Water Resources of the Big Black River Basin, Mississippi

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1899-F

Prepared in cooperation with the U.S. Army Corps of Engineers, Vicksburg District

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By B. E. WASSON

CONTRIBUTIONS TO THE HYDROLOGY OF THE UNITED STATES

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A general description of ground- and surface-water availability, quantity, and quality in a major river basin of the Gulf Coast region

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1971

UNITED STATES DEPARTMENT OF THE INTERIOR

ROGERS C. B. MORTON, *Secretary*

GEOLOGICAL SURVEY

W. A. Radlinski, *Acting Director*

Library of Congress catalog card No. 77-17964

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price $4 (paper cover)

STOCK NUMBER 2401-1155

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WATER RESOURCES OF THE BIG BLACK RIVER BASIN, MISSISSIPPI

By B. E. Wasson

ABSTRACT

Abundant supplies of water of good quality are available in the Big Black River basin from either ground-water or surface-water sources. For 90 percent of the time flow in the lower part of the Big Black River below Pickens is not less than 85 cfs (cubic feet per second), and low flows of more than 5 cfs are available in five of the eastern tributary streams in the upper half of the basin. Chemical quality of water in the streams is excellent, except for impairment caused by pollution at several places.

The Big Black River basin is underlain by several thousand feet of clay, silt, sand, gravel, and limestone. This sedimentary material is mostly loose to semiconsolidated and is stratified. The beds dip to the southwest at the rate of 20 to 50 feet per mile. The Big Black River flows southwestward but at a lower gradient; therefore, any specific formation is at a greater depth below the river the farther one goes down stream. The formations crop out in northwest-southeast trending belts.

Most of the available ground water is contained in six geologic units; thickness of these individual units ranges from 100 to 1,000 feet. The aquifers overlap to the extent that a well drilled to the base of fresh water will, in most places, penetrate two or more aquifers. Well depths range from less than 10 to 2,400 feet.

Water suitable for most needs can be obtained from the aquifers available at most localities. Dissolved-solids content of water within an aquifer increases down the dip. Also, generally the deeper a well is the higher will be the dissolved-solids content of the water. Shallow ground water (less than 200 ft deep) in the basin usually contains about 100 mg/l (milligrams per liter) of dissolved solids. Most water in the basin from more than 2,500 feet below land surface contains more than 1,000 mg/l of dissolved solids. In several areas fresh water is deeper than 2,500 feet, but near the mouth of the Big Black River brackish water is only about 300 feet below land surface.

Practically all water pumped for man's use in the basin is from the ground (about 11 million gallons per day); however, a small amount of surface water is used for supplemental irrigation of row crops. Wells producing 500 to 1,000 gpm (gallons per minute) are not unusual in the basin. Most of the area is underlain by one or more aquifers from which a properly constructed well could produce as much as 2,000 gpm. All the towns in the area have sufficient ground water available to at least double or triple their ground-water pumpage.

SCOPE AND PURPOSE OF REPORT

This report is a summary description of the geohydrology and water resources of the Big Black River basin and of ground water-surface water relations as of 1966. It is based principally on data in the files of the U.S. Geological Survey and on published reports covering parts of the basin and adjacent areas.

The study was made by the Water Resources Division of the U.S. Geological Survey as a part of the interagency comprehensive study of the Big Black River basin. The purpose of the studies is to present facts that will lead to optimum development of the natural and cultural resources of the basin.

DESCRIPTION OF AREA

The long and narrow (160 miles long and 20 to 25 miles wide) Big Black River basin is in west-central Mississippi (fig. 1). Land-surface altitudes range from about 80 feet above sea level at the confluence of the Big Black and Mississippi Rivers to more than 500 feet along the eastern rim of the basin. The highest and most rugged terrain in the basin is in the upper reaches of the eastern tributaries to the Big Black River. Generally, hills in the basin are well rounded and flood plains are wide.

Precipitation in the basin is heaviest during winter and spring, and the average annual amount is 52 inches. Average annual runoff is about 17 inches. Average annual temperature is 65° F (18° Celsius). Freezing temperatures seldom last more than a day or two and days having temperature maximums of 100° F (38° C) or more are unusual.

Canton (population 9,707) is the largest city in the basin. The economy is predominantly agricultural; industrial plants in the area are small to medium but contribute substantially to the economy of the basin.

GEOLOGIC AND WATER-RESOURCES INVESTIGATIONS IN AREA

Thirty-three publications listed in the bibliography describe, with varying degree of detail and emphasis, the geology and water resources of parts or all of the Big Black River basin and adjacent areas. Current (1966) water-resources investigations by the U.S. Geological Survey include a study in the Jackson area, a study of the Mississippi embayment, observation of low flow in the Big Black basin, and statewide collection of basic data.

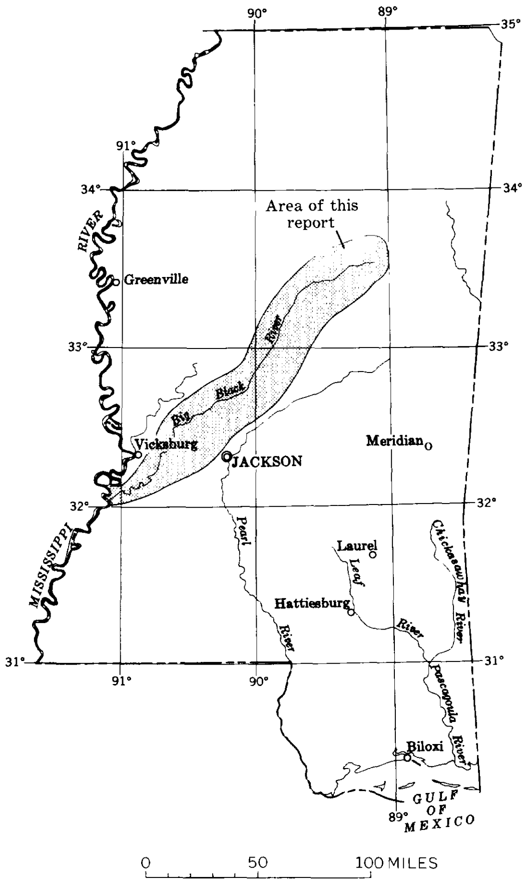

FIGURE 1—Location of Big Black River basin.

GEOLOGY

The Big Black River basin is in the south-central part of the Mississippi embayment, a downwarped extension of the Gulf Coastal Plain. The beds of sediment filling the Mississippi embayment are underlain by consolidated rocks of Paleozoic age. The Paleozoic rock is about 2,500 feet below land surface at the northeast end of the Big Black basin and slopes southwestward at about 80 feet per mile toward the trough of the embayment, which lies generally under the Mississippi River.

The sediments filling the Mississippi embayment trough consists mostly of clay, shale, silt, sand, and gravel, and range in age from Jurassic to Quaternary; however, most of the units that are of interest to water users in the basin are of Tertiary age. The belts of outcrop of the Tertiary formations (pl. 1) are, in general, transverse to the course of the Big Black River.

From the outcrops the formations dip southwestward about 30 feet per mile. Down the dip, the formations increase in thickness and generally the rates of dip increase. The dips and thicknesses of the formations are locally affected by several large and many small structural features in the area. The larger features are partially delineated by contour irregularities (pls. 2, 3).

GROUND WATER

OCCURRENCE

A geohydrologic section along the axis of the Big Black River basin (pl. 1) shows the occurrence and availability of ground water in the basin. On the section the geologic units are named and the aquifers are identified (aquifers in the basin are beds of saturated sand or gravel that will yield water to wells). Lithologic characteristics of the units are briefly stated on the section and more details can be seen in the electrical logs shown. The characteristics of several of the units that are not aquifers are consistent over large areas. Some of these nonaquifers, or aquicludes, are the Yazoo Clay, Cook Mountain Formation, Zilpha Clay, Porters Creek Clay, and Selma Group. Some of the units containing aquifers have reasonably predictable lithologic characteristics over large areas. Among these are the Gordo, McShan, and Eutaw Formations, Meridian-upper Wilcox aquifer, Tallahatta Formation, Winona Sand, and Cockfield Formation. Because of the more lenticular deposition of sediments in the Wilcox Group, Sparta Sand, Forest Hill Sand, and Catahoula Sandstone, it is more difficult to predict the thickness of sand beds, the percentage of sand, and the size and sorting of sand grains in these units. Capabilities of these last-named aquifer systems to yield water vary widely from place to place.

Not much is known about the alluvium in the lower part of the Big Black River flood plain, but it may be a good aquifier in places. With depth the alluvium usually grades from silt to sand and in places to gravel. Average depth of the alluvium above Bovina is about 25 feet. From Bovina downstream the thickness of the alluvium probably increases and may be more than 100 feet near the mouth of the Big Black.

The geohydrologic section is one aid in locating water-bearing sands. In addition, several structure maps have been drawn showing the configuration and altitude of the bases of seven of the principal aquifer systems (pls. 2, 3). Formation thicknesses in the basin generally do not change much along the strike, which is nearly transverse to the geohydrologic section (pl. 1). The depth of a well in a selected aquifer can be determined by (1) plotting the location on the appropriate structure-contour map, (2) determining the altitude of the base of the aquifer system at that point, and (3) algebraically applying this altitude to the land surface altitude at the locality. (Topographic maps showing land surface altitude are available for most of the basin.)

QUANTITY

AQUIFER CHARACTERISTICS

The quantity of water available to a well depends basically on the size and interconnection of the void space between grains of sand composing the aquifer. The size, shape, and sorting of the grains affect the void space and consequently the capacity of the aquifer to store and transmit water.

Aquifers underlying the Big Black River basin differ greatly in their capacity for transmitting water. Coefficients of transmissibility determined from pumping tests (table 1) ranged from 4,800 to 85,000 gpd (gallons per day) per foot. The coefficient of permeability (transmissibility divided by aquifer thickness in feet) ranged from 42 to 1,550 gpd per square foot. All the pumping tests were of artesian aquifers and most of the coefficients of storage were near 0.0001.

The ranges of permeability and transmissibility are probably greater than is indicated by the pumping test results. Certainly, some domestic wells are screened in thin beds of fine sand that have very low permeability and transmissibility values. The Coker, Gordo, lower Wilcox, Meridian-upper Wilcox, and Sparta aquifer systems each probably has a coefficient of transmissibility of more than 85,000 at places.

The amount of water that can be obtained from a well depends on the specific capacity of the well and the available drawdown in the well. Specific capacity of a well (the number of gallons of water per minute that the well will produce for each foot of drawdown after a specified period of pumping) reflects both the efficiency of the well and the characteristics of the aquifer. Well efficiency depends on design and development of the well; a few wells are 100-percent efficient, but most fall short of that standard for various reasons. The specific capacities of 100-percent efficient wells vary as the transmissibilities of the aquifers vary.

The available drawdown in a well is the distance from the static water level down to some limiting point, such as the bottom of the pump, the top of the screen, or a point calculated using a designated water lift. The product of available drawdown and specific capacity is the maximum production to be expected from a well.

The practical application of measured or assumed aquifer charac-

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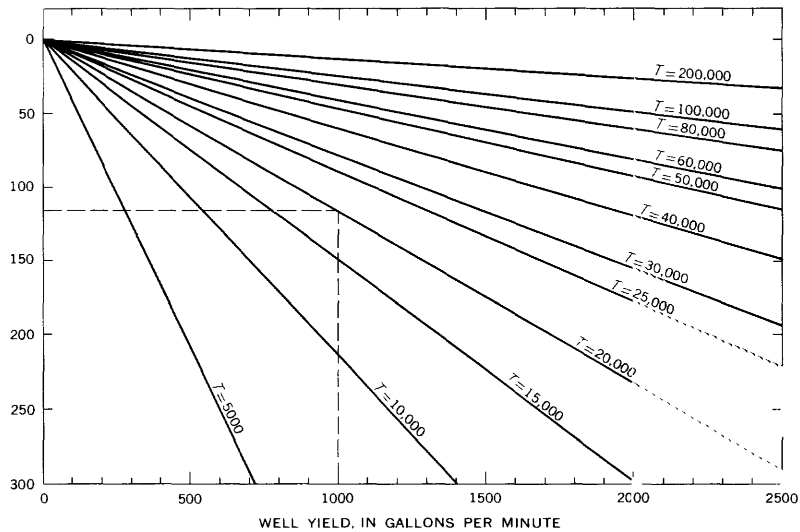

FIGURE 2.—Transmissibility (*T*)—drawdown—well yield relations. Where aquifer transmissibility is known or estimated the chart will provide the drawdowns caused by various pumping rates or the well yields for various amounts of drawdown. Values are based on artesian conditions and on a 100-percent-efficient 12-inch well; for well efficiencies less than 100 percent the yield will be decreased or the drawdown increased proportionately. Drawdown computations are based on 1 day of pumping; at 10 days the drawdown would be about 10 percent greater. (After Newcome, 1967.)

teristics is in predicting the yields of wells and the effects of ground-water withdrawal. A graph (fig. 2) relating transmissibility to drawdown and well yield is useful in estimating well yields and pump settings. Many of the sand beds listed in table 1 are capable of maintaining well yields in excess of the 2,500-gpm (gallons per minute) limit of the graph; however, no wells in the basin are constructed to supply more than that amount.

