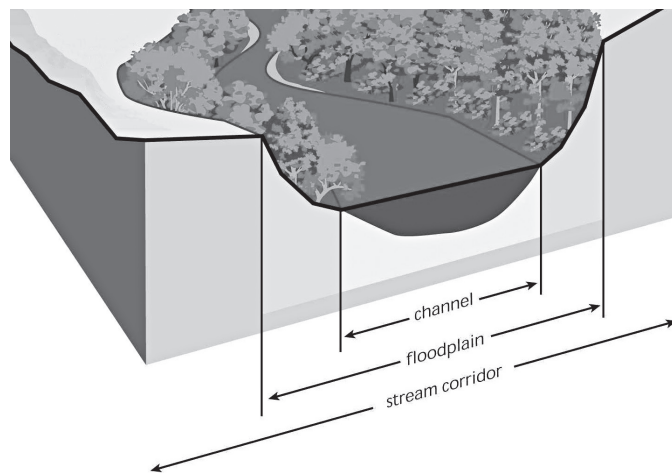




# Unit 7) Streams & Rivers

The U.S. Geological Survey defines all bodies of water flowing in a line as "streams," making no distinction between streams and rivers. Even so, most people use the term "river" to describe larger streams with tributaries. A stream (or river) is a body of water confined within two banks and a bed (bottom). A stream provides a physical path for flowing water through a depression, called a channel. The flow of a stream or river refers to the movement and volume of water that forms the channel of a stream. The sides, or banks, of the channel, are described as "right" or "left"—determined by which side of the water they are on when you are facing downstream. The slope of a streambank or riverbank describes the angle of the bank when compared to a flat surface. The volume of water passing a specific point in a stream's channel during a specified length of time is the "discharge," generally measured in meters per second.

Though once considered part of the Great American Desert, there are 134,458 miles of streams and rivers in Kansas. This includes 120



**Stream Labels**

Source: FISRWG

## INTRODUCTION

- KANSAS HISTORY

## CLASSIFYING STREAMS AND RIVERS

- NAMES
- STREAM ORDER
- DEVELOPMENTAL STAGE

## WATERSHEDS AND RIVER BASINS

- WATERSHEDS
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- ORIGINS
- EXPLORING RIVERS IN KANSAS

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- BACTERIA IN SURFACE WATER

## CHANNELS OF LIFE

## CAREER PROFILES

- KEN SHERRADEN, BIOLOGIST
- LEE ROLFS, ATTORNEY, KANSAS DEPARTMENT OF AGRICULTURE

## SHOWCASE

- SMOKY HILL RIVER

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## Streams & Rivers

miles of streams and rivers that form the state's borders and another 134,338 miles of streams and rivers inside the state's boundaries.

The Great Seal of the state of Kansas, reproduced in the center of the state flag, reflects the importance of streams and rivers in the state's history. The state seal, adopted by the Kansas Legislature in 1861, depicts "commerce" with a river and steamboat. Agriculture, representing the "basis of the future prosperity of the state," is portrayed on the state seal by a settler's cabin and a man plowing with horses. Although tractors have replaced horses and steamboats no longer travel up Kansas rivers, both agriculture and the state's streams and rivers are still very important to the state's economy and the health and well-being of the state's citizens.



*"To the lost man, to the pioneer penetrating a new country, to the naturalist who wishes to see the wild land at its wildest, the advice is always the same—follow a river. The river is the original forest highway. It is nature's own Wilderness Road."*

Edwin Way Teale, naturalist, writer, and photographer

Streams and rivers are critical links in the hydrologic (water) cycle. They are the links between precipitation (rain, ice, or snow) that falls over land and the water in the oceans. Water from rain, ice, or snow that does not soak into the soil becomes runoff, draining into nearby streams.



Missouri River, Leavenworth County

Credit: John Charlton, KGS

Those streams flow downhill, forming larger streams and rivers. Water in the rivers eventually flows into the oceans, the main reservoirs for the world's water supplies.

Rivers, streams, and associated riparian areas are vital natural resources. They provide drinking water for people and animals, as well as water for personal uses (showering, washing clothes, etc.), irrigation (lawns, golf courses, and agricultural crops), cooling systems for industrial equipment, the generation of electricity, and recreational activities, such as canoeing, camping, and fishing. Riverbeds and nearby floodplains provide materials for building roads and other construction purposes.

## DREDGING

Sand and gravel are dredged (mined) from riverbeds and nearby floodplains to provide materials for construction purposes and building roads. According to the Kansas Geological Survey, people living in the corridor from Topeka to Kansas City use more than two million tons of sand and gravel each year. In many Kansas rivers, the amount of sand that may be removed is limited to the amount of recharge—sand that will accumulate and gradually fill in the empty space over time.

## KANSAS HISTORY

Streams and rivers played an important role in the development of the United States. In the absence of roads, early explorers and settlers followed streams and rivers. As the country expanded, rivers became the "highways" used to transport people and goods back and forth between the frontier and cities and towns.

Rivers played an important role in the exploration of the state of Kansas. When the United States acquired the Louisiana Purchase in 1803, President Jefferson sent Meriwether Lewis and William Clark up the Missouri River to the northwest to find a route to the Pacific Ocean. One result of Lewis and Clark's explorations was the Oregon Trail, which crossed northeast Kansas. The southwestern region of the Louisiana Purchase was first explored by Lt. Zebulon Pike's expedition in 1806. Lt. Pike's orders included finding the source of the Arkansas River and an overland route to Santa Fe. Pike's expedition paved the way for the Santa Fe Trail, which followed the Arkansas and Cimarron rivers across central and western Kansas.

Rivers played a role in the development of Kansas as well. The Kansas River was a supply route for Fort Riley, where the first territorial capital of Kansas was located. In 1855, a steamboat from Cincinnati, Ohio, ran aground on a sandbar in the Kansas River near the townsite of New Boston, Kansas. The steamboat was carrying building materials for the development of a new town in central Kansas. Instead, the people onboard were convinced to stay where they had run aground and New Boston was renamed "Manhattan." Kansas rivers were used to transport many materials in the mid to late 1800s. For example, the railroad ties used to build railroads across central and western Kansas were made from trees harvested in the mountains of Colorado. Then the railroad ties were bundled together and floated down the Arkansas River to points as far east as Great Bend, Kansas.

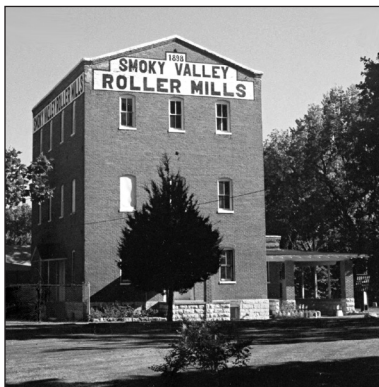
In Kansas, early settlers used the power of the water flowing in rivers and streams to operate gristmills, flour mills and sawmills. The first mill in the state was located at Auburn, operating around the

## LEWIS AND CLARK TRAIL

As early as 1792, Thomas Jefferson proposed an expedition to find a water route to the Pacific Ocean in the northwest. Once the United States acquired the Louisiana Purchase, the expedition became a reality. On May 14, 1804, Meriwether Lewis and William Clark started up the Missouri River on their way to the Pacific Ocean.

Today, K-7 (Kansas Highway 7) follows the Lewis and Clark Trail from Leavenworth to White Cloud. In places, the bluffs along the Missouri River rise more than 200 feet. Along those bluffs, the Four-State Lookout at White Cloud offers a panoramic view of the Missouri River and four states: Kansas, Missouri, Nebraska, and Iowa.

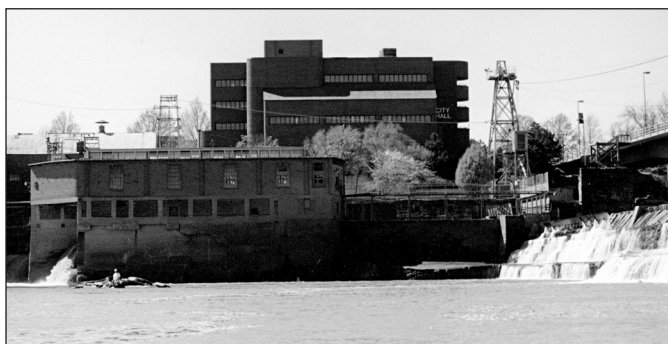
clock—as a sawmill during the day and grinding corn at night.<sup>1</sup> The father of William F. (Buffalo Bill) Cody was a partner in a mill at Valley Falls, erected in 1855 on the Grasshopper River (later renamed the Delaware River). That mill started out as a sawmill, developed into a gristmill, later operated a cotton gin, and added a woolen mill before it closed. Today, the millstones from those early mills can be found in the Valley Falls public parks. In the early days of Kansas, the federal government established five mills at military posts and two at Indian missions.<sup>2</sup> Traces of early dams and mill sites can still be found across Kansas. Once a year, the Smoky Valley Roller Mill at Lindsborg hosts a "Millfest." This mill, located on the Smoky Hill River, was built in 1898 and operated until 1955. Restoration was completed in 1981. It is located on the site of an earlier mill built in 1872. Other Kansas mills built in the 1870s that are still open to visitors include the 1875 Drinkwater & Schriver Flour Mill at Cedar Point on the Cottonwood River and the Old Oxford Mill in Sumner County, built on the Arkansas River in 1874.



**Smoky Valley Roller Mill, Lindsborg**

Credit: Tom Jaderborg;

Hydroelectric power, harnessing the forces of water to produce electrical energy, started in the mid-1800s. The United States is second only to Canada in the production of energy from hydropower, although other countries depend on hydroelectric power for a much higher percentage of their energy needs. Today, according to the U.S. Geological Survey, hydroelectric plants produce around 10 percent of the energy produced in the United States. The only hydroelectric facility in Kansas is the Bowersock Mills & Power Company on the Kansas River in Lawrence. Built in 1874, power production began at the facility in 1888. Some of the turbines in use at the Bowersock facility have been producing electricity since 1920 and are believed to be the oldest active electrical power-producing units in the United States.

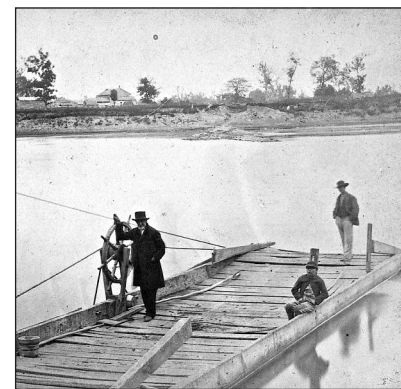


**Bowersock Mills & Power Company, Lawrence**

Courtesy: Bowersock Mills & Power Company

In Kansas, the location of towns and cities depended upon the availability of water. Some of the earliest towns were located at the sites of river crossings or early ferries. Ferries, which transported people, animals, and goods from one side of the river to the other, were used in Kansas before bridges were built. At one time, there

were at least 400 licensed ferries in the state of Kansas, including 103 ferries on the Kansas River.<sup>3</sup> Early towns were also established at the junctions of rivers or streams. Junction City is located at the "junction" of the Republican and Smoky Hill rivers. Many towns and counties took their names from the rivers, such as Republic County (Republican River), Cottonwood Falls (Cottonwood River), Salina (pronounced *suh-line-uh*) on the Saline (pronounced *suh-lean*) River, and Great Bend, which is located on a natural bend of the Arkansas River. In Kansas, the Arkansas River is generally pronounced *ar-kansas* even though it is pronounced *ar-kan-saw* by many outside the state of Kansas.



