Information Resources for Groundwater Exploration in the Dakota Aquifer

P. Allen Macfarlane, D. O. Whittemore, and J. H. Doveton

Introduction

Because of water-level declines in the Ogallala aquifer, more and more users are looking at the Dakota aquifer, which lies beneath the Ogallala, as the next potential water source. However, the Dakota is less predictable and more sensitive to heavy development than the Ogallala and other shallower sources of groundwater in Kansas.

The Dakota aquifer system consists of discontinuous sandstone bodies in the subsurface. These ribbon-like sandstone bodies occur sporadically, and the thickness of a given body can vary greatly over distances of less than a mile. At some locations, shallow zones of freshwater are found at the top of the aquifer, whereas at greater depth, salinity makes the groundwater unusable. Depending on the location, freshwater or highly saline water may be found at all levels in the aquifer.

In short, the Dakota's ability to produce water can vary dramatically from place to place. One well may produce large amounts of high-quality water, while a nearby well may be dry, or pump highly saline water. As a result, the search for suitable freshwater-bearing sandstones in the Dakota aquifer can be frustrating and costly, particularly if drilling locations are simply picked at random. To minimize the cost of drilling, and to make drilling more efficient, exploration efforts need to follow a systematic approach that is based on all the available information. Using this approach, the subsurface distribution of sandstone aquifers can be assessed and suitable drilling targets identified.

This publication briefly describes information available from the Kansas Geological Survey and other organizations that can be used to develop a systematic approach to the exploration for groundwater in the Dakota aquifer. Summary descriptions of the sandstone aquifer units and the factors controlling groundwater availability in the Dakota are included for background information. Terms printed in **boldface** type are defined in the Glossary at the end of this publication.

Local Aquifer Units in the Dakota

The Dakota aquifer system consists of three geologic units: the Cheyenne Sandstone, the Kiowa Formation, and the Dakota Formation. These rock layers were deposited during the Cretaceous Period of geologic history, about 100 million years ago; today they crop out or lie beneath much of the western half of the state (fig. 1). The combined thickness of these geologic units reaches a maximum of more than 700 feet (213 m) in parts of west-central Kansas. In Kansas, many of the geologic units in the Dakota aquifer consist largely of shales. These shales are not considered **aquifers** because they have very little pore volume and do not yield significant amounts of water to wells.

Sandstones in the Dakota aquifer, however, can be very porous, hold water, and thus serve as important

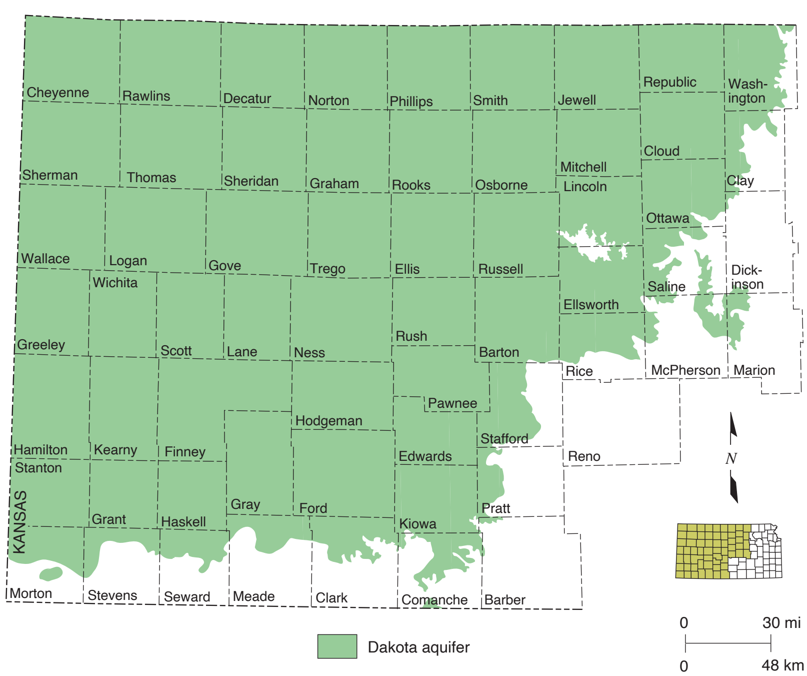

Figure 1. Extent of the Dakota aquifer in Kansas.

aquifers. These sandstone bodies may be up to 100 feet (30.5 m) thick, 1.5 miles (2.4 km) wide, and over 20 miles (32 km) long. Though the sandstone bodies can produce significant amounts of water, they occur sporadically (as shown in the schematic geologic column in fig. 2). The sandstone component of the Dakota ranges from less than 5 percent to more than 50 percent and varies dramatically even over distances of a few miles or less. Within Kansas, sandstone accounts for about 30 percent of the total thickness of the rocks that make up the Dakota aquifer.