An example of the graph's use follows:

An electric log of a test hole showed a 40-foot thickness of sand at a depth of 500 feet. From other wells tapping that aquifer the static water level is known to be 50 feet below land surface. How deep should a pump be set to supply 1,000 gpm from a 12-inch well?

If the permeability of the aquifer is estimated to be 500 gpd per square foot, the transmissibility would be 20,000 gpd per foot (40×500). Using the graph, the $T=20{,}000$ line crosses the 1,000 gpm line at the 115-foot drawdown line. As the static level is 50 feet, a drawdown of 115 feet would place the pumping level at 165 feet. This assumes a 100-percent-efficient well—one in which no head is lost in movement of water from the aquifer into the well. A fully

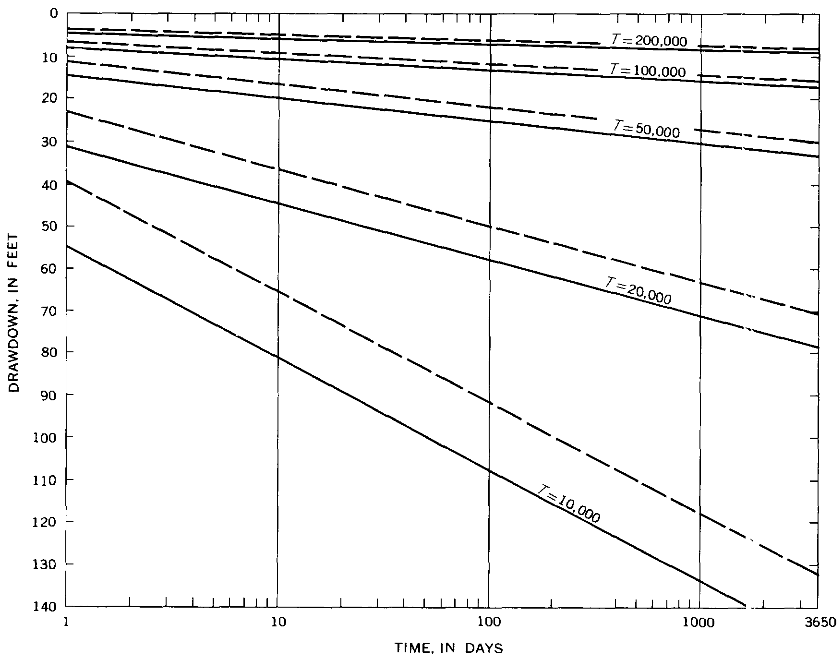

FIGURE 3.—Time-drawdown relations for selected aquifer characteristics. Pumping rate is 1,000 gpm; for other rates the drawdown will be proportional, solid line represents drawdown at a distance of 500 feet from pumped well; dashed line, 1,000 feet, *T*, coefficient of transmissibility, in gallons per day per foot. Coefficient of storage is assumed to be 0.0001. (After Newcome, 1967.)

efficient well is atypical; 75-percent efficiency is more realistic. Therefore, it is likely that a pumping level of nearly 200 feet would be required in this example. Of course, any deviation from the assumed permeability or well efficiency will affect the drawdown value.

The effect that pumping the above well would have on the artesian pressure surface for the aquifer can also be predicted. A second graph (fig. 3) relates transmissibility and drawdown effect at various times and distances for a selected rate of pumping. This graph is useful in guiding decisions on well spacing and withdrawal rates.

Using the graphs of figures 2 and 3, the amount of water that can be obtained from an aquifer in an area of a specified size and shape and with a specified maximum drawdown may be predicted. An example of this prediction is given in the following problem:

Situation: A square plot 1,000 feet on a side (23 acres) is available for installation of a well field needed to supply about 13 mgd (million gallons per day). Maximum pumping depth should be no lower than 300 feet below land surface. An aquifer available at a depth of 500 feet has a coefficient of transmissibility of 50,000 gpd per foot and a coefficient of storage of 0.0001. The static water level is 20 feet below average land surface.

Information desired: How many wells are needed, what should be their pumping rate, and how should they be spaced?

Answer: Eight fully efficient wells pumped at 1,125 gpm each and arranged around a 1,000-foot square on 500-foot centers. The greatest drawdown at the end of 1 year would be 274 feet (294 ft below land surface). This well field would supply 12.95 mgd. Water levels will be drawn down substantially in the area adjacent to the well field; however, the effects will decrease as distance from the well field increases.

The above example is an isolated well field in an idealized artesian aquifer; actual conditions are usually different. At most places more than one aquifer is available, which makes more water available than shown in the example. On the other hand, less water than shown in the example may be available if significant interference is felt from distant wells or well fields. On the basis of available data on aquifer characteristics and thicknesses of aquifers and assuming a drawdown to a depth of 300 feet below land surface, ground water available within 5 miles of the following locations is estimated as follows:

Locality	Million gallons per day	Locality	Million gallons per day
Benton	25-50	Grand Gulf	10-50
Bentonia	25-50	Jackson	10-25
Bolton	10-15	Kilmichael	10-25
Bovina	10-15	Kosciusko	10-25
Canton	25-50	Maben-Mathiston	10-15
Clinton	10-15	Madison	10-25
Durant	25-50	Pickens	25-50
Edwards	10-15	Port Gibson	10-15
Eupora	10-15	Utica	10-25
Flora	10-25	Vaiden	10-25
French Camp	10-15	West	10-25
Goodman	25-50	Winona	10-15

WELLS

Practically all wells more than 100 feet deep are rotary drilled and are artesian—that is, the water is under pressure and rises above the top of the aquifer when the aquifer is penetrated. Depths of water wells in the basin range from less than 10 to 2,400 feet. Diameters of casing in drilled wells range from 2 to more than 20 inches. In most wells a larger diameter casing is used in the upper part of the well than in the lower part. Various types, sizes, and lengths of well screens are used to hold the aquifer material in place while allowing water to enter the well. A pack of gravel placed between the screen and the aquifer commonly is used in an effort to increase the efficiency of a well.

Most wells are pumped at rates of less than 500 gpm; however, a few produce more than 1,000 gpm and some could produce more than 2,000 gpm without excessive drawdown. Over most of the basin it should be possible to construct wells that will produce 2,000 gpm from the best aquifer underlying the locality. At most places several aquifers are available for development.

WATER USE

Water use is light in the Big Black River basin, because the region is neither heavily populated nor industrialized. Practically all of the domestic, municipal, and industrial water is from wells, as is a small quantity of irrigation water. Canton, the largest city in the basin, used about 0.75 mgd in 1960. Winona is not as large as Canton but, owing to industrial demand, used about 1 mgd. No other city in the basin pumped more than 0.5 mgd (pl. 4). Total ground-water withdrawal, including water from many unused flowing wells, was probably not more than 10 mgd in 1960 and 11 mgd in 1965. In some areas adjacent to the basin, ground-water withdrawal in 1960 was comparatively heavy (pl. 4) with Jackson using 10 mgd, Yazoo City using 8 mgd, and Kosciusko using 2 mgd. (Pumpage from the Sparta Sand at Jackson and Yazoo City is shown on plate 4 because it affects the movement of water in the aquifer in the Big Black basin; a large amount of pumpage from the Mississippi River alluvium at Yazoo City is not shown because it has no effect on ground-water movement and availability in the basin.)

WATER LEVELS

Water-level fluctuations in an aquifer reflect recharge, discharge, water movement, and aquifer characteristics. Recharge raises water levels most in the area of recharge; conversely, discharge lowers water levels most in the immediate area of discharge. Ground water moves from areas where water levels are high to areas where water levels are low (seeps, springs, wells, or leaky confining beds). The amount of flow between two points depends directly on the ability of the aquifer to transmit water (transmissibility) and on the difference in water level (hydraulic gradient) between the points. A map showing water levels in an aquifer system (pl. 4) shows the direction of movement of water and reflects recharge, discharge, and aquifer characteristics. Spacing of contour lines indicates the hydraulic gradient; water movement is down gradient at right angles to the contour lines.

A water-level contour map of the Sparta Sand aquifer system is representative of the various aquifer systems underlying the basin, except that the Sparta system is more heavily pumped. Water levels in all the systems are higher in the outcrop (recharge) areas and lower to the southwest and west in areas of natural and artificial discharge. All the aquifers are full and they overflow to streams in outcrop areas (pl. 5) through springs and seeps. The ground water overflow is the base flow of streams.

Most ground-water levels along the Big Black River stand within 30 feet of, above or below, the altitude of the flood plain of the river. However, in the upper part of the basin the water levels in aquifers older than the Wilcox Group generally are almost 200 feet below flood-plain altitude. On the other hand, water levels in the deeper aquifers underlying the lower third of the basin may be more than 30 feet above the flood plain. Depth to water in wells located in the highlands generally is less than 100 feet below the tops of the wells.

Heavy pumpage from the Sparta Sand aquifer at Jackson and Yazoo City (pl. 4) causes the two prominent depressed areas shown on the water-level contour map. There is some interference between pumpage at the two localities, and increased pumping will cause the depressions to deepen. Water levels in wells in these areas have been declining for many years (fig. 4).

The relatively small pumpage at Canton has not resulted in a substantial depression in the water-level contours. However, withdrawal of 10 mgd at Canton probably would cause as much depression in the water level as now exists at Jackson, and water levels at each of the three cities would be slightly lower because of pumping at the other two cities.

The part of the Sparta aquifer system that underlies the basin probably would support several well fields producing 10 mgd each before areal water levels would be lowered as much as 200 feet. Well fields producing from the Sparta Sand but located just outside the basin, as at Jackson and Yazoo City, will continue to cause lower water levels in the basin. Water-level elevations will always be higher in and near the aquifer outcrop.

In most places the drawdown caused by pumping can be divided among two or more aquifers by constructing wells in all available aquifers. Naturally, two aquifers will yield more water, or will have less drawdown, than one aquifer.

QUALITY

Ground water of suitable quality for most uses is available throughout the Big Black River basin. However, quality of water in the artesian aquifers changes with distance down the dip away from the recharge areas (pl. 1). Changes in the quality of ground water underlying the basin are determined mostly by the following factors: (1) The time that water has been in contact with the aquifer material; (2) the chemical composition of the aquifer material; and (3) the degree of flushing of saline water by fresh water.

Water levels in all the aquifers indicate that precipitation enters

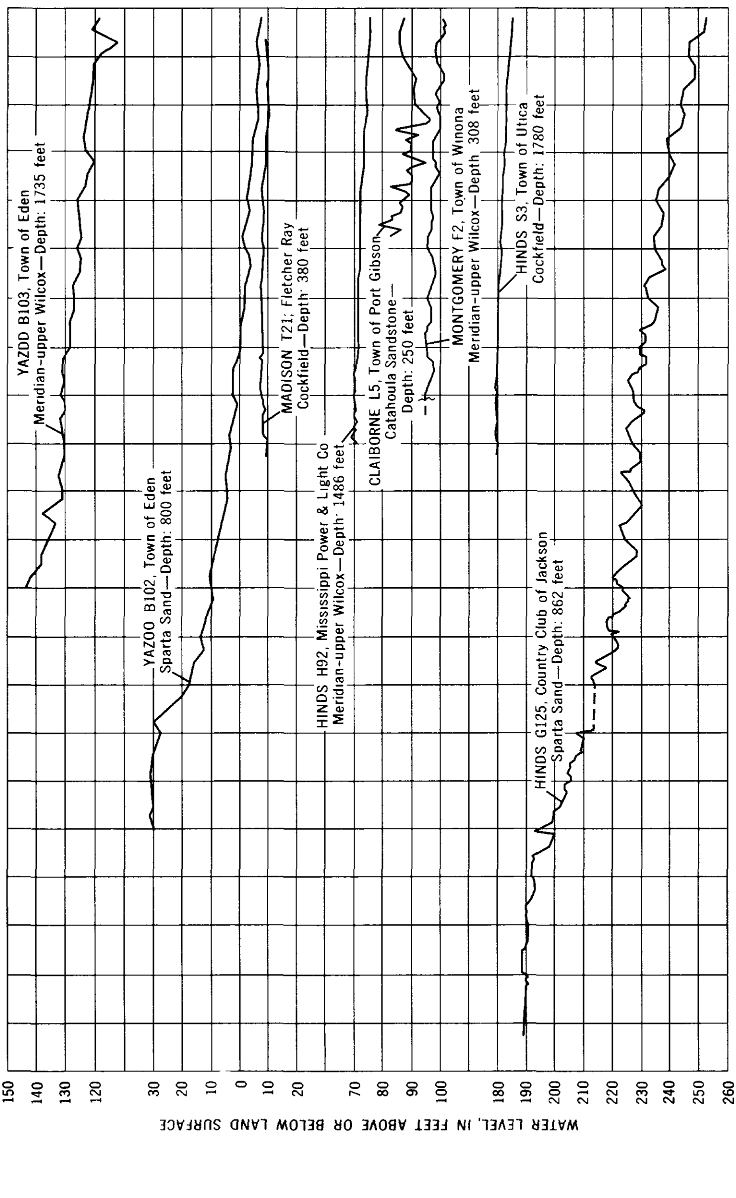

FIGURE 4.—Hydrographs of selected wells. See plate 1 for location of wells.

the aquifers in the outcrops and moves slowly in a southwesterly or westerly direction. Vertical movement through beds of clay and silt is extremely slow. The more permeable aquifers contain fresh water farther from the recharge area and deeper below land surface than do less permeable aquifers (pl. 1). Whether this is a result of differences in permeability or other factors has not been established.

