# Ground Water Resources of Eastern Arkansas in the Vicinity of U.S. Highway 70

*By* H. N. HALBERG *and* J. E. REED

CONTRIBUTIONS TO THE HYDROLOGY OF THE UNITED STATES

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CONTRIBUTIONS TO THE HYDROLOGY OF THE UNITED STATES

# GROUND-WATER RESOURCES OF EASTERN ARKANSAS IN THE VICINITY OF U.S. HIGHWAY 70

By H. N. HALBERG and J. E. REED

ABSTRACT

Throughout most of eastern Arkansas in the vicinity of U.S. Highway 70, the deposits of Quaternary age and of the Claiborne Group are major fresh-water aquifers. The "1,400-foot" sand of the Wilcox Group also will yield large quantities of fresh water to wells in eastern Cross, St. Francis, and Lee Counties. Wells tapping any of these deposits can be expected to yield between 300 and 2,000 gallons per minute. Less than 300 gallons per minute of fresh water may be obtained from the Claiborne and Wilcox Groups in Lonoke and Prairie Counties. Supplies sufficient for households and farms generally are available from the Atoka Formation in northwestern Lonoke County and from deposits of Pliocene(?) age along Crowleys Ridge.

## INTRODUCTION

### PURPOSE AND SCOPE OF THE INVESTIGATION

This report, one of a series of reports describing the ground-water resources of Arkansas, was prepared by the U.S. Geological Survey in cooperation with the Arkansas Geological Commission. The areas in which studies have been made since the cooperative program began in 1946 are shown in figure 1.

This report describes the availability of ground water for industrial and other uses in the vicinity of U.S. Highway 70 between Pulaski and Crittenden Counties, Ark. A strip about 12 miles wide on both sides of the highway was chosen for study because of the need for information about water supplies for industrial development along the principal arteries of commerce between Little Rock, Ark., and Memphis, Tenn. The area comprises about 2,900 square miles in Cross, Lee, Lonoke, Monroe, Prairie, St. Francis, and Woodruff Counties.

Other studies of the ground-water resources of the area between the two cities include reports on northeastern Arkansas (Stephenson and Crider, 1916), northern Lonoke and Prairie Counties (Counts, 1957),

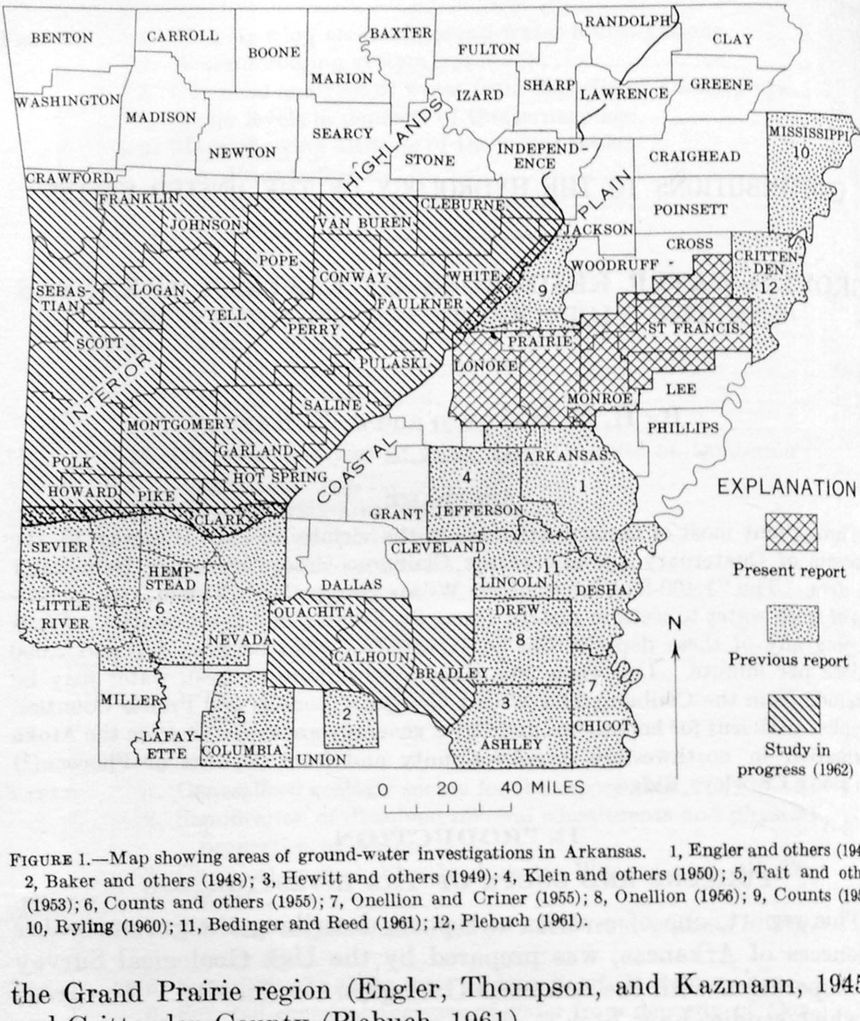


FIGURE 1.—Map showing areas of ground-water investigations in Arkansas. 1, Engler and others (1945); 2, Baker and others (1948); 3, Hewitt and others (1949); 4, Klein and others (1950); 5, Tait and others (1953); 6, Counts and others (1955); 7, Onellion and Criner (1955); 8, Onellion (1956); 9, Counts (1957); 10, Ryling (1960); 11, Bedinger and Reed (1961); 12, Plebuch (1961).

the Grand Prairie region (Engler, Thompson, and Kazmann, 1945), and Crittenden County (Plebuch, 1961).

Fieldwork for this report was done in 1960 and 1961. J. W. Stephens made most of the water-level measurements and collected most of the water samples. The samples were analyzed in the laboratory of the Quality of Water Branch, U.S. Geological Survey, as part of the cooperative program of the Survey and the University of Arkansas, Engineering Experiment Station.

## ACKNOWLEDGMENTS

The writers acknowledge, with thanks, the help received from many people and organizations in the course of the investigation. Many of

the data were furnished by Federal, State, county, and city officials, well drillers and owners, railroads, and industrial and agricultural organizations. Many individuals and establishments permitted use of their wells for water-level measurements and collection of water samples. The use of wells for pumping tests was permitted by Messrs. Melvin Parker, Wayne Tate, and A. W. Ward, by the cities of Brinkley and Forrest City, and by the Arkansas Power and Light Co.

## WELL-NUMBERING SYSTEM

Each well or test hole referred to in this report has been assigned a number based on its location according to the Federal land-survey system used in Arkansas (fig. 2). The number consists of the township, range, and section numbers separated by hyphens; three lowercase letters that indicate respectively the quarter section, quarter-quarter section, and quarter-quarter-quarter section in which the well is located; and a serial number to distinguish between wells in the same 10-acre tract.

## AQUIFERS

The report area is underlain by a sequence of rocks ranging in age from Paleozoic to Recent. The following generalized section (table 1) gives the name, age, lithology, and water-yielding characteristics of the geologic formations in the area.

Ground water is found in the geologic units in the area under water-table and artesian conditions at various depths below land surface. The rock units that contain the water are unconsolidated clay, sand, and gravel deposits. A deposit is called an aquifer if it yields water to wells in sufficient quantities to be a source of supply. A bed of fine-grained material that only transmits water slowly is called an aquiclude. A detailed discussion of the principles of occurrence of ground water in materials similar to those in the report area is given by Meinzer (1923).

The chemical quality of ground water is controlled principally by the chemical and physical characteristics of the aquifer materials. The chemical quality of water also determines the use of the water and the treatment that may be needed to make it satisfactory for certain uses. The effect of constituents and properties of water is discussed in detail by Hem (1959) and Rainwater and Thatcher (1960). The sources, causes, and significance of constituents and properties are summarized in table 2.

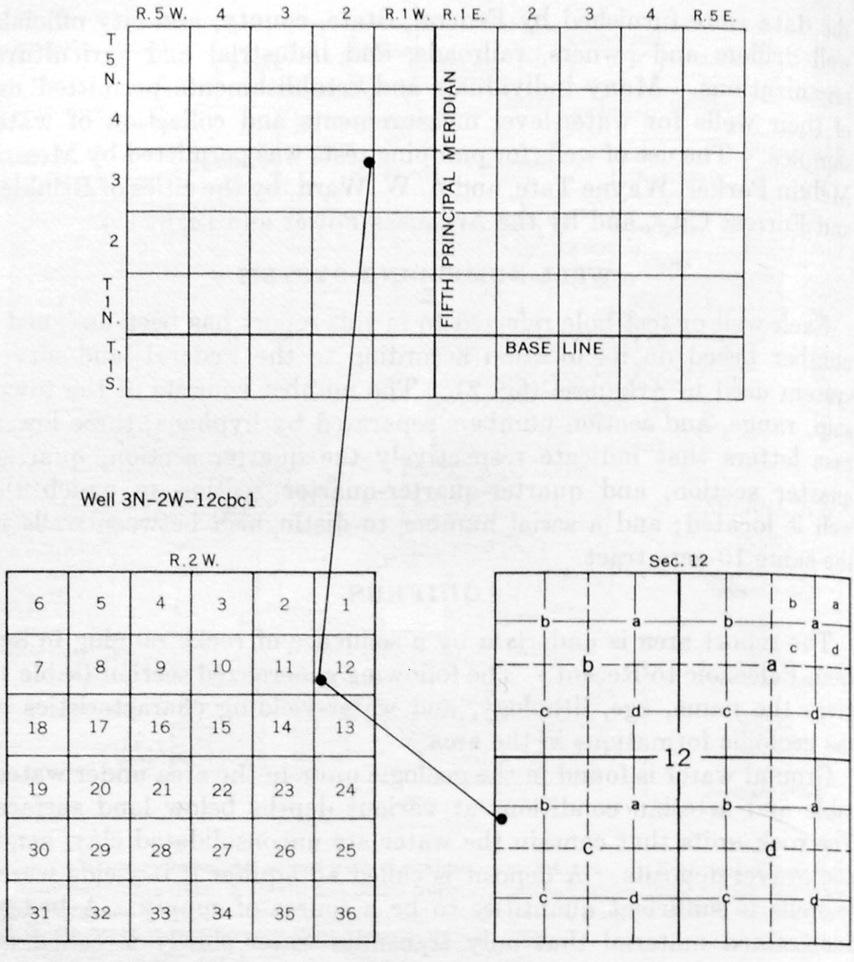


FIGURE 2.—Well-numbering system.

## ATOKA FORMATION

The Atoka Formation consists of hard, dense sandstone and shale that yield sufficient water from fracture zones to supply domestic wells in the area of outcrop in northwestern Lonoke County. The Atoka is not considered a source of large quantities of water.

## WILCOX GROUP ("1,400-FOOT" SAND)

The Wilcox Group consists of brown, gray, and green, generally lignitic clay, silt, fine to medium sand, and lignite. In Cross, St. Francis, and Lee Counties, the group is subdivided into three units. The uppermost and lowermost units consist of clay and silt. The middle unit consists of fine to medium sand and can be correlated with the "1,400-foot" sand of the Memphis area.

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TABLE 1.—*Generalized geologic section for the report area*

| Era | System | Series | Group | Subdivision | Thickness (feet) | | Lithology and water-yielding characteristics |
|---|---|---|---|---|---|---|---|
| Cenozoic | Quaternary | Recent and Pleistocene(?) | | Alluvial deposits | 0–200 | | Clay, silt, sand, and gravel. Yield large quantities of calcium bicarbonate water generally having high iron content and hardness. |
| | | Pleistocene | | Loess | 0–80 | | Silt. Not known to yield water. |
| | Tertiary | Pliocene(?) | | Deposits of Pliocene(?) age | 0–80 | | Sand and gravel. Yield highly mineralized magnesium bicarbonate water to domestic wells and springs. |
| | | Eocene | Jackson | | 0–200 | | Clay, silt, and fine sand. Not known to be utilized in the report area. Elsewhere yields small quantities of water of generally poor quality. |
| | | | Claiborne | Upper (undifferentiated) | 0–300 | 0–1,200 | Sand and clay, lignitic. Yield large quantities of hard, calcium bicarbonate water. |
| | | | | Sparta Sand | 0–300 | | |
| | | | | Cane River Formation. | 0–475 | | |
| | | | | Carrizo Sand | 0–140 | | |
| | | | | Undifferentiated deposits | 0–219 | | Clayey sand and sandy clay. Beds of clean sand occur locally. Yield small to moderate quantities of water of variable quality for public, industrial, and domestic use. |
| | | | Wilcox | | 0–930 | | Sand, silt, and clay, lignitic. In eastern part of area includes "1,400-foot" sand, which yields large quantities of sodium bicarbonate water of excellent quality. |
| | | Paleocene | Midway | | 0–680 | | Clay, lower part calcareous; not an aquifer. |
| Mesozoic | Cretaceous | Upper | | Undifferentiated | 0–915 | | Clay, marl, sandstone, and limestone. Probably contains only salty water. |
| Paleozoic | Pennsylvanian | Atoka | | Atoka Formation | 5,000(?) | | Shale and sandstone. In area of outcrop, fractures yield small quantities of water. |

