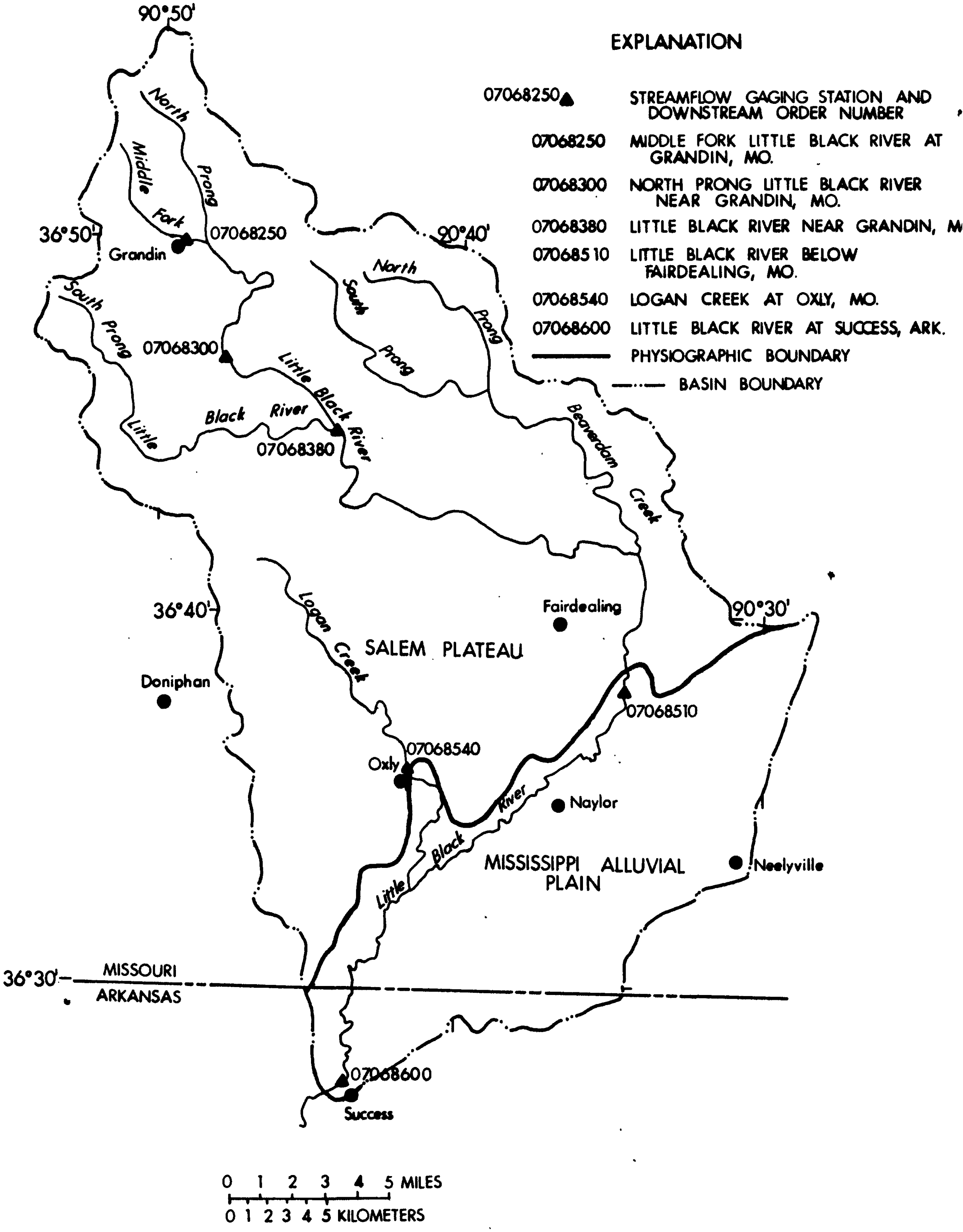


Figure 3.1-1.--Location of streamflow-gaging stations.

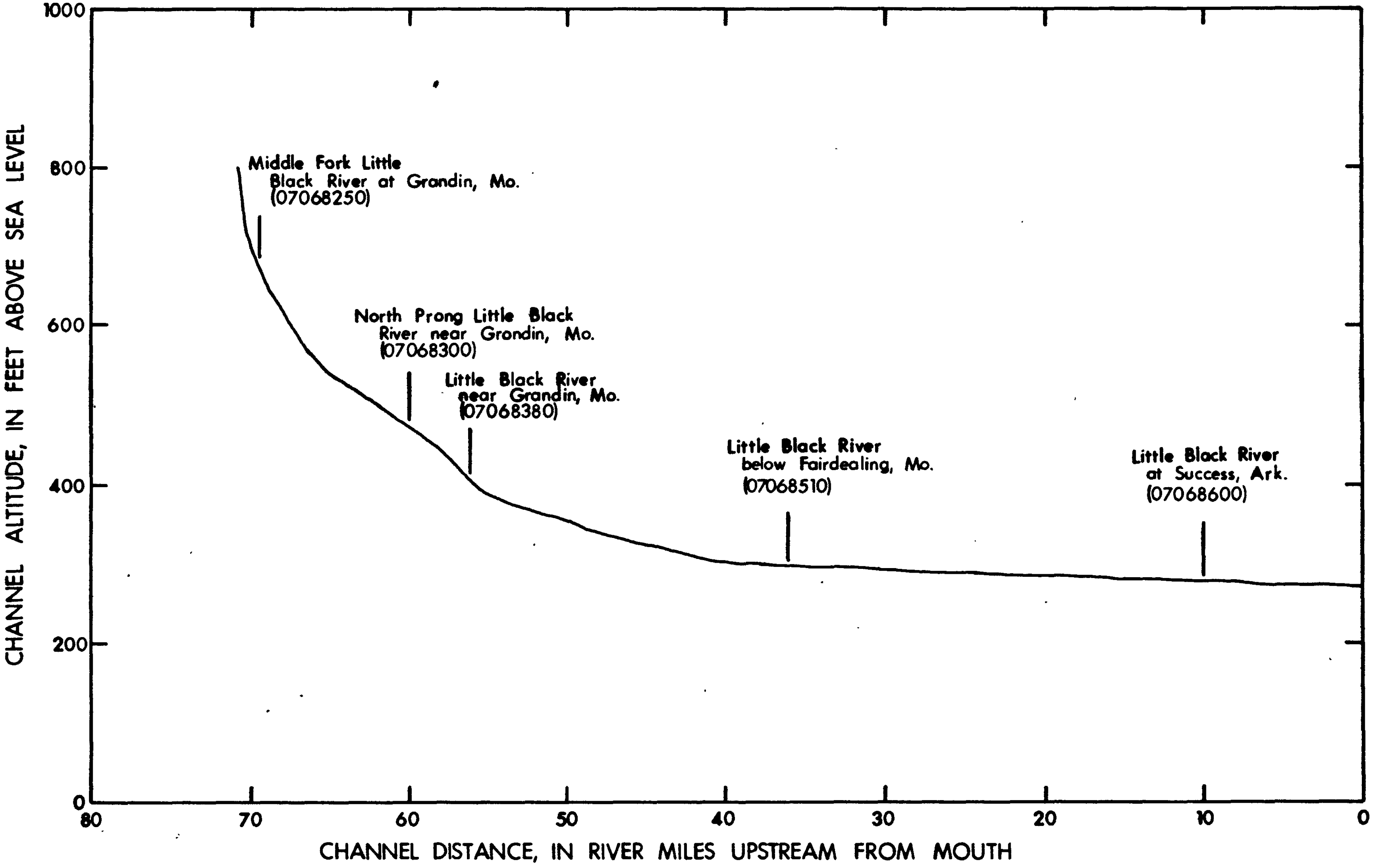


Figure 3.1-2.--Channel slope of the Little Black River.

