



Unit 10) Aquifers

Water is necessary for all life, yet many people take it for granted, especially when it is conveniently available for drinking water and other purposes. Water is often unappreciated until it is unavailable or in short supply. In Kansas, many of the water resources are hidden from view—stored in natural underground areas called aquifers.

"Water is the basis of life and the blue arteries of the earth!"
Sandra Postel, American environmentalist

Groundwater, water that can be pumped from a well, is stored underground in a body of rock or other materials called an aquifer. The area included in an aquifer is often determined by underground geologic formations. The storage capacity of an aquifer is determined by its area and qualities of the rock or sediments in the aquifer, including the ability of water to flow through the

WATER WORDS

Aquifer – a natural underground storage area for groundwater.

Groundwater – water that is stored underground.

Porosity – the capacity of a rock formation to absorb and store groundwater.

Permeability – the ability of a material to allow liquid to pass through it.

Water table – the top elevation of water in an aquifer.

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- LOU HINES, CEO, WESTERN SPRINKLERS, INC.

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materials. Aquifer materials may be consolidated, such as rock, or made of unconsolidated materials, such as sand or gravel that are not cemented together. In the rock layers, the rocks are filled with pores or holes that allow the rocks to absorb and store water.

Porosity, the capacity of a rock formation to absorb and store groundwater, is determined by the number and size of the pores. Pores can be microscopic or as large as caverns. Permeability is a description of the ability of fluids to move through porous rock or sediment, directly related to a combination of the size of the pores and the degree to which the pores are interconnected. Materials that allow water to pass through them easily are said to be permeable; those that permit water to pass through only with difficulty or not at all are impermeable.

TYPES OF AQUIFERS

"The work an unknown good man has done is like a vein of water flowing hidden underground, secretly making the ground green."

Thomas Carlyle, Scottish essayist and historian

There are two major types of aquifers beneath most of the land surface of the United States: unconfined and confined.

UNCONFINED AQUIFERS

Unconfined aquifers are the most common. These aquifers do not have rock layers over the top of them that trap or confine the water. Unconsolidated materials, such as sand, gravel, and sediment, cover unconfined aquifers. Water in unconfined aquifers is often considered very young, in geologic time, because it may have arrived recently by percolating through the soil and aquifer layers. The discharge and recharge rates of an unconfined aquifer depend on the hydrologic conditions on the earth's surface above the aquifer, such as rainfall

AQUIFERS IN THE UNITED STATES

Unconfined—most common; water percolates down into the aquifer through the materials covering it; affected by conditions at the earth's surface, such as rainfall and temperature; water flows freely so gravity and atmospheric pressure establishes the water table.

Confined—also known as artesian aquifers; water is trapped beneath impermeable materials under pressure; when an opening is created in the aquifer, pressure causes the water to rise above the top of the aquifer.

and temperature. Water in an unconfined aquifer is free to flow and establish an equilibrium level affected by gravity and atmospheric pressure.

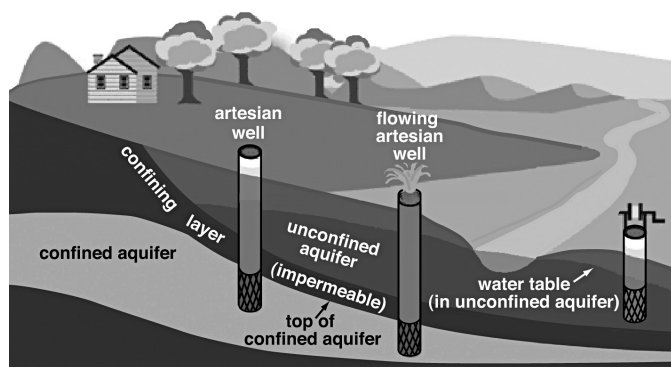
The top elevation of water in an aquifer is called the water table. It may rise or fall depending on precipitation trends. The water table is somewhat parallel to the land surface above the aquifer but it is not always a consistently straight line. When a well is drilled into an unconfined aquifer, the driller will encounter water when the well reaches the water table, which is the approximate level at which water will stand in the well.

CONFINED AQUIFERS

Confined aquifers, sometimes called artesian aquifers, exist where the groundwater is trapped beneath layers of impermeable materials. Water in confined aquifers may be very old, having arrived millions of years ago. Water in a confined aquifer may be under pressure.

A well in a confined aquifer is called an artesian well. When a well is drilled into the aquifer, pressure forces the water upwards. The water in these wells rises above the top of the aquifer because of the pressure; the level to which it rises is called the static water level. If the water level rises above the land surface, a flowing artesian well occurs. Southwestern and central Kansas were once home to numerous flowing artesian wells. The artesian valley of Meade County had a number of flowing wells, and water in one Meade County well rose as high as 17 feet above the land surface. Because of lowered groundwater levels, most of those wells no longer flow at the surface. However, a flowing artesian well still exists at Meade County State Lake. There are also flowing artesian wells in other parts of the state, such as northeastern Stafford County and western Marion County.

CONFINED AND UNCONFINED AQUIFERS



Source: KGS

KANSAS AQUIFERS

Alluvial aquifers—largest and most productive aquifers in Kansas; formed during recent geologic time; found in clay, silt, sand, or gravel deposited by running water in the bed of a stream or on its floodplain.

Bedrock aquifers—water trapped in layers of solid rock; most serve as local sources of water; water quality may vary.

Glacial drift aquifers—found in glacial debris that traps and holds water or in ancient river valleys buried by debris left behind when the continental glaciers melted and receded from northeastern Kansas; do not cover large areas.

KANSAS AQUIFERS

"Look deep, deep into nature, and then you understand everything better."

Albert Einstein, physicist

IDENTIFYING AQUIFERS

There are hundreds of aquifers in Kansas, depending on how the specific aquifers are identified and described. When names of water-bearing rock formations are used in the names of aquifers, it can become confusing. Geologists often define rock layers according to their nature and origin. The smallest possible layer of rock that can be mapped and described over a wide area is called a formation. For example, the Dakota Formation is a layer of sandstone and shale that lies beneath the western two-thirds of Kansas. However, hydrologists use the term "Dakota aquifer" to describe several geologic formations, including the Dakota Formation.

Hydrologists view aquifers according to function and interaction. In a single aquifer, hydrologists may include several geologic formations that were deposited at about the same time in geologic history and have water deposits that are interconnected. The High Plains aquifer in western and central Kansas is a hydrologic feature that includes geologically defined units, such as the Ogallala Formation, and various other units that can be defined either geographically or geologically, such as the Equus Beds aquifer and the Great Bend Prairie aquifer.