TABLE 2.—*Significance of dissolved mineral constituents and physical properties of water*

| Constituent or physical property | Source or cause | Significance |
|---|---|---|
| Temperature | | Affects usefulness of water for many purposes. Most users desire cold water. In general, temperature of ground water at shallow depth fluctuates seasonally, but at moderate depth it is constant and is approximately the same as the mean annual air temperature. In deep wells, water temperature generally increases about 1° F for each 60- to 100-foot increment of depth. |
| Silica ($SiO_2$) | Dissolved from practically all rocks and soils, generally in small amounts, from 1 to 30 ppm (parts per million). High concentrations, as much as 100 ppm, generally occur in highly alkaline waters. | Forms hard scale in pipes and boilers. Carried over 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 practically all rocks and soils. May also be dissolved from iron pipes, pumps, and other equipment. More than 1 or 2 ppm of soluble iron in surface water 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. Objected to in water for food processing, bottling of beverages, bleaching, brewing, dyeing, ice manufacture, papermaking, and other processes. U.S. Public Health Service (1962) 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 or acid waters. | Has same objectionable features as iron. Causes dark-brown or black stain. U.S. Public Health Service (1962) drinking-water standards recommend that manganese should not exceed 0.05 ppm. |
| Calcium (Ca) and magnesium (Mg) | Dissolved from practically 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. | Cause most of the hardness and scale-forming properties of water; soap consuming. (See "Hardness as $CaCO_3$" below.) Waters low in calcium and magnesium are desired in electroplating, tanning, dyeing, and in textile manufacturing. |
| Sodium (Na) and potassium (K) | Dissolved from practically all rocks and soils. Found also in connate water and industrial brines, sea water, and sewage. | Large amounts, in combination with chloride, give salty taste to water. 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 to 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 some industrial wastes. | Large amounts have a laxative effect on some people and, in combination with other ions, give a bitter taste to water. Sulfate in water containing calcium forms a hard scale in steam boilers. U.S. Public Health Service (1962) drinking-water standards recommend that chloride content should not exceed 250 ppm. |
| Chloride (Cl) | Dissolved from rocks and soils. Present in sewage and found in large amounts in sea water, connate water, and industrial brines. | Large quantity increases corrosiveness of water and, in combination with sodium, gives a salty taste to water. U.S. Public Health Service (1962) drinking-water standards recommend that chloride content should not exceed 250 ppm. |

| | | |
|---|---|---|
| Fluoride (F) | Dissolved in small to minute quantities from most rocks and soils. | Fluoride in drinking water reduces the incidence of tooth decay in children if the water is consumed during the period of enamel calcification. However, it may cause mottling of the teeth, the likelihood depending on concentration of fluoride, age of the child, amount of drinking water consumed, and susceptibility of the individual. According to U.S. Public Health Service (1962) drinking-water standards, the maximum concentration of fluoride naturally present in water in the study area should be 1.0 ppm; if the water is fluoridated, the average fluoride concentration should be kept between 0.7 and 1.0 ppm. |
| 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 in water. Concentrations much greater than the local average may indicate pollution. U.S. Public Health Service (1962) 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, which sometimes is fatal. Nitrate has been shown to be helpful in reducing intercrystalline cracking of boiler steel. |
| Dissolved solids | Chiefly mineral constituents dissolved from rocks and soils. Include any organic matter and some water of crystallization. | U.S. Public Health Service (1962) drinking-water standards recommend that dissolved-solids content should not exceed 500 ppm. Water having a dissolved-solids content of more than 1,000 ppm is unsuitable for many purposes. |
| Hardness as $CaCO_3$ | In most waters nearly all hardness is due to calcium and magnesium. Metallic cations other than alkali metals also cause hardness. | Hard water consumes soap before lather will form, deposits soap curd on bathtubs, and forms scale in boilers, water heaters, and pipes. Hardness equivalent to bicarbonate and carbonate called carbonate hardness. Any hardness in excess of carbonate hardness called noncarbonate hardness. In general, waters having hardness of 60 ppm or less are considered soft; 61–120 ppm, moderately hard; 121–180 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 suitability of water for irrigation use. |
| Specific conductance (micromhos at 25° C) | Mineral content of water | Specific conductance is measure of capacity of water to conduct 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 decrease pH. Carbonates, bicarbonates, hydroxides, phosphates, silicates, and borates increase pH. | The pH of water is measure of activity of hydrogen ions; pH of 7.0 indicates neutral solution; pH greater than 7.0 indicates alkalinity; pH less than 7.0 indicates acidity. Corrosiveness of water generally increases with decreasing pH. However, excessively alkaline water may also attack metal. |
| Color | Yellow-to-brown color of some water is caused by organic matter extracted from leaves, roots, and other organic substances. Objectionable color in water also results from industrial wastes and sewage. | Water for domestic and some industrial uses should be free from perceptible color. Color objected to in water for food and beverage processing and for many manufacturing processes. U.S. Public Health Service (1962) drinking-water standards recommend that color should not exceed 15 units on the platinum-cobalt scale. |

The aquifer has about the same thickness in eastern Cross, St. Francis, and Lee Counties as it has in the vicinity of Blytheville. If it is assumed that the lithology is the same between Mississippi and Lee Counties, well yields in the two counties can be expected to be the same; yields are known to range from 200 to 1,800 gpm (gallons per minute) in the vicinity of Blytheville.

Little is known of the detailed lithology of the "1,400-foot" sand in the area of the report. Drillers' logs refer to it by such terms as "sand," "good sand," or "water sand." In the Memphis area it consists of unconsolidated well-sorted fine to medium subangular to angular micaceous quartz sand and contains scattered interbeds of clayey sand and sandy clay (Criner and Armstrong, 1958, p. 7). The "1,400-foot" sand ranges in thickness from about 280 feet in eastern St. Francis County (pl. 1) to 45 feet in western Cross County. It is generally 300 to 315 feet thick in Crittenden County (Plebuch, 1961, p. 25).

An aquifer test of the "1,400-foot" sand at Blytheville, Mississippi County (Ryling, 1960, p. 40), indicated a coefficient of transmissibility [1] of 160,000 gpd per ft (gallons per day per foot) and a coefficient of storage [2] of 0.0002.

Information on water levels in wells tapping the "1,400-foot" sand is not available. However, water levels in wells screened in the aquifer probably are within 25 feet of the land surface.

The chemical quality of water from wells tapping the "1,400-foot" sand at Hughes and in Crittenden County is similar. (See table 3.) According to Plebuch (1961, p. 25), water from the "1,400-foot" sand in Crittenden County is a good-quality, very soft, sodium bicarbonate water. The iron content of samples of water from 14 wells in Crittenden County ranged from 0.07 to 1.5 ppm (parts per million); in samples from 8 of the wells it exceeded the limit of 0.3 ppm recommended by the U.S. Public Health Service (1962). A comparison of the chemical quality of water from the "1,400-foot" sand with that of water from other Tertiary formations is shown in figure 3.

Electric logs of wells indicate that the water is fresh in the "1,400-foot" sand from the eastern State line to about the western boundary of Cross, St. Francis, and Lee Counties. West of these counties, the water is too saline for most uses.

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[1] The coefficient of transmissibility is the rate of flow of water, at the prevailing water temperature, in gallons per day, through a vertical strip of the aquifer 1 foot wide and extending the full saturated height of the aquifer under a hydraulic gradient of 100 percent (Ferris and others, 1962, p. 72).

[2] The coefficient of storage is the volume of water released from, or taken into, storage per unit surface area of aquifer per unit change in head component normal to that surface (Wenzel, 1942, p. 87).

TABLE 3.—*Chemical analyses of water from the Wilcox Group ("1,400-foot" sand)*

[After Plebuch (1961). Results in parts per million except as indicated]

| | Ranges in concentration for 14 wells in Crittenden County | | City of Hughes public-supply well 4N-6E-16cdc | |
|---|---|---|---|---|
| | Minimum | Maximum | June 27, 1946 | Aug. 15, 1957 |
| Temperature (°F) | 73 | 77 | — | |
| Silica ($SiO_2$) | — | — | 11 | 5.6 |
| Aluminum (Al) | — | — | .6 | |
| Iron (Fe) | .07 | 1.5 | .12 | .22 |
| Calcium (Ca) | .3 | 2.6 | .6 | .4 |
| Magnesium (Mg) | .0 | .9 | .2 | .1 |
| Sodium (Na) | 36 | 55 | 51 | 46 |
| Potassium (K) | .5 | 2.6 | 2.0 | 1.8 |
| Bicarbonate ($HCO_3$) | 96 | 147 | 120 | 119 |
| Carbonate ($CO_3$) | 0 | 0 | 0 | 0 |
| Sulfate ($SO_4$) | .2 | 10 | 1.7 | 1.2 |
| Chloride (Cl) | 0 | 5.0 | 11 | 5.0 |
| Fluoride (F) | — | — | .2 | .1 |
| Nitrate ($NO_3$) | .0 | 1.1 | .8 | 1.3 |
| Dissolved solids (residue on evaporation at 180° C) | 108 | 148 | 139 | 130 |
| Hardness as $CaCO_3$, Ca, Mg | 1 | 10 | 2 | 1 |
| Noncarbonate hardness as $CaCO_3$ | 0 | 0 | — | 0 |
| Specific conductance (micromhos at 25°C) | 153 | 263 | 277 | 195 |
| pH | 7.4 | 8.2 | 7.4 | 7.8 |
| Color | — | — | — | 5 |

The "1,400-foot" sand unit constitutes a potential major aquifer in eastern Cross, St. Francis, and Lee Counties. To tap this aquifer, wells probably would have to be about 1,000 feet deep in Cross County, 1,700 feet deep in Lee County, and between 1,400 and 1,700 feet deep in eastern St. Francis County. According to Counts (1957, p. 9), fresh-water supplies possibly can be developed from the Wilcox in parts of Lonoke County and within Prairie County. In the rest of the report area, water from the Wilcox Group probably is too mineralized for most uses.

## UNDIFFERENTIATED DEPOSITS OF EOCENE AGE

Undifferentiated deposits consisting of sand and interbedded clay of probable Eocene age crop out in northwestern Lonoke County. Much of the sand contains disseminated clay particles, but clean sand lenses occur locally. The maximum known thickness of these deposits is 219 feet (Counts, 1957, p. 10).

Pumpage from the undifferentiated Eocene deposits in northwestern Lonoke County is small, probably about 0.2 mgd (million gallons per day). The city of Cabot pumps most of the water, and a small amount is used by households and farms in the areas of outcrop of the deposits.

Water levels in the undifferentiated deposits in western Lonoke County have not declined since 1955. The only changes in level have been seasonal fluctuations in response to precipitation. In general, water levels in these aquifers range from a few feet to about 35 feet below the land surface.

The quality of the water in the undifferentiated deposits of Eocene age is highly variable. According to Counts (1957, p. 28), six samples included calcium bicarbonate and calcium-sodium bicarbonate waters having a low concentration of dissolved solids; bicarbonate, sodium bicarbonate, and sodium chloride waters having a moderate concentration of dissolved solids; and a chloride water having a high concentration of dissolved solids. The character of the water could not be determined on the basis of 14 samples, but the mineralization of most of the water is low to moderate. Some of the water is corrosive.

The undifferentiated deposits of Eocene age in northwestern Lonoke County generally yield only sufficient water for household and farm supplies. About 5 miles southeast of Cabot, wells screened in these deposits are capable of yielding several hundred gallons per minute (Counts, 1957, p. 2, 23).

## CLAIBORNE GROUP

Deposits of the Claiborne Group underlie all the report area except northwestern Lonoke and Prairie Counties. The group has not been subdivided into formations except in southern Lonoke and Prairie Counties; there the Carrizo Sand and the Sparta Sand can be recognized in the subsurface (pl. 2).

In the report area the Claiborne Group consists of sand, clay, and lignite. Few details are known about the lithology, as few well samples are available and most drillers' logs are very generalized. In samples from a test hole at Brinkley (well 3N–2W–12cbc1), the Claiborne consisted of very fine to coarse subangular to subrounded lignitic and micaceous sand and interbeds of brown and light-green lignitic clay. North and east of Brinkley the group contains a high percentage of sand, and clayey zones more than 50 feet thick are uncommon.

The Claiborne Group has a maximum thickness of about 1,200 feet in eastern St. Francis and southern Prairie Counties. It thins to the northwest, chiefly because of erosion of the upper part of the group. In the vicinity of Cotton Plant, the group is about 600 feet thick, and near Des Arc it is about 350 feet thick. The group probably is absent in part of northwestern Prairie County and part of northern Lonoke County (Counts, 1957, pl. 1).

An aquifer test of the Claiborne Group, using public supply well 5N-3E-33aba (not in service) at Forrest City, indicated a coefficient of transmissibility of 55,000 gpd per ft and a coefficient of storage of 0.0009 for a sand between depths of 451 and 503 feet. A test using irrigation well 1S-5W-16cbb1 in Prairie County indicated a coefficient of transmissibility of 55,000 gpd per ft and a coefficient of storage of 0.0002. The tested aquifer consisted of three sand beds between depths of 454 and 662 feet.

Pumpage of water from sands of this group in the Highway 70 area is small. Altogether, about 10 irrigation wells tap sands of this group in the study area, all in Prairie County. A small quantity of water is pumped from them, probably not more than 2 mgd. This small pumpage does not significantly affect regional water levels as does the much greater pumpage from wells tapping the Sparta Sand a short distance south of the study area.

