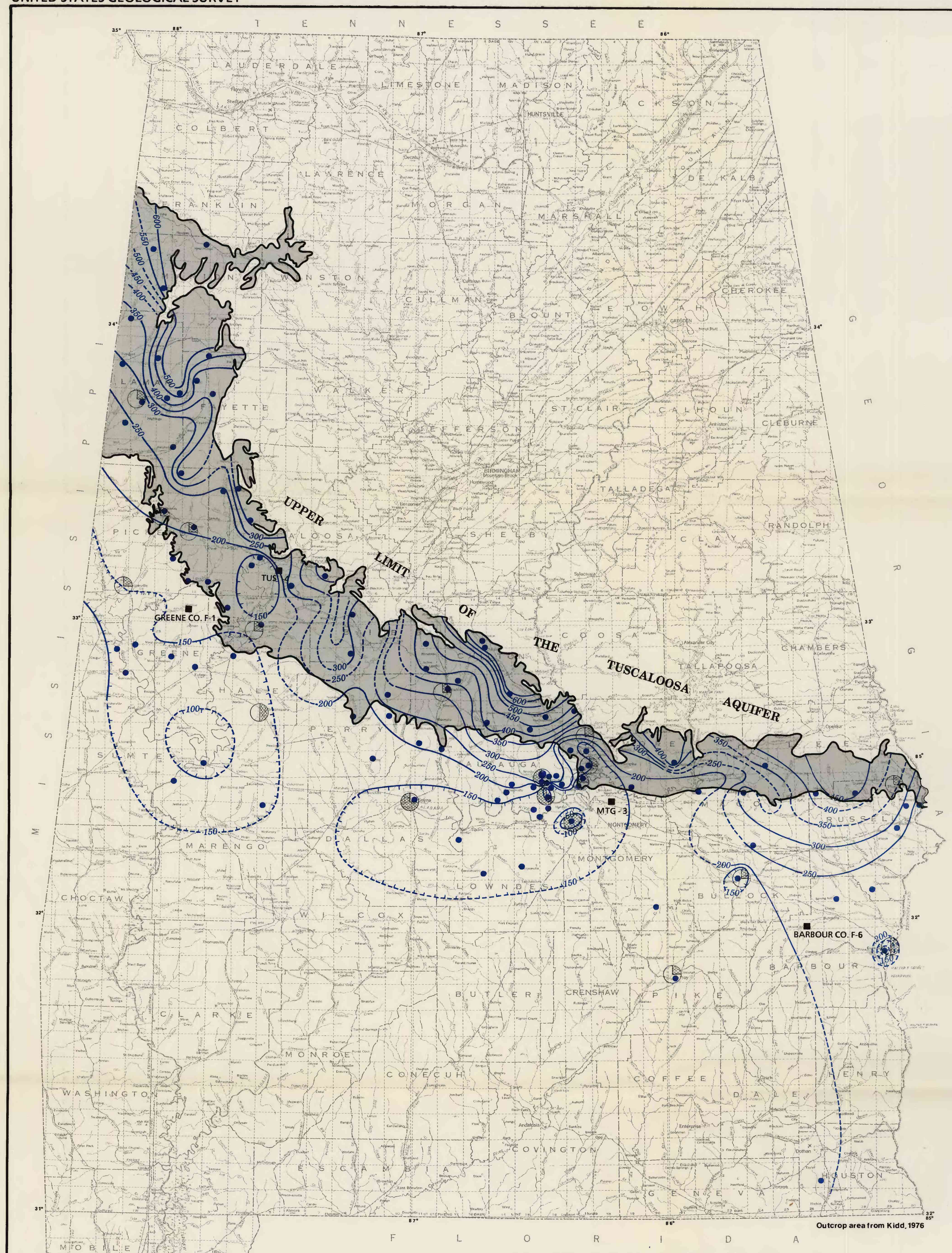
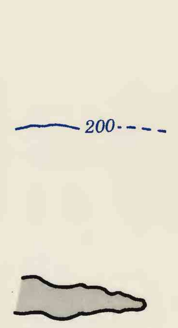


Outcrop area from Kidd, 1976

10 0 10 20 30 40 Miles

EXPLANATION



Potentiometric Surface Contour--Shows altitude at which water level would have stood in tightly cased wells. Dashed where approximately located. Contour interval 50 feet. Hachures indicate depressions. Datum is National Geodetic Vertical Datum of 1929 (NGVD of 1929): a geodetic datum formerly called mean sea level.