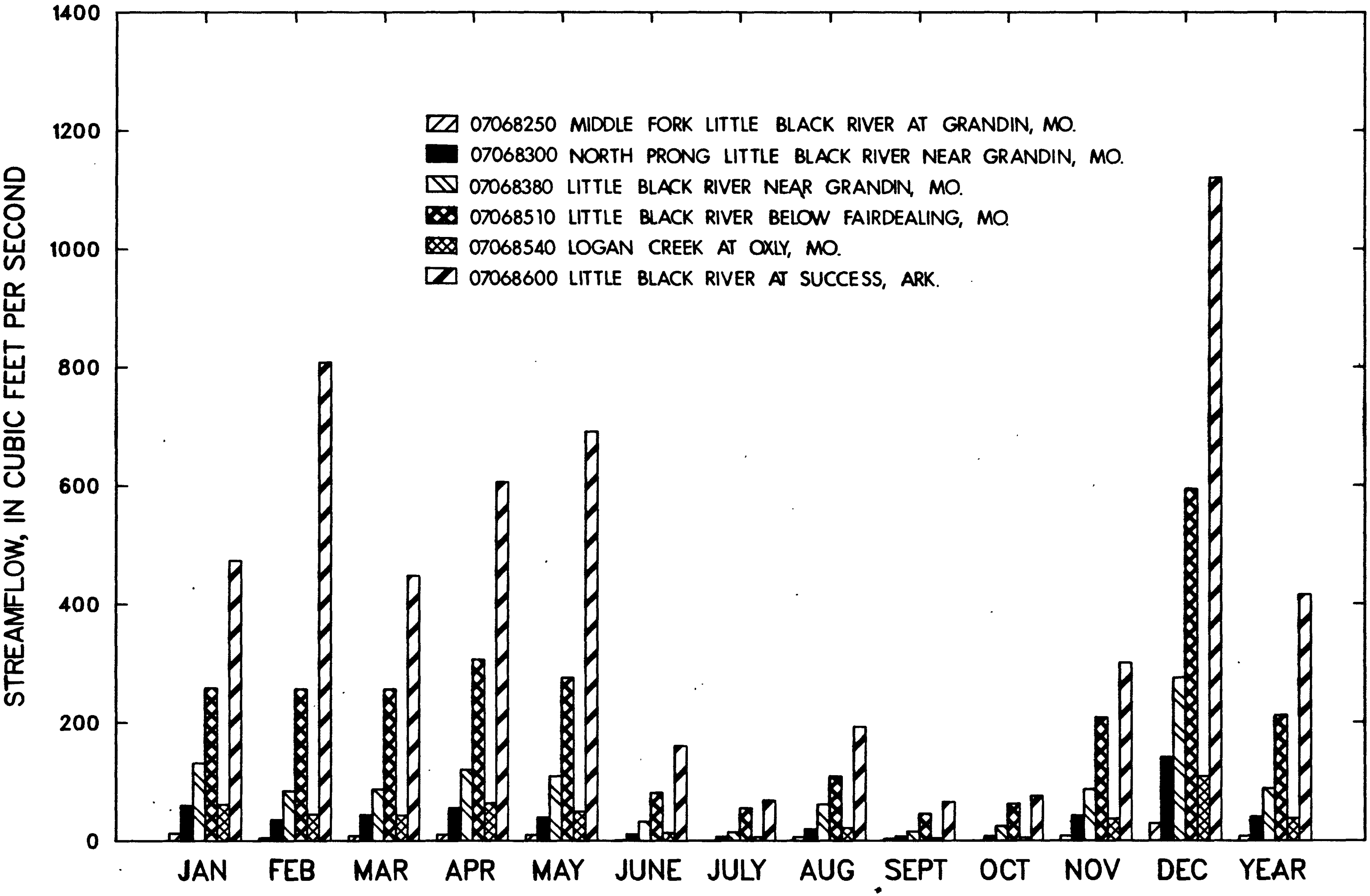


Figure 3.1-3.--Average monthly and annual streamflow at six streamflow-gaging stations, 1980-84.

3.0 SURFACE-WATER QUANTITY--Continued

3.2 Low flow

LOW FLOWS NORMALLY ARE WELL-SUSTAINED BY GROUND-WATER INFLOW

Seepage-run data indicate that the Little Black River is a gaining stream, except in most of the Mississippi Alluvial Plain.

Low-flow frequency data were computed for streams that have continuous-record streamflow-gaging stations (table 3.2-1) by using methods described by Riggs (1972). Data from October 1980 to September 1984 were used in the computations. Except at the Middle Fork Little Black River at Grandin, Mo., low flows were well-sustained by ground-water inflow.

In late summer 1980, the flow of the Little Black River at Success, Ark. was determined to be substantially less than upstream at Fairdealing. To determine where the flow in the Little Black River was being lost, a seepage run was made on August 12, 1980 (fig. 3.2-1). A seepage run is a series of discharge measurements along a stream reach made in a short time to identify where gains or losses occur. Extensive pumpage for rice and row-crop irrigation from shallow alluvial wells and, in some cases, directly from the streams in the Mississippi Alluvial Plain caused a significant decrease in streamflow downstream from Fairdealing. In this reach of the stream, the flow decreased about 62 percent.

The Little Black River generally is a well-sustained, gaining stream in the Salem Plateau. The seepage-run data indicate that water is lost when the stream flows into the Mississippi Alluvial Plain, and irrigation pumpage from the river probably is responsible for most of the loss.

Table 3.2-1.--Annual 7-day low flows, in cubic feet per second, at six streamflow-gaging stations, based on record from October, 1980 to September, 1984

Station number (fig. 3.1-1)	Station name	Drainage area, in square miles	Annual 7-day low-flow for indicated recurrence interval, in years	
			2	10
07068250	Middle Fork Little Black River at Grandin, Mo.	6.85	0.0	0.0
07068300	North Prong Little Black River near Grandin, Mo.	39.40	1.6	.9
07068380	Little Black River near Grandin, Mo.	79.50	6.1	3.3
07068510	Little Black River below Fairdealing, Mo.	194.00	23	14
07068540	Logan Creek at Oxly, Mo.	37.50	2.6	2.1
07068600	Little Black River at Success, Ark.[1]	386.00	--	--

[1] Irrigation pumpage from the river is not consistent every year; frequency computations are not feasible.

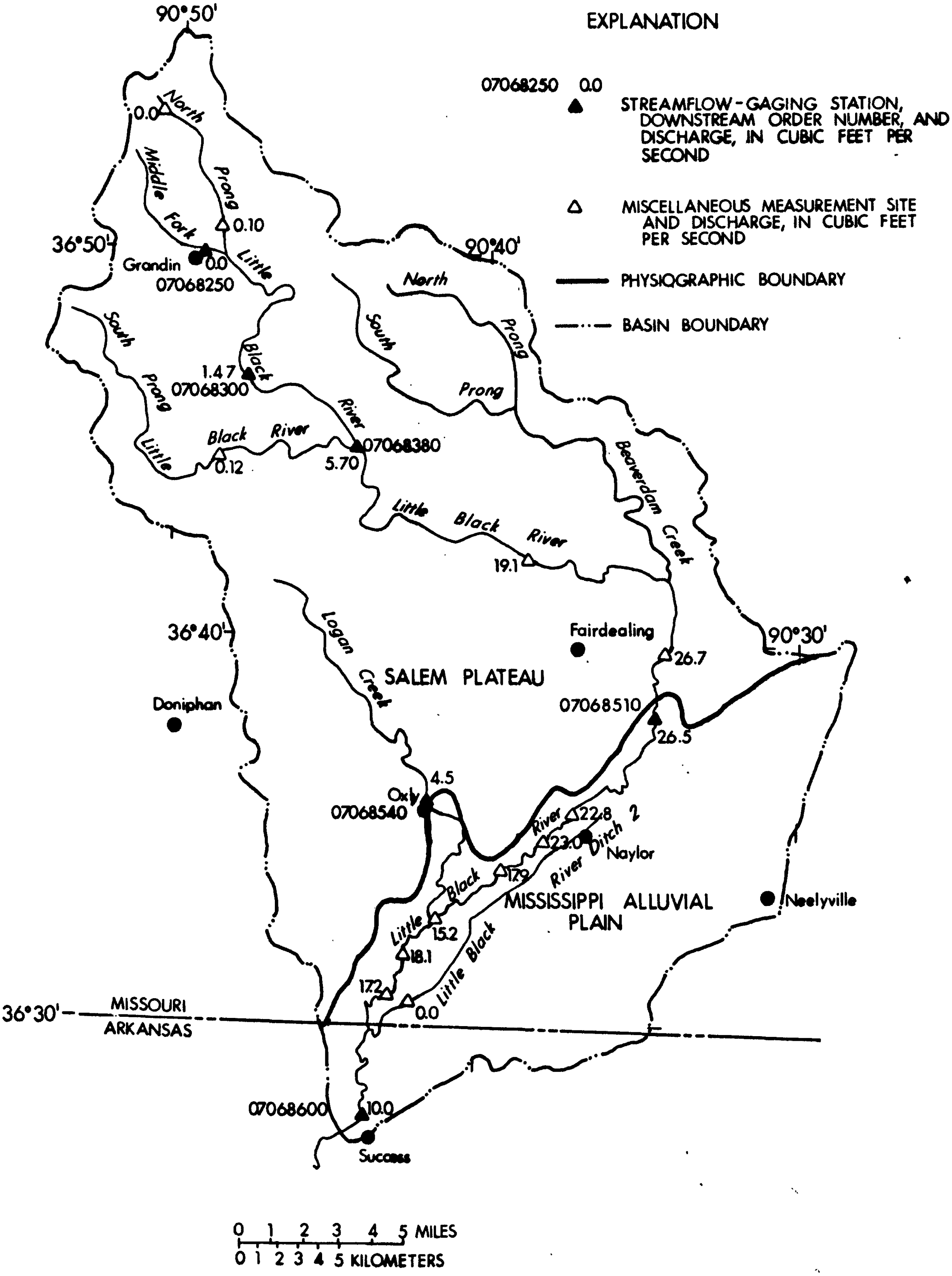


Figure 3.2-1.--Results of seepage run, August 12, 1980.

3.3 Floodflow

STATEWIDE FLOOD-MAGNITUDE AND FLOOD-FREQUENCY EQUATIONS ARE ADEQUATE FOR ESTIMATING THE MAGNITUDE AND FREQUENCY OF FLOODS IN THE LITTLE BLACK RIVER BASIN

Flood peaks in early December 1982 were larger than the estimated 100-year flood throughout most of the basin.

Estimates of flood magnitude and frequency at streamflow-gaging stations in the Little Black River basin are listed in table 3.3-1. These estimates were determined by using flood magnitude and flood-frequency equations derived by Hauth (1974). Because few peak-discharge data are available in the basin, the estimates are considered more accurate than those obtained from a log-Pearson analysis (U.S. Water Resources Council, 1981) of the peak-flow data for each station.