In addition to pumpage from the group for irrigation in Prairie County, a total of about 0.5 mgd is pumped for public supply at Brinkley, Clarendon, Cotton Plant, Parkin, and Wynne. Small quantities are used for washing gravel near Caldwell and for several domestic supplies along Crowleys Ridge. In the study area, the total use of water from sands of the Claiborne Group probably is not more than 3 mgd.

Few long-term water-level records are available for wells screened in sands of the Claiborne Group in the study area. Water levels in wells tapping these deposits along Highway 70 at Forrest City and near Hazen are approximately the same as when first measured in 1946 and 1958, respectively. However, water levels in wells tapping the Sparta Sand in southern Prairie County have declined as much as 31 feet since 1937 (fig. 10).

Throughout most of the area the Claiborne Group yields hard, calcium bicarbonate water that is similar in composition and concentration of dissolved solids to water from the overlying beds of Quaternary age (fig. 3; table 4). At Parkin the Claiborne Group yields soft, sodium bicarbonate water. In Prairie, Monroe, and part of Lee Counties, some sands of the group yield brackish water. At Brinkley, two wells tapping the Claiborne at a depth of 420 feet yield moderately mineralized water that contains much sodium and chloride. (See well 3N-2W-10dbb1 in table 4 and well 3N-2W-12cbc1 in table 4 and fig. 3.) Well 3N-2W-10dbb1 was backfilled to a depth of 250 feet and is used now as part of the Brinkley municipal supply. The water at this depth has a chloride content of 118 ppm.

TABLE 4.—*Selected chemical analyses of water from deposits of Tertiary age*

[Results in parts per million except as indicated]

| Well | Depth of well (feet) | 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 (residue on evaporation at 180° C) | Hardness as $CaCO_3$: Calcium-magnesium | Hardness as $CaCO_3$: Noncarbonate | Percent sodium | Sodium adsorption ratio | Specific conductance (micromhos at 25° C) | pH | Color |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Deposits of Pliocene(?) age** | | | | | | | | | | | | | | | | | | | | | | | | |
| 4N-3E-10adb1 | 99 | 10-23-61 | ---- | ------ | 0.02 | 0.00 | 67 | 52 | 29 | 1.2 | 482 | 0 | 4.8 | 29 | ----- | 0.9 | 437 | 381 | 0 | 14 | 0.6 | 743 | 8.0 | 5 |
| **Claiborne Group** | | | | | | | | | | | | | | | | | | | | | | | | |
| 2N-6W-21dad1 | 310 | 7-19-61 | 68 | 9.8 | 0.08 | 0.01 | 34 | 11 | 41 | 5.3 | 256 | 0 | 3.6 | 9.5 | 0.2 | 1.1 | 250 | 130 | 0 | 39 | 1.5 | 397 | 8.1 | 5 |
| 2N-6W-22dcb1 [1] | 438 | 5-31-61 | 68 | 9.3 | 2.0 | ------ | 66 | 15 | 28 | 4.5 | 314 | 0 | 5.6 | 18 | .3 | 1.4 | 314 | 226 | 0 | 21 | .7 | 516 | 7.3 | 8 |
| 3N-2W-10dbb1 | 420 | 2-24-50 | 65 | 15 | .29 | ------ | 52 | 16 | 660 | 10 | 486 | 0 | 7.4 | [2] 852 | .1 | 1.4 | [3] 1,810 | 196 | 0 | 87 | 21 | 2,930 | 7.4 | 0 |
| 3N-2W-12cbc1 [1] | 420 | 3-16-61 | 66 | 7.3 | .07 | ------ | 43 | 13 | 367 | 7.1 | 432 | 0 | .0 | 440 | .6 | 1.1 | 1,220 | 161 | 0 | 82 | 12 | 2,040 | 7.3 | 17 |
| 5N-2W-31dcb1 [1] | 270 | 3- 8-56 | 63 | 6.3 | .77 | ------ | 30 | 7.3 | 9.0 | 1.3 | 146 | 0 | .8 | 2.5 | .3 | .9 | 151 | 105 | 0 | 16 | .4 | 232 | 7.5 | 5 |
| 5N-3E-33aba3 [1] | 530 | 7-28-60 | 65 | 15 | 2.37 | ------ | 58 | 20 | 10 | 1.2 | 280 | 0 | 7.2 | 7.0 | .2 | .6 | 265 | 226 | 0 | 8.8 | .3 | 414 | 6.8 | 5 |
| 7N-5E-3bca [2] | 491 | 8-15-57 | ---- | 7.4 | [4] 1.4 | [4] 0 | 12 | 4.1 | 25 | 5.8 | 126 | 0 | 1.6 | 3.2 | .0 | 1.9 | 124 | 47 | 0 | 50 | 1.6 | 194 | 7.3 | 6 |
| **Sparta Sand** | | | | | | | | | | | | | | | | | | | | | | | | |
| 1S-5W-18add1 [1] | 940 | 5-24-50 | 75 | 16 | 0.18 | ------ | 5.7 | 1.6 | 297 | 8.0 | 280 | 0 | 11 | 304 | 0.1 | 3.0 | [5] 776 | 20 | 0 | 95 | 29 | 1,394 | 7.3 | ---- |
| 1S-5W-20abb1 [1] | 632 | 7-18-61 | 73 | ------ | 2.0 | .01 | 73 | 19 | 35 | 7.6 | 332 | 0 | 15 | 36 | ----- | 1.1 | 361 | 260 | 0 | 22 | .9 | 610 | 7.8 | 5 |
| 1N-3W-22bac2 | 687 | 3- 9-56 | 69 | 4.3 | .77 | ------ | 21 | 3.5 | 122 | 8.9 | 258 | 0 | 5.0 | 86 | .4 | .8 | 389 | 67 | 0 | 77 | 3.0 | 677 | 7.5 | 5 |
| 1N-6W-12cbc1 | 525 | 6-20-50 | 70 | 16 | 1.58 | ------ | 79 | 22 | 37 | 7.9 | 370 | 0 | 14 | 30 | 0 | .6 | [6] 381 | 288 | 0 | 21 | .9 | 670 | 7.1 | ---- |
| **Deposits of Eocene age, undifferentiated** | | | | | | | | | | | | | | | | | | | | | | | | |
| 4N-8W-17dda1 | 140 | 4-28-55 | ---- | 22 | 3.0 | ------ | 24 | 16 | 9.2 | 2.9 | 159 | 0 | 3.2 | 10 | ----- | .00 | 210 | 126 | 0 | 13 | .4 | 325 | 6.9 | 7 |
| **Wilcox Group ("1,400-foot" sand)** | | | | | | | | | | | | | | | | | | | | | | | | |
| 4N-6E-16cdc1 [1] | 1,780 | 8-15-57 | ---- | 5.6 | 0.22 | ------ | 0.4 | 0.1 | 46 | 1.8 | 119 | 0 | 1.2 | 5.0 | 0.1 | 1.3 | 130 | 1 | 0 | 96 | 17 | 195 | 7.8 | 5 |

[1] Analysis shown graphically in figure 3.
[2] Chloride (Cl), 350 ppm 12-26-49; increased to 852 ppm after well pumped 60 days.
[3] Includes 0.7 ppm aluminum (Al).
[4] February 1958, analysis by Arkansas State Board of Health.
[5] Includes 4.0 ppm aluminum (Al).
[6] Includes 3.8 ppm aluminum (Al).

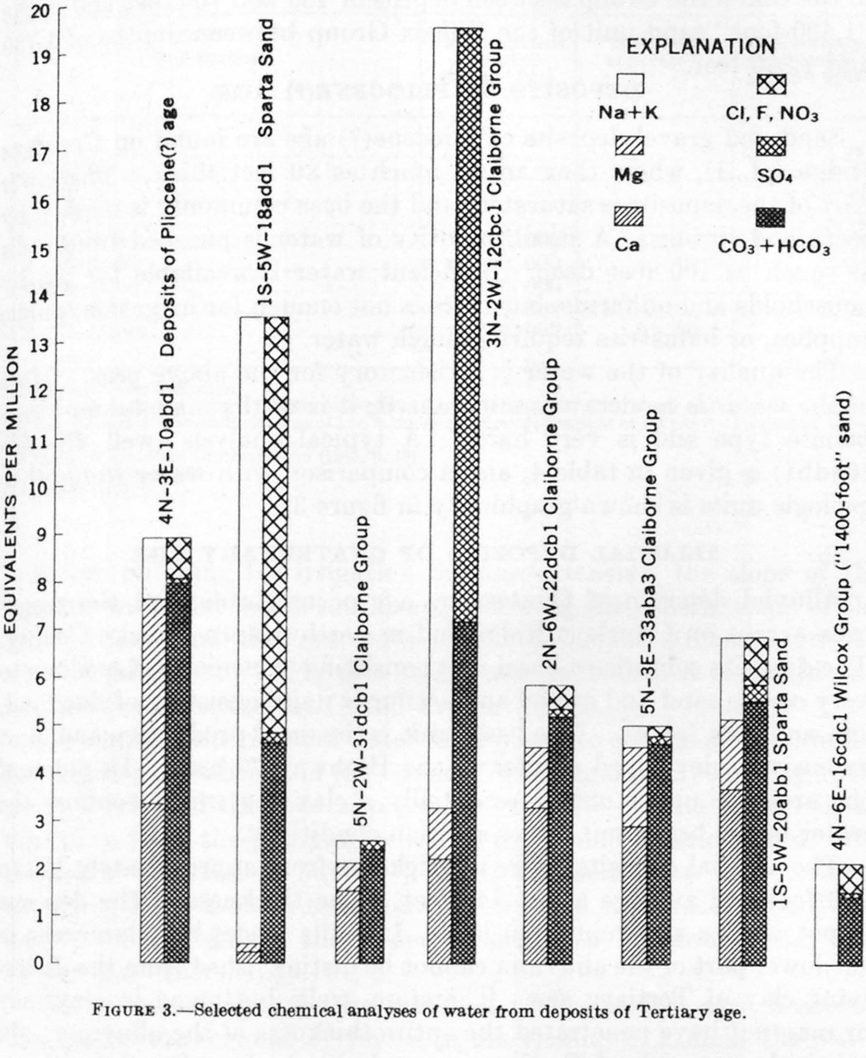


FIGURE 3.—Selected chemical analyses of water from deposits of Tertiary age.

The deepest known well in Prairie County taps a lower sand of the Claiborne Group that yields soft, bicarbonate water containing more sodium and chloride than does water from nearby wells screened in stratigraphically higher beds. (See fig. 3 and table 4, well 1S–5W–18add1 and nearby wells.)

Interpretations of electric logs of wells in Lonoke, St. Francis, Lee, and Cross Counties indicate that water from the Claiborne Group in these counties is fresh except in sec. 14, T. 2 N., R. 1 E., Lee County. At this location, saline water in the Claiborne Group is indicated at depths of 700 and 1,730 feet. However, the log indicates fresh water in the Claiborne Group between depths of 450 and 700 feet and in the "1,400-foot" sand unit of the Wilcox Group between depths of 1,730 and 1,840 feet.

## DEPOSITS OF PLIOCENE(?) AGE

Sand and gravel deposits of Pliocene(?) age are found on Crowleys Ridge (pl. 3), where they are as much as 80 feet thick. The lower part of the deposits is saturated, and the base commonly is marked by seeps and springs. A small quantity of water is pumped from wells as much as 100 feet deep. Sufficient water is available for use by households and on farms, but there is not enough for irrigation, public supplies, or industries requiring much water.

The quality of the water is satisfactory for the above uses. Most of the water is moderately mineralized; it is of the magnesium bicarbonate type and is very hard. A typical analysis (well 4N-3E-10adb1) is given in table 4, and a comparison with water from other geologic units is shown graphically in figure 3.

## ALLUVIAL DEPOSITS OF QUATERNARY AGE

Alluvial deposits of Quaternary age occur throughout the report area except on Crowleys Ridge and in northwestern Lonoke County. The deposits comprise a basal unit consisting principally of medium to very coarse sand and gravel and an upper unit consisting of fine sand, silt, and clay (pl. 4). The basal unit is the most productive and most extensively developed aquifer in the Highway 70 area. In much of the area the upper unit is essentially a clay cap which confines the water in the basal unit under artesian conditions.

The alluvial deposits range in thickness from approximately 100 to 200 feet and average about 140 feet. The thickness of the deposits is not always apparent from logs. In some places clay interbeds in the lower part of the alluvium cannot be distinguished from the underlying clay of Tertiary age. Therefore, wells bottomed in clay may or may not have penetrated the entire thickness of the alluvium. In other places, sands of Tertiary age underlie sands of Quaternary age, and the log may not differentiate between them. Most of the variation in thickness of the alluvium is due to relief of the underlying Tertiary surface.

Aquifer tests to determine the hydrologic properties of the deposits of Quaternary age have been made at seven locations in the report area. The results of these tests are given in table 5.

The water table in the deposits of Quaternary age in the project area is part of a regional water table in the Coastal Plain of Arkansas. The conformation of the regional water table throughout much of the Coastal Plain has been affected by pumping for irrigation. In many places the direction of flow has changed.

