

BASE FROM U.S. GEOLOGICAL SURVEY
DIGITAL LINE GRAPHS FROM 1:2,000,000 SCALE MAPS

Figure 2.--Dissolved solids in the A3 aquifer.



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Figure 3.--Dissolved chloride in the A3 aquifer.

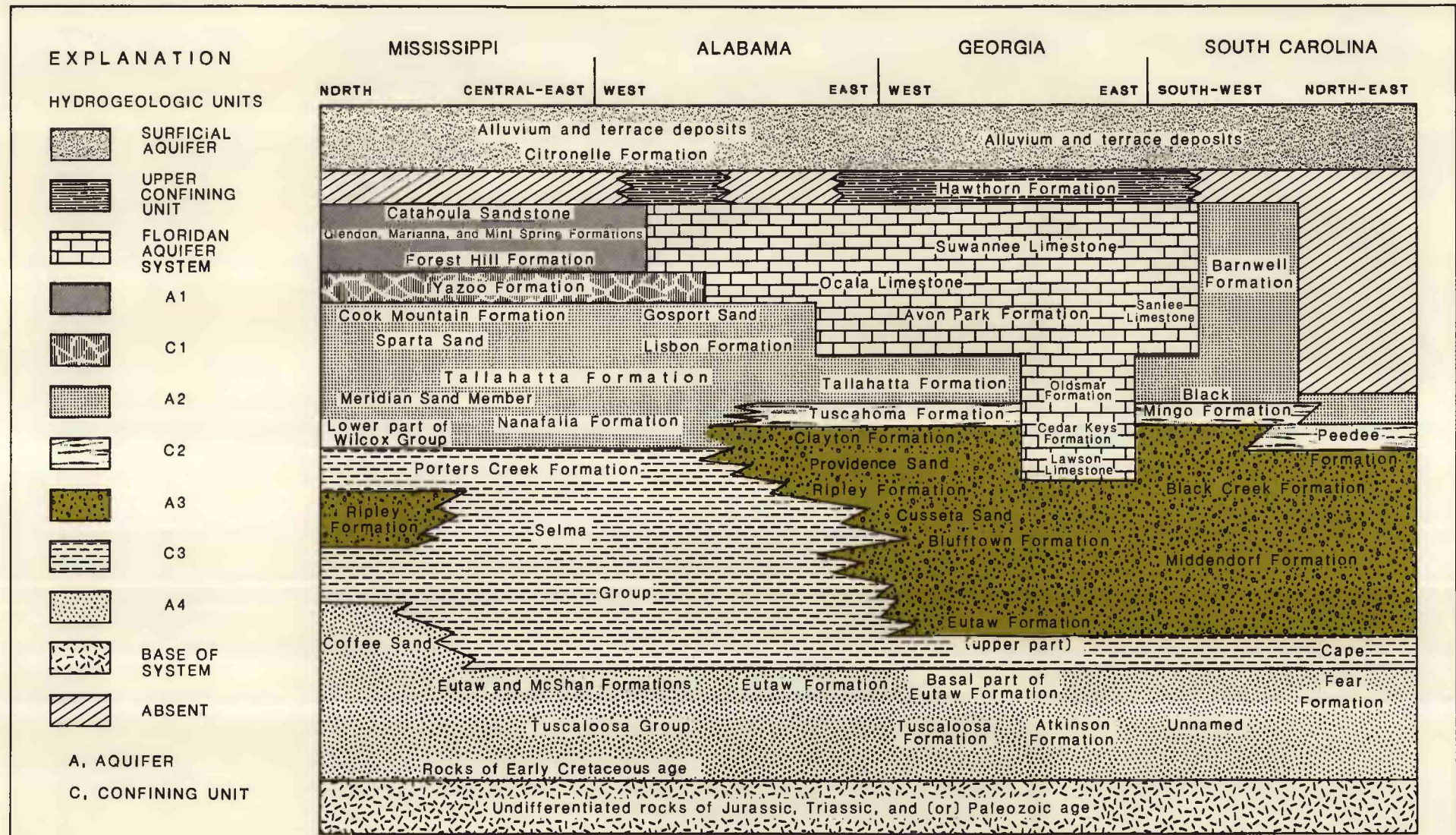


Figure 1.--Schematic diagram of regional hydrogeologic units and selected rock-stratigraphic units in the Southeastern U.S. Coastal Plain. (Modified from Renken, 1984)

