

INTRODUCTION

The Gulf Coast Regional Aquifer-System Analysis (Gulf Coast RASA) is a study of regional aquifers composed of sediments of mostly Cenozoic age that underlies about 230,000 mi² of the Gulf Coastal Plain in parts of Alabama, Arkansas, Florida, Illinois, Kentucky, Mississippi, Missouri, Tennessee, and Texas and all of Louisiana (fig. 1). The study also includes about 60,000 mi² of the Continental Shelf (Grubb, 1984). These regional aquifers, named the Gulf coast aquifer systems, are part of three aquifer systems: the Mississippi embayment aquifer system, the Texas coastal uplands aquifer system, and the coastal lowlands aquifer system (fig. 2). The Gulf coast aquifer systems have been divided into geologic units based on geologic and hydrologic factors (Weiss and Williamson, 1985; Pettijohn and others, 1988; Hosman and Weiss, 1991; Weiss, 1990).

Permeable zone E is part of the coastal lowlands aquifer system and is composed mostly of lower Miocene and upper Oligocene deposits. The deposits are complexly interbedded clays, silts, and sands (Hosman, 1991). Areas of maximum sand percentage (greater than 60 percent) occur in two narrow bands that are parallel to the coast of Texas and in a bifurcated lobe that begins at the outcrop in Mississippi and extends southward to the coast near the Mississippi-Louisiana border (Weiss, 1990). Permeable zone E has an average thickness of about 1,340 ft and generally dips from the outcrop area toward the Gulf of Mexico at about 75 to 120 ft/mi. The permeable zone had more than 80 Mg/d of pumpage since 1970 and about 100 Mg/d during 1985 (Mesko and others, 1990, p. 14). The relation of permeable zone E to overlying and underlying units is shown in figure 3.

The Gulf Coast RASA is a part of the U.S. Geological Survey's Regional Aquifer-System Analysis program. The program began in 1978 and is designed to provide an understanding and assessment of the Nation's groundwater resources on a regional basis (Bennett, 1979). A summary of progress in the RASA program through 1984 was given by Sun (1986), and progress on the Gulf Coast RASA was reported by Grubb (1987) and Williamson and others (1990).

Purpose and Scope

This report describes the water chemistry of permeable zone E (lower Miocene-upper Oligocene deposits), one of five water-yielding units in the coastal lowlands aquifer system. Maps in this report show the areal distribution of the concentration of dissolved solids, temperature, the primary water types, pH, and the concentrations of dissolved calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, and silicate. Also included are five maps showing the areal distribution of the milliequivalent ratios of (1) magnesium to calcium, (2) magnesium plus calcium to bicarbonate, (3) magnesium plus calcium to sodium plus potassium, (4) bicarbonate to sulfate, and (5) bicarbonate to chloride. The maps of constituent ratios are included for comparison with the same constituent ratios commonly reported for seawater and for water used for specific purposes such as industry and public supply. The ratios also have been used to show trends that may indicate major controls on the chemistry of the ground water.

Compilation of Maps

The maps in this report are based primarily on data from the U.S. Geological Survey's National Water Data Storage and Retrieval System (WATSTORE) and data from the Texas Department of Water Resources (Pettijohn, 1988). The data were accessed and explained by Pettijohn (1986) and were posted on maps in each 100-square-mile area where data exist. The 100-square-mile areas are the same as those illustrated by Grubb (1987, p. 115) and used for simulation of ground-water flow by Williamson (1987) and Williamson and others (1990).

These maps show regional trends in chemical properties. The concentration of dissolved solids, major ions, pH, and temperature vary with depth within the aquifer. 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. Because there are clusters of sampling sites at some locations the median value of a property or constituent in each 100-square-mile area is selected for constructing the maps. The density of sampling sites in each 100-square-mile area is shown as an inset on each of the maps of the respective property or constituent. The number of sampling sites per interval is indicated on the bar graph included with each map. The number of 100-square-mile areas and a summary of median values in 100-square-mile areas for selected constituents, properties, and ratios are shown in table 1.

The maximum values in table 1 are usually larger than the maximum limit of equal concentration shown on the corresponding maps. In some instances the maximum value in the table is much larger than the maximum limit shown on the map because the value in the table is for only one 100-square-mile area and there is not enough data of equal magnitude to justify adding additional intervals.

Major ion concentrations and pH are based on median values of all samples within each 100-square-mile area. The dissolved-solids concentrations greater than 10,000 mg/L and temperature are based on depth-averaged values from geophysical well logs (Pettijohn and others, 1988). The water type was computed from the cation and the anion that composed the largest percentage of milliequivalents per liter of the dissolved solids in a ground-water sample. Although water type was computed for each sampling site, only the most frequently observed water type (mode) in each 100-square-mile area is shown on the map. More detailed discussions of how the data were analyzed, processed, and mapped are given by Pettijohn (1986, 1988), Weiss (1987), and Pettijohn and others (1988).

