Water Resources of Pulaski and Saline Counties, Arkansas

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1839–B

Prepared in cooperation with the Arkansas Geological Commission

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By RAYMOND O. PLEBUCH *and* MARION S. HINES

CONTRIBUTIONS TO THE HYDROLOGY OF THE UNITED STATES

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CONTENTS

ILLUSTRATIONS

TABLES

CONTRIBUTIONS TO THE HYDROLOGY OF THE UNITED STATES

WATER RESOURCES OF PULASKI AND SALINE COUNTIES, ARKANSAS

By RAYMOND O. PLEBUCH and MARION S. HINES

ABSTRACT

Pulaski and Saline Counties constitute an area of 1,506 square miles in the geographic center of Arkansas. The area is divided into a hilly western part, known as the Interior Highlands, and a relatively flat eastern part, known as the Coastal Plain.

In the Interior Highlands, surface water offers greater possibilities than ground water for water supplies. Alum Fork, Middle Fork, and North Fork of the Saline River offer excellent impoundment possibilities and will yield water of good quality. In addition, with storage, many of the smaller streams are suitable for development of small supplies.

In contrast, in the Coastal Plain it is easier to develop ground water than surface water in relatively large quantities. Two aquifers, units 3 and 9, yield as much as 350 and 2,000 gallons per minute of water, respectively. A third acquifer, unit 7, is as yet relatively undeveloped in the project area, but yields 860 gallons per minute to a well south of the project area. These aquifers yield water that, with treatment, is suitable for most uses.

INTRODUCTION

This report is an appraisal of the water resources of Pulaski and Saline Counties, Ark. It provides information on the occurrence, availability, and chemical quality of surface and ground water in sufficient detail to identify, locate, and describe the best potential sources of water. The need for a study was made apparent by the increased number of requests for water information. The number of requests in Pulaski County was particularly great. This county, containing 13.6 percent of the State's inhabitants, is the most populous in Arkansas. The area is becoming highly industrialized, and water use is increasing rapidly. Average water use in the Little Rock metropolitan area increased from 23 to 29 million gallons per day between 1962 and 1965.

This study, which began in July 1962, was made by the Water Resources Division of the U.S. Geological Survey in cooperation with the Arkansas Geological Commission. The report is based not only on information obtained specifically for this investigation, but also

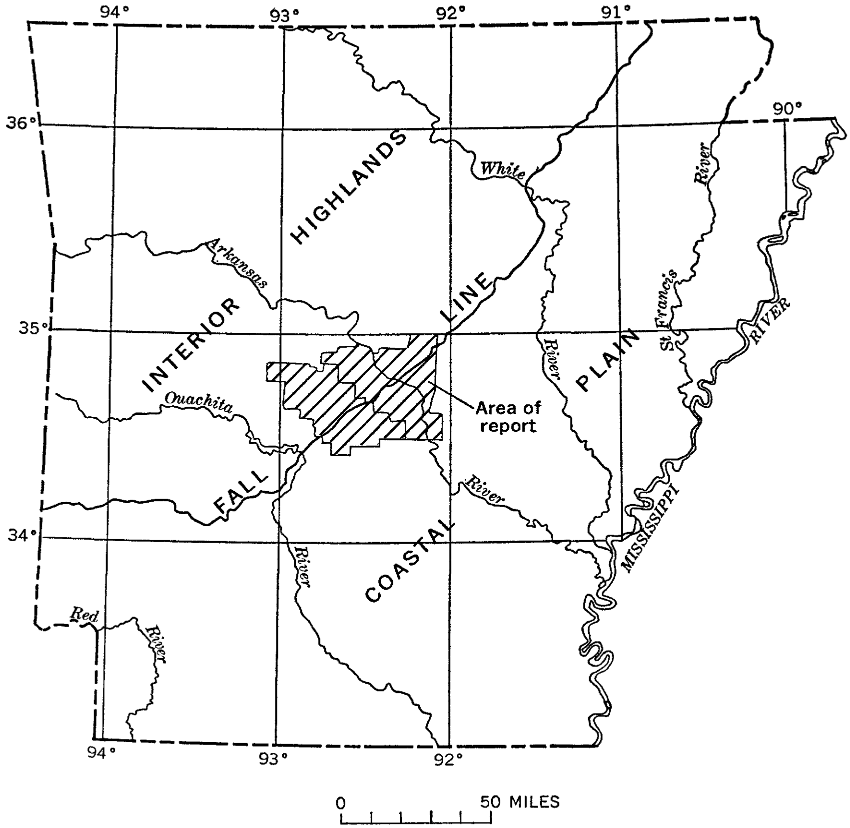


FIGURE 1.—Location of report area.

on data collected previously as part of the continuing program of water-resources studies in Arkansas. Previous geologic and hydrologic studies in the project area include a number of reports. (See list of references.)

Pulaski and Saline Counties, constituting an area of 1,506 square miles, lie in the geographic center of Arkansas (fig. 1). The project area is bordered on the north by Perry and Faulkner Counties, on the east by Lonoke County, on the south by Jefferson and Grant Counties, and on the west by Garland County. The area is drained primarily by the Arkansas and Saline Rivers and their tributaries. A few square miles in northeastern Pulaski County is drained by tributaries of the White River. This two-county area is divided physiographically into a hilly western part, known as the Interior Highlands, and a relatively flat eastern part, known as the Coastal Plain. About two-thirds of the area is in the Interior Highlands. Altitudes are lowest—less than 250 feet—in the Coastal Plain and highest—more than 1,000 feet—in the Interior Highlands.

The two physiographic divisions of the Pulaski-Saline County area are topographically distinct primarily because of geologic conditions. The Interior Highlands are underlain by consolidated rocks. In contrast, the Coastal Plain is underlain by a thick sequence of unconsolidated sediments, which dip gently to the southeast. In this report 10 geologic units have been differentiated—1 in the highlands and 9 in the Coastal Plain. The lithologic and water-bearing characteristics of these units and their vertical relationships are summarized in table 1 and figure 2. The distribution of the units is shown on the geohydrologic map (pl. 1). Persons interested in a more detailed discussion of the geology are referred to the list of references at the back of the report.

The most significant chemical constituents and physical properties of surface and ground water are discussed in the body of the report. More complete analyses of water from wells are listed in table 5. Wells listed in table 5 can be found on the geohydrologic map (pl. 1) by means of the well-location diagram on p. B20.

Quality-of-water requirements vary according to the user, particularly among industrial users. Comparison of data in the text and in table 5 with table 4, "Significance of dissolved mineral constituents and physical properties of natural waters," will be sufficient for some users. Those requiring more detailed information should refer to a publication by the California State Water Pollution Control Board (1952) entitled, "Water Quality Criteria."

WATER RESOURCES

The contrasting geologic conditions of the two topographically distinct divisions of the Pulaski-Saline County area have a definite effect on the water resources of the area. The consolidated rocks in the Interior Highlands have relatively low permeabilities, which limit the amount of ground water available and hinder its movement. The rocks are highly dissected, and the streams have steep gradients. Surface runoff, which averages 18 inches per year, is rapid and the streams crest and recede quickly, inhibiting flow of water from the streams to the ground-water reservoir. During high flow, water probably is held only temporarily in bank storage and released quickly to the streams at low stage. Perennial base flow occurs at only a few locations, and most of the tributaries cease to flow during periods of drought.

In contrast to the rocks of the Interior Highlands, the higher permeabilities of some of the Coastal Plain sediments favor the transmission of water, and greater amounts of ground water are available.

