OVERVIEW OF THE COCKFIELD AND SPARTA AQUIFERS IN THE JACKSON METROPOLITAN AREA, MISSISSIPPI

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Introduction

As part of the Federal-State Cooperative Program, the U.S. Geological Survey and the Mississippi Department of Environmental Quality, Office of Land and Water Resources, began a study in 1987 of the Cockfield and Sparta aquifers in Hinds, Madison, and Rankin Counties in west-central Mississippi (fig. 1). The purpose of the cooperative study is to provide State and local officials with the hydrogeologic information concerning the Cockfield and Sparta aquifers needed to manage the ground-water resources of the three-county area. An important part of this study is the development of a digital ground-water flow model of the Cockfield and Sparta aquifers for use as a tool to gain a better understanding of the flow dynamics and optimum water yielding capability of the two aquifers in the area. This paper presents a brief overview of the Cockfield and Sparta aquifers in the study area and is based largely on information assembled to develop the digital flow model of the two aquifers.

The three-county study area occupies 2,428 square miles (Spiers and Dalsin 1979) and has a population of about 400,000 people. Ground water supplies about 50 percent of the total water demand in the three-county area. The principal sources of ground water in the area for municipal and industrial demands are the Cockfield and Sparta aquifers. These two aquifers supply more than 95 percent of the ground water pumped in the area. The Pearl River, which flows through the study area, supplies most of the surface water used in Hinds, Madison, and Rankin Counties.

The first large-capacity well in the study area was drilled in Jackson in 1896 (Harvey, Callahan, and Wasson 1961). Since that time, ground water withdrawals from the Cockfield and Sparta aquifers have steadily increased with the greatest rate of increase occurring after 1950. As a result of these increased withdrawals, water levels have declined substantially in both aquifers from predevelopment levels.

Description of Study Area

The three-county study area is in the Mississippi embayment subdivision of the Gulf Coastal Plain physiographic province near the southern border of the Mississippi embayment. Land-surface altitudes in the area range from about 100 feet above sea level in southwestern Hinds County to about 500 feet above sea level in southeastern Rankin County. Geologic units that crop out in the study area range in age from Quaternary to Tertiary. Southwestern Madison and western Hinds Counties are underlain by as much as 20 feet of Quaternary loess deposits that form the Loess Hills (fig. 1; Harvey, Callahan,and Wasson 1964). Miocene deposits, which consist mostly of sand, shale, and sandstone, underlie the southern half of Hinds and Rankin Counties. In the central part of Hinds and Rankin Counties, the Oligocene Vicksburg Group crops out. The Vicksburg Group consists predominantly of clay, marl, limestone, and sand. In the central part of the study area in northern Hinds, southern Madison, and northern Rankin Counties, the Eocene Yazoo Clay (upper unit in the Jackson Group), a massive marine clay unit, is exposed. The Cockfield Formation crops out in northern Madison County. The Eocene Cockfield Formation (upper unit in the Claiborne Group) consists mostly of sand, clay,and shale (Spiers 1977). The Eocene Cook Mountain Formation, the oldest exposed stratigraphic unit in the study area, crops out in extreme northeastern Madison County.

The Hinds, Madison, and Rankin Counties area lies within the Mississippi embayment syncline and is underlain by sedimentary deposits consisting of clay, silt, sand, gravel, marl, and limestone to a depth of more than 10,000 feet (Spiers and Dalsin 1979). The Cockfield Formation and Eocene Sparta Sand (Claiborne Group), which contain the Cockfield and Sparta aquifers, respectively, are in the middle part of the Tertiary sedimentary deposits. The deepest Tertiary deposits are the Wilcox and Midway Groups. The Tertiary deposits usually dip about 15 to 25 feet per mile in a southwesterly direction (Harvey, Callahan, and Wasson 1964). A hydrogeologic section extending from southwest of the study area to

northeast of the study area approximately up the dip of the units is shown in figure 2. The line of the hydrogeologic section is shown in figure 1. In the Jackson area, the regional dip of the units is interrupted by the Jackson Dome. The stratigraphic units over the crest of the Jackson Dome are arched as much as 800 feet from a corresponding position not influenced by the dome. Because of the regional dip of stratigraphic units to the southwest, the older beds are at land surface in the northeastern part of the study area and dip beneath the surface toward the southwest. Progressively younger formations are at the surface toward the southwest.

