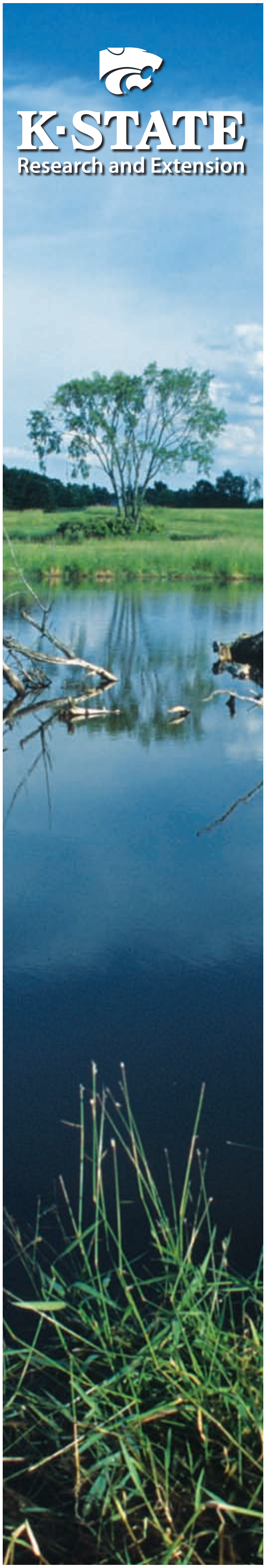

Water Primer: Part 1

OVERVIEW

Introduction

Water is an essential natural resource for sustaining virtually every aspect of life on Earth. The amount and character of water has remained generally unchanged since the earth was formed.

Agriculture requires water for animals and plants to grow. Industry uses water for cleaning, processing, transportation, and generating electricity. Consumers require water for health, hygiene, cooking, and recreation. Water is vital for people's health, economy, and general way of life. For example:

- The human body can survive for weeks without food, but only a few days without water.
- Humans require 2 quarts of water per day to help digest food, lubricate joints, clean eyes, remove body wastes, and cool the body.
- A dairy cow drinks 3 gallons of water to produce 1 gallon of milk. Approximately 25 gallons of water are needed to grow an ear of corn.
- A fast-food hamburger, french fries, and soft drink require 1,400 gallons of water to produce the food materials for the meal. Additional water is required for processing and transporting food products, and building and preparing the meal.
- The manufacturing of one car requires more than 100,000 gallons of water.

Earth is sometimes called "the water planet" because, unlike other known celestial spheres, nearly 75 percent of its surface is covered with water. If the current water supply covered the entire planet at a uniform depth, the water would measure 800 feet deep. Even though combustion and organic decay have produced minor changes in the amount of Earth's water, the total water supply today is essentially the same as centuries ago. With so much potential water available, why is there any concern about Earth's water supply?

The Hydrologic Cycle

Water is the only known substance on earth that commonly exists in three forms: solid (ice), liquid, and gas (vapor). As a solid, it is cold, strong, and retains its shape or structure. Liquid water is fluid, wet, and always in motion. Gaseous water is vapor that is present in the air at all temperatures. In pure form, water vapor is colorless, odorless, tasteless, and lightweight.

Water constantly moves and changes from a liquid or solid to a vapor or vice versa by evaporation and condensation. This continuous circulation of Earth's water is called the water cycle, or hydrologic cycle. (More information may be found in the second publication in this series, *The Hydrologic Cycle*, MF3021.)

World Water Budget

Although a large water supply exists, about 97 percent of Earth's total water is in oceans and salt seas. Much of the fresh water, approximately two-thirds, is frozen in polar ice and glaciers. The remaining fresh water (about 1 percent) is what humans rely on to sustain life. Only 2 percent of Earth's fresh, non-frozen water (or 0.02 percent of all water) is available on the surface in streams, ponds, and lakes to be used for recreation, industry, irrigation, and waste reception. Invisible atmospheric water is a significant

