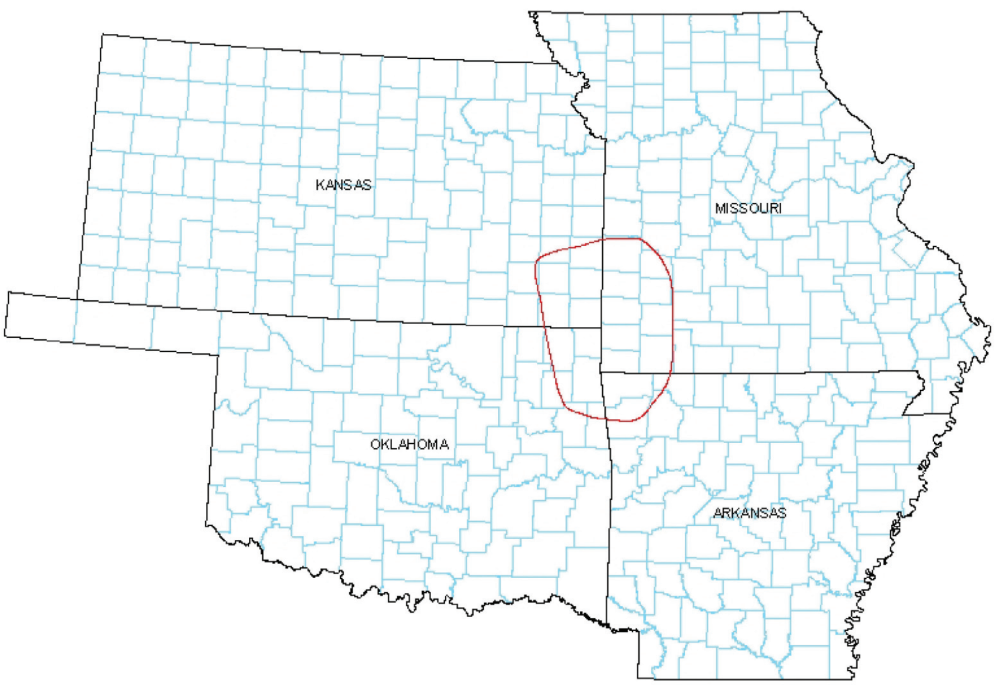
Prepared in cooperation with the Kansas Water Office

Potentiometric Surfaces in the Springfield Plateau and Ozark Aquifers of Northwestern Arkansas, Southeastern Kansas, Southwestern Missouri, and Northeastern Oklahoma, 2006



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U.S. Department of the Interior
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Conversion Factors and Datums

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
foot per mile (ft/mi)	0.1894	meters per kilometer (m/km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow rate	
foot per day (ft/d)	0.3048	meter per day (m/d)
gallon per minute (gal/m)	0.6308	liter per second (L/s)

Altitude, as used in this report, refers to distance above the vertical datum, and is referenced to the National Geodetic Vertical Datum of 1929 (NGVD of 1929).

Latitude and longitude are referenced to the North American Datum of 1983 (NAD of 1983).

Potentiometric Surfaces in the Springfield Plateau and Ozark Aquifers of Northwestern Arkansas, Southeastern Kansas, Southwestern Missouri, and Northeastern Oklahoma, 2006

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Abstract

The Springfield Plateau and Ozark aquifers are important sources of ground water in the Ozark Plateaus aquifer system. Water from these aquifers is used for agricultural, domestic, industrial, and municipal water sources. Changing water use over time in these aquifers presents a need for updated potentiometric-surface maps of the Springfield Plateau and Ozark aquifers.

The Springfield Plateau aquifer consists of water-bearing Mississippian-age limestone and chert. The Ozark aquifer consists of Late Cambrian to Middle Devonian age water-bearing rocks consisting of dolostone, limestone, and sandstone. Both aquifers are complex with areally varying lithologies, discrete hydrologic units, varying permeabilities, and secondary permeabilities related to fractures and karst features.

During the spring of 2006, ground-water levels were measured in 285 wells. These data, and water levels from selected lakes, rivers, and springs, were used to create potentiometric-surface maps for the Springfield Plateau and Ozark aquifers. Linear kriging was used initially to construct the water-level contours on the maps; the contours were subsequently modified using hydrologic judgment. The potentiometric-surface maps presented in this report represent ground-water conditions during the spring of 2006. During the spring of 2006, the region received less than average rainfall. Dry conditions prior to the spring of 2006 could have contributed to the observed water levels as well.

The potentiometric-surface map of the Springfield Plateau aquifer shows a maximum measured water-level altitude within the study area of about 1,450 feet at a spring in Barry County, Missouri, and a minimum measured water-level altitude of 579 feet at a well in Ottawa County, Oklahoma. Cones of depression occur in Dade, Lawrence and Newton Counties in Missouri and Delaware and Ottawa Counties in Oklahoma. These cones of depression are associated with private wells. Ground water in the Springfield Plateau aquifer generally flows to the west in the study area, and to surface features (lakes, rivers, and springs) particularly in the south and east of the study area where the Springfield Plateau aquifer is closest to land surface.

The potentiometric-surface map of the Ozark aquifer indicates a maximum measured water-level altitude of 1,303 feet in the study area at a well in Washington County, Arkansas, and a minimum measured water-level altitude of 390 feet in Ottawa County, Oklahoma. The water in the Ozark aquifer generally flows to the northwest in the northern part of the study area and to the west in the remaining study area. Cones of depression occur in Barry, Barton, Cedar, Jasper, Lawrence, McDonald, Newton, and Vernon Counties in Missouri, Cherokee and Crawford Counties in Kansas, and Craig and Ottawa Counties in Oklahoma. These cones of depression are associated with municipal supply wells. The flow directions, based on both potentiometric-surface maps, generally agree with flow directions indicated by previous studies.

Introduction

The Springfield Plateau and Ozark aquifers are important sources of ground water in the Ozark Plateaus Province (fig. 1). The Springfield Plateau aquifer is an important source of ground water primarily for domestic and agricultural use. The Ozark aquifer is the primary source of ground water in the Ozark Plateaus Province (Fennemen and Johnson, 1946), which includes parts of Arkansas, Kansas, Missouri, and Oklahoma (fig. 1), supplying water for municipal, agricultural, industrial, and private use.

In Arkansas, the amount of water withdrawn from the Ozark aquifer increased steadily through the 1990's but began to decline by 2000 (Holland, 1987, 1993, 1999, 2004) as municipal supply wells were abandoned in favor of surface-water impoundments. In addition, many domestic wells were abandoned as municipal water became available in rural areas. In Kansas, water use has shifted to the Ozark aquifer as concerns with contamination of the Springfield Plateau aquifer have resulted in a court order for the development of rural water districts (Iona Branscum, Kansas Water Office, written commun., 2007). Missouri relies heavily on the Ozark aquifer for municipal supply but the Springfield Plateau aquifer also is widely used. In Oklahoma, the Springfield Plateau aquifer and to a greater extent the Ozark aquifer continue to be used for municipal, agricultural, and domestic supplies. Water-use changes and future water-availability questions in these aquifers present a need for updated potentiometric-surface maps of the Springfield Plateau and Ozark aquifers.

The U. S. Geological Survey (USGS) in cooperation with the Kansas Water Office (and supported in part by Kansas State Water Plan) conducted a study in 2006 of the potentiometric surfaces of the Springfield Plateau and Ozark aquifers as part of a water availability investigation in a study area containing parts of northwestern Arkansas, southeastern Kansas, southwestern Missouri, and northeastern Oklahoma (fig. 1). The study area covers approximately 12,700 square miles.

Purpose and Scope

The purpose of this report is to describe the potentiometric-surface maps of the Springfield Plateau and Ozark aquifers in the study area representing conditions during the spring of 2006. The potentiometric-surface maps presented in this report allow comparison to water levels presented by previous investigators and provide a baseline to compare future changes in water levels in the study area. The potentiometric surfaces

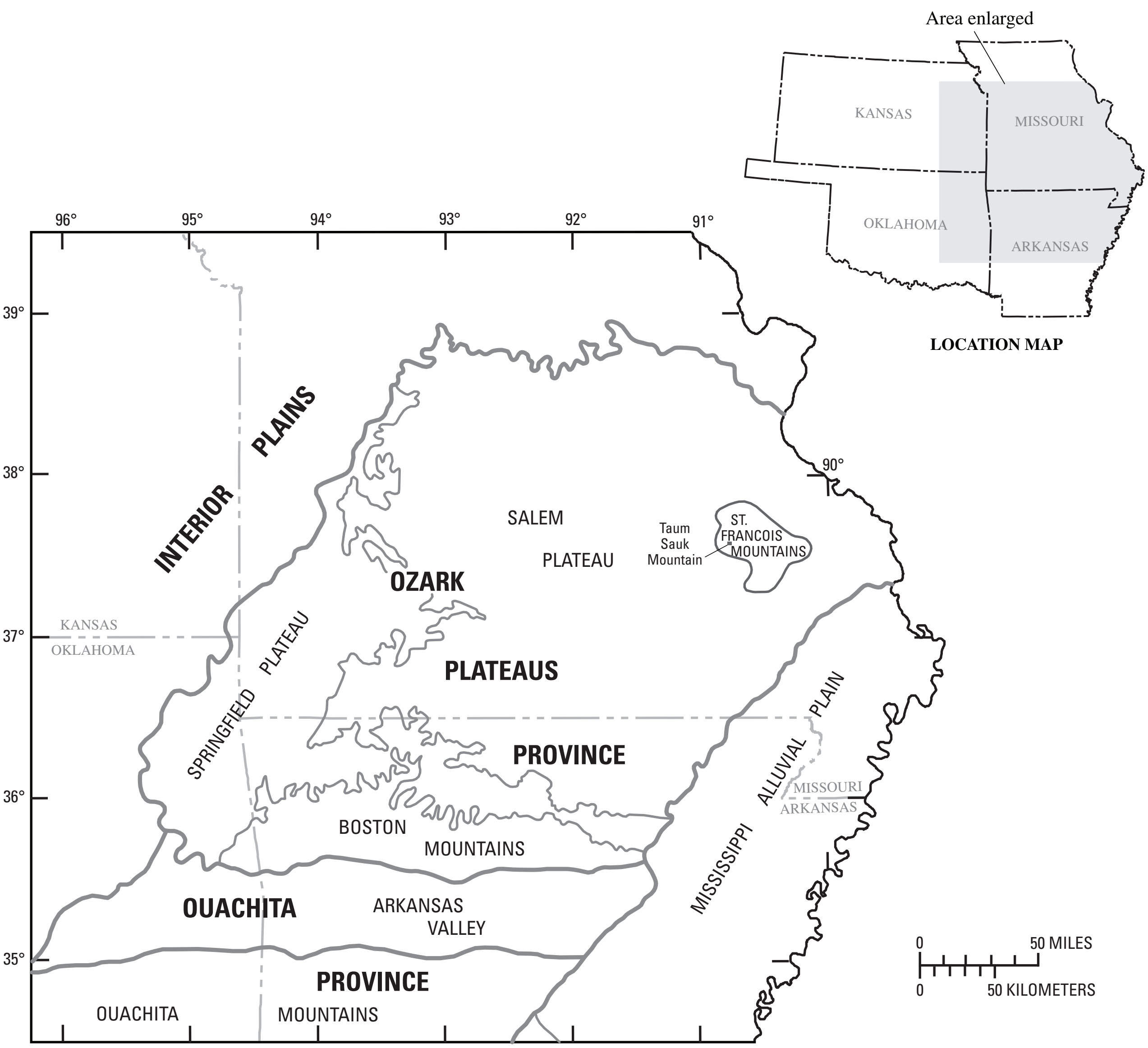


Figure 1. Physiographic subdivsions of the Ozark Plateaus Province and adjacent areas (modified from Imes and Emmett, 1994).

and water-level measurements are necessary components for constructing ground-water flow models that can be used to simulate ground-water flow in the Springfield Plateau and Ozark aquifers.