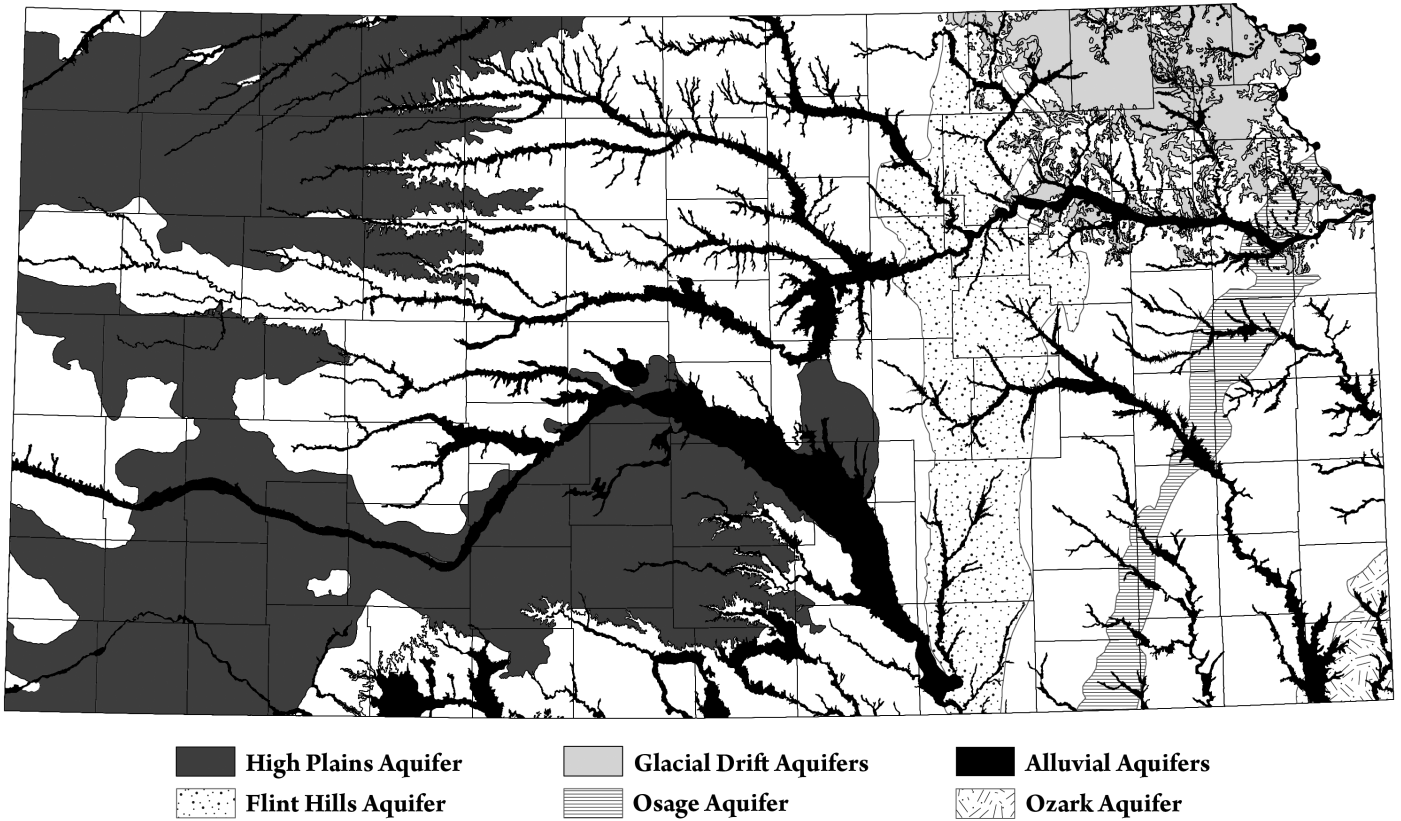
Aquifers in which wells can produce a few gallons per minute (gpm) may be adequate for domestic or livestock water supplies, but they would be inadequate for irrigation or municipal supply use where well yields of thousands of gallons per minute may be required. Likewise, aquifers that discharge water over significantly long periods

DAKOTA AQUIFER



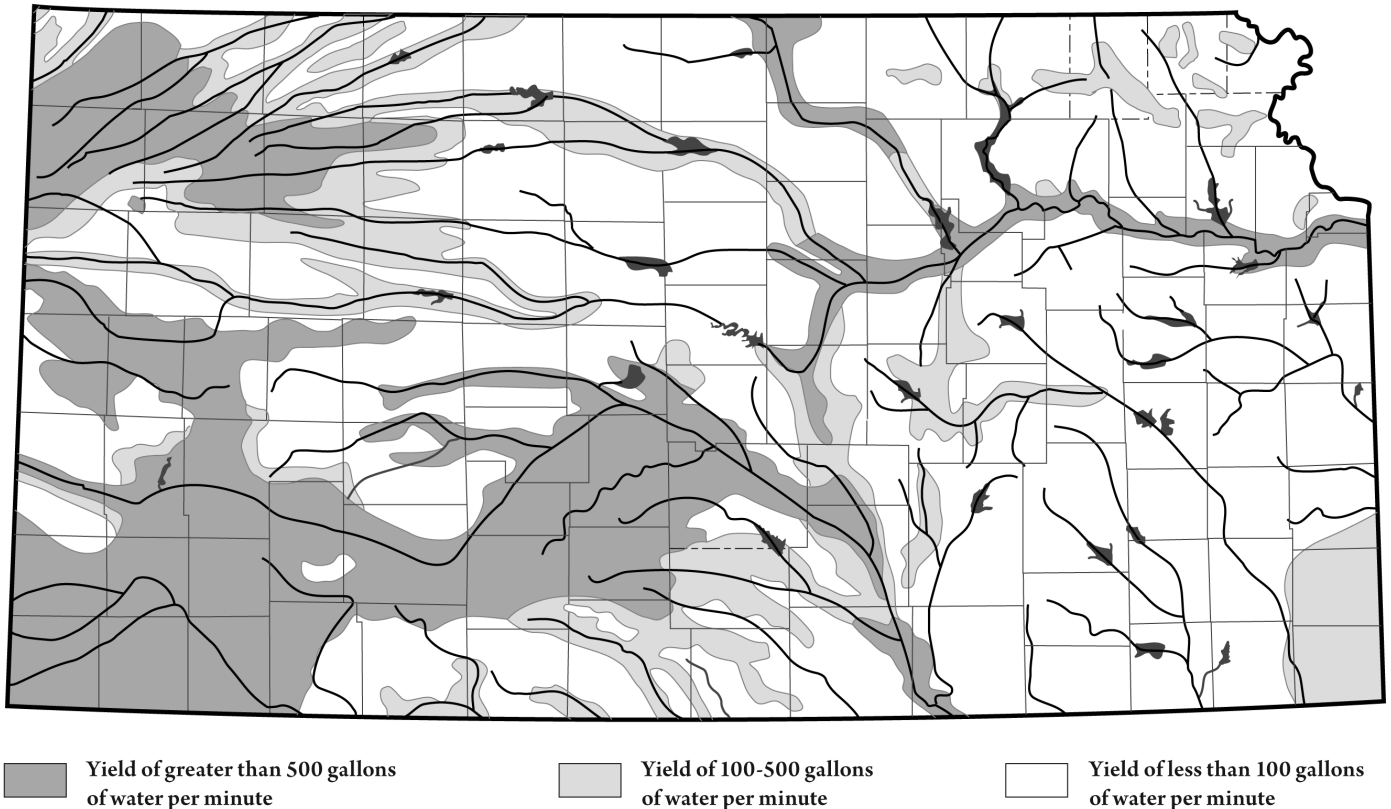
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KANSAS AQUIFERS