The amount of water the Dakota aquifer can yield depends directly on that sandstone. Yields from the Dakota can generally be placed in three categories. First, those that produce less than 50 gallons (189 liters) per minute. Second, those that produce 50 to about 200 gallons (757 liters) per minute. Wells in these two categories are sufficient for low to medium demand, including domestic, stock, industrial, and municipal uses. Wells that yield greater amounts — from 200 up to 1,000 gallons (757–10,000 liters) per minute — have been reported from Washington, Republic, Ford, and Hodgeman counties, where the Dakota is used for irrigation.

Factors Affecting Local Groundwater Availability

The yield of water from a well is affected by the well's design and condition, the pumping equipment, and the aquifer's ability to produce water. In the Dakota, this ability is a function of the thickness of the sandstone units available to the well and the **permeability** of the aquifer. In general, the greater the thickness of sandstone adjacent to the **well screen**, the greater the yield. Field and laboratory testing indicates that sandstones in the Dakota are generally more permeable in central than western Kansas.

The depth to the top of the Dakota from the surface is an important factor in drilling and in the cost of water production. The greater the depth to the aquifer, the greater the amount of energy needed to pump water to the surface, resulting in higher production costs. In northwestern Kansas, the top of the Dakota is more than 2,000 feet (610 m) deep. Where the Dakota is used as a source of water, the top of the aquifer is generally less than 1,000 feet (305 m).

Groundwater **salinity** also affects the water's usefulness (fig. 3). Typically, the freshest water in the Dakota is near the top of the aquifer. Salinity is a particular concern in parts of north-central and northwestern Kansas where the Dakota is unusable for most purposes. However, in southwestern Kansas, the aquifer yields usable water. Even here, treatment may

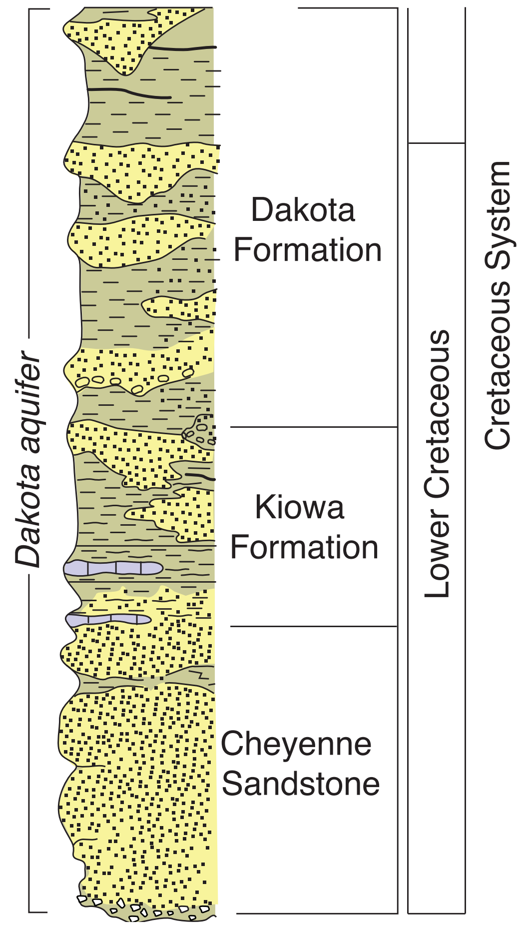

Figure 2. Geologic units of the Dakota aquifer.

