Prepared in cooperation with the
MISSISSIPPI DEPARTMENT OF ENVIRONMENTAL QUALITY
OFFICE OF POLLUTION CONTROL and the
MISSISSIPPI DEPARTMENT OF AGRICULTURE AND COMMERCE
BUREAU OF PLANT INDUSTRY

INTRODUCTION

Ground water, because of its extensive use in agriculture, industry, and public-water supply, is one of Mississippi's most important natural resources. Ground water is the source for about 80 percent of the total freshwater used by the State's population (Solley and others, 1993). About 2,600 Mgal/d of freshwater is withdrawn from aquifers in Mississippi (D.E. Burt, Jr., U.S. Geological Survey, oral commun., 1995). Wells capable of yielding 200 gal/min of water with quality suitable for most uses can be developed nearly anywhere in the State (Bednar, 1988). The U.S. Geological Survey (USGS), in cooperation with the Mississippi Department of Environmental Quality, Office of Pollution Control, and the Mississippi Department of Agriculture and Commerce, Bureau of Plant Industry, conducted an investigation to evaluate the susceptibility of ground water to contamination from surface and shallow sources in Mississippi. A geographic information system (GIS) was used to develop and analyze statewide spatial data layers that contain geologic, hydrologic, physiographic, and cultural information.

This report summarizes the selected factors used to evaluate the relative susceptibility of ground water to contamination from surface and shallow sources, explains the methods used in the evaluation, and provides maps and explanations of the results of the evaluation. The spatial data layers used in the investigation are discussed and illustrated. The evaluated relative susceptibility results are discussed and mapped for the entire State.

Two primary guidelines were established for the investigation: (1) to address the relative ease by which surface and shallow sources of contamination might reach the saturated zone, and (2) to assume ground water is susceptible to surface and shallow sources of contamination only in areas where aquifers are unconfined. The transport and fate of contaminants after reaching the saturated zone was beyond the scope of the study, as was the evaluation of ground-water susceptibility for areas where aquifers are confined. The confined parts of aquifers are characterized by areally extensive layers of relatively impermeable material between the top of the aquifer and the land surface and were not evaluated. Such layers may be spatially continuous or lensoidal and discontinuous.

It is important to note that this evaluation was made based solely upon the factors discussed in this report. Other physical, chemical, and biological factors that might influence the transport and fate of contaminants in the saturated or unsaturated zones are beyond the scope of this investigation. This report documents the use of new methods and approaches to evaluate the susceptibility of ground water to contamination from surface and shallow sources. Hydrologic analysis, not regulatory implementation, is the scope of the investigation. Nothing in this report should be taken as a substitute for site-specific investigations.

LOCATION AND PHYSICAL FEATURES

Mississippi has an area of about 47,800 square miles. The 1990 population was about 2.5 million (U.S. Bureau of the Census, 1991). The State, with the exception of an area in northeastern Mississippi, lies entirely within the East Gulf Coastal Plain (Fenneman, 1938). A diverse range of topographic and physiographic features occurs within Mississippi; these features can be assembled into at least 10 distinct physiographic districts (Stephenson and others, 1928) as listed below and shown in figure 1. Most of the physiographic districts within the State are lowlands, and the land-surface altitude ranges from sea level to 806 feet above sea level at Woodall Mountain in Tishomingo County. In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929) -- a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929. The land forms and altitudes are largely a result of differential weathering and erosion of parent materials that underlie the surface. Geologic formations comprised of sand and sandstone tend to be less eroded (rain infiltrates rather than running off and scouring the surface, Stephenson and others, 1928) than formations comprised of chalk and clay. Therefore, the division and geographic extent of physiographic districts in Mississippi roughly follows that of geologic units (fig. 2), with hilly regions in the outcrop areas of sandy formations and gently undulating or moderately rolling plains in the outcrop areas of formations comprised of chalk and clay (Stephenson and others, 1928). The two districts that have not been substantially developed by differential weathering and erosional processes are constructional plains-- the Mississippi Alluvial Plain and the Coastal Pine Meadows.

The physiographic districts in Mississippi (fig. 1) are briefly described below in order from northeast to south and east to west with brief descriptions based upon Fenneman (1938), except where noted.