Hauth's (1974) equations were derived by using data from the entire State. Because the State consists of several different physiographic areas that have different floodflow characteristics, the accuracy of Hauth's (1974) equations in the Little Black River basin had to be determined. An analysis of flood-magnitude and frequency data collected within 100 miles of the Little Black River basin indicated that Hauth's (1974) equations were applicable without modification.

Selected peak discharges in the basin and their estimated recurrence intervals are listed in table 3.3-2. Recurrence interval was estimated by comparison with the data in table 3.3-1. Four of the stations recorded one peak discharge in early December 1982 that was larger than the estimated 100-year flood.

Table 3.3-1.--Estimated magnitude and frequency of floods at six streamflow-gaging stations

[Data from Hauth, 1974]

Station number (fig. 3.1-1)	Station name	Drainage area, in square miles	Slope, in feet per mile	Magnitude of floods, in cubic feet per second, for indicated recurrence interval in years			
				10	25	50	100
07068250	Middle Fork Little Black River at Grandin, Mo.	6.85	130	4,120	5,700	6,770	7,920
07068300	North Prong Little Black River near Grandin, Mo.	39.4	24.2	7,300	9,710	11,200	12,900
07068380	Little Black River near Grandin, Mo.	79.5	18.7	11,000	14,600	16,800	19,400
07068510	Little Black River below Fairdealing, Mo.	194	9.28	15,000	19,700	22,400	25,700
07068540	Logan Creek at Oxly, Mo.	37.5	22.0	6,700	8,870	10,200	11,800
07068600	Little Black River at Success, Ark.	386	4.72	(1)	(1)	(1)	(1)

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[1] Peak-flow frequency data not computed because of backwater effects from the Current River.

Table 3.3-2.--Selected peak discharges and their estimated frequency at six streamflow-gaging stations

[>, greater than; <, less than]

Station number (fig. 3.1-1)	Station name	Date	Discharge, in cubic feet per second	Estimated recurrence interval,[1] in years
07068250	Middle Fork Little Black River at Grandin, Mo.	8-15-82	4,220	>10, <25
		12-03-82	6,080	>25, <50
		12-24-82	3,800	>5, <10
07068300	North Prong Little Black River near Grandin, Mo.	8-16-82	8,940	>10, <25
		12-03-82	31,800	>100
		12-24-82	9,060	>10, <25
07068380	Little Black River near Grandin, Mo.	1-31-82	12,300	>10, <25
		8-16-82	16,000	>25, <50
		12-03-82	41,800	>100
		12-24-82	17,800	>50, <100
07068510	Little Black River below Fairdealing, Mo.	1-31-82	14,100	>5, <10
		12-03-82	54,200	>100
		12-24-82	16,800	>10, <25
07068540	Logan Creek at Oxly, Mo.	1-31-82	5,280	>5, <10
		8-16-82	6,760	>10, <25
		12-03-82	15,200	>100
		12-24-82	6,250	>5, <10
07068600	Little Black River at Success, Ark.	(2)	(2)	(2)

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[1] Recurrence intervals were determined using equations developed by Hauth, 1974.

[2] Peak-flow discharge and frequency data not computed because of backwater effects from the Current River.

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4.0 SURFACE-WATER QUALITY

4.1 Water-Quality-Sampling Stations

SEVEN STATIONS WERE ESTABLISHED FOR COLLECTION OF WATER-QUALITY DATA

Water-quality data collected bimonthly included
13 properties and constituents.

Water-quality data for streams were collected bimonthly at 6 of 7 stations, and water-temperature data were collected hourly at 5 of 7 stations in the Little Black River basin (fig. 4.1-1). The properties and constituents sampled were specific conductance, water temperature, pH, dissolved oxygen, total nitrogen, organic nitrogen, ammonia, nitrite, nitrate, total phosphorus, orthophosphate, fecal-coliform bacteria, and fecal-streptococci bacteria. These are described in the following sections. The concentration of some of the constituents is compared to that for data collected by the U.S. Geological Survey from adjacent areas. All data are published in annual water-data reports for Missouri (U.S. Geological Survey, published annually).

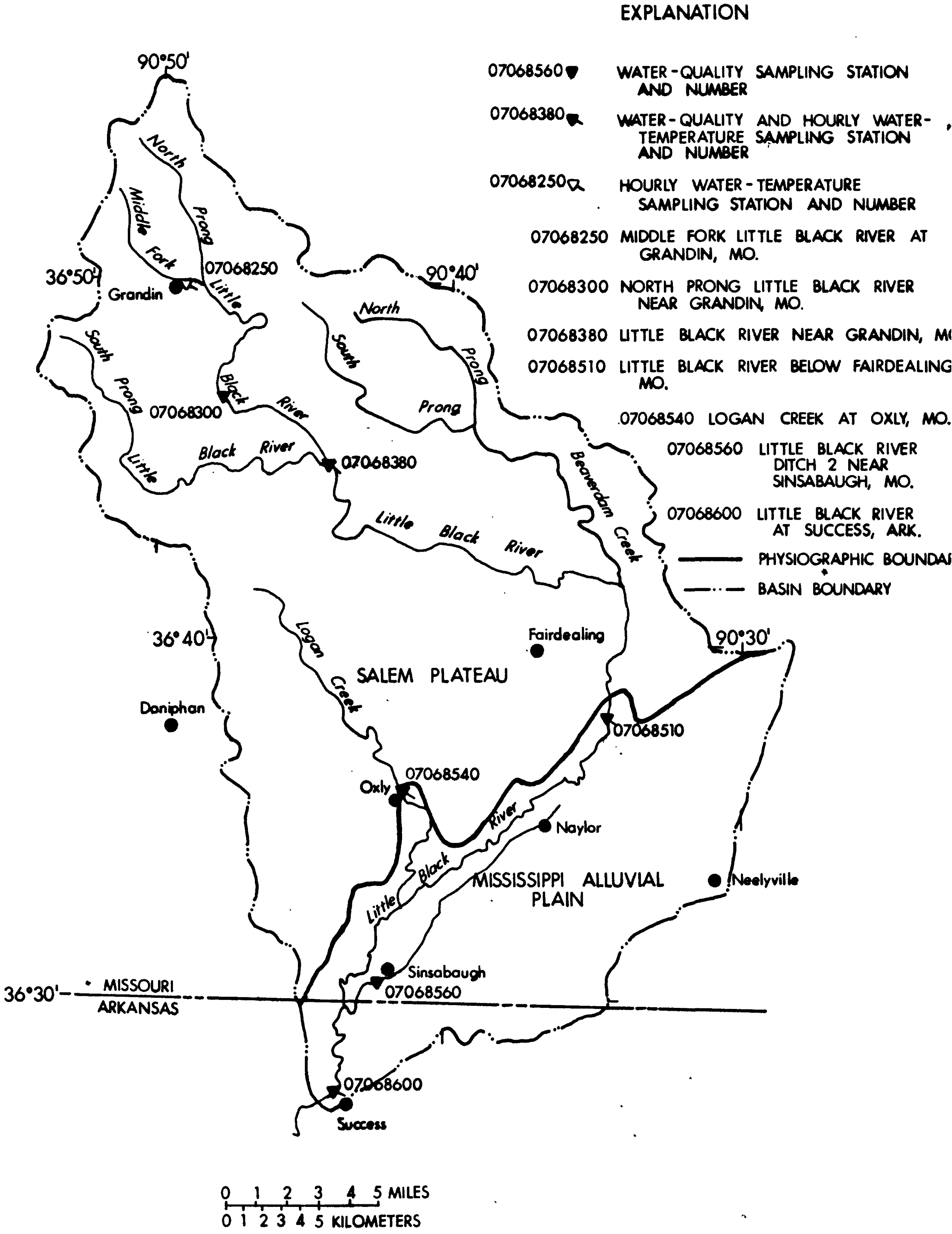

Figure 4.1-1.--Location of water-quality-sampling stations.

4.2 Specific conductance

SPECIFIC-CONDUCTANCE VALUES WERE LARGEST DURING LOW FLOWS

Specific-conductance values ranged from 50 to 400 microsiemens per centimeter at 25 °Celsius, which is slightly less than those from surrounding areas.

Specific conductance of water is a measurement of the capacity of water to conduct an electrical current. The presence of charged ions makes the water conductive. As the ionic concentration increases, the specific conductance increases. Therefore, the specific conductance is an indicator of the ionic concentrations of water.

The ionic concentration increases in water as the water comes in contact with chemical compounds that are soluble in water. When precipitation falls, it has had minimal contact with soluble compounds, so the specific-conductance value is low. Typically, specific conductance of precipitation ranges from 5.0 to 30 microsiemens per centimeter at 25 °Celsius (Davis and DeWiest, 1966). As the precipitation infiltrates into the soil and percolates to the ground-water system, it comes into contact with more soluble chemicals. The longer the water is in the ground-water system, the larger the specific-conductance value. The specific conductance of stream water is dependent upon the source of the water. During storm runoff, the specific conductance in a stream typically is small because most of the water comes from precipitation that has drained directly from land into the stream. During low flow, specific-conductance values are larger because most of the flow is from ground water seeping into the stream.