The potentiometric-surface maps presented in this report are the first potentiometric surfaces created from recent (2006) data for the Springfield Plateau and Ozark aquifers over the study area. A potentiometric surface of the Ozark aquifer in northern Arkansas was created from 2004 data (Schrader, 2005). Macfarlane and Hathaway (1987) presented a potentiometric-surface map for the Ozark aquifer in the tristate region of Kansas, Missouri, and Oklahoma for conditions representing the period 1979 to 1981. Predevelopment potentiometric surfaces for the Springfield Plateau and Ozark aquifers were approximated using a ground-water flow model with no water use specified, to simulate conditions without any human impact (Imes and Emmett, 1994, figs. 28 and 40). The potentiometric-surface maps presented in this report lie within the boundaries of the potentiometric-surface maps created by Imes and Emmet (1994) and cover a larger area than the potentiometric-surface map constructed by Macfarlane and Hathaway (1987).

To create the potentiometric-surface maps, water levels were collected in 285 wells completed in the Springfield Plateau and Ozark aquifers during the spring of 2006. Water-level data were collected by the USGS in Arkansas, Kansas, Missouri, and Oklahoma, as well as by the Kansas Geological Survey and the Missouri Department of Natural Resources. For the Springfield Plateau aquifer potentiometric-surface map, the altitude of lakes, rivers, and streams was used as additional water-level control points where the Springfield Plateau aquifer outcrops at land surface because the aquifer is in hydrogeologic connection with those surface-water bodies. The altitude of four springs also was used for the construction of the Ozark aquifer potentiometric surface.

Hydrogeologic Setting

The Springfield Plateau and Ozark aquifers are part of the Ozark Plateaus aquifer system, which is divided into five primary hydrogeologic units (Imes and Emmett, 1994; Jorgensen and others, 1996). The units can be distinguished by rocks with similar hydrologic properties, although the boundaries of the units do not always coincide with formation boundaries, and can span several geologic time systems. The geologic formations that make up the Ozark Plateaus aquifer system range from Cambrian to Mississippian age. The five major hydrogeologic units from youngest to oldest are: the Springfield Plateau aquifer, the Ozark confining unit, the Ozark aquifer, the St. Francois confining unit, and the St. Francois aquifer (fig. 2). The general correlation of the Springfield Plateau aquifer, the Ozark confining unit, and the Ozark aquifer are shown in table 1. The Western Interior Plains confining unit, consisting of less permeable hydrogeologic units of Mississippian to Pennsylvanian age, overlies the Ozark Plateaus aquifer system. The Precambrian basement confining unit underlies the Ozark Plateaus aquifer system. These hydrogeologic units and their members are discussed in detail in Imes and Emmett (1994). A brief discussion of the characteristics of the Springfield Plateau aquifer and the Ozark aquifer follows.

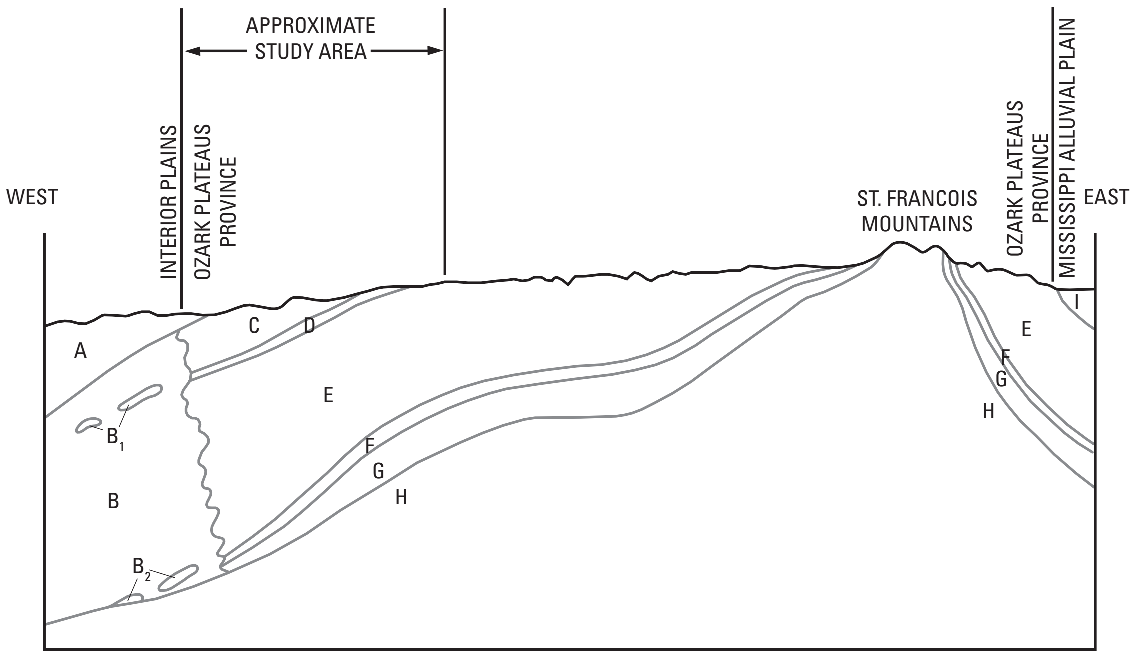
Springfield Plateau Aquifer

The Springfield Plateau aquifer is the uppermost hydrogeologic unit in the Ozark Plateaus aquifer system. The formations of the Springfield Plateau aquifer outcrop over much of the study area (fig. 2). There are small areas in Benton and Carroll Counties in Arkansas; Barry, Cedar, Christian, Dade, Green, McDonald, Newton, Polk, St. Clair, and Stone Counties in Missouri; and Adair, Cherokee, and Delaware Counties in Oklahoma where the Springfield Plateau aquifer is absent. The Springfield Plateau aquifer is overlain by the Western Interior Plains confining system in the western part of the study area and underlain by the Ozark confining unit.

The Springfield Plateau aquifer outcrops over the Springfield Plateau physiographic section, which consists of about one-third of the surface area of the Ozark Plateaus aquifer system. In the northern part of the Ozark Plateaus aquifer system, the Springfield Plateau aquifer dips gently to the northwest. West of the Springfield Plateau section, the aquifer is buried by the less permeable units of the Western Interior Plains confining system to a depth of up to 500 ft in southeastern Kansas and as much as 4,000 ft in Oklahoma near the Arkansas Valley. In Arkansas, the southward dip of the Springfield Plateau aquifer can exceed 200 ft/mi and the depth of burial exceeds 5,000 ft in the Arkansas Valley (Imes and Emmett, 1994).

The thickness of the Springfield Plateau aquifer ranges from 0 to more than 400 ft in the northwestern part of the study area. The aquifer generally is thicker in southeastern Kansas, southwestern Missouri, and northeastern Oklahoma. The thickness of the aquifer in northern Arkansas is less than 400 ft (Imes and Emmett, 1994).

The Springfield Plateau aquifer consists mainly of coarsely crystalline Mississippian age limestones with local high-percentage occurrences of chert. Dissolution of limestone leads to karst features, such as caves, sinkholes, and solutional channels along fractures. These karst features may result in a large secondary permeability, that is, permeability developed by the dissolution of carbonate rock along fractures and bedding planes. Springs are common where the Boone Formation and the St. Joe Limestone outcrop in Arkansas. The Springfield Plateau aquifer is anisotropic and heterogeneous. The average horizontal hydraulic conductivity is estimated to be 22 ft/d (Imes and Emmett, 1994). Wells completed in the Springfield Plateau aquifer typically produce less than 20 gal/min, although some industrial wells completed in this aquifer in southwestern Missouri yield up to 400 gal/min (Adamski and others, 1995). The Springfield Plateau aquifer receives recharge from its outcrop area and is uncon-



EXPLANATION

A **WESTERN INTERIOR PLAINS CONFINING SYSTEM**
B **WESTERN INTERIOR PLAINS AQUIFER SYSTEM**
B_1 **STRATIGRAPHICALLY EQUIVALENT TO OZARK CONFINING UNIT**
B_2 **STRATIGRAPHICALLY EQUIVALENT TO ST. FRANCOIS CONFINING UNIT**
OZARK PLATEAUS AQUIFER SYSTEM
C **SPRINGFIELD PLATEAU AQUIFER**
D **OZARK CONFINING UNIT**
E **OZARK AQUIFER**
F **ST. FRANCOIS CONFINING UNIT**
G **ST. FRANCOIS AQUIFER**
H **BASEMENT CONFINING UNIT**
I **POST-PALEOZOIC SEDIMENTS**

Figure 2. Generalized hydrogeologic section of the Ozark Plateaus aquifer system and adjacent hydrogeologic units (from Imes and Emmett, 1994).

Table 1. General correlation of hydrogeologic units of the Springfield Plateau aquifer, the Ozark confining unit, the Ozark aquifer, and the St. Francois confining unit.

Erathem	System	Southwestern Missouri	Southeastern Kansas	Northeastern Oklahoma	Northwestern Arkansas	Hydrogeologic unit
Paleozoic	Mississippian	St. Louis Limestone Salem Formation Warsaw Limestone Keokuk Limestone Burlington Limestone Elsey Formation Reeds Spring Formation Pierson Formation	St. Louis Limestone Salem Limestone Warsaw Limestone Keokuk Limestone Burlington Limestone Fern Glen Limestone	Moorefield Formation Keokuk Limestone Boone Formation Reeds Spring Member of Boone Formation St. Joe Limestone Member	Boone Formation Reeds Spring Member of Boone Formation St. Joe Limestone Member	Springfield Plateau aquifer
		Northview Shale Compton Limestone	Northview Shale	Northview Shale		Ozark confining unit
	Devonian	Chattanooga Shale	Chattanooga Shale	Woodford Chert Chattanooga Shale	Chattanooga Shale	
		Fortune Formation	Absent	Sallisaw Formation Frisco Limestone of Hunton Group	Clifty Limestone Penters Chert	Ozark aquifer
	Sillurian	Absent	Absent	St. Clair Limestone	Lafferty Limestone St. Clair Limestone Brassfield Limestone	
	Ordovician	Kimmswick Limestone Plattin Limestone Joachim Dolomite St. Peter Sandstone Everton Formation Smithville Formation Powell Dolomite Cotter Dolomite Jefferson City Dolomite Roubidoux Formation Gasconade Dolomite Van Buren Formation Gunter Sandstone Member of Gasconade Dolomite	Cotter Dolomite and Jefferson City Dolomite Dundifferentiated Roubidoux Formation Gasconade Dolomite Van Buren Formation Gunter Sandstone Member of Gasconade Dolomite of Arbuckle Group	Sylvan Shale Fernvale Limestone Viola Limestone Fite Limestone Tyner Formation Burgen Sandstone Smithville Equivalent Powell Dolomite of Arbuckle Group Cotter Dolomite of Arbuckle Group Jefferson City Dolomite of Arbuckle Group Roubidoux Formation of Arbuckle Group Gasconade Dolomite of Arbuckle Group Van Buren Formation of Arbuckle Group Gunter Sandstone Member of Arbuckle Group	Cason Shale Fernvale Limestone Kimmswick Limestone Plattin Limestone Joachim Dolomite St. Peter Sandstone Everton Formation Smithville Formation Powell Dolomite Cotter Dolomite Jefferson City Dolomite Roubidoux Formation Gasconade Dolomite Gunter Sandstone Member of Gasconade Fomation	
	Cambrian	Eminence Dolomite Potosi Dolomite	Eminence Dolomite Potosi Dolomite	Eminence Dolomite Potosi Dolomite	Eminence Dolomite Potosi Dolomite	
		Doe Run Formation Derby Formation Davis Formation	Doe Run Dolomite Derby Dolomite Davis Formation of Elvins Group	Doe Run Dolomite Derby Dolomite Davis Formation of Elvins Group	Doe Run Dolomite Derby Dolomite Davis Formation	St. Francois confining unit

fined over the majority of the study area. In the northwestern part of the study area, the Springfield Plateau aquifer is buried and may be confined. In the majority of the study area, where the Springfield Plateau aquifer crops out, the potentiometric surface represents the water table in the aquifer.

