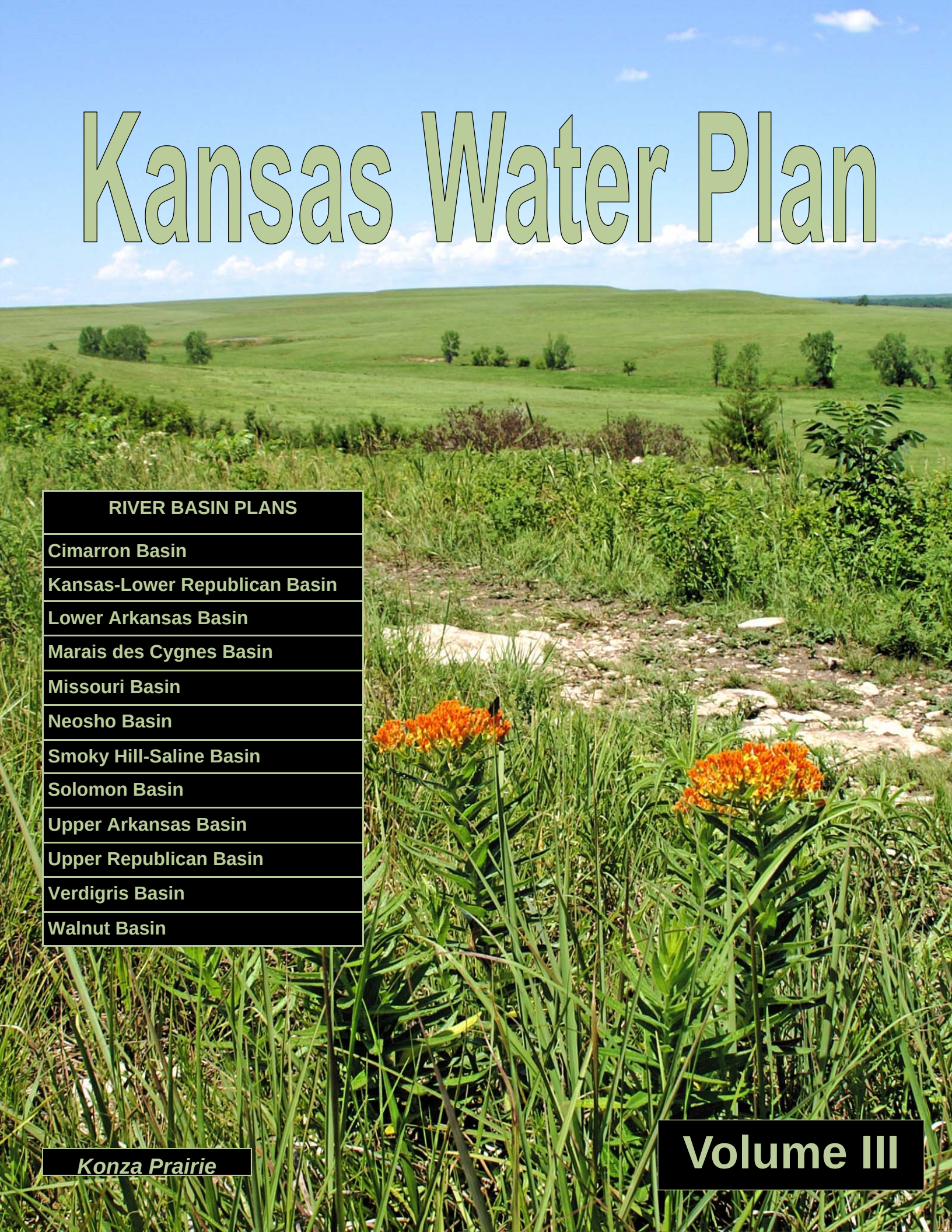
Kansas Water Plan



RIVER BASIN PLANS
Cimarron Basin
Kansas-Lower Republican Basin
Lower Arkansas Basin
Marais des Cygnes Basin
Missouri Basin
Neosho Basin
Smoky Hill-Saline Basin
Solomon Basin
Upper Arkansas Basin
Upper Republican Basin
Verdigris Basin
Walnut Basin

Konza Prairie

Volume III

Kansas Water Plan - Volume III
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Cimarron River Basin

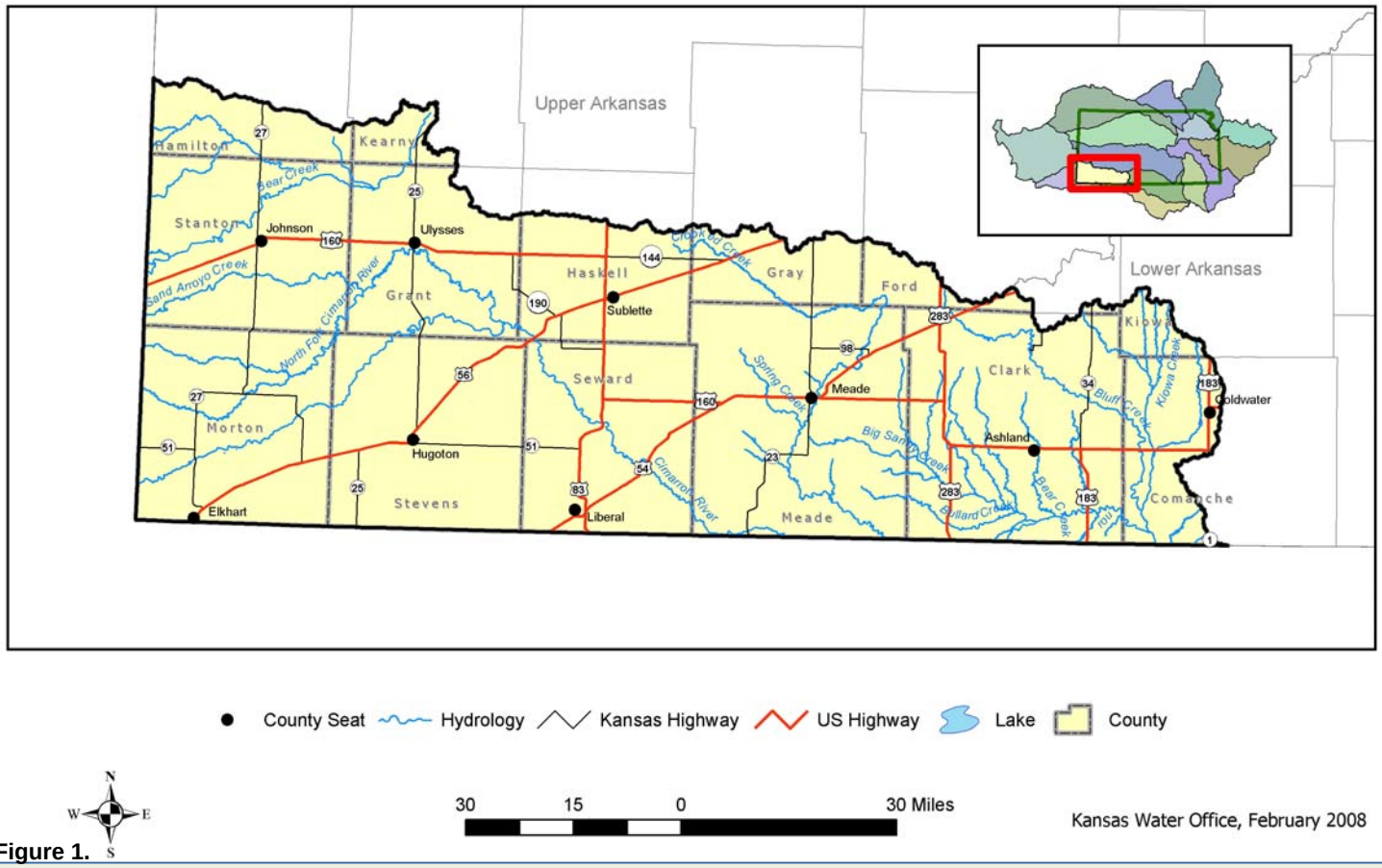


Figure 1.

General Description

The Cimarron Basin covers nearly 6,800 square miles of the southwest corner of Kansas. Nine 8-digit Hydrologic Unit Codes (HUCs) make up the basin. The basin includes all or parts of 14 counties. The major river in the basin is the Cimarron. There are no major federal reservoirs in the basin. Principal tributaries of the Cimarron River in Kansas are the North Fork Cimarron, Crooked Creek, Bluff Creek and, on occasions of high runoff, Bear Creek.

The Cimarron River has its source in Union County, New Mexico. It flows across the Oklahoma panhandle and the southeast corner of Colorado and enters Kansas nine miles northwest of Elkhart in Morton County. The Cimarron River leaves the state in the south-central portion of Meade County and reenters 30 miles east in Clark County. The river leaves the state for the last time in Comanche County and eventually joins the Arkansas River near Tulsa, Oklahoma.

Population and Economy

There were an estimated 54,300 residents in this basin in the year 2000.[1] According to the Kansas Division of Budget,[2] the total population of the 14 counties that are contained in whole or in part in the Cimarron basin had a population of 104,067 in 2000. By 2040, the county population is projected to decrease to 101,257.

This basin illustrates major demographic changes which are taking place in Kansas. In the past 40 years, two trends have dominated the state and the basin: 1) Rural counties have lost population, sometimes more than 10% every decade; and 2) Urban counties, particularly in the greater Wichita area and Kansas City areas, are gaining population at an even greater rate.

In the Cimarron Basin, counties with meat packing plants in the immediate vicinity are gaining population. Ford County, for example, went from a population 20,938 in 1960 to 33,268 in 2000. Other counties, however, are losing population. Comanche County, with a population of 3,271 in 1960, had a population of 1,636 in 2000.

The economy of the basin is very dependent on agricultural production. Crops grown include wheat, corn, grain sorghum, soybeans, forage sorghum and alfalfa.[3]

Seward County Community College offers opportunities for higher education.

Livestock production is an important component of the basin's economy. Beef cattle are the predominant livestock produced in the basin. Large cattle feeding operations are common. Beef processing is also a major economic factor in the basin.[3]

Gas and oil production is widespread and very important to the basin's economy. The first gas wells were drilled in the Hugoton field in the early 1920's, which remains a major national gas producing area. Other minerals are of minor importance to the basin.

Drilling rig, Anadarko Oil and Gas, Seward County. Photo courtesy Kansas Geological Survey.

Recreation is an increasing part of the economics of the basin, as is industry. The state parks and associated recreation and wildlife areas draw hunters to the area. The growing industrial contribution to the basin economy is primarily related to energy production, including ethanol. As of December 2008, an ethanol plants is permitted in Grant County and one ethanol plant is operational in Seward County. In 2007, Abengoa Bioenergy, a Spanish energy company, announced that Hugoton Kansas would be the site of the state's first cellulosic ethanol plant.

Physical Characteristics

Geology and Soils

The High Plains portion of the Cimarron River basin is underlain chiefly by Pliocene and Pleistocene deposits of which the Ogallala is the principal water-bearing formation of the area. The Ogallala formation consists primarily of unconsolidated sand, gravel, and silt formed from the igneous rocks of the Rocky Mountains and the sedimentary rocks of eastern Colorado. These materials were carried into Kansas and deposited by streams. These Pliocene and Pleistocene deposits occur in thicknesses up to 700 feet and are thickest in the south-central part of the basin.

Land Use/Land Cover

Land use in the basin typically is dominated by cropland (52.7%) or grassland (33.5%) or Conservation Reserve Program Land (13.1%). Less than one percent of land within the basin is comprised of residential, commercial/industrial and municipal use, open water and barren ground.

The Cimarron basin has the second lowest stream bank miles, 13,950, of the twelve major river basins in Kansas.

Within a 100-foot corridor along each bank, about 67% of the riparian area is pasture/grassland followed by cropland (25%).[4]

Climate

The climate of the basin is characterized by moderate to low precipitation, relatively high wind velocities, fairly rapid rates of evaporation, a wide range of temperatures and abrupt, sometimes violent changes in weather (Table 1).

Drought is a naturally recurring feature of this climate as exemplified by the Dust Bowl of the 1930s and the drought of 1952-1957. It is perhaps the most pervasive natural hazard affecting Kansas and other agricultural areas of the central United States. Kansas has been impacted by severe drought periodically throughout the present decade.

Table 1.

	Average Annual[1]		Freeze Dates (32 F.)[2]		
Location	Precipitation (inches)	Temperature (F)	Last	First	Days Between
Elkhart	18.90	55.0	Apr. 17	Oct. 18	178
Coldwater	26.13	57.5	Apr. 15	Oct. 20	187

[1]Source: National Climatic Data Center (1971-2000 data)
[2]Source: KSU Weather Data Library (1961-1990 data)

Wildlife and Habitat

The Cimarron River basin is located within the High Plains physiographic region which is comprised of rolling sand plains, rangeland, and cropland. Native vegetation in this region includes sand sagebrush, sand bluestem, prairie sandreed, little bluestem, blue grama, buffalograss, side oats grama, western wheatgrass, and scattered isolated sites with alkali sacaton and inland saltgrass.

"Point of Rocks", Ogallala outcropping in Morton County. Photo courtesy Kansas Geological Survey.

Numerous threatened and endangered species occur in the Cimarron Basin. Of these, one is an amphibian, ten are birds, two are mammals, four are reptiles and four are fish.

In April 2001, the U.S. Fish and Wildlife Service listed the Cimarron River in Clark, Meade and Seward counties, from U.S. Highway 54 bridge downstream to the Kansas-Oklahoma border, as critical habitat for the Arkansas River Shiner, a threatened species.

Southwest Kansas is a leading edge of the downstream movement of salt cedar. Salt cedar (also known as "tamarisk"), Russian olive and other invasive phreatophytes (a deep-rooted plant that obtains its water from the water table or the layer of soil just above it) have become a significant problem along the Cimarron River, Crooked Creek and other streams in the Cimarron basin.

Meade Lake State Park, located south of Meade, is the first state lake in Kansas.

Meade State Park was originally carved out of the Turkey Track Ranch in 1927. The location for the lake was chosen because springs fed by the Ogallala aquifer provided an adequate base flow. The state park and wildlife area comprise 803 acres of land and water.

Meade Lake State Park, Meade County.

Water Resources

The High Plains aquifer is the primary source of water in western Kansas. Nearly all of the reported water used in the Cimarron Basin is from ground water.[5] The High Plains aquifer is composed of several hydraulically connected aquifer units of which the largest is the Ogallala. It has been intensely developed, mostly for irrigation, leading to significant ground water declines.

The Cimarron basin contains 6,421 miles of intermittent and 432 miles of perennial streams for a total of 6,853 stream miles. The density of 1.0 stream miles per square mile, places the basin last among the twelve major river basins.

The Ogallala portion of the High Plains aquifer (Ogallala-High Plains aquifer) is characterized by low recharge and high declines. The expected "usable life" of the aquifer, when the aquifer is no longer able to support the current high rates of pumping, varies widely due to differences in amount of saturated thickness, hydraulic conductivity, withdrawals and other variables. The total irrigated acres in the Kansas High Plains increased 2.4% from 1999/1993 to 2001/2003. During the same time period there was an increase in corn, alfalfa and soybeans, crops that are typically water intensive. There has also been a wide spread adoption of more efficient irrigation systems. Even with the improvements, though, the aquifer is still declining.

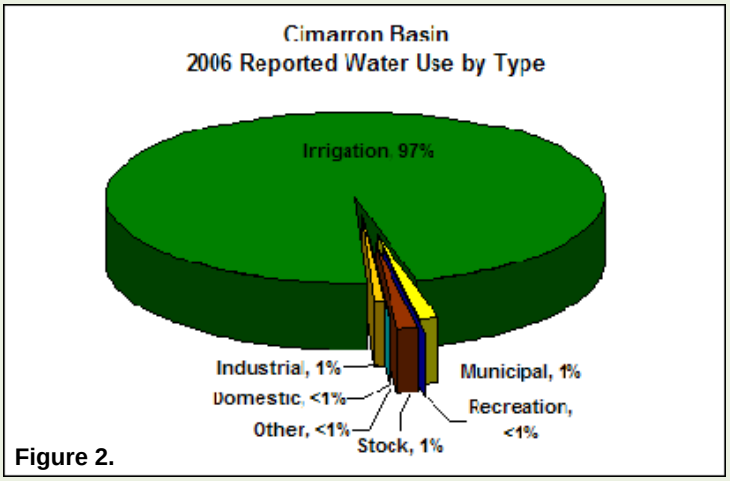


Figure 2.

Irrigation accounted for more than 97% of all reported water pumped or diverted. Municipal use accounted for less than one percent of water used in the basin; industry, recreation, stockwater and other uses combined equal less than three percent (2006).[5]

The High Plains aquifer is highly variable in Kansas. The amount of water in storage, the depth to water, the hydraulic conductivity (how readily the water moves through the sediments in the aquifer), the amount of withdrawals and the recharge rates all vary significantly throughout the basin.

Water Management

A majority of the basin is closed or restricted for new water appropriations. The State Chief Engineer's action on Southwest Groundwater Management District No. 3 (GMD3) rules took effect November 21, 2002. All the townships that were previously closed to new water development remain closed. Several additional townships were also closed and seventeen townships remain open to new appropriations.

Applications filed prior to the effective date for water from townships open at the time of application will be processed under the planned depletion standards. Applications for water after that date in any of the still open townships will be processed subject to the state-wide safe yield standard.

Minimum desirable streamflow (MDS) has not been set at any sites in the basin. No watershed districts have been organized in the basin.

The county conservation district is the primary local unit of government responsible for the conservation of soil, water and related natural resources within the county boundary. Each county within the Cimarron River basin has a county conservation district. Two Resource Conservation and Development (RC&D) districts serve the counties of the Cimarron basin: the Santa Fe Trail RC&D and the Coronado Crossing RC&D. The RC&Ds are designed to help community leaders develop rural economies by improving and conserving local natural, human and economical resources.


Center Pivot Irrigation near Elkhart, Morton County. USGS.

Resources

1. US Census data, 2000
2. Kansas Division of Budget 2007. County population estimates,
3. U.S. Department of Agriculture, Kansas 2006-2007 County Farm Facts, Agricultural Statistics and Ranking.
4. Wilson, Brownie, Assessment of Riparian Areas Inventory, State of Kansas, 2003. http://hercules.kgs.ku.edu/geohydro/ofr/2003_55/riparian/ofr_2003_55e.htm
5. Kansas Department of Agriculture-Division of Water Resources, December 13, 2007. Water Right Information System Database.
6. USDA-Natural Resources Conservation Service, Resource Conservation and Development Information. http://www.ks.nrcs.usda.gov/partnerships/rcd/
7. Kansas Water Office. 2003. *Kansas Water Plan*, Cimarron Basin and Water Quality Sections.
8. Kansas Water Resources Board Water Plan Studies Cimarron Unit. June 1962.

Cimarron National Grassland

The longest stretch of publicly-owned riparian habitat in Kansas is located within the Cimarron National Grassland in Morton and Stevens counties. The Grassland, administered by the USDA Forest Service, covers approximately 108,175 acres in the southwest corner of the Cimarron River basin.

Rock cliffs, cottonwood groves, grassy fields, yucca and sage brush are scattered throughout the land. Elevation ranges from 3,150 to 3,540 feet. Seasonal variety is provided by native grasses and riparian vegetation along the Cimarron River. The geology of the area is sandstone, shale, limestone, sand and gravel.

The third highest point in the basin of Kansas is located on the Grassland, Point of Rocks, at 3,540 feet. From this elevation, Colorado and Oklahoma are visible on clear days. Point of Rocks and other land features within the Grasslands were important landmarks for travelers on the Santa Fe Trail, which stretches across the Grasslands forming the longest publicly owned portion of the Trail in the country.

Cimarron National Grassland, blooming wildflowers.

The drought of the 1930's left the land in poor condition. Under Bankhead-Jones Farm Tenant Act in 1938, the federal government began purchasing the devastated land to restore it. Originally known as Land Utilization Projects, the lands were renamed Cimarron National Grassland in June 1960. Today the land is managed for wildlife, water conservation, livestock grazing, recreation and mineral production.

Cimarron River Basin Management Categories

January 2009

WATER MANAGEMENT CATEGORIES

The following categories include issues identified in the Cimarron basin plan as items that require attention in addition to the basin priority issues. These issues are addressed within the following management categories:

- Water Management
- Water Conservation
- Public Water Supply
- Water Quality
- Flood Management
- Water-Based Recreation
- Wetland and Riparian Management

These categories also correspond to the state-wide management categories and policies of the *Kansas Water Plan* found in Volume II. These documents contain new policy issues and the existing policy and statutory framework that relate to the management categories.

ISSUE: WATER MANAGEMENT

Southwest Kansas Groundwater Management District No. 3 (GMD3), is the major water management entity in the basin. A majority of the basin is closed or restricted for new water appropriations. The State Chief Engineer's action on GMD3 rules took effect November 21, 2002. All the townships that were previously closed to new water development remain closed. Several additional townships were also closed, and 17 townships remain open to new appropriations.

Applications filed prior to the effective date for water from townships open at the time of application will be processed under the planned depletion standards. Applications for water after that date in any of the still open townships will be processed subject to the state-wide safe yield standard.

Minimum desirable streamflow (MDS) levels have not been established for any sites in the basin.

The GMD3 has contracted with the Kansas Geological Survey (KGS) to map the practical saturated thickness (PST) of the Ogallala aquifer in their district. The PST, as determined primarily by well logs, is the net thickness of saturated sediments that significantly contribute to well yield from the water table down to the bedrock surface. It differs from the saturated thickness which is the total thickness of saturated sediments between the water table and the bedrock surface. The PST can provide a more accurate picture of water availability and may also provide insight into future water level trends at the scale of an individual well.

'Point of Rocks', overlooking Santa Fe Trail.
Photo courtesy Kansas Geological Survey

In 2006, the Kansas Water Office (KWO) calculated the median annual water level changes in wells from 1981 to 2005 for GMD3. Based upon the assessment, the data assembled for the 1981 through 2005 period indicates there was no statistically discernable change in the rate of ground water declines for southwest Kansas.

In 2007, the KWO, GMD3, and the U.S. Bureau of Reclamation contracted with the KGS for the development of a hydrologic model of the GMD3 region. The model will provide additional information on the water budget, and be able to project aquifer and stream flow responses to various future management scenarios.

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce water level decline rates within the Ogallala aquifer and implement enhanced water management in targeted areas.
- By 2015, achieve sustainable yield management of Kansas surface and ground water sources outside of the Ogallala aquifer and areas specifically exempt by regulation. Sustainable yield management would be a goal that sets water management criteria to ensure long term trends in water use will move as close as possible to stable ground water levels and maintenance of sufficient streamflows.

Applicable Programs

The following programs help to meet the objectives in the Water Management category. For more information

on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Appropriation Program
- State Conservation Commission: Water Right Transition Assistance Program
- Kansas Geological Survey and Kansas Department of Agriculture-Division of Water Resources: Water Well Measurement
- Kansas Geological Survey: High Plains Aquifer Technical Assistance Program
- Kansas Geological Survey: Stream Aquifer Interactions
- Kansas Water Office: Assessment and Evaluation Program/Ogallala Special Study Phase II, Cooperative Agreement with U.S. Bureau of Reclamation
- USDA-Natural Resources Conservation Service: Environmental Quality Incentive Program (EQIP)

ISSUE: WATER CONSERVATION

Water conservation is essential for the effective management of water resources in the basin to assure that a sufficient, long-term supply of water is available for the beneficial uses of the people of the state. Conservation is defined by Webster as a careful preservation and protection of something, especially the planned management of a natural resource to prevent exploitation or destruction. Water conservation is a part of maintaining a long-term water supply for Kansas.

Irrigation Nozzle

Water conservation activities apply to all uses: irrigation, municipal, industrial, etc., from all sources. Irrigation accounted for more than 97% of all reported water pumped or diverted. Municipal use accounted for less than one percent of water used in the basin, industry for one percent and recreation, stockwater, and other uses combined equal about 3 percent (2006).

Of the 614 public water suppliers in Kansas that have an approved conservation plan in place as of December 31, 2008, 16 plans have been approved in the Cimarron basin. Two hundred and forty nine plans have been approved for irrigation water rights (2006 data). The number of diversion points in western Kansas that reported irrigation application rates over the regional average decreased from 1991 to 2005. Of the total number of wells in the Cimarron basin that were reported to have diverted water in Kansas in 2006, more than 97% had meters.

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce the number of public water suppliers with excessive unaccounted for water by first targeting those with 30 percent or more unaccounted for water.
- By 2010, reduce the number of irrigation points of diversion for which the amount of water applied in acre feet per acre (AF/A) exceeds an amount considered reasonable for the area.
- By 2015, all non-domestic points of diversion meeting predetermined criteria will be metered, gaged or otherwise measured.
- By 2015, conservation plans will be required for water rights meeting priority criteria under K.S.A. 82a-733 if it is determined that such a plan would result in significant water management improvement.

Applicable Programs

The following programs help to meet the objectives in the Water Conservation management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture, Division of Water Resources: Water Appropriation Program
- Kansas State University Research and Extension: Water Conservation and Management Program
- State Conservation Commission: Water Resources Cost-Share
- Kansas Water Office: Water Conservation Program
- USDA - Farm Services Agency: Conservation Reserve Program

Cimarron River Basin Management Categories

ISSUE: PUBLIC WATER SUPPLY

The primary approach to addressing public water supply issues in the basin focuses on ensuring that there are adequate supplies of surface and ground water within the basin to meet future water demands, reducing the number of public water supply systems that are vulnerable to drought, and ensuring that systems have the technical, financial and managerial capacity to meet future needs for water quality and quantity.

There are 24 public water suppliers in the basin, including two rural water districts in Comanche County. All public water suppliers in the basin rely on ground water for their source of supply.

Coping with drought presents a challenge for public water suppliers. During drought periods the amount of raw water available typically is reduced at the same time customer demand for water increases. Although ground water is not as susceptible to droughts as surface water, public water suppliers that have an insufficient number of well or capabilities to meet increased demand are vulnerable. While all suppliers may be potentially impacted, some are particularly vulnerable. Of the public water suppliers in the basin, eight (36%) were considered drought vulnerable in 2006.

Applicable *Kansas Water Plan* Objectives

- By 2010, ensure that sufficient surface water storage is available to meet projected year 2040 public water supply needs for areas of Kansas with current or potential access to surface water storage.
- By 2010, less than five percent of public water suppliers will be drought vulnerable.
- By 2010, ensure that all public water suppliers have the technical, financial and managerial capability to meet their needs and to meet Safe Drinking Water Act requirements.

Applicable Programs

The following programs help to meet the objectives in the Public Water Supply management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Appropriation Program
- Kansas Department of Health and Environment: Public Water Supply Program
- Kansas Water Office: State Water Planning Program
- Kansas Water Office: Water Conservation Program
- Kansas Department of Health and Environment: Capacity Development Program

ISSUE: WATER QUALITY

Water quality and related water resource issues are addressed through a combination of watershed restoration and protection efforts utilizing voluntary, incentive based approaches, as well as regulatory programs.

The Section 303(d) list submitted to and approved by the U.S. Environmental Protection Agency (EPA), identifies 19 river segments and four lakes in the Cimarron River basin as water quality impaired. Among the streams, the greatest number of impairments was caused by excessive levels of chloride. Among the lakes, eutrophic conditions indicative of excessive algae production was the predominant cause.

Clark County State Lake on Bluff Creek.
Photo courtesy Kansas Geological Survey

Other pollutants limiting the use of the Cimarron River basin streams are fecal coliform bacteria, pH, sulfate and ammonia. Additional lake impairments were caused by dissolved oxygen depletion, pH and excessive aquatic plants. Each parameter causing impairment requires preparation of a Total Maximum Daily Load (TMDL). Seven watersheds and three lake TMDLs were developed for the Cimarron basin. The TMDLs describing the goals to reduce pollution and achieve water quality standards and the plans to meet those goals were submitted to EPA on June 29, 2000. The majority of these TMDLs were approved on September 11, 2000.

Eight counties in the basin have adopted state approved sanitary/environmental codes, with Comanche County recently having adopted codes.

Cimarron River Basin Management Categories

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce the average concentration of bacteria, biochemical oxygen demand, solids, metals, nutrients, pesticides and sediment that adversely affect the water quality of Kansas lakes and streams.
- By 2010, ensure that water quality conditions are maintained at a level equal to or better than year 2000 conditions.
- By 2010, reduce the average concentration of dissolved solids, metals, nitrates, pesticides and volatile organic chemicals that adversely affect the water quality of Kansas ground water.
- By 2010, maintain, enhance or restore priority wetlands and riparian areas.
- By 2015, nutrient reduction goals will be included in all WRAPS projects within the basin.
- By 2010, all public water suppliers will complete and implement a source water protection plan.

Applicable Programs

The following programs help to meet the objectives in the Water Quality management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Health and Environment: State Water Plan Program (Contamination Remediation)
- Kansas Corporation Commission: Conservation Division Programs
- Kansas Department of Health and Environment: Local Environmental Protection Program
- State Conservation Commission: Nonpoint Source Pollution Control Program
- State Conservation Commission: Water Resources Cost-Share Program

ISSUE: FLOOD MANAGEMENT

Flooding is a natural, recurring event associated with streams and rivers that has resulted in the formation of natural floodplains over time. While this inundation provided benefits under natural conditions, encroachment of urban and agricultural development onto floodplains has resulted in the potential for flood damage. In addition, some areas of Kansas are particularly prone to flash flooding which is characterized by a rapid rise in water level, fast-moving water and much flood debris.

Kansas Water Plan flood management guidance has emphasized targeting watershed dam construction assistance to priority watersheds encouraging participation in the National Flood Insurance Program and preparing updated floodplain maps for priority communities.

In 1993 the Kansas Department of Agriculture-Division of Water Resources launched the *Kansas Flood Mapping Initiative.* The FY 2005 *Kansas Water Plan* Flood Management Policy Section identified Seward County as a priority to be mapped, and digitized in the Cimarron basin. The map is under development and will be finalized and digitized in late 2009.

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce the vulnerability to damage from floods within identified priority communities or areas.

Applicable Programs

The following programs help to meet the objectives in the Flood Management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture - Division of Water Resources: Water Structures Program/Floodplain Management
- Kansas Department of Agriculture - Division of Water Resources: Water Structures Program/Dam Safety
- Kansas Division of Emergency Management: Hazard Mitigation Grants Program
- FEMA: National Flood Insurance Program
- State Conservation Commission: Watershed Dam Construction Program
- State Conservation Commission: Watershed Planning Assistance Program

Clark County State Lake on Bluff Creek
Photo courtesy of Kansas Geological Survey

Cimarron River Basin Management Categories

ISSUE: WATER-BASED RECREATION

The Cimarron basin has the least number and lowest percentage of public water-based recreation sites of any basin in the state.

In 2007, a 2,700-square foot educational center was completed at Meade State Park. The educational center overlooks the 80-acre Meade Lake and serves as an event facility with plans for future educational displays. Construction of the year round use educational center was endorsed by the Cimarron Basin Advisory Committee and was included in the 2003 *Kansas Water Plan*, Cimarron Basin Section.

Clark State Fishing Lake, a 300 acre impoundment with 900 acres open for public hunting, is located in Clark County.

Hunting is not as obviously tied to water resources as some other recreational activities such as boating and fishing, but significant activity occurs in the Cimarron basin on public wildlife areas, public and private wetland areas and adjacent to private streams and ponds. Hunting expenditures contribute significantly to the basin's economy.

Applicable *Kansas Water Plan* Objectives

- By 2010, increase public recreational opportunities at Kansas lakes and streams.

Applicable Programs

The following programs help to meet the objectives in the Water-Based Recreation management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Wildlife and Parks: Rivers and Stream Access
- Kansas Department of Wildlife and Parks: Fish Impoundments and Stream Habitats Program

ISSUE: WETLAND AND RIPARIAN MANAGEMENT

The primary approach to wetland and riparian management in the basin focuses on providing technical and financial assistance to landowners to protect and restore these resources in priority watersheds through the implementation of best management practices.

Riparian lands in the Cimarron basin have been seriously impacted by the infestation of non-native phreatophytes. Of greatest concern are the effects tamarisk (salt cedar) and Russian olive are having on the basin's native riparian ecosystems.

Applicable *Kansas Water Plan* Objectives

- By 2010, maintain, enhance or restore priority wetlands and riparian areas.

Applicable Programs

The following programs help to meet the objectives in the Wetland and Riparian management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Forest Service: Forest Stewardship Program and Conservation Tree Planting Program
- Kansas Department of Wildlife and Parks: State Parks and Wildlife Areas Planning and Development
- Kansas Department of Wildlife and Parks: Wildlife Habitat Improvement Program

Clark County Tamarisk Control.
Photo courtesy NRCS.

Cimarron Basin High Priority Issue
Management of the Ogallala High Plains Aquifer
January 2009

Issue

Management of the Ogallala-High Plains aquifer and associated alluvial aquifer is needed to reduce the rate of decline and to conserve the life of the aquifer.

Vision

Sufficient water resources in south western Kansas to support healthy, economically strong communities and rural lifestyles, today and for future generations.

Goal

Conserve and extend the life of the Ogallala - High Plains aquifer through management by aquifer subunits, targeting water conservation activities to high priority subunits, improved characterization of the aquifer and implementing strategies for improved agricultural practices with limited water resources.

Description

The High Plains aquifer is the primary source of water in western Kansas. Nearly all of the reported water used in the Cimarron basin is from ground water.[5] The High Plains aquifer is composed of several hydraulically connected aquifer units of which the largest is the Ogallala. It has been intensely developed, mostly for irrigation, leading to significant ground water declines. The Ogallala portion of the High Plains aquifer (Ogallala-High Plains aquifer) is characterized by low recharge and high declines. The expected "usable life" of the aquifer, when the aquifer is no longer able to support the current high rates of pumping, varies widely due to differences in amount of saturated thickness, hydraulic conductivity, withdrawals and other variables. The total irrigated acres in the Kansas High Plains increased from 2,681,000 to 2,746,000 acres between 1991-1993 and 2001-2003, a 2.4% increase.[9] During the same time period, there has been an increase in corn, soybeans and alfalfa acres, crops that are traditionally water intensive, as well as wide spread adoption of more efficient irrigation systems.[9] The annual water level measurements indicate that in most areas, for most years, for a five year or more trend the Ogallala-High Plains aquifer is declining.[10]

It has long been known that the aquifer was in decline in southwest Kansas, at least for localized areas. In 1958, the Kansas Water Resources Board issued a preliminary report highlighting the water "mining" problem in the Cimarron basin. More recently, the Statistical and Geostatistical Analysis of the Kansas High Plains Water Table Elevations, 2006 [1] shows Stanton, Grant and Stevens Counties have had water level drops of over 30 feet in the past ten years. Southwest Kansas still has significant amounts of ground water in storage, however, with much of the Cimarron basin projected to have enough ground water to support widespread pumping for 50 years or more, if the past water level decline trends continue. There are areas within Stevens, Grant and Stanton Counties though, where the aquifer is projected to decline within 25 years to where widespread pumping will not be feasible.

Figure one below is an estimated projection of how many more years the aquifer could support an assumed level of pumping, in this case with a well every quarter section, pumping at 400 gpm for 90 days. It projects the ground water level trends from 1996 to 2006 into the future; if the trend had been increasing, the area is shown as blue. This methodology is suitable to the Ogallala portion of the High Plains aquifer because of the extensive

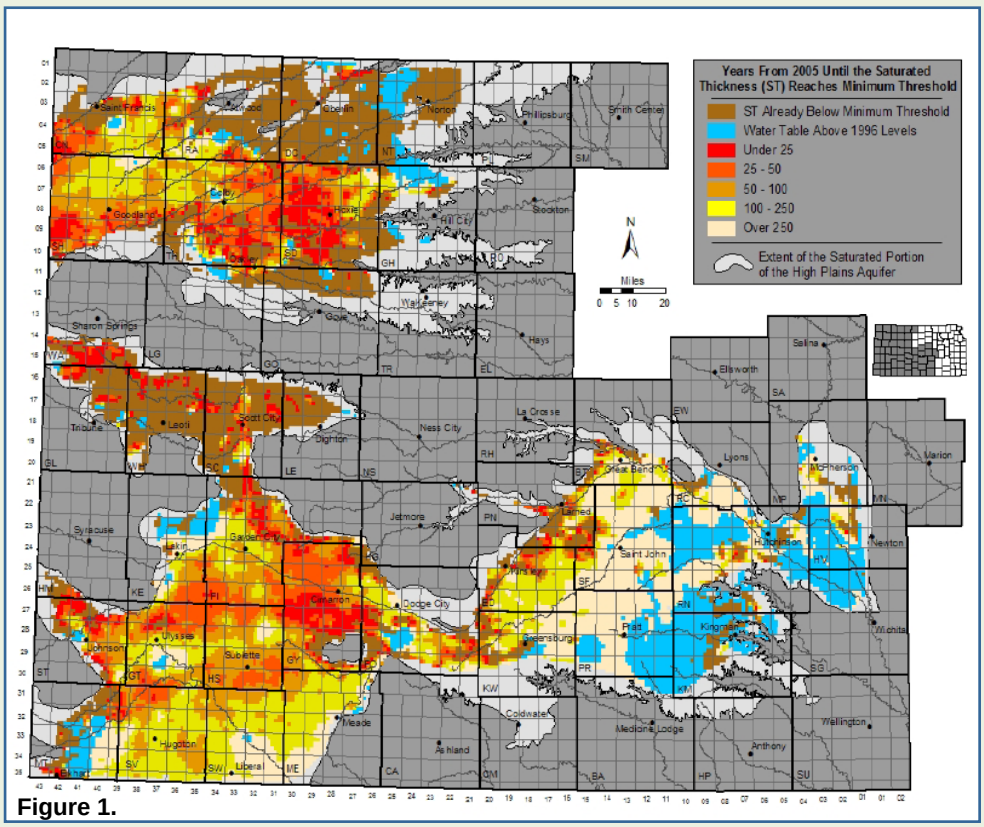


Figure 1.

data base available on the historic water level change and related variables.[7]

A majority of the basin is closed or restricted for new water appropriations. The Chief Engineer's action on Southwest Kansas Groundwater Management District No. 3 (GMD3) rules took effect November 21, 2002. All the townships that were previously closed to new water development remain closed. Several additional townships were also closed and 17 townships remain open to new appropriations. Applications filed prior to the effective date for water from townships open at the time of application will be processed under the planned depletion standards. Applications for water after that date in any of the still open townships will be processed subject to the state-wide safe yield standard.

Center pivot sprinkler. Photo courtesy Kansas Geological Survey.

The High Plains aquifer is highly variable in Kansas. The amount of water in storage, the depth to water, the hydraulic conductivity (how readily the water moves through the sediments in the aquifer), the amount of withdrawals and the recharge rates all vary significantly throughout western Kansas.

Water Appropriations

Approximately 2,124,038 acre feet of water are appropriated for use from ground water within GMD3. There are about 5,361 active ground water rights from 5,156 wells.[5]

Water Use

Nearly all of the reported water used in the Cimarron basin is from ground water. Irrigation accounted for more than 97% of all reported water pumped or diverted. Municipal use accounted for less than one percent of water used in the basin; industry, recreation, stockwater and other uses combined equal less than 3 percent (2006). The 2006 reported water use from the Cimarron basin was more than 1,000,000 acre feet.[5]

There has been wide spread adoption of more efficient irrigation systems in the Kansas High Plains from flood and center pivot to center pivot with drop nozzles.[9] A companion study by Kansas State University in 2006, found that the number of acres irrigated is a more important determinant of changes in water use than the adoption of more efficient irrigation systems.[2] The authors concluded that if the irrigated acres are held steady after conversion to a more efficient irrigation system, net water use would, on average, change little; it is with a decrease in irrigated acres that a reduction in water use is assured.

Activities and Progress

Various programs and activities have been initiated to reduce the decline rate of the Ogallala-High Plains aquifer and extend and conserve the aquifer. Tools such as ground water and surface water computer models and more detailed aquifer characterization have been developed. In the Cimarron basin, the determination of Ogallala High Plains aquifer subunit priority areas, setting subunit goals and developing management plans to reach these goals has been the responsibility of GMD3 and Kansas Department of Agriculture-Division of Water Resources (DWR) for areas outside the district.

Good data are essential to the determination of decline rates. Data development includes ground water models to better understand the aquifer and subunits. Water flowmeters, now required on almost all wells, provide improved information on withdrawals. Annual water level measurements, index wells and weather station data provide information contributing to better computer models.

Under a Cooperative Agreement between the U.S. Bureau of Reclamation and the Kansas Water Office (KWO), the state and GMD3 have contracted with the Kansas Geological Survey to develop a ground water Modflow model of the southwest district, incorporating

stream-aquifer interactions where applicable, to further characterize the hydrologic system and water availability. The model will provide more information on water in storage and allow future management scenarios to be projected.

Voluntary programs have been offered and targeted to areas determined by the management entity responsible for that area, GMD3 within district boundaries and in the fringe areas by DWR. The USDA Natural Resources Conservation Service (NRCS) Environmental Quality Incentive Program (EQIP) provides grants to transition from irrigated cropland to dryland production, for a minimum of four years.

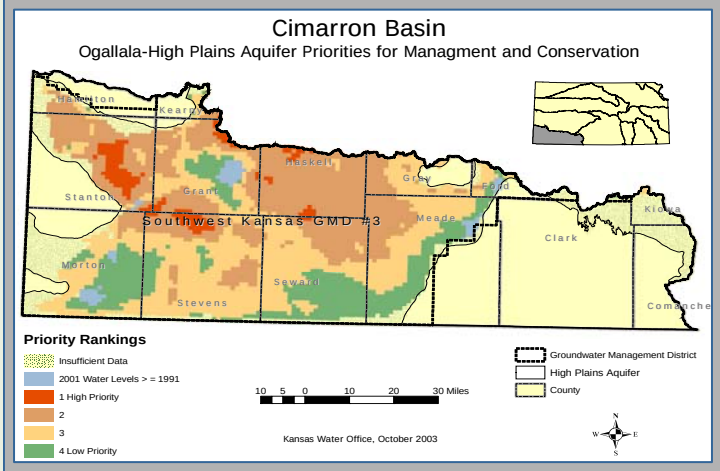
State programs have offered incentives to retire water rights, however that opportunity has not been provided to the Cimarron Basin area.

Regulatory programs have included the DWR Blatant and Recurring Overpumpers (BRO) program which makes special requirements on irrigators that have pumped in excess of their water rights to get them back into compliance. In addition, Kansas Water Appropriation laws protect senior water rights from impairment by junior water right pumping. In 2008, DWR administered a junior water right that was impairing a senior right in Stevens County.

Progress toward reducing the decline rate was evaluated by the KWO in 2006 using water level data from 1981-2005. The median annual water level changes were calculated for each region and standardized or indexed to antecedent moisture conditions using the Palmer Drought Severity Index (PDSI) for the appropriate region. The comparison of pre-1993 and 1993-2005 periods concluded that there was no discernable change in the rate of water level declines in the Ogallala–High Plains region. It also concluded that as of 2005, in the southwest Ogallala aquifer area (GMD3 and DWR in fringe areas), there has been no statistically significant change, at a five percent error level in the rate of decline.[3]

It should be noted that the reduction of total water use through the voluntary and regulatory programs is small. A measurable reduction in decline rates will likely take many years or decades, unless participation in reductions are greater.

Priority Aquifer Subunits: Priority aquifer subunit maps are used to guide state and federal efforts on water conservation. GMD3 has adopted the below map in their management plan. The DWR is working to identify priority subunits for the aquifer fringe. Specific target areas are defined for areas eligible for enrollment in the Conservation Reserve Enhancement Program (CREP), EQIP quick response areas and Water Right Transition Assistance Program (WTAP).



The priority rank shown on this map is based on an area's total score from two databases: estimated usable lifetime and density of ground water use. Useable lifetime is defined as the ability to support a 400 gpm well yield, on every quarter section, pumping for 90 days. Rank 1 indicates areas with a short estimated usable lifetime and a history of higher ground water usage. Rank 4, the lowest concern areas, have a relatively long useable lifetime and low total water use.

Cimarron Basin High Priority Issue
Management of the Ogallala High Plains Aquifer
January 2009

Recommended Actions

1. For priority aquifer subunits, develop specific goals and management strategies to extend and conserve the life of the aquifer.

2. Develop and maintain a ground water flow model of GMD3 area for evaluating management decisions and establishing conservation goals.

3. KWO will continue coordination among GMD3, DWR, stakeholders and other agencies.

4. Provide opportunities to permanently and temporarily reduce water use through voluntary programs (state, federal and local).

5. Develop local ownership and leadership of aquifer issues to assist in local adoption of specific conservation goals and programs.

6. Educate water users, decision makers and the general public on the conditions of the aquifer and methods and opportunities to reduce water use.

7. Evaluate the long-term impact of climate change on supply and demand for water resources in the basin.

8. Seek crop insurance option for limited irrigation crops from USDA Risk Management Agency.

9. Consider interstate discussions on water conservation and planning where aquifer subunits cross state boundaries and are not directly impacting an existing surface water compact.

10. Explore opportunities to augment aquifer recharge through artificial recharge during flood events and other means as feasible.

11. Support research into high value, lower water use crops that would be suitable for the region.

Resources

1. Bohling, Geoffrey C. and Wilson Blake B. 2007. *"Statistical and Geostatistical Analysis of the Kansas High Plains Water-Table Elevations, 2007 Measurement Campaign"*, KGS Open File Report 2007-32

2. Golden, Billy B, and Jeffrey Peterson. 2006. *Evaluation of Water Conservation from More Efficient Irrigation Systems*, Staff Paper 06-03, Kansas State University, 2006-20, July 2006.

3. Kansas Water Office. 2006. *Ogallala Aquifer Water Level Decline Rate, Status Report.*

4. Kansas Department of Agriculture. 2007. " *Kansas Irrigation Water Use Report 2006*".

5. Kansas Department of Agriculture. March 28, 2008. DWR water right data.

6. Wilson, Brownie. 2007. "*Ground-Water Levels in Kansas A Briefing to the Kansas Legislature House Agriculture and Natural Resources Committee, January 17, 2007*". KGS OFR 2007-1.

7. Kansas Geological Survey. 2000. High Plains Atlas. http://www.kgs.ku.edu/HighPlains/atlas/chstmap.gif

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10. Schloss, Jeffrey, Robert Buddemeier and Blake B. Wilson, eds., 2000. An Atlas of the Kansas High Plains Aquifer. Educational Series 14. Kansas Geological Survey. http://www.kgs.ku.edu/General/Personnel/tw/abs/Ogallala_decline_assessment.pdf

Cimarron Basin High Priority Issue
Arkansas River Shiner
January 2009

Issue

A portion of the Cimarron River is listed as critical habitat for the federally threatened Arkansas River Shiner, by the U.S. Fish & Wildlife Service. Coordination is needed among local landowners and the federal and state agencies responsible for managing the Arkansas River Shiner to identify solutions that may improve the condition of the species' habitat, to promote and restore healthy ecosystems, to maintain the integrity of landowners' rights, and to determine if the fish is extirpated from Kansas and if recovery is possible.

Description

The Arkansas River shiner (*Notropis girardi*) is a small minnow with a rounded snout and small mouth. Shiners are usually sandy above and silver laterally, grading to white on the belly. Dorsal scales are typically outlined with dark pigment. The shiner feeds mostly on aquatic invertebrates and spawns during the months of May, June and July in conjunction with flows following heavy rains. Eggs drift with the current during high flows until hatching occurs. If conditions are favorable, the shiner may reproduce several times during this period.

Arkansas River Shiner.

The U.S. Fish and Wildlife Service (USFWS) listed the Arkansas River shiner as threatened under the Endangered Species Act (ESA) in November 1998. Prior to listing, USFWS stated that limited survey data suggested the shiner only occupied 205 miles of its historic range. Historically, almost the entire Cimarron River main stem and several major tributaries were inhabited by the shiner. The shiner was last captured from the Cimarron River in August 2004 near Guthrie, Oklahoma by SWCA Environmental Consultants. A recent study of fish in Kansas reported that "Due to the lengthy absence of reported collections of the Arkansas River Shiner, *Notropis girardi,* from Kansas (and the attendant lack of probability of reproductive populations), we propose its addition to the list of extirpated fishes in Kansas."[5]

Protection of the Species

The ESA requires that when a federal action (such as funding through grants) may affect a listed species, the responsible agency or individual must enter into consultation with the USFWS. Activities on federal lands or federal actions that may affect the Arkansas River shiner or its critical habitat will require consultation with the USFWS. Individuals, organizations, states, local and tribal governments and other non-federal entities are affected by the designation of critical habitat only if their actions occur on federal lands, require a federal permit, license or other authorization, or involve federal funding.

Portions of the critical habitat designation for the federally threatened Arkansas River Shiner include the Cimarron River in Clark, Comanche, Seward and Meade counties from the US Highway 54 bridge downstream to the Kansas-Oklahoma border (Figure 1).

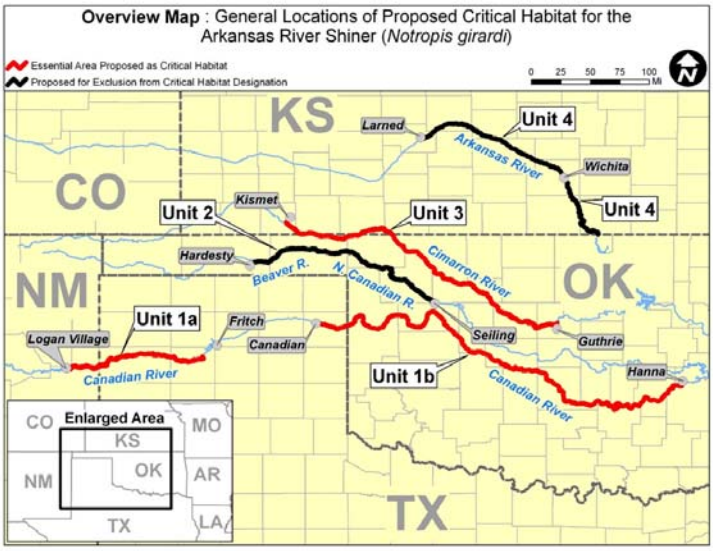

Figure 1.

The Arkansas River shiner receives protection in Kansas under the Kansas Nongame and Endangered Species Conservation Act of 1975 (Figure 2). Any time an eligible project is proposed that will impact the species preferred habitats within its probable range, the project sponsor must contact Kansas Department of Wildlife and Parks. Kansas Critical Habitat, as described by Kansas Administrative Regulations, for the Arkansas River shiner in the basin includes all reaches of the main stem Cimarron River located within the state.

Cimarron Basin High Priority Issue
Arkansas River Shiner
January 2009

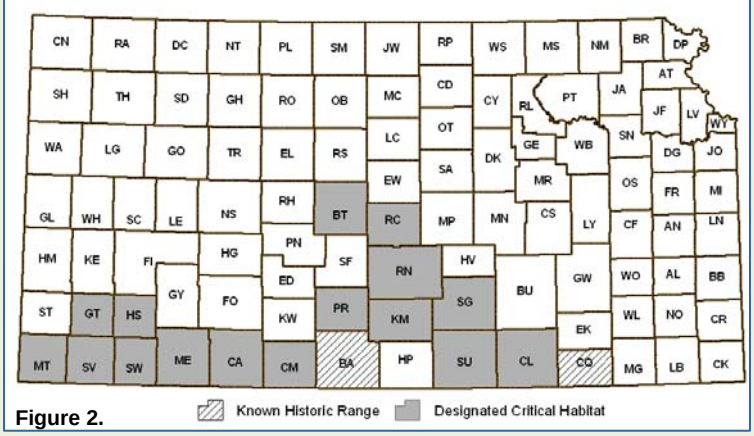

Figure 2.

Reasons for Species Decline

Declines in the Arkansas River Shiner populations cannot be isolated to a single factor; any combination of changes may have contributed to a reduction in the species' range and abundance. Reductions in streamflow and the occurrence and magnitude of high flow events, most likely produced by the diversion of water for irrigation have altered the nature of streambeds impacting the opportunities for shiner spawning.

Competition with introduced fishes also contributed to diminished distribution and abundance of the shiner in the Cimarron River. Incidental capture of the shiner and potential introductions of non-native minnows during pursuit of commercial baitfish species may contribute to reduced population sizes. The adverse affects of drought and other natural factors may have also contributed to the species' decline in this region.

Invasion of phreatophytic non-native plants, such as tamarisk (salt cedar) and Russian Olive, have further depleted streamflow and produced water quality changes that are not favorable to the Arkansas River Shiner. Naturally occurring saline inflows are concentrated by the high water use of phreatophytes. In some areas, tamarisk growths have narrowed the stream channels and resulted in deepening of the streams.

Cimarron River and High Plains Aquifer Conditions

Ground water table declines in the Ogallala-High Plains aquifer caused by high-volume, consumptive pumping of ground water for irrigation have occurred near the Cimarron River in southwest Kansas. These water level declines have decreased or eliminated ground water discharge to the perennial stretches of the river, thereby decreasing flow to or shortening the length of the perennial reaches. The primary area of perennial stretch shortening has occurred in northwest Seward County. The main location of current decrease in perennial streamflow is in southeast Seward County and southwest Meade County.[2]

Saltwater derived from mineral dissolution from the Permian bedrock intrudes into the overlying Ogallala-High Plains aquifer in southeast Seward County and southwest Meade County. Saline water that intrudes to the Ogallala-High Plains aquifer affects the usability of water in parts of the aquifer for irrigation and domestic use due to the high sodium and chloride contents. The saline water in the High Plains aquifer discharges into the overlying Cimarron River in these same counties. The river generally increases in salinity through this area. The decrease in fresh ground water discharge, caused by declines in the High Plains aquifer upstream of the saline water intrusion has resulted in an increase in the salinity of the river.[3]

While the degree of sensitivity of the Arkansas River shiner to salinity of the water in its habitat is not well defined, studies have found that more species are present in water of lower conductivity.[1] USFWS has indicated that water quality degradation within the river basin can cause localized impacts to shiner populations.[7]

The presence of invasive non-native, salt-loving plants such as tamarisk may contribute to the degradation of water quality in the Cimarron River in Kansas. Salt cedar growths consume larger quantities of water than native vegetation and draw salts up to the surface from deep in the soil. These salts are secreted on the plants' leaves,


Tamarisk Control. Photo courtesy Susan Metzger, KWO

which fall every year and give rise to increasingly saline surface and shallow soils. Salt cedar will tolerate this accretion of salt up to levels of 36,000 Mg/L, while native growths can only tolerate salinities on the order of 1,500 Mg/L.[1] When the area of growth is inundated by flooding or river rises, the salt is undoubtedly dissolved in the floodwaters and increases the salinity of the streamflow.

Management Plans

The Canadian River Municipal Water Authority (CRMWA) has prepared an approved Arkansas River Shiner Management Plan for the Canadian River in Texas and New Mexico.[1] The Oklahoma Farm Bureau has drafted a similar management plan for the Canadian and Cimarron Rivers. The purpose of these plans is to improve the condition of the Arkansas River Shiner habitat and to promote and restore healthy ecosystems. Additional goals of these plans include the exclusion for the need to designate some portions of the critical habitat and the eventual de-listing of the Arkansas River Shiner upon reestablishment of the species.

Recovery plans can be prepared by USFWS to list the specific actions needed to reverse the declines of a species. A recovery plan for the Arkansas River Shiner in Kansas has not yet been developed.

Opportunities for Watershed Improvement

Control of salt cedar will encourage sustained river flows by preventing peak flood flows from being excessively reduced as the floods progress downstream. If the shiner is present and viable in the Cimarron River in Kansas, this should help induce spawning and provide for more efficient egg transport during spawning. Control of salt cedar will also restore more natural flow regimes and increase the daily volume of water in the stream. Water quality will be improved by eliminating the excess salinity caused by the salt cedar.

There are many resources in Kansas that promote conservation and watershed ecosystem health, including the Kansas Watershed Restoration and Protection Strategies (WRAPS). Watershed partnerships such as WRAPS in the Cimarron basin could form coordinated approaches for long-term management of tamarisk and reestablishment of native vegetation, as well as, other activities that may improve the quality and quantity of water conditions in the basin.

Recommended Actions

1. Determine, monitor and document the status of Arkansas River shiner populations in Kansas.
2. Pursue opportunities with the U.S. Fish and Wildlife Service to delist the Kansas Cimarron River as critical habitat for the Arkansas River Shiner.
3. Evaluate the riparian and stream conditions of the Cimarron River within the critical habitat reach, and seek opportunities to protect and restore the ecosystem health.
4. Complete a hydrologic Modflow model of the Groundwater Management District No. 3 and determine the ground water – surface water conditions along the Cimarron River within the critical habitat reach.
5. Target state and privately-funded tamarisk control projects to the Cimarron River within the critical habitat reach to improve the riparian conditions.
6. Continue facilitating discussion and cooperation between local property owners, U.S. Fish and Wildlife Service, Kansas natural resource agencies and organizations and other interested stakeholders.

Point of Rocks Outcrop Overlooking Cimarron River
Photo courtesy Kansas Geological Survey

Resources

1. Canadian River Municipal Water Authority. June 2005. Arkansas River Shiner (*Nortopis girardi*) *Management Plan for the Canadian River from U.S. Highway 54 at Logan, New Mexico to Lake Meredith, Texas.*

2. Kansas Geological Survey. June 2005. Open File Report 2005-26. *Hydrogeologic Characteristics and Hydrologic Changes in the Cimarron River Basin, Southwestern Kansas.*

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5. Haslouer, Stephen G.,Kansas Dept of Health and Environment, Mark E. Eberle, David R. Edds, Keith B. Gido, Chris S. Mammoliti, James R. Triplett, Joseph T. Collins, Donald A. Distler, Donald G. Huggins and William J. Stark. 2005. *Current status of native fish species in Kansas*. Kansas Academy of Science.quote from p 44.

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7. United States Fish and Wildlife Service. 2001: Final Designation of Critical Habitat for the Arkansas River Basin Population of the Arkansas River Shiner (Federal Register /Vol 66, No. 65/ Wednesday, April 4, 2001).

Tamarisk Shrub.

Cimarron Basin High Priority Issue
Salt Cedar and Other Non-Native Phreatophyte Control
January 2009

Issue

Tamarisk (salt cedar), Russian olives and other invasive high water consuming vegetation are choking out native riparian habitat along the Cimarron River and other southwestern streams.

Description

Riparian lands in Kansas have been seriously impacted by the infestation of non-native phreatophytes. Of greatest concern are the effects tamarisk and Russian olive have on our native riparian ecosystems.[4, 5] Tamarisk is a tenacious shrub/small tree that has a deep root system (up to 100 feet) and leaves a salt residue on the soil surface. Tamarisk, a native of southern Europe and central Asia, is classified as a deciduous shrub that rapidly attains a height of five to twenty feet and grows best in sandy soils along streams. Tamarisk was brought to the United States for ornamental purposes and most likely was first established in Kansas in the early 1900s when it was planted in windbreaks. It has been widely used for bank stabilization and windbreaks since it is well suited for the western United States. There are many different species of tamarisk that are referred to with different common names. These problematic and invasive tamarisk species are commonly referred to as salt cedar.

Tamarisk Shrub.

Tamarisk can adapt to poor subsurface water quality. Tamarisk utilizes salt to increase the osmotic potential of its deep, extensive root system, which allows it to draw water from greater depths than the native vegetation. Therefore, tamarisk tends to out-compete native obligate phreatophytes during drought periods. The salt is excreted by the leaves and is concentrated in the leaf litter, thus impeding the growth of native species where tamarisk has gained a foothold. Tamarisk uses significant quantities of water. Actual water use by tamarisk depends on several factors: water availability, climate, water quality, population density, stresses, etc. However, it has been found that tamarisk will consume more water than some native vegetation in the same setting.[1, 2]

Russian olive, a different type of invasive phreatophyte shrub or small tree, was introduced in Kansas for windbreaks and wildlife plantings. The Russian olive, with its tendency to spread quickly, is a menace to riparian woodlands, threatening hardy native Kansas species like cottonwood and willow trees. Russian olive outcompete native vegetation, interferes with natural plant succession and nutrient cycling, and chokes irrigation canals in Kansas.

The resulting invasive thickets of tamarisk and Russian olive provide poor habitat for livestock and wildlife, increase fire hazards, decrease water quality and generally use more water than native vegetation. The vegetation does, however, provide shelter protection for livestock. Infestations of phreatophytes in Kansas are roughly estimated to occupy greater than 50,000 acres.

Scientists with the U.S. Department of Agriculture (USDA) have stated that, "*tamarisk infestation has reached epidemic proportions and is one of the greatest disasters to ever befall native riparian areas in western United State,".*[3] The National Invasive Species Council has identified tamarisk as one of its primary targets for control.

Tamarisk affects the water supply in both quantity and quality. The decrease in alluvial ground water levels due to tamarisk increases the transit loss of water delivered from John Martin Reservoir in the Arkansas River. Tamarisk affects water quality by reducing in-stream flows and the concentrating of naturally occurring salts in tamarisk stands.

Scientists with the U.S. Department of Agriculture (USDA) have stated that . . . *tamarisk infestation has reached epidemic proportions and is one of the greatest disasters to ever befall native riparian areas in western United States*. (2) The National Invasive Species Council has identified tamarisk as one of its primary targets for control.

Cimarron Basin High Priority Issue
Salt Cedar and Other Non-Native Phreatophyte Control
January 2009

Tamarisk affects the water supply in both quantity and quality. Tamarisk affects water quality by reducing in-stream flows and the concentration of naturally occurring salts in tamarisk stands.

Thick tamarisk stands promote narrowing of river and stream channels. Since tamarisk replaces native species, there is a loss of bio-diversity in the infested areas. In the Cimarron River basin, tamarisk is rapidly replacing the last remaining native Alkali sacaton (*Sporobolus airoides*) and western wheatgrass prairie. Wildfires are more intense in tamarisk infested areas; however, due to the nature of the tamarisk root crown, tamarisk recovers from fires quicker than native vegetation. Thus, fires tend to promote additional infestation. Tamarisk infestation is problematic in Kansas because it negatively impacts water quantity and quality, and results in the loss of land utilization options and value, as well as a loss of habitat.

Control demonstration, Clark County. Photo courtesy NRCS.

Estimates of the number of acres infested in the United States are between one and two million acres. Tamarisk has been identified in nearly every county in Kansas, but is concentrated along streams and lakes in the western portion of the state. Tamarisk is prevalent along the mainstem and tributaries to the Arkansas and Cimarron Rivers, as well as, the shorelines of several of the state's federal reservoirs.

Helicopter surveys of the Cimarron River were conducted in 2005 and 2006 by the Kansas Department of Agriculture. Estimates from the 2004 survey indicate that about 26,178 acres (73%) of the riparian corridor from the Colorado-Kansas state line east to the Kansas-Oklahoma state line along the Cimarron River are infested with tamarisk (Table 1). According to a state-wide county survey conducted in 2004, more than 50,000 acres of the land surveyed in Kansas are infested with tamarisk. In the Cimarron basin counties, there are over 27,000 acres infested (Table 1).

Table 1

County	Total Acres Tamarisk	Percent Tamarisk Infestation
Comanche	3,550	84
Clark	9,389	95
Meade	4,104	89
Seward	3,642	61
Morton	5,732	67
Grant	300	24
Stevens	553	25

Cimarron Basin High Priority Issue
Salt Cedar and Other Non-Native Phreatophyte Control
January 2009

Recommended Action

1. Continue to work with agencies and other groups on the water issue strategic plan and 10-Year Strategic Plan to coordinate and implement the variety of programs, research and educational efforts that are occurring or recommended.

2. Promote education and seek local input through the state's Basin Advisory Committees.

3. Continue an evaluation of the most effective and cost-efficient control measures for the basin.

4. As an effective control measure is identified for the basin, implement a wide scale, watershed-based control effort, with plans to replant with beneficial vegetation that helps stabilize the soil and provide other benefits the invasive species had provided.

5. Research and evaluate biological control of tamarisk using leaf beetles and/or other suitable organisms, but pilot it with extreme caution to avoid unintended consequences.

6. Deliver educational materials and technical information to legislators, property owners and the public within the basin related to non-native phreatophyte research and control through Kansas State University Ag Experiment Station & Cooperative Extension Service.

7. Quantify the actual non-beneficial use of water by tamarisk in the basin's different ecological settings. Existing research should be used and augmented with on-the-ground measurements of changes to both stream flow and ground water before and after tamarisk control activities. This research will help to establish the difference in water consumption in Kansas between non-native phreatophytes and typical riparian plant communities.

8. Evaluate the recovery benefits after tamarisk control to provide valuable information on the specie's true impact to water quality, wildlife habitat, water quantity, grazing land, risk reduction from flood damages and other features that impact the basin's ecology and economy.

9. Determine the potential disposal of tamarisk biomass holds for various value-added products such as ethanol, bedding, fiberboard, and fuel pellets, and identify how to harvest and remove tamarisk without damaging the riparian area.

Resources

1. Butler, Jim, Kluitenberg, Gerard, and Whittemore, Don. 2005. *Ground Water Assessment in Association with Salt Cedar Control – Report on Year One Activities*. Kansas Geological Survey Open File Report 2005-19.

2. Colorado Department of Natural Resources. 2004. *10-Year Strategic Plan on the Comprehensive Removal of Tamarisk and the Coordinated Restoration of Colorado's Native Riparian Ecosystem.*

3. Kansas Water Office. 2003. *Kansas Water Plan, Cimarron Basin Section*.

4. Kansas Water Office. 2005. *10-Year Strategic Plan for the Comprehensive Control of Tamarisk and Other Non-Native Phreatophytes*.

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Helicopter Survey of Tamarisk

Cimarron Basin High Priority Issue
Bioenergy and Water
January 2009

Issue

Renewable fuel production is a growing issue in the Cimarron basin, where increased biofuel production provides economic opportunity. As new biofuel facilities are sited and changes are made to the basin's cropping patterns, more evaluation is needed of the impacts from the increased demand on both water supply and water quality.

Description

Gas and oil production is the second largest industry in Kansas and is very important to the Cimarron basin's economy. The first gas wells were drilled in the Hugoton field in the early 1920s, which remains a major national gas producing area. The growing industrial contribution to the basin's economy is also related to energy production, primarily ethanol. As of December 2008, there is an ethanol plant permitted for construction in Grant County, a permit pending in Stevens County and an operational ethanol plant in Seward County. Hugoton, Stevens County, will also be the site of the state's first cellulosic ethanol plant (Figure 1).

Water Quantity

Ethanol production, like many industrial and agricultural practices, involves a consumptive use of water. A 50-million gallon per year (MGY) ethanol plant uses about 200 MGY of water (or about 550,000 gallons per day), primarily from evaporation during cooling and wastewater discharge. Ethanol production technology has uses water more efficiently; plants today use about 50 percent less water than 10 to 15 years ago. It currently takes three to four gallons of water to produce one gallon of ethanol. Under Kansas law for appropriating water, ethanol plants, as any industry, must purchase water from a rural water district a municipality or acquire a water right. Parts of the basin are closed to new water appropriations; in closed areas, any new venture must purchase an existing water right, and any change in use of that appropriation must be approved by the Chief Engineer of the Kansas Department of Agriculture-Division of Water Resources to ensure that the net consumptive use does not increase.

Nonetheless, some have raised concerns that increased corn production, a water-intensive crop, may cause additional declines over time.[2, 3]

Most U.S. ethanol is made from corn, but it can also be produced from other feedstocks such as grain sorghum, wheat, barley or potatoes. In Kansas, more than half of the ethanol produced comes from grain sorghum, with most facilities using corn and sorghum interchangeably.[2]

Ethanol production using corn grain has exploded throughout the Midwest. This new demand for corn, and the new opportunities for value-added processing and cattle production in rural communities, has created a significant economic development opportunity throughout Kansas and in the Cimarron basin. However, the potential changes to the basin's cropping patterns, specifically increasing the number of irrigated corn acres, may negatively impact the aquifer and stream conditions.

According to the U.S. Department of Agriculture National Agricultural Statistics Service (NASS) the number of irrigated corn acres in southwest Kansas grew from 438,000 acres in 1990 to 726,000 in 2007.[5] However, despite the growth over this period, recent years do not reflect the highest recorded irrigated corn acres for this region. Improved agro-

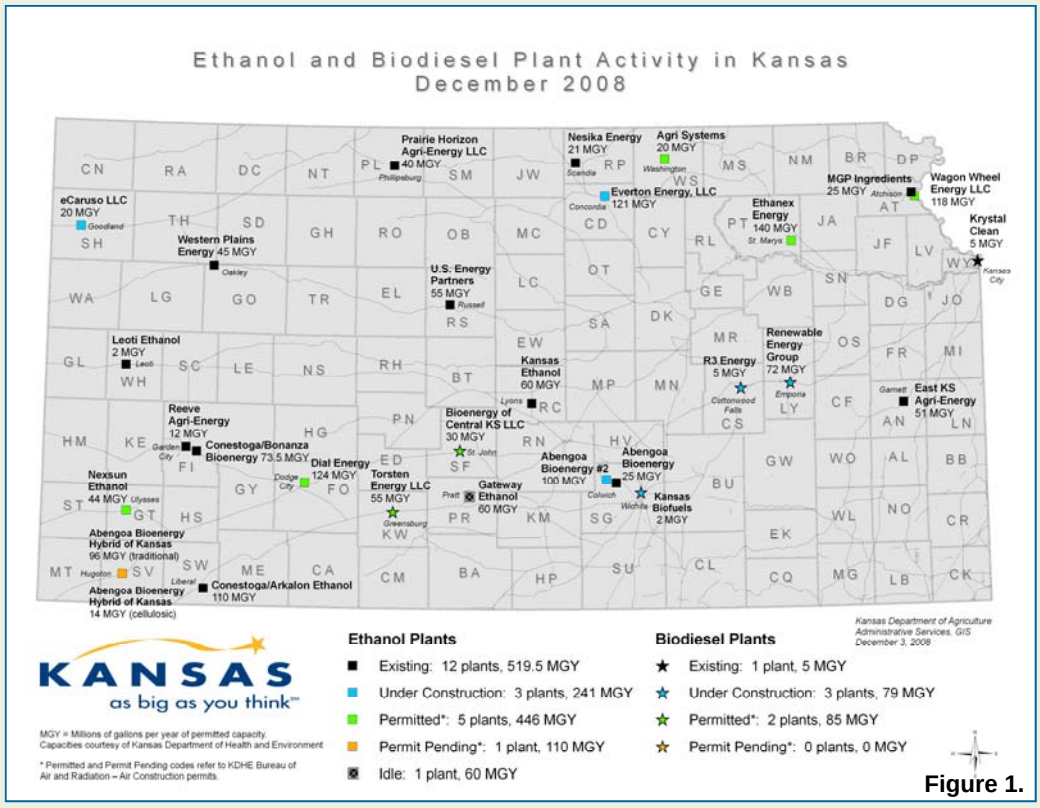
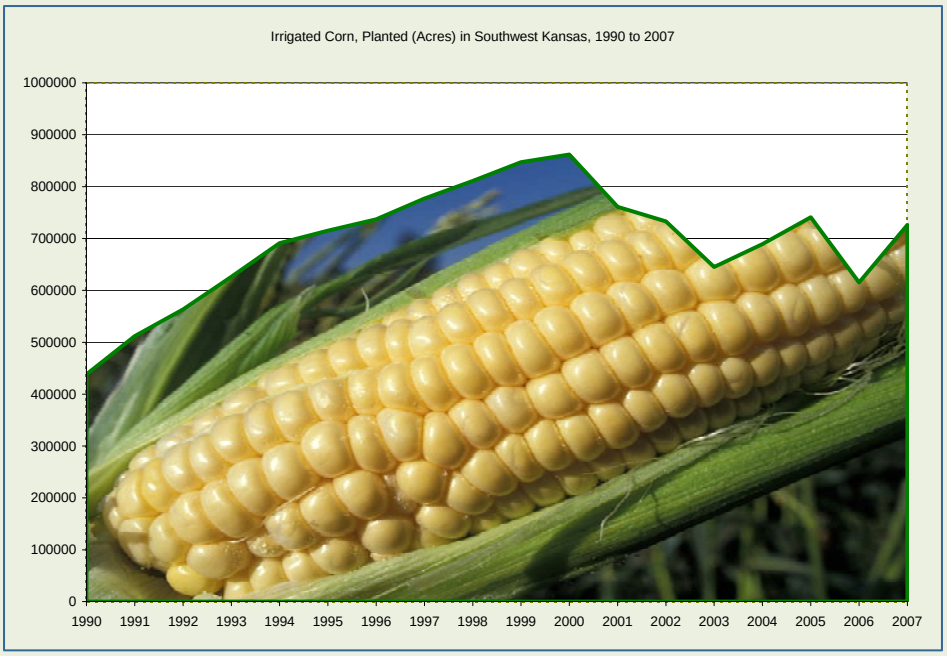


Figure 1.

nomic practices and crop genetics have led to higher corn yields. In southwest Kansas, while there was a 16% increase in irrigated corn acres from 1993 to 2003, there was a 52% increase in irrigated corn production. [10] According to the Kansas Department of Agriculture, Stevens County ranks first in all Kansas counties for irrigated corn acres.

In 2006, approximately 16% of Kansas corn and sorghum crops were used for ethanol production, up 13% from 2000. Corn production in Kansas may be slowing down. According to NASS, producers intended to plant eight percent fewer corn acres in 2008, as a result of multiple factors including crop rotation considerations and high input costs. In 2008, Kansas was expected to plant their largest soybean crops in history.[5]

Water Quality



Wastewater from ethanol plants is regulated by the Kansas Department of Health and Environment (KDHE), which administers both the federal National Pollution Discharge Elimination System (NPDES) permits and Kansas Water Pollution Control permits. In most instances, KDHE issues the state-level permit, which requires ethanol plants to use the wastewater for beneficial land applications rather than simply discharging into streams and rivers.

A rise in the number of corn acres may also impact the basin's water quality through increased fertilizer application and soil erosion. Corn has the greatest application rates of both fertilizer and pesticides per acre, higher than for soybeans and mixed-species grassland biomass. The switch from other crops or noncrop plants to corn may lead to higher application rates of highly soluble nitrogen. Harvested row crops, such as corn, have a higher potential for soil erosion than grasses or perennial crops. The potential water quality impact of an increased demand for corn may be mitigated through Best Management Practices (BMPs), especially those addressing soil erosion and herbicide applications.

Biodiesel

Biodiesel is produced using oils extracted from crops, animal fat or waste vegetable oil using a chemical process called transesterification. Most U.S. biodiesel is produced from soybean oil, although other vegetable oils such as canola, corn, cottonseed, flax seed, sunflower, or peanut oil can be used. As of December 2008, no biodiesel facilities are permitted for or located in the Cimarron basin.

Biodiesel production uses roughly three gallons of water per gallon, about a gallon of which is consumptive use. Wastewater from biodiesel plants, which may contain high amounts of oxygen, grease and oils, is regulated by the KDHE.

Cellulosic Ethanol

Cellulosic ethanol uses lignocellulose, the main structural material in any plant, as a feedstock. Cellulosic feedstocks require an extra step to break down the lignocellulose into fermentable starch, thus increasing production costs. The bulkier cellulosic feedstocks are also more costly to harvest, transport and store. Processing of cellulosic materials would require more water than corn, as the feedstock is dry. Research on cellulosic feedstocks, such as switchgrass, wood chips, and corn stover is ongoing. The U.S. Department of Energy has set 2012 as a target to achieve technological advances to make cellulosic ethanol cost competitive with corn ethanol. In 2007, Abengoa Bioenergy, a Spanish energy company, announced that Hugoton, Kansas would be the site of the state's first cellulosic ethanol plant. In conjunction with cellulosic ethanol research, some researchers are investigating the use of perennial polyculture crop systems for cellulosic feedstocks.

Production of cellulosic ethanol may have greater positive environmental impacts than grain based ethanol

such as reduced greenhouse gas emissions, decreased fertilizer application and less reliance on water intensive crops.

Corn Research and Varieties

Breeding of corn hybrids that maximize yield for ethanol production while reducing additional strains on water supplies has been a focus of much research by universities and corn breeding companies. Drought tolerant hybrids, specifically transgenic drought resistant corn, are especially important in areas of western Kansas where rainfall averages fewer than 16 inches per year. In addition to drought tolerant varieties, industries are identifying corn varieties that produce higher yield and more ethanol per acre. High total fermentable ethanol corn hybrids provide higher levels of fermentable starch, the sum of all starches and simple sugars that ferment during the typical dry grind process.[4,7]

Recommended Actions

1. Coordinate, where applicable, the development, implementation, and public input process between the *Kansas Water Plan* and Kansas energy policy.

2. Maintain regulatory oversight by state and local government on the siting of ethanol and biodiesel plants, with special emphasis on educating applicants on the water supply and availability.

3. Look for water recycling opportunities within the biofuel facilities.

4. Promote research for less water dependent corn varieties and improved irrigation scheduling that maintains or increases crop yield without increasing water use, and encourage more use of grain sorghum, sweet sorghum and other lower water use crops.

5. Promote research and pilot projects for viable, commercial cellulosic ethanol production and other biofuels less dependent on water intensive crop production.

6. Increase corn water use efficiency (amount of grain produced per inch of water) through research and extension efforts. Educational emphasis should be placed on utilization of irrigation scheduling tools such as KanSched and the Mobile Irrigation Lab.

7. Evaluate the biofuel facility watershed and watersheds of input crops, and identify potentially environmentally sensitive areas and target programs to mitigate environmental impacts, such as stream buffers, grass filters, BMPs, etc.

8. Provide education and/or incentives for marginal lands that have expiring, un-renewable Conservation Reserve Program contracts to stay in a conservation planting, with special consideration to acres that could return to irrigation.

Resources

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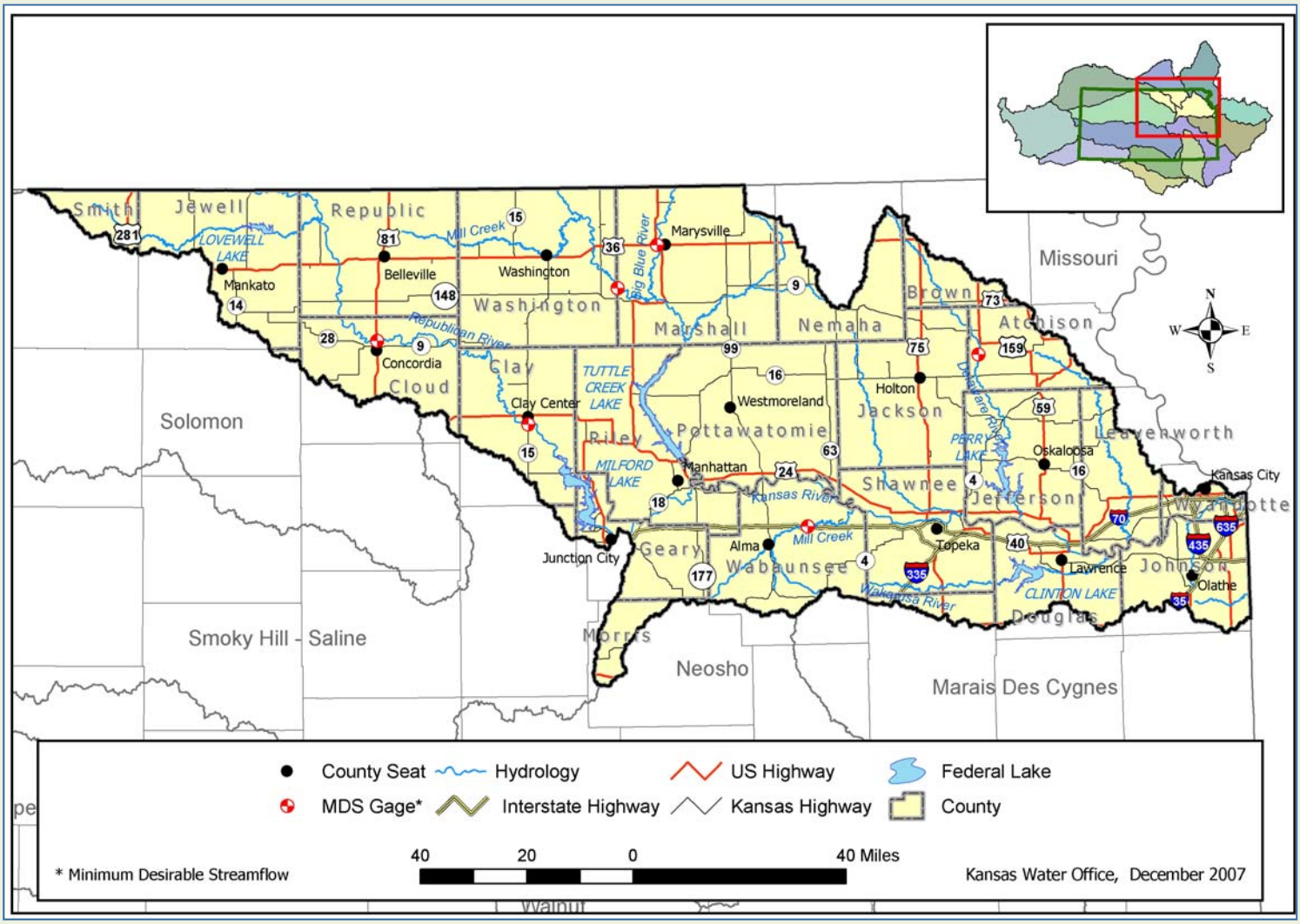
Kansas-Lower Republican River Basin



General Description

The Kansas-Lower Republican basin covers nearly 10,500 square miles of northeast Kansas and includes that portion of the state drained by the Republican River downstream of Harlan County Dam in Nebraska and the Kansas River which originates at the junction of the Republican and Smoky Hill rivers. For planning purposes, the portion of the Blue River drainage in Johnson County which joins the Missouri River in Jackson County, Missouri is also included in this basin. The basin includes all or part of 25 counties.

Major rivers and streams within the basin are: the Upper Kansas, including Vermillion, Mill and Soldier Creeks; Lower Republican; Blue, including the Little Blue River; Delaware; and Lower Kansas, including the Wakarusa River and Stranger Creek. Subbasins include Hydrologic Unit Codes (HUC): 10250016, 10250017, 10270101, 10270102, 10270103 10270104, 10270205 and 10270207. Major reservoirs in the basin are Lovewell, Milford, Tuttle Creek, Perry and Clinton. Ground water sources available in the basin include alluvial and glacial deposits and the Dakota aquifer.

The Kansas-Lower Republican basin slopes gently from west to east, dropping about 1,300 feet in elevation from its highest point in Smith County at approximately 2,050 feet above sea level to the confluence of the Kansas and Missouri rivers in Wyandotte County at approximately 730 feet. The basin covers portions of the High Plains, Smoky Hills, Flint Hills, Glaciated Region and Osage Cuestas physiographic regions.

The basin contains the major cities of Junction City, Manhattan, Topeka, Lawrence and Kansas City, Kansas along with many smaller cities and towns. The U.S. Army installation, Fort Riley is located north of Junction City. Tribal lands of the Prairie Band Potawatomi and Kickapoo nations are located in the basin.

Population and Economy

The basin has the largest population of all the twelve major river basins and had an estimated 1,025,644 residents in the year 2000. The 2000 U.S. Census recorded 1,235,516 residents in the 25 counties contained either wholly or partially within the basin.[2]

This population is projected to grow to nearly 1,583,584 in the year 2040. This basin illustrates major demographic changes which are taking place in Kansas. In the past 40 years, two trends have dominated the state and the basin. Rural counties have lost population, sometimes more than 10% every decade. Urban counties, particularly Johnson and Douglas, are gaining population at an even greater rate. Two examples demonstrate the polarity of these trends. Johnson County, with a population of 143,792 in 1960, had a population of 453,964 in 2000. Washington County, with a population of 10,734 in 1960, had a population of 6,465 in 2000.

Economic drivers in the basin range from agriculture in the upper portion becoming progressively more commercial and industrial in the lower basin. Most of the bottomland and about 50% of the uplands are planted to crops. The primary crops grown include wheat, corn, soybeans and grain sorghum. The value of crops in the 25 counties either partly or wholly in the basin was more than $1 billion in 2006.[3] Livestock are a significant part of the economy, particularly beef production in the Flint Hills. The value of livestock and dairy production exceeded $390 million in 2006. The most important mineral resources in the basin are oil, natural gas, coal, building stone and aggregate materials.

Flint Hill Pastures. Photo courtesy Kansas Geological Survey

Water-based recreation is important to the economy of the basin with five federal reservoirs, ten state fishing lakes and 43 community lakes attracting boaters, anglers, hunters and campers. State parks and commercial marinas are located on the federal reservoirs in the basin.

Physical Characteristics

Geology and Soils

The surface geology of the Kansas-Lower Republican basin is characterized by the exposure of sedimentary rock units which become progressively younger moving from east to west. These rock units are composed mainly of beds of limestone and shale with some major sandstone beds (Dakota Formation and Douglas Group). The area east of the Blue River and north of the Kansas River was glaciated and unconsolidated glacial deposits are widespread. Other unconsolidated deposits include alluvium in river flood plains and wind deposited loess, particularly in the Lower Republican subbasin.

Dakota Sandstone Hoodoo. Photo courtesy KGS.

There are 65 soil associations occurring in the Kansas-Lower Republican basin. In general, the more coarsely textured soils occur in the floodplains of the larger rivers. Finer soils are found in the uplands, particularly in the Glaciated Region and Flint Hills uplands physiographic regions. The soils within most watersheds in the Kansas-Lower Republican basin have a moderate to high slope-erodibility hazard. Only portions of the Upper Kansas, Delaware and Blue River watersheds have a low erodibility hazard.

Land Use/Land Cover

The predominant features in the basin are the grasslands in the Flint Hills, crop land in the Kansas River floodplain and urbanized areas of Junction City, Manhattan, Topeka, Lawrence and Kansas City. Grassland (46%) and cropland (35%) are the most widespread land cover classes covering more than three-quarters of the basin. In 2006, there were 18,740 farms comprising about 8.5 million acres in the 25 counties either wholly or partially within the basin. The average farm size is 454 acres.

Aerial of Topeka, from the east. Photo courtesy KGS.

The basin contains many important highway and rail transportation arteries. Interstate 70 and U.S. Highways 24, 40 and 36 traverse the basin east to west. Short sections of Interstates 35 and 335 along with U.S. Highways 69, 73, 59, 75, 77, 81, 159 and 281 cross from north to south. Burlington Northern/Santa Fe and Union Pacific rail lines follow the Kansas River with numerous spur lines across the basin.

The Kansas-Lower Republican basin has the most streambank miles, 60,604, of the 12 major river basins in Kansas. Within a 100-foot corridor along each bank, about 29% of the land is forested followed by pasture and grassland (21%), tree and pasture mix (18%) and crop land (16%). While comprising only two percent of the bank miles, the Kansas-Lower Republican basin has the largest amount of urban and tree/urban streambank area of the twelve Kansas basins.[4]

Climate

The climate of the Kansas-Lower Republican basin is classified as humid continental with cold winters and hot summers. Normal mean temperature generally increases from northwest to southeast across the basin. Temperatures and rainfall are highly variable. The average annual temperature of the basin is 53° F. Most of the precipitation falls in the summer and spring. June is typically the wettest month. The basin-wide average annual precipitation is 55 inches. Flood events, such as in July 1993 and the drought experienced from 1952-1956, illustrate the variability in precipitation.

	Average Annual[1]		Freeze Dates (32 F.)[2]		
Location	Precipitation (inches)	Temperature (deg. F.)	Last in Spring	First in Fall	Frost Free Days
Concordia	28.4	53.5	Apr. 21	Oct. 19	181
Manhattan	34.8	54.9	Apr. 18	Oct. 15	179
Lawrence	39.8	56.4	Apr. 10	Oct. 27	202

[1] Source: National Climatic Data Center (1971-2000 data)
[2] Source: KSU Weather Data Library (1961-1990 data)

Wildlife and Habitat

A total of 26 species of birds, fish and reptiles are listed as threatened or endangered in the Kansas-Lower Republican basin including single species of snake, snail and beetle.

The basin contains a wide variety of grassland, woodland and riparian habitats. Habitat loss due to urban development is an issue particularly in the Lower Kansas River basin.

In October 2007, zebra mussels were discovered in Perry Lake. This invasive species is expected to impact recreational use of the lake and move downstream with water releases to the lower Kansas River where water intakes and infrastructure could be affected.

Water Resources

The Kansas-Lower Republican basin contains 22,237 miles of intermittent and 5,392 miles of perennial streams for a total of 27,629 stream miles. The density of 2.7 stream miles per square mile places the basin fourth among the 12 major Kansas basins. By contrast, the Cimarron basin has a density of one stream mile per square mile.

There are five major federal reservoirs in the basin. Clinton, Perry, Tuttle Creek and Milford Lakes are operated by the U.S. Army Corps of Engineers (Corps) primarily for flood control. Lovewell Reservoir is operated by the U.S. Bureau of Reclamation (Bureau) and impounds White Rock Creek, but also receives water from the Republican River in Nebraska through the Courtland Canal.

Ground water is available, to a varying extent, throughout the Kansas-Lower Republican basin and is mainly located in three aquifers: the Dakota, Glacial Drift and Alluvial. The alluvial aquifers occupy the valleys of the Kansas, Republican, Blue Rivers and some tributaries. The Glacial Drift aquifer occupies the area roughly north of the Kansas River and east of the Big Blue River. The Dakota is found in Washington and Clay counties and westward.

Water Management

The Corps manages pool elevations in their four reservoirs in the basin according to specific operating rules. Flood flows are stored until downstream conditions allow their release. A conservation pool is maintained in accordance with the lake level management plans to optimize conditions for fish and wildlife benefits and recreational use.

Each lake contains storage to maintain downstream water quality. Milford, Perry and Tuttle Creek lakes contain storage for the state Water Marketing Program. Water supply storage in Clinton Lake is contracted directly with the cities of Lawrence and Baldwin and rural water districts (RWDs) in Douglas County.

Milford Dam - Corps of Engineers photo

Of the approximately 190 public water suppliers in the basin, most use ground water as a source. From the perspective of population served however, most residents in the basin get water from surface water (streams and reservoirs). There is an active Kansas River Water Assurance District in the basin. The Corps reservoirs are operated to meet eligible water right holder needs during periods of low flow through arrangements with the Water Assurance District and the Kansas Water Office (KWO).

There are minimum desirable streamflow (MDS) gages located on the Republican River at Concordia and Clay Center, the Big Blue River at Marysville, Little Blue River at Barnes, Delaware River at Muscotah and Mill Creek at Paxico. The mean annual flow of the Kansas River at De Soto is 4,860 cubic feet per second (cfs). The estimated 100-year flood discharge at this location is 240,000 cfs.

Irrigation is the largest water use in the basin at 45%, followed by municipal at 39%. Industrial uses account for more than 8 percent of water used. While there is some irrigation from the Kansas River alluvial aquifer, most irrigation is in the Lower Republican portion of the basin. Municipal and industrial water use is predominant in the lower basin associated with population centers along the Kansas River corridor. Surface water accounts for about 53% of the water used in the basin.[5]

Watershed Restoration and Protection Strategies (WRAPS) are stakeholder-driven watershed management programs designed to address multiple water resource issues. WRAPS projects have been established above the four federal reservoirs which provide public water supply as well as other watersheds in the basin. There are 17 watershed districts in the basin primarily engaged in flood control. Each county also has a conservation district dedicated to controlling soil erosion, water quality, range and pasture management, fish and wildlife habitat and other natural resource management issues.[6]

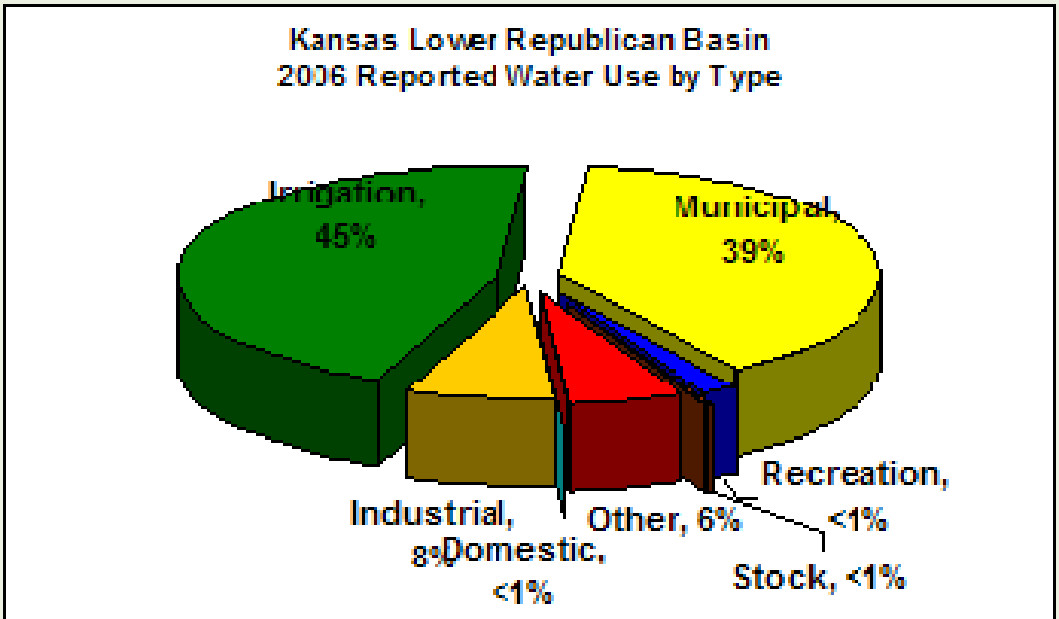


Figure 1.

Our national bird, the bald eagle, had once been reduced to 487 breeding pairs in the lower 48 states. The bald eagle was officially listed as an endangered species in 1967 in 43 states, including Kansas, in a law that preceded the Endangered Species Act. Eagle populations have rebounded strongly since the 1972 ban of several chlorinated hydrocarbon insecticides. The first recorded modern eagle nesting in Kansas occurred at Clinton Lake in 1998. The Kansas and Republican River corridors are listed as critical habitat for bald eagles. Populations have been trending upward in recent years with 250-500 bald eagles typically recorded during statewide winter surveys. In June 2007, the U.S. Department of Interior took the American Bald Eagle off the Endangered Species List. The bald eagle is still protected by the Migratory Bird Treaty and Bald and Golden Eagle Protection Act.

Photo by Bob Gress

Resources

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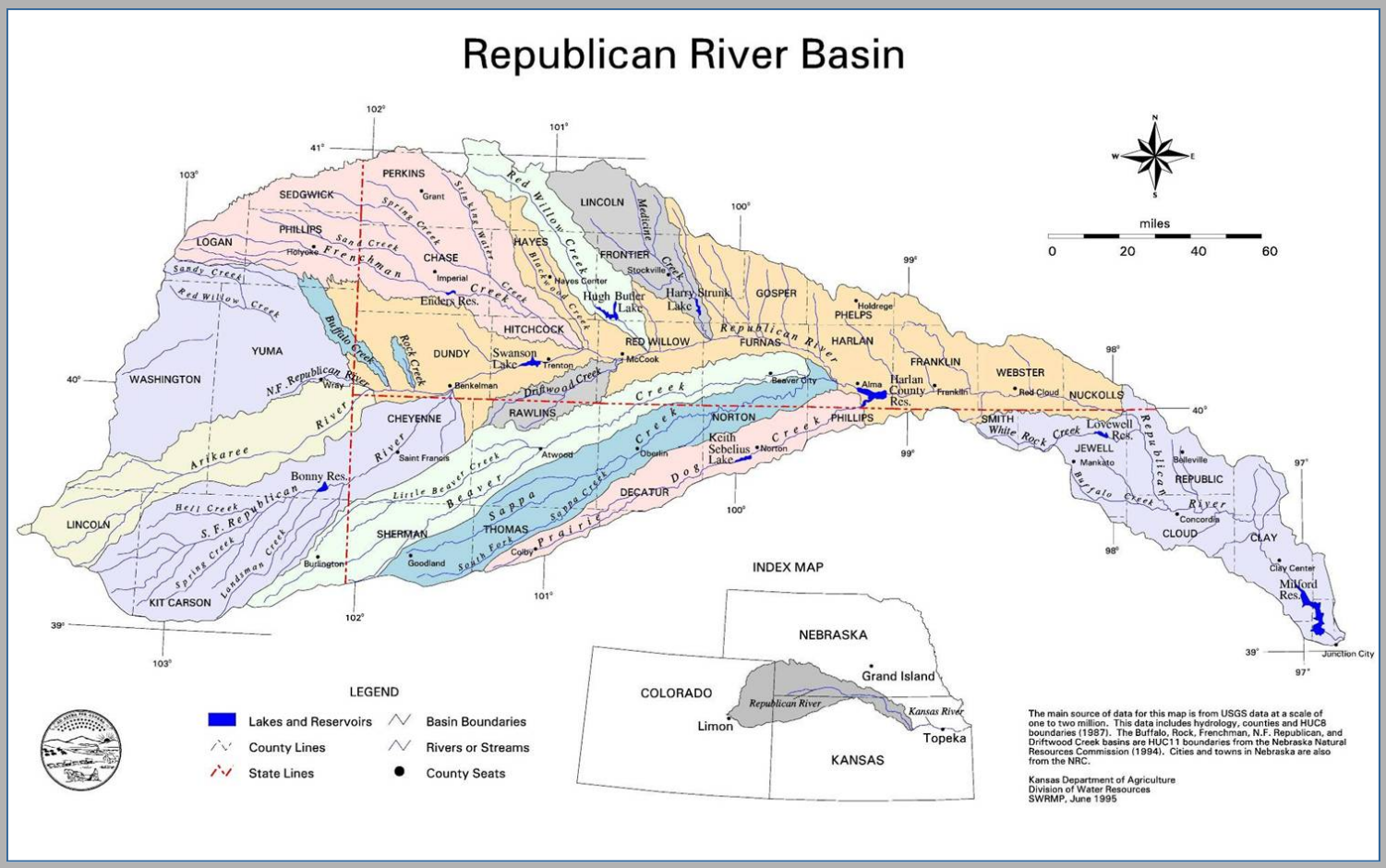
Republican River Compact and Settlement

The Republican River and its tributaries are important water resources to Kansas. Kansas' interests in the basin include ground water and surface water rights in the Upper Republican River basin and water supply to the Kansas-Bostwick Irrigation District in the Lower Republican basin.

The Republican River Compact was formally signed on December 31, 1942 by the states of Colorado, Kansas and Nebraska. The Compact makes specific allocations to each of the three states in 14 different subbasins and includes provisions related to the ability of the federal government to develop projects within the basin.



In May 1998, Kansas filed a lawsuit before the U.S. Supreme Court for breached terms of the Compact by Nebraska for proliferation and use of groundwater wells connected to the Republican River and its tributaries and by failing to protect the surface flows from other unauthorized appropriations.

As a result, the Republican River Compact Administration ground water model was developed. This tool is used to quantify ground water consumptive use by each state as part of the compact's accounting procedures. The first compliance check for the model's five-year running averages were for the years 2003-2007. The settlement also prescribes more restrictive compliance requirements during water-short conditions, including two-year averaging. The basin currently is water-short. Should the basin remain water-short, the first water-short compliance check would be for the years 2005-2006.

Kansas-Lower Republican River Basin Management Categories

January 2009

WATER MANAGEMENT CATEGORIES

The following categories include issues identified in the Kansas-Lower Republican basin plan as items that require attention in addition to the basin priority issues. These issues are addressed within the following management categories:

- Water Management
- Water Conservation
- Public Water Supply
- Water Quality
- Wetland and Riparian Management
- Flood Management
- Water-Based Recreation

These categories also correspond to the statewide management categories and policies of the *Kansas Water Plan* found in Volume II. These documents contain new policy issues and the existing policy and statutory framework that relate to the management categories.

ISSUE: WATER MANAGEMENT

See the Water Supply Management and Conservation priority issue in the Kansas-Lower Republican basin section.

Applicable *Kansas Water Plan* Objectives

- By 2015, achieve sustainable yield management of Kansas surface and ground water sources outside of the High Plains Ogallala aquifer and areas specifically exempt by regulation. Sustainable yield management would be a goal that sets water management criteria to ensure long-term trends in water use will move as close as possible to stable ground water levels and maintenance of sufficient streamflows.

- By 2015, meet minimum desirable streamflow (MDS) at a frequency no less than the historical achievement for the individual sites at time of enactment.

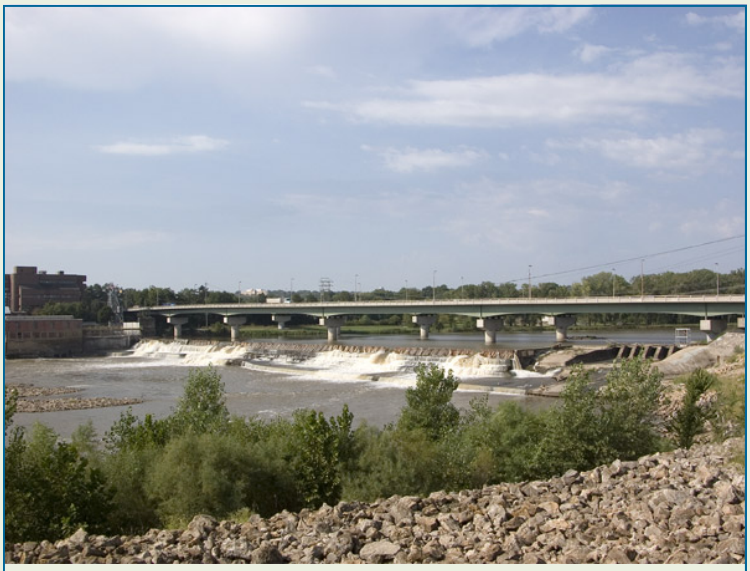
Applicable Programs

The following programs help to meet the objectives in the Water Management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Appropriation Program
- USDA-Natural Resource Conservation Service: Environmental Quality Incentive Program
- Kansas Water Office: Water Marketing Program
- Kansas Water Office: Water Assurance Program
- U.S. Army Corps of Engineers: Missouri River Reservoir Control Program

ISSUE: WATER CONSERVATION

Water conservation is essential for the effective management of water resources in the basin to assure that a sufficient, long-term supply of water is available for beneficial uses. Conservation is defined as a careful preservation and protection of something, especially the planned management of a natural resource to prevent exploitation or destruction. Water conservation is a part of maintaining a long-term water supply for Kansas. Water conservation activities apply to all uses: irrigation, municipal, industrial, etc, and from all sources. Irrigation (45%), municipal (39%), and industrial uses (8%) account for the majority of water used in the basin.



Bowersock Dam on the Kaw River at Lawrence.
Photo courtesy Kansas Geological Survey

Water use conservation plans are required for anyone: a) purchasing water from the Water Marketing Program, b) participating in the Water Assurance District Program, c) sponsoring or purchasing the public water supply portion of a Multipurpose Small Lakes Program project, d) transferring water under the Water Transfers Act and e) applying for a loan from the Public Water Supply Loan Fund. Out of the 190 public water suppliers in the basin, 132 had developed municipal water conservation plans as of 2006. All plans should be updated to incorporate the changes in the 2007 Municipal Conservation Plan Guidelines.

Water conservation plans include drought stage triggers that are the signals that a water shortage or other conditions indicative of drought have reached certain stages or levels. They act as the signal to begin implementation of actions appropriate to the stage. Triggers may be related to supply conditions or demand levels. A given stage should have more than one trigger to confirm that conditions are worsening. Appropriate conservation practices in the areas of education, management and regulation should be listed under each stage. Delay in action may lead to a major disruption of the water supply system at a later time.

Most water utilities consider water as a commodity and encourage the use of water by their customers by striving to keep rates low. The availability of plentiful inexpensive water is promoted by communities in attracting new growth. More recently, communities are adopting rate structures that result in increased cost with increased use. This is one form of demand management.

The four basic types of water rate structures used by public water suppliers in Kansas are described as flat rate, decreasing block rate, uniform block rate, and increasing block rate. Utilities with a flat rate charge each customer a fixed amount per month regardless of the amount of water used. With a decreasing block rate, the unit cost of water decreases as usage increases. The unit cost of water is the same for all levels of usage with a uniform block rate. With an increasing block rate, the unit cost of water rises as usage increases.

The type of rate structure can affect usage as measured in gallons per capita per day (gpcd). Systems with flat rates tend to use considerably more water per capita than systems that meter customer use. The other three types of rate structures, in which cost depends on amount of water used, have a less dramatic effect on gpcd. Decreasing block rates are assumed to discourage conservation because customers are charged lower rates for high-volume usage. Increasing block rates are considered an effective way to promote conservation among high-volume users while keeping the cost of moderate use affordable. However, the type of rate structure does not appear to influence usage by individual customers as much as the total monthly water cost and the geographic area in which they live.

Tuttle Creek Reservoir. Photo Courtesy Kansas Water Office

Applicable *Kansas Water Plan* Objectives

- By 2015, all non-domestic points of diversion meeting predetermined criteria will be metered, gaged, or otherwise measured.
- By 2015, conservation plans will be required for water rights meeting priority criteria under K.S.A. 82a-733 if it is determined that such a plan would result in significant water management improvement.

Applicable Programs

The following programs help to meet the objectives in the Water Conservation management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Appropriation Program
- Kansas State University Research and Extension: Water Conservation and Management Program
- Kansas Department of Health and Environment: Kansas Public Water Supply Loan Fund
- Kansas Water Office: Water Conservation Program
- USDA-Farm Service Agency: Conservation Reserve Program

ISSUE: PUBLIC WATER SUPPLY

See also, Surface Water Management and Conservation priority issue in the Kansas-Lower Republican basin section.

The primary approach to addressing public water supply issues in the basin focuses on ensuring that there are adequate supplies of surface and ground water within the basin to meet future water demands, reducing the number of public water supply systems that are vulnerable to drought, and ensuring that systems have the technical, financial and managerial capacity to meet future needs for water quality and quantity.

Kansas-Lower Republican River Basin Management Categories

There are 190 public water suppliers in the basin, including 60 rural water districts. The WaterOne (Johnson County) water district formed under specific statutory authority in 1961. There is one Public Wholesale Water Supply District operating in the basin. Ground water is the primary source for water use in the basin accounting for more than 53% of the total supply. There are four multipurpose small lakes in the basin. The Kansas River Water Assurance District is also active in the basin. The U.S. Army Corps of Engineers (Corps) operates Milford, Tuttle Creek and Perry lakes in coordination with the state to meet water assurance district member needs during periods of low flow.

Water usage (gpcd) is calculated for each water system in the state from reported data on water use and population served. Average gpcd figures for large, medium and small water suppliers are calculated in eight regions of the state based on similar geographic areas. The Kansas-Lower Republican basin is primarily located in regions 7 and 8 and a small portion of region 6. Average gpcd for large, medium and small suppliers in region 7 are 148, 107 and 96, respectively. Average gpcd in region 8 are 130, 102 and 84 for large, medium and small suppliers. This serves as a reference to indicate if individual suppliers are above or below average usage for the region.

Clinton Dam, on the Wakarusa River. Photo courtesy KGS.

Reducing "unaccounted for" water is a focus of water conservation efforts in the Kansas-Lower Republican basin. Unaccounted for water includes any unmetered uses plus water loss in the distribution system. Technical assistance is available through the Kansas Water Office (KWO) for systems with more than 30% unaccounted for water. High amounts of unaccounted for water may result from water line breaks, under registering customers, unmetered uses, faulty metering or inaccurate accounting. The statewide average percentage of unaccounted for water use in 2006 was 14%. Management of unaccounted for water is a fundamental tool in providing adequate water supply.

Drought vulnerable water supplies are those systems most likely to be the first ones impacted by drought due to basic source, distribution system or treatment capacity limitations; or that rely on a single well as a water supply source. Drought vulnerable water supplies were surveyed by the Kansas Department of Health and Environment (KDHE) and KWO in 2003 and 2006. The number of public water supplies considered drought vulnerable decreased from 23 to 21 between the two surveys. The KDHE Capacity Development Program has been beneficial in reducing drought vulnerability throughout the state as communities assess their systems and identify areas in need of improvement.

Capacity development is the process of water systems acquiring and maintaining adequate technical, financial and managerial (TFM) capabilities to assist them in providing safe drinking water. The capacity development provisions in the Safe Drinking Water Act provide a framework for the state and public water supply systems to work together to help ensure that systems acquire and maintain the TFM capacity needed to meet the public health protection objectives.

KDHE surveyed public water suppliers TFM capability in 2002, 2005, and 2008. The surveys provided information for a ranking system of high, medium and low for targeting the need for capacity development assistance. In the Kansas-Lower Republican basin, the number of systems rated high for the need of capacity development increased from 17 to 23 between 2002 and 2005 reports (2008 results pending).

Applicable *Kansas Water Plan* Objectives

- By 2010, ensure that sufficient surface water storage is available to meet projected year 2040 public water supply needs for areas of Kansas with current or potential access to surface water storage.
- By 2010, less than five percent of public water suppliers will be drought vulnerable.
- By 2010, ensure that all public water suppliers have the TFM capability to meet their needs and to meet Safe Drinking Water Act requirements.

Applicable Programs

The following programs help to meet the objectives in the Public Water Supply management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Appropriation Program
- Kansas Department of Health and Environment: Public Water Supply Program
- Kansas Water Office: State Water Planning Program
- Kansas Water Office: Water Conservation Program

ISSUE: WATER QUALITY

Water quality is addressed through a combination of restoration and protection efforts using both voluntary, incentive-based approaches and regulatory programs (see Watershed Restoration and Protection basin priority Issue).

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce the average concentration of bacteria, biochemical oxygen demand, solids, metals, nutrients, pesticides and sediment that adversely affect the water quality of Kansas lakes and streams.
- By 2010, ensure that water quality conditions are maintained at a level equal to or better than year 2000 conditions.
- By 2010, reduce the average concentration of dissolved solids, metals, nitrates, pesticides and volatile organic chemicals that adversely affect the water quality of Kansas ground water.
- By 2010, maintain, enhance, or restore priority wetlands and riparian areas.
- By 2015, nutrient reduction goals will be included in all Watershed Restoration and Protection Strategies (WRAPS) projects within the basin.
- By 2010, all public water suppliers will complete and implement a source water protection plan.

Applicable Programs

The following programs help to meet the objectives in the Water Quality management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Health and Environment: Watershed Management Section/WRAPS
- Kansas Department of Health and Environment: Watershed Planning Section/TMDL Program
- Kansas Department of Health and Environment: State Water Plan Program (Contamination Remediation)
- Kansas Corporation Commission: Conservation Division Programs
- Kansas Department of Health and Environment: Local Environmental Protection Program
- State Conservation Commission: Nonpoint Source Pollution Control Program
- State Conservation Commission: Water Resources Cost-Share Program

ISSUE: WETLAND AND RIPARIAN MANAGEMENT

The primary approach to wetland and riparian management in the basin focuses on providing technical and financial assistance to landowners to protect and restore these resources in priority watersheds through the implementation of best management practices (BMPs). See the Watershed Restoration and Protection basin priority issue for a discussion of current activities concerning wetland and riparian area protection.

Applicable *Kansas Water Plan* Objectives

- By 2010, maintain, enhance or restore priority wetlands and riparian areas.

Applicable Programs

The following programs help to meet the objectives in the Wetland and Riparian Management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Forest Service: Forest Stewardship Program and Conservation Tree Planting Program
- State Conservation Commission: Riparian and Wetland Protection Program
- Kansas Water Office: State Water Planning Program
- Kansas Department of Wildlife and Parks: State Parks and Wildlife Areas Planning and Development
- Kansas Department of Wildlife and Parks: Wildlife Habitat Improvement Program
- State Conservation Commission: Kansas Water Quality Buffer Initiative

ISSUE: FLOOD MANAGEMENT

The primary approach to flood management in the basin focuses on floodplain management through community participation in the National Flood Insurance Program

(NFIP) and the reduction of rural flood damages through the construction of watershed dams within organized watershed districts.

The basin has 26 communities (cities and counties) participating in the NFIP (2003). Four communities have been suspended from the Program and 11 communities with identified flood hazard areas do not participate. There are 16 active watershed districts in the basin.

Applicable *Kansas Water Plan* Objective

- By 2010, reduce the vulnerability to damage from floods within identified priority communities or areas.

Applicable Programs

The following programs help to meet the objectives in the Flood Management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Structures Program/Floodplain Management
- State Conservation Commission: Watershed Dam Construction Program
- State Conservation Commission: Watershed Planning Assistance Program
- Kansas Division of Emergency Management: Hazard Mitigation Grants Program
- FEMA: National Flood Insurance Program

ISSUE: WATER-BASED RECREATION

The state's rivers, streams and lakes represent a valuable recreational resource. Consideration of water based recreation issues, problems and concerns are addressed in the Water-Based Recreation Policy Section. Although the basin contains more federal reservoirs, state parks and community lakes than any other in Kansas, there is a demand for more water-based recreation facilities to meet the needs of the large population.

The Kansas River is one of the three rivers in the state considered open for public access. While additional access points have been developed, maintenance remains a challenge.

Applicable *Kansas Water Plan* Objective

- By 2010, increase public recreational opportunities at Kansas lakes and streams.

Applicable Programs

The following programs help to meet the objectives in the Water-Based Recreation management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Wildlife and Parks: Rivers and Stream Access
- Kansas Department of Wildlife and Parks: Community Fisheries Assistance Program
- Kansas Water Office: State Water Planning Program

ISSUES FOR FUTURE ACTION

- Regional public water supply coordination.
- Invasive species (zebra mussel) control and management.

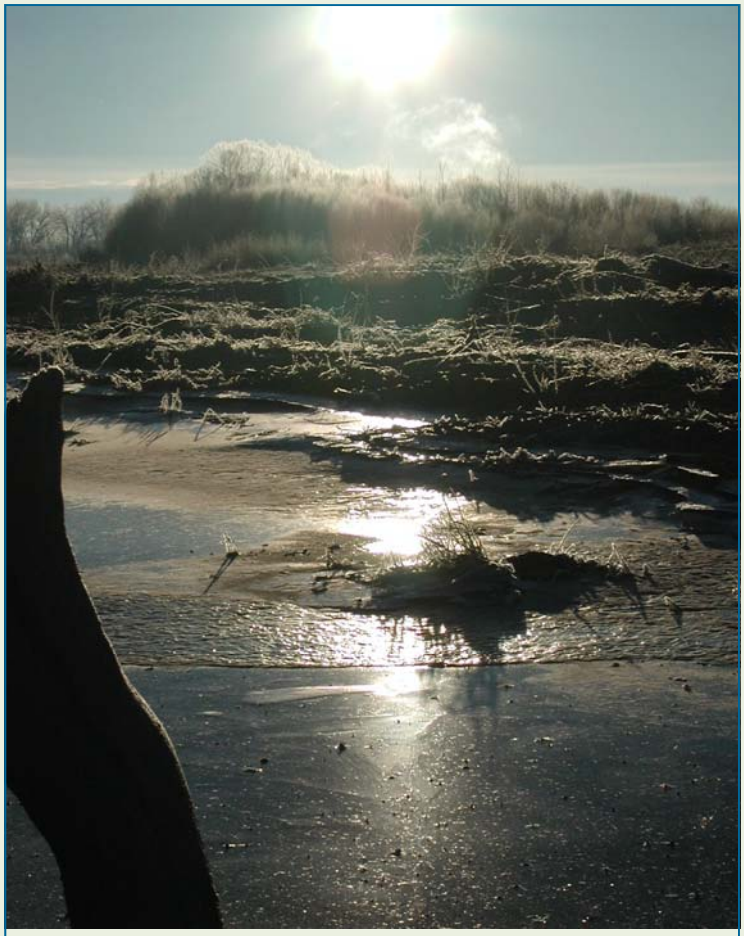
Perry Reservoir. Photo courtesy Dennis Schwartz

Kansas-Lower Republican Basin High Priority Issue
Kansas River Bed Degradation
January 2009

Issue

The Kansas River, often referred to as the Kaw, stretches 171 miles from its origin in Junction City to its confluence with the Missouri River, and is the primary source of drinking water for many communities in northeast Kansas. Bed degradation on the Kansas River threatens water intakes, bridges and other manmade "hard points" along the river channel. Aquatic habitats in the river have been negatively impacted by bed degradation. As the channel has become deeper, river banks have sloughed, impacting farm land and riparian habitats.

Initial emphasis was placed on the impact of sand and gravel dredging on Kansas River bed degradation. Other causes are also considered to contribute to bed degradation.



Kansas River. Photo by Kansas Water Office

Description

Streams and rivers are dynamic systems that continually respond to natural and manmade factors to achieve overall stability. Five major stream stability responses are possible: bed aggradation (build up), bed degradation, channel widening or narrowing and channel migration. These natural processes are impacted by controlled flows from reservoirs, weir construction, aggregate dredging and land use practices in the watershed and along the river.

The Kansas River has generally aggraded over time. The depths of alluvial sediment deposits along the Kansas River near Lawrence are estimated to be approximately 100 feet deep.[7] The Kansas River has exhibited down cutting over the last 1,000–1,500 years.[3] Degradation becomes a problem when the decrease in stream elevation significantly alters the river ecosystem or threatens the integrity of structures both on and near the river.

Causes of Degradation

The Kansas River has been a source of sand and gravel for building projects and road construction from the Kansas City metropolitan area to Topeka for more than 100 years.[2] Sand and gravel (aggregate) are primary ingredients in concrete and asphalt. Aggregate has typically been removed from the river by hydraulic dredging. Sand and gravel is then sorted and processed for transport at plants located on the river bank. Water used in the dredging process is returned to the river.

Since the 1950s, Kansas River flows have been regulated by releases from reservoirs constructed on tributary streams. Federal reservoirs controlling flows on the Kansas River include Milford, Tuttle Creek, Perry and Clinton along with Kanopolis Reservoir upstream on the Smoky Hill River. Sediment loads from tributary watersheds are largely deposited in the reservoirs. The relatively clear water released from these reservoirs has an increased sediment carrying capacity compared to pre-impoundment conditions. This "hungry water" from reservoir releases may be contributing to the rate of bed degradation.

In accomplishing their primary purpose of flood control, reservoirs prevent the Kansas River from extending into the floodplain under normal conditions. One measure of a healthy stream or riparian system is periodic inundation of the floodplain. Rather than dissipating energy across the larger stream valley in periodic floods, this energy is concentrated on the river channel through extended reservoir releases.

The bed of the Missouri River, of which the Kansas River is a major tributary, is also degrading. The tributaries of

a river which is exhibiting bed degradation will ultimately adjust to this downcut. The Missouri River bed degradation appears to have caused lowering of the bed elevation in some areas of the lower 15 miles of the Kansas River where both the Board of Public Utilities (BPU) of Kansas City, Kansas, and Water District No. 1 of Johnson County (WaterOne), have water supply intakes.

Missouri River bed degradation, as much as 12 feet since 1930,[5] and much of that since 1993, is believed to be a major factor in lowering of the stream bed below the WaterOne weir on the Kansas River and the resulting destabilization of the weir. The current streambed elevation above the weir is 732 feet above mean sea level (msl), but drops to 720 feet above msl below the weir.

Extent of Degradation

The degree and magnitude of Kansas River channel changes generally increases as one moves downstream. Localized streambed degradation on the Kansas River ranges from approximately two feet to greater than 12 feet in some locations.[5] It is important to note that some reaches of the Kansas River have aggraded, particularly above weirs.

Four manmade structures serve as major degradation controls on the Kansas River. These are Bowersock Dam (Lawrence), the WaterOne weir and the City of Topeka and Westar Energy (Topeka) weirs. While locally important, the effect on overall river morphology is considered to be minor. Natural rock deposits exist at several locations along the river and may control the lateral or vertical movement of the channel. Prominent rock control points exist at river mile 12.2 at the site of the historic Grinter's Ferry and mile 101.1 above the Willard Bridge west of Topeka.[3]

Impacts of Degradation

Water Intakes

Kaw Generating Station is an inactive Kansas City, Kansas BPU power plant located on the Kansas River at river mile 8. The plant was constructed in the early 1950s. The generating station has not operated since 2003 because the river surface elevation has not been adequate to allow water to flow into the cooling water intakes. Both Missouri River degradation (causing downcutting and a lack of backwater conditions) and Kansas River degradation have been partially responsible for reducing the surface water level at the intakes. Movement of the primary river channel has also been a contributing factor to losing use of this intake. The inability of the plant to use the river for coolant led to the closure of the plant 15 years earlier than anticipated.

Kansas River at Bowersock Dam, Lawrence, Kansas
Photo by Kansas Water Office

Johnson County Rural Water District 1 (later WaterOne) began diverting water from the Kansas River in 1964 at river mile 15. Low flow conditions and bed degradation led to the construction of a weir at this location in 1967.

Bed degradation on the Missouri River is thought to be a contributing factor in the failure of the WaterOne rock weir in 1977 and more recently in March 2004. It is being replaced with a new steel and concrete structure scheduled to be completed in late 2008.

A weir located at river mile 87 controls water to the intake of the City of Topeka water treatment plant. Approximately two feet of bed degradation has been recorded at this location.

Bowersock Dam is the oldest manmade structure on the Kansas River. It was constructed in 1872 at river mile 52 in Lawrence and originally provided mechanical power for a milling company and other manufacturing plants. The dam is privately owned and currently generates electricity. The location of the dam benefits operation of a Lawrence public water supply intake, which is upstream in the pool behind the dam.

The City of Lawrence and Bowersock Mills and Power Company signed an agreement in the early 1990s, which formalized a long-standing working relationship. The City of Lawrence has spent approximately $1 million in recent years maintaining and upgrading the structure.

One of the considerations was to stabilize the foundation of the dam from erosion, caused at least in part by downstream degradation.

Bowersock Dam, Lawrence, Kansas
Photo by Kansas Water Office

Well Fields

A consequence of bed degradation and corresponding reduction in surface water elevation is lowering of the water table along the river floodplain. Lower surface water elevations in the river channel and lower water table elevations in the floodplain have a high potential to adversely impact well yields, especially during low flows. When well field operations are impacted by riverbed degradation, a water supplier may need to modify or construct additional wells. In addition, lower ground water elevations result in higher costs due to increased power usage by lift pumps.

The City of Olathe well field, located near river mile 21, includes four horizontal collector wells and 11 vertical wells. During 1999 and 2000, the city reported that the elevation of the river channel in the vicinity of the well field had declined and they were also seeing a decline in the water levels and the capacity of their wells. Due to the loss of suction and low yield resulting from the decline in ground water elevation, the city is phasing-out some of the vertical wells.

The Junction City well field in the alluvial aquifer of the Republican River (a tributary of the Kansas River) has experienced a loss of pumping capacity. According to an engineering study requested by the city, there has been a 50% dewatering of the well field since 1991. Concurrently, bed degradation has occurred on the Republican River below Milford Lake and adjacent to Junction City.

WaterOne has also reported a loss in their Kansas River alluvial well field productivity, which is thought to be due to the lowering of the adjacent streambed and river elevation.

Bridges and Other Structures

Five of the seven railroad bridges crossing the Kansas River are located within two miles of the mouth in Kansas City. Thirty bridges carry roads and highways across the Kansas River between Junction City and the Missouri River confluence.

Riverbed degradation can undermine bridge piers and abutments, resulting in increased maintenance needs and compromising public safety. Unstable bridge pilings and piers must be stabilized in order to prevent failure of the structure. However, most bridges built since 1970 were constructed on bedrock and will not be affected by channel degradation.

Bed degradation also undermines bank protection structures such as dikes, jetties, revetments and other hard points. Boat ramps, pipelines and levees may also be affected.

Fish and Wildlife

Surveys conducted by the Kansas Department of Wildlife and Parks (KDWP), the University of Kansas, Ft. Hays State University and the interagency Kansas Cooperative Fish and Wildlife Research Unit based at Kansas State University all indicate the decline of several fish species in the Kansas River.[6] The pallid sturgeon is considered to no longer occur in the Kansas River and the once abundant plains minnow is absent in the lower reaches. In general, species adapted to shallow, turbid river conditions have declined while those with less specialized habitat needs have predominated. Studies have indicated a shift to lake-like aquatic species below river mile 22.

The Kansas Cooperative Fish and Wildlife Research Unit has maintained a study of Kansas River fishes since March 2005. Sampling has been conducted at 36 stations, five times per year within six reaches of the Kansas River including sample sites near Kansas City, Law-

rence above and below Bowersock Dam, Topeka, Wamego, and Manhattan.

The Kansas River is designated critical habitat for the piping plover and interior least tern. These bird species require sandbars free from vegetation for nesting habitat. Periodic high flows are necessary to scour sandbars of vegetation providing the necessary habitat conditions. Riverbed degradation may also lower the water table in the adjacent floodplain, adversely impacting wetlands and riparian habitat.

State and Federal Activities

The U.S. Army Corps of Engineers (Corps) developed a regulatory plan with permits for aggregate dredging on the Kansas River in 1990.[2] The Corps initially issued 12 dredging permits on the Kansas River for a 10 year period that expired on December 31, 2001. These permits were extended until August 2003 when the Corps invited public comment on reauthorization of 10-year permits for the 12 dredging operations. The Corps received more than 350 communications during the comment period.

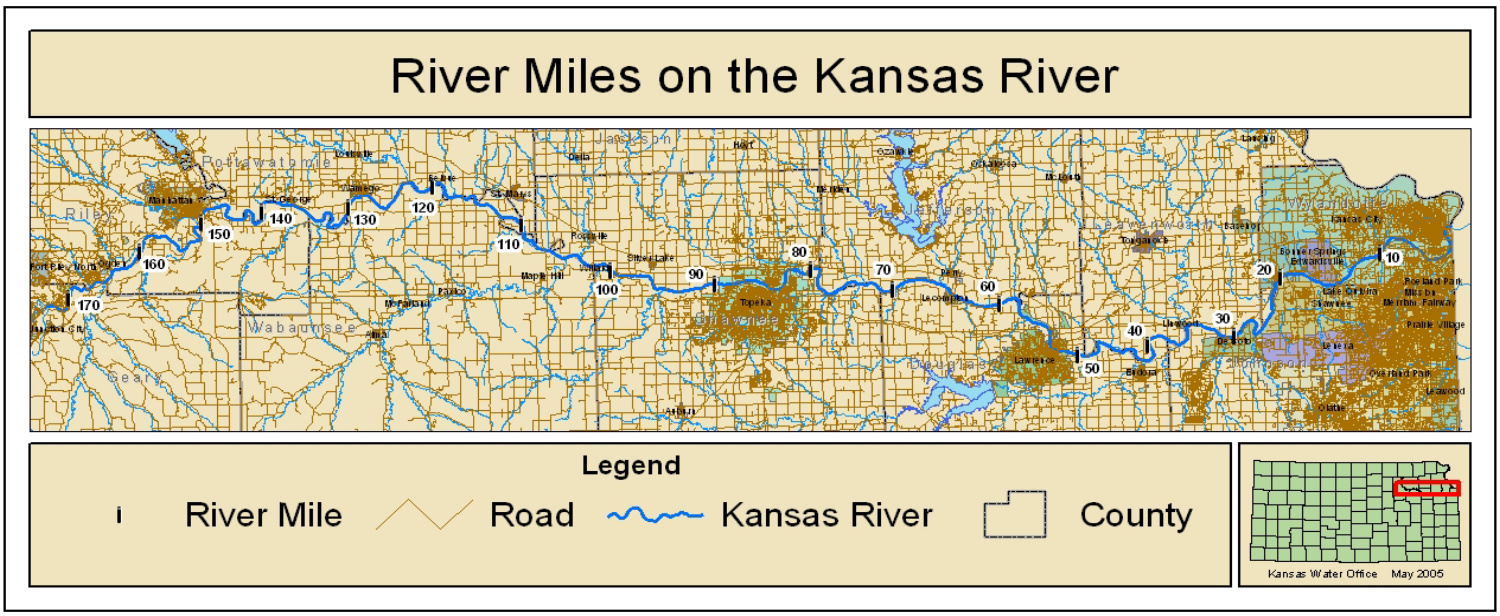
The Governor's Kansas Natural Resources Subcabinet (Subcabinet) sent a letter dated September 11, 2003 to the Corps in response to the public notice on the renewal of Kansas River dredging permits. The Subcabinet letter requested a public hearing be held and that a task force review the range of issues related to protection of the Kansas River. In February 2004, the Corps responded to the Subcabinet that there would be value in a process that would publicly review issues related to the dredging permits.