The Hinds, Madison, and Rankin Counties area has an abundant supply of surface water and ground water as a result of an average annual precipitation of about 54 inches (Southard 1989). About one-third of the rainfall in the area moves overland into the Pearl and Big Black Rivers (fig. 1). Most of the remainder of the rainfall is either evaporated or transpired by trees and other vegetation. The small amount remaining percolates into the ground and becomes ground water.

Five of the major aquifers in Mississippi exist in the study area. They are, from youngest to oldest: (1) Miocene aquifer system, (2) Oligocene aquifer system, (3) Cockfield, (4) Sparta, and (5) Meridian-upper Wilcox. Only the Cockfield and Sparta aquifers are present throughout the three-county area and contain freshwater throughout the three-county area. The Meridian-upper Wilcox is present throughout the area but contains freshwater only in northern Madison and Rankin Counties. The Miocene and Oligocene aquifers are present only in the southern half of Hinds and Rankin Counties and contain freshwater where they occur.

Cockfield Aquifer

The Cockfield aquifer, in the Cockfield Formation, is located in the upper part of the Claiborne Group. The Cockfield Formation is overlain by the Jackson Group and underlain by the Cook Mountain Formation of the Claiborne Group (fig. 2). The Cockfield Formation is at the surface or in the subsurface throughout the three-county area except in an extremely small area along the Madison-Attala County boundary where the Cook Mountain Formation crops out at land surface. The Cockfield Formation crops out over an extensive area in northern Madison County and in a very small area along the Pearl River over the Jackson Dome (fig. 1). The top of the Cockfield Formation is about 360 feet above sea level in northern Madison County where it crops out and dips to about 800 feet below sea level in southwestern Hinds County. As a result of the effect of the Jackson Dome, the top of the Cockfield Formation is at land surface (about 250 feet above sea level) along the Pearl River in Jackson. The dip of the Cockfield Formation averages about 20 feet per mile to the southwest across the area but is as great as 130 feet per mile on the southwestern flank of the Jackson Dome. In southwestern Hinds County, the top of the Cockfield Formation is as much as 1,000 feet below land surface (Spiers 1977).

Southwest of the outcrop area of the Cockfield aquifer, the aquifer is confined by the Jackson Group. The Yazoo Clay, a tight marine clay, is the principal unit in the Jackson Group. The Yazoo Clay crops out in southern Madison and northern Hinds and Rankin Counties. In the outcrop area, the thickness of the Yazoo Clay is as much as 400 feet. In the subsurface it reaches a thickness of 500 feet in southwestern Hinds County. Down dip of the outcrop area of the Cockfield Formation, the Yazoo Clay forms an excellent confining unit and isolates the Cockfield aquifer from the overlying units.

The Cook Mountain Formation, which exists in the subsurface throughout the three-county area, lies beneath the Cockfield Formation and separates the Cockfield from the deeper Sparta Sand. The Cook Mountain Formation consists of shale, clay, thinbeds of sand, and limestone. This formation does not readily yield water and is the lower confining unit for the Cockfield aquifer, even though it is not as thick and resistant to vertical flow as the Yazoo Clay. In the study area, the Cook Mountain Formation averages about 150 feet in thickness, except over the Jackson Dome where it thins to about 110 feet.

The Cockfield Formation consists of beds of fine-to-medium-grained sand, carbonaceous clay, and thin beds of lignite. The sand beds in the Cockfield Formation form the Cockfield aquifer. Total thickness of the sand beds in the Cockfield Formation ranges from less than 100 feet in outcrop areas and over the Jackson Dome to more than 400 feet in southwestern Hinds County (fig. 3). In most of the three-county area, total sand thickness ranges from 100 to 200 feet. Generally, the sand beds become thinner to the east and northeast in Rankin and Madison Counties and thicker to the west and southwest in Madison and Hinds Counties.

Most of the water supplied to the Cockfield aquifer is from precipitation on or near the outcrop area of the aquifer. From the outcrop area in northern Madison

County and in a small area over the Jackson Dome, water moves downdip to the southwest into the confined part of the aquifer. The Jackson Dome causes a distortion in the potentiometric surface of the Cockfield aquifer in the Jackson area. The uplift of the geologic units over the dome results in the Cockfield Formation being unconfined locally. Over the dome, the aquifer is under water-table conditions, and the aquifer receives recharge from sources at land surface. As a result of the surface recharge, the potentiometric surface of the Cockfield is higher over the dome than it would be if the dome were not present.