The ***Fall Line Hills*** (Tombigbee Hills, Stephenson and others, 1928) district in the northeastern part of the State is a dissected upland where hilltop altitudes reach more than 700 feet above sea level (Fenneman, 1938). Hills range from smooth and rounded with 40 to 50 feet of relief with few broad or flat divides to hills and ridges with 200 feet of relief (Stephenson and others, 1928) with steep slopes, narrow crests, and narrow separating valleys.

The ***Black Prairies*** district corresponds roughly in areal extent to the outcrop of the Selma chalk (Stephenson and others, 1928). This prairie belt is characterized by level plains and gently-sloped hills which rise 10 to 15 feet above the valley bottoms.

The ***Pontotoc Ridge*** (Pontotoc Hills, Stephenson and others, 1928, or Ripley Cuesta, Fenneman, 1938) district coincides with the outcrop of the Ripley and Clayton Formations. This district is characterized by gently-sloped hills with broadly rounded crests with 40 to 50 feet of relief in the western part of the district and sharply outlined, steeply sloped hills with relief of as much as 250 feet in the eastern part.

The ***Flatwoods*** district, a lowland that marks the outcrop of the Porters Creek Clay, is characterized by gently undulating to rolling wooded plains with altitudes above sea level that range from 500 feet in the north to 200 feet in the south (Stephenson and others, 1928).

The ***North Central Hills*** (Red Hills Belt or North Central Plateau, Fenneman, 1938) district is a hilly to moderately irregular upland shaped by stream erosion and underlain by the Wilcox and Claiborne Groups. The hills of this district range in altitude above sea level from 400 feet in the south to 600 feet in the north with intervening valleys that occur 50 to 250 feet below the hilltops (Stephenson and others, 1928).

The ***Jackson Prairies*** district is a relatively narrow strip of gently rolling land with many small prairie-like tracts roughly marking the outcrop of the Jackson Group (Yazoo Clay).

The ***Long-leaf Pine Hills*** (Stephenson, 1928, or Southern Pine Hills, Fenneman, 1938) district is an area of rolling to moderately rugged hills underlain by the Vicksburg Group, and the Catahoula, Hattiesburg, Pascagoula, and Citronelle Formations. The land forms of this district are largely determined by the sandy beds of the Citronelle Formation, and the hills range in altitude above sea level from less than 100 feet to 500 feet or more in the north and northeast (Stephenson and others, 1928).

The ***Coastal Pine Meadows*** district in the southeastern part of the State borders the Gulf of Mexico and is a low-lying area 7 to 20 miles wide. No part of this district is more than 100 feet above sea level, and most areas are less than 50 feet above sea level (Stephenson and others, 1928). Features of this area are gently rolling to flat lowlands near the coast with considerable areas of coastal marsh and swamp.

The ***Loess*** (or Bluff) ***Hills*** district is characterized by hills with steep slopes, narrow ridges, and narrow intervening valleys, formed on loess deposits along the eastern edge of the Mississippi Alluvial Plain. The loess deposits that underlie these hills thin gradually to the east and are bounded on the west by an abrupt escarpment that stands 150 to 250 feet above the level bottom lands of the Mississippi River (Stephenson and others, 1928).

The ***Mississippi Alluvial Plain*** district is a broad, flat, gently sloping plain formed by the Mississippi River and its tributaries (Stephenson and others, 1928).