Specific-conductance values for surface water measured in the Little Black River basin ranged from 50 to 400 microsiemens per centimeter at 25 °Celsius (table 4.2-1). The smallest specific-conductance values were measured during high flows. The smallest median specific-conductance values were measured at the North Prong Little Black River near Grandin, Mo., and at the Little Black River ditch 2 near Sinsabaugh, Mo. The North Prong Little Black River near Grandin, Mo., is in the headwater area of the basin where most of the flow is overland runoff or water with minimal ground-water residence time. The Little Black River ditch 2 near Sinsabaugh, Mo., drains agricultural land. Water in the ditch comes from overland runoff or from precipitation that has percolated through the soil to the water table and drained into the ditch. At both stations the residence time of the water in the ground-water system is minimal, resulting in small specific-conductance values. At the other stations, water seeping into the streams has been in the ground-water system much longer causing the specific-conductance values to be larger.

The U.S. Geological Survey has collected specific-conductance data outside the Little Black River basin at various stream locations in the Salem Plateau and the Mississippi Alluvial Plain. The specific-conductance values measured in both physiographic sections were similar, and the median specific-conductance values ranged from 185 to 516 microsiemens per centimeter at 25 °Celsius. The median values of the data collected in the Little Black River basin (table 4.2-1) were within the lower one-half of the range of median values measured in adjacent areas.

Table 4.2-1.--Specific-conductance values at six water-quality-sampling stations, August 1980 to September 1984

Station number (fig. 4.1-1)	Station name	Specific conductance, in microsiemens per centimeter at 25 °Celsius				Number of samples
		Maximum	Minimum	Mean	Median	
07068300	North Prong Little Black River near Grandin, Mo.	240	68	152	150	26
07068380	Little Black River near Grandin, Mo.	330	50	205	202	26
07068510	Little Black River below Fairdealing, Mo.	365	50	226	250	25
07068540	Logan Creek at Oxly, Mo.	375	85	237	255	25
07068560	Little Black River ditch 2 near Sinsabaugh, Mo.	250	70	145	115	10
07068600	Little Black River at Success, Ark.	400	70	228	242	24

4.3 Water Temperature

CLIMATE IS THE PRIMARY FACTOR AFFECTING SURFACE-WATER TEMPERATURE

Surface-water temperature is affected by fluctuating daily air temperature, precipitation, radiation heat, and ground water.

Water temperature has a direct effect on the use of surface water, including the quality of water for domestic supplies, fish culture, waste assimilation, and industrial and agricultural uses. Water temperature affects nearly every physical property of surface water, and it is a significant factor in most chemical reactions and all biological activity in the aquatic community. Generally, the rate of chemical reactions is doubled for each 10-°Celsius rise in temperature, and data also indicate that toxicity of organic compounds and trace metals increases with increased temperature (Stevens and others, 1975).

The principal physical properties that affect water quality include density, specific heat, visosity, vapor pressure, gas solubility, and gas diffusibility (Stevens and others, 1975). These properties, along with temperature, affect stratification, evaporation, velocity of settling particles, and the concentration and rate of replacement of dissolved oxygen. Water viscosity and density are inversely proportional to the velocity of settling particles. Because both of these properties cause increased settling rates at higher water temperatures, a difference in water temperature can affect the location and quantity of sediment and sludge deposits in slow-flowing rivers and streams. For agricultural use, extremely high or low irrigation-water temperature may affect crop growth and yields. The return of irrigation water can increase the water temperature of the receiving body of water.

Climate is the primary factor affecting temperatures of Missouri streams. Through natural changes in climate, the temperature of water will fluctuate daily as well as seasonally. Unshaded streams, such as the Little Black River at Success, Ark., show the effect of radiation heating, especially during summer months. These streams usually have water temperatures higher than the mean air temperature in the area (fig. 4.3-1). Further upstream at the Little Black River near Grandin, Mo., where the river channel is well shaded, a large difference is not apparent between the water and air temperature during the summer, which indicates less radiation heat effect and the effect on water temperature from the ground-water inflow. Data from selected streamflow-gaging stations in the Little Black River basin indicate large seasonal fluctuations (fig. 4.3-1), which indicates that climatic changes, such as air temperature and precipitation, are the primary contributors to water-temperature variations.

Water temperatures were measured hourly at five water-quality-sampling stations in the Little Black River basin. The mean monthly water temperature and the maximum and minimum measured temperatures for each month for the period of data collection are shown in figure 4.3-2. The mean water temperature at the most downstream station, the Little Black River at Success, Ark., usually was higher than that at the upstream stations.

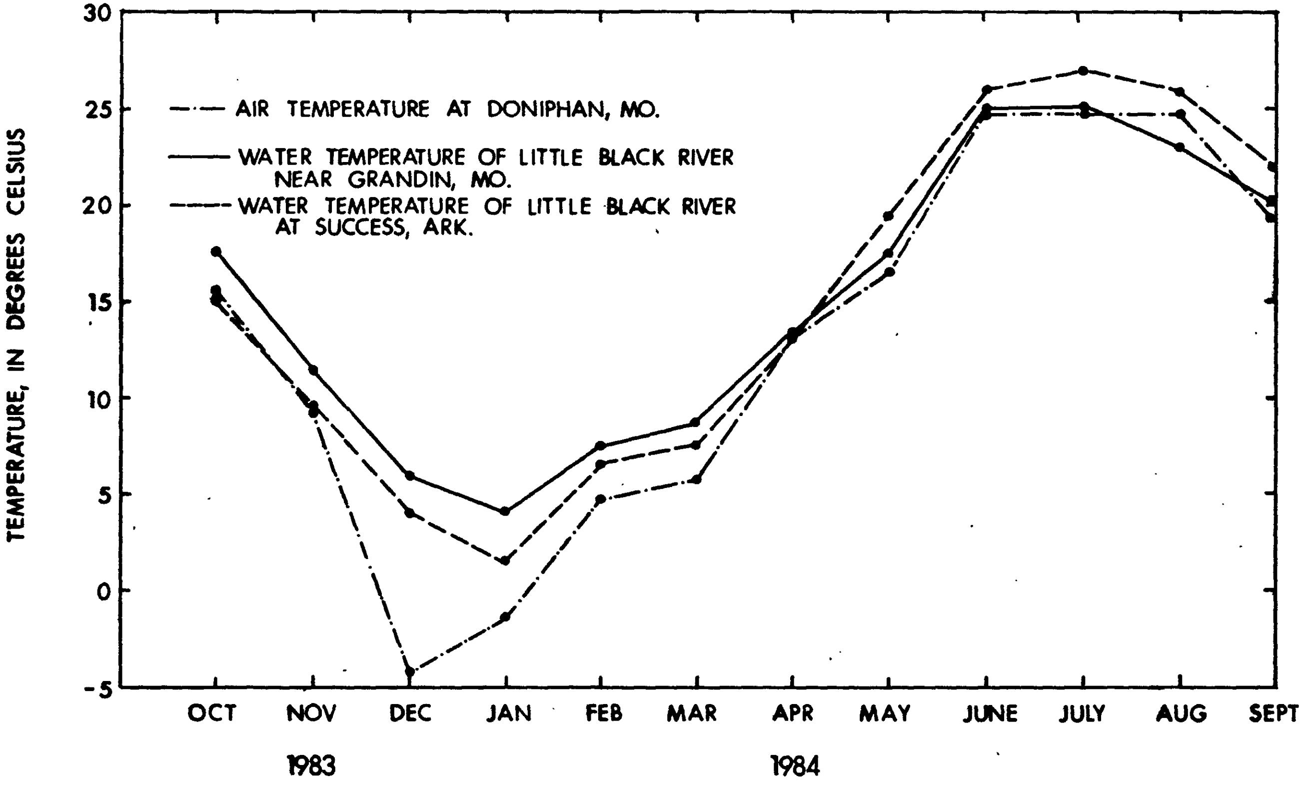

Figure 4.3-1.--Comparison of monthly mean air temperature and water temperature at selected sites.