Relief in the Coastal Plain is slight, and streams are sluggish. There are many swampy areas in the eastern part of Pulaski County along the Arkansas River. Tributary streams are not sufficiently incised to in-

TABLE 1.—*Lithologic and water-bearing characteristics of the rocks in Pulaski and Saline Counties, Ark.*

Age	Lithologic unit	Thickness (feet)	Lithologic and water-bearing characteristics
Quaternary	9	0–120	Clay and silt grading downward into sand and gravel; in places bordered or underlain by terrace deposits consisting of dark-red clay and white sand. The basal sand and gravel unit yields from 300 to 2,000 gpm of water to wells.
Tertiary (includes Jackson?, Claiborne, Wilcox and Midway Groups)	8	350+	Gray, green, bluish, cream, and ocher silty clay interbedded with brown carbonaceous clay, thin lignite beds, and medium to coarse sand. Yields small quantities of water to domestic wells.
	7	207–412	Continental homogeneous tan or gray fine to medium sand containing layers and lenses of gray silty clay; locally contains a bed of dark-brown woody lignite at the base. Utilized only for domestic supplies in the report area. Well yields up to 860 gpm reported 12 miles south of Saline-Grant County line.
	6	0–450	Dark-chocolate-brown silty to sandy carbonaceous clay interlaminated with white micaceous sand and containing scattered lignite and siderite layers; grades upward into dark-brown medium to coarse sand. A large deposit of gravel and coarse sand in the lower part fringes the highlands. Well yields are unpredictable, and test drilling is advisable.
	5	0–347	Greenish- to bluish-gray silty clay and grayish-green fine sand alternate with lignite, black lignitic and brown carbonaceous clay, and hard layers of siderite. Bauxite deposits fringe the syenite hills. Not a good source of water because of lack of coarse materials.
	4A	?	Nature of materials unknown, but apparently too fine grained to yield more than 1 or 2 gpm to wells in Jacksonville area and south of Benton.
	4	0–450	Dark-bluish-gray to black silty clay containing layers of siderite. Varicolored clay occurs at the top in places. Does not yield water to wells.
	3	0–185	Greenish-gray and dark-gray clay, sandy in places, interbedded with marl, sandy glauconitic limestone, and calcareous sandstone. Well yields up to 350 gpm are obtainable from the limestone and sandstone.
Cretaceous	2		Light-gray or bluish igneous rocks containing pendants of altered older rocks. Does not yield water to wells.
Pennsylvanian to Ordovician	1	?	Sandstones, shales novaculite, and chert. Well yields normally are 10 gpm or less, although the highly shattered cherts have yielded up to 200 gpm in Garland County. Well yields are dependent on local conditions, and dry holes are common. Well depths normally are less than 150 feet.

tersect the water table, and therefore most streams that originate in the Coastal Plain cease to flow during extended dry periods.

The major sources of surface-water supplies in Pulaski and Saline Counties are the Arkansas and Saline Rivers. The average water-year flow of the Arkansas River at Little Rock (site 3, pl. 1) for the period 1927–63 was 41,550 cfs (cubic feet per second). The daily average flow exceeded this amount about one-third of the time but varied widely throughout the years and from year to year. The average annual flow reached a high of 84,780 cfs in 1945 and a low of 10,820 cfs in 1940. Peak flow of 536,000 cfs was recorded on May 27, 1943, and a minimum flow of 850 cfs was reached on Aug. 23, 1934. All aspects of water supply on the Arkansas River at Little Rock will

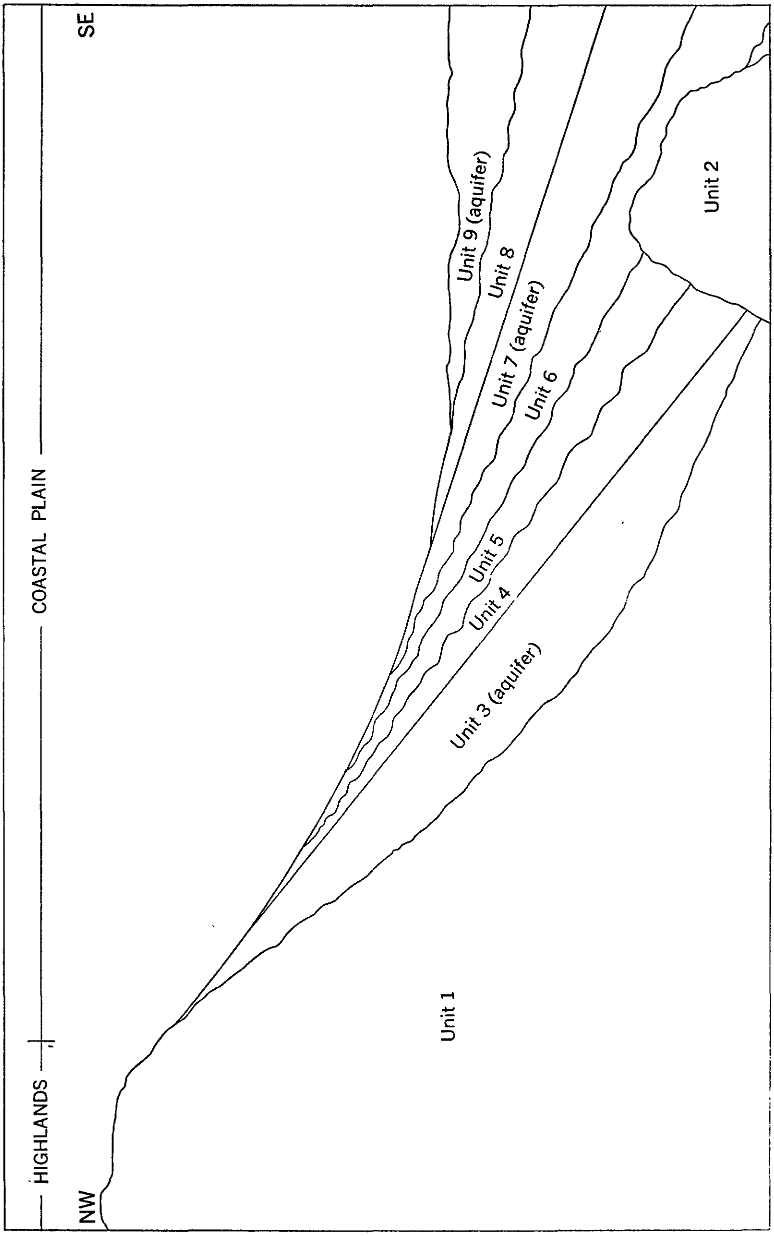


FIGURE 2.—Relationship of the rocks of the Coastal Plain to those of the Interior Highlands.

be improved as a result of the construction program now in progress (1965).

Streamflow in the Saline River at Benton (site 13, pl. 1) averaged 752 cfs for the period 1950–63. The daily average flow exceeded this amount about one-fourth the time. Peak flow reached 49,500 cfs on Dec. 4, 1952, and the stream ceased to flow for several days in 1954 and on Sept. 3, 1963, when the flow of the stream was diverted into the Benton water system. The highest average water-year flow was 1,212 cfs in 1957, and the lowest was 282 cfs in 1963.

WATER-SUPPLY POSSIBILITIES IN THE INTERIOR HIGHLANDS

SURFACE WATER AND ITS QUALITY

The water-supply potential of a stream is determined by the frequency with which streamflow recedes to minimal amounts (frequency distribution of annual low flows) and the length of time given flows are available (duration of daily flows). Minimum flows vary from time to time, from stream to stream, and between different points on the same stream. Statistical analyses of flow data are necessary to determine the dependable amount of water available. These statistical analyses of the magnitude and frequency of annual low flows and the duration of daily flows are presented for the Arkansas and Saline Rivers in table 2.

TABLE 2.—*Frequency of low flows and duration of daily flows*

Stream	Annual low flow (cfs), for indicated recurrence interval (years)					
	Period (days)	1.2	2	5	10	20
Arkansas River at Little Rock, Ark.	7	9,000	4,100	1,780	1,160	850
	15	9,700	4,350	1,880	1,240	920
	30	11,800	5,240	2,250	1,470	1,080
	60	16,700	7,000	2,800	1,820	1,380
	120	24,800	11,600	4,950	2,960	1,970
Saline River at Benton, Ark.	7	28	12	5.3	2.7	1.4
	15	34	15	6.8	3.6	1.9
	30	48	20	9.0	5.0	2.7
	60	75	28	11	6.9	4.5
	120	194	65	26	18	12

Stream	Daily flow (cfs), which was equaled or exceeded for indicated percentage of time								
	99	95	90	80	60	40	20	5	1
Arkansas River at Little Rock, Ark	1,410	2,850	4,540	7,450	15,000	28,000	62,000	155,000	280,000
Saline River at Benton, Ark	2.3	12	23	44	118	328	890	3,500	11,400

The minimum average flow for 7 consecutive days that is expected to occur once each 2 years (2-year recurrence interval) is considered to be a good index of the stream's low-flow character, and thus it is a measure of the stream's ability to meet a required water need.

This streamflow statistic is referred to as the 7-day, 2-year low flow. On the streams investigated in Pulaski and Saline Counties, the 7-day, 2-year low flow is available 90–95 percent of the time. For example, the 7-day, 2-year low flow of the Arkansas River at Little Rock is 4,100 cfs (table 2), and it will be equaled or exceeded more than 90 percent of the time.

Some water-supply studies are concerned with minimum average flows for several different periods of time and recurrence intervals. In addition, the complete range of daily-flow duration is useful for comparison of physical differences between streams. Therefore, average flows for arbitrary periods from 7 to 120 days with recurrence intervals from 1.2 to 20 years and selected flow-duration values from 1 to 95 percent are shown in table 2.

