PRIMARY WATER TYPES

The concept of primary water types, as used in this report is to delimit areas of a particular type of water on the basis of the principal cation and anion in ground water of each aquifer division within the Tertiary and Quaternary aquifers.

The primary water type, as mapped on this sheet for each designated aquifer, shows the areal change in primary water type from one 100-mi² area to another. The delimited areas of primary water type were determined by the concentration of major cations and anions composing the dissolved solids of ground water in that area expressed in milliequivalents per liter. The concentration of ions, in milligrams per liter, may be converted to milliequivalents per liter by multiplying by the reciprocals of the combining weights of the appropriate ions (Hem, 1970). Milliequivalents per liter expresses the concentration of major chemical constituents in terms of chemical equivalence, and more accurately describes the composition of water and the relationship between ions in solution. One milliequivalent of a cation (positively charged ion) will react with one milliequivalent of an anion (negatively charged ion).

The major ions determined in ground-water analyses and used to designate a primary water type are the cations—calcium, magnesium, and sodium-potassium—and the anions—bicarbonate, sulfate, and chloride. The cation and the anion that compose the largest percentage of milliequivalents per liter of the dissolved solids in a ground-water sample, determine the primary water type for that sample. For example, if the percentage of major ions were: calcium = 40, magnesium = 35, sodium-potassium = 25, bicarbonate = 45, sulfate = 25, and chloride = 30, the primary water type is calcium bicarbonate.

Although the primary water type was computed for the most recent analysis at each site, only the mode value for all analyses in each 100-mi² area was shown on the map. Blank areas occur where there were no analyses for a 100-mi² area or where it occurred outside the area of the aquifer group. Following is a discussion of primary water type in aquifers comprising each of the groups in ascending order (oldest to youngest).

Wilcox Aquifers

The primary water type is sodium bicarbonate in a large part of the Wilcox aquifers. This water type primarily occurs in northeast Texas, northwest Louisiana, northeast and southwest Arkansas, northern Mississippi, and the northern one-half of the study area in Alabama.

The primary water types in Kentucky and Missouri are calcium and sodium bicarbonate. In Tennessee, the primary water types are calcium bicarbonate, magnesium bicarbonate, sodium bicarbonate, and sodium chloride.

The primary water type is sodium chloride in the downdip, southern part of the mappable area of the Wilcox aquifers. The sodium chloride water occurs in an area about 40 mi wide, extending from the Rio Grande on the west side of the study area to Alabama on the east side of the study area. Most of the analyses used to determine the primary water type in this area are from the petroleum industry; most of the data probably are analyses of brackish ground water.

Claiborne Aquifers

Except for areas noted below, the primary water type in the Claiborne aquifers in the northern three-fourths of the study area is sodium bicarbonate. The excepted areas are northwest part of the study area in Texas, eastern Mississippi, western Tennessee, and Alabama where calcium bicarbonate is predominate.

In the southern one-fourth of the study area, where the Claiborne aquifers are at a greater depth, the primary water type is sodium chloride. The sodium chloride water occurs in an area 10 to 80 mi wide and extends from the Rio Grande on the west side of the study area to Mississippi on the east side of the study area. Most of the data used to determine the primary water type in this area came from the files of the petroleum industry; most of the data probably are analyses of brackish ground water.

Jackson Aquifers

The primary water types in the Jackson aquifers in Arkansas are calcium sulfate and sodium sulfate. In Texas, the primary water type principally is sodium chloride except in eastern Texas where sodium bicarbonate and sodium sulfate types predominate.

Vicksburg Aquifers

Water is obtained locally from the Vicksburg Group in small areas in Mississippi (Gandl, 1979). However, primary water types were not mapped because these aquifers are not significant regionally.

Miocene Aquifers

The primary water type in the Miocene aquifers is sodium bicarbonate in the southern one-third of Mississippi and the middle one-third of Louisiana. The primary water type is about 50 percent calcium bicarbonate and 50 percent sodium bicarbonate near the updip limit of the aquifers in Texas. In southern Alabama, the primary water type is sodium combined with either bicarbonate or sulfate or chloride. On the Continental Shelf and 30 to 80 mi inland from the coast, the primary water type is sodium chloride.

Pliocene Aquifers

The primary water type in the Pliocene aquifers is sodium bicarbonate in southern Mississippi and in a 50-mi wide band across Louisiana just south of the Mississippi border. The primary water type is calcium bicarbonate and sodium bicarbonate in southeast Texas and sodium bicarbonate and sodium chloride in southwest Texas. On the Continental Shelf south of the Louisiana coast, the primary water type is sodium chloride.

