Water-Resources Reconnaissance of the Ouachita Mountains Arkansas

By DONALD R. ALBIN

CONTRIBUTIONS TO THE HYDROLOGY OF THE UNITED STATES

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WATER-RESOURCES RECONNAISSANCE OF THE OUACHITA MOUNTAINS, ARKANSAS

By Donald R. Albin

ABSTRACT

Water for domestic and nonirrigation farm use can be obtained from wells nearly everywhere in the Ouachita Mountains, and ground-water supplies as large as 50,000 gpd (gallons per day) often can be developed. In general, the best procedure for developing ground-water supplies in the mountains is to drill wells on the flanks of anticlines (in synclinal valleys) and off the noses of plunging anticlines. Ground water for industrial or municipal use in the area may require treatment for removal of iron and calcium magnesium hardness.

Streams are the best potential sources of water for municipal growth and economic development in the Ouachita Mountains. Although most streams in the mountains occasionally have very little or no flow, with adequate storage facilities they generally are the best sources of supply when water demands approach 50,000 gpd. The streams contain water of excellent quality that chemically is suitable for nearly all uses.

INTRODUCTION

PURPOSE AND SCOPE

This reconnaissance has been made to determine the general availability of water for municipal growth and economic development in the Ouachita Mountains of Arkansas. The expanding urbanization and industrialization of the State is creating ever-increasing demands for good-quality water. To help satisfy these demands this report provides general information on the location, quantity, and quality of water in the Ouachita Mountains.

ACKNOWLEDGMENTS

Work on this project was done in cooperation with the Arkansas Geological Commission and the Engineering Experiment Station, University of Arkansas. The basic ground-water data were collected between July 1961 and June 1963, and the basic surface-water data were collected as part of a continuing program of streamflow-record

collection begun in 1927. Much of the basic ground-water data was collected by R. M. Cordova.

LOCATION-NUMBERING SYSTEM

In this report, all wells and points of interest are numbered according to the Federal land-survey system used in Arkansas. The component parts of a well or location number are the township number, the range number, the section number, and three lowercase lettters that indicate, respectively, the quarter section, the quarter-quarter section, and the quarter-quarter-quarter section in which the well or point of interest is located. The lowercase letters are assigned in counterclockwise order beginning with "a" in the northeast quarter. Serial numbers are appended where more than one well is located in a 10-acre tract. This location system is illustrated in figure 1.