Superimposed on selected maps are locations of geologic structures that are used as points of reference in describing the chemistry of the ground water from east to west. Uplift, midbay, and downdip are used as reference areas in describing the chemistry of the ground water from north to south. Uplift areas include outcrop and subcrop areas; midbay refers to areas about midway between the outcrop and the downdip limit of the permeable zone; and downdip refers to areas adjacent to the downdip limit of the data or the downdip limit of the permeable zone. A map showing the location of salt domes (Beckman and Williamson, 1990) and boundary of salt dome basins (fig. 4) is included for the purpose of relating salt structures to constituent concentrations.

CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATED WATER-QUALITY UNITS

Multiply	By	To obtain
foot (ft)	0.3048	meter
foot per mile (ft/mi)	0.1694	meter per kilometer
mile (mi)	1.609	kilometer
million gallons		cubic meters per
per day (Mgal/d)	0.04381	second
square mile (mi ²)	2.590	square kilometer

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929—a geodetic datum derived from a general adjustment of the first order level sets of the United States and Canada, formerly called Sea Level Datum of 1929.

Chemical concentrations and water temperature are given in metric units. Chemical concentration is given in milligrams per liter (mg/L). Water temperature is given in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by the following equation:

$$^{\circ}\text{F} = 1.8(^{\circ}\text{C}) + 32$$

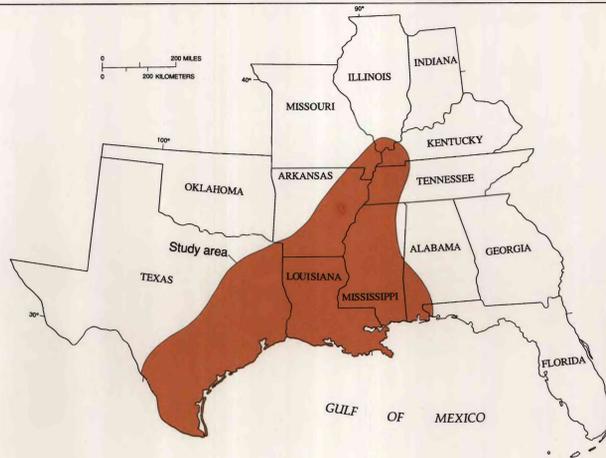


Figure 1.—Location of study area.

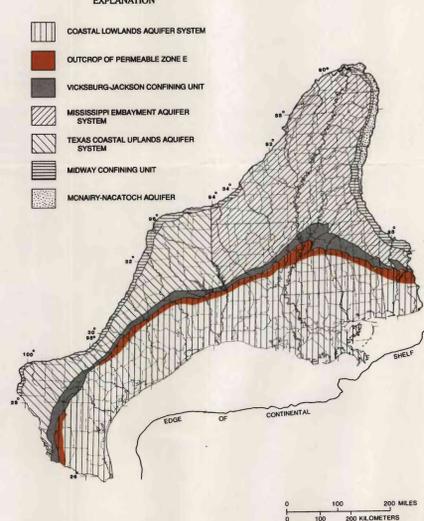


Figure 2.—Generalized outcrop of major aquifer systems and confining units in the Gulf Coast Regional Aquifer-System Analysis study area. Outcrop of permeable zone E (lower Miocene-upper Oligocene deposits) superimposed.

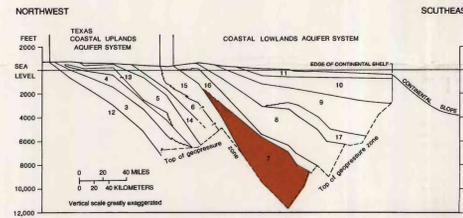


Figure 3.—Diagrammatic geohydrologic section through southwest part of study area.