In November 2004, the Kansas Water Office (KWO) recommended to the Subcabinet that a basin issue of Kansas River channel degradation be taken to the Kansas Water Authority (KWA) for consideration in the state water planning process.[5] The Subcabinet approved this request and the KWA approved a concept paper on channel degradation and formation of a technical advisory committee in 2005.[5]

The technical advisory committee was comprised of representatives of state agencies and the Corps (Kansas City District). Representatives of the aggregate production industry and environmental groups also participated. The committee met several times during 2005 and 2006. In April 2006, the committee decided not to recommend that in-river dredging permits be phased out because not enough technical information had been collected on the historical and current condition of the Kansas River. In 2007, the Corps approved reauthorization of nine dredging permits for five years, to be reviewed in 2012.

As a result of the technical advisory committee recommendations, two actions were initiated by the KWO. The Kansas Biological Survey completed an Index of Biological Integrity in 2007 consisting of a list of Kansas River fishes and their trophic level. KWO has contracted with an engineering company to install new cross section markers between river miles 50 to 77 and 96.5 to 170.4. These survey points will supplement similar cross section measurements required as a condition of the dredging permits issued by the Corps.

On August 20, 2007, the Corps (Kansas City District) issued a decision stating that due to increasing bed deg-



radation on the Missouri River below Rulo, Nebraska, there would be no authorizations for dredging on the Missouri after December 31, 2009 without completion of an Environmental Impact Statement (EIS). The Corps has also received funding to conduct a reconnaissance study to determine federal interest in Missouri River bed degradation.

Recommended Actions

1. Complete installation of cross section survey points in the non-dredged portions of the Kansas River.
2. Analyze historic cross section data from dredged locations to determine the potential correlation between high and low flows, reservoir operations and climatic conditions and bed degradation trends.
3. As cross section data from non-dredged areas is available, compare this information to dredged area as in action 2.
4. Compile an inventory of bridges constructed prior to 1970 which may be susceptible to bed degradation.
5. Monitor progress on study of Missouri River bed degradation for implications on the Lower Kansas River.
6. Compare cross section analysis information with data from the ongoing study of Kansas fish communities.
7. Develop a plan to stabilize the channel of the Kansas River.
8. Evaluate the state's regulatory framework as it applies to channel degradation.

Resources

1. Kansas Water Office. 2005. *Report to the Kansas Water Authority - Kansas River Channel Degradation.*
2. U.S. Army Corps of Engineers, Kansas City District. 1990. *Commercial Dredging Activities on the Kansas River, Kansas.*
3. Kansas Geological Survey, 1998. *The Kansas River Corridor-Its Geologic Setting, Land Use, Economic Geology, and Hydrology.*
4. Kansas River Channel Degradation Technical Advisory Committee, 2005, 2006. Meeting notes
5. Kansas Water Office. January 2005. Kansas Water Plan. *Concept Paper - Channel Degradation in the Kansas River.*
6. Transactions of the Kansas Academy of Science, 2005. *Current Status of Native Fish Species in Kansas.*
7. Dort, Wakefield Jr.. 2008. Draft - *Historical Channel Changes of the Kansas River and its Major Tributaries*, Bulletin 252, Kansas Geological Survey.

Dredge, Mile 13. Friends of the Kaw Photo

Kansas-Lower Republican Basin High Priority Issue
Watershed Restoration and Protection
Approved August 2006

Issue

The restoration and protection of watersheds, particularly those above public water supply reservoirs, is a priority in the Kansas-Lower Republican Basin. With growing urban populations within the basin, the restoration and protection of these watersheds and water bodies are of critical importance.

Description

There are five federal reservoirs in the Kansas-Lower Republican basin. Four of these reservoirs are operated by the U.S. Army Corps of Engineers (Corps): Milford, Tuttle Creek, Perry and Clinton. The fifth, Lovewell Reservoir, is operated by the U.S. Bureau of Reclamation (Bureau), and is used primarily for irrigation. Milford, Tuttle Creek, Perry and Clinton are used for public water supply programs that serve numerous cities and rural water districts (RWDs) in the basin, primarily in the rapidly growing urbanized communities within the Kansas River corridor. These reservoirs are also managed by the Corps for flood control, recreation and to support navigation in the Missouri River.

Water Quality Impairments

A number of reservoirs and streams within the basin are experiencing water quality impairments. Fecal coliform bacteria and dissolved oxygen are the most prevalent stream impairments. Eutrophication due to nutrient loading, pesticides and siltation are the primary water quality problems affecting reservoirs. Reservoir sedimentation is also a water quantity concern. As sediment accumulates in a reservoir's multipurpose pool, the capacity for water supply storage is reduced. Figure 1 shows the estimated percent of water supply storage capacity lost to sediment deposition in federal reservoirs in the basin since their construction.

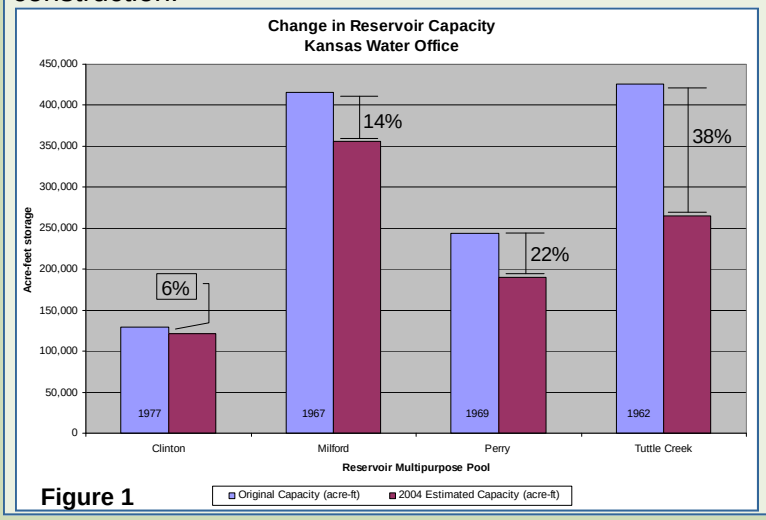


Figure 1

Water quality is addressed through a combination of restoration and protection efforts using both voluntary, incentive-based approaches and regulatory programs.

Surface water not meeting water quality standards in the basin are included on the 2004 303d list of impaired waters.[7] High priority Total Maximum Daily Loads (TMDLs) for impaired surface waters in the Kansas-Lower Republican basin were submitted to the Environmental Protection Agency by the Kansas Department of Health and Environment (KDHE) for approval on June 30, 1999. An additional round of TMDL development was completed in 2006. Table 1 provides information on rivers and lakes within the basin that are designated as a high priority for TMDL implementation. Figure 2 shows the location of these areas within the basin. High priority TMDL watersheds are identified to target voluntary, incentive based programs that provide technical and financial assistance for implementation of non-point source pollution management practices that can address designated pollutants.

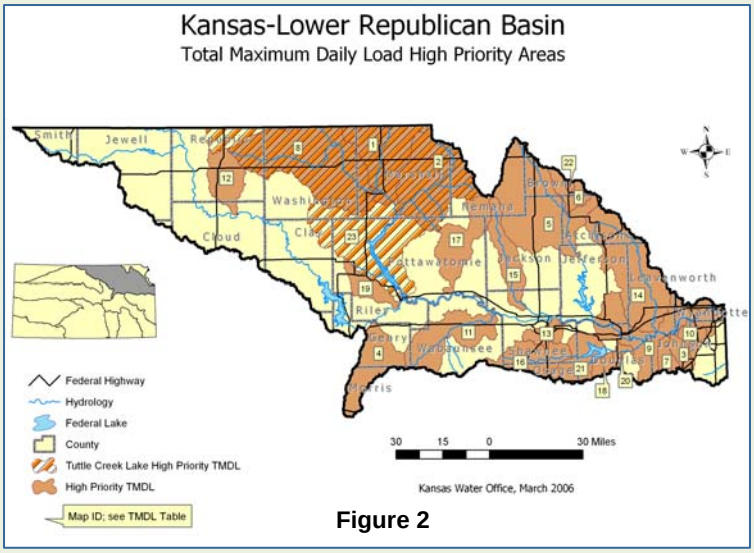


Figure 2

Surface Water Nutrient Reduction

Nutrient sources within the basin include both point and nonpoint sources. The major point sources in the basin include large wastewater treatment plants, which are regulated under the National Pollutant Discharge Elimination Program (NPDES) administered by KDHE (Figure 3).

TABLE 1
KANSAS-LOWER REPUBLICAN BASIN HIGH PRIORITY TMDLS

NEW MAP ID	WATERBODY	IMPAIRMENTS	HUC11 WATERSHEDS
STREAM SEGMENTS			
1	Big Blue River	FCB	10270205(040,070)
2	Black Vermillion River	FCB	10270205(050,060)
3	Cedar Creek	FCB, Nitrate	10270104(060)
4	Clarks Creek	FCB	10270101(010)
5	Delaware River above Perry Lake	FCB	10270103(010,020,030,040)
6	Grasshopper Creek	FCB	10270103(020)
7	Kill Creek	FCB	10270104(060)
8	Little Blue River	FCB	10270207(075,085,090)
9	Lower Kansas River	ECB	10270104(020,050,060)
10	Mill Creek (JO Co.)	FCB, BIO	10270104(060)
11	Mill Creek (WB Co.)	FCB	10270102(030,040)
12	Salt Creek	FCB, DO	10250017(030)
13	Shunganunga Creek	FCB, DO	10270102(090)
14	Stranger Creek	FCB	10270104(030,040)
15	Upper Soldier Creek	Sed	10270102(080)
16	Upper Wakarusa River	FCB, Sed/TSS, Nutr/BOD	10270104(010)
17	Vermillion Creek	FCB	10270102(020)
18	Washington Creek	DO	10270104(020)
19	Wildcat Creek	FCB, DO	10270101(020)
WETLANDS			
20	Baker Wetlands	DO	10270104(020)
LAKES			
21	Clinton Lake	E	10270104(010)
7	Gardner City Lake*	DO, E	10270104(060)
3	Lake Olathe & Cedar Lake	E	10270104(060)
22	Mission Lake	Pest, E	10270103(020)
23	Tuttle Creek Lake	Silt, Pest, E	10270205(011,031,040,050,060) 10270205 (070,080,090) 10270206(071) 10270207(034,035,075,085,090)

*The lake impairment is only related to the contributing area of Gardner Lake.

Key:

BIO: Biology
DO: Low dissolved oxygen in upper 3 meters of water column over deepest location in water body
E: Eutrophication, biological community impacts and excessive nutrient/organic loading. If applicable, the Eutrophication TMDLs are bundled with pH, aquatic plants, and/or DO impairments. These impairments are all interrelated and effected by nutrient loading.
ECB: E. coli Bacteria
FCB: Fecal Coliform Bacteria
HUC: U.S. Geologic Survey Hydrologic Unit Code
Nutr/BOD: Nitrogen and Phosphorus/Biochemical Oxygen Demand
Pest: Pesticides
TSS: Total Suspended Solids
Sed: Sediment

Major Wastewater Treatment Plants in the Kansas-Lower Republican Basin

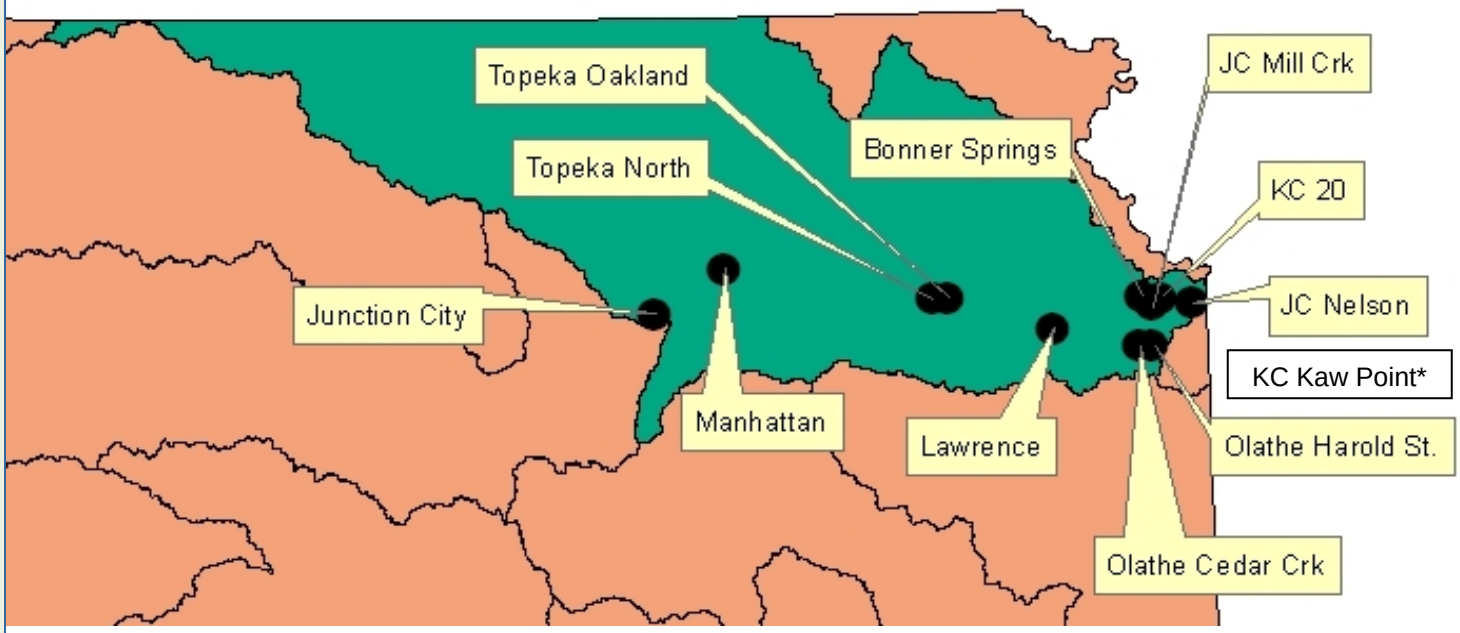


Figure 3

* The KC Kaw Point facility has an emergency discharge outfall to the Kansas River. The facility's primary discharge outfall is to the Missouri River. Therefore, the nutrient load for the KC Kaw Point facility is attributed to the Missouri River Basin.

The primary nonpoint sources of pollution include both agricultural and urban areas. Table 2 shows the relative contribution of point and nonpoint sources in the Kansas-Lower Republican basin for total phosphorus (TP) and total nitrogen (TN) leaving the state.

Table 2

Kansas-Lower Republican Nutrient Reduction Data
Source: KDHE Bureau of Water - February 14, 2006

Statewide Perspective

Parameter (Ton/yr)	State Total	KLR	% of State Total
TN Leaving State	51,205	23,543	46%
TP Leaving State	7,670	3,788	49%
Point Source TN	10,600	2,336	22%
Point Source TP	2,836	1,000	35%
Nonpoint Source TN	40,605	21,207	52%
Nonpoint Source TP	4,834	2,788	58%

Basin Perspective

Parameter (Ton/yr)	Total	Point Source	PS %	Non-point Source	NPS%
TN	23,543	2,336	10%	21,207	90%
TP	3,788	1,000	26%	2,788	74%

The *Kansas Surface Water Nutrient Reduction Plan*,[6] developed by KDHE, outlines a statewide strategy for reducing the export of TN and TP in surface waters leaving the state. This involves additional reductions in nutrients from point source discharges through the NPDES Program and reductions in nonpoint sources through development and implementation of Watershed Restoration and Protection Strategies (WRAPS). The Nutrient Reduction Plan includes Improvement Potential Index (IPI) maps for Kansas counties for TP and TN reductions.[6] In the Kansas-Lower Republican basin, Cloud, Brown, Nemaha and Republic counties showed the highest improvement potential for TP while White Cloud, Republic and Wabaunsee counties showed the highest improvement potential for TN.

Source Water Protection

All public water suppliers in the basin have completed source water assessments in cooperation with the KDHE. The next step is the development of voluntary source water protection plans.

There are 190 public water suppliers in the Kansas-Lower Republican basin that treat raw water. Most of these public water suppliers utilize ground water. Some public water suppliers with a surface water intake also use wells in the alluvium of the same river. From the perspective of the population served, surface water from

streams and reservoirs is the largest source, followed by alluvial wells, and then ground water. Most residents in the basin get water from the Kansas River or one of its major tributaries.

Each source water assessment included a susceptibility score which can help communities determine which contaminants pose the most significant threat to their water supply. A score generated from the susceptibility analysis, indicates whether the susceptibility range is low, moderate or high for potential threats of contamination in an assessment area. Each public water supplier received susceptibility scores in the following contaminant categories: microbiological, nitrates (ground water only), pesticides, inorganic compounds, synthetic organic compounds, volatile organic compounds, sedimentation (surface water only), and eutrophication/phosphorus (surface water only).

Of public water suppliers using ground water in the Kansas-Lower Republican basin, 59% had low susceptibility scores, 41% had moderate scores and none had high scores. Of public water suppliers using surface water, 63% had low scores, 31% had moderate scores and six percent had high scores. The most commonly identified problems with ground water were inorganic compounds, pesticides and nitrates. The most commonly identified problems with surface water were pesticides, microbes and inorganic compounds.

For communities using ground water, development of a wellhead protection program is recommended. For communities using surface water, the development of a Watershed Restoration and Protection Strategy (WRAPS) is the best mechanism to ensure water quality protection for their public water supply. Topeka, Lawrence and Manhattan are examples of large public water suppliers in the basin that have instituted source water protection efforts.

Aerial of Topeka from the East. Photo courtesy of KGS

Wetland and Riparian Area Management

The primary approach to wetland and riparian area management in the basin focuses on providing technical and financial assistance to landowners to protect and restore these resources in priority watersheds through the implementation of best management practices. Water quality has been a primary focus with implementation efforts targeted to high priority TMDL watersheds (Figure 2). In addition, the Republican River watershed above Milford Reservoir is identified in the *Kansas Wetlands and Riparian Areas Protection and Restoration Implementation Plan* as an area of high biological importance and a priority for implementation activities. Sixteen conservation districts in the basin have developed wetland and riparian protection plans.

Watershed Restoration and Protection Strategies

WRAPS are stakeholder-driven management plans designed to address multiple water resource issues within a specific watershed. The WRAPS process provides a means to integrate objectives from multiple local, state and federal programs into a comprehensive, coordinated strategy for a specific watershed. This can include TMDL attainment, nutrient reduction, source water protection, riparian and wetland management and other natural resource objectives.

Watersheds above the four federal reservoirs in the basin that serve public water supply needs have been identified as watersheds of significant state interest for development and implementation of WRAPS. WRAPS projects have been initiated in each of these watersheds as well as other watersheds within the basin including the middle and lower Kansas Rivers.[5] Watersheds with WRAPS projects currently underway in the basin encompass priority areas for TMDL implementation, areas with a high improvement potential index for nutrient reduction, source water assessment areas and priority areas for wetland and riparian protection.

An important consideration for watershed restoration and protection in this basin, particularly along the Kansas River corridor, is urbanization. Between 1950 and 2000, the population of Kansas increased by 783,000 people, half of this increase was in Johnson County alone. Five other counties in the basin (Douglas, Geary, Pottawatomie, Riley and Shawnee) contributed another 22% of this increase.

As the amount of impervious surface in a watershed (i.e. rooftops, roads, parking lots, etc.) increases, water resources can be adversely impacted. Runoff volume increases and additional pollutants associated with urban environments may enter streams and ponds unless preventive steps are taken by local governments and urban residents. Sound land use planning and stormwater management are essential to limit adverse effects.

Local land use planning and zoning authorities provide cities and counties effective tools to minimize the potential impacts of development on water resources. Urban stormwater management programs can be implemented to manage the amount of impervious surface in urbanizing watersheds and properly control increased runoff resulting from urbanization. Programs that provide technical assistance and education to urban residents regarding actions that can reduce or eliminate potential pollution sources also play an important role. These programs can be integrated with WRAPS projects to ensure a comprehensive approach to watershed management in urban areas. Urban communities in the basin that are implementing NPDES stormwater management programs and participating in WRAPS projects including Lawrence, Manhattan, Mission Hills, Olathe and Topeka.

Another consideration for watershed restoration and protection in the basin will be the potential for conversion of Conservation Reserve Program (CRP) acreage back to production agriculture as contracts expire. As of January 2006, nearly 289,000 acres were enrolled in the CRP in 20 Kansas counties contained wholly or partially within the basin. Contracts for approximately 45% of these acres expired in 2007.[8] If land is taken out of permanent grass cover, implementation of best management practices will be needed to minimize potential adverse impacts to water resources within the basin.

Other Watershed Related Activities

- All counties within the basin have adopted local sanitary/environmental codes and participate in the Local Environmental Protection Program (LEPP).
- Counties in the basin that have countywide planning and zoning programs include Clay, Douglas, Geary, Jackson, Jefferson, Johnson, Leavenworth, Pottawatomie, Osage, Riley, Shawnee, Wabaunsee and Wyandotte.
- All conservation districts in the basin have adopted nonpoint source pollution management plans. Buffer coordinators have also been employed in 14 counties in the basin to facilitate enrollment of stream buffers in the continuous CRP and the State Water Quality Buffer Initiative.
- A number of urban communities in the Kansas-Lower Republican basin are included in the Phase I and Phase II NPDES Stormwater Program.
- As of December 2005, there were six active contamination sites being remediated through the State Water Plan Contamination Remediation Program.
- An interstate collaborative partnership has been working to reduce sediment, nutrients, herbicides and bacteria loads in the Tuttle Creek Lake watershed. Local, state and federal water quality agencies in Nebraska and Kansas have been working together to conduct water quality monitoring and implement best management practices in the watershed under the leadership of the Water Quality Committee of the Blue River Compact Commission. In 2006, the project was awarded a grant from the EPA Targeted Watersheds Grant Program for additional monitoring and to provide enhanced funding for technical and financial assistance to implement best management practices in a four county target area within the watershed.
- There are 17 organized watershed districts in the basin.

Applicable Kansas Water Plan Objectives

- By 2010, reduce the average concentration of bacteria, biochemical oxygen demand, solids, metals, nutrients, pesticides and sediment that adversely affect the water quality of Kansas lakes and streams.

- By 2010, ensure that water quality conditions are maintained at a level equal to or better than year 2000 conditions.

- By 2010, reduce the average concentration of dissolved solids, metals, nitrates, pesticides and volatile organic chemicals that adversely affect the water quality of Kansas ground water.

- By 2010, maintain, enhance or restore priority wetlands and riparian areas.

Basin Specific Objectives

- By 2010, over 25% of the high priority TMDLs identified in 1999 and 2006 for the Kansas-Lower Republican basin will have data supporting their delisting as impaired on the 2012 Kansas 303(d) list.

- By 2010, all public water suppliers will complete and implement a source water protection plan.

- By 2015, nutrient reduction goals will be included in all WRAPS projects within the basin and sediment reduction goals included in WRAPS projects above the four federal priority reservoirs.

- By 2015, integrate urban stormwater management goals into all urban area WRAPS and support the implementation of urban stormwater management projects as outlined in WRAPS action plans.

Recommended Actions

1. Work with stakeholder groups to incorporate TMDL implementation, nutrient and sediment reduction, and urban stormwater management goals into applicable WRAPS projects.

2. Target technical and financial assistance programs for water quality protection and restoration to implement TMDLs and WRAPS action plans.

Resources

1. Kansas Water Office. 2006. *Kansas Water Plan Water Quality Policy and Institutional Framework Section*

2. Kansas Water Office. November 2003. *Kansas Water Plan Kansas Lower-Republican Basin Section, Watershed Restoration and Protection Issue.*

3. Kansas Department of Health and Environment, Bureau of Environmental Remediation. December 2005. *Basin Updates and Site Accomplishments*.

4. Kansas Department of Health and Environment, Bureau of Water. 2004. *Kansas Source Water Assessment Report*, www.kdheks.gov/nps/swap

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6. Kansas Department of Health and Environment, Bureau of Water. December 2004. *Surface Water Nutrient Reduction Plan*, www.kdheks.gov/water

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Kansas-Lower Republican Basin High Priority Issue
Water Supply Management and Conservation
January 2009

Issue

Increasing population and development in portions of the Kansas River corridor along with aging reservoirs and public water supply infrastructure, indicates a need to evaluate the river/reservoir system capacity to meet future water supply needs in the basin.

In 2007, the Kansas Water Office (KWO) prepared an analysis of *Surface Water Supply and Demand Projections for Selected Basins in Eastern Kansas*.[1] The analysis utilized historic streamflow, estimated reservoir yields, and projected population information to predict the total water supply and demand in the Kansas River basin over time. In those counties primarily served by the Kansas River and supported by federal reservoirs, the preliminary finding was that demand was predicted to exceed the total existing supply during a two percent probability drought in the year 2090 (Figure 1). This estimate includes the current supply owned by the State of Kansas along with the purchase of water supply storage reserved for future state use. Without the purchase of storage reserved for future use, demand is predicted to exceed supply in the year 2057. The analysis did not include the Lower Republican watershed, including Lovewell Reservoir or other areas of the Kansas River basin not served by the mainstem of the Kansas River.

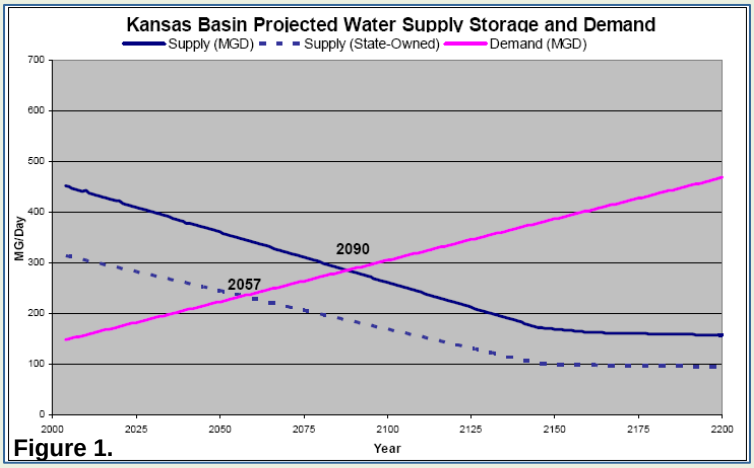

Figure 1.

Also in 2007, KWO released updated *Municipal Water Conservation Plan Guidelines* with practices for use by public water suppliers.[3] While the supply and demand analysis did include implementation of some conservation practices during drought, demand management could extend water supplies. Controlling water loss and enhancing treatment efficiency could further enhance demand management.

In 2008, KWO initiated the Reservoir Sustainability Initiative to conserve and potentially restore reservoir storage capacity and provide for long-term public water supply needs.[2] Four federal reservoirs in the Kansas River basin were constructed by the U.S. Army Corps of Engineers (Corps) from 1963 (Tuttle Creek) to 1977 (Clinton). Each reservoir pool was designed with storage designated for accumulated sediment. The estimated period to fill this storage was 50 years at Tuttle Creek and 100 years for the remaining three lakes. Public water supply storage has been impacted by sedimentation in all the Corps lakes in the Kansas River basin. Maintaining this storage is critical to meeting future public water supply needs.

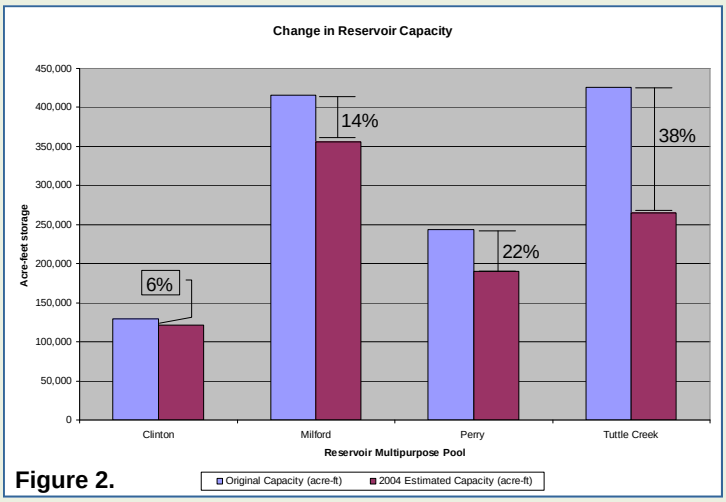

Figure 2.

Description

Water Supply

Water supply in the Kansas River basin is primarily provided by four Corps lakes, Milford, Tuttle Creek, Perry, and Clinton; along with four State Multipurpose Small Lakes; multiple city-owned lakes; ground water wells; and natural stream flows. Based on bathymetric survey information and projected sedimentation rates, estimated reservoir water supply storage and yield over time was updated by the KWO in 2002.[4] The 2007 analysis of supply and demand in the Kansas River basin used the previously calculated yield available from the federal reservoirs along with natural flows to estimate the total water supply available during a severe drought similar to the 1950s (Figure 3).

The 2007 analysis was not structured to account for the quantity of water supply available in specific stream reaches under different conditions. The initial analysis indicated a more robust water supply in the Kansas

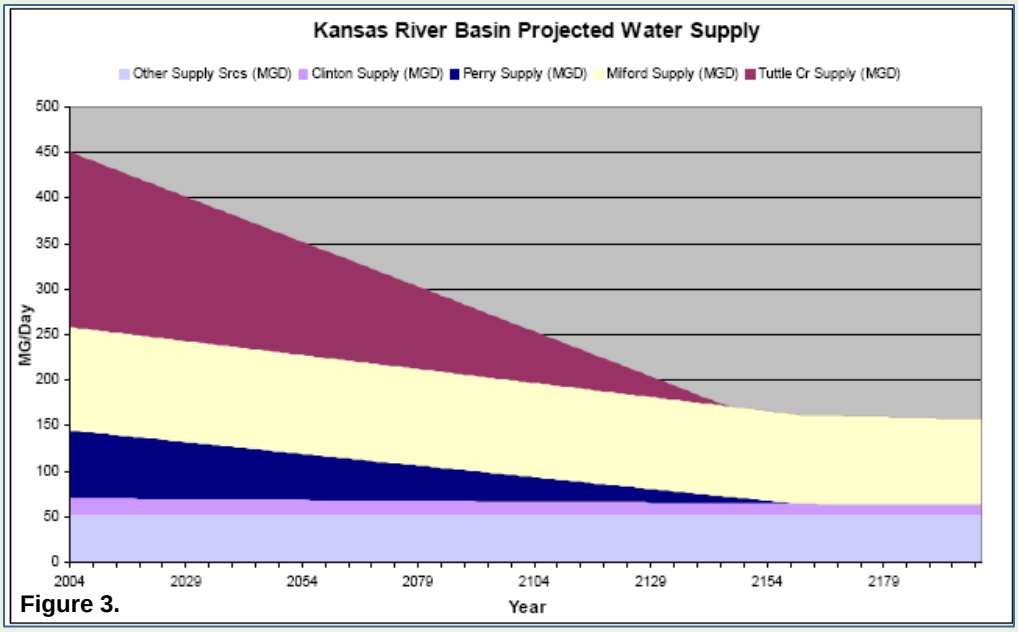

Figure 3.

River than in other eastern Kansas basins. A computer model to estimate the available water supply at specific demand points under various conditions in the Kansas River basin will be developed on a priority basis. In the future, KWO staff will be assigned to work with water supply utilities, industry, other water users, and the Kansas-Lower Republican Basin Advisory Committee (BAC) to obtain detailed information on expected water demand. Releases to support water quality and aquatic life would be accounted for in the computer model.

Marketing and Assurance

Reservoirs provide dependable water supplies in streams with highly variable flow, in addition to providing flood control, recreation, and other benefits. The 1958 Federal Water Supply Act made storage in federal reservoirs available to local governments if they agreed to repay the cost of construction, operation, and maintenance of the water supply storage. The State of Kansas has purchased water supply storage in each of the federal reservoirs in the Kansas River basin.[4]

The Water Marketing Program provides long-term (10 - 40 years) contracts for water supply for municipal and industrial uses only Customers of the Water Marketing Program pay for water on a per 1,000 gallon basis and the state pays the costs of capital investment and the annual operation and maintenance costs of the reservoir storage to the federal government. The marketing rate is based on the combined costs for the ten reservoirs where the state has purchased storage. The state currently has storage in Milford and Clinton lakes committed to the Water Marketing Program. Reserve storage at Tuttle Creek lake is owned by the state but currently not committed to either the Water Marketing or Assurance programs. This storage will be brought into service incrementally as demand requires (Table 1).

A determination is made by the Kansas Water Authority (KWA) prior to entering into negotiation for a contract with any applicant that the proposed withdrawal and use of water is in the interest of the people of the State of Kansas. The amount of water that can be contracted is limited to a quantity (yield capability) that is estimated to be available during a significant drought. Water not needed to meet long-term contract obligations can be acquired under a surplus contract. Surplus contracts are only good for one calendar year. These contracts have been written for irrigation purposes due to special authorizing language by Congress. There have been no surplus contracts for water in reservoirs in the Kansas River basin.

Table 1.

Reservoir	Water Assurance*	Water Marketing	Future Use or Reserve	Total Storage
Milford	55,000	46,650	198,350	300,000
Tuttle Creek	41,350	0	8,650	50,000
Perry	25,000	0	125,000	150,000
Clinton	0	53,500	35,700	89,200

*Storage expressed in acre-feet
** as per contract with Corps of Engineers

Access to water in storage is also available through the Water Assurance Program that operates the reservoirs in the basin as a system, maximizing the availability of water. Through this program, municipal and industrial water right holders that have formed a water assurance district can purchase storage in these reservoirs. Under agreements negotiated with the state, water in that portion of storage is released during dry periods to support the water rights of water assurance district members. These releases are protected from being diverted by other users. The Kansas River Water Assurance District No. 1 was formed in 1991 with 15 municipal and industrial water right holders. The Water Assurance District has purchased a portion of the state-owned storage in Milford, Tuttle Creek, and Perry lakes.

The key difference between the Water Assurance Program and the Water Marketing Program is that the water

assurance districts own the storage in the reservoirs in the particular basin and pay only those costs associated with the principal and interest, operation and maintenance for those reservoirs, along with the costs of administration and enforcement dedicated to the program. By contract, these costs are pooled for all state-owned reservoir storage in the Water Marketing Program and customers pay a statewide averaged cost.

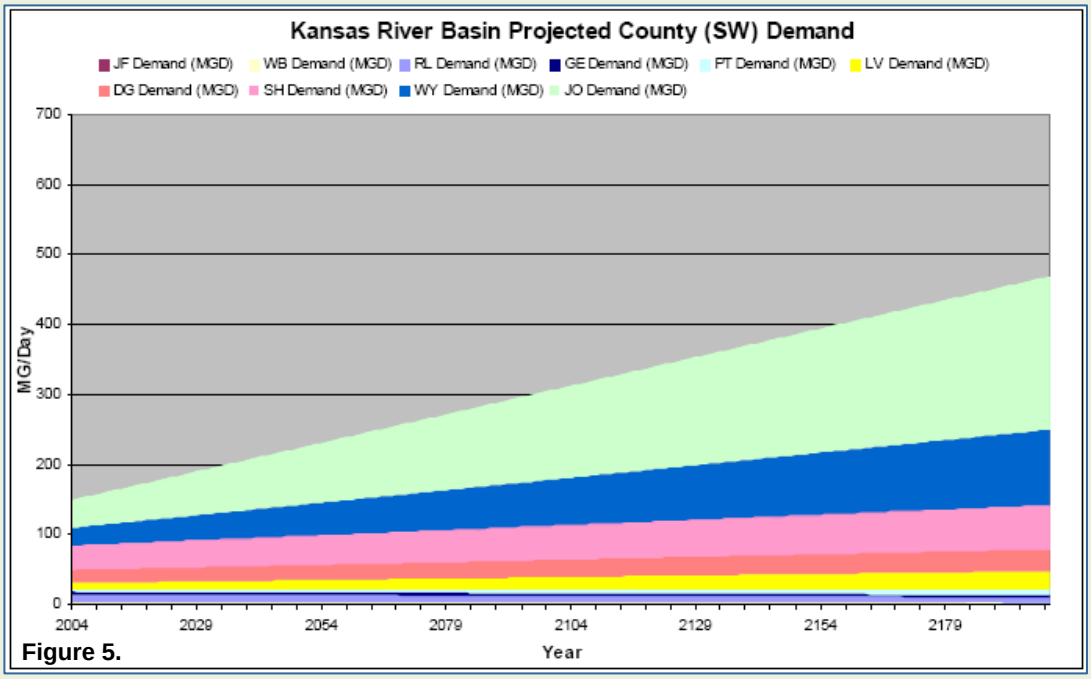

Figure 5.

Water Demand

In the 2007 KWO supply and demand analysis, demand was combined for the Kansas River basin in the same manner as water supply. Entire counties were assigned to the basin based upon predominance of area and existence of larger incorporated areas (Figure 4). For the analysis, the Kansas River corridor included Geary, Riley, Pottawatomie, Wabaunsee, Shawnee, Jefferson, Douglas, Leavenworth, Johnson, and Wyandotte counties. Population estimates were developed from the Kansas Division of Budget projections to the year 2027. These trends were further projected as necessary in the supply and demand analysis (Figure 5).

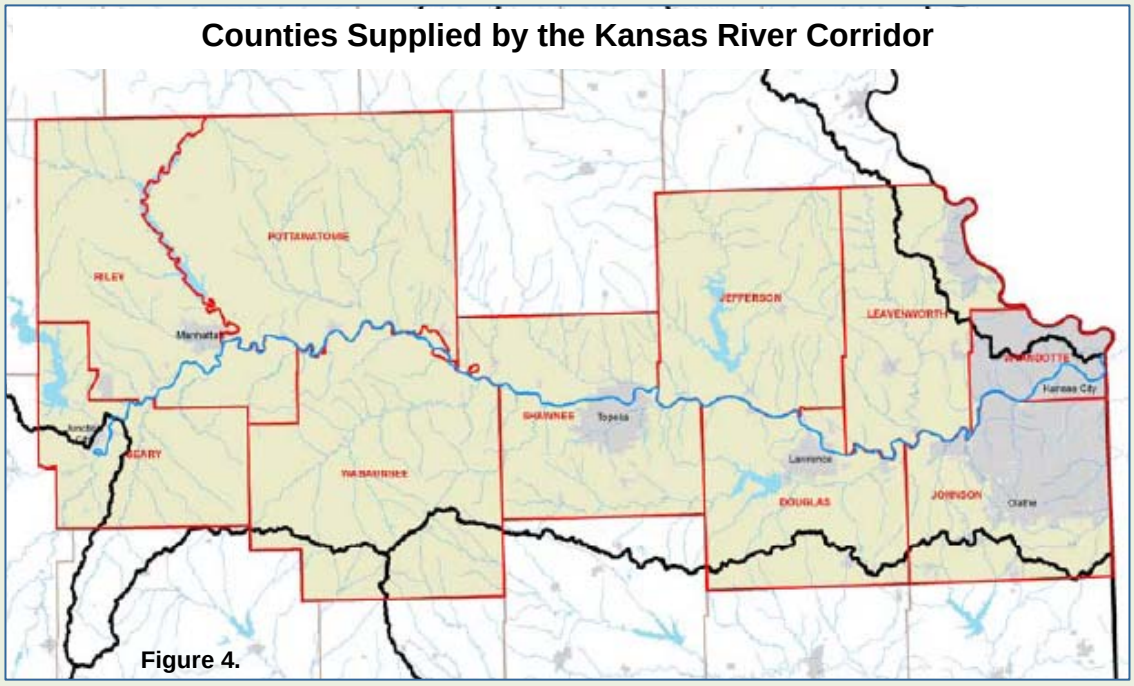

Figure 4.

Municipal and Industrial Demand

Water demand associated with population projections is based on municipal water use measured in gallons per capita per day (gpcd) reported to the Kansas Department of Agriculture-Division of Water Resources (DWR) for 2000 through 2004 by suppliers in the Kansas River basin.[6] The quantity of water that municipalities sold for non-domestic use is not included in those gpcd calculations but was added to the total. To develop the projected water use from industry, commerce, agriculture, and recreation, all non-municipal surface water points of diversion within five miles of the mainstem of the Kansas River were selected. The surface water demand increase on the Kansas River corridor is primarily associated with Johnson, Wyandotte, Shawnee, Douglas, and Leavenworth counties, specifically the future population growth projected to occur in those counties. Only 45% of the population growth in Johnson County was assumed to be supplied by surface water sources in the Kansas River basin.[1] This generally reflects the current

percent of supply coming from the Kansas River basin for that county (the Missouri River supplies the balance of the demand).

Refining Supply and Demand Projections

The KWO plans to use the Operational Analysis and Simulation of Integrated Systems (OASIS) computer model to analyze water supply and demand for the Kansas River basin. OASIS models the operations of the river/reservoir system by simulating the routing of water though a system represented by nodes (reservoirs, cities, etc.) and arcs (rivers). OASIS can account for physical constraints such as reservoir capacity, evaporation, and sedimentation. The model can also account for system management issues such as minimum release requirements and lake level management plans.

An advantage of OASIS modeling is that it can simulate the interaction of multiple reservoirs and rivers in a system. It improves the ability to simulate system management issues. OASIS can also identify "problem" areas in a system and evaluate alternative improvements to the system (off-stream storage, new reservoirs, dredging, reallocation, etc.). The KWO will be working with all users in the Kansas River corridor to identify supply and demand options. These options will be tested through the OASIS model and the results shared with basin stakeholders.

Conservation

The objective of water conservation is to achieve efficient use of the state's limited water resources through cost-effective practices to curtail the waste of water and to ensure water use does not exceed reasonable needs. In the Kansas River basin, conservation includes efficiency management in public water supply along with maintaining existing reservoir storage and water supply.

Local land use planning and zoning authorities provide cities and counties with effective tools to minimize the potential impacts of development on water resources. Counties with planning and zoning regulations often require landscape plans for new development. While landscaping can provide aesthetic and environmental benefits, heavily irrigated landscape designs can increase demand on public water supplies. Of the counties supplied by the mainstem of the Kansas River, all are zoned except Geary County.

Demand management is an important component of extending water supplies, but has not typically been incorporated into water utility operations. With the recognition of the potential for future water supply shortages, water suppliers and communities should begin to incorporate this concept into operational planning. Demand management may include less water intensive landscaping, low water use plumbing, conservation design for urban areas, water reuse, and other elements promoting responsible use of water contained in the *2007 Municipal Water Conservation Guidelines*. A movement beyond excessive use of water into more sustainable long-term management is needed. Increases in consumptive use cannot occur under existing, vested or otherwise fully perfected water rights. If a municipality is considering substantial changes in their system to reuse water, DWR must be consulted.

Conservation of reservoir storage has received attention as the impacts of sedimentation become increasingly apparent. While supply in the Kansas River basin is adequate in the near term, the closure of recreation areas in the upper reaches of Tuttle Creek and Perry lakes due to siltation is an indication of loss of water supply storage. Research has been conducted addressing the causes of reservoir storage loss and identifying solutions.[5] These measures generally fall into short-term strategies such as enhancing efficiency of reservoir operations and longer-term restoration of storage. Examples of reservoir efficiency include pool reallocation, raising dams/pools and modification of operational rules. Restoration includes dredging, reservoir flushing, treatment of the upstream watershed to limit erosion or other means of removing accumulated sediment.

Recommended Actions

1. Work with stakeholders to identify options for supply and demand management including: reservoir pool raise, pool reallocation, dredging, new supplies, modification of reservoir operations, operation of Water Marketing and Water Assurance programs and conservation measures.
    a. Test various options through the Kansas River basin model.
    b. Share information with stakeholders from the basin model including supply and demand information for specific stream segments.
    c. Implement the most beneficial and cost-effective options.
2. Encourage incorporation of water demand management into utility operating plans. Demand management should include education and interaction with the development community and existing local authorities.

Resources

1. Kansas Water Office. 2007. *Surface Water Supply and Demand Projections for Selected Basins in Eastern Kansas.*

2. Kansas Water Office. 2006. *Kansas Municipal Water Use.*

3. Kansas Water Office. 2007. *Kansas Municipal Water Conservation Plan Guidelines*.

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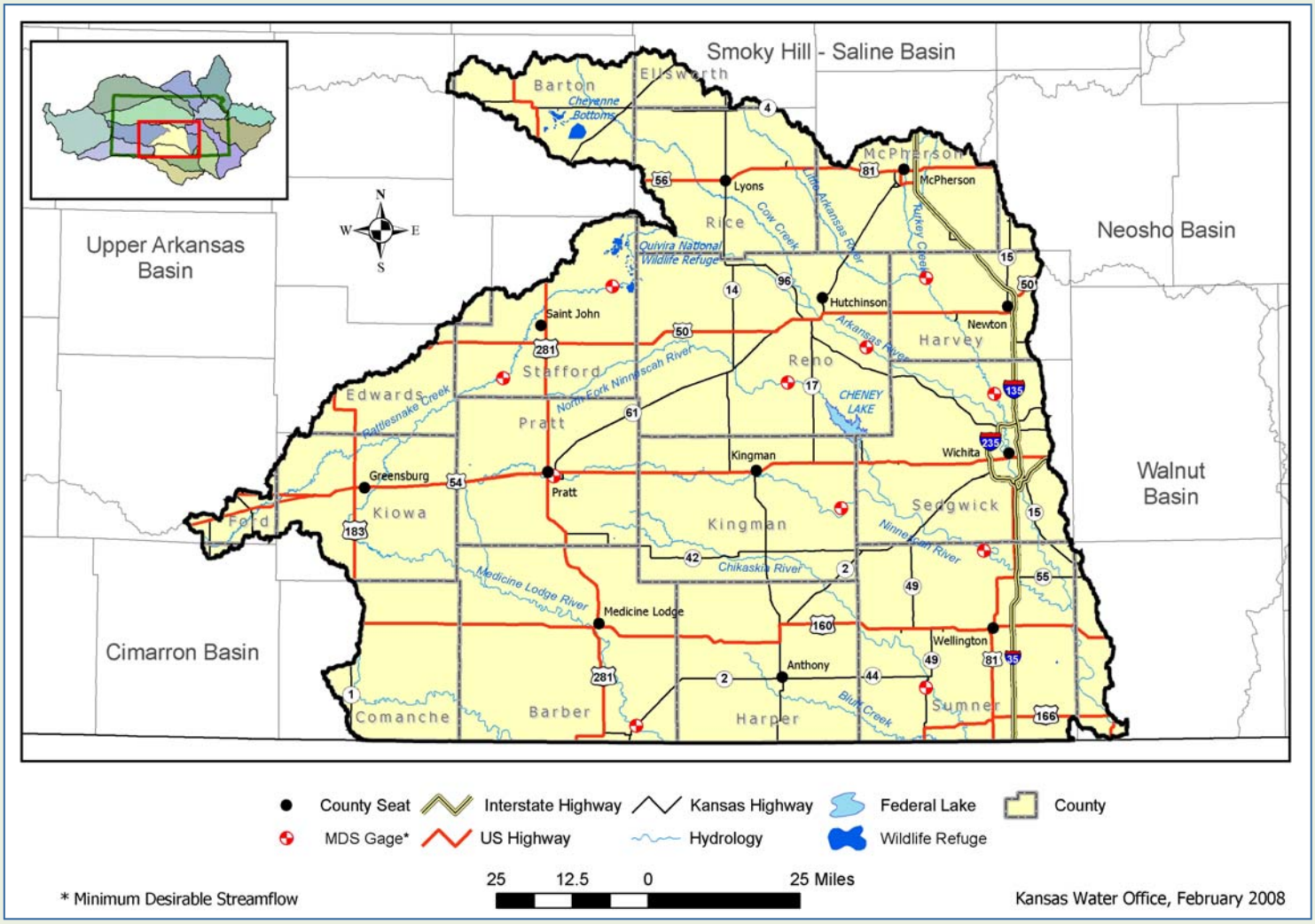
Clinton Dam. Photo courtesy KGS.

Lower Arkansas River Basin

January 2009



General Description

The Lower Arkansas River Basin in Kansas is part of the Arkansas River basin. The Arkansas River originates in central Colorado, where it flows southeast into and across southern Kansas. The Arkansas River crosses the Kansas-Oklahoma border south of Arkansas City (Cowley County). The Arkansas basin in Kansas is divided into two basins, Upper and Lower, for planning purposes. The Lower Arkansas basin begins where Rattlesnake Creek confluences with the Arkansas River in southwestern Rice County. Major tributaries entering the river along its course through the basin are Rattlesnake Creek, Cow Creek, Little Arkansas River, Ninnescah River and Slate Creek. Other major streams in the basin that flow within Kansas and join the Arkansas River in Oklahoma are the Chikaskia River, Medicine Lodge River and Salt Fork. The only major federal reservoir in the basin is Cheney Reservoir. The Lower Arkansas basin covers 11,500 square miles of south central Kansas and includes all or part of 20 counties.

Population and Economy

The basin has the second largest population of the twelve major river basins, with an estimated 641,000 residents in the year 2000.[1] According to projections conducted using Kansas Division of Budget population data, the population in the 20 counties included as a whole or in part in the basin, is projected to grow to nearly 887,450 in the year 2040.[2] Nearly all of this growth will be in Sedgwick and the surrounding counties. Major population centers include Wichita, Newton, Hutchinson, Wellington and McPherson.

This basin illustrates major demographic changes taking place in Kansas. In the past 40 years, two trends have dominated the state and the Lower Arkansas basin. Rural counties have lost population, sometimes more than 10 percent every decade. Urban counties, particularly in the greater Wichita area, are gaining population at an even greater rate. Two examples demonstrate these trends. Barber County, which had a population of 8,713 in 1960, had a population of 5,307 in 2000. Sedgwick County, which had a population of 343,321 in 1960, had a population of 452,869 in 2000.

The general economy of the basin is diversified with farming throughout the area and industrial activity most heavily concentrated in the Wichita-Newton-Hutchinson vicinity. Corn, wheat and livestock are the principal agricultural products.[3]

Many kinds of industries are represented in the basin, with the aircraft and oil and gas industries being of major importance. The salt mines of the state are located largely in this basin. There is a sizable gypsum production facility west of Medicine Lodge. There is one oil refinery located in the basin in McPherson.

Salt Mine near Lyons, Rice County.
Photo courtesy Kansas Geological Survey.

Wichita State University, and the Hutchinson and Pratt County Community Colleges offer opportunities for higher education.

Recreation is an increasingly significant part of the economics of the basin, as is industry. The state parks and associated recreation and wildlife areas draw hunters to the area. There is one multipurpose small lake, Wellington Lake in Sumner County, located in the basin.

The growing industrial contribution to the basin economy is primarily related to energy production, including ethanol. As of November 2008, three ethanol plants are located in the basin in Pratt (now idle), Sedgwick and Rice counties. An additional ethanol plant is under construction in Sedgwick County. Two biodiesel plants have been permitted for construction in Stafford and Kiowa Counties, and one is under construction in Sedgwick County.

Physical Characteristics

Geology and Soils

The subsurface formations within the Lower Arkansas basin include three major systems; from oldest to youngest: Permian, Cretaceous, and Quaternary. The formations in the Permian system are relatively poor sources of ground water in terms of quantity and quality. The same is true of the formations in the Cretaceous system, except in the northern part of the Lower Arkansas River valley where the Dakota Formation is a principal source of water supplies.

Permian-Cretaceous Contact, McPherson County.
Photo courtesy Kansas Geological Survey.

The sands and gravels of the Quaternary system are a good source of ground water in the basin.

The topography in the basin varies from flat, undulating plains of slight relief to rolling uplands and, in places, steep bluffs and hills. Elevation ranges from about 1700 feet to about 1100 feet. Sandy soils and sand dunes are prevalent, mostly in the river valleys, but fine textured soils, tight clays and many other soil types are also represented.

Land Use/Land Cover

Land use in the basin typically is dominated by cropland (55.8%) or grassland (32.5%) and Conservation Reserve Program land (5.5%). The remaining land cover is forest or woody (2.4%) and industrial use, municipal use, open water and barren ground.

The Lower Arkansas basin contains 49,108 stream bank miles. Within a 100-foot corridor along each bank, about 36% of the land is pasture/grassland followed by crop/tree mix (35%), cropland (34%), pasture/tree mix (13%) and forest land (11%). While comprising less than 1% of the bank miles, the Lower Arkansas basin has the most urban land stream bank area of the Kansas basins.[4]

Chikaskia River, Harper County.

Climate

The climate of the Lower Arkansas basin is classified as subhumid with moderate precipitation. The average annual temperature for the basin is about 57 degrees Fahrenheit, but temperatures fluctuate considerably within a year. The weather in this part of the state is subject to frequent and abrupt change.

Temperatures tend to increase mildly from west to east across the basin in response to declining elevations. At Greensburg, the average annual temperature is 54.3° F while at Wichita it is 56.4° F. Precipitation and the frost free period shows a similar west-to-east pattern (See table below).

	Average Annual[1]		Freeze Dates (32 F.)[2]		
Location	Precipitation (inches)	Temperature (F)	Last	First	Days Between
Greensburg	25.49	54.3	Apr. 17	Oct. 19	185
Wichita	30.38	56.4	Apr. 14	Oct. 25	194

[1]Source: National Climatic Data Center (1971-2000 data)
[2]Source: KSU Weather Data Library (1961-1990 data)

Wildlife and Habitat

The Lower Arkansas River basin is comprised primarily of four physiographic regions: High Plains, Red Hills, Arkansas River Lowlands and Wellington-McPherson Lowlands. Native vegetation in these regions ranges from mixed grass and sandsage prairie grasses to floodplain woodlands species such as cottonwood and black willow.

Numerous threatened and endangered species occur in the Lower Arkansas basin. Of these, ten are birds, two are mammals, three are reptiles, one is an amphibian and six are fish.

Water Resources

Ground water, which is very shallow in some places, i.e. the Equus Beds aquifer, is the source for 92 percent of supply for all reported uses in 2006. Irrigation accounted for nearly 75% of all reported water pumped or diverted. Municipal use accounted for 15% of water used in the basin; industry for five percent; and recreation, stockwater and other uses combined equal about five percent (2006).[5]

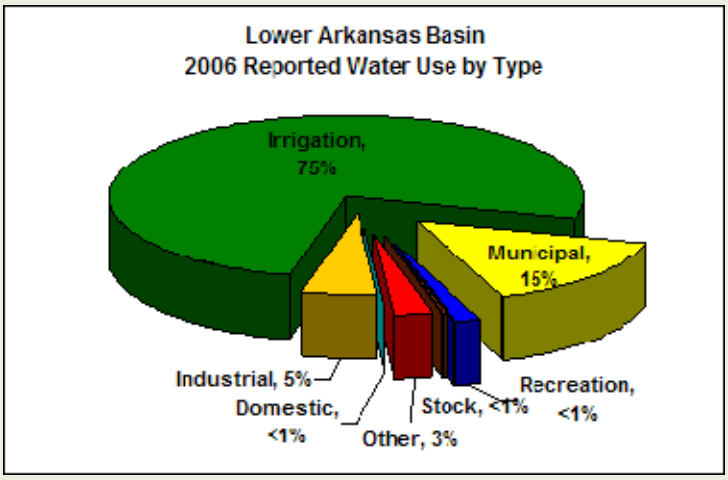
The Lower Arkansas basin contains 20,974 miles of intermittent and 2,592 miles of perennial streams for a total of 23,566 stream miles. The basin has a density of 2.1 stream miles per square mile.

Streamflows in the Lower Arkansas basin are highly variable within the year, and from one year to another. The major sources of surface water are Cheney Reservoir on the North Fork of the Ninnescah River in Reno County, and Wellington Lake in Sumner County, which drains into the Chikaskia River.

Water Management

There are two Groundwater Management Districts (GMDs) in the Lower Arkansas basin which cover most of the area. The Equus Beds GMD2 was formed in 1975 and operates under a “safe yield concept” in which appropriations are managed so that the quantity of ground water withdrawn from a given area is approximately equal to the average annual recharge to the same area. Big Bend GMD #5, in the northwestern part of the basin, was formed in 1976 and also operates under a safe yield policy.

There are two Intensive Ground Water Use Control Areas (IGUCAs) within GMD2: the McPherson Area IGUCA, and a 36 square mile area surrounding the town of Burrton in Harvey County. Each IGUCA is managed with programs and activities for the particular needs of that area. There are two IGUCAs in GMD5: the eastern portion of the Wet Walnut IGUCA, and the Pawnee IGUCA in Pawnee County.



Seven watershed districts are included in the Lower Arkansas basin: Upper Little Arkansas, Sand Creek, Mount Hope, Andale, Goose Creek, Spring Creek and Clear Creek.

The county conservation district is the primary local unit of government responsible for the conservation of soil, water and related natural resources within the county boundary. Each county within the Lower Arkansas River basin has a county conservation district. Three Resource Conservation and Development (RC&D) districts serve the counties of the Lower Arkansas basin: the Sunflower RC&D, Flint Hills RC&D and Central Prairie RC&D. The RC&Ds are designed to help community leaders develop rural economies by improving and conserving local natural, human and economic resources.[6]

Resources

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2. Kansas Division of Budget 2007. County population estimates.

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4. Wilson, Brownie, Assessment of Riparian Areas Inventory, State of Kansas, 2003, http://hercules.kgs.ku.edu/geohydro/ofr/2003_55/riparian/ofr_2003_55e.htm

5. Water Right Information System (WRIS) database, Division of Water Resources, December 13, 2007.

6. USDA Natural Resources Conservation Services, Resource Conservation and Development Information. http://www.ks.nrcs.usda.gov/partnerships/rcd/

7. Kansas Water Office, Kansas Water Authority, Lower Arkansas Basin Water Quality Management Category, *Kansas Water Plan.*

8. Kansas Water Resources Board Water Plan Studies Lower Arkansas Unit June 1962.

Braided Arkansas River south of Wichita.
Photo courtesy Kansas Geological Survey.

Cheyenne Bottoms/Quivira National Wildlife Refuge

Cheyenne Bottoms is a wetland of international importance located north of Great Bend in Barton County. It was designated as such by the Ramsar Convention in 2000. The wetland encompasses approximately 41,000 acres that includes 19,857 acres as a wildlife area. This wildlife area is recognized as an important migration point for shorebirds in North America. Past studies reflect almost half of the North America shorebirds migrate through the Bottoms. It is designated critical habitat for endangered species such as the Whooping Crane, Least Tern, Peregrine Falcon and numerous others. The Cheyenne Bottoms is owned by the State of Kansas and is managed by the Department of Wildlife and Parks.

Formed thousands of years ago, the wetland's natural depression has a drainage area of approximately 254 square miles including drainage from Blood and Deception Creeks. Availability of water plays a major role in productivity at the wetland.

Migrating pelicans at Cheyenne Bottoms, Barton County. Photo courtesy Kansas Geological Survey.

The wildlife refuge also receives surface water from the Arkansas River through a canal system. Through the years, the availability of surface water in the Arkansas River has been reduced due to human activities in the upper reaches of the river above the wetland's diversion point.

Cheyenne Bottoms Wildlife Area receives, on average, more than 50,000 visitors each year. Estimated total number of visitors and hunters on opening day of the regular duck season increased steadily from 1996 to 2001. Numbers were down during the drought of 2002-2003; however, 2004 had a rebound in hunters. Crane and duck presence at the Bottoms has been constant to slightly increasing since 1986. Geese populations have increased significantly with the largest peak occurring in 2002.

Quivira National Wildlife Refuge, 20 miles from Cheyenne Bottoms, is also recognized as a wetland of international importance recognized by the Ramsar Convention in 2001. Quivira contains 22,135 acres of prairie grass, salt water marshes, sand dunes, canals, dikes and timber. During spring migration, Quivira is a staging area for over 500,000 birds. Quivira and Cheyenne Bottoms are joined by a National Scenic Byway, also know as the Wetland and Wildlife Scenic Byway.

Lower Arkansas River Basin Management Categories

January 2009

WATER MANAGEMENT CATEGORIES

The following categories include issues identified in the Lower Arkansas basin plan as items that require attention in addition to the basin priority issues. These issues are addressed within the following management categories:

- Water Management
- Water Conservation
- Public Water Supply
- Water Quality
- Flood Management
- Water-Based Recreation

These categories also correspond to the statewide management categories and policies of the *Kansas Water Plan* found in Volume II. These documents contain new policy issues and the existing policy and statutory framework that relate to the management categories.

ISSUE: WATER MANAGEMENT

Ground water recharge rates are variable throughout the basin, with both the Big Bend Prairie and Equus Beds aquifer areas managed under a safe yield policy. A majority of the basin is restricted or closed for new water appropriations. The basin is managed for sustainability, with the local leadership of Equus Bed Groundwater Management District No. 2 (GMD2), Big Bend Groundwater Management District No. 5 (GMD5) and the Kansas Department of Agriculture-Division of Water Resources.

Minimum desirable streamflow (MDS) levels have been set for 11 sites in the basin. According to an assessment conducted by the Kansas Water Office (KWO) in 2006, five MDS gages in the basin have shown improvement in the annual frequency, magnitude or duration of meeting minimum desirable streamflow.

Two Intensive Groundwater Use Control Areas (IGUCAs), Burrton and McPherson, have been initiated in the basin by GMD2. In 2006, the KWO calculated the median annual water level changes in wells from 1981 to 2005 for GMD2 and GMD5. The data assembled indicates that sustainable ground water yield has not yet been attained in GMD2 and GMD5.

Intensive management focus has been placed on the Rattlesnake Creek sub-basin over the last several years. Under the U.S. Department of Agriculture, Natural Resources Conservation Service's Environmental Quality Incentives Program (EQIP), grants have been offered to irrigators in the Rattlesnake Creek subbasin "quick response area" to transition to dryland farming or other non-irrigated use. Non-use of the irrigation water right must be for a minimum of four years. The Rattlesnake Creek is also an eligible area for state purchase and retirement of irrigation water rights through the Water Right Transition Assistance Program.

Rattlesnake Creek. Photo courtesy KGS.

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce water level decline rates within the High Plain aquifer and implement enhanced water management in targeted areas.
- By 2015, achieve sustainable yield management of Kansas surface and ground water sources outside of the Ogallala aquifer and areas specifically exempt by regulation. Sustainable yield management would be a goal that sets water management criteria to ensure long term trends in water use will move as close as possible to stable ground water levels and maintenance of sufficient streamflows.
- By 2015, meet minimum desirable streamflow at a frequency no less than the historical achievement for the individual sites at time of enactment.

Applicable Programs

The following programs help to meet the objectives in the Water Management category. For more information on the programs and associated policies, see the Programs Manual.

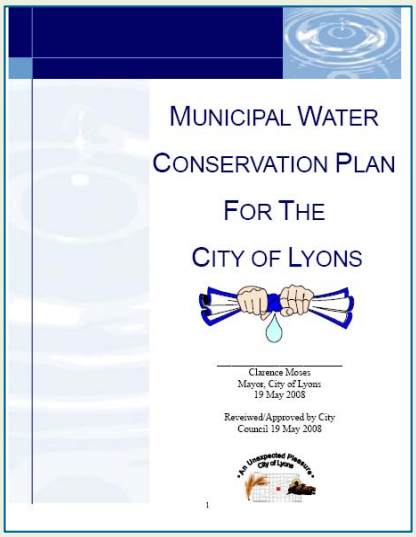
- Kansas Department of Agriculture-Division of Water Resources: Water Appropriation Program
- Kansas Department of Agriculture-Division of Water

Resources, Subbasin Water Resource Management Program
- Kansas Geological Survey, Kansas Department of Agriculture, Division of Water Resources: Water Well Measurement
- Kansas Water Office: State Water Planning Program
- State Conservation Commission: Water Right Transition Assistance Program
- USDA-Natural Resources Conservation Service: Environmental Quality Incentive Program (EQIP)
- Kansas Geological Survey: High Plains Aquifer Technical Assistance Program

ISSUE: WATER CONSERVATION

Water conservation is essential for the effective management of water resources in the basin to assure that a sufficient, long-term supply of water is available for the beneficial uses of the people of the state. Conservation is defined by Webster's Dictionary as a careful preservation and protection of something, especially the planned management of a natural resource to prevent exploitation or destruction. Water conservation is a part of maintaining a long-term water supply for Kansas.

Water conservation activities apply to all uses: irrigation, municipal, industrial, etc., and from all sources. Irrigation accounted for nearly 75% of all reported water pumped or diverted in the basin. Municipal use accounted for 15% of water used in the basin (2006).



Of the 614 public water suppliers in Kansas that had an approved conservation plan in place as of December 31, 2008, 81 plans were for suppliers in the Lower Arkansas basin. One hundred and eighty four conservation plans have been approved for irrigation water rights. The number of diversion points in central Kansas, including the Lower Arkansas basin, that reported irrigation application rates over the regional average decreased for the period from 1991 to 2005. In the 2006 water use report, 85% of the points of diversion in the Lower Arkansas basin that pumped water were metered.

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce the number of public water suppliers with excessive unaccounted for water by first targeting those with 30 percent or more unaccounted for water.
- By 2010, reduce the number of irrigation points of diversion for which the amount of water applied in acre feet per acre (AF/A) exceeds an amount considered reasonable for the area.
- By 2015, all non-domestic points of diversion meeting predetermined criteria will be metered, gaged or otherwise measured.
- By 2015, conservation plans will be required for water rights meeting priority criteria under K.S.A. 82a-733 if it is determined that such a plan would result in significant water management improvement.

Applicable Programs

The following programs help to meet the objectives in the Water Conservation management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Appropriation Program
- Kansas State University Research and Extension: Water Conservation and Management Program
- State Conservation Commission: Water Resources Cost-Share Program
- Kansas Water Office: Water Conservation Program
- USDA-Farm Service Agency: Conservation Reserve Program

ISSUE: PUBLIC WATER SUPPLY

The primary approach to addressing public water supply issues in the basin focuses on ensuring that there are adequate supplies of surface and ground water within the basin to meet future water demands, reducing the number of public water supply systems that are vulnerable to drought and ensuring that systems have the technical, financial and managerial capacity to meet future needs for water quality and quantity.

There are 118 public water suppliers in the basin, including 28 rural water districts. There are currently four public wholesale water supply districts in the basin. Ground water is the primary source for most public water supplies, accounting for over 90% of the total supply. The two major sources of ground water are the Equus Beds aquifer in Harvey, McPherson, eastern Reno and north-

ern Sedgwick counties, and the Great Bend Prairie aquifer, predominately underlying Pratt, Stafford, southern Barton, Edwards, Kiowa and Reno counties. Streamflows in the basin are highly variable within the year and from one year to another and so generally are not used as sources of public water supply. Cheney Reservoir, located on the North Fork of the Ninnescah River in Reno, Kingman and Sedgwick counties, supplies a portion of the water supply for the City of Wichita. Wellington Lake serves as a surface water supply for the City of Wellington.

Aerial of Wichita, Kansas. Photo courtesy of KGS.

Coping with drought presents a challenge for public water suppliers. During drought periods, the amount of raw water available typically is reduced at the same time customer demand for water increases. While all suppliers may be potentially impacted, some are particularly vulnerable. Of the public water suppliers in the basin, 13 (10%) were considered drought vulnerable in 2006.

Applicable *Kansas Water Plan* Objectives

- By 2010, ensure that sufficient surface water storage is available to meet projected year 2040 public water supply needs for areas of Kansas with current or potential access to surface water storage.
- By 2010, less than five percent of public water suppliers will be drought vulnerable.
- By 2010, ensure that all public water suppliers have the technical, financial and managerial capability to meet their needs and to meet Safe Drinking Water Act requirements.

Applicable Programs

The following programs help to meet the objectives in the Public Water Supply management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Appropriation Program
- Kansas Department of Health and Environment: Public Water Supply Program
- Kansas Water Office: State Water Planning Program
- Kansas Water Office: Water Conservation Program
- Kansas Department of Health and Environment: Capacity Development Program

ISSUE: WATER QUALITY

Water quality and related water resource issues are addressed through a combination of watershed restoration and protection efforts utilizing voluntary, incentive based approaches, as well as regulatory programs (see Watershed Restoration and Protection Basin Priority Issue).

All the counties within the basin with the recent addition of Comanche County have developed sanitary/environmental codes, and have a sanitarian funded by the Local Environmental Protection Program (LEPP). Counties in the basin that have countywide planning and zoning programs include Barton, Ford, Harper, Harvey, Kingman, Marion, McPherson, Pawnee, Reno, Rice, and Sumner. All conservation districts in the basin have adopted nonpoint source pollution management plans. Buffer coordinators have also been employed in nine counties in the basin to facilitate enrollment of stream buffers in the continuous Conservation Reserve Program (CRP) and State Water Quality Buffer Initiative. Several entities and municipalities in association with the Wichita urban area are included in the Phase I and Phase II National Pollutant Discharge Elimination System (NPDES) Stormwater Program. There are seven organized watershed districts in the basin.

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce the average concentration of bacteria, biochemical oxygen demand, solids, metals, nutrients, pesticides and sediment that adversely affect the water quality of Kansas lakes and streams.
- By 2010, ensure that water quality conditions are maintained at a level equal to or better than year 2000 conditions.
- By 2010, reduce the average concentration of dissolved solids, metals, nitrates, pesticides and volatile organic chemicals that adversely affect the water quality of Kansas ground water.
- By 2010, maintain, enhance or restore priority wetlands and riparian areas.
- By 2015, nutrient reduction goals will be included in all Watershed Restoration Protection Strategy

(WRAPS) projects within the basin.
- By 2010, all public water suppliers will complete and implement a source water protection plan.

Applicable Programs

The following programs help to meet the objectives in the Water Quality management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Health and Environment: State Water Plan Program (Contamination Remediation)
- Kansas Corporation Commission: Conservation Division Programs
- Kansas Department of Health and Environment: Local Environmental Protection Program
- Kansas Department of Health and Environment: Watershed Management Program
- State Conservation Commission: Nonpoint Source Pollution Control Program
- State Conservation Commission: Water Resources Cost-Share Program

ISSUE: FLOOD MANAGEMENT

Kansas Water Plan flood management guidance has emphasized targeting watershed dam construction assistance to priority watersheds encouraging participation in the National Flood Insurance Program and preparing updated floodplain maps for priority communities.

In 1993, the Kansas Department of Agriculture-Division of Water Resources launched the *Kansas Flood Mapping Initiative.* The FY 2005 *Kansas Water Plan* Flood Management Policy Section update identifies Sumner, Sedgwick, McPherson, and Barton counties to be mapped, remapped or to have existing information digitized in the Lower Arkansas basin. Financial assistance from the *State Water Plan Fund* has been provided for this mapping.

There is growing national concern that many small flood control dams that were built by local watershed districts with U.S. Department of Agriculture technical and financial assistance are at or near the end of their 50-year planned design life. Watershed Rehabilitation Amendments to the Watershed Protection and Flood Prevention Act of 1954 (PL 83-566) were enacted in 2000. These amendments authorize the USDA Natural Resources Conservation Service (NRCS), to work with local communities and watershed project sponsors to address the public health and safety concerns and potential adverse environmental impacts of aging dams.

Only dams that were constructed through USDA assisted water resource programs or authorizations qualify for rehabilitation assistance. Rehabilitation projects must be cost shared between the federal government and local project sponsors. The NRCS may provide up to 65% of the total cost of the rehabilitation project. To date, the NRCS has received one application for dam rehabilitation planning in Kansas. This request was for the Sand Creek Site #2 in Harvey County. There is about a 3-year project implementation time period.

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce the vulnerability to damage from floods within identified priority communities or areas.

Applicable Programs

The following programs help to meet the objectives in the Flood Management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Structures Program/Floodplain Management
- Kansas Department of Agriculture-Division of Water Resources: Water Structures Program/Dam Safety
- Kansas Division of Emergency Management: Hazard Mitigation Grants Program
- FEMA: National Flood Insurance Program
- State Conservation Commission: Watershed Dam Construction Program
- State Conservation Commission: Watershed Planning Assistance Program

Arkansas River near Wichita. Photo courtesy KGS.

Lower Arkansas River Basin Management Categories

ISSUE: WATER BASED RECREATION

Even though the Lower Arkansas basin has a wide variety and fairly high number of public water recreation sites proportional to the area covered, there is a demand for more water based recreation facilities to meet the needs of a comparatively large population.

The Arkansas River is one of the three streams in the state that are considered navigable as determined at time of statehood, and as such the land is considered public up to the channel's high water mark. Cheney Reservoir and State Park offer recreational opportunities including fishing, sailing, hunting and camping. The approach to enhancing opportunities for recreation is to improve access to water bodies in the basin.

Applicable *Kansas Water Plan* Objective

- By 2010, increase public recreational opportunities at Kansas lakes and streams.

Applicable Programs

The following programs help to meet the objectives in the Water-Based Recreation management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Wildlife and Parks: Rivers and Stream Access
- Kansas Department of Wildlife and Parks: Walk In Hunting Access Program
- Kansas Department of Wildlife and Parks: Fishing Impoundments and Stream Habitats Program/Walk-in Fishing

ISSUE: WETLAND AND RIPARIAN MANAGEMENT

The primary approach to wetland and riparian management in the basin focuses on providing technical and financial assistance to landowners to protect and restore resources in priority watersheds through the implementation of best management practices. Wetland and riparian management is addressed as a basin priority issue in the Lower Arkansas basin (see Watershed Restoration and Protection Basin Priority Issue). Cheyenne Bottoms and Quivira National Wildlife Refuge are designated wetlands of international importance that provide excellent birding, photography and hunting opportunities. In 2008, construction began on a Wetland Interpretive Center at Cheyenne Bottoms to expand public awareness of the Bottoms and the nearby Quivira wetland complex.

Riparian lands along the Arkansas River have been seriously impacted by the infestation of non-native phreatophytes. Of greatest concern are the effects tamarisk (salt cedar) and Russian olive are having on the basin's native riparian ecosystems.

Applicable *Kansas Water Plan* Objective

- By 2010, maintain, enhance or restore priority wetlands and riparian areas.

Applicable Programs

The following programs help to meet the objectives in the Wetland and Riparian management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Forest Service: Forest Stewardship Program and Conservation Tree Planting Program
- State Conservation Commission: Riparian and Wetland Protection Program
- Kansas Water Office: State Water Planning Program
- Kansas Department of Wildlife and Parks: State Parks and Wildlife Areas Planning and Development
- Kansas Department of Wildlife and Parks: Wildlife Habitat Improvement Program

Tamarisk Shrub.

Lower Arkansas River Basin High Priority Issue
Bioenergy and Water
January 2009

Issue

Renewable fuel production is a growing issue in the Lower Arkansas basin, where increased biofuel production provides economic opportunity. As new biofuel facilities are sited and changes are made to the basin's cropping patterns, more evaluation is needed of the impacts from the increased demand on both water supply and water quality.

Description

Gas and oil production is the second largest industry in Kansas and is very important to the Lower Arkansas basin's economy. The growing industrial contribution to the basin's economy is also related to bioenergy production, primarily ethanol. As of December 2008 (Figure 1), three ethanol plants are located in the basin in Pratt (idled), Sedgwick and Rice counties. An additional ethanol plant is under construction in Sedgwick county. Two biodiesel plants are permitted for construction in Kiowa and Stafford counties and one is under construction Sedgwick County.

Water Quantity

Ethanol production, like many industrial and agricultural practices, involves a consumptive use of water. A 50-million gallon per year (MGY) ethanol plant uses about 200 MGY of water (or about 550,000 gallons per day), primarily from evaporation during cooling and wastewater discharge. Ethanol production technology uses water more efficiently; plants today use about 50% less water than 10 to 15 years ago. It currently takes roughly three to four gallons of water to produce one gallon of ethanol. Under Kansas law for appropriating water, ethanol plants, as any industry, must purchase water from a rural water district or municipality or acquire a water right.

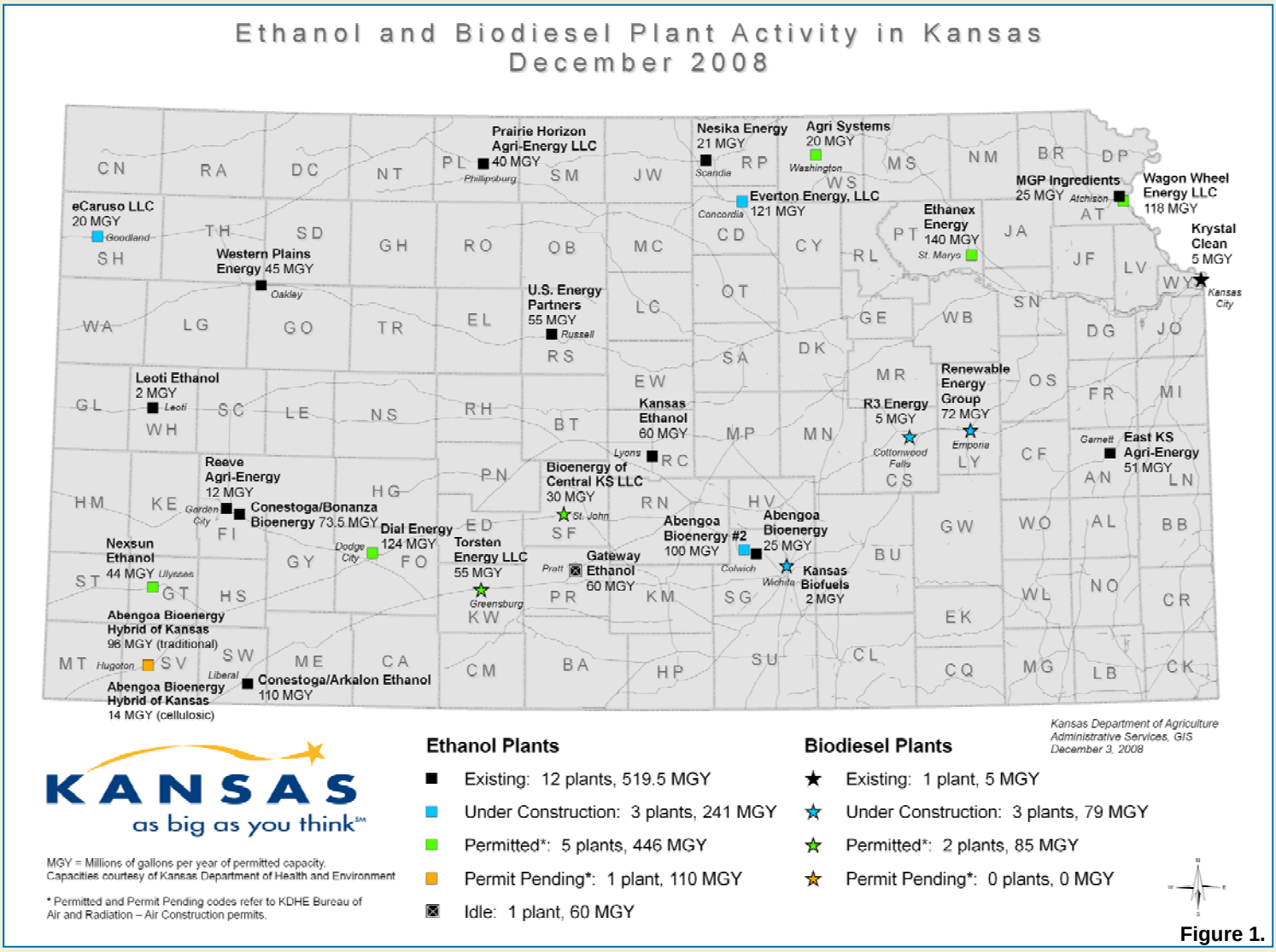


Figure 1.

Parts of the basin are closed to new water appropriations; in closed areas, any new venture must purchase an existing water right, and any change in use of that appropriation must be approved by the Chief Engineer of the Division of Water Resources to ensure that the net consumptive use does not increase. Nonetheless, some people have raised concerns that increased corn production, a water-intensive crop, for ethanol may cause additional declines over time.[2, 3]

Most U.S. ethanol is made from corn, but it can also be produced from other feedstocks such as grain sorghum, wheat, barley or potatoes. In Kansas, more than half of the ethanol produced comes from grain sorghum, with most facilities using corn and sorghum interchangeably.[2] This new demand for corn, and the new opportunities for value-added processing and distiller's grains for cattle feed in rural communities, has created a significant economic development opportunity in Kansas and throughout the Lower Arkansas basin. However, the potential changes to the basin's cropping patterns, specifically increasing the number of irrigated corn acres, may negatively impact the aquifer and stream conditions.

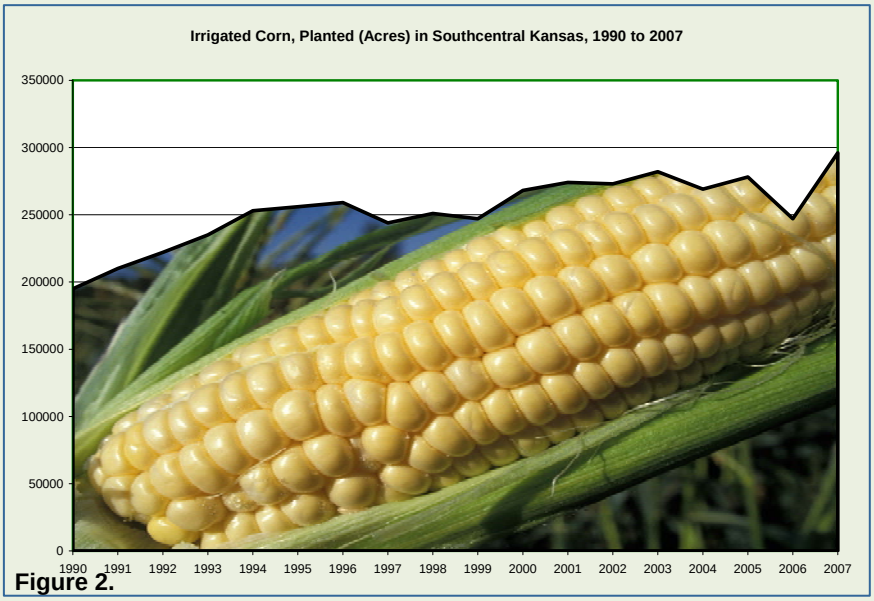


Figure 2.

According to the U.S. Department of Agriculture, National Agricultural Statistics Service (NASS), the number of irrigated corn acres in southwest Kansas grew from 195,000 acres in 1990 to 296,000 in 2007. Improved agronomic practices and crop genetics have led to higher corn yields. In south central Kansas, while there was a 26% increase in irrigated corn acres from 1993 to 2003, there was a 67% increase in irrigated corn production.[10] Recent years reflect the highest recorded irrigated corn acres for this region (Figure 2).[6] In 2006, approximately 16% of Kansas corn and sorghum crops were used for ethanol production, up 13% from 2000. Corn production in Kansas may be slowing down. According to NASS, producers intended to plant eight percent fewer corn acres in 2008, as a result of multiple factors including crop rotation considerations and high input costs. In 2008, Kansas was expected to plant their largest soybean crops in history.[5]

Water Quality

Wastewater from ethanol plants is regulated by the Kansas Department of Health and Environment (KDHE), which administers both the federal National Pollution Discharge Elimination System (NPDES) permits and Kansas Water Pollution Control permits. In most instances, KDHE issues the state-level permit, which requires ethanol plants to use the wastewater for beneficial land applications rather than simply discharging into streams and rivers.

A rise in the number of corn acres may also impact the basin's water quality through increased fertilizer application and soil erosion. Corn has the greatest application rates of both fertilizer and pesticides per acre, higher than for soybeans and mixed-species grassland biomass. The switch from other crops or noncrop plants to corn may lead to higher application rates of highly soluble nitrogen. Harvested row crops, such as corn, have a higher potential for soil erosion than grasses or perennial crops. The potential water quality impact of an increased demand for corn may be mitigated through Best Management Practices (BMPs), especially those addressing soil erosion and herbicide applications.

The restoration of watersheds with impaired water quality and the protection of watersheds above public water supply reservoirs and ground water sources used for drinking water supplies are also a high priority issue in the Lower Arkansas Basin.

Biodiesel

Biodiesel is produced using oils extracted from crops, animal fat or waste vegetable oil using a chemical process called transesterification. Most U.S. biodiesel is produced from soybean oil, although other vegetable oils such as canola, corn, cottonseed, flax seed, sunflower, or peanut oil can be used. As of December 2008, two biodiesel facilities, are permitted for the Lower Arkansas basin; one in St. John and one in Greensburg (Figure 1).

Biodiesel production uses roughly three gallons of water per gallon of fuel, about a gallon of which is consumptive use. Wastewater from biodiesel plants, which may contain high amounts of oxygen, grease and oils, is regulated by the Kansas Department of Health and Environment (KDHE).

Cellulosic Ethanol

Cellulosic ethanol uses lignocellulose, the main structural material in any plant, as a feedstock. Cellulosic feedstocks require an extra step to break down the lignocellulose into fermentable starch, thus increasing production costs. The bulkier cellulosic feedstocks are also more costly to harvest, transport and store. Processing of cellulosic materials would require more water than corn, perhaps twice as much, as the feedstock is dry. Research on cellulosic feedstocks such as switchgrass, wood chips and corn stover is ongoing. The U.S. Department of Energy (DOE) has set 2012 as a target to achieve technological advances to make cellulosic ethanol cost competitive with corn ethanol. While not located in the Lower Arkansas basin, in 2007, Abengoa Bioenergy, a Spanish energy company, announced that Hugoton, Kansas would be the site of the nation's first cellulosic ethanol plant. In conjunction with cellulosic ethanol research, some researchers are investigating the use of perennial polyculture crop systems for cellulosic feedstocks.

Production of cellulosic ethanol may have greater positive environmental impacts than grain-based ethanol such as reduced greenhouse gas emissions, decreased fertilizer application, and less reliance on water intensive crops.

Corn Research and Varieties

Breeding of corn hybrids that maximize yield for ethanol production while reducing additional strains on water supplies has been a focus of much research by universities and corn breeding companies. Drought tolerant hybrids, specifically transgenic drought resistant corn, are especially important in areas of western Kansas where rainfall averages fewer than 16 inches per year. In addition to drought tolerant varieties, industries are identifying corn varieties that produce higher yield and more ethanol per acre. High total fermentable ethanol corn hybrids provide higher levels of fermentable starch, consisting of the sum of all starches and simple sugars that ferment during the typical dry grind process.[4,7]

Recommended Actions

1. Coordinate, where applicable, the development, implementation and public input process between the *Kansas Water Plan* and Kansas energy policy.
2. Maintain regulatory oversight by state and local government on the siting of ethanol and biodiesel plants, with special emphasis on water supply availability.
3. Look for increased water recycling opportunities within the biofuel facilities.
4. Promote research for less water-dependent corn varieties and improved irrigation scheduling that maintains or increases crop yield without increasing water use.
5. Promote research and pilot projects for viable, commercial cellulosic ethanol production and other biofuels that are less dependent on water intensive crop production.
6. Increase corn water use efficiency (amount of grain produced per inch of water) through research and extension efforts. Educational emphasis should be placed on utilization of irrigation scheduling tools such as KanSched and the Mobile Irrigation Lab (MIL).
7. Evaluate the biofuel facility watershed and watersheds of input crops to identify potentially environmentally sensitive areas. Target programs such as stream buffers, grass filters, BMPs, etc., to mitigate environmental impacts.
8. Provide education and/or incentives to landowners of marginal lands that have expiring Conservation Reserve Program contracts that can not be renewed to stay in a conservation planting with special consideration to acres that could return to irrigation. If coming out of CRP, encourage landowners to explore all options for conservation.

Resources

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9. U.S. Department of Energy. http://www.doe.gov/energysources/bioenergy.htm

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Lower Arkansas River Basin High Priority Issue
The Role of Reuse in Water Conservation
January 2009

Issue

The State of Kansas should identify opportunities to better utilize reclaimed water as a valuable water resource.

Description

Many states have been remarkably successful in moving toward water reuse as a means for managing domestic wastewater, conserving water and managing water resources. Several states including Texas (10-16%), Arizona (20%) and California (50%) project that a significant portion of the future water supplies will come from wastewater reuse.[3]

Reclaimed water may play a significant role in water supply in Kansas. The State of Kansas should identify strategies for implementation of an institutional and regulatory framework to better utilize reclaimed water as a valuable water resource that should be used efficiently and effectively.

Water reuse should be considered an important component of both wastewater management and water resource management in the Lower Arkansas basin. Reuse offers an environmentally sound means for managing wastewater that dramatically reduces environmental impacts associated with discharge of wastewater effluent to surface waters. In addition, use of reclaimed water provides an alternative water supply for many activities that do not require potable quality water, such as irrigation, cooling water reuse, and toilet flushing, which serves to conserve available supplies of potable quality water. Finally, some types of reuse offer the ability to recharge and augment available water supplies with high quality reclaimed water.

Water Use in the Basin

In 2006, over 700,000 acre feet of water was reported used in the Lower Arkansas basin. Irrigation accounted for nearly 75 percent of all reported water pumped or diverted. Municipal use accounted for 15 percent of water used in the basin, industry for five percent and recreation, stockwater, and other uses combined equal about 5 percent[7]. According to projections conducted using Kansas Division of Budget population data, the basin population is projected to grow more than 38% by the year 2040. Projected future water supplies in the basin may not be adequate to meet the projected demands. Water reuse may provide an alternative supply while conserving current and future supplies to better serve the projected demands.

Center pivot sprinkler. Photo courtesy KGS.

Current Regulatory Authority

The Kansas Department of Health and Environment (KDHE), Bureau of Water administers programs related to public water supplies, wastewater treatment systems, the treatment and disposal of sewage and nonpoint sources of pollution. Programs are designed to provide safe drinking water, prevent water pollution and assure compliance with state and federal laws and regulations such as the federal Clean Water Act and Safe Drinking Water Act.

State Water Quality Standards include provisions for alternative disposal of treated wastewater and residue material resulting from the waste treatment process.[8] KDHE's minimum standards for the design of water pollution control facilities include guidelines for agricultural application of wastewater and sludge. Reuse of treated wastewater may contribute to water conservation within the basin.

In the 2008 Kansas Legislature, a bill was introduced that would authorize the Biological Survey at the University of Kansas to conduct a survey that examines the potential to treat non-potable waters for productive reuse.[5] The Kansas Water Authority, the Kansas Water Office, the Kansas Corporation Commission and the Kansas Geological Survey would collaborate with the Biological Survey to produce a report of the survey findings. The report would also identify potential amounts of water that can be productively treated, cost-estimates for the treatment, potential locations of these treatable waters; identify water discharged from municipal and industrial processes and the potential for productive reuse of such waters; and any policy recommendations to the Governor and the Legislature. The bill was introduced

and referred to the Committee on Energy and Utilities, but received no further action in 2008.

Examples of Reuse in Kansas

In Kansas, there are more than 140 communities and facilities that are authorized to reuse treated wastewater. The reuse of wastewater for applications like irrigating turf on golf courses and parks allows these communities to reserve potable water for residential use.

The City of Colby treats more than 2 million gallons of wastewater annually. Through their mechanical treatment process, the city reuses some of the water for irrigation of crops that are not for human consumption. The City of Hays also reuses a portion of its wastewater to irrigate golf courses, parks and ball fields.

In the Lower Arkansas basin, a total of 11 communities and commercial facilities are authorized to reuse treated wastewater (Figure 1). One commercial facility, located in Kingman, is authorized to utilize the wastewater effluent for the irrigation of grass and/or agricultural areas. As a condition of the permit, this facility must control tailwater to prevent runoff to surface waters, must only draw water from the final cell in the treatment process and must not irrigate crops for direct human consumption. Two industrial facilities, located in Colwich and Hutchinson, are authorized to use wastewater effluent for irrigation. Eight municipalities, including Hutchinson (four permits), Newton, Park City, Wellington and Winfield, are authorized to use the wastewater effluent for the irrigation of golf courses and other public use areas such as parks, ball fields and cemeteries.[1]

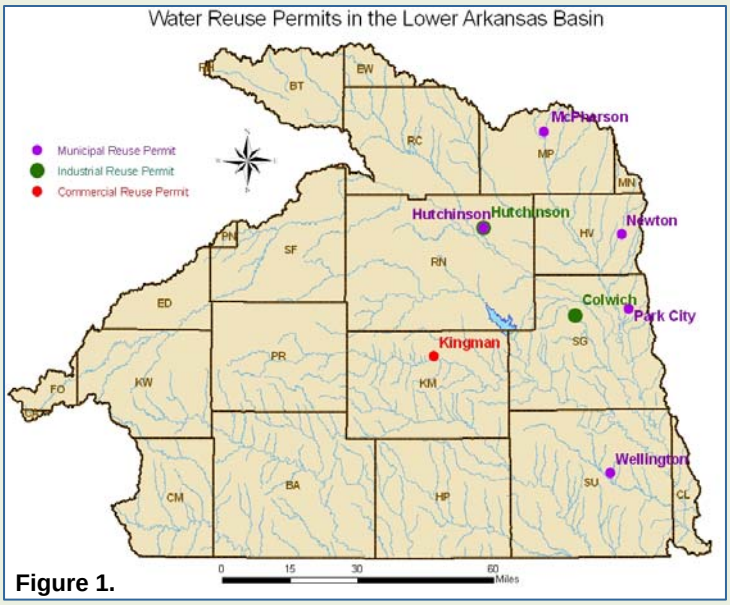


Figure 1.

Opportunities for Reuse

Renewable fuel production is a growing industry in the Lower Arkansas basin. Ethanol production, like many industrial and agricultural practices, involves a consumptive use of water. A 50-million gallon per year (MGY) ethanol plant uses about 200 MGY of water (or about 550,000 gallons per day), primarily from evaporation during cooling and wastewater discharge. As new facilities are sited and current facilities are improved, ethanol production in the basin presents an opportunity for industrial water reuse.

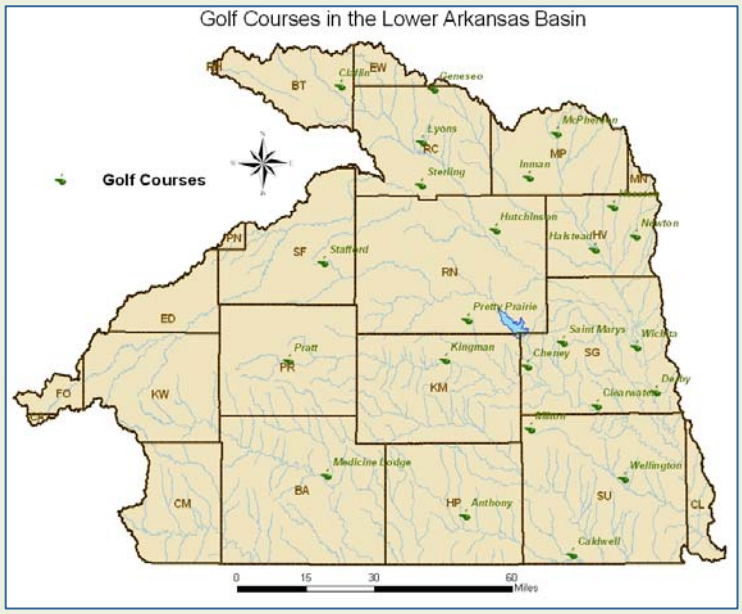
Irrigation accounts for nearly 75% of all reported water pumped or diverted in the basin.[7] Reclaiming water for irrigation of agricultural land could have a significant impact on water use in this region. As in Colby, most current examples of reuse for irrigation in Kansas are for the application to crops that are not for human consumption. Some other states such as Florida promote water reuse for edible crop irrigation. In 2001, a total of 34 million gallons per day was reused to irrigate edible crops such as citrus, tomatoes, cabbage, peppers and beans in Florida.


Recharge Basin.

Artificially recharging the Equus Beds aquifer, which underlies the City of Wichita well field, is one water reuse alternative being employed to meet future demands for water for the city and other users in the area. An additional benefit of artificial recharge includes creating a hydraulic high in the ground water, thus blocking migration of saltwater plumes from the Burrton oil field to the northwest into the aquifer region of the city well field. Diverting water from the Little Arkansas River through streambank storage (diversion) wells when flow in the river exceeds base flow and then artificially recharging water into the Equus Beds aquifer through injection wells and recharge

basins is an example of a successful water reuse strategy. The water is treated to drinking water standards prior to recharge at the Segdwick site. In 2007, over 350 million gallons were recharged into the aquifer through this project.

Parks, golf courses and other recreational facilities also hold an opportunity to utilize wastewater reuse. More than 24 communities in the basin have at least one golf course. Maintaining green turf for golf courses requires significant quantities of water. Average water use for those facilities with an irrigation water right for golf course turf in 2006 was about 47 acre feet per year. Some facilities, typically those larger than 150 acres, reported more than 200 acre feet of water use in 2006.[7]



South central Kansas is an area where communities rely on ground water from the High Plains, Arkansas River alluvial and Permian bedrock aquifers for domestic, municipal, agricultural and industrial uses. However, substantial areas of these aquifers contain brackish ground water which appreciably limits the locations and quantities of freshwater resources that can be withdrawn. A characterization of the quantities of high quality ground water available, and the suitability for various treatment schemes for brackish water, is needed. This may a region of future water shortages.

Barriers to Reuse

Protection of human health is the primary concern when developing and implementing a wastewater reuse program. KDHE identifies several standard management practices for reuse of treated domestic wastewater for instances when the wastewater will be applied to public areas such as golf courses or parks. Typical protective practices include an increased degree of disinfection, only applying the treated wastewater when public access is restricted and posting signs warning against swimming in or drinking ponded wastewater. Irrigation of crops produced for direct human consumption is not permitted by KDHE. Monitoring of the treated wastewater is required using Environmental Protection Agency (EPA) approved methods and KDHE certified laboratories if applicable.

Community involvement and public education is an important component in developing large scale wastewater reuse projects in the basin. In some states, public perception of utilizing reclaimed water to augment potable water sources, even in an indirect manner, has prevented some projects from implementation.

A portion of water diverted for all beneficial uses is considered “non-consumptive” when it is returned to the natural system through streamflow or ground water recharge. Consideration of the potential impacts of water reuse to downstream users is needed to ensure local water conservation activities do not negatively impact larger regional conditions. Under the rules and regulations of the Kansas Water Appropriation Act, the extent of consumptive use can not increase after a water right has been perfected.[9]

Water reuse and the associated change in water returned to the natural system may impact instream habitat. Numerous threatened and endangered species including six fish, occur in the Lower Arkansas basin. Consideration of the potential impacts to instream habitat and species viability is needed to ensure that water conservation measures do not negatively impact instream use.

Salt accumulation may be a factor when evaluating the potential for water reuse, especially on golf courses and in agricultural irrigation. Water softening and other activities can add substantial amounts of sodium chloride to the wastewater. Typical wastewater treatment processes in use today often do not remove or manage inorganic salts. Facilities choosing to irrigate with treated wastewater may need to alter plant species selections or use other methods to address total dissolved solids, sodium and salinity in effluent.

The use and disposal of pharmaceuticals and personal care products entering sewer systems and surface water is an emerging concern for wastewater treatment. Wastewater treatment plants are designed to remove

conventional pollutants such as suspended solids and biodegradable compounds, but they are not designed to remove low concentrations of synthetic pollutants, such as pharmaceuticals.[2] Depending on the purpose and application of treated wastewater, the affect and mitigation of these contaminants needs to be considered.

Recommended Actions

1. Provide public education on water reuse in irrigation, industry, municipal and domestic uses, and encourage communities to build in water reuse as part of their plans to meet future demand.

2. Where appropriate, establish the promotion and encouragement of water conservation and reuse as formal basin specific objectives for the Lower Arkansas basin.

3. Facilitate storage of seasonal reclaimed water from streamflow (including aquifer storage and recovery).

4. Facilitate interagency coordination between Kansas Department of Agriculture-Division of Water Resources and Kansas Department of Wildlife and Parks to ensure water reuse activities and permits remain in compliance with Kansas Water Appropriation rules and regulations and stream habitat issues are discussed.

5. KDHE evaluate the potential impact of water reuse on downstream users and stream habitat.

6. Encourage use of reclaimed water in lieu of other water sources in the agricultural irrigation, landscape irrigation, industrial/commercial/institutional and indoor water use sectors.

7. Link reuse to regional water supply planning including integrated water resource planning.

Resources

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Lower Arkansas River Basin High Priority Issue
Long Term Public Water Supply
January 2009

Issue

Projected sources of water supply are insufficient to meet projected demands in some areas of the Lower Arkansas River basin. Artificially recharging and conserving the existing supplies of the Equus Beds aquifer should be considered to meet future demands for water for Wichita and other users in the area, as well as to prevent degradation of the water quality of the aquifer by saltwater plumes. Another component of extending the future water supplies is ensuring the sustainability of water supply storage in Cheney Reservoir.

Description

Supply and Demand

In 2006, over 700,000 acre feet of water was reported used in the Lower Arkansas basin. Irrigation accounted for nearly 75% percent of all reported water pumped or diverted. Municipal use accounted for 15% of water used in the basin, industry for five percent with recreation, stockwater, and other uses combining to equal about 5 percent.[4] According to projections conducted using Kansas Division of Budget population data, the population of the basin is projected to grow more than 38% by the year 2040. Projected future water supplies in the basin may not be adequate to meet the projected demands.

In 2007, the Kansas Water Office (KWO) conducted an analysis of the surface water supply and demand projections for selected basins in eastern Kansas. The analysis compared population growth projections and non-municipal water use demand estimations with Federal reservoir yield and natural streamflow estimates. Demand anticipated to occur under sever drought conditions was then projected. In 2004, a supply and demand projection was conducted by the Burns & McDonnell engineering firm for five counties: Harvey, Butler, Sedgwick, Cowley and Sumner.[2] According to the Burns & McDonnell's population and demand projections, Sedgwick County would have the largest population increase amongst the five counties. The City of Wichita, the largest water user within the area, was shown to have a projected demand of 112 million gallons per day (MGD) in the year 2050. The Equus Beds Aquifer Storage and Recovery (ASR) project is part of the city's Integrated Local Water Supply Plan to meet these future demands, along with withdrawals from Cheney Lake.

An assessment of water needs in the southwest portion of this basin, Kingman, Harper, Pratt, Barber, Kiowa, Comanche, and three counties in Oklahoma, was reported by Bartlett & West in 2008, as a preliminary engineering report for Sunflower H_2O Initiative.[1] Current supplies appear to meet projected demands in this area.

An inventory of the current water supplies and potential demands was also conducted for nine counties of south central Kansas (Butler, Cowley, Harper, Harvey, Kingman, McPherson, Reno, Sedgwick and Sumner), as a Special Study by the U.S. Bureau of Reclamation for the Kansas Water Office and Regional Economic Area Partnership (REAP). The report provides information to support decision making by local entities to meet future water supply needs.

Aquifer Recharge

The water supply for the City of Wichita in south central Kansas currently comes from two primary sources: the City of Wichita well field in northern Sedgwick and southwestern Harvey counties, and Cheney Reservoir located mostly in southeastern Reno County. These sources will not be adequate to meet the projected water needs of the Wichita metropolitan area in the 21st century. Artificially recharging the Equus Beds aquifer, which underlies the city well field, is a strategy being implemented to meet future demands for water for Wichita and other users in the area. An additional benefit of artificial recharge includes establishing a hydraulic ridge, thus preventing migration of saltwater plumes originating from the Arkansas River to the southwest and the Burrton oil field to the northwest, which would degrade the water quality of the city's well field.

Recharge Basin.

The Wichita well field was developed in the Equus Beds aquifer to supply water to the city beginning in 1940. Declines in ground water levels can be attributed to

pumping from the aquifer by the City of Wichita and local irrigation water users. Increased reliance on surface water from Cheney Reservoir since 1965 and decreased city pumping from the Equus Beds aquifer have moderated the aquifer water level declines. Between 1992 and 2006, water levels recovered by more than 10 feet in much of the area.

Areas of the Lower Arkansas River basin are affected by salt contamination of fresh ground water and surface water (Figure 1). Several sources of salt have been identified as contributing to the contamination, including waste from salt mining or oil production, and human activities. Some of the salt is naturally occurring, arising from the dissolution of salt deposits in the underlying bedrock.

Artificial recharge is one strategy for addressing both water quantity and water quality concerns for the region. This approach is the vision of the City of Wichita, which has led the effort in partnership with the U.S. Bureau of Reclamation (Bureau) to test the approach and implement later phases.[9,10] In 1995, the Equus Beds Groundwater Recharge Demonstration Project was initiated to evaluate recharge techniques and their impact on the water quality of the aquifer. As part of the demonstration project, water was diverted from the Little Arkansas River during high flow events. The diverted water was either pumped to the Halstead recharge site and recharged to the aquifer by basin, trench or injection well, or treated and recharged at the Sedgwick recharge site. The demonstration phase of the project was completed in May 2002. The quantity of artificial recharge during the demonstration project was equivalent to less than three percent of the water pumped for municipal use from the aquifer by the City of Wichita (Table1).

Year	Halstead	Sedgwick	Total
1997	130,622,100	1,828,900	132,451,000
1998	258,947,500	40,360,300	299,307,800
1999	243,059,200	82,285,300	325,344,500
2000	86,436,400	11,530,700	97,967,100
2001	211,182,000	--	211,182,000
2002	16,917,400	--	16,917,400
Total	***947,164,600***	***136,005,200***	***1,083,169,800***

Table 1. Gallons of Water Recharged through May 2002 (Conclusion of Demonstration Project).

In 2006, the first non-demonstration phase of the project was initiated. The purpose of the Equus Beds Aquifer Storage and Recovery (ASR) Project, Phase I, is to inject larger quantities of water into the aquifer for the purposes of storage and later recovery and to form a hydraulic barrier to the brine plume. The project diverts water from the Little Arkansas River through bank storage (diversion) wells and surface water intakes, when flow in the river exceeds base flow. The diverted water then is artificially recharged into the Equus Beds aquifer through injection wells and recharge basins. In 2007, over 350 million gallons were recharged into the aquifer through the ASR project, and in the first six months of 2008, approximately 600 million gallons were recharged.

To protect water quality, the City of Wichita and the State Conservation Commission have cooperatively cost shared with farmers on implementing for atrazine control. Roughly 75% of the farmers planting grain sorghum in the Little Arkansas River watershed participated and implemented Best Management Practices (BMPs).

Design for Phase II (Figure 2) of the ASR project began in 2008 for the surface water intakes, with construction slated to begin in 2009 and the project to be operational in 2011. Bank storage wells may get incorporated into the project after the capacity performance is fully evaluated. Phase II design elements will cap-

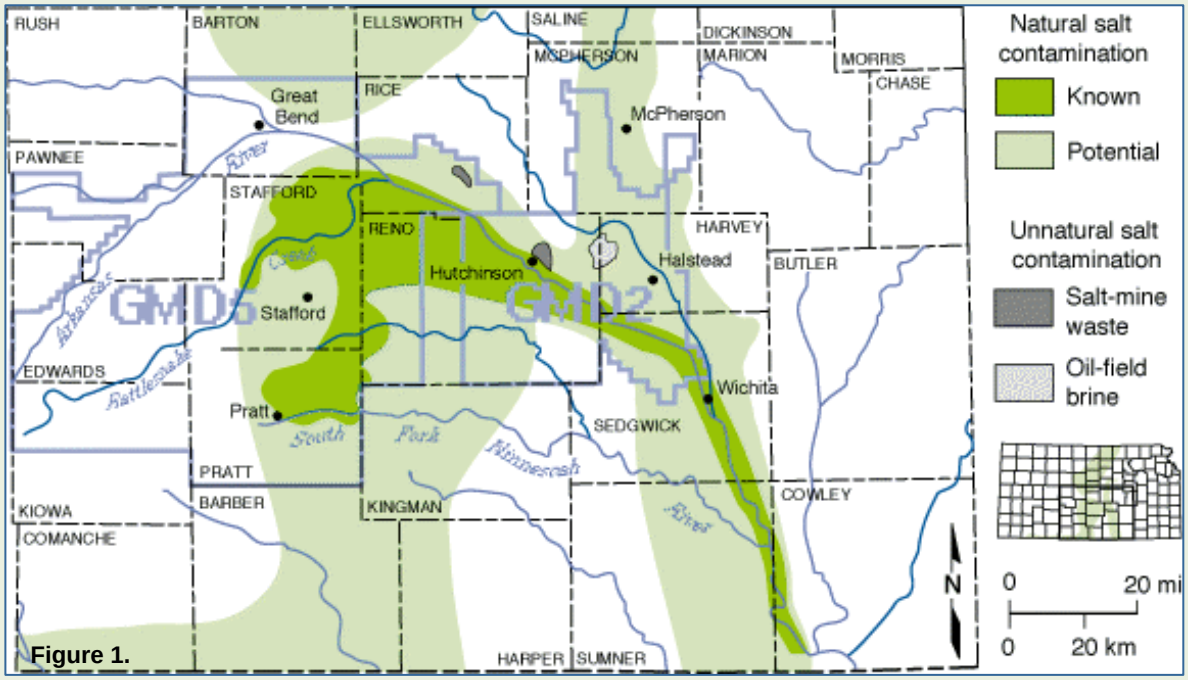


Figure 1.

ture and recharge up to 30 million gallons per day (MGD) and will rely on a treatment plant to treat the water adequately to return directly into recharge wells. The project includes replacement of approximately 17 miles of existing raw water pipeline and 26 recharge/recovery wells.

Phase I and II had been estimated to cost $137 million five years ago; in 2008, due to inflation, cost estimates for just Phase II are $200 million or more. There is federal authorization (but not yet an appropriation) that allows cost share of up to 25% of project costs or a maximum of $30 million (based on the original cost estimate). In addition to the federal assistance, the city is seeking $1 million from the State, annually, for 5 to 8 years. In fiscal year 2009, $1 million to the ASR was approved from the State Water Plan Fund. When complete, the ASR will be a major regional water supply for over 600,000 people.

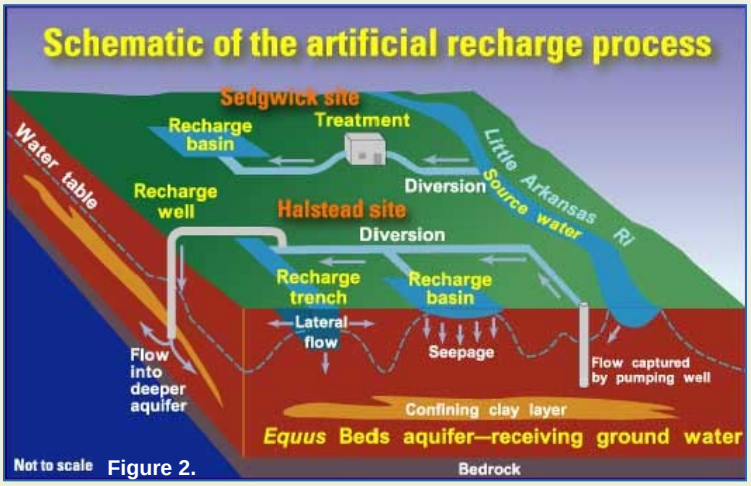


Figure 2.

Cheney Reservoir

Cheney Reservoir, located 24 miles west of Wichita on the North Fork of the Ninnescah River, was constructed in 1962-1965 by the Bureau.[7] The primary purposes for the dam's construction were water supply, flood control, recreation and wildlife benefits. The land use of the watershed that drains to Cheney is 99% production agriculture. The reservoir has storage of 151,800 acre feet at conservation pool, with an additional flood control capacity of 80,860 acre feet.[11] The City of Wichita draws more than 60% of its daily water supply from the reservoir.

Approximately 7,100 acre feet of sediment deposition occurred in Cheney Reservoir from 1965 through 1998. As of 1998, sediment had filled 27% of the reservoir's inactive conservation storage pool. Sedimentation affects both the useful life and aesthetic quality of a reservoir. Sediment quality is an important environmental concern because sediment may act as a sink for water quality contaminants and as a source of harmful constituents to the overlying water column and biota. Sedimentation also decreases the water storage capacity of the large federal reservoirs, including Cheney.

In 1992, the Reno County Conservation District created a task force including farmers and representatives of state, federal and local agencies to identify potential sources of pollution in the watershed and Cheney Reservoir. The task force prepared a master plan for watershed pollution management to reduce phosphorus and sediment and extend the life of the reservoir to 200 years. Implementation of the plan began in July 1994 under the leadership of the Citizen's Management Committee (CMC) which operates as a subcommittee of the Reno County Conservation District. All members of the CMC live in or own land in the watershed and are farmers, land owners or agribusiness persons with rural interests.

The CMC continues to partner with the agencies and organizations that assisted the original task force. One of the most significant achievements of the Cheney Reservoir Watershed Project is the partnership of rural-urban stakeholders. Because the City of Wichita recognized the value of correcting pollution problems prior to water entering the reservoir, they agreed to provide incentive payments to farmers for implementing BMPs which often times are non-income generating assets for the farmers. For the farmers, implementation carries the obligation of maintaining the practices for the long term.

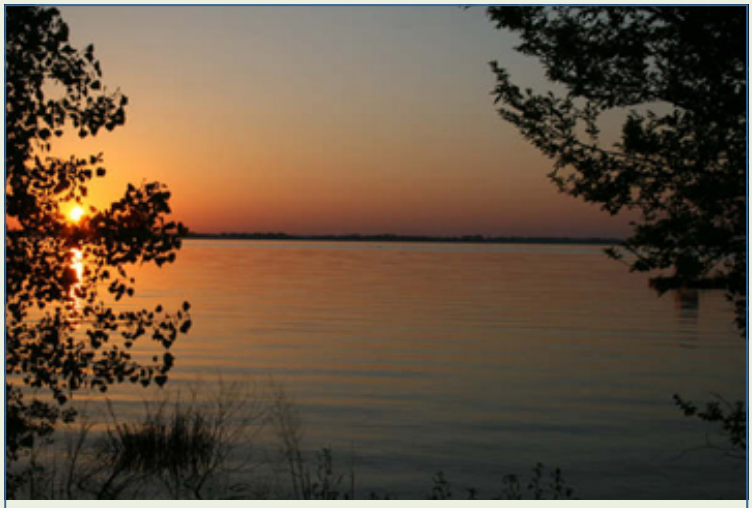
Since 1994, CMC's accomplishments include:

- Development of a citizen-led organization that promotes conservation practices through farmer-to-farmer information transfer;
- More than 1,400 BMPs implemented on watershed farms over the life of the project;
- Identification of key areas in the watershed with the potential to contribute the most sediment and nutrients to Cheney Reservoir; and
- Development of policy and programs to focus education and incentives to key areas.

Collaborative Water Resource Planning

The Regional Economic Area Partnership (REAP), is comprised of 34 city and county governments in nine counties of south central Kansas, which include Butler, Cowley, Harper, Harvey, Kingman, McPherson, Reno, Sedgwick and Sumner counties. REAP has established

a Water Resources Committee to identify and coordinate collaborative efforts on regional issues of water quality and supply in south central Kansas.



Cheney Reservoir.

REAP participated as a partner in a Special Study conducted by the Bureau, in conjunction with the KWO. The objective of the study was to provide information for the formulation of alternative opportunities to meet the future municipal and industrial demand and usage within the area. Findings of the study report provide areas for further review. These include a focus on the value of conservation and the full utilization of existing surface water supplies. Development of additional ground water sources in the alluvial river valleys or new reservoir supplies could be evaluated. Reuse of municipal & industrial effluent and desalination of brackish ground water in the area are other areas identified for potential future study.

The Sunflower H_2O Initiative is a consortium of rural communities and water districts in six counties (Barber, Comanche, Harper, Kingman, Kiowa, and Pratt) along with 3 counties in Oklahoma (Alfalfa, Grant and Woods) that are working together to address common water issues. The consortium conducted a regional planning study with funding assistance from the Kansas Department of Health and Environment to evaluate water needs in the area and the most cost effective manner of developing and delivering the needed water supply.[1] All current systems in the area are ground water dependent. Many water supplies have experienced contamination or have threats to their supplies. The Consortium is in the process of trying to move into a next phase of review to evaluate opportunities for further regionalization of resources and systems and to evaluate opportunities to develop additional supply sources, both ground and surface water.

The Equus Beds Groundwater Management District No. 2 (GMD2) is an important water management entity in the basin, covering the eastern portion of the basin where some of the larger municipalities are located. The Big Bend Groundwater Management District No. 5 (GMD5) is another major water management entity in the basin, covering much of the western portion of the basin, including much of the irrigated lands, where most of the water use in the basin occurs.

Recommended Actions

1. Conduct focused supply and demand analyses for areas of rapid growth and/or areas of projected shortage within the basin.

2. Support the Equus Beds Aquifer Storage and Recovery (ASR) Project.

3. Coordinate with and support the efforts of the Regional Economic Area Partnership (REAP), Water Resources Committee, to identify and develop long-term water supplies in south central Kansas.

4. Implement the recommended actions as proposed in the *Enhanced Stream Corridor and Wetland Management to Address Reservoir Sedimentation Policy Section* of the *Kansas Water Plan*.

5. Support the initiatives of the Cheney watershed Citizen's Management Committee's master plan for watershed pollution management, including the targeted voluntary implementation of conservation practices.

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Lower Arkansas River Basin High Priority Issue
Rattlesnake Creek Subbasin
January 2009

Issue

Management solutions are needed to address water level decline rates, the achievement of sustainable yield, and the meeting of minimum desirable streamflows in the Rattlesnake Creek Subbasin.

Description

Ground water depletion due to over appropriation, and the maintenance of minimum desirable streamflows (MDS), is a priority issue in the Rattlesnake Creek Subbasin. The subbasin is a targeted area to meet the 2010 and 2015 *Kansas Water Plan* objectives.[7] These objectives include the reduction of water level decline rates within the High Plains aquifer, the achievement of sustainable yield management of Kansas surface and ground water resources outside of the Ogallala aquifer and the meeting of minimum desirable streamflows.

When the amount of water withdrawn from an aquifer continually exceeds the recharge, a ground water depletion situation exists. The rate of depletion in a given area depends on the hydraulics of the water bearing formation, the amount of recharge and the amount of withdrawal. Ground water depletion may contribute to stream flow depletion, water quality deterioration, land subsidence and ecosystem disruption.

The Rattlesnake Creek Subbasin is located predominantly within Big Bend Groundwater Management District No. 5 (GMD5), with the exception of Ford County which is within Southwest Kansas Groundwater Management District No. 3 (GMD3). The Quivira National Wildlife Refuge wetlands, which have a senior surface water right, is located in this subbasin.

Declines in the ground water table result in lower streamflows that are often inadequate to meet appropriated surface water demands. The timing of irrigation water demands often coincides with demands for surface water from Rattlesnake Creek into the Quivira wetlands.

A water resource management program proposal was developed by the Rattlesnake Creek/ Quivira Partnership in 1999 to provide solutions, other than regulatory, for water resource scarcities within the Rattlesnake Creek Subbasin.[8] The partnership consists of GMD5; the U.S. Fish and Wildlife Service; the Kansas Department of Agriculture-Division of Water Resources (DWR) and WaterPACK, an organization of area irrigators. The program was accepted by the Chief Engineer, DWR in June 2000. It outlines a 12 year implementation schedule, as measured from August 1, 2000, to achieve the water use reduction goals and is reviewed every four years.

The goal of the management plan proposal is to stabilize ground water levels over the long term in an effort to improve streamflow in Rattlesnake Creek for the future (Figure 1). Within the Rattlesnake Creek corridor, ground water use is to decrease 12 percent under the plan to attain a 10-year moving average January streamflow of 25 cubic feet per second at the Zenith gage. Within the ground water management area beyond the stream corridor, annual ground water use is to decrease 16% or 16,400 acre feet, as measured in a 10-year moving average.

Current total appropriations within the subbasin are 221,068 acre feet/year. The average water use per year (72% of appropriations) is 158,189 acre feet/year. To achieve the management plan goals, a reduction of 28,620 acre feet in authorized quantity, or a reduction of 20,403 acre feet from the average water use, by the year 2012 is needed.

The management plan proposal includes the following strategies to achieve reduction in average water use per year: water banking, water right purchase, flex water right accounts, improved water conservation through

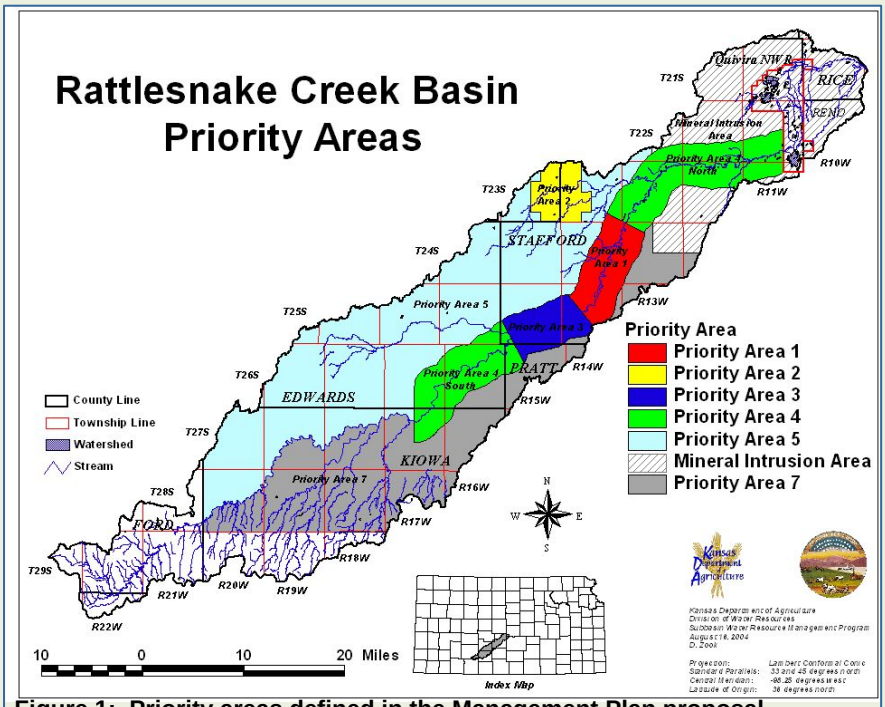

Figure 1: Priority areas defined in the Management Plan proposal.

education and irrigation water management, enhanced compliance with better enforcement of water right violations, water appropriation transfers away from high decline and river corridor areas, and end gun removals from irrigation systems. Strategies are also directed to decrease adverse effects of pumping that would aggravate a natural salt-water intrusion into the freshwater aquifer. Sufficient funding and participation in voluntary programs to implement and carry out these strategies are essential to avoid mandatory reductions. More recently, two other programs have been used: the State Water Right Transition Assistance Program (WTAP) and the USDA Natural Resources Conservation Service EQIP program for "quick response areas".

Water Banking

Water banking was proposed in the Rattlesnake Creek Management Plan proposal as a potential water conservation tool in need of consideration. The primary purpose of water banking in the Rattlesnake Creek subbasin is to provide incentives for water conservation and redistribution of water use within the subbasin. A state task force studied the concept and the legislature passed the Water Banking Act in 2001. Rules and regulations for the program were adopted in 2004. The water bank is authorized by the Chief Engineer. The Water Banking Act requires a minimum of 10% water savings in consumptive use on all deposit/lease transactions as well as the safe deposit boxes where a water right owner can save water for their own future use. In 2005, the Chief Engineer approved the Central Water Bank Charter, the first water banking charter in Kansas.[1] The charter targets the entire GMD5 district. This water bank charter is approved for seven years, at the end of which its operation will be reviewed to determine its effectiveness for water conservation. Actual consumptive use through water banking was reduced 40 acre feet in 2007.[2] Irrigators' awareness of the program is growing, as reflected in the increasing calls about the program and increasing deposits.

End Gun Removal

Voluntary end gun removal is a management strategy under the Management Plan that could decrease the appropriated quantity, amount of irrigation water pumped, and the number of acres irrigated. The end gun proposal has temporarily been halted by GMD5 until their board members can review various concerns surrounding end gun removal.

CENTRAL WATER BANK ACCOUNTING

DEPOSITS

Water Right Number	Auth. AF	'87 - '96 Avg AF	Bankable AF	Posted AF	Term Year(s)	Total Deposit	Cons. Amt.	AF Available for Lease
35437	90.00	68.49	54.14	54.14	5	291.08	20.38	270.71
29455	117.00	83.79	66.59	66.59	4	284.89	18.52	266.37

2007 SAFE DEPOSITS

Water Right Number	Date Opened	Auth. AF	Annual Deposit	Annual Used	Year-End Balance (-10%)	Quant Diverted (Last 3 Yrs)	Type of Use
24030	12/30/2005	177	Pending	—	—	425.32	IRR
31216	12/30/2005	236	Pending	—	—	217.96	IRR
12812	12/30/2006	95	Pending	—	—	99.66	IRR
28312	12/30/2006	195	Pending	—	—	240.26	IRR
18670	12/30/2006	214	Pending	—	—	383.59	IRR
18669	12/30/2006	221	Pending	—	—	366.00	IRR
32740	12/30/2006	183	Pending	—	—	437.66	IRR
39049	12/30/2006	198	19.91	88.65	17.92	335.36	IRR
YEARLY TOTALS			19.91	88.65	17.92	2475.81	

Tables 1 and 2: Deposits and Safe Deposits into the Central Water Bank. Deposits can be leased by others; safe deposits are for owner's future use. Both have conservation components.

Center pivot end gun.

Compliance and Enforcement

Voluntary, incentive-based water conservation programs can be most effective when combined with stronger enforcement of existing regulations. As a component of the Management Plan, DWR and GMD5 are seeking to enhance the current compliance and enforcement efforts to ensure water right conditions are followed.

Since 2000, DWR has focused the Blatant and Recurring Overpumping (BRO) Enforcement Program to the Rattlesnake Creek subbasin. Increased concentration of compliance inspections has increased awareness of the monitoring efforts as well as the quantity of water savings associated with these programs. To date, approximately 1,300 acre feet of water usage has been reduced by targeting the BRO program to the Rattlesnake Creek subbasin.

In 1978, the Kansas Legislature enacted provisions for the initiation and designation of Intensive Groundwater Use Control Areas (IGUCA) within the Groundwater Management District Act.[9] These statutes allow the Chief Engineer to implement additional corrective control provisions in areas where it is determined through a public hearing process, that ground water levels are declining excessively, the rate of ground water withdrawal exceeds the rate of ground water recharge, unreasonable deterioration of ground water quality has occurred or may occur, or other conditions exist warranting additional regulation to protect public interest. No IGUCAs are currently located within the Rattlesnake Creek subbasin.

Water Appropriation Transfers

The water appropriation transfer component of the Management Plan allows water right holders to move rights to other locations in the subbasin that are not experiencing major water level fluctuations. The goal of the strategy is an overall reduction in water use. No water rights would be allowed to be moved into the stream corridor, closer to the stream or into the priority high decline areas. There have been three water rights totaling 485 acre feet moved from within the Rattlesnake Creek corridor and the high decline area for a total savings of 30 acre feet.

Water Right Purchase Program and Water Transition Assistance Program

The Rattlesnake Creek Management Plan recommended using the State's Water Rights Purchase Program to permanently reduce water use in the stream corridor and areas of high decline within the management area. This program has been authorized for a number of years, but never funded. To assist with implementing the Rattlesnake Creek strategies, the Water Right Purchase Program was funded for two years; however, no viable offers were made to the state for a water right purchase. There are components with the program design that may have contributed to the lack of success.

In 2006, the Legislature approved the Water Right Transition Assistance Program (WTAP), a five year pilot for the purchase and retirement of water rights. This program corrected some of the concerns with the other water right purchase program. WTAP allows the state to purchase and permanently retire water rights in targeted, high priority areas. In 2007, the first year eligible, one water right was purchased in this subbasin, retiring 225 acre feet of authorized quantity. Rattlesnake Creek subbasin continues to be an eligible area for this program (Figure 2).

