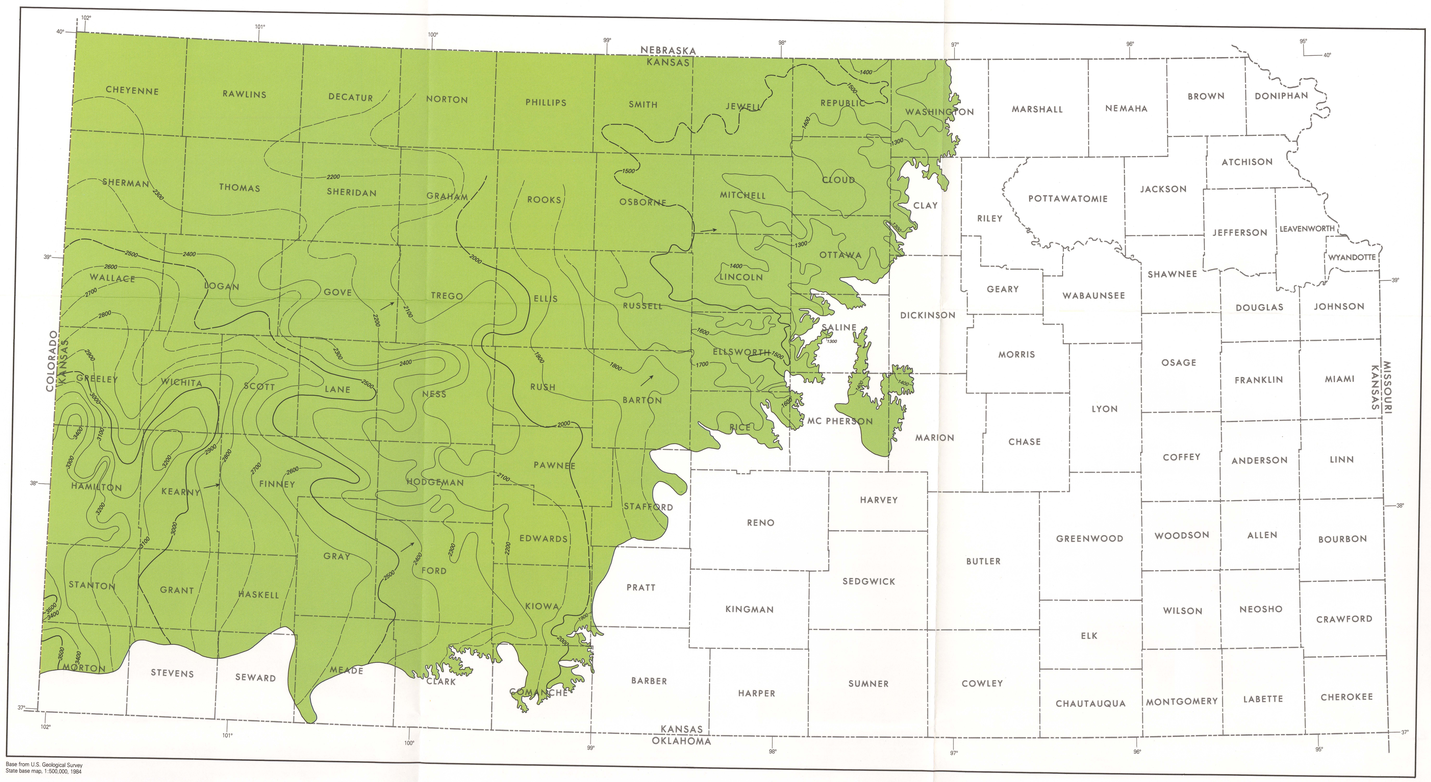


Base from U.S. Geological Survey
State base map, 1:500,000, 1984

SCALE 1:1,000,000
0 10 20 30 40 MILES
0 20 40 KILOMETERS

FIGURE 7.—Geohydrologic map showing potentiometric surface of Great Plains aquifer system.