Ozark Aquifer

The Ozark aquifer consists of Late Cambrian to Middle Devonian water-bearing rocks consisting of dolostone, limestone, and sandstone. The basal formation in the aquifer is the Potosi Dolomite of Cambrian age. The aquifer is overlain by the Ozark confining unit and underlain by the St. Francois confining unit. East of the study area, the Ozark aquifer outcrops at land surface in topographically high areas where direct recharge to the aquifer from infiltration of surface-water runoff and streamflow can occur. Younger formations within the aquifer may not be present as a result of erosion. The Ozark aquifer outcrop coincides with the Springfield-Salem plateaus physiographic section (Fenneman and Johnson, 1946) and within the study area, minor outcrops of the Ozark aquifer exist (fig. 1).

In the western part of the Ozark Plateaus Province within the study area, the Ozark aquifer dips gently to the west. The Ozark aquifer is less than 500 ft below land surface over most of the Springfield Plateau and reaches depths in excess of 1,000 ft below land surface in Kansas and Oklahoma. In the southern area of the Ozark Plateaus Province, the Ozark aquifer is buried to great depths by younger rocks, achieving a depth in excess of 5,000 ft below land surface beneath the Arkansas Valley (fig. 1).

The Ozark aquifer is the thickest and most productive aquifer in the study area. In southeastern Kansas, southwestern Missouri, and northeastern Oklahoma, the Ozark aquifer ranges in thickness from 800 to 1,500 ft (Imes, 1990b). In isolated areas in Oklahoma, the Ozark aquifer may be thinner as a result of highs in the Precambrian basement rocks. In northern Arkansas, the aquifer thickens to the south and ranges from 1,500 to 2,000 ft in thickness (Imes and Emmett, 1994).

The Ozark aquifer comprises several lithologies, which can cause permeability and porosity to vary greatly. Lithologies that comprise the Ozark aquifer include dolostone, limestone, sandstone, chert, and shale, with dolostone being the dominant rock type. Secondary permeability is well developed in the Ozark aquifer. Dissolution of carbonate rocks along fractures and bedding planes has increased permeability. In some areas, karst is well developed (Imes, 1989; Jorgensen and others. 1996). This is especially true in the eastern part of the study area where the Ozark aquifer crops out or is closer to the surface. The Ozark aquifer includes massive, clean, well-sorted sand bodies that are highly permeable in some areas.

The Ozark aquifer is anisotropic and heterogeneous as evidenced by horizontal hydraulic conductivity values that vary from 0.001 to 86 ft/d (Adamski and others, 1995; Macfarlane and others, 2005). Wells completed in the aquifer yield may yield as much as 2,000 gal/min (Macfarlane, 2007). Static water levels in wells completed in the Ozark aquifer typically will rise above the top of the Ozark aquifer, except in areas where large cones of depression have formed (Imes and Emmett, 1994). The Ozark aquifer receives recharge from its outcrop area in central and south-central Missouri outside the study area; within the study area, recharge originates from the overlying Ozark confining unit. A ground-water divide occurring near the Missouri-Arkansas State line within the study area is indicative of local recharge to the Ozark aquifer. The Ozark aquifer is confined, except for small areas where the Ozark outcrops in Arkansas, Missouri, and Oklahoma, therefore, the potentiometric surface may be higher than the top of the aquifer.

Potentiometric-Surface Construction Methods

A potentiometric-surface map indicates the altitude to which water levels will rise in tightly cased wells completed in and open to the aquifer, and provides a means to interpret ground-water flow direction. For this study, potentiometric-surface maps (plates 1 and 2) were prepared for the Springfield Plateau aquifer and Ozark aquifer using ground-water level data collected from 285 wells from late March through June of 2006 and water-levels for selected lakes, rivers, and springs. The potentiometric-surface maps represent ground-water conditions during the spring of 2006. During the spring of 2006, the region received less than average rainfall. Dry conditions prior to the spring of 2006 could have contributed to the observed water levels.

Wells were measured using calibrated steel or electric tapes, a sonic device, or air-pressure gage measurements. The calibrated tapes provide a measurement that is accurate to within 0.01 ft (Garber and Koopman, 1968), whereas the sonic and air-pressure methods can provide an accuracy of tenths of feet (Global Water Instrumentation, Inc., 2007; Lohman, 1953). In the case of the air-pressure method, accurate information of the length of the air line may be lacking. In addition, the condition of the air gage used to make the measurement was not always known. These unknowns may lead to substantial error in measurement on the order of 1 to 10 ft. The altitude of land surface for the wells was determined by plotting the well on a topographic map and then estimating the altitude at that location using the contours of the topographic map. Both 1:24,000 topographic maps published by USGS and digital quadrangle maps derived from the 1:24,000 topographic maps were used. The contour intervals on the maps were 10 and 20 ft, giving a possible error of 5 to 10 ft. An effort was made to measure wells that represent the static water level. However, many of the wells measured are in use and are pumped with varying frequency. If a measurement could not be made when the well was not pumping, it was not used. It is possible that some wells had not fully recovered from being pumped at the time of measurement, introducing further error. Because of the numerous potential sources for error, suspect data were discarded if it could not be verified.

Points along rivers and lakes were used to approximate water levels within the Springfield Plateau aquifer where it comes in contact with major surface-water bodies. Altitudes of some springs were used as water-level altitude points because they are indicative of a minimum altitude of ground water at the location of the spring. All spring data points were derived from the USGS National Water Information System (NWIS) (http://waterdata.usgs.gov/nwis). Most of the altitude data for springs was derived from topographic maps, giving a possible error of 5-10 ft. Data points representing major streams were obtained from the USGS National Hydrography Dataset (NHD), which are derived from digital topographic maps. In areas where the Springfield Plateau aquifer crops out, every hundredth point representing the altitude of major stream and river surfaces was extracted for use in constructing the potentiometric surface. Horizontal coordinate errors in NHD data can cause substantial error, so the NHD data points were culled to accurately represent the streams. Two major lakes (Grand Lake of the Cherokees and Beaver Lake) occur in the area where the Springfield Plateau aquifer crops out and are considered to be in hydrologic connection with the aquifer. An altitude of 740 ft (NGVD of 1929) (USGS) was used for the Grand Lake of the Cherokees in Oklahoma and an altitude of 1,106 ft (NGVD of 1929) (U.S. Army Corps of Engineers, 2007) was used for Beaver Lake in Arkansas. These altitudes reflect the approximate level of the lakes at the beginning of April 2006.

In the Ozark Plateau region, many wells are completed using surface casing that terminates at the top of the Springfield Plateau aquifer followed by an open borehole to total well depth. This completion technique allows water from both the Springfield Plateau aquifer and the Ozark aquifer to flow into the well. If a well was completed in this manner, a determination was made as to which aquifer the water level represented by comparing the water-level altitude from the well in question with the water-level altitudes of the nearest well pairs completed only in the Springfield Plateau aquifer and the Ozark aquifer. If the water-level altitude in question was within 25 percent of the difference between the water-level altitudes from the Springfield Plateau and Ozark aquifer well pair, then it was assigned to the aquifer that was closest to the two. For example, if the water-level altitude in question was 1,275 ft, with the nearest Springfield Plateau water-level altitude being 1,300 ft and the nearest Ozark aquifer water-level altitude being 1,120 ft, 25 percent of the difference (0.25 x (1,300 ft – 1,120 ft) = 45 ft) would be used to make the assessment. Because 1,275 ft is only 25 ft different than the Springfield Plateau aquifer water-level altitude, the assignment of that water level would be to the Springfield Plateau aquifer, as opposed to the Ozark aquifer, which is different by 150 ft. If no nearby wells had similar characteristics or the water-level altitude of the well in question could not be associated with a single aquifer, the water level from the well was not used. Of the 48 water-level altitudes from wells completed in both the Springfield Plateau and Ozark aquifers, 9 were not used. Twenty wells that are completed in the Springfield Plateau and Ozark aquifers were determined to represent the water-level altitude of the Springfield Plateau aquifer. These wells compose 17.5 percent of the wells used to create the potentiometric-surface map of the Springfield Plateau aquifer. Nineteen wells that are completed in the Springfield Plateau and Ozark aquifers were determined to represent the water-level altitude of the Ozark aquifer. These wells compose 11.1 percent of the wells used to create the potentiometric-surface map of the Ozark aquifer.

Ground-water levels were measured in 285 wells. Of the 285 wells, 114 wells represented the water-level altitude of the Springfield Plateau aquifer (appendix 1) and 171 wells represented the water-level altitude of the Ozark aquifer (appendix 2). For the Springfield Plateau aquifer, the water-level altitudes at 135 springs (appendix 3) were used, along with 82 points representing major rivers within the study area and 135 points representing the Grand Lake of the Cherokees. For the Ozark aquifer, the water levels at four springs (appendix 4) were used in addition to water levels from the wells.

To create the initial potentiometric surfaces, linear kriging (Gambolati and Volpi, 1979) with a grid size of 6,562 ft was used to create the potentiometric surfaces from the water-level data. Because of the variability of data distribution, a variable search radius was used. After the surface was generated, substantial manual adjustments were made to the contours to honor the data points and to more accurately represent the potentiometric surfaces based on hydrologic judgment.

Potentiometric Surfaces

A potentiometric-surface map may be used to infer the horizontal direction of ground-water flow. For isotropic conditions, ground water flows perpendicular to the contour lines in a downgradient direction. The potentiometric-surface maps may be used to infer the approximate water-level altitude in the study area, but should not be used to calculate exact depth to ground water in the respective aquifers at specific points because of potential inaccuracies associated with measurement errors (land-surface altitude and depth to water), seasonal variations in water-level altitudes, and errors in interpolating water-level altitudes between sparse data-point locations.

The potentiometric-surface map of the Springfield Plateau aquifer shows a maximum water-level altitude of 1,450 ft at a spring in Barry County, Missouri (appendix 3), and a minimum water-level altitude of 579 ft at a well in Ottawa County, Oklahoma (plate 1, appendix 1). Ground water in the Springfield Plateau aquifer generally flows to the west in the study area, and to surface-water features (lakes, rivers, and springs) particularly in the southern and eastern parts of the study area where it is closest to land surface. These flow directions generally are similar to the flow directions indicated by the predevelopment surface developed by Imes and Emmett (1994, fig. 40). Current (2006) water levels are not the same as the predevelopment surface of Imes and Emmett (1994) because of changing water use over time and differences in potentiometric-surface construction methods.