GMD5 has purchased one water right within the subbasin for a total savings of 195 acre feet of appropriated water. There has also been approximately 800 acre feet set aside through the U.S. Department of Agriculture, Natural Resources Conservation Service, Environmental Quality Incentive Program "quick response areas" for a minimum of four years, as the enrolled acres are converted to dryland farming or other non-irrigated uses.

The DWR, along with the rest of the subbasin partnership, reviews and evaluates the effectiveness of the management strategies at least every four years over

the 12 year implementation period (years 2004, 2008, and 2012) as indicated in the management program. In 2004, the total water use and water demands within the Rattlesnake Creek subbasin were reviewed to determine if progress was on track for reducing total water use and meeting demands, as outlined in the proposal.

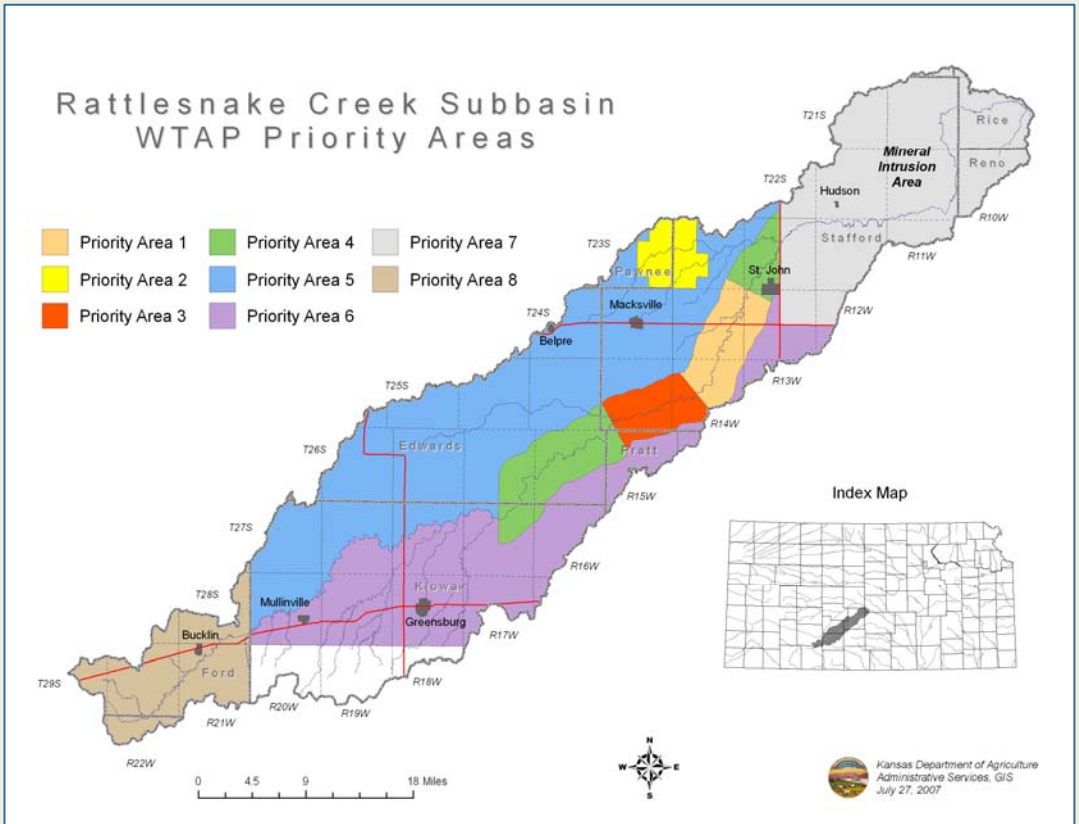

Figure 2. Priority areas defined for Water Transition Assistance Program enrollment

The four-year evaluation and review was completed by the Partnership for the Rattlesnake Creek Management Program in 2004.[3] In 2004, the streamflow goal (10-year rolling average of 25 cubic feet per second (cfs) or higher during January) at the Zenith USGS streamflow gage was met. The 10-year rolling average had been above 25 cfs from 1998 to 2008. Ground water levels declined for the third straight year for all the priority areas in 2004. The 10-year rolling average for water use in priority areas increased in both 2002 and 2003. Incentive programs like Water Banking and the Water Rights Purchase Program had not yet begun during this review period as they required legislation, adoption of rules and regulation and funding. The DWR provided enhanced compliance and enforcement to the subbasin. The BRO enforcement program was targeted to this subbasin which has increased awareness of monitoring efforts as well as water savings. It was noted during this review that approximately 58% (3,800 acres) of the acres previously enrolled in the USDA's Conservation Reserve Program were returned to irrigation in 1997 and 1998. Water use goals are based on the average water use from 1987 to 1996.

The eight-year review of the Rattlesnake Creek Management Plan began in August 2008. DWR has assembled findings for the initial evaluation of the eight-year review.[4]

If, by the year 2012, the final evaluation shows the goals have not been achieved, then reductions in water rights will be implemented to achieve the goals. Reductions in appropriations will be calculated by dividing the remaining amount of water use needed to reach the 72% reduction goal.

Ground Water Model

In 2008, DWR proposed updating a ground water model of the subbasin. GMD5 suggested that the entire district be modeled, including the Rattlesnake Creek subbasin. A district-wide model will reduce the boundary uncertainties. The district-wide Modflow model is under development, supported by both GMD5 and DWR. They have an open door policy on the development process, including inviting stakeholder groups and other agencies to all the meetings. The model will serve as a tool from which to base management options, administrative decisions and other applicable needs of the water resources in the subbasin. The model is scheduled to be completed in 2009.

Streamflow Augmentation

Streamflow augmentation was one of a number of the management strategies introduced in the June 29, 2000, Rattlesnake Creek Management Program Proposal by the Rattlesnake Creek/Quivira Partnership to address stream flow shortages due to fluctuating aquifer levels in the subbasin. In a report entitled, "Streamflow Augmentation of Rattlesnake Creek", the Kansas Water Office estimated the frequency that an augmentation year would occur in the future is about 50%. The typical quan-

tity of water needed for augmentation during a year that augmentation is necessary is about 1,460 acre feet. [5]

Should the augmentation strategy be implemented, the KWO recommended the use of freshwater sources for augmentation, that water rights be purchased rather than leased for the supply of augmentation water and that GMD5 be responsible for the strategy's operation and maintenance.

Based upon the projected frequency and magnitude of augmentation in the future, and the recommendations of its source, supply and operation, the KWO estimated in early 2006 the total water right purchase cost for the augmentation strategy at $2.9 million, the total engineering and construction cost of the strategy at $2.2 million, the annual operation and maintenance cost of the strategy should average about $74,370 per year (with an augmentation year operation and maintain cost of $92,000 per year) and a 10-year total strategy cost of $5.9 million.

Recommended Actions

1. Implement the Rattlesnake Creek Subbasin Management Program Proposal and evaluate effects of voluntary implementation measures to restore streamflows and stabilize ground water declines.

2. State water resource agencies should continue to work with the Rattlesnake Creek Quivira partnership to implement the management plan.

Resources

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Lower Arkansas Basin High Priority Issue
Watershed Restoration and Protection
Approved January 2007

Issue

The restoration of watersheds with impaired water quality and the protection of watersheds above public water supply reservoirs and ground water sources used for drinking water supplies are high priority in the Lower Arkansas Basin. Three main components guide watershed restoration and protection efforts: achievement of Total Maximum Daily Loads, development of Source Water Protection Plans, and restoration and protection of wetland and riparian areas.

Description

Water quality and related water resource issues are addressed through a combination of watershed restoration and protection efforts utilizing voluntary, incentive based approaches, as well as regulatory programs.

Water Quality Impairments

Surface waters not meeting surface water quality standards in the basin are included on the 2004 303d list. High priority Total Maximum Daily Loads (TMDLs) for impaired surface waters in the Lower Arkansas basin were submitted to the Environmental Protection Agency (EPA) for approval on June 29, 2000. An additional round of TMDL development was completed in 2006. Table 1 provides information on rivers and lakes within the basin that are designated as high priority for TMDL implementation. Figure 1 shows the location of these areas within the basin. High priority TMDL watersheds are used to target voluntary, incentive based programs that provide technical and financial assistance for implementation of nonpoint source pollution management practices that can address designated pollutants.

Six additional TMDLs covering nutrient impairments were drafted and submitted for public review from September 13 to 30, 2006; these TMDLs were submitted to EPA in late 2006. Atrazine impairments on the Little Arkansas River and its tributaries are being addressed through a watershed management plan implemented through the Little Arkansas Watershed Restoration and Protection Strategy (WRAPS). This alternative, categorized by EPA in its 2006 listing guidance as a "4B alternative", addresses the impairment in lieu of a TMDL.

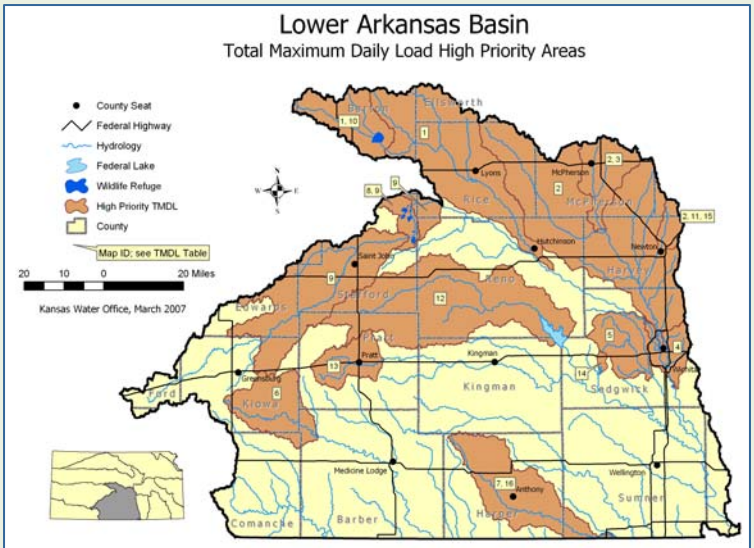

Figure 1. Lower Arkansas River Basin, TMDL Priority Areas

Table 1

Map ID	Waterbody	Impairments	HUC 8 Watersheds
1	Cow Creek Watershed	BAC, DO	11030011
2	Little Arkansas River Watershed	BAC, NUTR, SILT, ATZ	11030012
3	Turkey Creek Watershed	DO	11030012
4	Arkansas River below Wichita	BAC	11030010 11030013
5	Cowskin Creek Watershed	BAC, , BIO	11030013
6	Upper Medicine Lodge River Watershed	BAC	11060003
7	Bluff Creek Watershed	BAC, DO	11060005
8	Quivira Big Salt Marsh Watershed	EUTRO	11030009
9	Quivira Little Salt Marsh Watershed	EUTRO	11030009
10	Cheyenne Bottoms Watershed	EUTRO	11030011
11	Newton City Park Lake Watershed	EUTRO	11030012
12	Cheney Lake Watershed	EUTRO, SILT	11030014
13	Pratt County Lake Watershed	EUTRO	11030015
14	Lake Afton Watershed	EUTRO	11030016
15	Sand Creek Watershed	NITRATE	11030012
16	Lake Anthony	EUTRO, SILT	11060005

DO: Low dissolved oxygen in upper 3 meters of water column over deepest location in water body
EUTRO: Eutrophication, biological community impacts and excessive nutrient/organic loading. If applicable, the Eutrophication TMDLs are bundled with pH, aquatic plants, and/or DO impairments. These impairments are all interrelated and effected by nutrient loading.
NUTR: Nitrogen and Phosphorus
BAC: Bacteria
BIO: Biology impairment caused by excessive sediment, nutrients or organic matter
ATZ: Atrazine concentrations exceed 3 ppb on annual average and in a significant number of periodic samples
NITRATE: Nitrate concentrations exceed 10 ppb in surface water

A complete description of each TMDL is available on the Kansas Department of Health and Environment TMDL website.[9]

Surface Water Nutrient Reduction

Nutrient sources within the basin include both point and nonpoint sources. The major point sources in the basin include large wastewater treatment plants, which are regulated under the National Pollutant Discharge Elimination Systems (NPDES) Program (Figure 2).

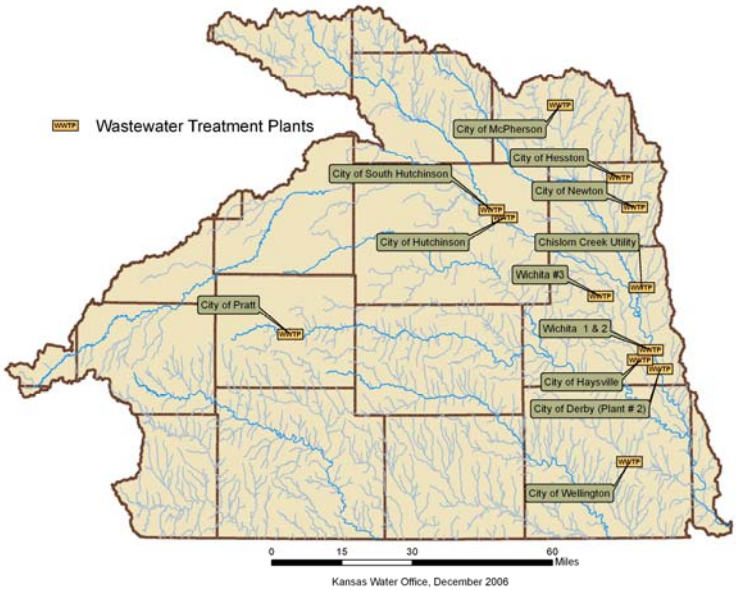

Figure 2. Major Wastewater Treatment Facilities in LARK Basin

A major component of the Kansas Surface Water Nutrient Reduction Plan (Plan) involved looking at nitrogen transport to the Gulf of Mexico. In order to calculate the contribution of nitrogen to the Gulf, nitrogen concentrations of waters exiting the state borders were collected and estimated.

As predicted by studies from the USGS, only a small amount of nitrogen is expected to be transported from watersheds in the upper part of the Arkansas River basin to the Gulf of Mexico. Thus, to try to predict the contribution the Upper Arkansas basin makes to the Lower Arkansas basin would be difficult. It should also be noted that while the Upper Arkansas basin is not predicted to produce a significant surface water impact, exfiltration to local aquifers could produce significant ground water impacts. Furthermore, TMDLs on the Arkansas River between Great Bend and Hutchinson are influenced by nutrient loading coming from the Upper Arkansas Basin. Therefore, some degree of nutrient reduction should be expected from the eastern portion of the Upper Arkansas basin.

Since there are no "exit points" for the Upper Arkansas basin, all contribution from this basin is added to the Lower Arkansas basin where the Arkansas River exits Kansas into Oklahoma. Therefore, for the purpose of the Plan, the Upper and Lower Arkansas River basins were combined as a single composite basin.[6]

The primary nonpoint sources of pollution include both agricultural and urban areas. Table 2 shows the relative contributions of point and nonpoint sources in the Lower Arkansas and Upper Arkansas basins for total phosphorous and nitrogen leaving the state.

Table 2

Statewide Perspective

Parameter (Ton/Year)	State Total	Upper and Lower Arkansas Basin	% of State Total
TN Leaving State	51,205	6,943	14%
TP Leaving State	7,670	1,582	21%
Point Source TN	10,600	3,503	33%
Point Source TP	2,836	886	31%
Nonpoint Source TN	40,605	3,440	8%
Nonpoint Source TP	4,834	696	14%

Basin Perspective

Parameter (Ton/Year)	UARK & LARK Basin Total	Point Source	Point Source %	Non-point Source	Nonpoint Source %
TN	6,943	3,503	50%	3,440	50%
TP	1,582	868	56%	696	44%

The Plan, developed by KDHE, outlines a statewide strategy for reducing the export of total nitrogen (TN) and total phosphorus (TP) in surface waters leaving the state.[6] This involves additional reductions in nutrients from point source discharges through the NPDES Program and reduction in nonpoint sources through development and implementation of Watershed Restoration and Protection Strategies (WRAPS). The Plan includes Improvement Potential Index (IPI) maps for Kansas counties for TP and TN reductions (see Water Quality Policy Section for statewide maps; basin maps Figures 3 and 4). In the Lower Arkansas basin, Barton, Rice, Reno, Stafford and Pratt counties showed the highest improvement potential for TN. Barton, Stafford, Pratt, Reno and McPherson counties showed the highest improvement potential for TP. These counties should receive priority consideration for the installation of nutrient management and reduction practices.

Source Water Protection

The KDHE, Bureau of Water administers programs related to public water supplies, wastewater treatment systems, the disposal of sewage and nonpoint sources of pollution. Programs are designed to provide safe drinking water, prevent water pollution and assure compliance with state and federal laws and regulations such as the Clean Water Act and Safe Drinking Water Act. State Water Quality Standards include provisions for alternative disposal of treated wastewater and residue material resulting from the waste treatment process.[10] KDHE's minimum standards for the design of water pollution control facilities include guidelines for agricultural application of wastewater and sludge. Reuse of treated wastewater may contribute to water conservation within the basin.

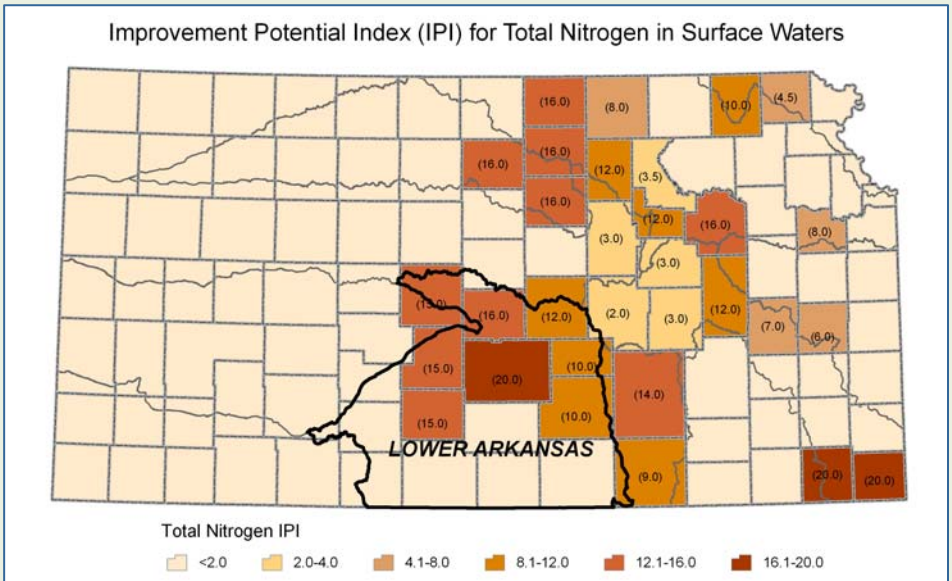

Figure 3. Improvement Potential Index (IPI) for Total Nitrogen (TN) in LARK River Basin

All public water suppliers in the basin have completed Source Water Assessments in cooperation with KDHE. The next step, which is voluntary, is the development of source water protection plans.[4]

There are 118 public water suppliers in the basin, including 28 rural water districts. There are currently four public wholesale water supply districts in the basin. Ground water is the primary source for most public water supplies, accounting for over 90% of the total supply. The two major sources of ground water are the Equus Beds aquifer in Harvey, McPherson, eastern Reno and northern Sedgwick counties, and the Great Bend Prairie aquifer, predominately underlying Pratt, Stafford, southern Barton, Edwards, Kiowa and Reno counties. Cheney Reservoir, constructed on the North Fork of the Ninnescah River in Reno County, supplies a portion of the water supply for Wichita. Wellington Lake serves as a surface water supply for the City of Wellington.

Each Source Water Assessment includes a susceptibility score that can help communities determine which contaminants pose the most significant threat to their water supply. A susceptibility score was generated from the susceptibility analysis and indicates whether the susceptibility range is low, moderate or high for potential threats of contamination in an assessment area. Each public water supplier received susceptibility scores in the following contaminant categories: microbiological, nitrates (ground water only), pesticides, inorganic compounds, synthetic organic compounds, volatile organic compounds, sedimentation (surface water only) and eutrophication-phosphorus (surface water only).

Of the public water suppliers using ground water in the Lower Arkansas River Basin, 41% had low susceptibility scores, 58% had moderate scores and one had a high score. Of the public water suppliers using surface water in the Lower Arkansas River Basin, 33% had low susceptibility scores, 67% had moderate scores and none had high scores.

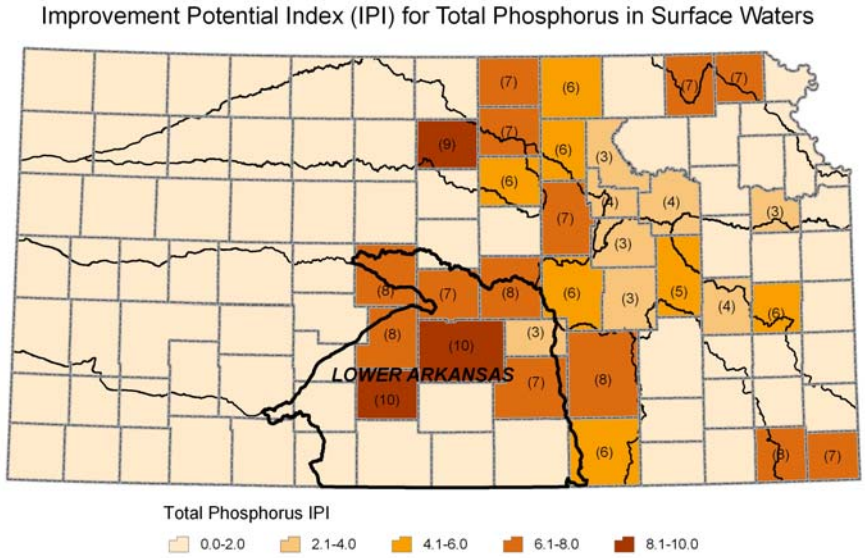

Figure 4. Improvement Potential Index (IPI) for Total Phosphorus (TP) in LARK River Basin

For communities using ground water, development of a wellhead protection program is recommended. For communities using surface water, the development of a watershed restoration and protection strategy (WRAPS) is the best mechanism to ensure water quality protection for their public water supply.

Wetland and Riparian Area Management

The primary approach to wetland and riparian management in the basin focuses on providing technical and financial assistance to landowners to protect and restore these resources in priority watersheds through the implementation of best management practices. Water quality has been a primary focus with implementation efforts targeted to high priority TMDL watersheds (Figure 1). In addition, several watersheds have been identified in the Kansas Wetlands and Riparian Areas Protection and Restoration Implementation Plan as areas of high biological importance and a priority for implementation activities. Sixteen conservation districts in the basin have developed wetland and riparian protection plans.

Watershed Restoration and Protection Strategies

Watershed Restoration and Protection Strategies (WRAPS) are stakeholder-driven watershed management plans designed to address multiple water resource issues within a specific watershed. The WRAPS process provides a means to integrate objectives from multiple local, state and federal programs into a comprehensive, coordinated strategy for a specific watershed. This can include TMDL attainment, nutrient reduction, source water protection, riparian and wetland management and other natural resource objectives.[5]

The watershed above Cheney Reservoir in the basin has been identified as a watershed of significant state interest for development and implementation of WRAPS. A WRAPS project is being implemented in this watershed as well as other watersheds within the basin including the Little Arkansas River watershed (see WRAPS Project Status Map in the Water Quality Policy Section). Watersheds in the WRAPS projects currently underway in the basin encompass priority areas for TMDL implementation, areas with a high improvement potential index for nutrient reduction, source water assessments areas and priority areas for wetland and riparian protection, and other watershed issues.

A consideration for watershed restoration and protection in the basin is the potential for conversion of Conservation Reserve Program (CRP) acreage back to production agriculture as contracts expire. Of the acres enrolled in the twenty Kansas counties contained wholly or partly within the Lower Arkansas basin, 330,872 acres will expire in 2007. Of those, 107,695 acres (33%) will be offered a 5-year reenrollment option and 73,127 acres (22%) will receive a 10-year reenrollment option.[8] If land is taken out of permanent grass cover, implementation of best management practices will be needed to minimize potential adverse impacts to water resources in the basin.

Other Watershed Related Activities

- All the counties within the basin have a sanitarian funded by the Local Environmental Protection Program (LEPP).
- Counties in the basin that have countywide planning and zoning programs include Barton, Cowley, Ford, Harper, Harvey, Kingman, Marion, McPherson, Pawnee, Reno, Rice, Sedgwick and Sumner.
- All conservation districts in the basin have adopted nonpoint source pollution management plans. Buffer coordinators have also been employed in nine counties in the basin to facilitate enrollment of stream buffers in the continuous CRP and State Water Quality Buffer Initiative.
- Several entities and municipalities in association with the Wichita urban area are included in the Phase I and Phase II NPDES Stormwater Program. A list of affected communities is available on the KDHE website.[11]
- There are seven organized watershed districts in the basin.

Recommended Actions

1. Work with stakeholder groups to incorporate TMDL implementation, nutrient and sediment reduction and urban stormwater management goals into applicable WRAPS projects.

2. Target technical and financial assistance programs for water quality protection and restoration to implement WRAPS action plans, including those addressing high priority TMDLs and counties with high Improvement Potential Index values for nutrient reduction.

Resources

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9. Kansas Department of Health and Evnironment, Bureau of Water, Watershed Planning Section Map and lists of TMDLs. http://www.kdheks.gov/tmdl/index.htm

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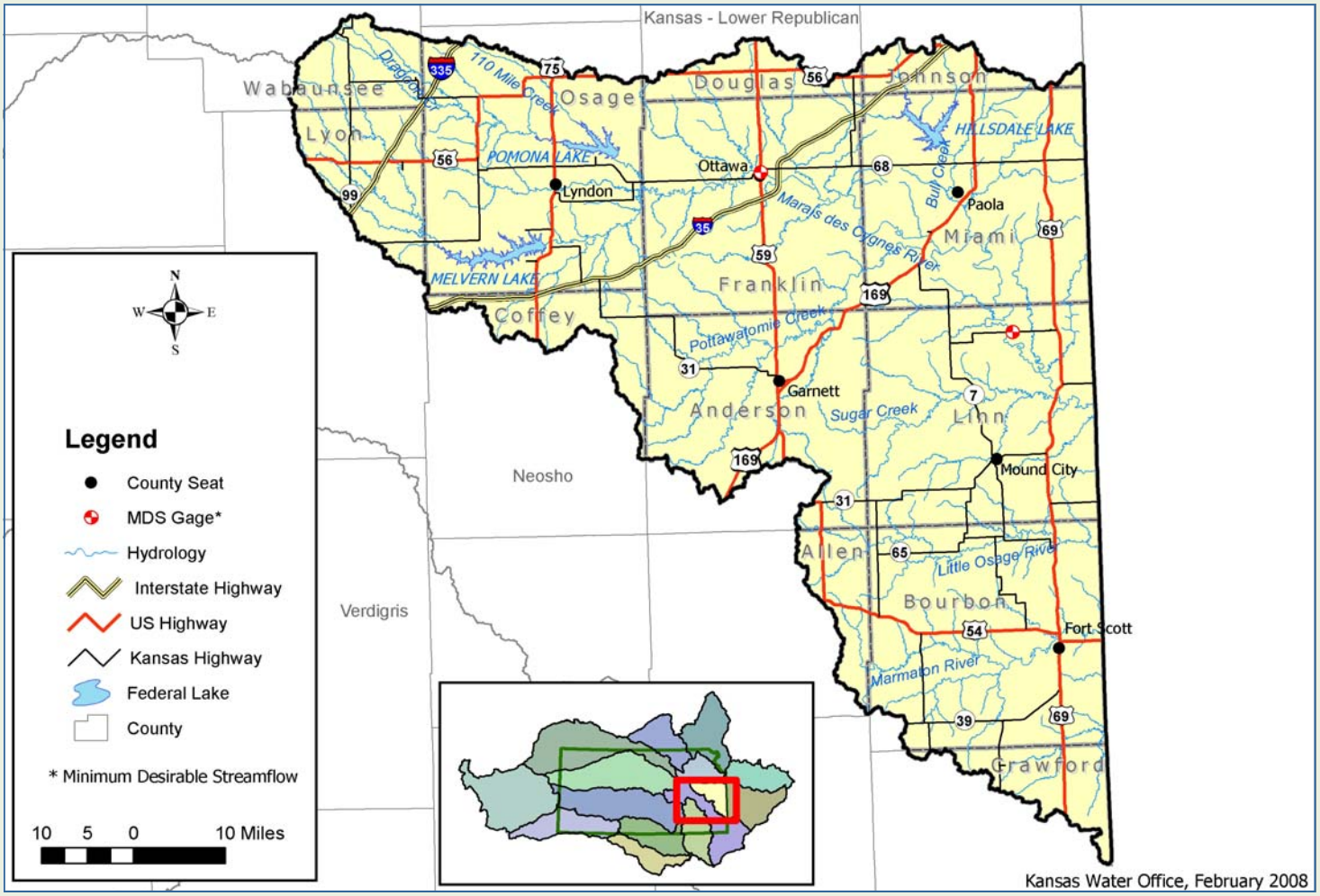
11. Kansas Department of Health and Environment, Division of Environment, Bureau of Water, Municipal Stormwater Program. http://www.kdheks.gov/stormwater/download/Phase_I_and_II_MS4s_in_Kansas.pdf

Marais des Cygnes River Basin



General Description

The Marais des Cygnes River rises near Eskridge in Wabaunsee County, Kansas and flows east and south to join the Little Osage River in Bates County, Missouri. The basin covers 4,304 square miles of east-central and southeast Kansas and includes all or parts of 13 counties. Dragoon Creek, Bull Creek, Pottawatomie Creek and Sugar Creek are major tributaries in Kansas. The Marmaton and Little Osage Rivers originate in Kansas and join in Missouri just above their confluence with the Marais des Cygnes to become the Osage River. The Marais des Cygnes basin includes four Hydrologic Unit Code (HUC) Subbasins: 10290101, 10290102, 10290103 and 10290104.

Major federal reservoirs in the basin are Melvern, Pomona and Hillsdale. Other significant lakes include the La Cygne Power Station Lake and impoundments within the Marais des Cygnes Wildlife Management Area and Refuge. Ground water aquifers underlying the watershed include portions of the Ozark and Glacial Aquifer and alluvial aquifers of the Marais des Cygnes River and its tributaries.

Population and Economy

There were an estimated 125,000 residents in the basin in the year 2000 (KWO estimate). The 13 counties either partly or wholly located within the basin had a combined population of 761,561 in 2000 (U.S. Census) and projected population of 1,076,146 in 2040.[1]

Miami County, in the northern part of the basin, is poised for growth as urbanization of the Kansas City metropolitan area moves south. Miami County, with a population of 28,499 in 2000, has a projected population of 41,917 in 2040. By contrast, Linn County had a population in 2000 of 9,606 and a projected 2040 population of 8,679.

Despite the continuing urban growth, the Marais des Cygnes watershed maintains a robust agricultural industry comprised of feed grain operations, grazing lands and confined animal feeding operations. Wheat and sorghum are the primary crops. The value of crops grown in the 13 counties either partly or wholly within the basin exceeded $318 million while livestock and dairy production topped $192 million in 2006. Two large retail distribution centers have been developed near Ottawa in Franklin County.

Water-based recreation is an important component of the basin economy with recreational development associated with the three federal reservoirs in the basin, four state fishing lakes, and 20 community lakes attracting boaters, anglers, hunters and campers. State Parks and commercial marinas are located at each federal reservoir in the basin. Waterfowl hunting on private, state, and federal lands is a major activity, particularly in the lower basin.

Physical Characteristics

Geology and Soils

The Marais des Cygnes basin slopes gently west to east from a surface elevation of 1,472 feet above sea level at the headwaters in Wabaunsee County to about 742 feet at the state line. The Marais des Cygnes basin lies predominantly within the Osage Cuestas physiographic region with the extreme southeast corner located in the Cherokee Lowlands. This area is characterized by many east-facing escarpments which trend irregularly north to south across the basin. Major cities in the basin include Osage City, Ottawa, Garnett, Paola, Louisburg and Fort Scott.

Most of the surface geology in the basin is Pennsylvanian in age with Permian age rock in the headwater counties. Strata consist primarily of alternating thin beds of limestone and shale with some local sandstone deposits in the Lawrence shale and Stranger formations. Between the ridges are flat or gently rolling plains formed by softer rocks in the region.

The consolidated sediments derived from the Permian and Pennsylvanian rocks lie in widespread and nearly parallel layers dipping gently toward the north and west. Unconsolidated rock of Tertiary and Quaternary age is present locally in uplands as gravel or chert deposits and as gravel, silt and clay deposits in alluvium.

There are 11 soil series represented in the basin and vary from easily-worked, productive soils to compacted clay. Soils may be divided into three major associations: upland, terrace and bottomland. Upland soils tend to be moderately deep and dark-colored with a clay subsoil and occupy approximately 87% of the basin. Bottomland soils, which are mostly undifferentiated, deep and well-drained, occupy about 11% of the basin. Terrace soils along the edges of stream channels occupy less than two percent of the basin and tend to be deep soils with a clay subsoil.

Land Use/Land Cover

The predominant land features in the basin are grasslands (55%) followed by cropland (23%) and woodlands (16%). In 2006, there were 10,780 farms comprised of 4.1 million acres, that lie in the 13 counties. Average farm size is 383 acres.

The basin contains many important highways. Interstates 35 and 135 cross the basin from northeast to southwest. U.S. Highways 75, 59, 169 and 69 cross the basin from north to south while U.S. 54 and 56 cross from east to west.

The Marais des Cygnes basin contains the largest percentage of riparian acreage of the twelve major river basins in Kansas. Within the 100-foot corridor along each bank of streams in the basin, 40% of the land is forested followed by cropland (17%) and pasture/grassland (15%).

Climate

The climate of the basin is classified as humid continental with cold winters and hot summers. Normal mean temperature generally increases from northwest to southeast across the basin. The average mean temperature of the basin is 54° F. Most of the precipitation falls in the summer and spring. June is typically the wettest month. Flood events and the drought experienced from 1952-1956, underscore the variability in precipitation.

Osage Cuestas - Photo courtesy Kansas Geological Survey

Table 1.					
	Average Annual[1]		Freeze Dates (32 F.)[2]		
Location	Precipitation (inches)	Temperature (F)	Last	First	Days Between
Eskridge	35.31	52.8	Apr. 15	Oct. 20	190
Fort Scott	44.14	56.1	Apr. 16	Oct. 23	195

[1]Source: National Climatic Data Center (1971-2000 data)
[2]Source: KSU Weather Data Library (1961-1990 data)

Wildlife and Habitat

The Marais des Cygnes basin encompasses a wide array of habitat types that support rich and diverse wildlife populations. Habitat ranges from tallgrass prairie in the western portion of the watershed to riparian forests in the east. Some bottomland along major streams has been cultivated for row crops. Twenty-five state or federally listed threatened or endangered species share a probable or historic range or critical habitat within the basin including seven birds, four reptiles, three amphibians, two fish, two mammals and six mollusks including one snail species.

Significant wildlife habitat includes extensive wetlands in the lower basin. The Marais des Cygnes State Wildlife Area and adjacent U.S. Fish and Wildlife Service refuge, along with numerous private duck clubs hold recreational water rights on the Marais des Cygnes River. Water is pumped from the river to flood marshes and attracts large numbers of waterfowl during migration.

Water fowl on Marais des Cygnes River

Water Resources

The Marais des Cygnes basin contains 8,821 miles of intermittent and 2,011 miles of perennial streams for a total of 10,832 stream miles. The density of 2.5 stream miles per square mile is typical among basins located in the eastern third of the state.

U.S. Army Corps of Engineers (Corps) operates three reservoirs in the Marais des Cygnes basin: Pomona, Melvern and Hillsdale. Four State Multipurpose Small Lakes have been constructed in the basin including Bone Creek, Xenia, Cedar Creek and Little Sugar Creek.

Ground water resources in the basin are associated with alluvial and terrace deposits along the larger stream valleys. Ground water deposits in the Flint Hills in the upper basin are characterized by thin saturated zones and high levels of dissolved solids and hardness.

Surface water is the principal source of supply in the basin, accounting for over 97% of the use in 2006. Alluvial deposits along streams provide a minor source of ground water in the basin. As shown in Figure 1, most water use withdrawals are made for municipal (27%) and industrial (53%) supply.(4) The primary industrial water user in the basin is the La Cygne electrical generating station where Kansas City Power and Light maintains a 2,600 acre cooling lake.

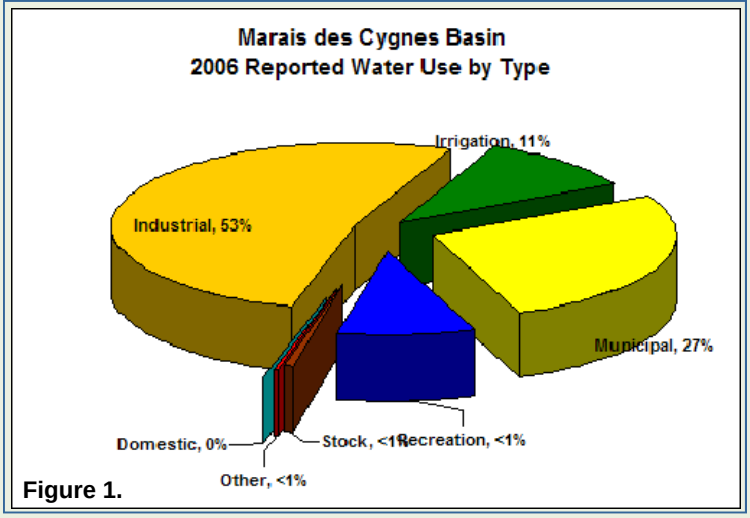


Figure 1.

Water Management

The Corps manages pool elevations in their three reservoirs according to specific operating rules. Flood flows are stored until downstream conditions allow their release. A conservation pool is maintained with a fluctuating pool plan to maximize fish and wildlife production and recreational use. Each federal lake contains storage to maintain downstream water quality.

Water storage in Melvern, Pomona and Hillsdale lakes is maintained under the state Water Marketing Program. The 40 public water suppliers in the basin rely predominantly on surface water. The Marais des Cygnes Water Assurance District No. 2 was organized in 1990 and became operational in 1995. Seven municipal and industrial water right holders on the river are members. State-owned water assurance storage is located in Melvern and Pomona Lakes.

Gages to monitor minimum desirable streamflow (MDS) are located on the Marais des Cygnes River at Ottawa in Franklin County (15 to 25 cubic feet per second) and La Cygne in Linn County (20 to 25 cubic feet per second).

There are eight organized watershed districts in the basin. Watershed districts may be formed to construct, operate and maintain works of improvement needed to provide for water management. The primary function is to develop a comprehensive general plan for a watershed that will provide flood protection for the residents and landowners.

Each county in the basin also has a Conservation District dedicated to reducing soil erosion, improving water quality and conserving natural resources. The basin is primarily covered by the federal Big Lakes Resource Conservation and Development (RC&D) Program, with three southeastern counties in the See-Kan RC&D.

Watershed Restoration and Protection Strategies (WRAPS) are local stakeholder-driven watershed management programs designed to address multiple water resource issues. WRAPS projects have been established above the three federal reservoirs in the basin which provide public water supply along with projects in the lower Marais des Cygnes and Marmaton watersheds.[6]

La Cygne Generating Station.
Photo courtesy Kansas Geological Survey

Resources

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2. USDA, *Kansas 2006-2007 Farm Facts, Agricultural Statistics and Ranking*

3. Wilson, Brownie. 2003. Assessment of Riparian Areas Inventory, State of Kansas.

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6. Kansas Department of Health and Environment. Accessed January 2009. Watershed Restoration and Protection Strategies (WRAPS) www.kswraps.org

Bi-State EPA Grant Holds Promise for Water Quality Improvement

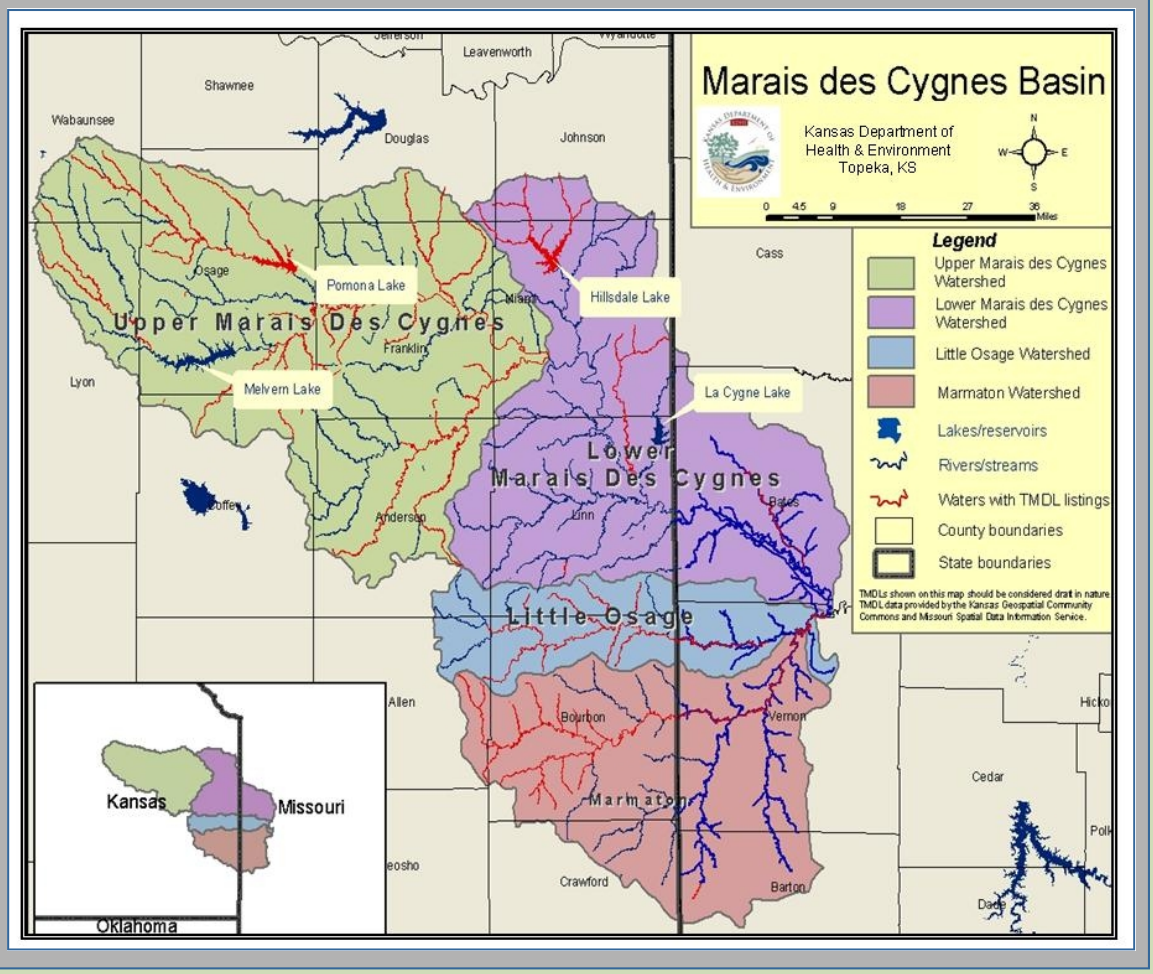
Kansas and Missouri received a $900,000 Targeted Watershed Grant for the Lower Marais des Cygnes River Basin from the Environmental Protection Agency on December 3, 2007. The funding will be devoted to watershed restoration and protection practices, cost shared with landowners and communities. The Kansas Department of Health and Environment developed and will administer the bi-state grant that was supported by Kansas Governor Kathleen Sebelius and Missouri Governor Matt Blunt. The project will supplement existing Watershed Restoration and Protection Strategies (WRAPS) in the Marais des Cygnes basin.

The bi-state initiative has five objectives: improve the health of riparian areas and the adjacent streams, reduce adverse water quality impacts (pollution) from livestock operations, reduce pollution from on-site wastewater systems, reduce the adverse affects of urbanization and study the aquatic insects, fish, and plant life of a stream or river to help assess their health.

A variety of educational programs targeted to specific audiences are planned including pasture management and grazing systems for livestock operations. For crop farmers, there will be clinics on stream bank stabilization and, riparian area restoration practices. For the general public, there will be training modeled after the Kansas Environmental Leadership Program (KELP) on basin water resource issues.

The problems in the bi-state Marais des Cygnes basin are well documented. Earlier scientific evaluation has determined which streams or sections of streams do not meet water quality standards for their intended designated uses including recreation activities such as fishing and swimming. The key causes of the pollution: excess nutrients, fecal coliform bacteria, and limited dissolved oxygen, also have been identified. The unknown, however, is the exact source of the pollutant. Given the difficulty in pointing to a specific source, as with a discharge pipe from industry or a municipality, this form of water contamination is known as nonpoint source pollution.

Once the possible water quality impairment are identified, best management practices will be determined. Through computer modeling, twelve such practices will be compared, ranked and promoted to landowners for their adoption. All of these activities are made possible, in whole or in part, by this bi-state grant.



Marais des Cygnes River Basin Management Categories

January 2009

MANAGEMENT CATEGORIES

The following categories include issues identified in the Marais des Cygnes basin plan as items that require attention in addition to the basin priority issues. These issues are addressed within the following management categories:

- Water Management
- Water Conservation
- Public Water Supply
- Water Quality
- Wetland and Riparian Management
- Flood Management
- Water-Based Recreation

These categories correspond to the *Kansas Water Plan,* Volume II. That contains new policy issues and the existing policy and statutory framework that relate to the management categories.

ISSUE: WATER MANAGEMENT

See the Water Supply Management and Conservation priority issue in the Marais des Cygnes basin section.

The mainstem of the Marais des Cygnes and Marmaton rivers and three federal reservoirs are the major sources of water supply in the basin. There are also four State Multipurpose Small Lakes that provide public water supply and alluvial deposits along streams provide a minor source of ground water in the basin. All the major streams in the basin are restricted to new appropriations for the period of July 1 through September 30. There are two sites in the basin where minimum desirable streamflows (MDS) have been set: Ottawa and La Cygne.

Melvern Lake

Applicable *Kansas Water Plan* Objectives

- By 2015, achieve sustainable yield management of Kansas surface and ground water sources outside of the Ogallala High Plains aquifer and areas specifically exempt by regulation. Sustainable yield management would be a goal that sets water management criteria to ensure long term trends in water use will move as close as possible to stable ground water levels and maintenance of sufficient streamflows.
- By 2015, meet minimum desirable streamflow at a frequency no less than the historical achievement for the individual sites at time of enactment.

Applicable Programs

The following programs help to meet the objectives in the Water Management (quantity) category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Appropriation Program
- Kansas Geological Survey and Kansas Department of Agriculture, Division of Water Resources: Water Well Measurement
- USDA-Natural Resource Conservation Service: Environmental Quality Incentive Program
- Kansas Water Office: Water Marketing Program
- Kansas Water Office: Water Assurance Program

ISSUE: WATER CONSERVATION

Water conservation is essential for the effective management of water resources in the basin to assure that a sufficient, long-term, supply of water is available for beneficial uses. Conservation is defined as a careful preservation and protection of something, especially the planned management of a natural resource, to prevent exploitation or destruction. Water conservation is a part of maintaining a long-term water supply for Kansas.

Water conservation activities apply to all uses: irrigation, municipal, industrial, etc, and from all sources. Industrial water supply (53%) accounts for the majority of water used in the basin followed by municipal supply (27%), irrigation (11%) and recreation (7 percent). Stock water, domestic and other uses make up the balance of water use in the basin (2006).

Water use conservation plans are required when: a) purchasing water from the state Water Marketing Program, b) participating in the Water Assurance District Program, c) sponsoring or purchasing the public water supply portion of a Multipurpose Small Lakes Program project, d) transferring water under the Water Transfers Act and e) applying for a loan from the Public Water Supply Loan Fund. There are sixty-one public water suppliers in the Marais des Cygnes basin with an approved municipal conservation plan.

Water conservation plans include drought stage triggers that are the signals that a water shortage or other conditions indicative of drought have reached certain stages

or levels. They act as the signal to begin implementation of actions appropriate to the stage. Triggers may be related to supply conditions or demand levels. A given stage should have more than one trigger to confirm that conditions are worsening. Appropriate conservation practices in the areas of education, management and regulation should be listed under each stage. Delay in action may lead to a major disruption of the water supply system at a later time.

Most water utilities consider water as a commodity and encourage the use of water by their customers by striving to keep rates low. The availability of plentiful, inexpensive water is often promoted by communities to attract new growth. More recently, some communities have adopted rate structures that result in higher unit cost with increased use. This is one form of demand management.

The four basic types of water rate structures used by public water suppliers in Kansas are described as flat rate, decreasing block rate, uniform block rate and increasing block rate. Utilities with a flat rate charge each customer a fixed amount per month regardless of the amount of water used. With a decreasing block rate, the unit cost of water decreases as usage increases. The unit cost of water is the same for all levels of usage with a uniform block rate. With an increasing block rate, the unit cost of water rises as usage increases.

The type of rate structure can affect water usage as measured in gallons per capita per day (gcpd). Systems with flat rates tend to use considerably more water per capita than systems that meter customer use. The other three types of rate structures, in which cost depends on amount of water used, have a less dramatic effect on gpcd. Decreasing block rates are assumed to discourage conservation because customers are charged lower rates for high-volume usage. Increasing block rates are considered an effective way to promote conservation among high-volume users while keeping the cost of moderate use affordable. However, the rate structure does not appear to influence usage by individual customers as much as the total monthly water cost and the geographic area in which they live.

Applicable *Kansas Water Plan* Objectives

- By 2015, all non-domestic points of diversion meeting predetermined criteria will be metered, gaged, or otherwise measured.
- By 2015, conservation plans will be required for water rights meeting priority criteria under K.S.A. 82a-733 if it is determined that such a plan would result in significant water management improvement.

Applicable Programs

The following programs help to meet the objectives in the Water Conservation category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Appropriation Program
- Kansas State University Research and Extension: Water Conservation and Management Program
- Kansas Water Office: Water Conservation Program
- Kansas Department of Health and Environment: Kansas Public Water Supply Loan Fund
- USDA-Farm Services Agency: Conservation Reserve Program

ISSUE: PUBLIC WATER SUPPLY

See also, Surface Water Management and Conservation priority issue in the Marais des Cygnes basin section.

The primary approach to addressing public water supply issues in the basin focuses on ensuring that there are adequate supplies of surface and ground water within the basin to meet future water demands, reducing the number of public water supply systems that are vulnerable to drought and ensuring that systems have the technical, financial and managerial capacity to meet future needs for water quality and quantity.

There are 84 public water suppliers in the basin, including 31 rural water districts. There are currently two public wholesale water supply districts in the basin. Surface water is the primary source for most public water supplies, accounting for over 97% of the total water use. There are four State Multipurpose Small Lakes in the basin that serve public water suppliers. The Marais des

Pomona Reservoir

Marais des Cygnes River Basin Management Categories

Cygnes Water Assurance District is also active in the basin. The U.S. Army Corps of Engineers (Corps) operates Melvern, Pomona and Hillsdale lakes in coordination with the state to meet Water Assurance District member needs during periods of low flow.

Hillsdale Reservoir.

Water usage in gpcd is calculated for each water system in the state from reported data on water use and population served. Average gpcd figures for large, medium and small water suppliers are calculated in eight regions of the state based on similar geographic areas. The Marais des Cygnes basin is located in regions 7 and 8. Average gpcd usage for large, medium and small suppliers is, 148, 107 and 96 respectively in region 7. Average gpcd in region 8 is 130, 102 and 84 for large, medium and small suppliers. These figures serve as a reference to indicate if individual suppliers are above or below average usage for the region.

Reducing unaccounted for water is a focus of water conservation efforts in the Marais des Cygnes basin. Unaccounted for water includes any unmetered uses plus water loss in the distribution system. Technical assistance is available through the Kansas Water Office (KWO) for systems with more than 30% unaccounted for water. High amounts of unaccounted for water may result from water line breaks, under registering customers, unmetered uses, faulty metering or inaccurate accounting. The statewide average percentage of unaccounted for water use in 2006 was 14%. Management of unaccounted for water is a fundamental tool in providing adequate water supply.

Drought vulnerable water supplies are those systems most likely to be first impacted by drought due to basic source, distribution system or treatment capacity limitations; or that rely on a single well as a water supply source. Drought vulnerable water supplies were surveyed by the Kansas Department of Health and Environment (KDHE) and KWO in 2003 and 2006. While the number of public water supplies considered drought vulnerable increased between the two surveys, issues causing supplies to be listed as vulnerable in 2003 have been corrected with one exception (Table 1). The KDHE Capacity Development Program has been beneficial in reducing drought vulnerability throughout the state as communities assess their systems and identify areas in need of improvement.

Capacity development is the process of water systems acquiring and maintaining adequate technical, financial and managerial (TFM) capabilities to assist them in providing safe drinking water. The capacity development provisions in the Safe Drinking Water Act provide a framework for the state and public water supply systems to work together to help ensure that systems acquire and maintain the TFM capacity needed to meet the public health protection objectives.

The KDHE surveyed the TFM capability of public water suppliers in 2002, 2005 and 2008. The surveys provided information for a ranking system of high, medium and low for targeting the need for capacity development assistance. In the Marais des Cygnes basin, the number of systems rated high for the need of capacity development decreased from 10 to 4 between 2002 and 2005 reports (2008 results pending).

Table 1.

Drought Vulnerable Public Water Supplies

Supplier name	County	New to list	Limitation
Baldwin City	Douglas	yes	contractual, treatment capacity
Bourbon RWD 02C	Bourbon	yes	distribution system
Fontana	Miami	no	basic source, single well
Franklin RWD 01	Franklin	yes	contractual
Fulton	Bourbon	yes	unknown
Linn RWD 02	Linn	yes	basic source
Louisburg	Miami	yes	treatment capacity
Osage RWD 02	Osage	yes	basic source, distribution system
Pleasanton	Linn	yes	basic source
Uniontown	Bourbon	yes	unknown
Wellsville	Franklin	yes	distribution system

Marais des Cygnes River Basin Management Categories

Applicable *Kansas Water Plan* Objectives

- By 2010, ensure that sufficient surface water storage is available to meet projected year 2040 public water supply needs for areas of Kansas with current or potential access to surface water storage.
- By 2010, less than five percent of public water suppliers will be drought vulnerable.
- By 2010, reduce the number of public water suppliers with excessive "unaccounted for" water by first targeting those with 30% or more "unaccounted for" water.
- By 2010, ensure that all public water suppliers have the technical, financial and managerial capability to meet their needs and to meet Safe Drinking Water Act requirements.

Applicable Programs

The following programs help to meet the objectives in the Public Water Supply category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Appropriation Program
- Kansas Department of Health and Environment: Public Water Supply Program
- Kansas Water Office: State Water Planning Program
- Kansas Water Office: Water Conservation Program

Richmond City Lake. Photo courtesy KGS.

ISSUE: WATER QUALITY

Water quality is addressed through a combination of restoration and protection efforts using both voluntary, incentive-based approaches and regulatory programs. See the Watershed Restoration and Protection basin priority issue for a discussion of current issues concerning water quality.

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce the average concentration of bacteria, biochemical oxygen demand, solids, metals, nutrients, pesticides and sediment that adversely affect the water quality of Kansas lakes and streams.
- By 2010, ensure that water quality conditions are maintained at a level equal to or better than year 2000 conditions.
- By 2010, reduce the average concentration of dissolved solids, metals, nitrates, pesticides and volatile organic chemicals that adversely affect the water quality of Kansas ground water.
- By 2010, maintain, enhance, or restore priority wetlands and riparian areas.
- By 2015, nutrient reduction goals will be included in all Watershed Restoration and Protection Strategy (WRAPS) projects within the basin.
- By 2010, all public water suppliers will complete and implement a source water protection plan.

Applicable Programs

The following programs help to meet the objectives in the Water Quality category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Health and Environment: Watershed Management Section/WRAPS
- Kansas Department of Health and Environment: Watershed Planning Section/TMDL Program
- Kansas Department of Health and Environment: State Water Plan Program (Contamination Remediation)
- Kansas Corporation Commission: Conservation Division Programs
- Kansas Department of Health and Environment: Local Environmental Protection Program
- State Conservation Commission: Nonpoint Source Pollution Control Program
- State Conservation Commission: Water Resources Cost-Share Program

ISSUE: WETLAND AND RIPARIAN MANAGEMENT

The primary approach to wetland and riparian management in the basin focuses on providing technical and financial assistance to landowners to protect and restore these resources in priority watersheds through the imple-

mentation of best management practices (BMPs). See the Watershed Restoration and Protection basin priority issue for a discussion of current activities concerning wetland and riparian area protection.

Applicable *Kansas Water Plan* Objective

- By 2010, maintain, enhance or restore priority wetlands and riparian areas.

Applicable Programs

The following programs help to meet the objective in the Wetland and Riparian Management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Forest Service: Forest Stewardship Program and Conservation Tree Planting Program
- State Conservation Commission: Riparian and Wetland Protection Program
- Kansas Water Office: State Water Planning Program
- Kansas Department of Wildlife and Parks: State Parks and Wildlife Areas Planning and Development
- Kansas Department of Wildlife and Parks: Wildlife Habitat Improvement Program
- State Conservation Commission: Kansas Water Quality Buffer Initiative

ISSUE: FLOOD MANAGEMENT

The primary approach to flood management in the basin focuses on floodplain management through community participation in the National Flood Insurance Program (NFIP) and reduction of rural flood damages through construction of watershed dams in organized watershed districts.

See the Comprehensive Flood Assessment priority issue for a discussion of current activities concerning flood management.

Applicable *Kansas Water Plan* Objective

- By 2010, reduce the vulnerability to damage from floods within identified priority communities or areas.

Applicable Programs

The following programs help to meet the objectives in the Flood Management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Structures Program/Floodplain Management
- State Conservation Commission: Watershed Dam Construction Program
- State Conservation Commission: Watershed Planning Assistance Program
- Kansas Division of Emergency Management: Hazard Mitigation Grants Program
- FEMA: National Flood Insurance Program

ISSUE: WATER-BASED RECREATION

The rivers, streams and lakes of Kansas represent valuable recreational resources. Consideration of the economic contribution of water-based recreation is addressed in the Water-Based Recreation Management Category. Even though the Marais des Cygnes basin has a wide variety and relatively high number of public water recreation sites, there is a demand for more water based-recreation facilities to meet the needs of the population.

The Marais des Cygnes River and its tributaries are not among the three rivers in the state legally accessible for public recreation. However, a portion of the river as it passes through the Marais des Cygnes state wildlife area and federal refuge is publicly owned. The approach to enhancing opportunities for recreation in the basin is to improve access to the federal reservoirs, community lakes and other water bodies that are available for public use.

Applicable *Kansas Water Plan* Objective

- By 2010, increase public recreational opportunities at Kansas lakes and streams.

Applicable Programs

The following programs help to meet the objectives in the Water-Based Recreation category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Wildlife and Parks: Rivers and Stream Access
- Kansas Department of Wildlife and Parks: Community Fisheries Assistance Program
- Kansas Water Office: State Water Planning Program

ISSUES FOR FUTURE ACTION

- Regional Public Water Supply Coordination
- Cellulosic Bioenergy Development

Marais des Cygnes Basin High Priority Issue
Comprehensive Flood Assessment
January 2009

Issue

Persistent flood damages in the Marais des Cygnes basin indicate a need for a comprehensive assessment of existing flood control infrastructure and storage to determine current status, mapping needs and opportunities for flood management actions in the future.

In the summer of 2007, widespread flooding occurred in the lower Marais des Cygnes basin. Heavy precipitation fell downstream of the federal flood control reservoirs in the basin. The City of Osawatomie and other communities sustained considerable flood damage. Numerous flood control structures and levees in the basin were also damaged.

The 2003 Marais des Cygnes Basin Section of the *Kansas Water Plan* contained a priority issue on Fort Scott Flooding. Major floods in the Marmaton River watershed impacted the City of Fort Scott in 1986 and 1998. Four water control structures received federal funding in 2004 in the Marmaton Joint Watershed District No. 102. To date, two of these flood control structures have been built and another is under construction.

Flood Insurance Rate Maps (FIRMS) have been prepared for most of the communities subject to flooding in the basin by the Federal Emergency Management Agency (FEMA). Dam breach inundation zone mapping has been conducted by the State Conservation Commission (SCC). Development downstream of some small dams has resulted in changes in hazard class and necessitated upgrading of some structures.

Description

Rivers and streams in the Marais des Cygnes basin have been historically prone to flooding during high rainfall events. Most communities and cities are sited near stream channels and Osawatomie and Fort Scott are located at the confluence of major drainages in the basin, making them especially vulnerable to flood damage.

Three federal reservoirs: Pomona, Melvern and Hillsdale, have been constructed in the basin by the U.S. Army Corps of Engineers (Corps), primarily for flood control. There are eight watershed districts in the basin administering 100 water retention structures (including permitted structures pending construction). These smaller flood control structures are located on tributary streams and have multiple benefits including protecting crops planted in the floodplain.

Pomona Reservoir

In 2002 the Kansas Legislature directed the Secretary of Agriculture and the Chief Engineer, Division of Water Resources (DWR) to evaluate the current policies regarding stream obstructions (roads, bridges, culverts, levees) and present a report outlining the strengths and weaknesses of a watershed approach to the permitting of dams and other stream obstructions. The Secretary and the Chief Engineer were to make recommendations to the Legislature with regard to clarifying the obligations of the Water Structures Program to upstream and downstream landowners.

A questionnaire was sent to city and county governments, the Kansas Department of Transportation (KDOT) and other interest groups to gather their input on pros and cons of a watershed-based approach to permitting of stream obstructions. The approach would have required more rigorous hydrologic and hydraulic modeling to evaluate the effect of structures further upstream and downstream of proposed projects than was currently required. Several alternatives were evaluated that would have imposed various levels of increased requirements.

Two public hearings were held. As a result of the evaluation and public input, the approach was not adopted due largely to concerns of local governments about increased costs and time to process permits. In addition, local governments did not recognize that the current procedures were causing problems and the benefits did not seem to justify the increased cost and work load. Some changes were made to the program including increased notification of upstream and downstream land owners of pending permits. An in-house evaluation was conducted on several streams with permitted structures to determine the downstream flooding impact resulting from the structures.

Accumulation of debris within and behind bridges, culverts and other structures can obstruct the flow of water and limit the ability of the stream to carry flood water through permitted stream obstructions. It is important that permitted obstructions be kept clear of log jams caused by trees, utility poles and other debris that may wash into streams during high flows. Management of riparian areas to prevent debris from entering the system and causing blockages is an important part of a preventive and routine maintenance program. Well-managed and healthy riparian and wetland areas along streams also benefit flood reduction by storing water on floodplains.

Summer 2007 Flooding

Nearly $40 million was approved by the FEMA and the U.S. Small Business Administration to assist those affected by the severe storms and flooding occurring from June 26 through July 25, 2007 in Kansas. The Kansas National Guard was sent to help with a mandatory evacuation of the City of Osawatomie, as overflowing Pottawatomie Creek inundated neighborhoods.

A total of 31 watershed district water control structures in the Marais des Cygnes basin sustained an estimated $378,500 in damage during the 2007 summer floods. Pottawatomie Creek Watershed District site H-26 had an estimated $250,000 in damage. On June 30, 2007, Cedar Creek Valley Reservoir which is the public water supply for the City of Garnett sustained an estimated $645,000 in damage when almost half of a 400-foot spillway wall was eroded.

Although the federal flood control reservoirs in the basin functioned properly, this event demonstrated that even with extensive structural efforts to control flooding, excessive rainfall over successive days can overcome the ability of the system to prevent damage. Additionally, the Marmaton River (Fort Scott) and Pottawatomie Creek (Osawatomie) watersheds lack flood protection from federal reservoirs.

National Flood Insurance

The Flood Management Policy Section of the *Kansas Water Plan* describes flood related activities of FEMA and the National Flood Insurance Program (NFIP).[1] DWR provides coordination and technical assistance for the NFIP in Kansas. DWR provides technical assistance to local governments and offers the *Floodplain Management Guide*[6] to landowners.

To be eligible to participate in the NFIP, cities or counties must enact flood control ordinances designed to limit floodplain development and to protect those buildings that are constructed in the floodplain from flood damage. Management of floodplain development is the first priority in preventing flood damage.

DWR assists cities and counties with the development of flood control ordinances and is responsible for approving them. In the Marais des Cygnes basin, seven counties and 24 cities have enacted floodplain ordinances. Property owners in these political subdivisions are eligible to buy flood insurance through the NFIP program. All eligible entities in the basin participate in the NFIP program with a total of 208 policies. Bourbon County had the seventh highest flood insurance payments of all Kansas counties since 1978, with $2,421,938 paid on only 59 claims (Table 1).

Table 1.

County	Number Policies	Total Coverage	Total Premium	Total Claims Since 1978	Total Paid Since 1978
ANDERSON	12	$ 690,100	$ 5,545	4	$ 190,554
BOURBON	34	$ 5,342,900	$ 31,163	59	$ 2,421,938
FRANKLIN	57	$ 6,787,100	$ 41,784	12	$ 164,432
LINN	7	$ 767,000	$ 4,560	0	$ 0
MIAMI	67	$ 8,742,500	$ 30,472	15	$ 608,546
OSAGE	31	$ 1,624,500	$ 9,110	10	$ 129,477

Source, Division of Water Resources, 2008

In 1997, FEMA initiated a plan to modernize the flood mapping program. The plan proposed a seven-year upgrade of the flood map inventory and enhancement of the associated products and services. Most existing FEMA flood maps were produced using now outdated manual cartographic techniques and do not include recent development. The desire was to produce digital maps compatible with computerized geographic information system (GIS) software. Federal funding to implement the map modernization plan has not yet been made available.

The FY 2005 *Kansas Water Plan Flood Management Policy Section* identified 29 priority counties to be mapped, remapped or to have existing information digitized. Financial assistance from the State Water Plan Fund has been provided for mapping in Allen, Anderson, Bourbon, Coffey, Douglas, Franklin, Johnson, Osage and Wabaunsee counties. Digital flood insurance maps were approved for Miami and Linn counties in 2007.

The Kansas Hazard Mitigation Plan was updated in 2007 by the Kansas Division of Emergency Management (KDEM).[1] In the prioritization of risk associated with 22 hazards conducted as part of the planning process, flooding and winter storms ranked second behind only tornadoes in the degree of risk present. The plan contains the following in the *Mitigation Action Strategy Summary*: "Integrate flood mitigation into KDOT construction projects. Lead agency: KDOT; Support Agency: Kansas Department of Agriculture". This is shown in the Hazard Mitigation Plan as having a medium planning priority. It is noted that this action applies to all new construction projects and that more coordination with other state and local agencies is needed. This recommendation also addresses some aspects of watershed based planning and permitting discussed above.

The *Kansas Hazard Mitigation Plan* includes a summary of high and significant risk dams (Table 2). A high hazard dam (Class C) is a structure located in an area where failure could result in any of the following: extensive loss of life, damage to more than one home, damage to industrial or commercial facilities, interruption of a public utility serving a large number of customers, damage to traffic on high volume roads, a high volume railroad line, inundation of a frequently used recreation facility serving a relatively large number of persons, or two or more individual hazards described in Hazard Class B. A significant hazard dam (Class B) is a dam located in an area where failure could endanger a few lives, damage an isolated home, damage traffic on moderate volume roads, damage low volume railroad tracks, interrupt the use or service of a utility serving a small number of customers, or inundate recreation facilities such as campground areas used intermittently and serving a relatively small number of persons. Dam hazard ratings are based on the risk for loss of life and/or property damage and are not related to the condition of the structure. The DWR requires emergency action plans to be developed for Hazard Class C dams. In May 2007, this requirement was extended to include Hazard Class B dams.

The Hazard Mitigation Plan also includes a summary of flood control levees in Kansas (Table 3). Levees, along with dams, are engineered to withstand floods with a computed risk of occurrence (100-year flood).

Table 2.
Dams in the Marais des Cygnes Basin

County*	Population	Total dams	High hazard (w/out plans)	Significant Hazard
Allen	13,677	23	0	1
Anderson	8,051	51	1 (1)	1
Bourbon	14,950	72	5 (2)	4
Coffey	8,701	53	0	5
Crawford	38,059	59	1 (1)	1
Douglas	112,123	97	7 (1)	3
Franklin	26,513	68	0	2
Johnson	516,731	103	20 (7)	14
Linn	9,962	81	8 (7)	7
Lyon	35,369	108	2 (1)	12
Miami	30,900	68	1	5
Osage	16,958	52	5 (1)	1
Wabaunsee	6,895	50	2	6

* Counties either wholly or partly within the MDC basin
Source: Kansas Hazard Mitigation Plan, 2007.

Table 3.
Levees in the Marais des Cygnes Basin

County*	Levee design standard	Flooding source	Protected Community	Federal Levee?
Franklin	100-year	Marais des Cygnes River	Ottawa	yes
Franklin	100-year	Marais des Cygnes River	Unincorporated	yes
Miami	100-year	Marais des Cygnes River	Osawatomie	unknown
Miami	100-year	Pottawatomie Creek	Osawatomie	unknown

* Includes only counties subject to flooding by the MDC River and tributaries
Source: Kansas Hazard Mitigation Plan, 2007.

Watershed Districts

The eight watershed districts in the Marais des Cygnes basin have developed general plans, approved by the SCC or the Natural Resources Conservation Service (NRCS), that describe the location and floodwater storage capacity of flood control retention and detention structures. Most impound water even during non-flood conditions and many have benefits in addition to flood control. General plans also include watershed protection actions including construction of terraces, grassed waterways and grade control structures to limit sediment delivery to the structures.

Watershed districts have the authority to levy taxes on residents within the district to be used for operating expenses, new structure construction, and routine maintenance of infrastructure. Local funding can also be used to implement best management practices (BMPs) to restore wetland and riparian areas that also provide flood detention benefits.

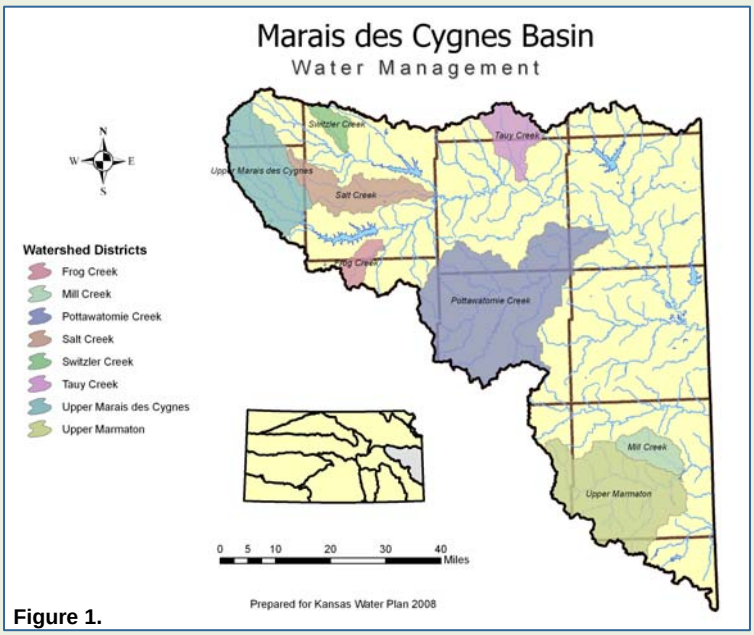


Figure 1.

Funding for construction of watershed structures comes from federal, state and local sources (Figure 1). Construction under the NRCS P.L. 83-566 Program in the basin includes a total nine structures built in the Frog and Middle Creek Watersheds. NRCS activity peaked in Kansas in 1964 with over 70 structures completed. There has been no funding in Kansas under the program since 2006.

One hundred SCC watershed district structures are in place with two pending permits in the basin. State assistance to the watershed dam construction program peaked in 1994 at about $1.6 million (Figure 2).

Local Floodplain Development and Management

Expansion of urban development in floodplains has increased the potential for flood damage. Future flood damages may be reduced by preventing inappropriate development in flood prone areas. Local governments can implement floodplain management through use of planning and zoning authority. There is no state requirement for local units of government to implement floodplain management.

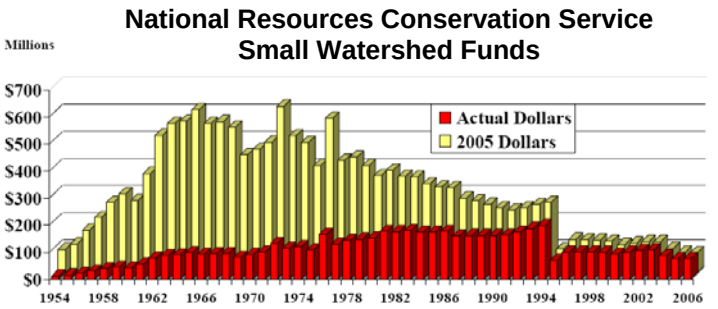


Figure 2.

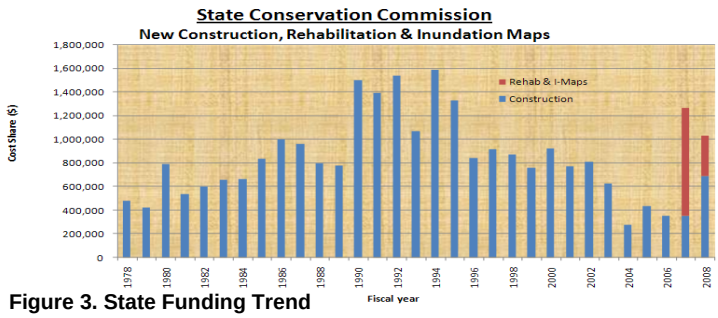


Figure 3. State Funding Trend

By minimizing structural development in floodplains, the land is available to allow flood waters to spread out, thus slowing the water and reducing erosive potential. Culverts and bridges can be designed to minimize flood damage by allowing adequate space for floodwater conveyance which reduces backwater effects and damage to upstream areas. Roads can be designed to be at elevations high enough to minimize floodwater encroachment. Increased watershed storage of floodwater in key areas can also reduce the volume of runoff, reducing impacts to structures.

Nonstructural mitigation measures including forecast and warning systems, and wetland and riparian areas can reduce flood damages. The National Weather Service (NWS) provides river stage and flood forecasts for the basin through its Missouri River Basin Forecast Center located in Pleasant Hill, Missouri. The Kansas Mesonet Steering Committee selected priority counties for new automated weather stations in 2008. River Forecast Center needs were considered in this process and additional near real-time hourly precipitation data stations are planned for Wabaunsee, Osage and Miami counties. This network will be informative in developing future design standards for permitted stream obstructions.

Watershed Planning Coordination

The 2005 Flood Management Policy Section of the *Kansas Water Plan* recommends multi-objective management of flood prone areas and the incorporation of non-

structural measures into watershed district plans to further reduce flood damage while providing other benefits. The 2007 Kansas Hazard Mitigation Plan supports incorporating nonstructural measures into wetland and riparian management plans to further enhance the reduction of damage from floods.

Since 2005, the state has coordinated the development of Watershed Restoration and Protection Strategies (WRAPS). Local WRAPS groups develop management plans to address locally identified priority issues. Each watershed district in the basin is also within an area covered by a WRAPS.

Recommended Actions

1. Assess the effectiveness of existing flood control infrastructure and develop plans to address necessary improvements.

2. Address repair of damaged flood control structures and deferred maintenance.

3. Determine the current floodplain status and promote model ordinances and BMPs to local units of government. Promote limiting development in the 100-year floodplain using FIRMs to delineate prohibited areas.

4. Engage basin WRAPS groups, watershed districts and federal agencies to integrate flood management with existing floodplain and riparian programs. Assess and inventory watersheds to identify potential locations for nonstructural flood control measures.

5. Examine the basin application of nonstructural flood controls.

6. Purchase properties having repetitive flood damage and prevent redevelopment of these areas.

7. Develop emergency plans for high hazard dams still needing them.

8. Complete breach inundation zone mapping.

9. Coordinate with DWR, Water Structures Program to determine if increased hydrologic and hydraulic evaluation of stream obstructions should be considered in the Marais des Cygnes basin in areas particularly prone to flooding. Identify and evaluate areas where flooding may be attributed to permitted stream obstructions. Consider the costs to repair flood damages against the costs to implement watershed based permitting.

10. Coordinate with county emergency management agencies on development of county-wide All Hazards Mitigation Plans.

Resources

1. Adjutant General's Department, Kansas Division of Emergency Management, *Kansas Hazard Mitigation Plan*. November 2007.

2. Federal Emergency Management Agency. August 1, 2002. National Flood Insurance Program: Program Description.

3. Kansas Water Office. July 2005. Kansas Water Plan Background Paper No. 76, Small Dam Safety and Rehabilitation.

4. Kansas Water Office. 2005. Kansas Water Plan Fiscal Year 2005 Update; Final Draft. Flood Management Policy Section.

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6. USDA-Natural Resources Conservation Service, Salina, Kansas. March 23, 2006. Kansas 2006 Update: Watershed Protection and Flood Prevention Program (PL-566).

7. Kansas Department of Agriculture, Division of Water Resources. Floodplain Management Guide. Accessed September, 2008. http://www.ksda.gov/includes/document_center/structures/Floodplain/ksqg_web.pdf

Marais des Cygnes Basin High Priority Issue
Watershed Restoration and Protection
Approved January 2008

Issue

Water quality is addressed through a combination of restoration and protection efforts using both voluntary incentive-based approaches and regulatory programs. The restoration and protection of watersheds, particularly those watersheds above public water supply reservoirs, is a priority in the Marais des Cygnes Basin. Growing populations in the northern portion of the basin, combined with a corresponding increase in the demand for water make the restoration and protection of these watersheds were important.

Description

There are three federal reservoirs, Pomona, Melvern and Hillsdale, in the Marais des Cygnes basin. All of these reservoirs are operated by the U.S. Army Corps of Engineers (Corps). The federal reservoirs are used for public water supply that serve numerous cities and rural water districts in the basin, primarily in the rapidly growing areas in the northeast portion of the basin. These reservoirs are also managed by the Corps for flood control and recreation.

Hillsdale and Pomona reservoirs and many streams within the basin are experiencing water quality impairments. Fecal coliform bacteria and low levels of dissolved oxygen are the most prevalent stream impairments. Sedimentation and eutrophication (nutrient loading) are the primary water quality problems affecting reservoirs in this basin.

Reservoir sedimentation is a major water quantity concern, particularly in reservoirs where the state owns water supply storage. As sediment accumulates in a reservoir's multipurpose pool, the capacity for water supply storage is reduced. Figure 1 shows the estimated capacity lost, including water supply storage, to sediment deposition in federal reservoirs in the basin since construction.

Water Quality Impairments

Surface waters not meeting water quality standards in the basin are included on the 2006 303d list. High priority Total Maximum Daily Loads (TMDLs) for impaired surface waters in the Marais des Cygnes basin were originally submitted to the Environmental Protection Agency for approval on June 30, 2001 by the Kansas Department of Health and Environment (KDHE). An additional round of TMDL development was completed in 2007 (Figure 2, Table 1). High priority TMDL watersheds are used to target technical and financial assistance for implementation of nonpoint source pollution management practices to address designated pollutants.

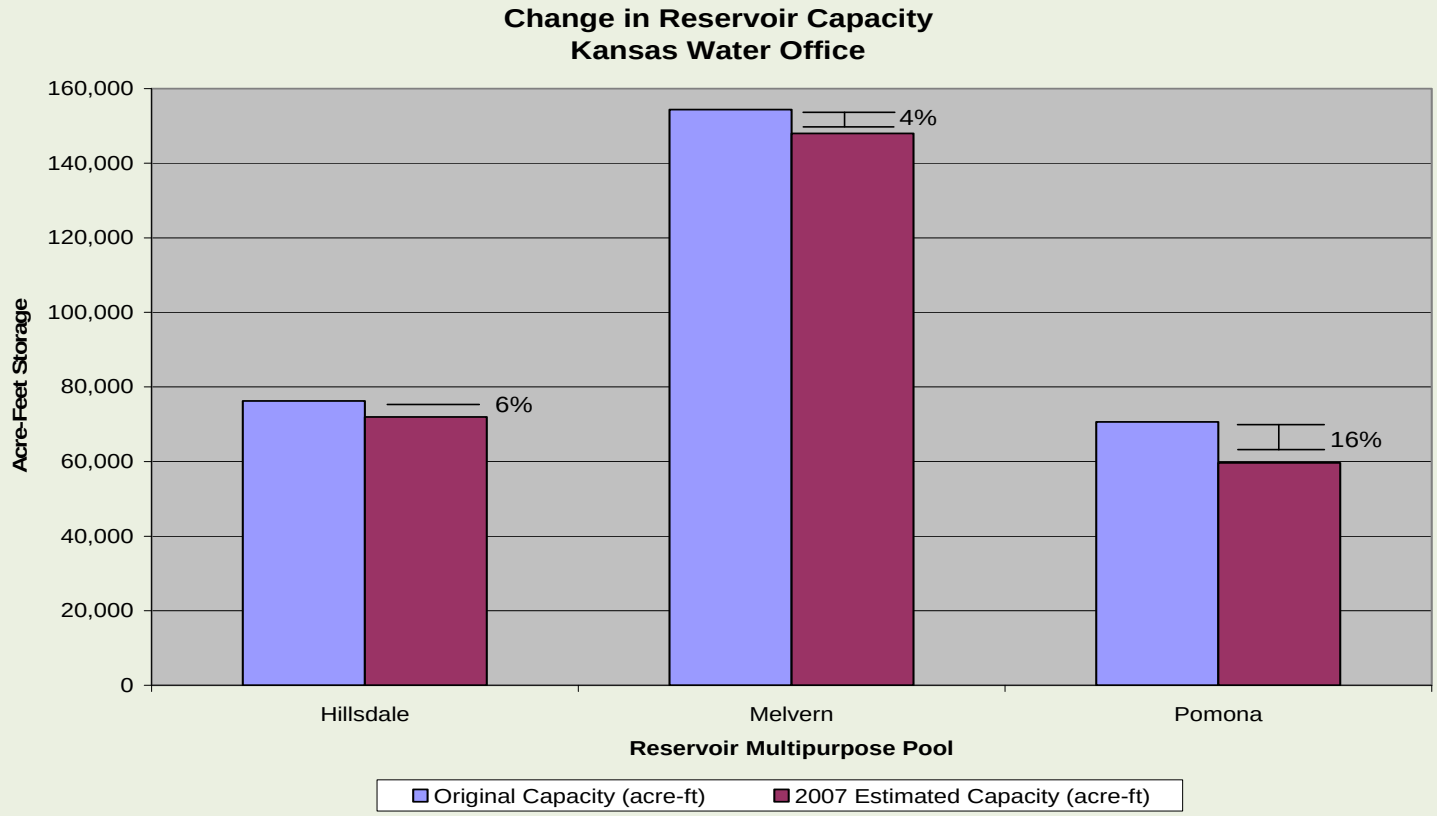

Figure 1.

A TMDL is the maximum amount of a pollutant that a water body can receive without violating water quality standards. Since pollution can arrive via point and non-point sources, the TMDL development process identifies contributing sources for the pollutant loads.

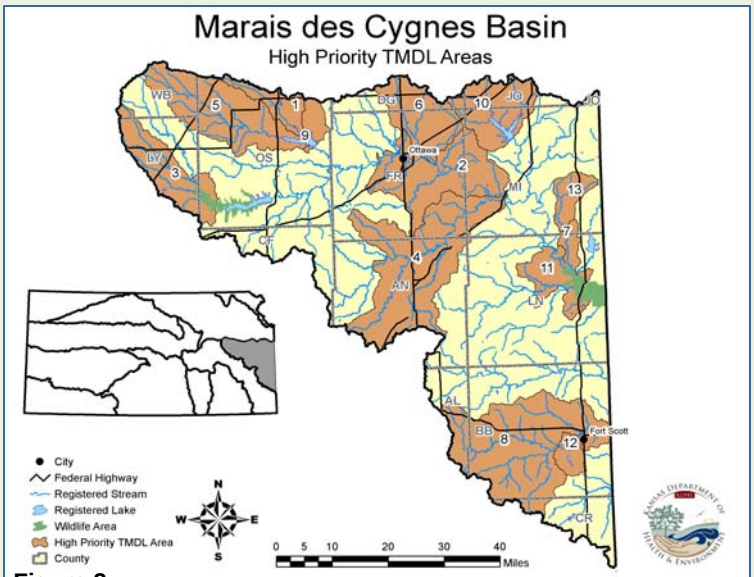

Figure 2.

Surface Water Nutrient Reduction

Nutrient sources within the basin include both point and non-point sources. The major point sources in the basin include large wastewater treatment plants, which are regulated under the National Pollutant Discharge Elimination System (NPDES) Program (Figure 3).[6]

Nonpoint sources of pollution include both agricultural and urban areas. Table 2 shows the relative contribution of point and non-point sources in the Marais des Cygnes basin for total phosphorus (TP) and total nitrogen (TN) leaving the state.

The Kansas Surface Water Nutrient Reduction Plan, developed by KDHE, outlines a statewide strategy for reducing the export of TN and TP in surface waters leaving the state. This involves additional reductions in nutrients from point source discharges through the NPDES Program and reductions in nonpoint sources through development and implementation of Watershed Restoration and Protection Strategy (WRAPS). The Nutrient Reduction Plan includes Improvement Potential Index (IPI) maps for Kansas counties for TP and TN reductions (see

TABLE 1
MARIAS DES CYGNES BASIN HIGH PRIORITY TMDLS

MAP ID	WATERBODY	IMPAIRMENTS	HUC 11 WATERSHEDS
STREAM SEGMENTS			
1	Hundred and Ten Mile Creek	DO	10290101030
2	Upper Marais des Cygnes River	FCB	10290101040 10290101070
3	One Hundred Forty Two Mile Creek	DO, FCB	10290101010
4	Pottawatomie Creek	DO	10290101050 10290101060
5	Dragoon Creek	DO	10290101030
6	Ottawa Creek	DO	10290101070
7	Middle Creek	DO	10290102060
8	Marmaton River	DO, BIO	10290104010 10290104020
LAKES			
9	Pomona Lake	E, Silt	10290101030
10	Hillsdale Lake	E	10290102010
11	Marais des Cygnes Wildlife Mgt. Area	DO, E, pH, Silt	10290102060 10290102070 10290102080
12	Rock Creek Lake	E	10290104010
13	Louisburg State Fishing Lake	E	10290102060

Key:
DO: Low dissolved oxygen in upper 3 meters of water column over deepest location in water body
BIO: Biology
E: Eutrophication, biological community impacts and excessive nutrient/organic loading
FCB: Fecal Coliform Bacteria
HUC: U.S. Geologic Survey Hydrologic Unit Code
pH: A measure of the hydrogen ion concentration.
Silt: Observed siltation and/or chronic turbidity that impacts development of trophic state

maps in Water Quality Policy Section). In the Marais des Cygnes basin, Anderson County showed the highest improvement potential for both TP and TN.

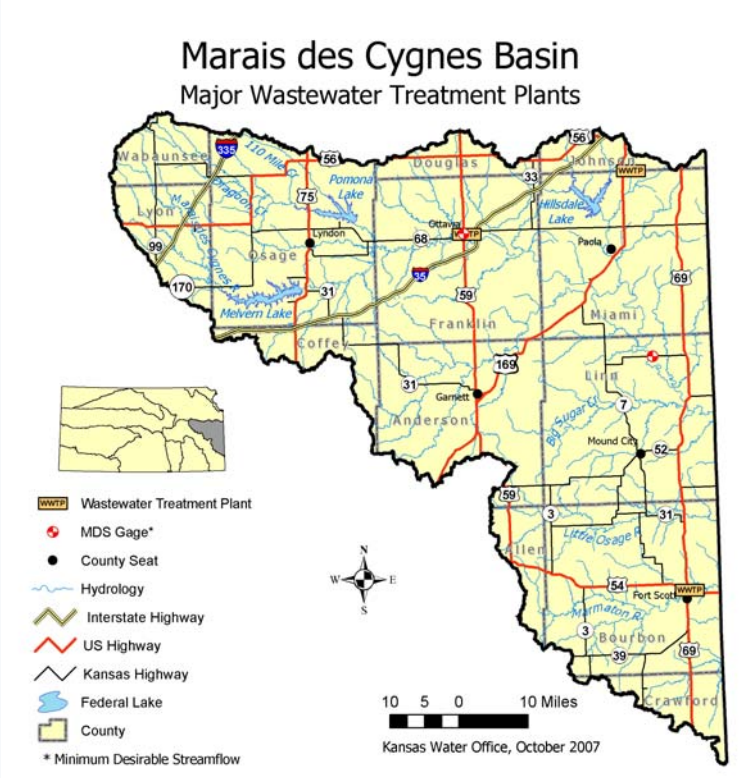

Figure 3

Table 2
MDC Nutrient Reduction Data
Source: KDHE Bureau of Water – February 14, 2006

Statewide Perspective

Parameter	State Total	MDC	% of State Total
TN Leaving State (Ton/yr)	51,205	4,751	9%
TP Leaving State (Ton/yr)	7,670	579	8%
Point Source TN (Ton/yr)	10,600	471	5%
Point Source TP (Ton/yr)	2,836	120	4%
Nonpoint Source TN (Ton/yr)	40,605	4,260	10%
Nonpoint Source TP (Ton/yr)	4,834	459	9%

Basin Perspective

Parameter	Total	PS	PS %	NPS	NPS%
TN (Ton/yr)	4,751	491	10%	4,260	90%
TP (Ton/yr)	579	120	21%	459	79%

Source Water Protection

All public water suppliers in the basin completed Source Water Assessments in cooperation with KDHE in 2004. The next step, which is voluntary, is the development of source water protection plans.

Forty public water suppliers in the basin treat raw water. Twenty-two use surface water and 18 use ground water. Most residents in the basin get water from the Marais des Cygnes River, one of its major tributaries or one of the three federal reservoirs in the basin.

Each source water assessment included a susceptibility score which can help communities determine which contaminants pose the most significant threat to their water supply. A score, generated from the susceptibility analysis, indicates whether the susceptibility range is low, moderate or high for potential threats of contamination in an assessment area.

KDHE provided public water suppliers susceptibility scores in the following contaminant categories: microbiological, nitrates (applicable for ground water only), pesticides, inorganic compounds, synthetic organic compounds, volatile organic compounds, sedimentation (surface water only) and eutrophication/phosphorus (surface water only).

Of public water suppliers using ground water in the Marais des Cygnes basin, 67% had low susceptibility scores and 33% had moderate scores. Of public water suppliers using surface water, 45% had low scores, 45% had moderate scores and nine (figures rounded) percent had high scores. The most commonly identified problems with ground water were volatile and synthetic organic compounds, pesticides and microbes. The most commonly identified problems with surface water were volatile and synthetic organic compounds, inorganic compounds, sediment and eutrophication/phosphorus.

Development of a wellhead protection program is recommended. The development of a WRAPS is the best mechanism to ensure water quality protection for their public water supply for communities using surface water. The Marais des Cygnes basin has one approved source water protection plan and another in progress.

Wetland and Riparian Area Management

The primary approach to wetland and riparian area management in the basin focuses on providing technical and financial assistance to landowners to protect and restore these resources in priority watersheds through the implementation of BMPs. Water quality has been a primary focus with implementation efforts targeted to high priority TMDL watersheds (Figure 2). All conservation districts in

the basin except Anderson and Coffey, have developed wetland and riparian protection plans.

Watershed Restoration and Protection Strategies

WRAPS are stakeholder-driven watershed management plans designed to address multiple water resource issues within a specific watershed. The WRAPS process provides a means to integrate objectives from multiple local, state and federal programs into a comprehensive, coordinated strategy for a specific watershed.

This can include TMDL attainment, nutrient reduction, source water protection, reduced reservoir sedimentation, riparian and wetland management and other natural resource objectives.

Watersheds above the three federal reservoirs in the basin that serve public water supply needs have been identified as watersheds of significant state interest for WRAPS development and implementation. WRAPS projects have been initiated in each of the watersheds above the federal reservoirs. WRAPS have been prepared for the entire basin and the Marmaton watershed. [(4)] Watersheds with WRAPS projects currently underway in the basin encompass high priority areas for TMDL implementation, areas with a high improvement potential index for nutrient reduction, source water assessment areas and priority areas for wetland and riparian protection.

An important consideration for watershed restoration and protection in this basin, particularly in the northern portion of the watershed, is urbanization. Between 2002 and 2006, the combined population of Miami and Franklin counties increased by 4,278 or 7.5%.

As the amount of impervious surface in a watershed (i.e. rooftops, roads, parking lots, etc.) increases, water resources can be adversely impacted. Runoff volume increases and additional pollutants associated with urban environments may enter streams and ponds unless preventive steps are taken by local governments and urban residents. Sound land use planning and storm water management are essential to limit adverse effects.

Local land use planning and zoning efforts provide cities and counties effective tools to minimize the potential impacts of development on water resources. Urban stormwater management programs can be implemented to manage the amount of impervious surface in urbanizing watersheds and properly control increased runoff resulting from urbanization. Programs that provide technical assistance and education to urban residents regarding actions that can reduce or eliminate potential pollution sources also play an important role. These programs can be integrated with WRAPS projects to ensure a comprehensive approach to watershed management in urban areas.

Other Watershed Related Activities

- The 13 counties either wholly or partly within the basin have adopted local sanitary/environmental codes or participate in the Local Environmental Protection Program.
- All counties have countywide planning and zoning programs.
- All conservation districts in the basin have adopted nonpoint source pollution management plans. Grants under the State Water Quality Buffer Initiative have also been awarded in nine counties in the basin supporting buffer coordinators and facilitating enrollment of stream buffers in continuous CRP.
- Of cities in the basin, only Ottawa is subject to the Phase II Permitted Municipal Separate Storm Sewer System under the NPDES Stormwater Program.
- As of December 2005, there were three active contamination sites being remediated through the *State Water Plan (*Contamination Remediation Program).
- There are eight organized watershed districts in the basin.

Applicable Kansas Water Plan Objectives

- By 2010, reduce the average concentration of bacteria, biochemical oxygen demand, solids, metals, nutrients, pesticides and sediment that adversely affect the water quality of Kansas lakes and streams.
- By 2010, ensure that water quality conditions are maintained at a level equal to or better than year 2000 conditions.
- By 2010, reduce the average concentration of dissolved solids, metals, nitrates, pesticides and volatile organic chemicals that adversely affect the water quality of Kansas ground water.
- By 2010, maintain, enhance or restore priority wetlands and riparian areas.

Basin Specific Objectives

- By 2010, over 25% of the high priority TMDLs identified in 2001 and 2007 for the Marais des Cygnes basin will have data supporting their delisting as impaired on the 2012 Kansas 303(d) list.

- By 2010, all public water suppliers will complete and implement a source water protection plan.
- By 2015, nutrient reduction goals will be included in all WRAPS projects within the basin and sediment reduction goals included in WRAPS projects above the three federal priority reservoirs.
- By 2015, integrate urban stormwater management goals into all urban area WRAPS and support the implementation of urban stormwater management projects as outlined in WRAPS action plans.

Recommended Actions

1. Work with stakeholder groups to incorporate TMDL implementation, nutrient and sediment reduction, and urban stormwater management goals into applicable WRAPS projects.
2. Target technical and financial assistance programs for water quality protection and restoration to implement TMDLs and WRAPS action plans.

Resources

1. Kansas Water Office. 2006. *Kansas Water Plan Water Quality Policy and Institutional Framework Section, 2006*.
2. Kansas Department of Health and Environment, Bureau of Environmental Remediation. December 2005. *Basin Updates and Site Accomplishments.*
3. Kansas Department of Health and Environment, Bureau of Water. 2004. *Kansas Source Water Assessment Report*. www.kdheks.gov/nps/swap
4. Kansas Department of Health and Environment, Bureau of Water. 2007. *Kansas Watershed Restoration and Protection Strategy*. www.kdheks.gov/nps/wraps
5. Kansas Department of Health and Environment, Bureau of Water. December 2004. *Surface Water Nutrient Reduction Plan*, www.kdheks.gov/water
6. Kansas Department of Health and Environment, Bureau of Water. 2007. *Watershed Planning and TMDL Program*. Accessed Jan. 2008. www.kdheks.gov/tmdl
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8. Kansas Department of Health and Environment TMDL website accessed Jan. 2008. http://www.kdheks.gov/tmdl/index.htm .

Marais des Cygnes Basin High Priority Issue
Water Supply Management and Conservation
January 2009

Issue

Increasing population and development in portions of the Marais des Cygnes basin along with aging reservoirs and public water supply infrastructure indicates a need to evaluate the river/reservoir system capacity to meet future water supply needs in the basin.

In 2007, the Kansas Water Office (KWO) prepared an analysis of surface water supply and demand projections for selected basins in eastern Kansas.[1] The analysis utilized historic climate, streamflow and population information to predict the total water supply and demand in the basin over time. In those counties primarily served by the Marais des Cygnes River and supported by federal reservoirs, demand was predicted to exceed the total existing supply during a two percent probability drought in the year 2109. This estimate includes the current state-owned supply along with the purchase of water supply storage in Hillsdale Reservoir reserved for future state use. The analysis did not include that portion of the basin supplied by Marmaton and Little Osage Rivers or other areas not served by the mainstem of the Marais des Cygnes.

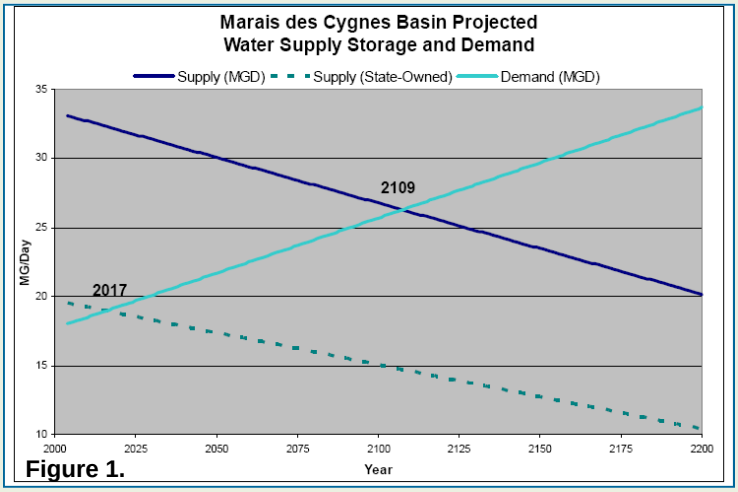

Figure 1.

Also in 2007, KWO released updated *Guidelines for Municipal Water Conservation Plans* for use by public water suppliers. While the supply and demand analysis did include implementation of some conservation practices during drought, demand management could extend water supplies. Controlling water loss and enhancing treatment efficiency could further enhance demand management.

In 2008, KWO initiated the Reservoir Sustainability Initiative (RSI) to conserve and restore reservoir storage capacity and provide for long-term public water supply needs. Public water supply storage has been impacted by sedimentation in all the federal reservoirs in the basin. Maintaining this storage is critical to meeting future public water supply needs.

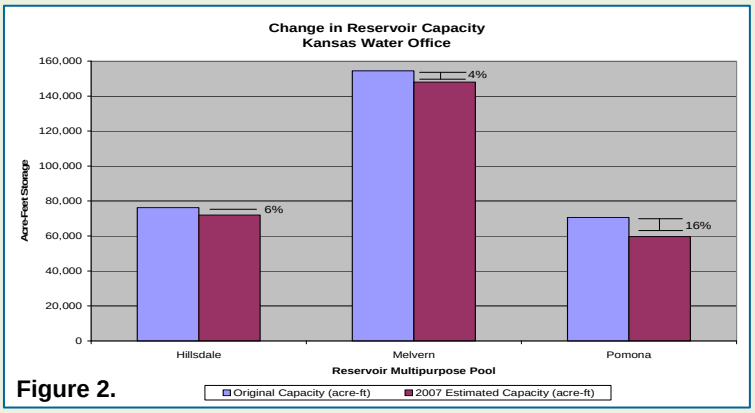

Figure 2.

Description

Water Supply

Water supply in the basin is primarily provided by three federal reservoirs: Pomona, Melvern and Hillsdale, along with four State Multipurpose Small Lakes, city-owned lakes, ground water wells and natural stream flows. All of the streams in this basin are restricted so that no new appropriation rights are available for the time period July through September (typically the irrigation season) unless there is an alternate source of water shown to be available.

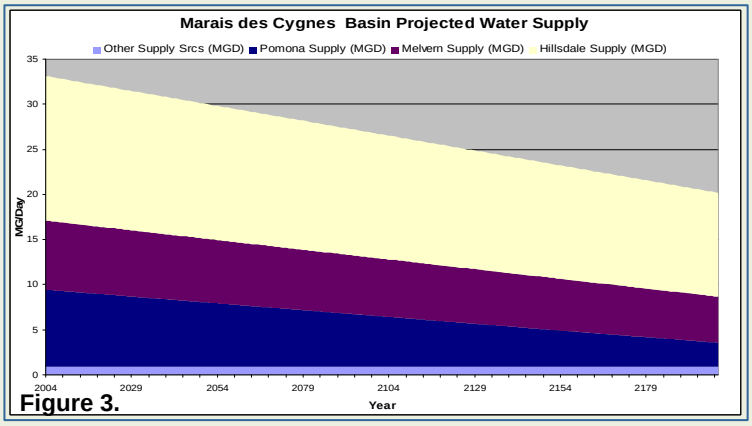

Figure 3.

Based on bathymetric survey information and projected sedimentation rates, reservoir water supply storage and yield was calculated over time in the basin by KWO in 2002.[4] The 2007 analysis of supply and demand in the Marais des Cygnes basin used the previously calculated yield available from the federal reservoirs in the basin along with natural flows to calculate the total available

water supply in a severe drought similar to the 1950s. While the analysis showed adequate water supply in the basin into the next century, efforts are being made to reduce the rate of sedimentation in the reservoirs to extend the existing supply further.

The 2007 analysis was not structured to account for the quantity of water supply available in specific stream reaches under different conditions. A more refined modeling process using a computer model to identify water supply and demand at specific points in the basin has been initiated by the KWO in the Marias des Cygnes basin. Through the computer model, the available water supply at specific demand points and under various conditions in the basin can be estimated. KWO staff will work directly with water supply utilities, industry, other water users and the Marais des Cygnes Basin Advisory Committee (BAC) to obtain detailed information on expected water demand in the future. Minimum desirable streamflows (MDS) to support water quality along with aquatic life would be accounted for in the model.

Marketing and Assurance

Reservoirs provide dependable water supplies in streams with highly variable flow in addition to providing flood control, recreation and other benefits. The 1958 Federal Water Supply Act made storage in federal reservoirs available to local governments if they agreed to repay the cost of construction, operation and maintenance of the water supply storage. The State of Kansas has purchased water supply storage in each of the federal reservoirs in the basin. The state gave a commitment to the federal government in 1969 that the water supply storage in Hillsdale Lake would be purchased if it was included during development of the reservoir.[4] Only a portion of this storage is currently being utilized; ultimately, all of the storage will be needed.

Table 1.
Storage Capacity Estimated for year 2035**

Reservoir	Water Assurance*	Water Marketing	Reserve Capacity	Future Use	Total Storage
Hillsdale	0	7,500	0	45,500	53,000
Melvern	7,700	14,350	27,950	0	50,000
Pomona	7,700	0	24,800	0	32,500

*Storage expressed in acre-feet
** as per contract with Corps of Engineers

In 1985, through a Memorandum of Agreement (MOA) between the State of Kansas and the U.S. Army Corps of Engineers (Corps), water quality storage in Pomona and Melvern Lakes was reallocated to water supply storage and purchased by the state at the original development cost.[4] The state purchased the maximum amount made available in the reallocation. In exchange for the significant reduction in cost, the state agreed to obtain water reservation rights for water quality storage and to protect water quality releases from diversion by water right holders.

The Water Marketing Program provides long-term (10-40 years) contracts for water supply for municipal and industrial uses only. Customers of the Marketing Program pay for water on a per 1,000 gallon basis and the state pays costs of the capital investment along with the annual operation and maintenance. The marketing rate is based on the combined costs for the 10 reservoirs where the state has purchased storage. The state currently has storage in Hillsdale and Melvern Lakes committed to the Water Marketing Program in the Marais des Cygnes basin. Hillsdale storage will be brought into service incrementally only as additional water supply is needed under the Water Marketing Program.

Prior to the KWO entering into negotiation for a contract under the Water Marketing Program, a determination is made by the Kansas Water Authority (KWA) that the proposed withdrawal and use of water is in the interest of the people of the State of Kansas. The amount of water that can be contracted is limited to a quantity that is estimated to be available during a significant drought. Water not needed to meet long-term contract obligations can be acquired annually under a surplus contract. Surplus contracts are only good for one calendar year. To date, there have there been no surplus contracts in the Marais des Cygnes basin.

Access to water in storage is also available through the Water Assurance Program that operates the Marais des Cygnes basin reservoirs as a system, maximizing the availability of water. Through this program, municipal and industrial water right holders that have formed a district can purchase storage in federal reservoirs. Under agreements negotiated with the state, water in the purchased portion of reservoir storage is released during dry periods to support the water rights of assurance district members. These releases are protected from diversion by other users.

The Marais des Cygnes Water Assurance District was formed in 1990 with seven municipal and industrial water right holders.[4] The District has purchased a portion of the water supply storage in Pomona and Melvern Lakes. Additional reserve storage at Melvern and Pomona is

owned by the state but is not currently committed to either the Water Marketing or Assurance programs. This storage will be sold to the Assurance District or committed to the Water Marketing Program incrementally as demand requires.

The key difference between the Water Assurance Program and the Water Marketing Program is that the water assurance districts own the storage in the reservoirs in the particular basin and pay only the principal and interest and operation and maintenance costs associated with that reservoir storage, as well as costs of the administration and enforcement dedicated to the program. These costs are pooled in the Water Marketing Program for all state-owned reservoir storage and customers pay a statewide averaged rate.

Water Demand

In the 2007 KWO supply and demand analysis, demand was combined for the basin in the same manner as water supply.[1] Population estimates were developed from the Kansas Division of Budget projections to the year 2027. These trends were further projected as necessary in the supply and demand analysis. Entire counties were assigned to the basin based upon predominance of area *and* existence of larger incorporated areas. The Marais des Cygnes corridor in the analysis included Osage, Franklin, Miami, Anderson and Linn counties.

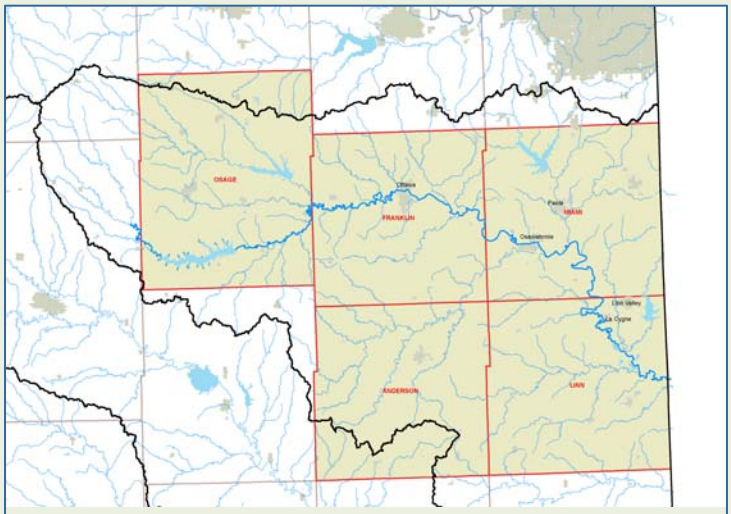

Figure 4. Counties Supplied by the MDC River Corridor

Municipal and Industrial Demand

Water demand associated with population projections is based on municipal water use as gallons per capita per day (gcpd) usage reported to the Kansas Department of Agriculture-Division of Water Resources (DWR), for 2000 through 2004 by suppliers in the basin.[6] The quantity of water that municipalities sold for non-domestic use is not included in those gpcd calculations but was added to the total. To develop the projected water use from industry, commerce, agriculture and recreation, all non-municipal surface water points of diversion within five miles of the mainstem of each basin were included.

The estimated surface water demand increase in the Marais des Cygnes River corridor is primarily associated with the population growth projected to occur in Miami County. While a significant increase in demand was demonstrated in the recreational sector in Linn County over the last 12 to 15 years,[1] recreation water use (waterfowl marshes) was limited to current levels since there is little to no suitable land remaining near the mainstem in the county that has not already been developed.

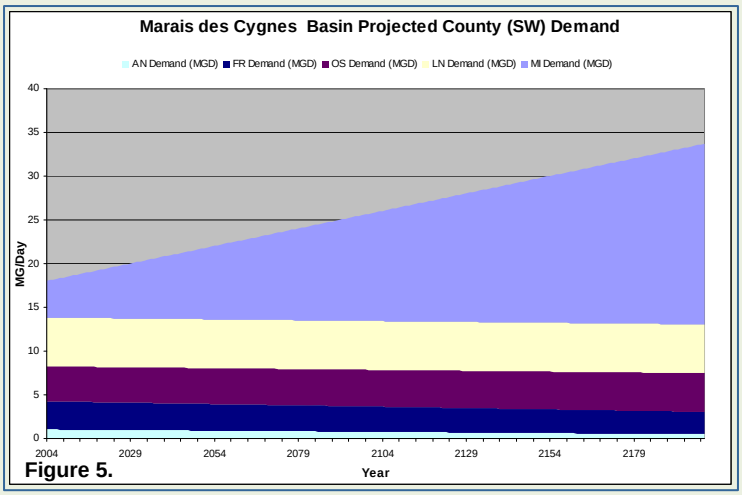

Figure 5.

The Kansas Division of Budget projections from the 2000 U.S. Census did not indicate significant future growth for Franklin County. There has been development of new industry and distribution centers in Ottawa since the last census and Franklin County is anticipated to show population growth in the next census. Updated growth projections can be incorporated in the OASIS model to more accurately reflect these changes as described below.

Refining Supply and Demand Projections

The KWO is currently using the simulation of Operational Analysis and Integrated Systems (OASIS) computer software product to further analyze the supply and demand in the Neosho and Marais des Cygnes basins. OASIS models the operations of the river/reservoir sys-

tem by simulating the routing of water though a system represented by nodes (reservoirs, cities, etc.) and arcs (rivers). OASIS can account for physical constraints such as reservoir capacity, evaporation and sedimentation. The model can also account for system management issues such as minimum release requirements and lake level management plans.

The advantage of OASIS modeling is that it can simulate the interaction of multiple reservoirs and rivers in a system. OASIS can also identify "problem areas" in a system and evaluate alternative improvements (off-stream storage, new reservoirs, dredging, reallocation, etc.). The KWO will be working with all users in the Marais des Cygnes River corridor to identify supply and demand options. These options will be tested through the OASIS model and the results shared with basin stakeholders.

In-Reservoir Demand

Water held in storage at federal reservoirs supports water-based recreation and associated economic activity. In 2007, the Corps performed an economic analysis of recreation at their lake projects.[7] Four components were analyzed to estimate economic effects: recreation spending, visitor use estimates, capture rates and economic multipliers. Hillsdale, Melvern and Pomona Reservoirs had a combined 1,075,471 visits in 2006. These visits were estimated to produce $26.25 million in total direct sales along with $13.12 million in value added through wages, salaries, payroll benefits, profits, rents and taxes. The three reservoirs were estimated to support 376 jobs in local communities.

Recreation use varies by season and reservoir condition with activity reduced during periods of flood storage and low water conditions. Lake level management plans for each reservoir are designed to maximize fish, wildlife and recreation benefits during periods of adequate inflow. Storage contracted under the Water Marketing and Assurance Programs is designated for municipal and industrial water supply.

Water Conservation

Water conservation and demand management are essential components of extending water supplies. Demand management is not a concept that has been routinely incorporated in water utility operations. With the recognition of the potential for future water supply shortages, water suppliers and communities should begin to incorporate this concept into their planning. Demand management may include less water-intensive landscaping, low water use plumbing, conservation design for urban areas, water reuse and other elements.[3] A movement beyond excessive use of water into more sustainable long-term management is needed.

Local land use planning and zoning authorities provide cities and counties with effective tools to minimize the impacts of development on water resources. Counties with planning and zoning regulations often require landscape plans for new development. While landscaping can provide aesthetic and environmental benefits, heavily irrigated landscape designs can increase demand on public water supplies. Of the counties either partly or wholly within the Marais des Cygnes basin, all are zoned with the exception of Bourbon County.

Conservation of reservoir storage has received attention as the impacts of sedimentation become increasingly apparent. While supply in the basin is adequate in the near term, the closures of recreation areas and algae blooms due to siltation in reservoirs in other areas of the state are indicators of a general loss of water supply. Research has been conducted on the causes of reservoir storage loss and on identifying solutions.[5] Solutions generally fall into short-term measures such as more efficient reservoir operations and longer-term strategies to restore storage. Examples of reservoir operations include pool reallocation, raising dams/pools, modification of operational rules. Restoration includes dredging, reservoir flushing, treatment of the upstream watershed to limit erosion or other means of removing accumulated sediment. Protection and restoration of streams, wetlands and riparian areas in the watershed and also measures to reduce sedimentation.

Pomona Reservoir Outlet Channel. Photo by Corps.

Marais des Cygnes Basin High Priority Issue
Water Supply Management and Conservation
January 2009

Recommended Actions

1. Work with stakeholders to identify options for supply and demand management including: reservoir pool raise, pool reallocation, dredging, new supplies, modification of reservoir operations, operation of Water Marketing and Water Assurance Programs and conservation measures.

   a. Test various options through the OASIS model.
   b. Share information with stakeholders from the basin model including supply and demand information for specific stream segments.
   c. Implement the most beneficial and cost-effective options.

2. Encourage incorporation of water demand management into utility operating plans. Demand management should include education and interaction with the development community and existing local authorities.

3. Compare annual Corps visitation figures to pool conditions during the primary recreation seasons. Determine when high and low pool levels create impacts on recreational use.

Resources

1. Kansas Water Office, 2007, *Surface Water Supply and Demand Projections for Selected Basins in Eastern Kansas.*

2. Kansas Water Office, 2006, *Kansas Municipal Water Use.*

3. Kansas Water Office, 2007, *Kansas Municipal Water Conservation Plan Guidelines.*

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5. Various authors, 2008, *Sedimentation in Our Reservoirs: Causes and Solutions*, Kansas Center for Agriculture and the Environment, Kansas Water Office, Kansas State University.

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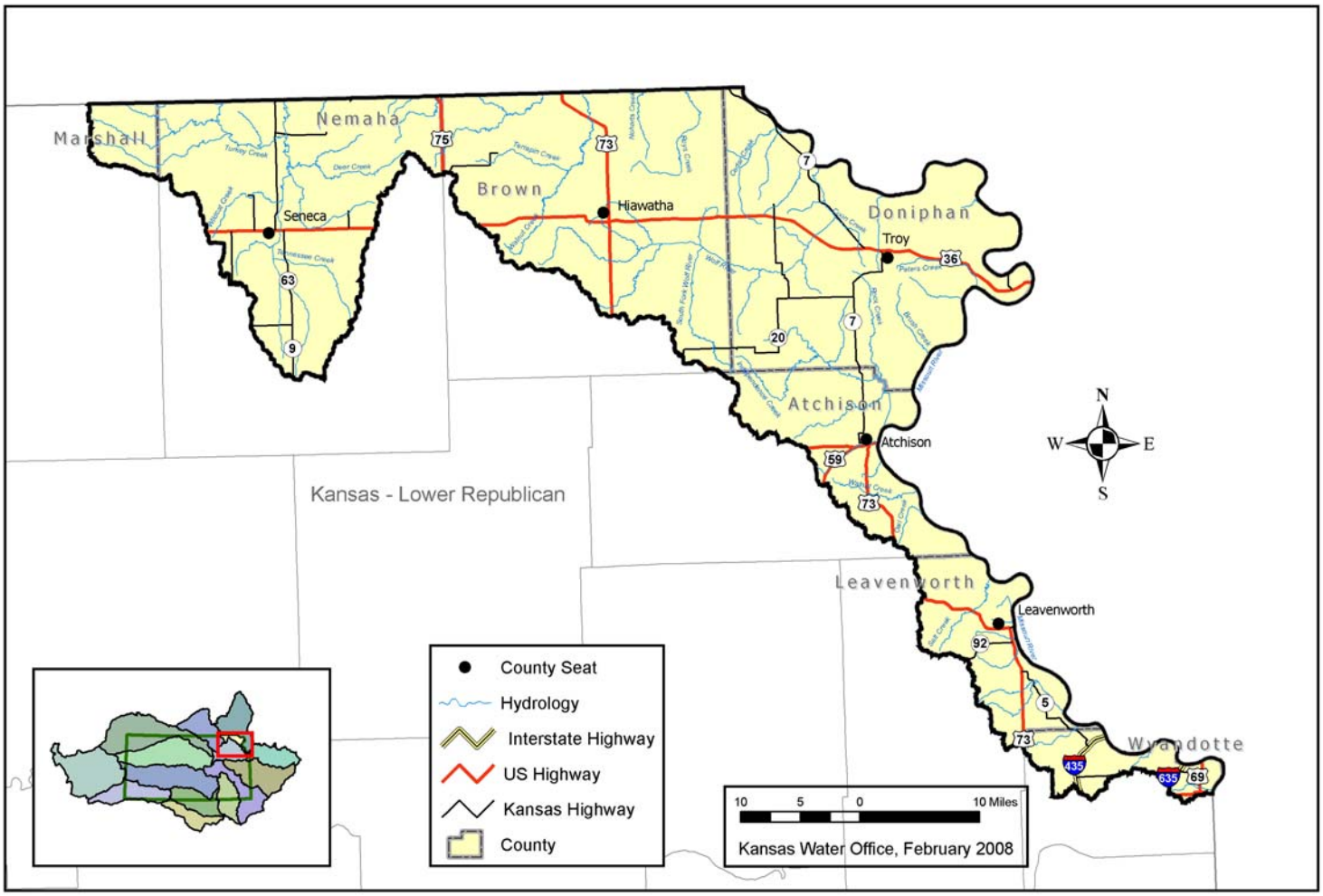
7. U.S. Army Engineer Research and Development Center, 2007, *National and Regional Economic Effects of Corps of Engineers Recreation Visitor Spending: An Update.*

Missouri River Basin



General Description

The Missouri basin covers about 1,600 square miles of the northeastern corner of Kansas including Hydrologic Unit Codes 10240007, 10240008, 10240005 and 10240011. This represents a small fraction of the entire Missouri River watershed which covers all or part of ten states and extends into Canada. The basin covers all or part of Marshall, Nemaha, Brown, Doniphan, Atchison, Leavenworth and Wyandotte counties in Kansas and is the smallest of the 12 major basins in the state, accounting for about two percent of the total land area.

Tributary streams include the South Fork of the Big Nemaha River which along with other tributaries in Washington, Nemaha and part of Brown County drains northward into Nebraska as part of the Big Nemaha River watershed which enters the Missouri River just upstream of the Kansas border. Tributaries of the Missouri River in Kansas include the Wolf River and numerous smaller creeks. There are no federal reservoirs in the basin. Ground water sources available in the region include alluvial and glacial deposits. For planning purposes, that portion of the Blue River drainage in Johnson County, which joins the Missouri River in Jackson County, Missouri is included in the Kansas-Lower Republican basin.

Elevations in the basin range from 1,340 feet above mean sea level (MSL) near Corning at the headwaters of the South Fork of the Big Nemaha River to 706 feet at the confluence with the Kansas River in Kansas City. The basin contains the cities of Leavenworth, Atchison, Troy, Hiawatha, Seneca and Kansas City, Kansas along with many smaller communities.

Population and Economy

There were an estimated 143,000 residents in the basin in the year 2000 (KWO estimate). According to the U.S. Census Bureau, the total population of the seven counties that are contained in whole or in part within the Missouri basin had a population of 284,011 in 2000.[1] By 2040, the population of these counties is projected to increase by about 16% to 330,470. However, nearly all this increase is projected to occur in Wyandotte and Leavenworth counties. The population in the remainder of the basin is projected to decrease by approximately eight percent.

This illustrates major demographic changes which are taking place in Kansas. In the past 40 years, two trends have dominated the state and the basin.

Rural counties have lost population, sometimes more than 10% every decade. Urban counties are gaining population, particularly Leavenworth which is projected to grow 36% by 2040. Every predominately rural county in the basin is expected to lose population except Brown and Marshall counties which are expected to grow by 694 people by 2040.

Confluence of the Missouri and Kansas Rivers. Photo courtesy KGS.

Wyandotte County is one of the most heavily developed areas of Kansas with little agricultural land. Expanding retail, entertainment and residential development in the western portion of the county will likely result in conversion of any remaining open land in the coming years and affect adjoining areas of southern Leavenworth County. Fort Leavenworth and the Leavenworth Federal Penitentiary along with the Lansing State Prison are major economic drivers in Leavenworth County. Private colleges are located in Leavenworth and Atchison and public community colleges are located in Highland and Kansas City, Kansas.

In the remainder of the basin, agricultural production is the primary economic activity. Corn, wheat, soybeans and grain sorghum are the primary crops with the highest quantity of harvested acres in the northern tier of counties. Beef cattle and hog production are also concentrated in the northern counties with significant dairy production in Leavenworth and Nemaha counties. The value of crops grown in the seven counties either wholly or partly within the Missouri basin exceeded $324 million in 2006 while livestock and dairy production topped $94 million.

While the basin lacks large federal reservoirs and associated wildlife areas, there are two State Fishing Lakes and a number of county and city lakes which support public recreation. Waterfowl hunting along the Missouri River and associated riparian areas attracts sportsmen to both private (with permission) and public lands.

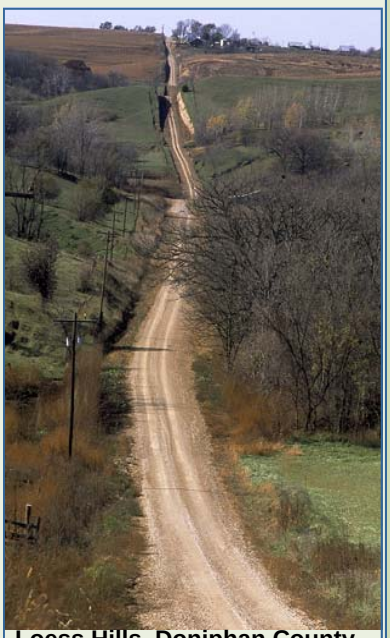
Physical Characteristics

Geology and Soils

The topography of the Missouri basin is influenced by glacial deposits of the Pleistocene age. The area is part of the glaciated region physiographic province and is also described as the Dissected Till Plains section of the Central Lowlands. In the upland areas between major streams, the land surface is flat to undulating with rounded hills and resembles the unaltered drift topography left after the last period of glaciation. The valleys of the smaller streams tend to be narrow and deep. Adjacent to the Missouri River, loess deposits replace the glacial drift and later erosion of this material created hilly terrain and steep bluffs.

Over much of the basin, glacial drift covers bedrock of Pennsylvanian and Permian systems which consist primarily of alternating layers of limestone and shale with some local sandstone. Glacial material is composed of unconsolidated till and outwash and reaches a thickness of up to 250 feet. Rock outcrops occur where principal streams have cut through the glacial drift.

Four major soil associations occur in the basin. The Monona and Marshall silt loams along the Missouri River bluffs are derived from loess and are productive for agriculture but prone to erosion. Further west, the Sharpesburg silty clay loam along with the Shelby and Marshall silt loams are less steep but still erodible. The western third of the basin contains the Grundy and Pawnee silty clay loams and the Burchard and Shelby silt loams. The clay loams are relatively level but have low permeability. The silt loams occupying the steeper slopes are more permeable. The alluvial soils which occupy the floodplains of the Missouri and larger streams are deep and productive.



Loess Hills, Doniphan County Photo courtesy KGS

Land Use/Land Cover

The predominant features in the basin are the crop land in the Missouri River floodplain and urbanized areas of Atchison, Leavenworth/Lansing and Kansas City, Kansas. Cropland (56%) and grassland (24%) are the most widespread land cover classes covering nearly 81% of the basin. In 2006 there were an estimated 4,920 farms containing 1,968,900 acres in the seven counties either partly or wholly within the basin, with the average farm about 400 acres. Within the 100-foot corridor along each bank of streams within the Missouri River basin, 39% of the land is forested followed by cropland (18%) and mixed trees and crops (15%).

The basin contains many important highway and rail transportation corridors. U.S. Highways 73, 75 and 159 cross the basin from north to south while U.S. 36 crosses from east to west. The Union Pacific Railroad services most of the basin. The Missouri River as it borders Kansas is also maintained for barge traffic by the U.S. Army Corps of Engineers although activity has been reduced in recent years by extended drought in the upper basin.

Climate

The climate of the Missouri River basin in Kansas is classified as humid continental with cold winters and hot summers. Normal mean temperature generally increases from northwest to southeast across the basin. The average annual mean temperature of the basin is 54 deg. F. Most of the precipitation falls in the growing season with June typically being the wettest month with a basin-wide average precipitation of 38 inches. Flood events, such as in July 1993 and the drought experienced from 1952-1956, underscore the variability in precipitation.

	Average Annual[1]		Freeze Dates (32 F.)[2]		
Location	Precipitation (inches)	Temperature (deg. F.)	Last in Spring	First in Fall	Frost Free Days
Atchison	38	54	Apr. 13	Oct. 21	192

[1] Source: National Climatic Data Center (1971-2000 data)
[2] Source: KSU Weather Data Library (1961-1990 data)

Wildlife and Habitat

The Missouri basin encompasses a variety of wildlife habitats ranging from cultivated bottomland to rolling uplands with a mixture of crops and grasslands. The Missouri River serves as a corridor for many migratory bird species. Habitat loss due to urban development is an issue, particularly in the lower basin.

Nineteen state or federally listed threatened or endangered species of wildlife share a probable or historic range within the basin. A total of nine fish, seven birds, two reptiles and one insect are listed as threatened or endangered in the Missouri basin, including designated critical habitat for ten species.

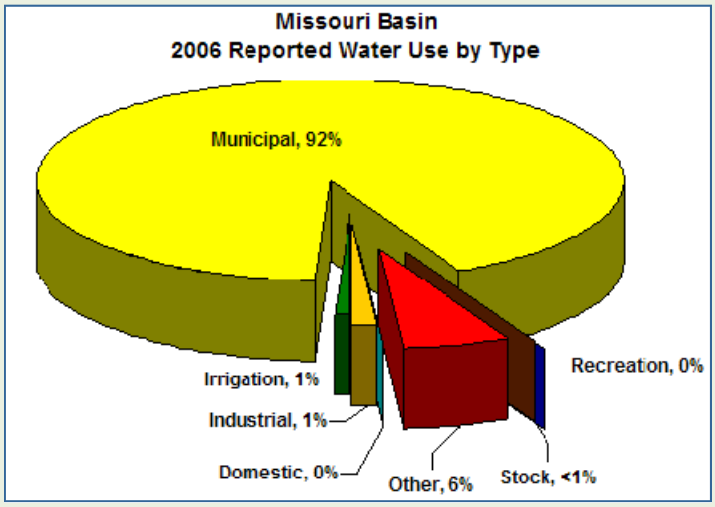
Water Resources

There are 3,341 stream miles in the Missouri basin. About 1,038 miles of these streams are considered perennial and 2,303 intermittent. Stream density is 2.3 stream miles per square mile which is typical for the eastern part of Kansas.