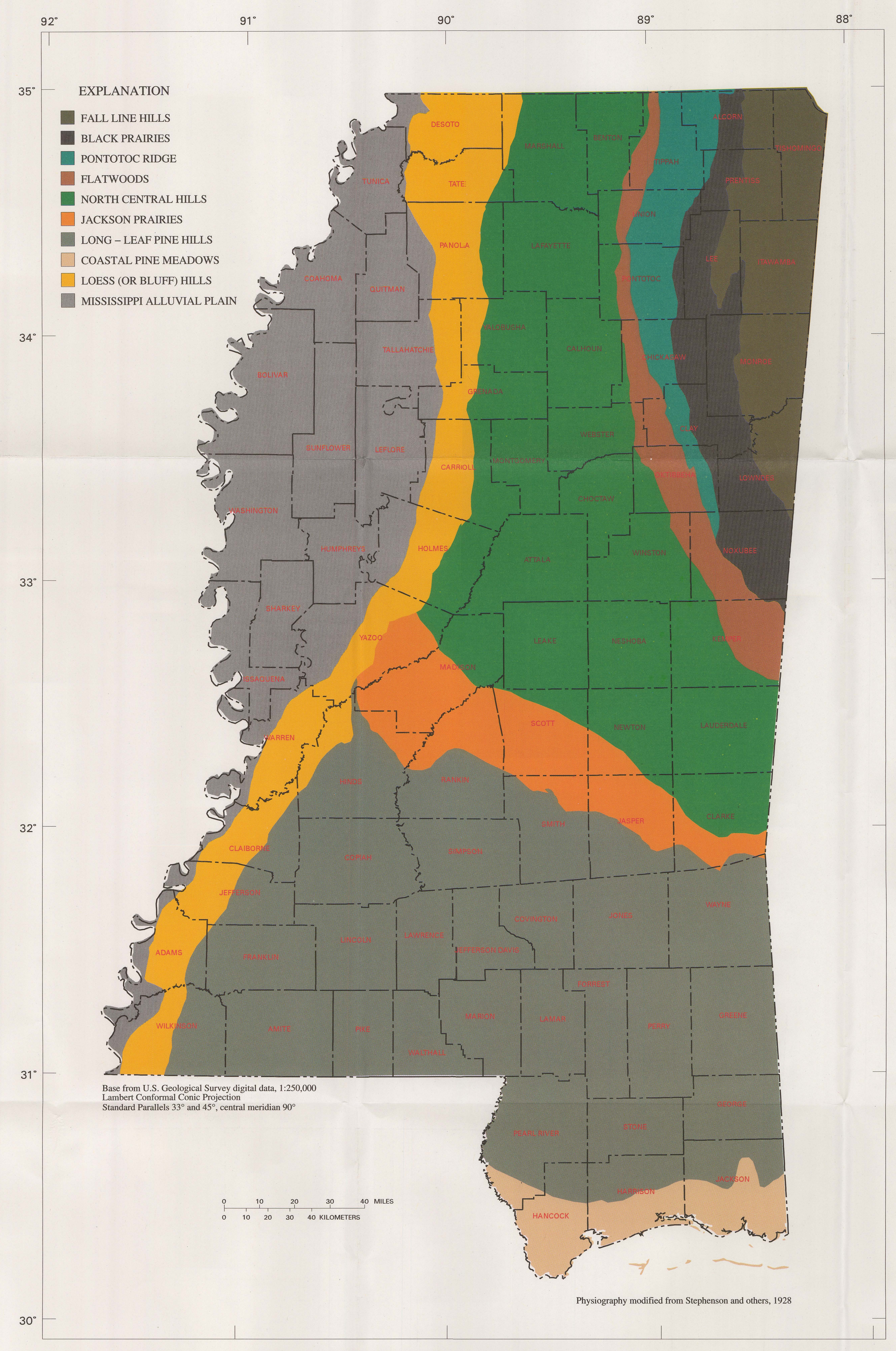

Figure 1. Physiographic districts in Mississippi.

GENERAL GEOLOGY

The land surface of Mississippi is underlain by a series of stratified sedimentary deposits that contain some of the most productive aquifers and aquifer systems in our Nation (table 1). The outcrop area of the 14 principal aquifers or aquifer systems in Mississippi (fig. 3) covers about 85 percent (41,000 square miles) of the land surface area of the State. The sedimentary deposits that underlie the State's land surface include unconsolidated materials such as clay, silt, sand, and gravel and consolidated sedimentary rocks such as limestone, sandstone, and shale. The geologic formations within the State that comprise these sedimentary deposits range in thickness from less than one hundred to thousands of feet and overlie "basement rocks" of more dense material such as granite, that are not exposed at the land surface within the State, but crop out in Alabama and eastern Tennessee. Wasson (1986), described the general geologic setting in Mississippi in the following manner:

> The geologic units, except the young alluvial and terrace deposits, dip toward the axis of the Mississippi embayment and, in the south, toward the Gulf of Mexico. In the northern part of the State, the dips are generally to the west; in central Mississippi the dips are generally southwest; and in southeastern Mississippi the dips are southwest to south. The dip is about 15 to 35 feet per mile where the geologic units are at or near the surface, but farther away from the outcrop areas the dip increases, and generally it is about 30 to 50 feet per mile. The dips in a few places in the State are affected by regional and local structures. Some of the geologic units are more than 1,000 feet thick; however, the thicknesses of most of the aquifers that occur within the units range from 100 to 400 feet.