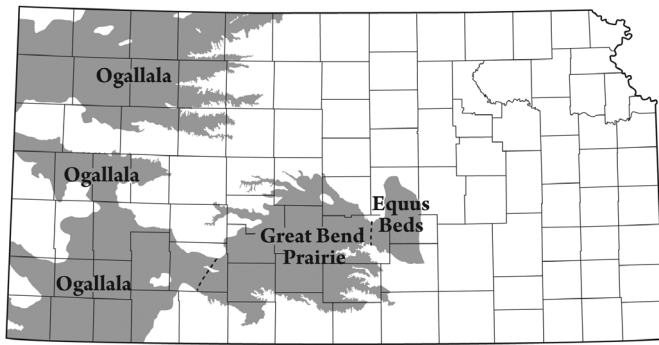
Source: KGS

GENERAL AVAILABILITY OF GROUNDWATER IN KANSAS



Source: KGS

HIGH PLAINS AQUIFER IN KANSAS



Source: KGS

of time may see the water table fall so that some wells stop producing water for a short time period. In both cases, the water-bearing formations may still be called aquifers.

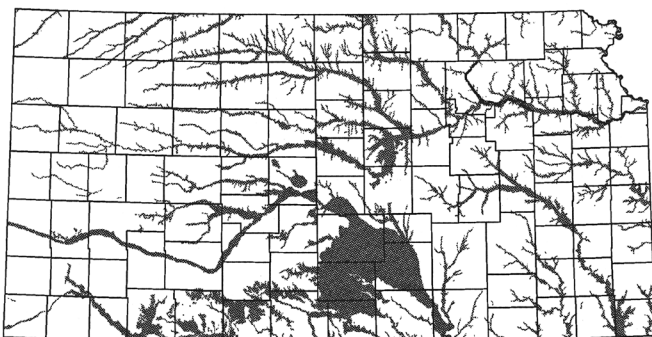
In addition, like mountain peaks, underground features tend to be named by the person who first discovers them. The names of aquifers and rock formations may reflect the background of the person who defined and named the feature.

ALLUVIAL AQUIFERS

Alluvial aquifers are the largest and most productive aquifers in Kansas. In an alluvial aquifer, the water table is usually fairly close to the earth's surface and, in many stream and river valleys, the water in the aquifer is directly connected to the surface water flowing in the stream or river. Most aquifers in Kansas are alluvial aquifers, formed by alluvium. Alluvium is sediment that is loosely arranged but not cemented together—clay, silt, sand, or gravel that was deposited during recent geologic time by running water in the bed of a stream or on its floodplain. These materials, which are not layered, are very permeable. In parts of eastern Kansas, alluvial aquifers are the only significant sources of groundwater. In western Kansas, alluvial aquifers often lie above or intersect with other aquifers.

All the major rivers and many of the smaller streams in Kansas have alluvial deposits associated with them. Rivers, such as the Arkansas and Republican rivers, have material that eroded during the formation of the Rocky Mountains so more coarse sand and gravel deposits are commonly found there. Smaller streams may have more silt or clay material resulting from the erosion of the limestone and shale found in the drainage area of the streams. The thickness of the alluvial material is highly variable, reaching up to 300 feet deep in some of the major river valleys such as the Arkansas.

KANSAS ALLUVIAL AQUIFERS



Source: KGS

THE HIGH PLAINS AQUIFER

The High Plains aquifer is a major regional hydrologic unit that underlies parts of eight states, including Kansas. The High Plains aquifer can be broken down into different geologic aquifer units formed at different times in various locations. The Kansas portion of the High Plains aquifer includes the Ogallala aquifer, Great Bend Prairie aquifer, Equus Beds aquifer, and various alluvial and sand dune aquifers. Streams flowing within, into, or through the state were the main sources of the water trapped in these alluvial aquifers.

The High Plains aquifer is the main source of groundwater for a region that supplies a major portion of the food supply for the United States and the world. The economy of the region depends on the successful production of crops and livestock. Although there was some irrigation beginning in the 1880s, dryland farming (dependent on natural precipitation) was common until after the extreme droughts during the 1930s. Groundwater irrigation intensified in the 1940s and again following a severe drought in the 1950s. The development of center

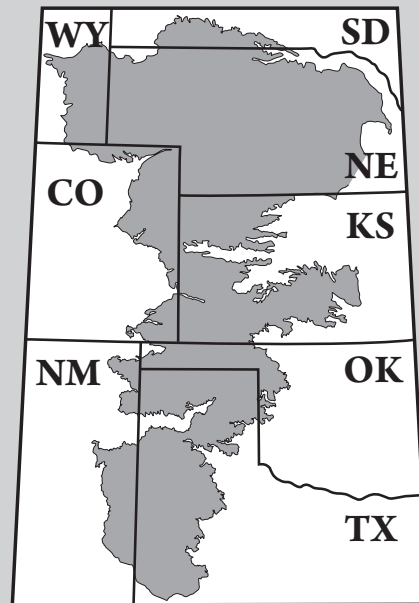
pivot irrigation systems in the 1960s increased the number of wells that were drilled for irrigation purposes. In a center pivot irrigation system, water is pumped from a well through a line of water-distribution pipes mounted on wheels, which rotate or pivot in a circle around the center of the irrigated area.



Irrigation Circle

Credit: USGS

More than 90 percent of the water pumped from the High Plains aquifer is used for irrigation of crops. This aquifer provides about 30 percent of the groundwater used for irrigation in the United States.



Source: KGS

In Kansas, productive alluvial aquifers are associated with the Kansas River (in the river valley from Junction City to Kansas City), the Republican River (from within Republic County to near Clay Center), and the Missouri River (near the junction of the Missouri River and Kansas River at Kansas City). Alluvial aquifers in other river valleys in Kansas, such as the Smoky Hill, Solomon, Saline, Neosho, Marais des Cygnes, and Verdigris, are also important sources

of groundwater. The High Plains aquifer is a major regional aquifer, which can be broken down into separate aquifer units. Alluvial aquifers included in the Kansas portion of the High Plains aquifer include the Ogallala aquifer, Great Bend Prairie aquifer, and the Equus Beds aquifer.