Upstream reservoirs that are proposed or under construction (1965) on the Arkansas River will affect the flow at Little Rock to the extent that minimum flows will be increased about 50 percent, and maximum flows will be reduced. At present (1965), the average annual flow in the Saline River at Benton is reduced about 30—35 cfs by diversion from Lake Winona to the Little Rock water system, and about 2.0 cfs by diversion from the stream to the Benton water system. Lake Winona, supplied by runoff from 43.5 sq. mi. of the Alum Fork watershed, and Lake Norrell, supplied by runoff from about 5 sq. mi. of the North Fork watershed, have only minor effects on maximum and minimum flow of the Saline River at Benton. However, water released from Lake Norrell increases the flow at Benton considerably during dry periods.

Low-flow-frequency and flow-duration information, based on discharge measurements, has been estimated for nine tributary streams in the interior Highlands and is summarized in table 3. The data for these sites show the variation in low flow between streams and direct attention to areas where streams are suitable for water supply. Table 3 shows that the average flow of Middle Fork at Crows is about 150 cfs, the 7-day, 2-year low flow is 3.6 cfs, and 90 percent of the time the flow will be at least 6.4 cfs.

Although many of the Interior Highland streams have dependable water supplies without storage, the amount of water available could be increased considerably by the construction of reservoirs. The topography in the highlands is suitable for reservoir construction as shown by Lakes Norell, Winona, and Maumelle, which have total capacities of 6,600, 43,000, and 208,000 acre-feet, respectively. The U.S. Army Corps of Engineers has recommended a multipurpose reservoir at Benton to provide flood control, water supply, and recreation, with basic facilities for future power installation. The proposed reservoir would have a capacity of 979,900 acre-feet at the flood-control pool altitude of 385.0 feet above mean sea level. The

TABLE 3.—*Water-supply characteristics of tributary streams*

Map No.	Station name	Tributary to—	Drainage area (sq mi)	Estimated Flow (cfs)			Remarks
				Average	7-day, 2-year	90-percent duration	
			Arkansas River basin				
1	Nowlin Creek near Pinnacle	Little Maumelle River	[1] 13	15	0.01	0.03	Drains Pulaski County game refuge. Without storage is useful for as much as 0.02 cfs.
2	Little Maumelle River at Maumelle.	Arkansas River	[1] 80	110	1.2	3.3	Flow of spring-fed upper tributaries consumed by evapotranspiration and seepage during dry periods.
4	Brodie Creek at Little Rock	Fourche Creek	[1] 9	10	0	0	Do.
5	Fourche Creek at Little Rock.	Arkansas River	162	220	.2	.8	Flow affected by urban development. Not suitable for most water supplies.
6	Kellogg Creek near Jacksonville.	Bayou Meto	[1] 18	25	0	0	Ground-water inflow sufficient for evapotranspiration. Irrigation and livestock supplies available from large pools.
			Saline River basin				
7	Alum Fork at Crows	Saline River	123	[2] 106	[2] 1.2	[2] 2.5	Based on yield of Lake Winona, 55–65 cfs available at Crows with storage of 80,000 acre-ft.
8	Middle Fork at Crows	Alum Fork	109	150	3.6	6.4	Based on yield of Lake Winona, 75–90 cfs available at Crows with storage of 110,000 acre-ft.
10	South Fork near Nance	do	[1] 115	150	1.3	2.1	Spring fed by tributaries in Garland County. Minimum flow at least 1.3 cfs since 1957.
11	North Fork at Paron	Saline River	[1] 23	30	0	0	Frequently recedes to no flow.
12	North Fork near Benton	do	132	[3] 170	[3] .7	[3] 1.8	Based on yield of proposed reservoir at Benton, 110 cfs available with storage of about 158,000 acre-ft.
14	Hurricane Creek near Sardis	do	66.1	90	[4] 1.0	[4] 1.8	Perennial flow is effluent from alumina processing. Poor-quality water.

[1] Estimated
[2] Affected by regulation at Lake Winona.
[3] Affected by regulation at Lake Norrell.
[4] Regulated.

NOTE.—1 cfs for 1 day = 646,317 gallons.

portion of storage allocated to water supply by the Corps of Engineers is sufficient to yield 300 mgd (million gallons per day), which has been estimated to be the ultimate need for municipal and industrial uses and stream-quality maintenance in the vicinity of Benton.

The following discussion of the chemical quality of surface water, although categorized under "Interior Highlands," applies equally to the Coastal Plain. The water samples were taken at or near the boundary between the highlands and the plains, and no significant change in water quality is expected to occur with the debouchment of the streams onto the plain.

Quality of water, Arkansas River.—Because the quality of the Arkansas River water varies considerably with time, only the extremes of certain selected constituents and properties are discussed. Daily samples of the river water at Little Rock have been taken since October 1945 to determine conductance and chloride content. These samples are composited for a period of 1–30 days, according to the conductance, and partial or complete analyses are then made on the composites. These analyses are found in the U.S. Geological Survey Water-Supply Papers dealing with quality of surface waters, given in the list of references.

Extremes at Little Rock between 1945 and 1964 were as follows:

Dissolved solids: Maximum, 2,400 ppm (parts per million) Nov. 28–29, 1953; minimum, 105 ppm Mar. 3, 1957.

Hardness: Maximum, 556 ppm Nov. 28–29, 1953; minimum, 46 ppm Feb. 2–4, 9, 12–18, 1957, and Mar. 9–26, 1964.

Specific conductance: Maximum, 5,050 micromhos Apr. 8, 1954; minimum, 173 micromhos Feb. 4, 1957, and Nov. 20, 1958.

Water temperature: Maximum, 98°F Aug. 16, 1954, and July 5, 1956; minimum, the freezing point on several days during December, January, and February of some years.

Arkansas River water is predominantly of the sodium chloride type (sodium and chloride are the dominant dissolved chemical constituents), and is characterized by wide variations of dissolved-solids and sediment content, in both time and place. The current multipurpose project, by the U.S. Army Corps of Engineers, for improvement of the Arkansas River and its tributaries in Arkansas and Oklahoma should reduce considerably the day-to-day fluctuations in dissolved-solids and sediment content.

Quality of water, Saline River.—Chemical analyses of Saline River water near Benton are available for the period October 1949–September 1953. They are tabulated in U.S. Geological Survey Water-Supply Papers 1188, 1199, 1252, and 1292.

Saline River water is of the calcium bicarbonate type. Extremes between October 1949 and September 1953 were as follows:

Dissolved solids: Maximum, 96 ppm Nov. 1–10, 1950; minimum, 29 ppm Mar. 12–14, 1950.

Hardness: Maximum, 74 ppm Oct. 21–31, 1950; minimum, 22 ppm, Mar. 12–14, 1950.

Specific conductance: Maximum, 204 micromhos Apr. 11, 1953; minimum 31.9 micromhos Feb. 13, 1950.

Water temperatures: Maximum, 91°F July 2–3, 1952: minimum, freezing point Dec. 16, 1949, Jan. 5, 1950, Jan. 30–31, Feb. 4, 1951.

GROUND WATER AND ITS QUALITY

Ground water in the Interior Highlands is obtained from a thick sequence of sandstone, shale, slate, chert, and novaculite (unit 1, pl. 1). The type of opening in which water occurs varies according to whether the opening is in the zone of alternate wetting and drying or in the zone of saturation. The lowest level of the water table separates these zones. Weathering has altered the rock above the water table to soil and "rotten rock," which together attain a maximum thickness of about 20 feet. The materials in the weathered zone are more porous and permeable than the original unweathered rock, and water occurs between the individual soil particles. Weathering has not affected the rock below the water table, and ground water occurs in secondary openings such as joints, fractures, and solution channels.

Ground water moves in the direction of slope of the water table. In the weathered zone this slope generally follows the topography. In the unweathered zone the slope of the water table is controlled mainly by geologic structure, and ground water generally moves toward the synclinal axes and away from the anticlinal axes.

Permeabilities are relatively low in the rocks of unit 1. Wells drilled into these rocks seldom yield more than 5–10 gpm (gallons per minute). However, wells in the highly shattered cherts have yielded as much as 200 gpm at some locations in adjoining Garland County. Generally, wells in the rocks of unit 1 are less than 150 feet deep. Water levels in the wells range from at or near land surface to about 85 feet below land surface. Maximum water-level fluctuations normally do not exceed 10–20 feet during a given year, although the levels in certain wells may fluctuate as much as 80 feet in a 6-month period.