Minor cones of depression are present in Lawrence and Newton Counties in Missouri and Delaware and Ottawa Counties in Oklahoma. These cones of depression are associated with private wells. The most substantial cone of depression is in Ottawa County, Oklahoma, at a private well near the Grand Lake of the Cherokees. The water level of Grand Lake of the Cherokees is 740 ft and it is believed to be hydrologically connected to the Springfield Plateau aquifer. The water level in the well is 579 ft, indicating either high water usage, slow recharge, improper well construction, or poor connection of the lake to the aquifer. In areas where the Springfield Plateau aquifer outcrops, it is the uppermost aquifer over most of the study area and, therefore, the potentiometric surface of the Springfield Plateau aquifer is highly related to the land-surface altitude. This characteristic of the potentiometric surface of the Springfield Plateau aquifer is especially apparent in the southern part of the study area, in particular because of the use of surface-water altitude control points to construct the potentiometric surface. The Springfield Plateau aquifer is also in hydrogeologic connection with many surface-water bodies. In areas where the water level in the Springfield Plateau aquifer is lower than the surface-water body, the body may lose water to the aquifer. If the surface-water body is incised into the aquifer, the aquifer may discharge water to the surface-water body.

Comparison of the potentiometric surface for the Springfield Plateau aquifer (plate 1) with the predevelopment potentiometric surface of Imes and Emmett (1994) shows general agreement, in large part because of the hydrologic controls imparted by streams and springs. However, Beaver Lake in Arkansas and Grand Lake of the Cherokees in Oklahoma are man-made reservoirs that did not exist during predevelopment time, nor did any wells. General flow direction is toward the surface-water drainages represented in each of the maps. Local cones of depression do not appear in plate 1, either because pumping rates are too small, the number of water-level altitude points are too few to show these cones, or the contour interval chosen is too large to represent them.

The potentiometric-surface map of the Ozark aquifer in the study area in 2006 indicates a maximum water level of 1,303 ft at a well in Washington County, Arkansas, and a minimum water level of 390 ft at a well in Ottawa County, Oklahoma (plate 2, appendix 2). The water in the Ozark aquifer generally flows northwestward in the northern part of the study area and westward in the remaining part of the study area.

Substantial cones of depression can be seen on the 2006 potentiometric surface. Cones of depression can be seen in Barry, Barton, Cedar, Dade, Jasper, Lawrence, McDonald, Newton and Vernon Counties in Missouri, Cherokee and Crawford Counties in Kansas, and Craig and Ottawa Counties in Oklahoma. Near the border of Barry and Lawrence Counties, Missouri, there is a cone of depression indicated by a monitoring well. The water-level altitude from a private well nearby also indicates the presence of this cone of depression. In Barton and Vernon Counties, Missouri, and Crawford County, Kansas there are shallow cones of depression indicated by the water-level altitude at rural public water supply wells. In central Jasper County, Missouri, there is a cone of depression indicated by a Missouri Department of Natural Resources monitoring well. In central Newton County, Missouri, there is a cone of depression associated with a public water-supply well field. A cone of depression occurs in the southwestern part McDonald County, Missouri, and includes five public-supply wells and two private wells. A large cone of depression occurs in parts of Craig and Ottawa Counties, Oklahoma. The lowest water level (390 ft) was measured in an observation well near the center of Ottawa County. This cone of depression occurs in an area where several pumping wells withdraw water for public water-supply and industry.

Aside from the cones of depression, the potentiometric surface of the Ozark aquifer generally reflects the changes in altitude of the top of the Ozark aquifer (Imes and Emmett, 1994). A substantial high can be seen in the potentiometric surface of the Ozark aquifer in Benton County, Arkansas. This location coincides with an areally extensive surficial outcrop of the Ozark aquifer, resulting in direct recharge to the aquifer. In addition, small water use in the area may contribute to the high water-level altitude in this area. In other areas, faulting may affect water-level altitudes in the Ozark aquifer. In south-central McDonald County, Missouri, two nearby wells have water-level altitudes differing by 133 ft and in southwestern Benton County, Arkansas, two nearby wells have water-level altitudes differing by 90 ft. These locations are near the Bella Vista fault. It is possible that secondary faulting or jointing influences the ground-water flow in these areas.

A comparison of the 2006 Ozark aquifer potentiometric surface (plate 2) with the predevelopment surface of Imes and Emmett (1994) shows general agreement between the two, except in those areas where cones of depression are depicted in the 2006 map that were not present in predevelopment times. A difference also is apparent in Barry County, Missouri where 2006 potentiometric contours are as much as 200 ft lower than those depicted for predevelopment in the 1994 map.

A comparison of the 2006 Ozark aquifer potentiometric-surface map (plate 2) to the generalized Ozark aquifer potentiometric surface map of Macfarlane and Hathaway (1987), indicates that water levels in 2006 are lower than those depicted in the 1987 map. Both maps depict cones of depression in Crawford County, Kansas, Ottawa County, Oklahoma, and Barton and Jasper Counties in Missouri. However, cones depicted in the 2006 map generally are different in extent and, in one case in Jasper County, Missouri, substantially deeper than those depicted in the 1987 map. It should be noted that differences in contour shapes and altitude between the 2006 and 1987 potentiometric-surface maps could be because of water-use induced changes in water levels or because of differences in available data points and the contour intervals used.

On the Macfarlane and Hathaway (1987) potentiometric-surface map, contours in Crawford County, Kansas, depict a southwest-northeast oriented ground-water divide. Because of sparse data points and the 50-ft interval used, potentiometric contours on the 2006 (plate 2) contour map do not depict the presence of this ground-water divide. Again, because of sparse data points in 2006, northwesterly ground-water flow from Crawford County to Neosho County implied from contours on the 1987 map is not depicted by contours on the 2006 contour map (plate 2).

Summary

The Springfield Plateau and Ozark aquifers are important sources of ground water in the Ozark Plateaus aquifer system. Water from these aquifers is used as municipal, agricultural, industrial, and domestic water sources. Water-use changes and future water-availability questions in these aquifers raises a need for updated potentiometric-surface maps. The U.S. Geological Survey, in cooperation with the Kansas Water Office, conducted a study of the potentiometric surfaces of the Springfield Plateau and Ozark aquifers.

The Springfield Plateau aquifer consists of water-bearing Mississippian-aged limestones and cherts. The Ozark aquifer consists of Late Cambrian to Middle Devonian water-bearing dolostones, limestones, and sandstones. Both aquifers are complex with areally varying lithologies, discrete hydrologic units, varying permeabilities, and secondary permeabilities because of fractures and karst features. The Springfield Plateau aquifer crops out over much of the Springfield Plateau physiographic section and receives recharge from its outcrop area. The Ozark aquifer receives recharge primarily from its outcrop area in central and south-central Missouri.

During the spring of 2006, ground-water levels were measured in 285 wells. Water-level data from these wells, 135 springs, 82 points representing major rivers, and 135 points representing the Grand Lake of the Cherokees were used to create potentiometric-surface maps for the Springfield Plateau and Ozark aquifers using a linear kriging method in conjunction with manual adjustments based on hydrologic judgment. The potentiometric-surface maps represent ground-water conditions during the spring of 2006. During the spring of 2006, the region received less than average rainfall and dry conditions prior to the spring of 2006 could have contributed to the observed water levels.

The potentiometric-surface map of the Springfield Plateau aquifer shows a maximum measured water-level of altitude of about 1,450 ft at a spring in Barry County, Missouri, and a minimum water-level altitude of 579 feet at a well in Ottawa County, Oklahoma. Ground water in the Springfield Plateau aquifer generally flows toward the west in the study area, and to surface-water features (lakes, rivers, and springs) particularly in the southern and eastern parts of the study area where it is closest to land surface. Cones of depression can be seen in Lawrence and Newton Counties in Missouri and Delaware and Ottawa Counties in Oklahoma. These cones of depression are associated with pumping from private wells.

The potentiometric-surface map of the Ozark aquifer in the study area in 2006 indicates a maximum water-level altitude of 1,303 ft in Washington County, Arkansas, and a minimum water-level altitude of 390 ft in Ottawa County, Oklahoma. The water in the Ozark aquifer generally flows northwestward in the northern part of the study area and westward in the remaining study area. Cones of depression occur in Barry, Barton, Cedar, Dade, Jasper, Lawrence, McDonald, Newton, and Vernon Counties in Missouri, Cherokee and Crawford Counties in Kansas, and Craig and Ottawa Counties in Oklahoma. These cones of depression are mainly associated with pumping from public water-supply wells. The flow directions of potentiometric-surface maps of the Springfield Plateau and Ozark aquifers generally agree with the potentiometric-surface maps from previous reports. Differences in water-level altitude, local flow directions, and geometry of the surfaces can be explained by changing water use or differences in available data points and the contour intervals used.

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Appendixes 1-4

Appendix 1. Information pertaining to wells completed in the Springfield Plateau aquifer.

[Horizontal datum is North American Datum of 1983 (NAD 83); Vertical datum is National Geodetic Vertical Datum of 1929 (NGVD 29); NA, not available; *, well completed in the Springfield Plateau and Ozark aquifers]

Latitude (decimal degrees)	Longitude (decimal degrees)	Station name	Land-surface altitude (feet above NGVD of 1929)	Well depth (feet below land surface)	Depth to water (feet below land surface)	Water-level altitude (feet above NGVD of 1929)	Date of measurement
		Benton County, Arkansas					
36.321	94.486	19N33W15CDB1	1,263	153	84.57	1,178.43	3/30/2006
36.401	94.600	20N34W21ADC1	1,029	105	12.19	1,016.81	3/30/2006
36.288	93.911	19N28W25ACB1	1,450	186	151.74	1,298.26	4/03/2006
36.419	93.945	20N28W10BDD1	1,450	25	3.44	1,446.56	4/04/2006
36.482	94.138	21N30W23ACB1	1,282	NA	117.50	1,164.50	4/04/2006
36.293	94.242	19N31W26ADD1	1,265	120	106.95	1,158.05	4/11/2006
		Washington County, Arkansas					
36.092	94.372	16N32W03CB1	1,163	94	29.28	1,133.72	3/10/2006
35.982	94.121	15N30W12CCD1	1,535	412	161.80	1,373.20	3/28/2006
35.965	94.496	15N33W21CAC1	1,182	100	29.29	1,152.71	3/30/2006
36.170	94.201	17N30W05DCC1	1,322	NA	54.95	1,267.05	4/10/2006
		Cherokee County, Kansas					
37.017	94.696	35S25E05CDDD	886	220	81.90	804.10	3/09/2006
37.010	94.673	35S25E09ACDD	928	208	91.60	836.40	3/07/2006
37.052	94.704	34S25E29CBBB	818	220	30.00	788.00	3/09/2006
37.001	94.630	35S25E13BBBB	1,001	NA	59.40	941.60	3/09/2006
37.015	94.655	35S25E10ABCD	971	263	56.30	914.70	3/17/2006
37.123	94.836	33S23E36DCAA	918	450	88.50	829.50	3/08/2006
37.148	94.785	33S24E28ABBA	869	382	150.90	718.10	3/11/2006
37.073	94.999	34S22E21AACC	812	507	127.90	684.10	3/07/2006
37.141	94.793	33S24E28CBAB*	883	580	181.80	701.20	3/11/2006
37.043	94.653	34S25E34AACC*	850	330	61.00	789.00	3/07/2006
37.237	94.719	32S25E19CCDD*	897	507	168.00	729.00	3/10/2006
37.207	94.986	33S22E03ABBC*	870	807	184.40	685.60	3/11/2006
		Crawford County, Kansas					
37.409	94.883	30S23E27BBDD	912	682	227.60	684.40	3/17/2006
37.403	94.669	30S25E28DAA2	903	NA	251.05	652.05	3/29/2006
		Labette County, Kansas					
37.176	95.124	33S21E17AACD	914	689	243.00	671.00	3/07/2006
37.181	95.112	33S21E09DCCB	880	675	200.60	679.40	3/17/2006
		Barry County, Missouri					
36.564	94.013	21N29W01DAD	1,330	120	31.95	1,298.10	3/08/2006
36.702	93.980	23N28W17CDD	1,475	200	76.70	1,398.30	3/08/2006
36.765	93.942	24N28W27ABB	1,510	110	85.40	1,424.60	3/08/2006
36.650	93.902	22N28W01ADD	1,422	210	70.60	1,351.40	3/09/2006