Quaternary Aquifers

The primary water type in the Quaternary aquifers in the east-trending band is shared somewhat equally between calcium bicarbonate, sodium bicarbonate, and sodium chloride. In the south-trending band, the primary water type is calcium bicarbonate.

DATA APPLICATION

Because this study is regional in scope, it probably is not possible to determine the acceptability of the quality of ground water at a specific site for a particular use based on the mapped data. For such a case, it may be necessary to collect and analyze additional ground-water samples from the local area of interest. The analyses need to include water-quality properties and constituents for which water-quality standards or criteria have been designated for the intended use. It is possible, however, to draw some inferences from the mapped data as to the acceptability of the water for irrigation, municipal, and industrial uses by comparing the mapped data with water-quality standard or criteria based on use.

Dissolved-solids concentrations and primary water type are two useful water-quality characteristics for appraising the significance and source of dissolved minerals in ground water. For example, if ground water in a delimited area contains 500 mg/L dissolved solids and the primary water type is calcium bicarbonate, the inference could be made that the soluble material in the Tertiary or Quaternary aquifers is composed chiefly of calcium carbonate rock and that the water is fresh and acceptable chemically for most uses. In contrast, if the dissolved-solids concentrations were 40,000 mg/L and the primary water type was sodium chloride, the inference could be made that the aquifer is mostly composed of sand deposited in or affected by a marine environment and that the water is brine and would require treatment for most uses.

The suitability of water for irrigation depends on both dissolved-solids concentration—commonly referred to as salinity—and the sodium content in relation to the proportion of calcium and magnesium (most abundant cation). When water containing a large proportion of sodium is applied to soil, some of the sodium is taken up by the clay in the soil. The clay gives up calcium and magnesium in exchange for sodium. Soil containing a substantial excess of calcium and magnesium ions tills easily and is permeable. If the same soil takes up sodium, it becomes sticky and slick when wet and has negligible permeability. When dry, this soil shrinks into hard clods that are difficult to break up by cultivation. Large concentrations of sodium salts develop alkali soils in which little or no vegetation will grow.

In contrast, if irrigation water contains calcium and magnesium ions in a quantity that equals or exceeds the sodium, a sufficient concentration of calcium or magnesium may be retained on the clay particles of the soil to maintain good tilth and permeability (Thorne and Peterson, 1954, p. 58–79).

Salinity, or concentration of dissolved solids affect the osmotic pressure of soil solution which in turn limits the availability of soil moisture for plant consumption. Consequently, excessive salinity may create physiological drought conditions. The severity of such conditions on the plant depends on the plant's tolerance to salinity and the concentration of dissolved solids (Thorne and Peterson, 1954, p. 62).

The maps in this report present data on the two water-quality characteristics—dissolved-solids concentrations (salinity) and primary water type (the most abundant cation and anion). From these mapped data it is possible to tentatively select areas within the aquifer groups from which acceptable irrigation-water supplies may be obtained.

The suitability of water for municipal use is determined by comparing the water analysis with Federal drinking-water standards which include bacteriological purity (U.S. Environmental Protection Agency, 1973). However most municipalities are prepared to treat their water for bacteriological quality, thus, the suitability of water for municipal use can not only be inferred, but tentatively determined, from the maps showing the concentrations of dissolved solids and the primary water types. For example if dissolved-solids concentrations are less than 500 mg/L, the water meets the Federal drinking water standards for dissolved minerals. If the primary cation, based on primary water type, is calcium or magnesium, the water probably is hard to very hard and may require treatment for hardness. If the primary cation is sodium, the water may be soft to slightly hard and probably requires little or no treatment for hardness.

The suitability of water for industry is determined by its use in a specific industry. Because of the numerous industrial uses, no meaningful criteria can be set to encompass a majority of such use. However the quality characteristics—dissolved solids concentrations, and primary water type—of raw water can be used by an industry to determine the probable treatment necessary to meet the standards set by that industry.

SELECTED REFERENCES

Back, William, 1961, Techniques for mapping hydrochemical facies: U.S. Geological Survey Professional Paper 424–D, p. 380–382.

Boswell, E.H., Cushing, E.M., and Hosman, R.L., 1968, Quaternary aquifers in the Mississippi Embayment, *with a discussion of* Quality of water by H.G. Jeffery: U.S. Geological Survey Professional Paper 448–E, 15 p.

Cushing, E.M., Boswell, E.H., Speer, P.R., and Hosman, R.L., 1970, Availability of water in the Mississippi Embayment: U.S. Geological Survey Professional Paper 448–A, 13 p.