Several factors control the depth to water in unit 1. Precipitation has a direct effect, in that periods of heavy rainfall are accompanied by corresponding decreases in depth to water. Conversely, dry periods are coincident with increases in depth to water. Depth to water is generally directly related to the topography of the area. Depth to water is greater in wells on the crests or slopes of ridges than in those in the nearby valleys.

Water from wells in the rocks of unit 1 may vary from a bicarbonate to a sulfate type. In 13 samples iron concentrations ranged from 0.01 to 0.74 ppm, dissolved solids from 72 to 414 ppm, and hardness from 12 to 330 ppm.

WATER-SUPPLY POSSIBILITIES IN THE COASTAL PLAIN

SURFACE WATER AND ITS QUALITY

The water-supply potential of streams flowing out of the Interior Highlands does not improve as the streams traverse the Coastal Plain. Tributary stream channels in the Coastal Plain are not sufficiently incised to intersect the ground-water table, precluding the possibility of a ground-water contribution to low flows. Minimum flows of the Arkansas and Saline Rivers, however, are increased slightly by ground-water inflow in the Coastal Plain, but the increase is assumed to be a small percentage of the total flow and therefore does not significantly change water quality or flow characteristics.

Low-flow-frequency and flow-duration information for the Arkansas and Saline Rivers, shown in table 2, is applicable to those parts of the streams in the Coastal Plain of Pulaski and Saline Counties. Estimates of water-supply characteristics for two tributary streams (sites 5 and 14, pl. 1) in the Coastal Plain are shown in table 3. This table shows that the average flow of Hurricane Creek at Sardis is 90 cfs, the 7-day, 2-year low flow is 1.0 cfs, and 90 percent of the time the flow will be at least 1.8 cfs. However, minimum flows in Hurricane Creek at Sardis represent effluent from an alumina processing plant, which is supplied with water from Hurricane Lake. The data are useful as an indicator of the water supply available when storage is provided.

Without storage facilities, most Pulaski and Saline County streams that originate in the Coastal Plain are without dependable water supplies and cease to flow during dry periods. Storage on most tributary streams in the Coastal Plain is limited to inchannel facilities. The flat topography is unsuitable for large reservoirs except for the main stem of the Saline River, which follows a pronounced depression about 2 miles wide and about 50 feet lower than the adjacent terraces.

GROUND WATER AND ITS QUALITY

Although nine geologic units are exposed in the Coastal Plain part of the report area (pl. 1, table 1), only three—units 3, 7, and 9—are of major importance as sources of water. Unit 2, which consists of granitic-type igneous rocks, does not yield water to wells. Unit 4, a dark-bluish-gray to black clay, also does not yield water to wells. Units 4A, 5, and 8 consist of materials that are too fine grained to be good sources of water. Wells in units 4A, 5, and 8 will yield only very small quantities of water at best. Unit 6 varies considerably in lithology, both horizontally and vertically. Although the upper sand yields water to shallow wells, drillers report difficulty in obtaining even domestic supplies in those areas where the dark-chocolate-brown clays in unit 6 are close to the surface.

One note of caution is advocated. Some of the analyses of water from wells in unit 6 (table 5) show a rather high concentration of nitrate (over 45 ppm). Seepage into the wells from the surface probably causes the high nitrate content. Water with nitrate concentrations greater than about 45 ppm may be harmful to infants, because it could result in methemoglobinemia, the so-called "blue-baby" disease. Proper curbing and well sealing near the surface would prevent contamination by seepage from the surface.

Unit 3, one of the three major aquifers, consists mainly of intergrading and interfingering beds of claystone, calcareous sandstone, sandy limestone, marl, and conglomerate—in that order of abundance—and includes minor beds of arkose, kaolin, and lignite (Gordon and others, 1958, p. 14). Where this unit is exposed at the surface, its measured thickness ranges from 7½ to nearly 60 feet. At depth the unit is thin or locally absent along the flanks of buried hills of igneous rock (pl. 1). The unit thickens rapidly eastward and attains a maximum known thickness of 185 feet. Very little is known about unit 3 in extreme eastern Pulaski County (pl. 1). However, it should not be overlooked as a possible source of supply in this area if suitable water is not obtained at shallower depths.

The sandstone and sandy limestone of unit 3 offer good prospects for water. Well yields as great as 350 gpm have been reported. A 40-gpm well near Mabelvale, T. 1 S., R. 13 W., had a reported drawdown of 6–7 feet, giving a specific capacity of approximately 6 gpm per foot of drawdown. A number of wells have been developed in the Mabelvale-Vimy Ridge-Bauxite area. Water levels in these wells range from 11 to 86 feet below land surface.

Wells developed in the arkose and conglomerate beds of unit 3 sometimes flow. One domestic well flowed 10 gpm when drilled. These beds are best developed near the upslope lip of the unit, particularly along the slopes of buried hills of igneous rock.

Wells in unit 3 yield a sodium bicarbonate water in some areas, and a calcium bicarbonate water in others, with no predictable pattern of occurrence. In six samples iron concentrations ranged from 0 to 0.3 ppm, dissolved solids from 178 to 426 ppm, and hardness from 57 to 154 ppm.

Unit 7, the second of the three major aquifers, consists of a homogeneous tan or gray fine to medium, loosely packed sand, containing some interbedded gray clay lenses. A conspicuous lignite bed is present locally at the base. The thickness of this unit ranges from 207 to 412 feet and averages 320 feet (Gordon and others, 1958, p. 56).

Hydrologic data are lacking for unit 7. The outcrop area is sparsely populated, and the aquifer is tapped by only a few shallow domestic wells in the Sardis area. These wells are designed to yield no more than 8–10 gpm, and little information as to the potential yield of the aquifer can be obtained from them. However, two wells at Sheridan, about 12 miles south of the Saline-Grant County line, yield 600 and 860 gpm, respectively, from this unit. The yields of these wells suggest that the unit should be capable of yielding large quantities of water in the outcrop area and in the subsurface to the southeast (pl. 1).

Yields in the project area are highest from wells drilled in unit 9. This unit consists of terrace deposits and alluvium. The terrace deposits consist of a maximum thickness of about 60 feet of dark-brick- to salmon-red clay, containing a variable amount of fine silt that grades locally into sand. The sand is common toward the top of the unit. Although not differentiated in plate 1, the terrace deposits border the highlands north of the Arkansas River. South and west of the Arkansas River, the eastern limit of these deposits extends south from College Station and approximately coincides with U.S. Highway 65. The western limit is the contact with units 6 and 8. South and west of the river, wells in the terrace deposits yield little water.

The alluvium consists of a relatively thick sequence of fluvial deposits which cover the eastern part of the project area, exclusive of the terrace deposits. The alluvium was deposited by the Arkansas and Mississippi Rivers, and it blankets much of the eastern half of Arkansas and adjacent States. It also includes the flood-plain deposits of the Saline River, Fourche Creek, and the Arkansas River northwest of Little Rock (pl. 1).

The predominant characteristic of the alluvium is the change from gravel or coarse sand at the base, to fine material at the top. The alluvium may generally be divided into two parts: a lower part consisting of gravel and sand with minor amounts of silt and clay, and an upper part consisting of silt and clay with minor amounts of sand. The alluvium attains a maximum thickness of 120 feet in eastern Pulaski County but is much thinner along the Saline River, Fourche Creek, and the Arkansas River northwest of Little Rock.

Well yields as high as 1,000 gpm have been reported from the basal sands and gravels of unit 9 in the Coastal Plain part of the project area, and wells may yield 2,000 gpm in some areas. However, such high yields are not available from the alluvium of Fourche Creek and of the Saline River because those deposits are too thin (generally less than 30 ft.) and too fine grained.

Northwest of Little Rock, well yields ranging from 300 to 700 gpm are obtainable from the alluvium deposited by the Arkansas River (Bedinger and others, 1963, p. L27).

Depths to water in wells in the alluvium deposited by the Arkansas River range from 5 to 35 feet below land surface northwest of Little

Rock. Annual fluctuations of water levels rarely exceed 20 feet. The water levels generally respond to changes in river stage, rising and falling with the river. However, the effect of changes in river stage on ground-water levels diminishes with increasing distance from the river (Bedinger and others, 1963, p. L13).

In eastern Pulaski County and in a small area in southeastern Saline County, depths to water in the alluvium range from 10 to 40 feet. Annual fluctuations of levels seldom exceed 10 feet and are caused by seasonal changes in pumpage and by variations in the rates of recharge from precipitation and discharge by evapotranspiration. Water levels normally begin to decline in late spring, reach their lowest point in the late summer or early fall, and rise to their highest point in the spring.