**River Ferry, 1867**

Source: Kansas State Historical Society

## CLASSIFYING STREAMS AND RIVERS

*"A river seems a magic thing. A magic, moving, living part of the very earth itself."*

Laura Gilpin, American landscape photographer

According to the Kansas Secretary of State's office, there are more than 50,000 streams large enough to be named in the state of Kansas. There are several ways to classify streams and rivers, including by size (water flow) and age.

### NAMES

All "linear flowing bodies of water" are classified as "streams" in the U.S. Geological Survey's official standard for geographic name use—the Geographic Names Information System (GNIS). However, when Kansas streams were first given names, large streams were usually designated as "rivers" and their tributaries were called "creeks." A tributary is a stream that flows into a larger body of water, such as a larger stream, a river, or a lake. In other areas of the United States, a smaller stream might be called a "brook" or "run," rather than "creek."

Kansas streams have some very interesting names, such as Chigger Creek, Granny Branch, Monkey Run, and Blaze Fork. There is a stream name for every letter in the alphabet, beginning with Acker Creek and ending with Zenithscak Creek. All but a few of the streams in Kansas are called creeks. There are 42 Dry Creeks and 42 Sandy Creeks but only 34 Rock Creeks and 20 Mud Creeks in the state. There are 14 Lost Creeks but only one Lost Shirt Creek. There are 10 streams named School Creek but Spring Creek is the most popular name, with 78 streams named Spring Creek in the state of Kansas.

### STREAM ORDER

Robert E. Horton is considered by many to be the father of modern hydrology, the science of water resources. During the 1930s, Horton introduced a system called "stream order" which labels tributaries within a river system according to how many levels of other tributaries have contributed to their flow. For example, a small stream with no tributaries would be a "first order" stream. When two "first order" streams join together, the result is a "second

**UNDERSTANDING STREAM ECOSYSTEMS**

**Stream**— a body of water confined within two banks and a bed (bottom); provides a physical path for flowing water through a channel.

**River**— often used to describe a larger stream with many tributaries.

**Tributary**— a stream that flows into a larger body of water, such as a larger stream, river, or lake.

**Stream corridor**— the stream valley; the ecosystem that includes the stream and the land, plants and animals associated with that stream or river.

**Floodplain**— the relatively level area bordering a stream or river that is covered by water during moderate to severe flooding.

**Riparian**— situated along or near the bank of a body of water, such as a stream or river; includes the adjoining floodplain.

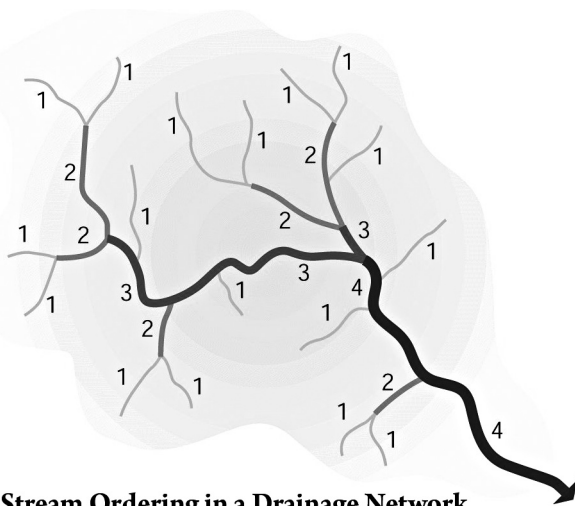
**Riparian area**— an area of vegetation supported by an adjacent stream, river, or other body of water.

**Riparian buffer**— strips or small areas of land in permanent vegetation that trap sediment, filter nutrients, and provide habitat for wildlife.

**Riparian forest buffer**— an area of trees and shrubs located adjacent to streams, lakes, ponds, and wetlands.

**Filter strip**— a strip of grasses, legumes, forbs, or small grains planted to filter potential contaminants in runoff moving toward surface waters.

order" stream; a "third" order" stream results from the joining of "second order" streams, and so on. Beginning with the "second order," streams may have multiple lower ranked tributaries. In general, the size of a stream's watershed (drainage basin) increases as the "order" designation goes higher. When two or more streams meet and begin flowing together or form a new stream, the place where the streams join together is called their "confluence." Above their confluence a



**Stream Ordering in a Drainage Network**  
**1 = first order stream; 2 = second order stream; etc.**

Source: FISRWG

**Confluence**—the place where two or more streams meet and begin flowing together.

few miles southeast of Emporia, the Cottonwood and Neosho rivers are "fourth order" streams. Below the confluence, the Neosho River becomes a "fifth order" stream. The Mississippi River is classified as a "tenth order" stream, the highest order designated for any river in North America. <sup>4</sup>

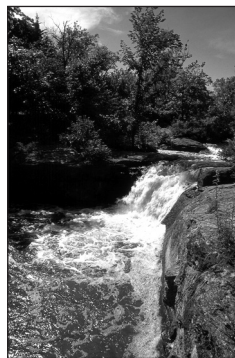
**DEVELOPMENTAL STAGES**

Every stream and river goes through similar developmental stages—youth, maturity, and old age. The time required for a stream or river to pass through each stage depends on the climate and the composition and structure of the rock through which the water flows. As a river or stream erodes its banks and channel, it changes the landforms it passes through and alters its own course. The slopes of the banks decrease as those features erode, causing the stream to widen and slow down. When the water slows down, it deposits material. As water flows around this material, the river or stream begins to meander, widening the valley in which it flows. These forces act on a stream or river and its watershed topography over time.

In the natural life cycle of a stream, rivers and streams are classified as "youthful," "mature," and "old age," according to specific characteristics. Kansas rivers and streams fall into all three classifications.

Generally, "youthful" rivers and streams are found at higher elevations where the slope of the land is steeper and water flows downhill very fast. Rapids may develop over rocks or round boulders and there may be waterfalls. The channel of a youthful river is shaped like a "V" with steep banks. Youthful rivers may be near the headwaters (the origin) of an older and larger river hundreds of miles away. In Kansas, the small streams in the upper areas of the Flint Hills would be considered youthful.

**THREE STAGES OF STREAMS**



**Butcher Falls, Middle Caney Creek**  
 Credit: John Charlton, KGS



**Wakarusa River, Douglas County**  
 Credit: John Charlton, KGS



**Missouri River at White Cloud**  
 Credit: Roberta Spencer

A "mature" river or stream is at the stage in between "youthful" and "old age." The channel of a mature river is U-shaped, rather than V-shaped like the channel of a youthful river. A mature river still erodes the slopes of the banks of the channel, though to a much lesser degree than a youthful river does. Instead, a mature river or stream carves out a wider channel, though not as broad as that of an old age river. The landscape over which a mature river passes is steep enough that the river's slope provides a rapid water flow capable of rolling and bouncing larger pebbles and small rocks along the riverbed. The landscape may be mountainous but "hilly" would often be a better description for the area surrounding a mature river or stream. There are no rapids in the channels of mature rivers, which carry a larger volume of water than youthful rivers and are deeper than the channels of old age rivers or streams. In Kansas, the middle segments of medium-sized streams, such as Mill Creek in Wabaunsee County and Soldier Creek in Shawnee County, would be classified as mature.

The channel of an "old age" river is wider than it is deep and the landscape around such a river is generally flat, with wide floodplains. One of the characteristics of an old age river is the presence of S-shaped meanders (bends). The Mississippi River is an example of an old age river, with slow-moving water that carries suspended sediment (particles that travel in the water at a slower speed than the water itself), giving the water a muddy appearance. During floods, the water flow of an old age river is capable of moving large boulders and large structures, such as houses. Flooding associated with old age rivers often results in extensive property and agricultural damage and the loss of life. In Kansas, the Republican, Big Blue, Little Blue, Smoky Hill, and Kansas rivers would be classified as old age rivers.

*Landform*—a natural physical feature of the earth's surface.

## WATERSHEDS AND RIVER BASINS

*"Rain! whose soft architectural hands have power to cut stones, and chisel to shapes of grandeur the very mountains."*

Henry Ward Beecher, American author and clergyman

### WATERSHEDS

Everyone lives in a watershed, no matter where they live. A watershed is an area of land that drains toward a downhill point. That point can be a stream segment, a river, a pond, a lake, or the lowest place within the watershed (where rainfall always collects). Since gravity directs the movement of water, land with higher points of elevation separates the watersheds.

Precipitation patterns, topography (terrain), soil types, and land use patterns are features that make each watershed unique. The treatment of natural resources—the soil, water, air, plants, and animals—influences what happens in each watershed.

### WATERSHED COMPONENTS

A watershed has two, sometimes three, basic components: tributaries, a main channel and, in some cases, a delta. A watershed contains a network of tributaries, streams that collect water and flow into larger streams. Each of the drainage areas, or smaller watersheds, contributes to the watershed of the larger stream or river. The second component of a watershed is its main channel. The main channel transports most of the water and other materials collected in the drainage area. The main channel consists of the main stream and

## WATERSHEDS AS HYDROLOGIC UNITS

The United States Geological Survey developed a classification system for dividing regions into hydrologic units. Each hydrologic unit (watershed) is assigned a "hydrologic unit code" (HUC). In Kansas, each watershed has been designated as an HUC 8, HUC 11, or HUC 14. HUC 8 watersheds are the largest, designated with eight numbers. Smaller watersheds within the HUC 8 watersheds are designated as HUC 11 watersheds. HUC 14 watersheds are smaller watersheds within the HUC 11 watersheds. Based on these classifications, there are 90 HUC 8 watersheds, 355 HUC 11 watersheds, and 2,020 HUC 14 watersheds in the state of Kansas.

the larger tributaries. When precipitation falls in a watershed, the amount of water that reaches the main channel is determined by the size of the drainage area, the number of tributaries, the soil's ability to hold water, the climate, the number and size of water storage areas (wetlands, ponds, and lakes), and the slope (angle of the downward slant) of the stream's channel. As Luna Leopold wrote, "The joining of channels as more and more tributaries enter a main or master stream means that the drainage area increases downstream, so channels get progressively larger as discharge is enhanced by continued additions."<sup>5</sup> The third feature of a watershed is the network of branches that may form at the mouth of a stream. A stream that flattens out (and slows) near its junction with a big body of water may deposit silt, sand, or fine rock particles the water has been carrying. Water flows around these deposits, creating a broad network of branches called a delta.

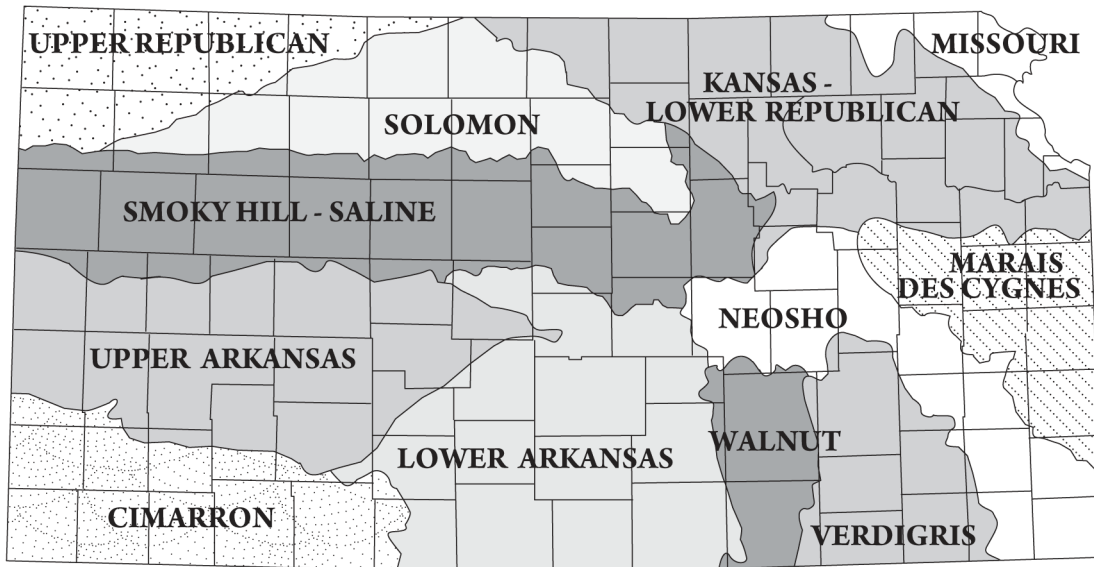
### RIVER BASINS

A river basin is also a watershed or a portion of a larger watershed. A bird's-eye view of a river basin would show that as the water moves downstream in the river basin, many drainage channels form a pattern of branches with the smaller streams joining together to form progressively larger streams. There are twelve major river basins in Kansas: the Cimarron, Kansas Lower-Republican, Lower Arkansas, Marais des Cygnes, Missouri, Neosho, Smoky Hill-Saline, Solomon, Upper Arkansas, Upper Republican, Verdigris, and Walnut river basins. Each of these river basins can be divided into several smaller watersheds based on topography. Each of the twelve river basins is also part of a larger multi-state river basin or watershed—either the Missouri River basin or the Arkansas River basin. To distinguish between the two "Missouri River" basins, remember that the smaller of the two only covers about 1,600 square miles in the northeast corner of Kansas. It includes part or all of only four Kansas counties—Doniphan, Atchison, Leavenworth, and Wyandotte counties. The larger Missouri River basin covers part or all of several states, including Kansas.