Of the 27 million gallons per day of freshwater withdrawn from the Cockfield and Sparta aquifers in the three-county area in 1990 (fig. 4), about 8.4 million gallons per day was from the Cockfield aquifer. Withdrawals from the Cockfield aquifer averaged less than 2.0 million gallons per day in the three-county area prior to 1970 but increased steadily between 1970 and 1990.

Water levels have declined as much as 60 feet in the last 30 years in the Cockfield aquifer in the Jackson area (fig. 5). Since 1965, water levels have declined as much as 2 to 3 feet per year in areas of increased pumping. Near outcrop areas and in areas of less pumping, water-level declines have not been as large.

Generally, the Cockfield aquifer contains water of suitable quality for most uses. The Cockfield aquifer contains freshwater throughout the three-county area, although total mineralization increases in a downdip direction. High color values and high dissolved iron concentrations are common in water from the Cockfield aquifer in parts of the three-county area. Water from the Cockfield aquifer has a color of more than 50 platimum-cobalt units in southern Hinds and Rankin Counties and in the upper Ross Barnett Reservoir area. Water from the Cockfield aquifer has iron concentrations of more than 0.3 milligram per liter in most of Madison County, in northeastern and in southwestern Rankin County, and in southeastern Hinds County. The largest iron concentrations in water from this aquifer generally exist in or near the outcrop areas.

Sparta Aquifer

The Sparta aquifer is in the Sparta Sand, which is in the upper middle part of the Claiborne Group. The Sparta Sand is overlain by the Cook Mountain Formation, which separates the Sparta Sand from the Cockfield Formation (fig. 2). The Zilpha Clay underlies the Sparta Sand and hydraulically separates the Sparta aquifer from deeper geologic units. The thickness of the Zilpha Clay ranges from about 100 feet in northeastern Madison County to more than 300 feet in southwestern Hinds County. The thickness of the Zilpha Clay over the three-county area averages about 200 feet.

The Sparta Sand does not crop out in the three-county area but is present in the subsurface throughout the area. The top of the formation dips to the southwest from about 100 feet above sea level in northeastern Madison County to more than 1,400 feet below sea level in southwestern Hinds County. The regional dip averages about 24 feet per mile, but in the Jackson area the Jackson Dome interrupts the regional trend and displaces the formation upward about 800 feet over the crest of the dome. On the southwestern flank of the dome between Jackson and Raymond in Hinds County the formation dip approaches 140 feet per mile (Spiers and Dalson 1979).

The Sparta Sand consists of beds of sand, clay, lignite, and sandy shale. The sandgrain size ranges from fine to medium with fair uniformity. Sand in the Sparta aquifer is coarser and more permeable than the sand in the Cockfield aquifer.

Total thickness of sand beds in the Sparta Sand is more than 500 feet in southwestern Madison and western Hinds Counties (fig. 6). Total sand thickness of the Sparta ranges from 200 to 400 feet throughout most of the three-county area. Generally, the total sand thickness is smallest in northeastern Madison and eastern Rankin Counties and greatest in southwestern and western Hinds County. The Jackson Dome interrupts this trend and causes units to be thinner over the crest of the dome. The total sand thickness generally is 100 to 200 feet greater for the Sparta Sand than for the Cockfield Formation.

The Sparta aquifer is recharged with water from rainfall on the outcrop area northeast of the three-county area (in Attala and Leake Counties). Water levels in the Sparta aquifer are higher in the outcrop area where the aquifer is under water-table conditions. Flow in the confined part of the aquifer is downdip to the southwest and toward areas of large ground water withdrawals from the aquifer.

The Sparta aquifer is the most intensively developed source of ground water in the study area and is the source of water for most of the large-capacity wells in the three-county area. In 1990, an estimated 18.5 million gallons per day was pumped from the Sparta aquifer, more than twice the amount pumped from the Cockfield aquifer (fig. 4). Withdrawals from the Sparta aquifer increased substantially between 1965 and 1980

-- from about 7.1 million gallons per day to 18.6 million gallons per day. Withdrawals from the Sparta aquifer have remained fairly stable since 1980.