BEDROCK AQUIFERS

The solid rock layer(s) underneath any unconsolidated sediment or soil is bedrock. Bedrock aquifers are the only local sources of groundwater for people living in much of eastern Kansas and parts of central Kansas. Bedrock aquifers are found in the Permian limestones in the Flint Hills, Pennsylvanian sandstones and limestones in eastern Kansas, the sandstones in the Codell Formation in central and west-central Kansas, the Mississippian limestones and the older Ordovician and Cambrian limestones and sandstones in extreme southeastern Kansas. These aquifers—including the Flint Hills, Osage Cuestas, and Ozark aquifer systems—may produce enough water to serve local communities, in addition to individuals living in rural areas.

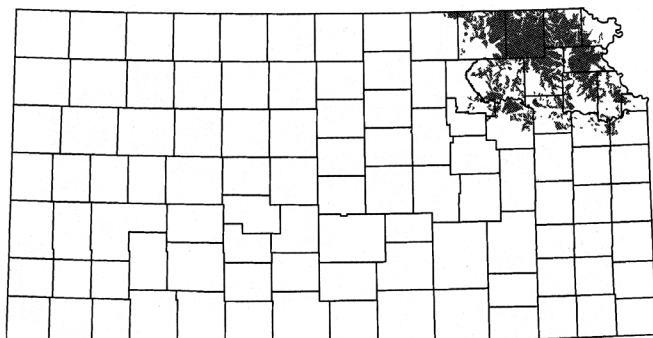
The quality of water in the Dakota aquifer, an important bedrock aquifer in the western two-thirds of Kansas, varies depending upon location. In much of southwestern Kansas, the Dakota aquifer lies beneath the Ogallala Formation of the High Plains aquifer. In places, water moves between the aquifers. In parts of central Kansas, the Dakota aquifer lies above saltwater-bearing aquifers, which recharge the Dakota aquifer and make the Dakota aquifer's water unusable.

GLACIAL DRIFT AQUIFERS

During one of the ice ages, about 750,000 years ago, the northeast corner of the state was invaded by continental glaciers that scraped up and transported large quantities of material ranging in size from boulders to clay. When the ice melted and the glaciers receded, this material was left behind, especially in low-lying areas. These deposits are now common in an area north of the Kansas River to the Nebraska state line and east of Tuttle Creek Lake to the Missouri River. The pore space in this alluvium is excellent at trapping and holding groundwater. These aquifers, however, do not cover large areas.

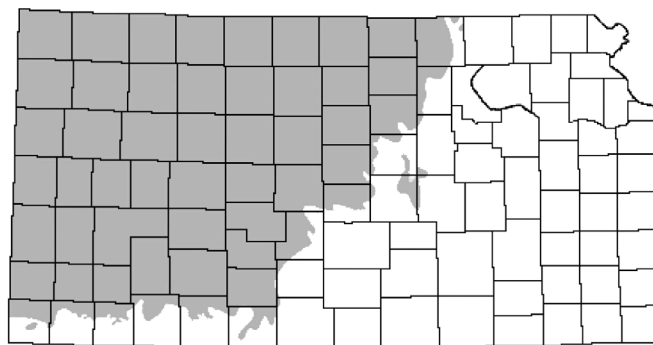
Some of the most prolific water-bearing formations are buried valleys—ancient river valleys partially filled with alluvium that was covered by glacial debris. The materials that filled and buried the valleys range from clay to sand and gravel, and the poorly sorted, coarse-grained deposits at the bottoms of the valleys yield large quantities of generally good-quality water. The buried valleys may be up to several miles wide, 400 feet deep, and tens of miles long.

GLACIAL DRIFT AQUIFERS IN KANSAS



Source: KGS

DAKOTA AQUIFER IN KANSAS



Source: KGS

Depth to reach the water is commonly between five and 50 feet, but may exceed 100 feet. Because these valleys are buried, they are difficult to locate. Published reports, water and oil and gas well records, test drilling, and other techniques are used to map the aquifers.

WATER QUALITY

"We forget that the water cycle and the life cycle are one."

Jacques Yves Cousteau, ocean explorer

Water is never found in a pure state in nature. Both groundwater and surface water may contain many components, including minerals, microorganisms, gases, and inorganic and organic materials. Some are present naturally and others are a result of human activities. The chemical nature of water continually changes as it moves through the water cycle, also called the hydrologic cycle. The most important natural changes in groundwater chemistry occur in the soil. Groundwater may dissolve substances it encounters or it may deposit some of its components along the way. The eventual quality of the groundwater depends on the kinds of rock and soil formations through which it flows.

GROUNDWATER QUALITY IN KANSAS

The quality of water available from aquifers varies. Most aquifers contain freshwater—water suitable for human consumption—but many Kansas aquifers contain and transport poor-quality water or brine, water with a high salt content. These aquifers do not provide water that is usable for human water supplies.

The chemical quality of the water in most alluvial aquifers is acceptable for most purposes. However, saltwater from Permian formations is known to leak into shallow groundwater in the Solomon and Smoky Hill river valleys in Saline and Dickinson counties, in the Cimarron River in southwest Kansas, in the Ninnescah River in south-central Kansas, in the Arkansas River valley downstream from Great Bend, and other areas. Similarly, the Dakota aquifer discharges saltwater into the Saline and Smoky Hill rivers in Russell County and the Solomon River in Mitchell

WATER QUALITY

Brine—water with a high salt content; also known as saltwater.

Total dissolved solids (TDS)—a measurement of the total quantity of minerals in water.

Aquifers

and Ottawa counties. High concentrations of total dissolved solids, a measurement of the total quantity of minerals in water, also are known to be present in the upper Smoky Hill River valley in Logan County and in the Arkansas River alluvial aquifer.

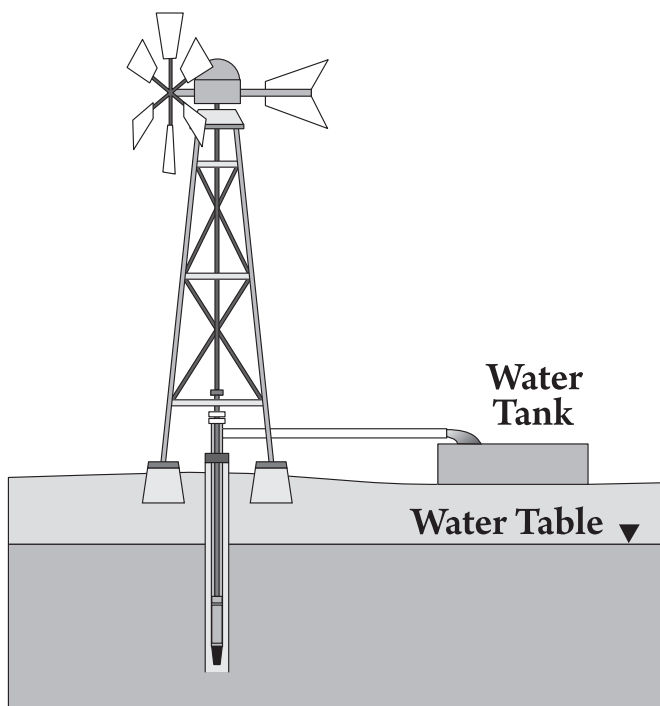
High concentrations of iron, manganese, sulfate, nitrate, chloride, sodium, and total dissolved solids occur in the groundwater in parts of northeastern Kansas. Many of these concentrations result from natural interactions between water and the geological formations, such as the movement of poor-quality water from bedrock surrounding the buried river valleys associated with glacial aquifers. Generally, the only problems that result from these high concentrations are scale deposits, appearance, or taste problems. However, high nitrate concentrations may cause a dangerous condition called cyanosis in infants and some young livestock.