Appendix 1. Information pertaining to wells completed in the Springfield Plateau aquifer.—Continued

[Horizontal datum is North American Datum of 1983 (NAD 83); Vertical datum is National Geodetic Vertical Datum of 1929 (NGVD 29); NA, not available; *, well completed in the Springfield Plateau and Ozark aquifers]

Latitude (decimal degrees)	Longitude (decimal degrees)	Station name	Land-surface altitude (feet above NGVD of 1929)	Well depth (feet below land surface)	Depth to water (feet below land surface)	Water-level altitude (feet above NGVD of 1929)	Date of measurement
			Barry County, Missouri—Continued				
36.771	94.050	24N29W27AD	1,395	232	125.00	1,270.00	3/09/2006
36.836	93.964	25N28W35DB	1,349	210	41.60	1,307.40	3/10/2006
36.917	93.814	25N26W31DAC	1,452	332	134.70	1,317.30	3/08/2006
36.928	93.890	26N27W33ABB*	1,372	525	95.80	1,276.20	3/08/2006
36.895	93.950	25N28W12BDB*	1,364	398	213.80	1,150.20	3/08/2006
			Barton County, Missouri				
37.396	94.258	31N30W32BAB	995	250	131.40	863.60	3/15/2006
			Cedar County, Missouri				
37.827	94.014	35N28W03CCC	920	NA	85.20	834.80	3/17/2006
			Dade County, Missouri				
37.358	93.749	30N26W01CCD	1,060	285	124.04	935.96	3/16/2006
37.556	93.862	33N27W35ACD	1,028	230	174.30	853.70	3/16/2006
37.367	93.990	30N28W02CBB	1,125	NA	23.10	1,101.90	3/17/2006
37.435	94.036	31N28W08CDC	1,093	425	135.80	957.20	3/17/2006
37.312	93.735	30N25W30BBB	1,157	190	40.48	1,116.52	3/15/2006
37.315	93.736	30N26W24DDD	1,070	150	14.82	1,055.18	3/15/2006
			Geene County, Missouri				
37.237	93.421	NA	1,254	170	69.00	1,185.00	6/16/2006
37.253	93.415	NA	1,230	71	16.40	1,213.60	6/14/2006
37.411	93.521	NA	1,175	NA	43.60	1,131.40	6/20/2006
			Jasper County, Missouri				
37.076	94.381	27N32W12A	1,052	145	76.60	975.40	3/09/2006
37.072	94.447	27N32W08DCA	1,080	359	97.10	982.90	3/09/2006
37.187	94.359	29N31W31CDA	972	195	55.40	916.60	3/09/2006
37.144	94.421	28N32W16DDA	985	220	36.80	948.20	3/10/2006
37.160	94.393	28N32W11DBB	940	180	51.60	888.40	3/10/2006
37.185	94.545	28N33W05AAA	902	265	47.65	854.35	3/09/2006
37.196	94.130	29N29W30DDC	1,120	220	69.60	1,050.40	3/09/2006
37.262	94.395	29N32W02CCA*	950	263	64.30	885.70	3/10/2006
37.262	94.395	29N32W02C	945	NA	46.70	898.30	3/10/2006
37.205	94.225	29N30W29DBB	1,038	200	90.60	947.40	3/16/2006
37.075	94.437	27N32W09CBA	1,035	160	19.20	1,015.80	3/16/2006
37.074	94.447	27N32W08DBD	1,085	400	93.70	991.30	3/16/2006
37.339	94.289	30N31W24ABA	968	NA	16.61	951.39	3/14/2006
37.341	94.328	30N31W15DCD	925	160	25.10	899.90	3/14/2006

Appendix 1. Information pertaining to wells completed in the Springfield Plateau aquifer.—Continued

[Horizontal datum is North American Datum of 1983 (NAD 83); Vertical datum is National Geodetic Vertical Datum of 1929 (NGVD 29); NA, not available; *, well completed in the Springfield Plateau and Ozark aquifers]

Latitude (decimal degrees)	Longitude (decimal degrees)	Station name	Land-surface altitude (feet above NGVD of 1929)	Well depth (feet below land surface)	Depth to water (feet below land surface)	Water-level altitude (feet above NGVD of 1929)	Date of measurement
			Jasper County, Missouri—Continued				
37.162	94.393	28N32W11CAA	950	405	74.30	875.70	3/10/2006
37.239	94.422	29N32W09DDC*	980	605	119.20	860.80	3/10/2006
37.204	94.223	29N30W29DBA*	1,045	450	91.60	953.40	3/16/2006
			Lawrence County, Missouri				
36.932	93.809	26N26W28CBB	1,375	75	62.60	1,312.40	3/14/2006
37.017	93.907	27N27W29CDD	1,338	189	68.00	1,270.00	3/14/2006
37.075	94.016	27N28W08BAB*	1,245	511	166.10	1,078.90	3/14/2006
37.164	94.013	28N28W05CDD*	1,150	450	101.50	1,048.50	3/14/2006
37.010	93.899	27N27W32ADD*	1,330	600	113.90	1,216.10	3/14/2006
37.246	93.949	29N28W11AAC*	1,210	330	119.00	1,091.00	3/15/2006
36.943	93.711	NA	1,517	704	134.90	1,382.10	6/20/2006
37.025	93.631	NA	1,340	549	58.30	1,281.70	6/20/2006
37.071	93.713	NA	1,336	300	168.30	1,167.70	6/20/2006
37.104	93.635	NA	1,247	500	98.50	1,148.50	6/20/2006
36.944	93.770	NA	1,375	200	67.50	1,307.50	3/16/2006
			McDonald County, Missouri				
36.723	94.204	23N30W18AAA*	1,309	200	52.80	1,256.20	3/06/2006
36.742	94.088	23N29W05BDD	1,340	160	74.05	1,265.95	3/06/2006
36.720	94.203	23N30W18AAA	1,299	346	162.98	1,136.02	3/07/2006
36.745	94.417	23N32W06DDD*	1,247	NA	117.90	1,129.10	3/06/2006
36.723	94.206	23N30W18AAA	1,309	660	183.30	1,125.70	3/06/2006
			Newton County, Missouri				
36.868	94.445	25N32W21CCB	1,140	220	112.50	1,027.50	3/06/2006
36.992	94.532	26N33W10BCB	1,110	120	76.50	1,033.50	3/07/2006
36.993	94.533	26N33W10BCB	1,110	130	83.20	1,026.80	3/07/2006
37.016	94.582	27N33W31CAC*	1,040	304	152.20	887.80	3/07/2006
37.008	94.297	27N31W03AAA	1,185	165	58.90	1,126.10	3/08/2006
36.758	94.166	24N30W33DAA	1,252	100	75.20	1,176.80	3/08/2006
36.905	94.481	25N32W07BCB	1,115	200	102.10	1,012.90	3/08/2006
36.752	94.087	24N29W32CAD	1,315	200	49.60	1,265.40	3/06/2006
36.893	94.140	25N30W07DDB	1,220	230	72.60	1,147.40	3/08/2006
37.012	94.542	26N33W04ABB	1,085	180	137.20	947.80	3/16/2006
36.949	94.517	26N33W27ADA	1,185	250	118.20	1,066.80	3/16/2006
36.975	94.527	26N33W15CAA*	1,110	492	119.10	990.90	3/08/2006
36.911	94.343	25N31W05DCB*	1,042	251	55.48	986.52	3/08/2006

Appendix 1. Information pertaining to wells completed in the Springfield Plateau aquifer.—Continued

[Horizontal datum is North American Datum of 1983 (NAD 83); Vertical datum is National Geodetic Vertical Datum of 1929 (NGVD 29); NA, not available; *, well completed in the Springfield Plateau and Ozark aquifers]

Latitude (decimal degrees)	Longitude (decimal degrees)	Station name	Land-surface altitude (feet above NGVD of 1929)	Well depth (feet below land surface)	Depth to water (feet below land surface)	Water-level altitude (feet above NGVD of 1929)	Date of measurement
			Newton County, Missouri—Continued				
36.758	94.166	24N30W33DAA*	1,252	505	76.00	1,176.00	3/08/2006
37.009	94.296	27N31W02BBB*	1,180	430	110.70	1,069.30	3/08/2006
			Vernon County, Missouri				
37.934	94.235	36N30W04ABB	875	NA	16.03	858.97	3/16/2006
			Craig County, Oklahoma				
36.723	95.037	NA	740	NA	127.80	612.20	3/23/2006
36.906	95.033	NA	835	60.5	16.36	818.64	3/29/2006
			Delaware County, Oklahoma				
36.383	94.825	NA	960	200	85.35	874.65	3/21/2006
36.438	94.666	NA	1,080	760	321.50	758.50	3/30/2006
36.591	94.665	NA	885	484	81.02	803.98	3/22/2006
36.202	94.921	NA	1,120	80	50.79	1,069.21	3/24/2006
36.223	94.707	NA	1,140	170	89.67	1,050.33	3/22/2006
36.313	94.992	NA	780	400	21.59	758.41	3/21/2006
			Ottawa County, Oklahoma				
36.982	94.813	NA	830	828	33.05	796.95	3/28/2006
36.987	94.741	NA	840	NA	17.45	822.55	3/28/2006
36.960	94.858	NA	827	289	33.66	793.34	3/23/2006
36.995	94.845	NA	820	116	35.46	784.54	3/23/2006
36.937	94.913	NA	780	17.2	16.23	763.77	3/29/2006
36.921	94.688	NA	929	455	60.00	869.00	2/28/2006
36.930	94.720	NA	860	250	86.00	774.00	3/28/2006
36.810	94.788	NA	810	125	71.30	738.70	3/23/2006
36.930	94.913	NA	780	210	20.10	759.90	3/29/2006
36.816	94.891	NA	805	277	44.98	760.02	3/29/2006
36.764	94.732	NA	900	430	320.60	579.40	3/29/2006

Appendix 2. Information pertaining to wells completed in the Ozark aquifer.