Pumping from the Sparta aquifer in the Jackson area has caused water levels in this aquifer to decline steadily since 1945 (fig. 6). Water levels in observation well G125 completed in the Sparta aquifer have declined as much as 120 feet since the mid 1940's. Prior to 1982, the rate of water-level decline in this well was from 2-1/2 to 3 feet per year, but the rate of decline has diminished since 1982 to about 1-1/2 feet per year. The reduced rate of decline of water levels in the Sparta aquifer in the Jackson area probably is a result of the increased use of surface water in Jackson and of the expansion of ground water public supplies to outlying areas. In most locations, the Sparta aquifer is an excellent source of large amounts of freshwater for the three-county area.

Water from the Sparta aquifer in the study area generally is suitable for most uses. The aquifer contains freshwater throughout the study area even though the mineralization increases in a downdip direction. Water with concentrations of iron of more than 0.3 milligrams per liter occurs in this aquifer in all of Madison County and in northeastern and southeastern Rankin County. Generally, iron concentrations in water from the Sparta aquifer decrease downdip from the outcrop area. Water with excessive color (more than 50 platimum-cobalt units) occurs in the southern half of Hinds County, the southwestern part of Rankin County, and in the area of the upper Ross Barnett Reservoir in northern Rankin and northeastern Madison Counties.

Summary

The Cockfield and Sparta aquifers are the most widely used sources of ground water in Hinds, Madison, and Rankin Counties, which constitute the Jackson metropolitan area of Mississippi. The Cockfield and Sparta are the only aquifers in the three-county area that extend throughout the area and contain freshwater at all locations. Both aquifers are in the upper part of the Eocene Claiborne Group. The Cook Mountain Formation separates the overlying Cockfield Formation from the underlying Sparta Sand. The Eocene Jackson Group overlies the Cockfield Formation and the Zilpha Clay underlies the Sparta Sand. The Jackson Dome, which underlies the Jackson area, causes all subsurface units in the area influenced by the dome to be arched upward.

The Cockfield Formation crops out within the three-county area in northeastern Madison County and in a small area along the Pearl River at Jackson. The top of the Cockfield Formation dips about 20 feet per mile to the southwest across the study area. The top of the formation ranges from land surface in the outcrop area in northeastern Madison County to about 1,000 feet below land surface in southwestern Hinds County. The top of the formation is at or near land surface over the crest of the Jackson Dome. Total sand thickness of the Cockfield Formation ranges from less than 100 feet in northeastern Madison County to more than 400 feet in southwestern Hinds County. Over most of the area, sand thickness ranges from 100 to 200 feet. In 1990, about 8.4 million gallons of water per day were pumped from the Cockfield aquifer in the study area. Withdrawals from the Cockfield aquifer account for about 30 percent of the ground water withdrawals in the study area in 1990.

Large withdrawals from the Cockfield aquifer have caused water levels in observation wells in the aquifer to decline as much as 60 feet in 30 years. Water levels near out-crop areas and in areas with less pumping have declined less. The Cockfield aquifer generally contains water suitable for most uses. High color in water from this aquifer is common in southern Hinds and Rankin Counties and in the area of the upper Ross Barnett Reservoir. Large iron concentrations in water from the Cockfield aquifer are common in all of Madison County, in northeastern and in southwestern Rankin County, and in southeastern Hinds County.

The Sparta Sand crops out to the northeast of the three-county area in adjacent Attala and Leake Counties. The regional dip of the Sparta Sand is about 24 feet per mile from northeast to southwest. The Jackson Dome causes a much steeper dip of the Sparta Sand on the southwestern flank of the dome between Jackson and Raymond in Hinds County. Over the crest of the dome, the top of the formation is about 800 feet nearer land surface than the top would be if the dome were not present.

Total sand thickness of the Sparta Sand is more than 500 feet in southwestern Madison and western Hinds Counties. Total sand thickness decreases eastward and northeastward. The total sand thickness of the Sparta Sand generally is about 100 to 200 feet greater than the total sand thickness in the Cockfield Formation.

The Sparta aquifer is the major source of ground water in the study area and supplied about 18.5 million gallons per day in 1990. Since 1980, withdrawals from the Sparta aquifer have been fairly stable. Prior to 1982, water-level declines in the Sparta aquifer in heavily pumped areas were as much as 2-1/2 to 3 feet

per year, but since 1982 declines have averaged about 1-1/2 feet per year.