Wells in unit 9 yield a calcium bicarbonate-type water whose dissolved-mineral constituents and physical properties vary greatly. Iron concentrations in 90 samples ranged from 0.1 to 52 ppm, dissolved solids in 3 samples from 242 to 327 ppm, and hardness in 76 samples from 6 to 505 ppm.

CONCLUSIONS

Alum Fork, Middle Fork, and North Fork of the Saline River offer excellent impoundment possibilities. Alum Fork at Crows will yield 55–65 cfs with storage of 80,000 acre-feet; Middle Fork at Crows will yield 75–90 cfs with storage of 110,000 acre-feet; and North Fork at Benton will yield 110 cfs with storage of 158,000 acre-feet. However, the ultimate development of the Saline River is the proposed dam at Benton, which would yield 465 cfs for water-supply purposes. Most of the smaller streams in the Interior Highlands part of the study area generally go dry in midsummer, but with storage they would be suitable for development of small surface-water supplies. The Arkansas River with a 7-day, 2-year flow of 4,100 cfs, or more than 2.5 billion gallons per day, is sufficient for any foreseeable development in areas accessible to the river.

Ground-water yields in the project area vary considerably. The consolidated rocks of the Interior Highlands generally yield less than 10 gpm of water to wells, although larger amounts may be obtained locally. In the Coastal Plain part of the area, the limestone and sandstone of unit 3, the sand of unit 7, and the basal sand and gravel of unit 9 offer the best possibilities for water. Wells in unit 3 yield as much as 350 gpm, and unit 7 could probably yield large amounts of water. Maximum yields of unit 7 in the project area are unknown, although yields of as much as 860 gpm are reported 12 miles south of the area. Yields from wells in unit 9 range from 300 to 700 gpm in the Arkansas River valley northwest of Little Rock to 2,000 gpm in eastern Pulaski County. Prospects of obtaining water from the alluvium deposited by the Saline River and Fourche Creek are poor.

SELECTED REFERENCES

Albin, D. R., 1965, Water-resources reconnaissance of the Ouachita Mountains, Arkansas: U.S. Geol. Survey Water-Supply Paper 1809–J, p. J1–J14.

Arkansas Geological Survey, 1929, Geologic map of Arkansas: scale 1:500,000.

——— 1937, List of Arkansas water wells: Arkansas Geol. Survey Inf. Circ. 11, 142 p.

Bedinger, M. S., 1961, Relation between median grain size and permeability in the Arkansas River valley *in* Short Papers in the Geological and Hydrological Sciences: U.S. Geol. Survey Prof. Paper 424–C, p. C31–C32.

Bedinger, M. S., Emmett, L. F., and Jeffery, H. G., 1963, Groundwater potential of the alluvium of the Arkansas River between Little Rock and Fort Smith, Ark.: U.S. Geol. Survey Water-Supply Paper 1669–L, p. L1–L29.

Bedinger, M. S., and Jeffery, H. G., 1963, Ground water in the lower Arkansas River valley: U.S. Geol. Survey Water-Supply Paper 1669–V, p. V1–V17.

Bramlette, M. N., 1936, Geology of the Arkansas bauxite region: Arkansas Geol. Survey Inf. Circ. 8, 68 p.

California State Water Pollution Control Board, 1952, Water quality criteria: California State Water Pollution Control Board Pub. 3.

Caplan, W. M., 1954, Subsurface geology and related oil and gas possibilities of northeastern Arkansas: Arkansas Resources and Devel. Comm., Div. Geol. Bull. 20, 124 p.

Corbin, M. W., and Heyl, G. R., 1941, Tertiary limestones of Pulaski and Saline Counties: Arkansas Geol. and Conserv. Comm. Inf. Circ. 13, 28 p.

Cordova, R. M., 1963, Reconnaissance of the Arkansas River valley province: U.S. Geol. Survey Water-Supply Paper 1669–BB, p. BB1–BB33.

Croneis, Carey, 1930, The geology of the Arkansas Paleozoic area with especial reference to oil and gas possibilities: Arkansas Geol. Survey Bull. 3, 457 p.

Cushing, E. M., Boswell, E. H., and Hosman, R. L., 1964, General geology of the Mississippi embayment: U.S. Geol. Survey Prof. Paper 448–B, p. B1–B28.

Geurin, J. W., and Jeffery, H. G., 1957, Chemical quality of surface waters of Arkansas, 1945–1955, a summary: Arkansas Univ. Eng. Expt. Sta. Bull. 25, 79 p.

Gordon, Mackenzie, Jr., Tracey, J. I., Jr., and Ellis, M. W., 1958, Geology of the Arkansas bauxite region: U.S. Geol. Survey Prof. Paper 299, 268 p.

Hines, M. S., 1965, Water-supply characteristics of selected Arkansas streams: Arkansas Geol. Comm. Water Resources Circ. 9, 43 p.

Meinzer, O. E., 1923, The occurrence of ground water in the United States, with a discussion of principles: U.S. Geol. Survey Water-Supply Paper 489, 321 p.

Patterson, J. L., 1964, Magnitude and frequency of floods in the United States, part 7, lower Mississippi River Basin: U.S. Geol. Survey Water-Supply Paper 1681, 636 p.

Plebuch, R. O., 1962, Ground-Water temperatures in the Coastal Plain of Arkansas: Arkansas Geol. and Conserv. Comm., Water Resources Summ. 2.

Purdue, A. H., 1905, Water resources of the contact region between the Paleozoic and Mississippi embayment deposits in northern Arkansas: U.S. Geol. Survey Water-Supply Paper 145, p. 88–119.

Spooner, W. C., 1935, Oil and gas geology of the Gulf Coastal Plain in Arkansas: Arkansas Geol. Survey Bull. 2, 516 p.

Stephenson, L. W., and Crider, A. F., 1916, Geology and ground waters of northeastern Arkansas: U.S. Geol. Survey Water-Supply Paper 399, 315 p.

U.S. Geological Survey, issued annually, Surface-water supply of the United States, part 7, lower Mississippi River Basin in 1899–1960: U.S. Geol. Survey Water-Supply Papers 37, 50, 65, 66, 75, 83, 84, 98, 99, 128, 131, 169, 173, 205, 209, 247, 267, 287, 307, 327, 357, 387, 407, 437, 457, 477, 507, 527, 547, 567, 587, 607, 627, 647, 667, 587, 702, 717, 732, 747, 762, 787, 807, 827, 857, 877, 897, 927, 957, 977, 1007, 1037, 1057, 1087, 1117, 1147, 1177, 1211, 1241, 1281, 1341, 1391, 1441, 1511, 1561, 1631, 1711.

——— 1941–1962, issued annually, Quality of surface waters of the United States: U.S. Geol. Survey Water-Supply Papers 942, 950, 970, 1022, 1030, 1950, 1102, 1133, 1163, 1188, 1199, 1252, 1292, 1352, 1402, 1452, 1522, 1573, 1644, 1744, 1884, 1944.

——— 1955, Compilation of records of surface waters of the United States through September 1950: part 7, lower Mississippi River Basin: U.S. Geol. Survey Water-Supply Paper 1311, 606 p.

——— 1964, Compilation of records of surface waters of the United States, October 1950 to September 1960, part 7, lower Mississippi River Basin: U.S. Geol. Survey Water-Supply Paper 1731, 552 p.

Veatch, A. C., 1906, Geology and underground water resources of northern Louisiana and southern Arkansas: U.S. Geol. Survey Prof. Paper 46, 422 p.