EXPLANATION

AREA OF GREAT PLAINS AQUIFER SYSTEM

—1300— POTENTIOMETRIC CONTOUR—Shows altitude at which water level would have stood in tightly cased wells. Dashed where approximately located. Contour interval 100 feet. Datum is sea level

DIRECTION OF GROUND-WATER FLOW

HYDROLOGIC CHARACTERISTICS

Ground-Water Availability

For many years, the Great Plains aquifer system in Kansas has been acknowledged as an important source of water for domestic and stock use. As the demand for water has increased, the aquifer system also has become an important source of supply for municipal, industrial, and irrigation use throughout the outcrop and the subcrop areas where water quality is adequate. Where the aquifer system is more deeply buried in northwestern Kansas, it generally is unused because sources with better quality water are available at shallower depths. To maintain irrigation supplies in parts of Grant, Morton, and Stanton Counties, many wells obtain their water from the Great Plains aquifer system to supplement yields from shallower aquifer systems (Gutentag and others, 1981).

In a broad band along the eastern and the southern margins of the aquifer system, many residents obtain from 10 to 100 gal/min from wells that were completed in relatively shallow sandstone of the Great Plains aquifer system. Some wells, especially in northeastern Finney and northern Ford Counties, yield from 1,000 to 2,000 gal/min from the sandstone (Lobmeyer and Waddy, 1979; Gutentag and others, 1981). The majority of wells that yield water from the Great Plains aquifer system probably obtain it from the upper aquifer unit. The confining unit commonly yields little or no water to wells throughout its extent but locally may yield from 10 to 50 gal/min (Bayne and others, 1971). Few wells are completed in the lower aquifer unit only; although estimates of its yield have not been made in most parts of Kansas, Fader and others (1964) estimated that the lower aquifer unit might yield as much as 500 gal/min.

An examination of well logs and drillers' records shows that well yields may differ greatly from one location to another. According to these records, wells in some areas may yield more than 1,000 gal/min, but those similarly constructed and developed in nearby areas may yield only about 500 gal/min from the same interval in the aquifer system (Lobmeyer and Waddy, 1979). Also, the largest yields may be from the upper aquifer unit at one location and from the lower aquifer unit at another location.

Examination of drillers' records suggests that well yields probably are related to the thickness of the sandstone, the percentage of silt and clay included, and the degree of cementation. Sustained well yields (or a continued source of water) may be dependent on the areal extent and the interconnection of the principal sandstone units. Similarly, the interference among wells during pumping may indicate the relative degree of interconnection and confinement within that specific producing zone in the aquifer system.

Potentiometric Surface

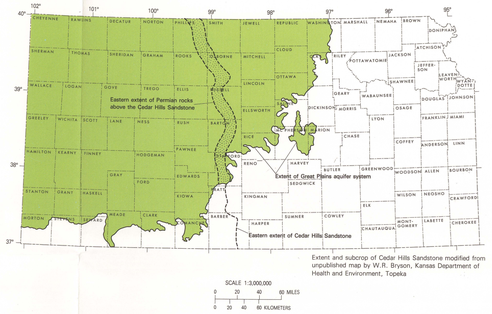
Potentiometric heads in the Great Plains aquifer system may differ significantly with well depth and from one site to another. Water may be present in many different horizons, and the degree of confinement may differ from one zone to another. Correlation of potentiometric heads among wells in different zones was not possible. About 1,100 of the approximately 1,200 water-level records of Great Plains aquifer system wells are for wells in the upper aquifer unit. For this reason, a generalized map (fig. 7) showing the altitude of the potentiometric surface of the Great Plains aquifer system was based principally on data from the upper aquifer unit.

Altitude of the potentiometric surface ranges from about 3,500 ft above sea level in the southwestern part of the study area to about 1,200 ft above sea level in the outcrop area to the east. Potentiometric heads commonly are sufficient to cause water to rise in the well and to flow at the surface in some low-lying areas. Water in the Great Plains aquifer system generally moves from western and southwestern Kansas to discharge areas in central Kansas where streams intersect the aquifer.

Relation to Other Aquifer Systems

Previous studies in Kansas suggest that recharge to the Great Plains aquifer system may occur in areas that directly underlie the High Plains aquifer system and that underlie the intervening Great Plains confining system. An investigation in southwestern Kansas (Gutentag and others, 1981) defined areas where the Great Plains aquifer system subcrops beneath thick, saturated deposits of the High Plains aquifer system (fig. 1). Evidence of significant recharge reportedly is shown by the occurrence of freshwater of calcium bicarbonate type that has been contributed from the overlying High Plains aquifer system (Kume, 1984). Model studies during the CMSASA also indicate that the small amounts of water [0.01 ft^3/d /mi^2] leaking through a very large area of the Great Plains confining system probably contribute significant amounts of recharge (Helgesen and others, in press).