PROTECTING AQUIFERS

Aquifers may be layered, just like the underground rock formations. Any type of opening, such as a water or oil well, that goes through one aquifer to reach a deeper aquifer must be carefully constructed and sealed so that water does not flow between the aquifers. Water quality problems may occur in freshwater supplies when water flows between aquifers if one aquifer produces poor-quality water. This is a common problem in much of central and southeast Kansas.

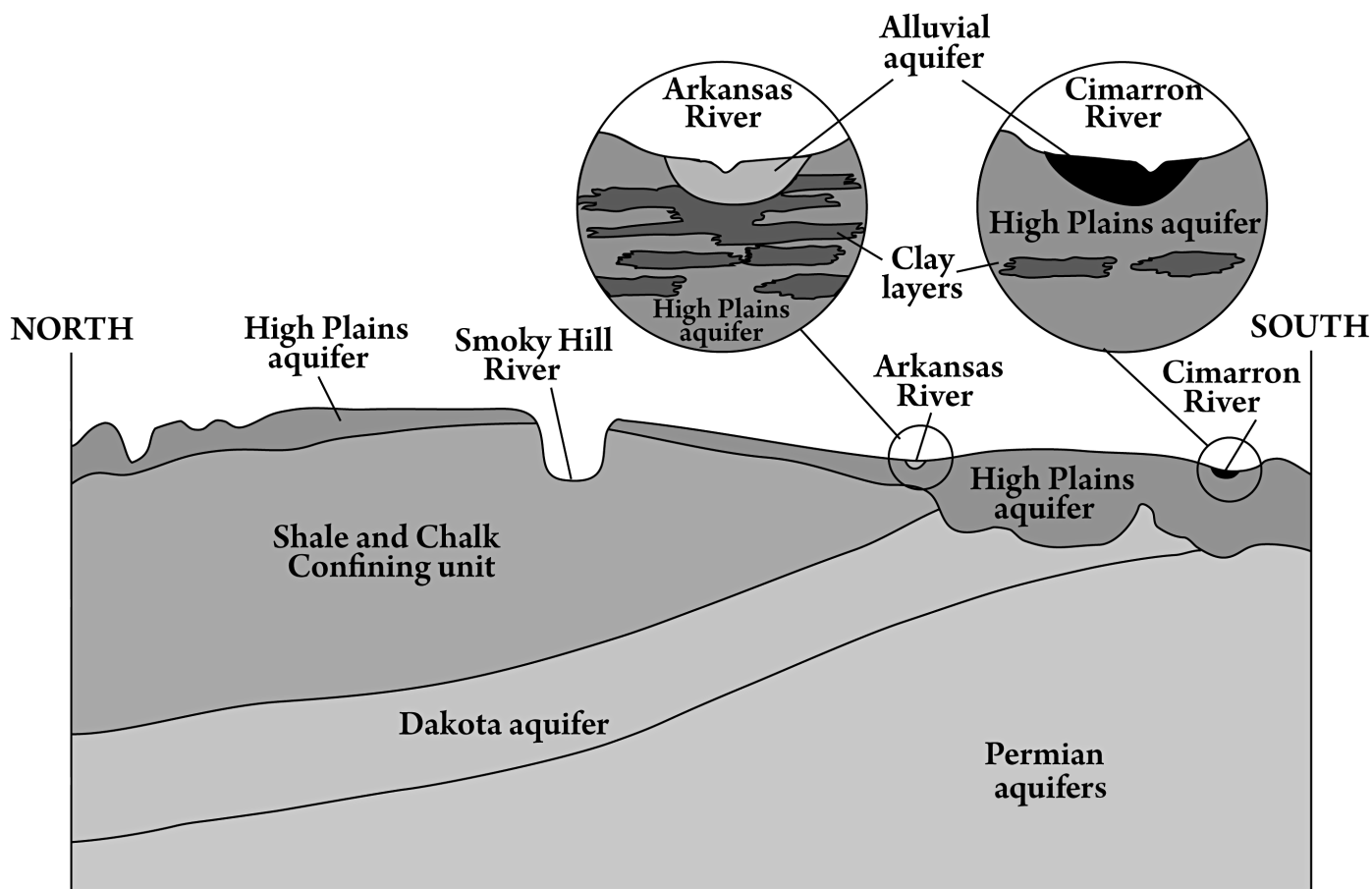
When there is an opening into an aquifer, the potential exists for water quality to be affected. A well, whether drilled to produce water or for monitoring water quality or water levels, provides a

WATER-PUMPING WINDMILL



Source: K-State Research and Extension

WESTERN KANSAS AQUIFERS



Source: KGS

GROUNDWATER SPEED

Water moves at a much slower speed in central and western Kansas aquifers than water flowing across the earth's surface. At the rate of about 1 foot per day, it will take approximately 15 years for groundwater to move a mile or almost 500 years to cross a typical Kansas county.

Source: KGS

direct opening into the aquifer. The construction of the well and the barriers that are constructed to prevent access to the opening are very important. In the past, many wells were drilled and later abandoned. The Kansas Department of Health and Environment (KDHE) estimates that more than 250,000 abandoned wells and test holes exist in Kansas. Kansas law now requires the proper plugging of all abandoned wells and test holes. The construction and plugging of water wells is regulated by KDHE while the Kansas Corporation Commission regulates the plugging of abandoned oil and gas wells.

Mining activities, such as the strip mining of coal or the dredging of sand and gravel, may include the removal of some, or all, layers of materials above an aquifer. When the materials that usually filter water as it moves deeper underground are removed, other measures must be taken to prevent contaminants from moving into the water in the aquifer.

In much of western and central Kansas, aquifers slope or dip down slightly to the east, resulting in a west-to-east flow of the groundwater. The speed at which the water in these aquifers flows is only about one foot per day, much slower than water would flow across the earth's surface. This means that it will take about 15 years for groundwater to move a mile, or almost 500 years to cross a typical county in Kansas. Even so, precautions must be taken to protect the water in the aquifer for use by future generations.

WATER MANAGEMENT

"All water has a perfect memory and is forever trying to get back to where it was."

Toni Morrison, American novelist

An aquifer is a container of a fixed size that can be emptied if water removal (discharge) exceeds water replenishment (recharge). Aquifers are out of sight, often making them difficult to identify and measure. Aquifers are not uniform in thickness, shape, porosity, or permeability. Determining a precise estimate of an aquifer's area, characteristics, or water content is often impractical, especially when the aquifer is deep underground or its characteristics are extremely variable.