INTRODUCTION

In the Coastal Plain of Mississippi, Alabama, Georgia, South Carolina, and southeastern North Carolina, water-bearing zones of sediments comprise major hydrogeologic units of an extensive sand aquifer system characterized by regional ground-water flow (Barker, 1985). The aquifer system is being studied as part of the U.S. Geological Survey's Regional Aquifer-System Analysis (RASA) program. This aquifer system has been divided by Renken (1984) into regional aquifers and confining units that correlate with geologic units in each State within the study area (fig. 1). A series of preliminary reports prepared by the RASA program depicts the ground-water hydrology and general chemistry of water in the sand aquifers that comprise the Southeastern Coastal Plain Regional Aquifer-System.

This report consists of maps that depict spatial distributions of concentrations of dissolved solids, dissolved iron, and dissolved chloride, and hydrochemical facies (Back 1961) in ground water for the A3 aquifer, which consists of Cretaceous and some Tertiary sediments. Several hundred chemical analyses of ground water were selected for mapping from the U.S. Geological Survey data base (WATSTORE) for geologic units corresponding to the A3 aquifer. An abundance of data were available in Georgia and South Carolina; less data were available in Alabama, Mississippi, and southeastern North Carolina. The nomenclature of the A3 aquifer is provisional and should be interchanged with more appropriate regional aquifer names for the Southeastern Coastal Plain when more conventional names are selected.

GROUND-WATER HYDROLOGY

The ground-water hydrology of the South Atlantic-Gulf region has been described by Cedestrom and others (1979). More detailed descriptions of the geology and hydrology of the Southeastern Coastal Plain may be found in county or multiple county reports in each State. The stratigraphy and hydrologic characteristics of sands and shales that form the major aquifers and confining units of the Southeastern Coastal Plain were delineated by Renken (1984) as part of the Southeastern Coastal Plain RASA (SCP-RASA) project. The hydrogeologic framework provides the basis for more detailed studies of the regional ground-water flow that will support development of digital simulations of ground-water flow in the Southeastern Coastal Plain.

The Southeastern Coastal Plain aquifer system has been divided into four regionally extensive aquifers that are separated by confining units consisting of clay, chalk, or other low-permeability materials (Renken, 1984). Each of these regional aquifers can be subdivided into zones based on vertical head differences or vertical differences of water chemistry within the aquifer. These differences in head and chemistry may be significant, or, as occurs in most of the A3 aquifer described herein, they may be small; the differences also may or may not coincide.

The middle water-bearing unit in the Southeastern Coastal Plain has been provisionally named the A3 aquifer (Renken, 1984), and is subject to renaming later. This regionally extensive aquifer is comprised of sands and shales of Late Cretaceous and early Tertiary age which were deposited in fluvial, deltaic, and associated near-shore environments. Potentiometric head differences among sands of the A3 aquifer were small enough to consider the sands as part of a single aquifer (Stricker and others, 1985). Chemical data of ground water in the A3 aquifer are well distributed areally, but are poorly distributed vertically. Locally, some vertical chemical differences exist in the sands comprising the A3 aquifer; however, for a regional appraisal, the chemical data show that most of the geologic units comprising the A3 aquifer may be considered as one aquifer similar to hydrologic considerations. The geologic units comprising the A3 aquifer are shown in figure 1, taken from Renken (1984).

In Mississippi, the Ripley Formation is equivalent to the A3 aquifer, where sands are calcareous, limited in extent, and grade laterally southeastward to chalk in Alabama. The chalk grades further eastward to interbedded sands and clays in eastern Alabama and western Georgia, where the subsurface geology is more complex. The major sand units included in the A3 aquifer in eastern Alabama and western Georgia are shown in figure 1. Major water-bearing units in this area include the Blufftown Formation, the Cusseta Sand, the Ripley Formation, and the Providence Sand, all of Late Cretaceous age, and the Clayton Formation, of Paleocene age.

In eastern Georgia and throughout South Carolina and part of North Carolina, major sands included in the A3 aquifer (fig. 1) are the Middendorf Formation, the Black Creek Formation, and its unnamed coastal-area equivalent sediments, and the Peeble Formation, all of Late Cretaceous age. Units of Paleocene age are not part of the aquifer in the eastern half of the study area.