The Missouri River as it borders Kansas is greatly influenced by water releases from the six federal reservoirs located in Montana, North Dakota, South Dakota and Nebraska. Water releases from these reservoirs support commercial navigation and other downstream uses. After eight consecutive years of drought in the Missouri basin, reservoir storage in the upper reservoirs has been significantly reduced resulting in shortened navigation seasons. The maximum daily discharge for the Missouri River at Kansas City for the period of 1958-2001 was 529,000 cubic feet per second (cfs). Mean daily flow at this location is 42,100 cfs and target flow for full navigation services is 41,000 cfs.

There is one state Multipurpose Small Lake, Pony Creek, in the basin which serves as the water supply for the City of Sabetha. Water is piped to the city which is located just south of the Missouri basin watershed divide.

Surface water is the primary source for the 33 public water suppliers in the basin, accounting for more than 93% of the use in 2006. Ground water sources available in the basin include alluvial and glacial deposits. Ninety-two percent water use in the basin is for public water supply.



Water Management

There are six watershed districts in the basin primarily engaged in flood control. Watershed districts are formed to construct, operate and maintain structures and improvements for water management. Each county also has a Conservation District dedicated to improving water quality and reducing soil erosion. Much of the basin is covered by the Glacial Hills Resource Conservation and Development Program.[6]

Watershed Restoration and Protection Strategies (WRAPS) are stakeholder-driven management plans designed to address multiple water resource issues within a specific watershed. A basin-wide Missouri River WRAPS is currently being developed.[5] It is anticipated that WRAPS projects in the basin will encompass priority areas for water quality improvement, source water assessment areas and priority areas for wetland and riparian protection.

Pony Creek Reservoir

Resources

1. U.S. Census Data, 2000.

2. USDA. *Kansas 2006-2007 Farm Facts, Agricultural Statistics and Ranking*.

3. Wilson, Brownie, 2003. *Assessment of Riparian Areas Inventory, State of Kansas*

4. Kansas Department of Agriculture-Division of Water Resources. 2007. Water Rights Information System (WRIS).

5. Kansas Department of Health and Environment. Accessed Jan. 2009. Watershed Restoration and Protection Strategies (WRAPS) www.kswraps.org

6. Natural Resources Conservation Service. Accessed Jan. 2009. Resource Conservation and Development Information. www.ks.nrcs.usda.gov.partnership.rcd/

The Missouri River Mitigation Project

The Missouri River Mitigation Project is designed to mitigate, or compensate, for fish and wildlife habitat losses that resulted from past channelization of the Missouri River. Managed by the U.S. Army Corps of Engineers, the Project extends from Sioux City, Iowa to the mouth of the Missouri River near St. Louis, a distance of 735 river miles.

Restoration will be accomplished by means of land acquisition from willing sellers, dredging filled-in areas, reopening historic chutes, bank stabilization, dike notching, pumping, dike/levee construction, vegetative plantings, and vegetation and land management.

In Kansas, three bottomland tracts have been acquired or are in the acquisition process. The project includes the 2,112-acre Benedictine Bottoms area which is managed by the Kansas Department of Wildlife and Parks for three habitat types that existed in the area before development: timber, native grass and wetlands.

Constructed Wetland, Benedictine Bottoms
Photo courtesy of the Corps of Engineers

Missouri River Basin Management Categories

January 2009

WATER MANAGEMENT CATEGORIES

The following categories include issues identified in the Missouri basin plan as items that require attention in addition to the basin priority issues. These issues are addressed with the following management categories:

- Water Management
- Water Conservation
- Public Water Supply
- Water Quality
- Wetland and Riparian Management
- Flood Management
- Water-Based Recreation

These categories correspond to the statewide management categories and policies of the *Kansas Water Plan* found in Volume II. These documents contain new policy issues and the existing policy and statutory framework that relate to the management categories.

ISSUE: WATER MANAGEMENT

The mainstem of the Missouri River and the glacial aquifer are the major sources of water supply in the basin. All the major streams in the basin are open to new appropriations. There are no sites in the basin where minimum desirable streamflows have been set.

Flows in the Missouri River are influenced by management of several mainstem reservoirs in Montana and the Dakotas. These reservoirs are operated by the U.S. Army Corps of Engineers for flood control, navigation and other purposes in accordance with the *Missouri River Master Manual*.

Missouri River from Benedictine College. Photo courtesy KGS

Applicable *Kansas Water Plan* Objectives

- By 2015, achieve sustainable yield management of Kansas surface and ground water sources outside of the Ogallala-High Plains aquifer and areas specifically exempt by regulation. Sustainable yield management would be a goal that sets water management criteria to ensure long term trends in water use will move as close as possible to stable ground water levels and maintenance of sufficient streamflows.

Applicable Programs

The following programs help to meet the objectives in the Water Management (quantity) category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Appropriation Program
- Kansas Geological Survey and Kansas Department of Agriculture-Division of Water Resources: Water Well Measurement
- U.S. Army Corps of Engineers: Missouri River Reservoir Control Program
- USDA-Natural Resources Conservation Service: Environmental Quality Incentive Program

ISSUE: WATER CONSERVATION

Water conservation is essential for the effective management of water resources in the basin to assure that a sufficient long-term supply of water is available for the beneficial uses of the people of the state. Conservation is defined as a careful preservation and protection of something, especially the planned management of a natural resource to prevent exploitation or destruction. Water conservation is part of maintaining a long-term water supply for Kansas.

Water conservation activities apply to all uses: irrigation, municipal, industrial, etc., and from all sources. Municipal water supply (92%) accounts for the majority of water used in the basin. Industrial and irrigation each represent one percent of water use with stock water and other uses making up six percent (2006).

Eighteen public water suppliers in the Missouri basin have approved municipal conservation plans. Plans for two suppliers were developed based on guidelines from 1986 with the remainder based on the 1990 guidelines. All these plans should be updated to incorporate the changes in the *2007 Municipal Water Conservation Plan Guidelines.*

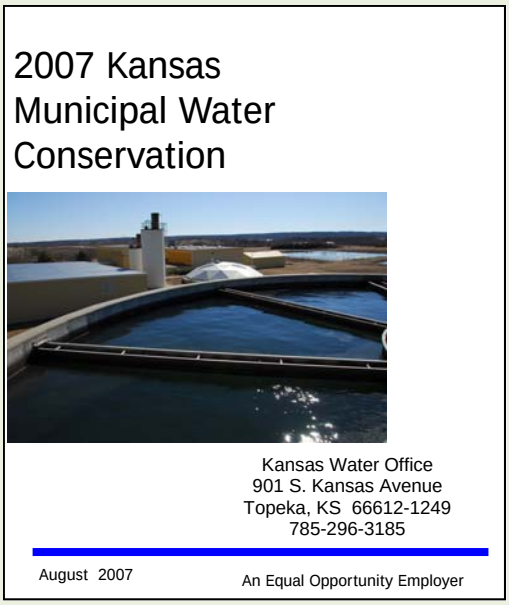
Water conservation plans include drought stage triggers that are the signals that a water shortage or other condi-

tions indicative of drought have reached certain stages or levels. They act as the signal to begin implementation of actions appropriate to the stage. Triggers may be related to supply conditions or demand levels. A given stage should have more than one trigger to confirm that conditions are worsening. Appropriate conservation practices in the areas of education, management and regulation should be listed under each stage. Delay in action may lead to a major disruption of the water supply system at a later time.

Most water utilities consider water as a commodity and encourage the use of water by their customers by striving to keep rates low. The availability of plentiful, inexpensive water is often promoted by communities to attract new growth. More recently, some communities have adopted rate structures that result in higher unit cost with increased use. This is one form of demand management.

The four basic types of water rate structures used by public water suppliers in Kansas are described as flat rate, decreasing block rate, uniform block rate, and increasing block rate. Utilities with a flat rate charge each customer a fixed amount per month regardless of the amount of water used. With a decreasing block rate, the unit cost of water decreases as usage increases. The unit cost of water is the same for all levels of usage with a uniform block rate. With an increasing block rate, the unit cost of water rises as usage increases.

The type of rate structure can affect water usage as measured in gallons per capita per day (gcpd). Systems with flat rates tend to use considerably more water per capita than systems that meter customer use. The other three types of rate structure, in which cost depends on amount of water used, have a less dramatic effect on gpcd. Decreasing block rates are assumed to discourage conservation because customers are charged lower rates for high-volume usage. Increasing block rates are considered an effective way to promote conservation among high-volume users while keeping the cost of moderate use affordable. However, the type of rate structure does not appear to influence usage by individual customers as much as does the total monthly water cost and the geographic area in which they live.



Applicable *Kansas Water Plan* Objectives

- By 2015, all non-domestic points of diversion meeting predetermined criteria will be metered, gaged, or otherwise measured.
- By 2015, conservation plans will be required for water rights meeting priority criteria under K.S.A. 82a-733 if it is determined that such a plan would result in significant water management improvement.

Applicable Programs

The following programs help to meet the objectives in the Water Conservation category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Appropriation Program
- Kansas Water Office: Water Conservation Program
- Kansas Department of Health and Environment: Kansas Public Water Supply Loan Fund
- USDA-Farm Services Agency: Conservation Reserve Program

ISSUE: PUBLIC WATER SUPPLY

The primary approach to addressing public water supply issues in the basin focuses on ensuring that there are adequate supplies of surface and ground water within the basin to meet future water demands, reducing the number of public water supply systems that are vulnerable to drought, and ensuring that systems have the technical, financial and managerial capacity to meet future needs for water quality and quantity.

There are 32 public water suppliers in the basin, including 13 rural water districts. There are currently no public wholesale water supply districts in the basin; however, negotiations are in progress to develop a district along with a portion of the Kansas River basin. Surface water is the primary source for most public water supplies, accounting for more than 93% of the total supply. There is one state multipurpose small lake in the basin which serves as the water supply for the City of Sabetha. Water from Pony Creek Reservoir is piped across the Mis-

souri basin watershed boundary to Sabetha, which is located just south of the basin.

Water usage in gpcd is calculated for each water system in the state from reported data on water use and population served. Average gpcd figures for large, medium and small water suppliers are calculated in eight regions of the state, based on similar geographic areas. The Missouri basin is located in region 8 with an average gpcd of 130, 102 and 84 for large, medium and small suppliers, respectively. This serves as a reference to indicate if individual suppliers are above or below average usage for the region.

Reducing "unaccounted for" water is a focus of water conservation efforts in the Missouri basin. Unaccounted for water includes any unmetered uses plus water loss in the distribution system. Technical assistance is available through the Kansas Water Office (KWO) for systems with more than 30% unaccounted for water. High amounts of unaccounted for water may result from water line breaks, under registering meters, unmetered uses, faulty metering or inaccurate accounting. The statewide average percentage of unaccounted for water use in 2006 was 14%. Management of unaccounted for water is a fundamental tool in providing adequate water supply.

Drought vulnerable public water supplies are those systems most likely to be the first ones impacted by drought due to basic source, distribution system or treatment capacity limitations; or that rely on a single well as a water supply source. The KWO and the Kansas Department of Health and Environment (KDHE) identified drought vulnerable water suppliers in 2006. Three public water supplies were considered drought vulnerable in the Missouri basin. The KDHE Capacity Development Program has been beneficial in reducing drought vulnerability throughout the state as communities assess their systems and identify areas in need of improvement.

Applicable *Kansas Water Plan* Objectives

- By 2010, ensure that sufficient surface water storage is available to meet projected year 2040 public water supply needs for areas of Kansas with current or potential access to surface water storage.
- By 2010, less than five percent of public water suppliers will be drought vulnerable.
- By 2010, reduce the number of public water suppliers with excessive "unaccounted for" water by first targeting those with 30% or more "unaccounted for" water.
- By 2010, ensure that all public water suppliers have the technical, financial and managerial capability to meet their needs and to meet Safe Drinking Water Act requirements.

Applicable Programs

The following programs help to meet the objectives in the Public Water Supply category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Appropriation Program
- Kansas Department of Health and Environment: Public Water Supply Program
- Kansas Water Office: State Water Planning Program
- Kansas Water Office: Water Conservation Program

ISSUE: WATER QUALITY

See the Watershed Restoration and Protection Priority Issue for a discussion of current issues concerning water quality.

Water quality is addressed through a combination of restoration and protection efforts using both voluntary, incentive-based approaches and regulatory programs.

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce the average concentration of bacteria, biochemical oxygen demand, solids, metals, nutrients, pesticides and sediment that adversely affect the water quality of Kansas lakes and streams.
- By 2010, ensure that water quality conditions are maintained at a level equal to or better than year 2000 conditions.
- By 2010, reduce the average concentration of dissolved solids, metals, nitrates, pesticides and volatile organic chemicals that adversely affect the water quality of Kansas ground water.
- By 2010, maintain, enhance, or restore priority wetlands and riparian areas.
- By 2015, nutrient reduction goals will be included in all WRAPS projects within the basin.
- By 2010, all public water suppliers will complete and implement a source water protection plan.

Applicable Programs

The following programs help to meet the objectives in the Water Quality category. For more information on the

programs and associated policies, see the Programs Manual.

- Kansas Department of Health and Environment: Watershed Management Section/WRAPS
- Kansas Department of Health and Environment: Watershed Planning Section/TMDL Program
- Kansas Department of Health and Environment: State Water Plan Program (Contamination Remediation)
- Kansas Corporation Commission: Conservation Division Programs
- Kansas Department of Health and Environment: Local Environmental Protection Program
- State Conservation Commission: Nonpoint Source Pollution Control Program
- State Conservation Commission: Water Resources Cost-Share Program

Loess Hills, Doniphan County. Photo courtesy KGS

ISSUE: WETLAND AND RIPARIAN MANAGEMENT

See the Watershed Restoration and Protection Priority Issue for a discussion of current activities concerning wetland and riparian area protection.

The primary approach to wetland and riparian management in the basin focuses on providing technical and financial assistance to landowners to protect and restore these resources in priority watersheds through the implementation of best management practices.

The U.S. Army Corps of Engineers conducts the Missouri River Mitigation Program to restore habitats in the floodplain. See the Increase Recreational Use and Access Priority Issue for additional information on this program.

Applicable *Kansas Water Plan* Objectives

- By 2010, maintain, enhance or restore priority wetlands and riparian areas.

Applicable Programs

The following programs help to meet the objectives in the Wetland and Riparian Management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Forest Service: Forest Stewardship Program and Conservation Tree Planting Program
- State Conservation Commission: Riparian and Wetland Protection Program
- Kansas Water Office: State Water Planning Program
- Kansas Department of Wildlife and Parks: State Parks and Wildlife Areas Planning and Development
- Kansas Department of Wildlife and Parks: Wildlife Habitat Improvement Program
- State Conservation Commission: Kansas Water Quality Buffer Initiative

ISSUE: FLOOD MANAGEMENT

The primary approach to flood management in the basin focuses on community participation in the National Flood Insurance Program and reduction of rural flood damages through construction of watershed dams within organized watershed districts.

As of 2003, the basin had 19 communities (cities and counties) participating in the National Flood Insurance Program. One community has been suspended from the program and three communities with identified flood hazard areas do not participate. There are six watershed districts organized in the basin.

Applicable *Kansas Water Plan* Objective

- By 2010, reduce the vulnerability to damage from floods within identified priority communities or areas.

Applicable Programs

The following programs help to meet the objectives in the Flood Management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Structures Program/Floodplain

Management
- State Conservation Commission: Watershed Planning Assistance Program
- Federal Emergency Management Agency (FEMA): National Flood Insurance Program
- Kansas Division of Emergency Management: Hazard Mitigation Grants Program

ISSUE: WATER-BASED RECREATION

See the Increased Water Recreation Use and Access Priority Issue for a discussion of current activities concerning water-based recreation in the basin.

Applicable *Kansas Water Plan* Objectives

- By 2010, increase public recreational opportunities at Kansas lakes and streams.

Applicable Programs

The following programs help to meet the objectives in the Water-Based Recreation category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Wildlife and Parks: Rivers and Stream Access
- Kansas Department of Wildlife and Parks: Community Fisheries Assistance Program
- Kansas Water Office: State Water Planning Program

ISSUES FOR FUTURE ACTION

- Increased public participation by federal, state and tribal entities in water management.

- Water management to maintain instream flows for fish, wildlife and their habitats.

Missouri Riverbank Catfishing Spot. Photo courtesy KGS

Missouri Basin High Priority Issue
Missouri River Bed Degradation Impacts
January 2009

Issue

Lowering of the Missouri River bed in the reach bordering Kansas threatens water intakes, bridge abutments and other "hard points" along the river channel. Wildlife habitat in the river and along its banks has also been negatively impacted by channel degradation.

Some impacts from bed degradation are well documented, such as the lowering of surface water levels at water intakes in Kansas City, Kansas. Others, such as the status of foundations of bridge abutments and piers, are less known. Another unknown is the rate of degradation. Observations from the Missouri River near Kansas City indicate that the rate of degradation is accelerating.

Missouri River bed degradation in Kansas potentially impacts water intakes for drinking water suppliers and electric power plants, underground pipelines, bridge and channel structures, levees and bank stabilization structures, recreational boat ramps and habitat for fish and wildlife including those federally listed as threatened or endangered. Old bridge piers previously removed to a certain level to guard against navigation obstructions are being exposed.

Description

The Missouri River System

The Missouri River has been heavily modified from presettlement conditions. Starting in 1930, the Kansas City District of the U.S. Army Corps of Engineers (Corps) has placed rock fill (revetments) on the bank of nearly every outer bend of the Missouri River.[3]

The Corps operates a system of six reservoirs on the Missouri River main stem controlling runoff from approximately half the basin. Together, they comprise the largest system of reservoirs in the United States. The upper three reservoirs, Fort Peck in Montana, Garrison in North Dakota, and Oahe in both North and South Dakota are the Corps' three largest reservoirs. Their water storage at normal pool represents more than 50 times the combined storage of Tuttle Creek, Milford and Perry lakes in the Kansas River basin.[5] The reservoir system also provides flood control and navigation benefits to Kansas.

The Missouri River is a significant source of water supply to the Kansas City metropolitan area and other communities of northeast Kansas along the river and beyond (including water for cooling at power generation facilities).

In addition to reservoirs, the Missouri River navigation channel is maintained by a complex series of dikes and revetments. These structures concentrate the flow of the river to maintain a channel depth sufficient for commercial barge traffic. The Missouri River flood plain also contains a system of levees and dikes to contain flood flows.

With the construction of reservoirs and bank stabilization structures in the 1960s, sediment concentrations in the Missouri River have decreased by approximately 80%.[3] Along the Kansas reach of the river, there are major stream gaging stations at Leavenworth, Kansas and at St. Joseph and Kansas City in Missouri. During several years of drought through 2007, these gages have recorded all-time low river levels each year.[3]

The Missouri River is exhibiting a significant bed degradation trend as illustrated on Figure 1. The most severe degradation is in the Kansas City reach between river miles 340 and 400[1], but is also occurring at other locations. Degradation on the Missouri is considered to be causing the lower Kansas River to degrade as well (see Kansas River Bed Degradation).

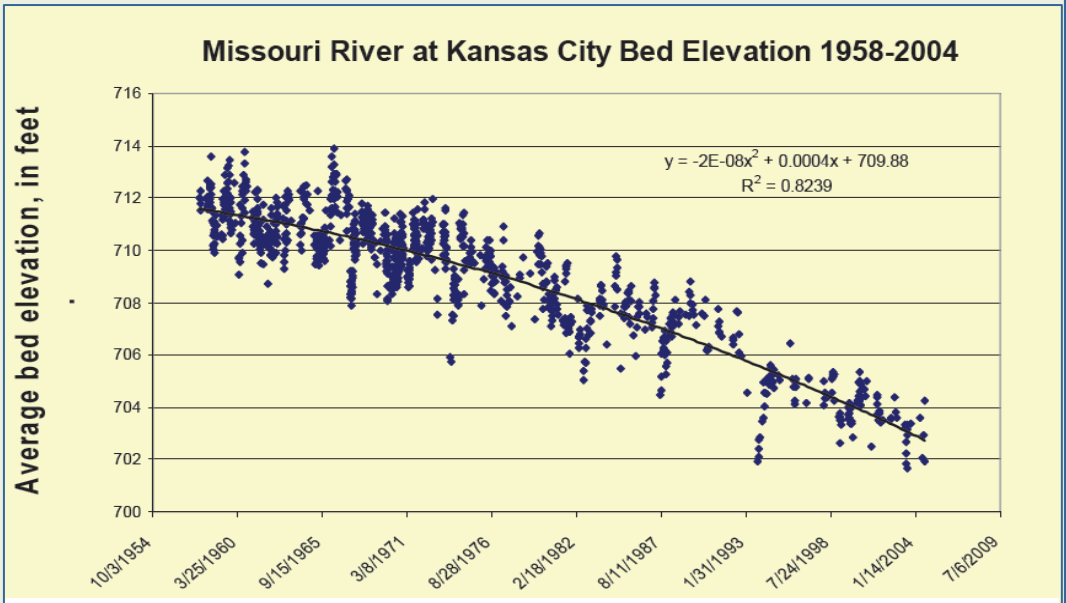


Figure 1. **Source: U.S. Geological Survey**

Corps of Engineers Actions

On August 20, 2007, the Corps issued a joint decision regarding commercial dredging operations in the Missouri River. The decision stated that due to increasing bed degradation throughout the river reach between St. Louis and Rulo, Nebraska, there would be no authorizations for dredging after December 31, 2009, without completion of an Environmental Impact Statement as required by the National Environmental Policy Act (NEPA).[1]

The Corps has received funding to conduct a reconnaissance study to determine federal interest in Missouri River bed degradation. The purpose of the study is to gather existing data and assess the need for additional data, develop a plan for modeling requirements and conduct preliminary geomorphology and sediment modeling. The Corps study will begin with the formation of a focused team of national experts and agencies such as U.S. Geological Survey. Together they will coordinate with river stakeholders to develop a coalition of sponsoring partners for the next phase of detailed investigations and design of any corrective action.

Known Impacts

In their proposal for the reconnaissance study, the Corps estimates the regional financial impact of Missouri River bed degradation as follows: Intake low-water costs from 2000 to 2004: $18,773,321; intake costs for actively planned projects in the near future: $63,159,120; low water future infrastructure: $286,075,000; federal levee upgrades: $250 million.[1]

The Wyandotte County Board of Public Utilities has detailed costs of retrofitting two electrical generating stations due to lowering of the water surface elevation on the Missouri.[3] While considered to be related to bed degradation, reduced flow due to drought in the upper Missouri basin and other factors also may contribute to the decrease in surface elevation.

The Nearman Creek Power Station is a 235 megawatt base load unit located at river mile 378.4. From 1999 to 2006, the surface water elevation had an average reduction of 15 feet. The intakes were designed for a river level of 735.5 above mean sea level. At elevation 725.5, cavitation begins, adding air and causing pumps to lose efficiency. Temporary pumps have been employed to lift water from elevations as low as 721 feet.

Nearman Creek Power Station

These changes required the construction of a new cooling tower at the Nearman Station at a cost of $20 million and $1.2 million for emergency pumps.

The Quindaro Station, a 78 megawatt power plant at river mile 373.3, required installation of emergency pumps at a cost of $1,400,000. Total impact of water level declines due to bed degradation to date with capital, operation and maintenance and purchased power is estimated by the Wyandotte County Board of Public Utilities to exceed $35 million.

The Kansas City (MO) Water Service has monitored historic bed degradation at their primary water treatment intake. Between 1930 and 1950, they recorded approximately 1.5 feet of degradation of the Missouri River bed. In 1951, they constructed a new intake. Between 1950 and 1970, there were two additional feet of degradation. Between 1970 and 1990, there were 2.5 additional feet of degradation with an additional five feet of degradation between 1990 and 2005. These changes have required the use of auxiliary pumps which are subject to ice damage.

Recommended Actions

1. Investigate the application in Kansas of infrastructure modifications from other states with similar conditions.

2. Monitor impacts to riparian habitats and species related to degradation.

3. Conduct an inventory of bridges, pipelines and other channel infrastructure considered to be susceptible to bed degradation.

4. Monitor and assist with the U.S. Army Corps of Engineers reconnaissance study of bed degradation on the Missouri.

5. Track the cost of past and ongoing repair for retrofit of water intakes (power and water supply) required due to bed degradation.

Resources

1. U.S. Army Corps of Engineers, Kansas City District. 2007. *Missouri River Degradation: Kansas and Missouri, Proposal under General Investigations, Section 216 of the Flood Control Act of 1970*.

2. U.S. Army Corps of Engineers, Kansas City District. 2007. News Release: *Missouri River Commercial Dredging Permits*.

3. Mid America Regional Council. March 2007. River Degradation meeting notes and presentations, North Kansas City, Missouri.

4. Kansas Water Office. January 2005. *Kansas Water Plan Concept Paper: Channel Degradation in the Kansas River*.

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Missouri Basin High Priority Issue
Increased Water Recreation Use and Access
January 2009

Issue

A lack of access to water-based recreational resources in the Missouri basin inhibits recreational activity and the associated economic, educational and stewardship benefits.

The Missouri basin does not contain the large federal reservoirs that support most water-based recreation in Kansas. There are two state fishing lakes managed by the Kansas Department of Wildlife and Parks (KDWP) plus ten county and community lakes in the basin.

The Missouri River borders Kansas for 1212 miles and is one of three rivers legally open to public recreational access. There are currently public boat ramps in Leavenworth, Atchison, Elwood, White Cloud and Kansas City, Kansas. There are additional ramps and accesses on the Missouri side of the river.

Benedictine Bottoms near Atchison was acquired by the U.S. Army Corps of Engineers (Corps) and has been managed for wildlife habitat and hunting since 1999 by the KDWP. Benedictine College also conducts biological research at this location. Two new parcels acquired under the Missouri River Mitigation Program will more than double the acreage in Kansas under this program. While management emphasis will be on habitat restoration, expanded recreational opportunities may be available at the new mitigation sites.

Description

The Missouri basin has the smallest land area of the twelve major river basins in Kansas. According to the U. S. Census Bureau, the total population of the seven counties that are contained in whole or in part by the Missouri basin was 284,011 in 2000, or about 10.5% of the State population. By 2040, the population of these counties is projected to increase by about 16% to 330,470. However, nearly all this increase is projected to occur in Wyandotte and Leavenworth Counties which are influenced by the Kansas City metropolitan area which is the largest potential recreational user base in the state.

There are no state parks within the basin. As measured from the City of Atchison in the central portion of the basin, the closest state parks are Perry (44 miles), Clinton (58 miles) and Hillsdale (81 miles). In Missouri, Lewis and Clark and Weston Bend State Parks border the Missouri River. The Missouri Basin Section of the *2003 Kansas Water Plan* identified an issue for future action on development of a "Missouri River Bluffs State Park." Due to the lack of a suitable location and funding constraints, action has been deferred on this issue.

The Missouri basin contains two state fishing lakes managed by the KDWP.[4] Brown County State Lake is a 60 acre impoundment near Robinson with an adjoining 188 acre wildlife area open to public hunting. In addition to fishing, picnicking and primitive camping are allowed at the lake with limited facilities. Atchison County State Fishing Lake northwest of Atchison contains 66 surface acres of water and 182 acres of land of which approximately 136 acres, plus the lake, are open to hunting. A rental cabin is under construction at Atchison State Fishing Lake to complement the existing primitive camping facilities.

One of the more widely distributed water-based recreational resources in the Missouri basin are small lakes and parks operated by cities and counties. Collectively known as community lakes, they have been developed and maintained by local governments with assistance through the Community Fisheries Assistance Programs , Land and Water Conservation Fund (parks), both administered by KDWP.[1] Table 1 identifies community lakes in the Missouri basin.

Table 1.
Community Lakes – Missouri Basin

Lake	Water Area	Managed By:
Atchison City Lakes 1-4, 6-9, 23, 24	90 acres	City of Atchison
Atchison County Lake	60 acres	Atchison County
Hiawatha City Lake	7 acres	City of Hiawatha
Lansing City Lake	1 acre	City of Lansing
Leavenworth - Jerry's Lake	¾ acre	Leavenworth County
Sabetha City Lake	100 acres	City of Sabetha
Troy 4-H Lake	5 acres	City of Troy
Wyandotte Co. - Big 11	3 acres	Unified Gov. - KCK, WYCO
Wyandotte Co. Lake	407 acres	Unified Gov. - KCK, WYCO
Wyandotte Co. - Pierson Park Lake	12 acres	Unified Gov. - KCK, WYCO

The Missouri River typically flows at four to five miles per hour creating potentially hazardous conditions for boaters. Wing dams, buoys, bridges, barge traffic and sand dredges can present hazards to watercraft when combined with the speed of the current. Due to the wide channel, high winds affect canoes and kayaks.[6] It is legal to camp along the river below the normal high water mark but sand bars are often covered during summer due to navigation releases from upstream of Kansas reservoirs.

Missouri Basin High Priority Issue
Increased Water Recreation Use and Access
January 2009

The distance between access points is important to unpowered recreational water craft. While access points are well-spaced in the upper river, access points are further apart above Kansas City.

The Missouri River Mitigation Project is administered by the Corps to acquire and develop aquatic and terrestrial habitat to compensate for losses resulting from past channelization of the Missouri River.[3] In Kansas, the 2,111 acre Benedictine Bottoms was purchased in 1994 and developed in 1998. Along with habitat restoration, the area supports research, fishing, bird watching, hiking and hunting (by special permit). Overnight camping, campfires, and/or motorized vehicles are not allowed on the mitigation lands.

Two additional properties have been acquired under the Mitigation Project near Elwood and Atchison. These additional parcels will approximately double the area managed under the program. While habitat restoration will be the primary purpose of these areas, options may exist to develop compatible recreational activities.

In 1989, the KDWP found that 30% of Kansas State Park users drive more than 50 miles for access to public lands and waters.[1] Fuel prices are likely to play a larger role in recreational use than in the past, making local access to parks, lakes and natural areas increasingly important. While the availability of public lands is not likely to significantly increase, planning to make optimal use of existing recreational resources will be needed.

Benedictine Bottoms. Photo courtesy Corps of Engineers

Recommended Actions

1. Evaluate the placement of existing access points on the Missouri River in both Kansas and Missouri, to determine the need for additional access points in Kansas.

2. Encourage recreational use of private lands through access programs such as walk-in hunting and fishing and other programs administered by Kansas Department of Wildlife and Parks.

3. Develop recreational opportunities on Missouri River Mitigation Program properties as consistent with the primary purpose of habitat restoration.

4. Emphasize the educational potential of existing water resources through interpretive signage and programs.

5. Investigate non-governmental support and funding to develop water-related recreation and educational opportunities in Kansas.

Resources

1. Kansas Wildlife and Parks. 2005. *Strategic Plan*, *Seventh Edition.*

2. Kansas Wildlife and Parks. 2003. *Kansas Comprehensive Outdoor Recreation Plan.*

3. U.S. Army Corps of Engineers. Accessed September 2008. Missouri River Mitigation Project, Iowa, Kansas, Missouri, Nebraska. http://www.nwk.usace.army.mil/projects/mitigation/index.htm

4. Kansas Wildlife and Parks Locations. Accessed September 2008. http://www.kdwp.state.ks.us/news/kdwp_info/locations

5. HTNB Corporation. April 2002. *Missouri River Recreation Study*.

6. Dave Murphy. 2008. *Paddling Kansas*. Trails Books. www.trailsbooks.com.

Missouri Basin High Priority Issue
Watershed Restoration and Protection
Approved January 2008

Issue

Water quality is addressed through a combination of restoration and protection efforts using both voluntary, incentive-based approaches and regulatory programs. The protection and restoration of watersheds draining to the Missouri River is a high priority in the Missouri Basin. With the urbanization of the southern part of the basin, protection and restoration of these watersheds has become more important.

Water Quality Impairments

Many streams within the basin are experiencing water quality impairments. Fecal coliform bacteria and biological stressors are the most prevalent stream impairments. Sedimentation and eutrophication due to nutrient loading are the primary water quality problems affecting reservoirs in this basin.

Surface waters not meeting water quality standards in the basin are included on the 2006 303d list of impaired waters.[1] High priority Total Maximum Daily Loads (TMDLs) for impaired surface waters in the Missouri basin were originally submitted to the Environmental Protection Agency for approval in 1998 by the Kansas Department of Health and Environment (KDHE). An additional round of TMDL development was completed in 2007. High priority TMDL watersheds are identified to target technical and financial assistance for implementation of non-point source pollution management practices to address designated pollutants.

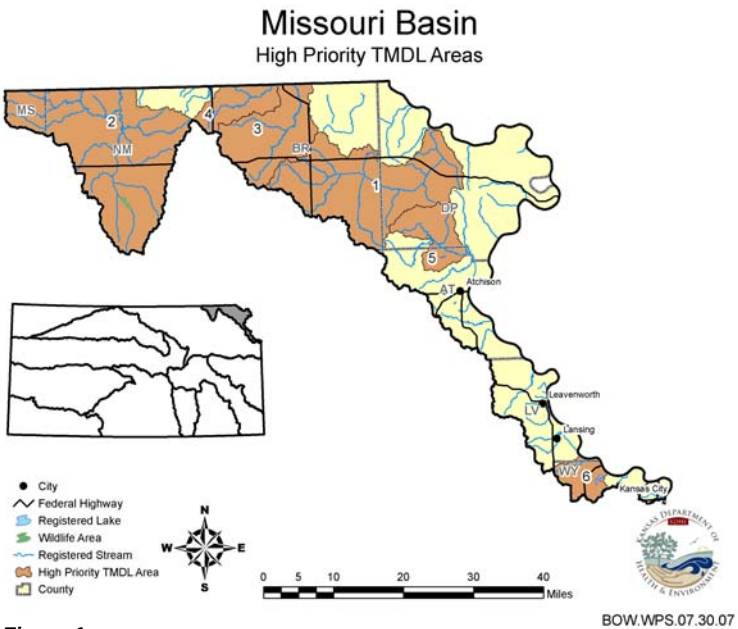


Figure 1

A TMDL is the maximum amount of a pollutant that a water body can receive without violating water quality standards. Since pollution can arrive via point and non-point sources, the TMDL development process identifies contributing sources for the pollutant loads. High priority TMDL areas are shown in Figure 1 and Table 1.[1]

TABLE 1
MISSOURI BASIN HIGH PRIORITY TMDLS

MAP ID	*WATERBODY*	IMPAIRMENTS	HUC 11 WATERSHEDS
STREAM SEGMENT			
1	Wolf River	FCB, BIO	10240005060
2	Big Nemaha River	FCB, BIO	10240007010 10240007021 10240007030
3	Walnut Creek	FCB	10240008050
LAKES			
4	Pony Creek Lake	E	10240008050
5	Atchison State Fishing Lake	E	10240011010
6	Wyandotte Co. Lake	E	10240011030

Note: For each of the high priority lakes in the basin, the TMDL only applies to the area upstream of the lake.

Key:
E: Eutrophication, biological community impacts and excessive nutrient/organic loading
BIO Biology
FCB: Fecal Coliform Bacteria
HUC: U.S. Geologic Survey Hydrologic Unit Code
See the KDHE TMDL website for additional information[1]

Surface Water Nutrient Reduction

Nutrient sources within the basin include both point and non-point sources. The major point sources in the basin include large wastewater treatment plants which are regulated under the National Pollutant Discharge Elimination System (NPDES) Program (Figure 2) administered by KDHE.

Figure 2

The *Kansas Surface Water Nutrient Reduction Plan*,[2] developed by KDHE, outlines a statewide strategy for reducing the export of total nitrogen (TN) and total phosphorus (TP) in surface waters leaving the state. This involves additional reductions in nutrients from point source discharges through the NPDES Program and reductions in non-point sources through development and implementation of Watershed Restoration and Protection Strategies (WRAPS).

The Nutrient Reduction Plan includes Improvement Potential Index (IPI) maps for Kansas counties for TP and TN reductions.[2] A scale (low potential improvement to high potential improvement) was developed for: phosphorus fertilizer use, excess on-farm manure phosphorus quantity, nitrogen fertilizer use, nitrogen fertilizer transport potential and excess on-farm manure nitrogen quantity.

These values were used to calculate IPI values for nitrogen (scale 1-20) and phosphorus (scale 1-10) on a county-by-county basis. The higher the ranking value, the greater the relative potential for improvements produced within that county. It should be noted that the IPI is a relative measure. It does not mean a county with an IPI of eight can make twice the improvement of a county with an IPI of four. The higher IPI only suggests there is a greater possibility of improvement. In the Missouri basin, Nemaha County showed an improvement potential range of 8.1 - 12.0 for TN with Brown County showing a range of 4.1 - 8.0 TN. The IPI index range for TP was 6.1 - 8.0 for both counties. All other counties in the basin had an IPI index of less than 2 for TN and TP.

Nonpoint sources of pollution include both agricultural and urban areas. KDHE has not assigned nonpoint source nutrient loads to the Missouri River due to the impractical nature of sampling for Kansas specific inputs. The Missouri basin, however, has one of the largest nutrient point sources in the state at the Kaw Point wastewater treatment plant in Kansas City, Kansas. While no data on nutrient reduction are available for the Kansas portion of the Missouri basin because of a lack of non-point source data, efforts are being made to work with Kansas City, Kansas to study nutrient reduction at the Kaw Point treatment plant.

Source Water Protection

All public water suppliers in the basin completed source water assessments in cooperation with KDHE in 2004.[3] The next step, is the development of voluntary source water protection plans.

Of the 17 public water suppliers in the basin which treat raw water, four use surface water and 14 use ground water (one uses both). Each source water assessment included a susceptibility score which can help communities determine which contaminants pose the most significant threat to their water supply. A score generated from the susceptibility analysis, indicates whether the susceptibility range is low, moderate or high for potential threats of contamination in an assessment area.

KDHE provided public water suppliers susceptibility scores in the following contaminant categories: microbiological, nitrates (applicable for ground water only), pesticides, inorganic compounds, synthetic organic compounds, volatile organic compounds, sedimentation (surface water only), and eutrophication/phosphorus (surface water only).

Of public water suppliers using ground water in the Missouri basin, 64% had low susceptibility scores and 36% had moderate scores. Of public water suppliers using surface water, 25% had low susceptibility scores and

75% had moderate scores. The most commonly identified problems with ground water were volatile and synthetic organic compounds, pesticides and microbes. The most commonly identified problems with surface water were volatile and synthetic organic compounds, inorganic compounds, sediment and eutrophication/ phosphorus.

For communities using ground water, development of a wellhead protection program is recommended. For communities using surface water, the development of a watershed restoration and protection strategy (WRAPS) is the best mechanism to ensure water quality protection for their public water supply. The Missouri basin has three complete and approved source water protection plans as of 2004.[3]

Wetland and Riparian Area Management

The primary approach to wetland and riparian area management in the basin focuses on providing technical and financial assistance to landowners to protect and restore these resources in priority watersheds through the implementation of best management practices. Water quality has been a primary focus with implementation efforts targeted to high priority TMDL watersheds (Figure 2). All conservation districts in the basin have developed wetland and riparian protection plans.

Watershed Restoration and Protection Strategies

Watershed Restoration and Protection Strategies (WRAPS) are stakeholder-driven management plans designed to address multiple water resource issues within a specific watershed. The WRAPS process provides a means to integrate objectives from multiple local, state and federal programs into a comprehensive, coordinated strategy for a specific watershed. This can include TMDL attainment, nutrient reduction, source water protection, riparian and wetland management and other natural resource objectives.

A basin-wide Missouri River WRAPS is currently being developed.[6] It is anticipated that WRAPS projects in the basin will encompass priority areas for TMDL implementation, areas with a high improvement potential index for nutrient reduction, source water assessment areas and priority areas for wetland and riparian protection.

An important consideration for watershed restoration and protection in this basin, particularly in the southern portion of the watershed, is urbanization. Between 2000 and 2006, the population of Leavenworth County increased by 4,929 or 7.2%. All other counties in the basin experienced declines in population. Although Wyandotte County declined in population by 1.5% over the period, it remains the most urbanized county in the basin.

As the amount of impervious surface in a watershed (i.e. rooftops, roads, parking lots, etc.) increases, water resources can be adversely impacted. Runoff volume increases and additional pollutants associated with urban environments may enter streams and ponds unless preventive steps are taken by local government and urban residents. Sound land use planning and storm water management are essential to limit adverse effects.

Local land use planning and zoning authorities provide cities and counties effective tools to minimize the potential impacts of development on water resources. Urban stormwater management programs can be implemented to manage the amount of impervious surface in urbanizing watersheds and properly control increased runoff resulting from urbanization. Programs that provide technical assistance and education to urban residents regarding actions that can reduce or eliminate potential pollution sources also play an important role. These programs can be integrated with WRAPS projects to ensure a comprehensive approach to watershed management in urban areas.

Another consideration for watershed restoration and protection in the basin will be the potential for conversion of Conservation Reserve Program (CRP) acreage back to production agriculture as contracts expire. Of the 90,251.6 acres enrolled in six of the seven Kansas counties contained wholly or partly in the Missouri basin, contracts on 18,942.1 acres expired on September 30, 2007.[4] The total CRP acreage in Wyandotte County is restricted under the Freedom of Information Act, but is considered to be minimal. If land is taken out of permanent grass cover, implementation of best management practices will be needed to minimize potential adverse impacts to water resources within the basin.

Other Watershed Related Activities

- The seven counties either wholly or partly within the basin have adopted local sanitary/environmental codes or participate in the Local Environmental Protection Program.
- Doniphan, Leavenworth and Wyandotte counties have countywide planning and zoning programs.
- All conservation districts in the basin have adopted nonpoint source pollution management plans.

Grants under the State Water Quality Buffer Initiative have also been awarded in Doniphan, Marshall and Nemaha counties to support buffer coordinators and facilitate enrollment of stream buffers in continuous CRP.

- Of cities in the basin, Kansas City, Kansas, Leavenworth and the Kansas portion of St. Joseph located west of the Missouri River have been issued Phase II Permitted Municipal Separate Storm Sewer System under the NPDES Stormwater Program.
- As of December 2006, there were three active contamination sites being remediated through the State Water Plan Program (Contamination Remediation)
- There are six organized watershed districts in the basin.

Applicable Kansas Water Plan Objectives

- By 2010, reduce the average concentration of bacteria, biochemical oxygen demand, solids, metals, nutrients, pesticides and sediment that adversely affect the water quality of Kansas lakes and streams.
- By 2010, ensure that water quality conditions are maintained at a level equal to or better than year 2000 conditions.
- By 2010, reduce the average concentration of dissolved solids, metals, nitrates, pesticides and volatile organic chemicals that adversely affect the water quality of Kansas ground water.
- By 2010, maintain, enhance or restore priority wetlands and riparian areas.

Basin Specific Objectives

- By 2010, over 25% of the high priority TMDLs identified in 2001 and 2007 for the Missouri basin will have data supporting their delisting as impaired on the 2012 Kansas 303(d) list.
- By 2010, all public water suppliers will complete and implement a source water protection plan.
- By 2015, nutrient reduction goals will be included in all WRAPS projects within the basin.
- By 2015, integrate urban stormwater management goals into all urban area WRAPS and support the implementation of urban stormwater management projects as outlined in WRAPS action plans.

Recommended Actions

1. Work with stakeholder groups to incorporate TMDL implementation, nutrient and sediment reduction, and urban stormwater management goals into applicable WRAPS projects.

2. Target technical and financial assistance programs for water quality protection and restoration to implement TMDLs and WRAPS action plans.

Resources

1. Kansas Department of Health and Environment, Bureau of Water. 2007. *Watershed Planning and TMDL Program*. www.kdheks.gov/tmdl

2. Kansas Department of Health and Environment, Bureau of Water. December 2004. *Surface Water Nutrient Reduction Plan*, www.kdheks.gov/water

3. Kansas Department of Health and Environment, Bureau of Water. 2004. *Kansas Source Water Assessment Report*. www.kdheks.gov/nps/swap

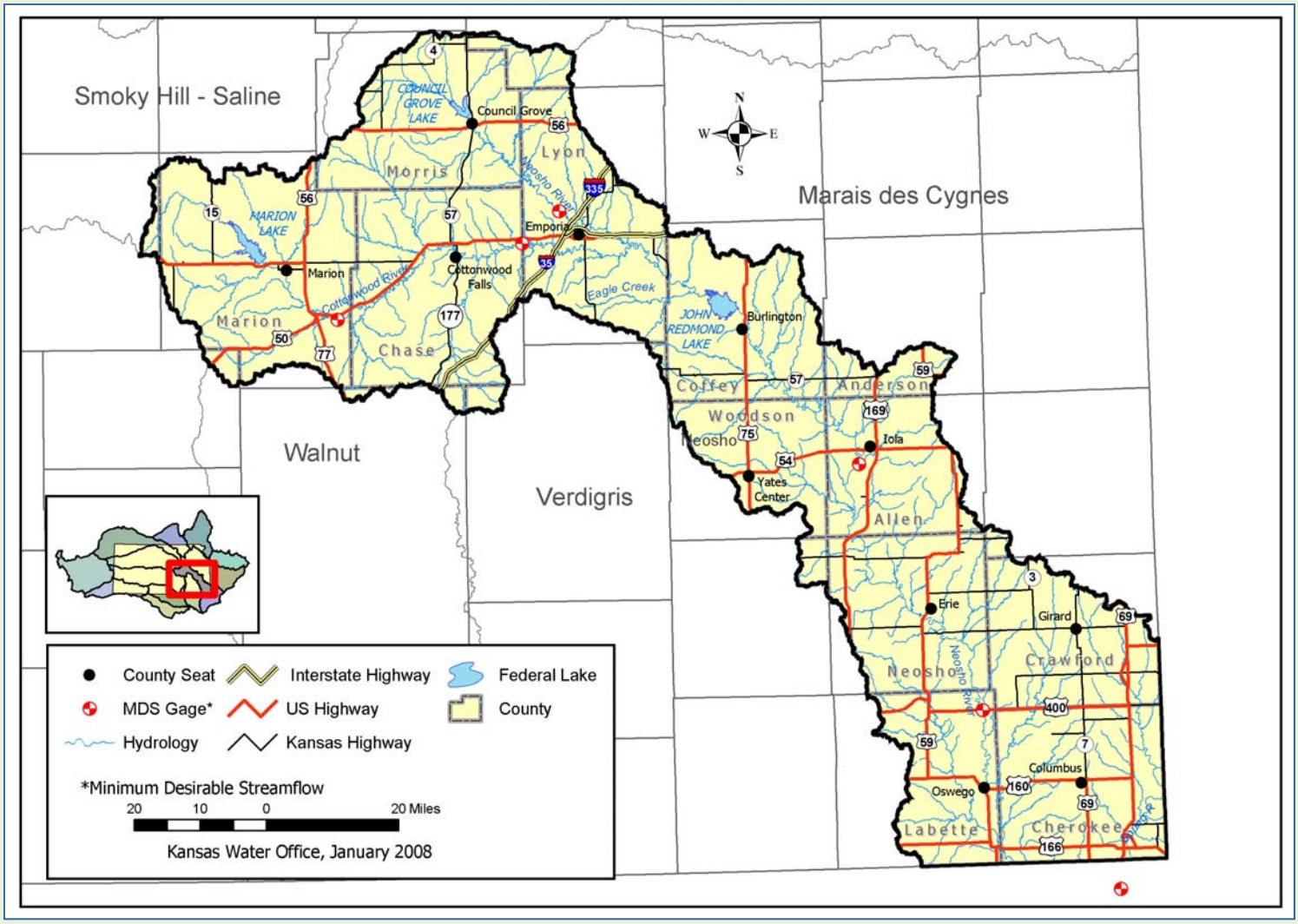
4. USDA Farm Service Agency. 2007. *Summary of Active and Expiring CRP Cropland Acres by County* www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=crt

5. Kansas Water Office. 2006. Kansas *Water Plan Water Quality Policy and Institutional Framework Section*.

6. Kansas Department of Health and Environment, Bureau of Environmental Remediation. December 2005. *Basin Updates and Site Accomplishments*

7. Kansas Department of Health and Environment, Bureau of Water. 2007. *Kansas Watershed Restoration and Protection Strategy*. www.kdheks.gov/nps/wraps

Neosho River Basin



General Description

The Neosho River basin covers approximately 6,300 square miles and encompasses all or parts of 18 counties in southeastern and east central Kansas. The area is drained by the Neosho River and its tributaries which also drain parts of Missouri, Arkansas, and Oklahoma. The Neosho Basin includes HUCs 11070201 through 11070207 in Kansas.

The major streams in the basin are the Neosho River and two major tributaries: the Cottonwood River and the Spring River. The Neosho River rises in Morris County and flows southeast to join the Arkansas River near Muskogee, Oklahoma. The Cottonwood River rises in Marion County and joins the Neosho River in Lyon County east of Emporia. The Spring River in the southeast part of the state originates in Missouri and drains about 500 square miles in Kansas. It enters Cherokee County in the east, flows across the southeastern corner of that county, and joins the Neosho River in Oklahoma a short distance below the Kansas state line.

The larger tributaries of the Cottonwood River are South Cottonwood River, Mud Creek, Clear Creek, Doyle Creek, Cedar Creek, Middle Creek, Diamond Creek, and South Fork Cottonwood River. Tributaries to the Neosho with drainage areas greater than 70 square miles are Rock and Allen Creeks above Emporia, and Eagle Creek, Long Creek, Big Creek, Turkey Creek, Deer Creek, Elm Creek, Owl Creek, another Big Creek, Flat Rock Creek, Lightning Creek, Cherry Creek, and Labette Creek below Emporia.

Elevations in the basin range from 1,320 feet in Marion County at the top of the basin to 826 feet in Cherokee County at the bottom of the basin in Kansas.

There are three major federal reservoirs in the river system: Marion Reservoir is on the Cottonwood River and Council Grove and John Redmond Reservoirs are on the mainstem of the Neosho River. Ground water is found in alluvial deposits along major streams.

***Population and Economy*[8]**

Major cities in the basin include, proceeding generally from northwest to southeast, Hillsboro, Marion, Council Grove, Strong City, Emporia, Burlington, Iola, Chanute, Parsons, Oswego, Pittsburg, Galena and Baxter Springs.

Downtown Council Grove.
Photo courtesy Kansas Geological Survey

There were an estimated 174,000 residents in the basin in the year 2000. The population of 13 of the counties that have significant land area in the basin was 204,349 in 2000 and is projected to decline to 189,127 by the year 2040. No counties in the basin are expected to gain population during this time but the more rural counties are projected to lose proportionally more population than the counties having regional urban centers. For example, the population of Chase County is projected to have a 15% decrease, while the population of Crawford County is projected to have only a 2 percent decrease by the year 2040.[9]

The local economy is based primarily on agriculture, general manufacturing, and retail trades. The major crops grown in the basin include wheat, grain sorghum and soybeans. The value of crop production in 2006 was estimated to be $372,524,860. The production of beef cattle is another important part of the area's agricultural economy. The value of livestock production in 2006 was estimated to be $261,789,300.[5]

The Neosho basin has a greater variety of minerals than any other area in Kansas. The production of oil and gas is a relatively small but important component of the economy. A significant amount of coal, lead and zinc mining occurred historically in the southeastern portion of the basin. Strip mining of coal is the only one of these mining activities which continues today. Lead and zinc mining peaked in 1926 and by 1958, mining of these minerals had all but ceased. Legacy heavy metal pollution[11] and dangerous underground mine shafts still plague southeast Kansas.

Natural resources of economic importance to area economies are oil, gas, cement, ceramic materials, coal, lead, zinc, stone, and sand and gravel. An additional component of the local economy is the only nuclear powered generating plant in Kansas, located near Burlington. The Wolf Creek Nuclear Power Plant is the largest single water user in the basin. A large biodiesel plant is under construction (November 2007) in Emporia.

Wolf Creek Nuclear Power Plant. Photo courtesy KGS

Water based recreation is important to the economy of the basin with three federal reservoirs, a State Fishing Lake in every county, and nine community lakes attracting boaters, anglers, hunters and campers. State Parks and commercial marinas are located on and around the federal reservoirs in the basin.

Located on the broad, flat flood plain below the junction of Flat Rock Creek and the Neosho River, the Mined Land Wildlife Area is a man-made marsh developed by the Kansas Department of Wildlife and Parks (KDWP) in 1960.

The area covers 3,246 acres. The five largest pools on the area represent 1,675 acres of the 1,787 of intensively managed wetlands. There are 16 independently managed wetlands throughout the area. The area was primarily designed, and is managed to, furnish a resting and feeding place for migratory waterfowl.

Emporia State University and Pittsburg State University provide opportunities for higher education as well as numerous community colleges including Ft. Scott, Labette County and Neosho County community colleges.

Physical Characteristics

Geology and Soils

The Neosho Basin lies chiefly in the Osage Cuestas section of the Central Lowlands Ecoregion.[2] However, all three subdivisions of that ecoregion occur in the Neosho Basin: The Flint Hills Upland, the Osage Cuestas, and the Cherokee Lowlands. The Flint Hills, in the western part of the basin, are an area of outcrop of flint-bearing Permian rocks. The Osage Cuestas division occupies over one half of the basin and is characterized by many east-facing escarpments which trend irregularly from north-northeast to south-southwest across the basin. Southeast of the Osage Cuestas section of the basin is the Cherokee Lowlands area. This is an erosional plain which slopes to the west at about 10 feet per mile.

Most of the consolidated surface rocks in the basin are of Pennsylvanian and Permian age. These rocks consist of alternating thin beds of limestone and shale. Coal is present in some areas. Mississippian age rocks are exposed in a small area in the extreme southeast corner of Cherokee County. Mostly composed of limestones and cherty limestones, these areas contain lead and zinc ores. Small areas of Cretaceous and Tertiary rocks are exposed in Marion and McPherson counties. The flood plains and terraces associated with the streams consist of deposits of clay, silt, sand, and gravel, which are mostly of more recent Quaternary age.

There are nine major soil groups in the basin. Soil types include fine textured low permeability types, silt loams, sand silt loams, dense claypans, and alluvial and terrace soils. More detailed soil information can be found on county soil maps.[12]

Clements stone arch bridge over Cottonwood River
Photo courtesy Kansas Geological Survey.

Land Use/Land Cover

The predominant features in the basin are the grasslands of the Flint Hills in the northwestern part of the basin, crop land in the Neosho River and other flood plains, in the Marion Reservoir watershed, and in the Cherokee County area, and the urbanized areas described previously.

Plant communities in the study area include Oak-Hickory Forest, Floodplain Forest, Cross Timbers, Cedar Glades, Bluestem Prairie, and Bluestem-Grama Prairie. Grassland (56%), and row crops, (38%) are the most widespread land cover classes covering about 3,738,540 acres of the basin.

In 2006, there were 8,530 farms covering 4,708,000 acres in the thirteen counties with significant area in the basin. The average farm size was 551 acres.[3]

The basin contains many important highway and rail transportation arteries. The basin map shows locations and coverage.

According to the 2003 Assessment of Riparian Areas Inventory by the Kansas Geological Survey (KGS), of the 37,257 bank miles of riparian area, within a 100 ft corridor along each bank in the basin, the dominant riparian cover is pasture/grassland (31%).

The second most common cover is forest land (25%), and third most common cover is a mixture of pasture and trees (20%)

The remaining riparian cover types, in descending order of dominance, are crop land, crop land/tree mix, shrub land, urban, urban/tree mix, and barren land. Overall land use/land cover in the basin mirrors riparian land use/cover with grassland covering 56% of the area, crop land covering 32%, and woodlands covering about 7 percent. The balance is made up of urban uses and water.[6]

Climate

The climate of the Neosho basin is humid in the southeastern half and sub-humid in the northwestern half. The annual precipitation in the basin varies from approximately 30 inches in the western-most part of the basin to almost 42 inches in the southeast. Approximately 70% of this precipitation falls between April and September. Ten to 18 inches of snow falls in an average winter. Table 1 illustrates variation in annual average precipitation and temperature, and freeze dates from areas in the northern, middle, and southern parts of the basin.

Table 1
Climate Summary
Neosho Basin

	Average Annual[1]		Freeze Dates (32 F.)[2]		
Location	Precipitation (inches)	Temperature (deg. F.)	Last in Spring	First in Fall	Frost Free Days
Cottonwood Falls	35.91	54.3	Apr. 19	Oct. 14	179
Iola	41.84	55.8	Apr. 11	Oct. 23	195
Columbus	44.47	56.2	Apr. 13	Oct. 22	192

[1] Source: National Climatic Data Center (1971-2000 data)
[2] Source: KSU Weather Data Library (1961-1990 data)

Wildlife and Habitat

The Tallgrass Prairie National Preserve in the Flint Hills, covering 1,895 acres, was established in 1997. The preserve protects a nationally significant example of the once vast tallgrass ecosystem. Of the 400,000 acres once covered in the North American Continent, less than 4 percent remains, primarily in the Flint Hills of Kansas. The Flint Hills National Wildlife Refuge above John Redmond Reservoir is one of a system of over 500 refuges administered by the U.S. Fish and Wildlife Service (USFWS) dedicated to the preservation and conservation of wildlife. Named for the Flint Hills Region just to the west, the refuge consists of 18,500 acres located on the upstream portion of John Redmond Reservoir on land owned by the U.S. Army Corps of Engineers (Corps).

Established in 1966, the refuge is managed primarily for migratory waterfowl. Intensive use by ducks and geese occurs during the spring and fall migration. Surrounding farmlands are managed on a share basis with area farmers with the refuge share providing food for migrating waterfowl and resident wildlife. Numerous ponds and a system of shallow marshes provide additional waterfowl habitat. Waterfowl and bald eagle management requires that portions of the refuge be closed and that public access be restricted during periods of intensive waterfowl use.

Shermerhorn Cave, South of Galena.
Photo courtesy Kansas Geological Survey.

Schermerhorn Park, just south of Galena in the southeast corner of the basin, contains a small part of the Ozark oak-hickory forest ecosystem. Many of the threatened and endangered (T & E) species live in the “Kansas Ozarks”. The area is characterized by sinkholes, caves, swift streams, and steep cliffs.

Much of the original Ozark oak-hickory forestlands still remain in this region. Spring River and Shoal Creek are in this area and provide unique aquatic habitat for many species.

There are 36 T&E species in the Neosho basin. Of these, one is an insect, three are mammals, 10 are mussels, seven are birds, and four are fish. For additional information on critical habitat for these species, please see the KDWP[13] website in the references.

Because the basin covers a large geographic area with many ecosystem types and diverse land uses, the potential for habitat alteration is widespread resulting in pressures on populations of important species.

Water Resources

There are three federal reservoirs in the basin: Marion, Council Grove, and John Redmond. Coffey County State Fishing Lake provides cooling water for the Wolf Creek Nuclear Power Plant. All counties have state fishing lakes. Council Grove City Lake serves as a water supply for the city of Council Grove. Other localized resources that provide various services including water supply, recreation and habitat, include Jones Park Pond, Olpe City Lake, Gridley City Lake, Altamont City Lake, Bartlett City Lake, Lake Kahola, Mined Land Resources Area and Lake, Parsons Lake, Pittsburg College Lake, Marion County Lake, New Strawn City Lake, and Playter's Lake.

Lake Kahola spillway
Photo courtesy Kansas Geological Survey.

Eighty percent of the streams in the basin are intermittent and 20% are perennial streams, for a total of 16,696 miles. Average stream density is 2.7 stream miles/square mile of area, the second highest density of all 12 basins in the state.

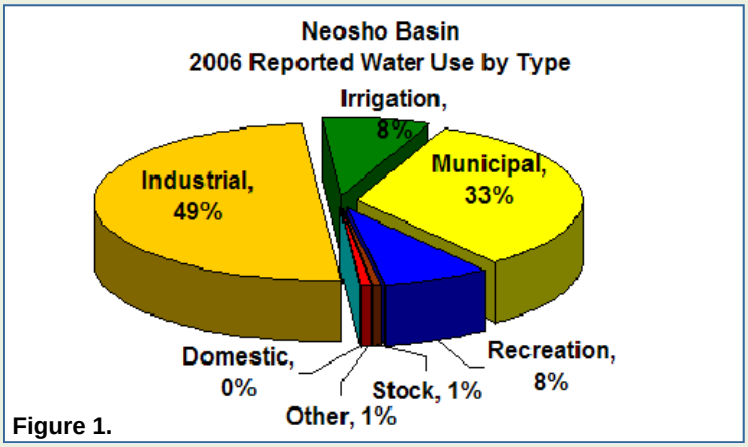


Figure 1.

The Ozark Plateau aquifer system and Spring River are water resources shared by Arkansas, Kansas, Missouri, and Oklahoma. Demand for water in the region is growing rapidly and concerns about water level declines and potential water quality degradation have prompted long-term management actions. See the Ozark Aquifer Priority Issue in this section for more information.

Nearly 77% of water used in the basin is from surface sources (2006 water use). About 49% of water used is for industrial use, (54% of this from surface water and 45% from ground water), making it the highest use type in the basin, followed by 33% for municipal use, about 8 percent for recreational use and 8 percent for irrigation use (Figure 1).[7]

Water Management

Significant water management entities include conservation districts throughout the basin, the See-Kan, Flint Hills and Lake Region Resource Conservation and Development Councils RC&Ds and 15 active watershed districts. By virtue of its responsibility for three major reservoirs, the Corps is another important water manager in the basin.

Watershed Restoration and Protection Strategy (WRAPS) groups are an emerging water management entity in the basin. These are coordinated by various entities including the See-Kan and Flint Hills RC&Ds, and local conservation districts.

Voluntary watershed management plans are developed by local stakeholders. The plans include management goals intended to improve the overall condition of land and water in the watershed. WRAPS groups have been formed above all three federal reservoirs, along Eagle Creek, the Spring River, and the area below John Redmond Reservoir.

The cities of Parson, Pittsburg, and Emporia are permitted under the KDHE Phase II Stormwater Permit Program. These municipalities are responsible for developing stormwater management programs to address both the quality and quantity of stormwater runoff within their boundaries.

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3. United States Geological Survey 2000. K. E. Juracek. Report No. 00-4177 "Estimation and Comparison of Potential Runoff Contributing Areas in Kansas Using Topographic, Soil, and Land Use Information.

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5. USDA, Kansas 2006-2007 County Farm Facts, Agricultural Statistics and Ranking.

6. Wilson, Brownie, Assessment of Riparian Areas Inventory, State of Kansas, 2003. http://hercules.kgs.ku.edu/geohydro/ofr/2003_55/riparian/ofr_2003_55e.htm.

7. WRIS database, Division of Water Resources, December 13, 2007.

8. US Census Data—2000.

9. County Population Estimates. KS Division of Budget. 2007.

10. Verdigris Unit Report—Kansas Water Resources Board Water Plan Studies.

11. Residual effects of lead and zinc mining on freshwater mussels in the Spring River Basin (Kansas, Missouri, and Oklahoma, USA. Robert t. Angelo, M. Steve Cringan, Diana L. Chamberlain, Anthony J. Stahl, Stephen G. Haslouer, Clint A. Goodrich. Kansas Department of Health and Enviroment, may 2007.

12. http://www.ks.nrcs.gov/news/annual_rpt02/soil.html

13. http://www.kdwp.state.ks.us/news/other-services/Threatened-and-Endangered-species

Impacts of Historic Mining Activities

Galena is a rural community located in southeast Kansas, within the Tri-State Mining District EPA Superfund Site in Cherokee County. For over a century, lead and zinc were mined in the region and resulted in production of nearly 3,000 abandoned mine shafts in Cherokee County. Even though lead and zinc mining activities subsided in the latter half of the 20th century, numerous environmental problems and other hazards remain.

Waste mine tailings, also known as chat, which are byproducts of the mining and milling processes for lead and zinc ore, cover 4,000 acres in southeastern Cherokee County according to the KGS. Chat hazards were not limited to just the tailings piles because the wind blew fine metal-bearing dust from tailings piles, spreading the contamination. In addition, leaching from the waste mine tailings has contaminated wells and ground water, with runoff moving contaminants into nearby streams and rivers.

Another by-product of mining operations was highly acidic mine drainage (acidic water, containing metals that can contaminate streams). When the lead and zinc mines were abandoned, they filled with water, and began contaminating local aquifers and surface waters.

Mining waste at Galena. Photo courtesy Kansas Geological Survey.

Neosho River Basin Management Categories

January 2009

WATER CATEGORIES

The following categories include issues identified in the Neosho River basin plan as items that require attention in addition to the basin priority issues. These issues are addressed within the following management categories:

- Water Management
- Water Conservation
- Public Water Supply
- Water Quality
- Wetland and Riparian Management
- Flood Management
- Water-Based Recreation

These categories also correspond to the statewide management categories and policies of the *Kansas Water Plan* found in Volume II. These documents contain new policy issues and the existing policy and statutory framework that relate to the management categories.

ISSUE: WATER MANAGEMENT

Applicable *Kansas Water Plan* Objectives

- By 2015, achieve sustainable yield management of Kansas surface and ground water sources outside of the Ogallala-High Plains aquifer and areas specifically exempt by regulation. Sustainable yield management would be a goal that sets water management criteria to ensure long term trends in water use will move as close as possible to stable ground water levels and maintenance of sufficient streamflows.

Applicable Programs

The following programs help to meet the objectives in the Water Management (quantity) category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Appropriation Program
- Kansas Geological Survey and Kansas Department of Agriculture-Division of Water Resources: Water Well Measurement
- Kansas Geological Survey: Stream Aquifer Interactions
- USDA-Natural Resources Conservation Service: Environmental Quality Incentive Program
- Kansas Water Office: Water Marketing Program
- Kansas Water Office: Water Assurance Program

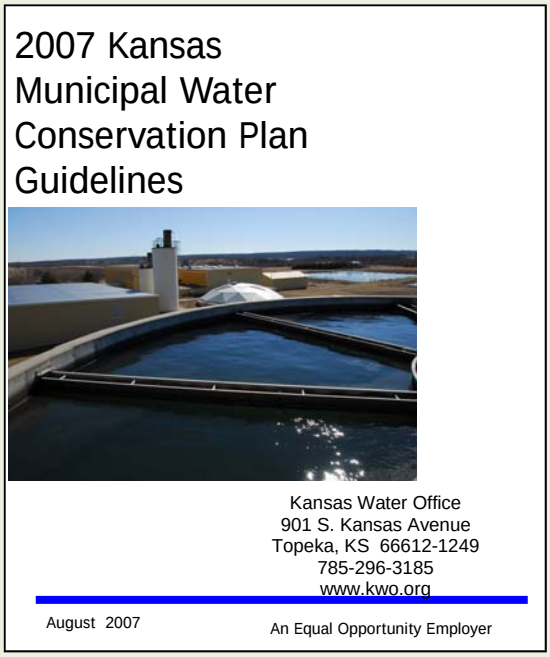
ISSUE: WATER CONSERVATION

Water conservation is essential for the effective management of water resources in the basin to assure that a sufficient, long-term supply of water is available for the beneficial uses of the people of the state. Conservation is defined as a careful preservation and protection of something, especially the planned management of a natural resource to prevent exploitation or destruction.

Water conservation activities apply to all uses; irrigation, municipal, industrial, etc, from all sources. Municipal (33%) and industrial uses (49%) account for the majority of water used in the basin. Irrigation and recreation uses both accounted for 8 percent with stock water (1 percent) and other uses (1 percent) making up the balance (2006).

Of the 111 public water suppliers in the basin 83 have developed a water conservation plan as of 2006. Twenty four plans following the new 2007 guidelines have been updated.

Most water utilities consider water as a commodity and encourage the use of water by their customers by striving to keep rates low. The availability of plentiful inexpensive water is promoted by communities in attracting new growth. More recently, communities are adopting rate structures that result in increased unit cost with increased use. This is one form of demand management.



The four basic types of water rate structures used in Kansas are described as flat rate, decreasing block rate, uniform block rate, and increasing block rate. Utilities with a flat rate charge each customer a fixed amount per month regardless of the amount of water used. With a decreasing block rate, the unit cost of water decreases

as usage increases. The unit cost of water is the same for all levels of usage with a uniform block rate. With an increasing block rate, the unit cost of water rises as usage increases.

The type of rate structure can affect gallons per capita per day (gpcd) usage. Systems with flat rates tend to use considerably more water per capita than systems that meter customer use. The other three types of rate structures, in which cost depends on amount of water used, have a less dramatic effect on gpcd. Decreasing block rates are assumed to discourage conservation because customers are charged lower rates for high-volume usage. Increasing block rates are considered an effective way to promote conservation among high-volume users while keeping the cost of moderate use affordable. However, the use of these types of rate structures does not appear to influence usage by individual customers as much as does the total monthly water cost and the geographic area in which they live.

Municipal Water Conservation Plans include drought stage triggers (Table 1) that are the signals that water shortage or other conditions indicative of drought have reached certain stages or levels. They act as the signal to begin implementation of actions appropriate to the stage. Triggers may be related to supply conditions or demand levels. A given stage should have more than one trigger to confirm that conditions are worsening. A water utility or other municipal water entity should enact the appropriate stage whenever the agreed upon set of triggers is reached. Delay in action may lead to a major disruption of the water supply system at a later time.

Table 1

Drought Stage Triggers used by public water suppliers with surface water sources:

1. Lake level in terms of elevation or capacity.
2. Stream level in terms of flow or stage.
3. Water level in relation to the dam.
4. Peak daily demand levels.
5. Percent capacity of treatment plant operations over a number of days.
6. Capacity of water system storage and ability to recover.
7. The provider for purchased water has issued a drought stage.
8. Emergency conditions related to repairs or water quality.
9. The Kansas Water Office has issued a drought stage based on the remaining water marketing storage in a basin reservoir.

Unaccounted for water includes any unmetered uses such as water used for fire fighting, plus water loss in the distribution system. Technical assistance is available through KWO for systems with more than 30% unaccounted for water. High amounts of unaccounted for water may result from water line breaks, under registering customers, unmetered uses, faulty metering, or inaccurate accounting. The statewide average percentage of unaccounted for water use in 2006 was 14%. Management of unaccounted for water is a fundamental tool in providing adequate water supply. Some unaccounted for water represents water that has been treated and then has been wasted and lost the potential to be put to beneficial uses.

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce the number of public water suppliers with excessive “unaccounted for” water by first targeting those with 30 percent or more “unaccounted for” water.
- By 2015, all non-domestic points of diversion meeting predetermined criteria will be metered, gaged, or otherwise measured.
- By 2015, conservation plans will be required for water rights meeting priority criteria under K.S.A. 82a-733 if it is determined that such a plan would result in significant water management improvement.

Applicable Programs

The following programs help to meet the objectives in the Water Conservation management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Appropriation Program
- Kansas State University Research and Extension: Water Conservation and Management Program
- State Conservation Commission: Water Resources Cost-Share Program
- Kansas Water Office: Water Conservation Program
- USDA-Farm Services Agency: Conservation Reserve Program

ISSUE: PUBLIC WATER SUPPLY

See Water Supply Management and Conservation Basin Priority Issue.

In addition to the Basin Priority Issue Water Supply Management and Conservation, there are continuing needs

to ensure that programs are in place and managed to address reducing the number of public water supply systems that are vulnerable to drought, and ensuring that systems have the technical, financial and managerial capacity to meet future needs for water quality and quantity.

Drought vulnerable water supplies are those suppliers most likely to be first impacted by drought due to basic source, distribution system or treatment capacity limitations; or that rely on a single well as a water supply source. Drought vulnerable water supplies were surveyed in 2003 and 2006. The number of public water suppliers considered drought vulnerable decreased from five to zero between the two surveys. There are currently no drought vulnerable water supplies in the basin. These reductions can be attributed to the Kansas Department of Health and Environment efforts in the Technical, Financial and Managerial and the KANCAP Programs.

There are 111 public water suppliers in the Neosho basin, of which 56 are rural water districts. There are six public wholesale water supply districts (PWWSDs) in the basin. About 77% of water used is from surface sources. The Cottonwood/Neosho River Basin Assurance District is also active in the basin. The Corps operates Council Grove, Marion and John Redmond reservoirs in coordination with the state to meet assurance district member's needs during periods of low flow.

Water usage in gpcd is calculated for each water system in the state from reported data on water use and population served. Average gpcd figures for large, medium, and small water suppliers are calculated in eight regions of the state based on similar geographic areas. The Neosho basin is located in regions 7 and 8. Average gpcd for large, medium and small suppliers in region 7 are 148, 107, and 96 respectively. Average gpcd in region 8 are 130, 102 and 84 for large, medium and small suppliers. This serves as a reference to indicate if individual suppliers are above or below average usage for the region.

Applicable *Kansas Water Plan* Objectives

- By 2010, ensure that sufficient surface water storage is available to meet projected year 2040 public water supply needs for areas of Kansas with current or potential access to surface water storage.
- By 2010, less than five percent of public water suppliers will be drought vulnerable.
- By 2010, ensure that all public water suppliers have the technical, financial and managerial capability to meet their needs and to meet Safe Drinking Water Act requirements.

Applicable Programs

The following programs help to meet the objectives in the Public Water Supply management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Appropriation Program
- Kansas Department of Health and Environment: Public Water Supply Program
- Kansas Water Office: State Water Planning Program
- Kansas Water Office: Water Conservation Program

ISSUE: WATER QUALITY

See the Watershed Restoration and Protection Basin Priority Issue

Water quality and related water resource issues are addressed through a combination of watershed restoration and protection efforts utilizing voluntary, incentive-based approaches, as well as regulatory programs.

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce the average concentration of bacteria, biochemical oxygen demand, solids, metals, nutrients, pesticides and sediment that adversely affect the water quality of Kansas lakes and streams.
- By 2010, ensure that water quality conditions are maintained at a level equal to or better than year 2000 conditions.
- By 2010, reduce the average concentration of dissolved solids, metals, nitrates, pesticides and volatile organic chemicals that adversely affect the water quality of Kansas ground water.
- By 2010, maintain, enhance, or restore priority wetlands and riparian areas.
- By 2015, nutrient reduction goals will be included in all WRAPS projects within the basin.
- By 2010, all public water suppliers will complete and implement a source water protection plan.

Applicable Programs

The following programs help to meet the objectives in the Water Quality management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Health and Environment: State Water Plan Program (Contamination Remediation)
- Kansas Corporation Commission: Conservation Division Programs
- Kansas Department of Health and Environment: Local Environmental Protection Program
- Kansas Department of Health and Environment: Watershed Management Section/WRAPS
- State Conservation Commission: Nonpoint Source Pollution Control Program
- State Conservation Commission: Water Resources Cost-Share Program

ISSUE: WETLAND AND RIPARIAN MANAGEMENT

See the Watershed Restoration and Protection Priority Issue for a discussion of current activities concerning wetland and riparian area protection.

The primary approach to wetland and riparian management in the basin focuses on providing technical and financial assistance to landowners to protect and restore these resources in priority watersheds through the implementation of best management practices.

Applicable *Kansas Water Plan* Objectives

- By 2010, maintain, enhance or restore priority wetlands and riparian areas.

Applicable Programs

The following programs help to meet the objectives in the Wetland and Riparian Management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Forest Service: Forest Stewardship Program and Conservation Tree Planting Program
- State Conservation Commission: Riparian and Wetland Protection Program
- State Conservation Commission: Kansas Water Quality Buffer Initiative
- Kansas Water Office: State Water Planning Program
- Kansas Department of Wildlife and Parks: Wildlife Habitat Improvement Program

ISSUE: FLOOD MANAGEMENT

The primary approach to flood management in the basin focuses on floodplain management through community participation in the National Flood Insurance Program (NFIP) administered by the Kansas Department of Agriculture-Division of Water Resources (DWR) and the reduction of rural flood damages through the construction of watershed dams in organized watershed districts.

The Neosho basin has 42 communities (cities and counties) participating in the NFIP. One community has been suspended from the program and nine communities with identified flood hazard areas do not participate. The counties, and incorporated cities within each, shown in Table 2 are in the process of updating their flood maps and will receive new flood hazard zone maps by September 2010. The counties and incorporated communities within each, listed in Table 3 have received new Flood Insurance Rate maps.

There are 15 active watershed districts in the basin.

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce the vulnerability to damage from floods within identified priority communities or areas.

Table 2 Updating Flood Hazard Maps
Allen County
Crawford County
Marion County
Labette County
Neosho County

Table 3 New Countywide Flood Insurance Rate Maps	
Lyon County	Feb. 20, 2008
Cherokee County	Nov. 19, 2009

Applicable Programs

The following programs help to meet the objectives in the Flood Management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Structures Program/Floodplain Management
- State Conservation Commission: Watershed Dam Construction Program
- State Conservation Commission: Watershed Planning Assistance Program

ISSUE: WATER-BASED RECREATION

Rivers, streams and lakes of Kansas represent a valuable recreational resource. Consideration of water based recreation problems and concerns are addressed in the Water-Based Recreation Policy Section. Even though the Neosho basin has a wide variety and fairly high number of public water recreation sites proportional to the area covered, there is a demand for more water based-recreation facilities to meet the needs of the population.

The Neosho River and its tributaries are not among the three rivers in the state legally open for public access. The approach to enhancing opportunities for recreation is to improve access to water bodies that exist in the basin that are open to public use.

Applicable *Kansas Water Plan* Objectives

- By 2010, increase public recreational opportunities at Kansas lakes and streams.

Applicable Programs

The following programs help to meet the objectives in the Water-Based Recreation management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Wildlife and Parks: Rivers and Stream Access
- Kansas Department of Wildlife and Parks: Community Fisheries Assistance Program
- Kansas Water Office: State water planning.

ISSUES FOR FUTURE CONSIDERATION

Comprehensive Flood Assessment.

Neosho Basin High Priority Issue
Watershed Restoration and Protection
January 2009

Issue

Watershed Restoration and Protection efforts are needed to address a variety of water quality and water resource concerns such as achieving Total Maximum Daily Loads (TMDL), Nutrient Reduction goals, development of Source Water Protection Plans, reduction of sedimentation in reservoirs and lakes, and protection or restoration of wetland and riparian habitats.

Description

There are three federal reservoirs in the Neosho basin: Marion, Council Grove, and John Redmond. All of these reservoirs are operated by the U.S. Army Corps of Engineers (Corps). All three reservoirs are used for public water supply programs that serve numerous cities and rural water districts. The reservoirs are also managed by the Corps for flood control and recreation.

All three reservoirs, and many streams and tributaries that connect them, are experiencing water quality impairments. Fecal coliform bacteria and low levels of dissolved oxygen are the most prevalent stream impairments. Sedimentation and eutrophication are the most prevalent reservoir and lake impairments.

Reservoir sedimentation is a major water quantity concern, particularly in reservoirs where the state owns storage for the Water Marketing Program, or where an assurance district owns storage. As sediment accumulates in a reservoir's multi-purpose pool, the capacity for water supply storage is reduced. Figure 1 shows the estimated percent of multipurpose pool capacity lost, including water supply storage, to sediment deposition in federal reservoirs in the Neosho basin since construction.

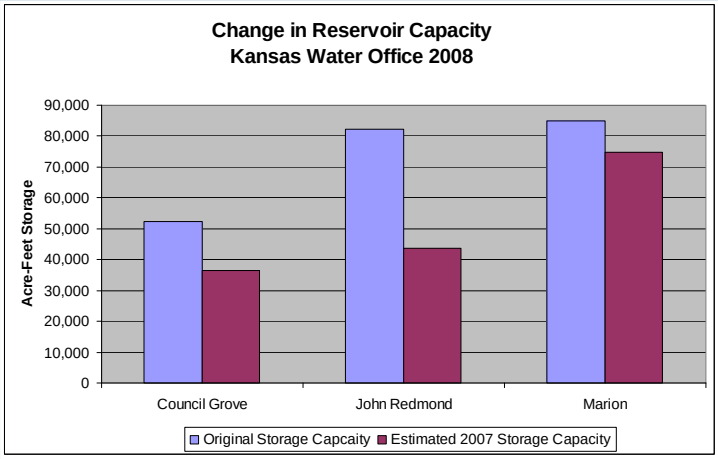


Figure 1. Loss of Reservoir Capacity

Loss of capacity in John Redmond Reservoir is the most pressing issue among the three reservoirs. Efforts are underway to determine the sources of sediment and to identify actions most likely to result in improvement in long term reservoir storage capacity. These efforts are described in other parts of this section.

Water Quality Impairments

Water quality protection and improvement is most effectively addressed at the watershed level, using regulatory and non-regulatory programs. Surface water quality monitoring is conducted to assess the level of pollutants in the water and the health of the biological community. If monitoring indicates that a river segment or other water body is consistently violating surface water quality standards, the water is classified as water quality impaired. Water bodies not meeting water quality standards for their designated use(s) are identified on the 303(d) list. The 303(d) list is used to identify those waters targeted for the development of Total Maximum Daily Loads (TMDLs). A TMDL is the maximum amount of a pollutant that a water body can receive without exceeding water quality standards. Since pollution can arrive via point and nonpoint sources, the TMDL process distributes responsibility for the pollutant load reductions among those contributing sources. TMDLs are assigned high, medium, or low priority status for implementation. High priority TMDLs are targeted for financial assistance programs. Medium priority TMDLs are addressed if resources are available after high priority TMDL needs are satisfied. Low priority TMDLs are monitored to track their status and are addressed last.[8]

The Kansas Department of Health and Environment (KDHE) has completed the first two rounds of TMDLs within the Neosho basin based on the 1998 and 2004 303(d) lists. There are 60 approved TMDLs within the Neosho basin that describe the strategies and goals to reduce pollution to achieve water quality standards. The 2008 303(d) list submitted to the Environmental Protection Agency (EPA) identifies watersheds associated with 26 stream chemistry sampling stations and two biological monitoring stations as water quality impaired. Among the streams, dissolved oxygen (D.O.) depletion, zinc, total phosphorus and copper cause the greatest number of impairments. Among the lakes, eutrophic conditions indicative of excessive algae production are the predominant cause of impairment. Many of the stream segments, configured in a watershed setting, have a TMDL applied to them as a whole. KDHE has reviewed and revised Neosho basin TMDLs and submitted them to EPA in late summer 2008. The following changes are

proposed: a new high priority Eutrophication and Siltation TMDL for Council Grove Reservoir, and a revision of the current Marion Reservoir High Priority TMDL.

Spring River Metals TMDL Review

Spring River and its tributaries in the far southeastern part of the basin, including Shoal Creek, Short Creek, Shawnee Creek, Turkey Creek and Center Creek in Cherokee County, is a valuable biological resource in the basin, providing habitat for many unique and some threatened or endangered species (HUC 11070207). Of particular concern are mussel populations that have been in decline since the start of heavy metal mining. Due to historic mining activities in the area, these waters are contaminated by lead, zinc, copper and cadmium. TMDLs have been developed for these streams. The ultimate endpoint for this TMDL is to achieve the established metals criteria for the Aquatic Life Use of the Spring River and its tributaries under the Kansas Water Quality Standards. However, because of the interdependency of the water quality criteria, total hardness and flow, the endpoints desired for the metal concentrations seen in the Spring River and tributaries will vary with flow condition. In addition, biological endpoints are included. See KDHE TMDL website Neosho River basin Total Maximum Daily Load for a complete description of this TMDL.[7] This TMDL has been evaluated during this round of TMDL submissions. No changes are being recommended.

Dissolved Oxygen TMDL Priority Review

KDHE completed a regional study of D.O. conditions and causes of low levels during 2007. As a result of this evaluation, KDHE has recommended that several D.O. TMDLs be moved from high priority to medium priority (Turkey and Mud creeks) and the Neosho Basin Advisory Committee (BAC) concurs with this recommendation.

Table 1 provides information on rivers and lakes within the basin that are designated high priority for TMDL implementation following the recommendations of moving several of the currently listed high priority D.O. TMDLs to medium priority. Figure 2 shows the location of these watersheds within the basin.

Needs Inventory

A component of the TMDL process is to quantify the cost to implement best management practices and technical assistance necessary to address the impairments. The State Conservation Commission has prepared a "needs inventory" to estimate costs associated with reducing nonpoint source pollution in this basin, and to guide implementation of best management practices. Programs are targeted at achieving high priority TMDL goals.

Table 1
Neosho River Basin High Priority TMDLs 2008

Map ID	Waterbody	Impairments	HUC 8 Watersheds
Stream Segments			
1	Spring River	Cd, Cu, Pb, Zn	11070207
2	Labette Creek	DO	11070205
3	Cherry Creek	DO	11070205
4	Eagle Creek	DO	11070201
5	Mud Creek	E. coli	11070202
6	Turkey Creek	E. coli	11070204
Lakes			
7	Marion Lake	E	11070202
8	Council Grove Lake	E, Silt	11070201
9	Olpe City Lake	E, Silt	11070201

Key:
DO: Low dissolved oxygen in upper 3 meters of water column over deepest location in water body
E: Eutrophication, biological community impacts and excessive nutrient/organic loading
FCB: Fecal Coliform Bacteria
E. Coli Indicator bacteria with FCB
HUC: U.S. Geologic Survey Hydrologic Unit Code
Silt: Observed siltation and/or chronic turbidity that impacts development of trophic state
Cd Cadmium
Pb Lead
Cu Copper
Zn Zinc

Surface Water Nutrient Reduction

The impacts of nutrients originating in Kansas have been well documented – Gulf of Mexico hypoxia, excessive productivity in Kansas and downstream reservoirs, and taste and odor problems in drinking water originating from reservoirs. Reduction and control of nutrients is needed to begin mitigating those impacts. Nutrient sources within the basin include both point and nonpoint sources. The major point sources in the basin include large wastewater treatment plants, which are regulated under the National Pollutant Discharge Elimination System (NPDES) (Figure 3).[4] Neosho basin water quality is also a concern in Oklahoma, particularly for nutrient loading in the Grand River and Grand Lake of the Cherokees. Several interstate watershed groups have been formed to develop regional strategies to implement restoration and protection objectives.

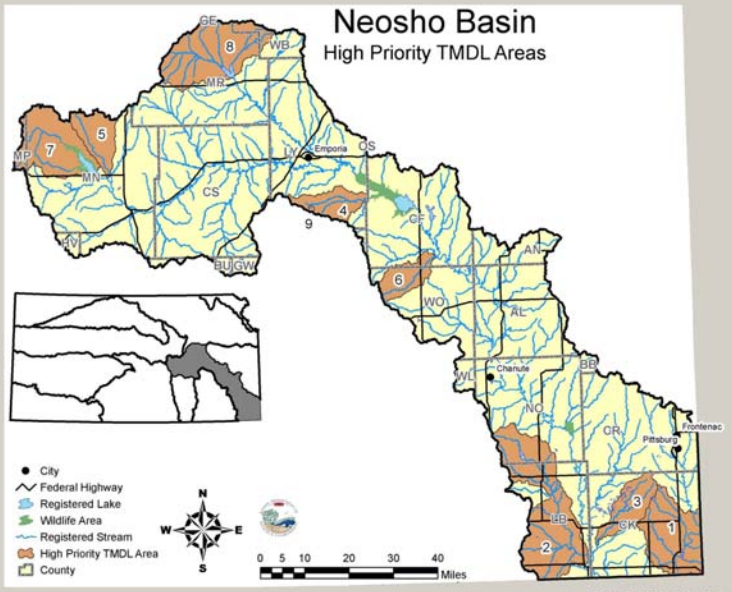


Figure 2. Neosho Basin High Priority TMDL Map

Nonpoint sources of pollution include both agricultural and urban areas. Table 2 shows the relative contribution of point and nonpoint sources in the Neosho basin for total phosphorus (TP) and total nitrogen (TN) leaving the state.

The Kansas Surface Water Nutrient Reduction Plan,[12] developed by KDHE, outlines a statewide strategy for reducing the export of TN and TP in surface waters leaving the state. This involves additional reductions in nutrients from point source discharges through the NPDES Program and reductions in nonpoint sources through development and implementation of Watershed Restoration and Protection Strategies (WRAPS). The Nutrient Reduction Plan includes Improvement Potential Index (IPI) maps for Kansas counties for TP and TN reductions

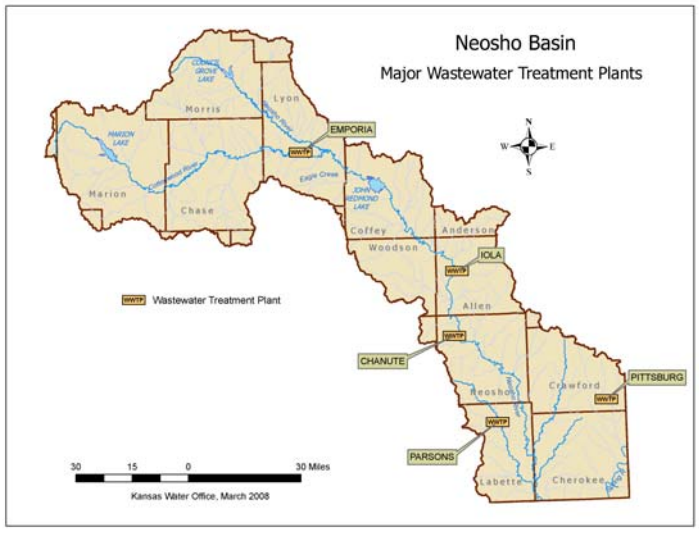


Figure 3. Neosho Basin Major Wastewater Treatment Plants

Table 2
Neosho Nutrient Reduction Data
Source: KDHE Bureau of Water – February 14, 2006
Statewide Perspective

Parameter	State Total	Neosho	% of State Total
TN Leaving State (Ton/yr)	51,000	9,260	18
TP Leaving State (Ton/yr)	7,700	832	11
Point Source TN (Ton/yr)	9,215	583	5
Point Source TP (Ton/yr)	1,925	231	7
Nonpoint Source TN (Ton/yr)	41,785	8,677	22
Nonpoint Source TP (Ton/yr)	5,775	601	12

Basin Perspective

Parameter	Total	PS	PS %	NPS	NPS%
TN (Ton/yr)	9,260	583	6	8,677	94
TP (Ton/yr)	832	231	28	601	72

(see maps in Water Quality Policy Section). In the Neosho basin, Cherokee and Labette counties showed the highest improvement potential for TP and TN.

U.S. Army Corps of Engineers John Redmond Feasibility Study[6]

The Kansas Water Office (KWO) is participating in a Feasibility Study with the Tulsa District Corps of Engineers in the watershed above John Redmond Reservoir. This study will provide information to the WRAPS project stakeholders as they develop their WRAPS plan (see description of this program further in this issue description). Specific objectives of the study include:

a. Preserve storage in John Redmond Reservoir for flood control, water supply, and other authorized purposes.
b. Revitalize John Redmond Reservoir for flood control, water supply, and other authorized purposes.
c. Reduce watershed contributions of sediment and harmful chemicals, such as phosphorous, into John Redmond Reservoir.
d. Restore riparian habitat (including native grass buffer zones) that improves the value and function of the ecosystem.
e. Restore wetlands that improve the value and function of the ecosystem.
f. Restore aquatic riverine habitat that improves the

value and function of the ecosystem.

g. Preserve riparian habitat (including native grass buffer zones) essential to the value and function of restored habitat above.
h. Preserve wetlands essential to the value and function of restored habitat above.
i. Preserve aquatic habitat essential to the value and function of restored habitat above.
j. Protect public resources, utilities, including power, water, and transportation, from the impacts of flooding, bank erosion, and channel changes.
k. Protect wetland and grasslands from invasive plant species.

Logjam Study, Sediment Monitoring, and Sub-watershed Assessment

Figure 4. Neosho River Logjam. Photo courtesy TWI

The KWO has also contracted a study of a logjam that has developed over more than 20 years at the inflow to John Redmond Reservoir, near the Jacob's Creek landing boat ramp (Figure 4). This logjam is largely a result of sedimentation at John Redmond where the Neosho River slows to form the reservoir. Input of large woody material from the watershed has resulted in accumulation of this material over about a 2.5 mile reach, blocking access to the river. Possible options to restore access to the river have been evaluated and recommendations as to the most cost effective solution have been provided and are under consideration. In addition, the USGS has installed several continuous monitoring stations in the watershed to gain a better understanding of sediment delivery dynamics to the reservoir. Efforts are underway to assess sub-watersheds within the basin to prioritize areas for streambank stabilization and riparian area improvement.

More information on project activities can be found at www.kwo.org.

Source Water Assessment Program[9]

Source Water Assessments were completed for all public water supplies across the state, either by the public water supplier or utility, or KDHE, in 2004. Source water may be ground water in the form of wells, surface water intakes on rivers and streams, or a combination of these. Source water assessments involve delineation of the source water assessment area, an inventory of potential contamination sources within the delineated area, and a susceptibility analysis and score. Assessments use a standardized system to identify all potential sources of pollution to surface and ground water within the contributing watershed, and conduct a susceptibility analysis to evaluate the threat from each potential pollutant to the water supply. A susceptibility score generated from the susceptibility analysis indicates whether the susceptibility range is low, moderate, or high for potential threats of contamination in an assessment area.

KDHE provided public water suppliers susceptibility scores in the following contaminant categories: microbiological, nitrates (applicable for ground water only), pesticides, inorganic compounds, synthetic organic compounds, volatile organic compounds, sedimentation (surface water only), and eutrophication-phosphorus (surface water only).

Of the 37 public water suppliers using ground water in the Neosho Basin, 68% had low susceptibility scores and 32% had moderate scores. Of public water suppliers using surface water, 32% had low scores, 53% had moderate scores and 16% had high scores. The most commonly identified problems with ground water were inorganic compounds, pesticides, and nitrates. The most commonly identified problems with surface water were pesticides, microbial contamination, and inorganic compounds. Of the 56 public water suppliers in the basin which treat raw water, 19 use surface water, 37 use ground water and one uses alluvial wells. Most residents in the basin get their water from the Cottonwood, Neosho, or Spring Rivers, ground water, or from one of the three major federal reservoirs. Ground water is a significant source in the southeastern part of the basin.

For communities using ground water, development of a wellhead protection plan is recommended. For communities using surface water, the development of a Water-

shed Restoration and Protection Strategy (WRAPS) is the best mechanism to ensure water quality protection for their public water supply. The Neosho basin has nine complete and approved source water protection plans in place.

Under the Source Water Assessment Program, about two thirds of the Neosho basin has been designated as critical area for protecting public water supplies, as defined by the stream reaches with a 24-hour or less travel time to a surface water diversion point. Much of the information from the assessment and risk rating can be used to develop WRAPS plans that can work to meet both TMDL goals and protect public water supplies from sources of pollution.

Five public water supplies were recommended by the EPA for participation in a five year, 2003 Atrazine monitoring program. This Atrazine risk reduction program includes runoff prevention in watersheds feeding public water supplies. These types of activities can help reduce pollution loading in the watersheds. As of 2005[10], the most recent year for which data are available, no system has exceeded the EPA criteria for Atrazine levels in public drinking water supplies.

Reservoir Sedimentation

Protection of the three federal reservoirs in this basin is another aspect of source water protection. The state has made significant investments in acquiring storage space in Council Grove, Marion, and John Redmond reservoirs for municipal and industrial use. Reducing sedimentation into the lakes is a water quality as well as water quantity issue. Efforts such as streambank stabilization can help reduce sedimentation.

Zebra mussels

Zebra mussels were confirmed to be present in Marion Reservoir in the summer of 2008. Despite efforts by the Kansas Department of Wildlife and Parks, and other agencies and organizations, to prevent infestations of the mussels spread from other reservoirs, this additional infestation is particularly troublesome due to the position of Marion Reservoir upstream from John Redmond Reservoir. John Redmond Reservoir supplements cooling water in the lake used by the Wolf Creek Nuclear Power Plant (Figure 5). Zebra mussels, once established, are almost impossible to eradicate, and cause hundreds of thousands of dollars, and sometimes millions of dollars, worth of damage to public water supply and industrial plant water intakes and other infrastructure. Efforts to prevent infestation of the mussels into John Redmond Reservoir and the Wolf Creek Lake are of utmost importance.

Figure 5. Wolf Creek Nuclear Power Station.
Photo courtesy Kansas Geological Survey.

Wetland and Riparian Area Management

Wetland and riparian areas are another focus of watershed protection and restoration. The primary approach to wetland and riparian area management in the basin focuses on providing technical and financial assistance to landowners to protect and restore these resources in priority watersheds through the implementation of best management practices (BMPs). Wetland and riparian areas are transitional lands between aquatic and upland locations. Wetlands include areas with hydric soils where standing water or wet soil conditions predominate. Riparian areas include streamside and floodplain areas where the vegetation, soils, or topography are distinguishable from that on adjoining uplands. Healthy riparian areas are an important component in filtering out pollutants and sediment from the streams and lakes. Healthy riparian areas can also control bank erosion, provide habitat and slow surface water runoff that leads to flooding. An analysis of the Neosho basin[11] indicates about 23% of the streams have crop land as the riparian land use. Wetlands provide unique wildlife habitat, and serve as flood water detention areas. Wetlands and riparian areas also provide aesthetic value.

An emerging concern is management and maintenance of forested riparian areas to prevent the entry of debris (dead and fallen trees, etc.) into the tributary/river system. Due to recent ice storms and catastrophic flooding, along with unstable streambanks, the potential for woody debris to collect in and clog bridges and culverts has been elevated. Preventing entry of woody debris into the system can help to manage this. The log jam discussed above is a consequence of this condition.

Neosho Basin High Priority Issue
Watershed Restoration and Protection
January 2009

The KWO is proposing a new policy that will provide a systematic approach to the assessment, protection and restoration of wetland and riparian areas and for the restoration of stream channels. The policy promotes a comprehensive evaluation of stream reaches and watershed wetland and riparian area condition.

Watershed Restoration and Protection Strategy (WRAPS) Groups

Citizens in sub-watersheds of the Neosho basin have formed WRAPS stakeholder leadership teams to assess their watersheds, water quality impairments, habitat needs, and other issues, and develop goals and objectives for addressing them. WRAPS groups develop stakeholder driven watershed management plans designed to address multiple water resource issues within a specific watershed. The WRAPS process provides a means to integrate objectives from multiple local, state and federal programs into a comprehensive, coordinated strategy for a specific watershed. This can include TMDL attainment, nutrient reduction, source water protection, reduced reservoir sedimentation, riparian and wetland management, and other natural resource objectives.

Watersheds above the three federal reservoirs in the basin that serve public water supply needs have been identified as watersheds of significant state interest for development and implementation of WRAPS. Implementation plans are being developed that will assist local groups to make the best use of existing funds to address the most critical problem areas first. Figure 6 shows the status of WRAPS groups in the basin.

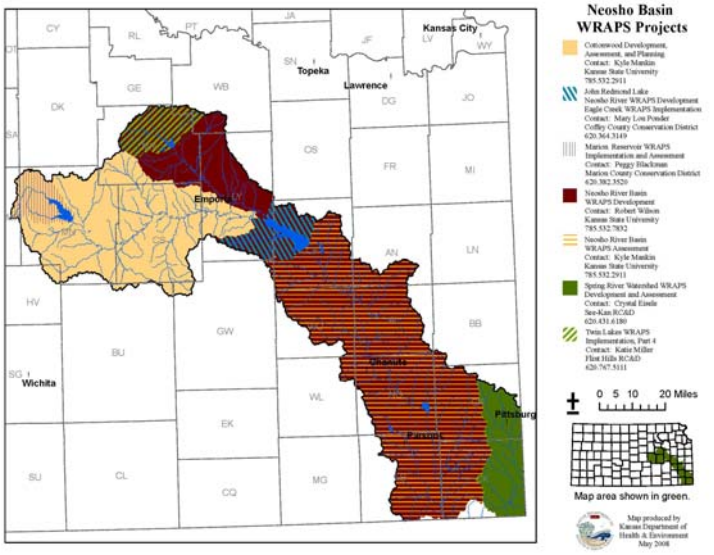


Figure 6. Watershed Restoration & Protection Strategy Groups

Several interstate groups have also formed to ensure high quality water in Grand Lake of the Cherokees in Oklahoma. A large part of the watershed draining into this highly used recreational and public water supply reservoir is in Kansas. An interstate effort involving Arkansas, Missouri, Oklahoma, and Kansas representatives is cooperatively developing a watershed based plan for the area. The efforts of WRAPS groups already underway in Kansas serve as a model for plan development and will be incorporated into the implementation plan.

A consideration for watershed restoration and protection in this basin is urbanization. As the amount of impervious surface in a watershed (i.e. rooftops, roads, parking lots, etc.) increases, water resources can be adversely impacted from increases in runoff volume and additional pollutants associated with urban environments. Efforts made by local governments and urban residents to minimize these adverse impacts through sound land use planning and stormwater management help to address these issues.

Local land use planning and zoning authorities provide cities and counties effective tools to minimize the potential impacts of development on water resources. Urban stormwater management programs can be implemented to manage the amount of impervious surface in urbanizing watersheds and properly control increased runoff resulting from urbanization. Programs that provide technical assistance and education to urban residents regarding actions that can reduce or eliminate potential pollution sources also play an important role. These programs can be integrated with WRAPS projects to ensure a comprehensive approach to watershed management in urban areas. In the Neosho basin, the cities of Emporia, Parsons and Pittsburg are required by the EPA Phase II Stormwater Program to develop management plans to minimize pollution entering receiving waters from within the boundaries of their municipalities.

Another consideration for watershed restoration and protection in the basin is the potential for conversion of Conservation Reserve Program (CRP) acreage back to production agriculture as contracts expire. Recently with commodity prices on the rise, this is even more of a concern. In the 12 counties contained wholly or partly in the Neosho basin, contracts on 37,259 acres covering 891 contracts expired on September 30, 2007. Lyon County had the highest number of expired contracts at 10,078 acres. If land is taken out of permanent grass cover, implementation of best management practices will be needed to minimize potential adverse impacts to water resources within the basin. CRP grass cover is very ef-

fective at trapping sediment and nutrients.

Other Watershed Related Activities

- All counties, excluding Chase County, either wholly or partly within the basin have adopted local sanitary/ environmental codes or participate in the Local Environmental Protection Program.
- Seven of the 12 counties have countywide planning and zoning programs.
- All conservation districts in the basin have adopted nonpoint source pollution control management plans. Grants under the State Water Quality Buffer Initiative have also been awarded in six counties supporting buffer coordinators and facilitating enrollment of stream buffers in continuous CRP in FY 2008.
- As of December 2007, there were 21 active contamination sites being remediated through the State Water Plan Contamination Remediation Program. Most of the contamination is from heavy metals resulting from past mining and smelting activities. Additional contamination is caused by volatile organic compounds, carbon tetrachloride and nitrate.
- There are 15 organized and active watershed districts in the basin.

Recommended Actions

1. Continue development and support of local WRAPS groups, with technical assistance from state and federal agencies to develop management plans. Coordinate funding from among sources to address highest priority problems first. Focus state resources towards high priority watersheds, particularly those that include high priority TMDLs, high biological priority, and source water protection.

2. Target resources to the improvement and management of riparian areas in priority watersheds.

3. Coordinate with the Kansas Department of Wildlife and Parks and other organizations and agencies to prevent the spread of Zebra mussels in the basin.

4. Continue cooperative inter-state efforts to improve water resource conditions in the entire Neosho/Grand River Lake of the Cherokees watershed.

5. Complete Corps John Redmond Feasibility study and incorporate results into WRAPS and other cooperative planning efforts.

6. Work with local governments, including conservation districts, local environmental protection programs, and stormwater utilities to develop and implement comprehensive urban stormwater and source water management plans.

7. Continue public outreach efforts to educate the public and landowners about the benefits of best management practices.

8. Encourage other agencies and entities in partnerships and participation to support WRAPS initiatives, activities and funding.

Resources

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Neosho Basin High Priority Issue
Water Supply Management and Conservation
January 2009

Issue

Evaluation of surface water supply, demand, management, and conservation, is needed to improve reservoir sustainability and provide adequate public water supply to meet long-term needs in the Neosho basin.

Increasing population and development in portions of the Neosho basin along with aging reservoirs (Figure 1) and public water supply infrastructure indicate a need to evaluate the long-term water system capacity to meet demands in the basin. The Neosho River has been having increasingly frequent low flow problems which have caused aquatic life stress and more frequent administration of water rights. Administration of water rights in the Spring River system occurred for the first time in 2006. The Neosho River is an area of high biological importance in the state with populations of freshwater mussels, sensitive fish species such as the Neosho Madtom, and populations that have declined from historic levels such as the paddlefish.[8] The viability of the river to support aquatic life and meet minimum desired stream flows needs to be maintained, while balancing the availability of water for public water supply.

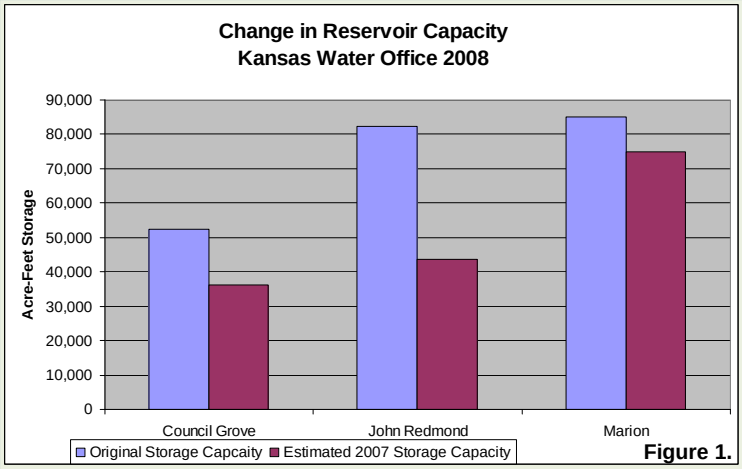

Figure 1.

In 2007, the Kansas Water Office (KWO) initiated an analysis of water supply and demand in several eastern Kansas river basins.[1] The analysis utilized historic climate and flow and current census information to predict the total water supply and demand in the Neosho basin over time. The preliminary finding for the Neosho basin is that in those counties primarily served by the Neosho River and tributaries, demand could exceed supply during a 2 percent probability drought by the year 2012 (Figure 2). This analysis did not include the far southeastern counties in the basin in which ground water and the Spring River are the primary water supplies. See the Management of the Ozark Plateau Aquifer System and the Spring River System issue for information on that area.

Of the four major southeastern Kansas river basins evaluated with this method, the Neosho basin has predicted water supply shortfalls the soonest. Enhanced modeling is underway to better understand where shortages could occur in specific reaches and to develop a means of evaluating alternatives and scenarios for water management, conservation and development that can be used for future planning and operations of the system.

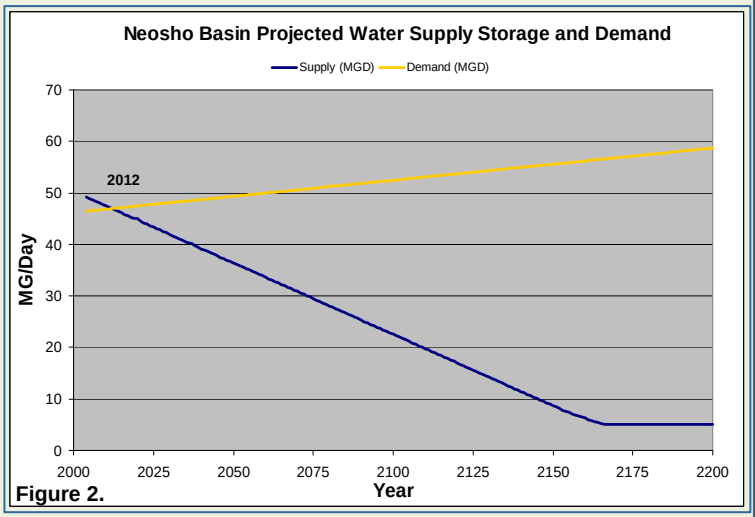

Figure 2.

Description

Water Supply

Water supply in the basin is provided primarily by three federal reservoirs, Marion, Council Grove, and John Redmond, along with numerous multipurpose or city owned small lakes, and natural stream flows. Coffey County State Fishing Lake provides cooling water for the Wolf Creek Nuclear Power Plant. Based on bathymetric survey information, federal reservoir water supply pool yields were used in the 2007 KWO analysis of supply and demand in the Neosho basin. This analysis combined the yield available from the federal reservoirs in the basin along with natural flows to calculate the total available water supply in a dry condition (Figure 3). Smaller city owned lakes were not included in this analysis.

The analysis described above was not structured to account for the quantity of water supply available in location specific areas under different conditions. A more refined modeling process using the OASIS (Operational Analysis and Simulation of Integrated Systems) model to identify water supply and demand at specific points in

Neosho Basin High Priority Issue
Water Supply Management and Conservation
January 2009

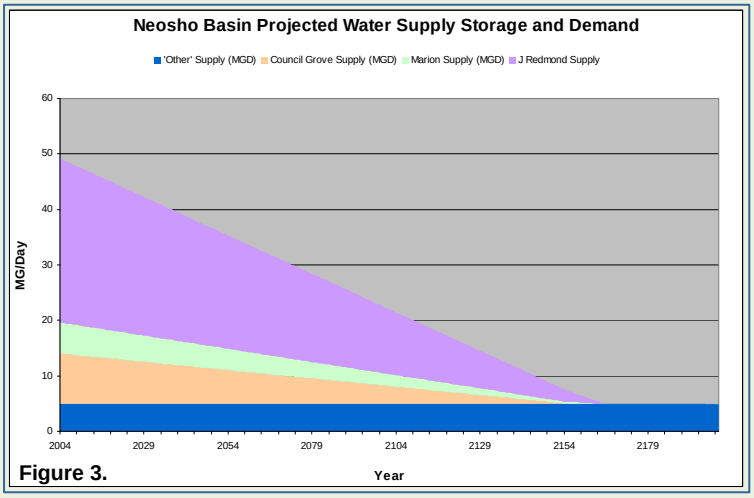

Figure 3.

the basin is being calibrated by the KWO in the Neosho basin. Once complete, the available water supply at specific demand points under various conditions in the basin will be able to be estimated. To assist with developing the model, KWO staff have been assigned to work directly with water supply utilities, industries, other water users, and the Neosho Basin Advisory Committee (BAC), to obtain detailed information on expected water demand in the future. Minimum desirable stream flows for aquatic and wildlife support are accounted for in the model.

Marketing and Assurance

Reservoirs are used, in part, to provide dependable water supplies in streams with highly variable flow. The 1958 Federal Water Supply Act made storage in federal reservoirs available to local governments if the local entities agreed to repay the cost of construction, operation, and maintenance of the water supply storage. The State of Kansas has purchased water supply storage in each of the federal reservoirs in the basin. All three reservoirs support both the Water Marketing and the Water Assurance Programs.

In 1985, through a Memorandum of Agreement between the State of Kansas and the U.S. Army Corps of Engineers (Corps), water quality storage in all three federal reservoirs in the basin was reallocated to water supply storage and purchased by the state at the original cost of storage. The state purchased the maximum amount made available in the reallocation. In exchange for the significant reduction in cost, the state agreed to obtain water reservation rights for water quality storage and to protect water quality releases from diversion by water right holders. In addition, the state developed the Water Assurance Program to operate the reservoirs as a coordinated system, maximizing the use of the water. A Water Assurance District (WAD) was formed in 1993 by the municipal and industrial water rights holders on the Cottonwood and Neosho Rivers. The WAD has purchased a portion of the state-owned storage in all three reservoirs and repays the state's capital cost investment along with annual operation and maintenance costs. Operation agreements under the Water Assurance Program allow the municipal and industrial water right holders in the Neosho basin to own storage that is released during dry periods to support their water rights.[4]

Water Demand

Municipal and Industrial Demand

In the 2007 KWO supply and demand analysis,[1] demand was combined for the basin in the same manner as water supply. Since all population projections were developed from the county level, entire counties were assigned to the basin based upon predominance of area *and* existence of larger incorporated areas. The Neosho River corridor included Allen, Chase, Coffey, Labette, Lyon, Marion, Morris, Neosho and Woodson counties.

Water demand (Figure 4) associated with the population projections is based on municipal water use as gallons per capita per day usage (gpcd) reported to the Kansas Department of Agriculture-Division of Water Resources (DWR) for 2000 through 2004 by suppliers in the Neosho basin.[2] The quantity of water that municipalities sold for non-domestic use is not included in gpcd calculations and was added to the total for this analysis. To develop the projected water use from industry, commerce, agriculture, and recreation, all non-municipal surface water points of diversion within five miles of the mainstem of each basin were selected.

The surface water demand increase on the Neosho River corridor is primarily associated with the anticipated demand increase of Lyon County, specifically the industrial sector growth seen in Emporia in the past 12 to 15 years. Also considered is future demand by the Wolf Creek Nuclear Power Generating Plant. Although a significant increase in demand was demonstrated in Neosho County, specifically in the recreational sector in the last 12 -15 years, that sector's growth was limited to current levels, since it is understood there is little to no desirable land remaining near the mainstem in Neosho County that has not already been developed for recreational use. Crawford and Cherokee counties were excluded from the future demand projections because of the ground water supplies and the supply from Spring River available to them.

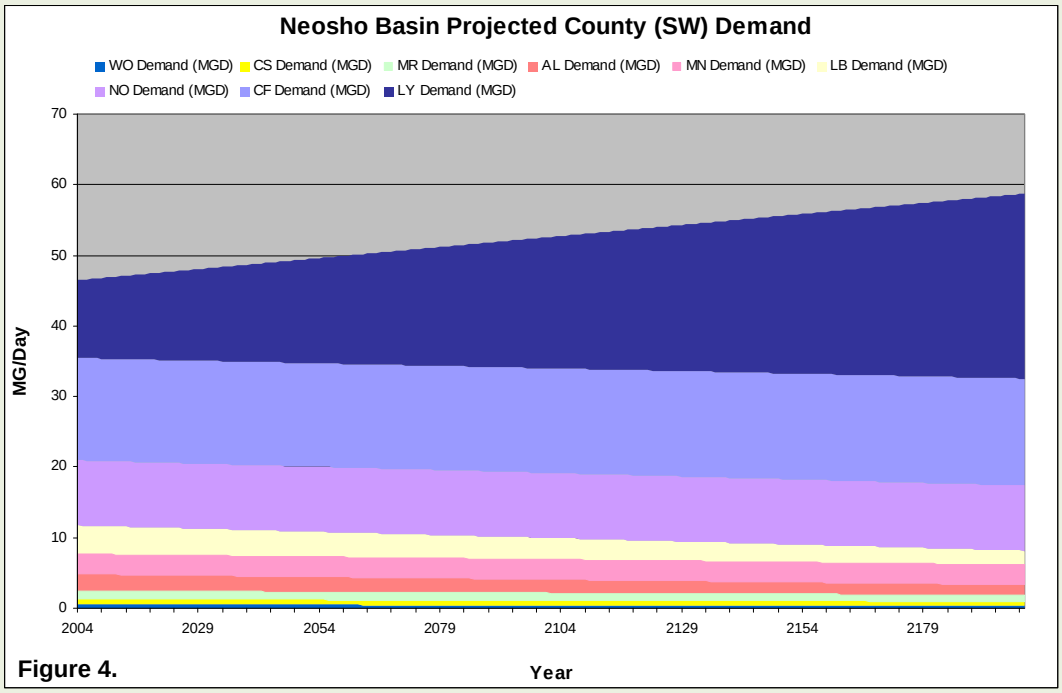

Figure 4.

Location Specific Demand

Further modeling in the Neosho basin will identify demand in specific locations and project this demand over time. The KWO is using the OASIS model to analyze the supply and demand projections for the Neosho basin. OASIS models the operations of a river reservoir system by simulating the routing of water though a system represented by nodes (reservoirs, cities, etc.) and arcs (rivers). OASIS can account for physical constraints such as reservoir capacity, evaporation, and sedimentation. The model can also account for system management issues such as minimum release requirements and lake level management plans.

The advantages of OASIS are that it can simulate the interaction of multiple reservoirs and rivers in a system. It improves the ability to simulate system management issues. OASIS can also identify "problem" areas in a system and evaluate alternative improvements to the system (off-stream storage, new reservoirs, reallocation, etc.). The KWO will be working with all users in the Neosho River corridor to get inputs for the model and then presenting the results upon completion of the model.

Nearly all the growth and associated water demand in the Neosho basin is associated with expansion of the Emporia area. In the southern part of the Neosho basin, interest in expansion of the old Army Ammunition Plant might add demand in that area. Depending on the results of location specific modeling, communities may need to consider water demand of future industries based on the projected supply.

Conservation

The objective of water conservation is to achieve efficient use of the limited water resources of the state through cost-effective practices to curtail the waste of water and to ensure water use does not exceed reasonable needs. In the Neosho basin, conservation includes efficiency management in public water supply along with maintaining existing reservoir storage and water supply. See the Watershed Restoration and Protection Strategy (WRAPS) basin priority issue in this section for additional information about efforts underway to improve water quality and preserve storage capacity of reservoirs in the basin.

Local land use planning and zoning authorities provide cities and counties with effective tools to minimize the potential impacts of development on water resources. Counties with planning and zoning regulations often require landscape plans for new development. While landscaping can provide aesthetic and environmental benefits, heavily irrigated landscape designs can increase demand on public water supplies.

Demand management is an important component of extending water supplies but has not typically been incorporated into water utility operations. With the recognition of the potential for future water shortages, water suppliers and communities should begin to incorporate this concept into operational planning. Demand management may include less water intensive landscaping, low water use plumbing, conservation design for urban areas, water reuse, and other elements including responsible use of water. A movement beyond excessive use of water into more sustainable long-term management is needed. Increases in consumptive use cannot occur under existing, vested, or otherwise fully perfected water rights. If a municipality is considering substantial changes in their system to reuse water, the DWR must be consulted.

Neosho Basin High Priority Issue
Water Supply Management and Conservation
January 2009

Conservation of reservoir storage has received attention as the impacts of sedimentation become increasingly apparent. While supply in the Neosho basin is being evaluated to develop management strategies, recreational impacts are also occurring, along with low flows in streams which can impact aquatic organisms. Research has been conducted addressing the causes of reservoir storage loss and identifying solutions. These measures generally fall into short-term strategies such as efficiency of reservoir operations or longer-term restoration of storage. Examples of reservoir efficiency include pool reallocation, raising dams/pools, modification of operational rules, and treatment of the upstream watershed to limit erosion. Restoration includes dredging, reservoir flushing, or other means of removing accumulated sediment.

Recommended Actions

1. Continue the calibration of the OASIS basin model with location specific supply and demand information.

2. Identify options for supply and demand management: reservoir pool raise, pool reallocation, dredging, off-channel storage, new supplies, modify reservoir operations, conservation measures, reverse levee operations.

3. Refine model to reflect possible outcomes of identified options and share results.

4. Implement the most beneficial and cost-effective options.

5. Begin incorporation of water demand management into utility operating plans. Demand management should also include education of and interaction with the development community and include existing local authorities.

Resources

1. Surface Water Supply and Demand Projections for Selected Basins in Eastern Kansas. 2007. Kansas Water Office.

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7. Public Water Suppliers, Sources and Purchasers. 2006. Kansas Department of Agriculture, Division of Water Resources.

8. Instream Flow Assessment and Verdigris and Neosho River Basins. 2006. Kansas Department of Agriculture, Division of Water Resources.

Neosho Basin High Priority Issue
Management of the Ozark Plateau Aquifer System and the Spring River
January 2009

Issue

Increased understanding and adjustment of management of the Ozark Plateau aquifer system and the Spring River system is needed to ensure a sustainable water supply for southeast Kansas.[1]

Description

The Ozark Plateau is in a four-state region located primarily in southern Missouri and northern Arkansas, including smaller areas in northwest Oklahoma and southeast Kansas (Figure 1). The Ozark Plateau consists of four physiographic regions: the Springfield Plateau, Salem Plateau, Saint Francois Mountains and Boston Mountains. Of these four regions only a small portion of the Springfield Plateau extends into the far southeastern corner of Kansas. Under this corner of Kansas lies a small but important part of the Ozark Plateau aquifer system.[2]

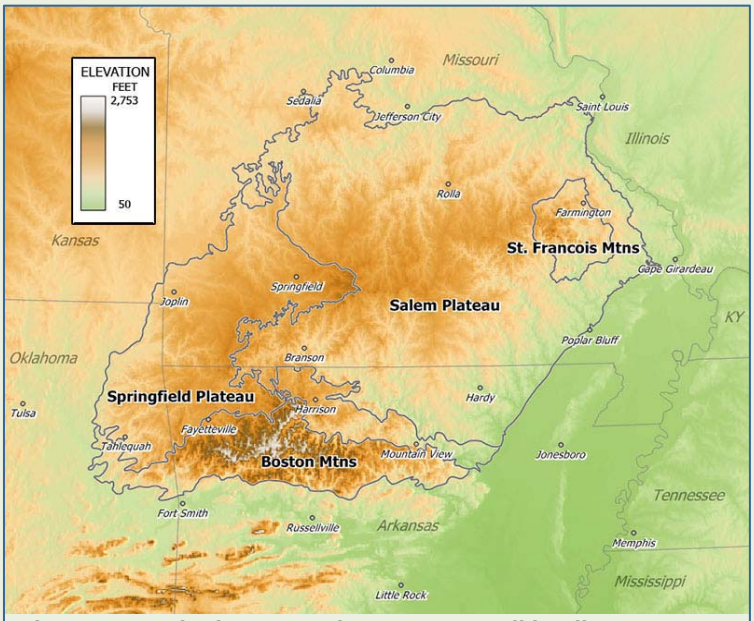

Figure 1. Ozark Plateau Region. Source: Wikipedia

The Neosho River and the Spring River are the two major river systems in Kansas that occur within the boundary of the Ozark Plateau aquifer system. The lower Neosho River flows through Neosho and Labette counties, and briefly flows through the southwest corner of Cherokee County before flowing out of Kansas into Oklahoma. The Spring River enters Kansas on the eastern side of Cherokee County, flows through Cherokee County, and exits the state in the southern part of the county into Oklahoma (Figure 2). Both river systems are monitored by the United States Geological Survey (USGS) and streamflow gages are positioned near Parsons, Kansas on the lower Neosho River, and near Quapaw, Oklahoma and Waco, Missouri on the Spring River (Figure 3).

Water Supply and Quality Concerns

Figure 2. Ozark Aquifer in Kansas

The Ozark Plateau aquifer and Spring River systems serve as important water supply sources in southeastern Kansas, southwestern Missouri and northeastern Oklahoma, an area known as the Tri-State Region. The demand for water in the region is growing rapidly, particularly in southwestern Missouri. Jasper and Newton counties in Missouri, have had strong population growth that has led to an increased water demand. All the high capacity wells in Jasper and Newton counties are drilled into the Ozark aquifer. Some of the well fields have been unable to meet their production goals. As new wells are installed, pumping interference becomes increasingly likely.[4]

Figure 3. Stream Gages in the Ozark Plateau Aquifer Area

Ground water in the Ozark Plateau aquifer system originates in Missouri and flows into the southeastern corner of Kansas and into Oklahoma. In-

creased withdrawals in Missouri will impact the amount of water moving into Kansas. This portion of southeast Kansas is almost entirely dependent on surface and ground water originating from Missouri. A study commissioned by Missouri American Water Company[7] (2003) projects possible water shortages in as few as 10 years (2013), during drought conditions, given the increasing water demands with the expected continued growth in the region (Figure 4).

Water-level Elevations in Wells
Tapping into the Ozark Aquifer (circa1980)

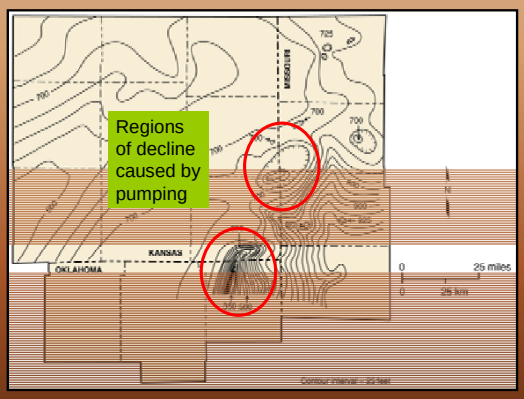

Figure 4. Areas of Water Level Decline

Water quality of the Springfield Plateau aquifer, which overlies the Ozark aquifer in Kansas, is poor and may be unfit for domestic use due to lead and zinc concentrations from extensive lead and ore mining in the area. Mining shafts have allowed contaminated water to move from the surface into the aquifer. The underlying Ozark aquifer contains usable water in southeast Kansas and is the source for most of the ground water supplied to area municipalities and rural water districts. At the bottom of the Ozark aquifer is a brine layer (salt water) that is moving west to east across Kansas. There is concern that significant ground water pumping in some areas could potentially cause upwelling of brines within the aquifer and adversely impact water quality.

The Ozark aquifer was heavily used during lead and zinc mining operations from the late 1880s up into the 1950s. Mining activities are generally inactive at this time but legacy heavy metal contamination in surface and ground water persists. Concerns about water level declines and potential water quality degradation have prompted the need for long-term management actions (Figure 5). In 2003, this issue was identified as a *Kansas Water Plan* basin priority issue by the Neosho River Basin Advisory

Water Quality in the Ozark Aquifer (circa1980)

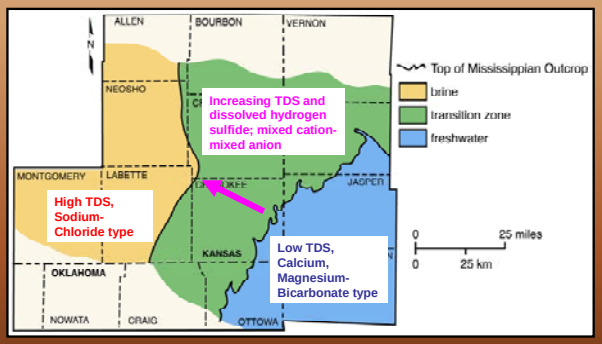

Figure 5. Water Quality in the Ozark Aquifer

Committee (BAC) and the Kansas Water Authority (KWA). Activities to address this issue have been initiated and are described below.

Water Rights Moratorium

Due to uncertainty about the available water supply in the Ozark aquifer, as well as water quality concerns, at the request of the Neosho BAC, in 2004 the Kansas Department of Agriculture's Division of Water Resources (DWR) established a moratorium on new appropriations from the aquifer in Kansas, except for some specified exceptions. K.A.R. 5-3-29 established the moratorium which is still in effect, with a December 31, 2010 deadline for evaluation of permit status. The moratorium exempts domestic wells, appropriation requests for less than five acre-feet under the provision of K.A.R. 5-3-16a, and allows both temporary and term permits from the Ozark Plateau aquifer system. Moratorium term permits may be filed, as long as the permittee can demonstrate availability of an alternate source of water supply. Moratorium permits are allowed through the December 31, 2010 deadline when the DWR will extend, convert, dismiss, or amend the term permits once the ground water model described below is complete.

The DWR has opened a satellite Field Office in Parsons, which is staffed with an environmental scientist under the enhanced water management program. The scientist in Parsons is specifically focused on the Ozark Plateau aquifer system and adjacent moratorium area, and is performing field work and monitoring in this area, as well as addressing water management aspects. An "Ozark Plateau 2007 Field Analysis Summary" has been pre-

pared that provides detailed information on the status and characteristics of the area.[8]

Regional Ground Water Model and Water Quality Assessment Study

To address water supply and quality issues, the state initiated a study supported by the water agencies in the three states that is being conducted by the USGS. Using MODFLOW computer software, a model of the Ozark and Springfield Plateau aquifers is being developed and calibration is almost complete as of April 2008. The model simulates ground water flow within both aquifers and includes interaction between ground and surface water. The model also allows simulation of the effect of withdrawal (diversion) of additional water from the aquifer. The study also will define and assess the current water quality conditions in the Ozark and Springfield Plateau aquifers.

In the spring of 2006, the depth to water was measured in more than 200 wells throughout the three-state region. The Ozark Aquifer Technical Advisory Committee, made up of representatives from the three states' water agencies, the USGS, the City of Monett, Missouri and a representative of local public water suppliers in Kansas, meets quarterly to discuss the study's progress. Annual public meetings that began in the fall of 2006 provide area residents with information about the study. The 3-year study is co-funded by the State of Kansas and the USGS. The ground water model and water-quality study reports are scheduled for publication in March 2009[9].