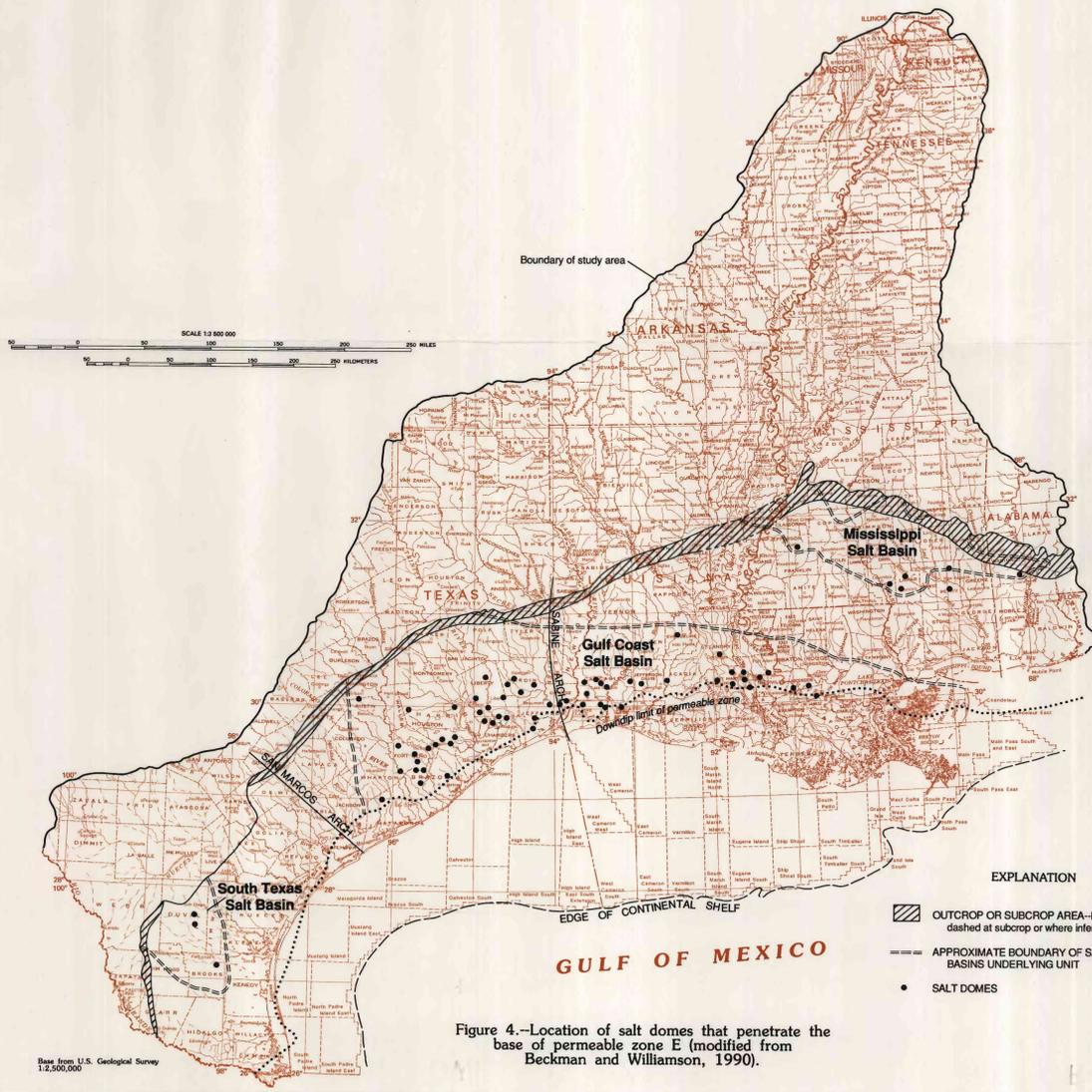


Figure 4.—Location of salt domes that penetrate the base of permeable zone E (modified from Beckman and Williamson, 1990).

SUMMARY AND CONCLUSIONS

The water chemistry of permeable zone E (lower Miocene-upper Oligocene deposits), which is part of the coastal lowlands aquifer system, is presented by a series of maps. These maps show the areal distribution of (1) the concentration of dissolved solids and temperature; (2) the primary water types and pH; (3) the concentrations of major ions and silicate; and (4) the milliequivalent ratios of selected ions. Dissolved constituents, pH, temperature, and ratios are based on the median values of all samples in each 100-square-mile area.

The concentration of dissolved solids ranges from 20 to 10,000 mg/L in the outcrop, 500 to 35,000 mg/L near midbay, and 35,000 to 221,300 mg/L in downdip areas. The increase in concentration of dissolved solids in a downdip direction is attributed to mineral-water interaction and specifically to the dissolution of evaporites comprising salt domes in the deeper parts of the permeable zone. The temperature ranges from about 13 degrees Celsius in the outcrop area to about 91 degrees Celsius in the downdip area of southern Louisiana.

The primary water types in permeable zone E, which are based on the most frequently observed type (mode) in each 100-square-mile area, are calcium and sodium bicarbonate in the outcrop and midbay areas east of the San Marcos arch and sodium chloride in the downdip areas and in the area southwest of the San Marcos arch. The pH ranges from 4.5 in the outcrop area east of the Mississippi River to 11.7 in an area between the outcrop and midbay in central Louisiana.