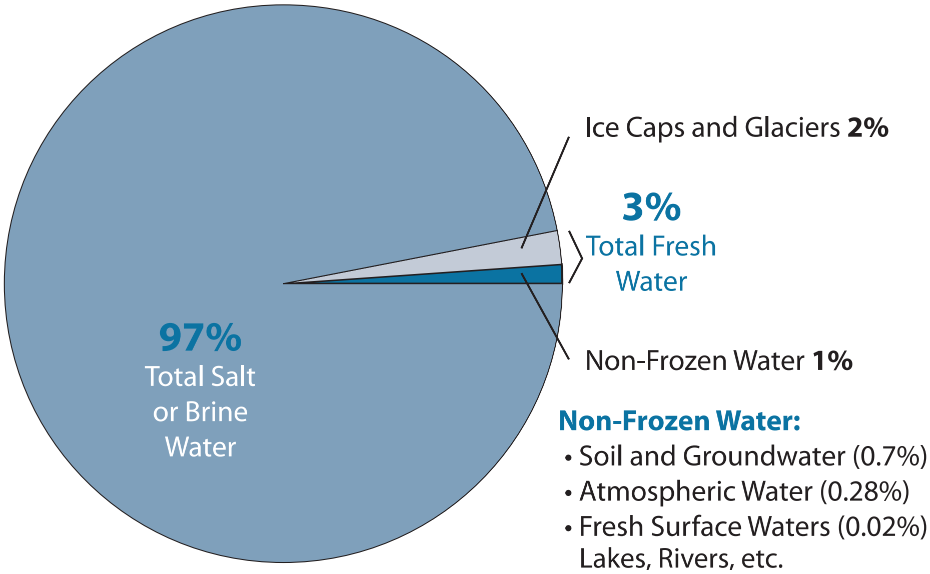

Figure 1. Fresh water as percentage of world water budget.

portion (0.28 percent) of Earth's fresh water supply. The fresh water in soil storage and groundwater (approximately 0.7 percent) supplies streams with base flow and provides much of Earth's water-use needs. Therefore, while water seems to be nearly everywhere on Earth, the annual available fresh water is limited to less than 1 percent of the world's total water supply, as illustrated in Figure 1.

United States Water Budget

In the United States, the lower 48 states have an average annual precipitation of 30 inches per year, and approximately 70 percent of the annual precipitation returns to the atmosphere as either evaporation or transpiration. Precipitation in the United States ranges from the highest of 460 inches per year at Mt. Waialeale, Hawaii, to 1.63 inches of annual precipitation in Death Valley, Calif. The other 30 percent eventually returns to the ocean from either surface water or groundwater flow.

Kansas Water Budget

The Kansas water budget is illustrated in Figure 2. More than 98 percent of available water enters the state as precipitation. Average annual precipitation in Kansas is 27 inches. Surface water flows both into and out of Kansas, with inflows averaging 0.38 inches and outflows of 2.96 inches. Evapotranspiration (the sum of evaporation and transpiration) constitutes the largest water use, averaging slightly more than 23 inches per year.

Kansas has approximately 30,000 miles of perennial streams throughout the state. Reservoirs and lakes cover more than 400,000 acres. This water is often referred to as surface water (see *Water Primer: Part 4, Surface Water,* MF3023). Many parts of the state also have underlying aquifers (see *Water Primer: Part 3, Groundwater*, MF3022). Fifty-one percent of all water used for public water supplies in Kansas comes from a surface water source, and 49 percent comes from groundwater. The primary water source for public water supply systems in the eastern third of the state is surface water (about 75 percent). The primary water source for the rest of Kansas and rural users is groundwater (about 75 percent).

The portion of the state's water budget that is diverted for use by people is only a small portion of the total water budget but critically important for quality of life and economic issues. These diversions are used for public and private drinking water supplies, industry, irrigation, stock water, power generation, and recreational activities. Figure 3 illustrates the uses of this portion of the water budget.