Well Monitoring Network

In 2004, a ground water well monitoring network was re-established for the Ozark aquifer moratorium area by the DWR. The network consists of 24 wells that are screened within the Springfield Plateau aquifer, the Ozark aquifer, or both aquifers (referred to as the Ozark Plateau aquifer system), and are measured on a quarterly basis (Figure 6). Also, in order to detect the potential eastward movement of salt water, a network consisting of 12 wells has been established from which water quality samples are taken quarterly. Lastly, three continuous monitoring wells have been drilled. Two of the monitoring wells are located in the Ozark aquifer at McCune and Pittsburg and one is located in the Springfield Plateau aquifer, also located at Pittsburg. All three wells have transducers installed and are equipped with satellite telemetry capabilities.

Assessment of Water Quality Changes

The recharge to this aquifer is from the overlying Springfield aquifer, which has numerous mining and industrial contaminants. Declines in the lower aquifer levels, if this is occurring, would induce recharge from the overlying aquifer and the contaminants. In addition, there exists an eastward migrating transition area of brine water, with increasing total dissolved solids, chloride concentrations and hardness, from south central Kansas. One municipal public water supply and a few industrial wells have been abandoned due to taste and odor problems with the brine transition water.

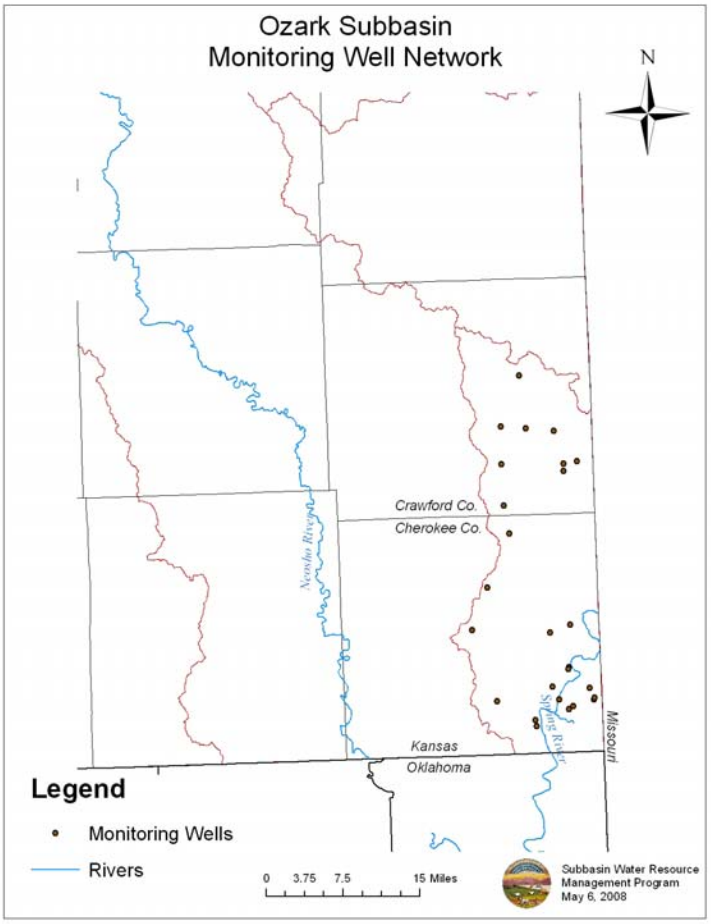

Figure 6. Well Sampling Locations

The Kansas Geological Survey (KGS) is in the second year of a study to assess the influence of pumping over time on the chemical quality of ground water produced by single and multi-aquifer wells within the Ozark aquifer water-quality transition zone in Kansas. This transition zone extends across most of Cherokee County and all of Crawford County; the depth to its top is variable. During the project's first year, monthly water sample collection

for chemical analysis, water-level surveys, and reports of ground water pumpage were used to assess seasonal changes in water quality. The project also compared water quality results from the recent sampling to results from samplings conducted 25 years ago. In its second year the project is focusing on water quality changes during periods of pumping. This report was made available in October 2008.

Tri-State Water Resource Coalition

The Tri-State Water Resource Coalition, a group of municipalities and rural water districts in the region organized in 2003, was formed to determine the region's water needs, better understand available water resources, and make recommendations to provide a long term supply of good quality, affordable water.[6] The Coalition retained Black and Veatch Engineering and the U.S. Army Corps of Engineers (Corps) to evaluate the area's water supply needs to the year 2045 and long-term water supply options to meet that need. The study was completed in the fall of 2006 and cited water supplies from Grand Lake of the Cherokees in Oklahoma, Table Rock Lake in Arkansas, or the construction of a new reservoir in southeast Missouri as the best alternatives. The Coalition has raised $140,000 to match a grant of $50,000 from the Missouri Department of Natural Resources to conduct a study to determine sites that are suitable for a new reservoir and the costs associated with construction. Tri-State Water Resource Coalition members from Kansas include: Baxter Springs, Cherokee Rural Water District No. 3, the City of Pittsburg and the Kansas Rural Water Association. The DWR employee in Parsons is a member of this group.

Figure 7. Spring River near Galena. Photo courtesy G. Manders

Multi-Basin Regional Watershed Council

This recently formed group is involving stakeholders from Arkansas, Oklahoma, Kansas and Missouri to address regional water concerns. Included are concerns about drinking water, wastewater, and water quality/ watershed issues. While the recent focus has been on water quality/watershed issues, the Ozark aquifer is part of the overall discussion.

4-All Collaborative

This group also has representation from all four states draining into Grand Lake of the Cherokees. Their recent emphasis has been on education and coordination of the various groups in the four states that are involved in watershed planning. They have sponsored two Environmental Conferences and a third is in the planning phase.

Grand Lake of the Cherokees Alliance Foundation (GLCAF)

The GLCAF is developing a Grand Lake Watershed Management Plan (Plan) with technical and planning assistance from the Oklahoma Conservation Commission. Development of the Plan involves a four state stakeholder-driven approach to watershed management. Once the Plan is developed the GLCAF will solicit private funding to implement recommendations in the plan with an emphasis on installation of targeted Best Management Practices. To date, the watershed has been characterized in all four states, common impairments, pollution sources and causes have been identified, priority impairments and desired reductions have been targeted, and basin-wide management strategies are under development. The Plan recognizes that sub-basin Watershed Restoration and Protection Strategy (WRAPS) plans in Kansas are also under development and seeks to support them through inclusion in the Grand Lake Watershed Management Plan. Once private funding is available from the GLCAF, it is anticipated that some of it will directed to implement Kansas Neosho basin WRAPS plans for priority projects in priority areas.

Spring River Watershed Restoration and Protection Strategy (WRAPS)

The Spring River (Figure 7) is the second largest unallocated water supply in the state. Although most of the

Ozark aquifer is currently the source of most public water supply in the area, the Spring River is another potential supply. Construction of a dam in southwest Missouri on the Spring River could impact the ability of public water suppliers in this area to use the Spring River as a future supply (see Tri-State Coalition discussion above). In addition, legacy heavy metal contamination (Figure 8) is still present in surface waters and Total Maximum Daily Loads have been developed to address this problem. See the Neosho basin Watershed Restoration and Protection Strategy for more information on Spring River water quality.

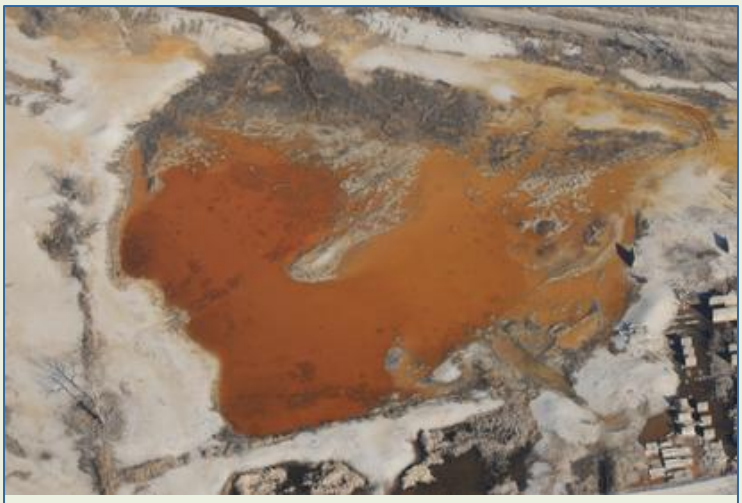

Figure 8. Acid rock drainage colors a body of water reddish-orange near Treece, KS. Source Lawrence Daily Journal World 2008.

Conversations among stakeholders in the Kansas portion of the Spring River began in 2006 and a WRAPS group has been formed to assess the water resource and watershed and formulate goals and objectives to maintain or improve them. Because stream flow is related to ground water levels, this group can serve as an important link for information and education related to the underlying aquifer. Efforts are underway to involve participation from stakeholders in Missouri, Arkansas, and Oklahoma.

Recommended Actions

1. Continue and complete the inter-agency strategy to address the complex water issues of multistate cooperative management, ground water declines and quality, surface water contamination, and public water supply concerns.

2. Use the USGS Regional Ozark Aquifer Study as a management decision support tool to assist DWR in determining the need for continuation or removal of the moratorium on new ground water rights in southeast Kansas, and develop appropriate management strategies.

3. Use the water quality monitoring network established by DWR as a decision support tool.

4. Continue interstate communications concerning the development of new water supplies or the use of existing supplies in adjoining states.

5. Support public water supplier (PWS) efforts to work cooperatively and acquire funding for infrastructure needs for cooperative regional supply systems.

6. Coordinate with Spring River WRAPS and other groups to provide additional information to the public.

Resources

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Smoky Hill-Saline River Basin

January 2009

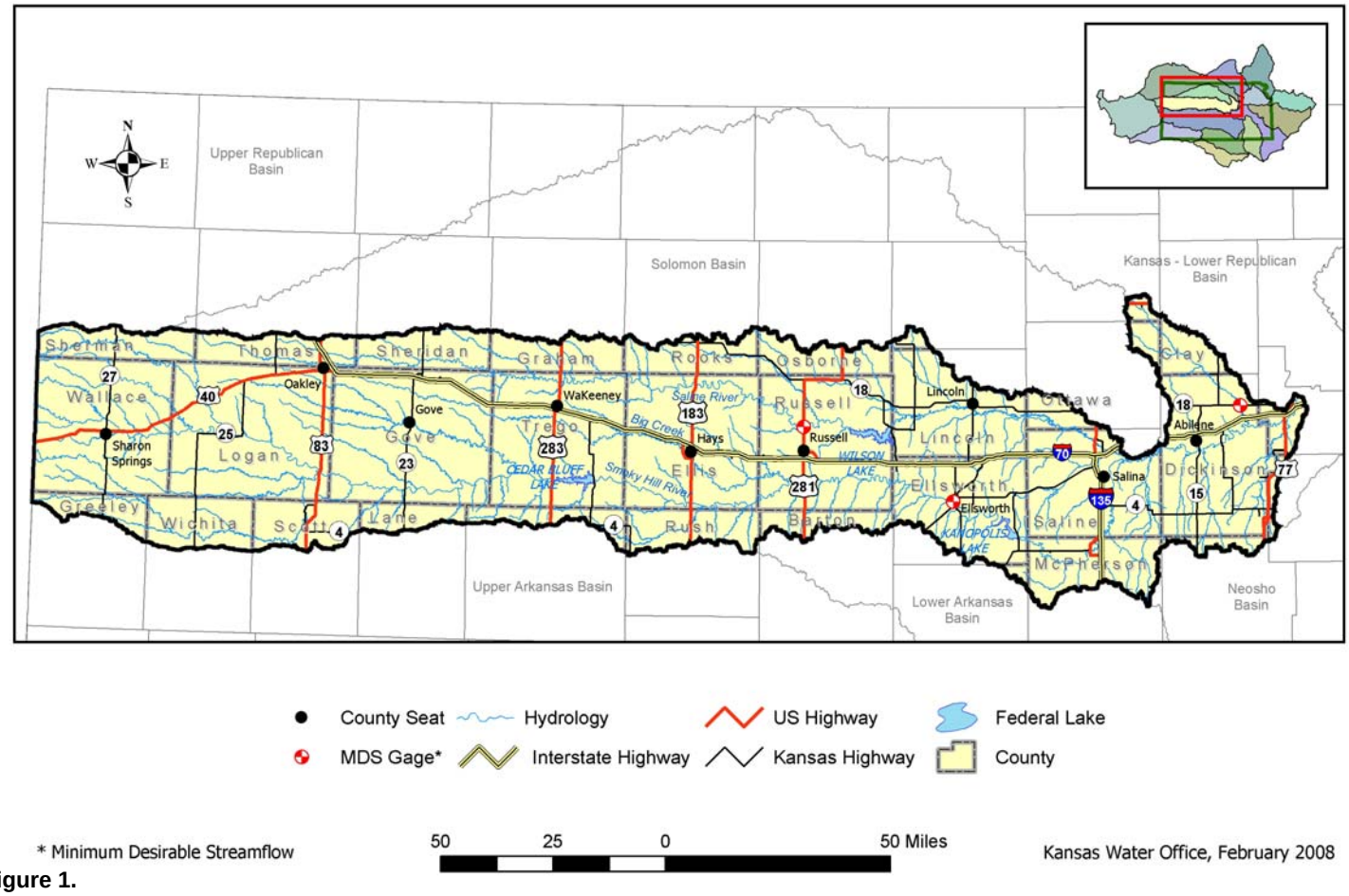

Figure 1.

General Description

The Smoky Hill-Saline basin lies within the Great Plains and Central Lowland physiographic provinces. The Smoky Hill-Saline basin in Kansas is an elongated drainage area, which extends eastward from the Colorado border approximately 250 miles to the vicinity of Junction City, Kansas. The Smoky Hill-Saline Basin covers all or parts of Sherman, Thomas, Sheridan, Graham, Wallace, Logan, Gove, Trego, Greeley, Wichita, Scott, Lane, Ness, Rooks, Osborne, Mitchell, Cloud, Ellis, Russell, Lincoln, Ellsworth, Dickinson, Geary, Morris, Saline, Rush, Barton, Rice, McPherson and Marion counties (Figure 1). The basin includes subbasins with hydrologic unit codes (HUCs) 10260001 thru 10260010.

The Smoky Hill River headwaters are located in eastern Colorado where the North and South Forks rise. These forks join in Logan County, Kansas. The Smoky Hill River has a drainage area of about 8,810 square miles. The Smoky Hill River flows eastward to Junction City to the confluence with the Republican River. Below this point the river is known as the Kansas River.

The drainage area of the Saline River is about 3,419 square miles. The Saline River, a tributary of the Smoky Hill, rises near the Sherman-Thomas County line in extreme western Kansas. The Saline River flows eastward to its confluence with the Smoky Hill River several miles east of Salina, Kansas.

The entire Smoky Hill-Saline basin in Kansas has a drainage area of about 12,229 square miles.

Topography within the basin is flat to gently rolling, with narrow, shallow valleys and low relief.

The highest point in Kansas, Mount Sunflower at 4,039 feet above mean sea level (MSL), is located in northwestern Wallace County. From this point, elevations in the basin decrease to approximately 1,087 feet above MSL at the confluence of the Smoky Hill and Republican rivers.

Highest point in Kansas, Mt. Sunflower in Wallace County
Photo Courtesy of Kansas Geological Survey

Population and Economy[1]

The basin had a population of 156,161 in 2000. The population of the 32 counties that are entirely or partially in the Smoky Hill-Saline basin was 330,631 in the year 2000 and is projected to be 288,939 in the year 2040. Rural counties have lost population, sometimes more than 10% in the last decade.

The economy of the basin is based primarily on agriculture and manufacturing. The major crops are wheat, grain sorghum, corn and alfalfa with a sizable portion of this acreage being irrigated.[2]

In 2006 there were an estimated 17,060 farms with 15,966,000 acres in the 32 counties with all or parts in the basin. The average farm is about 936 acres.[2]

Recreation is an increasing part of the economics of the basin. The federal reservoirs and associated recreation and wildlife areas draw hunters, fishermen and boaters to the area. In addition, the state supports fishing at: Kanopolis State Park Pond (2 acres, 33 miles SW of Salina on Hwy K-149 & K-141); and Saline State Fishing Lake (Periodically Dry) (38 acres, 2-1/2 N 2 W of Salina). Logan State Fishing Lake (60 acres, 2 N 2 W of Russell Springs) is still listed by Kansas Department of Wildlife and Parks as a fishing opportunity, however it has been dry for many years.

The growing industrial contribution to the basin economy is primarily related to energy production, including ethanol. As of December 2007, two ethanol plants were in operation in the basin.

Higher education opportunities in the basin include; Fort Hays State University; Kansas Wesleyan University, KSU College of Technology and Aviation, Brown Mackie College, North Central Kansas Technical College and Salina Area Technical School.

Physical Characteristics

Geology and Soils

Cretaceous bedrock underlying the basin consists of shale, limestone, and chalk. The most notable being the Niobrara Chalk and the Dakota Sandstone. The river and tributary valleys are comprised of unconsolidated deposits of gravel, sand, silt and clay. The bedrock has an east-to-southeast drainage trend. In the west, the rocks that outcrop are sedimentary in origin and range in age from Cretaceous to Recent.

The Ogallala Formation of Late Tertiary (Pliocene) age uncomfortably overlies these older formations.

Niobrara Chalk Trego County.
Photo Courtesy of Kansas Geological Survey

Thin, dissected and isolated deposits of sand and gravel of Pleistocene age occur along the larger streams, chiefly the South Smoky Hill and North Smoky Hill Rivers. These deposits have been derived from the Ogallala Formation and lithologically are very similar to the Ogallala. The Smoky Hill River is completely incised into the Cretaceous Niobrara Formation throughout most of Kansas, so has little contact with the Ogallala-High Plains aquifer. However, two major tributaries, the Saline River and Ladder Creek, do have substantial connection.

The terrace deposits and valley fill of the Smoky Hill valley become thicker and of greater areal extent to the east.[2]

The Smoky Hill-Saline basin soils vary widely in character. The soils are poor shallow soils in the west along streams with fertile loess soil in the uplands. Shallow, acidic and infertile soils occur through Trego, Ellis and Russell counties. Bottom land soils ranging from sand to clays and from permeable, friable soils to tight soils.[2,3]

Land Use/Land Cover

The basin covers approximately 7,726,235 acres. Over 48% is crop land, and more than 44% in grass. Crop land dominates in the west with grassland dominating through the central section of the basin. The major crops are wheat, sorghum, and corn. Approximately 249,596 acres were reported as irrigated in 2006. A major product is beef cattle.

The Kansas Geological Survey (KGS) categorized riparian land use in 2003. Statewide pasture/grass land is the dominant riparian land use type in Kansas, accounting for over 142,000 bank miles or roughly 38% of all land use types.[7] In this basin, the total of 56,730 bank miles vary in the riparian land use type, with 53% of the riparian cover being pasture/grass land. Table 1 provides more detail of riparian land within one mile of streams and water bodies.

Climate

The basin's climate is characterized by the extremes and highly variable precipitation and temperature common to mid-continent locations.

Average annual temperatures range from 52 degrees (^{o}) in the west to 56° in the east, with wide day to day variations and yearly extremes. Evapotranspiration consumes the major portion of the moisture in the basin.

Average annual precipitation increases from approximately 16 inches in the extreme west to 30 inches in the east. These annual quantities are subject to wide fluctuation, with thunderstorms accounting for most of the annual rainfall. Most of the precipitation occurs between April and September. Annual snowfall averages from 24 inches in the west to 18 inches in the east.

Table 2. Climate Summary Smoky Hill-Saline Basin

	Average Annual[1]		Freeze Dates (32 F.)[2]		
Location	Precipitation (inches)	Temperature (deg. F.)	Last in Spring	First in Fall	Frost Free Days
Sharon Springs	20.11	51.6	Apr. 30	Oct. 9	160
Russell	26.25	54.1	Apr. 24	Oct. 17	176
Abilene	32.74	56.5	Apr. 19	Oct. 11	177

[1] Source: National Climatic Data Center (1971-2000 data)
[2] Source: KSU Weather Data Library (1961-1990 data)

Flooding, when it occurs, is generally the result of intense storms of short duration on tributaries. The main stem of the Smoky Hill River experiences flooding due to storms covering a wide area of longer duration.[3]

Dust Cloud at Ransom, Kansas May 2004

Drought is a naturally recurring feature of this climate as exemplified by the Dust Bowl of the 1930s and the severe drought of 1952-1957. Kansas has been impacted by severe drought periodically. The western part of the basin is greatly affected by reductions in precipitation. The deficit is offset by ground water pumping to irrigate crop land that has not received sufficient rainfall. Drought increases the demand on the available water supply.

Table 1. Total Riparian Land Use Bank Miles for Smoky Hill-Saline Basin

Hydrologic Type	Animal Production	Barren Land	Crop Land	Crop/ Tree Mix	Forest Land	Pasture/Grass Land	Pasture/ Tree Mix	Shrub Land	Urban Land	Urban/ Tree Mix	Total
Intermittent	12	27	13,448	1,782	2,894	28,056	4,389	14	235	95	50,951
Perennial	2	8	89	575	1,711	599	803	15	13	18	3,832
Shoreline	2	48	131	23	94	1401	202.2	13	12.1	21	1,947
Total	16	83	13,668	2,380	4,699	30,056	5,394	42	260	134	56,730

Wildlife and Habitat

The Smoky Hill and Saline rivers landscape is comprised of rolling to nearly level tallgrass and mixed grass prairie vegetation. These contain some large tracts of high quality tallgrass and mixed grass prairie that are currently used primarily for grazing. These native prairie pastures provide important seasonal habitat for migrating birds as well as crucial nesting and brood rearing habitat for grassland nesting birds such as the greater prairie chicken.[5]

The Smoky Hill–Saline basin includes the range for numerous endangered or threatened species including the bald eagle, whooping crane, snowy plover, piping plover, peregrine falcon, black footed ferret, eastern spotted skunk, green toad and hornyhead chub. Eastern parts of the basin are also designated as critical habitat for the bald eagle. Wallace and Logan counties are designated critical habitat for the green toad.[12]

Cedar Bluff Wildlife Area varies in size with the fluctuating reservoir. At full pool the Reservoir is 6,800 surface acres and the surrounding Wildlife Area lands encompassing approximately 7,000 acres.

Outcrop north of Smoky Hill River near Schoenchen
Photo by Kansas Water Office

The area lies in the mixed grass prairie and chalk bluff region. Cedar Bluff derives it's name from a 1/2 mile of 100 foot chalk bluffs located on the southwest portion of the property.

Wilson Wildlife Area is located on the upper end of 9,000 acre Wilson Reservoir. The 8,069 acre public hunting area is made up of 5,000 acres of rugged rolling hills of native prairie, approximately 2,000 acres of cropland, and 1,000 acres of riparian timber along the Saline River, Cedar Creek, Turkey Creek, and Elm Creek.

Smoky Hill Wildlife Area at Kanopolis Lake offers 4,180 acres of land and 885 acres of water. The reservoir covers approximately 3,000 acres of water and the entire U.S. Army Corps of Engineers (Corps) property extends along the Smoky Hill River for over 15,000 acres.[6]

Water Resources

The Smoky Hill River headwaters are located in eastern Colorado where the north and south forks rise. These forks join in Logan County, Kansas. The Smoky Hill flows eastward to Junction City to confluence with the Republican River. Below this point the river is known as the Kansas River. The Saline River, a tributary of the Smoky Hill, rises near the Sherman-Thomas County line in extreme western Kansas. The Saline River flows eastward to its confluence with the Smoky Hill River several miles east of Salina, Kansas.

The streams include 50,951 intermittent stream miles and 3,832 perennial stream miles.[7] Drainage density is 0.31 mile per square mile in the basin (perennial streams only).

Minimum Desirable Streamflow (MDS), an amount of flow for instream uses and downstream water rights, has been set for three U.S. Geological Survey (USGS) gages in the basin. These are on the Smoky Hill River near Ellsworth, the Saline River near Russell and Chapman Creek near Chapman. MDS sets monthly flow targets at each gage. Flows have recently been below MDS for significant periods of time.

Three large federal irrigation and/or flood control projects are located in the Smoky Hill-Saline basin. Cedar Bluff Reservoir, a Bureau of Reclamation (Bureau) project, is located on the Smoky Hill River in Trego County. Wilson Lake on the Saline River and Kanopolis Lake on the Smoky Hill River are operated and maintained by the Corps.

Much of the western half of this basin is underlain by the Ogallala-High Plains aquifer, deposits of saturated sands, gravels and silts of Tertiary and Quaternary age. The High Plains aquifer underlies most of western and south central Kansas. The High Plains aquifer consists of several hydraulically connected aquifers, the largest of which is the Ogallala. The Ogallala-High Plains aquifer is distinctive from other aquifers in Kansas because it has low annual recharge.

The Ogallala-High Plains aquifer is found only in small parts of the western half of the Smoky Hill-Saline basin. It occurs in the southern portions of Sherman, Thomas, Sheridan, and Wallace counties and the northern parts of Logan, Gove, Trego, Ellis, Greeley, Wichita, Scott and Lane counties. Within the Smoky Hill-Saline basin the Ogallala-High Plains aquifer saturated thickness is generally less that 100 feet. In a few locations the saturated sediments are 150 or 200 feet thick when combined with the overlying alluvial sediments. Ground water resources also include the alluvial deposits along the rivers and tributaries and the Flint Hills aquifer in the eastern end of the basin.

Smoky Hill River. Photo by Kansas Water Office

The USGS estimated drainable water in storage in the High Plains aquifer in 1992 to be about 3.25 billion acre feet; 10% of that in Kansas.[8]

There were 3,593 water rights reporting use in the basin in 2006. These rights reported a total of 282,453 acre feet used from surface and ground water sources. Ground water sources accounted for 268,145 acre feet with the remaining from surface water.[9]

The primary reported water use in the basin was irrigation, at 246,134 acre feet followed by municipal use at 23,820 acre feet. Municipal water use (public water supply) includes communities and rural water districts as well as those industries that obtain water through a public water supply (Figure 2).

There were 99 public water suppliers in the basin in 2006. In 2006, 721 acre feet of water was marketed from Kanopolis Lake to one public water supplier who in turn supplied 11 other suppliers and rural customers.

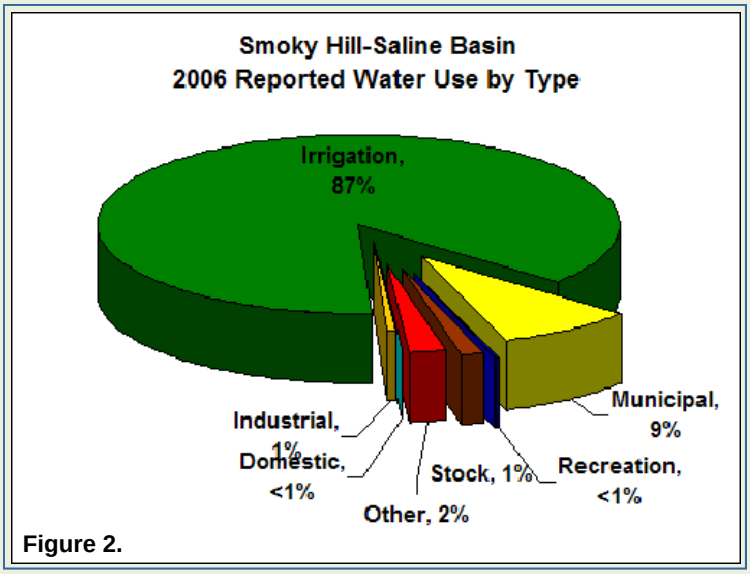

Figure 2.

Water Management

Western Kansas Groundwater Management District No. 1 (GMD1) and Northwest Kansas Groundwater Management District No. 4 (GMD4) each include portions of three (3) counties in the western end of the basin (Figure 3). The groundwater management districts are pro active in developing local water policy compatible with state Laws.

Water appropriations and use are overseen by the Kansas Department of Agriculture-Division of Water Resources. Most of the streams and alluvial corridors in the basin are closed or restricted for new water appropriations. This has eliminated the possibility of additional appropriations being approved in many areas of the basin. The exception is Ladder Creek and the Saline River which have not been closed to new appropriations.[11]

The Chief Engineer ordered Intensive Groundwater Use Control Areas (IGUCA) for two sections of the Smoky Hill River and for an area within the City of Hays. This closed the Smoky Hill River corridor in to further ground or surface water appropriations. An IGUCA can provide more comprehensive water management tools than provided under strict water right administration based on priority.

States generally have the responsibility to determine the management of the water resources in that state. The exception to this is the management of federal reservoirs by a federal agency. In the Smoky Hill-Saline basin, Cedar Bluff is managed by the Bureau, Wilson and Kanopolis are managed and operated by the Corps. The State of Kansas has purchased water supply storage in the Kanopolis Lake that provides water to a significant area of the basin.

Numerous other entities related to water resources may exist in the basin to address one or more water related issues. Watershed districts may be formed to develop and implement a comprehensive plan for a watershed that will provide flood protection for the residents and landowners. Parts of four watershed districts are included in the basin. These cover the watersheds for Spillman Creek Watershed Joint District No. 43 and, Lyons Creek Watershed Joint District No. 41 in Lincoln County, and Turkey Creek Watershed Joint District No. 32 and Lost Creek Watershed District No. 44 in Dickinson County.[10]

Each county has a county conservation district responsible for the conservation of soil, water, and related natural resources within that county. Multiple county groups may form Resource Conservation and Development areas (RC&Ds) to also address conservation of natural resources. Parts of five RC&Ds cover the Smoky Hill-Saline basin.[13]

Addressing water quality are four Watershed Restoration and Protection Strategy (WRAPS) programs that each cover a part of the basin. As of December 2007, all portions of the Smoky Hill River and parts of Big Creek were in some stage of the WRAPS process. In addition, drainage districts may also be formed in order to reclaim and protect land from the effects of water.

Russell County
Photo courtesy of Kansas Geological Survey

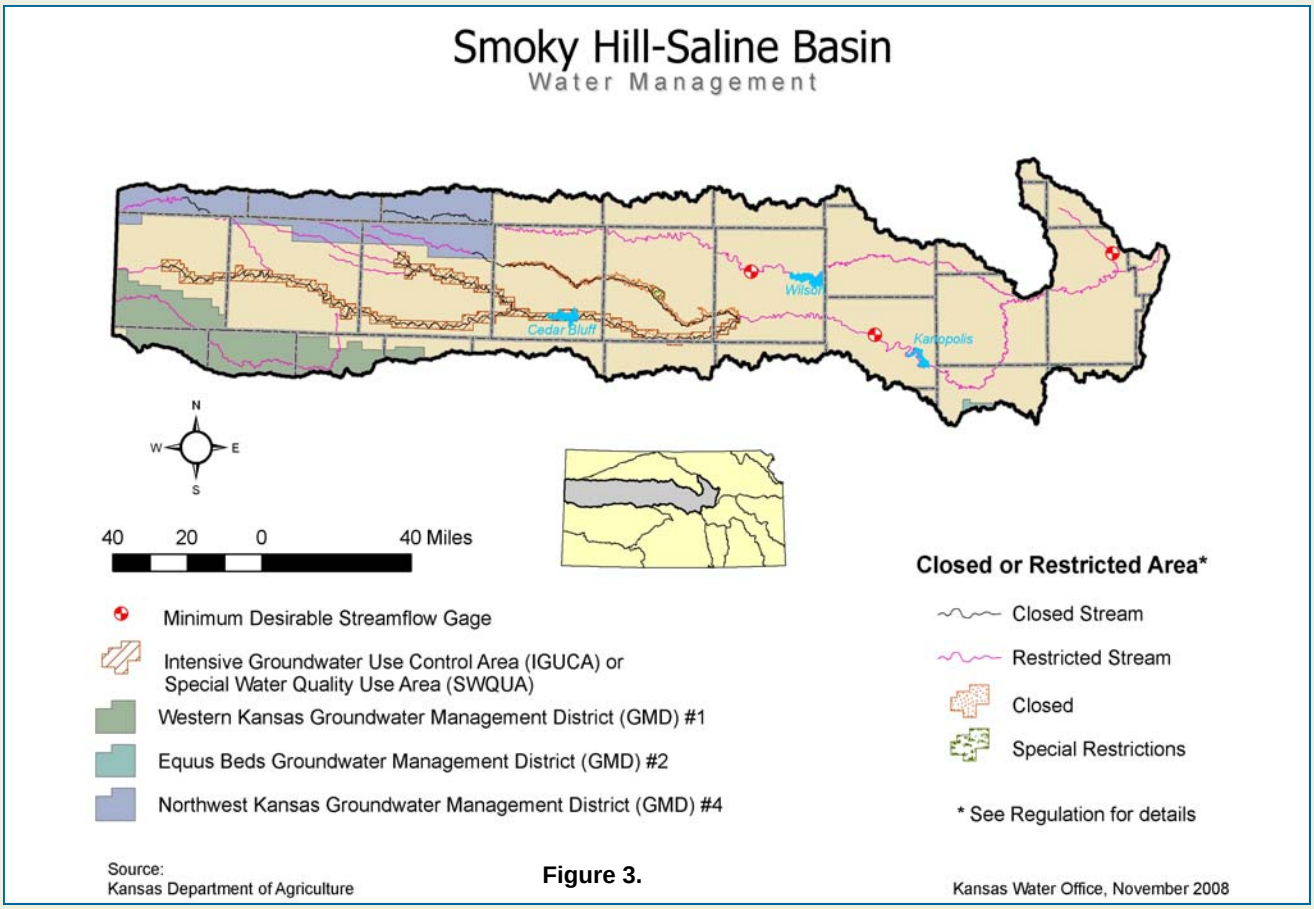

Figure 3.

Resources

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Reservoir Storage in the Smoky Hill-Saline Basin

Cedar Bluff Dam and Reservoir

Cedar Bluff Reservoir was completed in 1951 by the Bureau of Reclamation for flood control, water supply, irrigation, and other purposes. The main use of the lake was to support the operations of the Cedar Bluff Irrigation District. In 1963, the City of Russell entered into a contract with the Bureau of Reclamation for release of up to 2,000 acre-feet per year to recharge the city's well field.

When inflow into Cedar Bluff Reservoir was severely depleted in the 1960's and 1970's, the irrigation district ceased to be viable with the last delivery of water in 1978. The State of Kansas entered into an agreement with the Bureau of Reclamation and the Cedar Bluff Irrigation District in 1989 closing the irrigation district and giving control of all but 2,700 acre-feet of storage in the conservation pool to the State of Kansas. The main uses for the state storage are fish, wildlife and recreation as well as artificial recharge of the stream and alluvium downstream.

On January 9, 2006, the control of the majority of the stored water owned by the State in Cedar Bluff Reservoir was transferred to Kansas Department of Wildlife and Parks to better identify with the allowed uses of water and historic operations of the Reservoir. The Kansas Water Office retained control of the artificial recharge portion. The City of Russell continues to maintain their contract with the Bureau.

Kanopolis Dam and Lake

Kanopolis Lake storage of water in the lake began in February 1948. Kanopolis Lake was constructed and is operated by the U.S. Army Corps of Engineers. The lake was constructed to provide flood protection, recreation opportunities, fish and wildlife benefits, and maintain minimum stream flow on the Smoky Hill River.

Kanopolis Reservoir. Photo by KWO

In 2002, the State of Kansas acquired storage in Kanopolis Lake to be used for municipal and industrial water supply purposes through the State of Kansas Water Marketing Program. As of November 2007, Post Rock Rural Water District has a contract for a maximum quantity of 400 million gallons per year (mgy) or 1,227.555 acre feet (af) from Kanopolis Lake.

There are also irrigation and domestic use demands in the alluvial system downstream from the lake.

The Post Rock RWD currently serves retail customers and the cities of Brookville, Ellsworth, Dorrance, Gorham, Luray, Waldo, Paradise; the Wilson Lake Estates of Lincoln County Development; and the rural water districts #5 of Ellis County, #7 of Saline County and #2 of Osborne County. Requests for the remaining water in the Kansas Water Marketing Plan Storage are under consideration at the present time.

Wilson Dam and Lake

Wilson Dam and Lake, was completed by the U.S. Army Corps of Engineers in 1964. The project was authorized for flood control, irrigation, navigation, recreation, fish and wildlife and water quality purposes. Storage space was constructed for flood control storage, conservation storage and sediment storage. It was later determined that irrigation was not practical due to the concentration of dissolved minerals, primarily chlorides, that accumulate in the reservoir. The lake's maximum capacity is 736,000 acre feet (908 million m^3).

Wilson Lake. Photo courtesy of U.S. Army Corps of Engineers

Presently there is no storage allocated for water supply, but investigation of the use of Wilson to meet increasing needs in the region is underway. Technological advances in water quality treatment have reduced costs to remove the dissolved minerals.

Smoky Hill-Saline River Basin Management Categories

January 2009

WATER MANAGEMENT CATEGORIES

The following categories include issues identified in the Smoky Hill-Saline basin plan as items that require attention in addition to the basin priority issues. These issues are addressed within the following management categories:

- Water Management
- Water Conservation
- Public Water Supply
- Water Quality
- Wetland & Riparian Management
- Flood Management
- Water-Based Recreation

These categories also correspond to the statewide management categories and policies of the *Kansas Water Plan* found in Volume II. These documents contain new policy issues and the existing policy and statutory framework that relate to the management categories.

ISSUE: WATER MANAGEMENT

Management of Kansas' ground and surface water fits into six statewide categories, with five of these applicable in the Smoky Hill-Saline basin. These are:

1) River-Reservoir management
2) Stream reaches with established Minimum Desirable Streamflow;
3) Streams outside of Minimum Desirable Streamflow protected areas;
4) The Ogallala-High Plains aquifer
5) Ground water outside of the Ogallala-High Plains aquifer

Ground water is the primary water supply in the basin. The Ogallala-High Plains aquifer is a major source in the extreme western portion of the basin. Alluvial ground water is utilized where available throughout the basin. Ground water recharge rates are generally low throughout the basin except in the extreme eastern portion of the basin. A majority of the basin is restricted or closed for new water appropriations. The Ogallala-High Plains aquifer is managed with the local leadership of the Western Kansas Groundwater Management District No. 1 (GMD1) and Northwest Kansas Groundwater Management District No. 4 (GMD4). GMD1 has identified the entire district as high priority. GMD4 has identified six high priority subunits. Goals and management for each high priority subunit are under development. In 2008, a computer model developed for the six priority subunits in GMD4 was completed through cooperation of the Kansas Water Office (KWO), GMD4 and the U.S. Bureau of Reclamation. The model will aid in development and analysis of management scenarios.

In 2006, the KWO calculated the median annual water level changes in Ogallala–High Plains aquifer wells from 1981 to 2005. In the northwest Ogallala aquifer area, as of 2005, there has been no statistically significant change in the rate of decline. There was also no significant change in the water level decline rate for the west central Ogallala aquifer area.[6] Additional information on this issue may be found in the Smoky Hill-Saline basin priority issue section.

Photo by Kansas Water Office.

Reduced streamflow and runoff into streams has been reflected in lower reservoir water levels in the three federal reservoirs in the basin: Cedar Bluff, Kanopolis Lake and Wilson Lake. Yield analyses that have revised the estimated yield availability, along with known loss of storage due to sedimentation, have driven the need to revisit reservoir management. This is discussed in the basin priority issue Lower Smoky Hill River Water Management.

Requests for additional water from Kanopolis Lake exceed water available through the State Water Marketing Program. While mostly a public water supply issue, there is also a component of management of water in Kanopolis and the lower Smoky Hill River system to address before the public water supply issue can be resolved. Additional information on the public water supply issue may

be found in the Smoky Hill-Saline basin priority issue section.

There are three minimum desirable streamflow (MDS) locations in the basin that are part of the Smoky Hill River system: 1) on the Smoky Hill River near Ellsworth; 2) on the Saline River near Russell; and 3) Chapman Creek near Chapman. There was statistically no change in the frequency MDS was meet 1984 to 2004 when compared to historical frequency (1960 – 1983).

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce water level decline rates within the Ogallala-High Plain aquifer and implement enhanced water management in targeted areas.
- By 2015, achieve sustainable yield management of Kansas surface and ground water sources outside of the Ogallala Aquifer and areas specifically exempt by regulation. Sustainable yield management would be a goal that sets water management criteria to ensure long term trends in water use will move as close as possible to stable ground water levels and maintenance of sufficient streamflows.
- By 2015, meet minimum desirable streamflow at a frequency no less than the historical achievement for the individual sites at time of enactment.

Applicable Programs

The following programs help to meet the objectives in the water management category. For more information on the programs and associated policies, see the Programs Manual.

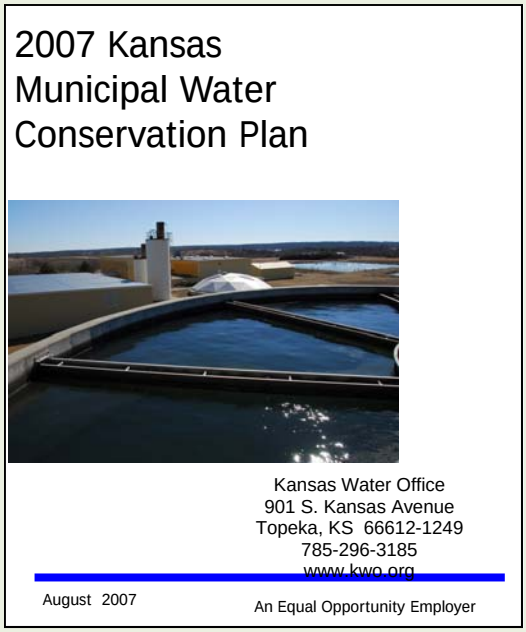
- Kansas Department of Agriculture-Division of Water Resources: Water Appropriation Program
- Kansas Geological Survey, Kansas Department of Agriculture, Division of Water Resources: Water Well Measurement
- State Conservation Commission: Water Right Transition Assistance Program
- USDA-Natural Resources Conservation Service: Environmental Quality Incentive Program (EQIP)
- Kansas Geological Survey: Stream Aquifer Interactions
- Kansas Geological Survey: High Plains Aquifer Technical Assistance Program
- Kansas Water Office: Water Marketing Program
- Kansas Water Office: Water Assurance Program
- Kansas Water Office: State Water Planning Program

ISSUE: WATER CONSERVATION

Water conservation is essential for the effective management of water resources in the basin to assure that a sufficient, long-term, supply of water is available for the beneficial uses of the people of the state. Conservation is defined as a careful preservation and protection of something, especially the planned management of a natural resource to prevent exploitation or destruction. Water conservation is a part of maintaining a long-term water supply for Kansas.

Water conservation activities apply to all uses, irrigation, municipal, industrial, and others, and from all sources. In 2006, irrigation accounted for 87% of all reported water pumped or diverted in the basin. Municipal use accounted for nine percent of water used in the basin, livestock water for one percent, and industry, recreation, and domestic uses for less than one percent each while other uses totaled two percent.

Of the 616 public water suppliers that have an approved conservation plan in place as of December 31, 2008, 65 plans have been approved in the Smoky Hill-Saline basin. As of August 2006, 139 conservation plans had been approved for irrigation water rights in the basin. The number of wells in Kansas that were reported to have irrigation application rates over the regional average fluctuated from about 3,700 to less than 500 from 1991 to 2005. Of the total number of wells that were reported to have diverted water in 2006, more than 59% in the Smoky Hill-Saline basin had a metered quantity, according to the Water Right Information System (WRIS) database.



Water conservation in the basin is exemplified by the efforts of the City of Hays. City policy has successfully kept consumption low while maintaining a viable and growing economy. Additional needs in the basin in the

future for growth and economic expansion indicate using water efficiently will be more important than ever.

GMD1 operates the Western Kansas Weather Modification Program for 10 counties in western Kansas. The Program goals include hail suppression and precipitation enhancement. Protection of crops from hail reduces water waste if irrigated crops should be lost.

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce the number of public water suppliers with excessive unaccounted for water by first targeting those with 30 percent or more unaccounted for water.
- By 2010, reduce the number of irrigation points of diversion for which the amount of water applied in acre-feet per acre (AF/A) exceeds an amount considered reasonable for the area.
- By 2015, all non-domestic points of diversion meeting predetermined criteria will be metered, gaged, or otherwise measured.
- By 2015, conservation plans will be required for water rights meeting priority criteria under K.S.A. 82a-733 if it is determined that such a plan would result in significant water management improvement.

Applicable Programs

The following programs help to meet the objectives in the Water Conservation management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Appropriation Program
- Kansas State University Research and Extension: Water Conservation and Management Program/MIL
- State Conservation Commission: Water Resources Cost-Share Program
- State Conservation Commission: Water Right Transition Assistance Program
- Kansas Water Office: Water Conservation Program
- Kansas Water Office: Weather Modification Program
- USDA-Natural Resources Conservation Service: Environmental Quality Incentive Program (EQIP)
- USDA-Farm Service Agency: Conservation Reserve Program

ISSUE: PUBLIC WATER SUPPLY

The primary approach to addressing public water supply issues in the basin focuses on ensuring that there are adequate supplies of surface and ground water within the basin to meet future water demands, reducing the number of public water supply systems that are vulnerable to drought, and ensuring that systems have the technical, financial and managerial capacity to meet future needs for water quality and quantity.

In 2006 there were 79 public water supplies in the Smoky Hill-Saline basin. Ground water is the primary source for most public water supplies, accounting for nearly 73% of the total supply, principally from the Ogallala-High Plains, the Dakota and the alluvial aquifers along major streams. In addition, the City of Russell obtains a portion of their water from surface flow in the Smoky Hill River, below Cedar Bluff Reservoir. Kanopolis Lake supplies a large geographic area through rural water district connections.

Smoky Hill River Dam at Pfeiffer. Photo by Kansas Water Office

Among the state's major river basins, the percentage of drought vulnerable public water suppliers in 2006 ranged from three percent (Neosho Basin) to 42% (Solomon Basin). Comparison of the KWO 2000 and 2006 lists shows a significant increase in the number of drought vulnerable public water suppliers in most western river basins including the Smoky Hill-Saline. There were 30 public suppliers considered drought vulnerable in the Smoky Hill-Saline basin in 2006.

Public water supply needs in the basin have increased in recent years and are expected to continue due to population and industrial growth in the central and eastern parts of the basin. Kanopolis and Wilson Lakes and their operation plans are under review as components to meeting future demands. Meeting public water supply needs is a basin priority issue. Additional information on

this issue may be found in the Smoky Hill-Saline Basin priority issue section.

Applicable *Kansas Water Plan* Objectives

- By 2010, ensure that sufficient surface water storage is available to meet projected year 2040 public water supply needs for areas of Kansas with current or potential access to surface water storage.
- By 2010, less than five percent of public water suppliers will be drought vulnerable.
- By 2010, ensure that all public water suppliers have the technical, financial and managerial capability to meet their needs and to meet Safe Drinking Water Act requirements.

Applicable Programs

The following programs help to meet the objectives in the Public Water Supply management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Appropriation Program
- Kansas Department of Health and Environment: Public Water Supply Program
- Kansas Department of Health and Environment: Kansas Public Water Supply Loan Fund
- Kansas Water Office: State Water Planning Program
- Kansas Water Office: Water Conservation Program

ISSUE: WATER QUALITY

Water quality and related water resource issues are addressed through a combination of watershed restoration and protection efforts utilizing voluntary, incentive-based approaches, as well as regulatory.

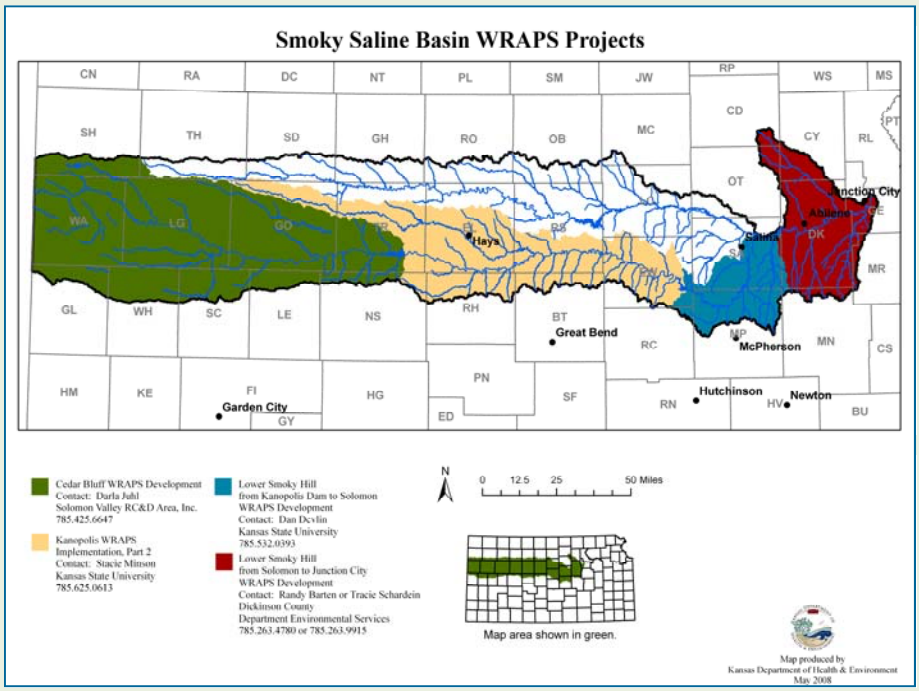
All the counties within the basin have a sanitarian funded by the Local Environmental Protection Program (LEPP).[2] All conservation districts in the basin have adopted nonpoint source pollution management plans. Buffer coordinators have also been employed in four counties in the basin to facilitate enrollment of stream buffers in the continuous Conservation Reserve Program (CRP) and State Water Quality Buffer Initiative.[4]

The Clean Water Act requires states to conduct Total Maximum Daily Load (TMDL) studies and develop TMDLs for water bodies identified on the state's List of Impaired Waters (Section 303(d) List). TMDLs are quantitative objectives and strategies needed to achieve the state's surface water quality standards. There are 33 approved TMDLs within the Smoky Hill-Saline basin. Five are high priority for implementation. There are 2 lakes, Lake Scott and Herrington Reservoir listed as water quality impaired by eutrophic conditions, pH, dissolved oxygen, and/or aquatic plants. Streams are sampled at 26 locations with dissolved oxygen depletion, total dissolved solids, selenium and total phosphorus identified as the cause of the greatest number of impairments. Other pollutants limiting use of Smoky Hill-Saline basin streams include arsenic, cadmium, lead, nitrates, dissolved oxygen, E. Coli bacteria, and biological stressors. Additional TMDL development is anticipated in 2009.

Kansas Watershed Restoration and Protection Strategy (WRAPS) is a planning and management framework that engages stakeholders within a watershed in a process to:

- Identify watershed restoration and protection needs.
- Establish watershed management goals.
- Create a cost-effective action plan to achieve goals.
- Implement the action plan.

As of March 2008, there were 44 active WRAPS projects located throughout Kansas[3]. Four are in the Smoky Hill-Saline basin, including all the watersheds for the Smoky Hill River.



Major point sources in the basin include waste water treatment plants. The City of Hays is included in Phase II National Pollutant Discharge Elimination System (NPDES) Stormwater Program as having municipal separate storm sewers (MS4s).

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce the average concentration of bacteria, biochemical oxygen demand, solids, metals, nutrients, pesticides and sediment that adversely affect the water quality of Kansas lakes and streams.
- By 2010, ensure that water quality conditions are maintained at a level equal to or better than year 2000 conditions.
- By 2010, reduce the average concentration of dissolved solids, metals, nitrates, pesticides and volatile organic chemicals that adversely affect the water quality of Kansas ground water.
- By 2010, maintain, enhance, or restore priority wetlands and riparian areas.
- By 2015, nutrient reduction goals will be included in all WRAPS projects within the basin.
- By 2010, all public water suppliers will complete and implement a source water protection plan.

Applicable Programs

The following programs help to meet the objectives in the Water Quality management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Health and Environment: State Water Plan Program (Contamination Remediation)
- Kansas Department of Health and Environment: Local Environmental Protection Program
- Kansas Department of Health and Environment: Watershed Management Section/WRAPS
- State Conservation Commission: Nonpoint Source Pollution Control Program
- State Conservation Commission: Water Resources Cost-Share Program
- Kansas Corporation Commission: Conservation Division Programs
- Kansas Department of Health and Environment: Watershed Management Section/TMDL

ISSUE: WETLAND & RIPARIAN MANAGEMENT

The primary approach to wetland and riparian management in the basin focuses on providing technical and financial assistance to landowners to protect and restore these resources in priority watersheds through the implementation of best management practices.

Photo by Kansas Water Office.

Riparian lands in the Smoky Hill-Saline basin have been impacted by the infestation of non-native phreatophytes, although not to the degree as in other western basins. Of greatest concern are the effects tamarisk (salt cedar) and Russian olive have on native riparian ecosystems.

Applicable *Kansas Water Plan* Objectives

- By 2010, maintain, enhance or restore priority wetlands and riparian areas.

Applicable Programs

The following programs help to meet the objectives in the Wetland and Riparian management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Forest Service: Forest Stewardship Program and Conservation Tree Planting Program
- State Conservation Commission: Riparian and Wetland Protection Program
- Kansas Water Office: State Water Planning Program
- Kansas Department of Wildlife and Parks: State Parks and Wildlife Areas Planning and Development
- Kansas Department of Wildlife and Parks: Wildlife Habitat Improvement Program

Smoky Hill-Saline River Basin Management Categories

ISSUE: FLOOD MANAGEMENT

Flooding is a natural, recurring event associated with streams and rivers that has resulted in the formation of natural floodplains over time. While this inundation provided benefits under natural conditions, encroachment of urban and agricultural development onto floodplains has resulted in the potential for flood damage. In addition, the Smoky Hill-Saline basin is prone to flash flooding which is characterized by a rapid rise in water level, fast-moving water and much flood debris.

Kansas Water Plan flood management guidance has targeted watershed dam construction assistance to priority watersheds, encouraged National Flood insurance participation and updating of floodplain maps for priority communities.

Significant flooding was experienced during 1903, 1938 and 1941 on the Smoky Hill River. Three federal dam projects: Cedar Bluff, Kanopolis and Wilson, contribute to flood control in the basin. Local watershed districts construct, operate and maintain works of improvement needed to provide for water management within designated boundaries. Their primary function is to develop a comprehensive general plan for a watershed that will provide flood protection for the residents and landowners. Three watershed projects are located in the basin, two of which are now completed.

Financial assistance from the State Water Plan Fund has been provided for flood mapping as part of the 1993 Kansas Department of Agriculture-Division of Water Resources *Kansas Flood Mapping Initiative* in Ellis and Saline counties in the basin. Ellsworth and McPherson counties are included in this initiative to have maps modernized by 2110.

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce the vulnerability to damage from floods within identified priority communities or areas.

Applicable Programs

The following programs help to meet the objectives in the Flood Management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Structures Program/Floodplain Management
- Kansas Department of Agriculture-Division of Water Resources: Water Structures Program/Dam Safety
- Kansas Division of Emergency Management: Hazard Mitigation Grants Program
- State Conservation Commission: Watershed Dam Construction Program
- State Conservation Commission: Watershed Planning Assistance Program
- FEMA: National Flood Insurance Program

ISSUE: WATER-BASED RECREATION

The Smoky Hill-Saline basin has a wide variety of public water recreation sites on state and federal land. There is a demand for more consistent water levels, and access to water based recreation facilities for area residents. Recreation contributes income to the economy by attracting sportsmen and women to the area for hunting at wildlife areas, camping and picnicking at recreation areas, and fishing and boating on reservoirs and lakes.

Cedar Bluff Reservoir and Kanopolis and Wilson lakes provide recreational opportunities including fishing, boating, and camping. Wildlife areas include Cedar Bluff Wildlife Area, Wilson Wildlife Area and the Smoky Hill Wildlife Area at Kanopolis Reservoir. In addition, the state supports fishing at Kanopolis State Park Pond, Logan State Fishing Lake and Saline State Fishing Lake (Periodically Dry).

Applicable *Kansas Water Plan* Objectives

- By 2010, increase public recreational opportunities at Kansas lakes and streams.

Applicable Programs

The following programs help to meet the objectives in the water-based recreation management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Wildlife and Parks: Rivers and Stream Access
- Kansas Department of Wildlife and Parks: State Parks

ISSUES FOR FUTURE ACTION

None identified at this time.

Smoky Hill-Saline Basin High Priority Issue
Ogallala-High Plains Aquifer Declines
January 2009

Issue

Management of the Ogallala-High Plains aquifer ground water declines in the Smoky Hill River basin.

Vision

Sufficient water resources in western Kansas to support healthy, economically strong communities and rural lifestyles, today and for future generations.

Goal

Extend and conserve the life of the Ogallala–High Plains aquifer

Description

The Ogallala Formation of the High Plains aquifer (Ogallala-High Plains aquifer) underlies western portions of Smoky Hill River basin (Figure 1). The Equus Beds aquifer, a shallower and geologically more recent portion of High Plains aquifer, underlies a small area in McPherson County. South of the Smoky Hill River, the Ogallala is found in southern Wallace and northern Greeley, Wichita and Scott counties. Most of these areas are in Western Kansas Groundwater Management District No.1 (GMD1), with fringe areas of the aquifer outside of GMD1 managed by the Kansas Department of Agriculture-Division of Water Resources (DWR). North of the Smoky Hill River, the Ogallala underlies Sherman, Thomas, Sheridan counties, parts of Graham, Rooks, Logan, Gove, Trego and Ellis counties. Sherman, Thomas and Sheridan counties and northern Logan and Gove counties are in the Northwest Kansas Groundwater Management District No. 4 (GMD4), with the aquifer fringe managed by DWR.

In the western half of the Smoky Hill basin, the Ogallala-High Plains aquifer has been developed so extensively that the amount of water withdrawn annually is significantly more than the recharge, resulting in ground water declines. As ground water levels decline, the aquifer loses hydraulic connection with the overlying alluvial aquifers and rivers, and no longer contributes much, if any, base stream flow. Since the 1950s (predevelopment), aquifer water levels in the basin have generally declined from 15% to over 50% in Wallace, Greeley, Wichita, Scott and Lane counties. However, water levels have declined 75 to 100 feet in parts of Wallace and Sherman counties, with the major portion of Wallace County declining 50 to 75 feet, from predevelopment through 1999.[1]

Aquifer water levels in the basin have declined up to 30 feet over the ten-year period from 1996-2006 with the greatest declines centered in the western townships of Wallace and Sherman counties. The overall decline has contributed to a progressive reduction in surface water flow during the past several decades. Note that the Saline River is not considered hydrologically connected to the Ogallala-High Plains at the headwaters in Thomas County.

Water users in parts of Wallace, Sherman, Thomas and Sheridan counties are experiencing shortages in meeting demand. To extend and conserve the life of the Ogallala–High Plains aquifer, GMD1, GMD4 and the DWR are defining priority areas to reduce aquifer declines. Federal and state voluntary incentive programs

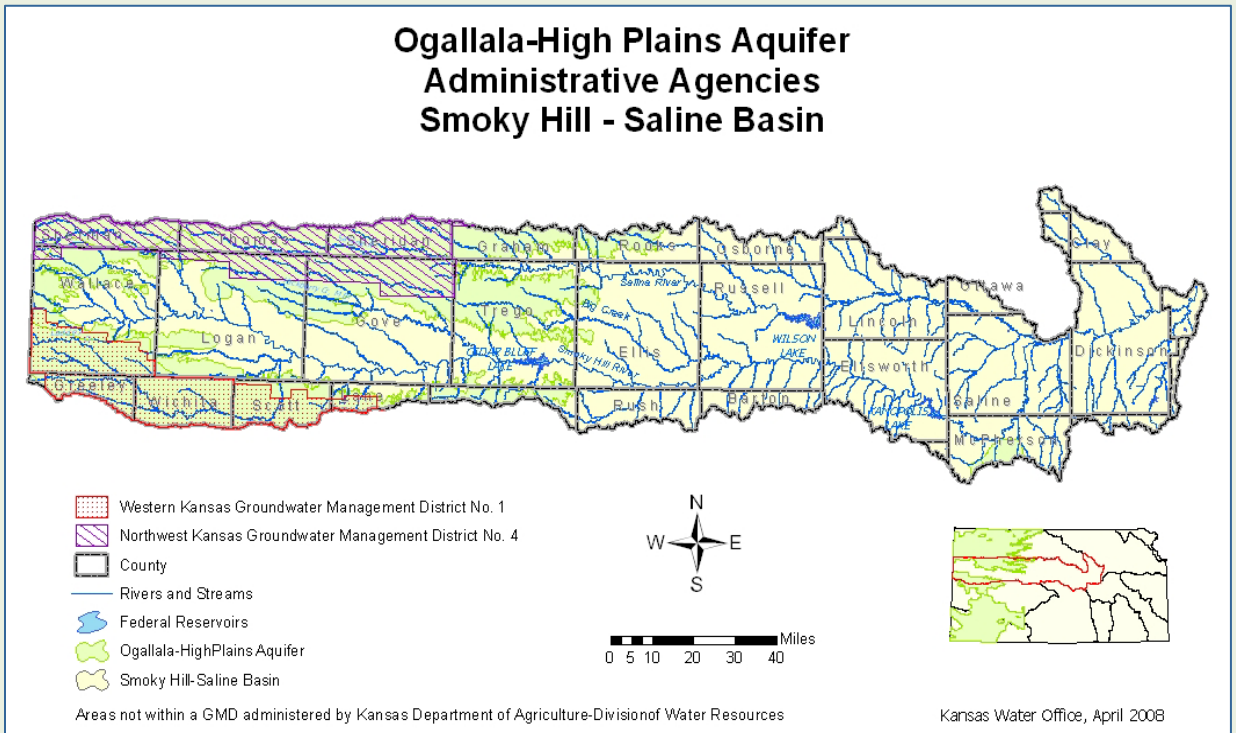


Figure 1.

to reduce water use have been developed and target priority areas.

A 2006 the Kansas Water Office (KWO) analysis of water level data from 1981-2005 indicated that the aquifer decline rate had not been reduced by a statistically significant amount between two time periods: 1981-1993, and 1993-2005.[2]

Water Appropriations

Approximately 608,381 acre feet of the ground water appropriations in the Smoky Hill-Saline basin are from the High Plains aquifer. Total appropriations in the basin from the Ogallala-High Plains aquifer are approximately 605,769 acre feet for all beneficial uses. There are about 2,265 active Ogallala-High Plains water rights from 2,625 wells.[5]

Water Use

The 2006 reported water use from the Ogallala-High Plains aquifer in the basin was 220,183 acre feet. Reported use in the basin within GMD1 and GMD4 was 146,839 acre feet and 64,746 acre feet respectively.[5]

There are 2,805 permitted ground water wells in the GMD1 pumping water from the Ogallala-High Plains aquifer. The average annual usage has been approximately 300,000 acre-feet per year. According to GMD1, the ground water decline in that district averaged approximately one foot for the year 2007.[3] Based on the amount of water in aquifer storage and the annual recharge rate, there is approximately 20 years of pumping left without any intervention.

Annual water use reported and quantified by township for 2002-2006 is provided in Table 1, based on data analysis by DWR.[4] Some townships have water use in more than one area, such as a GMD and the fringe, therefore the sum of the number of townships analyzed for each area is not the same as those included in "All" in Table 1. The majority of a township may be in another basin or have no access to the Ogallala aquifer.

There has been widespread adoption of more efficient irrigation systems in the Kansas high plains, shifting from flood and center pivot irrigation to center pivot with drop nozzles.[11] A study by Kansas State University in 2006 found that the number of acres irrigated is a more important determinant of changes in water use than the adoption of more efficient irrigation systems. The authors concluded that if the irrigated acres are held steady after conversion to a more efficient irrigation system, net water use would, on average, change little; it is with a decrease in irrigated acres that a reduction in water use is assured.[10]

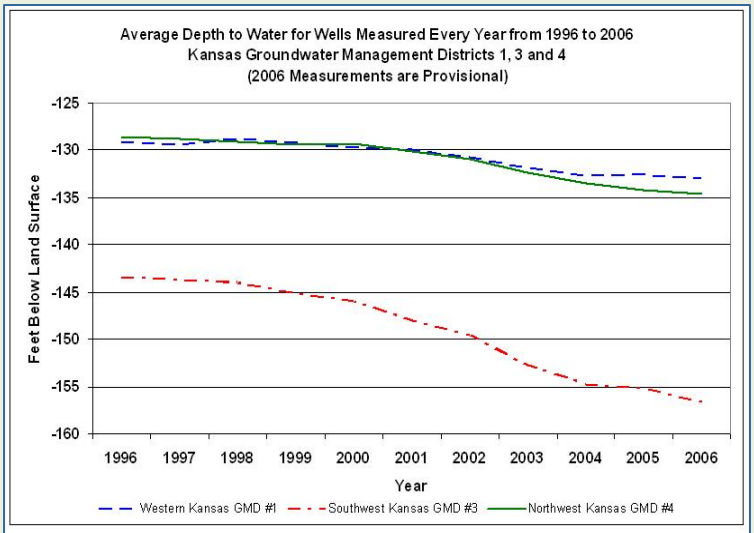


Figure 2.

Aquifer Declines

Average water levels in the aquifer within the ground water management districts have continued to decline over the past ten years (Figure 2).

The overall average ground water level decline in the Ogallala-High Plains region over the 2005 calendar year was 0.57 feet. This was more than the average decline over 2004 (0.15 feet), but less than the average annual decline rate over the five years since 2001 water measurements (approximately 0.98 feet/year).[7]

Figure 3 is an estimated projection of the years until the Ogallala-High

Table 1.

Irrigated Water Use for Ogallala Area in Smoky Hill-Saline Basin

Area	Number Townships	Number Points of Diversion	2006 Water Use (AF)	Acre-feet/ acre 2002	Acre-feet/ acre 2003	Acre-feet/ acre 2004	Acre-feet/ acre 2005	Acre-feet/ acre 2006
GMD1	29	1,523	140,870	1.14	0.99	0.96	0.85	0.94
GMD4	27	601	51,692	1.10	1.04	1.06	0.89	0.93
Fringe	10	190	12,202	1.01	1.04	0.97	0.81	0.87
All		2,217	197,391	1.14	0.99	0.96	0.85	0.94

Plains aquifer reaches a point where wells will only be able to produce 400 gallons per minute (gpm) if ground water level trends from 1996 to 2006 repeat continuously and unchanged into the future. This methodology is best suited to the Ogallala portion of the Ogallala-High Plains aquifer because of the relatively extensive data sets for the Ogallala. The variability of the system is the biggest drawback.[6]

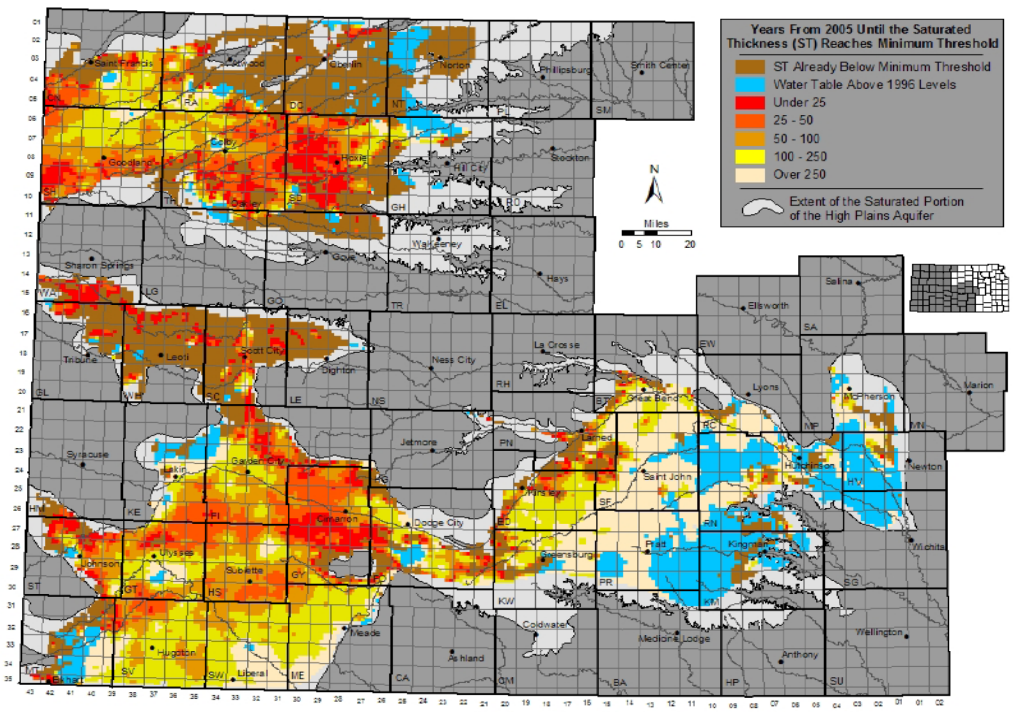


Figure 3. Estimated Usable Life of the High Plains Aquifer

Activities and Progress

Various programs and activities have been initiated to reduce the decline rate of the Ogallala-High Plains aquifer and to extend and conserve the aquifer. Tools such as ground water and surface water models and more detailed aquifer characterization have been developed. In the Smoky Hill-Saline basin, the determination of Ogallala subunit priority areas, setting subunit goals and developing management plans to reach these goals, has been the responsibility of GMD1, GMD4 and DWR.

Good data is essential to determine the decline rate. Data development includes calibration of ground water models to better understand the aquifer and subunits. Water meters, now required on almost all wells provide improved information on withdrawals. All wells in GMD4 should be metered by December 31, 2009. Wells in GMD1 are already metered. Annual water level measurements, three "index" wells, and weather station data provide information contributing to more accurate models.

GMD1 has identified the entire district as high priority. GMD4 has identified six high priority subunits. Portions of two are in the Smoky Hill-Saline basin (Figure 4). The GMD4 board is in the process of establishing water use goals and enhanced management actions for the high priority aquifer subunits.

The State and GMD4 have modeled management scenarios for the six high priority subunits in GMD4. Corresponding economic impact estimates were made for the modeled ground water levels.[13] The economic impact was based on likely farm decisions such as changing irrigated crops or going to dryland farming in response to specific water conditions as determined by Kansas State University with input from the GMD4 board. The different types of programs to reduce irrigation water use, such as limited irrigation or dryland with farming, dryland without farming, all make significant differences in the potential economic impact to various sectors (state, regional economy, or producer).

Voluntary programs have been targeted to areas determined by GMD1, GMD4 and DWR. Federal ground and surface water programs of the Environmental Quality Incentive Program (EQIP) have focused on areas selected annually. GMD1 and GMD4 areas utilized all available resources allocated for incentive payments of $100 per acre annually for three years on eligible acres to convert irrigated land to non-irrigated land.

State programs have offered incentives to retire water rights in some areas, however that opportunity has not been provided to the Smoky Hill-Saline basin. Regulatory programs have included special assistance by DWR to irrigators that have pumped in excess of their water rights or the area average.

Progress toward reducing the aquifer decline rate was evaluated by the KWO in 2006. The median annual water level changes were calculated for each region and

standardized or indexed to antecedent moisture conditions using the Palmer Drought Severity Index (PDSI) for the appropriate region. The comparison of 1981-1993 and 1993-2005 periods concluded that there was no discernable change in the rate of water level declines in the Ogallala–High Plains region. It also concluded that in the northwest Ogallala aquifer area (GMD4 and DWR in the fringe areas), that as of 2005, there has been no statistically significant change in the rate of decline. There was also no significant change in the water level decline rate for the west central Ogallala aquifer area (GMD1 and DWR fringe).[2]

It should be noted that the percentage of total water use that has been reduced through voluntary and regulatory programs is small. A reduction of decline rates will likely take many years or decades to be recognizable unless participation and reductions are greater.

Priority Aquifer Subunits: Priority aquifer subunit maps are used to guide state and federal efforts on water conservation. GMD1 has selected the entire district as priority subunit (hatched). GMD4 has identified 6 high priority subunits, parts of two in the basin. The DWR for areas of the Ogallala-High Plains aquifer outside of the districts, with input from the public. Specific target areas are defined for areas eligible for enrollment in the EQIP quick response areas and Water Right Transition Assistance Program (WTAP).

The priority rank shown on Figure 4 outside GMD4 is based on an area's total score from two databases: 1) estimated usable lifetime; and 2) density of ground water use. Useable lifetime is defined as the ability to support a 400 gpm well yield, on every quarter section, pumping for 90 days. Rank 1 indicates areas with a short estimated usable lifetime and a history of higher ground water usage. Rank 4, the lowest concern areas, have a relatively long useable lifetime and low total water use.

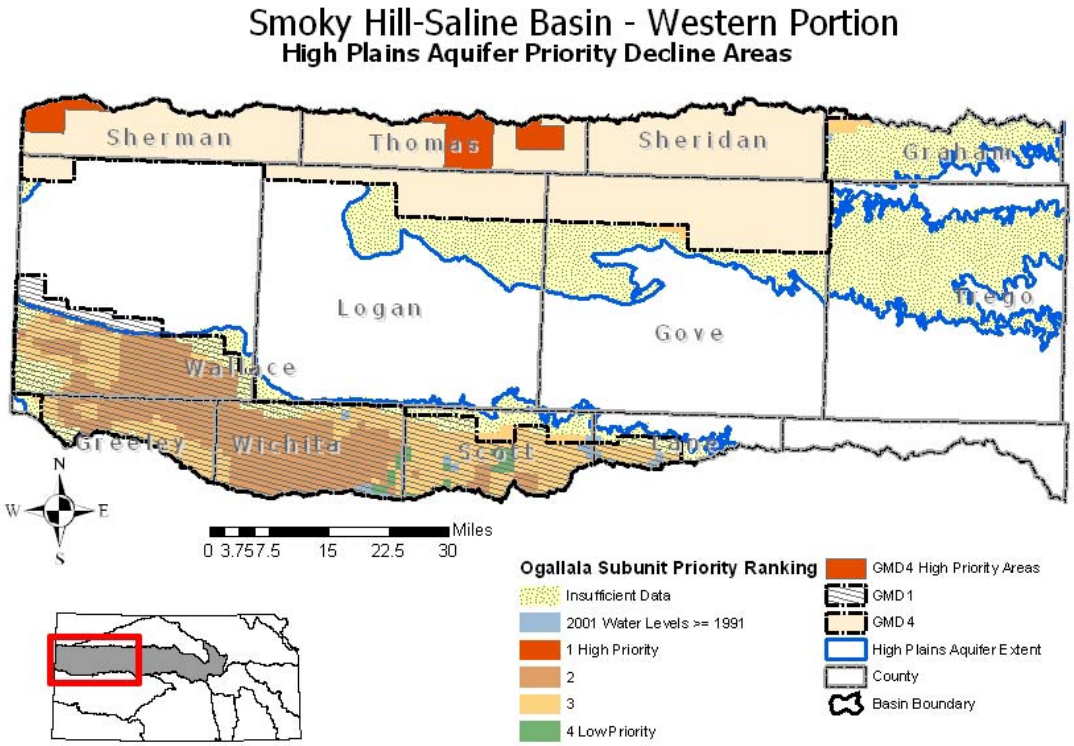


Figure 4. Kansas Water Office, December 2008

Recommended Actions

1. GMD1, and DWR where outside the district, identify priority aquifer subunits or areas, and GMD4, GMD1, and DWR develop specific goals and management strategies to extend and conserve the life of the aquifer.

2. GMD1, GMD4 and DWR manage aquifer subunits to maintain economic health while ensuring sufficient water resources for future generations of western Kansas communities and rural populations and chosen lifestyles.

3. Support research for high value, low water use crops.

4. Provide opportunities to permanently or temporarily reduce water use through voluntary programs (state, federal, and local).

5. Educate water users, decision makers and the general public on the condition of the aquifer and methods and opportunities to reduce water use.

6. Seek crop insurance option for limited irrigation crops from USDA Risk Management Agency.

In order to implement the main actions stated above the following specific activities are recommended:

- Provide technical support, including hydrologic modeling, if appropriate, to project aquifer current and future conditions. Identify and implement activities to promote local conservation to extend the life of the aquifer that accrue to the aquifer subunit or region where water savings has occurred.
- Recognize the benefit of aquifer subunit planning. Management of the aquifer by subunit can benefit the local community economic wellbeing and social connectedness; reduce over pumping, and widespread well shut offs from impairments.
    - Encourage ownership in one's aquifer subunit; promote local leadership.
    - Form subunit teams to provide local leadership on management of aquifer subunits or other local areas/subunits for reduced consumptive water use.
    - Target incentive-based programs to aquifer subunits that have a long term vision and plan.
    - Implement aquifer subunit plans that assure water into the future to help attract industry, thus contributing to the economic health of the subunit and area.
- Consider the long term impact of climatic change on the water demands for the region.
- Consider interstate discussions on water conservation and planning where aquifer subunits cross state boundaries, and are not directly impacting an existing surface water compact.

Resources

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Smoky Hill River. Photo courtesy KGS.

Smoky Hill-Saline Basin High Priority Issue
Water Supply
January 2009

Issue

Meeting central Kansas Smoky Hill-Saline regional public water supply (municipal and industrial) needs.

Providing for the changing uses, demands and distribution of water use in the central part of the Smoky Hill-Saline basin to meet public water supply is a recognized need in the basin. Resource management to maintain economic stability and provide for economic growth is part of any considerations in management decisions.

Description

The provision of adequate quantities of good quality water for municipal and industrial purposes is of major concern. Increasing industrial, agribusiness and municipal needs for water supply all exist in various portions of this diverse basin. Communities in the relatively dry western part of the basin seek to expand and diversify their economic base. The Smoky-Hill-Saline basin relies on water from surface storage in the eastern portion and/or ground water available from local aquifers. Much of the central portion of the basin receives water from Kanopolis Lake through rural water district distribution to supplement any ground water appropriation held by the public water supplier or individual. Many communities seek to provide for industry as well as meet needs for population growth. The eastern portion of the basin receives greater precipitation, however demand in this area is also increasing with economic and population growth.

Recent climatic conditions, the decline of ground water levels and reduced reservoir yields contribute to water supply concerns. This issue is directly related to the Lower Smoky Hill River Management issue also found in this basin section.

Water Resources

Water sources in basin include: Cedar Bluff, Kanopolis, and Wilson Dams and associated reservoirs; the Smoky Hill and Saline rivers and tributaries and associated alluvium; as well as the Ogallala-High Plains aquifer in western portions of the basin.

Cedar Bluff Reservoir provides flood protection and storage of water for fish and wildlife, along with municipal use by the City of Russell and recharge of the Smoky Hill River alluvium. Cedar Bluff Reservoir was originally authorized for irrigation, flood control, and water supply, with incidental benefits for recreation, fish and wildlife, and water quality. In 1992, Congress reformulated the project to create an operating pool for fish, wildlife, and recreation. Irrigation was abandoned as a project purpose and the irrigation district was dissolved. Results of an analysis by Kansas Water Office (KWO) to determine the water supply yield that can be expected during a 2 percent chance drought (required for the state Water Marketing Program) indicated Cedar Bluff is not suitable for storage of water under the Marketing Program. Therefore, Cedar Bluff Reservoir is not a potential source of additional municipal and industrial water supply.

Kanopolis dam and lake provides flood protection and storage of water for municipal and industrial use, along with fish, wildlife and recreation. The state Water Marketing Program purchase of storage of 12,500 acre feet in the multipurpose pool for municipal and industrial use was 46% of the pool based adjustments for 40 years of sedimentation. Storage capacity is presently estimated at 22,607 acre feet.. Kanopolis Lake was also analyzed by the KWO to determine water supply yield expected during a two percent chance drought. The available yield was revised in 2008 to an estimated 6.5 million gallons per day (MGD), reduced from earlier estimates.[5] The yield was originally estimated as 15.4 MGD, with 12.9 MGD yield estimated after 40 years due to sedimentation. The reduced 2008 yield is related to loss of inflow into the lake. Since 1950 there has been a significant reduction to the flow volume gain between the Bunker Hill and Ellsworth gages. This loss has reduced the volume of inflow to Kanopolis Lake.

Wilson Reservoir Dam on Saline River. Photo courtesy Kansas Geological Survey.

Smoky Hill-Saline Basin High Priority Issue
Water Supply
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Wilson dam and lake was originally authorized for construction by the U.S. Department of Interior, Bureau of Reclamation (Bureau) for the purposes of irrigation, navigation enhancement, flood control, recreation, fish and wildlife habitat, and water quality assurance. The multipurpose (conservation) pool has an estimated current capacity of 227,701 acre feet. Due to the high salinity of waters in Wilson Lake; irrigation, municipal and industrial water use from the lake were determined impracticable and the construction and operation of the lake were transferred to the U.S. Army Corps of Engineers (Corps). While an authorized purpose of the project, navigation is no longer a specific consideration for the daily operations due to Wilson Lake's distance from the Missouri River.

Wilson Lake lies in the vicinity of the cities of Russell, Hays and others with anticipated water needs in the future. The possibility exists for reallocation of storage at Wilson Lake to supply water for municipal and industrial needs. Treatment techniques to address the salinity are available now at more reasonable costs, making water supply potentially practical. This water could prove crucial to assuring the long-term economic viability of the area.

Streams in the basin include approximately 3,832 perennial stream miles.[4] Diversions totaling 241,950 acre feet are authorized from all surface water sources in the basin. Approximately 9,531 acre feet are authorized for public water supply from surface supplies.[3] Minimum Desirable Streamflow (MDS), an amount of flow for instream uses and downstream water rights, has been set for one U.S. Geological Survey (USGS) gage on the Smoky Hill River near Ellsworth. MDS sets monthly flow targets at a gage that may vary by month. On average, streamflow has been insufficient to meet the MDS.

Ground water is found in alluvial aquifers along the major rivers and tributaries, supplying some water for beneficial uses in the basin. Ground water appropriations total 78,828 acre-feet in the basin.[3] The High Plains aquifer provides water where the Ogallala Formation is present in the western part of the basin and from the Equus Beds aquifer in McPherson County. The USGS estimated water in storage in the High Plains aquifer to be about 3.25 billion acre-feet of drainable water in 1992, with ten percent of that in Kansas.[9] The Dakota aquifer underlies most of the basin, with outcrops in Russell, Lincoln, Ellsworth and eastern Saline counties. There is great variability in aquifer yield and quality from the Dakota. The salinity of Dakota aquifer waters is one of the most important factors limiting current exploration in the confined aquifer. Water availability and economics have caused the City of Hays to develop and utilize slightly saline waters in the Dakota in west central Ellis County. The Dakota-Cedar Hills aquifer underlies portions of Ellis, Russell, Rooks, Osborne, Rush and Barton counties in the basin.[8] The Flint Hills aquifer is found in the eastern end of the basin.

Availability of additional water appropriations is limited as all of the streams and alluvial corridors in the basin are either closed or restricted for new appropriations. The Ogallala-High Plains aquifer, in the western part of

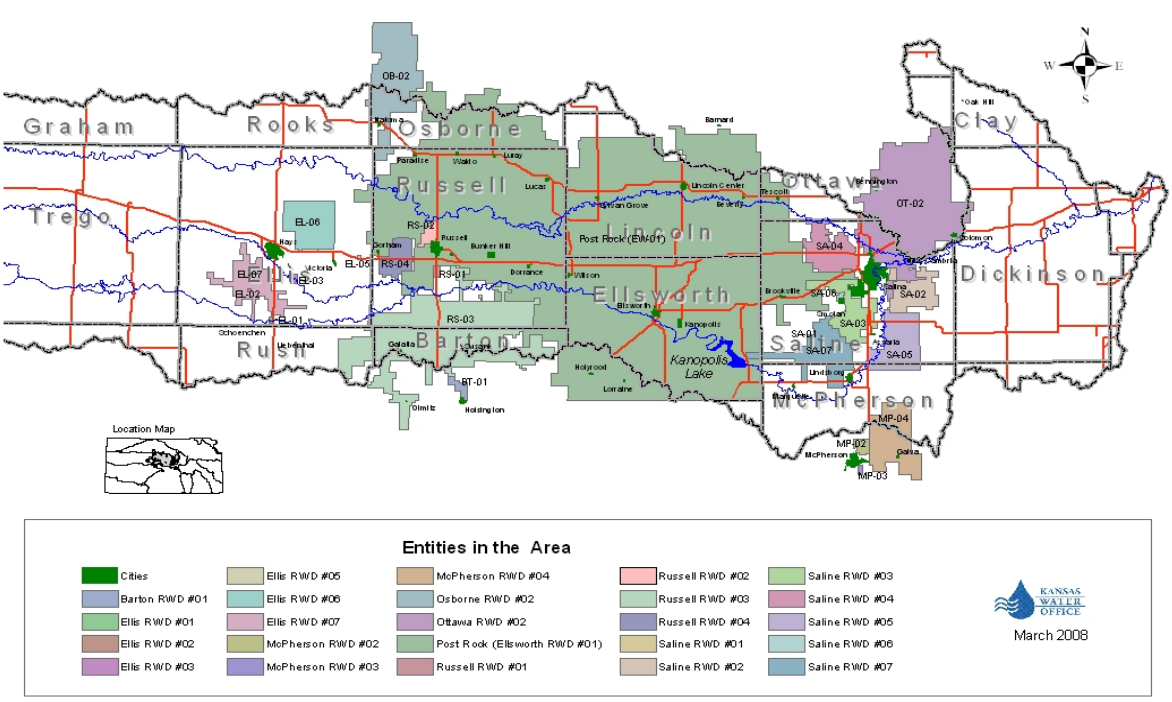

Figure 1.

the basin, is closed in Western Kansas Groundwater Management District No. 1 (GMD1), but small ground water appropriations may be obtained in some locations in Northwest Kansas Groundwater Management District No. 4 (GMD4).

Public Water Supply

Appropriations for municipal use water rights from all sources in the Smoky Hill-Saline basin totaled 35,247 acre feet per year. Industrial water rights, not included as part of municipal water rights, totaled an additional 7,319 acre feet per year. Corresponding water use reported for 2006 was 18,901 and 1,687 acre feet per year for municipal and industrial uses respectively.[3]

Delivery of water supply in the central portion of the basin is interrelated and interconnected among suppliers. In 2006, there were 99 public water suppliers in the basin. In 2006, 721 acre-feet of water was marketed from Kanopolis Lake to Post Rock Rural Water District who in turn supplied 11 other suppliers as well as rural customers. Eleven other public water suppliers in the basin also sell water to 13 other public water suppliers.

Post Rock Rural Water District currently has a contract for a maximum quantity of 400 million gallons per year (MGY) or 1,227.555 acre feet from Kanopolis Lake. Post Rock currently serves retail customers and the cities of Brookville, Ellsworth, Dorrance, Gorham, Luray, Waldo, Paradise; the Wilson Lake Estates of Lincoln County Development; and the rural water districts #5 of Ellis County, #7 of Saline County and #2 of Osborne County. In 2006, the City of Russell was added as a place of use in order to meet a shortage at that time. Post Rock is currently providing water to an ethanol plant in Russell.

Future Needs

The basin had an estimated population of 156,161 in 2000. The population of the 32 counties that are entirely or partially in the Smoky Hill-Saline basin was 330,631 in the year 2000 and is projected to be 288,939 in the year 2040. There are no population projections for the basin itself for 2040. Rural counties have lost population, sometimes more than 10 percent every decade. However the populations are expected to increase from 19,726 in 2006 to 35,455 in 2050 for Hays and 4,280 in 2006 to 6,631 for Russell in 2050, respectively.[2] Additional water demands are occurring presently as energy and other industrial users are requesting water through public water suppliers or directly.[10]

Water supply demand projections for the central area of the basin have been estimated numerous times over the past decades. The most recent study completed in 2005, estimated a need for 7.0 million gallons maximum day net water need for the regional area including the cities of Hays and Russell and other public water suppliers. The average day net water need was estimated at 3.0 million gallons per day (MGD) for the year 2050.[1] This estimated need did not include McPherson, located outside the basin, and the additional water to meet energy industry demands that increased in 2006.

More recent estimates indicate total maximum demand of 18.4 MGD will be needed to provide Post Rock Rural Water District, Wilson, and the cities of Hays, Russell, Victoria, Sylvan Grove and Bunker Hill in the north central part of the basin by 2050.[2] This is 7.5 MGD of maximum daily water demands above estimated available supplies in the central portion of the basin. This does not include the City of McPherson's request for 3.65 million gallons per year (MGY) (11,201 acre feet) from Kanopolis, or the needs of the cities of Salina and Lindsborg in the future. The City of Lindsborg filed an application in 1997 for 606.735 MGY (1,862 acre feet) from Kanopolis but has not pursued negotiations. The City of Salina's population in 2008 was 45,956, according to the Chamber of Commerce. KWO has projected Salina's population to be 58,790 by 2040, a 28% increase. Salina has not submitted an application for water from Kanopolis but is investigating options to meet future needs..

Smoky Hill River. Photo courtesy KGS.

In 2006, KWO projected demand from 2010 to 2040 for potential additional customers of Post Rock Rural Water District as shown in Table 1.[7]

Smoky Hill-Saline Basin High Priority Issue
Water Supply
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Although the estimated future water needs for public water supply (municipal and industrial uses) vary, all indicate a need for water in addition to that presently available through appropriation or water marketing. Not only does the quantity of water need to be addressed, but the distribution/transportation must be considered. Many public water suppliers in the basin are interconnected, either as a supplier or purchaser. These cooperative relationships are needed to provide water through out the basin. Planning to most effectively meet projected needs throughout the basin is the present challenge.

Table 1
Potential Customers for Post Rock Rural Water District
KWO Projected Water Demands in Millions of Gallons
2000 – 2040

Potential Customers	Year				
	2000*	2010	2020	2030	2040
Bunker Hill	4.401	5.095	4.735	4.323	3.911
Kanopolis	20.700	29.635	29.337	29.039	28.692
Lincoln	75.148	53.505	48.150	43.320	38.969
Lorraine	6.643	7.190	7.190	7.190	7.190
Natoma	12.372	12.187	10.961	9.850	8.853
Russell	373.757	218.224	215.852	213.434	211.061
Russell Co. RWD #1	1.576	2.626	2.626	2.626	2.626
Russell Co. RWD #2	1.199	1.737	1.737	1.737	1.737
Russell Co. RWD #3**	59.691	58.192	60.999	63.806	66.669
Russell Co. RWD #4**	6.124	3.830	3.785	3.785	3.741
Saline Co. RWD #2	20.449	20.860	20.028	19.252	18.475
Saline Co. RWD #3**	28.229	31.787	36.835	41.884	46.933
Saline Co. RWD #4	34.205	28.732	31.934	35.218	38.421
Saline Co. RWD #8	9.388	13.389	16.831	20.327	23.768
Saline Co. RWD #6	4.233	6.833	8.655	10.477	12.261
TOTAL	658.115	493.822	499.655	506.268	513.307

* Actual water use. ** Purchases from another source.

Recommended Actions

1. Evaluate (quantity) water resources in the basin and compare with appropriations (supply and demand analysis).

2. Evaluate management of various hydrologic systems and resources in the basin that may provide opportunities for additional water uses.

3. Develop strategy for additional supplies. Options include:
   a. Request federal reallocation of storage in Wilson Lake.
   b. Purchase Wilson Lake storage for Water Marketing Program, if determined feasible.
   c. Consider additional storage in Kanopolis Lake.
   d. Explore opportunities for long-term reconfiguring of connections if storage in Wilson Lake is purchased.

4. Negotiate water marketing contracts based on available water.

5. Explore methods to reduce need for additional water supplies such as:
   a. Evaluate opportunities to improve efficiency and conservation of existing municipal supplies to provide additional users with the savings.
   b. Explore options for reuse/recycling of water to allow for additional water users without increasing consumptive use.

6. Continue to support local conservation efforts and programs such as in the City of Hays and WaterOne district in Johnson County.

7. Continue to promote water quality measures to protect sources of public water supply.

Resources

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2. Burns & McDonnell. 2007. Preliminary data for Wilson Lake Public Assistance to States evaluation report.

3. Kansas Department of Agriculture-Division of Water Resources. 2008. Water Right Data.

4. Kansas Geological Survey. 2007. *KGS OFR 2003-55E: Assessment of Riparian Areas Inventory, State of Kansas.* http://hercules.kgs.ku.edu/geohydro/ofr/2003_55/riparian/ofr_2003_55e.htm.

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Smoky Hill-Saline Basin High Priority Issue
Lower Smoky Hill River Water Management
January 2009

Issue

Efficient management of the Smoky Hill River System, Kanopolis Lake and downstream reservoirs for beneficial water uses is needed.

Efficient management of the resources related to Kanopolis Lake and the Smoky Hill River below the dam is needed to meet the water needs under varying climatic conditions. Review of the available supply, expected demands and potential management scenarios to meet water appropriations and water marketing goals has been initiated.

Comprehensive understanding and management of the system and water use are needed to balance the water releases from Kanopolis Lake and the additional demands for water in the basin. An approach is needed that will allow the use of storage to meet contemporary needs, yet respect the current commitments under contract, and appropriated rights.

Description

The Smoky Hill River runs the west-east extent of the basin. Two federal reservoirs are located on the Smoky Hill River in the state, Cedar Bluff Reservoir in Trego County, operated by the U.S. Bureau of Reclamation (Bureau) and Kanopolis Lake, 100 miles downstream of Cedar Bluff, in Ellsworth County. Kanopolis Lake is operated by the U.S. Army Corps of Engineers (Corps).

Kanopolis Lake was initially authorized for flood control, irrigation and recreation purposes. Kanopolis Dam was completed in 1946 and the lake filled in 1948. The irrigation purpose of Kanopolis Lake was never developed due to the lack of an irrigation district downstream of the lake. Kanopolis Lake provides flood protection and storage of water for municipal and industrial use, along with fish, wildlife and recreation benefits. Storage capacity in the multipurpose pool (for municipal and industrial use) in the State Water Marketing Program is presently estimated at 22,607 acre feet. Kanopolis Lake was analyzed by the Kansas Water Office (KWO) to determine what water supply yield can be expected during a two percent chance drought. The yield was revised by KWO in 2008 to an estimated availability of 6.5 million gallons per day (MGD) in 2048, reduced from earlier estimates. [3] The yield was originally estimated as 15.4 MGD, reduced to 12.9 MGD yield after 40 years due to storage loss from sedimentation. The most recently reduced yield is related to loss of inflow into the lake. Since 1950, there has been a significant reduction to the flow volume gain between the Bunker Hill and Ellsworth gages upstream of the lake. This loss has reduced the volume of inflow to Kanopolis Lake.

In June 2002, the Kansas Water Office (KWO) and the Corps finalized a contract for the purchase of 46.6% of the multipurpose pool. This is an estimated 12,500 acre-feet of public water supply storage in Kanopolis Lake after adjusting for sedimentation of 40 years.

Kanopolis is the major source of municipal and industrial water to over 12,000 customers in parts of eight counties in north central Kansas through Post Rock Rural Water District (Post Rock). Post Rock has a contract for 400 million gallons per year (MGY) to meet this demand. Post Rock is the only current public water supply using water from Kanopolis Lake, leaving 7.5 MGD yield based on present yield estimates.

Like all Corps lakes, Kanopolis has a lake regulation manual that contains operating guidance. Releases from storage are made according to set schedules, most of which were established decades ago. The conservation storage pool typically contains a percentage identified as the water quality pool. Releases from this pool are generally intended to meet instream needs such as water quality and fish and wildlife support.

Recent drought years have brought attention to the operation of Kanopolis Lake. Specifically of concern are the water releases and lake levels during times of little or

Kanopolis Lake. Photo courtesy Kansas Geological Survey.

no inflow, such as in 2006, and the needs of downstream water users. In the 101 miles of river below Kanopolis Dam to the New Cambria gage, which is located east of the confluence of the Smoky Hill and Saline rivers, there are nearly 300 water rights for an authorized quantity totaling 43,123 acre feet per year from surface and alluvial ground water sources.[1] The larger portions of this quantity are appropriations for irrigation, and municipal and industrial use, including the City of Salina.

Table 1 and Figure 1 provide basic water appropriation and use information for the stream and ground water system below Kanopolis to the New Cambria gage.

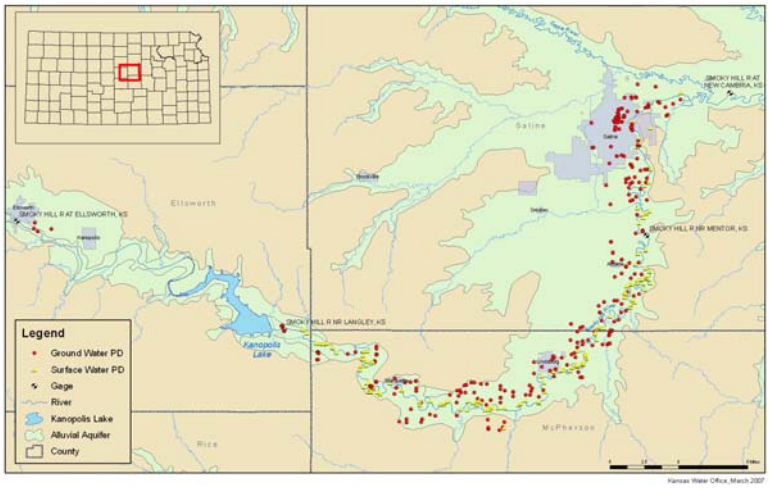


Figure 1. Water Appropriations in the Smoky Hill River Valley, Kanopolis Lake to New Cambria.

Six active applications totaling 23.4 MGD are on file with the KWO, including one from Post Rock Rural Water District for water stored (26,259.656 acre feet) in Kanopolis. This amount exceeds Kanopolis Lake's 2009 uncommitted yield of 7.5 MDG (8,401 acre feet per year).[5]

In November 2006, the Kansas Water Authority (KWA) identified specific information needed before negotiating any additional water marketing contracts from storage in Kanopolis Lake. Work began in 2007 and is ongoing to meet the informational needs. These include:

- Stream/aquifer and reservoir models of the Smoky Hill River and Kanopolis Lake.

Table 1

2008 Appropriations Below Kanopolis to New Cambria Gage

298 Authorized Water Appropriations

Use Made of Water (Acre-Feet)

Source	Domestic	Industrial	Irrigation	Municipal	Recreation	Stock	Other	Total
Surface	1	0	7,403	5,028	246	0	6,958	19,636
Ground	20	1,368	11,544	8,188	207	102	2,058	23,487
Total	21	1,368	18,947	13,216	453	102	9,016	**43,123**

Irrigated Acres Authorized by Source		
Surface	Ground	Total
8,047	10,239	18,286

2006 Reported Water Use Below Kanopolis to Mentor Gage

276 Water Rights Reporting

Use Made of Water (Acre-Feet)

Source	Domestic	Industrial	Irrigation	Municipal	Recreation	Stock	Other	Total
Surface	0	0	1,968	4,206	196	0	0	6,370
Ground	0	370	5,349	3,287	129	63	904	10,102
Total	0	370	7,317	7,493	325	63	904	**16,472**

2006 Reported Irrigated Acres by Source		
Surface	Ground	Total
2,155	6,456	8,611

Source: WIMAS Summary Results as of April 17, 2008

- Assessment of the impact of minimum releases, both in-lake and downstream.
- An updated yield of water marketing storage using data from1948 through present.
- Determination of interest and needs of communities and rural water districts in the area.
- Determination of impact on the lake level with full water marketing use.

Recommended Actions

The compilation and evaluation of data related to the hydrologic system along with a comparison of the system water budget to supply needs are essential in determining actions. All of the recommended actions will be completed with input and awareness of stakeholders in the area.

1. Complete and maintain the hydrologic model of the Smoky Hill River valley. Use the model to understand the relationship between the alluvial aquifer, streamflow and reservoir releases.

2. Incorporate the updated Kanopolis Lake yield information in the aquifer model to better understand impacts on the reservoir and hydrologic system.

3. Determine the impact of full utilization of the Water Marketing Program supply on lake level and corresponding recreation and downstream uses.

4. Develop a basic supply and demand analysis using population and demand trends and reported water use. Compare to information developed in above models.

5. Identify options to meet water use needs in the area based on results of models and other pertinent data. This may include review of the Kanopolis Lake Regulation Manual as part of the river system operation.

6. Develop an action plan to address preferred options for management needs based on hydrologic analysis/water budget and considering economic impacts.

Resources

1. Kansas Department of Agriculture-Division of Water Resources. 2008. Water Right Database-Water Resource Information System (WRIS).

2. Kansas Geological Survey. 2008. Smoky Hill River model – under development.

3. Kansas Water Office. May 2008. *Kanopolis Water Supply Yield Analyses and Review of Reservoir Inflow Depletions*.

4. Kansas Water Office. 2006, November 16. *Preliminary Findings Request by Rural Water District No. 1, Ellsworth County, DBA Post Rock Rural Water Supply District to Purchase Water From Kanopolis Lake for Water Supply Purposes*.

5. Kansas Water Office. 2008. Surplus Water Available in Water Marketing Program Lakes Calendar Year 2009. p 21-22.

Solomon River Basin

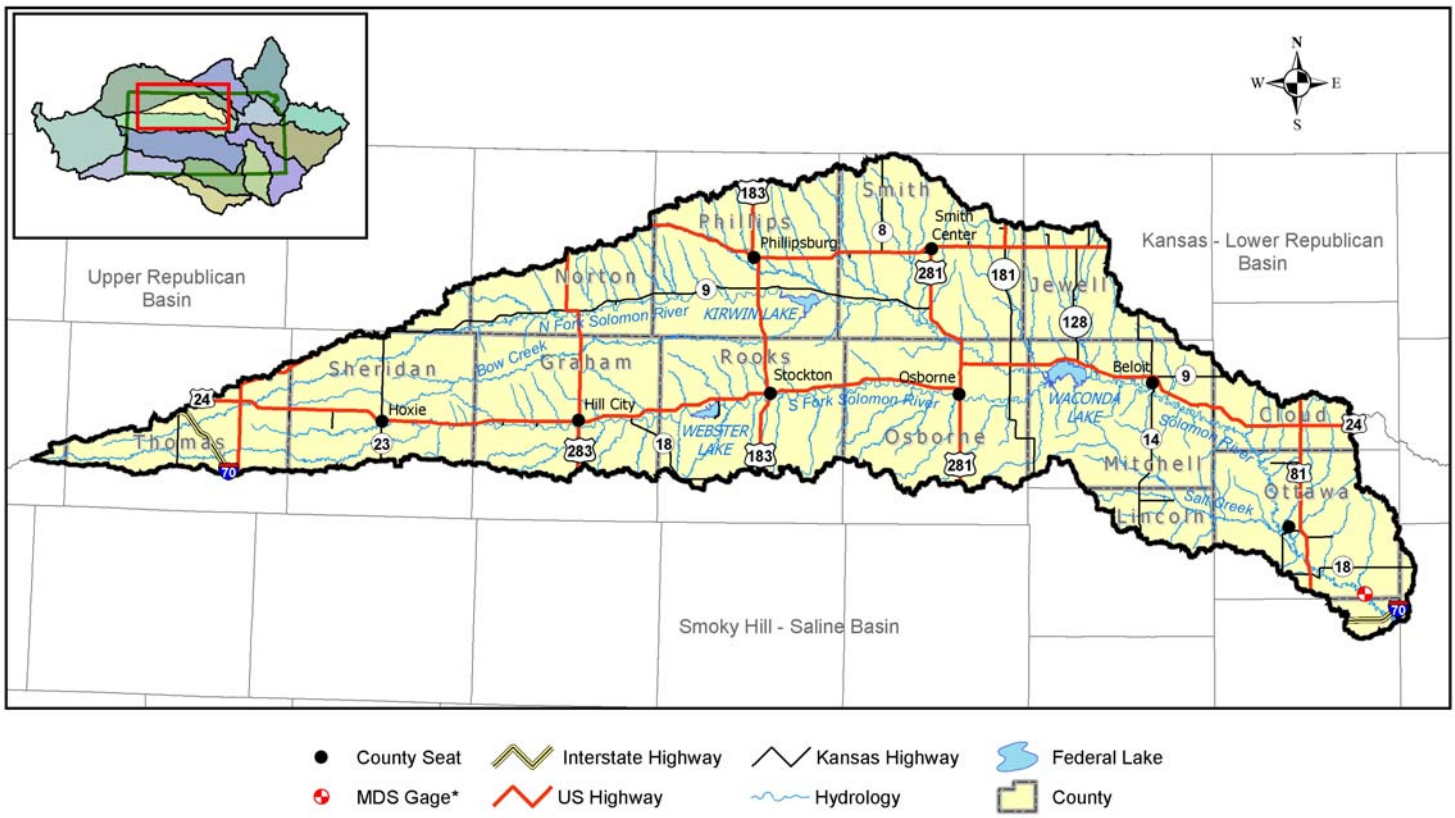


Figure 1.

* Minimum Desirable Streamflow

General Description

The Solomon River drains an area of 6,835 square miles of the Great Plains Physiographic Province, within northwest and north central Kansas. The Solomon River basin covers all or parts of Decatur, Norton, Phillips, Smith, Jewel, Sherman, Thomas, Sheridan, Graham, Rooks, Osborne, Mitchell, Cloud, Lincoln, Ottawa, Dickinson and Saline counties. The topography is generally flat to gently rolling hills with narrow, shallow valleys of low relief. The Solomon River is part of the Kansas River system. The basin includes subbasins with hydrologic unit codes 10260011, 10260012, 10260013, 10260014 and 10260015.[1]

The basin is unique in that all of its drainage area is within Kansas. From the headwaters of the North and South Forks of the Solomon near the Sherman-Thomas county line, the basin extends eastward to the confluence of the Solomon with the Smoky Hill River in Dickinson County.

Surface elevations in the Solomon River Basin decline from about 3,300 feet in the western North Fork drainage to 1,150 feet at the confluence with the Smoky Hill River.

Population and Economy[2]

There were an estimated 39,900 residents in the basin in the year 2000. The total population of the 17 counties that are entirely or partially in the Solomon basin was 154,233 in the year 2000 and is projected to be 128,912 by the year 2040. The large discrepancy in estimated population and the counties total is due to the inclusion of Saline and Dickinson counties. In the past 40 years, two trends have dominated the state. Rural counties have lost population, sometimes more than 10% every decade.

As one example, Osborne County, with a population of 7,506 in 1960, had only 4,452 residents in 2000. Only one county in the basin, Thomas, gained population in this 40-year period.

In 2006 there were an estimated 8,840 farms, with 8,761,000 acres in the 17 counties with all or parts in the basin. The average farm is about 991 acres.

Agriculture is the predominant economic activity throughout the basin with irrigated agriculture taking on added significance in the semi-arid west. Irrigated crops are important in some areas of the basin.

Livestock production is an important part of the area's agriculture and economy as well. Beef cattle are the predominant livestock raised in the basin.

Ogallala Outcrop Graham County
Photo courtesy of Kansas Geological Survey

Recreation is an increasing part of the economics of the basin, as is industry. The federal reservoirs and associated recreation and wildlife areas draw hunters, fishermen and boaters to the area. In addition, the state offers fishing at Jewell State Fishing Lake, (57 acres, 6 S 2 W of Mankato), Ottawa State Fishing Lake, (138 acres, 5 N, 1 E of Bennington), Rooks State Fishing Lake, (67 acres, 2-1/2 S 2 W of Stockton) and Sheridan State Fishing Lake, (67 acres, 11 E of Hoxie).

The growing industrial contribution to the basin economy is primarily related to energy production, including ethanol. As of April 2008 one 40 million gallons per year (MGY) plant was in operation at Phillipsburg.

Opportunities for higher education in the basin are offered through the Northwest Kansas Technical College at Beloit.

Physical Characteristics

Geology and Soils

Surface geology in the Solomon basin consists of unconsolidated and consolidated rocks of sedimentary origin. The unconsolidated deposits, considered of recent origin, consist of Quaternary alluvium, loess (wind born deposits) and the Tertiary Ogallala Formation. The Quaternary alluvial deposits are widespread, primarily found in the uplands in the western and central parts of the basin. The alluvial deposits can also be found in the channels and floodplains of major streams, consisting of gravel, sand, silt and clay.

The loess deposits mainly occur in the uplands and on the valley slopes. Terrace deposits are the reworked older alluvium and Ogallala Formation.

The Ogallala Formation, found in the western third of the basin consists of silt, sand, gravel and cemented calcium carbonate beds. The Ogallala ranges from 60 feet thick in northern Phillips County to about 260 feet in central Thomas County. The Ogallala Formation lies uncomfortably on the Pierre Shale in the western and on the Niobrara Formation in the eastern part of the basin.

The Dakota Formation underlies the basin and is near the surface in Ottawa County. Other consolidated units in the basin include the Carlile Shale, Greenhorn Limestone, Graneros Shale, Kiowa Shale, Cheyenne Sandstone, Niobrara Chalk and the Pierre Shale.

Principal water bearing units include the Ogallala, Dakota formations and the valley alluvium.

Rock City- Dakota Outcrop Ottawa County
Photo courtesy Kansas Geological Survey

Table 1. Total Riparian Land Use Bank Miles for Solomon Basin

Hydro Type	Animal Prod. Area	Barren Land	Crop Land	Crop/ Tree Mix	Forest Land	Pasture/ Grass Land	Pasture/ Tree Mix	Shrub Land	Urban Land	Urban/ Tree Mix	Total
Intermittent Stream	1	8	9,759	1,533	2,618	14,922	3,557	9	108	43	32,557
Perennial Stream	0	7	50	541	1,527	156	531	10	2	6	2,829
Shoreline	0.6	20	72	10	46	983	112	5	4	2	1,256
Total	1.6	35	9,881	2,084	4191	16,061	4,200	24	114	51	36,644

A wide variety of soils are present in the Solomon basin. These include loose sands; level, productive valley alluvium; moderately heavy soils on the slopes and uplands; and friable, less acidic soils. Productivity of the soils generally increases westward.

The majority of the bottom land and terrace soils are level to slightly sloping, friable soils constituting about 14 percent of the drainage. Some bottom lands are sandy, while others are clayey and impermeable.[4]

In the eastern part of the basin it has thin loess soils that are generally shallow, sloping, medium acid, and easily eroded. In the west and central portion of the basin, soils range between deep moderately heavy silt loams or loess to shallow silty or stony soils over the Ogallala Formation. The friable soils in the western portion of the basin are subject to severe water and wind erosion.[4]

Photo courtesy of Kansas Geological Survey

In the western part of the basin, most of the river valleys contain a more granular soil type resulting from stream-laid deposits. The primary soil is the Holdrege-Ulysses Association, consisting of deep to moderately deep, dark grayish-brown silt loams and moderately deep gray clays that are gently sloping.[4]

Land Use/Land Cover

The Solomon basin covers approximately 4,393,538 acres. More than 52 percent (%) was cropped, while over 40% was in grass in 2005.

Of the 2.5 million acres cropped annually, about 149,734 acres were irrigated in 2006 according to annual water use reports.[7] Irrigated crops are primarily corn, soybeans and alfalfa. The remaining acres area devoted to dryland crops including wheat, sorghum, corn, alfalfa, soybeans, sunflowers and hay and pasture.

The Kansas Geological Survey (KGS) categorized riparian land use in 2003. Statewide pasture/grass land is the dominant riparian land use type in Kansas, exceeding 142,000 bank miles or roughly 38% of all land use types. In this basin, the total of 35,386 bank miles varies in the type of riparian land use, with nearly 44% of the riparian cover being pasture/grass land.

Table 1 provides more detail for riparian land within one mile of streams and water bodies.[6]

Climate

The climate of the basin is classified as subhumid in the east and semiarid in the west. The climate characterized by moderate to low precipitation, relatively high wind velocities, high evaporation rates, a wide range of temperatures and abrupt changes in weather. Average annual total precipitation varies from 18 - 28 inches, west to east, while average annual surface runoff increases from 0.1 inches in the west to 4.0 inches in the east. Most of the precipitation occurs April through September. Annual evaporation from impoundments range from 54 inches in the east to 60 inches in the west.

Drought is a naturally recurring feature of this climate as exemplified by the Dust Bowl of the 1930's and the severe drought of 1952-1957. Kansas has been impacted by severe drought periodically. Reduced precipitation is offset by irrigation for crop production increasing the demand on the available water supply.

Flooding when it occurs, is generally the result of intense storms of short duration. The combination of limited channel capacity and flat flood plain can result in large portions of the valleys being inundated when storm intensity, coverage and duration contribute to runoff greater than the channel can handle.

Table 2. Climate Summary Solomon Basin

Location	Average Annual[1]		Freeze Dates (32 F.)[2]		
	Precipitation (inches)	Temperature (deg. F.)	Last in Spring	First in Fall	Frost Free Days
Hoxie	21.37	52.0	Apr. 28	Oct. 5	160
Smith Center	24.65	53.8	Apr. 22	Oct. 12	171
Minneapolis	30.28	56.2	Apr. 19	Oct. 18	183

[1] Source: National Climatic Data Center (1971-2000 data)
[2] Source: KSU Weather Data Library (1961-1990 data)

Wildlife and Habitat

Key wildlife habitat includes cropland, good and excellent rangeland, weedy and brushy fence rows and ungrazed areas, riparian areas, streams, and wetlands. Key wildlife species include ring-necked pheasants, greater prairie chicken, bobwhite quail, and whitetail and mule deer.(11)

Three wildlife areas are maintained by state or federal agencies near each of the federal reservoirs.

Kirwin National Wildlife Refuge is located in the rolling hills of the narrow North Fork of the Solomon River valley in southeastern Phillips County. The Kirwin Refuge lies in a transition zone between the tall grass prairies of the east and the short grass plains of the west. As a result, grasses and wildlife common to both areas are found on the Refuge.(4) The water in the Refuge, along with Kirwin Lake is considered an Outstanding National Resource Water and a Special Aquatic Life Use Water.

Webster Wildlife Area encompasses 7,622 acres of public hunting surrounding 1,678 surface acres of water. A variety of wildlife habitats are developed and maintained to enhance wildlife.

Glen Elder Wildlife Area encompasses almost 13,200 land acres surrounding the 12,500 acre Glen Elder Reservoir.

Numerous threatened or endangered species have range within the basin. These include the bald eagle, snowy plover, piping plover, whooping crane, peregrine falcon and Topeka shiner (historic range).(11)

Water Resources

The major streams in the basin are the Solomon River and its major tributaries, the North Fork Solomon and the South Fork Solomon, both originating near the Thomas-Sherman county line. Major tributaries include Bow and Salt creeks. Three U.S. Bureau of Reclamation (Bureau) dam/reservoir projects regulate streamflow in the Solomon basin. These are Kirwin on the North Fork, Webster on the South Fork and Glen Elder/Waconda at the confluence of North and South Forks of the Solomon River. Principal aquifers include the Ogallala Formation of the High Plains aquifer in the west, the Dakota in the east and alluvial/terrace deposits along major streams.

The streams include 32,557 intermittent stream miles and 2,829 perennial stream miles.(6) Drainage density is 0.41 mile in the basin (perennial streams only).

The Ogallala-High Plains aquifer region of the Solomon basin is located in the extreme western extent of the basin. The Ogallala-High Plains aquifer consists of several hydraulically connected aquifers, the largest of which is the Ogallala. The Ogallala-High Plains aquifer is distinctive from other aquifers in Kansas in that it has generally lower annual recharge.

The majority of ground water used, other than the Ogallala-High Plains aquifer is alluvial ground water. A portion of the natural recharge that reaches the alluvial aquifer contributes to streamflow through base flow.

Ground water is the principal water supply source in the Solomon basin, accounting for about 93 percent of reported water use. The North and South Forks and the main stem of the Solomon River are surface sources of water supply in the basin.

Irrigation is the predominant use of water in the basin accounting for 95% of all reported water use in 2006. There are 2,417 water rights in the basin that reported use of a total of 175,084 acre feet in 2006 from surface and ground water sources. Surface sources accounted for 23,646 acre feet while the majority, 151,438 acre feet was reported use from ground water.(7)

The second largest use, at more than 6,331 acre feet, was for municipal water use (communities and rural water districts). The quantities used for recreation, industrial and domestic uses are very small, so appear as less than one percent of the water used in the Solomon basin in 2006 (Figure 2).

There were 47 public water suppliers in the basin in 2006 providing water to urban and rural areas.

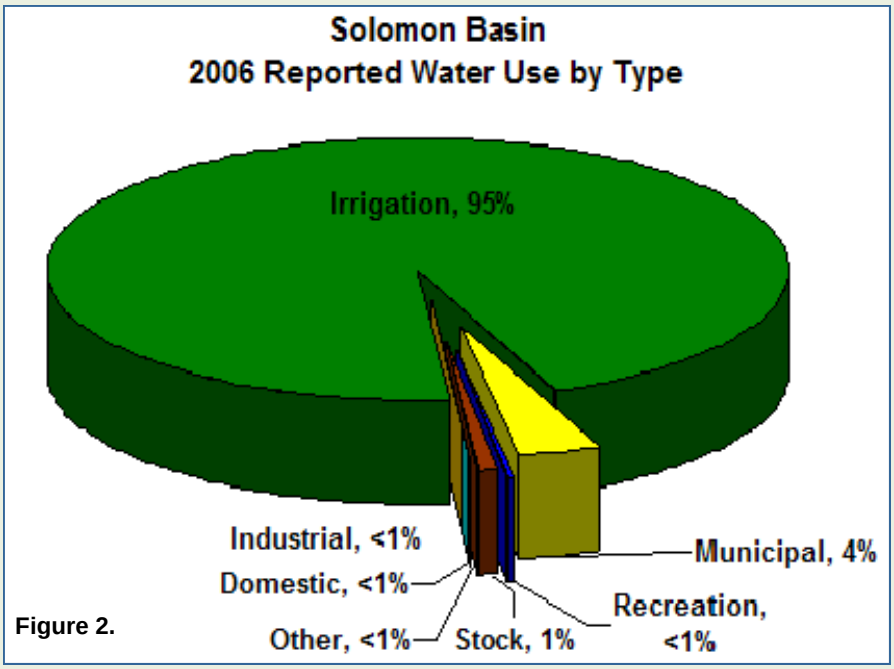


Figure 2.

ervoirs Kirwin, Webster and Waconda, respectively. When water is available from storage in the lakes the districts are authorized to irrigate up to 25,394 acres.

Watershed districts may be formed to construct, operate and maintain works of improvement needed to provide for water management. The primary function is to develop a comprehensive general plan for a watershed that will provide flood protection for the residents and landowners. One watershed district is organized in the basin, Salt Creek Watershed Joint District No. 46 (Figure 3).[9] In 2005 there was a second organized watershed district, Fisher & Criss Creek Watershed District No. 67.

Numerous other entities related to water resources may exist in the basin to address one or more water related issues.

Water Management

Northwest Kansas Groundwater Management District No. 4 (GMD4) is a water management entity in the basin, where it overlies the Ogallala-High Plains aquifer in Thomas, Sherman and Graham counties (Figure 3). GMD4, formed in 1976, is pro-active in developing local water policy compatible with state laws.

Water appropriations and use are overseen by the Kansas Department of Agriculture-Division of Water Resources. All of the streams and alluvial corridors in the basin are either closed to new appropriations or new appropriations are restricted. Minimum desirable streamflow has been set at one site on the Solomon River at Niles. Generally, the Ogallala-High Plains aquifer has no new appropriations available, but in limited cases a new water appropriation for ground water limited to quantities under 15 acre feet can be obtained by meeting some very specific criteria within GMD4.

States generally have the responsibility to determine the management of the water resources in that state. The exception to this is the management of federal reservoirs by a federal agency. In the Solomon basin the three federal reservoirs are managed by the Bureau, with some releases coordinated by the U.S. Army Corps of Engineers (Corps). The State of Kansas has not purchased any water supply storage in the federal reservoirs in the basin.

Three irrigation districts (Kirwin Irrigation District No. 1, Webster Irrigation District No. 4 and Glen Elder Irrigation District No. 8) operate using releases from the three res-

Each county has a county conservation district responsible for the conservation of soil, water, and related natural resources within that county boundary. Multiple county groups may form Resource Conservation and Development areas (RC&Ds) to also address conservation of natural resources. Parts of three RC&Ds cover the Solomon basin. In addition, drainage districts may also be formed to reclaimed and protected land from the effects of water.

Addressing water quality is one Watershed Restoration and Protection (WRAPS) program that covers a part of the basin. The Waconda Reservoir WRAPS began development in SFY2007. Project goal: develop stakeholder leadership team to lead WRAPS effort; compile watershed information.

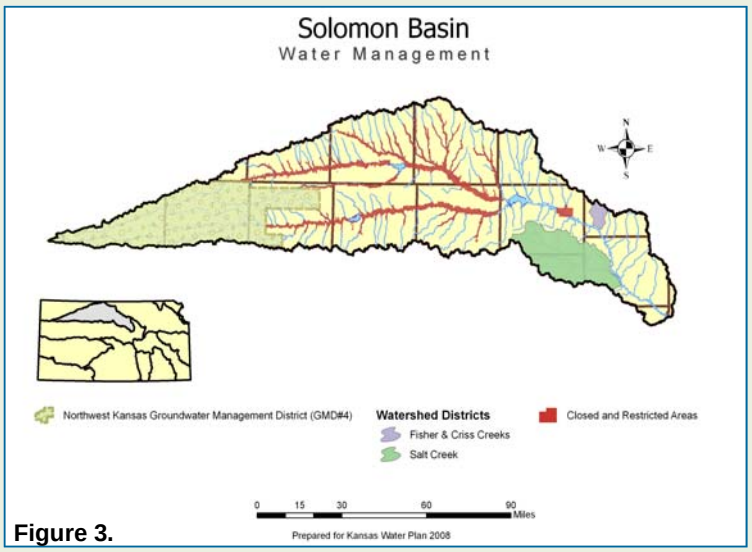


Figure 3.

Resources

1. US Department of Agriculture. 2008, http://www.ks.nrcs.usda.gov/technical/RWA/kansas_watersheds.html

2. U.S. census data, 2000.

3. Bureau of Reclamation, Solomon *River Basin Water Management Study*. Kansas, April 1984.

4. US Department of Agriculture. 2008. http://www.ks.nrcs.usda.gov/programs/csp/2005/usf_solomon.html.

5. US Fish and Wildlife Service. 2008. http://www.fws.gov/kirwin/

6. Wilson, Brownie. 2003. http://hercules.kgs.ku.edu/geohydro/ofr/2003_55/riparian/ofr_2003_55e.htm. Kansas Geological Survey.

7. Kansas Department of Agriculture-Division of Water Resources. WRIS database, December 13, 2007.

8. Kansas Department of Agriculture-Division of Water Resources Subbasin Program. 2002. Solomon River Basin Subbasin Notebook.

9. State Conservation Commission. 2008. http://scc.ks.gov/dmdocuments/Kansas%20Watershed%20and%20Drainage%20District%20Directory%20WORD%20for%20ACROBAT.pdf

10. U.S. Department of Agriculture. 2008. http://www.ks.nrcs.usda.gov/partnerships/rcd/

11. Kansas Department of Wildlife and Parks. 2008. http://www.kdwp.state.ks.us/news/other_services/threatened_and_endangered_species/threatened_and_endangered_species/range_maps Most of information from previous *Kansas Water Plan* sections.

Kirwin Terrace, Phillips County
Photo courtesy of Kansas Geological Survey

Irrigation and Recreation Storage

Surface water supplies account for about seven percent of water authorized for use in the basin which includes storage in the three federal reservoirs. Storage in the reservoirs include storage for irrigation and municipal use. Recreation is a side-benefit of the water stored in the lakes.

Webster Reservoir, on the South Fork of the Solomon River in Rooks County, was built to include providing irrigation water for 8,500 acres in Rooks and Osborne counties. Fewer acres are irrigated due to shortages of water in storage. Some years no irrigation occurs from District storage in Webster. Sedimentation has reduced conservation pool storage to 71,926 acre feet.

Kirwin Reservoir, on the North Fork of the Solomon River in Phillips County, was built to include irrigation on 11,435 acres in Phillips, Smith and Osborne counties. Often, fewer acres are irrigated due to shortages of water in storage. Some years no irrigation occurs from the District storage in Kirwin.[3] Sedimentation has reduced conservation pool storage to 89,639 acre-feet.

Waconda Lake is on the main stem of the Solomon River, west of Glen Elder. The Glen Elder Dam was completed in 1969, providing storage of 196,400 acre-feet of water in the conservation pool of Waconda Lake. Sedimentation has reduced conservation pool storage to 193,183 acre-feet. Glen Elder Dam is a multiple purpose dam and reservoir constructed by the Bureau of Reclamation in Osborne and Mitchell counties. The dam and reservoir authorization are for the purposes of flood protection, irrigation, recreation, fish and wildlife and water supply. Irrigation from the lake serves 21,000 acres of valley land.

Glen Elder Irrigation District No. 8 is authorized for 15,170 acre feet of water. In 2005 the District reported using 10,187 acre feet on 6,509 acres.

Water supply for Beloit includes up to 2,000 acre feet from Waconda Lake storage.

Glen Elder Dam. Photo courtesy of U.S. Bureau of Reclamation

Solomon River Basin Management Categories

January 2009

WATER MANAGEMENT CATEGORIES

The following categories include issues identified in the Solomon basin plan as items that require attention in addition to the basin priority issues. These issues are addressed within the following management categories:

- Water Management
- Water Conservation
- Public Water Supply
- Water Quality
- Wetland and Riparian Management
- Flood Management
- Water-Based Recreation

These categories also correspond to the statewide management categories and policies of the *Kansas Water Plan* found in Volume II. These documents contain new policy issues and the existing policy and statutory framework that relate to the management categories.

ISSUE: WATER MANAGEMENT

Management of Kansas' ground and surface water fits into six statewide categories, with five of these applicable in the Solomon basin. These are:

1) River-Reservoir management;
2) Stream reaches with established Minimum Desirable Streamflow;
3) Streams outside of Minimum Desirable Streamflow protected areas;
4) The Ogallala-High Plains aquifer; and
5) Ground water outside of the Ogallala-High Plains aquifer.

Ground water is the primary water supply in the basin. The Ogallala-High Plains aquifer is a major source in the western portion of the basin where it interconnects with alluvial ground water and may have an affect on streamflow. Ground water recharge rates are generally low throughout the basin. A majority of the basin is restricted or closed for new water appropriations. The Ogallala-High Plains aquifer area of the basin is managed with the local leadership by Northwest Kansas Groundwater Management District No. 4 (GMD4). GMD4 has identified six high priority aquifer subunits. Goals and management for each are under development. Portions of two subunits are in the basin. In 2008, a computer model developed for the six priority subunits was completed through cooperation of Kansas Water Office (KWO), GMD4 and the U.S. Bureau of Reclamation (Bureau). The model will aid in development and analysis of the management strategies.

In 2006, the KWO calculated the median annual water level changes in wells from 1981 to 2005. In the northwest Ogallala aquifer area, as of 2005, there has been no statistically significant change (at a +or- 5% error level) in the rate of water level decline.[1] Reducing the decline rate of the Ogallala-High Plains aquifer is a basin priority issue. Additional information on this issue may be found in the Solomon Basin Ogallala decline priority issue section.

Reduced streamflow and runoff into streams has been reflected in lower water levels in Webster Reservoir, Kirwin Reservoir and Waconda Lake. These conditions and reduced availability of irrigation water stored in the reservoirs have suggested a need to take a fresh look at reservoir management. Maintaining a minimum water level in Webster Reservoir is a basin priority issue. Additional information on this issue may be found in the Solomon Basin priority issue section.

Kirwin Reservoir on Solomon River and Bow Creek
Photo courtesy Kansas Geological Survey

There is one minimum desirable streamflow (MDS) location in the basin, located on the Solomon River near Niles. Statistically this gage had no change in the frequency that MDS was met from 1984 to 2004 and the historical frequency (1960 to 1983).

Subbasin water budgets are under development by the Kansas Department of Agriculture-Division of Water Resources. Analysis of water resources and their use by subbasin has been completed for the upper North and South Forks Solomon River. Analyses are planned for

the other subbasins to better understand and manage the resources.