Aquifer Recharge Area Boundary

Observation Well--Well in which water-level or artesian-pressure measurement was made in November, 1982.

MTG-3 Observation well for which hydrograph is shown in figure 2.

Withdrawal rates at major pumping centers in millions of gallons per day.

<1.00 ; 1.00 - 1.99 ; 2.00 - 4.99 ; >5.00

POTENTIOMETRIC-SURFACE AND WATER-USE MAP OF THE TUSCALOOSA AQUIFER IN ALABAMA, FALL 1982

By John S. Williams, Sydney S. DeJarnette, and Michael Planert

INTRODUCTION

The U.S. Geological Survey began a nationwide program in 1978, termed Regional Aquifer-System Analysis (RASA), to study a number of the major aquifer systems that provide a significant part of the country's water supply. One of the aquifer systems chosen for study was the thick and extensive sequence of sands of Cretaceous and early Tertiary age that underlies the Coastal Plain of the Southeastern United States. This system, which extends from Mississippi eastward to South Carolina, is called the Southeastern Coastal Plain aquifer system. It can be divided hydrogeologically into several separate aquifers. The map presented here, one of a series that portray the potentiometric surface and water use of the aquifers in Alabama that are included in the regional system, deals with the Tuscaloosa aquifer.

GEOHYDROLOGY

The Tuscaloosa aquifer comprises the Coker and Gordo Formations of the Tuscaloosa Group in western and central Alabama and the Tuscaloosa Formation in the eastern part of the State. These formations are composed of unconsolidated sediments, clays, and shales of Cretaceous age. The updip limit of the aquifer is the inner margin of the Coastal Plain where the Cretaceous sediments contact pre-Cretaceous consolidated rocks. Rocks of early Cretaceous age underlie most of the Tuscaloosa aquifer, and it is overlain by the Eutaw aquifer of the Eutaw Formation, with which it has a degree of hydraulic connection in some areas. The recharge area for the aquifer extends across the State in a slightly curving band 10 to 25 miles wide oriented generally northwest to southeast.

Recharge to the Tuscaloosa aquifer occurs through the infiltration of water from precipitation. Discharge from the aquifer occurs in as many as four ways: 1) water may leak upward or downward to adjacent aquifers, 2) emerge at land surface as springs, 3) be withdrawn from wells, or 4) drain to streams in the recharge area.

The accompanying map is a generalized depiction of the regional potentiometric surface of the Tuscaloosa aquifer based on water-level measurements made primarily in the Fall of 1982, and in some cases on stream stage. The potentiometric surface map illustrates, by means of contour lines, the altitude of the water table or the altitude to which water would rise in tightly cased wells tapping an artesian (confined) aquifer. The potentiometric surface depicted generally represents an average for the aquifer; the water-level altitude in any particular well may differ from the average to some extent depending on well depth and local geology. The orientation and shape of the contour lines are influenced by several factors, which include the geologic structure of the aquifer, the rate at which water passes through the aquifer (its transmissivity), and the location of discharge points such as wells, springs, or streams. Ground-water flow in the aquifer is approximately perpendicular to the contour lines.

Large streams and rivers drain significant amounts of water from an aquifer, often controlling regional flow patterns. The flow patterns depicted on this potentiometric surface map and digital-computer model simulation (Gardner, 1981) suggest that most of the discharge from the Tuscaloosa aquifer is to the Tombigbee-Black Warrior River system and to the Alabama River in the central part of the State. Where the Tuscaloosa aquifer is overlain by the Eutaw aquifer in the vicinity of those rivers, water from the Tuscaloosa aquifer apparently leaks upward into the Eutaw aquifer and thence to the rivers, passing through fractures in the Demopolis and Mooreville Chalks where those formations overlie the Eutaw aquifer (Gardner, 1981). Water entering the aquifer that is not immediately intercepted by streams in the recharge area or by pumpage has a longer flow path downdip through the confined part of the aquifer. Low permeability rocks and highly mineralized water far downdip in the aquifer present a barrier to flow, causing fresh ground water recharging the deeper parts of the aquifer to move updip and eventually discharge to the rivers.