TABLE 5.—*Summary of aquifer tests of deposits of Quaternary age*

| Well location | Field coefficient of transmissibility [1] (gpd per ft) | Coefficient of storage [1] | Field coefficient of permeability [2] (gpd per sq ft$^2$) |
|---|---|---|---|
| 1S-5W-9 | ---------- | ---------- | [3] 1,800 |
| 1N-7W-17 | ---------- | ---------- | [3] 2,100 |
| 2N-6W-32 | ---------- | ---------- | [3] 1,600 |
| 2N-9W-11 | ---------- | ---------- | [3] 1,900 |
| 3N-9W-31c | 70,000 | $4\times10^{-2}$ | [4] 1,000 |
| 4N-2E-3ddd | 320,000 | $4\times10^{-2}$ | 2,500 |
| 4N-5W-8ccd | 130,000 | ---------- | ---------- |
| 4N-8W-15 | 90,000 | ---------- | [5] 1,200 |
| 6N-5E-18aaa | 270,000 | $9\times10^{-4}$ | ---------- |

1 See page V8 for definition.
2 The field coefficient of permeability is the flow of water, at the prevailing water temperature, in gallons per day, through a cross-sectional area of 1 sq ft under a hydraulic gradient of 1 ft per ft (Ferris and others, 1962, p. 72).
3 Engler, Thompson, and Kazmann (1945, p. 43).
4 Plebuch (1961, p. 29).
5 Counts (1957, p. 17).

Before pumping for irrigation became extensive, the slope of the regional water table was southward following the general slope of the land surface and the gradients of the principal streams. In the western part of the study area, the water table sloped eastward and southeastward across the Grand Prairie (fig. 5).

The shape of the regional water table began to change after pumping for rice irrigation began in the Grand Prairie region in 1904. By 1915, water levels had dropped appreciably, and the decline spread in all directions from the pumping center in the Grand Prairie region. An ellipsoidal depression having a northwest-southeast axis formed, extending from Lonoke to a point a few miles southeast of De Witt, and water flowed into the Grand Prairie from all directions. (See Engler and others, 1945.)

The water table in the western half of the project area has been affected by the regional decline. In the vicinity of Lonoke the water table now slopes steeply to the southeast, and near De Valls Bluff it slopes to the south and southwest. Water levels have declined as far north as Des Arc and now slope south toward the depression. The area of decline eventually extended northeast across the White River and reached a small depression that had formed north of Wynne.

Water levels in deposits of Quaternary age have been measured in parts of eastern Arkansas since 1928 to determine long-term trends and to observe seasonal fluctuations. During the present study a network of observation wells was established to observe fluctuations of water level during a period of 1 year (fig. 4) and to secure data for a water-table contour map (fig. 9).

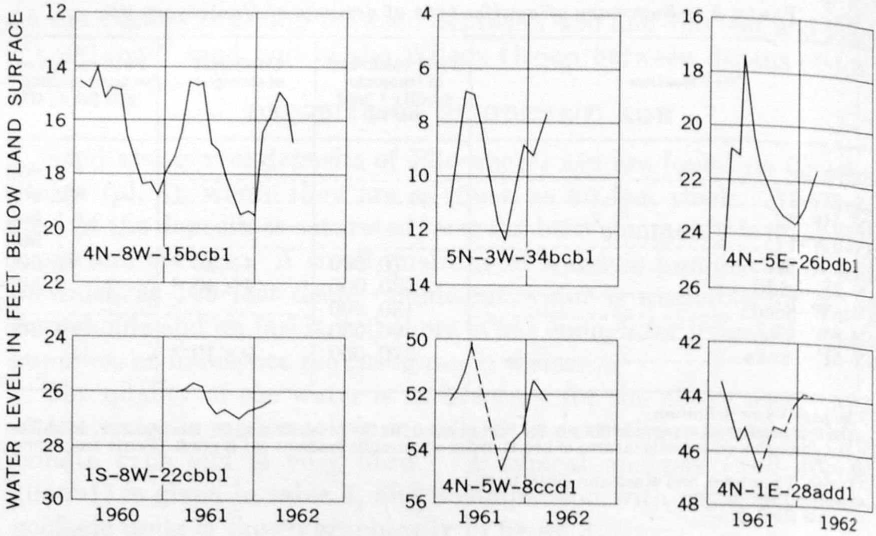


FIGURE 4.—Water levels in deposits of Quaternary age.

The altitude of the water table in parts or all of the study area prior to 1915, in the springs of 1929, 1938, and 1953, and in December 1961–January 1962 is shown in figures 5–9.

The difference in configuration of the water table prior to 1915 and in 1961–62 shows that water levels have declined 40–50 feet in the vicinity of Lonoke, Carlisle, and De Valls Bluff. The water level in well 2N–8W–26cdc1, about 3 miles east of Lonoke, has declined an average of 1.0 foot per year since 1915 (figs. 5, 10). Near Des Arc, water levels have not declined since 1955. In a few places near Des Arc they have risen slightly. In western St. Francis and Lee Counties, water levels have declined about 10 feet since 1936. Close to the west side of Crowleys Ridge and between the ridge and Crittenden County, water levels have declined little or not at all.

Lines of observation wells were established across the White River at Des Arc, De Valls Bluff, and Clarendon to determine whether the river and the deposits of Quaternary age are hydraulically connected (figs. 11, 12, 13).

Water levels in wells on the west side of the river were lower than the river stage throughout the year of record; so the water table sloped away from the river and into the depression in the Grand Prairie. Figures 11, 12, and 13 indicate that the river recharges the aquifer throughout the year.

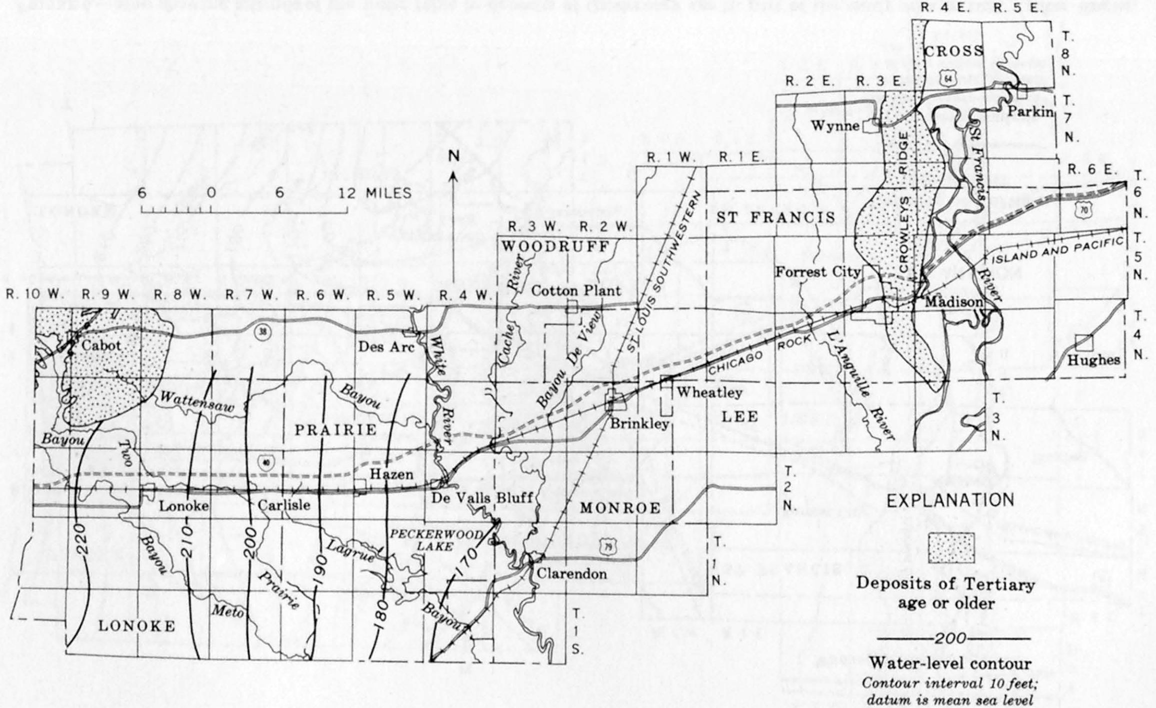


FIGURE 5.—Map showing altitude of the water table in deposits of Quaternary age in part of the study area prior to 1915. After Fricke (1948).

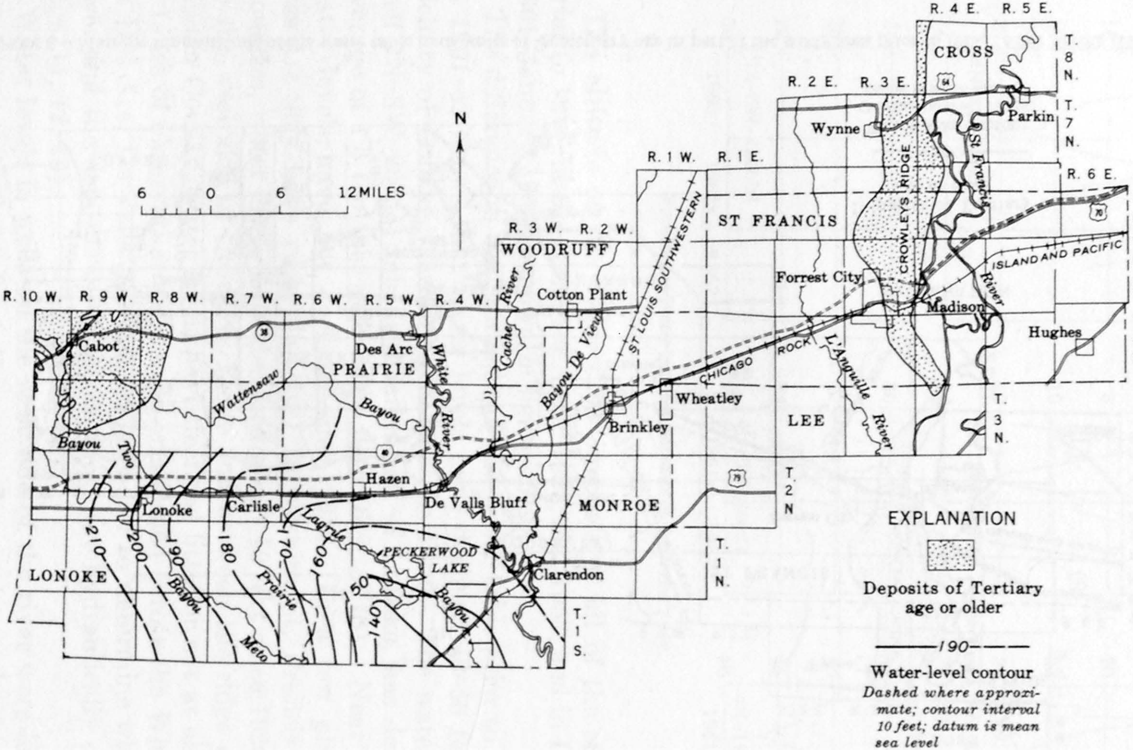


FIGURE 6.—Map showing altitude of the water table in deposits of Quaternary age in part of the study area in 1929. After Engler, Thompson, and Kazmann (1945).

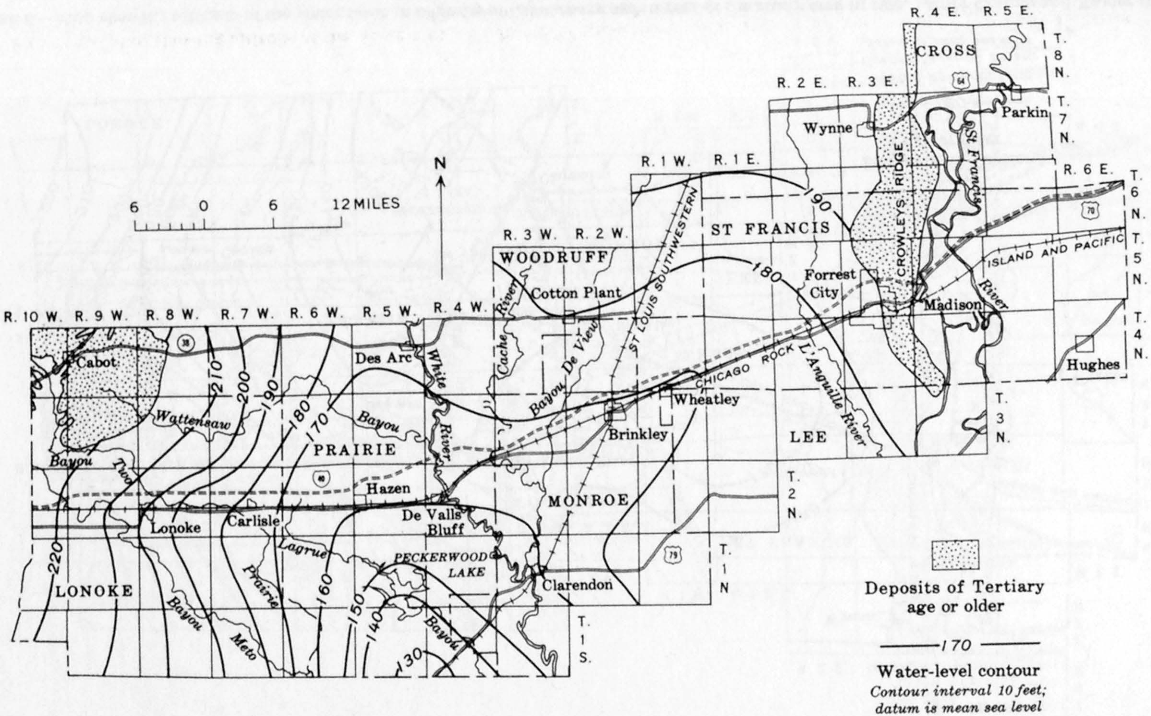


FIGURE 7.—Map showing altitude of the water table in deposits of Quaternary age in part of the study area in 1938. After Counts and Engler (1954).