RECHARGE OF AQUIFER WATER

Recharge is the movement of water into an aquifer. The primary source of natural recharge is precipitation. Other natural sources of recharge might include seepage from streams, ponds, or lakes or movement of water from one aquifer into another. Recharge determines the amount of groundwater available for use from an aquifer over the long term. The rate of recharge depends on the nature of the rocks, soil, and vegetation that cover the aquifer as well as the climate of the region. The amount of rainfall returned to the atmosphere as a result of evaporation and transpiration of plants ranges from 85 percent in eastern Kansas to as much as 99 percent in some areas of southwestern Kansas. This means that only 1 to 15

BALANCING THE WATER BUDGET

Recharge— water that enters an aquifer.

Discharge— water that is withdrawn or naturally flows out of an aquifer.

Water budget— average balance between recharges and discharges; also known as the water balance.

Sustainable yield— amount of groundwater that can be withdrawn without causing adverse effects to springs, streams, wetlands, or other groundwater-dependent activities.

percent of any rain that falls is available to percolate into an aquifer or flow into streams, wetlands, ponds, or lakes.

Groundwater in very shallow, permeable aquifers may recharge and drain on a time scale of years to decades. Deeper groundwater, sometimes referred to as "fossil water," may be thousands to millions of years old and it may take many years for precipitation at the earth's surface to reach a deep aquifer.

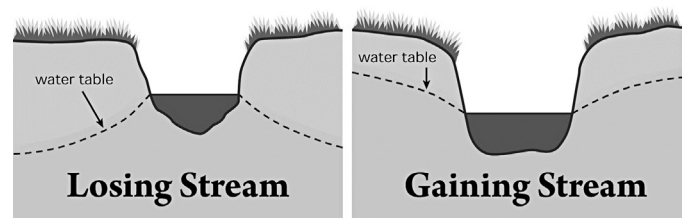
The rate of recharge is difficult to calculate and is made even more difficult by the unpredictability of climatic conditions. Recharge is part of the water balance, or water budget, of an aquifer, which is the average balance between the water that enters the area and the water that is withdrawn or discharges naturally. Hydrologists use water budget calculations in much the same way that homeowners balance their checkbooks or businesses monitor income and expenses. The amount of groundwater that can be withdrawn from an aquifer without causing adverse effects to springs, streams, wetlands, and other groundwater-dependent activities is called the sustainable yield. The sustainable yield is used to monitor and regulate activities that require the use of groundwater.

STREAMFLOW RELATIONSHIP

The general flow of groundwater is downstream. There is a close relationship between streamflow and groundwater in alluvial aquifers, which in turn are often connected to adjacent or underlying aquifers. During times of high streamflow, water often moves out of the stream channel and recharges the alluvial aquifer. When streamflow is low, water may flow back out of the alluvial aquifer and into the stream. This maintains streamflow even in times of little precipitation. However, in locations where the water table in an alluvial aquifer has been lowered, water levels may drop to the point that the aquifer does not replenish the streamflow.

Groundwater contributes to streamflow in many of the streams in eastern Kansas. In western Kansas, however, groundwater levels in many stream valleys have declined to the point where the

STREAM/AQUIFER INTERACTION



Source: FISRWG

Aquifers

groundwater's contribution to the stream is less than in the past. In some places, such as the streams contributing to the Pawnee, Walnut, Smoky Hill, Arkansas, and Solomon rivers, there is no groundwater discharge into the streams and the streams are intermittent, flowing only after runoff from precipitation. This relationship between streamflow and alluvial aquifers, often connected to other groundwater aquifers, emphasizes that groundwater cannot be understood or managed without understanding the larger hydrologic cycle.

CONSERVATION OF WATER RESOURCES

Western Kansas aquifers have been experiencing groundwater decline. While the decline has lessened in recent years, gradual depletion is still occurring in many local areas at the current use rates. Depletion of the groundwater reserves of western Kansas has only a minor direct effect on the availability of water resources in eastern Kansas. However, depletion will cause a loss of economic activity both locally and statewide. Farmers in the affected areas are reducing irrigation water usage through improved management techniques such as the installation of water meters, irrigation scheduling, and improved irrigation efficiency. The most notable evidence of irrigators' efforts is the conversion of flood-irrigated systems to center pivot irrigation, driven in part by a commitment to conservation. In eastern Kansas, many communities' water supplies are from surface water and they have experienced supply shortages during drought years. Population increases in these areas may lead to additional water shortages.



Center Pivot Irrigation

Credit: USGS

Reducing municipal water use is important for several reasons. Since municipal water must be treated before it is distributed to water users (i.e. the public and other water consumers), reducing the amount of water needing to be treated could prolong the life of water treatment systems. Since most surface and groundwater supplies in Kansas are already fully appropriated, reducing per capita consumption may allow a city or town to stay within its water right even with population expansion. Otherwise, additional water rights acquisition may become necessary. The purchase and transfer of water rights is highly regulated and can be quite expensive, in addition to impacting the industries and economy of the affected areas. Every drop saved by every water consumer soon adds up to larger savings for the city or town in many ways.



Hoisington Water Tower

Credit: Wayne Stoskopf

THE IMPORTANCE OF KANSAS AQUIFERS

When comparing the percentage of a state's surface area that is water, only four states have a lower percentage of surface area that is water than Kansas. Precipitation and groundwater make up for the lack of surface water to allow Kansas to be a leading agricultural state while providing the water necessary for the state's population and other industries.

Source: USGS

WATER FOR THE FUTURE

"Soil, water, minerals, vegetation, and animal life—these are the basis of our existence and the measure of our future."

Paul B. Sears, American ecologist and palynologist

At first glance, Kansas may not appear to have much water, certainly not in comparison to other states. According to the U.S. Geological Survey, only four states have a lower percentage of surface area that is water than Kansas. Even so, water is the lifeblood of the agricultural economy in Kansas, a leading agricultural state. Precipitation, in the form of rain and snow, provides much of the water needed to produce food and other agricultural products. Groundwater, stored in aquifers, provides additional water for agricultural, industrial, and municipal water uses. The challenge is to balance the needs of all water uses with the need to conserve water for future generations. Kansans are up to the challenge. ■

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U.S. Geological Survey. *Water Science for Schools*. <<http://www.ga.water.usgs.gov/edu/>>

Waterers and Watering Systems: A Handbook for Livestock Producers and Landowners. Manhattan, Kansas: Kansas State University, January 2007.