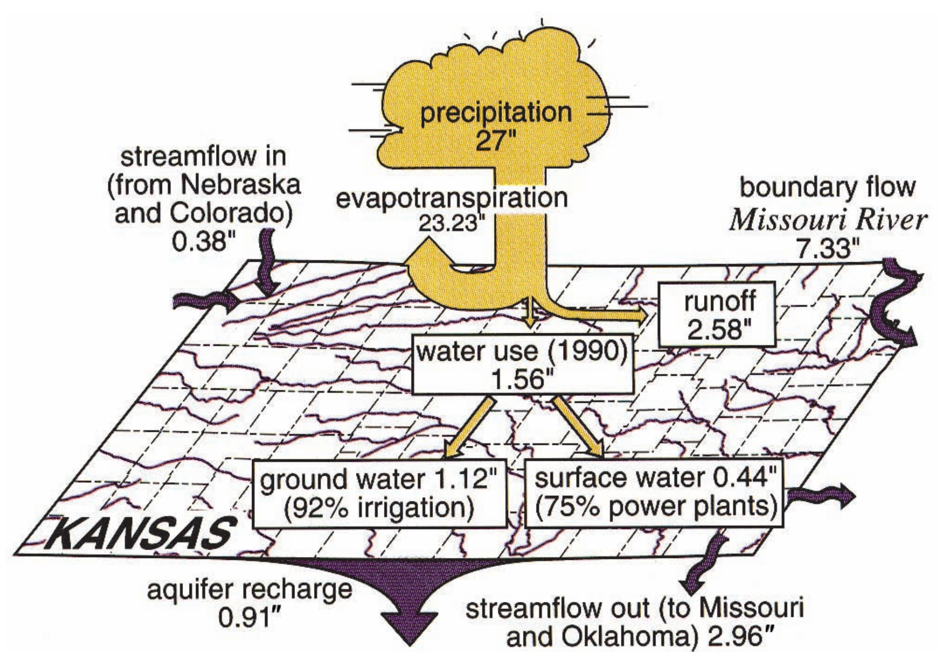

Figure 2. Water budget components for Kansas.
Source: Kansas Geological Survey

The importance of water to every Kansan cannot be overstated. The water supply available for urban and rural households, irrigation for crops, and water for livestock, wildlife, recreation, and industry affects everyone. Water is a renewable resource, but on a regional level and in the span of a human lifetime, this is not always apparent.

In the semiarid western portion of Kansas, many streams and rivers were historically intermittent, meaning that water may not have flowed all year. As the state was settled, the existing prairie grassland was converted to cropland. In the agriculture practice of the time, the soil residue cover was bare except during the summer growing season. This practice increased the potential surface runoff from the land to the streams. As more land was converted to cropland with the development of mechanized agriculture, the more the potential for runoff increased.

However, the cropland soil was also exposed to wind and water erosion, which led to the development of agricultural practices to reduce erosion potential to conserve soil resources. These practices include terrace systems, ponds, and reduced and no-tillage systems that maintain a protective residue cover on the soil surface.

From a human perspective, an observer from the late 1800s would have observed different conditions than an observer from the mid 1900s. As more conservation practices were implemented in the latter part of the 1900s and in the 2000s, the observations would be changing again. A limited number of stream flow measurement stations were also available to document stream flows, generally beginning in the latter half of the 1900s. Another impact on stream flow can be the development of water and irrigation wells. In western Kansas, large scale development of irrigation has resulted in substantial declines in the groundwater levels, which can affect surface water flow (see *Water Primer: Part 3, Groundwater*, MF3022).

State and local agencies recognize the significance of decreasing water levels. "Safe yield" policies that address sustainable development of surface water and groundwater to protect future generations have been implemented in some areas of the state. Studies of Kansas water resources explain why the entire water system (hydrologic cycle) needs to be considered in managing water, and how groundwater and surface water interact.

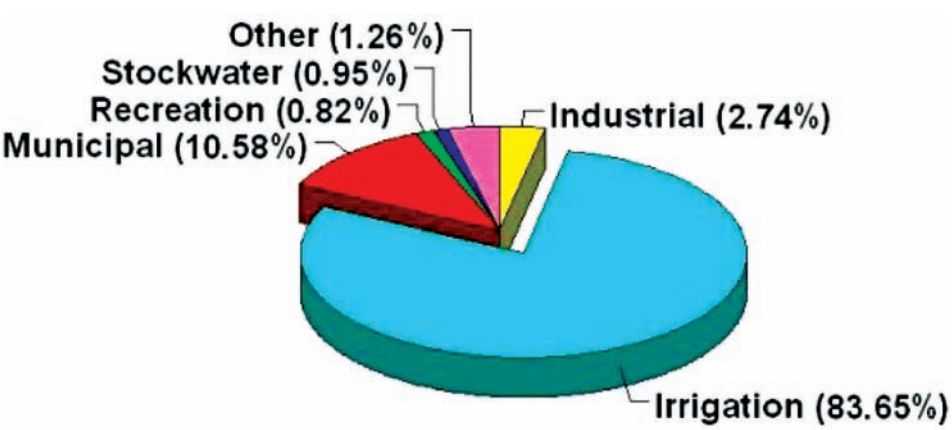

Figure 3. Water use in Kansas (based on 2006 water use).
Source: Kansas Department of Agriculture Division of Water Resources

Kansas Water Law and Water Agencies

Because of its importance to the economy of Kansas, water has been regulated by state statute since 1868. Current water law is governed by the Water Appropriation Act of 1945 (K.S.A. 82a-701 et. seq.), which established a prior appropriation system for streams and groundwater (See *Water Primer: Part 5, Water Law,* MF3024). In Kansas, all water is considered state-owned for citizens' use, and users are required to follow state rules defined in the Water Appropriation Act. "First in time-first in right" is the foundation of Kansas water-use law, which grants water rights to individuals on a first-in-time basis.