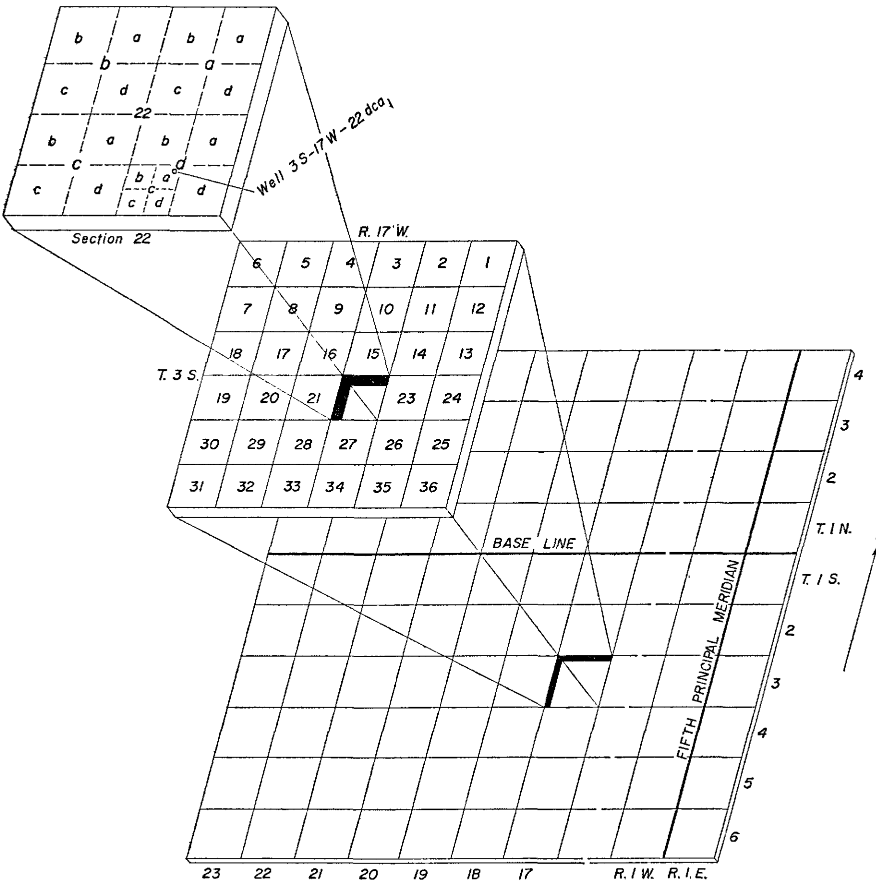

FIGURE 1.—Location-numbering system.

FRAMEWORK OF THE AREA

SIZE AND SHAPE

The Ouachita Mountain section constitutes the southern half of the Ouachita physiographic province, and is an oval, 12,000 square-mile area, about 55 miles wide by about 220 miles long. The section is divided into three subsections—the Fourche Mountains, the Broken Bow-Benton (or Novaculite) Uplift, and the Athens Piedmont Plateau. The Broken Bow-Benton Uplift is further subdivided as shown on figure 2.

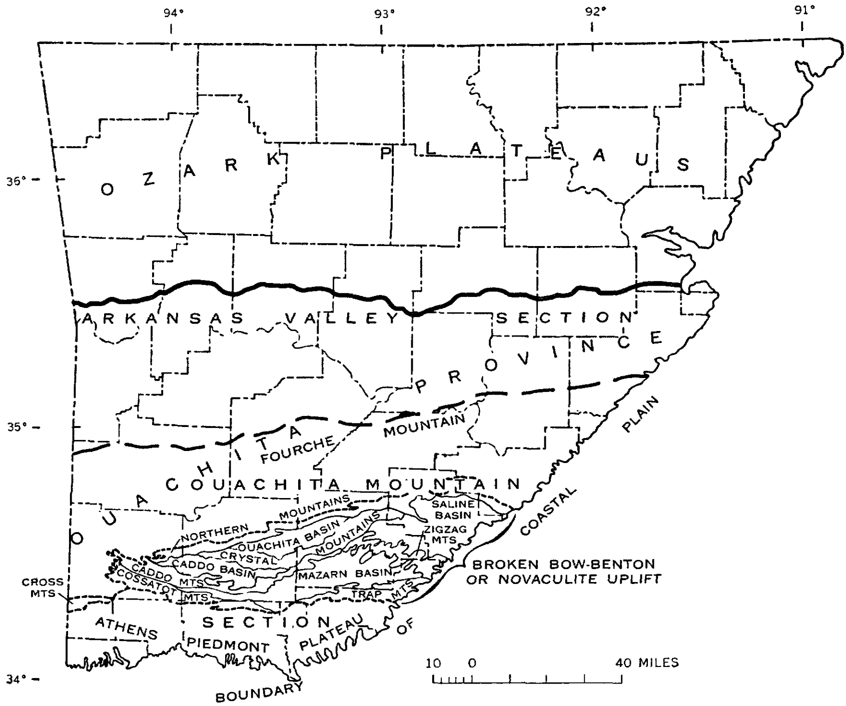

FIGURE 2.—Physiography of the Ouachita Mountain section, Arkansas.

The Fourche Mountains and the Broken Bow-Benton Uplift are characterized by long eastward-trending even-crested mountain ridges and flat intermontane basins. However, many short overlapping, curved, hooked, and even zigzag ridges have been created by truncation of pitching folds. The altitude of the ridge summits increases from about 500 feet above sea level near Little Rock (250 feet higher than the Coastal Plain) to about 2,600 feet above sea level near the

Arkansas-Oklahoma border (1,600 feet higher than the adjacent valley floors). The highest point in the Ouachita Mountains is about 2,700 feet above sea level on Rich Mountain near Mena, Ark. The principal streams in the Arkansas part of the Fourche Mountains and the Broken Bow-Benton Uplift flow eastward.