Because water is a solvent, it is obvious that the chemical composition of the aquifer material would directly affect the quality of water in the aquifer. However, it is difficult to differentiate between the indirect effect of permeability and that of chemical composition of aquifer material on the quality of water. The marine sands generally are less permeable and contain more of the easily dissolved solids than the nonmarine sands. Thus, the usual higher dissolved-solids content of water in marine sands may by attributed to these two causes.

The depth to which fresh water has replaced saline water is a measure of the degree of flushing. Rainwater contains practically no dissolved solids, and most shallow water contains less than 100 mg/l (milligrams per liter) of dissolved solids (table 2). Water from shallow aquifers in the basin generally is a soft to moderately hard calcium bicarbonate type. The water characteristically has low dissolved-solids content, pH, and color. Calcium, magnesium, iron, and free carbon dioxide are more likely to be present in the shallow parts of the aquifers. Even where iron is not present in objectionable quantities, an iron problem may develop in a water system because of the naturally corrosive character of water containing substantial carbon dioxide.

Down the dip of the aquifers, mineralization increases, color may increase, and the water changes from a calcium bicarbonate type to a sodium bicarbonate type. Most of the dissolved solids, except calcium, magnesium, and iron, increase. Fluoride content is low in the shallow parts of the aquifers, but it increases to objectionable amounts (more than 1 mg/l) down the dip in some aquifers. Near the base of fresh water (pls. 1, 5) the type of the water changes from sodium bicarbonate to sodium chloride. Mineralization of water in the deeper parts of the aquifers may be higher than that of sea water.

The artesian aquifers may be several thousand feet below land surface at points many miles down the dip from the outcrops. Several of the aquifer systems contain fresh water (less than 1,000 mg/l dissolved solids) to depths of more than 2,000 feet below sea level, and three of the aquifers have fresh water at almost 3,000 feet below sea level (pls. 1, 5). The slightly saline (1,000–3,000 mg/l dissolved solids) water lying below the fresh water in the aquifers is not used at present, but it may be usable for certain purposes in the future. Practically all water at depths of more than 4,000 feet below land surface is saline; therefore, its utility is limited.

Quality of water is related to the intended use; water of good quality for one use may be unfit for another use. Shallow water in the basin is good for irrigation, but it may need iron removal and pH adjustment for domestic use. Deeper water may be suitable for domestic use but, because of a high percent sodium, be unfit for irrigation. At most localities, two or more aquifers containing water of different quality are available. Table 2 contains analyses of water from various locations (pl. 1) and aquifers.

Temperature of water discharged from certain wells is also shown in table 2. The temperature of shallow ground water is about 65° F (18° C), the mean annual air temperature, and the temparature increases about 1° F per 70 feet (1° C per 125 ft) of additional depth below land surface.

SURFACE WATER

SOURCE AND AVAILABILITY

Most of the streams tributary to the Big Black River in the upper half of the basin are perennial; in the lower half of the basin, flow normally stops for some period each year in most tributary streams (pl. 5). This is attributed to the fact that the permeability of the surface and shallow subsurface sediments in the upper half of the basin is greater than in the lower half. All the artesian aquifer systems (pl. 1) are full and overflowing—that is, they receive water in the recharge areas in excess of the amount that will move downdip. The excess is discharged through seeps and springs in the outcrop area to form the base flow of streams. The amount of water discharged from aquifers to streams depends primarily on aquifer permeability, saturated thickness of aquifer, and slope of the water table. Several factors affect the saturated thickness and water-table slope: (1) topography, (2) frequency and amounts of recharge, (3) evapotranspiration, (4) depth of stream channel, and (5) stage of stream.

The shape and slope of the water table are largely determined by topography—that is, the water table tends to conform to the land surface. A sharp drop of about 100 feet in altitude from the Pearl and Yockanookany River basins to that of the Big Black causes a steep water-table gradient and high ground-water discharge to head-water streams of the eastern tributaries of the Big Black. The flood plains of the Yazoo River and its major tributaries are, in turn, about 100 feet lower than the flood plain of the Big Black. The topographic relations of the western and eastern margins of the Big Black River basin cause the eastern tributaries to be more productive during dry seasons than the western tributaries. The yield of one small eastern

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basin, about 12 square miles above station 30 (pl. 5) on Apookta Creek, was 0.3 cubic foot of water per second per square mile of drainage basin during a period (October 1965) when flow in the Big Black River was slightly more than for the median annual minimum of 7-day average flow.

Nearly two-thirds of the flow of the Big Black River during dry periods is from the upper half of the basin where perennial tributaries are numerous. Since tributaries in the lower half of the basin do not contribute appreciable quantities of water, it could be reasonably assumed that there would be little increase in flow in the lower part of the river. However, about one-third of the total low flow of the Big Black at U.S. Highway 61, which is near the river's mouth, is gained in the lower part of the river. Most of this increased flow in the lower end of the river probably is from the alluvium in the flood plain of the river.

DURATION OF FLOW

Flow-duration data (table 3) indicate that about 90 percent of the time the flow in the Big Black River is as much or more than the values shown on plate 5. Although flow-duration data are not available on the tributaries and upper reaches of the river, it is assumed that 90-percent flow duration in these streams would also be as much or more than the values shown. Storage reservoirs could be constructed to make more surface water available on a continuous basis at almost any place in the basin.

WATER USE

Probably less than 500 acre-feet of water is diverted annually from streams in the basin—mostly for supplemental irrigation of row crops. Practically all cattle in the basin are watered from either streams or ponds. The largest use of the streams by towns and industries is for sewage disposal. Water supply and recreational values of the streams increase with each effective sewage-treatment facility completed.

QUALITY

Specific conductance, in micromhos at 25°C, of water in the Big Black River at average or higher flows is less than 70 (table 4) unless there is more than usual pollution from sewage, industrial waste, or oil-field brines. (Specific conductance multiplied by 0.65 approximately equals dissolved-solids content in mg/l.) Limited data available on the tributaries indicate that water in practically all of them has a specific conductance of less than 60—if not polluted.

During low flow the specific conductance value of water in the lower part of the Big Black, about 320, may be more than twice as much as it is upstream from Pickens, about 120 (pl. 5 and table 4).

Hardness is twice as high downstream from Pickens, about 50 mg/1, as upstream, about 25 mg/1.

The first of two reasons for higher dissolved solids and hardness in the lower part of the Big Black at low flow is that there are more sources of pollution in the lower end. In addition to municipal and industrial waste, there is considerable oil-field waste at several places below Pickens. Some of the tributary streams also show pollution from oil fields (pl. 5).

The second reason for increased dissolved solids and hardness below Pickens is geologic. The reach from Pickens to station 78 below Bovina traverses outcrops of the Jackson (Yazoo Clay) and Vicksburg Groups, which are much more calcareous than the geologic units which crop out above Pickens. The calcareous mantle of loess in the lower part of the river could also contribute to the dissolved-solids content and hardness of shallow ground water and, therefore, to that of surface-water base flow. However, the Jackson, Vicksburg, and loess deposits contribute little or no water to tributary streams during dry periods (pl. 5). Since these geologic units do not contribute appreciable base flow to streams, they cannot directly affect the quality of base-flow water in the Big Black. However, the quality of water in the alluvium in the Big Black River valley probably is affected by the Jackson, Vicksburg, and loess sediments. Water in the alluvium is hard to very hard (150–350 mg/l) and moderately mineralized (200–500 mg/l dissolved solids). During very dry periods nearly half the flow in the lower end of the river may be alluvial water.

Except for water in the alluvium, there is generally no great difference in the quality of shallow water in the various aquifers—as is demonstrated by relating quality of water in streams at low flow (discharged ground water) to the geologic units traversed by the streams (pl. 5). However, stream stations 29 and 30 in Attala County show a significant contrast in water quality. Dissolved-solids content of water in the Winona Sand is higher than that of the Sparta Sand. Most of the water passing station 29 at low flow is from the Winona Sand, and most of the water passing station 30 is from the Sparta Sand. The specific conductance readings of 91 at station 29 and of 39 at station 30 seem to accurately reflect the quality of water in the two aquifers.

RELATIVE SIGNIFICANCE OF WATER SOURCES

Using quantity as a standard for judging sources of water, the normal annual low flow of the Big Black River is the most important source of water in the part of the basin downstream from Bentonia (pl. 5). From Bentonia up to Durant possibly as much ground water can be developed from large well fields as is available in the Big Black

River during a normal annual low flow period. Upstream from Durant and along the tributary streams, more water is generally available from ground water than from the streams during periods of low flow. Storage reservoirs could be constructed on many of the tributary streams that would yield more water than would be locally available from ground water.

The aquifers underlying the area are unequal in their ability to yield water. A geohydrologic section (pl. 1) classifies the aquifers with respect to their ability to yield water to wells, and eight of the aquifer systems in the basin are rated good or better (will yield 6 gpm or more per ft of drawdown to properly constructed wells).

Of what value is a particular aquifer system to the people and economy of the Big Black River basin? Quantity is not the only basis for judging the usefulness or importance of aquifers—other bases are quality, availability, pumping lift, treatment, and cost per unit volume. Plates 1 and 5 summarize and compare the quality of water in the various aquifers. Water levels in the aquifers were compared earlier in the report, and availability of the aquifers can be compared by using plates 1 through 3. An attempt is hereby made to evaluate and to rank the overall importance of the various aquifer systems to the people and to the economy of the basin. The aquifer systems are grouped and listed in descending order of importance as follows:

1. Sparta Sand
   Meridian-upper Wilcox
   Lower sandy zone of the Wilcox Group
2. Cockfield Formation
   Gordo Formation
   Middle sandy zone of the Wilcox Group
   Catahoula Sandstone
3. Winona-Tallahatta
   Coker Formation
   Forest Hill Sand
   Alluvium
4. Eutaw Formation
   McShan Formation

CONCLUSIONS

Large quantities of water are available from several of the geologic units underlying the basin; at most places water of good quality may be developed from two or more major aquifers, each of which will yield to a well more than 1,000 gpm with reasonable drawdown. Well fields in each major aquifer may produce more than 10 mgd. Water-level declines and pumping lifts can be minimized by pumping from all the aquifers available. Dissolved solids, pH, and percent sodium increase with depth; iron and hardness are more likely to be problems in shallow water; the base of fresh water averages about 2,000 feet below land surface. Most water supplies in the basin are from ground water.

Perennial streams are numerous in the upper part of the basin, and about 95 percent of the time, flow exceeds 100 cubic feet per second in the lower half of the river's main stem. Quality of surface water is excellent, except for minor organic pollution from municipal waste and brine pollution from several oil fields in the lower part of the basin. Presently, streams are used chiefly for recreation and waste disposal.

Base flow of the streams, which is ground-water overflow or discharge, probably will not be significantly affected by heavy pumping from the artesian aquifers. Heavy pumping for consumptive uses in the outcrops of the aquifers could significantly reduce the base flow of some streams, but consumptive use is not likely, except for irrigation.

Much more needs to be known about the geohydraulics of the aquifers in order to make accurate predictions of the effects of developments in them. Detailed ground-water investigations should precede large ground-water developments.