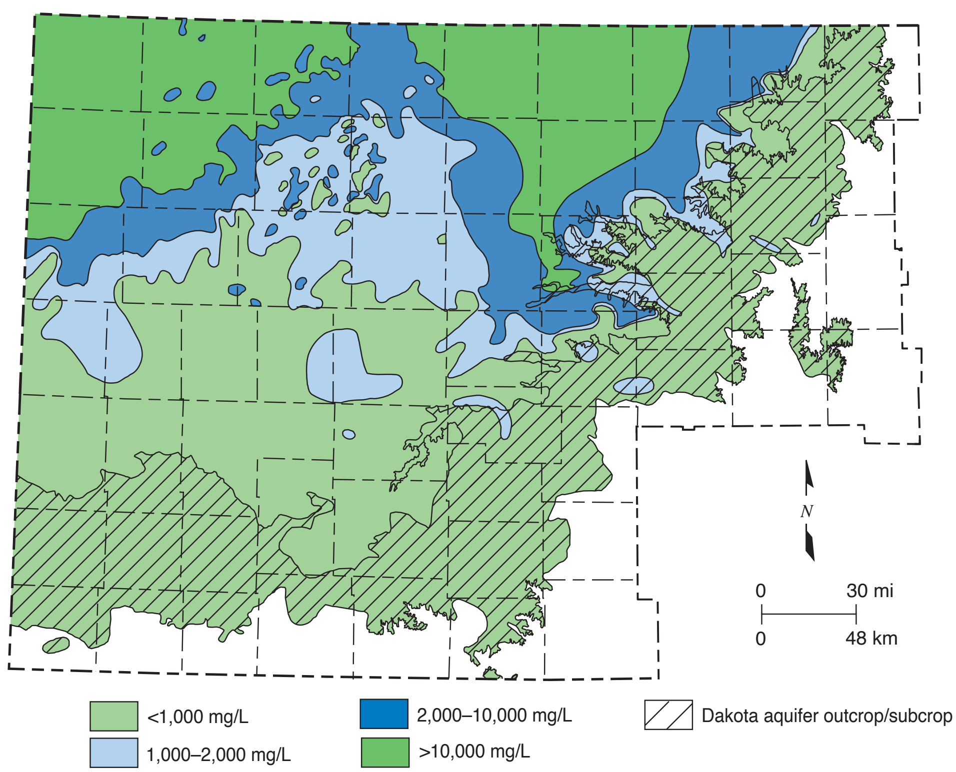

Figure 3. Distribution of total dissolved solids (TDS) concentrations in groundwaters in the upper Dakota aquifer in western and central Kansas.

be required to remove undesirable constituents from the water, such as iron and manganese, or to reduce the dissolved solids levels.

Information Resources at the KGS

The Kansas Geological Survey's Data Resources Library has information about the state's surface and subsurface geology and groundwater resources in the Dakota. This information can be used to locate aquifer zones, determine drilling depth, and, in some instances, to estimate water quality. The Data Resources Library contains driller's logs of water wells drilled prior to 1975; water-well completion records, required by the state since 1975; and geophysical logs of thousands of holes drilled for oil and gas in Kansas.

A driller's log is a written account, kept by the driller, of the rocks encountered during the drilling of a well. The log notes the nature of cuttings (small pieces of rock produced by the drill bit and brought up to the surface during the drilling of the well) that the well encounters. By visually examining these cuttings, the driller can piece together a picture of the rocks that make up the subsurface in the location being drilled. The log also notes the occurrence of groundwater, if any. The quality of logs varies, depending on the driller's knowledge of the local subsurface geology, the quality of the cuttings, and the driller's experience in interpretation. Because these logs are often very general, they may have limited use.

Since 1975, water-well drillers have been required by law to submit driller's logs and well-construction information on WWC-5 (Water Well Record) forms. These records are submitted to the Kansas Department of Health and Environment, and copies are filed at the Survey's Data Resources Library. The upper part of the form indicates the well's location, ownership, depth, type of use, water levels, well yield, and well construction information, such as depth of the intervals at which the well is screened, and the interval at which **gravel pack** was placed between the borehole and the well casing (fig. 4). Although most Dakota wells are gravel packed, a few may be completed without any gravel pack (called open-hole completion), if the sandstone grains are adequately bound by natural cementing agents so as not to collapse the borehole.