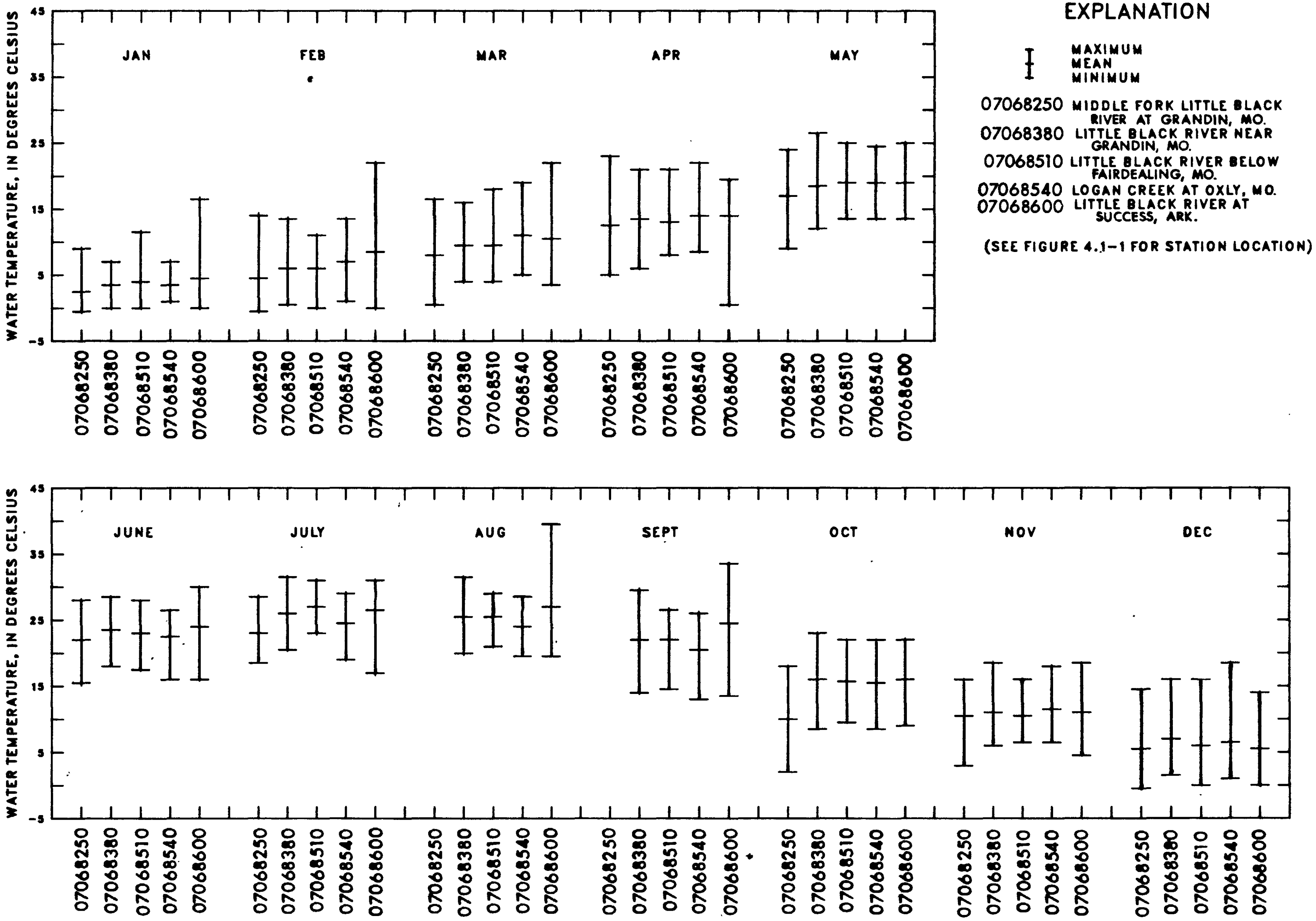

Figure 4.3-2.--Monthly maximum, minimum, and mean water temperatures at five water-quality-sampling stations, August 1980

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4.4 pH

VALUES OF pH ARE SIMILAR THROUGHOUT THE BASIN

The pH values range from 6.4 to 8.5 with a median of 7.4.

The pH value is the negative logarithm of the hydrogen-ion activity and ranges from 0 to 14 units. Water with a pH of 7 is considered neutral, a pH less than 7 is considered acidic, and a pH more than 7 is considered alkaline. The introduction of any solid, liquid, or gaseous matter that involves the hydrogen-ion activity in water can affect the pH. The pH value of natural water can be variable depending on the type of constituents in the water. The pH value also can be affected by the photosynthetic activity of the stream. During photosynthesis, carbon dioxide is used, which decreases the carbonic-acid concentration in the stream and increases the pH value. Conversely, during respiration carbon dioxide is produced, which increases the carbonic-acid concentration and decreases the pH value. The pH value is a significant property in streams because the toxicity of many compounds is affected by the hydrogen-ion activity. Cyanide toxicity to fish increases as the pH decreases. Conversely, the ammonia toxicity to fish increases as the pH increases (U.S. Environmental Protection Agency, 1976).

The Missouri water-quality standard for pH in the Little Black River basin states that water contaminants shall not cause the pH value to be outside the range of 6.5 to 9.0 (Missouri Department of Natural Resources, 1984). The pH values in the Little Black River basin ranged from 6.4 to 8.5 with a median of 7.4 (table 4.4-1) and are similar throughout the basin. Although minimal pH values were less than the Missouri water-quality standard, it is doubtful that water contaminants were the cause. The variation in pH probably was because of the natural fluctuations in the carbonic-acid concentrations in the stream.

The U.S. Geological Survey has collected pH data outside the Little Black River basin at various stream locations in the Salem Plateau and the Mississippi Alluvial Plain. No differences are indicated in the values obtained from both physiographic sections, and the medians of these pH values ranged from 7.6 to 8.2. The medians obtained in the Little Black River basin were all less than this range.

Table 4.4-1.--Values of pH at six water-quality-sampling stations, August 1980 to September 1984

Station number (fig. 4.1-1)	Station name	pH, in units			Number of samples
		Maximum	Minimum	Median	
07068300	North Prong Little Black River near Grandin, Mo.	8.5	6.8	7.4	26
07068380	Little Black River near Grandin, Mo.	8.2	6.6	7.5	26
07068510	Little Black River below Fairdealing, Mo.	8.0	6.7	7.4	25
07068540	Logan Creek at Oxly, Mo.	8.0	6.8	7.4	25
07068560	Little Black River ditch 2 near Sinsabaugh, Mo.	7.7	6.6	7.4	10
07068600	Little Black River at Success, Ark.	8.0	6.4	7.4	24

4.5 Dissolved Oxygen

MINIMUM DISSOLVED-OXYGEN CONCENTRATIONS WERE LESS THAN THE MISSOURI WATER-QUALITY STANDARD

The largest average dissolved-oxygen concentrations were measured in the headwaters, and the smallest average concentrations were measured near the mouth.

The dissolved-oxygen concentration in a stream is significant because oxygen is necessary for the respiration of organisms living in the streams. Oxygen can enter the water by photosynthesis of aquatic plants and by oxygen entering directly from the atmosphere. Oxygen is depleted by organisms consuming organic matter and by the oxidation of chemical compounds. To ensure survival of fish and other aquatic organisms, the dissolved-oxygen concentration needs to be relatively large. The Missouri water-quality standard states that water contaminants shall not cause the dissolved-oxygen concentration in the Little Black River basin to be less than 5.0 milligrams per liter (Missouri Department of Natural Resources, 1984).

The minimum dissolved-oxygen concentrations at six water-quality-sampling stations were less than the Missouri water-quality standard (table 4.5-1). Small dissolved-oxygen concentrations occur during low-flow conditions in summer when the water temperature was high because gases are not as soluble in warm water as in cool water. Small dissolved-oxygen concentrations also were measured during high-flow conditions because overland runoff washed material into the water that decomposed and depleted the dissolved oxygen. The largest median dissolved-oxygen concentrations were measured in the headwaters of the basin and the smallest median concentrations were measured near the mouth.

The U.S. Geological Survey has collected dissolved-oxygen data outside the Little Black River basin at various stream locations in the Salem Plateau and the Mississippi Alluvial Plain. The median dissolved-oxygen concentrations in the Salem Plateau outside of the study area ranged from 8.4 to 11.8 milligrams per liter. The median dissolved-oxygen concentration at water-quality-sampling stations in this part of the Little Black River basin were smaller than 8.4 milligrams per liter. The median dissolved-oxygen concentrations in the Mississippi Alluvial Plain outside of the study area ranged from 7.6 to 8.2 milligrams per liter. The median dissolved-oxygen concentrations at water-quality-sampling stations in this part of the Little Black River basin (Little Black River ditch 2 near Sinsabaugh, Mo., and the Little Black River at Success, Ark.) were smaller than 7.6 milligrams per liter.

Table 4.5-1.--Dissolved-oxygen concentrations at six water-quality-sampling stations, August 1980 to September 1984

[mg/L, milligrams per liter; percent, percent of saturation]

Station number (fig 4.1-1)	Station name	Dissolved-oxygen concentrations					Number of samples	Number of samples with concentrations less than water-quality standard[1]
		Unit	Maximum	Minimum	Mean	Median		
07068300	North Prong Little Black River near Grandin, Mo.	mg/L	12.8	4.8	8.2	8.0	26	1
		Percent	109	54	80	82	26	
07068380	Little Black River near Grandin, Mo.	mg/L	12.2	2.2	7.8	7.6	26	1
		Percent	99	25	76	81	26	
07068510	Little Black River below Fairdealing, Mo.	mg/L	10.6	2.8	6.8	6.2	25	5
		Percent	91	31	66	64	25	
07068540	Logan Creek at Oxly, Mo.	mg/L	11.4	3.0	7.1	7.0	25	3
		Percent	94	33	69	68	25	
07068560	Little Black River ditch 2 near Sinsabaugh, Mo.	mg/L	10.0	3.4	6.7	6.8	10	3
		Percent	82	41	64	70	10	
07068600	Little Black River at Success, Ark.	mg/L	10.8	2.8	6.6	6.2	24	6
		Percent	89	29	65	68	24	

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[1] Missouri water-quality standard is that dissolved-oxygen concentrations are to be larger than 5.0 milligrams per liter.

4.6 Nitrogen

ORGANIC NITROGEN IS THE MOST ABUNDANT FORM OF NITROGEN IN THE BASIN

The total nitrogen concentrations were larger in the Mississippi Alluvial Plain than in the Salem Plateau because of increases in organic nitrogen.