Unpublished data from the Kansas Department of Health and Environment (W.R. Bryson, written commun., 1988) indicate an area in the central part of the State where the westward-dipping Cedar Hills Sandstone (Permian age) subcrops beneath the Great Plains aquifer system (fig. 8). Data from drill-stem test records from brine-disposal wells in that area indicated that the potentiometric head in the Cedar Hills Sandstone was sufficient to cause an upward movement of fluid into the lower aquifer unit. A study by Swineford and Williams (1945) compared the chemical analyses of samples from different formations in Russell County. This comparison showed that ground water from the Permian rocks probably moved upward through the overlying lower aquifer unit and into the bottom of the upper aquifer unit.



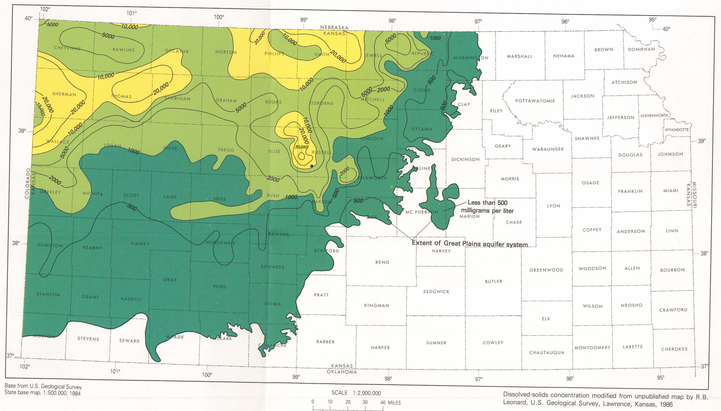
Extent and subcrop of Cedar Hills Sandstone modified from unpublished map by W.R. Bryson, Kansas Department of Health and Environment, Topeka

SCALE 1:3,000,000
0 20 40 60 MILES
0 20 40 60 KILOMETERS

EXPLANATION

APPROXIMATE AREA WHERE CEDAR HILLS SANDSTONE SUBCROPS BENEATH GREAT PLAINS AQUIFER SYSTEM

FIGURE 8.—Geohydrologic map showing relation of Cedar Hills Sandstone to Great Plains aquifer system.



Base from U.S. Geological Survey
State base map, 1:500,000, 1984

SCALE 1:2,000,000
0 10 20 30 40 MILES
0 20 40 KILOMETERS

Dissolved-solids concentration modified from unpublished map by R.B. Leonard, U.S. Geological Survey, Lawrence, Kansas, 1986

FIGURE 9.—Geochemical map showing dissolved-solids concentrations in Great Plains aquifer system.

EXPLANATION

GENERAL CLASSIFICATION OF WATER (dissolved solids, in milligrams per liter)

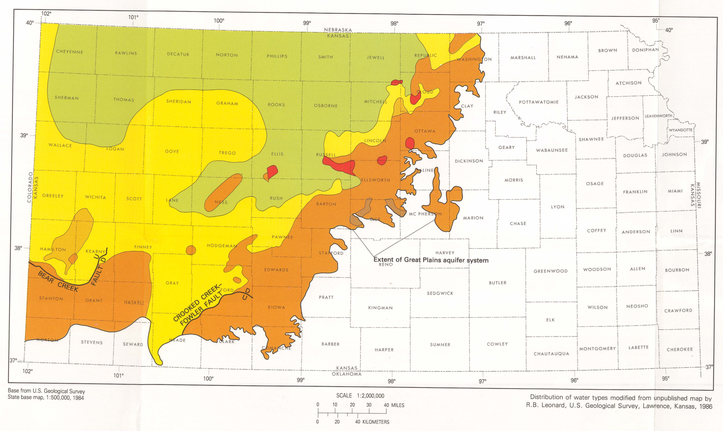
Freshwater (less than 1,000)

Saline water (1,000 to 10,000)

Brackish water (10,000 to 35,000)

—500— LINE OF EQUAL DISSOLVED-SOLIDS CONCENTRATION—Interval, in milligrams per liter, is variable

WELL—Used for lithology and water-quality data shown in figure 11



Base from U.S. Geological Survey
State base map, 1:500,000, 1984

SCALE 1:2,000,000
0 10 20 30 40 MILES
0 20 40 KILOMETERS

Distribution of water types modified from unpublished map by R.B. Leonard, U.S. Geological Survey, Lawrence, Kansas, 1986

FIGURE 10.—Geochemical map showing distribution of water types in Great Plains aquifer system.