There are no mountains in the Athens Piedmont Plateau. Even though the area consists of eastward-trending ridges that generally are 250 feet above the intervening valley floors, the view from one of the higher ridges shows a nearly flat horizon (Fenneman, 1938, p. 682–683). Except for the Caddo River which flows eastward, the principal streams in this area flow toward the south.

Approximately two-thirds of the Ouachita Mountain section is in the Red River basin and is drained by the Ouachita River and its tributaries. The northern part of the area is in the Arkansas River basin and is drained principally by the Fourche La Fave River and its tributaries. A major drainage divide between the Arkansas and Red River basins crosses the Ouachita Mountain section between T. 2 N. and T. 1 S.

GEOLOGY

The characteristics of the Ouachita Mountain section as a water container have been determined by three geologic events; (1) the formation of a long narrow, sinking trough, or geosyncline, in which a great thickness of rocks was deposited, (2) the deformation of these rocks into a complexly folded and thrust-faulted arch, or anticlinorium, and (3) a long period of epeirogenic uplift and erosion. A general description of the lithology and thickness of the rocks exposed in the Ouachita Mountains is given in table 1, and the general geology of the area is shown on figure 3.

The geosyncline formed in two distinct phases that lasted throughout most of the Paleozoic Era. During the first phase, approximately 7,000 feet of fine-grained rocks were deposited in the slowly sinking geosyncline. During the second phase the geosyncline sank very rapidly, and approximately 39,000 feet of predominantly clastic rocks poured into the trough. In order of principal occurrence, the rocks deposited in the Ouachita Mountain area during the two geosynclinal phases are shale, sandstone, novaculite, chert, conglomerate, limestone, and volcanic tuff. Many of these rocks originally were coarse grained enough to be aquifers, but most have been altered by pressures resulting from deep burial and orogenic movements.

Orogenic movements began in the Ouachita Mountain area during Atoka time and continued through the Middle Pennsylvanian Epoch. Tremendous compressive forces squeezed the rocks into half their