PRINCIPAL AQUIFERS

The lithology, confining conditions, water quality, and water use of the principal aquifers in Mississippi are described by Boswell (1985). Water quality and related topics (such as effects of land use on water quality and potential for water-quality changes) for Mississippi's principal aquifers are described by Bednar (1988). Additional information about the principal aquifers in Mississippi is available from Gandl (1982) and Wasson (1986). The following descriptions of principal aquifers in the State were extracted from Slack and Darden (1991), and are based largely on the reports by Gandl (1982), Boswell (1985), and Wasson (1986); the 1985 water-use data for aquifer units are from Callahan and Barber (1990). The geographic distribution of the principal aquifer outcrops is shown in figure 3.

Table 1. Geologic and aquifer units
(modified from Slack and Darden, 1991)

Erathem	System	Series	Group	Geologic unit	Principal aquifer or aquifer system	Average reported conductivity (*K*) (feet per day)
Cenozoic	Quaternary	Holocene and Pleistocene		Quaternary alluvium Mississippi River valley alluvium	Mississippi River alluvial aquifer	250
		Pleistocene		Loess Terrace deposits		
	Tertiary	Pliocene		Citronnelle Formation	Citronelle aquifers	100
				Graham Ferry Formation		
		Miocene		Pascagoula Formation Hattiesburg Formation Catahoula Sandstone, upper part Catahoula Sandstone, lower part Deposits of Miocene age	Miocene aquifer system	82.5
		Oligocene	Vicksburg Group	Bacutunna Formation Waynesboro sand lentil Byram Formation Glendon Formation Marianna Formation Mint Spring Formation Forest Hill Formation	Oligocene aquifer system	27.0
		Eocene	Jackson Group	Yazoo Clay Moodys Branch Formation		
			Claiborne Group	Cockfield Formation	Cockfield aquifer	46.0
				Cook Mountain Formation		
				Sparta Sand	Sparta aquifer	62.0
				Zilpha Clay		
				Winona Sand Tallahatta Formation Neshoba Sand Member Basic City Shale Member	Winona-Tallahatta aquifer	61.0
				Meridian Sand Member Meridian Sand Member and Wilcox Group, upper part	Meridian-upper Wilcox aquifer	44.0
			Wilcox Group	Wilcox Group, upper part Hatchetigbee Formation		
		Paleocene		Tuscahoma Formation Wilcox Group, middle part		
				Nanafalia Formation Fearn Springs Member Wilcox Group, lower part	Lower Wilcox aquifer	58.0
			Midway Group	Naheola Formation Porters Creek Clay Matthews Landing Marl Member Clayton Formation		
Mesozoic	Cretaceous	Upper Cretaceous	Selma Group	Prairie Bluff Chalk and Owl Creek Formation		
				Ripley Formation	Ripley aquifers	4.5
				Demopolis Chalk		
				Coffee Sand	Coffee Sand aquifer	23.5
				Mooreville Chalk Arcola Limestone Member		
				Eutaw Formation Tombigbee Sand Member Eutaw Formation, lower part McShan Formation	Eutaw-McShan aquifer	13.0
			Tuscaloosa Group	Gordo Formation Coker Formation Massive sand	Tuscaloosa aquifer system	41.5
		Lower Cretaceous		Undifferentiated		
Paleozoic				Undifferentiated Paleozoic Erathem	Paleozoic aquifer system	48.0