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TABLE 1.—*Aquifer characteristics determined from pumping tests in and near the Big Black River basin*

County	Location of test	Water-bearing unit	Aquifer thickness (ft)	Pumped well						Aquifer characteristics			
				No.	Diameter (in)	Depth (ft)	Yield (gpm)	Specific capacity (gpm per ft of drawdown at 24 hr)	Coefficient of transmissibility (gpd per ft)	Coefficient of permeability (gpd per sq ft)	Coefficient of storage	Theoretical specific capacity of 12-inch well (gpm per ft of drawdown at 24 hr)
Attala	Kosciusko	Meridian-upper Wilcox.	74	M44	18, 12	422	1, 000	29	55, 000	740	0. 0002	25
Do	Kosciusko, 8 miles south.	Merdian		S19	6	460	16	.8	9, 000			4
Carroll	Vaiden	Neshoba	83	02	12, 8	196	172	2. 6	4, 800	58	.0005	2
Claiborne	Port Gibson	Catahoula	27	L3	12, 7	153	240		15, 000	550	.0002	7
Hinds	Jackson (west)	Sparta	80	G3	4	802			42, 000	520	.0002	20
Do	Jackson (north)	do	130	H55	10, 6	796	400	19	80, 000	600		36
Do	do	do	73	H104	8, 6	810	150	8	34, 000	460	.00003	15
Do	Raymond	Cockfield	125	L5	12, 8	1, 185	239	4	35, 000	280	.0001	16
Do	Waterways Experiment Station.	do	55	M30	10	637	150		10, 000	180	.00007	4
Do	Utica	Catahoula	53	S2	10, 8	307	180	14	37, 000	700	.0024	19
Holmes	Lexington	Meridian	100	L46	8	1, 125	227		62, 000	620	.00009	24
Do	Durant	do	130	T4	10, 6	700	440		45, 000	350	.006	24
Montgomery	Winona	Meridian-upper Wilcox	60	F3	16, 10	306	550	24	56, 000	910	.0002	25
Do	Stewart	Wilcox	36	L2	6, 4	580	47	.4	1, 530	42		1
Oktibbeha	Maben	Gordo	55	A7	8	1, 951	300		85, 000	1, 550		40

TABLE 2.—*Chemical analyses of water*

[Constituents are in milligrams per liter. Analyst: U.S. Geological Survey except where

Well (pl. 1)	Owner	Depth (ft)	Yield (gpm)	Water-bearing unit	Date of collection	Dissolved solids
Recommended limits, U.S. Public Health Service (1962) drinking-water standards						500
Attala County						
C3	D. E. Wasson	402	10	Wilcox	10- 1-61	148
E1	Moore oil test 1	400?	100	Meridian-Wilcox	1- 3-62	156
G3	E. E. Gentry	6	1	Winona	2-13-57	32
G18	Woodrow Kelly	560	10	Wilcox	11- 7-63	135
K12	Ed Gordon	126	10	Sparta	2-28-57	96
K30	Norris Culpepper	130		do	8-21-62	
L6	W. R. McCrory	168	4	Tallahatta	2- 1-57	225
L21	H. E. Jenkins	212		do	10- 4-62	
M44	City of Kosciusko	422	1,000	Meridian-Wilcox	9- 5-62	134
S19	Natchez Trace (Holly Hill)	460	16	do	11- 7-63	187
Carroll County						
01	Town of Vaiden	210	110	Tallahatta	1- 4-57	197
02	do	196	180	do	11-15-62	136
Choctaw County						
B2	Town of Mathiston	44	75	Wilcox	1-18-57	104
D1	Natchez Trace (Little Mountain)	350		do	8- 1-58	193
F1	French Camp Academy	670		do	1-14-57	186
H1	Town of Ackerman	100	400	do	1-16-57	66
J1	Town of Weir	117	51	do	1-16-57	66
J6	do	105	150	do	7-29-65	67
Claiborne County						
F3	Port Gibson Oil Works	200		Catahoula	11- 3-61	412
L3	Town of Port Gibson	200	411	do	3-22-61	354
L12	do	1,740		Cockfield	1909	22,640
N1	Claiborne County Lumber Co	100	40	Catahoula	10-20-61	167
N5	Hugh Rials	200	6	do	10-18-61	483
Hinds County						
A4	Bill McGraw	204	5	Forest Hill	9- 9-59	791
C11	G. B. DeWees	890	40	Cockfield	10-26-56	359
C12	Texas Eastern Gas Transmission Co	1,111		Sparta	1-29-58	263
D1	Town of Edwards	1,154	300	Cockfield	10-22-56	394
D8	Town of Campbell	55		Alluvium	4-15-59	308
D9	J. C. Logan	1,000	9	Cockfield	7- 1-58	614
E3	Town of Bolton	1,027	300	do	10-22-56	382
F5	W. W. Newman	170		Forest Hill	9- 9-59	342
G36	Town of Clinton	726	293	Cockfield	10-22-56	393
H92	Mississippi Power & Light Co	1,486	5	Meridian-Wilcox	10- 2-56	1,210
J1	H. H. Canada	308	28	Forest Hill	9- 9-59	775
L5	Town of Raymond	1,185	251	Cockfield	10-22-56	398
L19	Hinds Junior College	874		do	2- 3-58	416
N35	Heidelberg Hotel	712	300	Sparta	1-30-57	330
R2	Jackson Reduction Co	1,275	350	do	1-30-58	380
S2	Town of Utica	307	180	Catahoula	1-30-58	359
S3	do	1,310	150	Cockfield	6-30-44	1,310
T7	Daisy Cochran	401		Forest Hill	9- 9-59	608
U16	D. Holliday	553	20	do	9- 9-59	741

See footnote at end of table.

from wells in the Big Black River basin

noted—MSBH, Mississippi State Board of Health; MCL, Mississippi Chemical Laboratory]

pH	Silica (SiO_2)	Total iron (Fe)	Hardness as $CaCO_3$	Sodium (Na)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Temperature (°C, °F)	Analyst
----	----	0.3	----	----	----	250	250	1.0	45	----	
Attala County—Continued											
6.5	35	0.03	59	6.4	81	12	0.0	0.1	0.3	19,66	
7.4	37	.82	68	6.9	92	11	2.0	.1	.0	19,67	
7.1	----	.48	17	5.6	15	1	12	.2	.5	----	
7.3	29	2.4	73	11	108	7.2	2.8	.1	.4	----	
----	----	----	40	21	88	7	6.5	.2	.7	----	
6.2	----	----	55	----	----	----	8.0	----	----	----	
7.2	----	----	174	14	198	23	12	.1	2.7	----	
7.0	----	----	105	----	----	----	4.8	----	----	----	
6.5	41	.17	52	2.5	60	13	3.1	.0	.1	19,67	
7.2	40	2.0	97	14	126	21	3.0	.1	4.7	20,68	
Carroll County—Continued											
6.0	----	2.5	101	7.4	90	42	3.8	0.0	1.9	18, 65	
6.1	9.2	1.0	96	----	64	41	6	.1	----	18, 65	MSBH
Choctaw County—Continued											
6.2	----	0.00	23	16	26	18	14	0.0	0.6	17, 62	
7.9	----	----	39	----	171	----	12	----	.0	----	MSCL
8.3	----	2.9	24	52	158	3.4	4.5	.0	.2	----	
5.5	9.8	.21	15	6.0	9	1.8	10	.1	6.3	18, 64	
6.0	----	.02	19	5.7	16	.6	12	.0	1.4	18, 64	
5.2	1.2	0	32	[1] 13	12	0	35	0	----	18, 65	MSBH
Claiborne County—Continued											
8.0	49	----	15	136	315	3.0	17	0.8	0.0	20, 68	
7.4	56	0.16	52	101	322	.6	8.3	.2	.1	20, 68	
----	99	----	----	----	----	----	----	----	----	----	MSCL
6.9	41	.18	55	17	52	21	20	.1	.0	----	
7.4	33	.32	8	177	451	.4	23	.3	.0	----	
Hinds County—Continued											
8.3	----	0.11	38	262	452	214	12	0.5	4.8	28,82	
8.3	----	.26	4	146	271	50	30	.2	1.1	22,71	
8.6	12	.10	2	78	254	3.2	3.2	.0	.8	----	
7.7	----	.35	9	122	241	62	16	.1	.4	31,87	
8.5	15	.04	224	16	244	22	10	.3	15	18,65	
8.2	9.5	.18	20	221	576	.8	24	2.8	3.0	21,69	
8.6	----	.12	3	142	272	40	26	----	.7	29,84	
8.1	9.3	.11	22	111	298	21	3.5	.3	2.1	22,71	
8.6	----	1.7	76	118	239	86	27	.1	2.1	24,76	
8.5	9.2	.85	6	485	1,170	1.2	14	6.0	2.4	29,84	
8.7	6.7	.37	8	289	656	.0	32	2.4	2.0	21,70	
8.5	----	.15	3	141	281	33	26	----	1.3	33,92	
8.6	12	.54	3	148	297	32	25	----	1.6	24,75	
8.8	12	.04	4	120	300	8.6	7.0	.4	.9	----	
8.2	11	.30	2	144	338	19	16	----	1.6	----	
7.2	41	.69	7	149	238	63	16	.3	.1	20,68	
8.3	13	.04	9	529	1,240	2.9	50	4.4	.0	31,88	
8.4	6.1	.04	9	220	542	15	9.0	2.0	2.9	23,73	
8.4	7.7	.14	4	279	692	3.8	12	4.0	4.3	26,78	

TABLE 2.—*Chemical analyses of water from*

Well (pl. 1)	Owner	Depth (ft)	Yield (gpm)	Water-bearing unit	Date of collection	Dissolved solids
			Holmes County			
F1	Town of West	412	55	Meridian-Wilcox	1- 4-57	148
F2	Town of West (at tank)	385	150	do	9-26-60	121
L45	Town of Lexington	900	150	Tallahatta	11- 3-58	416
L46	do	1,125	320	Meridian-Wilcox	3-13-40	184
T4	Town of Durant (water plant)	700	500	do	11-12-63	159
T17	do	701	560	do	1- 3-62	123
W2	Town of Pickens (water plant)	1,580	200	Wilcox	1- 3-57	242
W4	do	1,585	620	do	7-24-63	238
X1	Town of Goodman (old well)	1,080	120	Meridian-Wilcox	7-12-60	176
X2	do	980	596	do	11-12-63	165
X21	Town of Goodman	785	100	Tallahatta	8-22-19	372
			Madison County			
D17	Madison County Schools	730	75	Sparta	1-31-58	213
K1	Kearney Park Utility Co	1,332	430	do	11-20-42	220
K2	do	1,404	750	do	11-20-42	220
K5	Madison Development Co	1,398	455	do	11-20-42	227
L4	Tom Taylor	1,533		Wilcox	7- 3-57	494
M7	City of Canton	980	500	Sparta	10-26-56	166
M8	do	965	750	do	10-12-60	118.87
M9	do	975	1,100	do	10-12-60	115.06
R1	Town of Flora	1,366	510	do	10-26-56	218
R2	do	1,304	84	do	10-26-56	713
T20	H. E. Lee	462	12	Cockfield	10-26-56	209
V14	Theo Costas	898	105	Sparta	5- 4-56	744
W2	Town of Madison	650	80	Cockfield	6-13-58	387
W3	Town of Ridgeland	703	150	do	6-13-58	414
			Montgomery County			
A17	Town of Duck Hill	650	90	Wilcox	4-29-60	360
F3	City of Winona	314	525	Meridian-Wilcox	1-14-57	108
F4	City of Winona	306		do	4-29-60	66.35
F22	C. H. George	445	50	do	1- 3-62	146
J1	Mississippi State Forestry	360	600	do	1- 3-62	161
K2	Town of Kilmichael	169		do	11- 5-59	99.43
K3	do	150	75	do	1-18-57	138
K4	Kilmichael Colored School	588		Wilcox	1- 3-62	238
K5	Town of Kilmichael	480	200	do	5-22-63	191.41
			Oktibbeha County			
A1	Town of Maben	2,032	100	Gordo	10-27-54	574
A7	do	1,950	225	do	10-26-62	537.77
			Warren County			
C1	B. N. Simrall	1,076		Cockfield	3-16-62	490
C6	do	1,621	140	Sparta	3-16-62	325
F8	Hugh Morris	110		Forest Hill	3-16-62	332
J1	Vicksburg Industrial Park	1,208	8	Cockfield	9-28-62	1,070
J1	do	1,715	20	Sparta	12- 7-62	762
K13	J. P. Boler	1,128		Cockfield	3-15-62	955
M2	Vicksburg Municipal Airport	960		do	3-20-62	1,990
Q1	R. G. LeTourneau Co	1,100		do	3-20-62	4,870

See footnote at end of table.