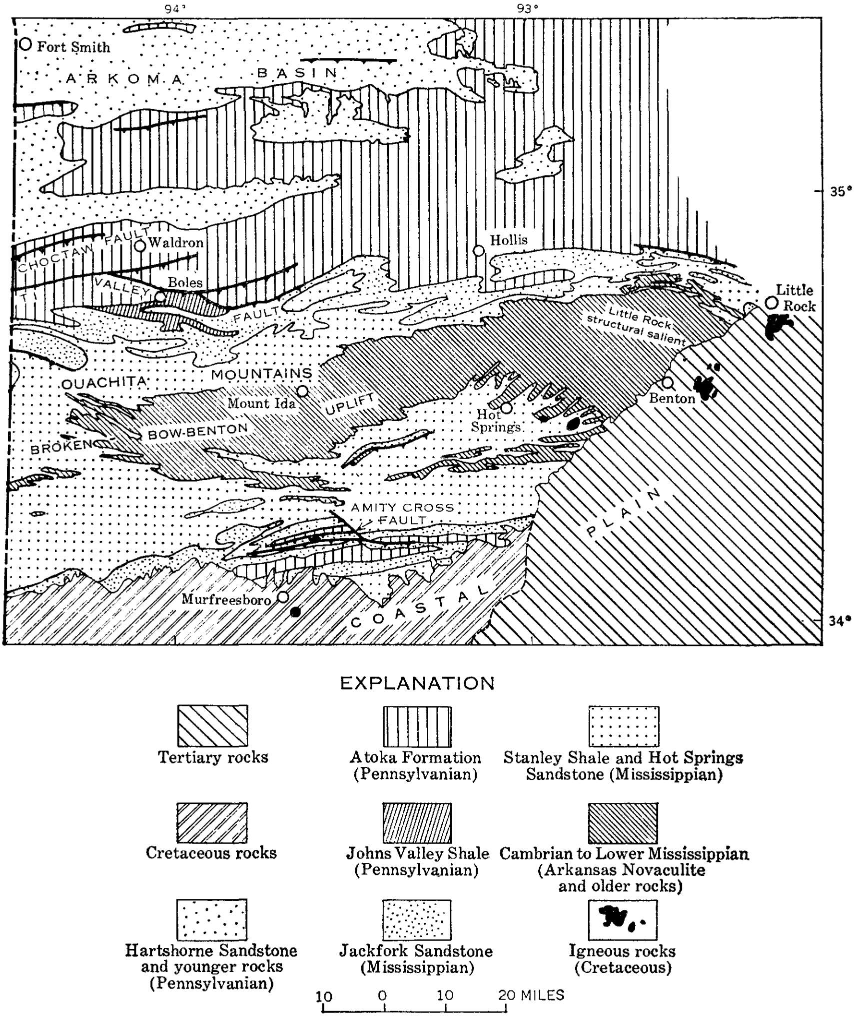

FIGURE 3.—General geology of the Ouachita Mountains, Ark. **Modified after Miser (1959).**

original width and formed them into a complexly folded and thrust-faulted anticlinorium. The folding is remarkably close in most of the area and nearly all types of folds are present. A great many of the folds are broken by thrusts or by high-angle reverse faults. In addition, there are many normal faults of limited extent and innumerable joints and fractures. The orogenic movements also caused widespread weak to low-grade low-temperature regional metamorphism.

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TABLE 1.—*Formations of Paleozoic age in the Ouachita Mountains, Arkansas*

[Thicknesses and lithologic descriptions after Purdue (1909); Purdue and Miser (1923); Miser and Purdue (1929); Croneis (1930); Arkansas Geol. Survey (1942); Reinemund and Danilchik (1957); and Flawn and others (1961)]

Age		Formation	Thickness (feet)	Lithology
Carboniferous	Pennsylvanian	Major unconformity		
		Atoka Formation	1,500–19,000	Shale, silty, micaceous, dark to black, and hard massive and thin-bedded light-gray to greenish-gray, commonly ripple-marked sandstone; near base is coarse grained and contains some grit. Sandstone and shale present in nearly equal amounts but shale generally predominant.
		Johns Valley Shale	200–1,000	Shale and claystone, highly sheared and crumpled, gray and tan to dark-gray; contains thin disconnected beds and lenses of sandstone, siltstone, and limestone, and erratic blocks of pre-Pennsylvanian formations.
	Mississippian	Jackfork Sandstone	1,150–7,000	Sandstone, fine- to coarse-grained, massive, light-gray to brown, quartzitic in part, and a few minor beds of green fissile shale; contains some millstone grit near base.
		Stanley Shale	6,000–12,000	Shale, bluish-black to black, fissile, and greenish quartzitic compact fine-grained sandstone; contains novaculite conglomerate and several beds of acidic vitric tuff near base. Lower part of shale locally is slaty.
		Hatton Tuff Lentil	(0–90)	
		Hot Springs Sandstone	0–200	Sandstone, fine- to medium-grained, gray, quartzitic, hard, laminated; novaculite-pebble conglomerate at base.
		— Unconformity —		
Mississippian and Devonian.		Arkansas Novaculite	230–950	Upper member: Novaculite, massive, light gray to bluish-black, calcareous. Middle member: Novaculite, thin-bedded, dark, and interbedded black clay shale. Lower member: Novaculite, dense, massive, white.
		— Unconformity —		
Silurian		Missouri Mountain Slate	0–300	Shale, hard, red and green; contains thin beds of chert and sandstone and, locally, a basal chert- and limestone-pebble conglomerate.
		— Unconformity —		
		Blaylock Sandstone	0–1,500	Sandstone, fine-grained, compact, light- to dark-gray or green, and dark-gray to black micaceous fissile shale. The sandstone generally is thin and even bedded, and locally contains abundant quartz veins.
		— Unconformity —		
Ordovician		Polk Creek Shale	0–175	Shale, fissile, graphitic, black, mostly soft, but slaty near base; contains abundant graptolites.
		Bigfork Chert	600–800	Chert, gray to black, thin-bedded, much shattered; contains thin interbedded layers of black siliceous and carbonaceous shale and some black siliceous limestone.
		Womble Shale	240–1,000	Shale, black and green, and some fine-grained sandstone and blue-black limestone.
		Blakely Sandstone	0–500	Shale, black and green, argillaceous, and interbedded gray siliceous medium-grained sandstone containing darker calcareous layers. Although shale predominates, the sandstone forms conspicuous ridges.
		Mazarn Shale	±1,000	Shale, clayey, fissile, black and green; contains thin layers of gray fine-grained sandstone and bluish-black limestone.
Ordovician(?)		Crystal Mountain Sandstone	850	Sandstone, coarse-grained, massive, white to light gray; beds with calcareous cement weather brown; contains many quartz veins and crystals.
		— Unconformity —		
Cambrian		Collier Shale	200+	Shale, soft, black, graphitic; contains thin beds of dark limestone and some dense black chert.