The quality of water in the Sparta aquifer generally is suitable for most uses. Objectionable color occurs in water from the Sparta aquifer in the southern half of Hinds County, the southwestern part of Rankin County, and in the area of the upper Ross Barnett Reservoir, in northern Rankin, and northeastern Madison Counties. Large concentrations of iron are common in water from the Sparta aquifer throughout Madison County and in northeastern and southeastern Rankin County.

Acknowledgments

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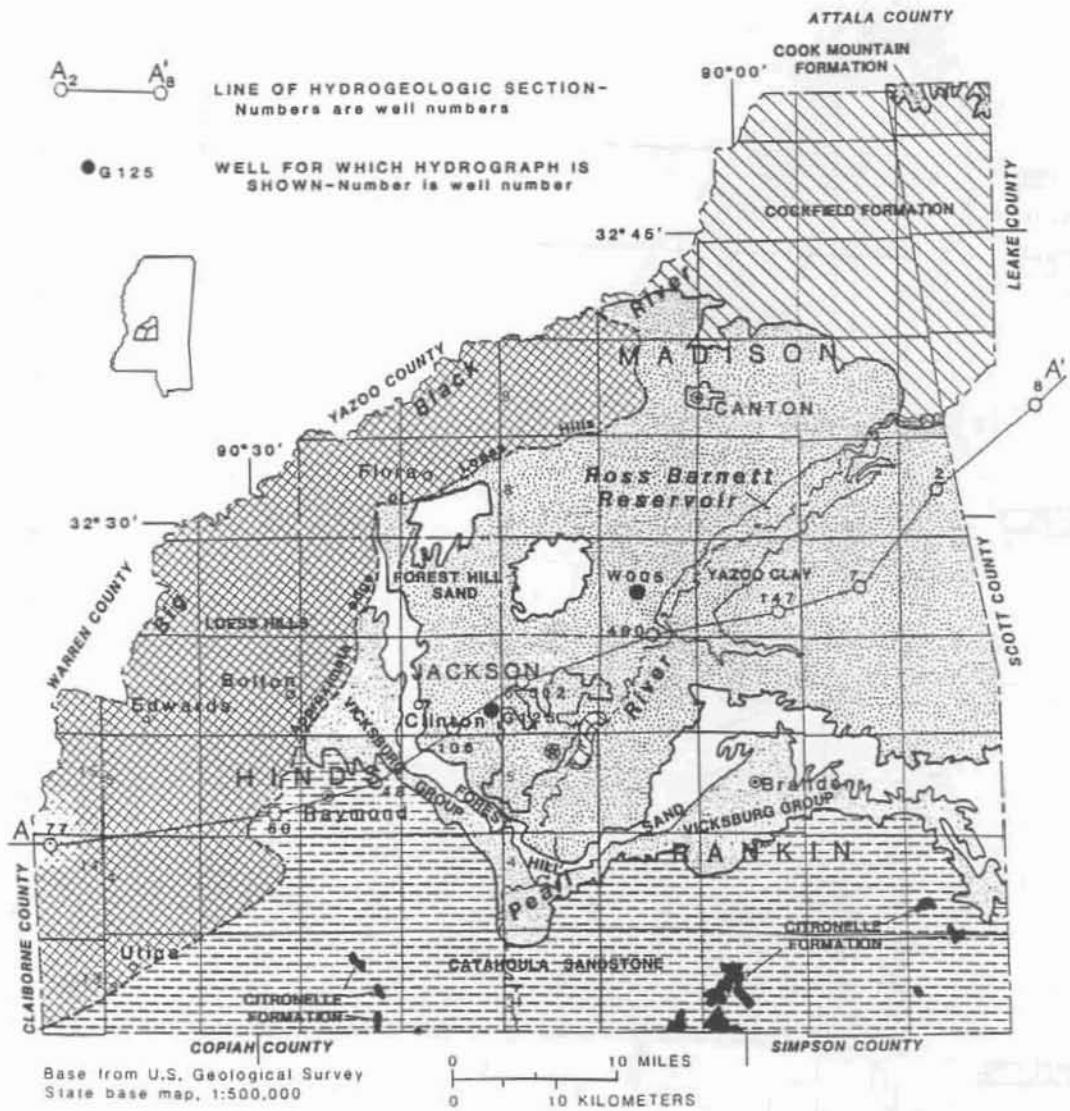

Figure 1.--Location of study area, generalized geology, line of hydrogeologic section, and location of wells for which hydrographs are shown.