wells in the Big Black River basin—Continued

pH	Silica (SiO_2)	Total iron (Fe)	Hardness as $CaCO_3$	Sodium (Na)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Temperature (°C, °F)	Analyst
					Holmes County—Continued						
7.4	...	1.9	57	17	104	6.6	2.5	0.0	1.5	19, 67	
6.5	14	4.4	69	[1]12	87	10.54	4	0	...	...	MSBH
7.8	43	0	0	[1]162	352	0	0	0	...	...	MSBH
8.3	17	.16	6.5	64	160	13	2.2	...	.0	...	
7.4	30	.78	56	28	130	12	3.0	.1	.1	21, 70	
7.4	.4	.5	...	[1]30	101	11	3	.1	...	...	MSBH
8.7	...	.09	4	86	206	9.6	2.2	.4	.6	28, 82	
7.4	15	.13	3	83	207	9.4	1.2	.2	.1	31, 87	
8.3	4.4	.2	2	[1]81	131	13	6	0	...	...	MSBH
7.8	14	.03	1	69	167	12	2.8	.1	1.0	24, 76	
...	50	.09	16	...	322	14	3.5	...	...	...	MSCL
					Madison County—Continued						
7.1	38	3.1	14	47	133	5.8	4.8	0.2	0.8	10, 50	
8.1	45	1.2	28	63	152	8.8	2.4	...	0	...	
8.0	48	1.2	30	61	151	7.0	2.4	...	.1	...	
8.0	62	...	19	64	143	10	2.8	...	0	...	
8.5	6.8	1.5	3	188	450	1.2	5.0	.1	1.7	27, 80	
8.1	...	2.4	20	37	99	.5	4.5	.1	.5	25, 77	
6.4	1.6	1.0	18.6	[1]40.94	...	13.33	6	0	...	...	MSBH
6.4	0	.75	18.4	[1]38.64	...	12.76	6	0	...	...	MSBH
8.6	...	.26	4	88	212	5.8	2.5	.3	.7	30, 86	
8.4	...	.96	23	250	252	170	130	.8	1.3	24, 75	
8.4	...	.99	65	47	153	30	7.5	.1	.7	21, 69	
8.2	...	.71	54	249	190	216	158	.3	2.3	28, 82	
7.5	...	0	15	120	248	53	20	.0	2.2	26, 78	
7.9	...	.04	6	142	268	51	32	.1	.2	26, 79	
					Montgomery County—Continued						
8.6	4.0	0.1	7.8	[1]148	266	0	44	0	...	...	MSBH
6.8	24	2.3	39	4.4	42	12	4.0	.1	0.3	18, 64	
5.7	10.8	4.0	33	[1]5.38	33	10.37	5	0	...	...	MSBH
7.4	32	9.4	56	7.6	73	13	2.9	.1	0	...	
7.5	37	1.8	70	6.9	78	21	3	.2	0	18, 65	
5.2	12.4	4.5	39.4	[1]2	11	36.71	15	.1	...	...	MSBH
5.7	...	.01	41	12	10	39	15	0	.3	18, 64	
8.1	9.5	.02	9	85	235	1.4	2.6	.2	0	...	
8.6	5.2	.1	14	[1]74.06	161	0	7	.2	...	...	MSBH
					Oktibbeha County—Continued						
7.6	9.7	0.17	49	3.5	29	1.4	2.5	0.2	0	18, 64	
7.8	2.8	.1	43.2	[1]197.57	120	0	250	...	...	32, 90	MSBH
					Warren County—Continued						
8.5	11	0.33	5	185	305	82	36	0.3	0.2	22, 72	
8.4	13	.15	2	130	324	.2	2.6	.2	.3	27, 80	
8.2	17	.03	150	47	306	.2	5.1	.1	.1	...	
8.2	9.4	3.4	12	396	1,020	10	2.0	.3	2.1	26, 78	
8.2	15	.37	5	294	704	.0	44	1.1	.0	32, 90	
8.2	10	.22	6	350	888	2	29	2.4	.0	23, 74	
8.9	4.9	.11	14	787	1,170	16	320	0	.5	22, 71	
8.6	7.0	.26	65	1,910	862	3.6	2,380	3	.2	22, 72	

TABLE 2.—*Chemical analyses of water from*

Well (pl. 1)	Owner	Depth (ft)	Yield (gpm)	Water-bearing unit	Date of collection	Dissolved solids
Webster County						
D2	J. E. Skelton	1,450		Eutaw	7-20-61	676
E2	H. I. Hill	1,120	6	do	6-10-60	520
E3	Natchez Trace Parkway	1,753	20	Gordo	6-10-60	471
H3	Town of Eupora	190	75	Wilcox	11- 4-60	176. 89
H4	do	175	99	do	1-18-57	170
H6	do	173	202	do	6-10-60	142
H11	Town of Walthall	2,410	150	Gordo	11-30-66	770
H12	Sapa Water Association	2,300	167	do	11-30-66	789
J2	D. Stewart	1,486		Eutaw	7-20-61	1,070
J3	Wood Junior College	1,720	11	do	3-19-62	962
K5	Cumberland School	1,380		do	10-22-58	806
Yazoo County						
C1	Jack W. Pepper	897	3	Sparta	8-10-59	198
C2	Clayton Saxton	417		Cockfield	5-29-59	206
C8	C. C. Swayze	1,682		Tallahatta	5-29-58	329
C9	W. N. Heidel	760		Sparta	6- 3-58	229
M15	D. F. Berry	1,772		Tallahatta	3- 3-58	1,233
N3	H. C. Oates	1,159		Sparta	5-28-58	231
N4	Lee Fox	433		Cockfield	5-28-58	203
S1	C. L. Ertle	1,065		Sparta	4-21-60	
S4	Clarence Vanderber	1,000		do	4-21-60	
W2	Town of Bentonia	621		Cockfield	8- 5-59	262
W13	do	640	100	do	4-13-64	271

[1] Sodium and potassium reported as sodium.

TABLE 3.—*Duration of flow of the Big*

[Adjusted to period 1929-57 by

Reference No. pl. 5	Station	Drainage area (sq mi)	Flow, in cubic feet				
			99.5	99	98	95	90
44	Big Black River at Pickens, Miss.	1,460	37	42	48	62	85
57	Big Black River near Bentonia, Miss.	2,340	58	64	74	96	130
66	Big Black River near Bovina, Miss.	2,810	70	78	90	116	157

wells in the Big Black River Basin—Continued

pH	Silica (SiO_2)	Total iron (Fe)	Hardness as $CaCO_3$	Sodium (Na)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Temperature (°C, °F)	Analyst
					Webster County—Continued						
7.9	11	0.00	10	259	478	0.6	141	1.9	0.7	----------	
8.0	5	.09	14	182	348	1.4	95	.8	1.3	----------	
7.1	3.5	.07	52	149	136	.0	190	.0	1.0	----------	
7.5	10.6	.7	110.4	[1]25.76	156	1.65	7	.2	----------	----------	MSBH
8.3	17	.28	20	46	133	.8	4.5	.1	.3	18, 64	
7.1	17	1.0	24	22	90	.0	2.0	.0	.2	18, 65	
7.5	15	.23	34	283	248	.2	334	.8	.1	32, 90	
7.2	16	.41	53	285	175	.8	378	.4	.1	32, 89	
8.1	10	.10	22	394	638	10	248	4.3	1.5	----------	
7.8	11	.72	24	346	538	2.2	234	3.6	1.1	----------	
8.1	4.6	.61	18	304	558	.4	160	3.5	2.6	23, 74	
					Yazoo County—Continued						
8.0	29	--------	32	33	114	6.8	4.5	0.4	2.2	----------	
7	---------	2.8	108	17	138	13	14	.1	.1	21, 70	
8.5	---------	.02	6	122	308	1.2	4.0	.3	1.2	27, 81	
7.8	---------	.32	6	62	148	12	7.0	.0	2.5	19, 67	
8.1	2.4	.0	2	[1]536	---------	.0	2.0	4.0	----------	----------	
7.7	---------	.24	4	66	156	17	5.0	.0	1.2	22, 72	
8.1	---------	.55	103	23	172	3.2	8.0	.1	1.1	23, 73	
7.5	---------	.4	6	---------	33	----------	----------	----------	----------	----------	
6.7	---------	.1	6	---------	54	----------	----------	----------	----------	----------	
7.3	6.8	.3	4	[1]103	212	36	10	.1	----------	----------	
7.7	24	--------	3	98	212	26	8.5	.0	.1	22, 71	

Black River at Pickens, Bentonia, and Bovina

comparison with long-time records]

per second, which was equaled or exceeded for indicated percentage of time											
80	70	60	50	40	30	20	10	5	2	1	0.5
136	208	326	540	910	1,600	2,800	5,000	7,600	11,700	15,200	19,200
208	320	500	860	1,480	2,480	4,350	7,900	11,800	16,800	20,800	25,800
250	388	610	1,030	1,790	3,050	5,300	9,600	14,400	20,600	25,500	30,800

TABLE 4.—*Chemical analyses of water*

[Constitutents are in milligrams per liter. Discharges reported are either daily mean discharges or discharges

Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe) in solution at time of analysis	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)
				Hays Creek near Vaiden (19)					
11-13-59	5.54	10	0.32	8.6	5.3	20	5.0	45	0
				Indian Creek at West (27)					
11-20-59	1.08	11	0.65	2.9	2.5	8.0	2.3	24	0
6- 1-60	.78	3.8	.13	4.1	3.4	12	1.1	30	0
				Spring, draining to Apookta Creek (28)					
2-13-57	[1] 0.01	---------	0.02	2.4	2.7	5.6	0.4	15	0
				Tributary of Apookta Creek (30)					
[2] 9-18-62	[1] 3								
				Big Black River at Durant (33)					
[2] 10- 4-62									
				Spring, at Castalian Springs (34)					
[2] 10- 4-62	[1] 0.01								
				Bogue Falaya Creek (Long Creek) (37)					
[2] 9-21-62									
				Lake at Holmes County State Park (35)					
[2] 10- 4-62									
				Seneasha Creek (43)					
[2] 9-21-62									
				Big Black River at Pickens (44)					
2-13-58	3,000	7.4	0.35	4.6	1.4	5.1	1.9	20	0
6-10-58	340	8.6	.04	6.9	1.6	5.6	2.7	21	0
10-22-58	179	4.6	.49	4.9	3.0	6.5	1.4	34	0
9-10-62	123	9.8	.16	3.4	1.6	5.8	1.8	22	0
10-29-62	106								
1-10-63	224								
1-21-63	740	7.6	.47	3.0	1.3	5.3	1.5	15	0
2-27-63	768								
4- 2-63	376								
5- 9-63	260	8.9	.04	4.9	1.9	6.0	1.6	22	0
5-29-63	933								
9-18-63	167	8.8	.18	3.0	1.6	6.7	2.1	17	0
10-14-63	68								
2- 6-64	920	13	.25	4.3	1.0	6.2	1.9	14	0

See footnotes at end of table.

from streams in the Big Black River basin

for the time when samples were collected. Number in parentheses after stream name refers to numbe~ on pl. 5]

Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$ Total	Hardness as $CaCO_3$ Noncarbonate	Specific conductance (micromhos at 25° C)	pH	Color	Temperature (° C, ° F)
Hays Creek near Vaiden (19)—Continued										
30	16	0.2	2.6	132	44	6	197	6.8	25	
Indian Creek at West (27)—Continued										
8.0	7.5	0.2	0.7	87	18	0	81	6.7	80	
16	8.0	.1	.4	78	24	0	111	6.6	5	25, 77
Spring, draining to Apookta Creek (28)—Continued										
1	12	0.2	0.5	32	17	4	60	7.1		
Tributary of Apookta Creek (30)—Continued										
	2.4				10		<50	6.6		
Big Black River at Durant (33)—Continued										
	4.0				20		60	6.8		22, 72
Spring, at Castalian Springs (34)—Continued										
	8.4				15		<50	<6.0		
Bogue Falaya Creek (Long Creek) (37)—Continued										
	3.4				10		<50	6.7		23, 73
Lake at Holmes County State Park (35)—Continued										
	7.2				20		60	7.1		23, 74
Seneasha Creek (43)—Continued										
	2.4				15		<50	6.6		23, 73
Big Black River at Pickens (44)—Continued										
7.8	4.5	0.5	0.8	44	18	1	65	6.7	20	7, 45
8.2	6.0	.5	1.9	52	24	6	78	6.4	22	29, 84
4.6	6.2	.0	1.0	50	24	0	87	6.8	5	18, 65
5.2	4.2	.0	.2	43	15	0	66	6.4	40	29, 84
							70			17, 62
							62			8, 47
5.8	4.4	.1	.8	37	13	1	57	6.4	120	
							62			7, 45
							80			21, 70
8.4	5.7	.1	.2	43	20	2	75	6.3	20	24, 76
							60			21, 70
6.6	7.5	.1	.2	45	14	0	68	6.0	60	25, 77
							80			23, 73
10	6.3	.2	.4	51	15	4	68	6.1	100	9, 48

