

DISTRIBUTION OF DISSOLVED-SOLIDS
CONCENTRATIONS AND TEMPERATURE
IN GROUND WATER OF THE GULF
COAST AQUIFER SYSTEMS, SOUTH-
CENTRAL UNITED STATES

INTRODUCTION

The areal extent of the Gulf Coast Regional Aquifer-System Analysis (RASA) study is about 230,000 square miles onshore (Grubb, 1984) and includes all or part of 10 States (fig. 1). The Gulf Coast aquifer systems mainly consist of eastward offlapping sediments of Tertiary and younger age that were subdivided into aquifers, permeable zones, and confining units by the following approaches:

- (1) Identifying areally extensive, low-permeability formations as regional confining units,
- (2) Identifying large hydraulic conductivity contrasts between adjacent aquifers not separated by regional confining units,
- (3) Identifying variations of hydraulic-head between permeable zones with depth, and
- (4) Extending the subdivisions, determined by approach 1, 2, or 3, as a constant proportion of the total thickness through areas where approaches 1, 2, or 3 could not be applied (Weiss and Williamson, 1985; J.S. Weiss and R.L. Hosman, U.S. Geological Survey, written commun., 1986).

The aquifers and permeable zones are as follows from youngest to oldest:

Mississippi River Valley alluvial aquifer and zone A (Holocene-upper Pleistocene deposits)	5
zone B (lower Pleistocene-upper Pliocene deposits)	5
zone C (lower Pliocene-upper Miocene deposits)	4
zone D (middle Miocene deposits)	4
zone E (lower Miocene-upper Oligocene deposits)	3
upper Claiborne aquifer	3
middle Claiborne aquifer	2
lower Claiborne-upper Wilcox aquifer	2
middle Wilcox aquifer	1
lower Wilcox aquifer	1

PURPOSE AND SCOPE

This report consists of a set of maps that show the areal distribution of dissolved-solids concentration and temperature in water for 10 of the aquifers in the Gulf Coast aquifer systems. The purpose of this report is to present mapped data of dissolved-solids concentrations and temperature for use with other reports from the Gulf Coast RASA that subdivide the Gulf Coast aquifer systems into aquifers and confining units using the approaches described above.

These maps show regional trends of depth-averaged values. The concentrations of dissolved solids and temperature vary with depth within the aquifers. Point values can be smaller or larger than the values shown on the map, depending on whether the point is at the top or bottom of the aquifer. Generally, concentrations of dissolved solids and temperature increase with depth; however, in places, the concentrations decrease with depth as described by Weiss (1987).

DATA BASE

The maps presented in this report were based on two types of data, water analyses in areas where the dissolved-solids concentrations are less than 10,000 milligrams per liter (mg/L), and borehole geophysical logs in areas where the estimated concentration is equal to or greater than 10,000 mg/L. Median concentration of dissolved solids per 100-square-mile area was calculated from water analyses, and a depth-weighted average dissolved-solids concentration was calculated from the geophysical logs. The details of the two data sources and mapping methods follow.

MAPPING METHOD

A large data base of water analyses containing concentrations of dissolved-solids and temperature was obtained from the U.S. Geological Survey's water-quality and brine files, and the Texas Department of Water Resources' data base (Pettijohn, 1986). Although depths reach 20,000 ft in the Gulf Coast aquifer systems, 80 percent of these analyses are of water samples from wells constructed at depths of less than 1,100 feet. Due to the variability in dissolved-solids concentration and a high density of point data within small areas, a criterion was established to obtain representative values for mapping. A median concentration of dissolved-solids per 100-square-mile area was selected. The selection of a 100-square-mile area was arbitrarily chosen, because it coincides with the cell size used in flow model simulations in the Gulf Coast RASA study. The selection of a median value per 100-square-mile area will affect the boundary of the concentration zones shown on the map. However, results from a preliminary evaluation using all data versus using only the median value per cell area show that the boundary delineating concentration zones changed very little at the scale mapped. Therefore, the general trend of these concentration zones probably will be maintained even if the cell size is greatly reduced.

Data from borehole geophysical logs were used to estimate dissolved-solids concentration in areas where water analyses were missing, sparse, or had concentrations equal to or greater than 10,000 mg/L. Due to extensive development of oil and gas, thousands of geophysical logs are available in the study area from various sources (Grubb, 1986a, p. 156). Therefore, the data gap on concentrations of dissolved solids can be filled in downip areas by using the borehole geophysical logs. The dissolved-solids concentration and temperature data from the borehole geophysical logs were presented by Wilson and Hosman (1988).

Concentrations of dissolved solids were estimated from spontaneous potential (SP) curves, mud-filtrate resistivities, and temperature data from borehole geophysical logs. This quantitative and unified method for interpretation of SP curves was described by Gondouin, Tixier, and Simard (1957). The method is based on the relation of formation-water resistivity to SP, temperature, equivalent mud-filtrate resistivity, and equivalent formation-water resistivity. The estimated formation-water resistivity is used to estimate concentration of dissolved solids. A procedure for making the necessary calculations has been discussed in detail by Bateman and Konen (1977) and was used in this study.