The lower part of the WWC-5 form contains the driller's log of the borehole. The source of water for the well can usually be identified by comparing the well-screen and gravel-pack intervals with the driller's log. If the gravel-pack interval spans most of the depth of the well, and the well-screen interval spans only a small portion of the well depth, it may indicate that water is coming into the well from several aquifers.

Landowners who are considering drilling a well into the Dakota may want to acquire copies of the driller's logs and WWC-5 forms for nearby wells. These logs can be used to estimate drilling depths, potential yields, and the types of rocks that will be encountered during drilling. Paper copies are available from the Survey. Some WWC-5 forms are also available electronically through the Survey's website (https://www.kgs.ku.edu/Magellan/WaterWell/index.html).

Geophysical Logs

Geophysical well logs provide useful information about the subsurface. These are graphic charts of the changes in the physical properties of the rocks encountered by wells drilled for oil, gas, or water. These records are made by pulling electrical, acoustic, and nuclear sensing devices through the borehole. Most geophysical well logs are produced for the oil and gas industry; however, many of the rock properties used to locate and describe oil and gas reservoirs are also useful in the search for aquifers containing usable groundwater. These logs provide quantitative information about the subsurface geology, whereas driller's logs usually consist of a generalized, somewhat subjective description of the geologic formations and the groundwater encountered during drilling. Geophysical logs can be used by geohydrologists to identify and map geologic units (such as sandstone bodies) in the subsurface. They can also be used to measure the water-storage capacity of the sandstone and to estimate water quality. Some

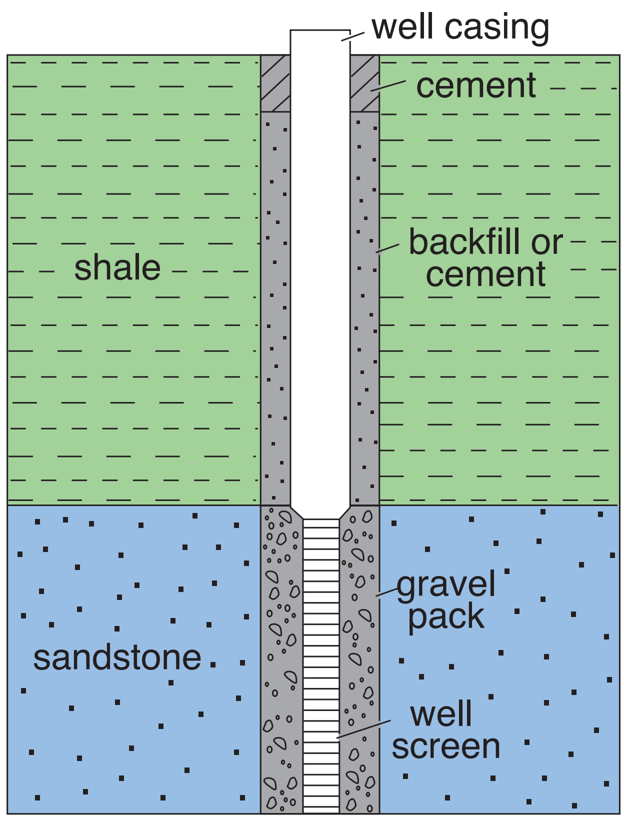

Figure 4. Typical water-well construction in Kansas.

technical training is required for the interpretation of geophysical logs.

One example of a geophysical log is the gamma-ray log, a graph of the natural radioactivity emitted by the rocks encountered by the borehole. Figure 5 is a gamma-ray log of a test hole in Lincoln County that penetrates the geologic units of the Dakota aquifer. Because sandstones generally emit much lower levels of radioactivity than shales, the gamma-ray log is useful for locating sandstone aquifers. The borehole for the well shown in fig. 5 penetrates significant amounts of aquifer-quality sandstone (the shaded intervals on the log). Other geophysical logging sensors (spontaneous potential, resistivity, and porosity) that were used in this location (but not shown in fig. 5) indicate that all of the sandstones, except those near the top, contained saline water. This was later confirmed by pumping tests.

Geophysical Logs on New Wells

A type of well log that is particularly useful for determining water quality is a spontaneous potential or SP log. The sensor that produces this log measures the natural electrical currents that exist near the borehole between the sandstone and the adjacent shale units. The strength and the path taken by those currents is determined by the contrast between the salinity of the drilling mud in the borehole and the groundwater adjacent to the borehole. Thus, the SP measurements on the log can be used to estimate the groundwater salinity if the salinity of the drilling mud in the borehole is known.