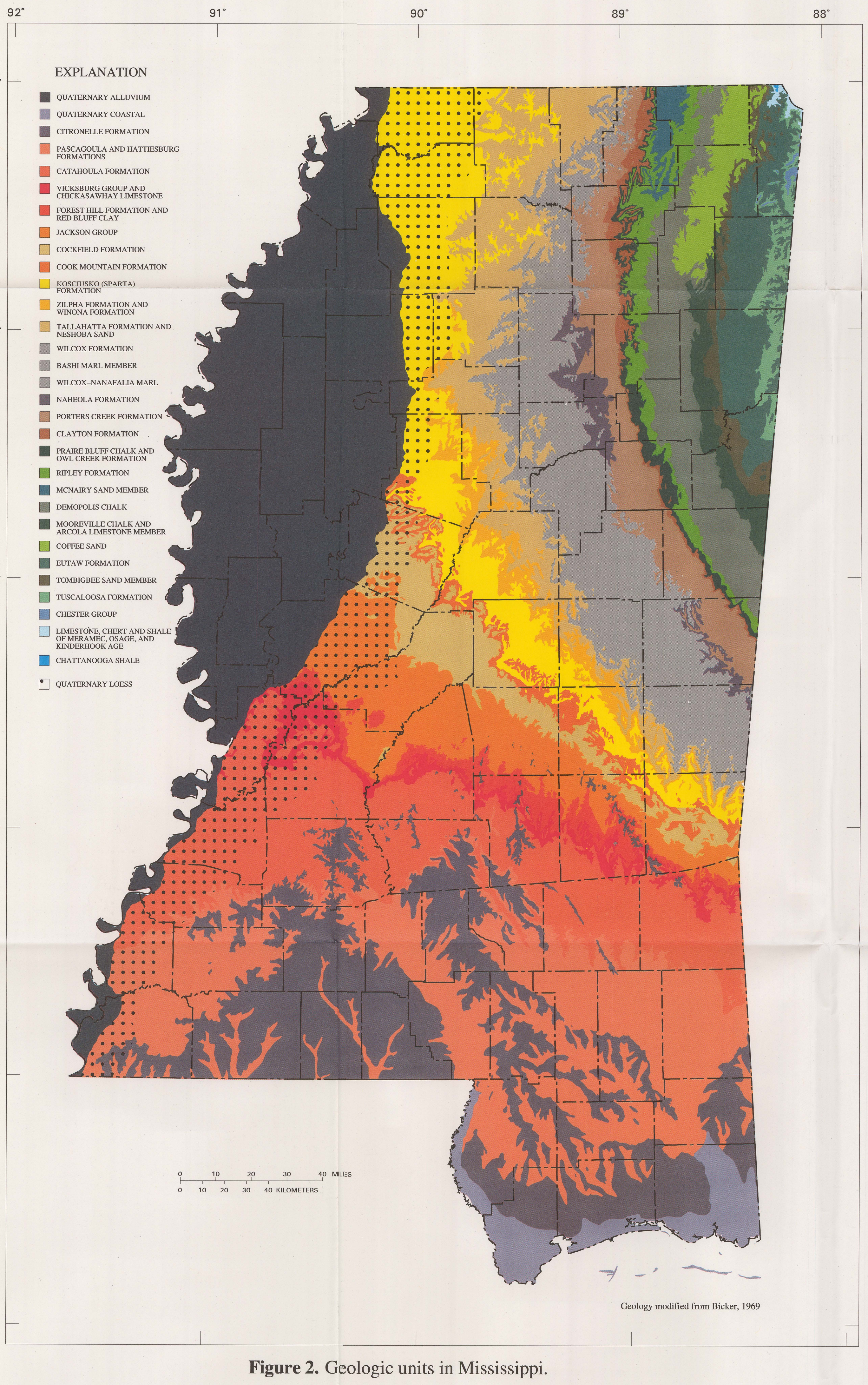

Figure 2. Geologic units in Mississippi.

DESCRIPTION OF PRINCIPAL AQUIFERS

The ***Mississippi River alluvial aquifer*** (Boswell, 1985) consists of alluvium--primarily clay, silt, sand, and gravel of Quaternary age. The Mississippi River alluvial aquifer is semiconfined and underlies an area of about 7,000 square miles in the northwestern part of the State that commonly is referred to as the "Delta." In 1985, more than 75 percent (1,190 Mgal/d) of all ground water used in the State was withdrawn from wells completed in this aquifer (Callahan and Barber, 1990). In 1994, more than 2,000 Mgal/d of ground water was withdrawn from wells completed in this aquifer (Arthur, 1995).