The Ouachita Mountain area has been rising as a result of epeirogenic uplift since the climax of orogenic deformation in Middle Pennsylvanian time. Erosion kept pace with uplift, however, and reduced the area to a peneplain (the Ouachita peneplain) by the end of the Mesozoic Era. Renewed epeirogenic uplift caused rapid erosion of the soft rocks lying in belts between the upturned edges of the harder rocks. The present-day physiography of long even-crested ridges and flat intermontane basins results from this erosional cycle. Much of the Athens Piedmont Plateau and the floors of the larger basins are part of a younger peneplain (the Hot Springs peneplain) that probably was formed by early Tertiary time. The relation between these two peneplains is shown on figure 4.

LOCATION AND QUANTITY OF WATER AVAILABLE

GROUND WATER

The primary porosity of all but the youngest rocks in the Ouachita Mountains has been destroyed by compaction due to deep burial, deformation pressures, or both. Therefore, ground water in the mountains principally occurs in secondary openings such as joints, fractures, and separations along bedding planes, and its availability at any point largely depends on the degree to which the rocks have been "broken up." Limited supplies of ground water are available at most places because secondary openings have been formed in nearly all the rocks. The Bigfork Chert of Ordovician age, which is very brittle and has been highly fractured, is the only geologic unit that generally is an aquifer throughout its area of occurrence.

Because the principal joint and fracture pattern runs eastward, wells drilled along this trend commonly tap the same ground-water reservoir. Conversely, wells along a north-trending line often are completely independent, and one well may be a "good" water-producer though an adjacent well is not. Additional wells generally can be drilled either east or west from proved supplies, but, if possible, wells should be spaced at least 1,000 feet apart to prevent excessive drawdowns. If this amount of separation is not practicable, or if the amount of additional water needed is as much as 20,000 gpd (gallons per day), a location north or south of the existing wells should be investigated to determine the possibility of developing a separate ground-water reservoir.

The best places to drill wells in the Ouachita Mountains generally are on the flanks of anticlines (in synclinal valleys) and off the noses of plunging anticlines. Differential movement between shale and sandstone beds during folding commonly has formed fractures and bedding-plane separations near the contact between the beds. When

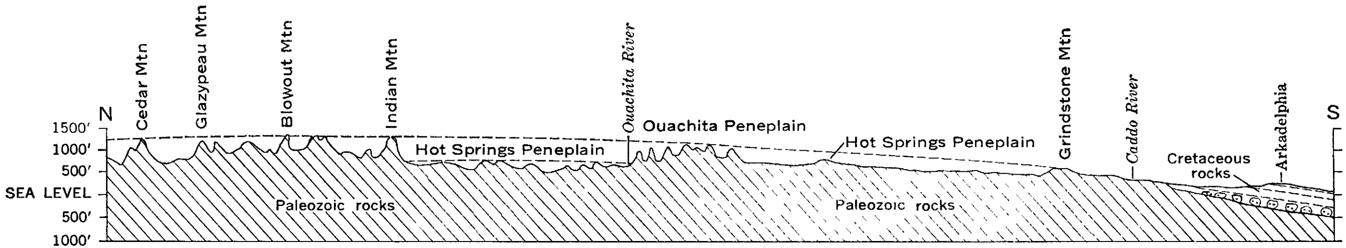

FIGURE 4.—Generalized cross section showing the relation between the Ouachita and Hot Springs peneplains.

the resultant porous zones are exposed to recharge, as on the flanks of anticlines, wells often can be constructed as shown in the foreground of figure 5. If the anticline plunges, wells also may be developed off the nose along the axis as shown in the background of the figure. Wells drilled at this location probably can obtain water from the highly fractured sandstone at the crest of the anticline.