From the largest viewpoint, the state of Kansas is part of the Mississippi River basin. This river basin covers 41 percent of the continental United States. It originates as an outlet stream from Lake Itasca in northern Minnesota. This tiny stream goes on to become one of the world's greatest river systems, draining 1.25 million square miles (all or parts of 31 states and two Canadian provinces) before it finally reaches the Gulf of Mexico. Just think—rain that falls in Kansas can eventually reach the Gulf of Mexico!

State and federal agencies, organizations, and individuals are involved in identifying and resolving water resource issues in Kansas.

**MAJOR RIVER BASINS IN KANSAS**



Source: KGS

In 1985, the Kansas Water Office adopted the 12 major river basins as planning areas. State law requires that public input is included in the basin planning process. Basin advisory committees, made up of citizens located within each of the 12 major river basins in the state, were established in 1985 to meet that requirement. Each committee has 9 or 11 members representing seven core categories of water use. The committees meet at least four times a year.

**KANSAS RIVER BASINS**

**MISSOURI RIVER SUBBASINS**

- Kansas-Lower Republican
- Missouri
- Marais des Cygnes
- Smoky Hill-Saline
- Solomon
- Upper Republican

**ARKANSAS RIVER SUBBASINS**

- Cimarron
- Lower Arkansas
- Neosho
- Upper Arkansas
- Verdigris
- Walnut

**MISSOURI VS. ARKANSAS RIVER BASINS**



Source: U.S. Geological Society

**KANSAS RIVERS**

*"In rivers, the water that you touch is the last of what has passed and the first of that which comes; so with present time."*

Leonardo da Vinci, Italian artist

Kansas lies within the drainage basin of the Mississippi-Missouri river system. Two major rivers in the state are the Kansas River, a tributary of the Missouri River (which is a tributary of the Mississippi River), and the Arkansas River, a major tributary of the Mississippi River.

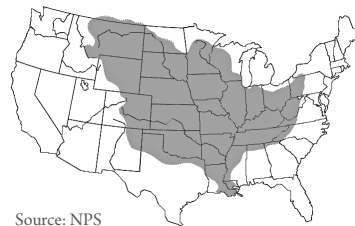
The largest bodies of water in Kansas were created by building dams on rivers. Milford Lake, the largest lake in Kansas, was built in the 1960s by constructing a dam across the Republican River. Tuttle Creek Lake, the second-largest lake in Kansas, is a long, winding reservoir behind Tuttle Creek Dam



**Tuttle Creek Lake**

Source: USFWS, Wetlands Mapper

**MISSISSIPPI RIVER BASIN AND SUBBASINS**

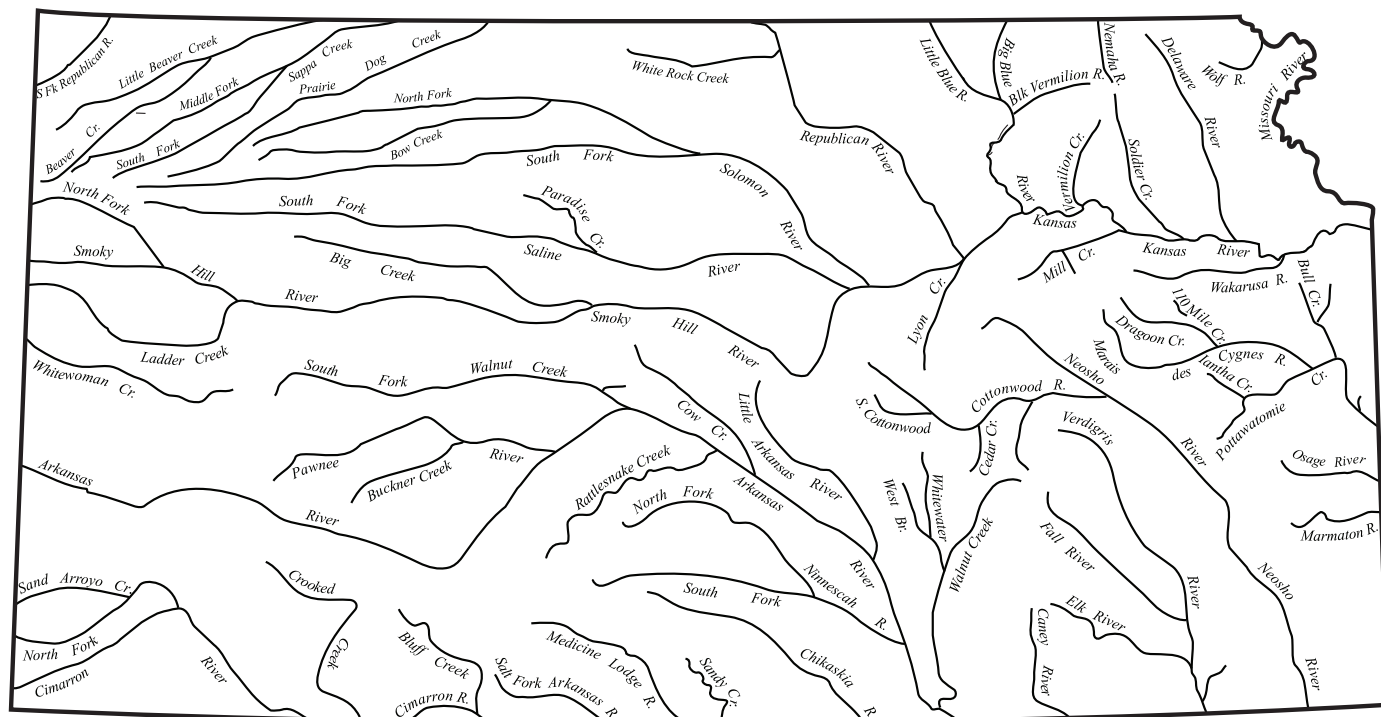


Source: NPS

**MISSISSIPPI RIVER SUBBASINS:**

- Missouri River basin
- Upper Mississippi River basin
- Arkansas-Red-White River basin
- Ohio River basin
- Tennessee River basin
- Lower Mississippi River basin

## MAJOR RIVERS IN KANSAS



Source: KGS

on the Big Blue River. Lakes or reservoirs have been built on most, but not all, of the major rivers in Kansas. Although there are dams on their tributaries, lakes or reservoirs do not impound the Arkansas or Missouri rivers in Kansas. There are no man-made dams on the Cimarron River.

### ORIGINS OF RIVERS IN KANSAS

The rivers in Kansas were formed by erosion due to water runoff. During the Pleistocene Era, from one to two million years ago to just 20,000 years ago, the physical features seen today were added to the Kansas landscape. Most of Kansas was fairly flat at the beginning of that time period, commonly referred to as the Great Ice Age. Only two sheets of glacial ice reached Kansas during the Great Ice Age, and those glaciers only extended into the northeastern corner of the state. However, glaciers in the Rocky Mountains also contributed to the formation of streams and rivers in Kansas. When those glaciers and the sheets of glacial ice north of Kansas began to retreat (melt), the water formed channels (streams). As in a delta, those streams spread sediment over the surface of the land. Later, dust storms lifted any loose particles and then re-deposited them, creating some of the most fertile soils in the world across Kansas. In some places, those wind-blown deposits reached a depth of more than 100 feet. In northeastern Kansas, they formed bluffs 60 to 100 feet thick along the Missouri River. Water from the melting glaciers flowed around the sediment and rock deposits and cut new channels in the landscape. Prior to this time, rivers through Kansas ran from north to south. During the Ice Age, Kansas streams began flowing eastward to southeastward, making their way to the Mississippi River. Streams trapped by physical features, such as the Walnut River on the west slope of the Flint Hills, may flow in a different direction, but all Kansas streams and rivers eventually drain into the Mississippi River. Floodplains formed when a river moved from one side of a valley

to another, changing the course (path) of the channel, or during flood events, when sediments were deposited on land adjacent to the channel.

### EXPLORING RIVERS IN KANSAS

The **Kansas River** is named after the Kansa Indians who lived along its banks. The river is formed by the junction of the Smoky Hill and Republican rivers at Junction City, Kansas. The Kansas River flows 170 miles downstream to Kansas City, where it empties into the Missouri River. In the early days of Kansas, the Kansas River was a major transportation "highway." In the 1800s, the unpredictable nature of the river and its shallow, braided course during periods of low flows made navigation difficult. Today, the Kansas River is classified as a navigable stream but no commercial navigation operates on the river. Eighteen federal reservoirs operated by the U.S. Army Corps of Engineers and the U.S. Bureau of Reclamation impound (collect and store) water on most of the major tributaries of the Kansas River. The river itself is impounded by Bowersock Dam, a low hydroelectric dam at Lawrence. The Kansas River drains over 60,000 square miles—over 34,000 square miles in Kansas and 26,000 square miles in Nebraska and Colorado. The Kansas River is also referred to as the Kaw River.

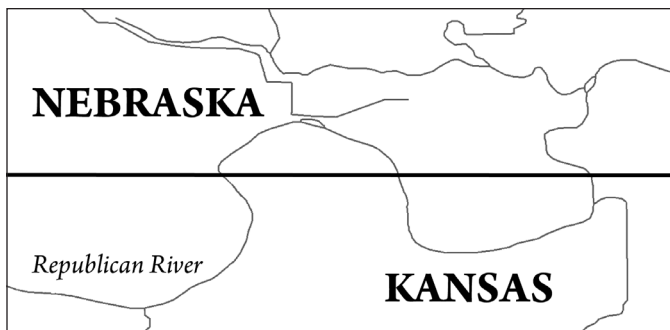
At 1,460 miles, the **Arkansas River** is the longest tributary to the Mississippi-Missouri river system. It originates near Leadville, Colorado, and carves out areas of scenic beauty, such as the Royal Gorge near Canon City, Colorado. This river travels through Kansas before entering northeastern Oklahoma where several other rivers join the Arkansas River. Then the river crosses the state of Arkansas, where it empties into the Mississippi River 600 miles north of New Orleans. Europeans discovered the Arkansas River before they found the Mississippi River. In 1541, the Spanish explorer Francisco Vasquez de Coronado crossed the Arkansas River near present-day

## Streams & Rivers

Dodge City, Kansas. In Kansas, the Arkansas River drainage is divided into two river basins: the Upper Arkansas and Lower Arkansas river basins. Several counties (Barton, Rice, Rush, Stafford, Pawnee, Ford, Edwards, and Kiowa) are divided between the two river basins.