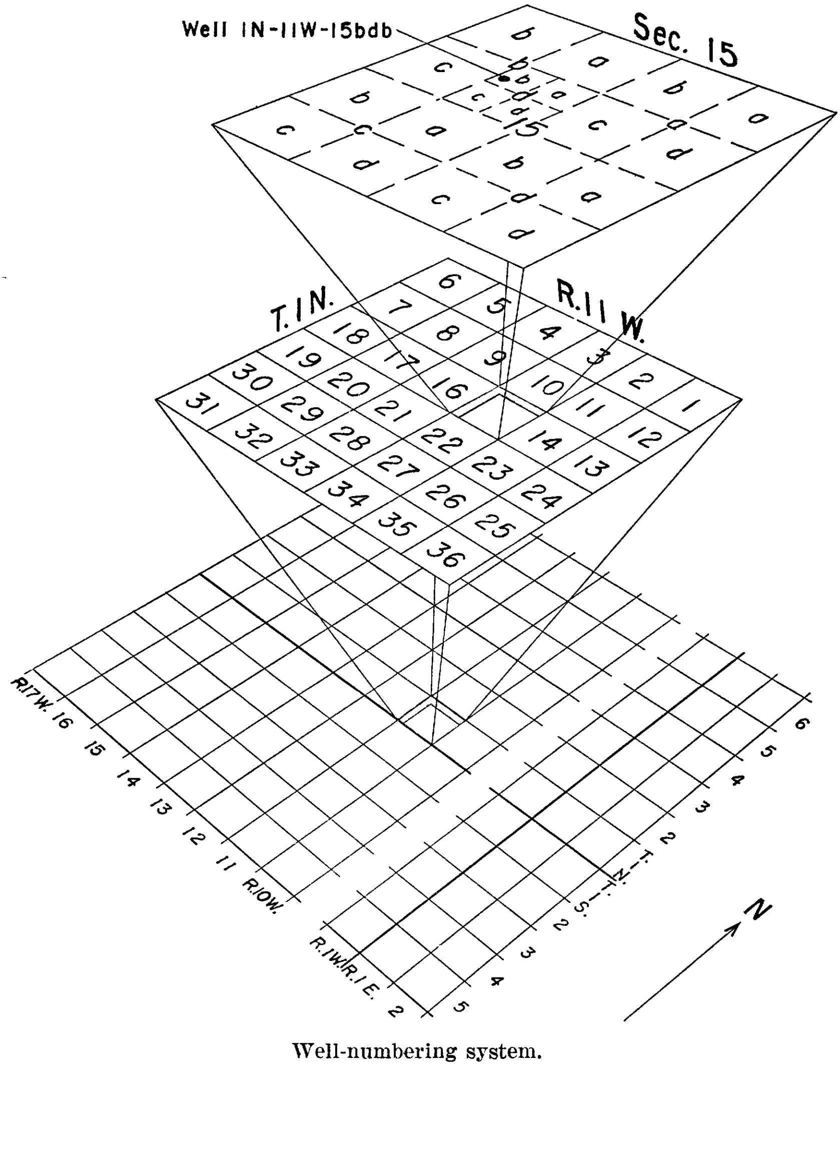
BASIC DATA

TABLE 4.—*Significance of dissolved mineral constituents and physical properties of natural waters*

Constituent or physical property	Source or cause	Significance
Silica (SiO_2)	Dissolved from almost all rocks and soils, generally in small amounts from 1 to 30 ppm. High concentrations, as much as 100 ppm, generally occur in highly alkaline waters.	Forms hard scale in pipes and boilers. Carried in steam of high pressure boilers to form deposits on blades of steam turbines. Inhibits deterioration of zeolite-type water softeners.
Iron (Fe)	Dissolved from almost all rocks and soils. May also be derived from iron pipes, pumps, and other equipment. More than 1 or 2 ppm of soluble iron in surface waters generally indicates acid wastes from mine drainage or other sources.	On exposure to air, iron in ground water oxidizes to reddish-brown sediment. More than about 0.3 ppm stains laundry and utensils reddish brown. Objectionable for food processing, beverages, dyeing, bleaching, ice manufacture, brewing, and other processes. U.S. Public Health Service drinking water standards recommend that iron should not exceed 0.3 ppm. Larger quantities cause unpleasant taste and favor growth of iron bacteria.
Manganese (Mn)	Dissolved from some rocks and soils. Not as common as iron. Large quantities commonly associated with high iron content and with acid waters.	Same objectionable features as iron. Causes dark-brown or black stain. U.S. Public Health Service drinking water standards recommend that manganese should not exceed 0.05 ppm.
Calcium (Ca) and magnesium (Mg).	Dissolved from almost all soils and rocks but especially from limestone, dolomite, and gypsum. Calcium and magnesium are found in large quantities in some brines. Magnesium is present in large quantities in sea water.	Causes most of the hardness and scale-forming properties of water; soap consuming (see hardness). Waters low in calcium and magnesium are desired in electroplating, tanning, dyeing, and in textile manufacturing.
Sodium (Na) and potassium (K).	Dissolved from almost all rocks and soils. Found also in ancient brines, sea water, some industrial brines, and sewage.	Large amounts, in combination with chloride, give a salty taste. High sodium content commonly limits use of water for irrigation. Sodium salts may cause foaming in steam boilers.
Bicarbonate (HCO_3) and carbonate (CO_3).	Action of carbon dioxide in water on carbonate rocks such as limestone and dolomite.	Bicarbonate and carbonate produce alkalinity. Bicarbonates of calcium and magnesium decompose in steam boilers and hot-water facilities to form scale and release corrosive carbon dioxide gas. In combination with calcium and magnesium cause carbonate hardness.
Sulfate (SO_4)	Dissolved from rocks and soils containing gypsum, iron sulfides, and other sulfur compounds. Commonly present in mine waters and in some industrial wastes.	Large amounts have a laxative effect on some people and, in combination with other ions, give a bitter taste. Sulfate in water containing calcium forms a hard scale in steam boilers. U.S. Public Health Service drinking water standards recommend that the sulfate content should not exceed 250 ppm.
Chloride (Cl)	Dissolved from rocks and soils. Present in sewage and found in large amounts in ancient brines, sea water, and industrial brines.	Large quantities increase the corrosiveness of water and, in combination with sodium, give salty taste. U.S. Public Health Service drinking water standards recommend that the chloride content should not exceed 250 ppm.

TABLE 4.—*Significance of dissolved mineral constituents and physical properties of natural waters*—Continued

Constituent or physical property	Source or cause	Significance
Fluoride (F)	Dissolved in small to minute quantities from most rocks and soils.	Fluoride in drinking water reduces the incidence of tooth decay when the water is consumed during the period of enamel calcification. However, it may cause mottling of the teeth depending on the concentration of fluoride, the age of the child, the amount of drinking water consumed, and the susceptibility of the individual. The maximum concentration of fluoride recommended by the U.S. Public Health Service for Arkansas is about 1.2 ppm; 0.9 ppm is considered to be the optimum concentration.
Nitrate (NO_3)	Decaying organic matter, legume plants, sewage, nitrate fertilizers, and nitrates in soil.	Nitrate encourages growth of algae and other organisms that produce undesirable tastes and odors. Concentrations much greater than the local average may suggest pollution. U.S. Public Health Service drinking water standards recommend that nitrate content should not exceed 45 ppm, as there is evidence that higher concentrations may cause methemoglobinemia in infants, the so-called "blue-baby" disease, that sometimes is fatal. Nitrate has shown to be helpful in reducing intercrystalline cracking of boiler steel.
Dissolved solids	Chiefly mineral constituents dissolved from rocks and soils. Includes any organic matter and some water of crystallization.	U.S. Public Health Service drinking water standards recommend that the dissolved solids should not exceed 500 ppm. Waters containing more than 1,000 ppm of dissolved solids are unsuitable for many purposes.
Hardness as $CaCO_3$	In most waters nearly all the hardness is due to calcium and magnesium. All the metallic cations other than the alkali metals also cause hardness.	Consumes soap before a lather will form, and deposits soap curd on bathtubs. Hard water forms scale in boilers, water heaters, and pipes. Hardness equivalent to the bicarbonate and carbonate is called carbonate hardness. Any hardness in excess of this is called noncarbonate hardness. In general, waters of hardness up to 60 ppm are considered soft; 61 to 120 ppm, moderately hard; 121 to 180 ppm, hard; more than 180 ppm very hard.
Percent sodium and sodium-adsorption-ratio.	See sodium	Values for these properties are used with specific conductance values to determine the suitability of water for irrigation use.
Specific conductance (micromhos at 25°C).	Mineral content of the water.	Specific conductance is a measure of the capacity of water to conduct an electric current. This property varies with concentration and degree of ionization of the constituents, and with temperature (therefore reported at 25°C).
Hydrogen-ion concentration (pH).	Acids, acid-generating salts, and free carbon dioxide lower the pH. Carbonates, bicarbonates, hydroxides, phosphates, silicates, and borates raise the pH.	A pH of 7.0 indicates neutrality of a solution. Higher values denote increasing alkalinity; lower values, increasing acidity. pH is a measure of the activity of the hydrogen ions. Corrosiveness of water generally increases with decreasing pH. However, excessively alkaline waters may also attack metals.
Temperature		Affects usefulness of water for many purposes. Most users desire water of uniformly low temperature. In general, temperature of shallow ground water shows some seasonal fluctuation, whereas temperature of ground water from moderate depths remains near the mean annual air temperature of the area. In very deep wells, water temperature generally increases about 1°F for each 60-ft increment of depth.