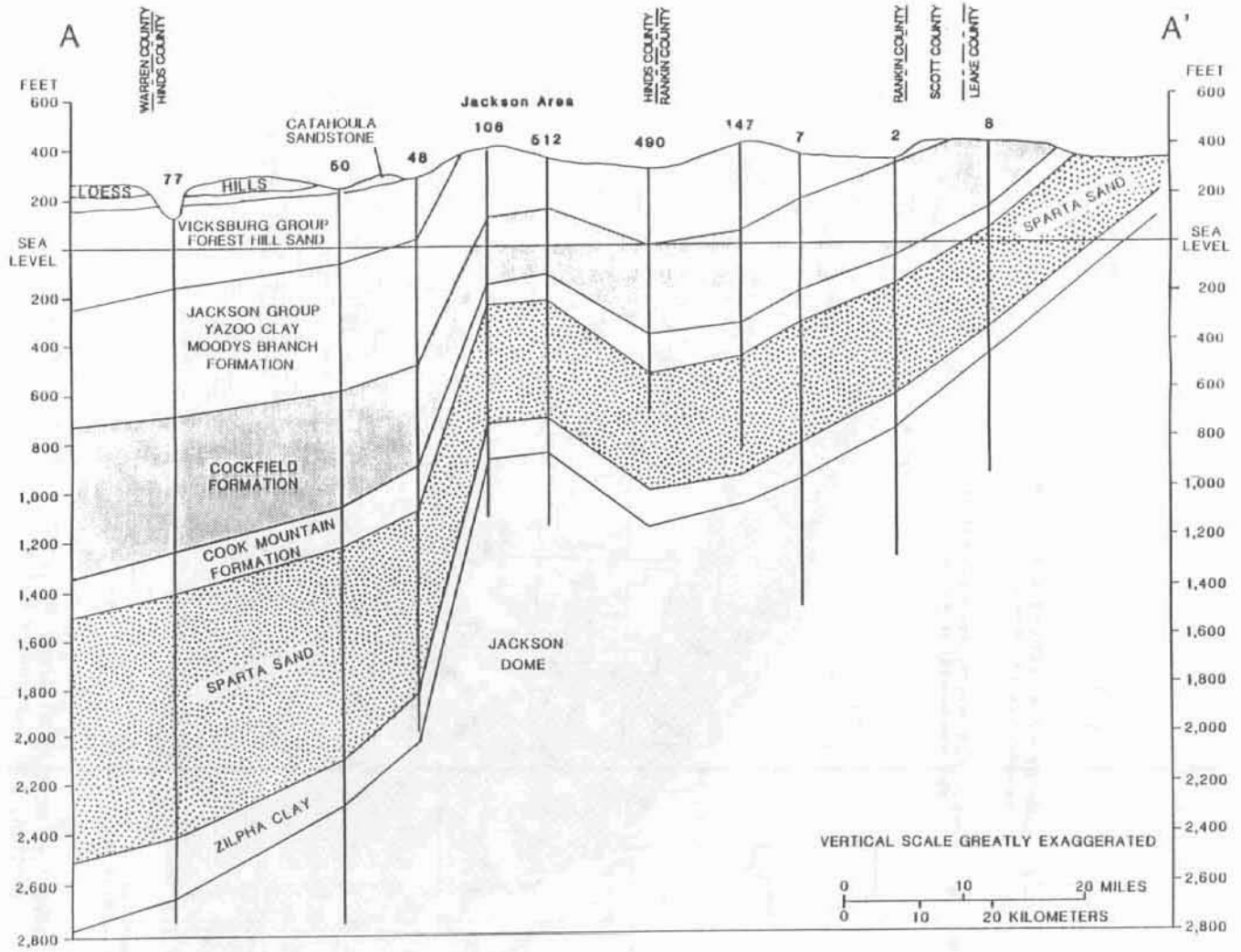

Figure 2.--Hydrogeologic section A-A' through study area (modified from Newcome, 1976).