GROUND-WATER USE

The Tuscaloosa aquifer provides water to several municipalities and industries, as well as to a large rural area across central Alabama. The municipal water systems withdrawing water from the aquifer at a rate of one million-gallons-per-day (Mgal/d) or greater are the cities of Greensboro, Selma, Prattville, Montgomery, and Eufaula. Several smaller public suppliers use more than 0.25 Mgal/d. Industrial users near Prattville account for another 3 Mgal/d. The total rate of withdrawal from the aquifer by all of these users was approximately 23 Mgal/d in 1982; individual rates are shown by pumpage category on the map. With the exception of the Prattville area, self-supplied industrial use of water from the aquifer is not concentrated in specific localities, and probably amount to less than 4 Mgal/d. Agricultural use of water from the Tuscaloosa aquifer is likewise thought to be more or less uniformly distributed and relatively insignificant. An exception is in Hale County, where catfish farming may account for withdrawals of up to 3 Mgal/d. Self-supplied domestic use of ground-water from the aquifer is difficult to quantify with certainty, but may total as much as 5 Mgal/d.Discharge from unregulated flowing wells, although probably significant, is likewise difficult to quantify. Gardner (1981) estimated such discharge from the Tuscaloosa aquifer to be in excess of 3 Mgal/d near river valleys in an area extending from Autauga County west to the state line.

Water-level observation wells have been monitored for several years to assess the effects of water withdrawals on the aquifer. The hydrographs shown on this map are a record of water levels measured in some of those wells. Before production wells are drilled and withdrawal begins, an aquifer is in a state of "dynamic equilibrium", where water levels in the aquifer rise and fall in an annual cycle corresponding to seasonal changes in precipitation. Water levels may also show fluctuations of longer duration due to long-term departures from normal rainfall amounts, but on the average remain nearly the same. This is because the amount of water that is entering the aquifer as recharge is also naturally discharged, either to other aquifers, to the land surface as springs, or to streams in the aquifer recharge area. Pumping changes this balance, and, as shown by the hydrographs, water levels usually begin to decline near major pumping centers. They will continue to decline until either an increase in recharge or a decrease in natural discharge balances the quantity of water being pumped.

At least two of the hydrographs, and possibly a third, show an initial water-level decline and subsequent stabilization near pumping centers. The hydrographs of observation wells Tus-4 and Mtg-5 (located near public-supply wells in the cities of Tuscaloosa and Montgomery) demonstrate that, although there were fluctuations due to annual cycles in pumping rate or precipitation, the aquifer had attained a new equilibrium during the years in which the wells were in use. In both instances this was the result of one or both of two causes: 1) both pumping centers are in or near the recharge area for the aquifer, and were able to capture water that would normally have left the aquifer through evapotranspiration or discharge to rivers; 2) the pumping distribution changed in the area as new, more distant wells were brought into service. The hydrographs also demonstrate the recovery of the aquifer in those areas after both systems switched from ground-water to surface-water supplies. The water level in Mtg-5 began to decline again in 1976 due to the City of Montgomery's return to the use of ground water. However, recent record indicates that is has begun to stabilize, suggesting that the aquifer is approaching a new equilibrium.

The significance of whether an aquifer in the area of a pumping center reaches equilibrium is that, if equilibrium is attained, the current pumping rate for that center may be considered dependable. However, if water levels continue to decline, a condition could arise where further withdrawal from the aquifer at the current rate would be impractical or uneconomical.