The method of Gondouin, Tixier, and Simard (1957) assumes that the only ions in solution are sodium and chloride. The formation water in the Gulf Coast RASA area contains other major ions as well as sodium and chloride (Pettijohn, 1986, table 5). However, the validity of the assumption of a water containing only sodium chloride on the relation between formation-water resistivity and concentration of dissolved solids was evaluated by Gondouin, Tixier, and Simard (1957). They concluded that this assumption probably creates an error of less than 10 percent. Their conclusion is derived from tests in laboratories with waters containing other major ions such as calcium and magnesium.

Weiss (1987) used the method described by Bateman and Konen (1977) to calculate concentrations of dissolved solids for waters in the Gulf Coast aquifers for each sand bed thicker than 20 feet from borehole geophysical logs of about 760 wells. He compared the calculated dissolved-solids values with measured values from water samples where they were available and concluded that the calculated values were closely correlated with the measured values.

Concentrations of dissolved solids vary with depth. Thus, an average concentration is required to be calculated for the aquifer thickness for each geophysical log. The depth-weighted average was calculated with a representative thickness for each sand bed as the weight factor for the sand bed's concentration (Weiss, 1987, fig. 7). The representative thickness was defined as from mid-point to mid-point between successive sand beds. Weiss' averaging method assumes that the water within the pore spaces of the fine-grained sediments between sand beds has the same dissolved-solids concentration as calculated for the closest sand-bed midpoint. The assumption probably is reasonable; however, it has not been evaluated in field studies.

The areal density of wells with concentrations estimated from borehole geophysical logs is much less than the areal density of wells with water analyses. Therefore, in areas where geophysical logs were used, the median values of concentrations for 100-square-mile areas were not calculated, instead the thickness-weighted values were used at each location of the geophysical log. The mapped values calculated from water analyses are median values for cell areas, whereas thickness-weighted values calculated from log data are depth-averaged point values.

The distribution of temperature was calculated in the same way as the distribution of concentrations of dissolved solids. If sufficient temperature data was available from water analyses, then the median value of temperature per 100-square-mile area was calculated. Otherwise the average values of temperature at the middle point of the aquifer thickness were calculated from temperature gradients determined from geophysical logs.

DISSOLVED-SOLIDS CONCENTRATIONS AND
TEMPERATURE

The concentration of dissolved solids is generally less than 500 mg/L in water from the outcrop and subcrop areas for the aquifers and permeable zones in the Gulf Coast aquifer systems. Also, areas with water having concentrations of dissolved solids less than 1,000 mg/L are in bands parallel to the outcrop and extend downip for several miles, such as shown in zone E (lower Miocene-upper Oligocene deposits) or for several hundred miles as shown in the middle Wilcox aquifer. Other areas, which have water with concentrations of dissolved solids less than 1,000 mg/L are in the northeastern part of the study area and extend from southern Illinois southward on either side of the Mississippi River to as far as northeastern Louisiana. These areas are present only in the upper Claiborne aquifer, the middle Claiborne aquifer, the lower Claiborne-upper Wilcox aquifer, the middle Wilcox aquifer, and the lower Wilcox aquifer.

There is a pronounced increase in the concentration of dissolved solids in aquifers and permeable zones in an area extending from western Mississippi westward into Louisiana and Arkansas. This area is largely a regional ground-water discharge area (Grubb, 1986b). The aquifers showing the most pronounced effect from ground-water discharge are the lower Claiborne-upper Wilcox, the middle Wilcox, and the lower Wilcox. Those aquifers or permeable zones showing some effect are zone D (middle Miocene deposits), the upper Claiborne, and the middle Claiborne.

The concentration of dissolved solids in the aquifers and permeable zones increases 1,000 mg/L or more over a distance of several miles in the downip direction in some places, for example, in zone E across central Louisiana. These areas of rapid increases in concentration are considered transition zones where the ground water changes from fresh to slightly saline or from slightly saline to brine. Downip from the transition zone to the downip limit of the aquifers, the concentration of dissolved solids in the ground water increases to as much as 150,000 mg/L or more.

The concentration of dissolved solids in ground water in zone A (Holocene-upper Pleistocene deposits) is generally less than 500 mg/L at the upip limit, but increases to about 3,000 mg/L in the onshore area, and to 70,000 mg/L in the continental shelf area. The Mississippi River Valley alluvial aquifer is a freshwater aquifer that has concentrations of dissolved solids generally in the range of 50 to 500 mg/L and up to 3,000 mg/L in a few isolated areas.

The temperature of ground water in aquifers and permeable zones generally ranges from 15 to 100 degrees Celsius. In the part of the aquifer systems containing fresh or slightly saline ground water, the temperature of the water is generally less than 30 degrees Celsius. The temperature of ground water in the Gulf Coast aquifer systems increases with depth.

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