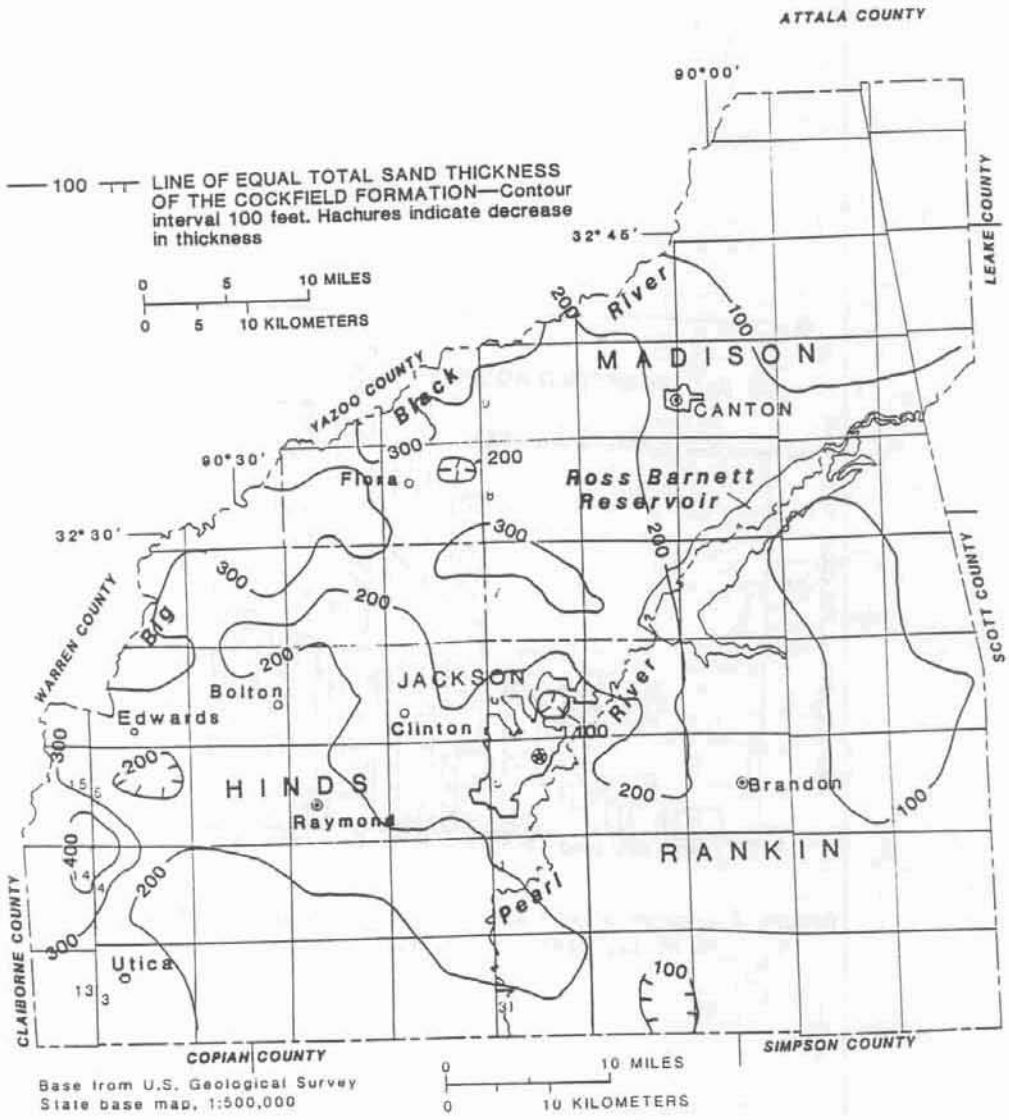

Figure 3.--Generalized total sand thickness of the Cockfield Formation.