Nitrogen is detected in a number of different forms. In water, the most common forms are organic nitrogen, ammonia, nitrite, and nitrate. In the presence of oxygen, nitrifying bacteria will oxidize all forms of nitrogen to nitrate. The quantity of organic nitrogen and ammonia present in water is dependent on the population of nitrifying bacteria and the time the compound has been in the water. Nitrite is easily oxidized to nitrate, so the nitrite concentrations in water generally are small.

Sources of the different nitrogen compounds in water vary, but the principal one is runoff. Organic nitrogen can enter a stream by feedlot runoff, but a large part of the organic nitrogen probably comes from dead plant or organic material that has fallen or washed into the stream. Sources of ammonia are feedlot runoff and runoff from agricultural land fertilized by ammonia compounds. Ammonia also is a primary constituent of sewage. Nitrate is the most mobile form of nitrogen. Unlike the other nitrogen compounds, nitrate is not absorbed onto soil particles, so sources of nitrate can be from drainage of farmland by surface or ground water.

At six water-quality-sampling stations in the Little Black River basin, the form of nitrogen detected in the largest concentration was organic nitrogen (table 4.6-1). Nitrate was detected in the second largest concentrations. Ammonia and nitrite concentrations throughout the basin were small.

Median concentrations of total nitrogen at water-quality-sampling stations in the Mississippi Alluvial Plain were larger than the median concentrations at water-quality-sampling stations in the Salem Plateau. Median organic-nitrogen concentrations at water-quality-sampling stations in the Mississippi Alluvial Plain were larger than those at water-quality-sampling stations in the Salem Plateau. Median ammonia, nitrite, and nitrate concentrations at water-quality-sampling stations in both physiographic sections were similar.

The U.S. Geological Survey has collected total-nitrogen data outside the Little Black River basin at various stream locations in the Salem Plateau, but not in the Mississippi Alluvial Plain. The medians of the total-nitrogen data collected in the Salem Plateau ranged from 0.36 to 1.60 milligrams per liter. The medians of total-nitrogen data collected in the Little Black River basin were within this range.

Table 4.6-1.--Nitrogen concentrations at six water-quality-sampling stations, August 1980 to September 1984

Station number (fig. 4.1-1)	Station name	Type	Nitrogen, in milligrams per liter, as nitrogen				Number of samples
			Maximum	Minimum	Mean	Median	
07068300	North Prong Little Black River near Grandin, Mo.	Total	1.40	0.30	0.66	0.60	25
		Organic	.70	.04	.36	.34	25
		Ammonia	.10	.01	.05	.06	25
		Nitrite	.03	.00	.01	.02	25
		Nitrate	1.98	.00	.27	.17	25
07068380	Little Black River near Grandin, Mo.	Total	2.20	.13	.74	.70	26
		Organic	2.10	.14	.52	.38	26
		Ammonia	.25	.01	.06	.06	26
		Nitrite	.04	.00	.02	.02	26
		Nitrate	.53	.00	.16	.09	26
07068510	Little Black River below Fairdealing, Mo.	Total	1.90	.23	.79	.61	24
		Organic	1.70	.00	.56	.41	24
		Ammonia	.20	.01	.07	.06	24
		Nitrite	.03	.00	.02	.02	24
		Nitrate	.77	.00	.18	.10	24
07068540	Logan Creek at Oxly, Mo.	Total	2.20	.21	.74	.60	25
		Organic	1.14	.11	.48	.54	25
		Ammonia	.10	.00	.05	.06	25
		Nitrite	.03	.00	.02	.02	25
		Nitrate	1.38	.00	.21	.08	25
07068560	Little Black River ditch 2 near Sinsabaugh, Mo.	Total	1.60	.64	1.10	.90	10
		Organic	.84	.31	.67	.64	10
		Ammonia	.46	.06	.14	.11	10
		Nitrite	.04	.00	.02	.02	10
		Nitrate	.80	.00	.28	.18	10
07068600	Little Black River at Success, Ark.	Total	2.20	.25	.97	.90	24
		Organic	1.70	.05	.71	.71	24
		Ammonia	.25	.00	.08	.07	24
		Nitrite	.05	.00	.02	.02	24
		Nitrate	.40	.00	.18	.18	24

4.7 Phosphorus

LARGEST AVERAGE PHOSPHORUS CONCENTRATION OCCURRED AT THE MOST DOWNSTREAM WATER-QUALITY-SAMPLING STATION

Maximum phosphorus concentrations occurred during high-flow conditions because of rainfall washing phosphorus into the streams.

Phosphorus is one of the primary nutrients required for plant growth and is essential for plant life. It has been credited with causing eutrophication in bodies of water, particularly lakes. Phosphorus is not the only cause of eutrophication, but usually it is the limiting nutrient. Therefore, increases in phosphorus concentrations tend to cause increases in plant growth. No widespread agreement exists on acceptable concentrations of total phosphorus in streams, primarily because of disagreements on what constitutes eutrophic conditions. The U.S. Environmental Protection Agency (1976) suggests an upper limit of 0.1 milligram per liter for preventing nuisance plant growths in streams.

Phosphorus enters streams from several different sources. Human and animal wastes and phosphate detergents have caused sewage to be a significant source. Runoff from agricultural land fertilized with phosphate fertilizer and runoff from feedlots can contribute phosphorus to a stream. Tree leaves and atmospheric deposition also are natural sources of phosphorus.

The smallest median total-phosphorus concentration in the Little Black River occurred in the headwaters of the basin and increased toward the mouth (table 4.7-1). At all except the most upstream water-quality-sampling station (North Prong Little Black River at Grandin, Mo.), the maximum total-phosphorus concentrations equaled or exceeded the limit suggested by the U.S. Environmental Protection Agency (1976). In all cases, the large total-phosphorus concentrations occurred during high-flow conditions in the basin when phosphorus was washed into the stream by precipitation. At the most downstream water-quality-sampling station (Little Black River at Success, Ark.) the maximum total-phosphorus concentration was larger than at any other water-quality-sampling station. This indicates that runoff from the Mississippi Alluvial Plain not drained by the Little Black River ditch 2 near Sinsabaugh, Mo., is contributing total phosphorus to the Little Black River basin.

The U.S. Geological Survey has collected total-phosphorus data outside the Little Black River basin at various stream locations in the Salem Plateau and the Mississippi Alluvial Plain. The medians of the total-phosphorus distributions in the Salem Plateau ranged from 0.01 to 0.05 milligram per liter as phosphorus. The medians of data collected in the Salem Plateau in the Little Black River basin are within this range of medians. The medians of the total-phosphorus data in the Mississippi Alluvial Plain ranged from 0.21 to 0.63 milligram per liter as phosphorus. The medians of data collected in the Little Black River basin in the Mississippi Alluvial Plain are less than this range of medians.

Table 4.7-1.--Total phosphorus and orthophosphate concentrations at six water-quality-sampling stations, August 1980 to September 1984

Station number (fig. 4.1-1)	Station name	Type	Total phosphorus and orthoposphate, in milligrams per liter, as phosphorus				Number of samples	Number of samples with concentrations larger than 0.1 milligram per liter
			Maximum	Minimum	Mean	Median		
07068300	North Prong Little Black River near Grandin, Mo.	Total phosphorus	0.05	0.01	0.02	0.01	25	0
		Orthophosphate	.02	.00	.01	.01	25	
07068380	Little Black River near Grandin, Mo.	Total phosphorus	.17	.00	.02	.01	23	1
		Orthophosphate	.08	.00	.02	.01	23	
07068510	Little Black River below Fairdealing, Mo.	Total phosphorus	.15	.01	.04	.03	24	1
		Orthophosphate	.07	.01	.02	.02	24	
07068540	Logan Creek at Oxly, Mo.	Total phosphorus	.10	.01	.02	.01	25	0
		Orthophosphate	.06	.00	.01	.01	25	
07068560	Little Black River ditch 2 near Sinsabaugh, Mo.	Total phosphorus	.10	.03	.06	.05	10	0
		Orthophosphate	.05	.01	.03	.03	10	
07068600	Little Black River at Success, Ark.	Total phosphorus	.29	.01	.09	.09	24	8
		Orthophosphate	.20	.01	.06	.05	24	

4.8 Bacteria

STORM RUNOFF IS THE PRIMARY CONTRIBUTOR TO BACTERIAL CONCENTRATION IN THE LITTLE BLACK RIVER

Livestock waste is the primary source of bacteria; storm runoff is the cause of large bacterial concentration.

Biological-indicator bacteria have become significant in defining water quality in streams of Missouri. Bacterial data generally are used to identify either environmental changes or to quantify contamination. Streams in the Little Black River basin were sampled for fecal-coliform and fecal-streptococci bacteria by the membrane-filter method during this study.

Fecal-coliform bacteria are bacteria that are present in the intestines of warm-blooded animals. The primary species in the fecal-coliform-bacteria group is *Escherichia coli*, a species that indicates fecal contamination and the possible presence of intestinal microorganisms capable of causing disease.

Fecal-streptococci bacteria are used as indicators of substantial contamination of water because the normal habitat of these bacteria is the intestines of man and other mammals. The presence of fecal-streptococci bacteria in surface water verify fecal contamination and may provide additional information concerning the probable source of contamination. Fecal-streptococci bacteria are not known to multiply freely in the environment. In combination with data for fecal-coliform bacteria, data for fecal-streptococci bacteria are used for sanitary evaluation when a more precise determination is needed.