The ***Citronelle aquifers*** consist primarily of clay, silt, sand, and gravel in Pliocene (or Pleistocene ?) deposits (Boswell, 1985). The Citronelle aquifers generally are unconfined. In 1985, about 0.4 percent (6.3 Mgal/d) of ground water used in the State was withdrawn from these aquifers (Callahan and Barber, 1990).

The ***Miocene aquifer system*** (Boswell, 1985; Wasson, 1986) includes aquifers in the Graham Ferry, Pascagoula, Hattiesburg and Catahoula Formations and consists primarily of clay, silt, sand, gravel, and sandstone. Aquifers of the Miocene system generally are confined throughout most of their area of use. In 1985, about 7.8 percent (124 Mgal/d) of the ground water used in the State was withdrawn from this aquifer system.

The ***Oligocene aquifer system*** (Boswell, 1985) includes the Waynesboro Sand lentil of the Bucatunna Formation, and the Byram, Glendon, Marianna, Mint Spring, and Forest Hill Formations, and consists primarily of clay, silt, sand, marl, and limestone. Aquifers of the Oligocene system generally are confined throughout most of their area of use. In 1985, less than 0.3 percent (4 Mgal/d) of the ground water used in the State was withdrawn from this aquifer system.

The Eocene aquifers in Mississippi (Boswell, 1985) include the ***Cockfield***, ***Sparta***, ***Winona-Tallahatta***, ***Meridian-upper Wilcox***, and ***lower Wilcox***. In 1985, about 11 percent (174 Mgal/d) of ground water used in Mississippi was withdrawn from Eocene aquifers.

The ***Cockfield aquifer*** (Gandl, 1982; Boswell, 1985) consists primarily of clay, silt, sand, marl, and lignite. Generally, the Cockfield is confined throughout most of its area of use.

The ***Sparta aquifer*** (Boswell, 1985) consists primarily of clay, silt, sand, and lignite. Generally, the Sparta aquifer is confined throughout most of its area of use.

The ***Winona-Tallahatta aquifer*** (Boswell, 1985) consists primarily of clay and glauconitic sand. Generally, this aquifer is confined throughout most of its area of use.

The ***Meridian-upper Wilcox aquifer*** (Boswell, 1985) consists primarily of clay, silt, sand, and lignite. Generally, this aquifer is confined throughout most of its area of use.

The ***lower Wilcox aquifer*** (Boswell, 1985) consists primarily of clay, silt, sand, and lignite. Generally, this aquifer is confined throughout most of its area of use.

The Cretaceous aquifers in Mississippi (Boswell, 1985) include the ***Ripley aquifers***, the ***Coffee Sand aquifer***, the ***Eutaw-McShan aquifer***, and the ***Tuscaloosa aquifer system***. A recent investigation (Strom and Mallory, 1995) provides evidence that the ***Eutaw-McShan aquifer*** and the ***Tuscaloosa aquifer system*** together compose an aquifer system. In 1985, about 4.9 percent (78 Mgal/d) of ground water used in the State was withdrawn from these aquifers.

The ***Ripley aquifers*** (Boswell, 1985) includes the Ripley Formation, the McNairy sand member, and undifferentiated sands and consists primarily of clay, sand, sandstone, and limestone. Generally, these aquifers are confined throughout most of their area of use.

The ***Coffee Sand aquifer*** (Boswell, 1985) consists primarily of clay, sand, and sandstone. Generally, this aquifer is confined throughout most of its area of use.

The ***Eutaw-McShan aquifer*** (Boswell, 1985) consists primarily of clay and sand. Generally, this aquifer is confined throughout most of its area of use.

The ***Tuscaloosa aquifer system*** (Boswell, 1985) includes aquifers in the Gordo and Coker Formations, the massive sand, and the Lower Cretaceous and consists primarily of clay, silt, and sand. These aquifers generally are confined throughout most of their area of use.

The ***Paleozoic aquifer system*** consists mostly of beds of chert, sandstone, shale, and limestone with most of the freshwater occurring in the upper 100 feet of highly weathered chert (Wasson, 1986). Most of the Paleozoic aquifer system is overlain by the Gordo, Eutaw, McShan, or Coker Formations. Generally, the aquifer is confined throughout most of its area of use (Boswell, 1985).