Copies of geophysical logs are available, for a fee, from the Kansas Geological Survey and from the Kansas Geological Society, headquartered in Wichita. Landowners who want to acquire copies of those logs will need to provide a legal description of the location where they are considering drilling. By combining the information on the driller's logs, water-well records, and interpretations of nearby geophysical logs, some idea of the depth, thickness, and water quality of subsurface aquifer zones can be obtained.

If economics permit (usually in the case of deeper, high-capacity wells), it may be helpful to run geophysical logs on test holes or new wells. In areas where limited subsurface information is available, geophysical logs may help them determine if additional drilling is warranted. Also, geophysical logs allow the driller or geohydrologist to accurately locate the top and bottom of the sandstone aquifer, and evaluate the quality of each aquifer encountered by the borehole. Without the information provided by these logs, well owners risk screening the wrong intervals in the well (they may screen shale units, which do not produce water, as opposed to the sandstone units, which do produce water), or zones containing saline water may be opened to the well bore. In addition, geophysical logs provide information that makes it possible to more accurately map the extent and thickness of the sandstone aquifers in the subsurface. The cost of a suite of geophysical logs varies according to the depth of the hole and other factors.

Other Sources of Information about the Dakota

When drilling a well in the Dakota, probably the most important source of information is the local water-well driller. Many drillers have a great deal of experience and are extremely familiar with the local geology. They are familiar with the uses and limitations of driller's logs; some water-well drillers also interpret geophysical logs. For a list of licensed water-well drillers in a specific area, contact the Kansas Groundwater Association, the professional association for water-well contractors.

For water users that require larger amounts of water, such as municipalities or rural water districts, or even for some individual landowners, local groundwater consultants may also be helpful. The Kansas Groundwater Association and the Kansas Geological Society can also offer information about geologic consultants who have expertise on subsurface geology of a given area.

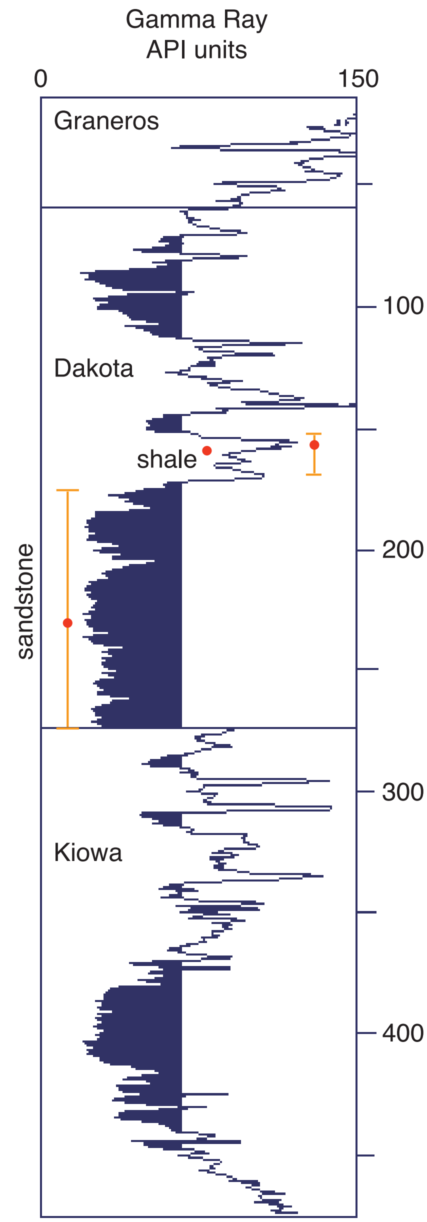

Figure 5. Gamma-ray log of a test hole in the Dakota aquifer in Lincoln County, Kansas. Shaded units are sandstones (potential water-bearing aquifers).

Another important source of information is the state's groundwater management districts. These are local units of government created to provide education and regulation of groundwater use. Five groundwater management districts have been created in the state. Only one, the Southwest Kansas Groundwater Management District #3, headquartered in Garden City, is located in an area where a significant number of wells are drilled into the Dakota aquifer, although a few Dakota wells are covered by parts of the Western Kansas Groundwater Management District #1 (headquartered in Scott City) and the Big Bend Groundwater Management District #5 (headquartered in Stafford). Groundwater management district staff are familiar with the local subsurface geology, groundwater quality problems, and other water issues that landowners encounter.