TABLE 4.—*Chemical analyses of water from*

Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe) in solution at time of analysis	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)
Big Black River at Pickens (44)—Continued									
3- 9-64	9,540								
4-23-64	2,660	10	.06	3.3	2.6	4.8	1.8	23	0
6- 3-64	507								
9- 9-64	110								
9-28-64	84								
12- 4-64	1,150								
12-17-64	2,680								
1-19-65	672								
4- 1-65	6,900								
5-18-65	173								
6-16-65	455								
8- 3-65	155								
9- 8-65	118								
10-13-65									
Doaks Creek near Canton at Highway 51 (52)									
11-13-59	22	9.7	1.4	5.1	2.7	6.8	1.7	25	0
6- 1-60	22	3.5	.00	6.5	2.9	8.0	1.7	29	0
Big Black River near Bovina at Old Highway 80 (66)									
10-20-58	392	4.6	0.55	8.6	4.9	12	3.6	52	0
2-17-59	9,980	1.5	.07	4.4	1.8	5.2	3.9	20	0
6-25-59	586	2.8	.42	11	4.7	11	2.6	56	0
[3] 10- 2-61		10.8		19	3.0	40		47	
[3] 10-30-61		6.8		23	3.1	40		61	
[3] 11-27-61		25.2		4.8	.9	7		13	
10- 3-62	154								
12- 3-62	245								
1-16-63	751								
2-25-63	1,960								
4- 3-63	595								
5-13-63	327								
5-31-63	210								
6-20-63	142								
8-16-63	378								
1-30-64	5,670								
6- 9-64	473								
7- 1-64	529								
9-24-64	149								
12-14-64	7,610								
3-23-65	4,050								
4-26-65	1,480								
6- 2-65	382								
9- 2-65									
10-12-65									
Big Black River near Port Gibson at Highway 61 (80)									
6- 3-61		5.2	0.11	27	6.5	11	2.3	83	0
7-12-61		8.2	.32	10	3.2	29	2.9	32	0
8-15-61		6.7	.51	8.1	2.9	27	3.4	29	0
9- 8-61		7.3	.32	9.1	3.0	16	3.9	34	
10-19-61		5.9	.00	21	8.2	55	3.9	82	
10-27-61		8.7	.00	22	6.6	40	2.4	95	
11-29-61		7.0	.34	17	6.5	18	2.4	78	
8-12-65	443								
8-27-65	467								
10-19-65	241								
11- 2-65	139								
11-30-65	212								
1- 5-66	2,300								

[1] Discharge estimated.
[2] Field analysis.
[3] Analysis by Mississippi State Board of Health.

streams in the Big Black River basin—Continued

Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$		Specific conductance (micromhos at 25° C)	pH	Color	Temperature (° C, ° F)
					Total	Noncarbonate				
Big Black River at Pickens (44)—Continued										
							60			9, 48
5.4	4.1	.1	.5	44	19	0	65	6.8	30	22, 72
							125			22, 71
							90			24, 76
							100			25, 77
							55			10, 50
							<50			9, 49
							90			4, 40
							<50			11, 51
							120			24, 76
							70			24, 76
							65			30, 86
							90			28, 82
							70			20, 68
Doaks Creek near Canton at Highway 51 (52)—Continued										
9.6	8.0	0.1	0.6	58	24	3	87	6.8	35	
12	8.0	.0	.5	57	28	4	102	6.9	15	24, 75
Big Black River near Bovina at Old Highway 80 (66)—Continued										
6.8	14	0.1	0.9	82	42	0	144	7.0	5	
7.6	6	.2	.2	41	18	2	67	6.4	5	15, 59
7.6	12	.1	1.7	82	47	1	151	6.9	80	
5.9	67			174	61			7.0		
7.1	62			178	70			7.3		
4.9	9			60	16			6.4		
							155			22, 72
							140			13, 56
							340			4, 40
							96			8, 46
							185			21, 70
							225			28, 82
							290			27, 80
							285			28, 82
							135			28, 82
							70			20, 68
							170			21, 70
							100			22, 72
							360			27, 80
							60			11, 52
							90			14, 57
							140			23, 74
							265			
							220			29, 84
							160			22, 71
Big Black River near Port Gibson at HighwaY 61 (80)—Continued										
30	16	0.2	0.4	140	94	26	250	6.8	80	
6.0	51	.2	.5	127	38	12	226	6.4	140	
5.8	47	.2	.7	173	32	8	230	6.4	120	
5.6	28	.2	.5	91	35	7	161	6.8	210	
7.8	96	.2	1.4	256	86	19	445	7.2	10	
6.8	62	.2	.2	200	82	4	354	6.8	20	
7.2	28	.1	.2	142	69	5	234	6.7	50	
							230			27, 81
							325			
							205			22, 72
							260			16, 60
							320			14, 58
							270			13, 55

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EXPLANATION

MAP

D17 — Water well for which chemical analysis is given in table in text
Water well numbers are assigned within a county by township-size lettered grid and a number

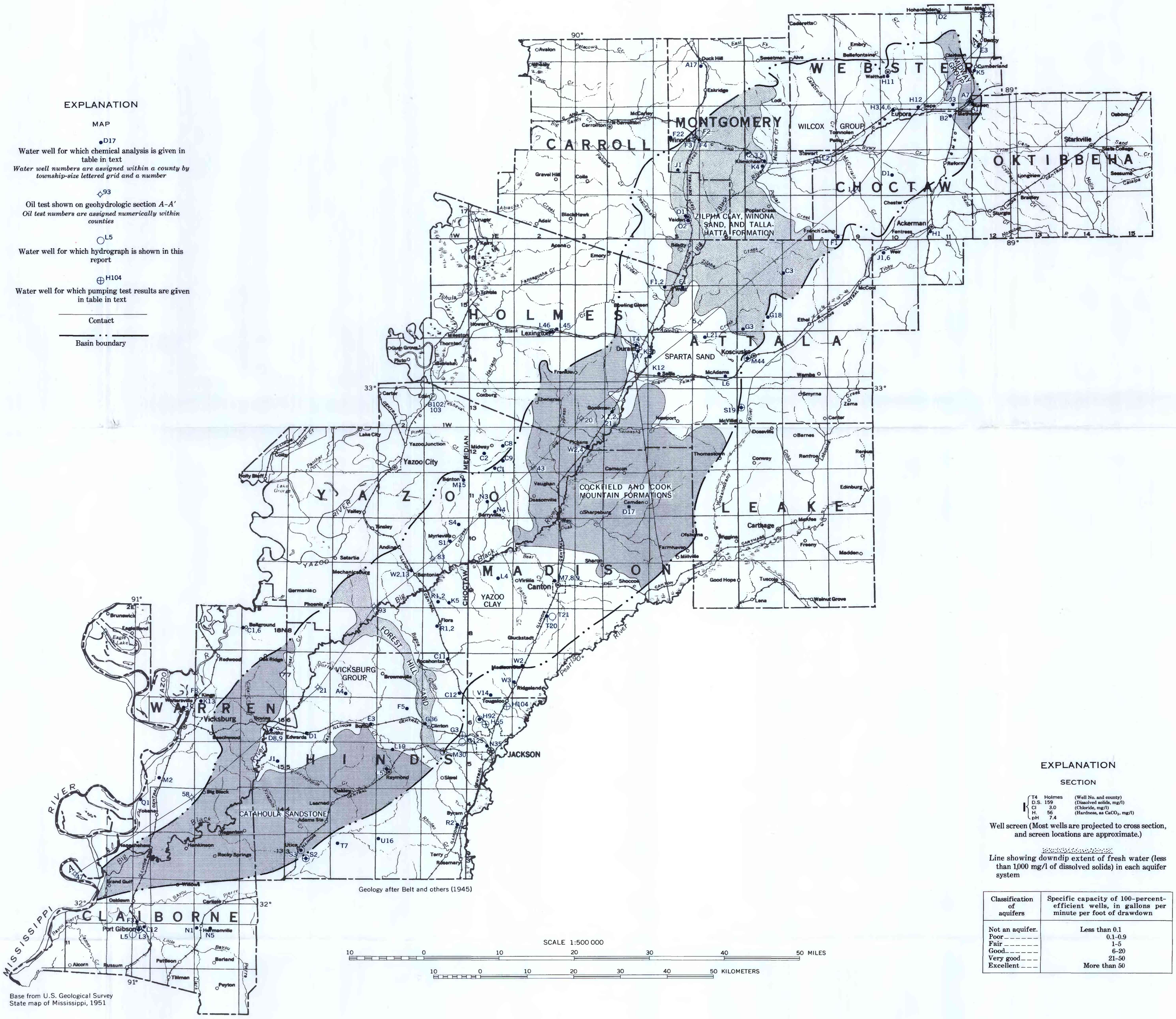
93 — Oil test shown on geohydrologic section *A–A'*
Oil test numbers are assigned numerically within counties

L5 — Water well for which hydrograph is shown in this report

H104 — Water well for which pumping test results are given in table in text

Contact

Basin boundary



EXPLANATION

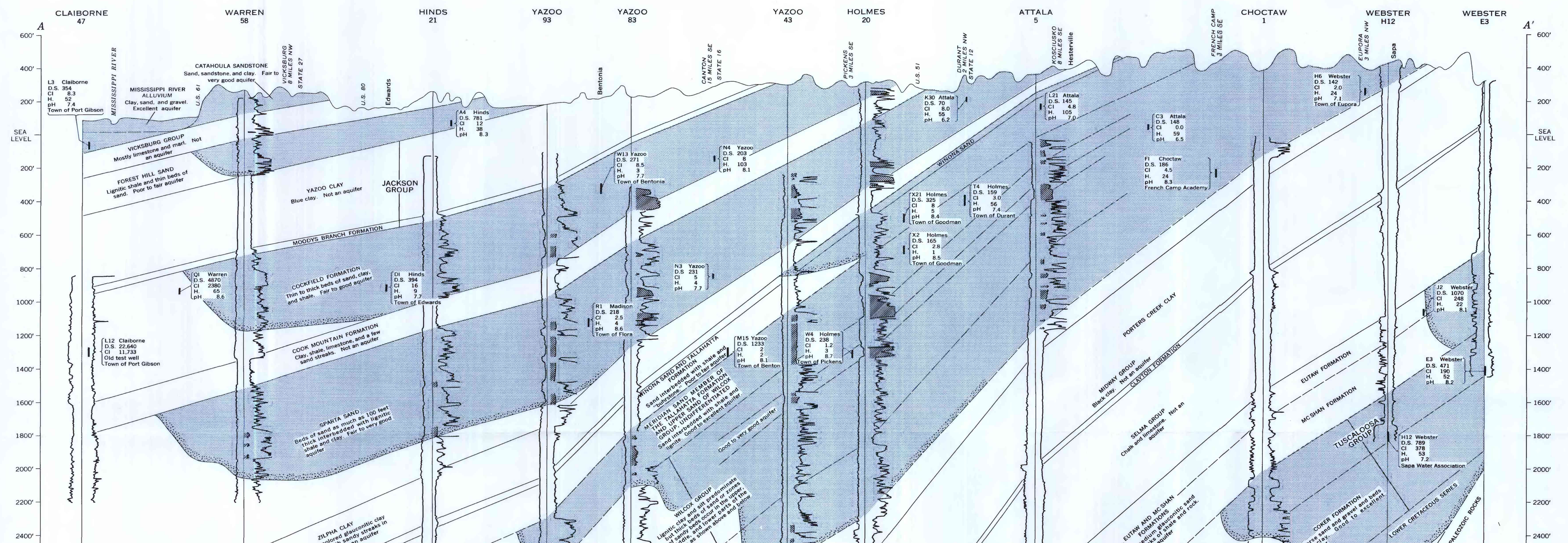
SECTION

T4	Holmes	(Well No. and county)
D.S.	159	(Dissolved solids, mg/l)
Cl	3.0	(Chloride, mg/l)
H.	56	(Hardness, as $CaCO_3$, mg/l)
pH	7.4	

Well screen (Most wells are projected to cross section, and screen locations are approximate.)

Line showing downdip extent of fresh water (less than 1,000 mg/l of dissolved solids) in each aquifer system