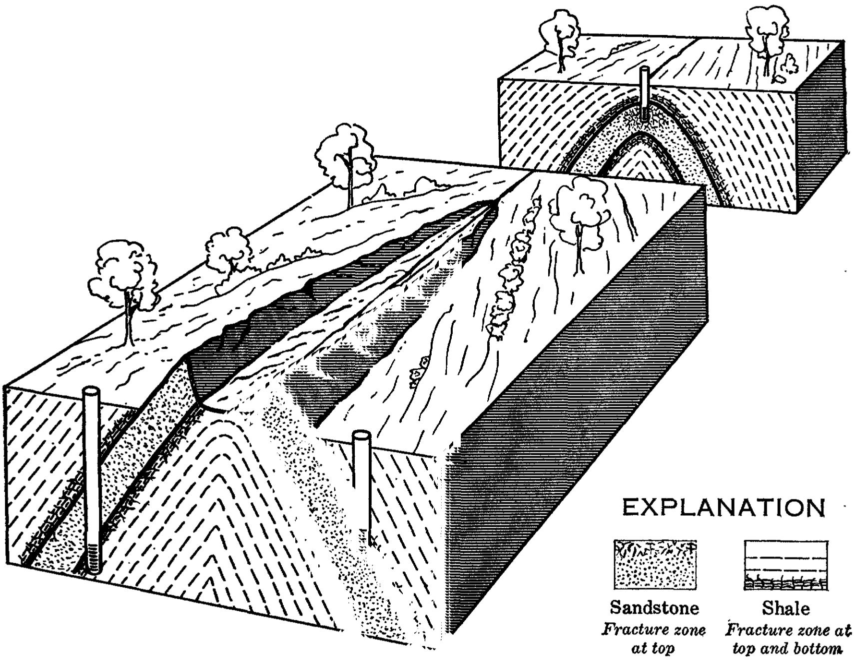

FIGURE 5.—Block diagram showing the best locations for drilling wells in the Ouachita Mountains.

Most wells in the mountains are less than 100 feet deep, but the larger yield wells generally range from 100 to as much as 627 feet deep. The static water level generally is less than 20 feet below land surface, and some of the wells flow. Pumping water levels may be as much as 150 feet below land surface. Seasonal water-level fluctuations in the wells generally are less than 10 feet. However, larger fluctuations are common in abnormally wet or dry years because the ground-water reservoirs have small storage capacities and are recharged by rapid infiltration of local precipitation. The location of wells in which water levels were measured periodically and from which water samples were taken for chemical analysis is shown on plate 1.

Aquifer tests at 10 locations in the Ouachita Mountains show that the coefficient of transmissibility generally is less than 1,000 gpd per foot and may be less than 50 gpd per foot. Specific capacities of most wells in the mountains range from 0.1 to 1.0 gpm (gallons per minute) per foot of drawdown after 90 minutes of pumping. The highest coefficient of transmissibility and specific capacity determined were about 20,000 gpd per foot and 9 gpm per foot of drawdown, respectively, for well 2S–19W–23acd which is developed in the Bigfork Chert. This well is known to yield as much as 350 gpm, but most wells in the mountains yield less than 50 gpm. In fact, wells almost anywhere in the mountain area that will yield more than 10 gpm continuously for a week are considered "large-yield" wells. Because of the large drawdowns required to produce even moderate quantities of water, wells tapping the same ground-water reservoir in the Ouachita Mountains should, if possible, be spaced about 1,000 feet apart.

Sufficient quantities of ground water for domestic and nonirrigation farm uses generally are available in the mountains, but only one community that has a population greater than 500 uses ground water for municipal supply. Ground water should not be considered as a source of supply for municipal growth and economic development in the Ouachita Mountains unless the quantity needed is small.