The **Missouri River** begins in Montana and travels through North Dakota, South Dakota, Nebraska, Iowa, Kansas, and Missouri before joining the Mississippi River. It is the longest river in the United States - 2,540 miles long and 200 miles longer than the Mississippi River. The Missouri River forms the boundaries between several states, including northeastern Kansas and Missouri. It passes through Kansas City, Kansas. Before the spread of railroads, the Missouri River was the primary means of transporting goods and people. The Missouri River drains nearly all of the northern Great Plains and a small portion of southern Alberta, Canada.

The **Republican River** was named for the "Republican" Pawnee Indians who lived along its banks. In the late 1700s, French traders who mistakenly thought that their form of government was a republic named them "Republican." The Republican River is the main source of water for Milford Lake. This river actually flows into northwest Kansas from Colorado, flows north out of Cheyenne County crossing the state border into Nebraska, re-enters the state in Jewell County, crosses back into Nebraska a second time, and then flows back down into Kansas in Washington County. This explains why the Republican River drainage is divided into two river basins—the Upper Republican river basin in northwest Kansas and the Kansas-Lower Republican river basin in north-central and northeastern Kansas. On a Kansas map, the two river basins do not appear to be connected. The Republican River is approximately 550 miles long, including 100 miles in Kansas, and is a part of the multi-state Missouri River watershed.



**Multi-State View of the Republican River**

Source: USFWS, Wetlands Mapper

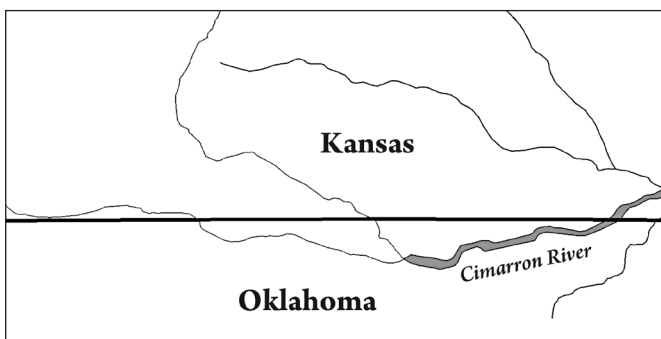
The **Smoky Hill River** rises (originates) in eastern Colorado, enters Kansas in Wallace County, and flows eastward through the state. At Junction City, the Smoky Hill River joins the Republican River to form the Kansas River. In the early to mid-1700s, the Smoky Hill River and the Kansas River were considered one stream, known as the "River of the Padoucas" because the Padouca Indians (the Siouan name of the Comanche) occupied the area. It was first identified as the Smoky Hill River in 1806 but no one knows why or who gave it that name. It is possible the name originated from the word "Kansas" in an Indian dialect, meaning "smoky water." Two dams on the river form Kanopolis Lake and Cedar Bluff Reservoir. The Smoky Hill River is 530 miles long and has a drainage area of 57,727 square miles. One of the major tributaries is the Saline River, which rises near the Sherman – Thomas county line in northwest

Kansas. The confluence of the Saline River and the Smoky Hill River is located east of Salina. The Smoky Hill River is in the Smoky Hill – Saline river basin, which stretches approximately 250 miles from the Colorado state line to Junction City. This river basin is a part of the multi-state Missouri River watershed.

The **Solomon River** begins as two streams, the North Fork and the South Fork, which merge to form one river. There are dams on each of the forks of the Solomon River, forming Kirwin Reservoir on the North Fork and Webster Reservoir on the South Fork. The Glen Elder Dam, which forms the Waconda Reservoir, is located below the confluence of the North and South Forks of the Solomon River. The Solomon River drains into the Smoky Hill River in Dickinson County. The Solomon River is 496 miles long, including both forks. It is part of the multi-state Missouri River watershed.

The **Marais des Cygnes River** was officially named by the United States Board of Geographic Names in 1971. Marais des Cygnes comes from the French language and means "marsh of the swans." Trumpeter swans, which were historically common in the Midwest, are thought to have used the wetlands adjacent to the Marais des Cygnes River during the spring and fall migrations. According to the U.S. Geological Survey, the source of this river (the head) is the junction of Elm Creek and One Hundred and Forty Two Mile Creek in Lyon County. The Marais des Cygnes River runs through the middle of the Marais des Cygnes National Wildlife Refuge, administered by the U.S. Fish and Wildlife Service. The river is impounded by Melvern Lake, which was built for flood control and to provide water for area communities. The Marais des Cygnes River is 140 miles long. It is part of the Marais des Cygnes river basin in Kansas, included in the multi-state watershed of the Missouri River.

The name of the **Cimarron River** is taken from the Spanish word "cimarron," which means "wild or unruly." The Cimarron River begins in the mountains of New Mexico and then goes through southeastern Colorado. It enters Kansas in two branches, which unite in Grant County. In Meade County, the Cimarron River exits Kansas and dips down into Oklahoma, just below the state line, for about 25 miles before re-entering Kansas in Clark County. In Commanche County, the river flows southeast back into Oklahoma where it empties into the Arkansas River. The Cimarron River is often dry as it passes through Colorado, Kansas, and Oklahoma. For about 100 miles, the Santa Fe Trail followed the valley of the Cimarron River. The Cimarron River is 698 miles long and is part of the Arkansas River watershed.



**Multi-State View of the Cimarron River**

Source: USFWS, Wetlands Mapper



The name of the **Neosho River** comes from the Osage Indian word "neosho," meaning "water within." This river was also known as the Six Bulls River and the Grand River. In the early 1900s, the Neosho River flooded 57 times in 34 years, with the worst flood coming in 1951. In 1950, the U.S. Congress authorized development of seven lakes for flood control in the Neosho River system, four in Kansas and three in Oklahoma. Even before the John Redmond Reservoir in Kansas was completed in 1965, it was used for flood control on the Neosho River. Council Grove Lake was also formed by constructing a dam on the Neosho River. Marion Reservoir was built on the Cottonwood River, a tributary of the Neosho River, but Cedar Point Reservoir, also on the Cottonwood River, was deauthorized and will not be built. The Neosho River is a tributary of the Arkansas River and part of the Mississippi River watershed. It is about 460 miles long, including about 300 miles in Kansas. Within Kansas, the river has a drainage area of approximately 5,100 square miles and is the principal river in the Neosho river basin.

The **Verdigris River** begins in Kansas with several small streams that come together and form the river. The lowest point in Kansas, just 679 feet above sea level, is found south of Coffeyville where the river crosses into Oklahoma. The Verdigris River had a number of fur trading houses along its course in the early days. The Treaty of 1834 with the Cherokee Indians named the Verdigris River as part of the boundary of their lands. The U.S. Army Corps of Engineers built two dams on the Verdigris River, forming Toronto Lake in Kansas and Oologah Lake in Oklahoma. In Kansas, there are three additional reservoirs on tributaries of the Verdigris River: Fall River Lake, Elk City Lake, and Big Hill Lake. The Verdigris River is about 270 miles long; just over half of the river's course is in Kansas. In Oklahoma, the Verdigris River is part of the McClellan-Kerr Arkansas River Navigation System (MKARNS) for 50 miles above its junction with the Arkansas River.

### ARKANSAS RIVER NAVIGATION SYSTEM

In 1946, Congress passed legislation authorizing an Arkansas River navigation system from Catoosa, Oklahoma, to the Mississippi River, known since 1971 as the McClellan-Kerr Arkansas River Navigation System (MKARNS). At the time construction began (1950), this was the largest civil works project ever undertaken by the U.S. Army Corps of Engineers. The MKARNS system is 445 miles long and includes 18 locks and dams. In 1971, the first barges traveled the entire length of the system. In 1986, the first international ocean-going vessel to travel up the Mississippi River and through the entire length of the MKARNS system arrived at the Tulsa Port of Catoosa, Oklahoma. This port is located on the Verdigris River, which the MKARNS system uses for 50 miles before connecting to the Arkansas River at Muskogee, Oklahoma. The newest lock and dam in the MKARNS system was dedicated on July 16, 2004.

The headwaters of the **Walnut River** are located near Cassoday in northeastern Butler County. This river flows to the south-southwest. The river's watershed covers approximately 2,009 square miles, including most of Butler County, 40 percent of Cowley County, and parts of Harvey, Marion, Chase, Greenwood, Sedgwick, and Sumner counties. Tributaries to the Walnut River include the Whitewater River, the Little Walnut River, and Timber Creek. The Walnut River is impounded by El Dorado Lake, completed in 1981 by the U.S. Army Corps of Engineers. The Walnut River is 147 miles long. It carries

water from the Flint Hills into the Arkansas River at Arkansas City, Kansas. The Walnut River is the principal river in the Walnut River basin, which is part of the Arkansas River watershed and the larger Mississippi River watershed.



Near the Walnut River Headwaters

Credit: Douglas S. Helmke, KRWA

There are many other important rivers in the state of Kansas, including those that are impounded by reservoirs or lakes, such as the Big Blue, Little Blue, Wakarusa, Ninnescah, Delaware, Elk, and Fall. Some Kansas rivers are tributaries to the larger rivers and only cross a few counties, such as the Pawnee, Chikaskia, Whitewater, Medicine Lodge, and Black Vermillion rivers. These rivers are important natural resources with interesting histories. For example, the Delaware River was originally called the Grasshopper River. Following the devastating grasshopper invasion of the state in 1874, the state legislature renamed the river in 1875.

## KANSAS STREAMS

*"Just as the water of a river near its mouth, in its final form, is composed largely of many tributaries, so an idea, in its final form, is composed largely of later additions."*

Willy Ley, science writer

### STREAM ORIGINS

Most Kansas streams originate inside the state. Like the rivers in Kansas, most streams were formed by erosion due to water runoff. Some streams do originate from the flow of water out of large springs and springs do contribute to the volume of water flowing in many streams. In Kansas, however, the runoff of surface water contributes the largest volume of water to Kansas streams.

### STREAM CHARACTERISTICS

A stream is a product of its watershed. The watershed's climate, topography (terrain), geology, vegetative cover, and land use all combine to determine the three physical characteristics of a stream: dimension, pattern, and profile. Dimension refers to the cross-sectional shape of a stream channel. Pattern is the configuration of the meanders (bends) and profile is the stream's slope (drop in elevation). In Kansas, land use and landcover varies, from prairie grasslands and fertile croplands in rural areas to asphalt streets and concrete parking lots in cities and towns. The topography of the land in Kansas changes dramatically as elevations in the different areas of the state range from 697 to 4,039 feet above sea level. These factors combine to create different volumes, frequencies, and velocities of water runoff, as well as variations in the resistance to erosion in stream and river corridors. The differences in stream characteristics have