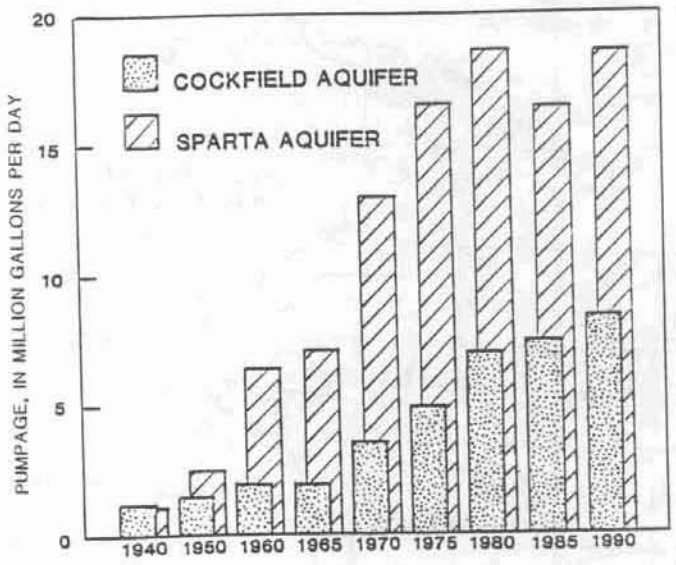

Figure 4.--Pumpage from the Cockfield and Sparta aquifers in Hinds, Madison, and Rankin Counties.

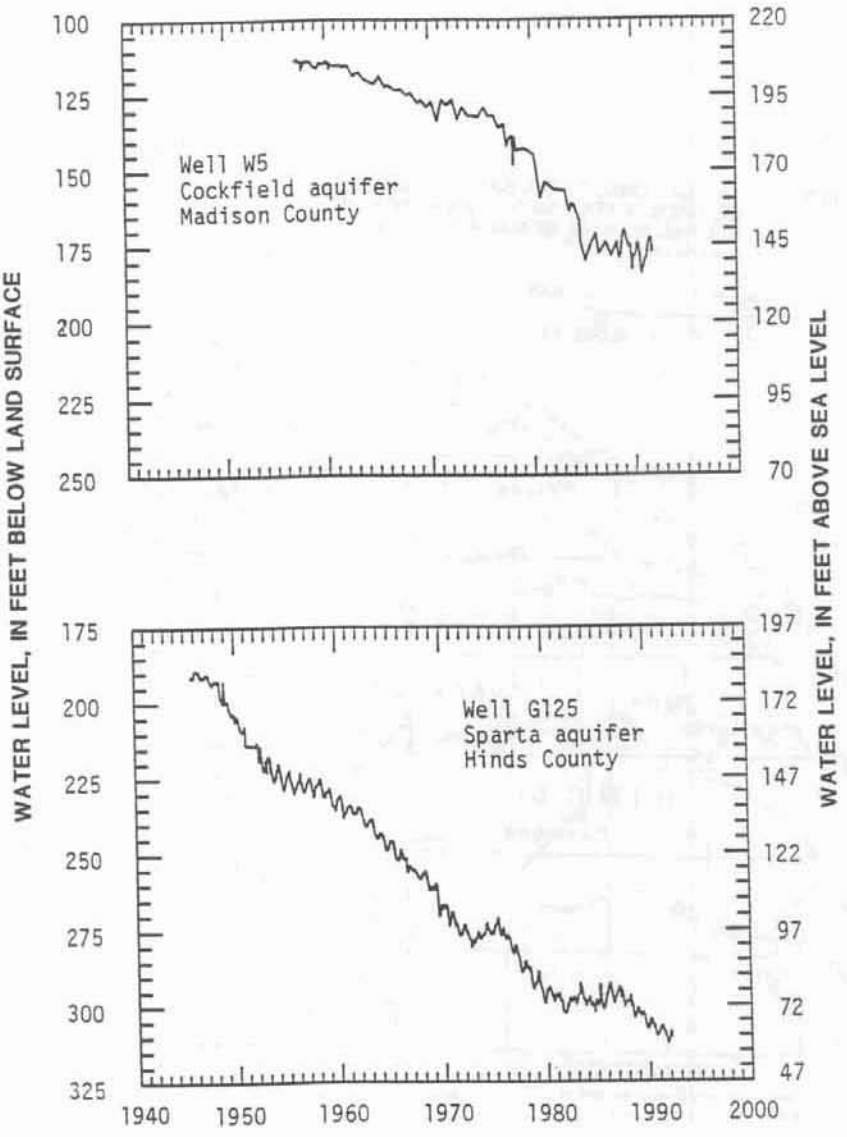

Figure 5.--Water levels in observation wells in the Cockfield and Sparta aquifers.