[Horizontal datum is North American Datum of 1983 (NAD 83); Vertical datum is National Geodetic Vertical Datum of 1929 (NGVD 29); NA, not available; *, well completed in the Springfield and Ozark aquifers]

Latitude (decimal degrees)	Longitude (decimal degrees)	Station name	Land- surface altitude (feet above NGVD of 1929)	Well depth (feet below land surface)	Depth to water (feet below land surface)	Water-level altitude (feet above NGVD of 1929)	Date of measurement
			Benton County, Arkansas				
36.335	93.932	19N28W11BAD1	1,260	1,030	202.29	1,057.71	4/04/2006
36.332	94.105	19N29W07DAA1	1,210	1,659	139.10	1,070.90	4/04/2006
36.175	94.425	17N32W06DDA1	1,061	425	86.69	974.31	4/05/2006
36.173	94.426	17N32W06DDD1	1,040	700	156.13	883.87	4/05/2006
36.259	94.440	18N33W01DDD1	1,235	1,235	94.90	1,140.10	4/05/2006
36.262	94.421	18N32W05CBC3	1,205	150	95.15	1,109.85	4/10/2006
36.373	94.288	20N31W28CCA1	1,313	610	82.47	1,230.53	4/11/2006
			Washington County, Arkansas				
36.086	94.378	16N32W09ABD1	1,135	1,815	141.48	993.52	3/10/2006
35.984	94.302	15N31W17BBD1	1,195	2,097	45.70	1,149.30	3/28/2006
36.138	94.031	17N29W13CCC1	1,330	NA	26.66	1,303.34	4/03/2006
36.131	94.234	17N31W24DBD1	1,140	220	68.84	1,071.16	4/17/2006
			Allen County, Kansas				
37.776	95.513	28S17E23ABBA	966	1,501	295.0	671.00	3/03/2006
			Cherokee County, Kansas				
37.093	94.704	34S25E08CBC1	849	NA	132.82	715.93	3/21/2006
37.074	94.693	34S25E20BAB1	825	NA	141.35	683.90	3/21/2006
37.064	94.669	34S25E21DAB1	918	NA	161.40	756.31	3/17/2006
37.060	94.677	34S25E28BBB2	912	NA	136.72	774.99	3/21/2006
37.072	94.632	34S25E23AAD1	961	NA	198.85	761.90	3/29/2006
37.075	94.631	34S25E13CCC4	963	NA	281.33	681.50	3/13/2006
37.089	94.639	34S25E14ABB3	949	NA	145.20	803.80	3/13/2006
37.046	94.737	34S24E36BBA6	822	NA	226.45	595.85	3/17/2006
37.037	94.735	34S24E36CBB5	826	NA	140.72	685.53	3/17/2006
37.075	94.804	34S24E17DCC1	856	NA	183.85	672.32	3/21/2006
37.117	94.675	34S25E04ABA1	853	NA	111.45	741.55	2/28/2006
37.170	94.705	33S25E18DAA1	871	NA	162.46	708.44	3/29/2006
37.180	94.669	33S25E09DAD2	885	NA	110.19	775.01	3/29/2006
37.177	94.843	32S23E13BAA4	894	NA	203.78	690.35	3/21/2006
37.237	94.813	32S24E29BBB1	912	NA	238.58	673.42	3/21/2006
37.313	94.771	31S24E27CDB1	924	NA	253.10	670.98	3/21/2006
37.141	94.793	33S24E28CBAB*	883	580	181.80	701.20	3/11/2006
37.174	94.809	33S24E17BCAA*	896	757	209.20	686.80	3/08/2006

Appendix 2. Information pertaining to wells completed in the Ozark aquifer.—Continued

[Horizontal datum is North American Datum of 1983 (NAD 83); Vertical datum is National Geodetic Vertical Datum of 1929 (NGVD 29); NA, not available; *, well completed in the Springfield and Ozark aquifers]

Latitude (decimal degrees)	Longitude (decimal degrees)	Station name	Land- surface altitude (feet above NGVD of 1929)	Well depth (feet below land surface)	Depth to water (feet below land surface)	Water-level altitude (feet above NGVD of 1929)	Date of measurement
			Crawford County, Kansas				
37.385	94.746	NA	904	1,275	237.00	666.70	3/10/2006
37.464	94.779	29S25E05CDD1	1,021	NA	337.02	683.48	3/20/2006
37.458	94.683	30S25E04CCA1	954	NA	291.19	663.08	3/22/2006
37.398	94.670	30S24E28DDD11	900	NA	252.86	646.84	3/29/2006
37.536	94.742	30S24E21ADA3	922	NA	248.38	673.62	3/20/2006
37.398	94.670	28S25E01ACA2	836	NA	156.79	679.66	3/22/2006
37.457	94.742	30S24E02DDD	948	NA	273.50	674.80	3/29/2006
37.403	94.669	30S25E28DAA1	904	NA	261.97	641.63	3/29/2006
37.411	94.780	30S24E28AAA1	928	NA	249.75	678.55	3/21/2006
37.353	94.778	31S24E16AAA3	909	NA	239.10	670.30	3/21/2006
37.461	94.645	30S25E23CCD1	926	NA	282.24	644.16	3/29/2006
			Labette County, Kansas				
37.018	95.091	35S21E03DCDD	826	1,400	139.90	686.10	3/07/2006
			Neosho County, Kansas				
37.599	95.252	28S20E20BBCB	955	1,300	268.40	686.60	3/09/2006
			Barry County, Missouri				
36.914	93.932	25N27W06BAB	1,287	1,475	417.20	869.80	3/06/2006
36.678	93.842	23N27W27BDC	1,465	1,470	422.90	1,042.10	3/09/2006
36.680	93.869	23N27W29A	1,335	1,200	383.90	951.10	3/09/2006
36.670	93.933	23N28W35BBD	1,501	1,002	277.20	1,223.80	3/09/2006
36.670	93.942	23N28W34ABD	1,555	1,022	337.00	1,218.00	3/09/2006
36.922	93.922	26N27W31DD	1,308	1,400	507.70	800.30	3/06/2006
36.815	93.919	24N27W11ACA	1,467	928	262.70	1,204.30	3/07/2006
36.577	93.815	22N27W35AD	1,042	100	41.90	1,000.10	3/07/2006
36.640	93.637	22N25W4DDB	1,100	380	106.20	993.80	3/07/2006
36.722	93.674	23N25W07ABC	1,222	NA	163.90	1,058.10	3/07/2006
36.825	93.650	24N25W34DAD	1,530	600	297.20	1,232.80	6/21/2006
36.677	93.891	NA	1,460	1500	370.00	1,090.00	3/10/2006
			Barton County, Missouri				
37.394	94.091	31N29W26CDD	1,060	893	263.01	796.99	3/14/2006
37.499	94.269	32N30W30ABB	975	981	296.97	678.03	3/14/2006
37.502	94.307	32N31W26BDD	995	1,200	328.00	665.00	3/15/2006
37.531	94.352	32N31W17AAA	995	900	328.00	665.00	3/15/2006
37.590	94.457	33N32W28BBB	970	905	306.00	662.00	3/15/2006
37.431	94.428	31N32W22AAA	995	900	361.00	632.00	3/15/2006

Appendix 2. Information pertaining to wells completed in the Ozark aquifer.—Continued

[Horizontal datum is North American Datum of 1983 (NAD 83); Vertical datum is National Geodetic Vertical Datum of 1929 (NGVD 29); NA, not available; *, well completed in the Springfield and Ozark aquifers]

Latitude (decimal degrees)	Longitude (decimal degrees)	Station name	Land- surface altitude (feet above NGVD of 1929)	Well depth (feet below land surface)	Depth to water (feet below land surface)	Water-level altitude (feet above NGVD of 1929)	Date of measurement
			Barton County, Missouri—Continued				
37.573	94.245	33N30W29DCD	985	1,135	284.00	699.00	3/15/2006
37.492	94.207	32N30W27ADD	1,030	940	390.00	638.00	3/15/2006
			Cedar County, Missouri				
37.609	94.001	33N28W15BBB	1,065	1,215	317.00	746.00	3/15/2006
37.858	94.017	36N28W28DCA	950	1,007	298.00	650.00	3/17/2006
37.730	93.918	34N28W05CDC*	933	485	228.50	704.50	3/17/2006
37.580	93.973	33N28W23DCC*	952	400	234.10	717.90	3/15/2006
			Christian County, Missouri				
37.031	93.474	27N23W20BDD	1394	1,300	300.00	1,094.00	6/15/2006
			Dade County, Missouri				
37.415	93.848	31N27W24AAC	1,080	1,585	139.30	938.00	3/15/2006
37.479	93.852	32N27W25CDA	1,033	565	249.80	783.20	3/16/2006
37.513	93.808	32N26W17ACD	1,003	700	273.80	729.20	3/16/2006
37.341	93.704	30N25W17ABA	1,065	892	101.60	963.40	3/17/2006
37.293	93.883	30N27W34DAD*	1,128	245	120.40	1,007.60	3/16/2006
37.447	93.897	31N27W09AAA*	940	345	168.87	771.13	3/16/2006
37.326	93.720	30N25W19AAA*	1,130	450	139.80	990.20	3/15/2006
37.476	93.825	32N26W30DDC*	1,000	426	217.00	783.00	3/17/2006
37.549	93.814	33N26W32CCD*	1,035	425	313.10	721.90	3/17/2006
37.349	93.696	30N25W09CBB	1,120	476	296.20	823.80	6/20/2006
37.525	94.003	NA	1,053	560	335.90	717.10	3/17/2006
37.521	93.935	NA	1,040	445	328.80	711.20	3/15/2006
37.333	94.045	30N28W20BBB	1,119	1,153	201.00	916.00	3/15/2006
			Greene County, Missouri				
37.114	93.455	28N23W21CDA	1,281	1,195	338.00	943.00	6/14/2006
37.129	93.497	28N23W18CCB	1,270	500	273.00	997.00	6/14/2006
37.306	93.428	30N23W26ABA	1,240	1,130	302.00	938.00	6/14/2006
37.340	93.564	30N24W10CDB	1,090	565	123.60	966.40	6/16/2006
37.412	93.548	31N24W14CCC	1,212	1,162	96.00	1,116.00	6/13/2006
			Jasper County, Missouri				
37.155	94.438	28N32W17AAA	1,011	1,112	198.00	811.00	3/09/2006
37.188	94.561	29N33W32CCD	920	1,475	220.80	699.20	3/09/2006
37.154	94.547	28N33W17ADD	936	1,600	102.00	832.00	3/09/2006
37.177	94.287	28N31W02CBA	955	1,825	339.00	616.00	3/09/2006
37.242	94.436	29N32W17AAA	964	1,100	225.10	738.90	3/10/2006

Appendix 2. Information pertaining to wells completed in the Ozark aquifer.—Continued

[Horizontal datum is North American Datum of 1983 (NAD 83); Vertical datum is National Geodetic Vertical Datum of 1929 (NGVD 29); NA, not available; *, well completed in the Springfield and Ozark aquifers]

Latitude (decimal degrees)	Longitude (decimal degrees)	Station name	Land- surface altitude (feet above NGVD of 1929)	Well depth (feet below land surface)	Depth to water (feet below land surface)	Water-level altitude (feet above NGVD of 1929)	Date of measurement
			Jasper County, Missouri—Continued				
37.100	94.376	NA	970	1,747	20.57	949.43	3/08/2006
37.060	94.405	NA	1,102	1,445	464.00	638.00	3/09/2006
37.073	94.472	NA	1,098	1,500	521.00	577.00	3/09/2006
			Lawrence County, Missouri				
36.928	93.797	26N26W29DCD	1,402	715	122.30	1,279.70	3/14/2006
36.946	94.003	26N28W21CCD	1,207	1,195	110.50	1,096.50	3/14/2006
37.102	93.944	28N28W36BAC	1,193	1,300	101.80	1,091.20	3/14/2006
37.021	93.897	27N27W28CBB	1,335	932	231.40.	1,103.60	3/14/2006
37.214	93.945	29N28W24BCB	1,238	1,250	169.00	1,069.00	3/14/2006
37.113	93.823	28N26W30BBC	1,240	1,108	216.50	1,023.50	3/15/2006
37.047	93.783	27N26W16CDB	1,202	410	76.50	1,125.50	3/15/2006
37.215	93.836	29N27W24BBD	1,300	1,076	221.40	1,078.60	3/15/2006
37.007	93.723	27N26W36ACD*	1,320	400	207.30	1,112.70	3/15/2006
37.201	93.689	NA	1,040	NA	0.00	1,040.00	3/14/2006
37.167	93.702	28N25W06ADC	1,233	530	113.20	1,119.80	6/21/2006
			McDonald County, Missouri				
36.559	94.485	21N33W10DCD	960	1,240	371.20	586.00	3/07/2006
36.553	94.486	21N33W15ACC	845	800	364.20	480.80	3/07/2006
36.547	94.493	21N33W15DC	992	1,113	344.25	645.00	3/07/2006
36.555	94.488	21N33W15AC	895	1,110	463.64	431.36	3/07/2006
36.543	94.484	21N33W22AAA	830	850	365.10	464.90	3/07/2006
36.539	94.465	21N33W23ADD	875	661	338.75	536.25	3/07/2006
36.544	94.184	21N30W16ACC	1,457	1,575	507.72	807.00	3/07/2006
36.619	94.286	22N31W21ACA*	900	85	17.40	882.60	3/07/2006
36.506	94.246	21N31W36BBB*	1,024	100	27.80	996.20	3/07/2006
36.742	94.429	NA	1,168	500	301.55	866.45	3/06/2006
36.539	94.466	NA	875	382	316.90	558.10	3/07/2006
36.592	94.450	NA	940	420	273.30	666.70	3/07/2006
36.555	94.169	NA	1,440	1,500	600.00	840.00	3/07/2006
36.547	94.315	NA	1,209	1,220	405.00	804.00	3/07/2006
36.501	94.259	NA	1,148	1,750	285.00	863.00	3/07/2006
36.651	94.580	NA	970	900	331.00	639.00	3/07/2006
			Newton County, Missouri				
36.873	94.369	25N31W19BCC	988	1,210	190.00	798.00	3/06/2006
36.790	94.446	24N33W24CDC	1,190	410	325.30	864.70	3/06/2006