The relation of concentrations of fecal-coliform bacteria to fecal-streptococci bacteria can provide information on the source of contamination (U.S. Environmental Protection Agency, 1978). Estimated contributions of indicator bacteria by humans and animals were used to determine ratios of fecal-coliform bacteria to fecal-streptococci bacteria (table 4.8-1). From these data, the U.S. Environmental Protection Agency (1978) determined that ratios larger than 4.0 indicate contamination from human wastes and that ratios less than 0.7 indicate that contamination could have resulted from livestock and poultry wastes, milk and food-processing wastes, or from storm runoff. Ratios between 0.7 and 4.0 indicate mixed sources of contamination.

The Missouri water-quality standard for fecal-coliform bacteria in the Little Black River states that for periods when the river is not affected by stormwater runoff, the fecal-coliform-bacteria count shall not exceed a geometric mean of 200 colonies per 100 milliliters of sample during the recreational season from April 1 to October 31 (Missouri Department of Natural Resources, 1984). Sampling will be based on a minimum of five samples collected on different days during a 30-day period. The tributaries of the Little Black River do not have a bacterial water-quality standard. The bacterial data collected in the Little Black River basin from August 1980 to September 1984 are listed in table 4.8-2. Because the sampling schedule did not meet the guidelines designated in the water-quality standard, the data cannot be used to determine if the standard for fecal-coliform bacteria was exceeded.

Table 4.8-1.--Sources of contamination as indicated by the ratio of fecal-coliform bacteria to fecal-streptocci bacteria

[data from U.S. Environmental Protection Agency, 1978]

Source	Ratio
Human	4.6
Ducks	.6
Sheep	.4
Chickens	.4
Pigs	.4
Cows	.2
Turkeys	.1

In the Little Black River basin, the primary cause of fecal-coliform-bacteria concentration exceeding 200 colonies per 100 milliliters is storm runoff. This concentration was exceeded in 12 to 30 percent of the samples collected at each water-quality-sampling station (table 4.8-2). None of the streams sampled had a median fecal-coliform-bacteria concentration larger than 110 colonies per 100 milliliters. The ratios between fecal-coliform bacteria and fecal-streptococci bacteria indicate that the primary source of fecal contamination is livestock waste.

The North Prong Little Black River near Grandin, Mo., and Logan Creek at Oxly, Mo., had fecal-coliform bacteria concentrations larger than 200 colonies per 100 milliliters in 20 percent of the samples collected and the median concentration was 56 and 57 colonies per 100 milliliters. Analyses of samples collected at these water-quality-sampling stations indicated some human-waste contamination, but the primary cause of the large fecal-coliform-bacteria concentrations was storm runoff. The median ratios of fecal-coliform bacteria to fecal-streptococci bacteria indicate that a large part of the bacteria present was because of fecal contamination from livestock.

Twelve percent of the fecal-coliform bacteria samples collected at the Little Black River near Grandin, Mo., exceeded 200 colonies per 100 milliliters and had a median concentration of 36 colonies per 100 milliliters. The source of contamination causing the large concentrations is uncertain. No clear relation was indicated between large concentrations and an increase in discharge, or a specific source. The median ratio of fecal-coliform bacteria to fecal-streptococci bacteria was 0.5, indicating animal-waste contamination.

The Little Black River below Fairdealing, Mo., had the largest median concentration of fecal-coliform bacteria, 110 colonies per 100 milliliters, with 29 percent of the sample concentrations larger than 200 colonies per 100 milliliters. The median ratio of fecal-coliform bacteria to fecal-streptococci bacteria was 0.4, indicating fecal contamination from livestock.

The Little Black River ditch 2 near Sinsabaugh, Mo., had the largest percentage (30) of samples with more than 200 colonies per 100 milliliters of fecal-coliform bacteria. This ditch flows only when there is storm runoff; therefore, the bacterial counts are indicative of storm-runoff water. The median fecal-coliform bacteria concentration was 105 colonies per 100 milliliters, and the median ratio of fecal-coliform bacteria to fecal-streptococci bacteria was 0.2, indicating fecal contamination from livestock.

Seventeen percent of the fecal-coliform bacteria samples collected from the Little Black River at Success, Ark., had concentrations larger than 200 colonies per 100 milliliters with a median concentration of 96 colonies per 100 milliliters. Occurrence of concentrations exceeding 200 colonies per 100 milliliters coincided with large increases in stream discharge because of storm runoff. The median ratio of fecal-coliform bacteria to fecal-streptococci bacteria was 0.3, indicating fecal contamination from livestock.

Table 4.8-2.--Fecal-coliform and fecal-streptococci bacteria concentrations at six water-quality-sampling stations, August 1980 to September 1984

[<, less than]

Station number (fig. 4.1-1)	Station name	Type of fecal bacteria	Bacterial concentrations, in colonies per 100 milliliters			Total number of samples	Number of samples with fecal-coliform-bacteria concentrations exceeding 200 colonies per 100 milliliters
			Maximum	Minimum	Median		
07068300	North Prong Little Black River near Grandin, Mo.	Coliform	800	<6	56	25	5
		Streptococci	17,000	<8	230	22	
07068380	Little Black River near Grandin, Mo.	Coliform	820	<4	36	24	3
		Streptococci	7,800	<13	78	23	
07068510	Little Black River below Fairdealing, Mo.	Coliform	4,000	<20	110	24	7
		Streptococci	16,000	35	245	24	
07068540	Logan Creek at Oxly, Mo.	Coliform	1,000	<7	57	25	5
		Streptococci	3,600	<9	115	24	
07068560	Little Black River ditch 2 near Sinsabaugh, Mo.	Coliform	2,400	58	105	10	3
		Streptococci	11,000	53	440	10	
07068600	Little Black River at Success, Ark.	Coliform	3,100	<11	96	23	4
		Streptococci	5,600	44	320	23	

5.0 SUSPENDED SEDIMENT

SUSPENDED-SEDIMENT DISCHARGE INCREASES AND SUSPENDED-SEDIMENT YIELD DECREASES DOWNSTREAM

Suspended-sediment concentrations in the headwaters of the river usually were less than concentrations near the mouth of the river.

As the Little Black River flows from the Salem Plateau to the Mississippi Alluvial Plain, changes in soil type, land use, and topography affect the sediment concentrations of the stream. The Salem Plateau has steep slopes that could cause some large sediment concentrations during rainstorms, but the dense vegetation, shallow soil, and short distance to the river retards large increases in sediment discharge. Although the Mississippi Alluvial Plain constantly is disturbed by agricultural use of the fertile, deep soil, erosion is limited by the slight land-surface slope.

A graph (fig. 5.0-1) of streamflow and suspended-sediment concentration at the Little Black River at Success, Ark., shows that two predominant types of sediment peaks typically occur at the four sediment-sampling stations (table 5.0-1) in the Little Black River basin. Advanced peaks, defined as peak suspended-sediment concentrations that occur before peak stream flow, and simultaneous suspended-sediment and streamflow peaks occurred most frequently. Both advanced and simultaneous peaks are indicative of low flows before storm runoff and a short distance from point of erosion to a sediment-sampling station. Storm runoff after dry weather results in a larger suspended-sediment peak than when the storm is preceded by wet weather.

Daily suspended-sediment concentrations were determined at four sediment-sampling stations in the Little Black River basin from October 1, 1980, to September 30, 1984. Because suspended-sediment concentrations are not normally distributed, the descriptors of a normal distribution, such as mean and standard deviation were not used. The range and frequency of occurrence of daily suspended-sediment concentrations measured at the four sediment-sampling stations are presented in table 5.0-1 and displayed graphically in figure 5.0-2. The data indicate that the suspended-sediment concentrations in the headwaters of the river usually were less than the concentrations near the mouth of the river.