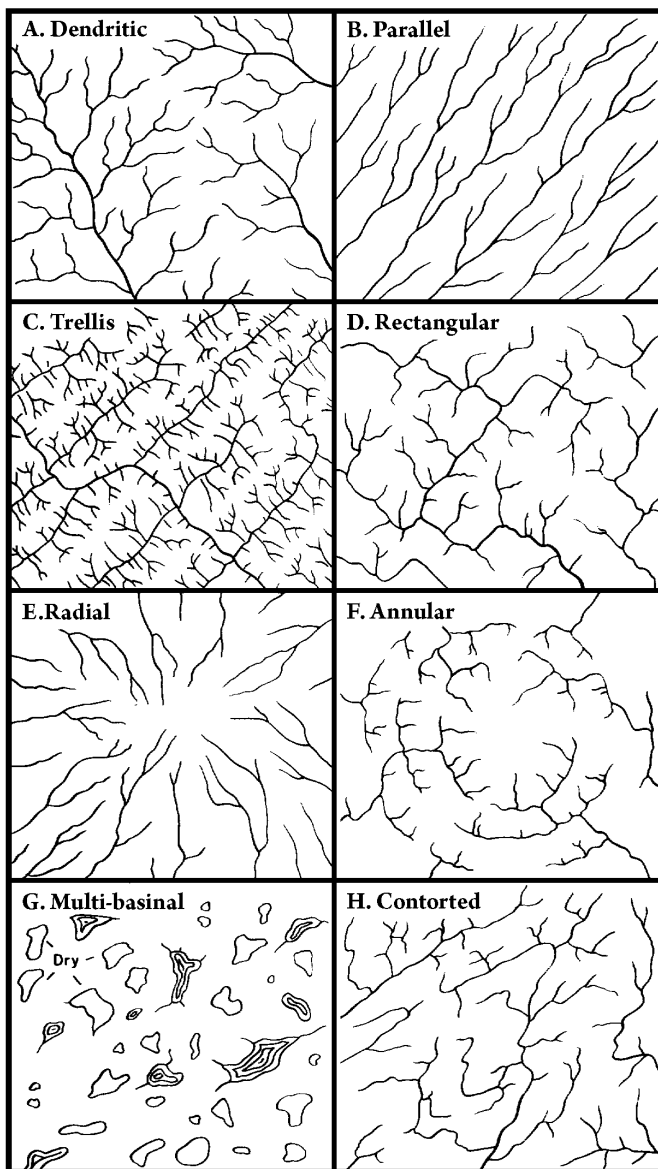
### PHYSICAL CHARACTERISTICS OF A STREAM

**Dimension**— cross-sectional shape (for example, U- or V-shaped).

**Pattern**— configuration of the meanders (bends).

**Profile**—slope (drop in elevation).

**STREAM PATTERNS**



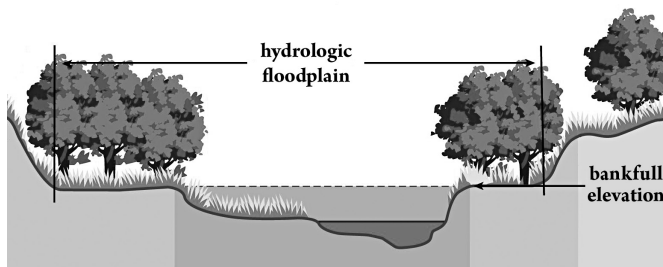
Source: AAPG ©1967, reprinted by permission of the AAPG whose permission is required for further use.

**KANSAS STREAMS AND RIVERS**

<b>Intermittent streams</b>	<b>110,225 miles</b>
<b>Perennial streams</b>	<b>23,731 miles</b>
<b>Canals and drainage ditches</b>	<b>382 miles</b>
<b>Total interior stream miles</b>	<b>134,338 miles</b>
<b>Border stream miles</b>	<b>120 miles</b>
<b>Total stream miles in Kansas</b>	<b>134,458 miles</b>

Source: State Conservation Commission

**BANKFULL FLOW**



Source: FISRWG

**STREAM CLASSIFICATIONS**

**Ephemeral**— normally dry; flows only after it rains or snow melts.

**Intermittent**— flows most of the year but usually dry during one or two months.

**Perennial**—flows throughout the year; may be dry during an extended drought.

helped develop a wide variety of stream corridors across the state.

Eight variables determine the form and structure of a stream: channel width, depth, velocity, discharge, slope, roughness of channel materials, sediment load, and sediment size. A change in any one of these variables can lead to changes in other variables, resulting in changes to the dimension, pattern, or profile of the stream.

The flow of a stream or river refers to the movement and volume of water that forms the channel of a stream. One of the most important factors affecting the physical characteristics of a stream is referred to as "bankfull flow," a measurement of the maximum volume of water in a stream or river at the moment of highest flow. The bankfull flow transports sediment and excess water from the watershed. It forms the stream's channel, determining width, depth, and shape. Bankfull flow varies from stream to stream but the frequency of these events is similar for most Kansas streams. Based on completed surveys of Kansas streams, on average, a bankfull flow is likely to occur once every 14-18 months, according to the Kansas State Conservation Commission.

**CLASSIFYING KANSAS STREAMS**

Based on the periods of water flow, Kansas streams can be classified as ephemeral, intermittent, or perennial. Ephemeral streams are normally dry and flow only during or shortly after a rainfall or snowmelt event. Intermittent streams flow most of the year but are normally dry during one or two months of each year. Perennial streams flow throughout the year but may be dry during periods of extended drought. Approximately 80 percent of Kansas stream miles are intermittent or ephemeral.

**RIPARIAN AREAS**

*"Any river is really the summation of the whole valley. To think of it as nothing but water is to ignore the greater part."*

Hal Borland, American author

Riparian areas are areas of streamside vegetation, including plants and trees along the streambank and in the adjoining floodplain, the relatively level area of land bordering a stream channel that is covered

### NATURAL RIPARIAN AREAS IN KANSAS

**Riparian meadows**— composed of water-tolerant grass species; usually found along small streams in upper portions of watersheds.

**Riparian forests**— wide variety of tree species in canopy with small trees and shrubs in the understory; more common in the eastern one-third of the state.

**Riparian shrublands**— composed of shrubs or small trees; usually associated with intermittent streams that flow most of the year.

**Riparian woodlands**— limited number of canopy trees, along with shrubs and grasses; common along perennial streams in central and eastern Kansas.

with water during moderate to severe floods. Riparian areas are distinguished from upland areas (higher ground) by vegetation, soils, and topography. The width of natural riparian areas, and the plant community, depends on the terrain, soil type, and available moisture. In general, natural riparian areas along perennial streams are wider than those found along intermittent or ephemeral streams because the water table within those riparian areas is normally maintained at relatively constant and shallow depths during the plants' growing season.

### NATURAL RIPARIAN AREAS

Kansas has four types of natural riparian areas: riparian meadows, riparian shrublands, riparian woodlands, and riparian forests.

Although riparian meadows are more common in western Kansas, they can be found throughout the state. Usually, they are found along small headwater streams in upper portions of watersheds. The riparian meadow plant community is composed of grasses which are more water-tolerant than other native grass species. Species such as prairie cord grass, switchgrass, and sedges make up the vegetative community of most riparian meadows. Bulrushes, cattails, smartweed, or spikerush may occur if the riparian area is extremely wet.

Riparian shrublands are usually associated with intermittent streams. In these areas in Kansas, the plant community typically consists of sandbar willow, false indigo, roughleaf dogwood, or buttonbush. Although saltcedar (tamarisk) may be found in riparian shrublands, this small tree or shrub has been declared an aquatic nuisance species in Kansas and other states. Saltcedar was first imported into North America in the 1800s as an ornamental plant and was also used for windbreaks and erosion control. According to the Kansas Department of Wildlife and Parks, saltcedar is now found in 49 counties in Kansas. Large saltcedar plants can use up to 200 gallons of water a day, depleting water resources and altering the ecosystem of a riparian area.

Riparian woodlands are normally composed of cottonwood, black willow, ash, elm, or box elder trees. A more open canopy cover in these riparian areas allows for the growth of grasses and shrubs in the understory. Riparian woodlands can be found throughout the state, but are more common along perennial streams in central and eastern Kansas.

Riparian forests are more common in the eastern one-third of the state. Riparian forests contain a wide variety of tree species

depending on their location in the state. Tree species commonly found in Kansas riparian forests include silver maple, cottonwood, black walnut, green ash, red oak, bur oak, elms, box elder, hickories, hackberry, and sycamore.

Small trees, shrubs, and vines are found in the understory

of riparian forests in Kansas. Harvesting mature trees in a riparian forest can improve the health of the forest while providing economic benefits to the landowner. The negative impacts of harvesting operations can be reduced through planning and applying practices such as minimizing the number of stream crossings, crossing streams at a 90-degree angle, and limiting cutting to no more than 25 percent of the streamside forest when harvesting immediately adjacent to a stream.



*Stranger Creek near Tonganoxie*

Credit: John Charlton, KGS

### RESTORING AND STABILIZING STREAMBANKS

The true meaning of streambank restoration is to return a riparian area to its original state. This is not always possible or may not even be the best option. Most Kansas streams do not have the same dimension, pattern, or profile they had prior to European settlement. Therefore, the challenge of restoration efforts is to attain the best possible condition that a particular riparian area is capable of achieving under present circumstances. In most cases, this means establishing permanent vegetation by planting grass and trees in the riparian area. Historically, a particular stream may not have had trees along the banks. However, where the channel has cut into the banks of a river or stream, establishing trees will help reduce the erosion. The root systems of trees reinforce the soil similar to how concrete is reinforced with rebar.

In long, sandy stream systems, such as the Republican River, trees are a vital component of healthy riparian vegetation. Along reaches (stretches) of this river that do not have trees, the channel is more than twice as wide as that of adjacent reaches with forested riparian areas.

Streambank stabilization is the slowing or stopping of erosion along a streambank. Riparian restoration alone is not enough to solve some streambank erosion problems. Along many streams, the banks are eroding too quickly for riparian plantings to become established. In these areas, the streambank must be stabilized prior to riparian restoration. On large streams, this may include installing rock structures such as bendway weirs or rock vanes, low rock structures designed to slow the velocity of the water and redirect the water flow away from the streambank. Since the entire streambank is not covered with rock, there is room for riparian vegetation to be established between the rock structures. As the speed of the water becomes slower, sediment is deposited near the streambank and

#### STREAMBANK EROSION

Large eroded streambanks can contribute more than 50,000 tons of sediment to a stream or river each year. That is enough soil to fill an area 10 feet high, 20 feet wide, and almost one mile long.

Source: Soil Conservation Commission

## Streams & Rivers

vegetation will become established naturally. This process can be accelerated with additional plantings. Vertical streambanks may be re-shaped to provide a sloped surface for planting a mixture of appropriate grasses and trees. To stabilize the streambank, unrooted cuttings from willow, cottonwood, or sycamore trees can be used to establish new trees. Live willow stakes, placed on lower portions of the streambank, can produce roots over six feet long in just three or four months.

Permits may be required for any project that will change the dimension, pattern, or profile of a stream or when a project will be placing any type of fill (rock or soil) in a stream channel. Approval from one or more government agencies must be received before beginning any streambank stabilization or restoration project. Depending on the location and size of the project, the appropriate agencies might include the U.S. Army Corps of Engineers, the Kansas Department of Agriculture's Division of Water Resources, the Kansas Department of Wildlife and Parks, or the Kansas Department of Health and Environment.

## THE STREAM ECOSYSTEM

*"The outstanding scientific discovery of the twentieth century is not television, or radio, but rather the complexity of the land organism. Only those who know the most about it can appreciate how little we know about it. The last word in ignorance is the man who says of an animal or plant: 'What good is it?'"*

Aldo Leopold, American ecologist and forester

Many diverse organisms play an important role in a stream's ecosystem. These organisms include plants, animals, fish, insects, and macroinvertebrates. When carefully studied, each organism—even the smallest of worms and bugs—reveals something about how it meets the challenges of its environment and where it fits in the web of life in a stream.

## AQUATIC LIFE

A river or stream is filled with small organisms known as macroinvertebrates that are visible but often go unnoticed. These organisms are easily collected and studied, providing an opportunity to research changes that occur over time. Macroinvertebrates found in streams and rivers include clams and worms, as well as the aquatic stages of many insects. Other insects cling to rocks or burrow into silt. Benthic (bottom-dwelling) macroinvertebrates are small organisms that live in, crawl upon, or attach themselves to the bottom of a body of water. Most benthic macroinvertebrates in flowing water are aquatic insects such as stonefly nymphs, mayfly nymphs, caddisfly larvae, and midge larvae. Streams with silt or mud bottoms support invertebrate species, such as tube-building worms, burrowing mayflies, "blood worms" (midge larvae), mussels, and clams. These organisms are an important part of the river ecosystem and aquatic food chain.