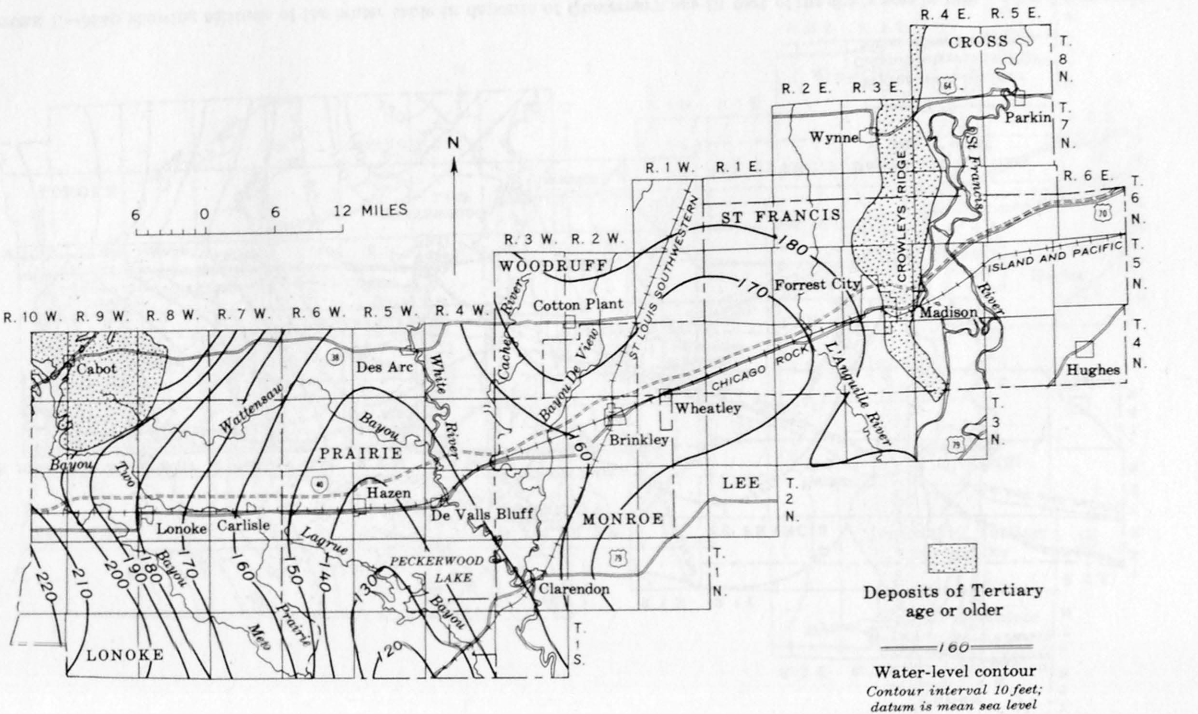


FIGURE 8.—Map showing altitude of the water table in deposits of Quaternary age in part of the study area in 1953. After Counts and Engler (1954).

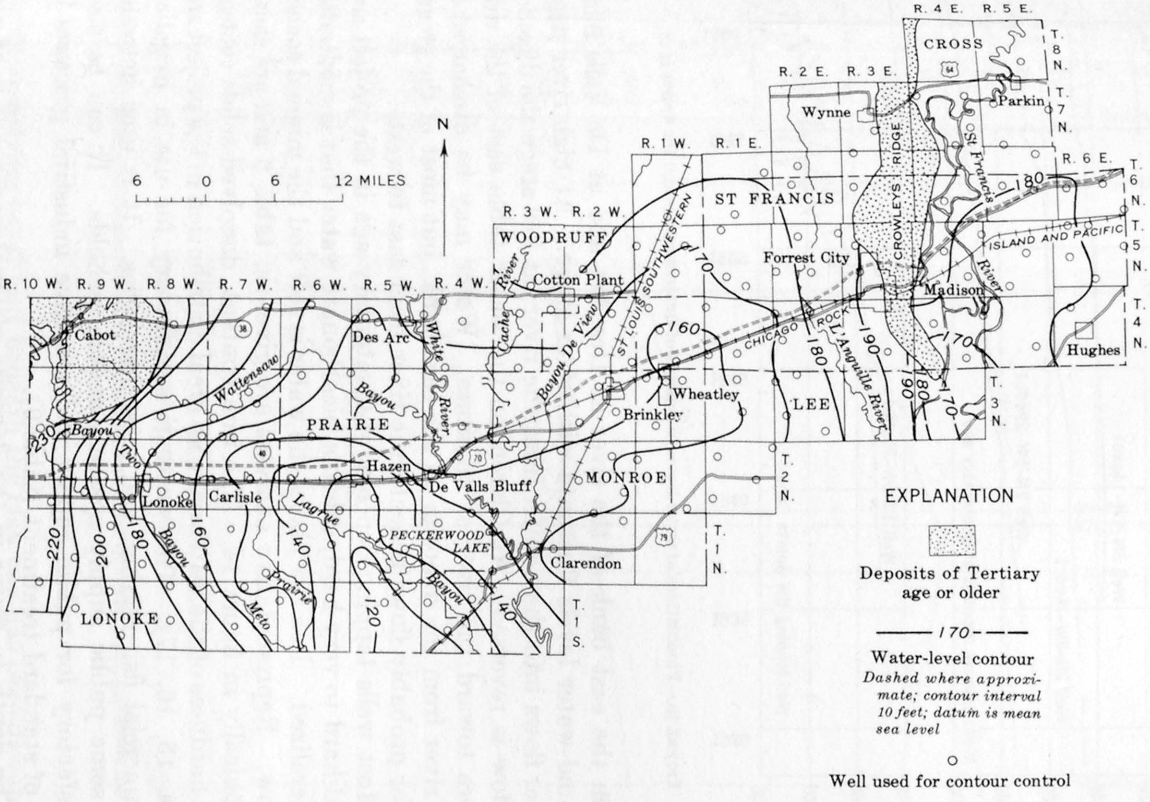


FIGURE 9.—Map showing altitude of the water table in deposits of Quaternary age in the study area in 1961–62.

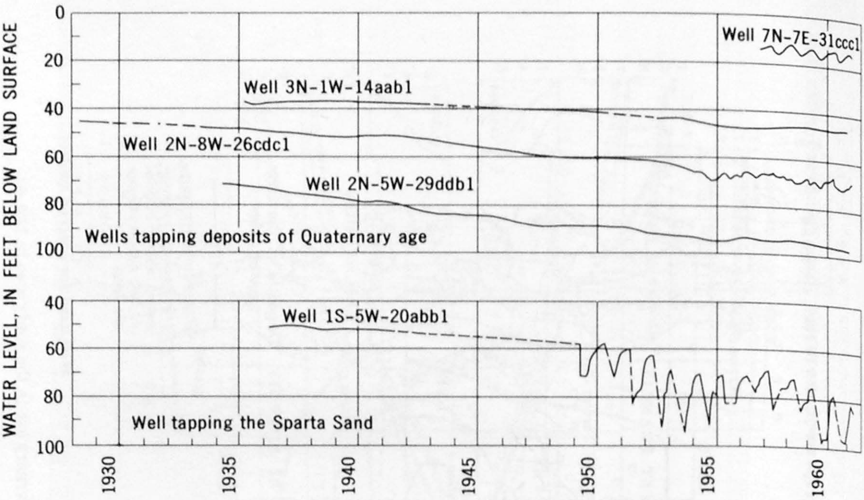


FIGURE 10.—Fluctuations of water levels in deposits of Quaternary age and the Sparta Sand.

On the east bank of the river at Des Arc and at De Valls Bluff, ground-water levels fluctuate with river stage. At high river stage, water flows into the aquifer from the river; at low stage the direction of flow is reversed. At Clarendon the water table east of the river slopes toward the river at all times. Water may be discharged to the river from the deposits on the east bank, but most of the ground water probably flows beneath the river from east to west.

Most wells tapping deposits of Quaternary age in the project area yield hard to very hard, calcium bicarbonate water that is moderately mineralized. In a few places the water is soft and the mineral content is low. Representative analyses are given in table 6 and are shown graphically in figure 14. The iron content, dissolved-solids content, and hardness of the water have an areal distribution in the project area (figs. 15, 16, 17). The water is satisfactory for use in irrigation, commercial fish rearing, and most industries. It is used untreated by some public supply systems and households. It can be made satisfactory for public supply and sensitive industrial processes by use of standard treatment (table 9).

The depth to water in the deposits of Quaternary age is affected by differences in the altitude of the land surface, the proximity of bodies of surface water hydraulically connected with the aquifer, and by pumpage. West of the White River the depth to water in 1961–62 ranged from a few feet below the land surface near small streams to about 100 feet near Hazen and in southern Prairie County; in places, the water table has been drawn down so far that the upper part of

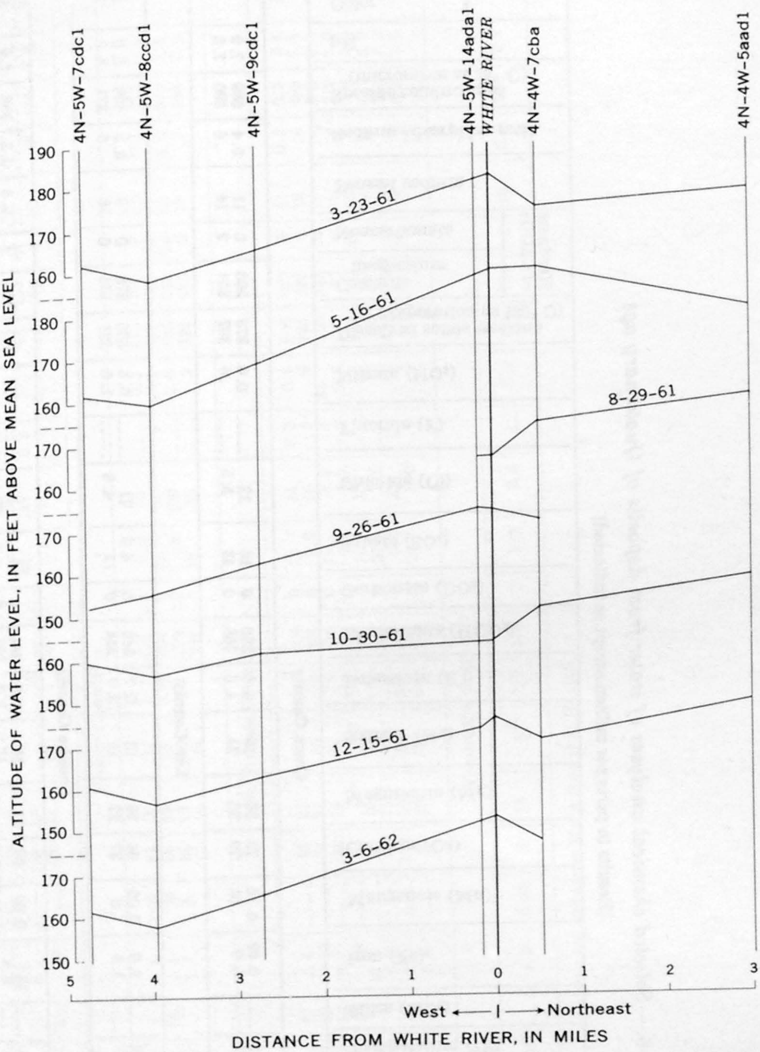


FIGURE 11.—Fluctuations of water levels in wells tapping deposits of Quaternary age; line across the White River at Des Arc.

the water-bearing basal unit beneath the clay cap has been dewatered and the aquifer is no longer artesian. Between the White River and Crowleys Ridge the depth to water in 1961–62 generally was 10–40 feet; east of the ridge the depth to water was 15–30 feet. In western St. Francis and Lee Counties and southeastern Woodruff County, where pumping for irrigation has been heavy for many years, the depth to water 1961–62 was about 40–50 feet.