The hydrograph for well F-6 in Barbour County shows a continual decline in water-levels since the first recorded water-level measurement in 1967. The well is located some 20 mi from pumping centers in the area withdrawing water from the Tuscaloosa aquifer, the downward trend in water level may represent a regional decline in the potentiometric surface. Over the past approximately 20 yrs, water levels in Union Springs and Eufaula public supply wells screened in the Tuscaloosa aquifer have fallen over 50 and 80 ft respectively. The continued decline of water-levels in observation well F-6 suggests that the aquifer may not be in equilibrium in the eastern part of the State, and that the downward trend in water levels in public supply wells in both Union Springs and Eufaula may continue.

In contrast, observation well F-1 in Greene County is located in an area of the State in which ground-water withdrawal rates are relatively low and pumping centers widely dispersed, in may cases being located near the aquifer recharge area. The hydrograph shows that the water level in the observation well has declined little through time, indicating that stress on the aquifer in western Alabama has been insignificant relative to the eastern part of the State.

The potential for future development of the Tuscaloosa aquifer for both public supply and industrial uses is good in most areas of Alabama. Future development near Prattville, Union Springs, and Eufaula, however, will depend on whether the aquifer in the vicinity of those pumping centers can reach equilibrium given current or increased ground-water withdrawal rates.

Another factor governing aquifer development is the chemical quality of the water. Chloride ion, for example, can impart a salty taste to water at a concentration above 500 milligrams per liter (mg/L). With a very high chloride content, water may even become unpotable. Areas of the State in which the Tuscaloosa aquifer contains water having chloride ion in excess of 500 mg/L include southern Lowndes County (Scott, 1957, p. 19) and parts of some west-central Alabama counties (Wahl, 1966, fig. 7; Avrett, 1968; Newton and others, 1971, p. 8; Davis and others, 1980, p 17). Other water-quality conditions that may affect decisions concerning the suitability of ground water for various uses are high iron, bicarbonate, and hydrogen sulfide. These conditions are present locally in water from the Tuscaloosa aquifer in some parts of the State (Avrett, 1968; Kidd, 1976, chap. 9, p. 13).