Dickinson, George, 1953, Geological aspects of abnormal reservoir pressure in Gulf Coast Louisiana: American Association of Petroleum Geologist Bulletin, v. 37, p. 410–432.

Fertl, W.H., 1976, Abnormal formation pressures: Amsterdam, Holland, Elsevier Scientific Publishing Company, p. 14.

Fogg, G.E., and Kreitler, C.W., 1982, Ground-water hydraulics and hydrochemical facies in Eocene aquifers of the east Texas Basin: The University of Texas at Austin Bureau of Economic Geology Report of Investigations 127, 71 p.

Grubb, H.F., 1984, Planning report for the Gulf Coast Regional Aquifer-System Analysis in the Gulf of Mexico Coastal Plain, United States: U.S. Geological Survey Water-Resources Investigations Report 84–4219, 30 p.

Gandl, L.A., 1979, The Oligocene aquifer system in Mississippi: U.S. Geological Survey Open-File Report 79–28, 2 sheets.

Hem, J.D., 1970, Study and interpretation of the chemical characteristics of natural waters: U.S. Geological Survey Water-Supply Paper 1473, 363 p.

Hosman, R.L., Long, A.T., Lambert, J.W., and others, 1968, Tertiary aquifers in the Mississippi embayment, *with discussions of* Quality of water by H.G. Jeffery: U.S. Geological Survey Professional Paper 448–D, 29 p.

Hosman, R.L., (in press), Geohydrologic framework of the Gulf Coastal Plain: U.S. Geological Survey Hydrologic Investigations Atlas HA–695.

Jones, P.H., 1968, Hydrodynamics of geopressure in the northern Gulf of Mexico Basin: Journal of Petroleum Technology, v. 21, p. 802–810.

Jones, P.H., and Wallace, R.H., Jr., 1974, Hydrogeologic aspects of structural deformation in the northern Gulf of Mexico Basin: U.S. Geological Survey Journal of Research, v. 2, no. 5, p. 511–517.

Muller, D.A., and Price, R.D., 1979, Ground-water availability in Texas: Texas Department of Water Resources Report 235, 77 p.

Nyman, D.J., 1984, The occurrence of high concentrations of chloride in the Chicot aquifer system of southwestern Louisiana: Louisiana Department of Transportation and Development Office of Public Works Water Resources Technical Report 33, 75 p.

Rollo, J.R., 1960, Ground water in Louisiana: Department of Conservation, Louisiana Geological Survey and Louisiana Department of Public Works Water Resources Bulletin 1, 84 p.

Taylor, R.E., 1975, Chemical analyses of ground water for saline-water resources studies in Texas Coastal Plain stored in National Data Storage and Retrieval System: U.S. Geological Survey Open-File Report 75–79, 669 p.

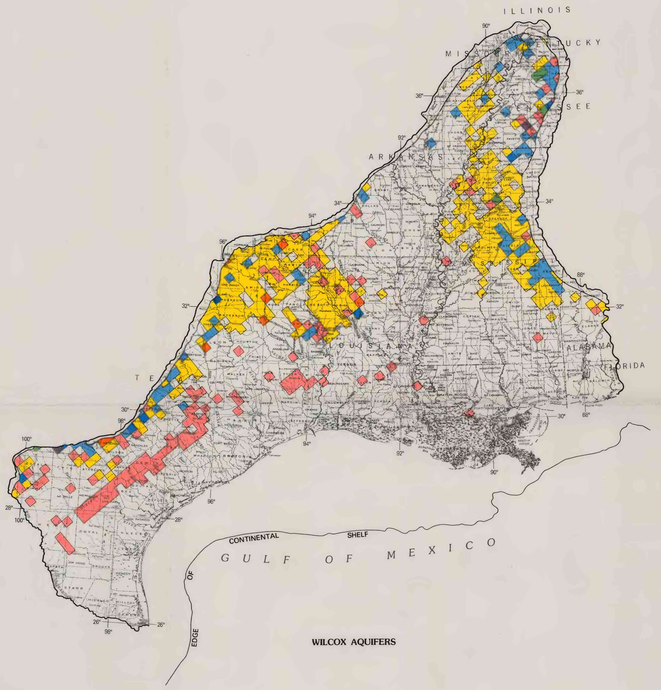
Thorne, D.W., and Peterson, H.B., 1954, Irrigated soils: New York, The Blakiston Company, Inc., 255 p.