**Jackson Heights High School Students**

Credit: Roberta Spencer



**Mussels**

Credit: Curtis Wolf

## FISH

The type of fish living and reproducing in a stream or river identifies whether the stream is a cold water, cool water, or warm water fishery. Cold water fish include species such as trout and salmon, which are members of the trout family. These species live in well-oxygenated streams that have a swift current. Trout grow best in water temperatures between 50 to 65 degrees Fahrenheit. They are insectivores, feeding only on insect species like mayflies and stoneflies. Trout are not native to Kansas. However, the Kansas Department of Wildlife and Parks stocks trout by releasing hatchery-raised fish in many locations around Kansas for sport fishing.



**Trout**

Credit: Ken Hammond, USDA

The smallmouth bass is a typical species found in cool water fisheries, stream segments that are marginal for trout. Bass prefer a habitat of riffles and deep pools. Their activity is normally restricted to one pool where the bass feed on insects or crayfish flushed out by turtles and bottom-feeding fishes.

Warm water species, such as largemouth bass, crappie, bluegill, and catfish, are found where water temperatures are higher. Warm water fish eat mainly invertebrates (animals such as insects or worms that do not have a backbone). However, the largemouth bass—one of the most popular sport fish in North America—is a predator that feeds on almost any animal that swims or falls into the water, including fish, crayfish, large insects, frogs, snakes, or mice. Catfish are omnivores, eating both plants and animals. Channel catfish are found in nearly all the streams and rivers in Kansas.



**White Crappie**

Credit: Ken Hammond, USDA



**Largemouth Bass**

Credit: Ken Hammond, USDA

The 135 species of fish found in Kansas includes 116 native and 19 introduced (non-native) species. The number of native fish species in Kansas exceeds those native species found in any state farther west or directly north of Kansas. Some of the native fish species found in Kansas are typical of prairie streams. On the other hand, Kansas is the western limit of the range of many fish species found in the forested regions of the eastern United States. No species of fish



**Catfish**

Credit: Bob Savannah, USFWS

## EATING HABITS

**Carnivore**—eats animals.

**Herbivore**—eats plants.

**Insectivore**—feeds primarily on insects.

**Omnivore**—eats both plants and animals.

**KANSAS FISH SPECIES**

**ENDANGERED**

- Arkansas River Shiner
- Arkansas River Speckled Chub
- Pallid Sturgeon
- Sicklefin Chub
- Silver Chub

**AQUATIC NUISANCES**

- Asian Carp (Bighead Carp, Black Carp, and Silver Carp)
- Round Goby\*
- Rudd
- Ruffe\*
- White Perch

*\*listed but not found in Kansas yet*

Source: Kansas Department of Wildlife and Parks

lives only in Kansas but a few species are more abundant here than in any other state. Five fish species have disappeared from the wild in Kansas and another five fish species are listed as "endangered." Five species of fish are listed as aquatic nuisance species, non-native fish that can threaten native species by disrupting the natural ecosystem. At this time, the white perch is the only fish that is an aquatic nuisance species affecting other fish populations in Kansas.

Fishing is a Kansas tradition. However, all streams in Kansas, other than the Arkansas, Missouri, and Kansas rivers, are under private ownership of the adjoining landowners. This means that, unless otherwise posted, anglers must obtain permission to fish in these streams, even from roadways, bridges, or railroad rights-of-way. Through the FISH (Fishing Impoundment and Stream Habitat) program, the Kansas Department of Wildlife and Parks provides public access to more than 83 miles of streams on private land. The Arkansas, Missouri, and Kansas rivers are public property up to the normal high-water line; however, anglers must obtain permission before crossing private property to fish in those rivers.

**MAMMALS**

Riparian areas are areas of streamside vegetation supported by the adjacent stream or river. The combination of cover, water, and food resources in riparian areas make them desirable habitat for large mammals such as mule deer and white-tailed deer. Other mammals, such as the otter, ringtail, raccoon, beaver, muskrat, swamp rabbit, short-tailed shrew, and mink, normally live in riparian areas. Riparian areas also provide tall dense cover for roosts, water, and abundant prey for a number of bat species, including the little brown bat, big brown bat, and pallid bat.



**Otter**  
Source: USDA NRCS



**Deer**  
Credit: Ken Hammond, USDA



**Bat**  
Source: USDA NRCS



**Raccoon**  
Credit: Bob Savannah, USFWS

**Beaver**  
Credit: Bob Savannah, USFWS

Certain animal activities also influence stream corridors and riparian areas. For example, beavers build freestanding lodges that act as dams and cause ponds to form within a stream channel or in a floodplain. These ponds kill much of the existing vegetation, although they do create wetlands and open water areas for fish and migratory waterfowl. If appropriate woody plants in the floodplain are scarce, beavers extend their cutting activities into other areas, which can significantly alter riparian and stream corridors. In Kansas, beavers generally dig their dens in streambanks rather than building lodges that dam up streams or rivers. <sup>6</sup> Beaver cutting changes the mix of tree species found in that area, increasing the number of trees that grow rapidly, such as alder, willow, and poplar.

**REPTILES, AMPHIBIANS, AND TURTLES**

Nearly all amphibians (salamanders, toads, and frogs) depend on aquatic habitats for reproduction and surviving extreme temperatures. Amphibians start their life in the water in a larval state (with gills), called tadpoles in frogs and toads. There are 30 species of amphibians found in Kansas, including the barred tiger salamander—designated as the state amphibian in 1994. Although reptiles (lizards and snakes) lay their eggs on land, many of the 76 species of reptiles found in Kansas are found in stream corridors and riparian habitats. The eastern hognose snake, which lives along rivers and streams in eastern Kansas and is listed as a "threatened" species in Kansas, eats only toads. There are 15 species of turtles found in Kansas, most of which are aquatic species. The state turtle of Kansas, the ornate box turtle, is a terrestrial (land-dwelling) turtle.



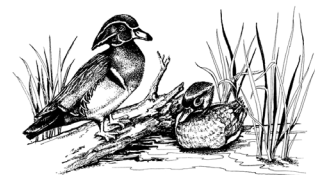
**Turtle**  
Source: USDA NRCS

**BIRDS**

Birds are the most commonly observed terrestrial wildlife in riparian corridors. Nationally, over 250 species have been reported using riparian areas during some part of the year. <sup>7</sup> Birds make up the majority of the animal species found in Kansas, with the Kansas Department of Wildlife and Parks reporting that there have been 468 bird species confirmed in the state. Because they can fly, birds can change locations and use different areas during different seasons. Both migratory and resident bird species use stream corridors in Kansas, including species that forage for insects on foliage (vireos and warblers) or on the ground or in trees (thrushes and woodpeckers). Other bird species forage for seeds on the ground (doves, orioles, grosbeaks, and sparrows). Some bird species, such as the wood duck, eat seeds from aquatic plants, seeds that fall into the water, insects, and small crustaceans. In the winter, bald eagles are attracted to areas of open water, including along the Arkansas River in Wichita and the Kansas



**Canada Geese**  
Credit: Tim McCabe, USDA



**Ducks**  
Source: USDA NRCS



**Bald Eagle**  
Source: USDA NRCS

## Streams & Rivers

River in Lawrence. Other migrant bird species nest on sandbars and gravel areas in rivers, such as the least tern and piping plover, which were first reported nesting on the Kansas River in the mid-1990s.

### DOMESTIC LIVESTOCK

Stream corridors provide water for domestic livestock, in addition to providing protection from the weather (cooling shade in the summer or shelter from harsh winter winds). Many stream corridors produce vegetation for grazing animals, including domestic livestock. However, unless carefully managed, livestock can overuse these areas, causing a loss in vegetative cover that contributes to streambank erosion and alters the composition and diversity of species found in the stream corridor and associated riparian areas. Farmers and ranchers manage livestock use of riparian areas by limiting grazing periods or timing grazing periods to coincide with the availability of certain vegetation. Farmers and ranchers may also limit access to streams for watering, provide alternative water supplies or shelters, or stabilize in-stream watering points to reduce the potential for erosion or bacterial contamination of the water from livestock waste.



Horses

Credit: Tim McCabe, USDA

### WATER MANAGEMENT

*"The most delicate and yielding of our necessities, water, can be the most powerful destroyer, swallowing everything."*

James Broughton, poet, playwright, and filmmaker

### SURFACE WATER

The water in streams, rivers, ponds, and lakes is called "surface water." Precipitation provides most of the surface water for the streams and rivers in Kansas. The distribution of surface water across the state of Kansas reflects the variation in the climate across the state. Annual runoff, water that moves across the land's surface, varies greatly—from 0.1 inch in western Kansas (less than 0.6 percent of annual precipitation) to approximately 10 inches (25 percent of annual precipitation) in eastern Kansas.<sup>8</sup>

In Kansas, surface water cannot be diverted from a stream or river and used without a water right or permit issued by the state of Kansas through the Kansas Department of Agriculture's Division of Water Resources. Minimum desirable streamflows may also be established to maintain and protect instream water uses. The purpose of a minimum desirable streamflow is not to keep the stream flowing through all climatic conditions, such as severely dry periods or extended droughts. Instead, minimum desirable streamflows allow the Chief Engineer of the Division of Water Resources to manage the diversion and uses of water to protect the flow of water. When the supply of surface water in a designated stream or river is not sufficient to satisfy all existing water rights and maintain the established minimum desirable streamflow, steps may be taken to reduce the amount of water available for diversion and other uses. An area may even be closed to new appropriations, meaning no new water rights or permits will be issued in that specific area. In Kansas, minimum desirable streamflows have been established at 33 locations on 23 streams and rivers.

Over 20 separate national, state, and local governmental agencies address water or water-related issues in Kansas. The involvement of so many agencies is, in part, a reflection of the many ways in which water is used. A single water resource often has multiple designated uses. Since many Kansas streams and rivers drain into lakes and reservoirs, they may simultaneously provide flood control, energy production, wildlife habitat, a recreational resource, drinking water, and an irrigation water supply. Each use has quality and quantity issues relating to it. These uses often affect each other, and may also be impacted by other uses both upstream and downstream, such as navigation or waste removal.

### WATER COMPACTS

Surface water flows between states. Water compacts are legal agreements between states on how to equitably divide and distribute the water supply of a river or river basin. Kansas is a member of the Republican River Compact, the Blue River Compact, and two Arkansas River Compacts, one with Colorado and one with Oklahoma. In 1998, the state of Kansas filed suit against the state of Nebraska over the administration of water rights under the Republican River Compact, signed in 1943 by Colorado, Kansas, and Nebraska. In 2003, the states reached a settlement that requires Nebraska to limit the number of new wells in the Republican River basin in that state, leaving water in the river to reach Kansas.

### FLOOD MANAGEMENT

During an average year, at least one Kansas stream has severe flooding. Numerous floods on Kansas streams, such as those in 1935, have resulted from storms that occurred either entirely or partly outside the state. Other floods result from widespread rainfall on saturated soils, such as the 1951 floods that extended over nearly one-half of the state. Occasionally, intense local storms produce extremely large quantities of runoff, which was the case in the June 1981 flood of Great Bend and the September 1977 flooding of the Kansas City metropolitan area. Regional floods can result from moderate to heavy rainfall lasting several days and occurring over a wide geographic area. As smaller streams empty into larger streams or rivers, the main channel receives large volumes of water. Flooding continues over a long period for some distance along the main channel, which is what happened during the spring and summer of 1993 when much of the eastern two-thirds of the state of Kansas experienced flooding. However, the level of flooding in 1993 was significantly reduced due to the federal reservoirs built for flood control on Kansas rivers and streams following the floods of 1951. In 1993, no lives were lost in Kansas due to the flooding even though the Federal Emergency Management Agency (FEMA) declared 57 counties to be disaster areas and there was nearly \$286 million in flood-related damages in the state.