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce water level decline rates within the Ogallala-High Plain aquifer and implement enhanced water management in targeted areas.
- By 2015, achieve sustainable yield management of Kansas surface and ground water sources outside of the Ogallala aquifer and areas specifically exempt by regulation. Sustainable yield management would be a goal that sets water management criteria to ensure long term trends in water use will move as close as possible to stable ground water levels and maintenance of sufficient streamflows.
- By 2015, meet minimum desirable streamflow at a frequency no less than the historical achievement for the individual sites at time of enactment.

Applicable Programs

The following programs help to meet the objectives in the Water Management (quantity) category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Appropriation Program
- Kansas Geological Survey and Kansas Department of Agriculture-Division of Water Resources: Water Well Measurement
- State Conservation Commission: Water Right Transition Assistance Program
- USDA-Natural Resources Conservation Service: Environmental Quality Incentive Program (EQIP)
- USDA-Farm Services Agency: Conservation Reserve Enhancement Program
- Kansas Geological Survey: High Plains Aquifer Technical Assistance Program
- Kansas Water Office: State Water Planning Program

ISSUE: WATER CONSERVATION

Water conservation is essential for the effective management of water resources in the basin to assure that a sufficient, long-term supply of water is available for the beneficial uses of the people of the state. Conservation is defined as a careful preservation and protection of something, especially the planned management of a natural resource to prevent exploitation or destruction.

Water conservation activities apply to all uses; irrigation, municipal, industrial, and others, and from all sources. In 2006, irrigation accounted for nearly 95% of all reported water pumped or diverted in the basin. Municipal use accounted for four percent of water used in the basin, with stock water at one percent and industry, recreation, domestic and other uses at less than one percent each.

Of the 616 public water suppliers that have an approved conservation plan in place as of December 31, 2008, 38 plans have been approved in the Solomon basin. As of August 2006, 139 conservation plans had been approved for irrigation water rights in the basin. The number of diversion points in Kansas that reported irrigation application rates over the regional average fluctuated from about 3,700 to less than 500 from 1991 to 2005. Of the total number of individual points of diversions that

Irrigation. Photo courtesy Kansas Geological Survey

reported diversion of a measurable quantity of water in Kansas in 2006, more than 45% reported a metered quantity at least once during that year in the Solomon basin. (Source: DWR-Water Right Info. System).

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce the number of public water suppliers with excessive unaccounted for water by first targeting those with 30% or more unaccounted for water.
- By 2010, reduce the number of irrigation points of diversion for which the amount of water applied in acre feet per acre (AF/A) exceeds an amount considered reasonable for the area.
- By 2015, all non-domestic points of diversion meeting predetermined criteria will be metered, gaged, or otherwise measured.

- By 2015, conservation plans will be required for water rights meeting priority criteria under K.S.A. 82a-733 if it is determined that such a plan would result in significant water management improvement.

Applicable Programs

The following programs help to meet the objectives in the Water Conservation category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Appropriation Program
- Kansas State University Research and Extension: Water Conservation and Management Program
- State Conservation Commission: Water Resources Cost-Share Program
- State Conservation Commission: Water Right Transition Assistance Program
- Kansas Water Office: Water Conservation Program
- USDA-Natural Resources Conservation Service: Environmental Quality Incentive Program (EQIP)
- USDA-Farm Services Agency: Conservation Reserve Program

ISSUE: PUBLIC WATER SUPPLY

The primary approach to addressing public water supply issues in the basin focuses on ensuring that there are adequate supplies of surface and ground water within the basin to meet future water demands, reducing the number of public water supply systems that are vulnerable to drought, and ensuring that systems have the technical, financial and managerial capacity to meet future needs for water quality and quantity.

In 2006, there were 49 public water supplies in the Solomon basin. Ground water is the primary source for most public water supplies, accounting for over 95% of the total supply, principally from the Ogallala-High Plains and Dakota aquifers and alluvial deposits along major streams. The City of Beloit obtains their water from surface flow in the Solomon River below Waconda Lake.

Waconda Lake. Photo by Kansas Water Office.

Among the state's major river basins, the percentage of drought vulnerable public water suppliers in 2006 ranged from three percent (Neosho Basin) to 42% (Solomon basin). Comparison of the KWO 2000 and 2006 lists show a significant increase in the number of drought vulnerable public water suppliers in most western river basins including the Solomon. There were 20 public suppliers considered drought vulnerable in the Solomon basin in 2006.

Applicable *Kansas Water Plan* Objectives

- By 2010, ensure that sufficient surface water storage is available to meet projected year 2040 public water supply needs for areas of Kansas with current or potential access to surface water storage.
- By 2010, less than five percent of public water suppliers will be drought vulnerable.
- By 2010, ensure that all public water suppliers have the technical, financial and managerial capability to meet their needs and to meet Safe Drinking Water Act requirements.

Applicable Programs

The following programs help to meet the objectives in the Public Water Supply category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Appropriation Program
- Kansas Department of Health and Environment: Public Water Supply Program
- Kansas Department of Health and Environment: Kansas Public Water Supply Loan Fund
- Kansas Water Office: State Water Planning Program
- Kansas Water Office: Water Conservation Program

ISSUE: WATER QUALITY

Water quality and related water resource issues are addressed through a combination of watershed restoration and protection efforts utilizing voluntary, incentive-based approaches, as well as regulatory programs.

Solomon River Basin Management Categories

All the counties within the basin have a sanitarian funded by the Local Environmental Protection Program (LEPP). All conservation districts in the basin have adopted nonpoint source pollution management plans. Buffer coordinators have also been employed in three counties in the basin to facilitate enrollment of stream buffers in the continuous Conservation Reserve Program (CRP) and State Water Quality Buffer Initiative.

The federal Clean Water Act requires states to conduct Total Maximum Daily Load (TMDL) studies and develop TMDLs for water bodies identified on the state's List of Impaired Waters (Section 303(d) List). TMDLs are quantitative objectives and strategies needed to achieve the state's surface water quality standards. There are 21 approved TMDLs within the Solomon Basin. Dissolved oxygen on Limestone Creek is a high priority for implementation. There are three lakes in the basin listed as water quality impaired. Streams are sampled at 15 locations within the basin with dissolved oxygen, total suspended solids (TSS), and total phosphorous (TP) identified as the cause of the greatest number of impairments. Other pollutants limiting use of Solomon basin streams include arsenic, biological stressors, copper, E. coli bacteria and sulfate. TMDL development for bacteria total suspended solids and total phosphorous are anticipated in 2009.

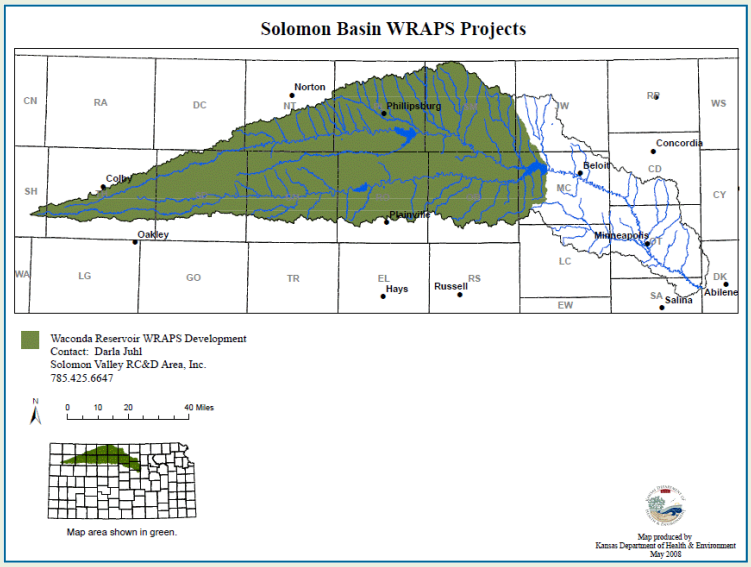
Kansas Watershed Restoration and Protection Strategy (WRAPS) is a planning and management framework that engages stakeholders within a watershed in a process to:

- Identify watershed restoration and protection needs.
- Establish watershed management goals.
- Create a cost-effective action plan to achieve goals.
- Implement the action plan.

As of March 2008, there were 44 active WRAPS projects located throughout Kansas. One project is in the Solomon basin and includes the watersheds above Glen Elder Dam/Waconda Lake.

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce the average concentration of bacteria, biochemical oxygen demand, solids, metals, nutrients, pesticides and sediment that adversely affect the water quality of Kansas lakes and streams.
- By 2010, ensure that water quality conditions are maintained at a level equal to or better than year 2000 conditions.
- By 2010, reduce the average concentration of dissolved solids, metals, nitrates, pesticides and volatile organic chemicals that adversely affect the water quality of Kansas ground water.
- By 2010, maintain, enhance, or restore priority wetlands and riparian areas.
- By 2015, nutrient reduction goals will be included in all WRAPS projects within the basin.
- By 2010, all public water suppliers will complete and implement a source water protection plan.



Applicable Programs

The following programs help to meet the objectives in the Water Quality category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Health and Environment: State Water Plan Program (Contamination Remediation)
- Kansas Corporation Commission: Conservation Division Programs
- Kansas Department of Health and Environment: Local Environmental Protection Program
- Kansas Department of Health and Environment: Watershed Management Program/WRAPS
- Kansas Department of Health and Environment: Watershed Planning Section/TMDL Program
- State Conservation Commission: Nonpoint Source Pollution Control Program
- State Conservation Commission: Water Resources Cost-Share Program

ISSUE: WETLAND & RIPARIAN MANAGEMENT

The primary approach to wetland and riparian manage-

ment in the basin focuses on providing technical and financial assistance to landowners to protect and restore these resources in priority watersheds through the implementation of best management practices.

Riparian lands in the Solomon basin have been impacted by infestation of non-native phreatophytes, although not to the degree as in other western basins. Of greatest concern are the effects tamarisk (salt cedar) and Russian olive on native riparian ecosystems. A biological control project releasing leaf eating beetles occurred in the basin in 2005 and 2006. It was determined that the timing of the release limited success.

Applicable *Kansas Water Plan* Objectives

- By 2010, maintain, enhance or restore priority wetlands and riparian areas.

Applicable Programs

The following programs help to meet the objectives in the Wetland and Riparian Management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Forest Service: Forest Stewardship Program and Conservation Tree Planting Program
- State Conservation Commission: Riparian and Wetland Protection Program
- Kansas Water Office: State Water Planning Program
- Kansas Department of Wildlife and Parks: State Parks and Wildlife Areas Planning and Development Program
- Kansas Department of Wildlife and Parks: Wildlife Habitat Improvement Program

ISSUE: FLOOD MANAGEMENT

Flooding is a natural, recurring event associated with streams and rivers that has resulted in the formation of natural floodplains over time. While this inundation provided benefits under natural conditions, encroachment of urban and agricultural development onto floodplains has resulted in the potential for flood damage. In addition, the Solomon basin is prone to flash flooding which is characterized by a rapid rise in water level, fast-moving water and much flood debris.

Kansas Water Plan flood management guidance has targeted watershed dam construction assistance to priority watersheds, encouraged National Flood insurance participation and updating floodplain maps for priority communities.

Significant flooding was experienced during 1903, 1908, 1915, 1919, 1935, 1941 and 1973 on the Solomon River. Three federal projects; Kirwin, Glen Elder and Webster dams contribute to flood control in the basin. There is one organized watershed district in the basin. Two watershed dam projects are complete in the basin.

Kirwin Reservoir. Photo courtesy Kansas Geological Survey.

Financial assistance from the State Water Plan Fund has been provided for flood mapping as part of the 1993 Kansas Department of Agriculture-Division of Water Resources, Kansas Flood Mapping Initiative in Ottawa County in the basin.

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce the vulnerability to damage from floods within identified priority communities or areas.

Applicable Programs

The following programs help to meet the objectives in the Flood Management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Structures Program/Floodplain Management
- Kansas Department of Agriculture-Division of Water Resources: Water Structures Program/Dam Safety
- Kansas Division of Emergency Management: Hazard Mitigation Grants Program
- State Conservation Commission: Watershed Dam

Construction Program
- State Conservation Commission: Watershed Planning Assistance Program
- FEMA: National Flood Insurance Program

ISSUE: WATER-BASED RECREATION

The Solomon basin has a wide variety of public water recreation sites on state and federal land. There is a demand for more consistent water levels to provide access to water-based recreation facilities for area residents and recreational income by attracting sportsmen and women to the area.

The federal dam projects include Kirwin Reservoir, Waconda Lake and Webster Reservoir and associated recreation and wildlife areas that draw hunters, fishermen and boaters to the area. Public hunting areas include Kirwin National Wildlife Refuge, Webster Wildlife Area and Glen Elder Wildlife Area. The state also offers fishing at Jewell, Ottawa, Rooks, and Sheridan state fishing lakes. In addition, Antelope Lake-Graham County and Logan City Lake are community lakes supported by Kansas Department of Wildlife and Parks Community Lakes Assistance Program.

Maintaining a minimum water level in Webster Reservoir is a basin priority issue. Additional information on this issue may be found in the Solomon Basin Webster Water Level priority issue section.

Applicable *Kansas Water Plan* Objectives

- By 2010, increase public recreational opportunities at Kansas lakes and streams.

Applicable Programs

The following programs help to meet the objectives in the Water-Based Recreation category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Wildlife and Parks: Rivers and Stream Access
- Kansas Department of Wildlife and Parks: State Parks

ISSUES FOR FUTURE ACTION

Irrigation Districts needs if any.

Solomon Basin High Priority Issue
Ogallala-High Plains Aquifer Declines
January 2009

Issue

Long-term management of the Ogallala-High Plains and alluvial aquifers to extend and conserve the life of the aquifer, while meeting area needs.

Vision

Sufficient water resources in western Kansas to support healthy, economically strong communities and rural lifestyles, today and for future generations.

Goal

Extend and conserve the life of the Ogallala–High Plains aquifer.

Description

The Ogallala portion of the High Plains aquifer (Ogallala-High Plains aquifer) underlies western portions of the Solomon River basin. Within the basin, the Ogallala underlies Thomas, Sheridan and Graham counties, along with parts of Norton, Phillips and Rooks counties, and southern Smith County. Thomas and Sheridan counties and part of Graham County are in Northwest Kansas Groundwater Management District No. 4 (GMD4). The aquifer fringe outside GMD4 is managed by Kansas Department of Agriculture-Division of Water Resources (DWR).

Ground water supplies significant appropriations (95% in 2006) of municipal, irrigation, industrial and domestic water in the basin from the alluvial and Ogallala-High Plains aquifers. The Ogallala-High Plains aquifer has been developed so extensively that the amount of water withdrawn annually is significantly more than the recharge, resulting in ground water declines. Some areas are already experiencing shortages in meeting demand. As ground water levels decline, the aquifer loses hydraulic connection with the overlying alluvial aquifers and rivers and no longer contributes much, if any, base stream flow. Since the 1950s (predevelopment), Ogallala water levels have declined as much as 45 percent in Thomas, Sheridan and Graham Counties. Water levels have been reduced up to 50 feet in the majority of those portions of Thomas and Sheridan counties located in the basin.

More recently, water levels have declined up to 30 feet over the ten-year period from 1996-2006. The greatest decline is centered south of Hoxie in Sheridan County. Generally, Thomas and Sheridan county areas in the basin have declined by 5-20 feet in the ten-year period. The overall decline has contributed to a progressive reduction in flow during the past several decades in the upper North Fork and upper South Fork of the Solomon River.(1)

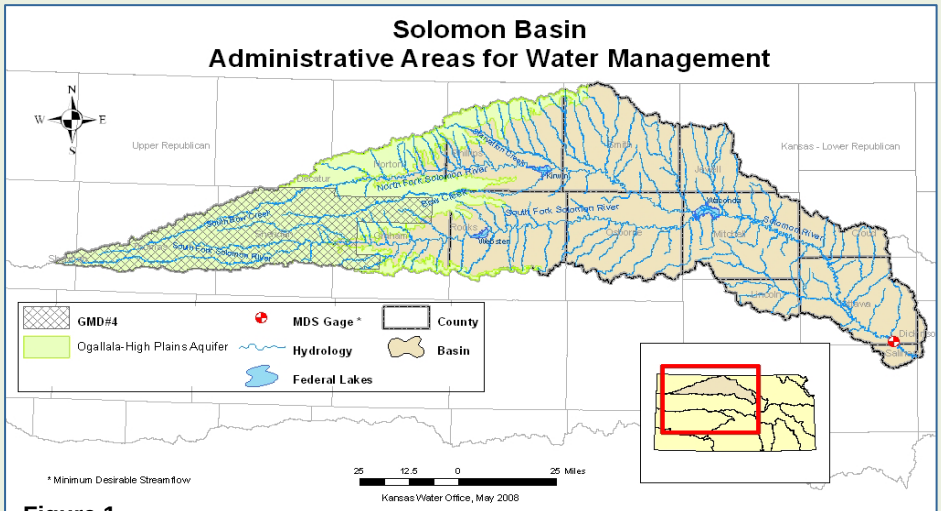
Water users in parts of Thomas, Sheridan and Graham counties are already experiencing shortages in meeting demand. To extend and conserve the life of the Ogallala–High Plains aquifer, GMD4 and DWR are defining priority areas to reduce aquifer declines. Federal and State voluntary incentive programs to reduce water use have been developed and targeted to priority areas.

A 2006 Kansas Water Office (KWO) analysis of water level data from 1981-2005 indicated that the aquifer decline rate had not been reduced by a statistically significant amount between two time periods: pre-1993, and 1993-2005.(4)

Ground Water Appropriations

Total appropriations in the basin from the Ogallala-High Plains aquifer and overlying alluvium are approximately 249,860 acre feet for all beneficial uses in the Solomon basin. This represents 1,100 active water rights from 1,211 wells.(6)

The majority of the producing wells in the Ogallala-High Plains aquifer and associated alluvium, about 1,044 wells, are within the GMD4. These appropriations total 243,827 acre feet, or nearly 98% of the Ogallala appropriations in the basin.



* Minimum Desirable Streamflow

Kansas Water Office, May 2008

Figure 1.

Solomon Basin High Priority Issue
Ogallala-High Plains Aquifer Declines
January 2009

Water Use

The 2006 reported ground water use from the Ogallala-High Plains aquifer area was 132,778 acre feet. Reported water use for 2006 within GMD4 was 129,635 acre feet from 1,010 wells. Irrigation use is 98% of the Ogallala-High Plains reported use in the basin.[7]

Annual irrigation water use reported and quantified by township for 2002-2006 is provided in Table 1 below, based on data analysis by DWR.[6] (Note some townships have water use in more than one area, such as a GMD and the fringe, therefore the sum of the number of townships analyzed for each area is not the same as those included in "ALL" in the table.) The majority of a township may be in another basin or have no access to the Ogallala–High Plains aquifer.

There has been widespread adoption of more efficient irrigation systems in the Kansas High Plains, shifting from flood and center pivot irrigation to center pivot with drop nozzles.[8] A study by Kansas State University in 2006 found that the number of acres irrigated is a more important determinant of changes in water use than the adoption of more efficient irrigation systems.[2] The authors concluded that if the irrigated acres are held steady after conversion to a more efficient irrigation system, net water use would, on average, change little; it is with a decrease in irrigated acres that a reduction in water use is assured.

Aquifer Declines

Average water levels in the aquifer within the groundwater management districts have continued to decline over the past ten years.

The overall average water table (top of ground water) decline in the High Plains region over the 2005 calendar year was 0.57 feet, which was somewhat more than the average decline during 2004 (0.15 feet) but less than the average annual decline rate over the five years since the 2001 measurements (approximately 0.98 feet/year).

Figure 2 is an estimated projection of the years until the High Plains aquifer reaches a point where wells will only be able to produce 400 gallons per minute (gpm) if ground water level trends from 1996 to 2006 repeat continuously and unchanged into the future.[10] This methodology is best suited to the Ogallala portion of the Ogallala-High Plains aquifer because of the relatively extensive data sets for the Ogallala. The variability of the system is the biggest drawback.

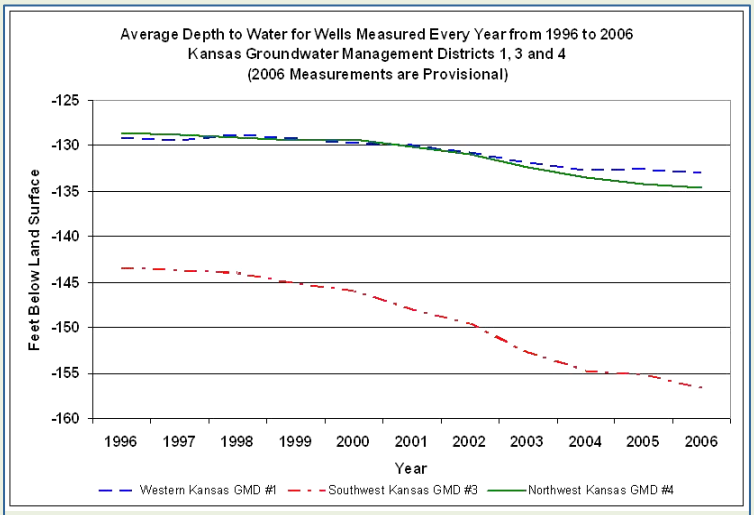


Figure 2.

Activities and Progress

Various programs and activities have been initiated to reduce the decline rate of the Ogallala-High Plains aquifer and to extend and conserve the aquifer. Tools such as ground water and surface water models and more detailed aquifer characterization have been developed. In the Solomon basin, the determination of Ogallala subunit priority areas, setting subunit goals and developing management plans to reach these goals has been the responsibility of GMD4 along with DWR for areas outside the district.

Good data is essential to the determination of decline rates. Data development includes calibration of the ground water model or models to better understand the aquifer and subunits. Water flowmeters, now required on

Table 1. Water Use for Ogallala Area in Solomon Basin

Area	Number Townships Quantified	Number Points of Diversion	2006 Water Use (AF)	Acre-feet/ acre 2002	Acre-feet/ acre 2003	Acre-feet/ acre 2004	Acre-feet/ acre 2005	Acre-feet/ acre 2006
GMD4	32	1,242	150,104	1.32	1.21	1.19	1.01	1.05
Fringe	7	123	4,501	0.86	0.80	0.67	0.56	0.59
All	NA	1,386	143,216	1.21	1.06	0.97	0.80	0.91

Solomon Basin High Priority Issue
Ogallala-High Plains Aquifer Declines
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almost all wells, provide improved information on withdrawals. All wells in GMD4 should be metered by December 31, 2009. Annual water level measurements from "index" wells as well as weather station data to quantify precipitation provide information contributing to more accurate models.

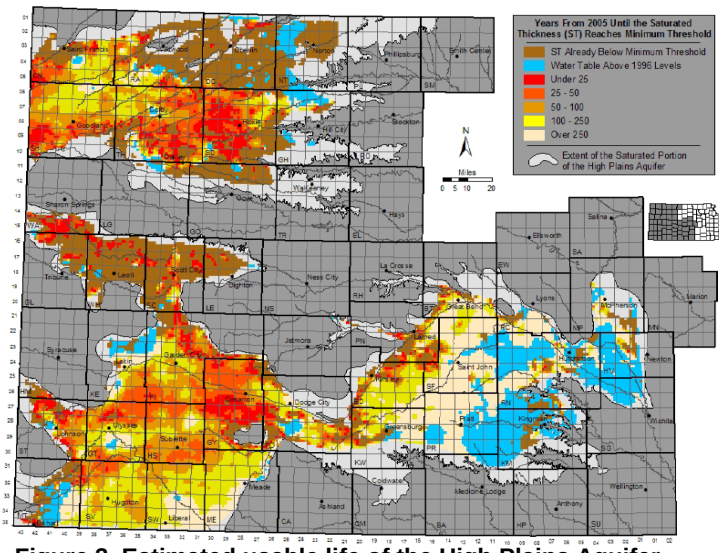

Figure 3. Estimated usable life of the High Plains Aquifer

GMD4 has identified six high priority subunits within their area, portions of which are in the Solomon basin. The GMD4 board is in the process of establishing preliminary water use goals and enhanced management actions for the high priority aquifer sub-units.[5]

The state and GMD4 have modeled management scenarios for six high priority subunits shown in Figure 4. Based on hydrologic conditions, corresponding economic estimates were produced for the cropping changes anticipated to occur as ground water levels change, based on historical farm decision triggers determined by K-State. The study considered a variety of water conservation policies aimed at achieving a 30% reduction in current ground water consumption levels. The economic effects of various water conservation policies on producer gross profits and regional economy were estimated.[3]

Voluntary programs have been targeted to areas determined by GMD4 within district boundaries and by DWR in the fringe areas. Federal Ground and Surface Water Programs of the Environmental Quality Incentive Program (EQIP) were focused for two years on these areas with projects selected annually. GMD4 utilized all resources allocated for their areas for incentive payments of $100 per acre annually for three years on eligible acres that convert irrigated land to non-irrigated land.

State programs have offered incentives to retire water rights in some areas, however that opportunity has not been provided to the Solomon basin through 2008. GMD4 high priority subunits may be eligible in the future. Regulatory programs have included special assistance by DWR to irrigators that have pumped in excess of their water rights and the area average.

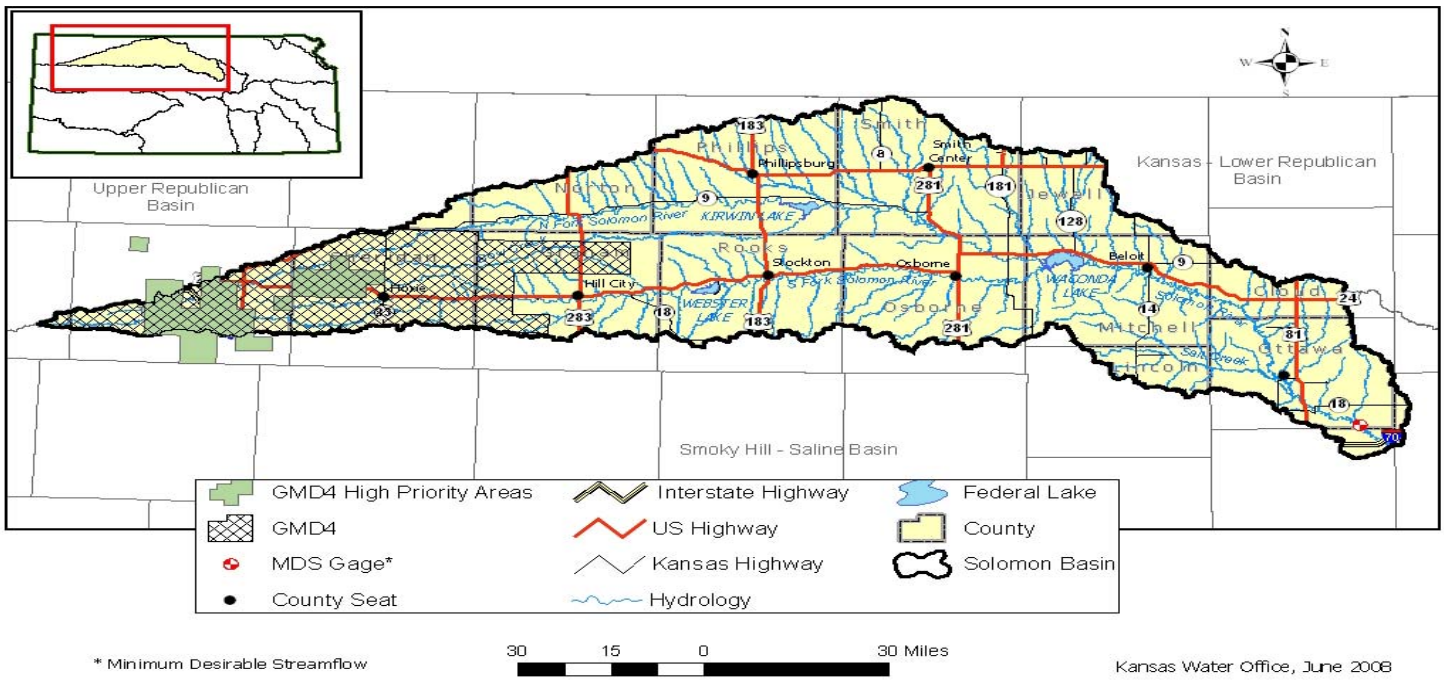

Figure 4. Northwest Kansas GMD No. 4 High Priority Areas

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Progress toward reducing the aquifer decline rate was evaluated by the Kansas Water Office in 2006 using water level data from 1981 to 2005. The median annual water level changes were calculated for each region and standardized or indexed to antecedent moisture conditions using the Palmer Drought Severity Index (PDSI) for the appropriate region. The comparison of pre-1993 and 1993-2005 periods concluded that there was no discernable change in the rate of water level declines in the Ogallala–High Plains region. It also concluded that in the northwest Ogallala aquifer area (GMD4 and DWR fringe areas), as of 2005, there has been no statistically significant change (at a five percent error level) in the rate of decline.[4]

It should be noted that the percentage of total water use that has been reduced through voluntary and regulatory programs is small. A reduction of decline rates will likely take many years or decades to be recognizable unless participation and reductions are greater.

Priority Aquifer Subunits: Priority aquifer subunit maps are used to guide state and federal efforts on water conservation. The priority aquifer subunit areas are being further defined by the groundwater management districts inside each district, and the Division of Water Resources for areas of the Ogallala-High Plains aquifer outside of the district, with input from the public. Currently, Figure 5 illustrates priorities. This will be used until new priority aquifer subunit maps are defined and approved. Specific target areas are defined for areas eligible for enrollment in EQIP quick response areas and the Water Transition Assistance Program (WTAP).

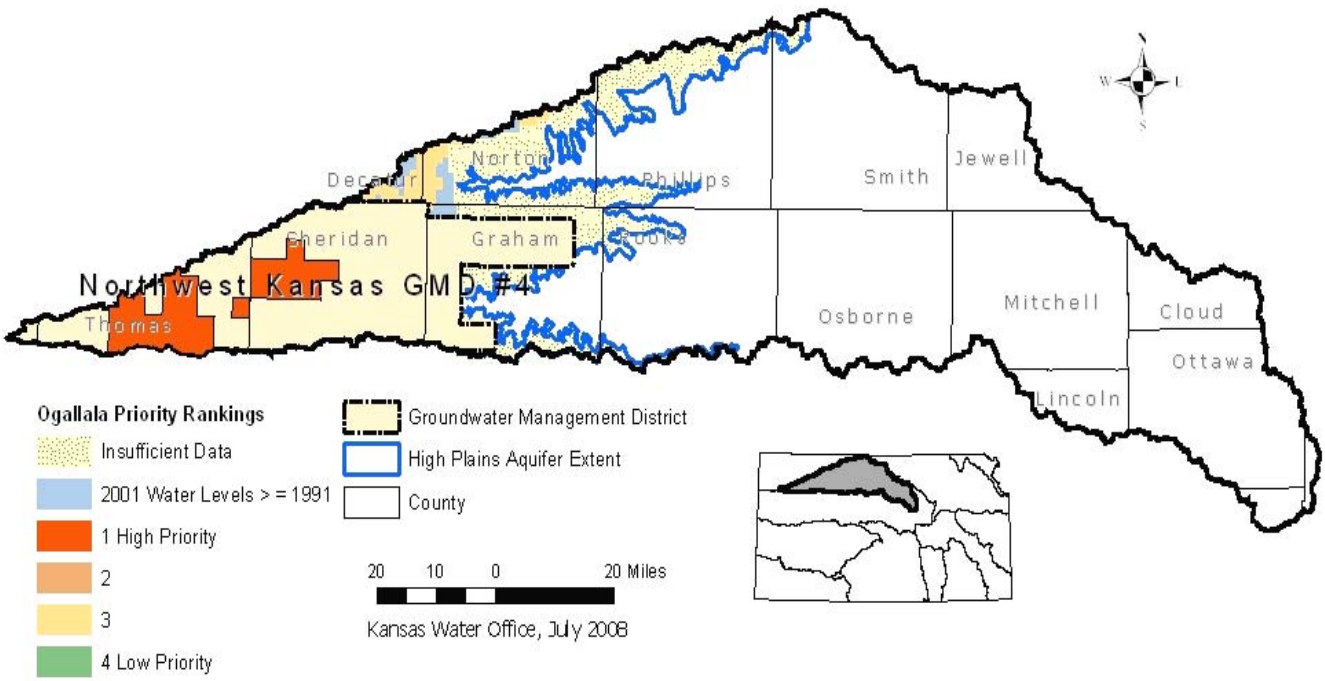

Figure 5.

The priority rank shown on this map outside GMD4 is based on an area's total score from two databases: estimated usable lifetime and density of ground water use. Useable lifetime is defined as the ability to support a 400 gpm well yield, on every quarter section, pumping for 90 days. Rank 1 indicates areas with a short estimated usable lifetime and a history of higher ground water usage. Rank 4, the lowest concern areas, have a relatively long useable lifetime and low total water use.

Recommended Actions

1. DWR should identify priority subunits. In their areas of responsibility, GMD4 and DWR should identify priority aquifer subunits or areas and develop specific goals and management strategies to extend and conserve the life of the aquifer.

2. GMD4 and DWR should manage aquifer subunits to maintain economic health while ensuring sufficient water resources for future generations of western Kansas communities and rural populations and chosen lifestyles.

3. Provide opportunities to permanently or temporarily reduce water use through voluntary programs (state, federal, and local).

4. Educate water users, decision makers and the general public on the condition of the aquifer and methods and opportunities to reduce water use.

5. Support research for high value, low water use crops.

6. Seek crop insurance option for limited irrigation crops from USDA Risk Management Agency.

In order to implement the actions stated above, the following specific activities are recommended:

- Provide technical support, including hydrologic modeling, if appropriate, to project current and future aquifer conditions. Identify and implement activities to promote local conservation to extend the life of the aquifer that accrues to the aquifer subunit or region where water savings has occurred.
- Recognize the benefit of aquifer subunit planning. Management of the aquifer by subunit can benefit the local community's economic well-being and social connectedness, reduce over pumping and well shut offs from impairments.
    - Encourage ownership in one's aquifer subunit; promote local leadership.
    - Form subunit teams for local leadership of aquifer subunits or other methods of managing local areas/subunits for reduced consumptive water use.
    - Target incentive based programs to aquifer subunits that have a long-term vision and plan.
    - Implement aquifer subunit plans that assure water into the future to help attract industry, thus contributing to the economic health of the subunit and area.
- Consider the long term impact of climatic change on the water demands for the region.
- Consider interstate discussions on water conservation and planning where aquifer subunits cross state boundaries, and are not directly impacting an existing surface water compact.

Resources

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2. Golden, Billy B, and Jeffrey Peterson. *2006 Evaluation of Water Conservation from More Efficient Irrigation Systems,* Staff Paper 06-03. Kansas State University, 2006-20, July 2006.

3. Golden, Bill, Petersen, Jeff, and O'Brien, Dan. 2008. *Potential Economic Impact of Water Use Changes in Northwest Kansas*.

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9. Schloss, J. A. and Buddemeier, R.W. 2000. *Kansas Geological Survey High Plains Atlas*. http://www.kgs.ku.edu/HighPlains/atlas/chstmap.gif .

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11. Young, David P, Whittemore, Donald O., and Wilson, Blake B. 2007. *Bedrock Surface and Aquifer Properties of the Alluvial Valleys of the Upper North and South Forks of the Solomon River Basin, Kansas.* Kansas Geological Survey Open-file Report 2007-4.

Ogallala Outcrop. Photo courtesy Kansas Geological Survey

Solomon Basin High Priority Issue
Subbasin Water Management
January 2009

Issue

Solomon River water resources management by sub-basins to stabilize hydrologic systems and improve reliability of water availability to water users.

Description

The Solomon River drains an area of 6,835 square miles including all or parts of Decatur, Norton, Phillips, Smith, Jewel, Sherman, Thomas, Sheridan, Graham, Rooks, Osborne, Mitchell, Cloud, Lincoln, Dickinson and Saline counties. The basin includes subbasins with hydrologic unit codes 10260011-upper North Fork Solomon River, 10260012-lower North Fork Solomon River, 10260013-upper South Fork Solomon River, 10260014-lower South Fork Solomon River and 10260015-mainstem Solomon River (Figure 1).

The present allocations and operation of water resources and the associated problems varies by watershed within the Solomon basin. Three U.S. Bureau of Reclamation dam/reservoir projects regulate streamflow in the Solomon basin. These are; Kirwin along the North Fork Solomon, Webster along the South Fork Solomon, and Glen Elder/ Waconda at the confluence of North and South Forks of the Solomon River. Streamflow is dependent on runoff and climatic factors that cannot be regulated and vary widely year to year.

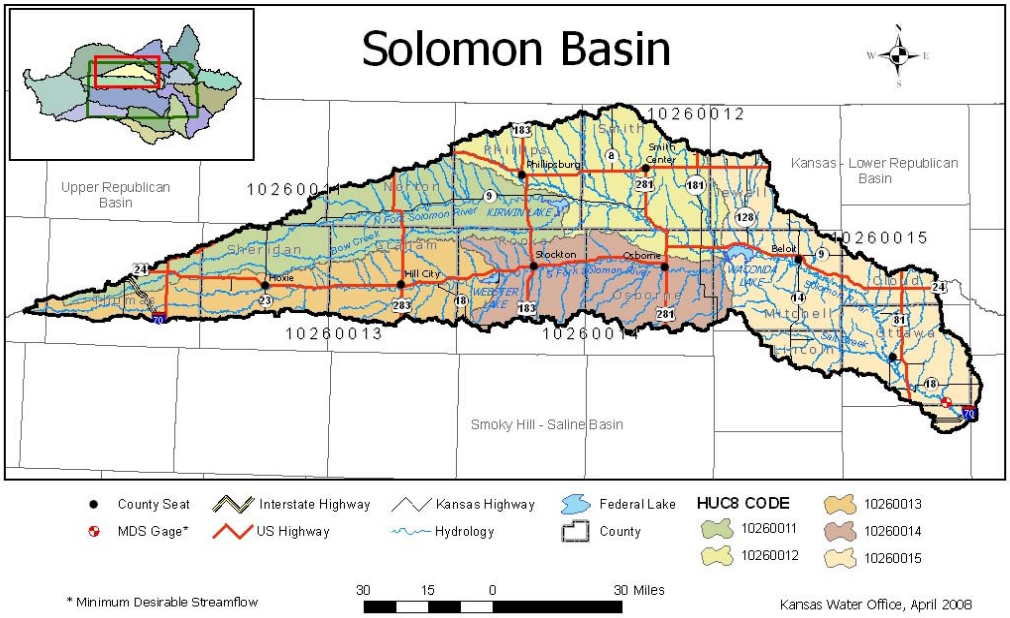

Figure 1.

Ground water depletion due to pumping occurs in the Solomon River basin in the Ogallala-High Plains and the alluvial aquifers. Low stream flows have occurred in recent years as well. Stream flow has a direct effect on ground water recharge, especially in the alluvial aquifer.

The Ogallala-High Plains aquifer occurs in the western third of the basin. The alluvial/stream systems interact with the Ogallala-High Plains in the upper North and South Forks of the Solomon River. Alluvial ground water supplies depend on recharge from runoff and stream flow from water released from the reservoir storage.

Three irrigation districts; Kirwin Irrigation District No. 1, Webster Irrigation District No. 4 and Glen Elder Irrigation District No. 8 operate using releases from the three reservoirs. These reservoirs are Kirwin, Webster and Waconda respectively. When water is available from storage in the lakes, the irrigation districts are authorized to irrigate up to 25,394 acres. Water storage in the reservoirs has often been well below levels needed to meet water allocations in recent years.

Water appropriations by sub-basin are shown in Table 1. Almost 425,000 acres are authorized for irrigation in the Solomon basin from surface and ground water sources.[1]

The major water use in the basin is irrigation. Ground water is the source for the upper North and South Forks and the lower North Fork, while surface water is the main source for the lower South Fork and the Solomon River subbasins.

Upper Solomon subbasins (above Kirwin and Webster reservoirs) annual water use average ranged from 66,461 acre-feet in 1993 to 246,868 acre-feet in 1998. The average water use for the subbasins from 1987-2006 was 147,004 acre-feet.[2]

The average annual water use in the lower Solomon subbasins (Kirwin and Webster reservoirs to the confluence of the North and South Forks) ranged from 5,384 acre-feet in 1993 to 30,821 acre-feet in 2000. Average water use for the subbasins from 1987-2006 was 19,911 acre-feet.[3]

Solomon Basin High Priority Issue
Subbasin Water Management
January 2009

Table 1.
SOLOMON BASIN APPROPRIATIONS BY SUB BASIN (HUC08)
Acre-Feet per Year

	Domestic	Industrial	Irrigation	Municipal	Recreation	Stock	Other	Total
Upper North Fork Solomon River	16	16,288	163,751	2,039	320	1,424	586	184,424
Lower North Fork Solomon River	1,246	3	17,215	1,464	0	172	683	20,783
Upper South Fork Solomon River	4	734	111,939	2,077	204	369	0	115,327
Lower South Fork Solomon River	15	249	34,253	2,709	98	2,684	291	40,299
Solomon River	154	226	34,852	3,449	499	668	774	40,622
BASIN TOTAL	**1,435**	**17,500**	**362,010**	**11,738**	**1,121**	**5,317**	**2,334**	**401,455**

Mainstem Solomon subbasin (below Glen Elder) annual water use ranged from 2,990 acre-feet in 1993 to 30,326 acre feet in 2002. Average water use for the subbasin from 1987-2006 was 14,503 acre feet.[4]

In the upper North and South Fork Solomon, streamflow observations at U.S. Geological Survey (USGS) gages at Glade (North Fork), Bow Creek at Stockton and above Webster Reservoir on the upper South Fork have been in operation since at least 1952. The average streamflow for their periods of record were 25 cubic feet per second (cfs), 12 cfs and 49 cfs respectively. During the 1990s flow was higher, averaging 38 cfs, 17 cfs and 55 cfs. Reduced flows averaging 7 cfs, 6 cfs and 13 cfs have occurred in the 2000s.

On the lower North and South Fork of the Solomon, streamflow observations at USGS gages at Portis and Osborne indicate average flows have declined from the 1990s flows of 175 cfs and 168 cfs, respectively. Declines in flows since records began in the 1940s, averaging 115 cfs and 105 cfs, respectively, are also documented. Averages for the 2000s, so far, are 33 cfs and 20 cfs. Ground water in these subbasins displays seasonal fluctuations which are affected by the operations of surface water delivery systems through the Kirwin and Webster irrigation districts. Overall ground water levels were down throughout the subbasin in 2007.

In the mainstem Solomon subbasin, streamflow observations at USGS gages located below Glen Elder Reservoir, downstream from Niles and on Salt Creek at Ada, indicate average flows over their periods of record were 219 cfs, 539 cfs and 64 cfs, respectively. (The period of record varies for each gage, but includes at least 1965 through present.) During the 1990s streamflow levels were higher averaging 468 cfs below Glen Elder, 883 cfs at Niles and 108 cfs on Salt Creek. Reduced flows occurred in the 2000s averaging 58 cfs, 154 cfs and 23 cfs respectively.

The Niles gage has minimum desirable streamflow (MDS) set in 1984. Most of the time MDS criteria is met at Niles, although in 2002 MDS was not met.

Ground water measurements indicate an average decline of 0.78 feet from 2006 to 2008. The five-year rolling average shows a cyclical pattern with a declining trend since 1998.

Recommended Actions

1. Complete the refinement of water balance of subbasins within the Solomon basin.
2. Continue modeling of upper North and South Fork with scenarios of possible future water use patterns.
3. Develop management operations to improve reliability of water available to water right holders.
4. Work with federal agencies to make appropriate reservoir storage and operation changes to meet sustainable yield management and other goals of *Kansas Water Plan*.

Resources

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3. Kansas Department of Agriculture-Division of Water Resources. 2008. *Lower Solomon Subbasin 2007 Field Analysis Summary*. Subbasin Water Resources Management Program.

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Solomon and Smoky Hill Rivers. Photo courtesy KGS.

Solomon Basin High Priority Issue
Minimum Water Levels in Webster Reservoir
January 2009

Issue

Increase water levels in Webster Reservoir for improved recreational opportunities.

Description

Webster Dam and Reservoir are located on the South Fork Solomon River in Rooks County approximately eight miles west of Stockton. It is a modified, homogenous, earth-filled embankment with a structural height of 154 feet above the streambed and a crest length of 10,720 feet. Top of the conservation pool is elevation 1,892.45 feet above mean sea level. The dam, which impounds Webster Reservoir, was completed in June 1956.

Webster Reservoir was built by the U.S. Bureau of Reclamation (Bureau) for irrigation, flood control, recreation and fish and wildlife purposes. The Webster Reservoir has afforded recreation as a byproduct of storage space in the lake for other purposes. The State of Kansas may have the opportunity to acquire storage for recreation. The space has become available as a result of a decision by the Webster Irrigation District No. 4 to negotiate the possible sale or lease of a portion of its storage in the reservoir. The Kansas Water Appropriation Act limits the consumptive use of the hydrologic system to the historic amounts. Any changes to the water rights and use of the reservoir would require that the consumptive use of the system be at or below present levels. Capacity of Webster Reservoir is 400,422 acre feet for dead, inactive, conservation and flood control storage. The conservation storage capacity is 76,157 acre feet.

When the reservoir is at the top of the conservation pool, water backs upstream approximately five miles from the dam. At this level, the reservoir has a shoreline length of approximately 45 miles with a water surface area of 3,739 acres. The total controlled storage of Webster Reservoir is 259,510 acre feet. The lake capacity includes 1,256 acre feet of dead storage, 6,096 acre feet of inactive storage, 71,926 acre feet of active storage, and 183,353 acre feet for flood control.

The Bureau is required by the Reclamation Act of 1956 to provide irrigation districts holding long-term water service contracts the first right to a stated share of the available water supply. The available water supply to the Webster Irrigation District No.4 is the natural flows of the South Fork of the Solomon River and the storage waters available for release above the established reservoir shutoff elevation.

The normal irrigation season for Webster Irrigation District No.4 is from May 1 to September 30. Irrigation water can be released any time during this period. The District has a water right to store water in Webster Reservoir. The District also has a storage use right in Webster Reservoir and a natural flow water right for irrigation from the South Fork Solomon River of 158 cfs (23,607 acre feet per year). There are 8,537 irrigable acres within the District. Water is initially released into the South Fork Solomon River and diverted into the Osborne Canal approximately 19 miles downstream at Woodston Diversion Dam 1.5 miles west of Woodston (Figure 1). Bypasses are made at the request of the state for senior water rights.

The diversion control system includes one 8-foot by 18-foot radial sluiceway gate and one 84-inch by 78-inch canal outlet gate to the Osborne Canal. Fifty-four acres of the Woodston Diversion Dam land area is operated and maintained by the Webster Irrigation District No. 4. The Kansas Department of Wildlife and Parks (KDWP) under a lease with the Bureau, is responsible for wildlife

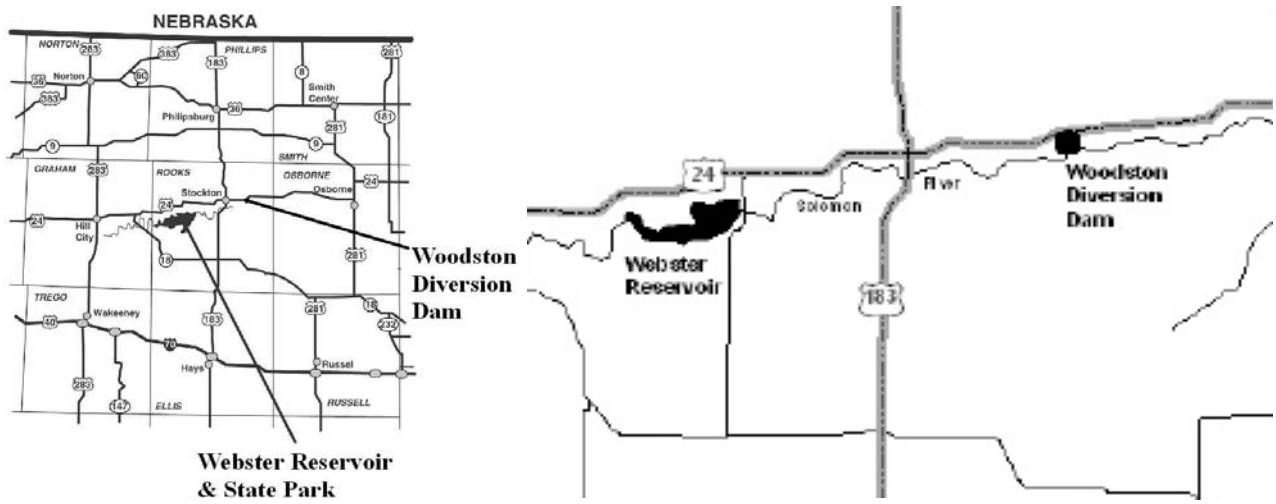

Figure 1. Webster Reservoir Irrigation Components.

Solomon Basin High Priority Issue
Minimum Water Levels in Webster Reservoir
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management on the remaining 210 acres of land surrounding the diversion dam. KDWP also manages 54 acres reserved for operation and maintenance purposes. [2]

The *Solomon River Basin Resource Management Assessment and Environmental Assessment/Finding of No Significant Impact* was completed in May 2002 to analyze the conversion of the Webster Irrigation District No. 4's long-term water service contract to a repayment contract. Specifically, the alternative contract provides for minimum pool elevations at Webster Reservoir, which results in secondary benefits to fisheries and recreation by providing carryover irrigation storage. In addition, the alternative provides for an increased delivery efficiency of nine percent for Webster Irrigation District No. 4 and to increase collective on-farm irrigation efficiency by five percent. [1]

The preferred alternative identified in the assessment provides for the inclusion of specific environmental measures in the District's operating plans. Those related to water level include:

- Continue irrigation with specified water conservation goals and practices to be outlined in the Irrigation District's Water Conservation Plan. There is a minimum pool elevation at Webster Reservoir of 1,863.0 feet above mean sea level (msl) (7,352 acre feet). The annual shutoff elevation for Webster Reservoir would be established according to the Webster Irrigation District Operating Plan.

- Establish policies to maintain reservoir levels.

The effect of ground water depletion on base streamflow and farm conservation practices have greatly reduced inflow to the Reservoir. Since the mid 1950s, the surface water supply in the river basin has decreased significantly. The 10-year moving average inflow to Webster Reservoir has decreased from 81,800 acre feet in 1955, to 44,200 acre feet in 1970, to 12,700 acre feet in 1985, to 11,700 acre feet in 1992. This decrease in reservoir inflow has drastically changed District operations. The reduced inflow has created lower pool levels. Greater water surface fluctuation at these lower pool levels (Figure 2).

The Webster Irrigation District No. 4 is in negotiation with the state to establish a cooperative partnership between the two parties to achieve a minimum conservation pool in the lake. This pool would provide suitable habitat for fisheries production, safe access to the lake by anglers

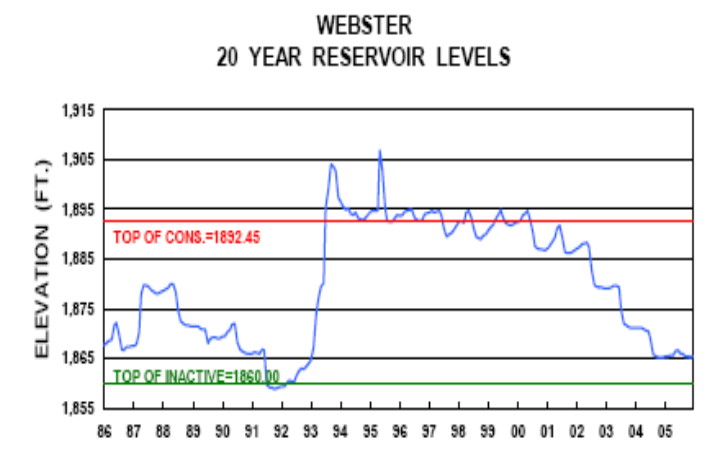

Figure 2.

and boaters, and habitat for water fowl and other wildlife more consistently.

Discussions include the possible state purchase or lease of the water rights/storage or maintenance of minimum water levels. Although recreation is an authorized use, no storage space in the lake has been dedicated to that purpose.

Recreation at Webster Reservoir includes on-lake boating and fishing as well as activities on federal land and Webster State Park. The state park offers five boat ramp lanes and three courtesy docks that provide boaters ample launching facilities at conservation level.

Raising the water level in the lake is considered to aid fisheries management at Webster Reservoir. Rising or stable water levels during the spring promote reproduction, survival and growth of various fish species by providing quality spawning habitat and nursery cover and enhancing primary productivity.

In a study conducted by the KDWP for the U.S. Bureau of Reclamation [3], the total estimated economic value of the Webster fishery (stilling basin included) was $11,129,238 during the 20-month period of evaluation. Past visitation records at Webster State Park show that the higher the water level, the higher the visitation. Activities enhanced by the higher, more stable lake levels are fishing, boating, skiing, swimming, and camping. These activities increase park customer satisfaction, which increases visitation and optimizes the economic benefits associated with the state park and the local economy.

The boat ramps within the state park and the wildlife area are usable when water levels are maintained at a higher level. As water levels decline to five feet below

conservation level, the ramp on the Wildlife Area becomes unusable and ramp access to the water becomes more difficult and often unusable.

Recommended Actions

1. Establish a cooperative partnership between the Webster Irrigation District No. 4 and the State of Kansas to achieve the highest possible conservation pool water level in the Webster Reservoir.

2. Consider/negotiate water right acquisition in Webster Reservoir.

3. Obtain rights to water by (in order of preference):
   a. Purchase of Webster Irrigation District's water rights and convert storage in Webster Reservoir for fish, wildlife, and recreation purposes;
   b. Negotiation of a long-term lease; or
   c. Negotiation of a partial purchase of Webster Irrigation District water rights and conversion to fish, wildlife and recreation storage.

Note: Purchase of water rights and associated storage is preferred.

4. Maintain consumptive use of the stream/aquifer/reservoir system at or below present historical levels.

Webster Lake.

Resources

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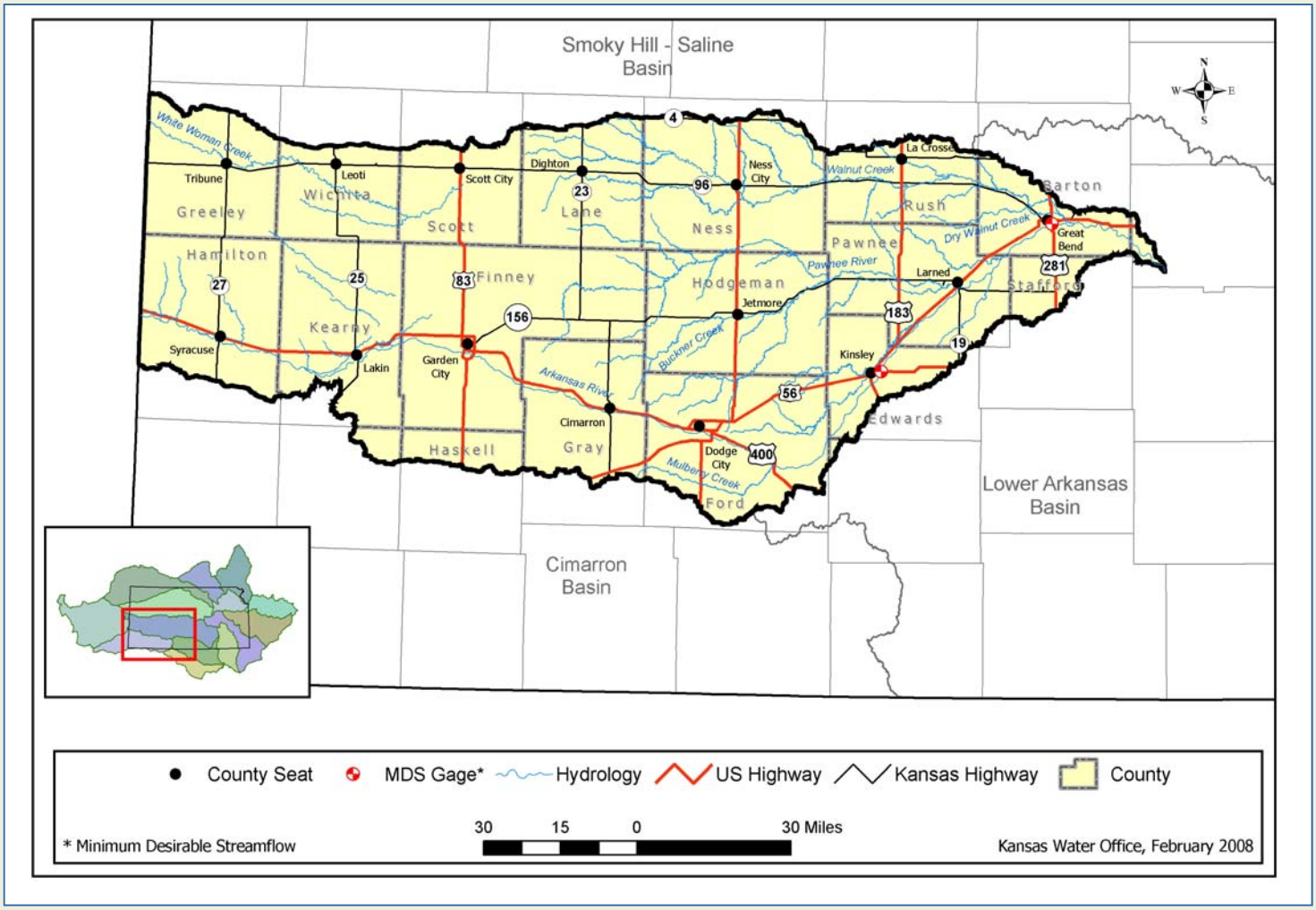
Upper Arkansas River Basin

January 2009



General Description

The Upper Arkansas basin covers 10,300 square miles of west central Kansas. The basin includes all or parts of 20 counties. The Arkansas River is the dominant river. It receives water from snow and rain run off resulting in periodic high flows. There are no major tributaries to the Arkansas River until Mulberry Creek in Ford County; west of this, flows are highly dependent on flows entering from Colorado. The Pawnee River, Walnut Creek and Coon Creek are major tributaries of the Arkansas River in this basin. Declines in the alluvial aquifer have reduced or ceased baseflow contributions for most of the river west of Kinsley, with discharge from the alluvial aquifer only after high flow events have recharged bank storage. Some or all of the Arkansas River flow is lost as infiltration from the stateline to Dodge City. Whitewoman Creek and James Draw drain a portion of the basin but end in depressions. Remaining areas of the basin are drained by numerous small direct tributaries of the Arkansas River.

Kansas Arkansas River basin overlies the High Plains aquifer. The High Plains aquifer, of which the Ogallala is the dominant portion, has been identified as a national concern regarding water quantity.

Population and Economy

There were an estimated 128,500 residents in the basin in the year 2000.[1] According to the Kansas Division of Budget, the total population of the 19 counties that are contained in whole or in part by the Upper Arkansas basin had a population of 171,733 in 2000. By 2040, the county population is projected to decrease to 163,207.[2]

This basin illustrates major demographic changes that are taking place in Kansas. In the past 40 years, two trends have dominated the state and the basin: 1) Rural counties have lost population, sometimes more than 10 percent every decade; 2) Urban counties particularly in the great Wichita area and Kansas City area are gaining population at an even greater rate.

In the Upper Arkansas basin counties with meat packing plants in the immediate vicinity are gaining population. Finney County went from a population of 16,093 in 1960 to 40,712 in 2000.

Ford County went from a population of 16,093 in 1960 to 40,712 in 2000. Other rural counties, however, are losing population. Greeley County, with a population of 2,087 in 1960, had only 1,537 people in 2000. Ness County, which had 5,470 people in 1960, lost more than 2000 residents by the year 2000.

The economy of the basin is based primarily on agriculture and manufacturing. The major crops are wheat, grain sorghum, corn and alfalfa with a sizable portion of this acreage being irrigated. Irrigation has helped stabilize the agricultural economy in this area of marginal precipitation.[5]

The total value of regional economic activity was about $10.3 billion in 2003. Manufacturing, where meat packing and other food processing is represented, is by far the largest economic sector. Regional employment totaled more than 83,000 jobs. This economic activity generated about $3.8 billion in value added income, the most important measure of regional household welfare associated with regional economic activity.[3]

Dodge City, Garden City and Barton County Community Colleges offer opportunities for higher education.

Recreation is an increasing part of the economics of the basin. The state parks and associated recreation and wildlife areas draw hunters to the region. There is one Multipurpose Small Lake, Jetmore Lake in Hodgeman County, located in the basin. In April 2008, construction began on HorseThief Reservoir, a 450-acre watershed lake. The lake will provide flood control and water-based recreation for the region.

A growing contribution to the basin economy is related to energy production, including ethanol. As of December 2008, two ethanol plants are located in Finney County and one in Wichita County. One additional ethanol plants is planned for Ford County.

View from Pawnee Rock, Barton County. Photo courtesy of Kansas Geological Survey.

Physical Characteristics

Geology and Soils

The Tertiary and Quaternary undifferentiated sediments deposits in the area are underlain by Cretaceous age bedrock deposits. The bedrock has an east-to-southeast drainage trend. Major structural controls are the Bear Creek fault in Hamilton and Kearny counties, and Crooked Creek-Fowler fault in Ford County. These faults created a vertical displacement up to 250 feet, and bound a subsidence that filled with the younger, unconsolidated sediments of the aquifer. West of Bear Creek fault, alluvial sediments overlie Cretaceous bedrock and the High Plains aquifer is not present. The impermeable nature of this bedrock allows for minimal to no infiltration beyond the alluvial deposits. East of the fault, the alluvial sediments overlie the Tertiary and Quaternary deposits in which the High Plains aquifer occurs.

Land features are comprised predominantly of level to gently rolling tableland that is dissected with narrow drainage ways. Soils are deep on the ridge tops and moderately deep to shallow on the side slopes. Soil texture ranges from medium to fine.

Several different soil associations are found in the basin. Along the Arkansas River floodplain and terraces, sandy, loamy and clay soils predominate. South of the river, there are also areas of sand hills, classified as duny soils.

Land Use/Land Cover

Land use in the basin typically is dominated by cropland (64.6%) or grassland (24.1%) or Conservation Reserve Program land (10.3%). Less than one percent of land within the basin is comprised of residential, commercial/industrial and municipal use, open water and barren ground.

The Upper Arkansas basin has 28,531 stream bank miles. Within a 100-foot corridor along each bank, about 52% of the land is pasture/grassland followed by cropland (37%).

While comprising less than one percent of the bank miles, the Upper Arkansas basin has the most animal production stream bank area of the Kansas basins.[6]

Climate

The basin climate is characterized by the extremes and variability of precipitation and temperature common to mid-continent locations. Average annual precipitation increases from approximately 16 inches at the Colorado border to 26 inches in the east These annual quantities are subject to wide fluctuation, with thunderstorms accounting for most of the annual rainfall. Most of the precipitation occurs between April and September.

Temperatures tend to increase from west to east across the basin in response to declining elevations. At Garden City the average annual temperature is 53.1° F. while at Great Bend it is 56.0° F. The frost free period shows a similar west-to-east pattern (Table 1).

	Average Annual[1]		Freeze Dates (32 F.)[2]		
Location	Precipitation (inches)	Temperature (F)	Last	First	Days Between
Garden City	18.77	53.3	Apr. 26	Oct. 13	169
Great Bend	26.45	56.1	Apr. 15	Oct. 21	191

[1]Source: National Climatic Data Center (1971-2000 data)
[2]Source: KSU Weather Data Library (1961-1990 data)

Drought is a naturally recurring feature of this climate as exemplified by the Dust Bowl of the 1930s and the severe drought of 1952-1957. It is perhaps the most pervasive natural hazard affecting Kansas and other agricultural areas of the central United States. Kansas has been impacted by severe drought periodically throughout the present decade.

Windswept dune, Sandhill south of Arkansas River in Kearny County. Photo courtesy Kansas Geological Survey.

The Upper Arkansas River basin is greatly affected by reductions in precipitation that are offset by ground water pumping to irrigate cropland that has not received sufficient rainfall. Drought increases the demand on the available water supply. Precipitation events moisten the soils near the surface but soil moisture needed for crops is lacking, reservoirs water levels are at record lows and streamflow is down.

Wildlife and Habitat

The Upper Arkansas River basin encompasses a wide array of habitat types that support rich and extremely diverse wildlife populations. The wildlife community includes 54 reptiles and amphibians, 48 fish, 54 mammals, and 283 bird species. Fifteen state or federally listed threatened or endangered species share a probable or historic range or critical habitat within the basin.

In 1996, the U.S. Geological Survey (USGS) reported that Kansas has about 435,000 acres of wetlands, which include sandhill pools along the Arkansas River, playa lakes in western Kansas, freshwater marshes such as those in Cheyenne Bottoms, and salt marshes such as those in Quivira National Wildlife Refuge.

Kansas has lost about one-half its wetlands during the last 200 years, mostly due to conversion to cropland, and depletion of surface and ground water by irrigation withdrawals.

Water Resources

The Arkansas River receives water from snow and rain run off resulting in periodic high flows associated with precipitation. Colorado Rocky Mountain snowmelt and runoff have a major impact on water flowing in the river as well as runoff in Kansas. There are no major tributaries to the Arkansas River in Kansas until Mulberry Creek in Ford County.

The principal sources of ground water in the basin are the saturated sands, gravels and silts in the thick deposits of Tertiary and Quaternary age. This includes the alluvial deposits along the river and tributaries and the Ogallala Formation of the High Plains aquifer.

The thickness of the Arkansas River alluvium ranges from about 10 feet to over 80 feet. Alluvial ground water levels are highly variable but a steady decline throughout the basin has occurred, with significant declines east of Garden City.

Aerial view of center pivots in Kearny County. Photo courtesy Kansas Geological Survey.

The Upper Arkansas basin contains 13,165 miles of intermittent and 843 miles of perennial streams for a total of 14,008 stream miles. The density of 1.3 stream miles per square mile, places the basin second to last among the twelve major river basins.

Minimum Desirable Streamflow (MDS) has been set for two USGS gages inside the basin: one near Great Bend and one near Kinsley. On average, streamflow has been insufficient to meet the MDS goals at these locations (Great Bend, 66-88%; Kinsley 55-66%). During the recent drought, the frequency at which these locations have been able to meet MDS has decreased.

Ground water is the source for 96% of supply for all reported uses in 2006. Irrigation accounted for nearly 95% of all reported water pumped or diverted. Municipal use accounted for two percent of water used in the basin, industry for one percent and recreation, stockwater and other uses combined equal about two percent (2006).[7]

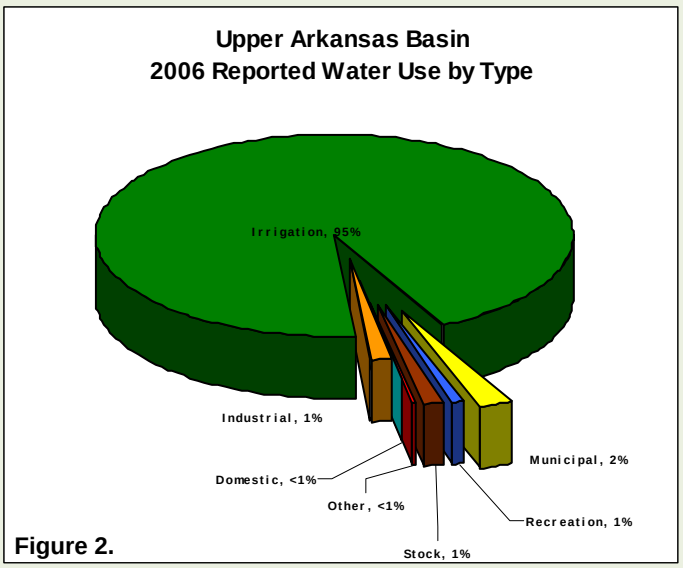


Figure 2.

Authorized withdrawals for irrigated agriculture use the majority of all water used in the Upper Arkansas River basin. The ground water levels have declined due to the withdrawals that exceed recharge. Saturated thickness of the aquifer system in the basin has decreased generally between 10 and 50 ft, but as much as 150 feet in parts of the Finney County. This translates to greater than 60% reduction in saturated thickness since predevelopment of irrigation in the 1940s.[14]

Water Management

Groundwater Management District Nos. 1, 3, and 5 are major local water management entities in the basin.

Several townships in the Arkansas River basin are closed to new appropriations. The closures were proposed by the local GMDs, under authorities established in the Groundwater Management District Act. The adoption of these rules and regulations eliminated the possibility of additional appropriations being approved in many areas of the basin.

In 1986 and amended in 1987, the Chief Engineer ordered an Intensive Groundwater Use Control Area (IGUCA),[13] which closed the Arkansas River corridor in Hamilton, Kearny, Finney, Gray and Ford counties to further ground or surface water appropriations. An IGUCA can provide more comprehensive water management tools than provided under strict water right administration based on priority.

Arkansas River flows in Colorado are contained and then released from John Martin Reservoir near Lamar Colorado. An interstate compact between Kansas and Colorado apportions the river flows with minimum flows at the State line and required usage prior to the gage at Garden City. These flows are primarily withdrawn by irrigation districts.

Six active irrigation ditches, Frontier, Amazon, Great Eastern, Garden City, South Side and Farmers, in southwest Kansas are supplied from streamflow in the Arkansas River. The irrigation ditches historically served approximately 70,000 acres; more recently, they have provided surface water supply to approximately 44,000 acres in Hamilton, Kearny and Finney counties.

Parts of five watershed districts are included in the basin: Cimarron Watershed District No. 3, James Draw Watershed Joint District No. 87, Lakin Watershed District No. 49, Pawnee Watershed Joint District No. 81 and Wet Walnut Creek Watershed Joint District No. 58.

The county conservation district is the primary local unit of government responsible for the conservation of soil, water and related natural resources within the county boundary. Each county within the Upper Arkansas River basin has a county conservation district. Four Resource Conservation and Development (RC&D) districts serve the counties of the Upper Arkansas basin: the Santa Fe Trail, Coronado Crossing, Central Prairie and Smoky Hill. The RC&Ds are designed to help community leaders develop rural economies by improving and conserving local natural, human and economic resources.[8]

Resources

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Arkansas River, Kendal, KS, Oct. 2007.
Photo courtesy of Kevin Salter

Upper Arkansas River Compact

Kansas and Colorado have had a long history of litigation over the apportionment of the waters of the Arkansas River with interstate litigation filed before the United States Supreme Court in the early 1900s. As Special Master Arthur Littleworth described it, "The meaning of the Arkansas River Compact cannot be fully understood apart from the rich history of controversy over the river, and the early efforts to apportion its waters between the two states. Nor can its meaning be divorced from the views of the men in both states who fought the apportionment issues for more than a decade …."[11] The Arkansas River Compact, ratified in 1948, was the culmination of decades of failed settlements and temporary agreements. The Compact sought to protect the status quo between the states as well as allocate the benefits of John Martin Reservoir. The Compact recognized there would be additional development in both states, but such development should not materially deplete flows that would otherwise be available to Kansas.

What the Compact did not do was provide a definite allocation of water supply to either state. With regard to water stored (conservation storage) in John Martin Reservoir, either state acting alone or both states together, could release that water up to a maximum rate. Without a specific allocation, both Kansas and Colorado sought to utilize any stored water quickly, before the other state used it all up, causing what was known as the 'race to the reservoir.' If one state called for a release, the other state generally called for its release as well.

Lake McKinney, Kearny County. Photo courtesy of Grace Muilenburg, KGS.

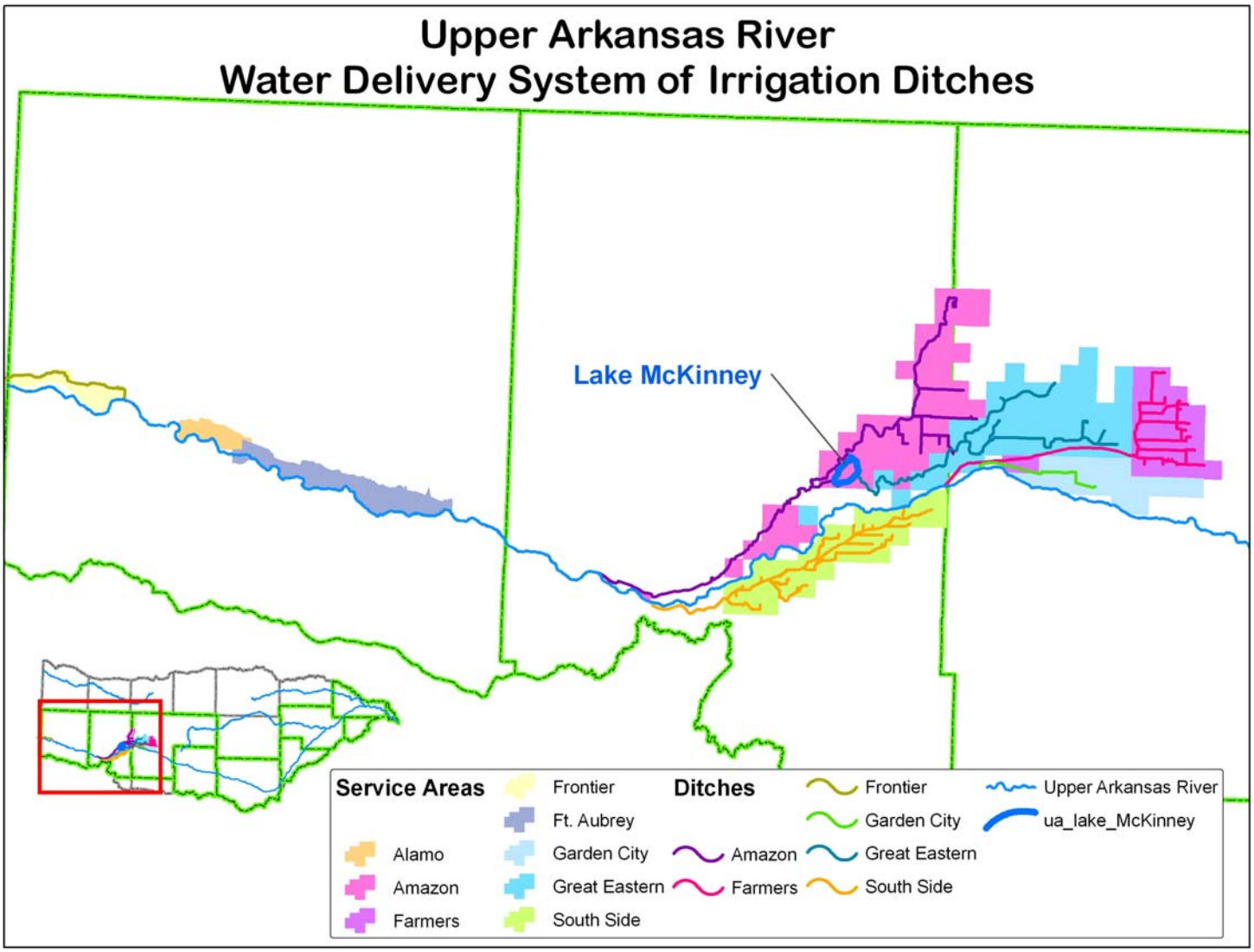
In the late 1970s it was recognized that conservation storage in John Martin Reservoir could be used more effectively. In 1980, an operating plan was developed that provided water stored in John Martin Reservoir under the Compact would be allocated 40% to Kansas and 60% to Colorado. This allocation was accomplished through the use of separate accounts for each state. These separate accounts have allowed both states to improve the effectiveness of the use of water stored in John Martin Reservoir.

There are six active Kansas irrigation ditches which divert surface water from the Arkansas River between the Colorado-Kansas stateline and Garden City. These ditches benefit under the terms of the operating plan, since they can call for water at any time and any rate, while being assured 40% of the water stored under the Compact. This allows the Kansas ditches to call for water during peak growing demand of summer crops, usually in July. This is in stark contrast to when Kansas had to call for water in April or May when releases were being called for by Colorado ditches.

The Arkansas River flows in both States have been appropriated by existing water rights and are diverted from the Arkansas River. Therefore, the river flow in southwestern Kansas is highly dependent on the irrigation demands of Kansas ditches, which have been diverting surface water since the 1880s. Water called for by the six Kansas irrigation ditch companies is put to beneficial use in Hamilton, Kearny and western Finney county as permitted under their vested water rights.

Since the adoption of the Compact, Colorado allowed the construction of hundreds of high capacity wells along the Arkansas River. Kansas filed Kansas v. Colorado, No. 105, Original, in 1985 to enforce the terms of the Arkansas River Compact. In 1994, Special Master Littleworth recommended that the Supreme Court determine that Colorado had violated terms of the Arkansas River Compact by means of post-compact well pumping in Colorado. The United States Supreme Court agreed. As the result of the damages and remedies phase, Colorado paid Kansas more than $34 million for Colorado's compact violations during the period 1950 through 1999. In 2006, Colorado paid Kansas an additional $1.1 million. This money has been deposited in three funds created by statute that specify generally how and where the money will be spent. One fund, the Western Water Conservations Projects Fund, is administered by Southwest Kansas Groundwater Management District No. 3 with input from the Arkansas River Litigation Fund Advisory Committee, and is to be spent on improved water efficiencies, water conservation, recharge and similar projects in the area impacted by past compact violations. The Director of the Kansas Water Office must approve all final projects.

The Special Master submitted his Fifth and Final Report[12] to the United States Supreme Court in January 2008, including the Judgment and Decree which was jointly developed by Kansas and Colorado. Colorado compliance with the Compact will be determined using a hydrologic-institutional model and accounting procedures as set out in the decree. In December 2008, the Special Master's Fifth and Final Report and the Kansas Exception went before the U.S. Supreme Court.



Upper Arkansas River Basin Management Categories

January 2009

WATER MANAGEMENT CATEGORIES

The following categories include issues identified in the Upper Arkansas basin plan as items that require attention in addition to the basin priority issues. These issues are addressed within the following management categories:

- Water Management
- Water Conservation
- Public Water Supply
- Water Quality
- Flood Management
- Water-Based Recreation
- Wetland and Riparian Management

These categories also correspond to the statewide management categories and policies of the *Kansas Water Plan* found in Volume II. These documents contain new policy issues and the existing policy and statutory framework that relate to the management categories.

ISSUE: WATER MANAGEMENT

The Southwest Kansas Groundwater Management Districts (GMD) No. 3 (GMD3), the West Central Kansas GMD No. 1 (GMD1) and Big Bend GMD No. 5 (GMD5) are major local water management entities in the basin. Most townships in the basin are closed to new appropriations.

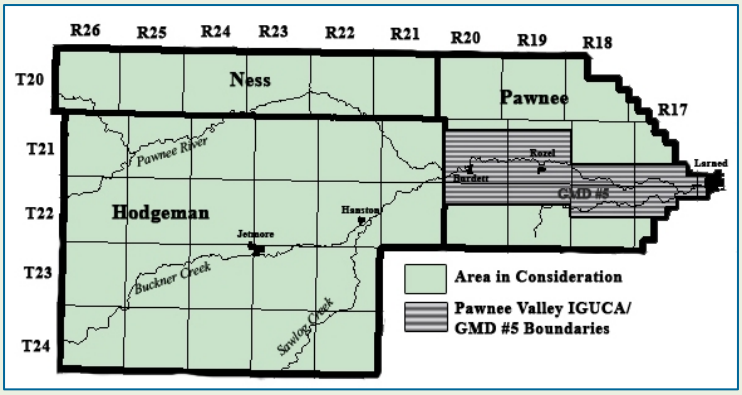
There are five organized watershed districts in the basin, including the Pawnee Watershed District, the largest watershed district in the United States.

Minimum Desirable Streamflow (MDS) levels have been set for two sites in the basin: one near Great Bend and one near Kinsley. According to an assessment conducted by the Kansas Water Office (KWO) in 2006, both MDS gages in the basin have shown declines in the annual frequency, magnitude or duration of meeting MDS.

The *Kansas Water Plan* directed the need for further water resource management in the Pawnee River Valley. The Kansas Department of Agriculture-Division of Water Resources (DWR) Subbasin Water Resources Management Program began work with stakeholders in 1996 to evaluate the hydrologic properties of the alluvial valley and recommend long-term management strategies for the Pawnee Buckner subbasin. The committee recommended in their 2000 management proposal that the Chief Engineer amend the order establishing the Pawnee Valley Intensive Groundwater Use Control Area (IGUCA) to include the part of the subbasin within Hodgeman and Ness counties, in addition to the area within Pawnee County, and require water resource management during drought conditions (Figure 1).

In 2007, the Chief Engineer gave an order to expand the boundaries of the Pawnee Valley IGUCA. A phase II hearing would identify the goals to be accomplished with the amended IGUCA, and the corrective control provisions.

An IGUCA has closed the Arkansas River corridor in Hamilton, Kearny, Finney, Gray and Ford counties to any further ground or surface water appropriations, and to prevent re-drilling a well closer to the river.



In 2006, the KWO calculated the median annual water level changes in wells from 1981 to 2005 GMD3. Based upon the assessment, the data indicates that sustainable yield has not yet been attained in GMD3.

On December 20, 2007, the U.S. Department of Agriculture (USDA)-Farm Service Agency, in partnership with the State Conservation Commission, began accepting applications to enroll land in the Conservation Reserve Enhancement Program (CREP). This voluntary program seeks to provide incentives and cost sharing to participants that enroll their land into eligible conservation practices such as native vegetation establishment or wildlife conservation for a period of 14 to 15 years. The CREP project area lies within 10 counties along the Arkansas River corridor, covering 1,571,440 acres. As of December 2008, nearly 8,200 acres were enrolled in the CREP program. For the acres enrolled into the CREP program, 16,479 acre feet of the authorized water quantity will be permanently retired from irrigation.

The GMD3 has contracted with the Kansas Geological Survey (KGS) to map the practical saturated thickness (PST) of the Ogallala-High Plains aquifer in their district. The PST, as determined primarily by well logs, is the net

thickness of saturated sediments that significantly contribute to well yield from the water table down to the bedrock surface. It differs from the saturated thickness which is the total thickness of saturated sediments between the water table and the bedrock surface. The PST can provide a more accurate picture of water availability and may also provide insight into future water level trends at the scale of an individual well.

In 2007, the KWO, GMD3, and the U.S. Bureau of Reclamation (Bureau) contracted with the KGS for the development of a hydrologic model of the GMD3 region. The model will provide additional information on the water budget, and be able to project aquifer and streamflow responses to various future management scenarios.

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce water level decline rates within the Ogallala aquifer and implement enhanced water management in targeted areas.
- By 2015, achieve sustainable yield management of Kansas surface and ground water sources outside of the Ogallala aquifer and areas specifically exempt by regulation. Sustainable yield management would be a goal that sets water management criteria to ensure long term trends in water use will move as close as possible to stable ground water levels and maintenance of sufficient streamflows.
- By 2015, meet minimum desirable streamflow at a frequency no less than the historical achievement for the individual sites at time of enactment.

Applicable Programs

The following programs help to meet the objectives in the Water Quantity Management category. For more information on the programs and associated policies, see the Programs Manual.

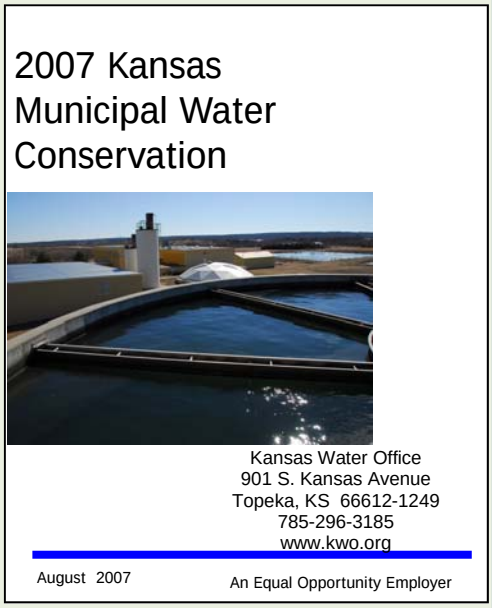
- Kansas Department of Agriculture-Division of Water Resources: Water Appropriation Program
- Kansas Department of Agriculture, Division of Water Resources, Subbasin Water Resource Management Program
- Kansas Geological Survey, Kansas Department of Agriculture-Division of Water Resources: Water Well Measurement
- Kansas Water Office and U.S. Bureau of Reclamation: Assessment and Evaluation Program/Ogallala Special Study Phase II, Cooperative Agreement
- Kansas Water Office: State Water Planning Program
- Kansas Geological Survey: High Plains Aquifer Technical Assistance Program
- Kansas Geological Survey: Stream Aquifer Interactions
- USDA-Natural Resources Conservation Service: Environmental Quality Incentive Program (EQIP)
- USDA–Farm Services Agency: Conservation Reserve Enhancement Program

ISSUE: WATER CONSERVATION

Water conservation is essential for the effective management of water resources in the basin to assure that a sufficient, long-term supply of water is available for the beneficial uses of the people of the state. Conservation is defined in Webster Dictionary as a careful preservation and protection of something, especially the planned management of a natural resource to prevent exploitation or destruction. Water conservation is a part of maintaining a long-term water supply for Kansas.

Water conservation activities apply to all uses: irrigation, municipal, industrial, etc., and from all sources. Irrigation accounted for nearly 95% of all reported water pumped or diverted in the basin. Municipal use accounted for two percent of water used in the basin, industry one percent, while recreation, stockwater and other uses combined equaled about two percent (2006 water use reports).

Of the 614 public water suppliers in Kansas that have an approved conservation plan in place as of December 31, 2008, 43 plans have been approved in the Upper Arkansas basin. Three hundred and twenty one plans have been approved for irrigation water rights. The number of diversion points in western Kansas that reported irrigation application rates over the regional average decreased during the period from 1991 to 2005. Of the total number of wells in the Upper Arkansas basin that were reported to have diverted water in 2006, more than 90% had meters.



Upper Arkansas River Basin Management Categories

The DWR Subbasin Water Resources Management Program began work with stakeholders in 1998 in the Middle Arkansas basin to address water concerns. In 2004, the team created water management strategies, which they presented to the Chief Engineer. These include encouragement of a 10% water use reduction, based from the 1988–2000 water use reports, as well as development of water conservation plans. The KWO and DWR contracted with the KGS for development of a hydrologic model of the Middle Arkansas subbasin. The computer model was able to provide information on the water budget and project aquifer and streamflow responses to various future conditions and possible management scenarios (Figure 2).

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce the number of public water suppliers with excessive unaccounted for water by first targeting those with 30 percent or more unaccounted for water.
- By 2010, reduce the number of irrigation points of diversion for which the amount of water applied in acre-feet per acre (AF/A) exceeds an amount considered reasonable for the area.
- By 2015, all non-domestic points of diversion meeting predetermined criteria will be metered, gaged, or otherwise measured.
- By 2015, conservation plans will be required for water rights meeting priority criteria under K.S.A. 82a-733 if it is determined that such a plan would result in significant water management improvement.

Applicable Programs

The following programs help to meet the objectives in the Water Conservation management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Appropriation Program
- Kansas Department of Agriculture-Division of Water Resources: Subbasin Water Resources Management Program
- Kansas State University Research and Extension: Water Conservation and Management Program
- State Conservation Commission: Water Resources Cost-Share Program
- Kansas Water Office: Water Conservation Program
- Kansas Water Office: State Water Planning Program
- Kansas Water Office: Weather Modification Program
- USDA-Natural Resources Conservation Service: Environmental Quality Incentive Program (EQIP)
- USDA-Farm Service Agency: Conservation Reserve Program

ISSUE: PUBLIC WATER SUPPLY

The primary approach to addressing public water supply issues in the basin focuses on ensuring that there are adequate supplies of surface and ground water within the basin to meet future water demands, reducing the number of public water supply systems that are vulnerable to drought, and ensuring that systems have the technical, financial and managerial capacity to meet future needs for water quality and quantity.

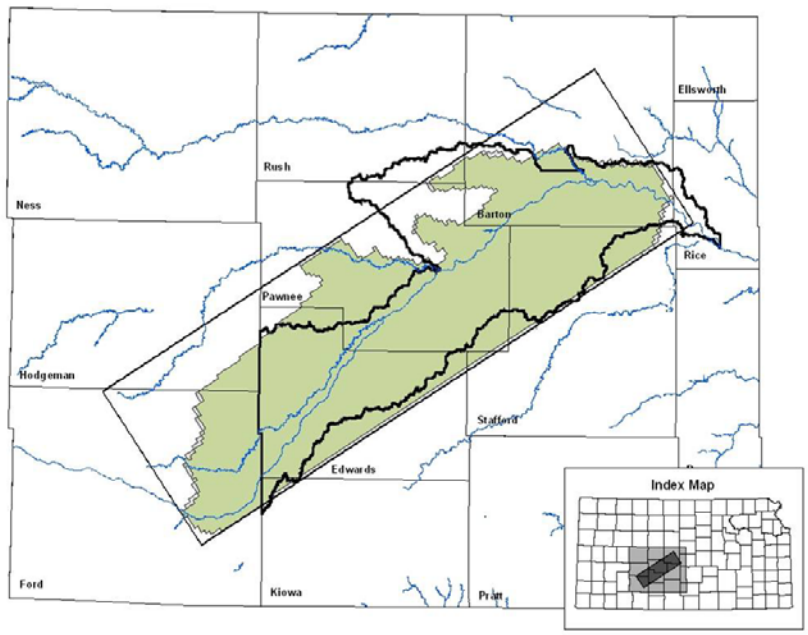


Figure 2. From KGS 2006. Box indicates model boundaries. Dark outline is subbasin boundary.

There are 46 public water suppliers in the basin, including two rural water districts. There are no public wholesale water supply districts in the basin. Ground water is the primary source for most public water supplies, accounting for 96% of the total supply.

Coping with drought presents a challenge for public water suppliers. During drought periods, the amount of raw water available typically is reduced at the same time customer demand for water increases. Although ground water is not as susceptible to droughts as surface water, public water suppliers that have an insufficient number of wells or capabilities to meet increase demand are vulnerable. While all suppliers may be potentially impacted,

some are particularly vulnerable. Of the public water suppliers in the basin, seven (16%) were considered drought vulnerable in 2006.

Applicable *Kansas Water Plan* Objectives

- By 2010, ensure that sufficient surface water storage is available to meet projected year 2040 public water supply needs for areas of Kansas with current or potential access to surface water storage.
- By 2010, less than five percent of public water suppliers will be drought vulnerable.
- By 2010, ensure that all public water suppliers have the technical, financial and managerial capability to meet their needs and to meet Safe Drinking Water Act requirements.

Applicable Programs

The following programs help to meet the objectives in the Public Water Supply management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Appropriation Program
- Kansas Department of Health and Environment: Public Water Supply Program
- Kansas Water Office: State Water Planning Program
- Kansas Water Office: Water Conservation Program
- Kansas Department of Health and Environment: Kansas Public Water Supply Loan Fund

ISSUE: WATER QUALITY

Water quality and related water resource issues are addressed through a combination of watershed restoration and protection efforts utilizing voluntary, incentive based approaches, as well as regulatory programs (see Watershed Restoration and Protection Basin Priority Issue).

All the counties within the basin with the recent addition of Haskell County have a sanitarian funded by the Local Environmental Protection Program (LEPP). All counties in the basin, except Kearny and Ness, have countywide planning and zoning programs. All conservation districts in the basin have adopted nonpoint source pollution management plans. Buffer coordinators have also been employed in six counties in the basin to facilitate enrollment of stream buffers in the continuous conservation reserve program and State Water Quality Buffer Initiative. Dodge City, Garden City, and Great Bend are included in the Phase II National Pollutant Discharge Elimination System (NPDES) Stormwater Program as having Municipal Separate Storm Sewers (MS4s).

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce the average concentration of bacteria, biochemical oxygen demand, solids, metals, nutrients, pesticides and sediment that adversely affect the water quality of Kansas lakes and streams.
- By 2010, ensure that water quality conditions are maintained at a level equal to or better than year 2000 conditions.
- By 2010, reduce the average concentration of dissolved solids, metals, nitrates, pesticides and volatile organic chemicals that adversely affect the water quality of Kansas ground water.
- By 2010, maintain, enhance, or restore priority wetlands and riparian areas.
- By 2015, nutrient reduction goals will be included in all WRAPS projects within the basin.
- By 2010, all public water suppliers will complete and implement a source water protection plan.

Applicable Programs

The following programs help to meet the objectives in the Water Quality management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Health and Environment: State Water Plan Program (Contamination Remediation)
- Kansas Corporation Commission: Conservation Division Programs
- Kansas Department of Health and Environment: Local Environmental Protection Program
- Kansas Department of Health and Environment: Watershed Management Program
- State Conservation Commission: Nonpoint Source Pollution Control Program
- State Conservation Commission: Water Resources Cost-Share Program

ISSUE: FLOOD MANAGEMENT

Kansas Water Plan flood management guidance emphasizes targeting watershed dam construction assistance to priority watersheds; encouraging participation in the National Flood Insurance Program; and preparing updated floodplain maps for priority communities. All counties in the basin, except Ness County, have county wide breech zoning plans.

In 1993, the DWR launched the *Kansas Flood Mapping Initiative.* The FY 2005 *Kansas Water Plan* Flood Management Policy Section identified three priority counties to be mapped, remapped or to have existing information digitized in the Upper Arkansas basin. These counties are Barton, Hamilton, and Rice. Financial assistance from the *State Water Plan Fund* has been provided for this mapping. The Barton County map conversion into a digital format is near completion.

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce the vulnerability to damage from floods within identified priority communities or areas.

Applicable Programs

The following programs help to meet the objectives in the Flood Management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Structures Program/Floodplain Management
- Kansas Department of Agriculture-Division of Water Resources: Water Structures Program/Dam Safety
- Kansas Division of Emergency Management: Hazard Mitigation Grants Program
- FEMA: National Flood Insurance Program
- State Conservation Commission: Watershed Dam Construction Program
- State Conservation Commission: Watershed Planning Assistance Program

ISSUE: WATER-BASED RECREATION

While frequently dry within the basin, the Arkansas River is one of the three streams in the state that are considered navigable (as determined at time of statehood), and therefore is considered public land up to the channel's high water mark. Water-based recreation opportunities are limited in the basin. Fishing is popular at the few county fishing lakes. Jetmore Lake and Scott State Park Lake both provide fishing, boating and camping. Horsethief Reservoir began construction in 2008. When completed and filled, Horsethief will offer swimming, boating, fishing and camping. Horsethief Reservoir is a 450 acre lake located 18 miles north of Dodge City. Cheyenne Bottoms is a designated wetland of international importance, and provides excellent birding and hunting opportunities. In 2008, construction began on a Wetland Interpretive Center at Cheyenne Bottoms to expand public awareness of the Bottoms and the nearby Quivira wetland complex.

Applicable *Kansas Water Plan* Objectives

- By 2010, increase public recreational opportunities at Kansas lakes and streams.

Applicable Programs

The following program helps to meet the objectives in the Water-Based Recreation management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Wildlife and Parks: Rivers and Stream Access

ISSUE: WETLAND AND RIPARIAN MANAGEMENT

The primary approach to wetland and riparian management in the basin focuses on providing technical and financial assistance to landowners to protect and restore these resources in priority watersheds through the implementation of best management practices. Wetland and riparian management is addressed as a basin priority issue in the Upper Arkansas basin (see Watershed Restoration and Protection Basin Priority Issue).

Riparian lands in the Upper Arkansas basin have been seriously impacted by the infestation of non-native phreatophytes. Of greatest concern are the effects tamarisk (salt cedar) and Russian olive have on the basin's native riparian ecosystems.

Applicable *Kansas Water Plan* Objectives

- By 2010, maintain, enhance or restore priority wetlands and riparian areas.

Applicable Programs

- Kansas Forest Service: Forest Stewardship Program and Conservation Tree Planting Program
- State Conservation Commission: Riparian and Wetland Protection Program
- Kansas Water Office: State Water Planning Program
- Kansas Department of Wildlife and Parks: State Parks and Wildlife Areas Planning and Development
- Kansas Department of Wildlife and Parks: Wildlife Habitat Improvement Program

Upper Arkansas River Basin High Priority Issue
Management of the Ogallala High Plains Aquifer
January 2009

Issue

Management of the Ogallala-High Plains aquifer and alluvial aquifer is needed to reduce the rate of decline and to conserve the life of the aquifer.

Vision

Sufficient water resources in western Kansas to support healthy, economically strong communities and rural lifestyles, today and for future generations.

Goal

Conserve and extend the life of the Ogallala - High Plains aquifer through management by aquifer subunits, by targeting water conservation activities to high priority subunits, improved characterization of the aquifer and implementing strategies for improved agricultural practices with limited water resources.

Description

The High Plains aquifer is the primary source of water in western Kansas. Nearly all of the reported water used in the Upper Arkansas basin is from ground water. The High Plains aquifer is composed of several hydraulically connected aquifer units of which the largest is the Ogallala. The Ogallala has been intensely developed, mostly for irrigation, leading to significant ground water declines. The Ogallala portion of the High Plains aquifer (Ogallala-High Plains aquifer) is characterized by low recharge and high declines. The expected "usable life" of the aquifer, or when the aquifer is no longer able to support the current high rates of pumping, varies widely due to differences in amount of saturated thickness, hydraulic conductivity, withdrawals and other variables. The total irrigated acres in the Kansas High Plains increased from 2,681,000 to 2,746,000 acres between 1991-1993 and 2001-2003, a 2.4% increase.[8] During the same time period, there has been an increase in corn, soybeans and alfalfa acres, crops that are traditionally water intensive, as well as wide spread adoption of more efficient irrigation systems.[8] The annual water level measurements indicate that in most areas, for a five year or more trend, the Ogallala-High Plains aquifer is declining.[1, 9]

It has long been known that the aquifer was in decline in western Kansas, at least for localized areas.[4] Kearny, Finney and Gray counties have had water level drops of over 30 feet in the past ten years. In general, southwestern Kansas still has significant amounts of ground water in storage, with many areas of the Upper Arkansas basin projected to have enough ground water to support widespread pumping for 50 years or more, even if the past water level decline trends continue (Figure 1). However, most of the aquifer within Greeley, Wichita and Scott counties has already declined to where the saturated thickness is below the minimum threshold needed to support widespread pumping. Areas within Finney, Gray and Stanton counties may face a similar situation within 25 years.[10]

Ogallala outcrops near Lake Scott. Photo courtesy Kansas Geological Survey.

Figure 1 is an estimated projection of how many more years the aquifer could support an assumed level of pumping, in this case with a well every quarter section, pumping at 400 gpm for 90 days. It projects the ground water level trends from 1996 to 2006 into the future. If the past trend had been increasing, the area is shown as blue.[10]

Upper Arkansas River Basin High Priority Issue
Management of the Ogallala High Plains Aquifer
January 2009

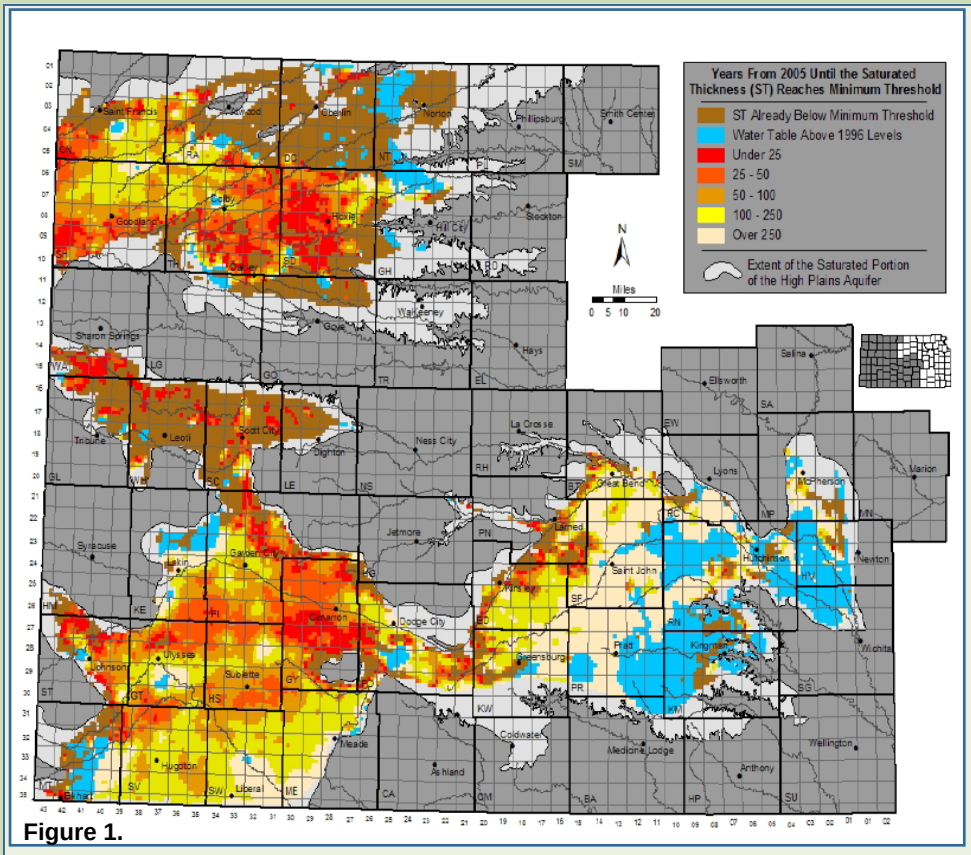


Figure 1.

Southwest Kansas Groundwater Management District (GMD) No. 3 (GMD3), West Central Kansas GMD No. 1 (GMD1) and Big Bend GMD No. 5 (GMD5) are major local water management entities in the basin. A majority of the basin is closed or restricted for new water appropriations. Intensive Groundwater Use Control areas (IGUCA)[11] have been established for the Arkansas River corridor, Wet Walnut Creek and Pawnee River valley to provide increased management of ground water in those areas.

The High Plains aquifer is highly variable in Kansas. The amount of water in storage, the depth to water, the hydraulic conductivity (how readily the water moves through the sediments in the aquifer), the amount of withdrawals and the recharge rates all vary significantly throughout western Kansas.

Water Appropriations

Approximately 1,514,000 acre feet of ground water are appropriated for use within the Ogallala aquifer portion of GMD3 in the Upper Arkansas basin. There are about 4,567 active Ogallala–High Plains water rights from 5,592 wells.

Water Use

Ground water was the source for 96% of supply within the basin for all reported uses in 2006. Irrigation accounted for nearly 95% of all reported water pumped or diverted. Municipal use accounted for two percent of water used in the basin, industry for one percent, and recreation, stockwater and other uses combined to equal two percent. The 2006 reported water use from the Ogallala-High Plains in the basin was 874,563 acre feet.[6]

There has been widespread adoption of more efficient irrigation systems in the Kansas High Plains, from flood and center pivot to center pivot with drop nozzles.[8] A companion study by Kansas State University[2] found that the number of acres irrigated is a more important determinant of changes in water use than the adoption of more efficient irrigation systems. The authors concluded that if the irrigated acres are held steady after conversion to a more efficient irrigation system, net water use would, on average, change little. Therefore, it is with a decrease in irrigated acres that a reduction in water use is assured.[2]

Activities and Progress

Various programs and activities have been initiated to reduce the decline rate of the Ogallala-High Plains aquifer in order to extend and conserve the aquifer. Tools such as ground water and surface water computer models and more detailed aquifer characterization have been developed. In the Upper Arkansas basin, the determination of Ogallala-High Plains aquifer subunit priority areas, setting subunit goals and developing management plans to reach these goals has been the responsibility of the GMDs and Kansas Department of Agriculture–Division of Water Resources (DWR) for areas outside the districts.

Good data are essential to the determination of decline rates and aquifer characteristics. An important management tool is the development and calibration of interactive surface and ground water models. Water flow meters, now required on almost all wells, provide improved information on withdrawals. Annual winter water level measurements, continuous measurements from an index well in Haskell County, and weather station data,

provide valuable input information to hydrologic models.

Under a Cooperative Agreement between the U.S. Bureau of Reclamation (Bureau) and the Kansas Water Office (KWO), the state and GMD3 have contracted with the Kansas Geological Survey (KGS) to develop a computer water model of the GMD3, incorporating stream-aquifer interactions where applicable to further characterize the hydrologic system and water availability. The model will provide more information on water in storage and project likely aquifer responses to possible future conditions and management scenarios.

Voluntary programs have been offered and targeted to areas determined by the management entity responsible for that area, GMD3 within district boundaries and in the fringe areas by DWR. The U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS) Environmental Quality Incentive Program (EQIP) provides grants to transition from irrigated land to dryland production for a minimum of four years.

On December 20, 2007, the USDA Farm Service Agency began accepting applications to enroll land in the Conservation Reserve Enhancement Program (CREP) (Figure 3). This voluntary program seeks to provide incentives and cost-sharing to participants that enroll their land into eligible conservation practices such as native vegetation establishment or wildlife conservation for a period of 14 to 15 years. The CREP project area lies within 10 counties along the Arkansas River corridor within the basin, covering 1,571,440 acres. In the CREP area, 718,683 acres are authorized for ground water irrigation; approximately another 10,680 acres are authorized for irrigation from surface water. The program allows enrollment up to 20,000 acres. Reducing irrigation demands on the stream-aquifer system will help slow the aquifer declines, mitigate the spread of saline waters into the aquifer, and help restore stream and riparian health throughout the CREP area.

As of December 30, 2008, 8,198 acres had been enrolled in the CREP program with additional offers pending. For the acres enrolled into the CREP program, 16,479 acre feet of authorized quantity will be permanently retired from irrigation.

Regulatory programs have included the DWR Blatant and Recurring Overpumpers (BRO) program which makes special requirements on irrigators that have pumped in excess of their water rights to get them back into compliance. In addition, Kansas Water Appropriation laws protect senior water rights from impairment by junior water right pumping. In 2008, DWR administered a junior water right that was impairing a senior right in Stevens County.

Priority Aquifer Subunits: Priority aquifer subunit maps are used to guide state and federal efforts on water conservation in Kansas (Figure 2). GMD1 has selected their entire district as a priority subunit (hatched). GMD3 has adopted subunits as shown on Figure 2. The DWR is working to identify priority subunits for the aquifer fringe outside the GMDs. Specific target areas are defined for areas eligible for enrollment in the Conservation Reserve Enhancement Program (CREP), EQIP quick response areas and Water Right Transition Assistance Program (WTAP).

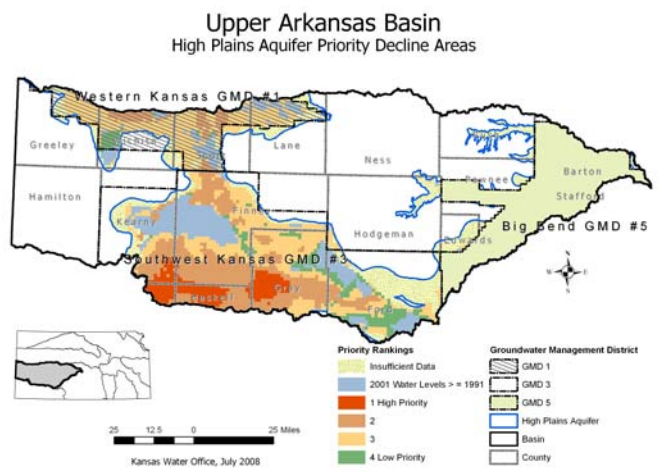


Figure 2.

The priority rank shown on this map is based on an area's total score from two databases: estimated usable lifetime and density of ground water use. Useable lifetime is defined as the ability to support a 400 gpm well yield, on every quarter section, pumping for 90 days. Rank 1 indicates areas with a short estimated usable lifetime and a history of higher ground water usage. Rank 4, the lowest concern areas, have a relatively long useable lifetime and low total water use.

Progress toward reducing the aquifer decline rate was evaluated by the KWO in 2006 using water level data. The median annual water level changes were calculated for each region and standardized or indexed to antecedent moisture conditions using the Palmer Drought Severity Index for the appropriate region. The comparison of 1981-1993 and 1993-2005 periods concluded that there was no discernable change in the rate of water

level declines in the Ogallala –High Plains region. Also concluded that as of 2005, in the southwest and western Ogallala aquifer area (GMD3, GMD1, and DWR fringe areas), there has been no statistically significant change, at a 5 percent error level in the rate of decline.

It should be noted that the reduction of total water use through the voluntary and regulatory programs is small. A measurable reduction in decline rates will likely take many years or decades to be recognizable unless participation in reductions are greater.

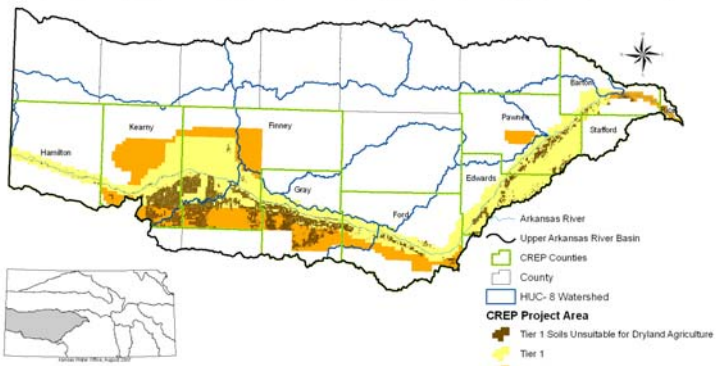


Figure 3.

Recommended Actions

1. For priority aquifer subunits, develop specific goals and management strategies to extend and conserve the life of the aquifer.

2. Develop and maintain a ground water flow model of GMD3 area for evaluating management decisions and establishing conservation goals.

3. Kansas Water Office will continue coordination among the GMDs, DWR, stakeholders and other agencies.

4. Provide opportunities to permanently and temporarily reduce water use through voluntary programs (state, federal and local).

5. Educate water users, decision makers and the general public on the conditions of the aquifer and methods and opportunities to reduce water use.

6. Develop local ownership and leadership of aquifer issues, to assist in local adoption of specific conservation goals and programs.

7. Evaluate the long-term impact of climate change on supply and demand for water resources in the basin.

8. Seek crop insurance option for limited irrigation crops from USDA Risk Management Agency.

9. Consider interstate discussions on water conservation and planning where aquifer subunits cross state boundaries and are not directly impacting an existing surface water compact.

10. Explore opportunities to augment natural aquifer recharge through artificial recharge during flood events and other means as may be feasible.

11. Support research into high value, lower water-use crops that would be suitable for this region.

Resources

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4. Kansas Water Resources Board, 1958. *Preliminary Appraisal of Kansas Water Problems,* Part A, Section 2, Cimarron Unit, State Water Plan Studies.

5. Kansas Department of Agriculture-Division of Water Resources. 2007. *Kansas Irrigation Water Use Report 2006*.

6. Kansas Department of Agriculture-Division of Water Resources. March 28, 2008. Water right information system (WRIS) database.

7. Kansas Geological Survey, http://www.kgs.ku.edu/General/Personnel/tw/abs/Ogallala_decline_assessment.pdf

8. Perry, Charles, 2006, Effects of Irrigation Practices on Water Use in the Groundwater Management Districts Within the Kansas High Plains, 1991-2003, Scientific Report 2006-5069, US Geological Survey.

9. Schloss, Jeffrey, Robert Buddemeier, and Blake B. Wilson, eds., 2000. *An Atlas of the Kansas High Plains Aquifer*, Educational Series 14, Kansas Geological Survey. http://www.kgs.ku.edu/General/Personnel/tw/abs/Ogallala_decline_assessment.pdf

10. Wilson, Blake B, January 17, 2007. *Ground-Water Levels in Kansas: A Briefing to the Kansas Legislature* House Agriculture and Natural Resources Committee, KGS OFR 2007-1.

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Upper Arkansas River Basin High Priority Issue
Middle Arkansas Subbasin
January 2009

Issue

Reduction of ground water withdrawals is necessary to stabilize the hydrologic system in the Middle Arkansas subbasin.

Description

The water resources in the Middle Arkansas subbasin, which covers all or parts of Stafford, Edwards, Barton, Pawnee, Kiowa, Rush and Rice counties, have been heavily developed (Figure 1). Irrigation accounts for approximately 82% of the authorized water use, with recreation the next highest user. Most of the recreational use is for Cheyenne Bottoms Wildlife Area. Cheyenne Bottoms has a fairly senior water right in the subbasin, at file number 2427, which authorizes 18,185 acre feet from the Arkansas River and 19,175 acre feet from the Wet Walnut Creek. There are three appropriations up for certification that authorize additional quantities from the Dry Walnut, Blood Creek and Deception Creek. There are 1,836 points of diversion for an authorized 258,147 acre feet of water in the subbasin. Annual reported use is typically about 60% of the authorized amount. The Arkansas River streamflow, as measured at the Kinsley gage, has reduced drastically in recent decades, as shown in the median monthly streamflow from 1945-1973, and 1974-2002. Ground water is withdrawn from both the alluvial aquifer and the Great Bend Prairie aquifer, part of the High Plains aquifer. The ground water table has had significant decreases and at times no longer contributes water to the Arkansas River, resulting in depletion of the stream baseflow. With ground water levels stabilized, during normal or wetter climatic conditions, it could rise to streambed elevation and baseflow be re-established.

Arkansas River streamflow at Kinsley has been around 0.1 cubic feet per second (cfs) for much of 2007-2008, with increases in September 2007 and January 2008 to almost 0.4 cfs. Drops in streamflow to zero, which has occurred as recently as 2006, suggest that the ground water elevation has dropped below the streambed, so that the stream is not in hydraulic contact with the aquifer and baseflow has apparently ended. Long-term streamflow recovery most likely depends on aquifer recovery.

The Kansas Water Appropriation Act[8] was amended in 1984 to protect waters necessary to preserve and maintain streamflows at or above the minimum desired levels. Although not a water right in itself, the Chief Engineer, Kansas Department of Agriculture-Division of Water Resources (DWR), is to withhold from appropriation that amount of water needed to maintain Minimum Desirable Streamflow (MDS).[9] MDS established before July 1, 1990 have a priority date of April 12, 1984. The purpose of MDS is to protect flow from depleted conditions as a result of extensive water appropriation.

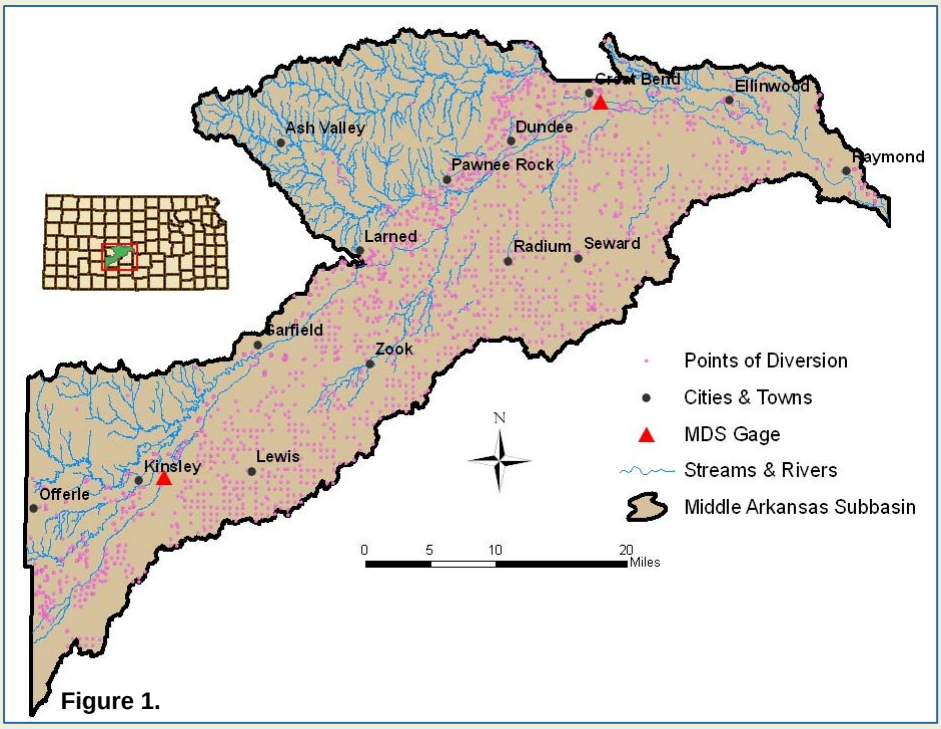

Figure 1.

A MDS is set at the US Geological Survey (USGS) stream gage near Kinsley. The MDS is set at a high of 5 cfs in May and June, to a low of 1 cfs in August through September. Minimum desirable streamflows protect flow for instream uses relative to fish, wildlife, water quality, general aesthetics and downstream domestic and senior water rights.

The DWR has worked with water users and others in the Middle Arkansas subbasin to address the water shortages. This effort began in 1998 to develop a water management plan that identifies strategies to reduce water withdrawals, and works toward a sustainable hydrologic system.[4] The management plan proposal was approved by the Chief Engineer in 2004.[5] The goals are to stabilize the ground water levels, return ground water levels to channel elevation and maintain a baseflow in the river under normal climatic conditions. A number of strategies

are identified, one of which is more efficient irrigation systems. One recommendation is to remove end-guns from center pivot irrigation systems.

Cheyenne Bottoms. Photo courtesy KGS

Kansas State University, under contract for the Kansas Water Office (KWO), evaluated the water use efficiency of end guns in the region to crop production and farm economy. One tool developed is a computer spreadsheet program for individual site assessments. Users enter general system and field characteristics; the model will provide expected yields, water use efficiency values and costs associated with the use of the end gun in that site's operation.

Circle K Ranch

The Circle K Ranch, located in the Middle Arkansas subbasin, is owned by the Cities of Hays and Russell. The ranch has 8,039 acre feet of water rights appropriated for irrigation. In 2004, it was proposed that the State of Kansas purchase the ranch to be managed by the Kansas Department of Wildlife and Parks, possibly for a wildlife viewing and hunting area. The goal is to reduce water use in this area while minimizing the economic impact to the region.[3] The Middle Arkansas Modflow model was used to evaluate the effect of the retirement of these water rights and it was shown there would be a localized benefit. As of 2008, no state purchase of Circle K Ranch has been made and it appears unlikely to occur. In 2007, a significant number of water rights were enrolled into a 10-year Water Right Conservation Program at DWR, to protect the right from abandonment while not used. The associated acres were enrolled into a U.S. Department of Agriculture, Natural Resources Conservation Services (NRCS) program to transition to dryland.

EQIP Quick Response Areas

A number of irrigated acres have been enrolled in the USDA NRCS Environmental Quality Incentive Program (EQIP) as quick response areas to transition to dryland for four years. Many of the associated water rights enrolled in the DWR Water Right Conservation Program for 10 years, which protects water right from abandonment during a period of non-use. NRCS provides payments to transition to dryland use, such as farming, pasture or grass. The EQIP program requires the land remain non-irrigated a minimum of 4 years, but it does not require the water right to be permanently retired. The Groundwater Management Districts' boards make the initial recommendation for the quick response areas, which is then reviewed by the Kansas Technical Committee and determined by the State Conservationist. For areas outside a district, DWR makes recommendations for quick response areas.

Conservation Reserve Enhancement Program (CREP)

On December 20, 2007, the Kansas Farm Service Agency began accepting applications to enroll land in the Conservation Reserve Enhancement Program (CREP).

This voluntary program provides incentives and cost–sharing to participants that enroll their land into eligible conservation practices such as native vegetation establishment or wildlife conservation for a period of 14 to 15 years.[6] The CREP project area lies within 10 counties along the Arkansas River corridor, covering 1,571,440 acres. In the CREP area, 718,683 acres are authorized for ground water irrigation; approximately another 10,680 acres are authorized for irrigation from surface water. The state seeks to enroll up to 20,000 acres into the program over the next several years. Reducing irrigation demands on the stream-aquifer system will help slow the aquifer declines, mitigate the spread of saline waters into the aquifer, and help restore stream and riparian health throughout the CREP area and within the Middle Arkansas subbasin.

As of December 30, 2008, 8,198 acres had been enrolled in the CREP program. For the acres enrolled into the CREP program, 16,479 acre feet of authorized quantity will be permanently retired from irrigation.

Upper Arkansas River Basin High Priority Issue
Middle Arkansas Subbasin
January 2009

Ground Water Model

The DWR and the KWO contracted with the Kansas Geological Survey to develop a Modflow water model to provide additional information on the nature of stream-aquifer interactions and the effect of ground water pumpage, for use in planning and management of water resources in the Middle Arkansas subbasin.[7] The computer model extends from northeast Ford County through much of Edwards and Pawnee counties to north-central Stafford and southern Barton counties (Figure 3).

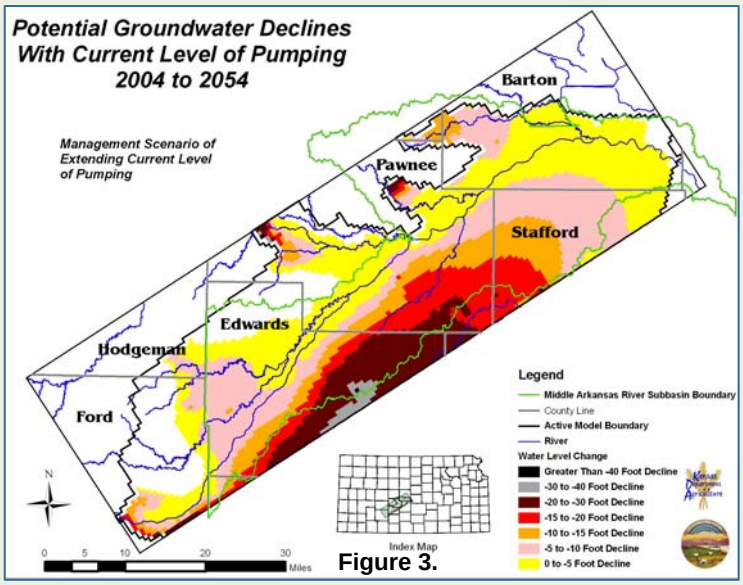

Figure 3.

Five different scenarios were simulated with the model: 1) increased streamflow from 1980-2004, 2) continued pumping at current levels; 3) no pumping; 4) 24% reduction of pumping in the proposed area for the CREP, and 5) retirement of water rights in the Circle K Ranch.

Regulatory Options

One recommended action under the current *Middle Arkansas Subbasin Management Plan* is to implement regulatory options to help achieve water conservation.[5] In 1978, the Kansas Legislature enacted provisions for designation of Intensive Groundwater Use Control Areas (IGUCA) within the Groundwater Management District Act.[10] These statutes allow the Chief Engineer to implement additional corrective control provisions in areas where it is determined, through a public hearing process, that ground water levels are declining excessively, the rate of ground water withdrawal exceeds the rate of ground water recharge, unreasonable deterioration of ground water quality has occurred or may occur, or other conditions exist warranting additional regulation to protect public interest.

Recommended Actions

1. Coordinate interagency efforts to implement strategies identified in the *Middle Arkansas Subbasin Management Plan*, as approved by the Chief Engineer.

2. Use the hydrologic model to evaluate future management scenarios and strategies that may be needed to achieve the subbasin goals.

Resources

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Upper Arkansas River Basin High Priority Issue
Salt Cedar and Other Non-Native Phreatophyte Control
January 2009

Issue

Salt cedar (Tamarisk), Russian olive and other invasive high water consuming vegetation are choking out native riparian habitat along the upper Arkansas River and other western streams in Kansas.

Description

Riparian lands in Kansas have been seriously impacted by the infestation of non-native phreatophytes. Of greatest concern are the effects tamarisk and Russian olive have on our native riparian ecosystems.[4, 5] Tamarisk is a tenacious shrub/small tree that has a deep root system (up to 100 feet) and leaves a salt residue on the soil surface. Tamarisk, a native of southern Europe and central Asia, is classified as a deciduous shrub that rapidly attains a height of five to twenty feet and grows best in sandy soils along streams. Tamarisk was brought to the United States for ornamental purposes and most likely was first established in Kansas in the early 1900s when it was planted in windbreaks. It has been widely used for bank stabilization and windbreaks since it is well suited for the western United States. There are many different species of tamarisk that are referred to with different common names. These problematic and invasive tamarisk species are commonly referred to as salt cedar.

Tamarisk can adapt to poor subsurface water quality. Tamarisk utilizes salt to increase the osmotic potential of its deep, extensive root system, which allows it to draw water from greater depths than the native vegetation. Therefore, tamarisk tends to out-compete native obligate phreatophytes during drought periods. The salt is excreted by the leaves and is concentrated in the leaf litter, thus impeding the growth of native species where tamarisk has gained a foothold. Tamarisk uses significant quantities of water. Actual water use by tamarisk depends on several factors, water availability, climate, water quality, population density, stresses, etc. However, it has been found that tamarisk will consume more water than some native vegetation in the same setting.[1, 2]

Russian olive, a different type of invasive phreatophyte shrub or small tree, was introduced in Kansas for windbreaks and wildlife plantings. The Russian olive, with its tendency to spread quickly, is a menace to riparian woodlands, threatening hardy native Kansas species like cottonwood and willow trees. Russian olive outcompete native vegetation, interferes with natural plant succession and nutrient cycling, and chokes irrigation canals in Kansas.

Tamarisk flowers. Photo courtesy Kansas Water Office

The resulting invasive thickets of tamarisk and Russian olive provide poor habitat for livestock and wildlife, increase fire hazards, decrease water quality and generally use more water than native vegetation. The vegetation does, however, provide shelter protection for livestock. Infestations of phreatophytes in Kansas are roughly estimated to occupy greater than 50,000 acres.

Scientists with the U.S. Department of Agriculture (USDA) have stated that, "*tamarisk infestation has reached epidemic proportions and is one of the greatest disasters to ever befall native riparian areas in western United State,".*[3] The National Invasive Species Council has identified tamarisk as one of its primary targets for control.

Tamarisk affects the water supply in both quantity and quality. The decrease in alluvial ground water levels due to tamarisk increases the transit loss of water delivered from John Martin Reservoir in the Arkansas River. Tamarisk affects water quality by reducing in-stream flows and the concentration of naturally occurring salts in tamarisk stands.

Thick tamarisk stands promote narrowing of river and stream channels. The U. S. Army Corps of Engineers have studied the Upper Arkansas River channel capacity and documented that tamarisk is occupying space within the channel and flood zone, thus increasing the potential risk of flood damage.[7, 8] Since tamarisk replaces native species, there is a loss of biodiversity in the infested areas. Wildfires are more intense in tamarisk infested areas, however, due to the nature of the tamarisk root crown, it recovers from fires quicker than native vegetation. Thus, fires tend to promote additional

infestation. Tamarisk infestation is problematic in Kansas because it negatively impacts water quantity and quality, results in the loss of land utilization options and value, as well as a loss of wildlife habitat.

Estimates of the number of acres infested in the United States are between one and two million acres. Tamarisk has been identified in nearly every county in Kansas, but is concentrated along streams and lakes in the western portion of the state. Tamarisk is prevalent along the mainstem and tributaries to the Arkansas and Cimarron rivers, as well as the shorelines of several of the state's federal reservoirs.

Helicopter surveys of the Upper Arkansas River were conducted in 2004 and 2005 by the Kansas Department of Agriculture. Estimates from these surveys indicate that more than 15,000 acres of the riparian corridor from the Colorado-Kansas state line east to the Rice County line along the Arkansas River are infested with tamarisk (Table 1) . According to a statewide county survey, more than 50,000 acres of the land surveyed in Kansas are infested with tamarisk.

Table 1

County	Total Acres Tamarisk
Hamilton	5,606
Kearny	3,644
Finney	2,078
Gray	960
Ford	1,798
Edwards	989
Pawnee	492
Barton	58

Recommended Actions

1. Continue to work with agencies and groups on the water issue strategic plan and 10-Year Strategic Plan to coordinate and implement the variety of programs, research and educational efforts that are occurring or recommended.

2. Cooperate with stakeholders in Colorado to implement tamarisk control projects that cross state lines.

Recommended Actions Continued

3. Promote education on invasive plants and seek local input through the Basin Advisory Committees.

4. Continue an evaluation of the most effective and cost-efficient control measures for the Upper Arkansas River basin, and provide cost share on tamarisk control and shelter belt replacement.