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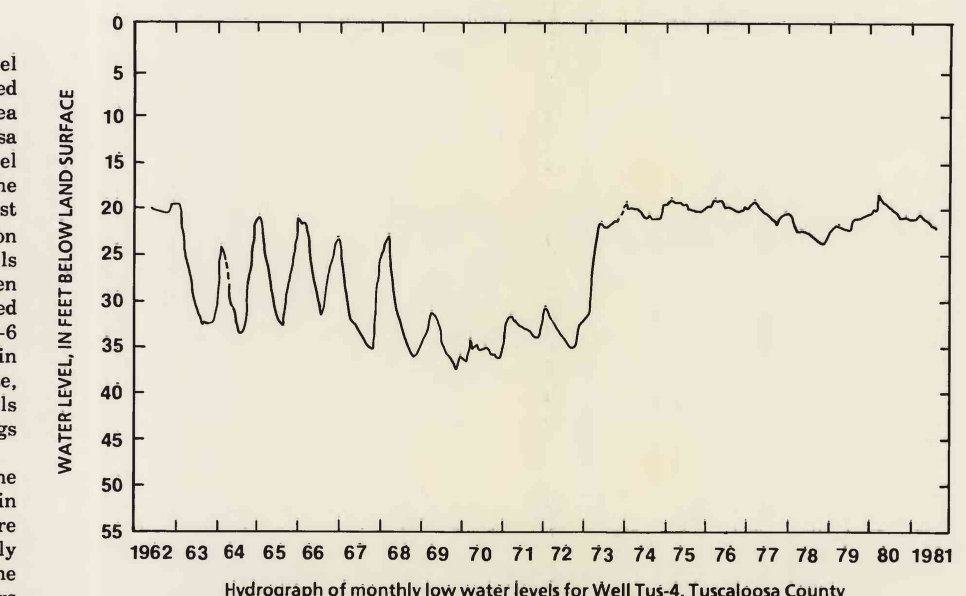
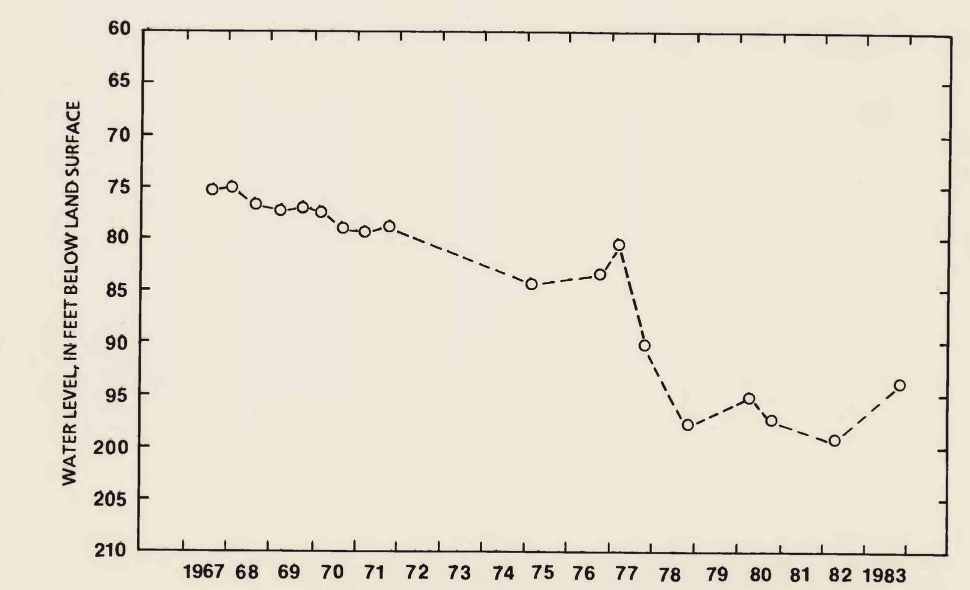
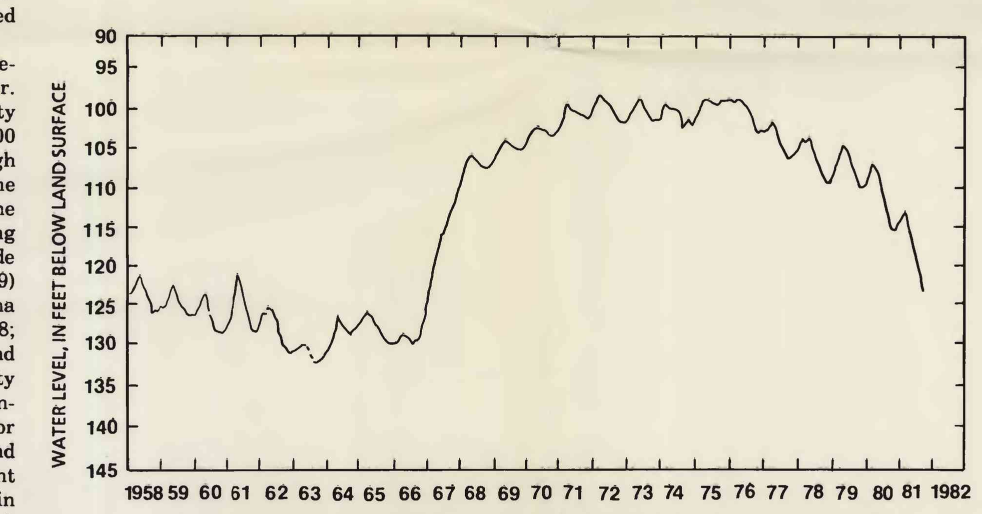