EXPLANATION

WATER TYPES

Sodium chloride

Sodium bicarbonate

Sodium sulfate

Calcium chloride

Calcium bicarbonate

Calcium sulfate

U/D FAULT—U, upthrown side; D, downthrown side

CHEMICAL QUALITY OF WATER

The chemical quality of water in the Great Plains aquifer system generally is related to the quantity and the quality of recharge and to the interaction between chemical constituents of the rock and the ground water within the aquifer system or adjacent systems.

In this report, water is classified by type according to the principal constituents and by general categories in terms of dissolved-solids concentrations expressed in milligrams per liter. Freshwater is defined as having dissolved-solids concentrations of less than 1,000 milligrams per liter (mg/L); saline water, from 1,000 to 10,000 mg/L; and brackish water, from 10,000 to 35,000 mg/L.

Distribution of Dissolved Solids

Concentrations of dissolved solids in water from the Great Plains aquifer system vary from less than 500 to more than 20,000 mg/L (fig. 9). Freshwater occurs in most of the southern and the southwestern parts of the aquifer system and in a band along the eastern margin. Saline water occurs within the remainder of the aquifer system, except for three relatively large areas of brackish water in north-central and northwestern Kansas.

This distribution of dissolved-solids concentrations indicates that the freshwater in the southern and the southwestern parts of Kansas probably reflects significant amounts of freshwater recharge from the High Plains aquifer system. The effects of recharge from the High Plains aquifer system to the underlying Great Plains aquifer system in southwestern Kansas were described by Gutentag and others (1981). The movement of recharge through dune sand and unconsolidated deposits of the High Plains aquifer system to the underlying Great Plains aquifer system in parts of Ford, Edwards, and Pawnee Counties was described by Fader and Stullken (1978). In the band along the eastern margin, it is probable that the freshwater reflects local recharge from precipitation that has leaked through the weathered and fractured rocks to the aquifer system where it is at or near land surface. The gradational increases in dissolved solids toward the north and the west probably reflect a mixing of the freshwater recharge with very mineralized water in the aquifer system in an area that lacks freshwater recharge.

Water Types

The chemical composition of water in the Great Plains aquifer system may differ significantly with depth from one area to another. In local areas, the aquifer system may contain freshwater in a shallow zone and saline water in a deep zone. Also, there are many gradationally mixed types of water from one area to another. These differences result from the source and the quality of recharge, the depth and the character of sediments in the aquifer system, and the chemical interaction with water or soluble minerals in adjacent rocks. Because of the complex geohydrologic character of the Great Plains aquifer system, it is necessary to generalize the interpretation of chemical-quality data.

Five major types of water, which were classified on the basis of principal constituents, are indicated from the available chemical-quality data. Most of the water in the Great Plains aquifer system of Kansas is classified as a calcium bicarbonate, a sodium bicarbonate, or a sodium chloride type (fig. 10). In some less extensive areas, sodium sulfate and calcium sulfate water also may be significant.

Calcium bicarbonate water occurs in most of the area along the eastern and the southern margins of the aquifer system. This type of water probably is associated with precipitation that infiltrates through overlying unconsolidated deposits or through zones of weathered and fractured rocks where the aquifer system is shallow or crops out. In the north-central and the northwestern parts, the type of water in the aquifer system reflects the relatively large concentrations of sodium and chloride that generally occur in the deep formations of Kansas. North and west from the marginal areas, a transitional zone of predominantly sodium bicarbonate type water occurs in the aquifer system. In this transitional zone, the predominant type of water probably results partly from ion exchange and partly from mixing of the recharged calcium bicarbonate water with the sodium chloride water of the deeper parts of the aquifer system.