5. As an effective control measure is identified for the basin, implement a wide-scale, watershed-based control effort, and combine with plans for successful beneficial vegetation that helps stabilize the soil, has potential for windbreaks and other benefits.

6. Research and evaluate biological control of tamarisk using leaf beetles and/or other suitable organisms, but pilot it with extreme caution to avoid unintended consequences.

7. Deliver educational materials and technical information to legislators, property owners and the public within the basin related to non-native phreatophyte research and control through Kansas State University Agricultural Experiment Station and Cooperative Extension Service.

8. Quantify the actual non-beneficial use of water by tamarisk in the basin's different ecological settings. Existing research should be used and augmented with on-the-ground measurements of changes to both streamflow and ground water before and after tamarisk control activities. This research will help to establish the difference in water consumption in Kansas between non-native phreatophytes and typical riparian plant communities.

9. Evaluate the recovery benefits after tamarisk control to provide valuable information on the specie's true impact to water quality, wildlife habitat, water quantity, grazing land, reduction of risk from flood damage and other features that impact the basin's ecology and economy.

10. Determine the potential value of tamarisk biomass for various value-added products such as ethanol, bedding, fiberboard, and fuel pellets, or if not suitable for alternative uses, determine how to dispose of dead plant materials.

Resources

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Upper Arkansas River Basin High Priority Issue
Bioenergy and Water
January 2009

Issue

Renewable fuel production is a growing issue in the Upper Arkansas basin, where increased biofuel production provides economic opportunity. As new biofuel facilities are sited and changes are made to the basin's cropping patterns, more evaluation is needed of the impacts from the increased demand on both water supply and water quality.

Description

Gas and oil production is the second largest industry in Kansas and is very important to the Upper Arkansas basin economy. The growing industrial contribution to the basin economy is also related to bioenergy production, primarily ethanol. As of December 2008, three operating ethanol plants are located in the basin in Wichita and Finney counties. One ethanol plant is permitted in Ford County (Figure 1).

Water Quantity

Ethanol production, like many industrial and agricultural practices, involves a consumptive use of water. A 50-million gallon per year (MGY) ethanol plant uses about 200 MGY of water (or about 550,000 gallons per day), primarily from evaporation during cooling and wastewater discharge. Ethanol production technology uses water more efficiently; plants today use about 50 percent less water than 10 to 15 years ago. It currently takes roughly three to four gallons of water to produce one gallon of ethanol. Under Kansas law for appropriating water, ethanol plants, as any other industry, must purchase water from a rural water district, a municipality or acquire a water right. Most of the basin is closed to new water appropriations; in closed areas, any new venture must purchase an existing water right, and any change in use of that appropriation must be approved by the Chief Engineer, Kansas Department of Agriculture-Division of Water Resources (DWR), to ensure that the net consumptive use does not increase.

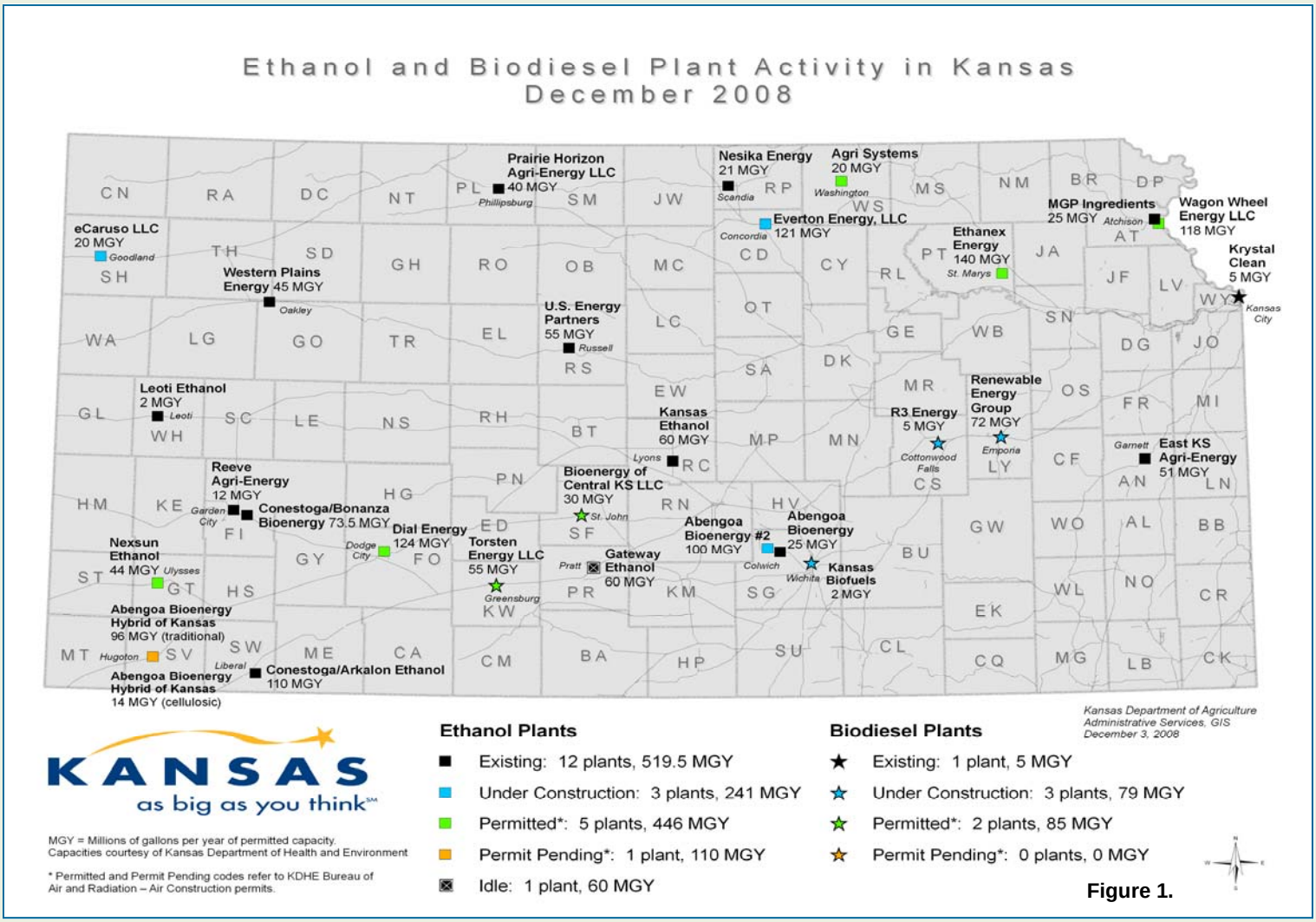

Figure 1.

Nonetheless, some have raised concerns that increased corn production, a water-intensive crop, may cause additional water table declines over time.[3, 4]

Most U.S. ethanol is made from corn, but it can also be produced from other feedstocks such as grain sorghum, wheat, barley or potatoes. In Kansas, more than half of the ethanol produced comes from grain sorghum, with most facilities using corn and sorghum interchangeably.[3] This new demand for corn, and the new opportunities for value-added processing and cattle production in rural communities, has created a significant economic development opportunity in Kansas and throughout the Upper Arkansas basin. However, the potential changes to the basin cropping patterns, specifically increasing the number of irrigated corn acres, may negatively impact the aquifer and stream conditions.

According to the U.S. Department of Agriculture National Agricultural Statistics Service (NASS) the number of irrigated corn acres in west central Kansas grew from 103,000 acres in 1990 to 139,000 in 2007 (Figure 2).[6] Improved agronomic practices and crop genetics have led to higher corn yields. In west central Kansas, while there was a 15% increase in irrigated corn acres from 1993 to 2003, there was a 79% increase in irrigated corn production.[13] In 2006, approximately 16% of Kansas corn and sorghum crops were used for ethanol production, up from 13% in 2000. Corn production in Kansas may be slowing down. According to NASS, producers intended to plant eight percent fewer corn acres in 2008, as a result of multiple factors including crop rotation considerations and high input costs. In 2008, Kansas was expected to plant their largest soybean crops in history.[6]

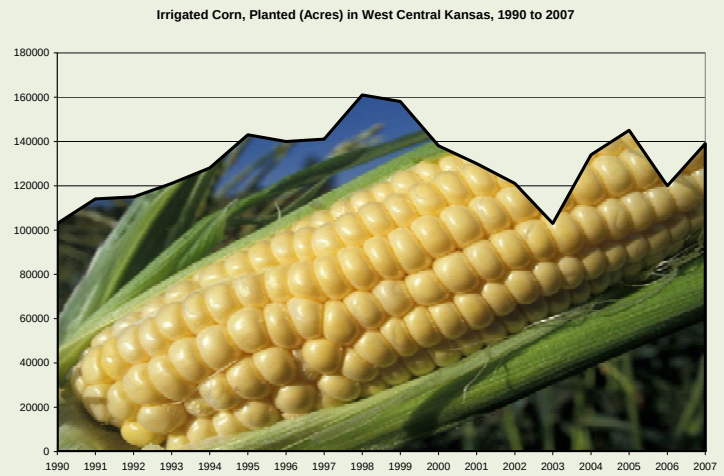

Figure 2.

Water Quality

Wastewater from ethanol plants is regulated by the Kansas Department of Health and Environment (KDHE), which administers both the federal National Pollution Discharge Elimination System (NPDES) permits and Kansas Water Pollution Control permits. In most instances, KDHE issues the state-level permit, which requires ethanol plants to use the wastewater for beneficial land applications rather than simply discharging into streams and rivers.

A rise in the number of corn acres may also impact the basin water quality through increased fertilizer application and soil erosion. In Kansas, corn has the greatest application rates of both fertilizer and pesticides per acre, higher than for soybeans and mixed-species grassland biomass. The switch from other crops or noncrop plants to corn may lead to higher application rates of highly soluble nitrogen. Harvested row crops, such as corn, have a higher potential for soil erosion than grasses or perennial crops. The potential water quality impact of an increased demand for corn may be mitigated through Best Management Practices (BMPs), especially those addressing soil erosion and herbicide applications.[1]

The restoration of watersheds with impaired water quality and the protection of watersheds above public water supply reservoirs and ground water sources used for drinking water supplies are also a high priority issue in the Upper Arkansas basin.

Biodiesel

Biodiesel is produced using oils extracted from crops, animal fat or waste vegetable oil using a chemical process called transesterification. Most U.S. biodiesel is produced from soybean oil, although other vegetable oils such as canola, corn, cottonseed, flax seed, sunflower or peanut oil can be used. As of December 2008, no biodiesel plants are permitted in the Upper Arkansas basin.

Biodiesel production uses roughly three gallons of water per gallon biodiesel, about a gallon of which is consumptive use. Wastewater from biodiesel plants, which may contain high amounts of oxygen, grease and oils, is regulated by KDHE.

Biogas

Kansas has more than 36,000 farms with cattle and calves and ranks first nationwide in commercial cattle

processed with more than eight million head.[8] Because of the high number of livestock facilities in the state and in the Upper Arkansas basin, anaerobic digestion of wastes and the capture of methane gases may provide an alternative fuel source, while increasing the value-added potential of the industry. The key by-products of anaerobic digestion include digested solids and methane, the primary component of "biogas". Biogases can be used to fuel a variety of cooking, heating, cooling and lighting applications, as well as to generate electricity. Capturing and using methane, a potent greenhouse gas, also reduces its release to the atmosphere.[5]

Cellulosic Ethanol

Cellulosic ethanol uses lignocellulose, the main structural material in any plant, as a feedstock. Cellulosic feedstocks require an extra step to break down the lignocellulose into fermentable starch, thus increasing production costs. The bulkier cellulosic feedstocks are also more costly to harvest, transport and store. Processing of cellulosic materials would require more water than corn, as the feedstock is dry. Research on cellulosic feedstocks (such as switchgrass, wood chips, and corn stover) is ongoing. The U.S. Department of Energy has set 2012 as a target year to achieve technological advances to make cellulosic ethanol cost competitive with corn ethanol. In 2007, Abengoa Bioenergy, a Spanish energy company, announced that Hugoton would be the site of the state's first cellulosic ethanol plant. In conjunction with cellulosic ethanol research, some researchers are investigating the use of perennial polyculture crop systems for cellulosic feedstocks.

Production of cellulosic ethanol may have greater positive environmental impacts than grain-based ethanol such as reduced greenhouse gas emissions, decreased fertilizer application and less reliance on water intensive crops.

Corn Research and Varieties

Breeding of corn hybrids that maximize yield for ethanol production while reducing additional strains on water supplies has been a focus of much research by universities and corn breeding companies. Drought tolerant hybrids, specifically transgenic, drought-resistant corn, are especially important in areas of western Kansas where rainfall averages fewer than 16 inches per year. In addition to drought tolerant varieties, industries are identifying corn varieties that produce higher yield and more ethanol per acre. High total fermentable ethanol corn hybrids provide higher levels of fermentable starch, consisting of the sum of all starches and simple sugars that ferment during the typical dry grind process.[6,9]

Recommended Actions

1. Coordinate, where applicable, the development, implementation and public input process between the *Kansas Water Plan* and Kansas energy policy.

2. Maintain regulatory oversight by state and local government on the siting of ethanol and biodiesel plants, with special emphasis on the water supply and availability.

3. Look for water recycling opportunities within the biofuel facilities.

4. Promote research for less water-dependent corn varieties and improved irrigation scheduling that maintains or increases crop yield without increasing water use.

5. Promote research and pilot projects for viable, commercial cellulosic ethanol production and other biofuels that are less dependent on water intensive crop production.

6. Increase corn water use efficiency (amount of grain produced per inch of water) through research and extension efforts. Educational emphasis should be placed on utilization of irrigation scheduling tools such as KanSched and the Mobile Irrigation Lab.

7. Evaluate the biofuel facility watershed and watersheds of input crops, and identify potentially environmentally sensitive areas. Target programs to mitigate environmental impacts, such as stream buffers, grass filters, BMPs, etc.

8. Provide education and/or incentives for marginal lands that have expiring Conservation Reserve Program contracts that will not be renewed to stay in a conservation planting, with special consideration to acres that could return to irrigation.

Resources

1. Huggins, Don, W. Spotts, S. Wang, D. Baker, J. Anderson, and N. Lim, 2003. *Validation of Best Management Practices on Eight Kansas Farms*, KBS Technical Report 105. www.kbs.ku.edu/larc/tech/assets/CWFPReport.pdf

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11. Science Daily. Retrieved April 4, 2008. http://www.sciencedaily.com/releases/2007/10/071010120538.htm

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Corn Field.

Upper Arkansas Basin High Priority Issue
Interstate Cooperation to Address Water Quality
January 2009

Issue

Interstate cooperation and management is needed to address poor quality surface water that is impacting or threatening public water supply wells along the Arkansas River corridor. Protection of the fresh ground water in the region is critical for municipal, industrial and agricultural uses.

Description

The Arkansas River in western Kansas is among the most saline in the country. The contamination is caused by high levels of salinity in the river as it enters Kansas from eastern Colorado (Figure 1).[6] In 2000, Kansas began to address the salinity issue by developing a Total Maximum Daily Load (TMDL) on the upper Arkansas River for sulfate. The Colorado Water Quality Control Division (Division) was consulted in the development of the TMDL. One of the outcomes after the TMDL approval was establishment of a comparable water quality criterion for sulfate. The sulfate TMDL is now consistent between Kansas and Colorado. In this phase of the TMDL, an interim endpoint is to reduce the long term average sulfate concentration below the current average of 1875 mg/L that occurs at Pierceville, near Garden City.

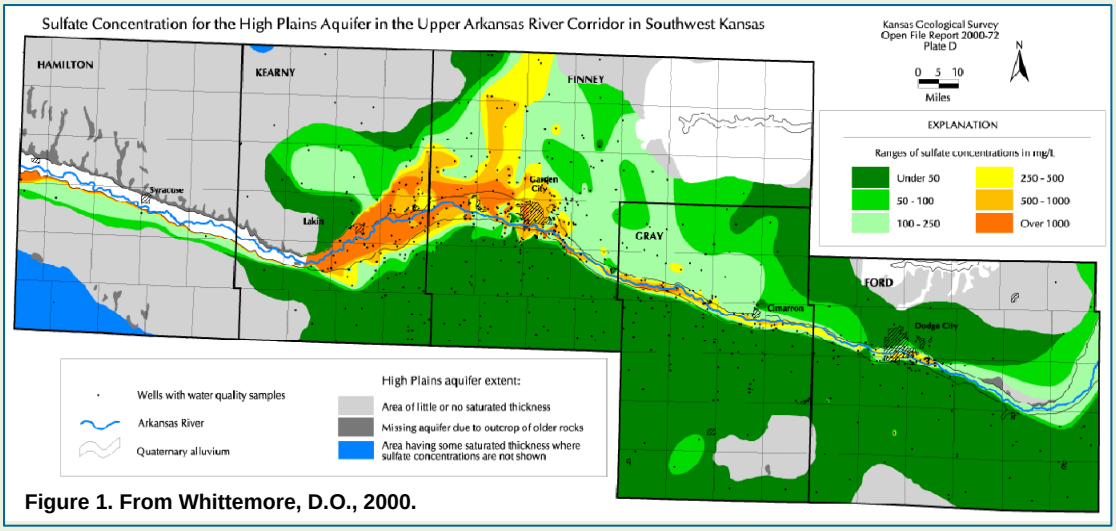

Figure 1. From Whittemore, D.O., 2000.

In 2007, the Kansas Department of Health and Environment (KDHE) completed a TMDL to address selenium water quality impairments along the Arkansas River from the Colorado stateline to Pierceville. Selenium concentrations are high during summer (April to September) when deliveries to Kansas irrigation ditches are made by Colorado pursuant to the Arkansas River Compact. Moreover, concentrations during the irrigation off-season (October to March) remain elevated with the onset of drier conditions. The greatest concentrations of selenium are seen in the immediate vicinity of the river where large-scale irrigation diversion of ground water begins east of the Bear Creek fault in Kearny County. In short, irrigation return flow deliveries from Colorado are poorer water quality than main stem deliveries, and the best water quality is from releases from John Martin Reservoir that never is diverted for Colorado farmland irrigation. The diminishment of streamflow east of Garden City confines the intrusion of saline water to the immediate alluvium of the river above this point.

Data from the U.S. Geological Survey and the Kansas Geological Survey (KGS) show uranium concentrations in the river during saline low flows generally exceeding the Environmental Protection Agency (EPA) drinking water standards. The dissolved concentrations of uranium are well correlated with sodium, sulfate, and chloride concentrations.

In general, selenium and uranium concentrations increase with increasing salinity of the surface and ground waters. Just as the primary source of the sulfate in the waters is natural (leaching of rocks and soils), the primary source of the uranium is natural. However, the high concentrations of both sulfate and uranium in the Arkansas River surface water and ground water affected by the river are not natural but the result of the evapotranspiration consumption of water in Colorado, leaving the residual salts dissolved in a much smaller volume of water.

The saline water from the Arkansas River seeps into the subsurface alluvial aquifer and then the Ogallala-High Plains aquifer in Kansas, thereby contaminating the ground water with high sulfate and uranium concentrations (Figure 1). In some cases, additional uranium may be derived from the sediments in which ground waters reside, and in other cases, some uranium may be removed by chemical conditions in ground water or by the sediments.

Stakeholders from Kansas, including KDHE, Kansas Department of Agriculture–Division of Water Resources (DWR), Southwest Kansas Groundwater Management

District No. 3 (GMD3), KGS, and Kansas Water Office (KWO) have been actively engaged in discussions with stakeholders from Colorado, including Colorado Water Quality Control Commission and Colorado State University to discuss the common issues and concerns related to the water quality along the Arkansas River.

Tamarisk Control

Infestations of tamarisk, a non-native, high water consuming plant, along the Arkansas River also impacts the water quality in the basin. Tamarisk is prevalent along the mainstem and tributaries to the Arkansas River; surveyed infested riparian acres exceed 15,000 within the Upper Arkansas basin. To a lesser extent, Russian olive has also infested the river corridor, and control measures for tamarisk and Russian olive are similar. In order to achieve true, long-term successful tamarisk control, Kansas will need to actively coordinate with Colorado on this issue. Working collaboratively will allow Kansas to identify opportunities that make the most effective use of our collective resources.

In 2008, Kansas and Colorado initiated plans to implement a cooperative control project in Prowers County, Colorado and Hamilton County, Kansas. The project seeks to build partnerships and develop local leadership so long-term tamarisk control will be successful. Treating tamarisk infestation in the watershed will improve the limited streamflow and the interconnected alluvial and Ogallala-High Plains aquifers along the Arkansas River where tamarisk has become a significant problem.

Conclusion

The Arkansas River system is excessively high in total dissolved solids, one of which is sulfate, impairing the environmental and economic uses of the river on both sides of the stateline. This issue highlights the need for Kansas and Colorado to derive common goals for future water quality conditions, including the components of selenium and sulfate. Kansas recognizes the complications between achieving the goals of the Clean Water Act and water quality standards, while maintaining compliance with the Arkansas River Compact. However, both can be achieved through development of joint solutions.

Recommended Actions

1. Initiate meetings in 2008 and 2009 between Kansas and the Colorado water quality and water appropriation agencies to discuss proposals to improve water quality in the Arkansas River within the context of the Arkansas River Compact. Coordinate with water compact representatives. Identify pilot areas in the Arkansas River valley in 2009 to test remedial measures for lowering salinity in the river.

2. Cooperate with Colorado State University in the investigation of nitrate management as a means to reduce selenium loadings in irrigated areas below John Martin Reservoir.

3. Investigate, through the KGS, radionuclide loading from the Arkansas River into the aquifer sources of Kansas communities such as Deerfield and Lakin.

4. Collaborate between Colorado State University and KGS on the use of a model to identify salinity loading regions and the potential impact.

5. Initiate installation of Best Management Practices in pilot areas along the Arkansas River over 2010-2012 to determine the effect of those practices on water quality improvement and water management under the Compact.

6. Based on results from the pilot efforts, jointly obtain funding with Colorado in 2012 to implement salinity reduction measures throughout the Arkansas River valley, including EPA Targeted Watershed Grants, Water Resource Development Act (WRDA) environmental restoration projects and state funded projects.

7. Cooperate with Colorado on joint tamarisk and other non-native phreatophyte control in the Arkansas River watershed.

Resources

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2. KDHE. 2000. *Upper Arkansas Basin Total Maximum Daily Load for the Arkansas River near Garden City*, Water Quality Impairment: Sulfate.

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4. Kansas Geological Survey. November 2000. *Arkansas River Water High in Salinity*. News Release.

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Upper Arkansas Basin High Priority Issue
Watershed Restoration and Protection
Approved January 2007

Issue

The restoration of watersheds with impaired water quality and the protection of watersheds ground water sources used for drinking water supplies and irrigation are high priority in the Upper Arkansas basin. Three main components guide water quality efforts; achievement of Total Maximum Daily Loads (TMDL), development of Source Water Protection Plans, and restoration and protection of wetland and riparian areas.

The Upper Arkansas River has problems with both low flows and very saline water quality as it enters Kansas from Colorado.[14] The flow in the Arkansas River has been impacted by uses of water in Colorado since the late 1940s and the operation of John Martin Reservoir through the provisions of the Arkansas River Compact. The streamflow issue is being addressed with improved Arkansas River Compact compliance and monitoring. Improved water quality is necessary as the river crosses the state border. Poor quality surface water is seeping into and degrading the good water quality High Plains aquifer along the river corridor. The degradation is impacting or threatening public water supply wells along the river corridor. Protection of the fresh ground water in the region is critical for municipal, industrial and agricultural uses.

Description

Water quality and related water resource issues are addressed through a combination of watershed restoration and protection efforts utilizing voluntary, incentive based approaches, as well as regulatory programs.

The state continues to protect its interest in the Arkansas River Compact with Colorado. Final resolution of the reimbursement for past damages of the Kansas v. Colorado No. 105 lawsuit over compact violations by Colorado resulted in monetary awards. These funds have been credited according to law.[15] After litigation expenses were recovered, two thirds of the monetary award was deposited into a Water Conservation Projects Fund and one third was credited to the State Water Plan for water conservation projects. The Water conservation Projects Fund is now the Western Water Conservation Fund, administered by the Southwest Kansas Groundwater Management District No. 3.

Water Quality Impairments

Surface waters not meeting surface water quality standards in the basin are included on the 303d list.[16] High priority TMDLs for impaired surface waters in the Upper Arkansas basin were approved by the Environmental Protection Agency (EPA) in September 2000 and again in February 2008. Table 1 provides information on rivers and lakes within the basin that are designated as high priority for TMDL implementation. Figure 1 shows the location of these areas within the basin. High priority TMDL watersheds are used to target voluntary, incentive based programs that provide technical and financial assistance for implementation of nonpoint source pollution management practices that can address designated pollutants.[9]

A selenium TMDL on the Arkansas River from Coolidge to Pierceville was approved in 2008. Biological data from the Kansas Biological Survey indicate that selenium is accumulating within the biota of the river, often above the fish tissue criteria proposed by EPA. Previous analyses indicate ambient in-stream selenium levels regularly exceed existing state criteria for aquatic life. Current analysis by Colorado State University is focusing on the increase in selenium seen between John Martin Dam in Colorado and the stateline, the reason for the high selenium levels since the cessation of surplus water in the valley in June 2000, and reviewing ongoing research on Best Management Practices.

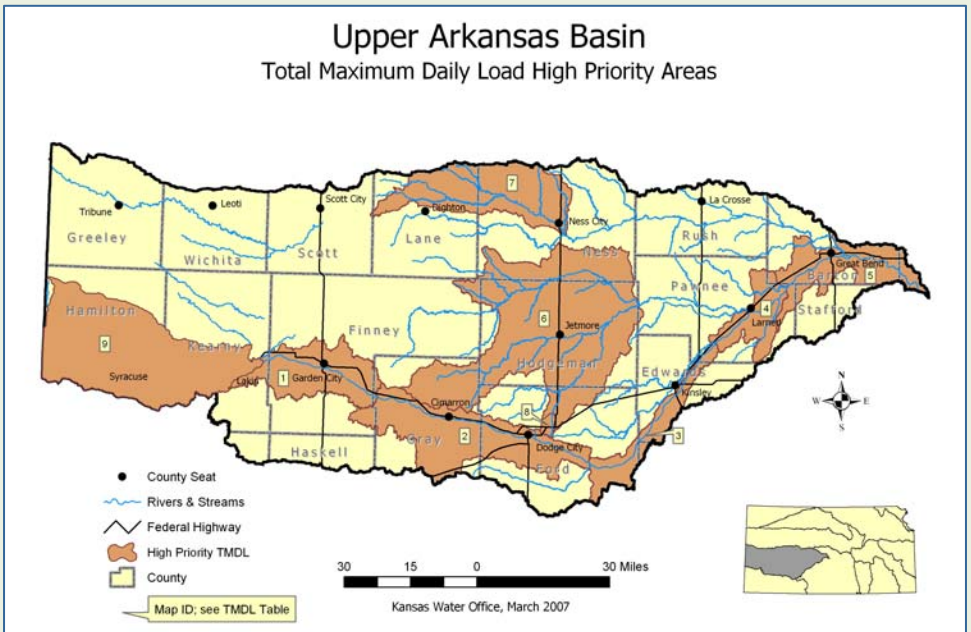

Figure 1. Upper Arkansas Basin TMDL High Priority Areas

Colorado currently has adopted a temporary modification to its Table of Value Standards for dissolved selenium on the Arkansas River (22.5 ppb). The Colorado Arkansas River Water Quality Standards were revised in 2007. In 2007, Kansas Department of Health and Environment (KDHE) provided testimony to Colorado to highlight the need for reduced selenium concentrations. As part of the Colorado Water Quality Standards review process, Kansas proposed stateline selenium levels of 7 ppb in April through October and 10 ppb in November to March, consistent with the TMDL.

Table 1
Upper Arkansas River Basin TMDL High Priority Areas

Map ID	Waterbody	Impairments	HUC 8 Watersheds
1	Arkansas River below Garden City to Pierceville	BAC	11030001 11030003
2	Arkansas River - Garden City to Ford	BAC	11030003 11030004
3	Arkansas River - Ford to Kinsley	BAC	11030004
4	Arkansas River - Kinsley to Dundee	BAC	11030004
5	Arkansas River - Dundee to Great Bend	BAC	11030004 11030008
6	Pawnee River/Buckner Creek Watershed	BAC	11030005 11030006
7	Walnut Creek Watershed	BAC	11030007
8	Ford County Lake Watershed	EUTRO, DO, pH	11030006
9	Arkansas River from Stateline to Pierceville	SEL	11030001 11030003

DO: Low dissolved oxygen in upper 3 meters of water column over deepest location in water body
EUTRO: Eutrophication, biological community impacts and excessive nutrient/organic loading. If applicable, the Eutrophication TMDLs are bundled with pH, aquatic plants, and/or DO impairments. These impairments are all interrelated and effected by nutrient loading.
BAC: Bacteria
SEL: Selenium – typically set at some natural background level that exceeds the current chronic aquatic life criterion of 5 ppb

KDHE's testimony focused on establishing the desired selenium level for the Kansas segment of the Arkansas River and collaborative management of Arkansas River water quality by the two states.

A complete description of each TMDL is available on the KDHE TMDL website.[17]

Surface Water Nutrient Reduction

Nutrient sources within the basin include both point and nonpoint sources. The major point sources in the basin include large wastewater treatment plants, which are regulated under the National Pollutant Discharge Elimination System (NPDES) Program (Figure 2).

A major component of the Kansas Surface Water Nutrient Reduction Plan (Plan) involved looking at nitrogen transport to the Gulf of Mexico.[8] In order to calculate the contribution of nitrogen to the Gulf, nitrogen concentrations of waters exiting the state borders were collected and estimated. Since there are no "exit points" for the Upper Arkansas basin, all contribution from this basin is added to the Lower Arkansas basin where the Arkansas River exits Kansas into Oklahoma. Therefore, for the purpose of the Plan, the Upper and Lower Arkansas River basins were combined as a single composite basin.

Figure 2
Major Wastewater Treatment Facilities in UARK River Basin

As predicted by studies from the U.S. Geological Survey, only a small amount of nitrogen is expected to be transported from watersheds in the upper part of the Arkansas River basin to the Gulf of Mexico. Thus, to try to predict the contribution the Upper Arkansas basin makes to the Lower Arkansas basin would be difficult. It should also be noted that while the Upper Arkansas basin is not predicted to produce a significant surface water impact, infiltration to local aquifers could produce significant ground water impacts. Furthermore, TMDLs on the Arkansas River between Great Bend and Hutchinson are influenced by nutrient loading coming from the Upper Arkansas basin. Therefore, some degree of nutrient reduction should be expected from the eastern portion of the Upper Arkansas basin. Additionally, nutrient loading leaving Kansas along the Arkansas River may be implicated for causing eutrophication problems in Kaw Lake in Oklahoma.

The primary nonpoint sources of pollution are agricultural. Table 2 shows the relative contributions of point and nonpoint sources in the Upper Arkansas and Lower Arkansas basins for total phosphorous and nitrogen leaving the state.

Based on land use, the nonpoint sources in this basin are overwhelmingly agricultural. To add urban in as a "co-primary source" may leave the impression that urbanized areas play more of a role than they actually do. The three urban areas in the basin, Garden City, Great Bend and Dodge City all fall under the Phase 2 stormwater rules, so their runoff is addressed as a point source under NPDES.

Table 2

Upper and Lower Arkansas River Basin Nutrient Reduction Data
(Source: KDHE, Bureau of Water, February 15, 2006)

Statewide Perspective

Parameter (Ton/Year)	State Total	UARK & LARK Basin	% of State Total
TN Leaving State	51,205	6,943	14%
TP Leaving State	7,670	1,582	21%
Point Source TN	10,600	3,503	33%
Point Source TP	2,836	886	31%
Nonpoint Source TN	40,605	3,440	8%
Nonpoint Source TP	4,834	696	14%

Basin Perspective

Parameter (Ton/Year)	UARK & LARK Basin Total	Point Source	Point Source %	Nonpoint Source	Non-point Source %
TN	6,943	3,503	50%	3,440	50%
TP	1,582	868	56%	696	44%

The Kansas Surface Water Nutrient Reduction Plan, developed by KDHE, outlines a statewide strategy for reducing the export of total nitrogen (TN) and total phosphorus (TP) in surface waters leaving the state. This involves additional reductions in nutrients from point source discharges through the NPDES program and reduction in nonpoint sources through development and implementation of Watershed Restoration and Protection Strategies (WRAPS). The Nutrient Reduction Plan includes Improvement Potential Index (IPI) maps for Kansas counties for TP and TN reductions (see Water Quality Policy Section for statewide maps; Figure 3 & 4). In the Upper Arkansas basin, Barton, Rice and Stafford counties showed the highest improvement potential for both TN and TP. These counties should receive priority consideration for the installation of nutrient management and reduction practices.

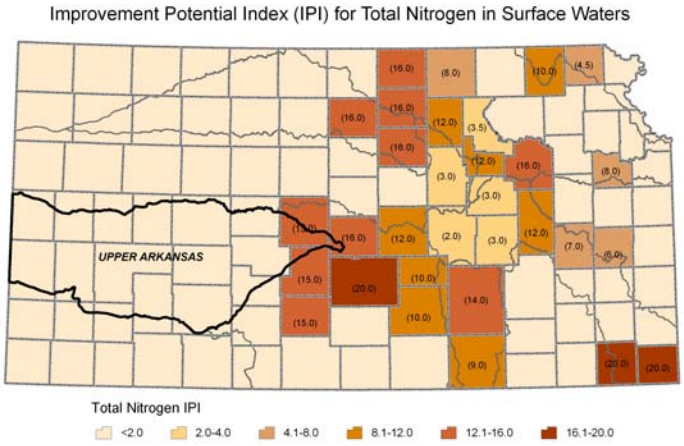

Figure 3
Improvement Potential Index (IPI) for Total Nitrogen (TN) in the UARK River Basin

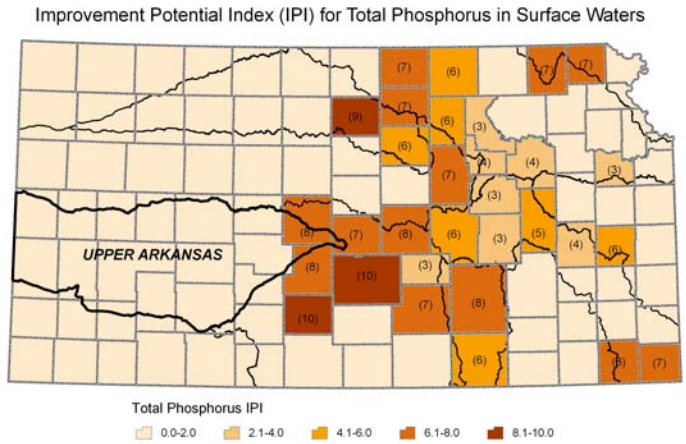

Figure 4
Improvement Potential Index (IPI) for Total Phosphorus (TP) in the UARK River Basin

Source Water Protection

All public water suppliers in the basin have completed Source Water Assessments in cooperation with KDHE. The next step, which is voluntary, is the development of source water protection plans.[6]

There are 46 public water suppliers in the Upper Arkansas basin, two of which are rural water districts. Ground water is the primary public water supply source in the basin. The major source of ground water is the Ogallala-High Plains aquifer.

Each Source Water Assessment included a susceptibility score that can help communities determine which contaminants pose the most significant threat to their water supply. A susceptibility score was generated from an analysis that indicates whether the susceptibility range is low, moderate, or high for potential threats of contamina-

tion in an assessment area. Each public water supplier received susceptibility scores in the following contaminant categories: microbiological, nitrates (ground water only), pesticides, inorganic compounds, synthetic organic compounds, volatile organic compounds, sedimentation (surface water only) and eutrophication-phosphorus (surface water only).

Of the public water suppliers using ground water in the Upper Arkansas River Basin, 50% had low susceptibility scores, 50% had moderate scores.

The Kansas Corporation Commission (KCC) regulates rates, service and safety of public utilities, as well as, oil and gas production. KCC has established minimum surface casing requirements for oil and gas pipelines in each county in the Upper Arkansas River Basin to protect fresh and usable water.[4] Water well construction and abandonment is regulated by the KDHE.

For communities using ground water, development of a wellhead protection program is recommended. For communities using surface water, the development of a WRAPS is the best mechanism to ensure water quality protection for their public water supply.

Wetland and Riparian Area Management

The primary approach to wetland and riparian management in the basin focuses on providing technical and financial assistance to landowners to protect and restore these resources in priority watersheds through the implementation of best management practices. Water quality has been a primary focus with implementation efforts targeted to high priority TMDL watersheds (Figure 1). In addition, several watersheds have been identified in the *Kansas Wetlands and Riparian Areas Protection and Restoration Implementation Plan* as areas of high biological importance and a priority for implementation activities. Seventeen conservation districts in the basin have developed wetland and riparian protection plans.

Channel capacity and conveyance is an inter-related problem with water quality and streamflow. Reduced flows over an extended period and the reduction of peak flows have allowed channel encroachment. Encroachments are from a variety of sources, including agricultural land use, sand mining and non-native vegetation. The heavy growth of tamarisk (salt cedar) has significantly altered the conveyance of the channel as well as the flow patterns. These findings were consistent with an aerial survey conducted by the Kansas Department of Agriculture in 2004-2006. According to the survey, approximately 56% of the corridor from the stateline to Hutchinson is infested with tamarisk with the heaviest infestation closer to the stateline. Tamarisk is a nonnative, invasive plant that quickly displaces native vegetation, interfering with natural plant succession and nutrient cycling, and chokes irrigation canals in Kansas. The resulting invasive thickets provide poor grazing and forage for wildlife and livestock; however, it does provide a windbreak. The dense growths also increase fire hazards, decrease water quality and generally use more water than native vegetation. Activities and programs targeted at reducing tamarisk infestation are outlined in the *10-Year Strategic Plan for the Comprehensive Control of Tamarisk and Other Non-Native Phreatophytes*.

Tamarisk flowers. Photo courtesy Kansas Water Office

Watershed Restoration and Protection Strategies

Watershed Restoration and Protection Strategies (WRAPS) are stakeholder-driven watershed management plans designed to address multiple water resource issues within a specific watershed. The WRAPS process provides a means to integrate objectives from multiple local, state and federal programs into a comprehensive, coordinated strategy for a specific watershed.[7] This can include TMDL attainment, nutrient reduction, source water protection, riparian and wetland management and other natural resource objectives.

WRAPS projects have been initiated in the eastern portion of the Upper Arkansas River watershed (see WRAPS Project Status Map in the Water Quality Policy Section).[1] WRAPS projects currently underway in the basin encompass priority watersheds for TMDL implementation, areas with a high improvement potential index for nutrient reduction, source water assessments areas, and priority areas for wetland and riparian protection.

A consideration for watershed restoration and protection in the basin will be the potential for conversion of Conservation Reserve Program (CRP) acreage back to production agriculture as contracts expire. Of the acres enrolled in the nineteen Kansas counties contained wholly or partly within the Upper Arkansas basin, 522,448 CRP acres expired in 2007. Of those, 85,393 acres (16%) were offered a 5-year reenrollment option and 102,773 acres (20%) received a 10-year reenrollment option.[11] If land is taken out of permanent grass cover, implementation of best management practices will be needed to minimize potential adverse impacts to water resources in the basin.

In December, 2007, the State of Kansas entered into an agreement with United States Department of Agriculture (USDA) for the purpose of encouraging irrigators along the upper Arkansas River corridor to enroll in a Conservation Reserve Enhancement Program (CREP). The state seeks to enroll up to 20,000 acres into the program over the next five years. In return for annual payments, irrigators permanently retire water rights and put acres in a conservation planting for 14-15 years. Reducing irrigation demands on the stream-aquifer system will help slow the aquifer declines, mitigate the spread of saline waters into the aquifer, and help restore stream and riparian health.

Other Watershed Related Activities

- All the counties within the basin have a sanitarian funded by the Local Environmental Protection Program (LEPP).
- All counties in the basin, except Kearny and Ness, have countywide planning and zoning.
- All conservation districts in the basin have adopted nonpoint source pollution management plans. Buffer coordinators have also been employed in six counties in the basin to facilitate enrollment of stream buffers in the continuous CRP and State Water Quality Buffer Initiative.
- There are five organized watershed districts in the basin.
- Western Water Conservation Project Fund conservation activities recognize water quality issues and are taking water quality impacts into consideration.

Recommended Actions

1. Work with stakeholder groups to incorporate TMDL implementation and nutrient and sediment reduction goals into applicable WRAPS projects.

2. Target technical and financial assistance programs for water quality protection and restoration to implement TMDLs and WRAPS action plans.

3. Continue coordination of agencies' programs and activities to achieve the high priority TMDLs, and show water quality improvements. Lead state agencies include KDHE, SCC, along with Kansas Department of Wildlife and Parks and Kansas Water Office (KWO). Include others as appropriate.

4. Continue inter-agency cooperation and update the water issue strategic plan (WISP) to address the complex inter-state Upper Arkansas Water Quality concerns. Key state agencies include KDHE, SCC, Kansas Department of Agriculture – Division of Water Resources (DWR), and KWO. Include others as appropriate.

5. Encourage enrollment in the Conservation Reserve Enhancement Program (CREP) with emphasis on acres enrolling in the Conservation Practice (CP9) to develop or restore shallow water areas.

Resources

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Upper Republican River Basin January 2009

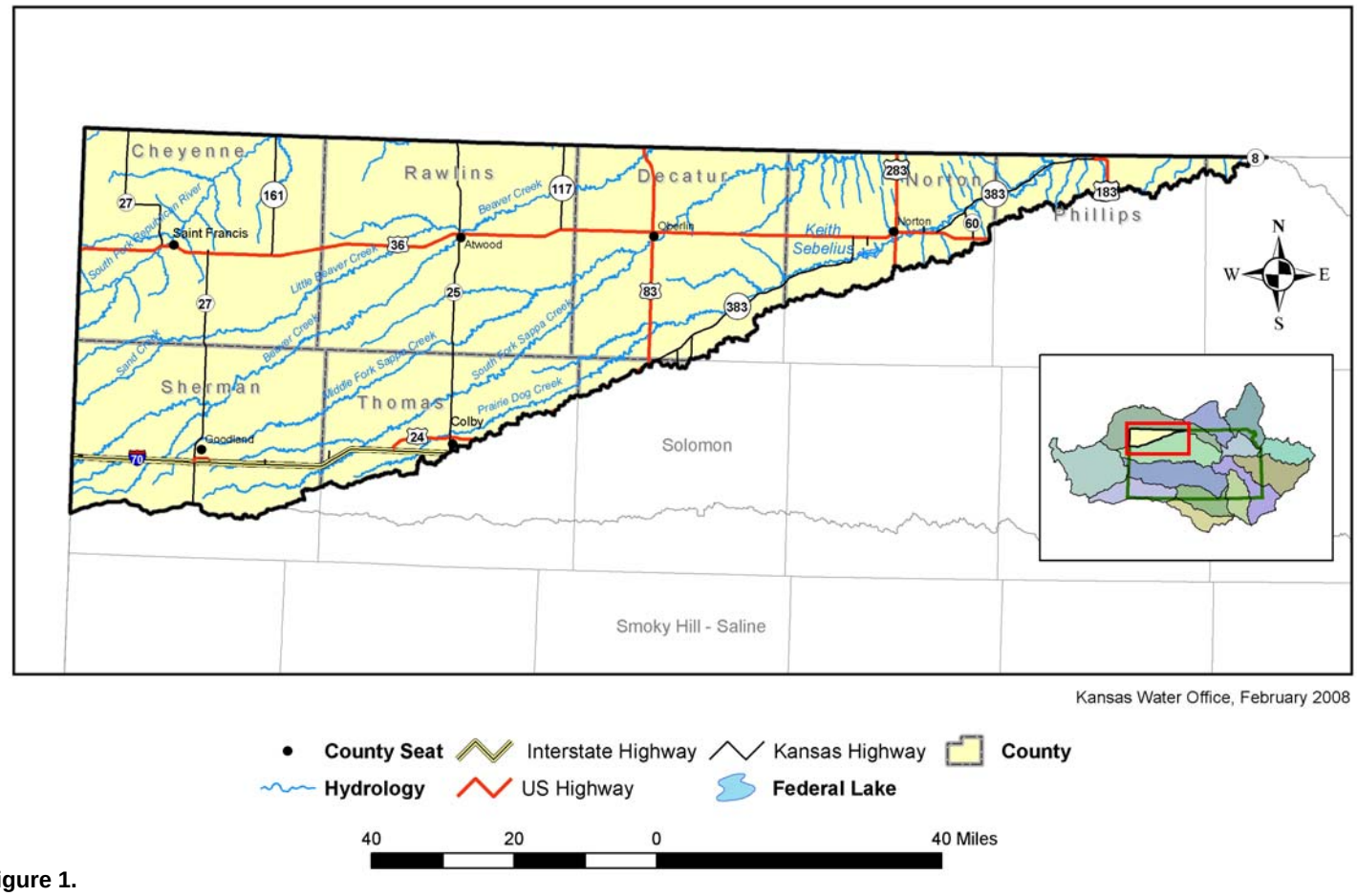

Figure 1.

General Description

The Upper Republican River basin is located in the High Plains physiographic region of western Kansas. The Kansas portion of the basin is bordered by Colorado on the west and Nebraska on the north covering approximately 4,900 square miles. The basin covers all or parts of Cheyenne, Rawlins, Decatur, Norton, Phillips, Sherman, Thomas and Sheridan counties. The Upper Republican basin includes hydrologic unit codes (HUCs) 10250001, 10250003, 10250012, 10250013, 10250014 and 10250015.

The High Plains region is an open expanse of flatlands and gently rolling hills that were once covered by shortgrass prairie. Much of the land is now farmed and only small areas of prairie remain. Land surface elevation ranges from nearly 4,000 feet above mean sea level (msl) in southwest Sherman County to less than 2,000 feet above msl in north central Phillips County. This region was once crossed by many rivers that carried sediment such as sand and gravel when the Rocky Mountains were forming millions of years ago. The stream valleys in the basin are mostly broad and shallow, however, in some localities the relief is as much as 200 feet.

The Upper Republican basin in Kansas is part of the Republican River system that begins in the plains of northeast Colorado. The Republican River then flows through northwest Kansas and southwest Nebraska and ultimately returns to Kansas, emptying into Milford Lake in the Kansas-Lower Republican basin.

Principal tributaries in the Upper Republican basin are Beaver, Sappa and Prairie Dog creeks. A small portion of the Arikaree River flows through the northwest corner of Cheyenne County.

Population and Economy

There were an estimated 28,480 residents in the basin in the year 2000.[1] The population of the nine counties that are entirely or partially in the Upper Republican basin was 43,721 in the year 2000 and is projected to be 41,063 by the year 2040. In the past 40 years, two trends have dominated the state. Rural counties have lost population, sometimes more than 10% every decade. Urban counties are gaining population at an even faster rate. In the Upper Republican basin, every county but Thomas has lost population in the past 40 years.

Typical of this trend is Rawlins County, which had a population of 5,279 in 1960 and a population of 2,918 in 2000.

In 2006, there were an estimated 4,070 farms with 5,189,000 acres in the nine counties entirely or partially in the basin. The average farm is about 1,275 acres.

Agriculture is the basis of the economy of the basin. Crops grown include wheat, corn, grain sorghum, soybeans, forage sorghum, alfalfa and sunflower. Irrigation is widespread and extremely important to the area economics. Crop value in 2006 was estimated by the U.S. Department of Agriculture (USDA) in farm facts as nearly $361 million.[3] Livestock production is an important part of the area's agriculture. Beef cattle are the predominant livestock raised in the basin.

Recreation is an increasing part of the economics of the basin. Keith Sebelius Lake and associated recreation and wildlife areas draw hunters, fishermen and boaters to the area. In addition, state operated lakes offer fishing in the basin including; Sherman State Fishing Lake (210 acres, 10 S 2 W of Goodland); and St. Francis Sand Pits, (5 acres, 1 W 2 S of St. Francis). Sherman State Fishing Lake is listed by Kansas Department of Wildlife and Parks (KDWP)[8] as a fishing opportunity although noted as periodically dry. It has been reported as dry for the past 20 years.[7]

The growing industrial contribution to the basin economy is primarily related to energy production, including ethanol. As of December 2008, one ethanol plant was in operation in the basin.

High Plains Irrigation
Photo courtesy of Kansas Geological Survey

Educational opportunities in the basin include Colby Community College, and Northwest Kansas Technical College.

Physical Characteristics

Geology and Soils

The Quaternary age, Ogallala Formation underlies the basin, as do the older Cretaceous age units. Outcrops of these sedimentary origin formations occur as well. The Ogallala Formation consists of sand, gravel and silt beds, cropping out in stream valleys in all but the north and east edges of the basin and may be as thick as 300 feet in the southwest part of the basin.

Windblown silt (loess), alluvial and terrace deposits and minor amounts of dune sand cover most of the basin. Upland soils in the basin are primarily those derived from loess. Topography varies from relatively flat undulating plains to rolling uplands and some steep hills and bluffs.

Most of the river valleys contain a more granular soil type resulting from stream-laid deposits. About 95 percent (%) of the basin consists of upland soil associations.

East of Decatur County, the level uplands consist of relatively deep Hastings-Holdrege association of silt loams. The sloping lands are covered by the shallower Colby silt loam.

The primary soils overlying the western part of the basin is the Keith silt loam on the upland. This is a relatively deep soil, subject to erosion on the long gentle slopes as well as the steeper slopes.[3]

Land Use/Land Cover

The Upper Republican basin covers approximately 3,169,099 acres. In 2005, over 59% was cropland, with grassland covering over 36%. A very minor, less than one percent, of the land in the basin was involved in residential and industrial uses.

Over 1.9 million acres were reported as crop acres in 1990. In 2006, 233,447 acres are reported as irrigated according to water right records. The Kansas Geological Survey (KGS) categorized riparian land use in 2003.[4] Statewide, pasture/grassland is the dominant riparian land use type in Kansas, accounting for over 142,000 bank miles or roughly 38% of all land use types. The predominant riparian land use for the 16,321 bank miles was pasture/grassland (68%) in this basin.

Table 1 identifies land cover in more detail for riparian land within one mile of streams and water bodies.

Ogallala Outcrop Cheyenne County
Photo courtesy of Kansas Geological Survey

Climate

The climate of the basin is characterized by moderate to low precipitation, relatively high wind velocities, fairly rapid rates of evaporation, a wide range of temperatures and abrupt, sometimes violent changes in weather. Average annual precipitation amount varies from 17 inches in the west to 22 inches in the east. According to the National Climatic Data Center, average annual temperature was 51 degrees Fahrenheit from 1971-2000. First frost generally occurs in late September or early October depending on location. The average annual runoff varies from about 0.2 inches in the west to 1.1 inches in the east.

Most of the precipitation occurs April through September. Evaporation averages 55 inches per year from impoundments. High wind and low humidity of the region contribute to the high evaporation rate. Evaporation from land surfaces is also high in this basin.

Drought is a naturally recurring feature of this climate, as exemplified by the Dust Bowl of the 1930's and the severe drought of 1952-1957. From 1952-1956, the town of St. Francis averaged only 11.77 inches of rain. Kansas has been impacted by severe drought periodically throughout the present decade, increasing the demand on the available water supply.[(2)]

Excessive rainfall can occur, primarily from thunderstorms of short duration in a localized area. The most common flood months have been June and July, but flood problems have occurred throughout the year. The combination of limited channel capacity and flat floodplain can result in large portions of the valleys being inundated.

Table 2. Climate Summary Upper Republican Basin

	Average Annual[1]		Freeze Dates (32 F.)[2]		
Location	Precipitation (inches)	Temperature (deg. F.)	Last in Spring	First in Fall	Frost Free Days
Goodland	19.76	50.7	May 3	Oct. 6	156
Atwood	22.75	50.6	May 8	Sep. 29	144
Norton	24.89	51.0	Apr. 30	Oct. 8	164

[1] Source: National Climatic Data Center (1971-2000 data)
[2] Source: KSU Weather Data Library (1961-1990 data)

Wildlife and Habitat

Key wildlife habitats include cropland, rangeland, weedy and brushy fence rows and ungrazed areas, riparian areas, streams and wetlands. Key wildlife species include ring-necked pheasants, greater prairie chicken, bobwhite quail, whitetail and mule deer.[(3)]

Historic range for numerous endangered species include parts of the basin. These include the bald eagle, black footed ferret, eastern spotted skunk, flathead chub, piping plover, peregrine falcon, whooping crane and the Topeka shiner. In addition, critical habitat for the bald eagle has been designated in Cheyenne County.[(9)]

Table 1. Total Riparian Land Use Bank Miles for Upper Republican Basin

Hydro Type	Animal Prod. Area	Barren Land	Crop Land	Crop/ Tree Mix	Forest Land	Pasture/ Grass Land	Pasture/ Tree Mix	Shrub Land	Urban Land	Urban/ Tree Mix	Total
Intermittent Stream	7	10	2,759	364	395	10,838	795	12	38	12	15,230
Perennial Stream	0	11	15	168	320	56	171	15	0.2	4	760
Shoreline	1.7	3	84	1	2	224	14	0	1	0.1	330.8
Total	8.7	24	2,858	533	717	11,118	980	27	39.2	16.1	16,320.8

Water Resources

The major streams in the basin (from west to east) are the South Fork Republican River, Beaver Creek, Sappa Creek and Prairie Dog Creek.

Keith Sebelius Lake is located on Prairie Dog Creek in the eastern part of the basin. It is a federal project built for flood control, municipal and industrial water supply, recreation and irrigation. The lake is operated and maintained by the U.S. Department of the Interior, Bureau of Reclamation (Bureau).

The basin streams include 15,230 intermittent stream miles and 760 perennial stream miles. Drainage density is 0.31 miles per square mile in the basin (perennial streams only).[4]

Principal aquifers include the High Plains (Ogallala included) and alluvial aquifers. The Dakota aquifer is present in the basin but is seldom used due to high mineral content. All of the alluvial corridors in the basin are closed to new water right appropriations.

The High Plains aquifer consists of several hydraulically connected aquifers, the largest of which is the Ogallala. The Ogallala-High Plains aquifer is distinctive from other aquifers in Kansas in that it generally low annual recharge.

The majority of ground water outside of the Ogallala-High Plains aquifer is alluvial ground water. A portion of the natural recharge that reaches the alluvial aquifer may contribute to stream base flow.

Ground water is the principal water supply source in the Upper Republican River basin, accounting for about 98% of reported water use in 2006. Irrigation is the predominant use of water.

There were 2,395 water rights reporting water use in 2006. These reported a total of 275,419 acre feet surface and ground water used. Surface sources accounted for 502 acre feet. The majority, 274,917 acre feet, was reported used from ground water.[5]

The primary reported water use in the basin is irrigation, with over 267,207 acre feet used in 2006 (Figure 2). Municipal water use (communities and rural water districts) is the next largest user at 5,386 acre feet authorized. There are 16 public water suppliers in the basin.

Water Management

All or part of six counties in the basin are included in Northwest Kansas Groundwater Management District No. 4 (GMD4), which is the local water management entity for areas over the Ogallala-High Plains aquifer. GMD4, formed in 1976, is pro active in developing local water policy compatible with state laws.

Water appropriations and use are overseen by the Kansas Department of Agriculture-Division of Water Resources (DWR). All of the streams and alluvial corridors in the basin are either closed to new appropriations or new appropriations are restricted. Minimum desirable streamflow has not been set at any sites in the basin. Generally, the Ogallala-High Plains aquifer has no new appropriations available. In limited cases a new water appropriation for ground water, limited to quantities under 15 acre-feet, can be obtained by meeting some very specific criteria within GMD4.

States generally have the responsibility to determine the management of their water resources. The exception to this is the management of federal reservoirs by a federal agency. In the Upper Republican basin Norton Dam, is managed by the U.S. Bureau of Reclamation (Bureau). The State of Kansas has not purchased any water supply storage in Keith Sebelius Lake, the reservoir formed by construction of Norton Dam.

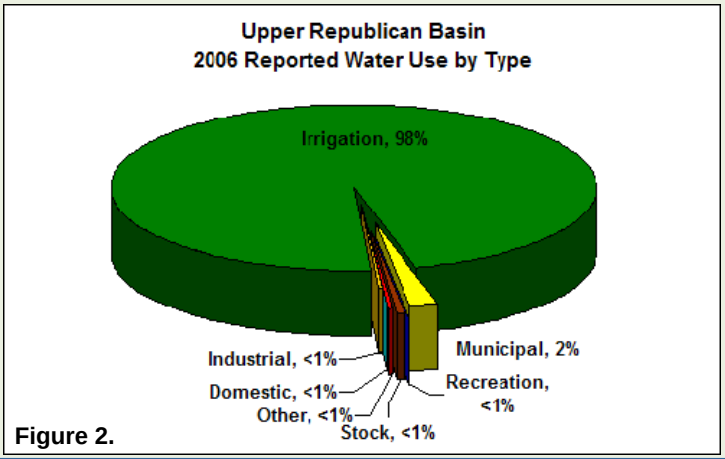

Figure 2.

One irrigation district (Almena) operates using releases from Keith Sebelius Lake at Norton Dam.

When water is available from storage there is the possibility to irrigate up to 5,763 acres in the irrigation district.

Numerous other entities may exist in the basin to address one or more water related issues. Watershed districts may be formed to develop and implement a comprehensive plan for a watershed that will provide flood protection for the residents and landowners. There are no watershed districts in the Upper Republican basin.

Each county has a county conservation district responsible for the conservation of soil, water, and related natural resources within that county. Multiple county groups may form Resource Conservation and Development areas (RC&Ds) to also address conservation of natural resources. Parts of two RC&Ds cover the Upper Republican Basin.[6]

Addressing water quality are two Watershed Restoration and Protection Strategy (WRAPS) programs that cover parts of the basin.

Keith Sebelius Dam, Norton County
Photo courtesy of Kansas Geological Survey

Resources

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Republican River Compact and Settlement

The Republican River and its tributaries are resources important to Kansas. Kansas interests in the basin include ground water and surface water rights in the Upper Republican River tributaries of northwest Kansas including the South Fork Republican River, Sappa Creek, Beaver Creek and Prairie Dog Creek.

The Republican River Compact was formally signed on December 31, 1942 by the states of Colorado, Kansas and Nebraska (Figure 3). The Compact makes specific allocations to each of the three states in 14 different subbasins and includes provisions related to the federal government's ability to develop projects within the basin.

In May 1998, Kansas filed a lawsuit before the U.S. Supreme Court for breached terms of the Compact by Nebraska for proliferation and use of ground water wells connected to the Republican River and its tributaries, and by failing to protect the surface flows from other unauthorized appropriations. As part of the settlement agreement, the Republican River Compact Administration (RRCA) ground water model was developed. The model is a tool used to quantify ground water consumptive use by each state as part of the compact's accounting procedures.

The first compliance check of consumptive use was the five-year running average for the years 2003-2007. The settlement also prescribes more restrictive compliance requirements during water-short conditions, including two-year averaging. The first water-short compliance check was for the years 2005-2006. Accounting indicated Kansas met it's obligations, but did not receive it's allotted share.

Keith Sebelius Lake

Norton Dam, constructed by the U.S. Bureau of Reclamation in 1964 to form Keith Sebelius Lake, is a valuable source of water in northwest Kansas. It was built for flood control, irrigation and public water supply. Although recreation is an authorized use, no storage space in the lake has been dedicated to that purpose.

Releases for irrigation purposes are controlled by the Almena Diversion Dam, about 11 miles downstream from Norton Dam. Water diverted from Prairie Dog Creek is carried by the Main and South Canals and a system of laterals to the lands of the Almena Irrigation District No. 5.

Beginning in 2007, the Almena Irrigation District entered into a ten-year agreement with the state to achieve a minimum conservation pool in the lake. This pool provides suitable habitat for fisheries production, safe access to the lake by anglers and boaters, and habitat for water fowl and other wildlife.

Keith Sebelius Reservoir. KWO photo.

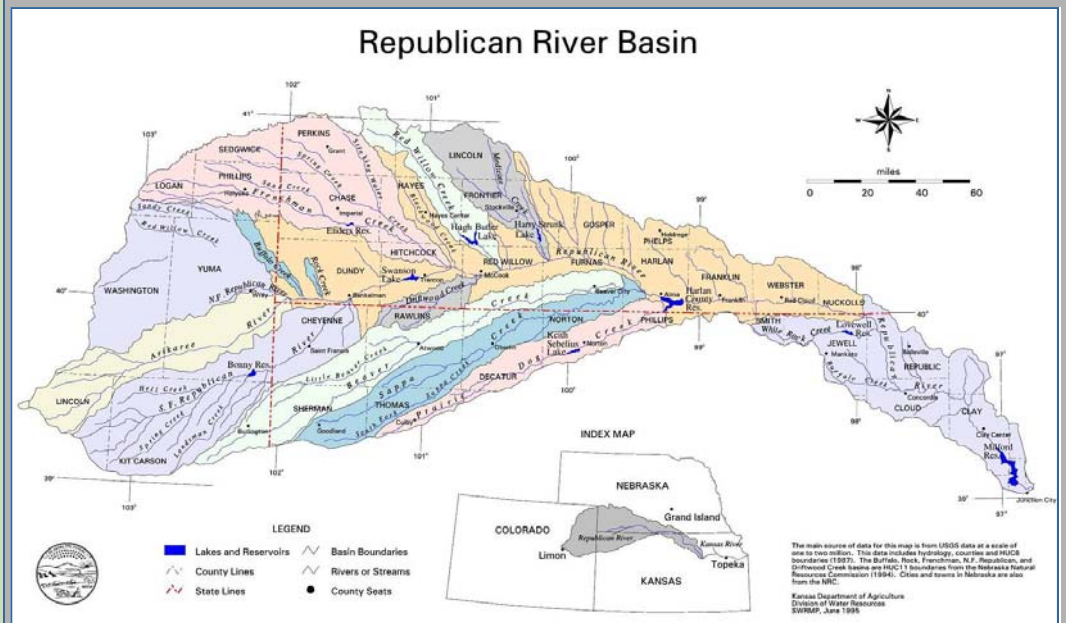


Figure 3.

Upper Republican River Basin Management Categories

January 2009

WATER MANAGEMENT CATEGORIES

The following categories include issues identified in the Upper Republican basin plan as items that require attention in addition to the basin priority issues. These issues are addressed in the following management categories:

- Water Management
- Water Conservation
- Public Water Supply
- Water Quality
- Wetland and Riparian Management
- Flood Management
- Water-Based Recreation

These categories also correspond to the statewide management categories and policies of the *Kansas Water Plan* found in Volume II. These documents contain new policy issues and the existing policy and statutory framework that relate to the management categories.

ISSUE: WATER MANAGEMENT

Management of Kansas' ground and surface water fits into six statewide categories, with five of these applicable in the Upper Republican basin. These are:

1) River-Reservoir management
2) Streams outside of Minimum Desirable Streamflow protected areas;
3) The Ogallala-High Plains aquifer
4) Ground water outside of the Ogallala-High Plains aquifer
5) Interstate water management

Ground water is the primary water supply in the basin, supplying 98 percent (%) of water used in 2006. The Ogallala-High Plains aquifer is a major source in the basin. Where it interconnects with alluvial ground water, it may have an affect on streamflow. Ground water recharge rates are generally low throughout the basin. A majority of the basin is restricted or closed for new water appropriations. Water resources in the basin are managed with the local leadership of the Ogallala-High Plains aquifer area by Northwest Kansas Groundwater Management District No. 4 (GMD4). GMD4 has identified six high priority aquifer subunits. Goals and management for each are under development.

In 2008 a computer model developed for the six priority subunits was completed through cooperation of the Kansas Water Office (KWO), GMD4 and the U.S. Bureau of Reclamation (Bureau). The model will aid in development and analysis of management scenarios.

In 2006, the KWO calculated the median annual water level changes from 1981 to 2005. In the northwest Ogallala aquifer area, as of 2005, there has been no statistically significant change (at a 5% error level) in the rate of decline. Reducing the decline rate of the Ogallala-High Plains aquifer is a basin priority issue.
Reduced streamflow and runoff into streams has been reflected in water levels in Keith Sebelius Lake, the federal project in the basin. These conditions and reduced availability of irrigation water stored in the reservoirs have suggested a need to take a fresh look at reservoir management.

Kansas entered into agreement with Colorado and Nebraska in 1943 to divide Republican River and tributary flows. Kansas has met its obligations leaving the state but has been shorted on water entering the Upper Republican basin.

South Fork Republican River, Cheyenne County.
Photo courtesy Kansas Geological Survey

Compliance with the Republican River Compact Settlement and Agreement and management of the Upper Republican River water resources in Kansas is a basin priority issue. Additional information on this issue may be found in the Upper Republican Basin Priority Issue section.

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce water level decline rates within the Ogallala-High Plain aquifer and implement enhanced

water management in targeted areas.

- By 2015, achieve sustainable yield management of Kansas surface and ground water sources outside of the Ogallala Aquifer and areas specifically exempt by regulation. Sustainable yield management would be a goal that sets water management criteria to ensure long-term trends in water use will move as close as possible to stable ground water levels and maintenance of sufficient streamflows.
- By 2015, meet minimum desirable streamflow at a frequency no less than the historical achievement for the individual sites at time of enactment.

Applicable Programs

The following programs help to meet the objectives in the Water Management (quantity) category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Appropriation Program
- Kansas Geological Survey, Kansas Department of Agriculture-Division of Water Resources: Water Well Measurement
- Kansas Geological Survey: High Plains Aquifer Technical Assistance Program
- State Conservation Commission: Water Right Transition Assistance Program
- USDA-Natural Resources Conservation Service: Environmental Quality Incentive Program (EQIP)
- Kansas Water Office: State Water Planning Program

ISSUE: WATER CONSERVATION

Water conservation is essential for the effective management of water resources in the basin to assure that a sufficient, long-term supply of water is available for the beneficial uses of the people of the state. Conservation is defined as a careful preservation and protection of something, especially the planned management of a natural resource to prevent exploitation or destruction. Water conservation is a part of maintaining a long-term water supply for Kansas.

Irrigation. Photo courtesy Kansas Geological Survey.

Water conservation activities apply to all uses, irrigation, municipal, industrial, and others, and from all sources. In 2006, irrigation accounted for nearly 98% of all reported water pumped or diverted in the basin. Municipal use accounted for two percent of water used in the basin, stock, industry, recreation, domestic and other uses for less than one percent each.

Of the 616 public water suppliers that have an approved conservation plan in place as of December 31, 2008, 11 plans have been approved in the Upper Republican basin. As of August 2006, 210 conservation plans had been approved for irrigation water rights in the basin. The number of diversion points in Kansas that reported irrigation application rates over the regional average fluctuated from about 3,700 to less than 500 from 1991 to 2005. Of the total number of individual points of diversions that were reporting use of a measurable quantity of water in Kansas in 2006, more than 44% reported a metered quantity at least once during that year in the Upper Republican basin. (Source: DWR: Water Right Information System).

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce the number of public water suppliers with excessive unaccounted for water by first targeting those with 30% or more unaccounted for water.
- By 2010, reduce the number of irrigation points of diversion for which the amount of water applied in acre feet per acre (AF/A) exceeds an amount considered reasonable for the area.
- By 2015, all non-domestic points of diversion meeting predetermined criteria will be metered, gaged, or otherwise measured.
- By 2015, conservation plans will be required for water rights meeting priority criteria under K.S.A. 82a-733 if it is determined that such a plan would result in significant water management improvement.

Applicable Programs

The following programs help to meet the objectives in

the Water Conservation category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Appropriation Program
- Kansas State University Research and Extension: Water Conservation and Management Program/MIL
- State Conservation Commission: Water Resources Cost-Share
- State Conservation Commission: Water Right Transition Assistance Program
- Kansas Water Office: Water Conservation Program
- USDA - Natural Resources Conservation Service: Environmental Quality Incentive Program (EQIP)
- USDA - Farm Service Agency: Conservation Reserve Program

ISSUE: PUBLIC WATER SUPPLY

The primary approach to addressing public water supply issues in the basin focuses on ensuring that there are adequate supplies of surface and ground water within the basin to meet future water demands, reducing the number of public water supply systems that are vulnerable to drought, and ensuring that systems have the technical, financial and managerial capacity to meet future needs for water quality and quantity.

In 2006 there were 16 public water suppliers in the Upper Republican basin. Ground water is the primary source for most public water supplies, accounting for over 95% of the total supply, principally from the Ogallala and Dakota aquifers and alluvial deposits along major streams. The City of Norton obtains a portion of their water from storage in Keith Sebelius Reservoir.

Among the major river basins, the percentage of drought vulnerable public water suppliers in 2006 ranged from three percent (Neosho Basin) to 42% (Solomon Basin). Comparison of the KWO 2000 and 2006 lists by river basin shows a significant increase in the number of drought vulnerable public water suppliers in most western river basins, but the Upper Republican remained the same at three One of these communities considered drought vulnerable in 2000 is still considered to be at risk due to basic source limitations in 2006. The other two listed in 2006 were not on the 2000 list.

Applicable *Kansas Water Plan* Objectives

- By 2010, ensure that sufficient surface water storage is available to meet projected year 2040 public water supply needs for areas of Kansas with current or potential access to surface water storage.
- By 2010, less than five percent of public water suppliers will be drought vulnerable.
- By 2010, ensure that all public water suppliers have the technical, financial and managerial capability to meet their needs and to meet Safe Drinking Water Act requirements.

Applicable Programs

The following programs help to meet the objectives in the Public Water Supply category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Appropriation Program
- Kansas Department of Health and Environment: Public Water Supply Program
- Kansas Department of Health and Environment: Kansas Public Water Supply Loan Fund
- Kansas Water Office: Water Conservation Program
- Kansas Water Office: State Water Planning Program

ISSUE: WATER QUALITY

Water quality and related water resource issues are addressed through a combination of watershed restoration and protection efforts utilizing voluntary, incentive based approaches, as well as regulatory programs.

All the counties within the basin have a sanitarian funded by the Local Environmental Protection Program (LEPP).

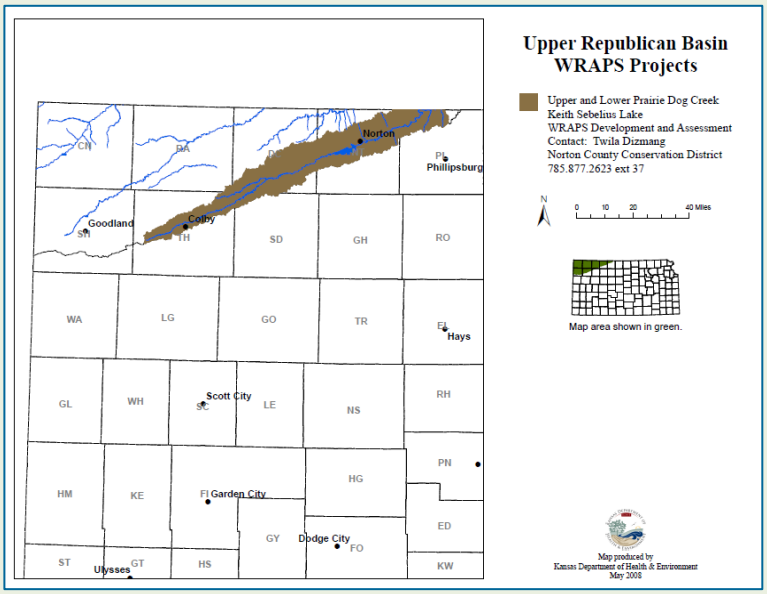
South Fork of Republican River. Photo courtesy KGS.

Upper Republican River Basin Management Categories

All conservation districts in the basin have adopted nonpoint source pollution management plans. A buffer coordinator has also been employed in Thomas County to facilitate enrollment of stream buffers in the continuous Conservation Reserve Program (CRP) and State Water Quality Buffer Initiative.

The Clean Water Act requires states to conduct Total Maximum Daily Load (TMDL) studies and develop TMDLs for water bodies identified on the state's List of Impaired Waters (Section 303(d) List). TMDLs are quantitative objectives and strategies needed to achieve the state's surface water quality standards. There are 11 approved TMDLs within the Upper Republican basin; dissolved oxygen on lower Prairie Dog Creek is a high priority for implementation. Colby City pond and Norton Lake are listed as water quality impaired by eutrophic conditions, dissolved oxygen, and/or pH. Other pollutants limiting use of Upper Republican basin streams include fluoride, selenium, pH and sulfate. TMDL development for additional parameters is anticipated in 2009.
Kansas Watershed Restoration and Protection Strategy (WRAPS) is a planning and management framework that engages stakeholders within a watershed in a process to:

- Identify watershed restoration and protection needs.
- Establish watershed management goals.
- Create a cost-effective action plan to achieve goals.
- Implement the action plan.



As of March 2008, there were 44 active WRAPS projects located throughout Kansas. One is on Prairie Dog Creek, in the Upper Republican basin, including the watersheds above and below Keith Sebelius Lake.

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce the average concentration of bacteria, biochemical oxygen demand, solids, metals, nutrients, pesticides and sediment that adversely affect the water quality of Kansas lakes and streams.
- By 2010, ensure that water quality conditions are maintained at a level equal to or better than year 2000 conditions.
- By 2010, reduce the average concentration of dissolved solids, metals, nitrates, pesticides and volatile organic chemicals that adversely affect the water quality of Kansas ground water.
- By 2010, maintain, enhance, or restore priority wetlands and riparian areas.
- By 2015, nutrient reduction goals will be included in all WRAPS projects within the basin.
- By 2010, all public water suppliers will complete and implement a source water protection plan.

Applicable Programs

The following programs help to meet the objectives in the Water Quality category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Health and Environment: State Water Plan Program (Contamination Remediation)
- Kansas Corporation Commission: Conservation Division Programs
- Kansas Department of Health and Environment: Local Environmental Protection Program
- Kansas Department of Health and Environment: Watershed Management Program
- State Conservation Commission: Nonpoint Source Pollution Control Program
- State Conservation Commission: Water Resources Cost-Share Program

ISSUE: WETLAND AND RIPARIAN MANAGEMENT

The primary approach to wetland and riparian management in the basin focuses on providing technical and financial assistance to landowners to protect and restore these resources in priority watersheds through the implementation of best management practices.

Riparian lands in the Upper Republican basin have been impacted by the invasion and infestation of non-native phreatophytes, although not to the degree as in other western basins. Of greatest concern are the effects

tamarisk (salt cedar) and Russian olive on native riparian ecosystems.

Applicable *Kansas Water Plan* Objectives

- By 2010, maintain, enhance or restore priority wetlands and riparian areas.

Applicable Programs

The following programs help to meet the objectives in the Wetland and Riparian Management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Forest Service: Forest Stewardship Program and Conservation Tree Planting Program
- State Conservation Commission: Riparian and Wetland Protection Program
- Kansas Water Office: State Water Planning Program
- Kansas Department of Wildlife and Parks: State Parks and Wildlife Areas Planning and Development
- Kansas Department of Wildlife and Parks: Wildlife Habitat Improvement Program

ISSUE: FLOOD MANAGEMENT

Flooding is a natural, recurring event associated with streams and rivers that has resulted in the formation of natural floodplains over time. While this inundation provided benefits under natural conditions, encroachment of urban and agricultural development onto floodplains has resulted in the potential for flood damage. In addition, the Upper Republican basin is particularly prone to flash flooding which is characterized by a rapid rise in water level, fast-moving water and much flood debris.

Significant flooding was experienced during 1903, 1915, 1935 and 1941 on the Upper Republican River. One federal project, Norton Dam and associated Keith Sebelius Lake contributes to flood control in the basin. There are no watershed dam projects in the basin.

Kansas Water Plan flood management guidance has emphasized targeting watershed dam construction assistance to priority watersheds; encouraging participation in the National Flood Insurance Program; and preparing updated floodplain maps for priority communities.

Financial assistance from the State Water Plan Fund has been provided flood mapping as part of the 1993 Kansas Department of Agriculture-Division of Water Resources *Kansas Flood Mapping Initiative.* None has occurred in the Upper Republican basin.

Keith Sebelius Reservoir. Photo courtesy Diane Coe, KWO.

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce the vulnerability to damage from floods within identified priority communities or areas.

Applicable Programs

The following programs help to meet the objectives in the Flood Management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Structures Program/Floodplain Management
- Kansas Department of Agriculture-Division of Water Resources: Water Structures Program/Dam Safety
- Kansas Division of Emergency Management: Hazard Mitigation Grants Program
- FEMA: National Flood Insurance Program

ISSUE: WATER-BASED RECREATION

The Upper Republican basin has public water recreation sites on state and federal land. There is a demand for more consistent water levels, and access to water based recreation facilities for area residents that provide recreational income to the economy by attracting sportsmen and women to the area.

The Keith Sebelius Lake and associated recreation areas including Prairie Dog State Park, draw hunters, fish-

ermen and boaters to the area. In addition, state-operated lakes offer fishing in the basin including; Sherman State Fishing Lake when sufficient water is present, and St. Francis sand pits.

Applicable *Kansas Water Plan* Objectives

- By 2010, increase public recreational opportunities at Kansas lakes and streams.

Applicable Programs

The following programs help to meet the objectives in the Water-Based Recreation category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Wildlife and Parks: Rivers and Stream Access
- Kansas Department of Wildlife and Parks: State Parks

ISSUES FOR FUTURE ACTION

None identified.

Prairie Dog State Park at Keith Sebelius Reservoir. Photo courtesy Kansas Geological Survey

Upper Republican Basin High Priority Issue
Ogallala-High Plains Aquifer Declines
January 2009

Issue

Long-term management of the Ogallala-High Plains aquifer to extend and conserve the life of the aquifer.

Vision

Sufficient water resources in western Kansas to support healthy, economically strong communities and rural lifestyles, today and for future generations.

Goal

Extend and conserve the life of the Ogallala–High Plains aquifer.

Description

The Ogallala portion of the High Plains aquifer (Ogallala-High Plains aquifer) underlies most of Upper Republican River basin (Figure 1). Within the basin, the Ogallala underlies all or part of Cheyenne, Rawlins, Decatur, Norton, Phillips, Sherman, Thomas, and Sheridan counties. Thomas and Sherman counties along with parts of Cheyenne, Rawlins, Decatur, and Sheridan counties are in Northwest Kansas Groundwater Management District No. 4 (GMD4). The aquifer fringe, outside GMD4 is managed by the Kansas Department of Agriculture-Division of Water Resources (DWR).

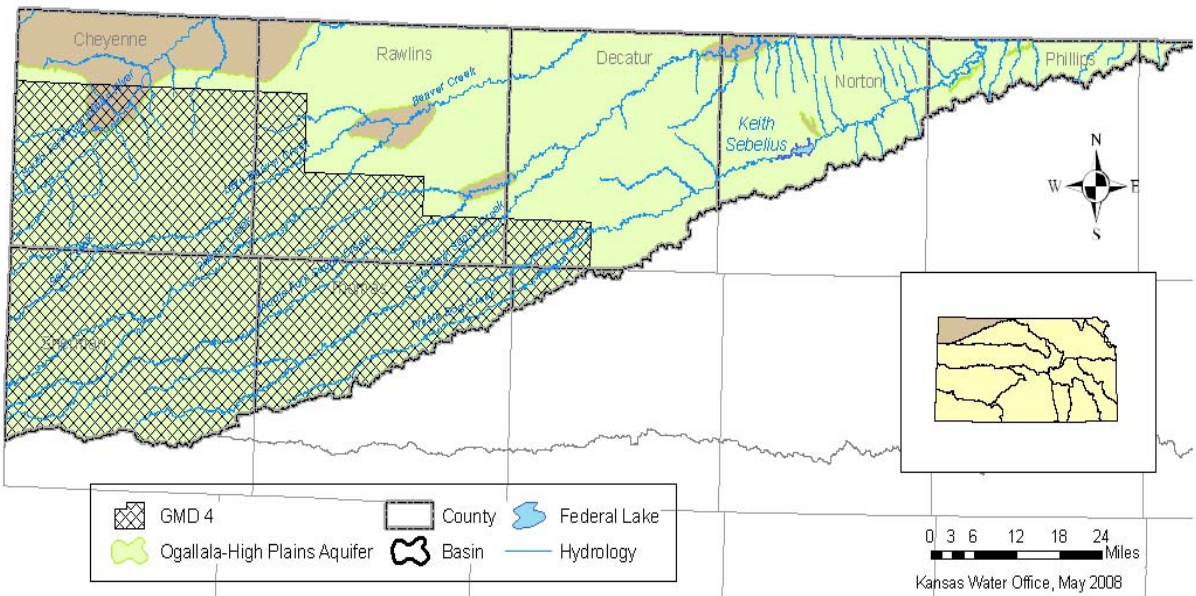


Figure 1.

Ground water supplies significant amounts (95% of appropriations in 2006) of municipal, irrigation, industrial and domestic water in the basin.[1] The Ogallala-High Plains aquifer has been developed so extensively that the amount of water withdrawn annually is significantly more than the annual recharge, resulting in ground water declines. As ground water levels decline, the aquifer loses hydraulic connection with the overlying alluvial aquifers and rivers and no longer contributes much, if any, base stream flow. Since the 1950s (predevelopment), Ogallala water levels have declined as much as 75 feet in that portion of Sherman County located in the basin. The majority of Thomas and Sherman counties in the basin have measured declines, some up to 50 feet.

Aquifer water levels in the basin have declined up to 30 feet over the ten-year period from 1996-2006. With the greatest decline centered in southwest Sherman County. Generally, Sherman and Thomas county areas in the basin have declined by 5-20 feet in the ten-year period. The overall decline has contributed to a progressive reduction in surface water flow during the past several decades.

Water users in parts of Wallace, Sherman, Thomas, Sheridan and Graham counties are already experiencing shortages in meeting demand. To extend and conserve the life of the Ogallala–High Plains aquifer, GMD4 and the DWR are defining priority areas and management goals to reduce aquifer declines. Federal and state voluntary incentive programs to reduce water use have been developed and targeted to priority areas.

A 2006 Kansas Water Office (KWO) analysis of water level data indicated that the aquifer decline rate had not

been reduced by a statically significant amount between two time periods, 1981-1993, and 1993-2005.[2]

Water Appropriations

Approximately 530,391 acre feet of the ground water appropriations in the Upper Republican basin. Total appropriations in the basin from the Ogallala-High Plains aquifer are approximately 515,902 acre feet for all beneficial uses. There are about 2,312 active Ogallala-High Plains water rights from 2,683 wells.[1]

The majority of the producing wells in the Ogallala-High Plains aquifer and associated alluvium are within the GMD4. The appropriations for these wells total 468,011 acre feet, or about 89% of the Ogallala-High Plains appropriations in the basin.

Water Use

The 2006 reported water use in the basin from the Ogallala-High Plains aquifer was 268,077 acre feet. Reported water use for 2006 within GMD4 in the basin was 242,649 acre feet, from 1,933 wells. Irrigation use was 97% of the Ogallala-High Plains reported use in the basin.

Annual water use reported and quantified by township for 2002-2006 is provided in Table 1, based on data analysis by DWR.[3] Some townships have water use in more than one area, such as a GMD and the fringe, therefore the sum of the number of townships analyzed for each area is not the same as those included under ALL in Table 1. The majority of a township may be in another basin or not underlain by the Ogallala aquifer.

There has been widespread adoption of more efficient irrigation systems in the Kansas High Plains shifting from flood and center pivot to center pivot with drop nozzles.[4] A study by Kansas State University in 2006 found that the number of acres irrigated is a more important determinant of changes in water use than the adoption of more efficient irrigation systems.[5] The authors concluded that if the irrigated acres are held steady after conversion to a more efficient irrigation system, net water use would, on average, change little; it is with a decrease in irrigated acres that a reduction in water use is assured.

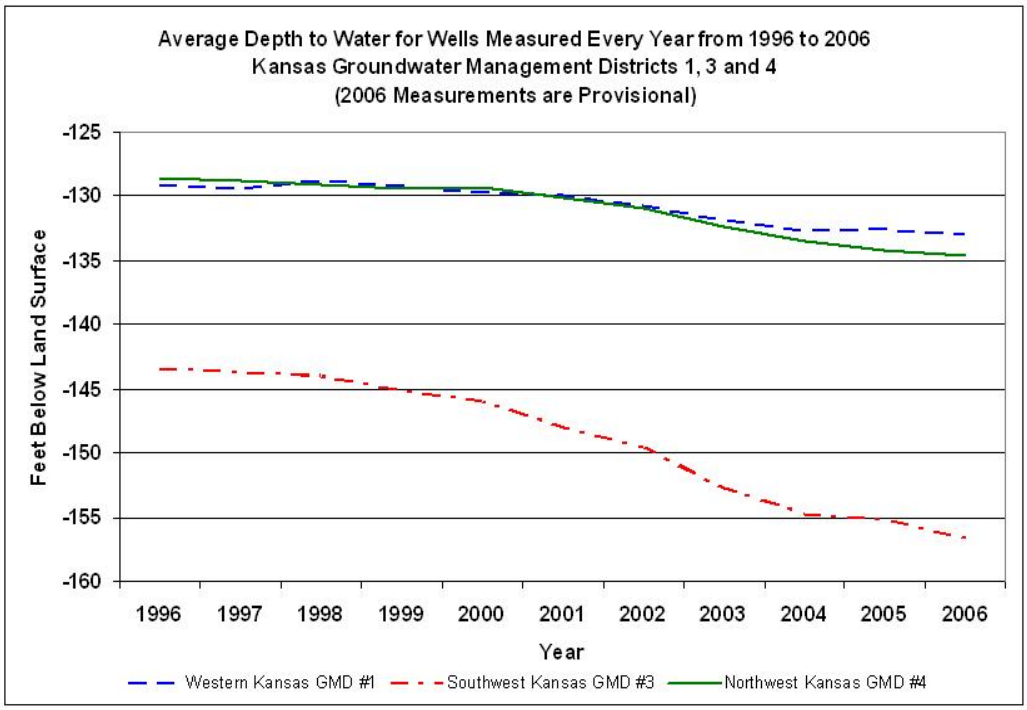


Figure 2.

Aquifer Declines

Average water levels in the aquifer within the groundwater management districts have continued to decline over the past ten years (Figure 2).

The overall average water level decline in the Ogallala-High Plains region over the 2005 calendar year was 0.57

Table 1.

Irrigated Water Use for Ogallala Area in Upper Republican Basin

Area	Number Townships Quantified	Number Points of Diversion	2006 Water Use (Acre Feet)	Acre feet/ acre 2002	Acre feet/ acre 2003	Acre feet/ acre 2004	Acre feet/ acre 2005	Acre feet/ acre 2006
GMD4	64	1,787	242,193	1.28	1.18	1.18	1.00	1.08
Fringe	21	552	22,254	1.02	0.85	0.99	0.71	0.89
All	NA	2,392	267,460	1.22	1.10	1.13	0.94	1.03

feet. This was more than the average decline over 2004 (0.15 feet), but less than the average annual decline rate over the five years since 2001 measurements (approximately 0.98 feet/year).

Figure 3 is an estimated projection of the years until the Ogallala-High Plains aquifer reaches a point where wells will only be able to produce 400 gallons per minute (gpm) assuming ground water level trends from 1996 to 2006 repeat continuously and unchanged into the future. This methodology is best suited to the Ogallala portion of the Ogallala-High Plains aquifer because of the relatively extensive data sets for the Ogallala. The variability of the system is the biggest drawback.

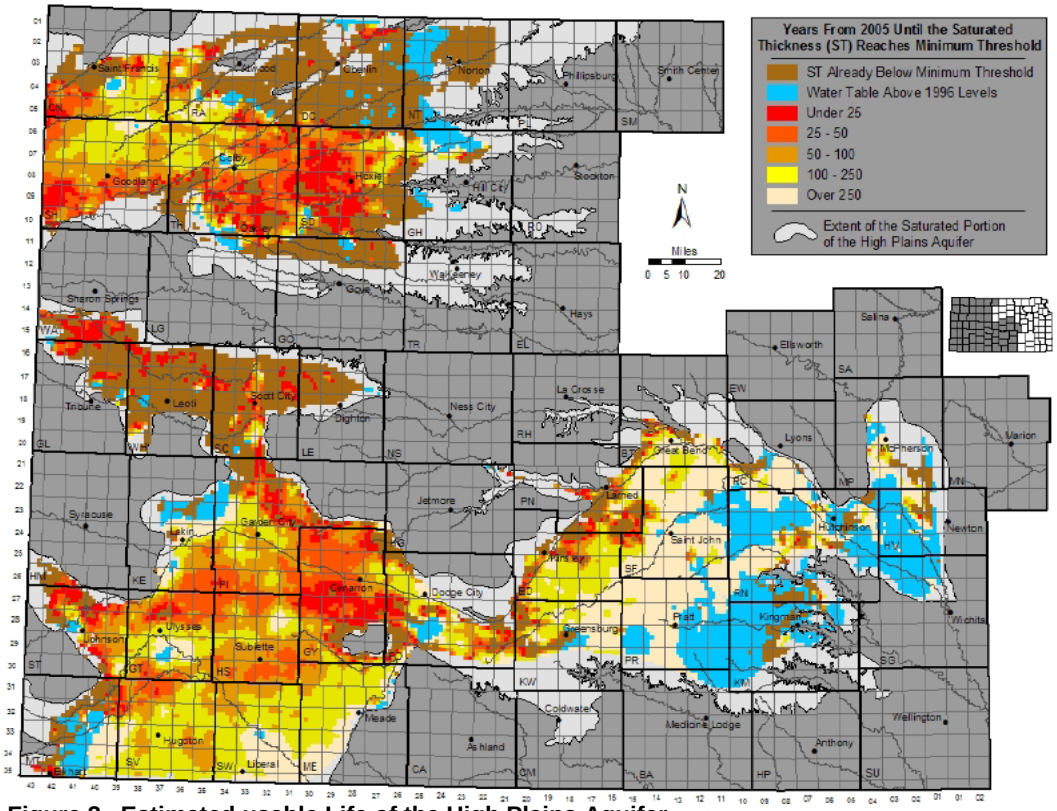


Figure 3. Estimated usable Life of the High Plains Aquifer

Activities and Progress

Various programs and activities have been initiated to reduce the decline rate of the Ogallala-High Plains aquifer and extend and conserve the aquifer. Tools such as ground water and surface water models and more detailed aquifer characterization have been developed. In the Upper Republican basin, the determination of Ogallala subunit priority areas, setting subunit goals, and developing management plans to reach these goals has been the responsibility of GMD4, and the DWR.

Good data is essential to the determine the decline rate. Data development includes calibration of ground water models to better understand the aquifer and subunits. Water meters, now required on almost all wells, provide improved information on withdrawals. All wells in GMD4 should be metered by December 31, 2009. Annual water level measurements, "index" wells and weather station data provide information contributing to better models.

GMD4 has identified six high priority subunits within their area, of which portions of five are in the Upper Republican basin (Figure 4). The GMD4 board is in the process of establishing water use goals and enhanced management actions for the high priority aquifer sub-units. These areas are the target of incentive programs.

The state and GMD4 have modeled management scenarios for the six high priority subunits. Corresponding economic estimates were produced for the anticipated cropping changes as ground water levels change, based on historical farm decision triggers as determined by Kansas State University.[5]

For areas outside GMD4, but still overlying the Ogallala-High Plains aquifer, DWR is to set high priority areas and develop goals.

Voluntary programs have been previously offered and targeted to areas determined by the appropriate management entity. Federal ground and surface water programs of the Environmental Quality Incentive Program (EQIP) were focused for two years on areas selected annually. GMD4 targeted areas utilized all available resources allocated for incentive payments of $100 per acre annually for three years on eligible acres to convert irrigated land to non-irrigated land.

The Water Right Transition and Assistance Program

(WTAP) has been available to retire water rights along portions of Prairie Dog Creek. State programs offer incentives to retire water rights. However that opportunity was not available to the Upper Republican basin Ogallala-High Plains area.

Regulatory programs have included special assistance by DWR to irrigators that have pumped in excess of water rights and the area average.

Progress toward reducing the decline rate was evaluated by the KWO in 2006 using water level data from 1981-2005.[2] The median annual water level changes were calculated for each region and standardized or indexed to antecedent moisture conditions using the Palmer Drought Severity Index (PDSI) for the appropriate region. The comparison of 1981-1993 and 1993-2005 periods concluded that there was no discernable change in the rate of water level declines in the Ogallala–High Plains region. It also concluded that in the northwest Ogallala aquifer area (GMD4 and DWR fringe areas), as of 2005, there has been no statistically significant change in the rate of decline.

It should be noted that the percentage of total water use that has been reduced through the voluntary and regulatory programs is small. A reduction of decline rates will likely take many years or decades to be recognizable unless participation and reductions are greater.

Priority Aquifer Subunits

Priority aquifer subunit maps are used to guide state and federal efforts on water conservation. The priority aquifer subunit areas are being further defined by the groundwater management districts inside each district, and the DWR for areas of the Ogallala-High Plains aquifer outside of the districts, with input from the public. Currently, an interim map (Figure 4) is being used until new priority aquifer subunit maps are defined and approved. Specific target areas are defined for areas eligible for enrollment in the Conservation Reserve Enhancement Program (CREP) (Upper Arkansas basin), EQIP quick response areas (statewide) and WTAP (statewide). Eligibility requirements are determined by each program.

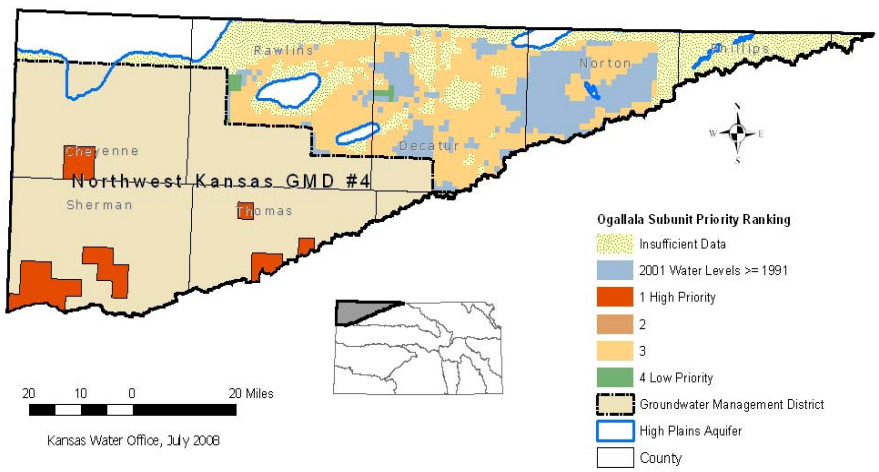


Figure 4.

The priority rank shown on this map outside GMD4 is based on an area's total score from two databases: estimated usable lifetime and density of ground water use. Useable lifetime is defined as the ability to support a 400 gallons per minute (gpm) well yield, on every quarter section, pumping for 90 days. Rank 1 indicates areas with a short estimated usable lifetime and a history of higher ground water usage. Rank 4, the lowest concern areas, have a relatively long useable lifetime and low total water use.

Recommended Actions

1. DWR identify priority aquifer subunits or areas, and GMD4 and DWR develop specific goals and management strategies to extend and conserve the life of the aquifer.

2. GMD4 and DWR manage aquifer subunits to maintain economic heath while ensuring sufficient water resources for future generations of western Kansas communities and rural populations and chosen lifestyles.

3. Provide opportunities to permanently and temporarily reduce water use through voluntary programs (state, federal, and local).

4. Educate water users, decision makers and the general public on the condition of the aquifer and methods and opportunities to reduce water use.

5. Support research for high value, low water use crops.

6. Seek crop insurance option for limited irrigation crops from USDA Risk Management Agency.

In order to implement the main actions stated above, the following specific activities are recommended:

- Provide technical support, including hydrologic modeling if appropriate, to project aquifer current and future conditions. Identify and implement activities to promote local conservation to extend the life of the aquifer that accrue to the aquifer subunit or region where water savings has occurred.
- Recognize the benefit of aquifer subunit planning. Management of the aquifer by subunit can benefit the local community economic wellbeing and social connectedness, reduce over pumping and widespread well shut offs from impairments.
    - Encourage ownership in one's aquifer subunit; promote local leadership.
    - Form subunit teams for local leadership of aquifer subunits or other methods of managing local areas/subunits for reduced consumptive water use.
    - Target incentive-based programs to aquifer subunits that have developed a long term vision and plan.
    - Implement aquifer subunit plans that assure water into the future that can help attract industry thus contributing to the economic health of the subunit and area.
- Consider the long term impact of climatic change on the water demands for the region.
- Consider interstate discussions on water conservation and planning.

Ogallala Outcrops Along Ravine, Rawlins County, KS
Photo courtesy Kansas Geological Survey

Resources

1. Kansas Department of Agriculture. April 29, 2008. DWR water right data.

2. Kansas Water Office. 2006. *Ogallala Aquifer Water Level Decline Rate, Status Report*.

3. Kansas Department of Agriculture. 2007. *Kansas Irrigation Water Use Report 2006*.

4. Perry, Charles. 2006. *Effects of Irrigation Practices on Water Use in the Groundwater Management Districts Within the Kansas High Plains, 1991-2003, Scientific Report 2006-5069*, US Geological Survey.

5. Golden, Billy B, and Jeffrey Peterson. 2006. *Evaluation of Water Conservation from More Efficient Irrigation Systems, Staff Paper 06-03*, Kansas State University, 2006-20, July 2006.

6. Bohling, Geoffrey C. and Wilson Blake B. 2006. *Statistical and Geostatistical Analysis of the Kansas High Plains Water-Table Elevations, 2006 Measurement Campaign*, KGS Open File Report 2006-20, July 2006.

7. Western Kansas Groundwater Management District No 1. 2008. http://www.gmd1.org/WaterResources.htm, 04/10/08

8. Schloss, J. A. and Buddemeier, R.W. 2000. *KGS High Plains Atlas*. http://www.kgs.ku.edu/HighPlains/atlas/chstmap.gif ,

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10. Young, David P, Wittemore, Donald O., and Wilson, Blake B. 2007. *Bedrock Surface and Aquifer Properties of the Alluvial Valleys of the Upper North and South Forks of the Solomon River Basin, Kansas*. KGS Open-file Report 2007-4.

Ogallala Outcrop. Photo courtesy KGS.

Upper Republican Basin High Priority Issue
Republican River System Management: Compact Compliance and Damages
January 2009

Issue

Planning and coordination is needed for the Republican River system in the Upper Republican basin for efficient water use, compliance with the Republican River Compact and the beneficial use of Compact Settlement payments.

Description

Water resource management challenges in the Upper Republican basin include meeting the needs of irrigators and other water users; compact compliance; and the desire for recreation in Keith Sebelius Lake.

The tributaries to the Republican River in Kansas include the Arikaree, South Fork Republican, Sappa (north fork, south fork and main), Beaver, Little Beaver, and Prairie Dog creeks (Figure 1). The basin includes 15,230 intermittent stream miles and 760 perennial stream miles. Drainage density is 0.31 mile per square mile in the basin (perennial streams only).

Keith Sebelius Lake, above Norton Dam, is located on Prairie Dog Creek in the eastern part of the basin. It is a federal lake built for flood control, municipal and industrial water supply, recreation and irrigation. The lake is operated and maintained by the U.S. Department of the Interior, Bureau of Reclamation.

Principal aquifers include the High Plains (Ogallala included) and alluvial aquifers. The alluvial aquifers and portions of the Ogallala-High Plains aquifer in the basin are hydrologically connected to the streams, thus management of the surface water must also consider ground water. The Dakota aquifer is present in the basin but is seldom used due to mineral content. All of the alluvial corridors in the basin are closed to new appropriations.

The Republican River Compact was enacted by Colorado, Nebraska and Kansas to divide the water supply of the Republican River basin. The Republican River basin includes portions of eastern Colorado, northwest Kansas and southwest Nebraska. The Republican River eventually flows though portions of north central Kansas to Milford Reservoir.

The "*Republican River Compact and Settlement Agreement*" (RRCA) requires Kansas to meet specific quantity goals for water leaving the Upper Republican basin. Climatic conditions, lack of runoff, alluvial ground water pumping, and reduced stream flows often limit water leaving the state. During the first accounting period under the settlement agreement (2003-2007), Kansas met its obligations under the compact. Meeting these obligations in the future may prove a challenge under some conditions. Management of the hydrologic system is needed to optimize use in Kansas while meeting flow required under the Settlement.[1]

Results of the first accounting period for the RRCA indicate Nebraska and Colorado have not met the terms of the Agreement. Monetary payments as well as water could be received by Kansas.

Substitute for Senate Bill No. 89 was signed by the Governor on April 4, 2008 to address damage payments under the RRCA.[2] This bill stipulates the distribution of any cash damage payments from Colorado and Nebraska to the following accounts; the interstate water litigation fund,[3] the Republican River water conservation projects-Nebraska (RRNE), and the Republican River water conservation projects - Colorado (RRCO). One-third of the RRNE and RRCO funds are to be credited

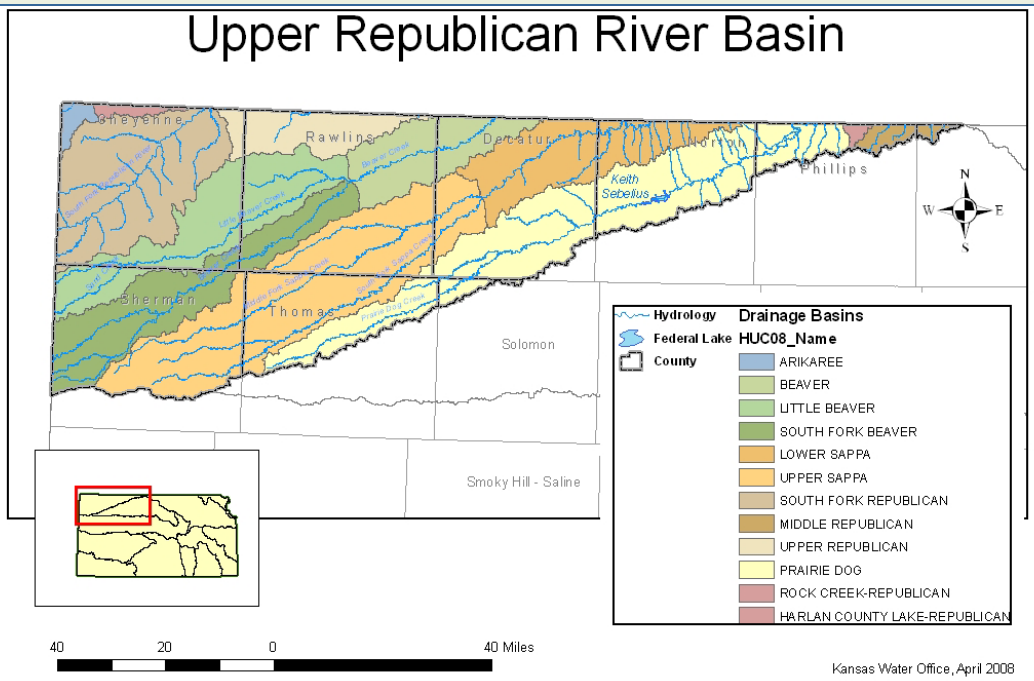


Figure 1.

to the *Kansas Water Plan* Fund for water conservation projects. The portion from Nebraska must enhance the ability of Kansas to remain in compliance with the RRCA. The remaining, two-thirds (the RRCO) are to be expended in the portions of Cheyenne, Decatur, Norton, Phillips, Rawlins, Sheridan, Sherman and Thomas counties in the Upper Republican River basin for conservation, efficiency, administrative and delivery projects. The RRNE are for use in the Lower Republican basin for similar projects .

The director of the Kansas Water Office (KWO) and the chief engineer of the Kansas Department of Agriculture-Division of Water Resources (DWR) shall review and approve each proposed project. The director and the chief engineer shall give priority to: projects needed to achieve or maintain compliance with the Republican River compact, projects that achieve greatest water conservation efficiency for the general good, and projects that have been required by the DWR.

The State of Colorado has proposed delivery of water by pipeline to meet RRCA compliance. This may replace monetary payments from Colorado. In the event additional water is delivered, the uses and transportation of the water from the state line will need to be identified.

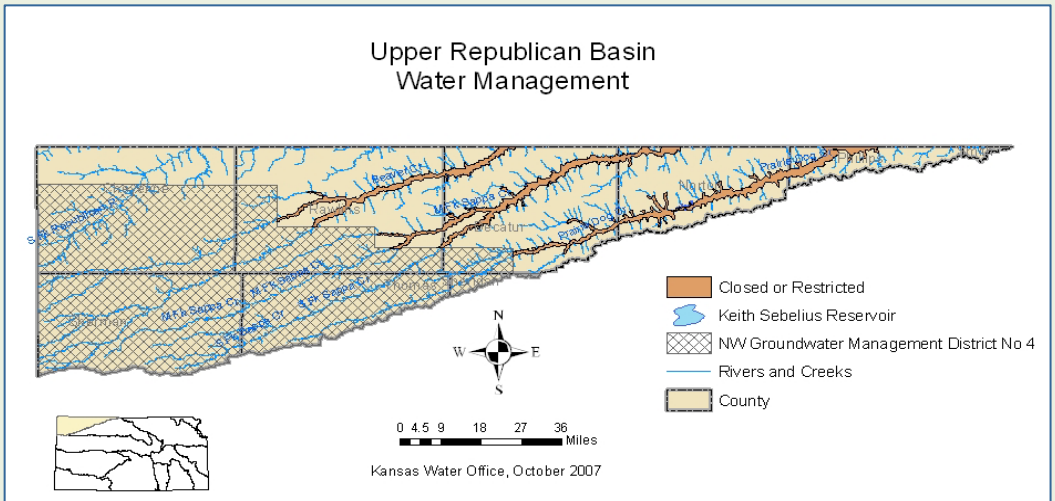


Figure 2.

Water Management

Numerous factors and entities are involved with the management of the water resources in the Upper Republican basin in Kansas.

Water appropriations and use are overseen by DWR. All of the streams and alluvial corridors in the basin are either closed to new appropriations or new appropriations are restricted (Figure 2). Compliance with the RRCA is also the responsibility of DWR

All or parts of six counties in the basin are included in Northwest Kansas Groundwater Management District No. 4 (GMD4). GMD4, formed in 1976, is pro active in developing local water policy compatible with state laws. GMD4 has identified six high priority subunits of the Ogallala-High Plains aquifer for priority management and programs. Portions of five of these areas are in Upper Republican basin. DWR identified two additional areas in the basin for targeting of a federal water use reduction program in 2009. Prairie Dog Creek has also been a targeted subbasin area for permanent water right retirement by the state's Water Right Transition Assistance Program (WTAP).[4]

The Bureau of Reclamation operates and maintains Keith Sebelius Lake. Throughout the history of this reservoir, irrigation draw downs and evaporative losses in excess of inflow have occurred. The probability of water levels remaining at or above conservation level in the future are low. Lake water levels frequently due to irrigation releases and inadequate inflow. A ten-year agreement between the Almena Irrigation District and the State of Kansas allows for some additional water to be stored at times. This may contribute to Kansas remaining in Compact compliance. Water stored in Keith Sebelius Lake can aid Compact compliance if water is available for release when needed.

Each county has a conservation district responsible for the conservation of soil, water, and related natural resources. Parts of two Resource Conservation and Development areas (RC&Ds) cover the Upper Republican basin: the Western Prairie and Solomon Valley RC&Ds. The Prairie Dog Creek Water and Sediment Control Basin-Stream Steward Project is in the assessment phase of a Watershed Restoration and Protection Strategy (WRAPS) through local conservation district and RC&D leadership. Projects selected for cost-share through these programs and organizations should consider their impact on Compact compliance but are not obligated to do so.

Recommended Actions

1. Review hydrologic system operation (some modeling may occur by federal agencies).

2. Review Keith Sebelius Lake management and operation.

3. Determine needs in the basin for continued compliance with RRCA. Develop a work plan to address identified needs to maintain compliance.

4. Identify areas where Republican River Compact compliance has restricted water use.

5. Identify potential projects to meet requirements of Senate Substitute Bill 89. Consider the economic benefits to the basin in the use of any financial payments and/or water received.

6. Develop coordination of state-funded projects such as nonpoint source (NPS) cost-share and WRAPS with projects funded by damage payments.

7. Consider benefits to the area economy in determining priority uses for damage payments.
   a. Consider economic impacts when determining use of payments from Colorado.
   b. Consider economic impacts when determining use of payments from Nebraska to maintain compact compliance.

Resources

1. Kansas Department of Agriculture-Division of Water Resources. 2008. *Republican River Compact and Settlement.* http://www.ksda.gov/interstate_water_issues/content/142

2. Kansas Legislature. 2007-2008. *Substitute Senate Bill 89*.

3. Water Litigation. K.S.A. 82a-1802. http://www.kslegislature.org/legsrv-statutes/getStatuteInfo.do

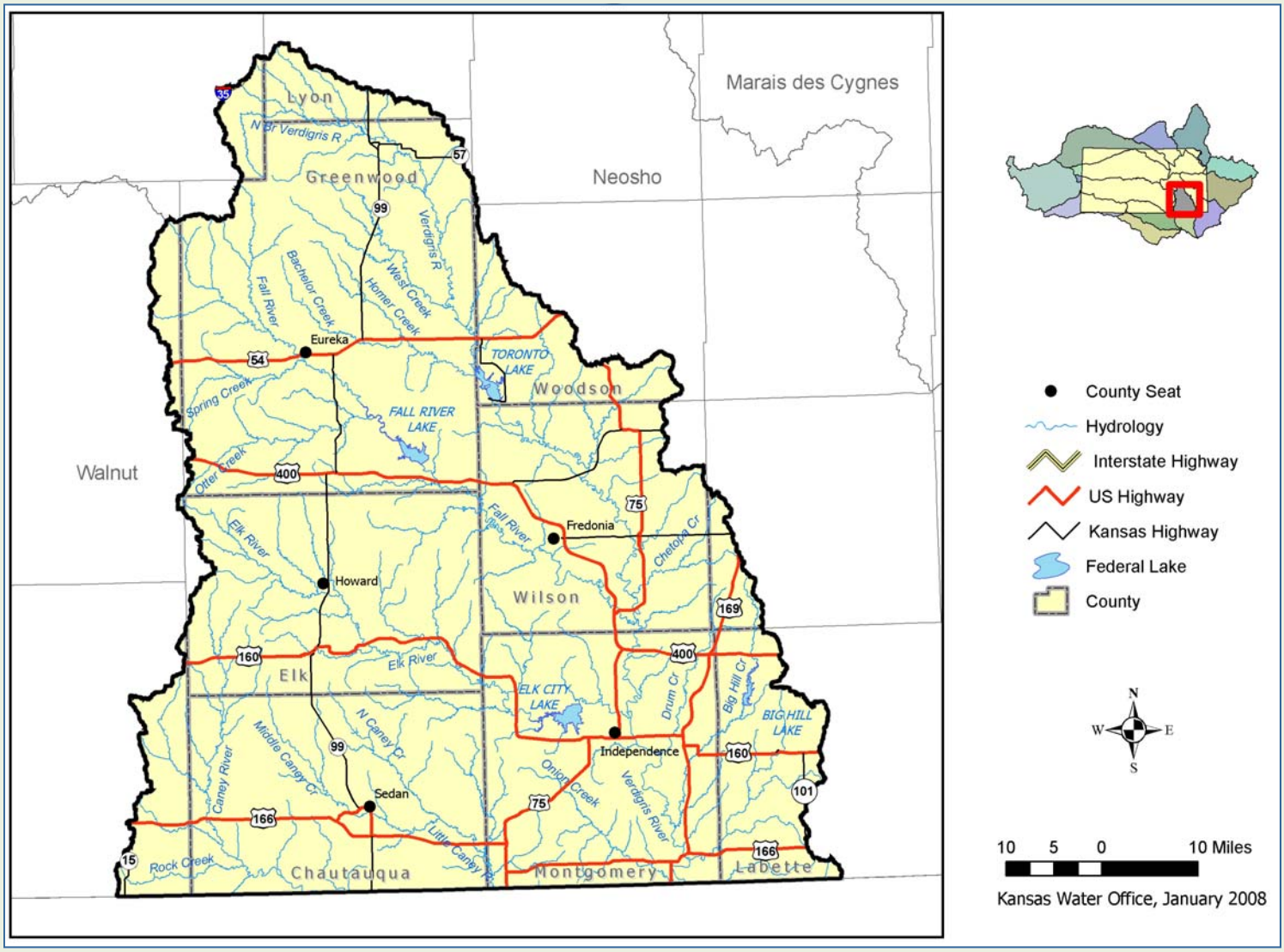
4. State Conservation Commission. September 2008. Water Transition Assistance Program. http://scc.ks.gov/index.php?option=com_content&task=view&id=715&Itemid=88

5. Kansas Department of Wildlife and Parks, Fisheries and Wildlife Division, Region 1. *1979 – 1998; annual reports. Fisheries progress and management plans, Pratt, Kansas, USA.*

6. Kansas Water Office. 2008. *Lake Level Management Plans Water Year 2008*.

Keith Sebelius Lake. Photo courtesy Kansas Geological Survey

Verdigris River Basin



General Description

The Verdigris River is a tributary of the Arkansas River and the basin includes Hydrologic Unit Codes 11070101, 11070102, 11070103, 11070104, and 11070105. The Arkansas River originates in central Colorado, where it flows southeast into and across Kansas before crossing into Oklahoma just south of Arkansas City. The Verdigris River mainstem rises in the southeastern corner of Chase County and flows in a general south-southeasterly direction for about 350 miles to its junction with the Arkansas River near Muskogee, Oklahoma. Elevation ranges from about 1,650 feet at the headwaters to about 680 feet at the state line. The Verdigris basin in Kansas covers approximately 4,440 square miles and encompasses all or parts of 11 counties in the southeastern part of the state. Near the City of Grove Oklahoma, the Verdigris River is dammed to form Oolagah Reservoir, a major drinking water supply storage for the City of Tulsa. Approximately two-thirds of the watershed above this reservoir is in Kansas.

Four federal reservoirs were constructed in the basin between 1949 and 1981; from oldest to youngest they are Fall River, Toronto, Elk City and Big Hill.

Major transportation routes include Highways 54 and 400 which run generally east to west through the basin. Highways 169 and 75 run north and south. See the basin map for locations.

Population and Economy[7]

There were an estimated 103,000 residents in the Kansas portion of the basin in the year 2000 and the population is expected to decrease to around 78,527 by 2040 according to Kansas Water Office (KWO) projections. No counties in the basin are projected to gain population. Major population centers include Independence, Coffeyville, Eureka, Neodesha and Fredonia.

Outside of major population centers, the population is generally rural with small agricultural communities.

The local economy is based primarily on agriculture with some manufacturing and light industrial activity including the Cobalt boat production facility in Neodesha. The major crops grown in the basin are wheat, grain sorghum and soybeans and the production of beef cattle is an important part of the agricultural economy. In 2006 there were an estimated 3,690 farms, with 2,632,000 acres in the five major counties in the basin. The average farm size was 713 acres. Crop value in 2006 was estimated by the Kansas Department of Agriculture at about $113 million. Livestock production value was estimated to be about $119 million.[4]

Toronto Lake Dam. Photo courtesy Kansas Geological Survey.

Education, health and social services, forestry, fishing and hunting, and mining also contribute to the local economy. Another significant contributor is the production of oil and gas. Along with this comes historic contamination from oil and gas production before more stringent regulations were in place to manage brine waste. Thousands of abandoned wells dot the landscape.

Coffeyville and Independence community colleges offer opportunities for higher education.

The four federal reservoirs in the basin offer water based recreation, hunting and other opportunities for experiencing natural environments. A 980 acre park at Fall River Reservoir features forested floodplains, blackjack oak savannahs and tallgrass prairie. Toronto Reservoir has a 4,700 acre park with riparian timber areas, grassland, and wetland communities. Native prairie and timbered areas can be enjoyed on 1,320 acres at Big Hill Reservoir, and Elk City Reservoir has 857 acres of native prairie, limestone bluffs, and deciduous forest. All parks offer camping, swimming, boating, water skiing, hiking, picnicking, bird watching, and photographic opportunities. Public wildlife areas are managed for both game and non-game species. The recreational resources these reservoirs provide are important to the local economy as visitors purchase amenities while in the area.

Physical Characteristics

Geology and Soils

The area is generally characterized as being in the Osage Cuestas Ecoregion with a physiography of cuestas and gentle undulating plains dissected by perennial and intermittent streams. Silty and clayey residuum and colluvium with alternating layers of Pennsylvanian sandstone, limestone, and shale characterize area geology. Glacial drift is fairly abundant in the extreme northern part of this ecoregion. Soils in the western part of the basin were developed from the underlying limestones and shales and in most parts of the area the soils are relatively shallow, making them best suited for native pastures. In the eastern part of the basin, soils are generally sandy residual soils which are low in fertility and quite erosive. These soils occur on undulating to hilly topography and are relatively shallow. In general, this area is more suitable for grazing than for cultivation.

Land Use/Land Cover

Land cover is a mosaic of grassland (74%), cropland (14%), and woodland (9 percent). All other land cover types represent less than 1 percent of the total land cover except for water which represents about 1.5 percent of the land cover. Most of the land use is for agriculture, either grazing and haying or crop production. Most of the crops are grown in the floodplains of the Verdigris River and its tributaries. Natural vegetation transitions from mostly tallgrass prairie in the west to a combination of tallgrass prairie and oak hickory woodland in the east. Upland forests are dominated by shagbark hickory, bitternut hickory, red oak, white oak, and black oak, with Ohio buckeye, American bladderpod, and pawpaw common understory trees. A remnant of the Cross Timbers Forest occurs in the basin.

According to the 2003 Assessment of Riparian Areas Inventory by the Kansas Geological Survey[5] (KGS), of the 25,722 miles of stream bank riparian area in the basin, the dominant riparian cover in a 100 foot zone from the streambank is pasture/grassland (34%).

The second most common cover is forest land (29%), and third most common cover is a mixture of pasture and trees (19%). The remaining riparian cover types, in descending order of dominance, are crop land, crop land/tree mix, shrubland, urban, urban/tree mix, and barren land.

The Natural Resources Conservation Service (NRCS) completed a Rapid Watershed Assessment (RWA) on HUC 11070101 in the basin.[10] The RWA report provides a detailed accounting of land uses and the application and condition of best management practices in this HUC unit. While the information cannot be directly extrapolated as being descriptive of the rest of the basin, it is likely that general trends are comparable.

The Upper Verdigris sub-basin described in the RWA is comprised of 767,225 acres in southeast Kansas including Chase, Lyon, Greenwood, Neosho, Wilson, and Woodson Counties. According to the National Land Cover Data (NLCD), approximately 12% of the sub-basin is in grain and row crop; 78% is in grassland, pasture, and hay; and the rest is in other various land uses. These percentages correspond well with the larger basin.

Resource concerns are numerous in the RWA sub-basin. They include, but are not limited to, soil erosion, soil compaction, diminishing surface water quality, deteriorating plant conditions and inadequate water for domestic livestock. Economic issues such as the high capital costs of crop production and farm operation and unreliable profits may delay the acceptance and implementation of conservation practices on agricultural lands in the subbasin.

There are approximately 811 farms and 1,168 operators in the Upper Verdigris subbasin. The estimated average farm size in 2002 was 809 acres, an increase of 15% from the 1987 estimate.

Six NRCS service centers, six county conservation districts, the Upper Verdigris Watershed District and the Flint Hills and See-Kan Resource Conservation and Development (RC&D) councils provide conservation assistance in the sub-basin.

With the exception of Chautauqua County, all counties in the Verdigris basin have adopted and are enforcing environmental codes. Five of the 11 counties have adopted land use zoning regulations.

Climate

Annual precipitation in the basin varies from approximately 34 inches in the west to almost 40 inches in the southeast corner. Approximately 70 percent of this precipitation falls between April and September. Between 11 and 18 inches of snow falls in an average year. The average temperature varies from 34 degrees in the winter to 79 degrees in the summer.

Table 1 summarizes average annual precipitation, temperature and freeze data for years between 1971 and 2000 for the cities of Eureka in the western part of the basin and Independence in the southeast part of the basin.

Table 1.
Climate Summary
Verdigris Basin

	Average Annual[1]		Freeze Dates (32 F.)[2]		
Location	Precipitation (inches)	Temperature (deg. F.)	Last in Spring	First in Fall	Frost Free Days
Eureka	37.78	55.6	Apr. 17	Oct. 16	182
Independence	43.46	57.1	Apr. 10	Oct. 23	198

[1] Source: National Climatic Data Center (1971-2000 data)
[2] Source: KSU Weather Data Library (1961-1990 data)

Pasture in Chase County. Photo courtesy Kansas Geological Survey.

Wildlife and Habitat

Numerous threatened and endangered (T&E) species occur in the Verdigris basin. Of these, there is one reptile, one invertebrate, and one mammal. Seven are mussels, seven are birds and three are fish.

The Verdigris River basin provides habitat for several species of T&E mussel species. The presence of mussels generally indicates good water quality since they are not able to move easily from one habitat to another. Mussels provide important filtering functions where they occur, helping to keep the water free of pollutants.

Ouachita Kidneyshell Mussel

Water Resources

Surface water is abundant during rainfall/runoff events and many streams are perennial; however the streams are flashy, characterized by flooding during storm events, followed by low flows during dry weather. There is no assurance that water is present when and where it is needed on a consistent basis. Of the 11,411 stream miles in the basin, 9,724 miles are intermittent, with the remaining 15%, or 1,688 miles, perennial. Stream density of both types is 2.6 stream miles/square mile area, making this basin tied with third place in stream density of the 12 basins in the state.

Due to numerous intermittent streams, surface water is undependable for public water supplies. This, combined with historic flooding, led to construction of four federal reservoirs in the basin, beginning in 1949, with the most recent completed in 1981.

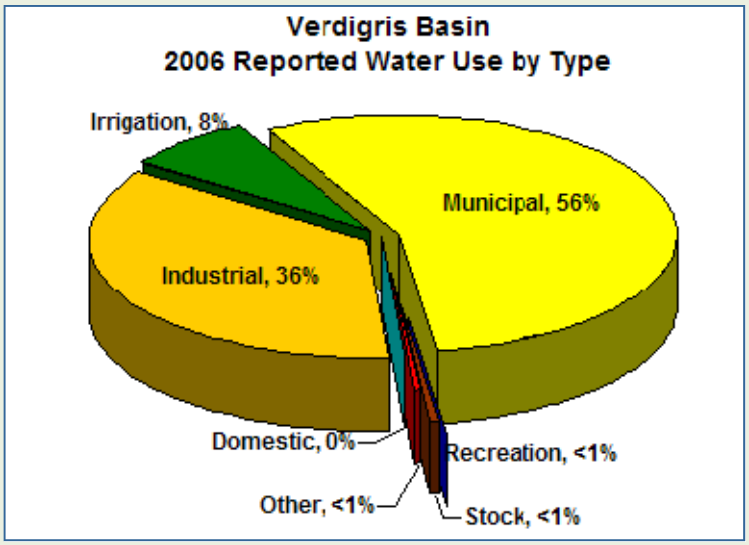
The major streams in the basin are the Verdigris, Elk, Fall, Caney and Little Caney Rivers, and Big Hill and Caney Creeks. Elk and Fall Rivers and Big Hill Creek are tributaries to the Verdigris River in Kansas, while the Caneys join the river in Oklahoma.

In addition to the federal reservoirs in the basin, all counties have state fishing lakes. Other community water resources include the Woodson Wildlife area, Cherryvale City Lake and LaClaire Lake.

Ground water supplies are quite limited in the basin, occurring mostly in alluvial aquifers.

Watershed Districts in the basin have constructed flood control structures to address rural flooding. Most impound water even during non-flood conditions. Several of these are available as back up sources of drinking water. Most are also used for livestock watering.

Surface water is the predominant source of water for beneficial uses in the Verdigris basin, with a very small amount, about one percent overall, derived from alluvial deposits along streams. In the Kansas part of the basin, surface water makes up over 98% of the water used. The majority of water used is for industrial (36%) and municipal (56%) purposes. Recreation (<1 percent), irrigation (8 percent), stockwater (<1 percent) and other uses (<1 percent) make up the remainder of the water used in the basin.[6]



Water Management

Significant water management entities include conservation districts throughout the basin, public water suppliers, the See-Kan Resource Conservation and Development Council (RC&D), and 12 watershed districts. By virtue of its responsibility for the four major reservoirs in the basin, the Corps is an important water management entity.

The City of Coffeyville is permitted under the Kansas Department of Health and Environment (KDHE) Phase II Stormwater Program which gives the city responsibility for managing surface water quality and quantity.

Watershed Restoration and Protection Strategy (WRAPS) groups are an emerging water management entity in the basin. These are coordinated by either the See-Kan RC&D or the Flint Hills RC&D. Voluntary watershed management plans are developed by local stakeholders. The plans include management goals intended to improve the overall condition of land and water in the watershed.

Resources

1. KWP-Verdigris Basin Section. November 2003.

2. U.S. Geological Survey 2000. K.E. Juracek. Report No. 00-4177 "Estimation and Comparison of Potential Runoff Contributing Areas in KS Using Topographic, Soil, and Land Use Information.

3. Kansas Water Office Reservoir Fact Sheets.

4. USDA, Kansas 2006-2007 County Farm Facts, Agricultural Statistics and Ranking.

5. Wilson, Brownie, Assessment of Riparian Areas Inventory, State of Kansas. 2003. http://hercules.kgs.ku.edu/geohydro/ofr/2003_55/riparian/ofr_2003_55e.htm

6. WRIS database, DWR, December 13, 2007.

7. U.S. Census Data—2000.

8. County Population Estimates. KS Division of Budget 2007.

9. Verdigris Unit Report-Kansas Water Resources Board Water Plan Studies.

10. ftp://ftp-fc.sc.egov.usda.gov/ks/outgoing/web-files/tecchnical-resources

Cross Timbers Forest

Large tracts of ancient deciduous forest still occur on the ridges and rugged escarpments of southeast Kansas, Oklahoma, and central Texas. These woodlands are dominated by centuries-old post oak (Quercus stellata) and are part of the Cross Timbers ecosystem. The Cross Timbers are a complex mosaic of upland forest, savanna and glade which form the broad ecotone between the eastern deciduous forests and the grasslands of the southern Great Plains. The pre-settlement Cross Timbers are believed to have covered some 30,526 square miles extending from central Texas across Oklahoma into southeastern Kansas. The short, stout oaks of the Cross Timbers were not ideal for lumber production, so the original Cross Timbers have often survived on steep terrain that was unsuitable for farming. Literally thousands of ancient post oak can still be found in this region, and there is no doubt that the Cross Timbers is one of the least disturbed forest types left in the eastern United States.

Cross Timbers Forest

Verdigris River Basin Management Categories

January 2009

WATER MANAGEMENT CATEGORIES

The following categories include issues identified in the Verdigris basin plan as items that require attention in addition to the basin priority issues. These issues are addressed within the following management categories:

- Water Management
- Water Conservation
- Public Water Supply
- Water Quality
- Wetland and Riparian Management
- Flood Management
- Water-Based Recreation

These categories also correspond to the statewide management categories and policies of the *Kansas Water Plan* found in Volume II. These documents contain new policy issues and the existing policy and statutory framework that relate to the management categories.

ISSUE: WATER MANAGEMENT

See Protecting and Enhancing Instream Flow Basin Priority Issue

Applicable *Kansas Water Plan* Objectives

- By 2015, achieve sustainable yield management of Kansas surface and ground water sources outside of the Ogallala-High Plains aquifer and areas specifically exempt by regulation. Sustainable yield management would be a goal that sets water management criteria to ensure long term trends in water use will move as close as possible to stable ground water levels and maintenance of sufficient streamflows.
- By 2015, meet minimum desirable streamflow at a frequency no less than the historical achievement for the individual sites at time of enactment.