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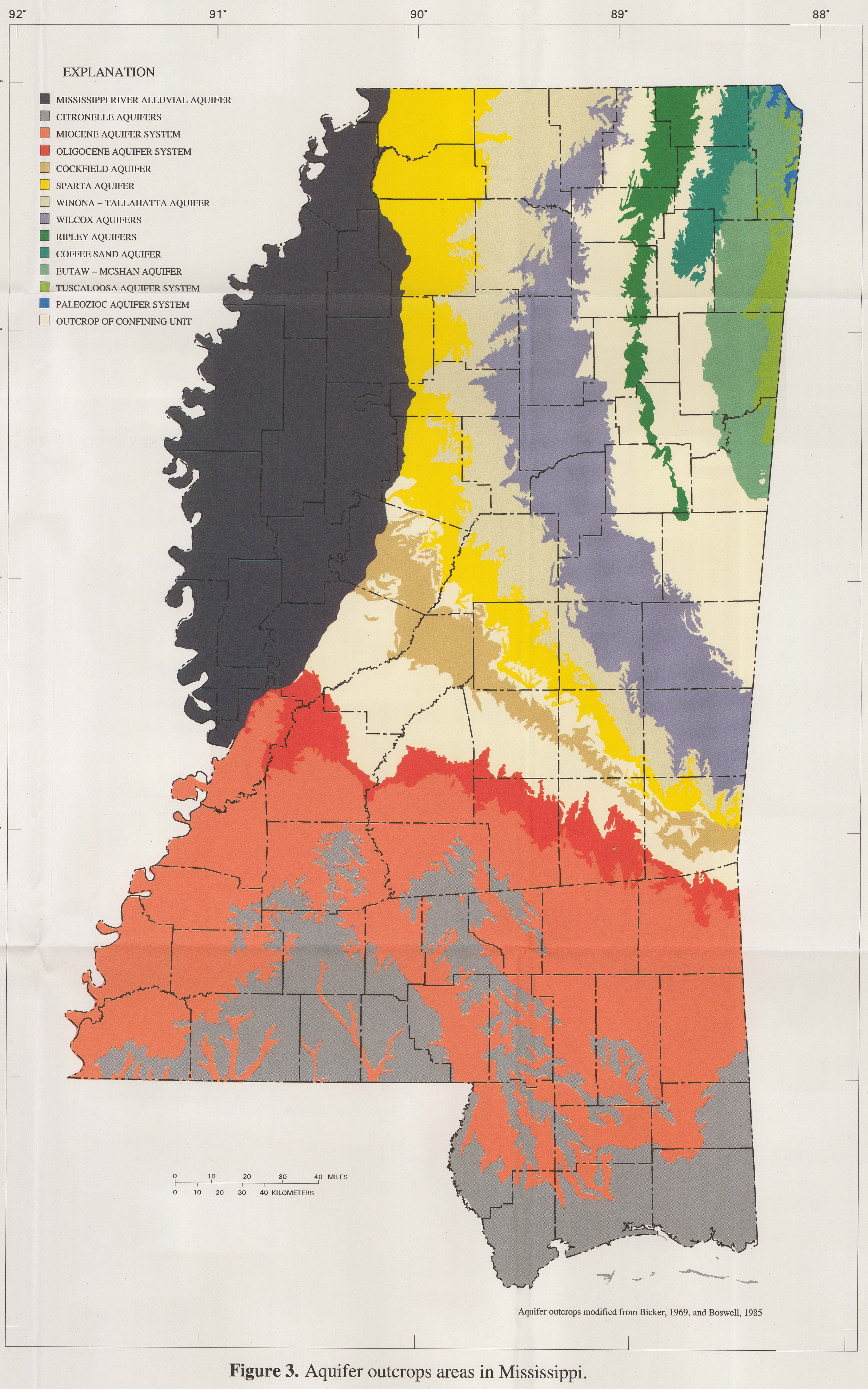

Figure 3. Aquifer outcrops areas in Mississippi.

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SUSCEPTIBILITY OF GROUND WATER TO SURFACE AND SHALLOW SOURCES OF CONTAMINATION IN MISSISSIPPI

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