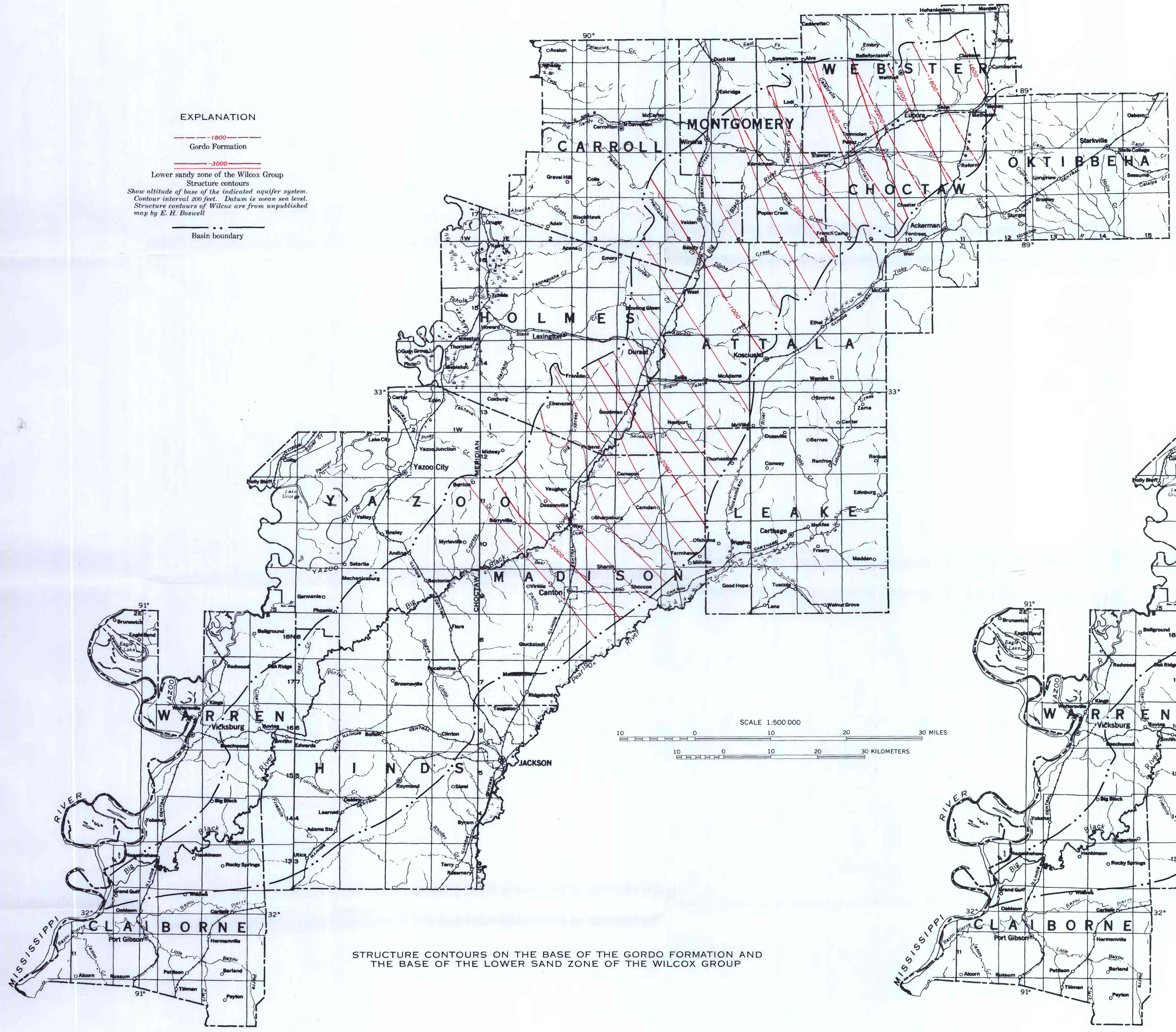
Classification of aquifers	Specific capacity of 100-percent-efficient wells, in gallons per minute per foot of drawdown
Not an aquifer	Less than 0.1
Poor	0.1-0.9
Fair	1-5
Good	6-20
Very good	21-50
Excellent	More than 50



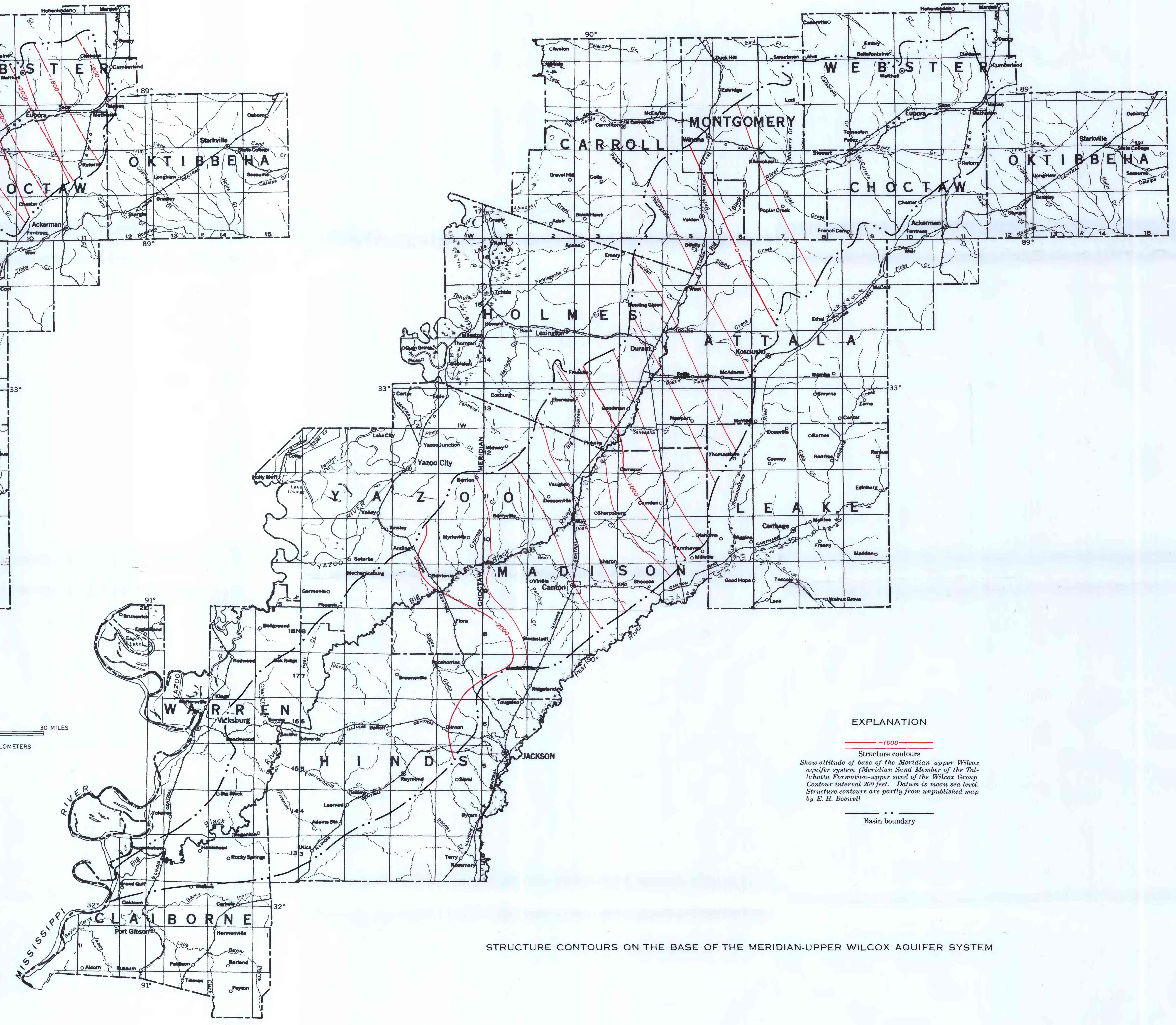
GEOHYDROLOGIC MAP AND SECTION, BIG BLACK RIVER BASIN, MISSISSIPPI

428-012 O - 71 (In pocket) No. 1

PREPARED IN COOPERATION WITH THE
U.S. ARMY CORPS OF ENGINEERS
VICKSBURG DISTRICT



STRUCTURE CONTOURS ON THE BASE OF THE GORDO FORMATION AND THE BASE OF THE LOWER SAND ZONE OF THE WILCOX GROUP



STRUCTURE CONTOURS ON THE BASE OF THE MERIDIAN-UPPER WILCOX AQUIFER SYSTEM

Base from U.S. Geological Survey
State map of Mississippi, 1951

MAPS SHOWING STRUCTURE CONTOURS ON THE BASES OF THE GORDO FORMATION, LOWER SANDY ZONE OF THE WILCOX GROUP, AND THE MERIDIAN-UPPER WILCOX AQUIFER SYSTEM, BIG BLACK RIVER BASIN, MISSISSIPPI

PREPARED IN COOPERATION WITH THE
U.S. ARMY CORPS OF ENGINEERS
VICKSBURG DISTRICT

STRUCTURE CONTOURS ON THE BASE OF THE SPARTA SAND AQUIFER SYSTEM

STRUCTURE CONTOURS ON THE BASE OF THE COCKFIELD FORMATION, THE BASE OF THE FOREST HILL SAND, AND THE BASE OF THE CATAHOULA SANDSTONE

Base from U.S. Geological Survey
State map of Mississippi, 1951

MAPS SHOWING STRUCTURE CONTOURS ON THE BASES OF THE SPARTA SAND, COCKFIELD FORMATION, FOREST HILL SAND, AND THE CATAHOULA SANDSTONE, BIG BLACK RIVER BASIN, MISSISSIPPI