Appendix 2. Information pertaining to wells completed in the Ozark aquifer.—Continued

[Horizontal datum is North American Datum of 1983 (NAD 83); Vertical datum is National Geodetic Vertical Datum of 1929 (NGVD 29); NA, not available; *, well completed in the Springfield and Ozark aquifers]

Latitude (decimal degrees)	Longitude (decimal degrees)	Station name	Land- surface altitude (feet above NGVD of 1929)	Well depth (feet below land surface)	Depth to water (feet below land surface)	Water-level altitude (feet above NGVD of 1929)	Date of measurement
Newton County, Missouri—Continued							
37.000	94.491	26N32W10CAC*	1,070	425	176.10	893.90	3/07/2006
37.012	94.520	27N33W34DCD*	975	384	65.10	909.90	3/07/2006
36.774	94.358	24N32W26CCA*	1,095	525	161.10	933.90	3/07/2006
36.988	94.446	26N32W08DAA*	1,000	520	144.10	855.90	3/10/2006
36.818	94.090	24N29W08BBD	1,285	1,070	190.00	1,095.00	3/08/2006
36.761	94.192	NA	1,130	950	211.00	919.00	3/08/2006
36.835	94.605	24N34W09BDB	940	1,456	290.40	649.60	3/08/2006
36.843	94.615	25N34W35DBC	991	1,279	344.30	646.70	3/08/2006
36.945	94.516	26N33W26CBB	1,185	1,580	313.00	872.00	3/16/2006
37.046	94.387	NA	1,126	1,500	304.00	822.00	3/09/2006
37.032	94.369	NA	1,126	1,495	218.00	908.00	3/09/2006
37.054	94.363	NA	1,126	1,518	304.00	822.00	3/09/2006
Polk County, Missouri							
37.457	93.501	32N24W31CAD	1,040	650	247.20	792.80	6/15/2006
37.599	93.442	33N23W10CDC	1,129	1,195	318.00	811.00	6/15/2006
37.603	93.435	33N23W10DAC	1,120	1,200	170.00	950.00	6/15/2006
Vernon County, Missouri							
37.706	94.317	34N31W10DCC	927	950	291.00	633.00	3/16/2006
37.660	94.182	34N30W26DDD	985	1,115	265.00	718.00	3/16/2006
37.798	94.164	35N30W19ADA	890	900	213.00	674.00	3/16/2006
38.018	94.115	38N29W33DDD	758	750	37.35	720.65	3/16/2006
37.794	94.168	35N30W19DBA*	890	800	195.00	695.00	3/16/2006
37.899	94.231	30N36W15BCC*	855	840	147.00	706.00	3/16/2006
37.659	94.298	34N31W35ABD*	912	850	212.50	697.00	3/17/2006
Stone County, Missouri							
36.810	93.458	24N23W06DBB	1,155	500	239.10	915.90	6/20/2006
36.896	93.516	25N24W01CAC3	1,075	200	12.80	1,062.20	6/20/2006
36.902	93.513	25N24W01ACB	1,205	387	146.10	1,058.90	6/20/2006
36.926	93.501	26N23W30CBC	1,152	550	68.50	1,083.50	6/15/2005
37.065	93.557	27N24W09AAD	1,362	1,,190	158.00	1,204.00	6/15/2006
Craig County, Oklahoma							
36.878	95.088	28N21E29	830	600	165.05	664.95	3/24/2006
36.879	95.088	28N21E29	830	1,200	172.75	657.25	3/24/2006
36.802	95.077	27N21E20	795	1,045	296.87	498.13	3/24/2006
36.838	95.119	27N20E12	890	688	211.96	678.04	3/23/2006

Appendix 2. Information pertaining to wells completed in the Ozark aquifer.—Continued

[Horizontal datum is North American Datum of 1983 (NAD 83); Vertical datum is National Geodetic Vertical Datum of 1929 (NGVD 29); NA, not available; *, well completed in the Springfield and Ozark aquifers]

Latitude (decimal degrees)	Longitude (decimal degrees)	Station name	Land- surface altitude (feet above NGVD of 1929)	Well depth (feet below land surface)	Depth to water (feet below land surface)	Water-level altitude (feet above NGVD of 1929)	Date of measurement
			Craig County, Oklahoma—Continued				
36.839	95.119	27N20E12	900	1,091	205.76	694.24	3/23/2006
36.635	95.057	25N21E21	770	487	108.84	661.16	3/23/2006
36.627	95.018	25N21E23	760	600	103.74	656.26	3/23/2006
36.677	95.160	25N20E03	700	600	28.35	671.65	3/23/2006
36.690	95.108	26N20E36	740	770	72.80	667.20	3/23/2006
36.621	95.001	25N21E25	815	720	102.70	712.30	3/15/2006
36.904	95.030	28N21E14	860	NA	92.90	767.10	3/29/2006
			Delaware County, Oklahoma				
36.377	94.938	22N22E22	760	210	30.38	729.62	3/23/2006
36.406	94.825	22N23E11	1,074	1,442	267.52	806.48	3/21/2006
36.586	94.779	24N24E06	840	975	143.52	696.48	3/23/2006
36.425	94.632	23N25E33	1,080	1,160	61.04	1,018.96	3/30/2006
36.263	94.683	NA	1,200	1,790	380.00	820.00	6/01/2006
			Ottawa County, Oklahoma				
36.839	94.748	27N24E08	830	1,030	159.60	670.40	3/23/2006
36.972	94.868	29N22E25	830	1,030	138.00	692.00	3/23/2006
36.693	94.966	26N22E32	780	991	128.27	651.73	3/23/2006
36.875	94.867	28N23E30	770	1,490	379.84	390.16	3/23/2006
36.943	94.798	28N23E02	840	NA	390.35	449.65	3/23/2006

Appendix 3. Information pertaining to springs in the Springfield Plateau aquifer.

[Horizontal datum is North American Datum of 1983 (NAD 83); Vertical datum is National Geodetic Vertical datum of 1929 (NGVD 29)]

Latitude (decimal degrees)	Longitude (decimal degrees)	Water-level altitude (feet above NGVD of 1929)
Benton County, Arkansas		
36.453	94.164	1,210
36.198	94.393	1,060
36.220	94.446	1,120
36.242	94.216	1,150
36.259	94.257	1,145
36.261	94.219	1,100
36.262	94.420	1,200
36.264	93.974	1,280
36.283	94.276	1,138
36.298	93.958	1,160
36.297	94.395	1,300
36.300	94.300	1,200
36.301	94.300	1,198
36.303	94.391	1,330
36.305	94.390	1,330
36.310	94.279	1,170
36.331	94.455	1,250
36.354	94.433	1,200
36.357	94.286	1,259
36.389	94.389	1,058
36.395	94.117	1,190
36.399	94.425	1,100
36.406	94.557	1,120
36.420	94.082	1,190
36.441	94.071	1,340
36.446	94.223	1,085
36.453	94.164	1,210
36.440	94.036	1,386
Washington County, Arkansas		
36.076	94.465	1,040
36.105	94.383	1,200
36.126	94.229	1,125
36.126	94.225	1,140
36.136	94.203	1,150
36.136	94.203	1,150
36.144	94.175	1,250
36.146	94.180	1,292
Washington County, Arkansas—Continued		
36.151	94.240	1,195
36.151	94.240	1,195
36.151	94.293	1,160
36.154	94.225	1,180
36.163	94.225	1,195
36.172	94.085	1,320
36.199	94.323	1,090
36.206	94.235	1,150
36.206	94.235	1,150
36.214	94.155	1,225
Barry County, Missouri		
36.650	93.896	1,360
36.669	93.850	1,360
36.685	93.956	1,450
36.740	93.836	1,250
36.773	94.014	1,280
36.783	94.032	1,250
36.797	93.959	1,350
36.830	94.047	1,200
36.835	94.056	1,210
36.859	94.049	1,180
36.883	94.005	1,230
36.896	94.059	1,160
36.898	94.059	1,152
Cedar County, Missouri		
37.594	93.905	945
37.700	93.796	912
Dade County, Missouri		
37.296	93.645	1,090
37.329	93.825	1,002
37.330	93.825	1,005
37.403	93.881	1,080
37.551	93.660	920
37.561	93.718	908
Jasper County, Missouri		
37.092	94.459	990
37.150	94.525	900

Appendix 3. Information pertaining to springs in the Springfield Plateau aquifer.—Continued

[Horizontal datum is North American Datum of 1983 (NAD 83); Vertical datum is National Geodetic Vertical datum of 1929 (NGVD 29]

Latitude (decimal degrees)	Longitude (decimal degrees)	Water-level altitude (feet above NGVD of 1929)
Jasper County, Missouri—Continued		
37.155	94.187	1,000
37.163	94.513	900
37.222	94.401	900
Lawrence County, Missouri		
36.947	94.007	1,200
36.958	93.802	1,300
37.038	93.654	1,285
37.038	93.654	1,290
37.049	94.007	1,170
37.111	93.880	1,130
37.136	93.708	1,220
37.177	93.731	1,130
37.244	93.632	1,120
37.246	93.729	990
36.964	93.611	1,260
McDonald County, Missouri		
36.656	94.445	900
36.657	94.501	1,020
36.718	94.422	1,080
Newton County, Missouri		
36.807	94.149	1,160
36.815	94.324	1,180
36.817	94.320	1,180
36.853	94.320	1,100
36.864	94.369	1,040
36.870	94.372	1,040
36.874	94.369	1,020
36.946	94.443	995
36.990	94.431	960
37.004	94.458	930
37.021	94.468	940
37.030	94.520	900
37.031	94.086	1,150
37.031	94.521	890
Adair County, Oklahoma		
36.027	94.721	950
36.033	94.727	930
Adair County, Oklahoma—Continued		
36.062	94.776	1,080
36.071	94.681	1,050
36.088	94.593	1,000
36.089	94.600	1,100
36.096	94.649	1,050
36.123	94.661	1,100
36.125	94.703	1,000
36.131	94.653	950
36.140	94.657	1,000
36.145	94.663	939
Delaware County, Oklahoma		
36.172	94.590	1,100
36.546	94.622	950
36.546	94.650	880
36.174	94.668	1,030
36.177	94.803	1,030
36.203	94.750	1,000
36.208	94.867	1,100
36.210	94.704	1,000
36.211	94.617	1,000
36.238	94.666	1,000
36.264	94.725	1,050
36.276	94.663	1,000
36.411	94.789	900
36.463	94.975	800
36.470	94.650	1,100
Mayes County, Oklahoma		
36.192	95.092	850
36.197	95.149	850
36.261	95.006	700
36.281	95.053	800
36.311	95.009	700
36.464	95.031	660
Ottawa County, Oklahoma		
36.783	94.648	845
36.828	94.717	823

Appendix 4. Information pertaining to springs in the Ozark aquifer.