TABLE 6.—*Selected chemical analyses of water from deposits of Quaternary age*

[Results in parts per million except as indicated]

| Well | Depth of well (feet) | 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 (residue on evaporation at 180° C) | Hardness as $CaCO_3$: Calcium-magnesium | Hardness as $CaCO_3$: Noncarbonate | Percent sodium | Sodium adsorption ratio | Specific conductance (micromhos at 25° C) | pH | Color |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cross County** | | | | | | | | | | | | | | | | | | | | | | | | |
| 6N-2E-9bba1 | 159 | 7-20-61 | 62 | ---- | 0.69 | 0.16 | 73 | 30 | 18 | 4.1 | 380 | 0 | 18 | 12 | ----- | 0.6 | 373 | 306 | 0 | 11 | 0.4 | 589 | 7.9 | 5 |
| 7N-4E-34bbb1 | 58 | 8- 3-61 | 63 | ---- | 5.0 | .01 | 79 | 26 | 24 | 4.0 | 368 | 0 | 43 | 5.5 | ----- | .5 | 397 | 304 | 2 | 14 | .6 | 590 | 7.8 | 7 |
| **Lee County** | | | | | | | | | | | | | | | | | | | | | | | | |
| 2N-2E-19caa1 | 145 | 8- 4-61 | 62 | ---- | 2.0 | 0.00 | 64 | 29 | 13 | 0.7 | 346 | 0 | 4.6 | 11 | ----- | 0.5 | 308 | 278 | 0 | 9 | 0.3 | 498 | 8.0 | 5 |
| 3N-3E-22abb1 | 55 | 7-21-61 | 65 | ---- | 1.8 | .0 | 37 | 22 | 16 | 3.9 | 244 | 0 | 11 | 4.8 | ----- | 1.0 | 221 | 183 | 0 | 16 | .5 | 371 | 8.0 | 5 |
| **Lonoke County** | | | | | | | | | | | | | | | | | | | | | | | | |
| 1S-8W-7abc1 | ----- | 7-11-61 | 63 | ---- | 13 | 0.00 | 64 | 11 | 10 | 1.0 | 244 | 0 | 16 | 5.8 | ----- | 0.5 | 250 | 204 | 4 | 9.6 | 0.3 | 388 | 7.9 | 5 |
| 2N-9W-31bba1 | 100 | 5-11-59 | 63 | ---- | 3.8 | ------ | ----- | ------ | 17 | 1.3 | 156 | 4 | ------ | 20 | ----- | ------ | ------ | 123 | ---- | 14 | .5 | 308 | 8.4 | ---- |
| 3N-8W-21bcc1 [1] | 154 | 8- 9-54 | 64 | ---- | .33 | ------ | 34 | 8.5 | 15 | ----- | 150 | 0 | 5.2 | 18 | ----- | .4 | 191 | 120 | 0 | 21 | .6 | 302 | 7.9 | 3 |

| | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Monroe County** | | | | | | | | | | | | | | | | | | | | | | | | |
| 1N-3W-24bbd1 | 123 | 7-14-61 | 63 | ---- | 4.9 | 0.01 | 36 | 12 | 7.0 | 1.6 | 168 | 0 | 8.4 | 7.5 | ----- | 0.8 | 210 | 140 | 2 | 10 | 0.3 | 292 | 7.2 | 5 |
| 2N-1W-33add1 | 129 | 8-4-61 | 63 | ---- | 1.8 | .02 | 96 | 34 | 35 | 2.7 | 488 | 0 | 15 | 25 | ----- | .5 | 457 | 380 | 0 | 17 | .8 | 742 | 7.9 | 5 |
| 3N-2W-10dbc5 [2] | 150 | 4- -61 | ---- | ---- | 2.4 | 0 | 123 | 37 | ------- | ----- | ----- | ---- | 68 | 118 | 0.2 | ------- | 768 | 459 | 67 | ------ | ----- | ------ | 7.6 | ---- |
| 3N-2W-29bcd1 [1] | 128 | 3-29-61 | 63 | 18 | .29 | ------ | 75 | 23 | 31 | 2.2 | 346 | 0 | 2.2 | 45 | .3 | 1.8 | 315 | 282 | 0 | 19 | .8 | 634 | 7.4 | 5 |
| **Prairie County** | | | | | | | | | | | | | | | | | | | | | | | | |
| 1N-6W-22dad1 [1] | 140 | 7-12-61 | 64 | ---- | 1.5 | 0.01 | 68 | 18 | 20 | 1.7 | 322 | 0 | 5.6 | 12 | ----- | 0.7 | 316 | 244 | 0 | 15 | 0.6 | 490 | 7.8 | 5 |
| 2N-5W-24aaa1 | 120 | 11-1-61 | 66 | 16 | 4.1 | .00 | 89 | 24 | 35 | 3.0 | 364 | 0 | 52 | 30 | .0 | .1 | 441 | 320 | 22 | 19 | .8 | 680 | 7.3 | 5 |
| 3N-5W-3dbb1 [1] | 130 | 7-19-61 | 65 | ---- | 1.5 | .0 | 69 | 17 | 115 | 5.3 | 270 | 0 | .8 | 190 | ----- | 2.0 | 585 | 242 | 20 | 50 | 3.2 | 974 | 7.8 | 5 |
| 3N-6W-5abb1 | 130 | 8-10-54 | 63 | ---- | 1.4 | ------ | 67 | 12 | 22 | ----- | 281 | 0 | 16 | 18 | ----- | .2 | 329 | 216 | 0 | 18 | .7 | 509 | 7.2 | 4 |
| **St. Francis County** | | | | | | | | | | | | | | | | | | | | | | | | |
| 4N-1E-30ddc1 | ---- | 5-31-61 | 64 | 17 | 1.4 | ------ | 91 | 23 | 19 | 2.0 | 404 | 0 | 12 | 14 | 0.3 | 0.9 | 401 | 322 | 0 | 11 | 0.5 | 613 | 7.8 | 15 |
| 4N-2E-3ddd3 | 151 | 4-11-61 | 63 | 22 | .00 | ------ | 51 | 27 | 20 | .8 | 298 | 0 | 9.8 | 18 | .5 | .9 | 335 | 238 | 0 | 15 | .6 | 493 | 7.8 | 5 |
| 4N-5E-26bdb1 | 40 | 6-29-61 | 61 | 16 | 3.1 | ------ | 32 | 14 | 12 | .8 | 136 | 0 | 14 | 8.0 | .4 | 30 | 240 | 138 | 26 | 16 | .4 | 302 | 6.6 | 10 |
| 5N-3E-21dcc1 [1] | 141 | 7-20-60 | 62 | 19 | .04 | ------ | 24 | 7.8 | 9.4 | 1.2 | 116 | 0 | 4.6 | 5.2 | .3 | 2.8 | 150 | 92 | 0 | 18 | .4 | 219 | 8.0 | 5 |
| 5N-4E-1bca1 | ---- | 8-19-55 | 63 | ---- | 12 | ------ | 98 | 26 | 23 | ----- | 372 | 0 | 70 | 13 | ----- | .6 | 451 | 352 | 46 | 12 | .5 | 699 | 7.0 | 10 |
| 5N-5E-31adc1 [1] | ---- | 8-19-55 | 64 | ---- | 5.6 | ------ | 46 | 15 | 18 | ----- | 209 | 0 | 29 | 7.5 | ----- | .6 | 266 | 176 | 5 | 18 | .6 | 401 | 8.0 | 7 |
| 6N-1E-33aca1 [1] | 140 | 5-24-61 | 62 | 17 | 2.0 | ------ | 112 | 29 | 30 | 2.4 | 504 | 0 | 9.4 | 28 | .3 | .7 | 481 | 398 | 0 | 14 | .7 | 776 | 7.8 | 10 |
| 6N-5E-23cbc1 [1] | ---- | 6-29-61 | 62 | 16 | 8.8 | ------ | 92 | 26 | 24 | 4.2 | 426 | 0 | 28 | 8.0 | .3 | .5 | 441 | 336 | 0 | 13 | .6 | 653 | 7.8 | 12 |
| **Woodruff County** | | | | | | | | | | | | | | | | | | | | | | | | |
| 5N-2W-27cba1 | 107 | 7-14-61 | 62 | ---- | 1.9 | 0.22 | 37 | 10 | 6.7 | 1.2 | 176 | 0 | 1.2 | 2.5 | ----- | 0.9 | 178 | 134 | 0 | 10 | 0.3 | 262 | 7.8 | 8 |

[1] Analysis shown graphically in figure 14. [2] Analysis by Arkansas State Board of Health.

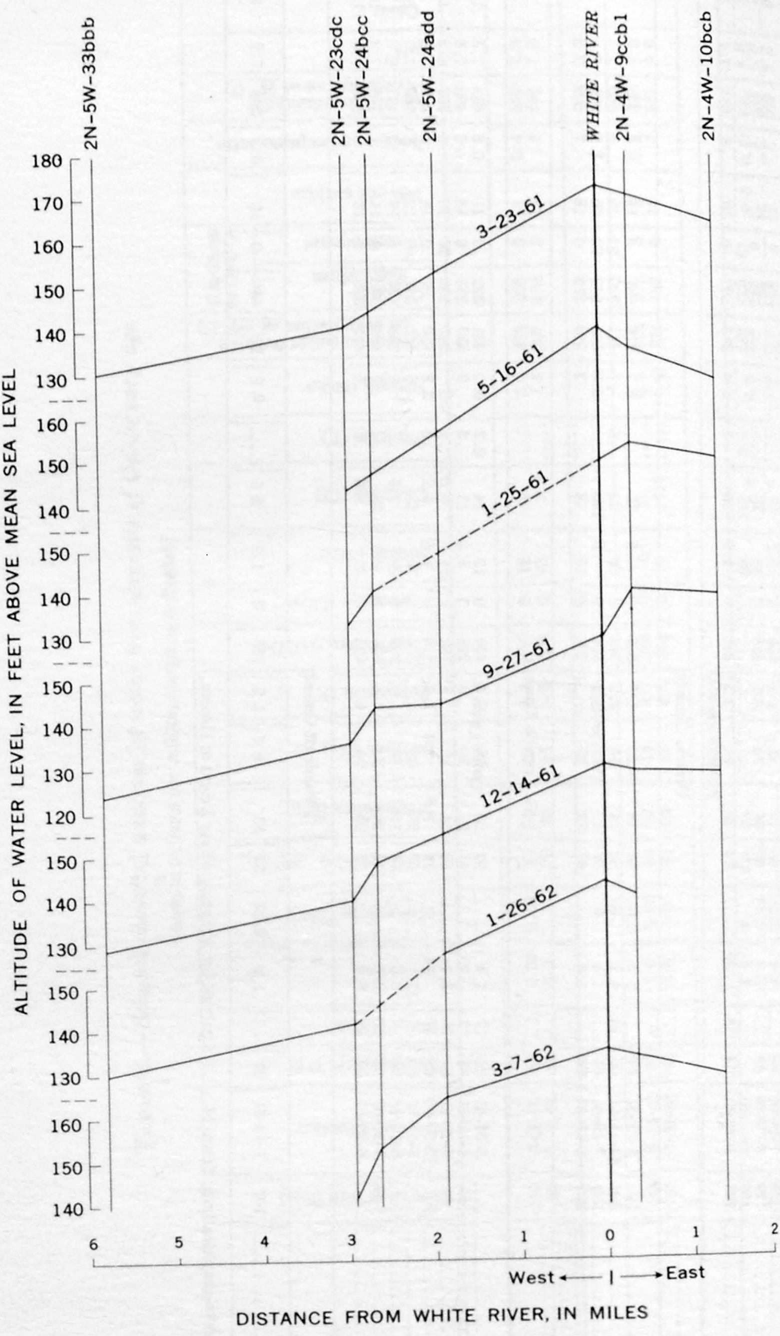


FIGURE 12.—Fluctuations of water levels in wells tapping deposits of Quaternary age; line across the White River at De Valls Bluff.

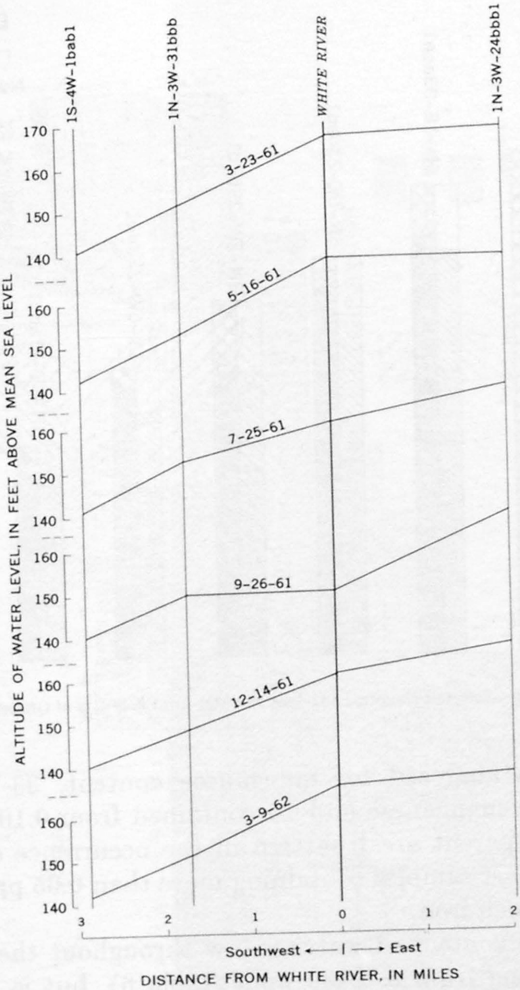


FIGURE 13.—Fluctuations of water levels in wells tapping deposits of Quaternary age; line across the White River at Clarendon.

The temperature of water from the deposits of Quaternary age throughout the area ranges from 61° to 65° F and averages about 63°. The uniform temperature reflects the depths of the wells and the mean annual air temperature. The depths of most of the wells range from 60 to 150 feet, and in that range ground-water temperature generally is 3°–6° F higher than the mean annual air temperature (Collins, 1925, p. 98). The mean annual air temperature for the report area is 62.4° F (U.S. Weather Bureau, 1962, p. 158).