SURFACE WATER

The streams of the Ouachita Mountains are the best potential source of water for municipal growth and economic development. With adequate storage facilities, surface water is the most reliable and, in many places, the only source of supply when water demands approach 50,000 gpd. The streams are utilized for municipal supply by nine of the ten communities in the mountains that have populations greater than 500.

The mountain area receives between 50 and 55 inches of precipitation in a normal year, and 16 to 24 inches of this total appears in the streams as surface runoff. Plate 1 shows the points where streamflow data are being collected in the Ouachita Mountains and the extreme and average flows for those points. For example, the flow of the Fourche La Fave River near Gravelly (streamflow station 2615) has varied from no flow to a maximum of 69,400 cfs (cubic feet per second). However, the average flow at this station during the period of record was 560 cfs.

Table 2 provides an analysis of streamflow data for the principal streams in the Ouachita Mountains. The data on flow characteristics have been expressed in cubic feet per second per square mile (cfs per sq mi) of drainage area so they can be applied not only to the point where they were collected, but, by adjusting for the size of the drainage area, to other points on the stream as well.

TABLE 2.—*Selected streamflow data from the Ouachita Mountains, Arkansas*

Streamflow station No.	Streamflow station Name	Period of record used	Drainage area above station (sq mi)	Average yield (cfs per sq mi)	90 percent flow duration (cfs per sq mi))	7-day, 2-year low flow (cfs per (sq mi)	Index of variability
2470	Poteau River at Cauthron	1940–60	200	1.13	0.001	0	1.24
2600	Dutch Creek at Waltreak	1946–60	74	1.30	0	0	1.41
2605	Petit Jean Creek at Danville	1917–47	741	[1] 1.13	.016	.001	.86
2615	Fourche La Fave River near Gravelly	1940–60	413	1.36	.002	.001	1.14
2625	Fourche La Fave River near Nimrod	1937–42	680	[1] 1.14	.008	.001	.95
2630	South Fourche La Fave River near Hollis	1942–60	211	1.49	.001	0	1.14
3395	Rolling Fork near DeQueen	1948–60	181	1.68	.007	.002	1.07
3405	Cossatot River near DeQueen	1938–60	361	1.71	.036	.019	.80
3410	Saline River near Dierks	1938–60	124	1.56	.003	.001	1.18
3560	Ouachita River near Mount Ida	1941–60	410	1.87	.076	.039	.71
3565	South Fork Ouachita River at Mount Ida	1949–60	64	1.53	.078	.047	.62
3598	Caddo River near Alpine	1939–41, 1947–58	312	1.75	.11	.077	.61
3600	Ouachita River at Arkadelphia	1906, 1930–52	2,311	[1] 1.59	.11	[2] .081	.61
3610	Little Missouri River near Murfreesboro	1929–49	380	[1] 1.69	.034	.020	.84
3630 [3]	Saline River at Benton	1950–60	569	1.41	.039	.021	.76

[1] Flow regulated at present time by reservoir upstream. Figures shown are for unregulated conditions.
[2] Estimated.
[3] City of Little Rock diverts an average of 30 cfs from Lake Winona, and city of Benton diverts an average of 1.6 cfs above station.

Continuing the example of streamflow station 2615, we find in table 2 that (1) the average yield of the Fourche La Fave River near Gravelly is 1.36 cfs per sq mi, (2) the yield has equaled or exceeded 0.002 cfs per sq mi 90 percent of the time, and (3) about once every 2 years the average yield has been as low as 0.001 cfs per sq mi for 7 consecutive days. Multiplying these "unit-yield" values by the drainage area gives flow values in terms of cubic feet per second, and multiplying once more by 646,317 gives flow values in terms of gallons per day. Thus the average flow of the Fourche La Fave River near Gravelly is about 360 million gpd, at least 534,000 gpd flows by the station 90 percent of the time, and about once every 2 years the flow is as low as about 267,000 gpd for a 7-day period. This same procedure can be used to estimate streamflow characteristics at points upstream or downstream from the data-collection stations simply by finding the size of the drainage area above those points and multiplying by the "unit-yield" values at the nearest streamflow station listed in table 2. However, the procedure must be used with some caution. Significant natural or man-made changes in basin or channel characteristics between the streamflow station and the point of interest (such as changes in the geology or hydrologic properties of the rocks, the confluence with a major tributary, or the construction of navigation channels, dams, or reservoirs) will alter the values listed in the table.