Sand units of the A3 aquifer usually crop out along the inner margin of the Coastal Plain. In eastern Alabama, Georgia, and South Carolina, the Fall Line is the contact between sands of the A3 aquifer and basement rock. In western South Carolina and eastern Georgia, the A3 aquifer is covered by younger overlapping rocks and consequently, crops out in a discontinuous pattern. The wedge-shaped body of sediments that comprises the aquifer thickens seaward to a maximum of about 2,000 feet. Recharge to the aquifer generally occurs by rainfall in the outcrop areas. Water entering the aquifer near the Fall Line regionally flows toward adjacent coastal areas. Locally, small streams in the outcrop areas may provide some recharge to the A3 aquifer, or may be drains, but larger streams such as the Chatahoochee and Savannah Rivers are regional ground-water drains. Downgradient, seaward or brine are present in sands of the A3 aquifer. Ground-water pumping from wells completed in sands near the fresh-water-saltwater interface poses the potential for degrading the water quality of drinking water supplies by drawing saltwater mixed with freshwater as a result of pumping.

GENERAL WATER CHEMISTRY

The quality of water from sand aquifers in the Southeastern Coastal Plain is within U.S. Environmental Protection Agency drinking water standards (U.S. EPA, 1977) for most constituents at most places but may exceed one or more standards in many areas. Concentrations of dissolved solids in excess of 500 mg/L occur as a result of mineral-water interactions in the aquifers, or mixing of fresh ground waters with seawater or brine present in the deeper parts of the water-bearing zones. Most of the waters are dominated by sodium and bicarbonate ions (Lee, 1985) with dissolved-solids concentrations less than about 1,000 mg/L. In deeper parts of the aquifers, sodium and chloride ions dominate (Cedestrom and others, 1979) and concentrations of dissolved solids may exceed 10,000 mg/L. Concentrations of dissolved iron may exceed 5,000 µg/L in freshwater areas of noncalcareous sands.

Maps of concentrations of dissolved solids, dissolved iron, and dissolved chloride, and hydrochemical facies for the A3 aquifer illustrate spatial distributions of principal water-quality parameters in the Southeastern Coastal Plain. Chemical data used to prepare the maps were collected by state and federal agencies during the last half century and have been published in county or state reports in each State within the project area. Much of the available data were entered into WATSTORE, part of the nationwide data base of the U.S. Geological Survey. Chemical data used to prepare the maps of the project area were selected on the basis of well location, geologic unit, and the necessary chemical analyses. Complete chemical analyses with a cation-anion balance of less than ±10 percent error were used in constructing the hydrochemical facies map.

Dissolved Solids

A map showing the areal distributions of dissolved-solids concentrations in the A3 aquifer (fig. 2) was prepared using values of residue on evaporation at 180 °F, where available, or calculated dissolved solids if no residue on evaporation was recorded. In southern Georgia and parts of South Carolina, ground water in the Floridan aquifer system is plentiful and suitable for most uses. As a result, water wells generally do not penetrate the deeper sand aquifers; thus, chemical data are not available.

A contour line showing a concentration of 1,000 mg/L dissolved solids as sodium chloride, derived from geophysical data of Brown and others (1979), has been used to supplement chemical distribution on the maps. A similarly derived contour line produced by Gandt (1982) for the Ripley aquifer in Mississippi has been used for that part of the study area.

Concentrations of dissolved solids in ground water generally increase with distance downgradient from the outcrop areas where recharge occurs. In areas near recharge, concentrations of dissolved solids in the A3 aquifer may be less than 50 mg/L, similar to dissolved-solids

concentrations observed in rainfall (Junge and Werby, 1958). Water in the A3 aquifer that contains dissolved solids less than 500 mg/L usually results from ground-water-rock chemical interaction (Lee, 1985). Concentrations of dissolved solids that are greater than 500 mg/L generally result from a combination of water-rock chemical interaction and mixing of meteoric ground water with sodium chloride-dominated water. However, ground water in some areas of South Carolina that exceeds dissolved-solids concentrations of 1,500 mg/L is dominated by sodium and bicarbonate ions (Zack, 1980). Mixing of ground waters with low dissolved solids and saline waters with elevated dissolved solids results in water that has intermediate concentrations of dissolved solids (greater than 10,000 mg/L). Sodium and chloride ions dominate these waters which are present in the deep downgradient parts of the water-bearing zones in the study area. In areas such as coastal South Carolina, withdrawals of ground water for industrial or municipal uses may have produced sufficient head decline to cause some landward migration of saline water, thus increasing concentrations of dissolved solids in these areas.