Locally, movement of water into the Great Plains aquifer system from overlying and underlying units substantially has affected the chemical composition of water in the aquifer system. Small areas of principally calcium sulfate water in the northeastern part result from an increased dissolution of gypsum in the Kiowa Shale (Keene and Bayne, 1977). In other parts of Kansas, water movement from the underlying Permian rocks of the Western Interior Plains confining system has a substantial effect on the quality of water in the aquifer. Large quantities of very mineralized water discharged from the subcrop of the Permian Cedar Hills Sandstone greatly increase the sodium and the chloride concentrations in the lower part of the aquifer system. Discharge from this Permian unit affects an area extending from Phillips County in the north to Barton County in the south. The dissolution of salt and gypsum from other underlying Permian rocks along the Crooked Creek-Fowler Fault in southwestern Kansas also has increased the concentrations of calcium, sodium, chloride, and sulfate. The source of the relatively fresh (about 500–1,000 mg/L dissolved solids) sodium sulfate water in Hamilton, Kearny, and Wichita Counties is not known. However, this sodium sulfate water may result from downward leakage of irrigation water through the alluvial deposits and thin overlying shale of the Great Plains confining system into the shallow Great Plains aquifer system.

Changes in Quality with Depth

As noted in the section "Hydrologic Characteristics," potentiometric heads in the Great Plains aquifer system may differ significantly with depth. In areas where horizontal and vertical movement of water in the lower aquifer unit have been restricted by low permeability, the heads in that unit may differ greatly from those in the upper aquifer unit. In the same manner, differences in the chemical quality of water between the lower aquifer unit (Cheyenne Sandstone) and the upper aquifer unit may increase as flow between the aquifer units is more restricted.

In a comparison of dissolved-solids concentrations in water from wells in southwestern Kansas, Kume (1984) reported a median value of 500 mg/L for 5 wells in the lower aquifer unit (Cheyenne Sandstone) and 390 mg/L for 21 wells in the upper aquifer unit (Dakota Formation). The type of water in both aquifer units was similar, but the concentrations of sodium, bicarbonate, sulfate, and chloride generally increased in the lower aquifer unit. Thus, the effects of freshwater recharge through the unconsolidated deposits in this area were greatest in the upper aquifer unit.

Chemical-quality data from 12 wells in Russell County (north-central Kansas) show significant differences with depth that were caused by the discharge of brine from underlying Permian rocks (Swineford and Williams, 1945). Analyses of samples taken from four depths within one of the wells in southwestern Russell County provides a comparison of water from each aquifer unit and the underlying confining system (fig. 11). At this well, water samples were obtained from the Western Interior Plains confining system (Permian), the lower aquifer unit (Cheyenne Sandstone), and two zones in the upper aquifer unit (Dakota Formation). Bar graphs compare the concentrations of principal constituents (in milliequivalents per liter); the dissolved solids (in milligrams per liter) are shown at the top of each bar. It is evident at this site that brines containing very large concentrations of sodium and chloride discharge upward from the Western Interior Plains confining system to mix with water in the lower and the upper aquifer units. In the Great Plains aquifer system in Russell County, dissolved solids increase abruptly, and water quality changes from fresh to brackish within relatively short distances, as shown in figure 9. Upward discharge of magnesium and sulfate also occurs at this site, but these concentrations are less significant percentages of the chemical composition. Similar, though less dramatic, differences in chemical composition of water with depth are evident in samples from three wells in Hamilton and Kearny Counties (Kume, 1984).

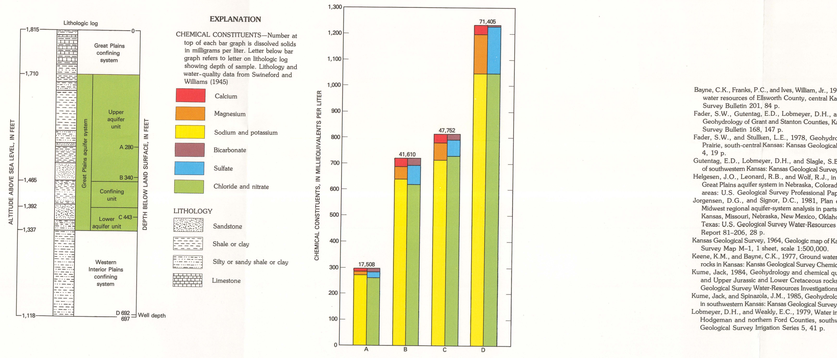


FIGURE 11.—Changes in water quality with depth in Great Plains aquifer system.

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