Well-numbering system.

TABLE 5.—*Chemical analyses of water from selected wells in Pulaski and Saline Counties, Ark.*

[Chemical constituents in parts per million except as indicated]

Well	Date of collection	Temperature (°F)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Sodium-adsorption-ratio	Specific conductance (micromhos at 25° C)	pH
Unit 1																						
1N-13W- 9baa	1-17-63	------	5.6	0.08	0	2.3	9.7	8	0.3	39	0	11	15	0.2	0.3	72	45	14	28	1.2	134	6.9
1N-15W-36cbb	10-22-62	------	------	.10	0.0	6.0	3.7	16	6.4	31	0.0	15	14	.2	18	95	30	4	48	1.3	165	7.2
1N-16W-35bcd	8-25-64	60.5	11	.37	0	56	8.9	3	.1	180	0	22	10	.4	.9	201	176	28	------	------	323	7.9
1N-17W-13ddd	1-14-63	------	7.8	.11	.1	11	27	18	1.1	63	0	97	15	.6	.3	209	138	87	22	.7	332	6.5
2N-17W-22acb	8-25-64	------	8.4	.44	.4	6.4	5.8	82	2	244	0	5.8	4.6	.4	.8	237	40	0	------	------	392	8.1
3N-15W-35aac	1-14-63	------	5.9	.08	0	14	29	17	.9	202	0	5.8	14	.1	1.2	187	154	0	19	.6	321	8.0
1S-13W- 9aab	1- 7-54	------	------	.74	------	120	7.2	9.8	------	283	------	88	15	------	0	414	330	98	------	------	------	7.5
1S-14W-14aaa2	3-31-59	66	------	.44	------	61	13	8.6	2.5	244	0	15	10	.5	.4	259	206	6	8	------	421	7.3
15bda [1]	9- 5-61	------	------	.62	------	89	12	4.2	------	264	------	74	6.5	.08	.09	341	322	106	------	------	------	6.6
24daa [1]	9-28-56	------	------	2.10	------	45	1.3	15	------	178	------	2	24	.3	0	229	164	18	------	------	------	7.2
2S-15W-29ddd	3-14-63	64	8.9	.16	.05	17	4.9	71	3.7	220	0	1.2	31	.6	.1	247	62	0	------	------	426	7.7
3S-15W-18daa	3-28-63	69	10	.01	.04	4.7	.7	123	1.8	312	0	1.6	20	1.3	.1	317	14	0	------	------	523	7.9
29aba	4-19-63	70.5	10	.11	0	3.7	.8	140	1.2	262	1	0	68	.8	.4	355	12	0	------	------	615	8.3
Unit 3																						
1S-13W-22baa	4-17-63	66.5	12	0.30	0	40	13	7.4	3.1	188	0	8.6	7.4	.2	0.1	184	154	0	------	------	318	8.1
1S-14W-34bda	4-12-63	64	7.8	0	0	40	12	34	8.8	254	0	11	7	.5	0	246	150	0	------	------	396	7.6
34bdd	5-22-63	64	16	.01	0	19	13	35	9	188	6	7.6	12	.4	2.6	213	101	0	------	------	352	8.5
2S-14W-10abd	6-25-63	64	16	.03	0	23	11	126	8	254	2	14	97	4.7	0	426	103	0	------	------	752	8.4
2S-15W-32dca	3-14-63	------	8.9	.07	.05	16	4.1	70	3.6	218	0	1.2	29	.5	.1	241	57	0	------	------	415	7.8
3S-15W- 5cba	4-24-63	62	9.1	.14	0	27	9	26	4.2	179	4	0	9.6	.4	.2	178	105	0	------	------	304	8.4

See footnote at end of table.

TABLE 5.—*Chemical analyses of water from selected wells in Pulaski and Saline Counties, Ark.*—Continued

Well	Date of collection	Temperature (°F)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Sodium-adsorption-ratio	Specific conductance (micromhos at 25° C)	pH
Unit 6																						
1N-11W-35C	3-9-64	62	------	1.4	------	92	24	27	1.7	410	0	15	18	------	0.4	395	328	0	------	------	698	6.9
1S-12W-15bcd	4-22-63	65	------	.78	------	3	1.2	2.7	1.4	15	0	4.8	4.4	------	0	42	12	0	------	------	53	7.0
1S-14W-34acc	11-20-53	64	------	.95	------	------	------	------	------	10	0	18	58	------	2.5	------	21	13	------	------	224	6.9
34cad	11-20-53	63	------	.29	------	------	------	------	------	6	0	14	7.2	------	3.4	------	4	0	------	------	63	6.7
34dcb	11-20-53	61	------	1.1	------	------	------	------	------	2	0	16	63	------	72	------	64	62	------	------	387	5.0
35bcc	11-20-53	61	------	.67	------	------	------	------	------	65	0	15	4.2	------	2.6	------	62	9	------	------	155	7.8
35bdb	11-20-53	------	------	9.3	------	------	------	------	------	0	0	1	30	------	90	------	48	48	------	------	298	4.3
2S-12W-18abb	6-26-63	62.5	------	.12	------	1.2	.8	1	.6	5	0	0	2	0	3.4	21	6	2	------	------	26	5.4
2S-13W-7bbc	3-29-54	------	------	.21	------	------	------	------	------	9	0	4	4.5	------	1.4	------	7	0	------	------	39	6.2
7bdd	3-29-54	------	------	.06	------	------	------	------	------	72	0	9	5	------	6.4	------	63	4	------	------	168	7.8
17acc	3-29-54	------	------	.05	------	------	------	------	------	16	0	1	10	------	12	------	27	14	------	------	89	7.2
17bca	3-30-54	------	------	.14	------	------	------	------	------	24	0	2	3.5	------	1.8	------	21	1	------	------	59	7.3
18ada	3-30-54	------	------	.06	------	------	------	------	------	5	0	2	3.2	------	5.2	------	7	3	------	------	34	6.3
19dda	3-30-54	------	------	.10	------	------	------	------	------	3	0	5	4	------	3	------	6	4	------	------	43	5.0
20ada	3-29-54	------	------	.25	------	------	------	------	------	76	0	9	44	------	38	------	82	20	------	------	392	7.8
20daa	3-29-54	------	------	.43	------	------	------	------	------	75	0	52	8	------	11	------	113	51	------	------	265	7.5
20dad	3-29-54	------	------	.24	------	------	------	------	------	69	0	5	36	------	17	------	68	11	------	------	280	7.3
2S-14W-1cdd	3-29-54	------	------	4.2	------	------	------	------	------	18	0	2	9	------	1.9	------	12	0	------	------	69	7.0
3aba	11-20-53	62	------	.12	------	------	------	------	------	3	0	15	32	------	6.8	------	21	19	------	------	174	6.2
10dac	11-20-53	62	------	.13	------	------	------	------	------	6	0	3	5	------	6.2	------	4	0	------	------	48	6.5
11dad	3-29-54	------	------	.05	------	------	------	------	------	0	0	12	76	------	5.5	------	60	60	------	------	325	4.5
11dbd	3-29-54	------	------	.21	------	------	------	------	------	98	0	74	40	------	2.9	------	114	34	------	------	450	7.8
12aac	3-29-54	63	------	.18	------	------	------	------	------	14	0	2	3.5	------	3.3	------	12	1	------	------	38	6.4
12aca	3-29-54	------	------	12	------	------	------	------	------	40	0	6	3	------	7	------	24	0	------	------	------	------
13bab	3-30-54	------	------	.03	------	------	------	------	------	9	0	6	38	------	10	------	20	13	------	------	183	6.0
13bad	3-30-54	------	------	1.20	------	------	------	------	------	0	0	100	14	------	.8	------	28	28	------	------	386	3.4