In the A3 aquifer, water-rock chemical interactions produce concentrations of dissolved solids of 200 mg/L or greater over a large part of the study area. Concentrations of dissolved solids that exceed 1,500 mg/L are primarily caused by mixing of freshwater with saline water. Ground water in the A3 aquifer in northern Mississippi may evolve to concentrations of dissolved solids that exceed 500 mg/L because the Ripley aquifer contains much soluble calcareous material. The abundance of soluble material in the Ripley aquifer may also account for the steep dissolved-solids gradient in the A3 aquifer in north-central Mississippi. Similar changes in dissolved-solids content may occur in the A3 aquifer in western Alabama, as indicated by the steep gradient and elevated concentrations of dissolved solids.

The areal distribution of dissolved solids in the A3 aquifer may be influenced by regional ground-water drains, local geochronological systems, and the occurrence and distribution of saline waters in deeper aquifers. Regional ground-water discharge to the Chattahoochee River along the Alabama-Georgia State border may be responsible for the displacement of the 200 mg/L contour in a northerly direction. Upward leakage from deeper, more saline aquifers, or perhaps the presence of more soluble minerals, may also account for this observation. A similar situation may occur near the Savannah River along the Georgia-South Carolina State border. Slightly saline waters are present in the A3 aquifer along the coastal area of South Carolina as indicated by the "scallop" appearance of the dissolved-solids contours in the area, especially the 800 mg/L contour. It may be possible that wells screen different sands with vertical variations in water chemistry within the A3 aquifer. Ground-water withdrawals in these areas may cause migration of saline water to some wells, although this has not been demonstrated. Near the South Carolina-North Carolina border, concentrations of dissolved solids that exceed 1,000 mg/L have been observed in water from inland wells.

Several local features of interest appear on the dissolved-solids map. In southeast Wilcox County, in south-central Alabama, an area of anomalously elevated dissolved solids appears

to be associated with upward leakage of saline water through faults known to be present in this area. Other small closed contours north of the 100 mg/L contour reflect local influences on water chemistry, perhaps due to man-induced effects in those areas.

Dissolved Chloride

The distribution of dissolved chloride in the A3 aquifer (fig. 3) shows the extent of fresh-water flushing of saline brines. Mixing of meteoric ground water with saltwater is indicated by pronounced increases in concentrations of dissolved chloride near the downwind limits of fresh-water (fig. 3).

Concentrations of dissolved chloride show trends similar to concentrations of dissolved solids where dissolved solids exceed 500 mg/L because most of the increase in dissolved solids is in sodium and chloride ions. A line showing concentrations of 1,000 mg/L dissolved solids as sodium chloride (fig. 2) has been mapped in Mississippi by Gandt (1982) and in Georgia by Brown and others (1979). Because few chemical data exist from the deeper downgradient parts of the A3 aquifer, it was useful to add these contour lines with chemical data. For example, the location of the 1,000 mg/L dissolved-solids line is near the line showing concentrations of 500 mg/L dissolved chloride and would roughly correspond to 600 mg/L dissolved chloride.

Concentrations of dissolved chloride are less than 50 mg/L over most of the study area. Concentrations greater than 500 mg/L in Marengo and Wilcox Counties, Alabama, probably indicate incomplete flushing of relic seawater from lower permeability sediments or saline water that has migrated upward into the A3 aquifer. Similarly, elevated concentrations of dissolved chloride in southeastern Wilcox County, Alabama, probably indicate upward migration of saline water along known faults. Gradients in concentrations of dissolved chloride steepen where concentrations of dissolved chloride exceed 50 mg/L.

In South Carolina, the presence of saline water (probably relic seawater or brine) in the aquifer is indicated by steep concentration gradients along the coast. The steep gradient and concentrations of dissolved chloride greater than 1,000 mg/L present at the North Carolina-South Carolina border are indicative of incomplete flushing of the aquifer.

Two isolated areas where dissolved-chloride concentrations exceed 50 mg/L in the outcrop area in eastern Alabama may be due to localized anomalies.

WATER-QUALITY MAPS FOR THE UPPER CRETACEOUS AND LOWER TERTIARY AQUIFER IN THE SOUTHEASTERN COASTAL PLAIN OF MISSISSIPPI, ALABAMA, GEORGIA, SOUTH CAROLINA, AND SOUTHEASTERN NORTH CAROLINA

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1988