#### THE FLOODS OF 1951

From July 9–13, 1951, some areas in the Kansas River basin received over 18 inches of rain while other areas averaged eight inches. One hundred sixteen cities and towns were affected by flooding, including more than 3,000 businesses and over 22,000 residences. In the Kansas River basin, the flood demolished nearly 2,500 residences, destroyed nearly 350 businesses, and damaged over 10,000 farms. Losses exceeded \$725 million. At today's values, that would be approximately \$5 billion.

Dam failures can also result in flooding, generally impacting property immediately downstream. In 2005, the U.S. Army Corps of Engineers began a project to bring the Tuttle Creek Dam up to current standards for earthquake and flood resistance. The goal of the project was to strengthen the dam, which forms Tuttle Creek Lake, so that it could withstand a moderate to strong earthquake. Very small earthquakes occur routinely in Kansas in deep fault zones, including the Humboldt fault zone located 12 miles from Tuttle Creek Dam. These microseismic earthquakes are detectable with specialized equipment but result in little or no evidence at the earth's surface. However, stronger earthquakes have occurred in the Manhattan area, including an 1867 earthquake with a magnitude of 5.1 centered near Wamego, Kansas. In 1906, an earthquake with a magnitude of 4.7 was centered in the Manhattan area while in 1929, the area surrounding Manhattan experienced a series of earthquakes measuring from 3.2 to 4.2 on the Richter scale.

To manage floodwaters and reduce flood-related damage, both structural and non-structural measures are used in Kansas. Flood control projects, such as the construction of dams and levees, are examples of structural measures. In 1953, the state legislature passed the Kansas Watershed District Act, which establishes watershed districts to construct, operate, and maintain "works of improvement on streams to assist in managing floodwater, erosion and sediment damages that occur in the watersheds of rivers and streams in Kansas." According to the State Association of Kansas Watersheds, there are 85 separate watershed districts in 43 Kansas counties. Since 1953, those watershed districts have built more than 1,300 watershed dams in Kansas, with another 1,200 planned. Watershed dams hold water back and release it slowly, allowing the water to soak into the ground and recharging groundwater supplies in addition to providing flood control. Flood control is also provided by the reservoirs built in Kansas by the U.S. Army Corps of Engineers and the U.S. Bureau of Reclamation. Funding for flood control projects, multipurpose small lakes, and the construction and maintenance of watershed dams is provided by the state of Kansas, the U.S. Department of Agriculture's Natural Resources Conservation Service, the State Conservation Commission, and other state and federal agencies. Some cities have also built levees, embankments to prevent flooding along rivers and streams, using local and federal funds.

To reduce the potential for flood damage, local governments may take non-structural measures, such as preventing development from occurring in flood-prone areas, removing structures that are likely to be damaged during flooding, and protecting or restoring riparian areas and wetlands. Managing flood-prone areas for multiple purposes can reduce the risk of damage from future floods while providing recreational, water quality, and wildlife habitat benefits. Other examples of non-structural measures taken to reduce flood damage include forecast and warning systems and evacuation planning.

## WATER QUALITY

*"Soil and water are the very foundation of our agriculture and of our whole Nation. It is therefore the responsibility of every American—every individual and every group—to work together to see that these resources are used wisely and protected for the use of generations that will follow."*

Clinton P. Anderson, U.S. Secretary of Agriculture, 1945–1948

### HISTORICAL USES

The history of civilization is linked to the availability of water for human needs. Ancient civilizations were forced to relocate when water supplies dried up or were polluted. Hippocrates, an ancient Greek physician, was one of the first to recognize that environmental factors, such as polluted water, could cause disease or illness.

When the colonists arrived in America, settlements clustered in areas where freshwater supplies were abundant. By 1790, nearly four million people lived in the United States, mainly along the eastern seaboard. At that time, the Mississippi River was the western boundary of the country. In 1790, farmworkers accounted for nearly 75 percent of the U.S. work force. During the next century, that number dropped to about 40 percent as the Industrial Revolution spread to the United States and machines replaced manual labor. People moved from rural areas to cities to work in factories. The population of the country kept growing, from 9.6 million people in 1820 to nearly 106 million in 1920. By 1900, there were 38 cities with more than 100,000 residents compared to only nine such cities in 1860.<sup>9</sup>

Until the mid-1800s, each household or business handled the disposal of garbage and human waste by dumping it into streets, alleys, ditches, or streams. Time and natural elements eventually broke down the waste materials or carried it farther downstream. As cities grew, raw sewage, dirt, grease, trash, and organic matter accumulated at a faster rate than it could decompose. This led to the development of the first sanitation sewers, which collected waste from large areas. However, most of the early sewers concentrated the waste and discharged it through fewer outlets, merely changing the location of the problems.

During the Industrial Revolution, factories were located near sources of clean water, a key resource in most manufacturing processes. Industrial wastes were discharged (dumped) into streams and rivers, creating additional quality problems in the nation's waters. As the population continued to grow rapidly, water quality problems increased.

Even though it became a state in 1861, Kansas did not experience a large population increase until after the Civil War. Early on, water problems in Kansas were usually related to quantity, rather than quality.

However, even rural states like Kansas experienced water quality problems. The conversion of grasslands into croplands increased erosion, which added sediment in streams and rivers. Animal waste from increased numbers and concentrations of domestic livestock contributed to the contamination of surface waters. The disposal and treatment of human waste also needed attention. In 1968, according to the U.S. Department of Agriculture, 43,000 communities in the United States still lacked an adequate sewage system and 33,000 still lacked a public water system.<sup>10</sup> Almost all of those communities were in rural areas, many in Kansas.

## SURFACE WATER MILESTONES

**1899**– Rivers and Harbors Act; prohibited dumping refuse or building structures in navigable waters without approval from federal government.

**1927**– first water pollution survey in U.S.; conducted by the Izaak Walton League of America.

**1948**– Water Pollution Control Act of 1948; established federal–state cooperation over water quality issues but limited federal enforcement authority.

**1956**– 1948 law amended to provide federal regulation of waste discharges.

**1951**– record flooding in Kansas.

**1953**– Kansas Watershed District Act; established districts to manage floodwaters.

**1963**– State Water Plan Act; directed Kansas Water Resources Board (renamed Kansas Water Office in 1981) to present a comprehensive state water plan to the Kansas Legislature.

**1965**– Water Quality Act; directed states to develop water quality standards for interstate waterways.

**1972**– Clean Water Act (as amended); addresses all pollution sources affecting the waters of the United States.

**1981**– establishment of the Kansas Water Authority board, which is responsible for approving the State Water Plan, regulations, legislation, and federal contracts proposed by the Kansas Water Office.

**1982**– State Water Resources Planning Act; requires Kansas Water Office to develop and implement the State Water Plan for the management, conservation, and development of the water resources of the state.

**1985**– first basin advisory committees appointed in all twelve river basins in Kansas.

**1998**– Kansas Water Quality Buffer Initiative; provides financial incentives to install riparian forest buffers and grass filter strips to improve water quality in high priority watersheds.

## FEDERAL LEGISLATION

The first water pollution legislation in the United States was the Rivers and Harbors Act of 1899, which prohibited dumping refuse or constructing structures (dams, bridges, piers, etc.) in navigable waters without federal approval. However, the act made no provisions for obtaining such approval, issuing permits, or enforcing the legislation.

In 1922, concerned about the deteriorating conditions of America's top fishing streams, sportsmen formed the Izaak Walton League of America to combat water pollution and other environmental issues. In 1927, President Calvin Coolidge asked members of the organization to conduct the nation's first water pollution survey.

The federal government began to control and manage water quality through passage of the Water Pollution Control Act in 1948, which was amended in 1956 to regulate waste discharges. The Water Quality Act, passed in 1965, set water quality standards for surface waters that flow beyond the borders of just one state. The Clean Water Act, passed in 1972 and amended in 1997, addresses all sources of pollution in all waters of the United States.

Since the enactment of these laws, the states have established programs to monitor water quality and address problems. In Kansas, the Kansas Department of Health and Environment monitors streams and rivers and reports violations of the surface water quality standards (specific water quality goals set for each body of water in the state).

## HUMAN IMPACTS ON STREAMS AND RIVERS

Since erosion is a natural process, also occurring along the banks and channels of rivers and streams, there will always be some sediment or suspended solids in streams. Although not considered a human health hazard, suspended solids can lead to undesirable water quality conditions by clouding the water and reducing light penetration. This, in turn, reduces photosynthesis and affects aquatic life and plant growth. Conservation practices can improve water quality by reducing the amount of sediment or suspended solids in streams, rivers, and other bodies of water. Anything that slows the water will cause the particles to settle (stop floating and sink to the bottom). In Kansas, filter strips or riparian buffers next to rivers and streams are effective in removing soil particles from runoff. Planted to grass or other permanent vegetation, these areas trap sediments (both mineral and organic), absorb and transform potential pollutants into nontoxic compounds, and provide food and habitat for wildlife. Filter strips and riparian buffers also create corridors for wildlife movement and may recharge groundwater supplies.

To restore water quality in high-priority watersheds, the state of Kansas enacted the Kansas Water Quality Buffer Initiative in 1998. Administered by the State Conservation Commission, the program provides financial incentives to landowners in selected counties who install riparian forest buffers and grass filter strips through the U.S. Department of Agriculture's Conservation Reserve Program (CRP).

Human activities may add materials to surface water that affect its suitability for aquatic plants and animals or human uses. Any additions that affect odor, color, taste, clarity, or chemical composition of the water may have a negative effect on organisms.

## RIPARIAN FOREST BUFFERS

Doyle Derrick owns several farms in Brown and Doniphan counties. He planted 93 acres (approximately 20,000 trees) of riparian forest buffers north of Sparks in 2003 and another 53 acres in 2004. Some might say that Derrick's vision for his Doniphan County land is "nuts," and it is—walnuts. In the past 25 years, he has planted over 100,000 walnut trees. "Trees are ideal," says Derrick, "and Doniphan County has some of the best soil for growing them." When pressed to say exactly why he is planting thousands of walnut trees, Derrick simply states, "I like walnuts. And they make a good log."

The Natural Resources Conservation Service (NRCS) office in Troy, and the Doniphan County Conservation District helped design Derrick's riparian forest buffers as part of the Conservation Reserve Program (CRP) and the Kansas Water Quality Buffer Initiative.



URBAN IMPACTS
Urban (non-agricultural) applications of fertilizers, pesticides, and herbicides often exceed agricultural applications when compared on a per square foot basis.
Stormwater runoff is the largest source of pollution to Kansas streams and lakes.
In urban areas, 75 percent of the water entering streams comes from storm sewers.
In high population density areas, 70 percent of the surfaces are impervious (paved or roofed) and 50 percent of all rainfall never touches the soil.

Source: KSU

Some materials form a filmy or oily layer on the surface of the water or cause a physical mess. Others are invisible, but may alter the chemistry of the water and stimulate excessive growth of some plants or algae, crowding out and reducing oxygen and nutrients available to other species. For example, phosphorus encourages plant growth. It is used as fertilizer for agricultural crops, lawns, and gardens and is also found in many detergents. When overused or disposed of improperly, phosphorus will attach to soil particles and may eventually work its way into surface waters. There, excess phosphorus in the water can turn sandbars into weed patches, cover clean rocks with slime and moss, and turn clear water cloudy due to an overabundance of microscopic plant life. The added plant life produces more dead plant material and the decomposition of the additional plant matter robs the water of its oxygen supply, which—in the worst cases—can suffocate fish and aquatic animals.