The concentrations of major ions generally increase from the outcrop to the downdip limit of the data. The concentration of dissolved calcium ranges from 0.3 mg/L in midbay area east of the Sabine arch to 19,600 mg/L in a midbay area of southern Texas. The concentration of dissolved magnesium ranges from about 0.01 mg/L in outcrop and midbay areas east of the Sabine arch to 1,990 mg/L in a midbay area in southern Texas. The concentration of dissolved sodium ranges from 1.5 mg/L in outcrop areas east of the Sabine arch to 62,600 mg/L in an area between the outcrop and midbay in southern Texas. The concentration of dissolved potassium ranges from 0.2 mg/L along the outcrop area to 7,540 mg/L at the downdip limit of the data in southern Texas. The concentration of dissolved bicarbonate ranges from 2 mg/L in the outcrop in southwestern Alabama to 1,450 mg/L in a downdip area in southeastern Texas. The concentration of dissolved sulfate ranges from 0.4 mg/L in the outcrop area west of the Mississippi River to 5,300 mg/L near the downdip limit of the data in southern Texas. The concentration of dissolved chloride ranges from 0.2 mg/L in the midbay area of southern Mississippi to 137,000 mg/L in the downdip area of southern Texas. The concentration of silicate ranges from 1.2 to 856 mg/L. However, in most of permeable zone E the concentration ranges from 10 to 50 mg/L.

The milliequivalent ratio maps of constituents in water from permeable zone E show areal distributions that vary in nature from the outcrop area to the downdip limit of the data. The milliequivalent ratio of magnesium to calcium ranges from less than 0.01 in southern Texas to 5.2 near the outcrop in southwestern Alabama and the map shows no areal trend. The milliequivalent ratio of magnesium plus calcium to bicarbonate (Mg+Ca/HCO₃) ranges from less than 0.01 in the midbay area east of the Sabine arch to 1.40 in a downdip area in southern Texas. The Mg+Ca/HCO₃ ratio generally increases in a downdip direction in areas between the Sabine arch and the Mississippi River and between the San Marcos arch and the Rio Grande. The Mg+Ca/HCO₃ ratio increases from outcrop to midbay and decreases from midbay to downdip in the area between the Sabine arch and the San Marcos arch. The milliequivalent ratio of magnesium plus calcium to sodium plus potassium (Mg+Ca/Na+K) ranges from less than 0.01 near the downdip limit of the data in southern Mississippi to 8.9 in the outcrop west of the Mississippi River. The Mg+Ca/Na+K ratio generally decreases from the outcrop to the downdip limit of the data in the area of the Sabine arch southward to the Rio Grande.

The milliequivalent ratio of bicarbonate to sulfate ranges from 0.01 near the downdip limit of the data in southern Texas to 7.20 at the downdip limit of the data in southern Mississippi but the map shows no areal trend. The milliequivalent ratio of bicarbonate to chloride (HCO₃/Cl) ranges from less than 0.01 along the downdip limit of the data in southern Texas. The HCO₃/Cl ratio generally decreases from the outcrop to the downdip limit of the data in all areas except between the San Marcos arch and the Rio Grande where the ratio is small and appears to have no trend.

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TABLE 1.—Summary of median values in 100-square-mile areas for selected properties and chemical constituents in ground water from permeable zone E (lower Miocene-upper Oligocene deposits)

[All dissolved ion concentrations are in milligrams per liter. All dissolved ion concentrations used to calculate ratios, for example Ca/Mg, are in milliequivalents per liter. Temperatures are in degrees Celsius. pH is in standard units. Chemical symbols: Ca, calcium; Mg, magnesium; Na, sodium; K, potassium; HCO₃, bicarbonate; SO₄, sulfate; Cl, chloride; <, less than]

Property or constituent	Statistics for median values of 100-square-mile areas			Number of 100-square-mile areas
	Median	Minimum	Maximum	
pH	7.2	4.5	11.7	323
Temperature	29.2	13.1	91.1	388
Dissolved-solids	13,220	20.0	221,300	416
Calcium	3.0	0.3	19,600	312
Magnesium	4.0	0.01	1,990	304
Sodium	142	1.5	62,600	311
Potassium	2.6	0.2	7,540	194
Bicarbonate	201	2.0	1,450	325
Sulfate	13.0	0.4	5,300	291
Chloride	0.2	0.2	137,000	345
Silica	32.0	1.2	856	218
Ratio Mg:Ca	0.33	<0.01	5.2	304
Ratio Mg+Ca:HCO ₃	0.96	<0.01	1.40	293
Ratio Mg+Ca/Na+K	0.11	<0.01	8.9	183
Ratio HCO ₃ :SO ₄	0.10	0.01	720	299
Ratio HCO ₃ :Cl	1.52	<0.01	340	325

PROPERTIES AND CHEMICAL CONSTITUENTS IN GROUND WATER FROM PERMEABLE ZONE E (LOWER MIOCENE-UPPER OLIGOCENE DEPOSITS), COASTAL LOWLANDS AQUIFER SYSTEM, SOUTH-CENTRAL UNITED STATES

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