The iron content of water from wells tapping deposits of Quaternary age ranges from 0 to 26 ppm and generally is less than 5 ppm (table 6; fig. 15). The manganese content generally is less than 0.05 ppm.

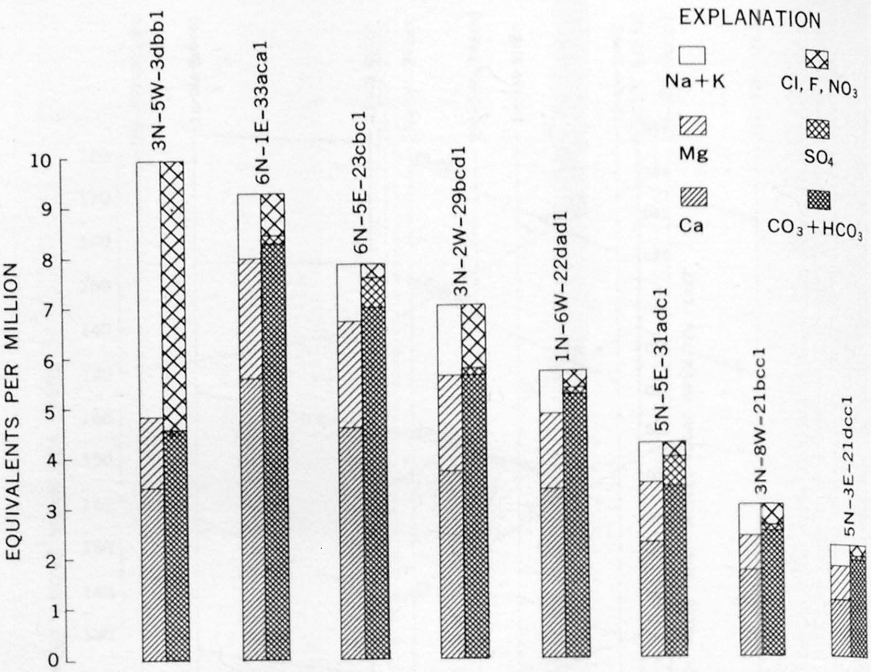


FIGURE 14.—Selected chemical analyses of water from deposits of Quaternary age.

Of 48 samples analyzed for manganese content, 33 contained less than 0.05 ppm manganese and 15 contained from 0.10 to 0.90 ppm. There is no apparent areal pattern in the occurrence of manganese. Most of the water samples containing more than 0.05 ppm manganese also contain much iron.

The chloride content of water is low throughout the project area, generally ranging from 5 to 30 ppm (table 6), but is higher in two small areas. Water from three wells about 4 miles south of Des Arc contains 400, 210, and 114 ppm chloride. According to Counts (1957), the water from the deposits of Quaternary age is of the calcium bicarbonate type and is contaminated by sodium chloride water from deeper formations. Reportedly, an unplugged oil-test well nearby contains water that has a high chloride content. It is likely that the ground water in this small area is contaminated by salt water from deeper strata, but whether the salt water travels upward in a well or along faults or other natural courses has not been determined. The second small area of high chloride content extends from Brinkley southwest about 4 miles along Highway 70. The chloride content in this area ranges from 47 to 152 ppm.

The fluoride content ranges from 0 to 0.6 ppm but generally is 0.3 to 0.4 ppm.

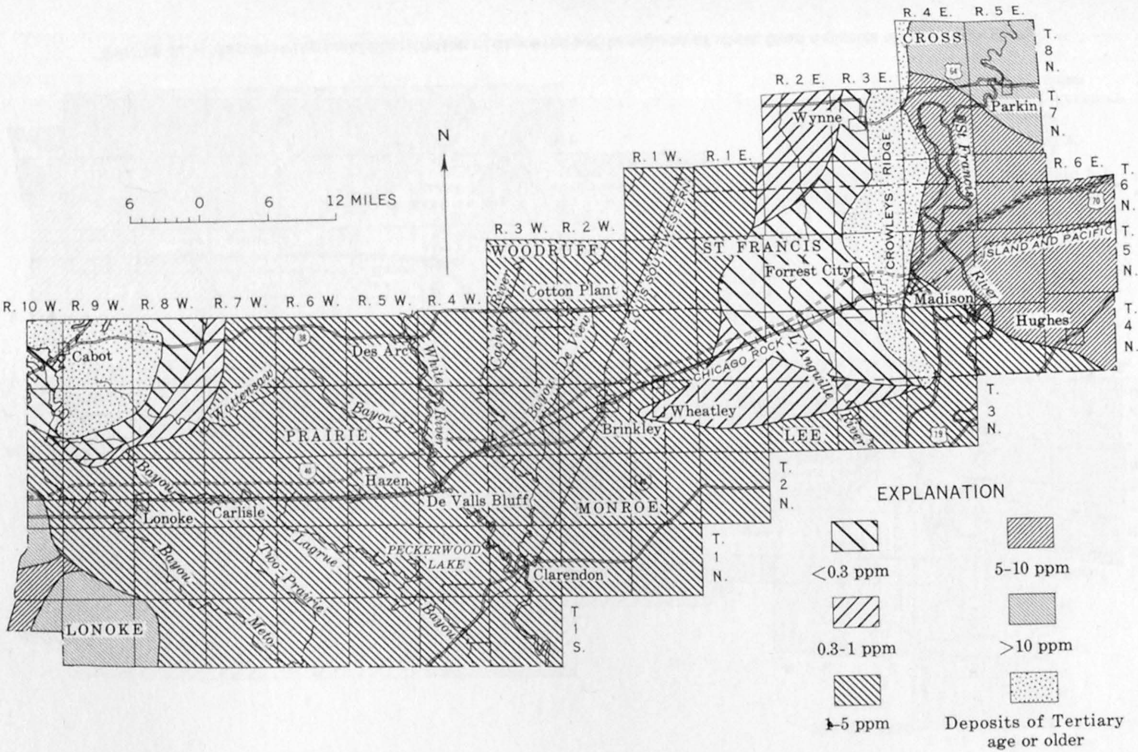


FIGURE 15.—Map showing areal distribution of iron content of water from deposits of Quaternary age.

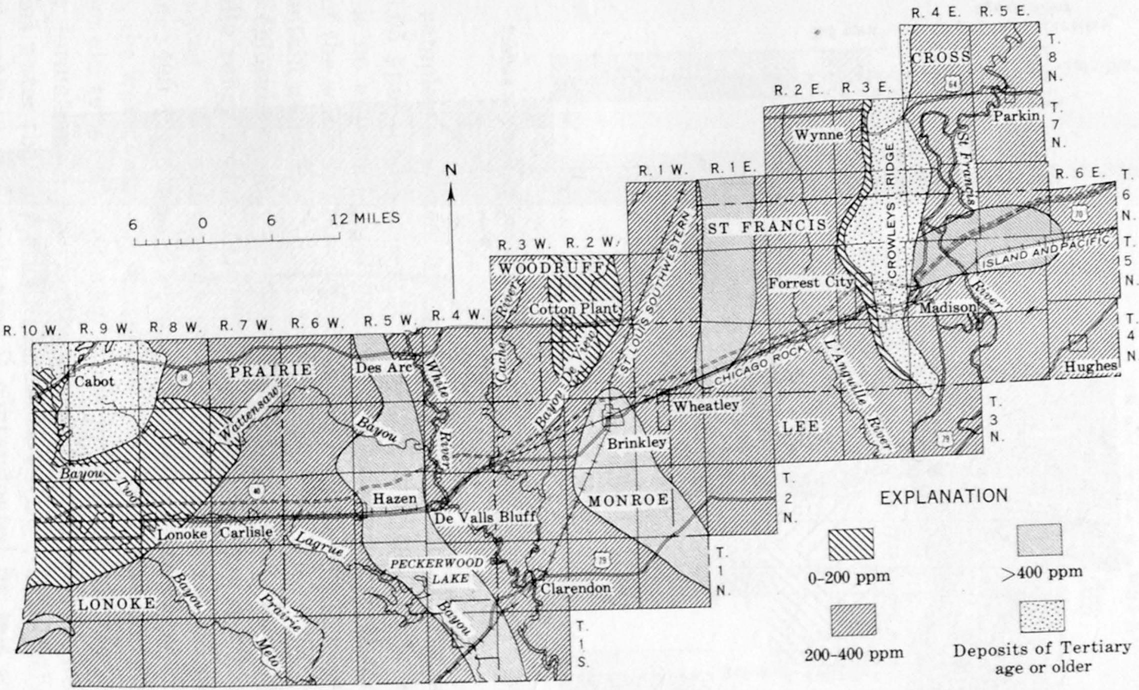


FIGURE 16.—Map showing areal distribution of dissolved-solids content of water from deposits of Quaternary age.

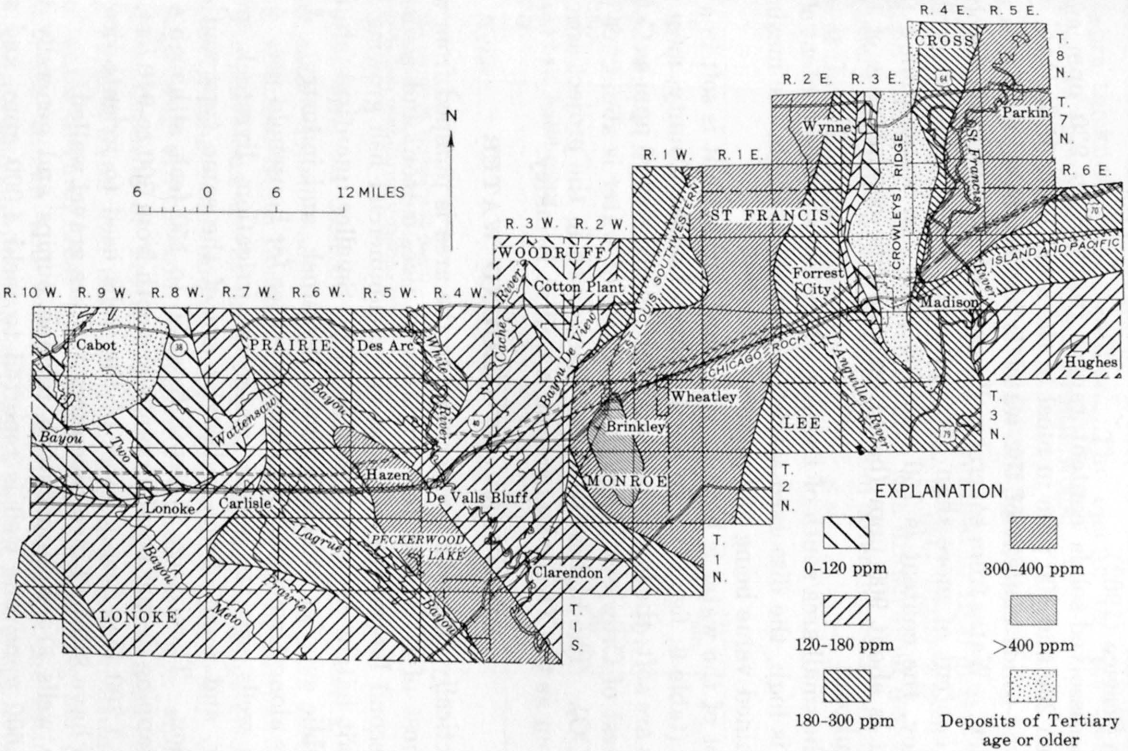


FIGURE 17.—Map showing areal distribution of hardness of water from deposits of Quaternary age, in parts per million as $CaCO_3$.

The nitrate content is low. In all but 4 of 113 samples analyzed for nitrate content, it was less than 3 ppm, and only in 1 sample was it greater than the limit of 45 ppm recommended by the U.S. Public Health Service (1962).

The dissolved-solids content ranges from 58 to 930 ppm and is between 200 and 400 ppm in most of the area (table 6; fig. 16). The dissolved-solids content of the water is highest in a small area near Brinkley. Water from several wells south of the city has a dissolved-solids content of more than 500 ppm. In water from two wells in Brinkley, the content is 750 and 768 ppm. In water from a third well, it is about 900 ppm (based on a specific conductance of 1,520 micromhos).

In the small area south of Des Arc where the chloride content of the water is high, the dissolved-solids content also is high, the maximum determined value being 930 ppm.

Most of the water is hard to very hard, although it is soft in a few places (table 6; fig. 17). In northwestern Lonoke County, most well waters are soft; the lowest hardness determined was 10 ppm as $CaCO_3$. Just west of Crowleys Ridge the hardness of water is about 100 ppm as $CaCO_3$. The highest hardness determined in the project area was 459 ppm as $CaCO_3$ for water from a well at Brinkley.

## RECOVERY OF GROUND WATER

Practically all ground water used in the area is pumped from wells and most of it is used for irrigation of rice, cotton, and soybeans. The second largest use of water is for commercial fish growing (fish and bait hatcheries or minnow farms). Smaller quantities are used for public supply, rural households, livestock, and industry. A few springs along Crowleys Ridge supply water for household use.