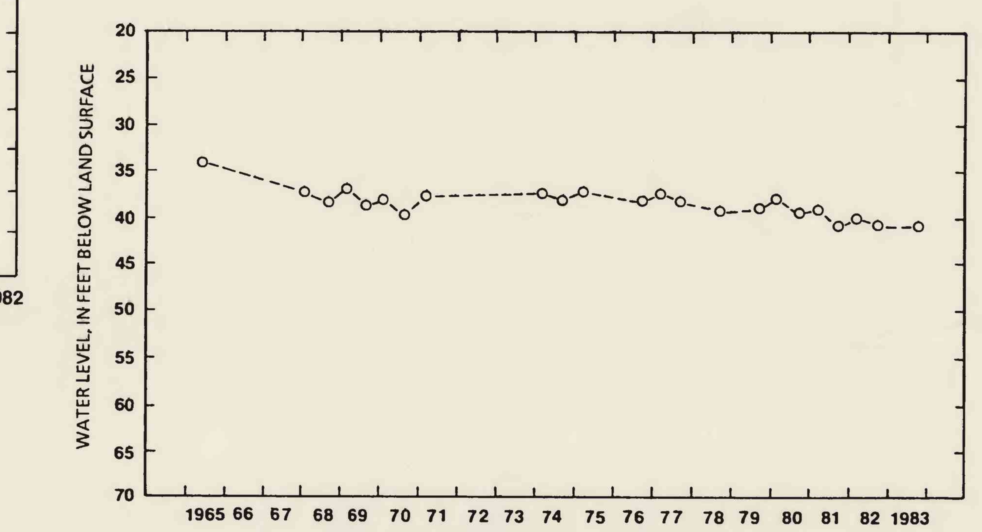
Hydrograph of monthly low water levels for Well Tus-4, Tuscaloosa County (adapted from information and data provided by the U.S. Geological Survey, 1983).



Hydrograph of water levels for Well F-6, Barbour County.



Hydrograph of monthly low water levels for Well Mtg-5, Montgomery County (adapted from information and data provided by the U.S. Geological Survey, 1983).



Hydrograph of water levels for Well F-1, Greene County.

Generalized correlation of hydrogeologic units and rock-stratigraphic units of the Southeastern Coastal Plain Aquifer System in Alabama

Period	Epoch	Hydrogeologic Unit	Rock-Stratigraphic Unit: West Alabama	Rock-Stratigraphic Unit: East Alabama
Tertiary	Eocene	Confining unit	Yazoo Clay	Ocala Limestone
Tertiary	Eocene / Paleocene	Lisbon aquifer	Moodys Branch Formation Gosport Sand Lisbon Formation Tallahatta Formation Hatchetigbee Formation Bashi Formation Upper part of Tuscahoma Formation	Moodys Branch Formation Gosport Sand and Lisbon Formations, undifferentiated Tallahatta, Hatchetigbee, and Bashi Formations, undifferentiated Upper part of Tuscahoma Formation
Tertiary	Paleocene	Confining unit	Middle part of Tuscahoma Formation[1]	Middle part of Tuscahoma Formation
Tertiary	Paleocene	Nanafalia-Clayton aquifer	Lower part of Tuscahoma Formation Nanafalia Formation Naheola Formation	Lower part of Tuscahoma Formation Nanafalia Formation Porters Creek Formation Upper part of Clayton Formation
Tertiary	Paleocene	Confining unit	Porters Creek Formation Clayton Formation	Lower part of Clayton Formation[2]
Cretaceous	Late	Providence-Ripley aquifer	Prairie Bluff Chalk Ripley Formation	Providence Sand Ripley Formation
Cretaceous	Late	Confining unit	Demopolis Chalk Mooreville Chalk	Demopolis Chalk, Mooreville Chalk / Blufftown Formation
Cretaceous	Late	Eutaw aquifer	Eutaw Formation	Eutaw Formation
Cretaceous	Late	Confining unit	Upper part of Gordo Formation	Upper part of Tuscaloosa Formation[2]
Cretaceous	Late / Early	Tuscaloosa aquifer	Lower part of Gordo Formation, Coker Formation (Tuscaloosa Group) Unnamed Early Cretaceous rocks[3]	Tuscaloosa Formation Unnamed Early Cretaceous rocks[3]
Pre-Cretaceous		Confining unit	Pre-Cretaceous rocks	Pre-Cretaceous rocks

[1]May be only partially confining or absent in western Alabama.
[2]May be only partially confining or absent in eastern Alabama.
[3]Largely unstudied; may be locally hydraulically connected with overlying sediments.