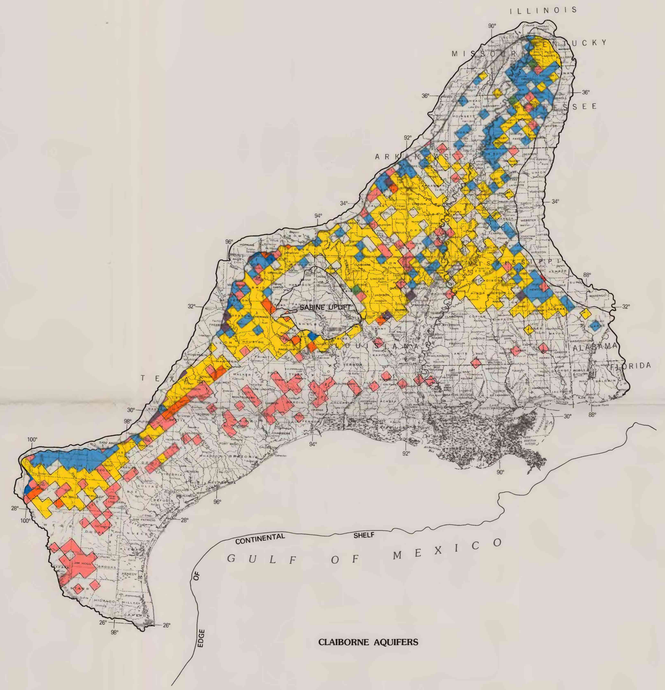
U.S. Environmental Protection Agency, 1973, Water quality criteria—1972: A report of the National Academy of Science—National Academy of Engineering, Washington, D.C., U.S. Environmental Protection Agency Ecological Research Service, 594 p.

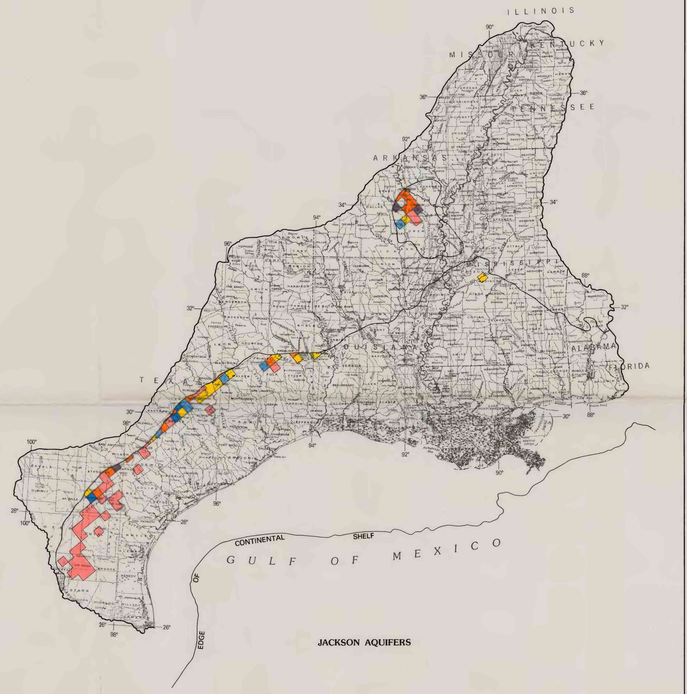
Wesselman, J.R., 1983, Structure, temperature, pressure, and salinity of Cenozoic aquifers of south Texas: U.S. Geological Survey Hydrologic Atlas HA 654, 1 sheet.

Whitfield, M.S., Jr., 1980, Chemical character of water in the Red River alluvial aquifer, Louisiana: U.S. Geological Survey Open-File Report 80–1018, 95 p.

Winslow, A.G., and Kister, L.R., 1956, Saline-water resources of Texas: U.S. Geological Survey Water-Supply Paper 1365, 105 p.







Base from U.S. Geological Survey
United States base map, 1972

MAPS SHOWING DISTRIBUTION OF PRIMARY WATER TYPES IN THE DESIGNATED AQUIFERS BASED ON MODE VALUE PER 100-SQUARE-MILE AREA

SCALE 1:5 000 000

100 0 100 200 300 400 500 MILES

100 0 100 200 300 400 500 KILOMETERS

EXPLANATION

PRIMARY WATER TYPES

- Calcium bicarbonate
- Calcium sulfate
- Calcium chloride
- Magnesium bicarbonate
- Magnesium sulfate
- Magnesium chloride
- Sodium bicarbonate
- Sodium sulfate
- Sodium chloride
- No data
- Boundary of study area
- Boundary of updip limit

INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1988

DISSOLVED–SOLIDS CONCENTRATIONS AND PRIMARY WATER TYPES, GULF COAST AQUIFER SYSTEMS, SOUTH–CENTRAL UNITED STATES

By
Robert A. Pettijohn

1988