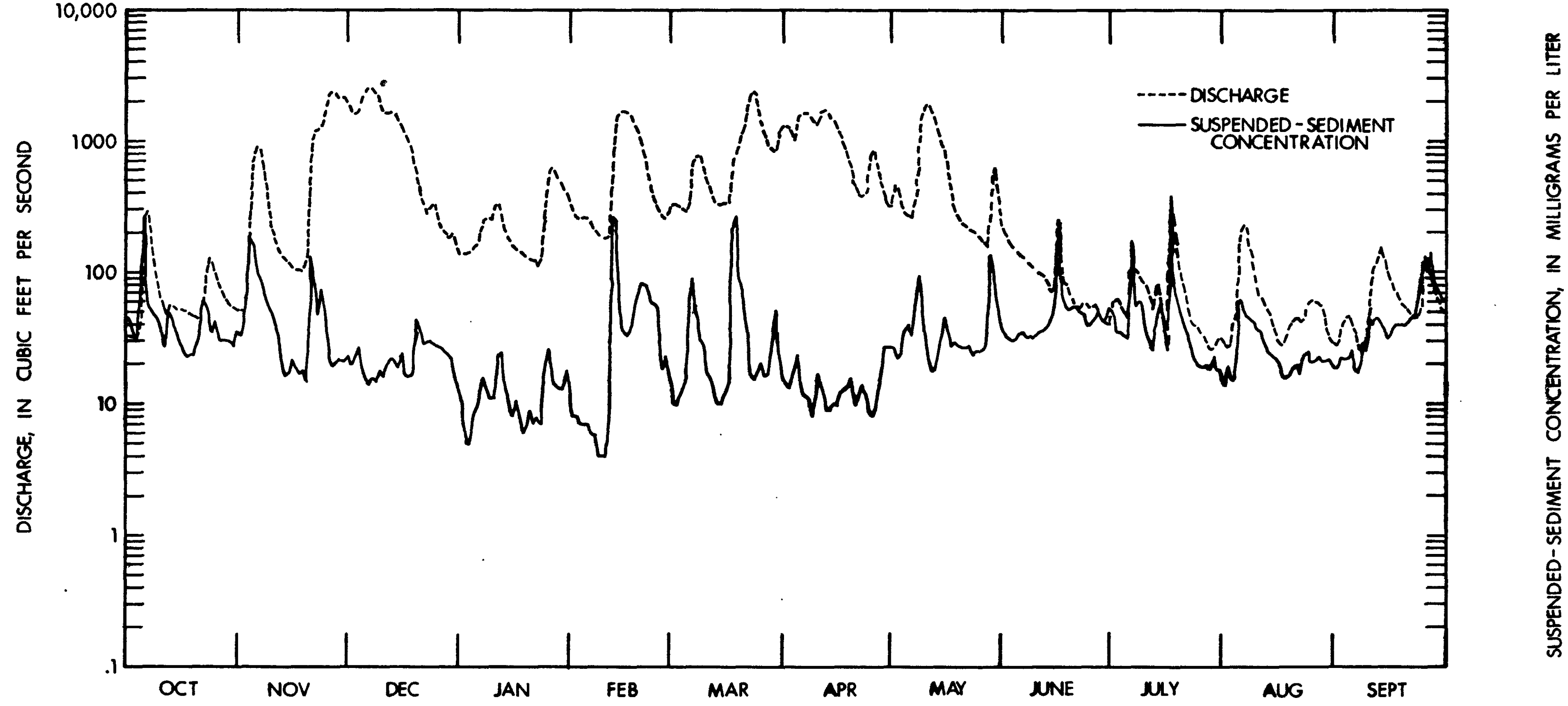

Figure 5.0-1.--Discharge and suspended-sediment concentrations of the Little Black River at Success, Arkansas (station 07068600), for the 1984 water year.

5.0 SUSPENDED SEDIMENT--Continued

Suspended-sediment discharge, in tons, was calculated from suspended-sediment concentration and streamflow at each sediment-sampling station. Suspended-sediment yield, in tons per square mile, was calculated by dividing the suspended-sediment discharge at each sediment-sampling station by the drainage area (table 5.0-2). Suspended-sediment discharge is affected by precipitation, which causes land erosion and increases channel erosion. The suspended-sediment data were collected during 4 years characterized by extremes in precipitation. During the 1981 water year (October 1, 1980, to September 30, 1981), less-than-normal precipitation caused small suspended-sediment yields at all sediment-sampling stations. The 1982 and 1983 water years had several intense rainstorms in January, August, and December 1982, which caused major floods. This caused substantial sediment yield during these months. The 1984 water year had less-than-normal precipitation during the summer, but more than normal precipitation during the rest of the year. However, the suspended-sediment yield was smaller than the previous 2 years.

The data indicate that the suspended-sediment discharge increased downstream during the study. The suspended-sediment yield for each water year decreased downstream, except for water year 1981. The change in channel slope and velocity were the primary contributors to the decreased suspended-sediment yield. As the channel slope decreases, velocity decreases, and sediment particles settle out, causing a decrease in suspended-sediment yield at Success, Ark.

Table 5.0-1.--Range and frequency of occurence of daily suspended-sediment concentrations at four sediment-sampling stations, October 1980 to September 1984

[<, less than]

Station number (fig. 4.1-1)	Station name	Suspended-sediment concentration, in milligrams per liter						
			Percentage of the time median concentration was less than listed concentration					
		Minimum	10	25	50	75	90	Maximum
07068380	Little Black River near Grandin, Mo.	<1	1	2	4	7	13	330
07068510	Little Black River below Fairdealing, Mo.	1	5	10	18	32	49	634
07068540	Logan Creek at Oxly, Mo.	<1	1	2	3	6	12	447
07068600	Little Black River at Success, Ark.	1	11	21	36	63	106	2,390

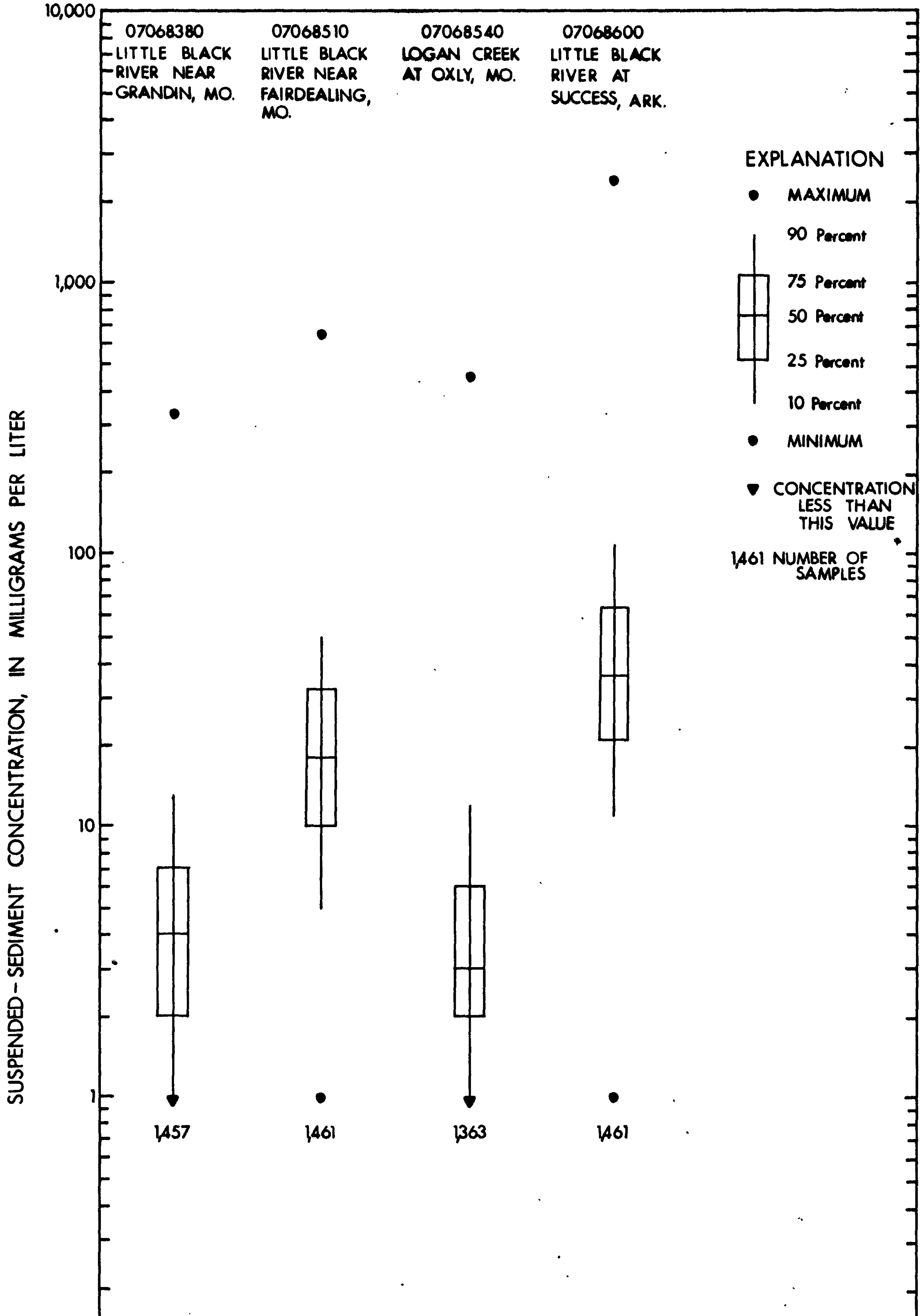

Figure 5.0-2.--Statistical summary of daily suspended-sediment concentrations at four sediment-sampling stations, October 1980 to September 1984.

Table 5.0-2.--Suspended-sediment discharge and yield at four sediment-sampling stations, October 1980 to September 1984

[Discharge reported in tons; yield reported in tons per square mile]

Station number (fig. 4.1-1)	Station name	Drainage area, in square miles	Suspended sediment									
			Water Years									
			1981		1982		1983		1984		Average annual	
			Discharge	Yield	Discharge	Yield	Discharge	Yield	Discharge	Yield	Discharge	Yield
07068380	Little Black River near Grandin, Mo.	79.5	345	4.3	12,500	157	12,500	157	2,010	25.3	6,840	85.9
07068510	Little Black River below Fairdealing, Mo.	194	3,310	17.1	22,300	115	30,200	156	10,600	54.6	16,600	80.7
07068540	Logan Creek at Oxly, Mo.	37.5	111	3.0	3,030	80.8	3,640	97.1	2,150	57.3	2,230	59.6
07068600	Little Black River at Success, Ark.	386	10,500	27.2	45,900	119	37,800	97.9	16,900	43.8	27,800	72.0

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