Atrazine, a common herbicide used in producing agricultural crops, is another potential water contaminant. For brief periods in the spring, a number of rivers, streams, and lakes in eastern Kansas sporadically exceed the maximum containment level for atrazine concentrations in Kansas surface water. Agricultural producers are addressing concerns over atrazine, phosphorus, and other pesticides and fertilizers through a variety of management practices designed to keep potential contaminants from reaching surface waters. Per square foot of application, urban (non-agricultural) applications of fertilizers, insecticides, and herbicides often exceed agricultural applications.

### BACTERIA IN SURFACE WATER

Surface water often contains a variety of pathogens including viruses, fungi, protozoa, and bacteria. Bacteria represent the largest number of organisms present in surface water. Bacteria are easily grown under laboratory conditions and can be monitored and used as indicators of human health risks. Human health risks generally occur when there is fecal (solid waste) contamination from human sources. Waste from animals, such as domestic livestock, pets, and wildlife, can also pose risks to human health. Fecal coliform bacteria are always present in the digestive tract of warm-blooded animals and are found in their waste. The Kansas Department of Health and Environment monitors fecal coliform bacteria levels in surface water, using those levels as an indicator of other fecal contamination and evaluating the risk of disease associated with drinking, swimming, or using the water in other ways. If the levels of fecal coliform bacteria are high in water,

there is a high probability that there are other fecal pathogens present. Bacterial levels in water vary widely depending upon the time of year, rainfall, environmental conditions, and the distance between the source(s) of contamination and the body of water. Typically, bacterial levels in water decrease as the distance from the source(s) of contamination increases. Fecal coliform bacteria are associated with fecal material, but similar organisms may be found naturally in soil and water or on the surface of leaves.

Monitoring of surface water by the Kansas Department of Health and Environment found that 75 percent of Kansas streams and 7 percent of lakes were impaired by bacterial contamination. Proper collection, treatment, and disposal of human and animal wastes can reduce bacterial levels in surface waters. Practices that reduce the rate and volume of runoff and allow vegetative buffer areas to filter the water before it enters a river or stream can reduce bacterial survival and protect surface waters.

### CHANNELS OF LIFE

*"The care of the rivers is not a question of the rivers but of the human heart."*

Tanaka Shozo, 19th century Japanese conservationist

All streams and rivers have a beginning and an end but the water in those streams and rivers never reaches a final destination. It only changes form as it is recycled through the hydrologic cycle. Kansas rivers and streams are an important part of this state's history and continue to be valued natural resources. They provide Kansans with one of life's essential nutrients—water. It is the responsibility of Kansas citizens to be stewards of these natural resources so that future generations can have safe, clean water to enhance their lives. ■

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## Career Profile:

### **KEN SHERRADEN**

**Biologist (Retired), Natural Resources Conservation Service**

Ken Sherraden first noticed his interest in the animals and wildlife around him when he was in the third grade. "My father bought me a copy of Roger Tory Peterson's *A Field Guide to Western Birds* so I could start bird watching as a hobby," Sherraden says. "That passion grew into a career." Sherraden recently retired as a biologist with the Natural Resources Conservation Service (NRCS).

The U.S. Congress established NRCS, formerly known as the Soil Conservation Service, in 1935 to assist private landowners in conserving soil, water, and other natural resources. At the time, the extended drought of the Dust Bowl era led to dust storms and created many problems for farmers who were trying to plant crops in Kansas and other Midwestern states.

Today, NRCS employs people in many different disciplines such as agronomy, rangeland management, agricultural engineering, and soil science who are working toward the same conservation goals. As a biologist, Sherraden was involved in many different types of conservation projects to protect natural resources. One task was to conduct studies to assess the impact that these projects have on humans and on the environment. For example, an environmental assessment must be completed before any natural resources project is started. The assessment requires many studies to evaluate how important the area is to the environment and wildlife, as well as how future development might change the current conditions. These studies once required many different people and a lot of time. Today, technology has enabled fewer people to conduct the same studies in much less time. "Technology has allowed information to be at our fingertips," Sherraden said. "This drastic change has enabled NRCS to provide better service to the public."

An education with a strong interest in math and science is important to being a good biologist, according to Sherraden. He also said a person in his former position, besides having an interest in the environment, must be good at working with people. A biologist with the NRCS spends 90 percent of his or her time working with people. NRCS works with agricultural producers to develop environmentally friendly practices that can prevent water and soil erosion and ensure good water quality. Most farmers understand the benefits of being good stewards to their land, Sherraden said.



Courtesy: Ken Sherraden

**Career Profile:****LEE ROLFS***Attorney, Kansas Department of Agriculture*

United States of America founding father Benjamin Franklin once said, “When the well is dry, we learn the worth of water.” It is Lee Rolfs’ job to ensure that Kansans have enough water in their wells—and all Kansas water sources—both for today and in the future.

“Having an adequate supply of clean, usable water is one of the most important issues facing Kansas, the United States, and the world,” Rolfs says. “Usable water is essential to all phases of our lives, and there is no substitute.”

Rolfs is a staff attorney for the Kansas Department of Agriculture’s Division of Water Resources based in Topeka. His primary responsibility for the last 29 years has been to help enforce the laws of the state that regulate the use of water. He also helps oversee the water compacts and agreements that regulate water use between Kansas and other states.

Rolfs developed an appreciation for agriculture from his grandfathers who farmed and ranched. He attended grade school and junior high school in Topeka and graduated from high school in Hays.

After graduating from the School of Law at the University of Kansas, Rolfs served a two-year clerkship with the Kansas Supreme Court. He then became Kansas’ first water attorney to represent the state.

The effects of precipitation, and the differences in water use, are obvious as one travels across the state. There could be green, lush pasture in the east, while a city in western Kansas is enacting water conservation regulations.

Kansas has one of the best systems of any state to determine who has the rights to a water source, according to Rolfs. The Department of Agriculture has issued more than 30,000 active water rights and permits that allow people to use water for irrigation, to serve residents of cities, for industry, power plants, recreation, and other uses. Each year, every permit holder must report how much water they used, and the Division of Water Resources verifies they are providing accurate data.

Rolfs says he is sometimes flooded with work relating to water.

“I am extremely lucky to have had a wide variety of issues come through my office since I started practicing water law. New issues continue to arise on a daily basis. I have answered questions about water laws from the public and from other attorneys, appeared in administrative and court hearings, and testified before the Kansas Legislature,” Rolfs says.

Two of his most attention-getting cases involved proceedings before the U.S. Supreme Court involving neighboring states and shared rivers. In one case, Kansas sued Nebraska for failing to share the waters flowing in the Republican River as the compact agreement between the states provided.

“That case was taken care of in five years—the parties agreed how to settle the issues,” Rolfs says. “Nebraska now has to limit its water use from the Republican River.”

In the other case, Kansas sued Colorado.

“Colorado failed to live up to an agreement it made with Kansas in 1949 to fairly share the waters that flowed in the Arkansas River that runs from Colorado to Kansas,” Rolfs says. “The Supreme Court determined that Kansas was correct; Colorado was ordered to pay Kansas more than \$34 million for the damage it caused to our state.”

The Arkansas River case hasn’t been completely finished, Rolfs says. It has been going on for nearly 22 years, but he’s hopeful it will end soon.

“In Kansas, as well as in many other places, the water supply continues to decrease as the demand for water increases,” Rolfs says. “As more people want to use water, the number of disagreements over water increases.”

Like the water itself, discussions about water rights will continue to flow.



Credit: Kansas Department of Agriculture

**TEACHER RESOURCES****BOOKS:**

AR - Accelerated Reading Level

***Dog of Discovery: A Newfoundland’s Adventures with Lewis and Clark***

Pringle, Laurence P. 2004 (AR - 7.6)

***Mesopotamia***

Farndon, John. 2007

***Mesopotamia***

Shuter, Jane. 2005 (AR - 6.9)

***Minn of the Mississippi***

Holling, Holling Clancy. 1978 (AR - 5.6)

***Mississippi River: A Journey Down the Father of Waters***

Lourie, Peter. 2004 (AR - 6.5)

***On the Trail of Lewis and Clark: A Journey Up the Missouri River***

Lourie, Peter. 2004 (AR - 6.1)

***Paddle-to-the-Sea***

Holling, Holling Clancy. 2004 (AR - 5.4)

***Plants on the Trail with Lewis and Clark***

Patent, Dorothy Hinshaw. 2003 (AR - 7.7)

**Streams and Rivers Showcase:****SMOKY HILL RIVER**

The Smoky Hill River starts its 530-mile run in the foothills of the Rocky Mountains and drains 57,727 square miles. The river rises (originates) in two places in eastern Colorado—the north fork in Kit Carson County and the south fork in Cheyenne County. Both branches of the river run east into Wallace County, Kansas, where they meet near Russell Springs and begin flowing together. From there, the Smoky Hill River flows eastward through central Kansas. East of Salina, the Saline River drains into the Smoky Hill River as does the Solomon River in Dickinson County. At Junction City, the confluence of the Smoky Hill and Republican rivers forms the Kansas River.

**FOSSILS**

In the late Cretaceous period, a shallow sea covered western Kansas. As organisms living in the warm seawater died, they sank to the sea floor and formed a thick mud, later covered by other sediment and compressed. Underwater currents helped shape the sea floor, which was exposed when the sea eventually receded. In depressions where water flowed eastward, wind and water carved out deep river valleys through the limestone and sandstone deposits that once formed the sea floor. The chalk beds of northwestern Kansas, home to some of the richest fossil beds in the world, are famous for their marine fossils. Dinosaur fossils have also been found in western Kansas. Fossil hunters continue to explore the Smoky Hill river valley in search of new specimens.

**WATER SOURCE**

During his expedition across the southern region of the Louisiana Purchase in 1806, Lt. Zebulon Pike was one of the first to record the name of the river as the Smoky Hill River. American Indians, including the Comanche, Kiowa, Sioux, and Arapaho, used the Smoky Hill river valley as their hunting grounds and fiercely opposed the presence of travelers pouring west. In east-central Kansas, the Santa Fe Trail followed the river from Junction City to Ellsworth. The discovery of gold near Denver in 1858 led to widespread use of the Smoky Hill Trail which followed the river. The government used that trail to move troops and supplies and since the trail was the quickest way to reach the gold fields in Colorado and later California, much of the emigration to those areas went over the Smoky Hill Trail or the Butterfield Overland Trail. The Atchison–Denver route of the Butterfield Overland Despatch, a stage and freight line in operation from 1865–1870, followed the Smoky Hill River valley. Military forts were established along the Smoky Hill River to protect traffic along these routes as well as early Kansas settlers and those building railroads through Kansas. These forts included Fort Harker near Kanopolis, Fort Ellsworth, Fort Hays, and Fort Wallace near Sharon Springs.

Recognized as a water source for early travelers, the Smoky Hill River also attracted those seeking to establish towns in central and western Kansas. Towns along the Smoky Hill River include Abilene, Salina, Lindsborg, Ellsworth, and Sharon Springs. Kanopolis Lake, one of the oldest lakes in Kansas, and Cedar Bluff Reservoir were built on the Smoky Hill River to control flooding and provide irrigation and municipal water supplies. Many cities and communities also draw water from alluvial aquifers in the Smoky Hill river valley.

**Monument Rocks**

Credit: Cindy Hart

**TEACHER'S RESOURCES (CONTINUED)*****River of Life***

Miller, Debbie S. 2000 (AR - 3.4)

***A River Ran Wild***

Cherry, Lynne. 2002 (AR - 4.7)

***Rivers and Lakes***

Oxlade, Chris. 2003 (AR - 6.1)

***Rivers: Nature's Wondrous Waterways***

Harrison, David L. 2002 (AR - 4.2)

***Rivers: Sculptors of the Land***

Frahm, Randy. 2002 (AR - 6.6)

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