EXPLANATION

85
Aquifer symbol showing location of water use and number showing thousands of gallons per day used in 1960

AQUIFER SYSTEM SYMBOLS

Catahoula Sandstone

Cockfield Formation

Sparta Sand

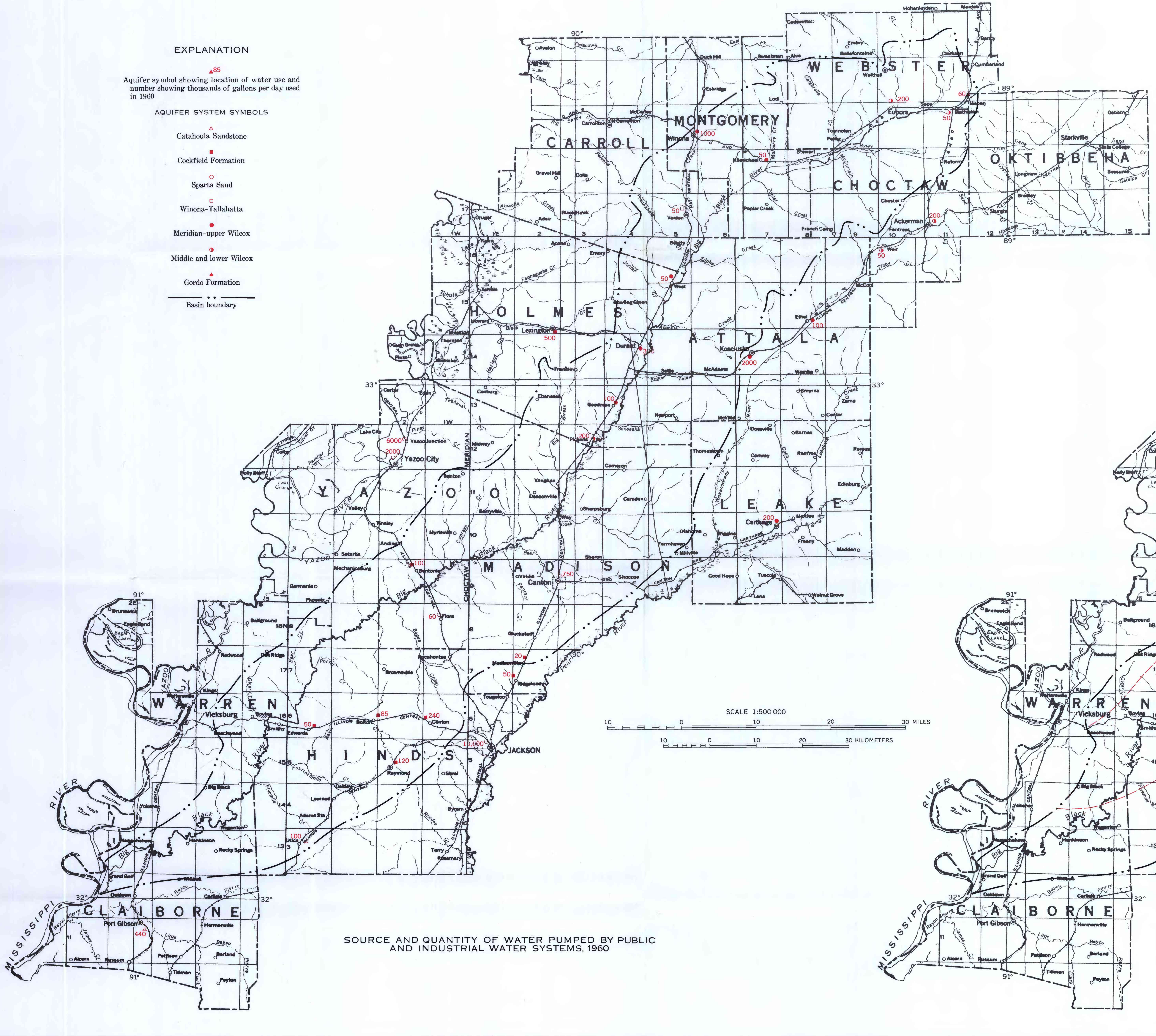
Winona-Tallahatta

Meridian-upper Wilcox

Middle and lower Wilcox

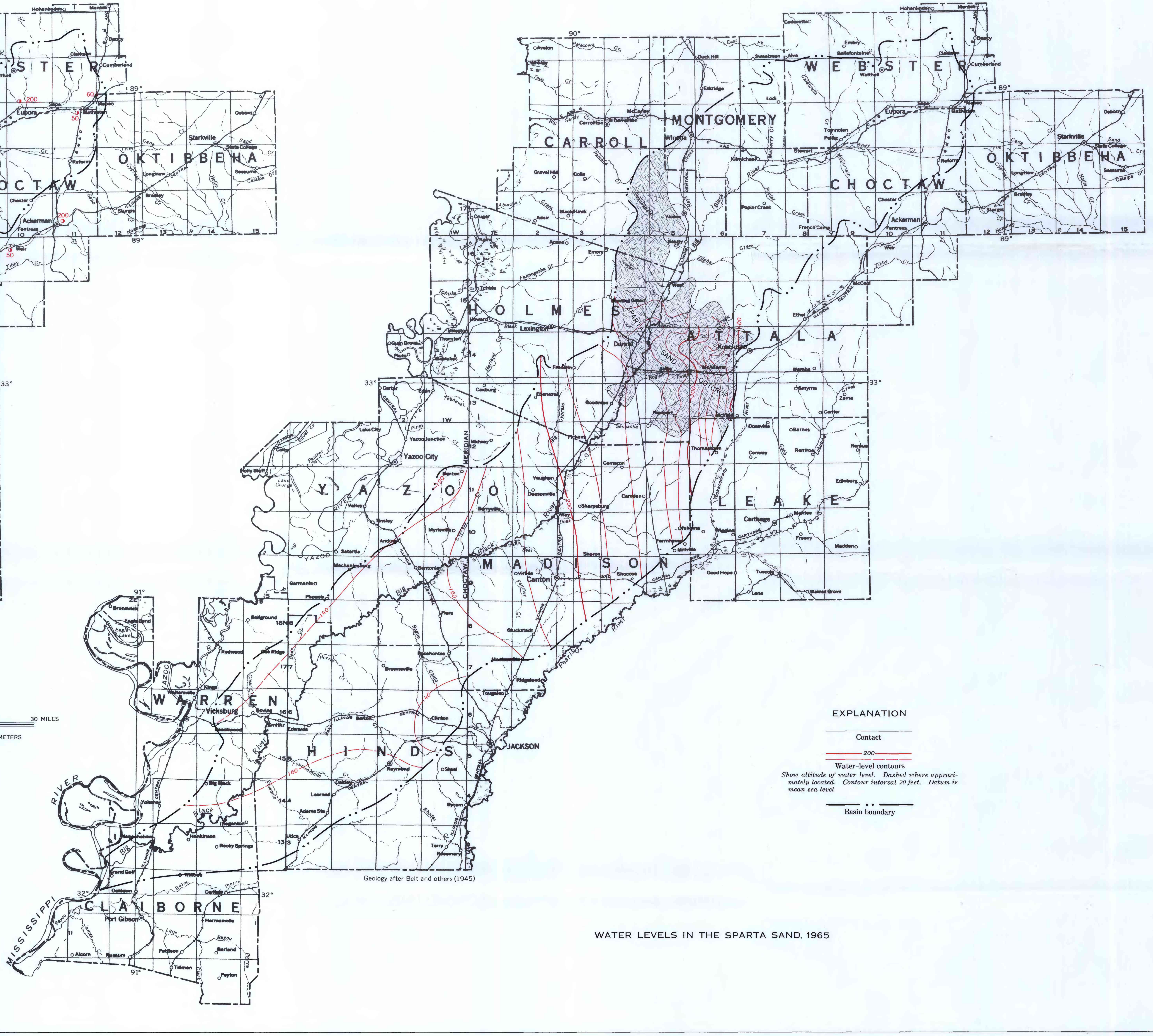
Gordo Formation

Basin boundary



SCALE 1:500 000
10 0 10 20 30 MILES
10 0 10 20 30 KILOMETERS

SOURCE AND QUANTITY OF WATER PUMPED BY PUBLIC AND INDUSTRIAL WATER SYSTEMS, 1960



EXPLANATION

Contact

200
Water-level contours
Show altitude of water level. Dashed where approximately located. Contour interval 20 feet. Datum is mean sea level

Basin boundary

WATER LEVELS IN THE SPARTA SAND, 1965

Base from U.S. Geological Survey
State map of Mississippi, 1951

MAPS SHOWING GROUND-WATER PUMPAGE AND WATER LEVELS IN THE SPARTA SAND, BIG BLACK RIVER BASIN, MISSISSIPPI

428-012 O - 71 (In pocket) No. 4

EXPLANATION

-200-
Water-zone contour
Shows altitude of base of fresh-water zone (water having less than 1,000 mg/l dissolved solids). Contour interval 200 feet. Datum is mean sea level

Line showing where the base of fresh water shifts from one aquifer system to another

The deepest fresh water occurs in the delineated parts of the following aquifer systems:

① Catahoula Sandstone

② Sparta Sand

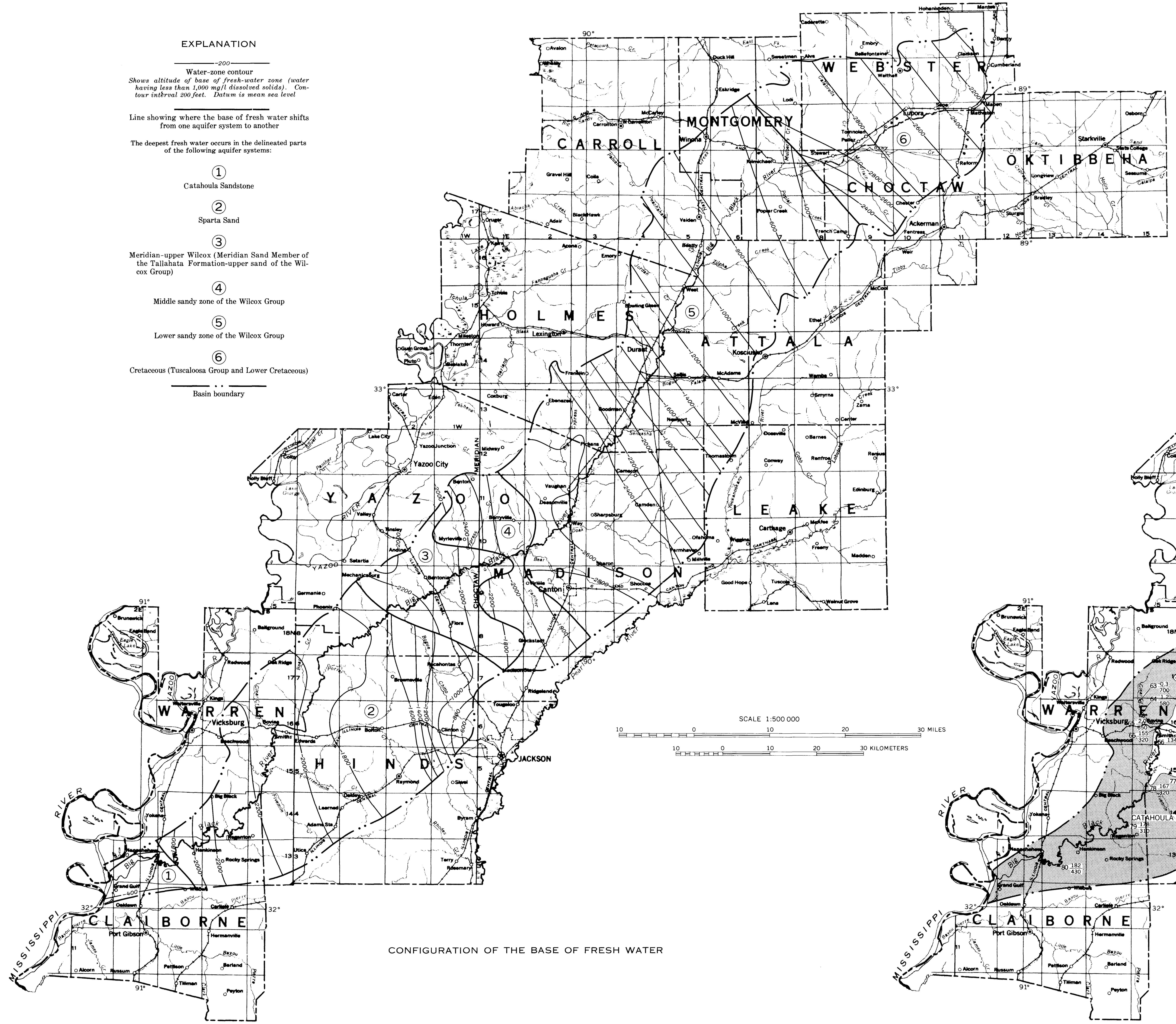
③ Meridian-upper Wilcox (Meridian Sand Member of the Tallahata Formation-upper sand of the Wilcox Group)

④ Middle sandy zone of the Wilcox Group

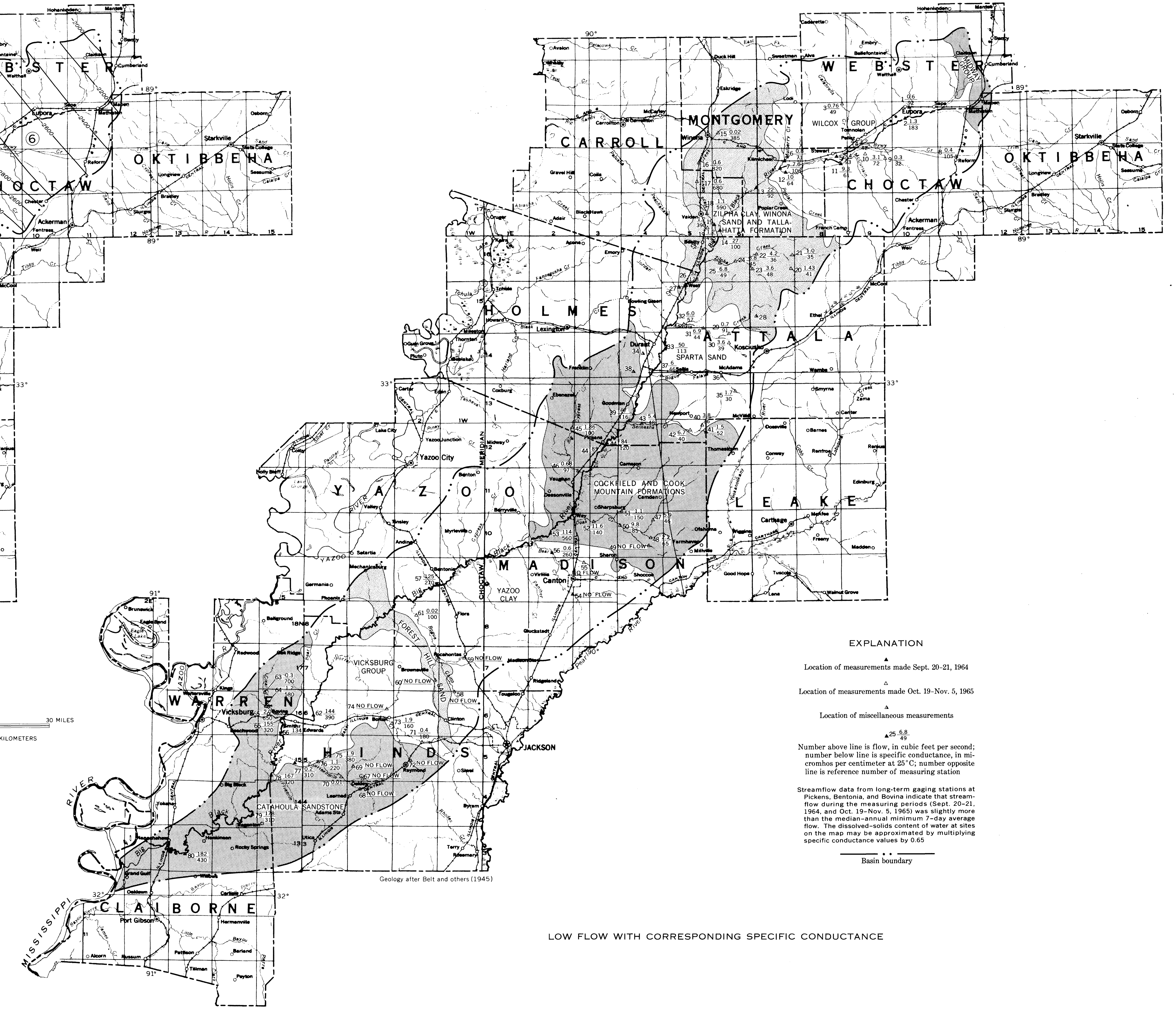
⑤ Lower sandy zone of the Wilcox Group

⑥ Cretaceous (Tuscaloosa Group and Lower Cretaceous)

Basin boundary



CONFIGURATION OF THE BASE OF FRESH WATER



LOW FLOW WITH CORRESPONDING SPECIFIC CONDUCTANCE

EXPLANATION

▲ Location of measurements made Sept. 20-21, 1964

△ Location of measurements made Oct. 19-Nov. 5, 1965

Location of miscellaneous measurements

▲25 $\frac{6.8}{49}$

Number above line is flow, in cubic feet per second; number below line is specific conductance, in micromhos per centimeter at 25°C; number opposite line is reference number of measuring station

Streamflow data from long-term gaging stations at Pickens, Bentonia, and Bovina indicate that streamflow during the measuring periods (Sept. 20-21, 1964, and Oct. 19-Nov. 5, 1965) was slightly more than the median-annual minimum 7-day average flow. The dissolved-solids content of water at sites on the map may be approximated by multiplying specific conductance values by 0.65

Basin boundary

Base from U.S. Geological Survey
State map of Mississippi, 1951

MAPS SHOWING BASE OF FRESH WATER AND LOW FLOW WITH CORRESPONDING SPECIFIC CONDUCTANCE, BIG BLACK RIVER BASIN, MISSISSIPPI