The Kansas Department of Agriculture Division of Water Resources is the lead agency for water appropriation; however, several other entities and agencies are granted water responsibilities, including the Kansas Department of Health and Environment, Kansas Geological Survey, and local groundwater management districts (See *Water Primer: Part 6, Water Agencies in Kansas,* MF3025).

Municipal and Industrial Water Use

The per capita consumption of water by Kansans averages about 1,360 gallons per day (U.S. Geological Survey, 2009) but is higher in the west than in the east (See *Water Primer: Part 7, Municipal Water,* MF3026)

Irrigation in Kansas

Irrigation is the single largest permitted water use in the state, and one of the largest in the United States and world (see *Water Primer: Part 8, Irrigation Law,* MF3027). Irrigation makes a significant contribution to the Kansas economy — especially to the local economies in western Kansas — but faces critical challenges because of declining water levels in the High Plains Aquifer.

Water Quality

Water is an ideal solvent because it dissolves a portion of almost everything with which it comes in contact. The purer the water and softer the material, the more dissolving takes place. Precipitation is the purest natural liquid water on the earth. Thus, rainwater more aggressively dissolves material than groundwater or water in streams. As precipitation falls through the atmosphere, contaminants are picked up from the air. When the precipitation reaches the earth's surface, it acquires more contaminants from plants, soil, waste materials, animals, and rock. Water readily dissolves some of the soft rocks, limestone, or dolomite found in Kansas, causing the water to become harder. The pH factor also affects the ability of water to dissolve most materials.

Residual salt still exists in geologic formations across Kansas, meaning deeper groundwater generally has a higher salt content. Because almost all groundwater is in motion, some of the salty groundwater from deeper depths is forced upward where it forms salt marshes or salty springs flowing into streams.

Human activities also affect water quality. For instance, oil and gas exploration and development require drilling through deep formations, some of which have high salt content. Historically, cases occur where salt water produced with oil has escaped into the environment. In other cases, salt water produced with oil was mixed into surface ponds where it leaked into the ground, contaminating soil and groundwater.

In the end, human activity also protects water from needless contamination that degrades water quality. Many environmental laws and regulations have been enacted to help protect water from degradation. These laws and regulations help reduce water contamination from a majority of sources. However, there are no laws or regulations to prevent most nonpoint source pollution.

References

Clement, Ralph W., L. Dean Bark, and Thomas C. Stiles. *Kansas Floods and Droughts.* U.S. Geological Survey National Water Summary. Water Supply Paper 2375, pp 287–294 1988-89.

Hairston, James E. *Getting to Know Water: Understanding Water as a Resource.* Auburn University, Cooperative Extension Service. WQ–111. al. June 1995.

Kansas Geological Survey. Public Information Circular #9, U.S. Geological Survey.

Rogers, Danny H. and William M. Sothers. *Kansas Water Supplies.* Kansas State University. Agricultural Experiment Station and Cooperative Extension Service. L–910 Revised October 1997.

The Water Footprint

The water footprint is a geographically precise indicator of direct and indirect water use by a consumer or producer and is measured in water volume consumed and/or polluted over time. The water footprint is used to measure the impact of individuals, businesses, and entire nations.

Authors:

Danny H. Rogers, professor, irrigation systems, biological and agricultural engineering
G. Morgan Powell, retired professor, biological and agricultural engineering
Kerri Ebert, extension assistant, biological and agricultural engineering

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

MF3020 **March 2012**

K-State Research and Extension is an equal opportunity provider and employer. Issued in furtherance of Cooperative Extension Work, Acts of May 8 and June 30, 1914, as amended. Kansas State University, County Extension Councils, Extension Districts, and United States Department of Agriculture Cooperating, Gary Pierzynski, Interim Director.