13cbd	3-30-54			3.50						14	0	10	42		50		50	4			281	5.9
13cdb	3-30-54			.01						24	0	6	14		14		29	9			145	6.8
24bba2	3-30-54			.09						62	0	22	36		48		94	43			350	6.8
24bba3	3-30-54			.01						2	0	1	59		34		19	17			279	4.8
24bca	3-30-54			.30						45	0	4	8.5		8.9		42	5			126	7.0
24bdc	3-30-54			.03						49	0	40	48		27		86	46			366	6.5
24cbd	3-30-54			.56						37	0	2	25		5.5		39	9			159	7.0
Unit 9																						
1N-10W- 4abc	6-11-51	64		9.1						85	0	17	5.5		0.5		70	0			174	7.4
21bcb	6-13-51	64		13						420	0	4	4.5		.6		351	7			630	7.6
1N-11W- 1ddc	7-14-59	63		5.3				24	0	152	0	42	31				176	0			410	7.5
4bbb	6-12-51	64		9.9						177	0	14	8.2		.9		146	1			311	7.8
4dbd	6-12-51	64		18						219	0	16	14		.5		181	1			381	6.9
15bdb	7-14-59	66		19				30	3.9	604	0	30	24				505				921	7.3
16ddc	?- ?-51	64								442	38	31	25		.3		6	0			833	8.9
27bda	7- 9-51	64		.59						140	7	6	6		15		135	9			294	8.2
28daa	7-14-59							16	0	60	0	19	9				68				189	7.6
30bdc	7-16-59			15				15	0	176	0	0	21				152				335	7.3
31acb	7-16-59			23				18	.6	208	0	0	18				161				366	7.0
32bca	7-16-59			2				6.8	0	164	0	8.6	7				137				266	7.8
32cdc	7-16-59			.64				8.3	0	88	0	15	5				79				180	6.8
34aba	7-14-59			3.5				16	.7	408	0	48	24				396				701	8.1
34cda	7- 9-51	64		.1						312	6	38	10		21		317	51			571	8.4
34cdd	2-27-59			25				9.4	.7	212	0	22	8				188				349	8.2
1N-12W- 1ccd	6-14-51	64		.5						211	0	92	112		6.2		309	136			875	7.6
1dbc	6-14-51	64		9.8						347	0	72	88		.5		394	110			917	7.7
2bbd	9-14-51	65		8.7						218	0	88	113		2		274	95			789	7.9
12bdd	6-14-51			.18						193	0	59	34		3.8		210	52			540	7.2
2N-10W- 5bcc	6-11-51	64		2.5						415	0	4	28		.5		334	0			703	7.7
16bcd	8- 2-51	64		10						311	0	3	14		1.5		248	0			502	7.5
16bdc	7-14-59	64		5.3				15	.3	268	0	0	17				215				421	8.2
31cac	6-13-51	64		12						132	0	2	.2		.3		93	0			211	7.5
2N-11W-31ddb	6-13-51			21						205	0	7	18		.2		182	14			377	7.4
32bbc	6-13-51			13						145	0	18	17		.2		152	33			339	7.4
33cdb	6-12-51	64		25						370	0	6	34		.9		310	7			648	7.7
2N-12W-36dca	6-14-51	64		35						154	0	137	51		2.3		290	164			692	7.0
2N-13W- 7ddc	1-26-59			.15									102								1020	6.9
8cdd	1-26-59			9.2									6.5								425	6.7
16bab	7-20-51	64		2.9						316	10	28	19		6.1		294	18			604	
16bac1	1-26-59			1.6									20								616	6.6

See footnote at end of table.

TABLE 5.—*Chemical analyses of water from selected wells in Pulaski and Saline Counties, Ark.*—Continued

Well	Date of collection	Temperature (°F)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Sodium-adsorption-ratio	Specific conductance (micromhos at 25° C)	pH
Unit 9—Continued																						
2N-13W-16bbb	11-19-58			3.7		52	13	13	6	204	0	27	11		1.5	242	183	16	13	0.4	396	
16bbb	10-27-54			4.2		44	14	18		195	0	24	11		1.9	265	167	8	19	.6	392	
3N-10W-31dcd	3- 7-56	64	10	1.5		78	14	23	2	294	0	7.8	32		1.2	327	252	11	16		563	
32ccd	6-11-51	64		.17						400	0	3	14		.3		312	0			646	
3N-13W-30bbc	1-28-59			6.6									11								657	6.7
3N-14W- 2cbb	1-27-59			2.9									7								494	6.7
3dbb	1-27-59			2.9									130								957	6.6
3ddd	1-27-59			.18									4								453	6.7
10aba	1-26-59			11									32								499	6.8
10acc	10-27-50			.97						106	0	13	7.5		21		127	40			255	
10dcd	10-27-50			30						360	0	2	31		2		308	13			608	
11bcc	10-27-50			5.9						382	0	10	31		.8		349	36			624	
11cdb	1-27-59			8.6									19								586	6.6
14bbb	10-27-50			1.6						352	0	25	10		1.6		327	38			593	
14cab	1-27-59												5.5								456	6.6
14cab	1-27-60	64										25	4.8								460	
14cba	10-27-50			1.7						140	0	24	19		7.2		180	65			340	
15adc	10-27-50			7.6						206	0	22	19		5.3		218	49			395	
15bbd	1-27-59			1.4									43								581	6.6
15bdb	10-27-50			25						331	0	23	14		.4		312	41			564	
15daa	10-27-50			1.9						240	0	34	21		27		270	73			513	
15dbc	1-27-59			9.2									10								621	7.0
15dbc	10-23-59	65										25	7.2								589	
15dda	10-27-50			26						354	0	8	5		.6		300	10			535	
16dcd	1-26-59			7									8								356	6.9

16dcd	10-23-59	64										1.8	3.8								210	
22aaa	10-27-50			11						183	0	10	4.5		7.8		167	17			322	
22aad	1-27-59			.15									3								406	6.6
22abc	1-27-59			7.2									19								625	6.9
23add	1-27-59			5.1									16								619	7.0
23bab	1-27-59			7.4									7								529	6.7
26ccd	1-26-59			.11									22								978	7.2
1S-10W-17caa	6-13-51	66		14						496	0	8	6.5		1.1		304	0			654	8.1
17ccd	6-13-51	64		.60						485	0	7	7		2.9		418	20			741	7.5
23ccb	7-14-59	64		13				12	.7	152	0	11	8				106				261	7.1
25bad	8-14-59	64		8.7				12	.5	148	0	12	13				122				271	8.1
25ddb	7-16-51	64		16						162	14	11	20		.5		166	10			372	8.4
26baa	?- ?-51	66		.48						26	10	9	13		15		60	22			162	8.7
29aba	?- ?-51	66		12						288	20	13	24		.6		262	0			542	8.5
29bba	?- ?-51	66		2.90						325	11	8	3.2		1		290	5			503	8.3
1S-11W-6caa	10-22-59	67		4.5				169	6.2	430	16	21	165		4.3		269				1,200	8.5
6caa	2- 8-60	67											12								385	
8bdc	7-16-59			13				15	.4	262	0	8.2	8				209				412	7.3
9caa	7-14-59	63		3.4				7	.3	84	0	6.6	5				74				161	6.8
9cbb	7-16-59	64.5		.96				9.7	.3	316	0	11	5				269				457	8.2
10acd	7-14-59			7.7				8.8	.1	288	0	19	6				256				457	7.9
16cbb	7-16-59			9.8				8.1	.0	134	0	14	6				123				239	8.2
25ddb	7-14-59	64		16				12	1.1	492	0	1	8				406				705	7.4
27bcc	6-11-51	64		9						304	0	36	66		.8		334	85			700	7.5
28cbb	7-17-59			14				29	1.2	374	0	9.8	11				289				553	8.2
1S-12W-15daa1	6-12-51			.63						2	0	2	21		34		32	30			154	4.9
15daa2	6-12-51			.22						146	0	10	16		15		129	9			325	7.6
27aac	6-12-51			1.3						39	0	4	6		3.3		25	0			85	6.7
2S-10W-14ddb	9-22-53	63		.32		36	8.6			236	0	32	13		.1		126	0			449	6.8
21bbb1	7-13-59	65		8.7				26	1.1	260	0	23	45				258	0			562	6.9
21bbb2	7-16-51	65		6.9						314	6	36	10		.6		264	0			550	8.2
23bba	7-16-51			43						391	7	69	141		.3		408	76			1,120	8.1
27dbd	7-16-51	64		31						296	0	7	57		.5		275	32			615	7.6
32daa	7-16-51	65								462	0	28	9.5		40		409	30			802	7.9
35ccc	7-31-59	64		25				79	4.5	192	0	72	128				244				854	8.0
35ccd	8- 2-51	64		49						290	0	50	116		1.4		310	72			876	7.0
35dcb1	8- 2-51	64		52						294	0	29	60		1.5		284	43			667	6.8
35ddd	8- 2-51	64		47						308	0	12	79		1.1		309	56			724	7.0
2S-11W-5acd	6-11-51			.38						18	0	67	68		1		50	35			412	6.7
9dcc	7-17-59			21				39	2.8	276	0	17	38				220				547	7.2
20bdd	10-22-59	65		1.1				18	4.4	14	0	12	27				16				142	6.7

[1] Arkansas State Board of Health analysis.

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