In some situations, information about current water levels in wells drilled in the Dakota aquifer is also useful for judging the likelihood of obtaining water in a specific location. Water-level information is available in hard copy and electronic form (either CD-ROM or over the World Wide Web) from the Survey. It is also available from the Division of Water Resources of the Kansas Department of Agriculture. The Division also maintains regional offices throughout Kansas that can offer information, particularly related to water quantity.

Additional Information from the Kansas Geological Survey

A User's Guide to the Dakota Aquifer in Kansas, by P. Allen Macfarlane, D. O. Whittemore, and J. H. Doveton (KGS Technical Series 2, in press) [available online]

Kansas Ground Water, compiled by Rex Buchanan and Robert Buddemeier (KGS Educational Series 10)

A User's Guide to Well-Spacing Requirements for the Dakota Aquifer in Kansas, by P. Allen Macfarlane and Robert S. Sawin (KGS Public Information Circular 1)

The Dakota Aquifer System in Kansas, by P. Allen Macfarlane (KGS Public Information Circular 7) and ***The Water-Supply-Suitability Areas of the Dakota Aquifer in Kansas***, by P. Allen Macfarlane (KGS Public Information Circular 8)

Additional information on the Dakota aquifer can be obtained by contacting the Geohydrology Section at the Kansas Geological Survey.

Glossary

Aquifer: A part of a geologic formation (or one or more geologic formations) that is porous and permeable enough to transmit water at a rate sufficient to feed a spring or for economic extraction by a well.

Gravel pack: Coarse sand and gravel placed in the annular space between the borehole and the well casing in the vicinity of the well screen. The purpose of the gravel pack is to minimize the entry of fine sediment into the well, stabilize the borehole, and allow the flow of groundwater into the well.

Permeability: A measure of the ease with which water will move through an aquifer. A geologic unit is **permeable** if groundwater moves easily through it.

Salinity: The sum of the dissolved materials in water expressed in milligrams/liter (mg/L). The upper limit for freshwater is 1,000 mg/L; natural seawater has a salinity of approximately 35,000 mg/L.

Well screen: A slotted section of pipe usually placed in the borehole adjacent to the main aquifer unit or units that supplies the well with water.

Contact Information

Kansas Geological Survey, 1930 Constant Ave., Lawrence, KS 66047; phone 785-864-3965, http://www.kgs.ku.edu/

Kansas Geological Society, 212 North Market, Wichita, KS 67202; phone 316-265-8676, http://www.kgslibrary.com/

Kansas Ground Water Association, P.O. Box 107, Mullinville, KS 67109-0107; phone 316-548-2996, http://www.kgwa.org/

Western Kansas Groundwater Management District #1, Box 604, Scott City, KS 67871; phone 316-872-5563, http://www.gmd1.org/

Southwestern Kansas Groundwater Management District #3, 409B Campus Drive, Garden City, KS 67846; phone 316-275-7147, http://www.gmd3.org/

Big Bend Groundwater Management District #5, P.O. Box 7, 125 South Main, Stafford, KS 67578; phone 316-549-3891, http://www.gmd5.org

Division of Water Resources, Kansas Department of Agriculture, Mills Building, 209 SW 9th, Suite 202, Topeka, KS 66612-1283; phone 785-296-3717

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The Kansas Geological Survey (KGS) is a research and service division of the University of Kansas that investigates and provides information about the state's natural resources. KGS scientists pursue research related to surface and subsurface geology, energy resources, groundwater, and environmental hazards. They develop innovative tools and techniques, monitor earthquakes and groundwater levels, investigate water-quality concerns, and map the state's surface geology.

The KGS has no regulatory authority and does not take positions on natural resource issues. The main headquarters of the KGS is in Lawrence in the West District of the University of Kansas, and the Kansas Geologic Sample Repository of the KGS is in Wichita.

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Kansas Geological Survey
The University of Kansas
1930 Constant Avenue
Lawrence, KS 66047-3724
785-864-3965
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