The wells used to supply water for irrigation, livestock, public supply, and some of the industries are of the same type and construction. They range in depth from 80 to 150 feet, although a few wells tapping deeper aquifers range in depth from 300 to 940 feet, and one is 1,700 feet deep. Most of the wells used to irrigate rice and cotton have 8- to 12-inch diameters and are gravel walled.

The wells are equipped with turbine pumps and generally yield 500–1,500 gpm; one well is reported to yield 4,000 gpm, and some wells yield as little as 300 gpm.

In the vicinity of Cotton Plant, where the water level is less than 25 feet below land surface, most irrigation wells are equipped with centrifugal pumps. Most of the pumps have capacities of less than 400 gpm and are installed in 4- to 6-inch diameter wells. These small-capacity pumps and small-diameter wells are used to irrigate cotton and soybeans, which require less water than rice requires.

Most of the domestic wells have 2- to 4-inch diameters and are equipped with screens 3–10 feet long. The wells generally are shallower than nearby irrigation wells, as they do not penetrate the entire thickness of the aquifer. The ejector or "jet" pump is the principal type used on the domestic wells.

## UTILIZATION OF GROUND WATER

About 228 mgd of ground water was pumped in 1960 in the project area. Of this pumpage, about 93 percent (211 mgd) was used for irrigation (table 7). Most of the water was drawn from deposits of Quaternary age; only 3 mgd was drawn from older deposits, principally sands of the Claiborne Group.

TABLE 7.—*Estimated use of water, 1960*

[Data in million gallons per day]

| | Ground water | Surface water | Total by use |
|---|---|---|---|
| Municipal supply | 3.1 | 0 | 3.1 |
| Rural households | 2.0 | 0 | 2.0 |
| Irrigation | [1,2] 211 | [3] 29 | 240 |
| Livestock | .7 | .9 | 1.6 |
| Fish and bait hatcheries | 11 | .5 | 11.5 |
| Industry | .5 | 0 | .5 |
| Total | 228.3 | 30.4 | 258.7 |

[1] Rice 150, cotton 36, soybeans 25 (mgd).
[2] 237,000 acre-feet, used during irrigation season.
[3] 32,600 acre-feet, used during irrigation season.

Ground water is used by all the municipal water systems, which supply about 36,000 people (table 8). According to data furnished by the Arkansas State Board of Health and by the municipalities, in 1960 the cities and towns used 3.04 mgd, of which about 2.73 mgd was used by households and 0.31 mgd was used by industries. About 1.87 mgd was drawn from deposits of Quaternary age, and 1.17 mgd from deposits of Tertiary age. The chemical quality of the public supply water and the way it is treated are shown in table 9. Use of water in rural areas was computed by multiplying per capita uses by the human and livestock populations. Of the estimated 60,000 people who supply their own water, about 36,000 have running water in their homes and use about 50 gpd per capita; the other 24,000 use about 10 gpd per capita.

About 237,000 acre-feet (211 mgd) of ground water was pumped from 1,800 wells in 1960 to irrigate rice, cotton, and soybeans. About 94,000 acres of rice, 60,000 acres of cotton, and 57,000 acres of soybeans were irrigated with ground water. A small amount was applied to other crops and to pastures.

TABLE 8.—*Use and source of ground water for public supply, 1960*

[Aquifer: Tw, Wilcox Group ("1,400-foot" sand); Te, deposits of Eocene age, undifferentiated; Tc, Claiborne Group, undifferentiated; Qt, deposits of Quaternary age]

| Municipality | Population in 1960 | Source of water | | Water use (mgd) | Per capita use (gpd) |
|---|---|---|---|---|---|
| | | Aquifer | Depth of well (feet) | | |
| Brinkley | 4,571 | Qt<br>Tc | 150<br>250 | 0.50 | 100 |
| Cabot | 1,313 | Te | ---------- | .20 | 152 |
| Carlisle | 1,507 | Qt | 142 | .12 | 80 |
| Clarendon | 2,272 | Tc | 678 | .18 | 79 |
| Cotton Plant | 1,682 | Tc | 270 | .10 | 59 |
| De Valls Bluff | 655 | Qt | 108 | .04 | 61 |
| Des Arc | 1,478 | Qt | 154 | .10 | 68 |
| Forrest City | 9,850 | Qt | 140 | [1] .78 | 79 |
| Hazen | 1,458 | Qt | 152 | .12 | 82 |
| Hughes | 1,954 | Tw | 1,780 | .15 | 77 |
| Lonoke | 2,276 | Qt | 120 | .17 | 75 |
| Madison [2] | 749 | Qt | 108 | .04 | 53 |
| Parkin | 1,478 | Tc | 491 | .11 | 74 |
| Wynne | 4,884 | Tc | 498<br>759 | [3] .43 | 88 |
| Total | 36,127 | ---------- | ---------- | 3.04 | 84 |

[1] Includes 0.28 mgd used by industry.
[2] Use of local supply discontinued in 1962, water now purchased from Forrest City.
[3] Includes 0.03 mgd used by industry.

Fish growing (minnow farms or bait hatcheries and fish farms) is commercially important in Arkansas. About 11 mgd of ground water was supplied in 1960 to the 9,700 acres of ponds devoted to this activity in the study area. The quantity of water used for commercial fish rearing was estimated on the basis of pond-acreage figures furnished by the Arkansas Game and Fish Commission and on the quantity of water needed to replace evaporated water and to refill drained ponds.

Industries in the project area having their own sources of supply use little water. Cotton compresses and gins, gravel-washing plants, ice plants, and motels used about 0.5 mgd in 1960.

TABLE 9.—*Chemical analyses of water from public supplies*

[Results in parts per million except as indicated. Water treatment: A, aeration; C, chemical dosage for coagulation; Dc, disinfection by chlorination; Dh, disinfection by hypochlorination; F, filtration; H, softening; I, iron removal; K, stabilization with polyphosphates; S, sedimentation; V, fluoridation. Aquifer: Tw, Wilcox Group ("1,400-foot" sand); Te, deposits of Eocene age, undifferentiated; Tc, Claiborne Group, undifferentiated; Qt, deposits of Quaternary age]

| Municipality | Water Treatment | Aquifer | 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 (residue on evaporation at 180°C) | Hardness as $CaCO_3$ | | Percent sodium | Sodium adsorption ratio | Specific conductance (micromhos at 25°C) | pH | Color |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | | Calcium-magnesium | Noncarbonate | | | | | |
| Brinkley | A, C, Dc, F, H, I, S. | Qt, Tc | 10- 9-61 | 65 | 12 | 0.00 | 0.00 | 33 | 29 | 88 | 3.4 | 150 | 0 | 93 | 120 | 0.3 | 2.3 | 490 | 202 | 78 | 48 | 2.7 | 787 | 7.6 | 0 |
| Cabot [1] | A, Dc, K | Te | 2- -59 | ---- | ---- | 0 | 0 | 6.2 | 1.7 | ---- | ---- | 21 | 0 | 0 | 5.0 | .1 | ---- | 85 | 23 | 5.6 | ---- | ---- | ---- | 6.5 | ---- |
| Carlisle | A, F, I | Qt | 10- 9-61 | 66 | 18 | .03 | .00 | 42 | 12 | 25 | 2.2 | 200 | 0 | 15 | 22 | .3 | 1.0 | 248 | 154 | 0 | 26 | .9 | 389 | 7.6 | 0 |
| Clarendon [1] | Dc, K | Tc | 9- -60 | ---- | ---- | .74 | 0 | 18 | 4.5 | ---- | ---- | 258 | 0 | 0 | 82 | .2 | ---- | 405 | 64 | 0 | ---- | ---- | ---- | 7.3 | ---- |
| Cotton Plant. | A, I, S | Tc | 10- 9-61 | ---- | 19 | .46 | .02 | 25 | 13 | 7.6 | 1.2 | 152 | 0 | .0 | 4.5 | .3 | .9 | 154 | 116 | 0 | 12 | .3 | 239 | 7.8 | 0 |
| De Valls Bluff. | Dh | Qt | 10- 9-61 | ---- | 18 | 3.0 | .01 | 43 | 13 | 5.5 | .9 | 194 | 0 | 2.8 | 6.5 | .3 | 1.4 | 211 | 161 | 2 | 7 | .2 | 306 | 7.5 | 5 |
| Des Arc [1] | A, Dh, I, S | Qt | 1- -60 | ---- | ---- | .95 | .1 | 67 | 14 | ---- | ---- | 258 | 0 | 0 | 24 | .2 | ---- | 306 | 226 | 14 | ---- | ---- | ---- | 7.7 | ---- |
| Forrest City | A, Dc, V | Qt | 7-21-60 | ---- | 25 | .22 | ---- | 21 | 11 | 10 | .8 | 124 | 0 | 5.0 | 6.0 | .9 | 7.5 | 180 | 98 | 0 | 18 | .4 | 216 | 6.7 | 5 |
| Hazen | A, Dc, F, I | Qt | 10- 9-61 | 66 | 23 | .00 | .00 | 64 | 20 | 22 | 1.8 | 312 | 0 | 12 | 16 | .3 | 1.2 | 327 | 242 | 0 | 16 | .6 | 509 | 7.8 | 0 |
| Hughes | Dc | Tw | 8-15-57 | ---- | 5.6 | .22 | ---- | .4 | .1 | 46 | 1.8 | 119 | 0 | 1.2 | 5.0 | .1 | 1.3 | 130 | 1 | 0 | 96 | 17 | 196 | 7.8 | 5 |
| Lonoke | Dh, K | Qt | 10- 9-61 | 66 | 18 | .18 | .01 | 29 | 11 | 15 | 1.0 | 164 | 0 | 7.2 | 7.5 | .2 | .9 | 175 | 118 | 0 | 21 | .6 | 276 | 7.4 | 0 |
| Madison | None | Qt | 7-22-60 | 63 | 11 | .49 | ---- | 74 | 18 | 18 | 3.0 | 320 | 0 | 13 | 12 | .3 | 3.3 | 357 | 258 | 0 | 13 | 4.8 | 525 | 7.2 | 5 |
| Parkin | A, Dc, F, I | Tc | 8-15-57 | ---- | 7.4 | .40 | ---- | 12 | 4.1 | 25 | 5.8 | 126 | 0 | 1.6 | 3.2 | .0 | 1.9 | 124 | 47 | 0 | 50 | 1.6 | 194 | 7.3 | 6 |
| Wynne | A, C, Dc, F, H, I, S, V. | Tc | 8-14-57 | ---- | 9.7 | .01 | ---- | 47 | 23 | 7.6 | 1.9 | 263 | 0 | 6.8 | 3.8 | .8 | 2.4 | 229 | 212 | 0 | 7 | .2 | 411 | 7.9 | 5 |

[1] Analysis by Arkansas State Board of Health.

## CONCLUSIONS

Ground water is the principal source of present and potential water supply in the U.S. Highway 70 study area. Most of the water is drawn from deposits of Quaternary age; smaller quantities are drawn from deposits of Tertiary age.

Deposits of Quaternary age constitute the principal aquifer in the area. Wells in these deposits are as much as 200 feet deep and generally yield 1,000–2,000 gpm although yields of as much as 3,000 gpm are known. In southern Lonoke and Prairie Counties, where water levels have declined appreciably since 1915, well yields are about 300–800 gpm. Deposits of Tertiary age constitute the second most productive aquifer. Sands of the Claiborne Group yield as much as 1,200 gpm to wells throughout the area. Wells screened in these deposits generally range in depth from 270 feet in southern Woodruff County to 640 feet in southern Prairie County.

The "1,400-foot" sand unit of the Wilcox Group yields as much as 1,000 gpm in eastern Cross, St. Francis, and Lee Counties. Deposits of Pennsylvanian and Eocene age in northwestern Lonoke County and deposits of Pliocene(?) age on Crowleys Ridge in Cross, St. Francis, and Lee Counties yield enough water for household needs.

The water from deposits of Quaternary age and from the Claiborne Group is commonly of the calcium bicarbonate type and is hard. However, near Parkin, east of Crowleys Ridge, the water from the Claiborne Group is soft and is of the sodium bicarbonate type. The dissolved-solids content, iron content, and hardness of water from deposits of Quaternary age have an areal distribution; they are lowest in northwestern Lonoke County and near the west side of Crowleys Ridge. Brackish water is found in deposits of Quaternary age in a small area south of Des Arc and in deposits of the Claiborne Group in a narrow band from Brinkley west to a few miles south of Des Arc. Water from deposits of Pliocene(?) age is of the magnesium bicarbonate type and is hard. East of Crowleys Ridge, water from the "1,400-foot" sand is of the sodium bicarbonate type and is soft.

In 1960 about 228 mgd of water was pumped in the area, and 93 percent of this water was used for irrigation. All but 3 mgd was drawn from deposits of Quaternary age. Most of the 3 mgd was drawn from the Claiborne Group; a small quantity was pumped from the "1,400-foot" sand.

Much more water can be obtained from the deposits of Quaternary age and from the Claiborne Group throughout most of the area and from the "1,400-foot" sand in the eastern part of the area. The decline in water level and consequent decrease in saturated thickness precludes the possibility of extensive development of the aquifer of Quaternary age in southern Lonoke and Prairie Counties. However, well yields of as much as 1,600 gpm can be obtained from individual wells in this area of decreased saturated thickness.

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