The final column in table 2 lists the index of variability of streamflow at the various stations. The indexes reflect the variability of precipitation as modified by basin characteristics, and provide a general indication of the source and dependability of low flows. Storage, either on the surface or in the ground, serves to reduce the variability of flow. In the Ouachita Mountains, indexes of variability much greater than 1 indicate little storage capacity in the drainage basin; lower values indicate that a significant amount of streamflow is maintained by the discharge of ground water from storage during periods of little precipitation.

The information in table 2 is suitable for making initial decisions as to whether sufficient surface-water supplies are available to meet prospective demands. At particular points of interests in the Ouachita Mountains, more detailed studies of available data or the collection of additional data probably will be necessary before the design of specific projects is possible.

Several reservoirs have been constructed in the mountains for water supply, conservation, flood control, recreation, power production, or combinations of these purposes. The storage capacities of the principal reservoirs and the stream on which they are located are listed below.

Reservoir	*Storage capacity (acre-feet)*	*Stream*
Nimrod Reservoir	336, 000	Fourche La Fave River.
Lake Maumelle	208, 680	Maumelle River.
Millwood Reservoir (under construction)	1, 858, 000	Little River.
Lake Ouachita	2, 768, 000	Ouachita River.
Lake Hamilton	190, 100	Do.
Lake Catherine	32, 250	Do.
DeGray Reservoir (under construction)	1, 377, 000	Caddo River.
Lake Greeson	408, 000	Little Missouri River.
Lake Winona	42, 960	Alum Fork Saline River.

QUALITY OF THE WATER

Water samples from 49 wells and 17 streamflow stations (pl. 1) in the Ouachita Mountains were analyzed to determine the chemical suitability of the water without reference to its bacteriological content. The analyses indicate that ground water in the mountains primarily is of a mixed calcium and sodium bicarbonate type and chemically is suitable for most domestic and farm uses. However, some ground-water samples were high in calcium magnesium hardness and contained iron (Fe), manganese (Mn), chloride (Cl) nitrate (NO_3), or dissolved solids in excess of concentrations recommended for water supplies by the U.S. Public Health Service (1962, p. 7). The most common complaint by water users about ground-water supplies is that the water is hard and high in iron content. Water from well 3S–26W–28daa, which is adjacent to a barnyard, should not be fed to infants because it contains nitrate (NO_3) considerably in excess of the Public Health Service recommendations. Serious and occasionally fatal poisonings of infants have occurred following ingestion of water containing more than about 45 ppm (parts per million) nitrate (U.S. Public Health Service, 1962, p. 47–50).

The analyses also indicate that water in the mountain streams generally is of excellent quality and chemically is suitable for nearly all uses. The concentrations of most mineral constituents in the surface waters are low, even during periods of little streamflow. However, water in the Rolling Fork near DeQueen and South Fork Ouachita River at Mount Ida is moderately hard (as much as 100 ppm as $CaCO_3$) during periods of low flow.

SUMMARY

The decision whether to develop ground- or surface-water supplies in the Ouachita Mountains often will be difficult and will depend on several factors; primarily, the amount of water needed, the use for which it is intended, the geology of the area of interest, and the distance to and availability of water in streams. If the amount of water needed is less than about 50,000 gpd, if the local geology is favorable, and if the user can tolerate the water "as is" or is willing to pay for some treatment of it, then ground water can and should be considered a possible source of supply. In general, development of ground-water supplies will be cheaper than development of surface-water supplies. However, if quantities larger than 50,000 gpd of good-quality water are needed, the potential user will be limited to developing surface-water supplies at most places in the Ouachita Mountains. If possible, a complete investigation of the alternatives should be made by a qualified consultant at each locality where a water supply is desired.

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