[Horizontal datum is North American Datum of 1983 (NAD 83); Vertical datum is National Geodetic Vertical Datum of 1929 (NGVD 29)]

Latitude (decimal degrees)	Longitude (decimal degrees)	Water-level altitude (feet above NGVD of 1929)
	Benton County, Arkansas	
36.484	94.458	900
36.489	94.471	900
	Barry County, Missouri	
36.592	93.833	1,045
	Lawrence County, Missouri	
37.117	93.681	1,180

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U.S. Geological Survey
Arkansas Water Science Center
401 Hardin Road
Little Rock, AR 72211-3528
(501) 228-3600

http://ar.water.usgs.gov

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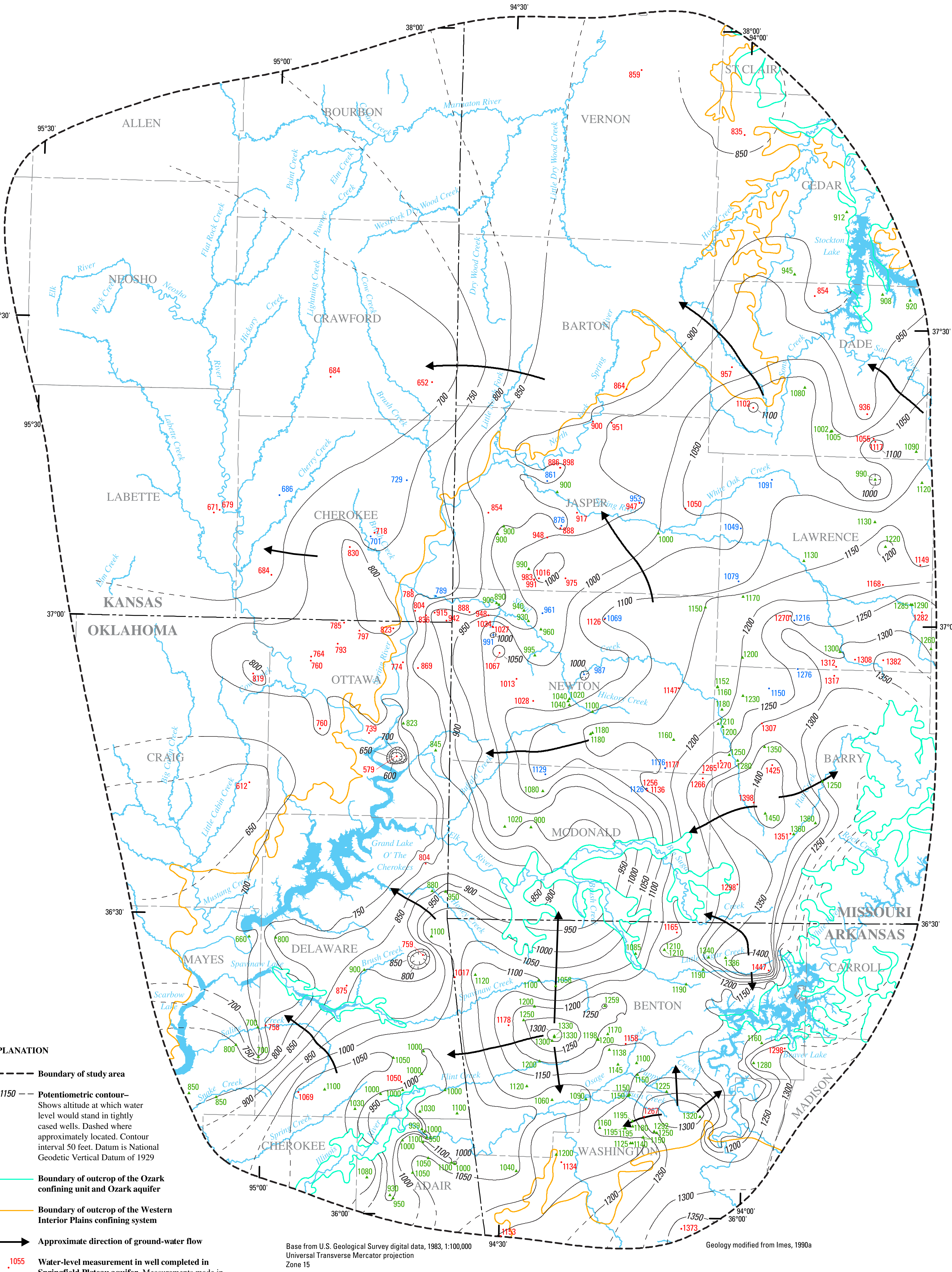

Base from U.S. Geological Survey digital data, 1983, 1:100,000
Universal Transverse Mercator projection
Zone 15

Geology modified from Imes, 1990a

0 10 20 MILES
0 10 20 KILOMETERS

EXPLANATION

Boundary of study area

1150 Potentiometric contour–Shows altitude at which water level would stand in tightly cased wells. Dashed where approximately located. Contour interval 50 feet. Datum is National Geodetic Vertical Datum of 1929

Boundary of outcrop of the Ozark confining unit and Ozark aquifer

Boundary of outcrop of the Western Interior Plains confining system

Approximate direction of ground-water flow

1055 Water-level measurement in well completed in Springfield Plateau aquifer–Measurements made in spring 2006. Value is water-level altitude, in feet. Datum is National Geodetic Vertical Datum of 1929

1150 Water-level measurement in well completed in Springfield Plateau and Ozark aquifers, used for Springfield Plateau aquifer–Measurements made in spring 2006. Value is water-level altitude, in feet. Datum is National Geodetic Vertical Datum of 1929

1152 Water-level altitude of spring in Springfield Plateau aquifer–Value is water-level altitude, in feet. Datum is National Geodetic Vertical Datum of 1929

Potentiometric Surface of the Springfield Plateau Aquifer in Northwestern Arkansas, Southeastern Kansas, Southwestern Missouri, and Northeastern Oklahoma, 2006

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J.A. Gillip, J.B. Czarnecki, and D.N. Mugel
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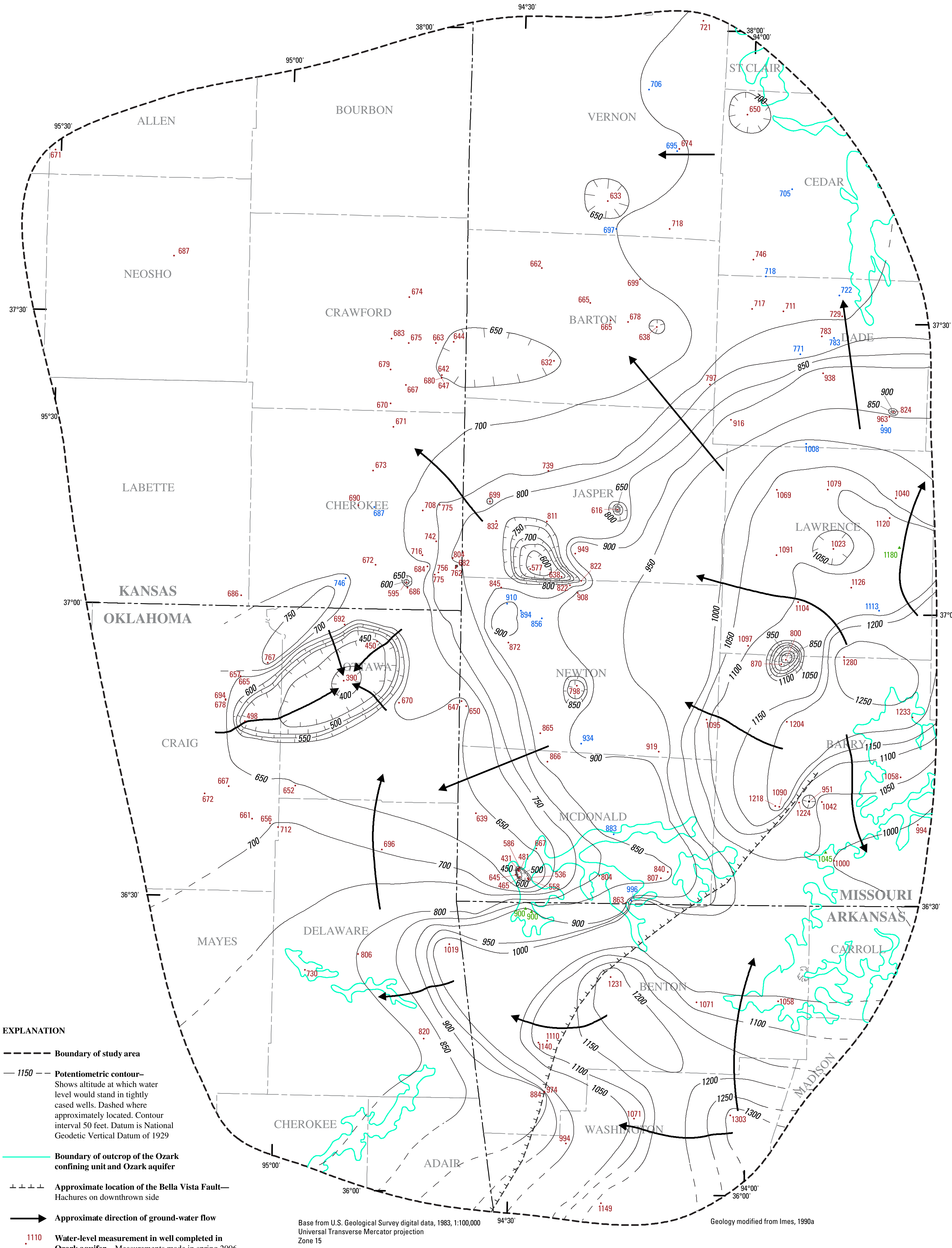

Base from U.S. Geological Survey digital data, 1983, 1:100,000
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EXPLANATION

Boundary of study area

1150 **Potentiometric contour**–Shows altitude at which water level would stand in tightly cased wells. Dashed where approximately located. Contour interval 50 feet. Datum is National Geodetic Vertical Datum of 1929

Boundary of outcrop of the Ozark confining unit and Ozark aquifer

Approximate location of the Bella Vista Fault—Hachures on downthrown side

Approximate direction of ground-water flow

1110 **Water-level measurement in well completed in Ozark aquifer**—Measurements made in spring 2006. Value is water-level altitude, in feet. Datum is National Geodetic Vertical Datum of 1929

934 **Water-level measurement in well completed in Springfield Plateau and Ozark aquifers, used for Ozark aquifer**—Measurements made in spring 2006. Value is water-level altitude, in feet. Datum is National Geodetic Vertical Datum of 1929

900 **Water-level altitude of spring in Ozark aquifer**—Value is water-level altitude, in feet. Datum is National Geodetic Vertical Datum of 1929

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