TEACHER RESOURCES

BOOKS:

* *Teachers & Advanced Readers; AR - Accelerated Reading Level*

Ellen Fremedon

Givner, Joan. 2004 (AR - 5.4)

Rainmakers – A Photographic Story of Center Pivots

The Groundwater Foundation. 2005

Ryan and Jimmy: And the Well in Africa That Brought Them Together

Shoveller, Herb. 2006 (AR - 5.6)

They Called Her Molly Pitcher

Rockwell, Anne F. 2002 (AR - 5.4)

Water Under Ground

Nadeau, Isaac. 2003 (AR - 5.5)

Career Profile:**MAHBUB ALAM**

***Irrigation and Water Management Specialist
Kansas State University Research and Extension***



Courtesy: Mahbub Alam

Mahbub Alam expresses a joy of learning and a passion for his work. Since 1996, Alam has been an irrigation and water management specialist with Kansas State University Research and Extension. He provides leadership and support for irrigation technology and water management educational programs for county extension agents who provide information directly to agricultural producers. His current educational programs focus on evapotranspiration-based irrigation scheduling, subsurface drip irrigation, and the evaluation of center pivot irrigation systems for water distribution uniformity and efficiency. Alam is active in the Ogallala Initiative Project focusing on water use issues in the Ogallala aquifer. On the international scene, he is involved in international agricultural programs and provides assistance to the Department of Irrigation and Drainage at China Agricultural University in Beijing, China, and the Bangladesh Agricultural Research Council, Dhaka, Bangladesh.

Alam followed in his father's footsteps and aspired to become an engineer as a young man in Pakistan. As he was graduating from his high school studies, he became aware of an opportunity to study abroad on a U.S. scholarship available to students in developing countries. He learned that he could pursue a degree in agriculture engineering. After passing the necessary tests, he chose to attend the American University of Beirut in Beirut, Lebanon. There, at the age of 18, he combined his love for growing things and engineering into studies with a focus on irrigation.

After obtaining his bachelor's degree in agriculture engineering in 1961, Alam returned to his home country to work on a large project in Bangladesh. His challenge was to design a system that would help protect farmers from flooding during the wet season and from drought during the dry season. He and his team were successful in building dams and a canal system that helped stabilize crop production and the local economy. Seeing the positive results of his work with local farmers energized Alam to become even more dedicated in his work in agriculture engineering and irrigation. Several years later, the civil unrest and war in Pakistan destroyed the project his team had worked so hard on. Fortunately, with help from the U.S. Agency for International Development and the Pakistan government, Alam and his team rebuilt the system, much to the relief of local farmers.

Alam returned to the American University of Beirut in Lebanon in the mid-1970s to pursue a masters degree in irrigation engineering. He persevered through a civil war in Lebanon, including several evacuations, and received his degree in 1978. "I would not trade education and its value for the world," says Alam.

Prior to immigrating to the United States, Alam was the principal scientific officer in charge of the Soils and Irrigation Engineering Division for the Bangladesh Agricultural Research Council in Pakistan. Once in the United States, he worked towards his Ph.D. in irrigation at Colorado State University, earning that distinction in 1985. From 1988 to 1995, Alam was on the faculty at Colorado State University and worked as an irrigation specialist for the Colorado River Salinity Control Project.

Alam still has connections and work in Pakistan. As a result of his work in that region, he was selected as a Fulbright Scholar by the U.S. Department of State in 2003. Alam says, "Education is fascinating. It opens the door to the world. It makes you a better person locally and internationally. It helps you expand your horizons and see connections to the whole world."

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WEBSITES:

Division of Water Resources

Kansas Department of Agriculture
www.ksda.gov

Equus Beds Information Resource

www.equusinfo.org/

High Plains/Ogallala Aquifer

Kansas Geological Survey
www.kgs.ku.edu/HighPlains/index.shtml

High Plains Regional Ground Water Study

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http://co.water.usgs.gov/nawqa/hpgw/HPGW_home.html

Kansas Groundwater Management Districts

www.gmdausa.org/ks.htm

Mobile Irrigation Lab

K-State Research & Extension
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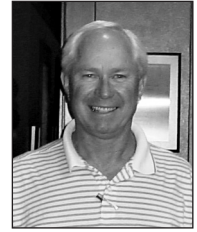
Water Resources Information

Kansas Geological Survey
www.kgs.ku.edu/Hydro/hydroIndex.html

Career Profile:

LOU HINES

Chief Executive Officer, Western Sprinklers, Inc.



Courtesy: Lou Hines

Lou Hines grew up on a small farm but his vision of agriculture was anything but small. Today, Hines is the chief executive officer of Western Sprinklers, an award-winning international business. Western Sprinklers has been named Dealer of the Year two different times by Valmont Irrigation, manufacturer and distributor of Valley® irrigation systems worldwide.

Growing up on a dairy farm in Nebraska, Hines did not intend to have a career in production agriculture. However, he did learn how to set up irrigation systems as a way of earning tuition money for college. Hines believes strongly in leaving home to seek a higher education in a field that interests an individual. He attended Kearney State College (now University of Nebraska at Kearney)—studying biology, math, and chemistry—never realizing that those studies would eventually help him grow his own business. Hines earned a B.S. in education and spent several years teaching junior high math and science and coaching basketball.

His career in education allowed him to work weekends and summers at something he loved just as much as teaching. He quickly learned that drilling irrigation wells and constructing irrigation systems more than paid his living expenses. In 1975, Hines left teaching to develop his own business, Western Sprinklers, Inc., which specializes in the sales, installation, and maintenance of irrigation systems. With offices in Colby and St. Francis, the company now has networks spanning the globe.

Hines says that the opportunity to enter a field he was fascinated with—and constantly learns more about—has influenced his business decisions. “Today’s technology has increased the efficiency of our water use. Moving from flood irrigation to center pivots increased water efficiency by 50 percent. Now, changes in center pivot irrigation systems have increased the efficient use of water by another 30 percent.”

According to Hines, irrigation provides consumers a safe supply of a variety of inexpensive foods. In addition, per acre yields are generally significantly higher on irrigated cropland than dryland. “If we take irrigation out of Kansas, we will have to turn the recreational areas into farmland. It would be unfair to ask the farmers to cut their water use unless we are willing to do the same for water parks, car washes, irrigation of lawns in town and on golf courses, or lower the amounts of water available for swimming pools and hot tubs. Farmers are, after all, growing food, fiber, forests, and fuel for many nations.”

Hines also values the economic contribution of irrigation. “Irrigation brings in additional gross revenues. Every dollar the agricultural producer receives turns over seven times in the community and contributes to the state’s economy,” says Hines.

Even though he left the education system to pursue a career in business, Hines continues to teach and build teams through business networking. Moreover, although he never intended to return to the family farm, he chose to build a business vitally linked to production agriculture. “Proper management of our water and other natural resources is a huge part of the agriculture business. We are living on the land. It would be most unwise of us to not understand our resources and be aware of how to use them efficiently,” says Hines. “Just as teachers are the caretakers of much of the education of our future and its leaders, agriculture must feed, clothe, house, and fuel the citizens of the future.”

NOTES:

Aquifers Showcase:

OGALLALA AQUIFER

The Ogallala aquifer is the largest aquifer included in the High Plains aquifer, which covers parts of eight states. In fact, the High Plains aquifer system was originally known as the Ogallala aquifer until it was determined that the Ogallala Formation was not the only geological formation in the aquifer system. The Kansas portion of the High Plains aquifer accounts for less than 20 percent of the aquifer's total area, although the aquifer underlies 38 percent of the state. In western Kansas, the Ogallala aquifer is generally identical to the High Plains aquifer. However, the part of the High Plains aquifer extending into south-central Kansas (east of Ford County) is divided into the Great Bend Prairie aquifer and the Equus Beds aquifer.

HISTORY

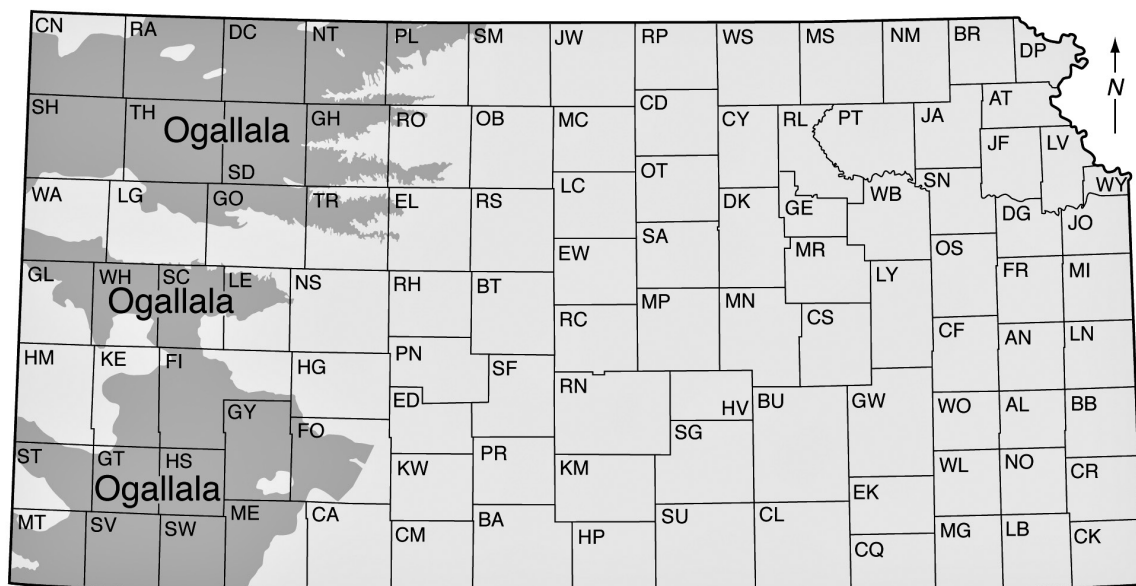
The Ogallala aquifer was named after the town of Ogallala, Nebraska, in 1899. The aquifer formed during the erosion of the newly uplifted Rocky Mountains over 20 million years ago. During this time, streams carried sand and gravel downstream where the sediments formed a sponge-like structure that soaked up rainfall and snowmelt and became what is known as the Ogallala aquifer.

Streams and rivers in western Kansas generally do not provide a reliable source of water since this region receives very little rainfall compared to other areas of the state. When settlers and farmers first came to the region, windmills were used to withdraw water from the aquifer. Crops were dependent on precipitation and often failed. Western Kansas farms were devastated by the extreme prolonged drought of the 1930s. Those conditions led to the development of irrigation technologies that allowed cost-effective drilling and pumping from deep wells. These advancements made it possible for farmers in western Kansas to produce crops despite the lack of rainfall.

In the beginning, irrigation was mainly used to supplement rainfall during dry periods. Another significant drought in the 1950s led to increased irrigation in the 1960s and irrigation became a significant factor in the success of crop production in western Kansas. Irrigation made it possible for crop yields in western Kansas and other states to match or exceed those in states with high annual precipitation, such as Illinois and Ohio. Irrigation provided states such as Kansas and Nebraska the ability to grow the grain needed to feed large livestock operations. Cattle feedlots were located near the grain supplies, which led to the development of beef processing plants and other related industries. Texas, Nebraska, and Kansas became the leading states in beef production. Today, only Texas outranks Kansas in the number of cattle being fed each year.

In Kansas, the Water Appropriation Act became law in 1945. This law established a required permitting process for water wells drilled for non-domestic purposes. Water rights granted by the state give holders the right to use a set quantity of water for a specific purpose each year. In Kansas, water rights are granted on a "first in time, first in right" basis. This principle means that in times of shortage, the earliest water right or permit holders have first rights to use the water. However, later amendments to the law allowed for the establishment of special management areas called Intensive Groundwater Use Control Areas (IGUCAs) where additional actions, rather than only the strict reverse order of priority, can be taken.

By the 1970s, concerns had been raised about the long-term impacts of increased water usage from aquifers all over the United States. Kansas passed legislation, the Groundwater Management District (GMD) Act of 1972, to allow for the local management and regulation of groundwater supplies. The majority of the irrigated acres in the state fall within the boundaries of the five groundwater management districts, three of which regulate water usage in the Ogallala aquifer.



Source: KGS

Ogallala Aquifer (continued)**ECONOMIC IMPACT OF IRRIGATION**

The economic impact of irrigation is significant. Irrigated cropland produces over 21 percent of the total value of crops harvested in Kansas, even though only 14 percent of the harvested cropland is irrigated. About 30 percent of all Kansas farms with harvested cropland include at least some irrigated cropland acres. More than 90 percent of the water pumped from the Ogallala aquifer is used to irrigate crops, such as corn, soybeans, alfalfa, and wheat.

As water levels in the Ogallala aquifer decline or restrictions on water usage are put in place, farmers are faced with difficult decisions. Profit margins are already slim and switching to more efficient irrigation technologies can be expensive. Crops that require less water to grow in western Kansas may not provide the necessary income to sustain a farm family. If irrigated land is converted to dryland, crop production and income will decrease dramatically.

Potential impacts extend beyond the individual farms. Cropland is valued according to its ability to produce crops; therefore, irrigated land is valued higher than dryland. Property taxes would be affected if irrigated land becomes dryland, impacting schools and communities in western Kansas. The decrease in crop production that would result from irrigated land becoming dryland would also result in a decrease in the amount of feed produced near livestock feeding operations. Those feedlots and related industries might choose to move to another area or state closer to necessary feed supplies, resulting in a loss of jobs that would impact the local and state economies in many ways.

Kansas has been grappling with these issues. Groundwater management districts have taken measures to restrict the development of new wells and to decrease the rates of water usage. Water levels and the rate of recharge are constantly monitored and research into aquifer-related issues is ongoing.

Water usage from the Ogallala aquifer actually declined in the 1980s and 1990s. It has stabilized at 1970s levels. However, water levels continue to decline in some parts of the aquifer so additional measures are being considered that will keep the aquifer viable as a water resource for future generations.