Applicable Programs

The following programs help to meet the objectives in the Water Management (quantity) category. For more information on the programs and associated policies, see the Programs Manual.

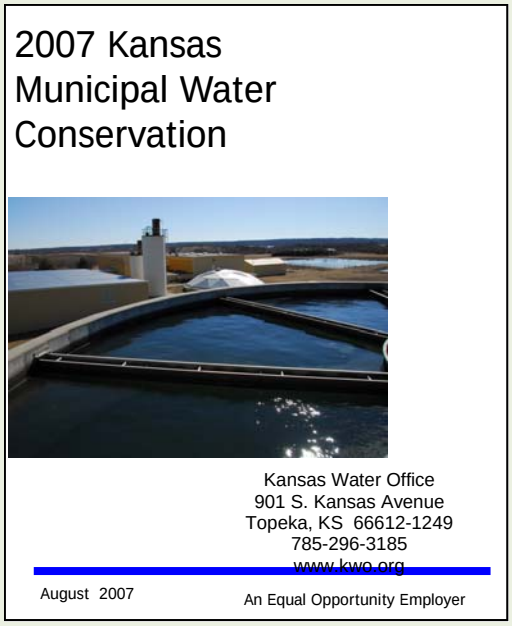
- Kansas Department of Agriculture-Division of Water Resources: Water Appropriation Program
- Kansas Geological Survey and Kansas Department of Agriculture-Division of Water Resources: Water Well Measurement
- USDA-Natural Resources Conservation Service: Environmental Quality Incentive Program

ISSUE: WATER CONSERVATION

Water conservation is essential for the effective management of water resources in the basin to assure that a sufficient, long-term, supply of water is available for the beneficial uses of the people of the state. Conservation is defined as a careful preservation and protection of something, especially the planned management of a natural resource to prevent exploitation or destruction. Water conservation is a part of maintaining a long-term water supply for Kansas.

Unaccounted for water includes any unmetered uses such as water used for fire fighting and watering of public areas, plus water loss in the distribution system. Technical assistance is available through the Kansas Water Office (KWO) for systems with more than 30% unaccounted for water. High amounts of unaccounted for water may result from water line breaks, under registering customers, unmetered uses, faulty metering or inaccurate accounting. The statewide average percentage of unaccounted for water use in 2006 was 14% statewide. Management of unaccounted for water is a fundamental tool in providing adequate water supply. Some unaccounted for water represents water that has been treated and then has been wasted and lost the potential to be put to beneficial uses.

Of the 66 public water suppliers in the Verdigris basin, 42 have an approved municipal conservation plan. Of those suppliers with approved plans, only two have submitted updated plans under the 2007 KWO Municipal Conservation Plan Guidelines. All other plans were developed based on guidelines from 1990 and should be updated to incorporate the 2007 changes.



Verdigris River Basin Management Categories

Most water utilities consider water as a commodity and encourage the use of water by their customers by striving to keep rates low. The availability of plentiful inexpensive water is promoted by communities in attracting new growth. More recently, communities are adopting rate structures that result in increased cost with increased use. This is one form of demand management.

The four basic types of water rate structures used by public water suppliers in Kansas are described as flat rate, decreasing block rate, uniform block rate, and increasing block rate. Utilities with a flat rate charge each customer a fixed amount per month regardless of the amount of water used. With a decreasing block rate, the unit cost of water decreases as usage increases. The unit cost of water is the same for all levels of usage with a uniform block rate. With an increasing block rate, the unit cost of water rises as usage increases.

The type of rate structure can affect gallons per capita per day (gpcd) usage. Systems with flat rates tend to use considerably more water per capita than systems that meter customer use. The other three types of rate structures, in which cost depends on amount of water used, have a less dramatic effect on gpcd. Decreasing block rates are assumed to discourage conservation because customers are charged lower rates for high-volume usage. Increasing block rates are considered an effective way to promote conservation among high-volume users while keeping the cost of moderate use affordable. However, the use of these types of rate structures does not appear to influence usage by individual customers as much as does the total monthly water cost and the geographic area in which they live.

Drought Stage Triggers (Table 1) are the signals that water shortage or other conditions indicative of drought have reached certain stages or levels. They act as the signal to begin implementation of the appropriate stage. Triggers may be related to supply conditions or demand levels. A given stage should have more than one trigger to confirm that conditions are worsening. A water utility or other municipal water entity should enact the appropriate stage whenever the agreed upon set of triggers is reached. Delay in action may lead to a major disruption of the water supply system at a later time.

Every public water supply drought response plan should be set up in stages, each one more stringent than the one before it. Triggering mechanisms should be identified to signal the start of a given stage and specific goals should be identified as the desired outcome for each stage. Finally, appropriate conservation practices in the areas of education, management and regulation should be listed under each stage. Stages are appropriate to implement drought response practices or actions because the impact of conservation practices of a moderate stage may preclude the need for the municipal water entity to enact more severe conservation practices at a subsequent stage.

Table 1.
Drought Stage Triggers used by public water suppliers with surface water sources:

1. Lake level in terms of elevation or capacity.
2. Stream level in terms of flow or stage.
3. Water level in relation to the dam.
4. Peak daily demand levels.
5. Percent capacity of treatment plant operations over a number of days.
6. Capacity of water system storage and ability to recover.
7. The provider for purchased water has issued a drought stage.
8. Emergency conditions related to repairs or water quality.
9. The KWO has issued a drought stage based on the remaining water marketing storage in a basin reservoir.

Drought vulnerable public water supplies are those suppliers most likely to be first impacted by drought due to basic source, distribution system or treatment capacity limitations; or that rely on a single well as a water supply source. Drought vulnerable water supplies were surveyed in 2003 and 2006. The number of public water supplies considered drought vulnerable decreased from 21 to 10 between the two surveys (Table 2). Delivery of the Kansas Department of Health and Environment (KDHE) Capacity Development Program has been beneficial in reducing drought vulnerability throughout the state as communities assess their systems and identify areas in need of improvement.

Table 2.

Supplier Name	New to List	Limitation
Cedar Vale	No	Basic Source
Grenola	No	Basic Source
Hamilton	Yes	Unknown
Longton	No	Basic Source
Madison	Yes	Basic Source
Neodesha	Yes	Unknown
Wilson RWD 01	No	Contractual
Wilson RWD 02	No	Contractual
Wilson RWD 05	No	Contractual
Wilson RWD 07	No	Contractual

Verdigris River Basin Management Categories

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce the number of public water suppliers with excessive "unaccounted for" water by first targeting those with 30% or more "unaccounted for" water.
- By 2015, all non-domestic points of diversion meeting predetermined criteria will be metered, gaged or otherwise measured.
- By 2015, conservation plans will be required for water rights meeting priority criteria under K.S.A. 82a-733 if it is determined that such a plan would result in significant water management improvement.

Applicable Programs

The following programs help to meet the objectives in the Water Conservation category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Appropriation Program
- Kansas Water Office: Water Conservation Program
- Kansas Department of Health and Environment: Kansas Public Water Supply Loan Fund
- USDA-Farm Service Agency: Conservation Reserve Program

ISSUE: PUBLIC WATER SUPPLY

Also see Surface Water Management and Conservation Basin Issue Paper.

The primary approach to addressing public water supply issues in the basin focuses on ensuring that there are adequate supplies of surface and ground water within the basin to meet future water demands, reducing the number of public water supply systems that are vulnerable to drought, and ensuring that systems have the technical, financial and managerial capacity to meet future needs for water quality and quantity.

There are 66 public water suppliers in the basin, including 36 rural water districts. There are currently four public wholesale water supply districts (PWWSD) in the basin. Surface water is the primary source for most public water supplies, accounting for over 99% of the total supply. Streamflows in the basin are highly variable within the year, and from one year to another. Fall River, Toronto, Elk City and Big Hill reservoirs are operated through a memorandum of agreement to maximize use of the stored water.

A Regional Public Water Supply Planning Grant to PWWSD #24 (Elk City, Howard, Longton, Severy and Moline) was completed in 2007. The district is pursuing consolidation with PWWSD #20 as the best solution to water supply vulnerability concerns. Construction of the project will decommission five small surface water treatment plants that are currently out of compliance with Safe Drinking Water Act requirements. The other PWWSDs are #4, which utilizes Big Hill Reservoir as a water source for 16 cities and rural water districts, and #23, that is under development and plans to upgrade and utilize the Fredonia treatment plant and distribution system.

Water Tower South of Cherryvale. Photo courtesy KGS.

Water usage in gpcd is calculated for each water system in the state from reported data on water use and population served. Average gpcd figures for large, medium and small water suppliers are calculated in eight regions of the state based on similar geographic areas. The Verdigris basin is located in region 7. Average gpcd for large, medium and small suppliers in region 7 are, 148, 107 and 96 respectively. This serves as a reference to indicate if individual suppliers are above or below average usage for the region. The average gpcd water consumption is 105 in the Verdigris basin.

Applicable *Kansas Water Plan* Objectives

- By 2010, ensure that sufficient surface water storage is available to meet projected year 2040 public water supply needs for areas of Kansas with current or potential access to surface water storage.
- By 2010, less than five percent of public water suppliers will be drought vulnerable.
- By 2010, ensure that all public water suppliers have the technical, financial and managerial capability to meet their needs and to meet Safe Drinking Water Act requirements.

Applicable Programs

The following programs help to meet the objectives in the Public Water Supply category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Appropriation Program
- Kansas Department of Health and Environment: Public Water Supply Program
- Kansas Water Office: State Water Planning Program
- Kansas Water Office: Water Conservation Program

ISSUE: WATER QUALITY

See Watershed Restoration and Protection Basin Priority Issue.

Water quality and related water resource issues are addressed through a combination of watershed restoration and protection efforts utilizing voluntary, incentive based approaches, as well as regulatory programs

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce the average concentration of bacteria, biochemical oxygen demand, solids, metals, nutrients, pesticides and sediment that adversely affect the water quality of Kansas lakes and streams.
- By 2010, ensure that water quality conditions are maintained at a level equal to or better than year 2000 conditions.
- By 2010, reduce the average concentration of dissolved solids, metals, nitrates, pesticides and volatile organic chemicals that adversely affect the water quality of Kansas ground water.
- By 2010, maintain, enhance, or restore priority wetlands and riparian areas.
- By 2015, nutrient reduction goals will be included in all Watershed Restoration and Protection Strategy (WRAPS) projects within the basin.
- By 2010, all public water suppliers will complete and implement a source water protection plan.

Applicable Programs

The following programs help to meet the objectives in the Water Quality category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Health and Environment: State Water Plan Program (Contamination Remediation)
- Kansas Corporation Commission: Conservation Division Programs
- Kansas Department of Health and Environment: Local Environmental Protection Program
- Kansas Department of Health and Environment: Watershed Management Program
- State Conservation Commission: Nonpoint Source Pollution Control Program
- State Conservation Commission: Water Resources Cost-Share Program

Verdigris River near Coffeyville. Photo courtesy KGS.

ISSUE: WETLAND AND RIPARIAN MANAGEMENT

See the Watershed Restoration and Protection Priority Issue for a discussion of current activities concerning wetland and riparian area protection.

The primary approach to wetland and riparian management in the basin focuses on providing technical and financial assistance to landowners to protect and restore these resources in priority watersheds through the implementation of best management practices.

Applicable *Kansas Water Plan* Objectives

- By 2010, maintain, enhance or restore priority wetlands and riparian areas.

Applicable Programs

The following programs help to meet the objectives in the Wetland and Riparian Management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Forest Service: Forest Stewardship Program and Conservation Tree Planting Program
- State Conservation Commission: Riparian and Wetland Protection Program
- Kansas Water Office: State Water Planning Program
- Kansas Department of Wildlife and Parks: State Parks and Wildlife Areas Planning and Devleopment
- Kansas Department of Wildlife and Parks: Wildlife Habitat Improvement Program
- Kansas Department of Wildlife and Parks: Conservation Easement Program

ISSUE: FLOOD MANAGEMENT

See Comprehensive Flood Assessment Basin Priority Issue.

The primary approach to flood management in the basin focuses on floodplain management through community participation in the National Flood Insurance Program and reduction of rural flood damages through construction of watershed dams in organized watershed districts.

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce the vulnerability to damage from floods within identified priority communities or areas.

Applicable Programs

The following programs help to meet the objectives in the Flood Management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Structures Program/Floodplain Management
- State Conservation Commission: Watershed Dam Construction Program
- State Conservation Commission: Watershed Planning Assistance Program
- Kansas Division of Emergency Management: Hazard Mitigation Grants Program
- FEMA: National Flood Insurance Program

ISSUE: WATER-BASED RECREATION

The state's rivers, streams and lakes represent a valuable recreational resource. Consideration of water basin recreation issues, problems and concerns are addressed in the Water Based Recreation Policy Section. Even though the Verdigris basin has four large federal lakes that have recreation components, there is still a demand for more water based recreation facilities, particularly for fishing, hiking, motor boating and water skiing. The Verdigris River and its tributaries are not among the three rivers in the state considered open for public access.

Applicable *Kansas Water Plan* Objectives

- By 2010, increase public recreational opportunities at Kansas lakes and streams.

Applicable Programs

The following programs help to meet the objectives in the Water-Based Recreation category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Wildlife and Parks: Rivers and Stream Access
- Kansas Water Office: State Water Planning Program
- Kansas Department of Wildlife and Parks: Fishing Impoundments and Stream Habitats (F.I.S.H.) Program/Walk-in Fishing
- Kansas Department of Wildlife and Parks: Walk-in Hunting Access Program
- Kansas Department of Wildlife and Parks: Community Fisheries Assistance Program

ISSUES FOR FUTURE ACTION

- Recreational use of the Verdigris River.

Verdigris Basin High Priority Issue
Watershed Restoration and Protection
January 2009

Issue

The restoration and protection of watersheds, particularly those watersheds above public water supply reservoirs, is a priority in the Verdigris basin. The Verdigris and Caney rivers drain south into Oklahoma so interstate water quality issues are also important to ensure high quality water crossing the state line.

There are four federal reservoirs: Fall River, Toronto, Elk City and Big Hill, in the Verdigris basin. All of these reservoirs are operated by the U.S. Army Corps of Engineers (Corps). All four reservoirs are used for public water supply programs that serve numerous cities and rural water districts in the basin. The reservoirs are also managed by the Corps for flood control and recreation.

Many streams within the basin are experiencing water quality impairments. Fecal coliform bacteria and low levels of dissolved oxygen (D.O.) are the most prevalent stream impairments.

Reservoir sedimentation is a major water quantity concern, particularly in reservoirs where the state owns storage for the Water Marketing and Water Assurance programs. As sediment accumulates in a reservoir's multipurpose pool, the capacity for water supply storage is reduced. Figure 1 shows the estimated percent of multipurpose pool capacity lost, including water supply storage, to sediment deposition in federal reservoirs in the Verdigris basin since construction.

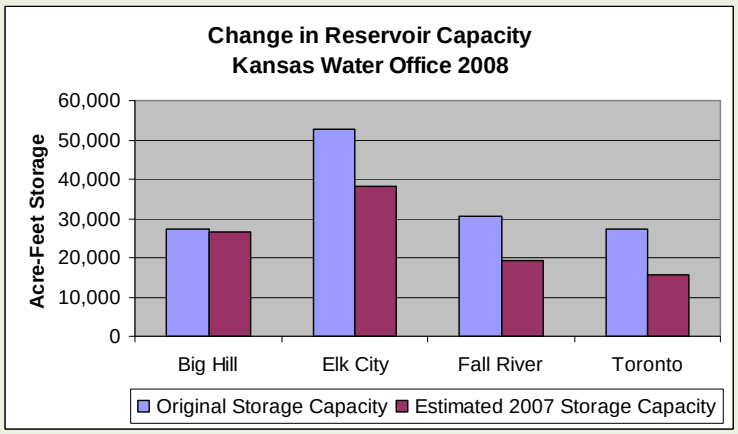


Figure 1. Changes in Reservoir Capacity Since Construction.

Description

Water quality and related water resource issues are addressed through a combination of watershed restoration and protection efforts utilizing voluntary, incentive-based approaches, as well as regulatory programs.

Water Quality Impairments

Water quality protection and improvement is most effectively addressed at the watershed level using regulatory and non-regulatory programs. Surface water quality monitoring is conducted to assess the level of pollutants in the water and the health of the biological community. If monitoring indicates that a river segment or other water body is consistently violating surface water quality standards, the water is classified as water quality impaired. Water bodies not meeting water quality standards for their designated uses are identified on the 303 (d) list. The 303(d) list is used to identify those waters targeted for the development of Total Maximum Daily Loads (TMDLs). A TMDL is the maximum amount of a pollutant that a water body can receive without exceeding water quality standards. Since pollution can arrive via point and nonpoint sources, the TMDL process distributes responsibility for the pollutant load reductions among those contributing sources. High Priority TMDL watersheds are used to target technical and financial assistance for implementation of nonpoint source pollution management practices that can address designated pollutants.

Surface waters not meeting surface water quality standards in the basin are included on the 2006 303(d) list. The Kansas Department of Health and Environment (KDHE) completed the first round of TMDLs within the Verdigris basin based on the 1998 303(d) list. There are 20 approved TMDLs within the Verdigris basin that describe the strategies and goals to reduce pollution to achieve water quality standards. The 2008 303(d) list submitted to the Environmental Protection Agency (EPA) identifies watersheds associated with six stream chemistry sampling stations and two biological monitoring stations as water quality impaired. There are seven lakes in the Verdigris River basin listed as water quality impaired. Among the streams copper causes the greatest number of impairments. Other pollutants of concern in Verdigris streams include zinc, lead, D.O. deficiency and E. coli bacteria. Among the lakes eutrophic conditions indicative of excessive algae production, D.O. depletion, and siltation are the causes of impairment.

Each parameter causing impairment requires a TMDL. Many of the stream segments configured in a watershed setting have a TMDL applied to them as a whole. KDHE has reviewed and revised Verdigris basin TMDLs and submitted them to EPA in late summer 2008. The following changes are proposed: a new high priority eutrophi-

cation, D.O., and siltation TMDL for Fall River, a new high priority eutrophication, D.O., and siltation TMDL for Toronto Reservoir, a new high priority eutrophication TMDL for Big Hill Reservoir, a new medium priority siltation TMDL for Eureka Lake and a new medium priority eutrophication and siltation TMDL for Elk City Reservoir. The TMDL for Elk City Reservoir will remain a medium priority until a viable Watershed Restoration and Protection Strategy (WRAPS) group is formed in the watershed above it.

KDHE completed a regional study of D.O. conditions and causes of low levels during 2007. As a result of this evaluation, KDHE has proposed that several D.O. TMDLs be moved from high priority to medium priority, and the Verdigris Basin Advisory Committee (BAC) concurs with this recommendation.

Table 1 provides information on rivers and reservoirs within the basin that are designated a high priority for TMDL implementation, following the recommendations of moving several of the currently listed high priority D.O. TMDLs to medium priority. Figure 2 shows the location of these watersheds within the basin.[6]

TABLE 1
VERDIGRIS BASIN HIGH PRIORITY TMDLS

MAP ID	WATERBODY	IMPAIRMENTS	HUC 8 WATERSHEDS
STREAM SEGMENTS			
1	Fall River	FCB	11071020
LAKES			
2	Fall River Lake	E, DO, Silt	11070102
3	Toronto Lake	E, DO, Silt	11070101
4	Big Hill Lake	E	11070103

Key:
DO: Low dissolved oxygen in upper 3 meters of water column over deepest location in water body
E: Eutrophication, biological community impacts and excessive nutrient/organic loading
FCB: Fecal Coliform Bacteria
HUC: U.S. Geologic Survey Hydrologic Unit Code
Silt: Observed siltation and/or chronic turbidity that impacts development of trophic state

Surface Water Nutrient Reduction

The impacts of nutrients originating in Kansas have been well documented. These include Gulf of Mexico hypoxia, excessive productivity in Kansas and downstream reservoirs, and taste and odor problems in drinking water originating from reservoirs. Reduction and control of nutrients is needed to begin mitigating those impacts. Nutrient sources within the basin include both point and nonpoint sources. The major point sources in the basin include large wastewater treatment plants, which are regulated under the National Pollutant Discharge Elimination System (NPDES) Program (Figure 3).

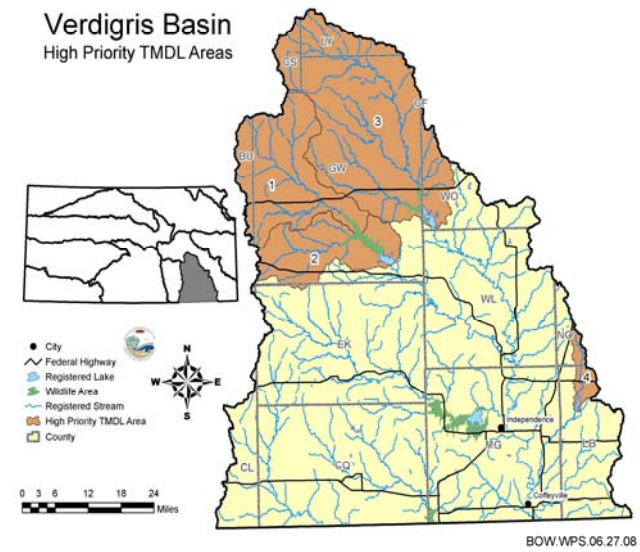


Figure 2. High Priority TMDL Map

Nonpoint sources of pollution include both agricultural and urban areas. Table 2 shows the relative contribution of point and nonpoint sources in the Verdigris basin for total phosphorus (TP) and total nitrogen (TN) leaving the state. The Kansas Surface Water Nutrient Reduction Plan, developed by KDHE, outlines a statewide strategy for reducing the export of TN and TP in surface waters leaving the state. This involves additional reductions in nutrients from point source discharges through the NPDES Program and reductions in nonpoint sources through development and implementation of WRAPS. The Nutrient Reduction Plan includes Improvement Potential Index (IPI) maps for Kansas counties for TP and TN reductions (see maps in Water Quality Policy Section). In the Verdigris basin, no counties currently show high improvement potential for TP and TN. However, with the recent development of high priority TMDLs for all four reservoirs in the basin, this could change as the plan is updated. Any actions taken in the basin to reduce nutrients in surface waters will also benefit downstream water users in Oklahoma.

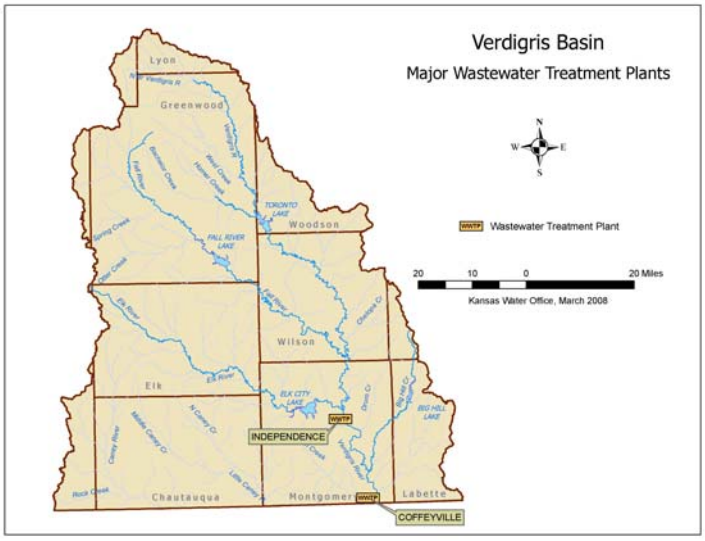


Figure 3. Major Wastewater Treatment Plants

Table 2
VERDIGRIS Nutrient Reduction Data
Source: KDHE Bureau of Water – February 14, 2006

Statewide Perspective

Parameter	State Total	Verdi-gris	% of State Total
TN Leaving State (Ton/yr)	51,000	3,468	7
TP Leaving State (Ton/yr)	7,700	385	5
Point Source TN (Ton/yr)	9,215	369	4
Point Source TP (Ton/yr)	1,925	58	3
Nonpoint Source TN (Ton/yr)	41,785	2,925	7
Nonpoint Source TP (Ton/yr)	5,775	347	6

Basin Perspective

Parameter	Total	PS	PS %	NPS	NPS%
TN (Ton/yr)	3,468	441	13	3,027	87
TP (Ton/yr)	385	83	21	314	79

Source Water Protection

All public water suppliers in the basin completed Source Water Assessments[3] in cooperation with the KDHE in 2004. The next step, which is voluntary, is the development of source water protection plans. For communities using ground water, development of a wellhead protection program is recommended. For communities using surface water, the development of a WRAPS is the best mechanism to ensure water quality protection for their public water supply. No source water or wellhead protection plans have been developed in the Verdigris basin.

Each Source Water Assessment included a susceptibility score which can help communities determine which contaminants pose the most significant threat to their water supply. A susceptibility score was generated from the susceptibility analysis and indicates whether the susceptibility range is low, moderate or high for potential threats of contamination in an assessment area.

KDHE provided public water suppliers susceptibility scores in the following contaminant categories: microbiological, nitrates (applicable for ground water only), pesticides, inorganic compounds, synthetic organic compounds, volatile organic compounds, sedimentation (surface water only), and eutrophication-phosphorus (surface water only).

Of the 25 public water suppliers in the basin which treat raw water, 19 use surface water and 6 use ground water. Most residents in the basin get water from the Verdigris or Fall River, major tributaries or one of the four federal reservoirs in the basin.

Of public water suppliers using ground water in the Verdigris basin, 83% had low susceptibility scores and 17% had moderate scores. Of public water suppliers using surface water, 74% had low scores and 26% had moderate scores. The most commonly identified problems with ground water were inorganic compounds, pesticides, and nitrates. The most commonly identified problems with surface water were pesticides, microbes, and inorganic compounds.

Wetland and Riparian Area Management

The primary approach to wetland and riparian area management in the basin focuses on providing technical and financial assistance to landowners to protect and restore these resources in priority watersheds through the implementation of best management practices. Water quality has been a primary focus with implementation efforts targeted to high priority TMDL watersheds (Figure 3). All conservation districts in the basin have developed wetland and riparian protection plans. An emerging concern is management and maintenance of forested riparian areas to prevent the entry of debris (dead and fallen trees, etc.) into the tributary/river system. Due to recent ice storms and catastrophic flooding, along with unstable streambanks, the potential for woody debris to collect in and clog bridges and culverts has been elevated. Preventing entry of woody debris into the system can help to manage this.

The Kansas Water Office is proposing a new policy that will provide a systematic approach to the assessment, protection and restoration of wetland and riparian areas and for the restoration of stream channels. The policy promotes a comprehensive evaluation of stream reaches and watershed wetland condition.

As part of the WRAPS effort described below, a partial inventory of riparian area and streambank condition on the mainstem of the Verdigris River has been completed. A similar assessment of the Fall River and tributaries has also been completed.

Elk Falls on the Elk River. Photo courtesy KGS.

Zebra mussels

Confirmation of Zebra mussel infestation has not yet occurred in any Verdigris basin federal reservoir or other impoundment. However, new occurrences of Zebra mussels in reservoirs in other basins continue to be documented. Zebra mussels cost hundreds of thousands of dollars to control once they become established and begin to build up on water intake and other structures. The most effective mechanism for prevention of future infestations is information and education of boaters and anglers to drain, wash and dry their equipment and boats when leaving any water body and before entering another one. Water quality impacts of Zebra mussels are being monitored, along with changes in biological communities.

Watershed Restoration and Protection Strategies

Watershed Restoration and Protection Strategies (WRAPS)[4] are stakeholder-driven watershed management plans designed to address multiple water resource issues within a specific sub-watershed within a river basin. The WRAPS process provides a means to integrate objectives from multiple local, state and federal programs into a comprehensive, coordinated strategy for a specific watershed. This can include TMDL attainment, nutrient reduction, source water protection, reduced reservoir sedimentation, riparian and wetland management, habitat enhancement and other natural resource objectives.

Watersheds above the four federal reservoirs in the basin that serve public water supply needs have been identified as watersheds of significant state interest for development and implementation of WRAPS. WRAPS projects have been initiated in two (Fall River and Toronto) of the watersheds above the federal reservoirs and efforts are underway to organize stakeholders in the watersheds above Elk City and Big Hill reservoirs. Watersheds with WRAPS projects currently underway in the basin encompass high priority areas for TMDL implementation, source water assessment areas and priority areas for wetland and riparian protection.

Figure 4 shows WRAPS projects coverage and contact information for projects in the basin.

Oolagah WRAPS Interstate Cooperation

The Verdigris River exits Kansas and is impounded in Oklahoma to form Oolagah Reservoir, a drinking water source for the city of Tulsa. About two-thirds of the watershed for Oolagah Reservoir is in Kansas, so discharge of clean water across the state line is a priority for the Verdigris basin. In 2002**,** the City of Tulsa entered into an agreement with the Tulsa District Corps of Engineers to perform a feasibility study to evaluate watershed pollution potential and possible impacts to the reservoir from water flowing into it. The Soil and Water Assessment Tool (SWAT) model has been calibrated for the watershed draining into the reservoir. In Kansas, the watershed area below the four federal reservoirs is included in the model. Various scenarios are being evaluated to guide the implementation of best management practices (BMPs) throughout the watershed and will be used by the Kansas WRAPS groups. Staff from water resource agencies in both states, including the city of Tulsa, have been meeting to coordinate activities and funding to help ensure high quality water flowing into Oolagah Reservoir. BMP implementation will focus on actions to achieve nutrient and sediment reduction goals.

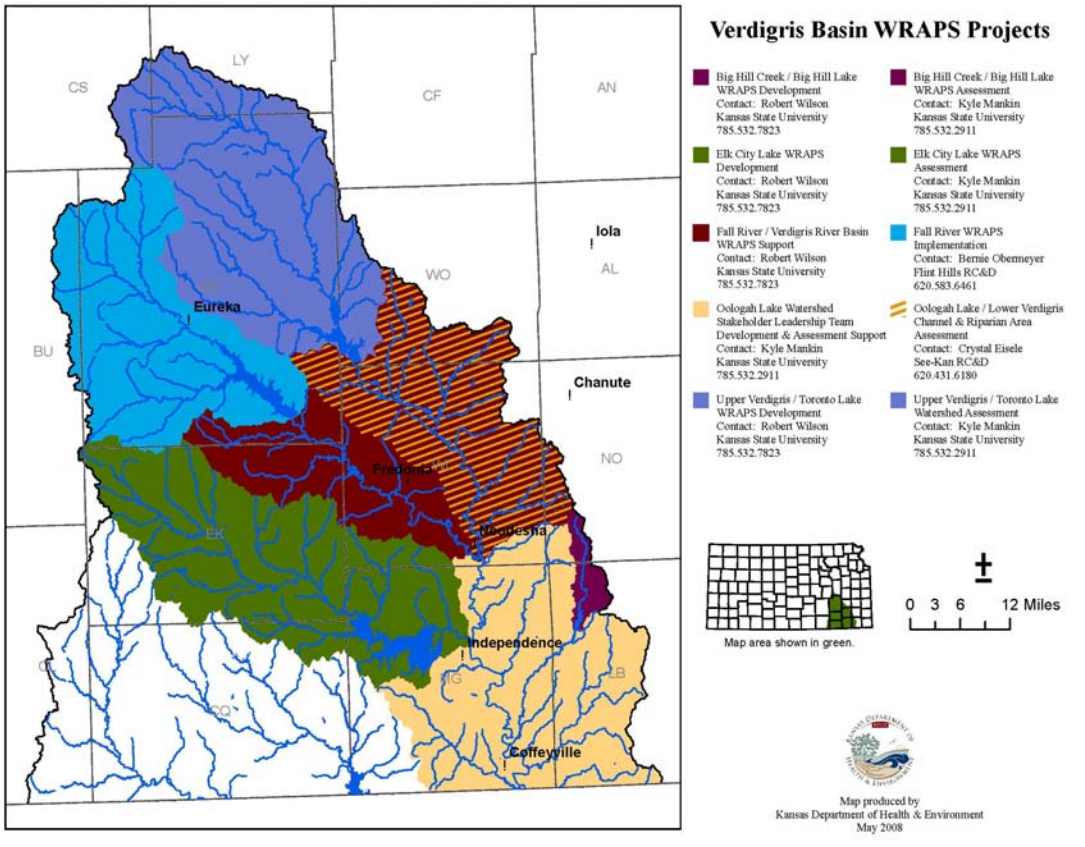


Figure 4. Watershed Restoration and Protection Strategy Groups.

grams can be integrated with WRAPS projects to ensure a comprehensive approach to watershed management in urban areas.

An important consideration for watershed restoration and protection in the basin will be the potential for conversion of Conservation Reserve Program (CRP) acreage back to production agriculture as contracts expire. Eight hundred twenty three contracts on 39,131 acres enrolled in the 12 Kansas counties contained wholly or partly in the Verdigris basin expired on September 30, 2007.[7] If land is taken out of permanent grass cover, implementation of BMPs will be needed to minimize potential adverse impacts to water resources within the basin.

Local Authorities for Water Quality Management

While no counties in the Verdigris basin are projected to substantially increase in population, some communities are experiencing growth and expansion which increases impervious areas. As the amount of impervious surface in a watershed (i.e. rooftops, roads, parking lots, etc.) increases, water resources can be adversely impacted from increases in runoff volume and additional pollutants associated with urban environments. Efforts made by local governments and urban residents to minimize these adverse impacts through sound land use planning and stormwater management help to address these issues.

Local land use planning and zoning authorities provide cities and counties effective tools to minimize the potential impacts of development on water resources. Urban stormwater management programs can be implemented to manage the amount of impervious surface in urbanizing watersheds and properly control increased runoff resulting from urbanization. Programs that provide technical assistance and education to urban residents regarding actions that can reduce or eliminate potential pollution sources also play an important role. These pro-

Other Watershed Related Activities

- Ten counties either wholly or partly within the basin have adopted local sanitary/environmental codes or participate in the Local Environmental Protection Program (LEPP). Chautauqua County has no local sanitary code and does not participate in the LEPP.
- Five counties in the basin have countywide planning and zoning programs.
- All conservation districts in the basin have adopted nonpoint source pollution management plans. Grants under the State Water Quality Buffer Initiative have also been awarded in four counties in the basin supporting buffer coordinators and facilitating enrollment of stream buffers in continuous CRP.
- Of cities in the basin, Coffeyville is subject to the Phase II Permitted Municipal Separate Storm Sewer System under the NPDES Stormwater Program.
- As of December 2007, there were six contamination sites being investigated or remediated through the State Water Plan Contamination Remediation Program.[2]
- There are 12 organized watershed districts in the basin.

Recommended Actions

1. Work with stakeholder leadership groups to incorporate TMDL implementation, nutrient and sediment reduction and urban stormwater management goals into applicable WRAPS projects.

2. Target technical and financial assistance programs for water quality protection and restoration to implement TMDLs and WRAPS action plans. Coordinate with development of Source Water Protection Plans.

3. Continue coordination efforts with the City of Tulsa to ensure good water quality entering Oklahoma from the Verdigris River in Kansas.

4. Complete assessment projects with particular attention to riparian and wetland assessments to target resources. Encourage private landowner efforts to maintain riparian areas to prevent introduction of excess woody debris into the tributary and river system.

5. Continue public outreach efforts to educate the public and landowners about the benefits of best management practices. Encourage other agencies and entities in partnerships and participation to support WRAPS initiatives, activities and funding.

6. Continue efforts to prevent the spread of Zebra mussels from infected water bodies.

Resources

1. *Kansas Water Plan*. 2006. Water Quality Policy and Institutional Framework Section. Kansas Water Office.

2. Kansas Department of Health and Environment, Bureau of Environmental Remediation. December 2005. *Basin Updates and Site Accomplishments.*

3. Kansas Department of Health and Environment, Bureau of Water. 2004. *Kansas Source Water Assessment Report*. www.kdheks.gov/nps/swap.

4. Kansas Department of Health and Environment, Bureau of Water. 2007. *Kansas Watershed Restoration and Protection Strategy*. www.kdheks.gov/nps/wraps.

5. Kansas Department of Health and Environment, Bureau of Water. December 2004. *Surface Water Nutrient Reduction Plan*. www.kdheks.gov/water.

6. Kansas Department of Health and Environment, Bureau of Water. 2007. *Watershed Planning and TMDL Program*. www.kdheks.gov/tmdl.

7. USDA Farm Service Agency. 2007. *Summary of Active and Expiring CRP Cropland Acres by County*. www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=crt

Verdigris Basin High Priority Issue
Water Supply Management and Conservation
January 2009

Issue

Reservoirs, community lakes, and streams in the Verdigris basin provide water for municipal and industrial water supply, irrigation, recreation, and aquatic life. There is a need for a comprehensive management and conservation strategy by communities within the basin to make efficient use of the water resource.

Description

The rural nature of the Verdigris basin led to many small communities developing their own water supplies, either from direct intakes on the major rivers and streams or from construction of individual community lakes. Over time, as communities have grown and in many cases gotten smaller, water demands have changed. As treatment requirements have increased and become more expensive, numerous communities have faced challenges in meeting water supply needs, especially during drought conditions. Federal reservoirs have been built which also provide water supply and efforts are underway to operate them more efficiently for this purpose.

Water Supply

All of the streams in this basin are restricted so that no new appropriation rights are available for the time period July to September (typically the irrigation season) unless there is an alternate source of water shown to be available. There are four federal reservoirs in the basin: Fall River, Toronto, Elk City and Big Hill along with numerous multipurpose or city-owned small lakes, and natural stream flows available for water supply.

An assessment of long-term water supply availability for public water supply systems in the basin completed in 2002[8] indicated that additional authorized quantities of water were needed for 11 public water supply systems to meet their projected 2040 demands (1998 data). In 2007 the Kansas Water Office (KWO) completed a preliminary water supply and demand analysis[1] in the Verdigris basin (Figures 1 & 2) and in four other basins in the eastern part of the state. In all counties included in the Verdigris basin study, population and demand for water is projected to decrease in the future. That projection could change should a major industry locate in the basin. Even so, the supplies available are decreasing and the needs of an albeit decreasing population must still be met.

Reservoirs are used, in part, to provide dependable water supplies in streams with highly variable flow. Fall River and Toronto Reservoirs, among the oldest reservoirs in the state, were constructed with water supply storage capacity built in, before the federal law requiring state or local financial participation for water supply storage was enacted. The state may ask for municipal and industrial releases from these reservoirs without having to pay for the storage. In the other two basin reservoirs, Elk City and Big Hill, that were built after the local cost share requirement, the state does own water marketing storage and is required to pay for that storage capacity along with annual operation and maintenance payments. All four of these reservoirs are used to satisfy water supply demand in various parts of the basin.

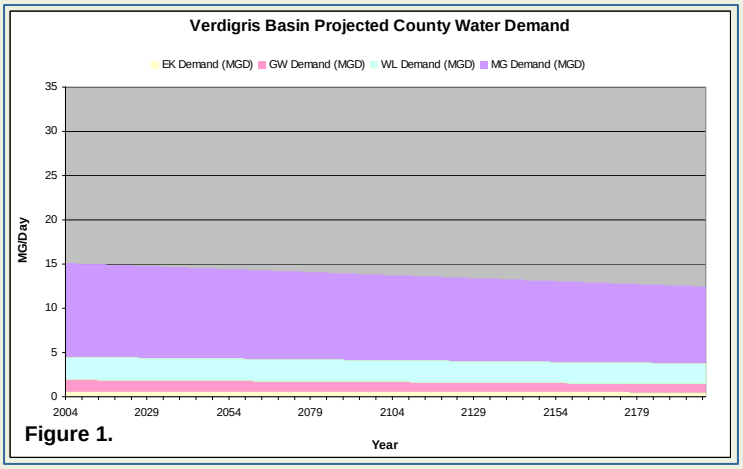


Figure 1.

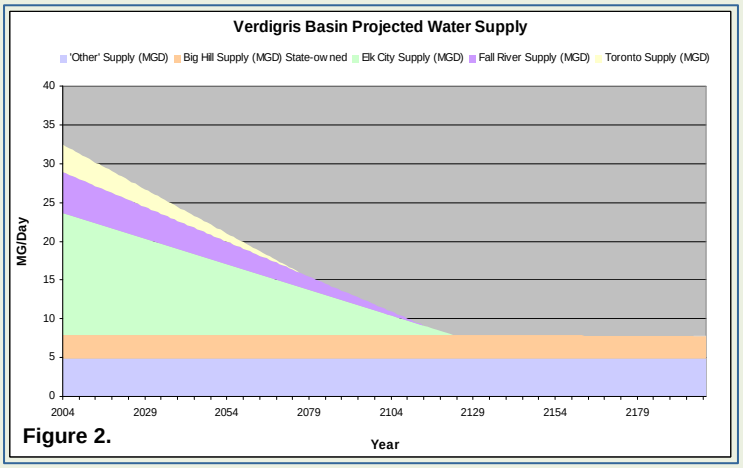


Figure 2.

Communities along the main stem of the Fall and Verdigris rivers explored the possibility of establishing a water assurance district during 2004-2005 in order to better manage the system of reservoirs to distribute stored water throughout the basin when and where it is needed. An assurance district would also reduce the inequity in the system caused by the fact that payment is only required for use of water stored in Elk City and Big Hill reservoirs. As of 2008, no assurance district has been established.

Releases are made from federal reservoirs in the basin to satisfy downstream water supply needs in accordance with a Memorandum of Agreement (MOA) between the KWO and the Kansas Department of Agriculture-Division of Water Resources (DWR). The MOA was updated in 2006 and provides that water needs in the upper portion of the basin are satisfied with releases from Fall River and Toronto reservoirs. Water needs in the lower part of the basin, below the confluence of the Elk River with the Verdigris River, are satisfied with releases from Elk City Reservoir. Water supply storage in Elk City Reservoir is used by the City of Coffeyville and Coffeyville Resources through water marketing contracts.

The update of the MOA incorporated a more comprehensive reservoir system management approach to operations of the reservoirs in the basin in which Toronto, Fall River and Elk City reservoirs are operated as a single system. Releases from the reservoirs for industrial and municipal water supply are coordinated to achieve greater benefit from the water stored in the reservoirs while still meeting water supplier's needs. This approach also helps to ensure that water quality and quantity goals are met throughout the basin. An assurance district, or an alternative arrangement for assuring adequate supply to downstream users, would further improve the ability of the state to maximize water storage releases from the reservoirs in the most beneficial manner.

Water Demand

Municipal and Industrial Demand

Based on the 2007 KWO supply and demand analysis, demand for water could exceed existing supplies in the basin by the year 2073 during a 2 percent probability drought similar to the 1950s (Figure 3). All four reservoirs in the basin are accumulating sediment and if current sedimentation trends continue, this accumulation will result in reduction of supply of stored water. More detailed analysis is needed to determine location specific water demands. Efforts are being made to reduce the rate of sedimentation in the reservoirs to extend the existing supply further into the future as part of the Reservoir Sustainability Initiative.

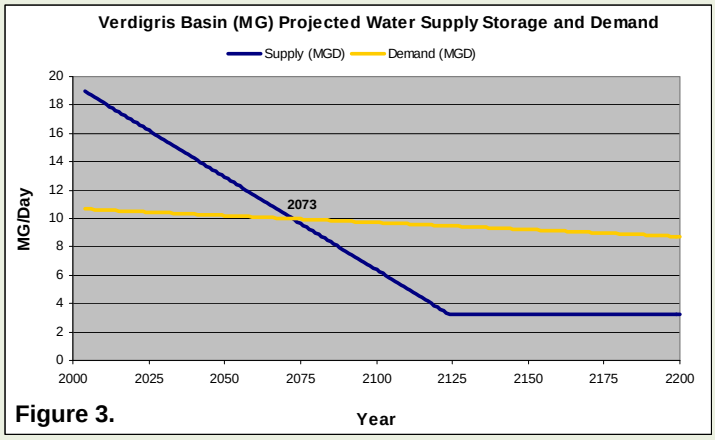


Figure 3.

Water Conservation and Demand Management

The objective of water conservation[3] is to achieve efficient use of the state's limited water resources through cost-effective practices to curtail the waste of water and to ensure water use does not exceed reasonable needs. In the Verdigris basin, conservation strategies include efficiency management in public water supply along with maintaining existing reservoir storage and water supply. See the Watershed Restoration and Protection Strategy (WRAPS) basin priority issue in this section for additional information about efforts underway to improve water quality and preserve storage capacity of reservoirs.

Local land use planning and zoning authorities provide cities and counties with effective tools to minimize the potential impacts of development on water resources. Counties with planning and zoning regulations often require landscape plans for new development. While landscaping can provide aesthetic and environmental benefits, heavily irrigated landscape designs can increase demand on public water supplies.

Demand management is an important component of extending water supplies but has not typically been incorporated into water utility operations. With the recognition of the potential for future water shortages, water suppliers and communities should begin to incorporate this concept into operational planning. Demand management may include less water intensive landscaping, low water use plumbing, conservation design for urban areas, water reuse, and other elements including responsible use of water. A movement beyond excessive use of water into more sustainable long-term management is needed. By Kansas law, increases in consumptive use cannot occur under existing, vested, or otherwise fully perfected water rights. If a municipality is considering substantial changes in their system to reuse water, the DWR must be consulted.

Conservation of reservoir storage has received attention as the impacts of sedimentation become increasingly apparent. While supply in the basin is being evaluated to develop management strategies, reservoir recreational impacts are also occurring, along with increasing occur-

rence of low flows in streams. Research has been conducted addressing the causes of reservoir storage loss and identifying solutions. These measures generally fall into short-term strategies such as efficiency of reservoir operations and longer-term restoration of storage. Examples of reservoir efficiency include pool reallocation, raising dams/pools, modification of operational rules, and treatment of the upstream watershed to limit erosion. Restoration includes dredging, reservoir flushing or other means of removing accumulated sediment.

Resources

1. Kansas Water Office. 2007. Surface Water Supply and Demand Projections for Selected Basins in Eastern Kansas.

2. Kansas Water Office. 2006. Kansas Municipal Water Use.

3. Kansas Water Office. 2007. Kansas Municipal Water Conservation Plan Guidelines.

4. Kansas Water Office. 2002. Status Report: State of Kansas, Water Marketing and Assurance Programs, Multipurpose Small Lakes Program.

5. Kansas Department of Health and Environment. 2006. Public Water System Capacity Development Assessment.

6. Kansas Department of Health and Environment. 2006. Public Water Supplies Drought Vulnerability Assessment.

7. Kansas Department of Agriculture, Division of Water Resources. 2006. Public Water Suppliers, Sources and Purchasers.

8. Kansas Water Office. Kansas Water Resources Conditions.

Recommended Actions

1. Develop a basin model of the hydrologic system with location specific supply and demand information.

2. Identify options for supply and demand management: reservoir pool raise, pool reallocation, dredging, new supplies, modification of reservoir operations and conservation measures.

3. Refine models to reflect possible outcomes of identified options.

4. Based on results from model scenarios, implement the most beneficial and cost-effective options.

5. Compare the benefits of development of a water assurance district or an improved river/reservoir water management system to ensure sufficient supplies for all water users served by Fall River, Toronto and Elk City reservoirs.

6. Begin incorporation of demand management into water utility plans. Demand management should also include education of and interaction with the development community and include existing local authorities.

Verdigris Basin High Priority Issue
Comprehensive Flood Assessment
January 2009

Issue

Persistent flood damages in the Verdigris basin indicate a need for a comprehensive evaluation of existing flood control infrastructure and storage to determine current status, mapping funding needs, and opportunities for flood management actions and flood damage reduction in the future.

During the weekend of June 30-July 1, 2007 heavy rains caused the Verdigris River to overflow its banks, top protective levees and flood the cities of Fredonia, Neodesha, Independence and Coffeyville, including the Coffeyville Resources refinery and nitrogen fertilizer operations. Numerous smaller communities throughout the basin were also affected. Heavy rain persisted in the area for two weeks, pushing the Verdigris River out of its banks forcing up to 3,000 people from their homes.

Summer 2007 Flooding in the Verdigris Basin

Although the upstream federal flood control reservoirs functioned properly, and numerous smaller watershed dams also detained water, this catastrophic event served as a reminder that even with extensive structural efforts to control flooding, excessive rainfall over successive days will overcome the ability of the system to prevent damage.

Description

Summer 2007 Flooding

The Verdigris River at Independence rose to a record 52.4 feet on July 1, 2007, exceeding the old mark of 47.6 feet and more than 20 feet above flood stage. The river crested in Coffeyville at 30.4 feet - 12 feet above flood level and 4.2 feet above a protective levee. The Caney River, in the southwestern portion of the basin, crested at 21.8 ft on July 2nd.

Nearly $40 million dollars in 20 southeast Kansas counties, including the Verdigris basin, was approved by the Federal Emergency Management Agency (FEMA) and the U.S. Small Business Administration (SBA) to assist the State of Kansas and the Kansas Division of Emergency Management (KDEM) in the recovery from the severe storms and flooding June 26-July 25, 2007. Thousands of residents throughout the basin were forced to evacuate their homes and businesses and the National Guard was called in to assist. Water and wastewater treatment plants and industrial facilities were shut down for weeks. Roads were covered for several days, cutting off parts of the basin from access by emergency vehicles.

A total of 56 watershed district flood control structures in the basin sustained a conservative estimate of $2,107,500 in damages during the 2007 summer flood. In Montgomery County, a reach of streambank was destabilized, threatening a county road that was estimated to cost $135,100 to repair.

Rivers and streams in the Verdigris basin have historically been prone to flooding during high rainfall events. Most of the basin land cover is native prairie with fairly steep slopes and shallow soils making it unsuitable for crop production. As a result, row crop agriculture occurs mainly in the fertile floodplains of rivers and streams. Most communities and cities are sited near stream channels and several, including Neodesha, Independence and Coffeyville, are located at the confluence of major rivers in the basin, making them vulnerable to flood damage.

Four federal reservoirs to manage flooding and provide reliable water supply were constructed in the basin between 1949 and 1981; from oldest to youngest they are Fall River, Toronto, Elk City and Big Hill. The 13 watershed districts in the basin have constructed 222 water retention structures on tributaries within the basin. Several levees have been constructed in Montgomery County.

Expansion of urban development in floodplains increases the potential for flood damage. Future flood damages may be reduced by preventing inappropriate development in flood prone areas and by converting land uses subject to flood damage in existing flood prone areas to other more compatible uses. Local governments can implement floodplain management through use of planning and zoning authority and in some cases through requirements in county sanitary codes. There is no state requirement for local units of government to implement floodplain management. The Kansas Department of Agriculture-Division of Water Resources (DWR) provides technical assistance to local governments and offers the following publication for landowners: Quick Facts. Floodplain Management Guide.[1]

By minimizing structural development in floodplains, the floodplain area is available to allow flood waters to spread out on the floodplain, slowing the water, allowing sediment to settle out, and reducing its erosive potential. Culverts and bridges can be designed to minimize flood damage by allowing adequate space for floodwater conveyance through them which also reduces backwater effects and damage to upstream areas. Design of these structures can consider total anticipated build out (according to comprehensive plans) land use flows. Consideration can be given to allowing enough space for instream structures to allow adequate movement of floodwater through them without backing up. Roads can be designed to be at elevations high enough to minimize floodwater encroachment. Increased watershed storage of floodwater in key areas can also reduce the volume of runoff. This can reduce the amount of time it takes to convey the water through structures, reducing localized flooding.

Summer 2007 Flooding in the Verdigris Basin

In 2002 Senate Bill 436 was passed that directed the Secretary of Agriculture and the Chief Engineer, DWR to evaluate the Department of Agriculture's current policies regarding stream obstructions (roads, bridges, culverts, levees) and present a report outlining the strengths and weaknesses of a watershed approach to the permitting of dams and other stream obstructions. The Secretary and the Chief Engineer were to make recommendations to the Legislature with regard to clarifying the Water Structures Program's obligations to upstream and downstream landowners. A questionnaire was sent to city and county governments, the Kansas Department of Transportation (KDOT), and other interest groups to gather their input on pros and cons of a watershed based approach to permitting of stream obstructions. The approach would have required more rigorous hydrologic and hydraulic modeling to evaluate the effect of structures further upstream and downstream of proposed projects than was currently required. Several alternatives were evaluated that would have imposed various levels of increased requirements.

Two public hearings were held. As a result of the evaluation and public input, the approach was not adopted due largely to concerns of local governments on increased costs and time to process permits. In addition, local governments did not recognize that the current procedures were causing problems and the benefits did not seem to justify the increased cost and work load. Some changes were made to the program including increased notification of upstream and downstream land owners of pending permits. An in-house evaluation was conducted on several streams with permitted structures to determine the downstream flooding impact resulting from the structures.

Accumulation of debris within and behind bridges, culverts and other structures is another concern. These accumulations obstruct the flow of water and can exacerbate the ability of the stream to carry flood water through permitted stream obstructions. It is important that permitted obstructions be kept clear of log jams caused by trees, utility poles and other debris that wash into streams during high flows. Management of riparian

areas to prevent debris from entering the system and causing blockages is an important part of a preventive and routine maintenance program. Well managed and healthy riparian and wetland areas along streams also benefit flood reduction by storing water on floodplains.

Non-structural flood management measures also include flood forecast and warning systems. The National Weather Service provides river stage and flood forecasts for the basin through its River Forecast Center located at the Arkansas-Red River basin office in Tulsa. The Kansas Mesonet Steering Committee selected priority counties for new automated weather stations in 2008. River Forecast Center needs were considered in this process and additional near real-time hourly precipitation data stations are planned for Woodson and Elk counties. This network will become increasingly informative and valuable if the developing trend towards increased frequency of heavy rainfall continues. This information may prove valuable for future design standards for permitted stream obstructions.

Existing Programs and Activities

Federal Emergency Management Act and National Flood Insurance Program [2]

The Flood Management Policy Section of the *Kansas Water Plan* describes flood related activities of the FEMA and the National Flood Insurance Program (NFIP). The DWR provides coordination and technical assistance for the NFIP in Kansas.

To be eligible to participate in the NFIP, communities must enact flood control ordinances designed to limit floodplain development and to protect those buildings that are constructed in the floodplain from flood damage. Management of floodplain development is the first priority to prevent flood damage.

The DWR assists communities with the development of flood control ordinances and is responsible for approving them. In the Verdigris basin, Wilson County and 17 individual communities have enacted flood plain ordinances. These communities are eligible to buy flood insurance through the NFIP program.

No counties in the basin are in the top ten list of counties in the state for flood insurance dollars paid from 1978-2007. Montgomery County has received the most flood insurance money in the basin, followed by Wilson County. The same is true for the amount of claims filed.

In 1997, FEMA initiated a plan to modernize the flood mapping program. The plan proposed a seven-year upgrade to the flood map inventory and an enhancement of the associated products and services. Most existing FEMA flood maps were produced using now outdated manual cartographic techniques. The desire was to produce digital maps compatible with computerized geographic information system software. Federal funding to implement the map modernization plan has not been made available as of 2008. Of communities that need updated FEMA maps, the highest priority is Montgomery County.

Elk Creek Falls, Elk County, Kansas. Photo courtesy KGS.

Kansas Hazard Mitigation Plan

The Kansas Hazard Mitigation Plan (Plan)[3] was updated in November 2007 by the KDEM. In the prioritization of risk associated with 22 hazards that was conducted as part of the planning process, flooding and winter storms ranked second behind only tornadoes in the degree of risk present. The updated Plan contains the following in the Mitigation Action Strategy Summary (Table 4.7, p. 4.53): “Integrate flood mitigation into KDOT construction projects.” Lead agency: KDOT; Support Agency: Kansas Department of Agriculture. This is shown as having a medium planning priority. It is noted that this action applies to all new construction projects and that more coordination with other agencies is needed. This recommendation also addresses some aspects of watershed based planning and permitting discussed above.

In the Plan, KDEM included a summary of high and significant risk dams. A high hazard dam (Class C Dam) is a dam located in an area where failure could result in any of the following: extensive loss of life, damage to more than one home, damage to industrial or commercial facilities, interruption of a public utility serving a large number of customers, damage to traffic on high volume roads that meet the requirements for hazard class C dams or a high volume railroad line, inundation of a frequently used recreation facility serving a relatively large number of persons, or two or more individual hazards described in Hazard class B. A significant hazard dam (Class B) is a dam located in an area where failure could endanger a few lives, damage an isolated home, damage traffic on moderate volume roads that meet the requirements for hazard class B dams, damage low volume railroad tracks, interrupt the use or service of a utility serving a small number of customers, or inundate recreation facilities, including campground areas intermittently used for sleeping and serving a relatively small number of persons. Dam hazard ratings are based on the risk for loss of life and/or property damage and are not related to the condition of the structure. DWR requires emergency action plans to be developed for high hazard dams. In May 2007, this requirement was extended to include significant hazard dams (Table 1).

Table 1.
Significant or High Hazard Dams in the Verdigris Basin

County*	Population	Total Dams	High Hazard (w/out plans)	Significant Hazard
Butler	63,147	232	11 (5)	9
Chase	3,070	83	0	7
Chautauqua	3,953	84	3 (1)	1
Cowley	34,931	128	4 (3)	14
Elk	3,077	85	4 (4)	5
Greenwood	7,067	155	3 (3)	9
Labette	22,203	58	0	3
Lyon	35,369	108	2 (1)	12
Montgomery	34,692	40	2 (1)	0
Neosho	16,298	65	1 (1)	1
Wilson	9,889	41	1	0
Woodson	3,507	42	0	1

* Counties either wholly or partly within the Verdigris Basin.

Development downstream of some small dams has resulted in changes in hazard class and necessitated upgrade of the structures. Since 1983, any dam classified as high hazard is required to have a breach inundation map prepared to identify the extent of downstream flooding that would occur if the dam were breached during a catastrophic event. These maps are available to be used by local governments to limit development of houses or other structures in these inundation zones. In the Verdigris basin, there are 31 high hazard dams, of which 19 are in need of breach inundation mapping. There are 62 significant hazard dams.

The Plan also includes a summary of known flood control levees in Kansas. Levees, along with dams, are engineered to withstand floods with a computed risk of occurrence (100-year flood). The only county with known levees is Montgomery County (Table 2).

Table 2.
Levees in the Verdigris Basin

County*	Levee Design Standard	Flooding Source	Protected Community	Federal Levee?
Montgomery	100-yr	Duck Creek	Elk City	unknown
Montgomery	100-yr	Verdigris River	Independence	unknown
Montgomery	100-yr	Verdigris River	Coffeyville	unknown

*Includes only counties subject to flooding by Verdigris River and tributaries.

Watershed Districts

The 13 watershed districts in the basin have developed general plans, approved by the DWR that describe the location and floodwater storage capacity of flood control retention and detention structures recommended to address rural flooding and protection of infrastructure. Most impound water even during non-flood conditions and may have benefits in addition to flood control. Several are available as back up sources of drinking water and some also provide recreational opportunities. Many are used for livestock watering and also protect local roads and bridges. General plans include watershed protection actions including construction of terraces, grassed waterways, and grade control structures to control sediment delivery to the structures.

General plans have been developed, modified and updated since the program was authorized in Kansas in 1953. Modifications to plans generally occur when structures are de-authorized or relocated, or when structures are added to the plan. Funding for construction comes from federal, state and local sources and there has been a downward trend in funding in recent years. Figures 1 and 2 show the trends in state and federal funding for watershed structures.

Construction under the Natural Resource Conservation Service (NRCS) P.L. 566 program ended in the Verdigris

basin in 1988 with 172 structures built. There has been no funding in Kansas under the program since 2006. Ninety two additional structures have been funded with State Conservation Commission (SCC) funding. SCC statewide funding for watershed structures through the Watershed Planning Assistance Program peaked in 1994 at about 1.6 million dollars. In all, 1,147,326 acres in the basin drain into watershed flood control structures.

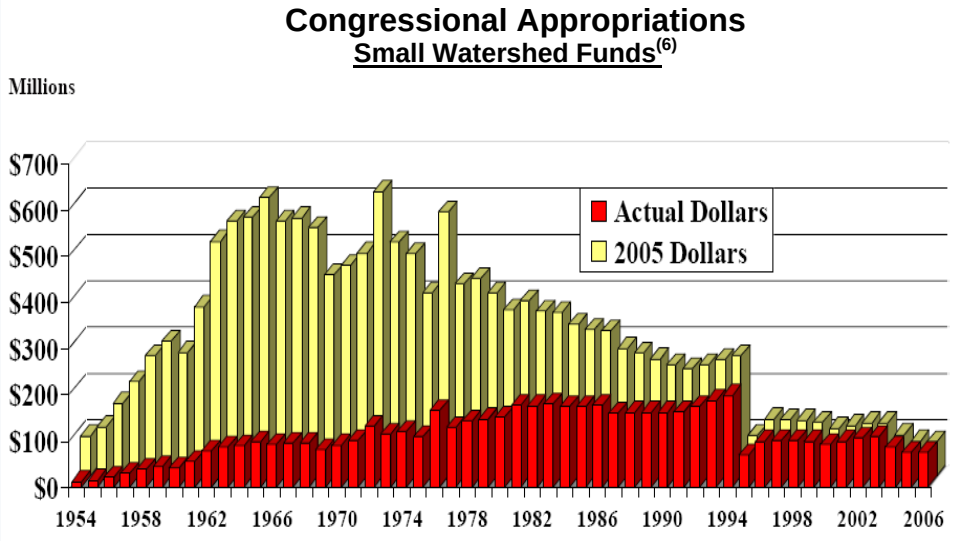


Figure 1. Federal Funding

Watershed districts have the authority to levee taxes on residents within the district to be used for operating expenses, new construction, and routine maintenance of infrastructure. Local funding can also be used to implement best management practices such as wetlands and riparian areas that also provide flood detention benefits.

Because of recent changes in permitting procedures for new dams by the U.S. Army Corps of Engineers (Corps), environmental issues have emerged that must be addressed before a permit can be issued. These issues are becoming increasingly challenging to address and construction of new dams has slowed in the past 10 years. It is unlikely that all dams proposed in the general plans will be constructed due to these challenges and decreased funding.

Local Floodplain Development and Management and Watershed Restoration and Protection Coordination

The 2005 Flood Management Policy Section in the *Kansas Water Plan* recommends multi-objective management of flood prone areas and the incorporation of non-structural measures into watershed district plans to further enhance the reduction of damages from floods while also providing other benefits. The 2007 Kansas Hazard Mitigation Plan[3] supports incorporating nonstructural measures into watershed plans, such as those being developed as part of the Watershed Restoration and Protection Strategy (WRAPS) (see WRAPS Priority Issue), to further enhance the reduction of damage from floods while also providing other benefits.

Since 2005, the state has coordinated the development of WRAPS development. WRAPS groups develop management plans to address locally identified priority issues. Figures 3 and 4 illustrate the common boundaries between watershed districts and WRAPS groups.

Many WRAPS groups have identified flooding as issues of concern in their watersheds. Watershed Districts and WRAPS groups can work together to address multiple

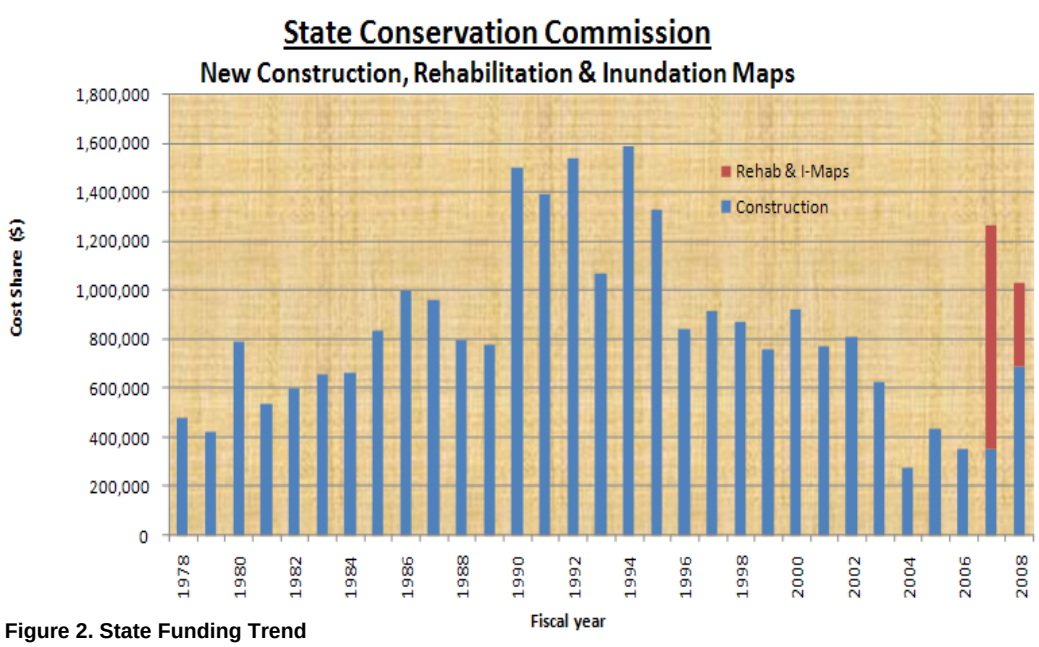


Figure 2. State Funding Trend

resource concerns through implementation of best management practices. Actions taken to address total maximum daily load concerns, such as establishing or maintaining healthy riparian areas, can also positively impact flood flows. A one acre wetland has the potential to provide storage for 1.5 million gallons of floodwater, while also filtering pollutants before discharge. Management of riparian areas to prevent debris accumulation can also be addressed by WRAPS. By sharing resources and expertise, multiple objectives can be achieved.

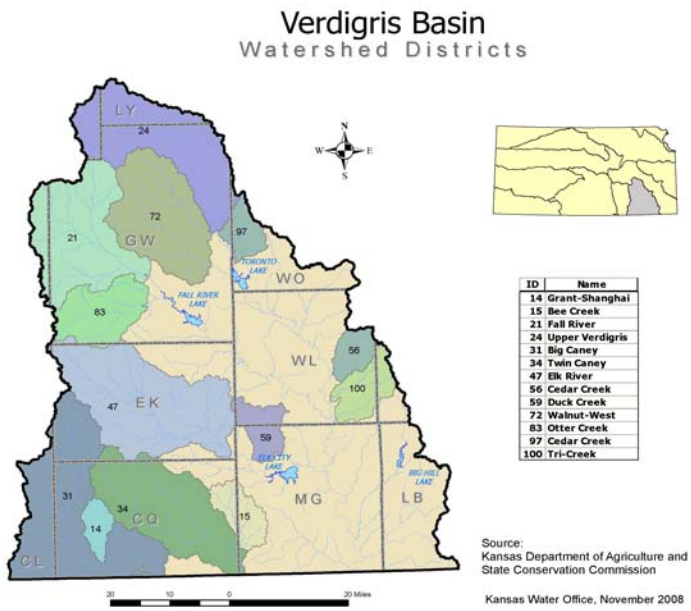


Figure 3.

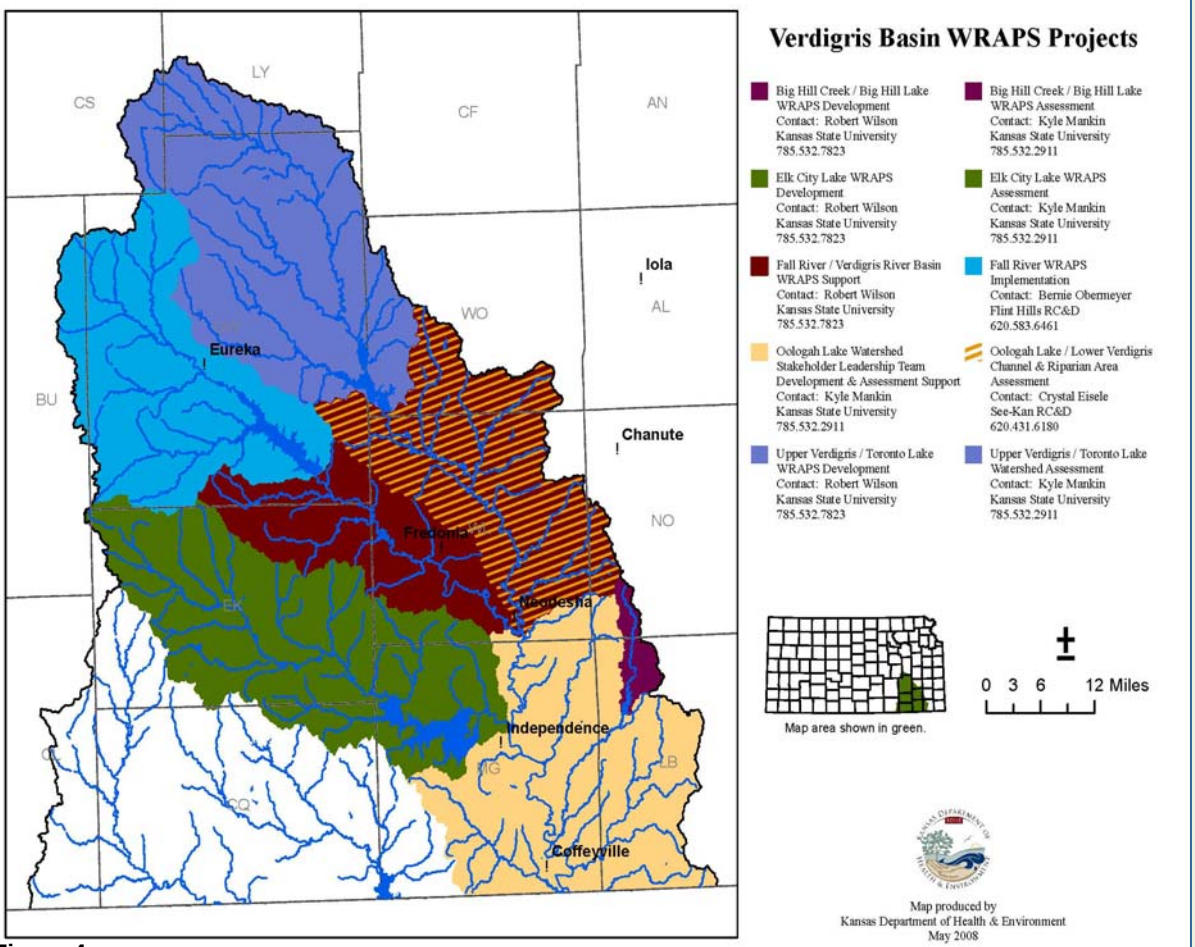


Figure 4.

Recommended Actions

1. Assess the effectiveness of existing flood control infrastructure and develop plans to reduce flood damage to this infrastructure. Ensure that stream obstructions are maintained and free of debris accumulation.

2. Complete repairs of damaged flood control structures and deferred maintenance needs.

3. Determine the current floodplain status and promote NFIP participation, model ordinances and BMPs to local units of government. Limit development in the 100 year floodplain using Flood Insurance Rate Maps to delineate prohibited areas.

4. Engage in WRAPS to integrate comprehensive watershed based flood management with exiting floodplain, wetland, and riparian programs. Assess and inventory watersheds to identify potential locations for non-structural flood control measures.

5. Develop emergency plans for high hazard dams still needing them.

6. Complete breach zone mapping.

7. Coordinate with the DWR Water Structures Program to determine if increased hydrologic and hydraulic evaluation of stream obstructions should be considered in the Verdigris basin or in parts of the basin particularly prone to flooding. Identify and evaluate flood prone areas that may be attributed to permitted stream obstructions. Consider costs to repair damages against costs to implement the program.

Resources

1. Kansas Department of Agriculture-Division of Water Resources. Floodplain Management Guide. http://www.ksda.gov/includes/document_center/structures/Floodplain/ksgg_web.pdf

2. Federal Emergency Management Agency. August 1, 2002. *National Flood Insurance Program: Program Description.*

3. Kansas Division of Emergency Management Adjutant General's Department, November 2007. *Kansas Hazard Mitigation Plan*.

4. Kansas Water Office. July 2005. *Small Dam Safety and Rehabilitation*. Kansas Water Plan Background Paper No. 76.

5. The *Kansas Water Plan* Fiscal Year 2005 Update; July 2003. Final Draft. *Flood Management Policy Section.*

6. USDA Natural Resources Conservation Service. *Kansas 2006 Update: Watershed Protection and Flood Prevention Program (PL-566)*. Salina, Kansas: March 23, 2006.

Verdigris Basin High Priority Issue
Protecting and Enhancing Instream Flows
January 2009

Issue

Streams in Kansas are to meet water quality standards, support a healthy aquatic and riparian habitat, and maintain access to diversions for beneficial uses. The Verdigris River and associated tributaries have been having increasingly frequent occurrences of low flow conditions. Low flows have caused aquatic life stress and impaired water quality. Threatened and endangered species, especially mussels, in the Verdigris River system are impacted by these conditions. Many streams within the basin are experiencing water quality impairments. E. coli bacteria and low levels of dissolved oxygen (D.O.) are the most prevalent stream impairments.

Description

The Verdigris River is an area of high biological importance in the state with populations of freshwater mussels and other sensitive species, and populations that have declined from historic levels. Mussel species are the fauna most consistently in peril throughout the state. Their survival and viability depends on a complex interaction of flow regime, water quality, and the presence of appropriate fish species. Efforts are needed now to begin restoration of streams to a condition where these populations remain viable in the long term.

The droughts of 2000 and 2002 raised concerns in the Verdigris basin, and elsewhere, on maintaining adequate flows for fish and other aquatic life and water quality standards in the Verdigris River. Instream flow needs were not met on several occasions during these droughts. A water issue strategic plan (WISP) working group has been established to evaluate instream flow needs and recommend strategies to meet those needs. The goal of the WISP is to develop instream flow management concepts and apply where flow protection is needed to maintain the ecological functions and processes of a stream. The Upper Verdigris and Fall River were identified as pilot areas for developing these strategies. For more information on the goals of this team effort, refer to the Water Management Policy Section of the FY2005 *Kansas Water Plan* Issue: *Protecting and Enhancing Instream Flow*.

Verdigris River. Photo courtesy Kansas Geological Survey.

All of the streams in this basin are restricted so that no new appropriation rights are available for the time period July 1 through September 30 (typically the irrigation season). Instream flow needs have been determined for the Verdigris River between Toronto Dam and Neodesha, and the Fall River between Fall River Dam and Neodesha. In 2006, the Kansas Department of Agriculture-Division of Water Resources (DWR) released a report titled *"Instream Flow Assessment of the Neosho and Verdigris River Basins"*.[2] The concept of instream flow is the idea of protection and recovery of streamflow as it relates to habitat, species, and water quality. The term instream flow recognizes that some minimum flow is needed to maintain suitable aquatic habitat and water quality.

The two key objectives of the study were: 1. To develop and apply a means of evaluating surface water availability in the basins; and 2. To consider management options available to the State of Kansas, given that a means of evaluating surface water availability could be adopted as a basis for decisions governing further appropriations. The study sought to determine a way to quantify a safe yield in the Verdigris basin in order to determine how much water is available under various conditions and how much could be appropriated for desired uses.

Water right appropriations are based on the diversion of an authorized quantity of water to be applied to an authorized place of use according to the prior appropriation doctrine in Kansas Water Law. The concept of a water right for an authorized quantity of water flowing in a stream is not supported by Kansas Water Appropriation Act (KWAA). The report contains recommendations for necessary changes to statutes and regulations to incorporate this concept.

No changes have been made to the KWAA that would allow for recommendations in the report to be implemented. However, progress has been made toward a means to determine safe yield for surface water similar to ground water that could eventually incorporate instream flow needs.

Verdigris Basin High Priority Issue
Protecting and Enhancing Instream Flows
January 2009

A memorandum of agreement (MOA) between the Kansas Water Office (KWO) and the DWR allows for reservoir operations that maintain target flows at gaging stations in the basin. Target flows recognize the importance of instream flows and the MOA currently serves as an indirect means of ensuring available water for aquatic life. However, many of the challenges for maintaining aquatic habitat and species diversity occur in tributary streams where flow regulation supplemented by upstream federal reservoirs is not an option. In these cases, additional options such as acquisition of abandoned water rights associated with currently unused city water supply lakes need evaluation for providing flow to the tributary and mainstem system.

It is recognized that one solution will not be able to address instream flow problems throughout the basin and that site specific implementation will be needed in many cases. Updated bathymetric surveys are being completed to provide a better understanding of how much water is currently stored in federal and other reservoirs. This information will be used in the Operational Analysis and Simulation of Integrated Systems (OASIS) model to further evaluate the ability of the river-reservoir system to support additional instream flows. The WISP working group continues to meet to consider how other states have responded to similar situations, develop recommendations for changes to statutes and regulations, complete site identification, develop recommendations for pilot implementation for specific areas, and other concerns in need of interagency coordination.

Resources

1. Kansas Water Office. 2003. Fiscal Year 2005 *Kansas Water Plan*.

2. Instream Flow Assessment and Verdigris and Verdigris River Basins. 2006. Kansas Department of Agriculture, Division of Water Resources.

Recommended Actions

1. Continue to work towards coordinated management of the reservoir system to ensure that instream needs are met.

2. Evaluate the potential for using abandoned surface water rights on tributaries to provide flow.

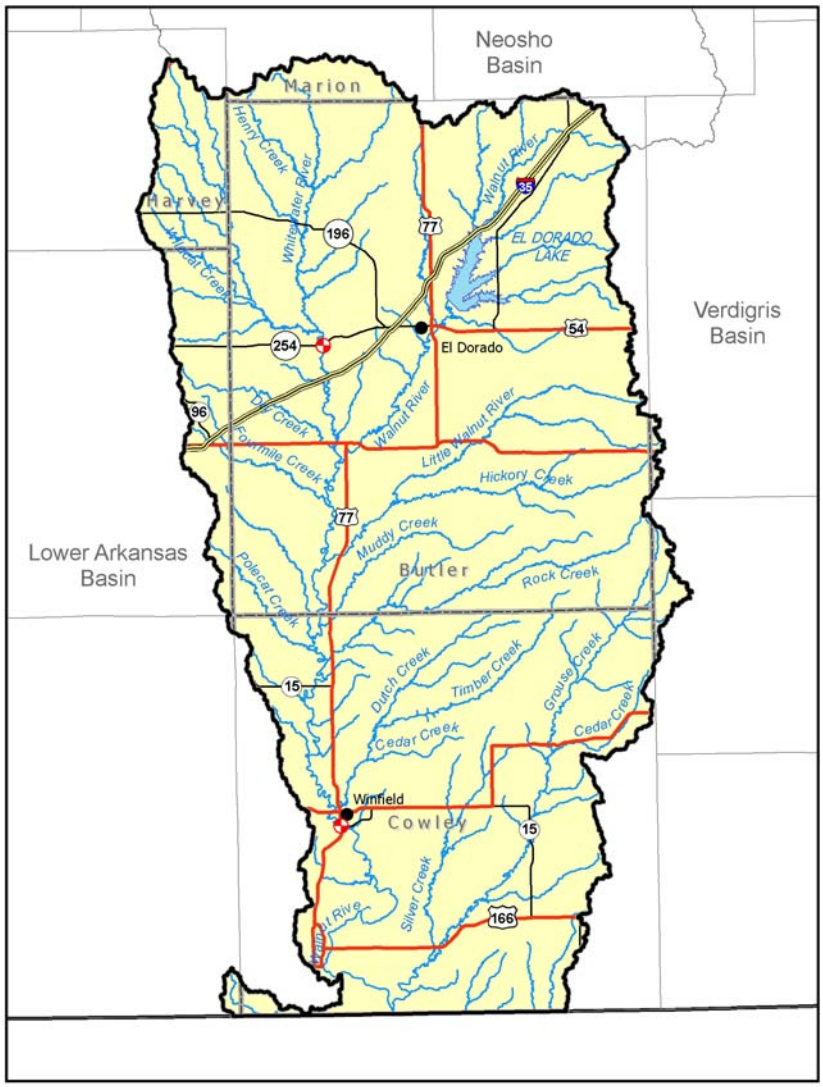
3. Continue water issue strategic plan meetings to ensure intrastate coordination.

4. Identify scenarios and create site specific criteria for improvement. Identify pilot reaches for implementing site specific projects.

5. Participate in interstate discussions to evaluate other states instream flow programs and their applicability to Kansas.

6. Complete the scheduled bathymetry on reservoirs in the basin and use in conjunction with the OASIS model as a decision support tool.

Walnut River Basin



General Description

The Walnut River basin covers approximately 2,380 square miles and encompasses most of Butler and Cowley counties, as well as small portions of five other counties in south central Kansas (HUCs 11030027 and 11030018). The Walnut River rises in the northeastern part of Butler County, joining the Arkansas River at Arkansas City in Cowley County, about 120 miles to the south, and just north of the Kansas-Oklahoma state line.

Other major streams in the basin are the Whitewater River, Timber Creek, Little Walnut River, West Branch Walnut River (all tributaries to the Walnut River), and Grouse Creek. Both the Walnut River and Grouse Creek join the Arkansas River just before it leaves the State of Kansas.

There are two major reservoirs on the river system: El Dorado Reservoir and Winfield City Lake. El Dorado Reservoir is formed by damming four headwater tributaries to the Walnut River in the northern part of the basin: Satchel Creek, Durechen Creek, Bemis Creek, and Cole Creek. Winfield City Lake is built on Timber Creek in the southern part of the basin, northeast of the City of Winfield.

Elevations range from 1,625 ft. at the top of the basin to 1,148 ft. in the Walnut River valley. Major cities in the basin include county seat El Dorado in Butler County and county seat Winfield in Cowley County. Other communities in the basin include Augusta and Andover in eastern Butler County and Arkansas City in southern Cowley County.

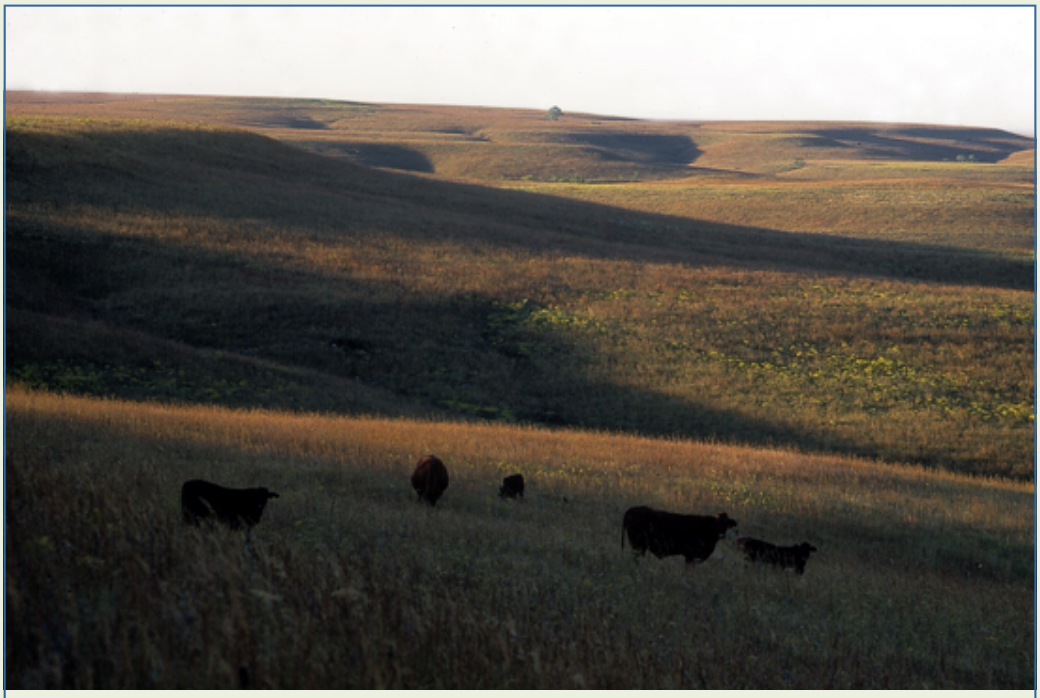
Population and Economy

There were an estimated 95,925 residents in Butler and Cowley counties in the year 2000.

According to the Kansas Division of Budget, the total population in these two counties is projected to increase to 129,243 by the year 2040.[9] This basin illustrates major demographic changes taking place in Kansas. In the past 40 years, two trends have dominated the state and the basin. Rural counties have lost population, sometimes more than 10 percent every decade. While the population of Butler County is projected to increase by 36,756 by 2040, the population of Cowley County is projected to decrease by 3,441 during the same period of time.

The major crops are wheat, soybeans, cotton, hay, sorghum and corn. Crop value was estimated by the U.S. Department of Agriculture, (USDA) to be $83,149,500 in 2006. Livestock production is also an important part of the area's agriculture with beef cattle the predominant livestock raised in the basin. USDA estimates the value of this production to be $88,236,400.[5]

Farm related employment is a small part of total employment in the basin, even though the majority of the land use is for agricultural purposes. The northern part of the basin, generally in Butler County, is one of the fastest growing areas in the state, with Butler County as a whole ranked ninth in population growth between 2000 and 2005. While the rural farm based population is generally declining, there is continued growth in rural areas of non-farm residences outside of city limits in which residents generally commute to employment in either El Dorado, Wichita, or the surrounding suburban communities.



Open Range on the Flint Hills. Photo courtesy Kansas Geological Survey

Although Sedgwick County and Wichita are in the Lower Arkansas River basin to the west, the western part of the Walnut basin is influenced by the Wichita metropolitan area economy and population. The influence of the Wichita Metropolitan area on population in the Walnut basin, especially in Butler County, has been apparent since the 1950s. Growth in the western parts of the counties can be attributed to an eastward expansion of the Wichita industrial and metropolitan area. This is enhanced by the well developed transportation system shown on the basin map. For more information on this issue, see the Regional Planning for Urbanization section.

Petroleum production and refining also supports the basin economy. Several pipelines run through the upper area of the basin. The state correctional facilities and light industry are growing segments of the economy. In addition, construction, wholesale trade, retail, finance, insurance, educational and health care services, arts, entertainment and recreation, and the accommodation and food service industries account for major economic growth sectors. Butler and Cowley County Community Colleges provide opportunities for advanced education.

The Walnut and Whitewater rivers are not considered to be navigable under Kansas law and are generally not accessible to the public for water based recreational activities. See the Recreational Use of the Walnut River Basin Priority Issue. However, El Dorado Reservoir provides an important water based economic resource in the upper part of the basin. El Dorado Reservoir was constructed by the U.S. Army Corps of Engineers (Corps) and was completed in June of 1981.

The reservoir consists of approximately 8,000 surface acres of water, 4,500 acres of park lands and 3,500 acres of wildlife area. The Kansas Department of Wildlife and Parks (KDWP) manages these areas.

Close to one million people visit El Dorado State Park each year. Recreation opportunities include fishing, hunting, camping, boating and observing wildlife.

Reservoir and park visitors also stop in El Dorado and other Butler County communities and purchase products, goods and services which generates around $15 million annually, an estimate that is considered to be conservative. Winfield City Lake provides similar economic benefits in the southern part of the basin.

Zebra mussels, an aquatic invasive species, have populated both of these reservoirs in recent years. Zebra mussels have razor sharp shells and upset the ecological balance of the waters. It is not known at this time what impact the presence of Zebra mussels may have on visitation rates and fisheries production at these area reservoirs. The Zebra mussel, *Dreissena polymorpha*, is a bivalve mussel native to freshwater lakes of southeast Russia. Zebra mussels get their name from the striped pattern on their shells, though not all shells bear this pattern. They are usually about the size of a fingernail, but can grow to a maximum length of nearly two inches.

Its native distribution is in the Caspian Sea. Zebra mussels are considered an invasive species in North America and in Sweden.

Zebra Mussel build up on wet well trash rack , El Dorado Lake

Physical Characteristics

Geology and Soils

The topography of the Walnut basin features a series of east-facing escarpments or hills, including the southern section of the Flint Hills belt which bisects the state from the Nebraska to the Oklahoma borders. The limestone beds in the Flint Hills contain large amounts of flint or chert. Where these beds mantle the uplands, erosion of the underlying soft shales has been reduced. The streams in the Flint Hills upland area characteristically have deep and narrow valleys, lined with outcropping limestone ledges.[2]

The rocks that crop out at the surface in the basin belong to geologic formations of Permian age that were formed about 200 million years ago. The rocks consist of alternating beds of limestone, cherty limestone and shale. Unconsolidated deposits of more recent geologic age occur locally in the uplands and in the valleys of major streams. Chert gravels were deposited in the uplands by ancient streams that traversed the area before the present drainage pattern was established. The unconsolidated valley deposits consist of chert gravel, sand, silt, and clay. Thin, discontinuous deposits of loess or windblown silt also occur locally in the uplands and in the major stream valleys. In most areas, loess deposits are only a few feet thick, but along the Arkansas River in Cowley County east of Arkansas City, the loess is about 30 feet thick.

Limestone cave & spring, Butler Co. Photo courtesy KGS

Soils were developed from the underlying limestones and shales and in most parts of this predominantly hilly area the soils are relatively shallow, making them best suited for native pastures. Upland soils are subject to extensive sheet and gully erosion. This makes the already thin topsoils particularly vulnerable to being washed from the surface contributing to downstream sedimentation in streams and reservoirs.

Conservation treatment of agricultural lands is a major strategy in reducing erosion. Before European settlement, the soils were held in place by deep rooted tall grasses and forbs. Grazing impacts were minimal as the native bison herds moved throughout the expansive grasslands. As a result of more recent intensive cattle grazing, much of the prairie is overgrazed, exposing the soil to erosive forces.

Land Use/Land Cover

West of the Whitewater River, land use is predominately crop land; east of the Whitewater River the land use is predominately grassland except for along the floodplains of the Walnut River and its tributaries. Overall, grassland covers about 66% of the basin, crop land covers about 23% and woodlands cover 5 percent. Subbasins dominated by grassland are the Little Walnut River (82%), Timber Creek (72%), and the Walnut River upstream from El Dorado Lake (81%). Cropland is dominant in the Whitewater River subbasin (65%).[3] (USGS). Less than 3 percent of the basin is urban and less than 2 percent is water.

In 2006 there were an estimated 2,310 farms, covering 1,382,000 acres in the two counties. The average farm size was 608 acres.[5]

According to the 2003 Assessment of Riparian Areas Inventory by the Kansas Geological Survey (KGS), of the 14,887 bank miles of riparian area within 100 ft. of the streams in the basin, the dominant riparian cover is pasture/grassland (41%). The second most common cover is forestland (20%) , and third most common cover is crop land (16%). The remaining riparian cover types, in descending order of dominance, are pasture/tree mix, crop land/tree mix, shrubland, urban, urban/tree mix, and barren land.

Climate

The climate is characterized as humid continental with cold winters and hot summers. Annual precipitation varies from 32 inches in the western part to 34 inches in the eastern part of the basin. Approximately 72% of this precipitation falls between April and September. In an average year snowfall varies between 10 and 15 inches. Table 1 summarizes climate conditions in El Dorado and Winfield for the period between 1971 and 2000.

Table 1
Climate Summary
Walnut Basin

	Average Annual[1]		Freeze Dates (32 F.)[2]		
Location	Precipitation (inches)	Temperature (deg. F.)	Last in Spring	First in Fall	Frost Free Days
El Dorado	35.51	55.5	Apr. 17	Oct. 17	183
Winfield	37.64	56.4	Apr. 14	Oct. 20	189

[1] Source: National Climatic Data Center (1971-2000 data)
[2] Source: KSU Weather Data Library (1961-1990 data)

Wildlife and Habitat

The basin is home to numerous species of fish and wildlife. Approximately 70 species of butterflies have been identified in Butler County alone. The El Dorado Reservoir watershed is located within the Central Flyway for migratory birds. The entire area is part of the Flint Hills Ecoregion. The Flint Hills Tall Grasslands is the smallest grassland ecoregion in North America and is distinguished from other grassland associations by the dominance of tallgrass species–and from the Central Tall Grasslands to the north by its more limited biota and a thin soil layer spread over distinct beds of limestone. These flinty beds of limestone, from which the name of this ecoregion is derived, rendered large areas unsuitable for corn or wheat farming. Today, the Flint Hills Tall Grasslands is an anomaly–an essentially unplowed (although heavily grazed) remnant of the tallgrass prairie. Historically, fire, drought and grazing by bison and other ungulates were the principle sources of habitat disturbance in this ecoregion.

The dominant grass species in this ecoregion are big bluestem, switchgrass and Indian grass. Like other ecoregions of this section of North America, bison and elk once roamed these tallgrass prairies, where they were hunted by the prairie wolf. These species are now gone, although bison are being reestablished in this ecoregion.

There are 14 threatened or endangered species in the basin. Seven are birds, five are fish, one is a mammal and one is a mussel. Butler County has critical habitat for the bald eagle and Topeka shiner, and Cowley County has critical habitat for the Arkansas darter, the Arkansas River shiner, the Arkansas River speckled chub, and the silver chub. Grouse Creek is considered a reference stream in Kansas meaning that it has geomorphologic, biologic, and chemical conditions characteristic of pre-settlement conditions.

Arkansas River Shiner. Photo courtesy Gerald Sneegas

Water Resources

There are no natural lakes in the basin but numerous manmade surface water impoundments have been constructed. Reservoirs in the watershed include Augusta Lake, Winfield City Lake and El Dorado Reservoir. El Dorado Reservoir is operated by the Corps for the primary purpose of flood control. At the top of the conservation pool, the lake is approximately 8,000 acres and has 98 miles of shoreline. Community and other lakes include Fox Lake, Lake Clymer, Rogers Pond, Cowley County Lake, Harvey County East Lake, and Santa Fe Lake. All counties also have state fishing lakes.

The Walnut basin contains 6,830 miles of streams; 5,729 miles of these are intermittent and 1,101 miles are perennial. Stream density in the basin is 2.8 stream miles/ square mile area, making it the basin with the highest stream density in the state.

The major streams in the basin are the Walnut River and its tributaries, the Whitewater River and Little Walnut Creek; and Grouse Creek. Grouse Creek is actually a direct tributary of the Arkansas River and is not hydrologically connected to the Walnut River; however, for planning purposes, the Kansas Water Office (KWO) includes the Grouse Creek drainage with the Walnut River basin. Both the Walnut River and Grouse Creek join the Arkansas River just before it leaves the State of Kansas.

Ground water is present in alluvial deposits along major streams. Real-time water level information can be found at the U.S. Geological Survey (U.S.G.S.) website.[11]

Surface water makes up over 85% of the water used in the basin. The major use of water in the basin is for municipal purposes, at over 75% and 96% of this is from surface sources. Irrigation uses about 14% (77% from surface water) and recreation, industrial, stockwater and other uses account for the remaining 11% (Figure 1).

Water Management

Surface water management and conservation is a priority issue for this basin.

The major streams in the basin are closed to new appropriations during the May to September timeframe. There are two sites where minimum desirable streamflows (mds) have been set (see Basin Map).

Significant water management entities in the basin include the conservation districts in Butler and Cowley counties and eight watershed districts, which cover approximately 95% of the land area of the basin. The

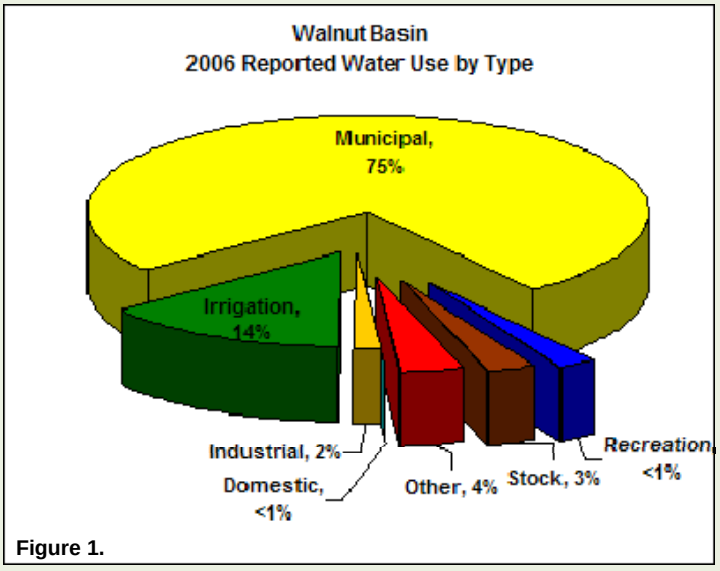


Figure 1.

Corps, responsible for the operation of El Dorado Reservoir, is an important water manager in the basin. The City of El Dorado contracts with the Corps for all of the public water supply storage space in El Dorado Reservoir, making the City another important water manager.

Some communities and rural water districts (RWDs) in the Walnut basin get their public drinking water supply from Wichita.

The cities of Winfield, El Dorado and Arkansas City are permitted, since 2004, under the Kansas Department of Health and Environment Stormwater Program. These municipalities are responsible for managing the quality and quantity of stormwater runoff within their boundaries.

Watershed Restoration and Protection (WRAPS) teams are an emerging water management entity in the basin.

Resources

1. *Kansas Water Plan 2003—Walnut Basin Section*

2. Kansas Water Resources Board Geology and Soils Preliminary Assessment reports; Ecoregion descriptions

3. United States Geological Survey 2000. K. E. Juracek. Report No. 00-4177 "Estimation and Comparison of Potential Runoff Contributing Areas in Kansas Using Topographic, Soil, and Land Use Information.

4. Kansas Water Office. 2008. Reservoir Fact Sheets

5. U.S. Department of Agriculture, Kansas. 2006-2007 County Farm Facts, Agricultural Statistics and Ranking.

6. Wilson, Brownie. 2003. Assessment of Riparian Areas Inventory, State of Kansas. http://hercules.kgs.ku.edu/geohydro/ofr/2003_55/riparian/ofr_2003_55e.htm.

7. Water Rights Information System. Kansas Department of Agriculture-Division of Water Resources, December 13, 2007.

8. U.S. Census Data—2000.

9. Kansas Division of Budget. 2007. County Population Estimates.

10. Kansas Water Resources Board Water Plan Studies. Verdigris Unit Report.

11. http://waterdata.usgs.gov/ks/nwis/rt

Walnut River Feasibility Study

A Walnut River Basin Reconnaissance Study and an El Dorado Reservoir Feasibility Study/Watershed Management Plan have recently been completed by the Tulsa District Corps. The Reconnaissance Study was initiated in 2001 and the Feasibility Study was initiated in 2004.

The scope of the Feasibility Study began as an examination of the Walnut River basin and potential ecosystem restoration opportunities that would use the state's established best management practices (BMPs). Eventually, the study was re-focused to evaluate just the area above El Dorado Reservoir and the reservoir operations and processes, and ultimately to develop a Watershed Management Plan. The purpose of the plan is to identify and evaluate solutions to in-reservoir and watershed problems identified by the State of Kansas and the City of El Dorado that could be implemented in small steps all leading toward long term watershed objectives.

Development of the watershed management plan was guided by two long term restoration and protection goals and twelve specific objectives formulated by the state and the city. The goals were: 1. Identify effective reservoir restoration and protection measures to ensure long range availability of storage space for public water supplies in federal reservoirs, using El Dorado Reservoir as a pilot (with 8 objectives); and 2. Identify watershed restoration and protection needs and determine opportunities to implement effective management practices (with 4 objectives).

The Plan provides valuable information for near term restoration and preservation planning and implementation. A software watershed model was developed using the Soil and Water Assessment Tool (SWAT) to satisfy several of the watershed objectives. Additional data were collected as part of the study, such as a bathymetric survey to determine the current storage in El Dorado Reservoir.

For a complete copy of the report, contact the Kansas Water Office at 785-296-3185.

Walnut River Basin Management Categories

January 2009

MANAGEMENT CATEGORIES

The following categories include issues identified in the Walnut basin plan as items that require attention in addition to the basin priority issues. These issues are addressed within the following management categories:

- Water Management
- Water Conservation
- Public Water Supply
- Water Quality
- Wetland and Riparian Management
- Flood Management
- Water-Based Recreation

These categories also correspond to the statewide management categories and policies of the *Kansas Water Plan* found in Volume II. These documents contain new policy issues and the existing policy and statutory framework that relate to the management categories.

ISSUE: WATER MANAGEMENT

The major streams in the basin are closed to new appropriations during the May to September timeframe. There are two sites where minimum desirable streamflows have been set. One is on the Whitewater River before the confluence with the Walnut River and the other is on the Walnut River above Arkansas City. (Basin Map)

Applicable *Kansas Water Plan* Objectives

- By 2015, achieve sustainable yield management of Kansas surface and ground water sources outside of the Ogallala-High Plains aquifer and areas specifically exempt by regulation. Sustainable yield management would be a goal that sets water management criteria to ensure long term trends in water use will move as close as possible to stable ground water levels and maintenance of sufficient streamflows.
- By 2015, meet minimum desirable streamflow at a frequency no less than the historical achievement for the individual sites at time of enactment.

Applicable Programs

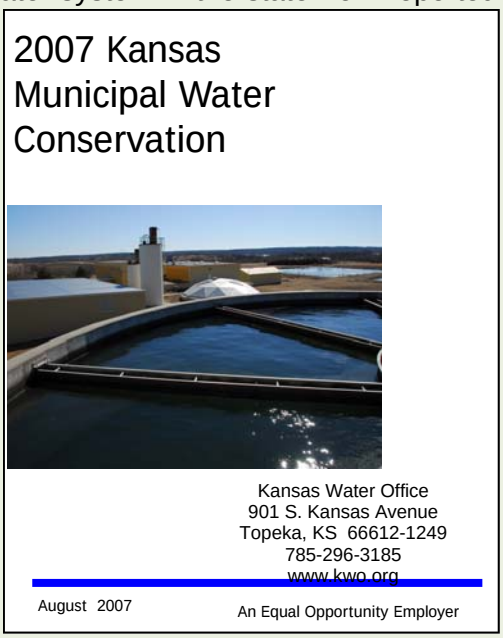
The following programs help to meet the objectives in the Water Management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Water Office: Water Marketing Program
- Kansas Water Office: Water Assurance Program
- Kansas Department of Agriculture-Division of Water Resources: Water Appropriation Program
- Kansas Geological Survey, Kansas Department of Agriculture-Division of Water Resources: Water Well Measurement
- Kansas Water Office: State Water Planning Program
- USDA-NRCS: Environmental Quality Incentive Program

ISSUE: WATER CONSERVATION

Water conservation is essential for the effective management of water resources in the basin to assure that a sufficient, long-term, supply of water is available for the beneficial uses of the people of the state. Conservation is defined as a careful preservation and protection of something, especially the planned management of a natural resource to prevent exploitation or destruction.

Water usage in gallons per capita per day (gpcd) is calculated for each water system in the state from reported data on water use and population served. Average gpcd figures for large, medium and small water suppliers are calculated in eight regions of the State based on similar geographic areas. The Walnut basin is located in region 7. Average gpcd for large, medium and small suppliers in region 7 are: 145, 107 and 100 gpcd respectively. This serves as a reference to indicate if individual supplies are above or below average usage for the region.



Unaccounted for water includes any unmetered uses, such as water used for fire fighting plus water loss in the distribution system. High amounts of unaccounted for water may result from water line breaks, under registering customers, unmetered uses, faulty metering or inaccurate accounting. The statewide average percentage of unaccounted for water use in 2006 was 14%. Technical assistance is available through KWO for systems with more than 30% unaccounted for water.

Walnut River Basin Management Categories

Management of unaccounted for water is a fundamental and manageable tool in providing adequate water supply. Some unaccounted for water represents water that has been treated and then has been wasted and lost the potential to be put to beneficial uses.

The KWO develops and maintains guidelines for water conservation plans and practices. The primary goal of water conservation plans is to achieve more efficient use of the limited water resources of the state. The Water Conservation Plan Guidelines were updated in 2007. Of the 33 public water suppliers in the Walnut basin, 25 have approved water conservation plans, but all but four of these need to update the plans to comply with the 2007 guidelines. All other plans were developed based on guidelines from 1990.

The four basic types of water rate structures used in Kansas are described as flat rate, decreasing block rate, uniform block rate, and increasing block rate. Utilities with a flat rate charge each customer a fixed amount per month regardless of the amount of water used. With a decreasing block rate, the unit cost of water decreases as usage increases. The unit cost of water is the same for all levels of usage with a uniform block rate. With an increasing block rate, the unit cost of water rises as usage increases.

The type of rate structure can affect gpcd usage. Systems with flat rates tend to use considerably more water per capita than systems that meter customer use. The other three types of rate structures, in which cost depends on amount of water used, have a less dramatic effect on gpcd. Decreasing block rates are assumed to discourage conservation because customers are charged lower rates for high-volume usage. Increasing block rates are considered an effective way to promote conservation among high-volume users while keeping the cost of moderate use affordable. However, the use of these types of rate structures does not appear to influence usage by individual customers as much as does the total monthly water cost and the geographic area in which they live.

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce the number of public water suppliers with excessive “unaccounted for” water by first targeting those with 30% or more “unaccounted for” water.
- By 2015, all non-domestic points of diversion meeting predetermined criteria will be metered, gaged, or otherwise measured.
- By 2015, conservation plans will be required for water rights meeting priority criteria under K.S.A. 82a-733 if it is determined that such a plan would result in significant water management improvement.

Tallgrass Prairie, Butler County, Kansas. Photo courtesy KGS.

Applicable Programs

The following programs help to meet the objectives in the Water Conservation management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Appropriation Program
- Kansas State University Research and Extension: Water Conservation and Management Program
- State Conservation Commission: Water Resources Cost-Share Program
- Kansas Water Office: Water Conservation Program
- USDA-FSA: Conservation Reserve Program

ISSUE: PUBLIC WATER SUPPLY

See Surface Water Management and Conservation Basin Priority Issue.

The primary approach to addressing public water supply issues in the basin focuses on ensuring that there are adequate supplies of surface and ground water within the basin to meet future water demands, reducing the number of public water supply systems that are vulnerable to drought, and ensuring that systems have the technical, financial and managerial capacity to meet future needs for water quality and quantity.

Walnut River Basin Management Categories

There are 33 public water suppliers in the Walnut basin, of which 16 are rural water districts (RWD). There is one public wholesale water supply district (PWWSD) in the basin. PWWSD #8 was established in 1982 and is operated by Butler County RWD #3 and El Dorado State Park. The district supplies water to members through a water purchase contract with the City of El Dorado. PWWSDs are considered to enhance the long-term availability of water supply in the areas of the basin they serve.

Drought vulnerable water supplies are those supplies most likely to be first impacted by drought due to basic source, distribution system or treatment capacity limitations; or that rely on a single well as a water supply source. Drought vulnerable water supplies were surveyed in 2003 and 2006. The number of public water suppliers considered drought vulnerable in the Walnut basin decreased from 14 to 4 between the two surveys (Table 1).

Table 1.

Supplier Name	Limitation
Butler RWD # 04	Contractual
Cambridge	Contractual
Dexter	Contractual
Leon	Basic Source

Drought Stage Triggers (Table 2) are the signals that water shortage or other conditions indicative of drought have reached certain stages or levels. They act as the signal to begin implementation of the appropriate stage. Triggers may be related to supply conditions or demand levels. A given stage should have more than one trigger to confirm that conditions are worsening. A water utility or other municipal water entity should enact the appropriate stage whenever the agreed upon set of triggers is reached. Delay in action may lead to a major disruption of the water supply system at a later time.

Every drought response plan should be set up in stages, each one more stringent than the one before it. Triggering mechanisms should be identified to signal the start of a given stage and specific goals should be identified as the desired outcome for each stage. Finally, appropriate conservation practices in the areas of education, management and regulation should be listed under each stage. Stages are appropriate to implement drought response practices or actions because the impact of conservation practices of a moderate stage may preclude the need for the municipal water entity to enact more severe conservation practices at a subsequent stage.

Table 2.
Drought Stage Triggers used by public water suppliers with surface water sources:

1. Lake level in terms of elevation or capacity.
2. Stream level in terms of flow or stage.
3. Water level in relation to the dam.
4. Peak daily demand levels.
5. Percent capacity of treatment plant operations over a number of days.
6. Capacity of water system storage and ability to recover.
7. The provider for purchased water has issued a drought stage.
8. Emergency conditions related to repairs or water quality.
9. The Kansas Water Office has issued a drought stage based on the remaining water marketing storage in a basin reservoir.

Applicable *Kansas Water Plan* Objectives

- By 2010, ensure that sufficient surface water storage is available to meet projected year 2040 public water supply needs for areas of Kansas with current or potential access to surface water storage.
- By 2010, less than five percent of public water suppliers will be drought vulnerable.
- By 2010, ensure that all public water suppliers have the technical, financial and managerial capability to meet their needs and to meet Safe Drinking Water Act requirements.

Applicable Programs

The following programs help to meet the objectives in the Public Water Supply management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Appropriation Program
- Kansas Department of Health and Environment: Public Water Supply Program
- Kansas Water Office: State Water Planning Program
- Kansas Water Office: Water Conservation Program

ISSUE: WATER QUALITY

See Watershed Restoration and Protection Strategy Basin Priority Issue

Water quality and related water resource issues are addressed through a combination of watershed restoration and protection efforts utilizing voluntary, incentive based

approaches, as well as regulatory programs.

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce the average concentration of bacteria, biochemical oxygen demand, solids, metals, nutrients, pesticides and sediment that adversely affect the water quality of Kansas lakes and streams.
- By 2010, ensure that water quality conditions are maintained at a level equal to or better than year 2000 conditions.
- By 2010, reduce the average concentration of dissolved solids, metals, nitrates, pesticides and volatile organic chemicals that adversely affect the water quality of Kansas ground water.
- By 2010, maintain, enhance, or restore priority wetlands and riparian areas.
- By 2015, nutrient reduction goals will be included in all WRAPS projects within the basin.
- By 2010, all public water suppliers will complete and implement a source water protection plan.

Stone Bridge over Badger Creek, Cowley County
Photo courtesy Kansas Geological Survey

Applicable Programs

The following programs help to meet the objectives in the Water Quality management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Health and Environment: State Water Plan Program (Contamination Remediation)
- Kansas Corporation Commission: Conservation Division Programs
- Kansas Department of Health and Environment: Local Environmental Protection Program
- Kansas Department of Health and Environment: Watershed Management Program
- State Conservation Commission: Nonpoint Source Pollution Control Program
- State Conservation Commission: Water Resources Cost-Share Program

ISSUE: WETLAND AND RIPARIAN MANAGEMENT

See Watershed Restoration and Protection Basin Priority Issue for more information.

The primary approach to wetland and riparian management in the basin focuses on providing technical and financial assistance to landowners to protect and restore these resources in priority watersheds through the implementation of best management practices.

Applicable *Kansas Water Plan* Objectives

- By 2010, maintain, enhance or restore priority wetlands and riparian areas.

Applicable Programs

The following programs help to meet the objectives in the Wetland and Riparian category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Wildlife and Parks: Wildlife Habitat Improvement Program
- Kansas Department of Wildlife and Parks: State Parks and Wildlife Areas Planning and Development
- Kansas Forest Service: Forest Stewardship Program and Conservation Tree Planting Program

ISSUE: FLOOD MANAGEMENT

See Comprehensive Flood Assessment Basin Priority Issue

Applicable *Kansas Water Plan* Objectives

- By 2010, reduce the vulnerability to damage from floods within identified priority communities or areas.

Applicable Programs

The following programs help to meet the objectives in the Flood Management category. For more information

on the programs and associated policies, see the Programs Manual.

- Kansas Department of Agriculture-Division of Water Resources: Water Structures Program/Floodplain Management
- State Conservation Commission: Watershed Dam Construction Program
- State Conservation Commission: Watershed Planning Assistance Program
- Kansas Division of Emergency Management: Hazard Mitigation Grants Program
- FEMA: National Flood Insurance Program

ISSUE: WATER-BASED RECREATION

See Recreational Access to the Walnut River Basin Priority Issue

Even though the Walnut basin has a wide variety and fairly high number of public water recreation sites proportional to the area covered, there is a demand for more water based recreation facilities, to meet the needs of a comparatively large population. The approach to enhancing opportunities for recreation is to improve access to water bodies that exist in the basin that are open to the public.

Applicable *Kansas Water Plan* Objectives

- By 2010, increase public recreational opportunities at Kansas lakes and streams.

Applicable Programs

The following programs help to meet the objectives in the Water-Based Recreation management category. For more information on the programs and associated policies, see the Programs Manual.

- Kansas Department of Wildlife and Parks: Rivers and Stream Access
- Kansas Department of Wildlife and Parks: Walk In Hunting Access Program
- Kansas Department of Wildlife and Parks: Fishing Impoundments and Stream Habitats (F.I.S.H.) Program/Walk in Fishing

Walnut Basin High Priority Issue
Watershed Restoration and Protection
January 2009

Issue

The restoration and protection of watersheds, particularly those watersheds above public water supply reservoirs and lakes, is a priority in the Walnut basin. With growing populations in the northern portion of the basin and a corresponding increase in the demand for water, the restoration and protection of these watersheds and the reservoirs below them are of high importance.

Description

El Dorado Reservoir and Winfield City Lake are the two major sources of stored water supply in the basin. El Dorado Reservoir is operated by the U.S. Army Corps of Engineers (Corps). The City of El Dorado manages all of the water stored for public water supply. El Dorado Reservoir is used for public water supply programs that serve numerous cities and rural water districts (RWDs) in the basin, primarily in the rapidly growing areas in the northwest portion of the basin influenced by the Wichita metropolitan area. It is also managed by the Corps for flood control and recreation. Winfield City Lake is owned and operated by the City of Winfield and is also heavily used for recreation.

Reservoir sedimentation and eutrophication are major water supply concerns. As sediment accumulates in a reservoir's multipurpose pool, the capacity for water supply storage is reduced. A recent bathymetric survey of El Dorado Reservoir did not result in a new sedimentation rate for the reservoir due to issues with equipment and accuracy of the original topographic maps. There was also uncertainty about quantities of sedimentation behind the several highway and road bridges, and in borrow pits resulting from dam construction that were not mapped. Future work will involve additional bathymetric surveys and sediment core samples to get a better idea of how capacity in the reservoir has changed since construction. Recent bathymetry in Winfield City Lake indicates that the lake has lost about 713 acre feet of storage to sediment accumulation, leaving approximately 17,921 acre-feet of storage, or about 95% of its original storage capacity, still available.

Zebra mussels

In 2003, the presence of Zebra mussels in El Dorado Reservoir was confirmed, and in 2005 their presence was confirmed in Winfield City Lake. Zebra mussels have also been found in the Walnut River. It is not yet known what the impacts on water quality and recreation in these reservoirs will be. The City of El Dorado, state agencies including the Kansas Departments of Wildlife and Parks (KDWP) the Kansas Department of Health and Environment (KDHE), and the Corps are closely monitoring to identify affects of the mussels on water quality and biology, and to prevent their further spread throughout the basin and into other basins.

Water Quality Impairments

Water quality and related water resource issues are addressed through a combination of watershed restoration and protection efforts utilizing voluntary, incentive-based approaches, as well as regulatory programs.

Surface waters not meeting surface water quality standards in the basin are included on the 303(d) list. The KDHE has completed the first round of Total Maximum Daily Loads (TMDLs) within the Walnut basin based on the 1998 303(d) list, and an additional round of TMDL development was initiated in 2007. Many of the stream segments, configured in a watershed setting, have a TMDL applied to them as a whole. There are 14 approved TMDLs within the Walnut basin that describe the strategies and goals to reduce pollution to achieve water quality standards.[6]

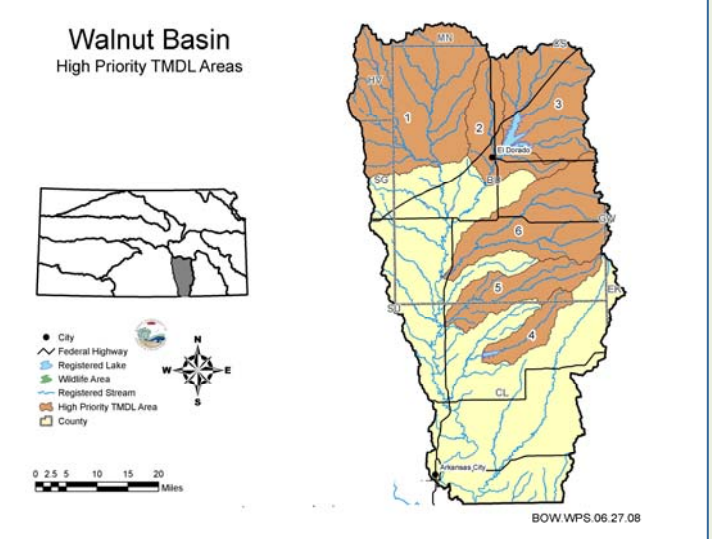


Figure 1.

The 2008 303(d) list submitted to the U.S. Environmental Protection Agency (EPA) identifies watersheds associated with six stream chemistry sampling stations as water quality impaired. There are three lakes in the Walnut basin listed as water quality impaired. Among the streams Atrazine, copper, sulfate and total phosphorus cause impairments. Among the lakes eutrophic conditions indicative of excessive algae production were the

causes of impairment. Each parameter causing impairment requires a TMDL.

KDHE recently reviewed and revised Walnut basin TMDLs and submitted them to EPA in late summer 2008. A new high priority eutrophication TMDL for Winfield City Lake is proposed. The current El Dorado Reservoir TMDLs were evaluated during this round of TMDL submissions and no changes are recommended at this time. Dissolved oxygen (D.O.) and bacteria TMDLs were reviewed and revision of priorities have also been proposed.

High priority TMDL watersheds (Figure 1) are used to target technical and financial assistance for implementation of nonpoint source pollution management practices that can address designated pollutants. Table 1 describes the impairments in each watershed.

TABLE 1
Walnut BASIN HIGH PRIORITY TMDLS

MAP ID	WATERBODY	IMPAIRMENTS	HUC 11 WATERSHEDS
STREAM SEGMENTS			
1	Whitewater River	FCB	11030017
2	Upper Walnut River	FCB	11030017
5	Rock Creek	E. coli	11030018
6	Little Walnut River	E. coli	11030018
LAKES			
3	El Dorado Lake	Eutrophication	11030017
3	El Dorado Lake	Silt	11030017
4	Winfield City Lake	Eutrophication	11030018

Key:
E: Eutrophication, biological community impacts and excessive nutrient/organic loading
FCB: Fecal Coliform Bacteria
HUC: U.S. Geologic Survey Hydrologic Unit Code
Silt: Observed siltation and/or chronic turbidity that impacts development of trophic state
E. coli Indicator organism within FCB

A component of the TMDL process is to quantify the cost to implement best management practices (BMPs) and technical assistance necessary to address the impairments. The State Conservation Commission (SCC) has prepared a "needs inventory" to estimate costs associated with reducing nonpoint source pollution in this basin, and guide implementation of BMPs. Programs are targeted at achieving high priority TMDL goals.

See the KDHE TMDL website listed in the resources for additional information.[6]

Surface Water Nutrient Reduction

The impacts of nutrients originating in Kansas have been well documented – Gulf of Mexico hypoxia, excessive productivity in Kansas and downstream reservoirs, and taste and odor problems in drinking water originating from reservoirs. Reduction and control of nutrients is needed to begin mitigating those impacts. The Kansas Surface Water Nutrient Reduction Plan, developed by KDHE, outlines a statewide strategy for reducing the export of total nitrogen (TN) and total phosphorus (TP) in surface waters leaving the state.[5] This involves additional reductions in nutrients from point source discharges through the National Pollutant Discharge Elimination System (NPDES) Program and reductions in nonpoint sources through development and implementation of Watershed Restoration and Protection Strategies (WRAPS). The Nutrient Reduction Plan includes Improvement Potential Index (IPI) maps for Kansas counties for TP and TN reductions (see maps in Water Quality Policy Section). In the Walnut basin, Butler County showed the highest improvement potential for TN. Both Butler and Cowley counties have high potential for improvement for phosphorus.

Nutrient sources within the Walnut basin include both point and nonpoint sources. The major point sources in the basin include large wastewater treatment plants, which are regulated under the NPDES Program (Figure 2).

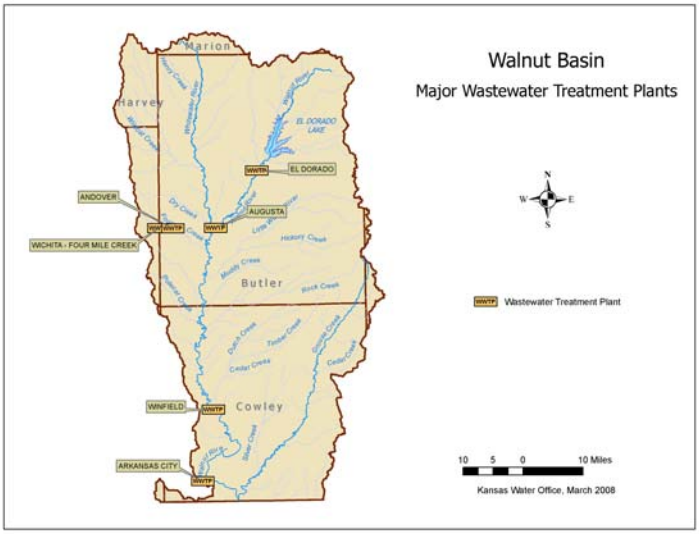


Figure 2. Major Wastewater Treatment Plants in the Walnut Basin

A major component of the Nutrient Reduction Plan involved looking at nitrogen transport to the Gulf of Mexico. In order to calculate the contribution of nitrogen to

the Gulf, nitrogen concentrations of waters exiting the state borders were collected and estimated. Because the Walnut River confluences with the Arkansas River before leaving the state there are no "exit points" for the Walnut River. All contribution from the Walnut basin is added into the Arkansas basin (Upper and Lower) where the Arkansas River exits Kansas into Oklahoma. Therefore, for the purposes of this Plan, the Walnut basin contribution is combined with the Upper and Lower Arkansas basins.

Nonpoint sources of pollution include both agricultural and urban areas. Table 2 shows the relative contribution of point and nonpoint sources in the Lower and Upper Arkansas and Walnut basins for TP and TN leaving the state.

Table 2
Walnut Nutrient Reduction Data
Source: KDHE Bureau of Water – February 14, 2006

Statewide Perspective

Parameter	State Total	UA/ LA/ WAL	% of State Total
TN Leaving State (Ton/yr)	51,205	6,943	14%
TP Leaving State (Ton/yr)	7,670	1,582	21%
Point Source TN (Ton/yr)	10,600	3,503	33%
Point Source TP (Ton/yr)	2,836	886	31%
Nonpoint Source TN (Ton/yr)	40,605	3,440	8%
Nonpoint Source TP (Ton/yr)	4,834	696	14%

UA/LA/Walnut Basin Perspective

Parameter	Total	PS	PS %	NPS	NPS%
TN (Ton/yr)	6,943	3,503	50%	3,440	50%
TP (Ton/yr)	1,582	868	56%	696	44%

The KDHE Bureau of Water administers programs related to public water supplies, wastewater treatment systems, the disposal of sewage, and nonpoint sources of pollution. Programs are designed to provide safe drinking water, prevent water pollution, and assure compliance with state and federal laws and regulations such as the Clean Water Act and Safe Drinking Water Act. State Water Quality Standards include provisions for alternative disposal of treated wastewater and residue material resulting from the waste treatment process. KDHE's minimum standards for the design of water pollution control facilities include guidelines for agricultural application of wastewater and sludge. Reuse of treated wastewater may contribute to water conservation within the basin.

Source Water Protection

All public water suppliers in the basin completed Source Water Assessments in cooperation with the KDHE in 2004.[3] The next step, which is voluntary, is the development of source water protection plans.

Of the 12 public water suppliers in the basin which treat raw water, 3 use surface water and 9 use ground water. Most residents in the basin get water from the Walnut River, one of its major tributaries, El Dorado Reservoir or Winfield City Lake. While more suppliers use ground water than surface water, the populations served by surface water is larger.

Each Source Water Assessment included a susceptibility score which can help communities determine which contaminants pose the most significant threat to their water supply. A susceptibility score was generated from the susceptibility analysis and indicates whether the susceptibility range is low, moderate or high for potential threats of contamination in an assessment area.

KDHE provided public water suppliers susceptibility scores in the following contaminant categories: microbiological, nitrates (applicable for ground water only), pesticides, inorganic compounds, synthetic organic compounds, volatile organic compounds, sedimentation (surface water only), and eutrophication-phosphorus (surface water only).

Fifty-eight percent of the public water suppliers in the Walnut basin had moderate susceptibility scores. Of the public water suppliers in the basin using ground water, 22% had low susceptibility scores and 78% had moderate scores. All of the public water suppliers using surface water received low susceptibility scores.

The most commonly identified problems with ground water were volatile and synthetic organic compounds, pesticides and microbes. The most commonly identified problems with surface water were volatile and synthetic organic compounds, inorganic compounds, sediment and eutrophication (phosphorus). The highest potential non-regulatory source of contamination is single family housing.

For communities using ground water, development of a wellhead protection program is recommended. For communities using surface water, the development of a Watershed Restoration and Protection Strategy (WRAPS) is the best mechanism to ensure water quality protection

for their public water supply. The Walnut basin has no completed source water protection plan and none in progress.

Wetland and Riparian Area Management

The primary approach to wetland and riparian area management in the basin focuses on providing technical and financial assistance to landowners to protect and restore these resources in priority watersheds through the implementation of BMPs. Water quality has been a primary focus with implementation efforts targeted to high priority TMDL watersheds (Figure 1). All conservation districts in the basin have developed wetland and riparian protection plans.

An emerging concern is management and maintenance of forested riparian areas to prevent the entry of debris (dead and fallen trees, etc.) into the tributary/river system. Due to recent ice storms and catastrophic flooding, along with unstable streambanks, the potential for woody debris to collect in and clog bridges and culverts has been elevated. Preventing entry of woody debris into the system can help to manage this.

The Kansas Water Office (KWO) has developed a policy that will provide a systematic approach to the assessment, protection and restoration of wetland and riparian areas and for the restoration of stream channels. The policy promotes a comprehensive evaluation of stream reaches and watershed wetland condition.

Watershed Restoration and Protection Strategies

WRAPS are stakeholder-driven watershed management plans designed to address multiple water resource issues within a specific watershed. The WRAPS process provides a means to integrate objectives from multiple local, state and federal programs into a comprehensive, coordinated strategy for a specific watershed. This can include TMDL attainment, nutrient reduction, source water protection, reduced reservoir sedimentation, riparian and wetland management and other natural resource objectives.[4, 9]

Two watershed planning studies have been conducted in the Walnut basin by the Tulsa District Corps. The first phase, a reconnaissance study, also called a Section 905(b) analysis, was conducted by the Corps to examine water resources problems and identify measures that would resolve problems. This effort was at full federal expense and covered the entire Walnut basin. Successful completion was realized with the identification of several potential solutions to water resource problems in the basin.

El Dorado Reservoir

The second phase was completed in early 2008 and was conducted as a cost shared effort between the Corps, KWO, and the City of El Dorado.[8] The study area for this phase shifted from the entire basin to the evaluation of the upper Walnut River basin consisting of the El Dorado Reservoir and its watershed. The purpose of the study was to identify and evaluate solutions to reservoir and watershed problems identified by the KWO and the City of El Dorado that could be implemented in small steps all leading toward long term watershed objectives. Two goals guided the study:

1. Identify effective reservoir restoration and protection measures to ensure long term availability of storage space for public water supplies in federal reservoirs, using El Dorado Reservoir as a pilot (eight objectives); and
2. Identify watershed restoration and protection needs and determine opportunities to implement effective management practices (four objectives).

The goals of the project were generally met, but some objectives were either not fully met or were not achievable within the time and budget resources of the study. The watershed management plan provided in the report provides information valuable for near term restoration and preservation planning and implementation. A software watershed model was developed using the Soil and Water Assessment Tool (SWAT) to satisfy several of the watershed objectives. A significant finding of the modeling was the consistent result that installation of

grass filter strips as BMPs along streams and riparian areas and as field borders has the potential to reduce sediment delivery by 70% to 80%. The results of this effort will allow more strategic targeting of future BMPs.

The entire report is available on the KWO website.[10] This report will serve as the basis for a WRAPS plan to be developed and implemented locally. Plans are underway to apply for funding to accomplish this. The Butler County Conservation District has been implementing BMPs in the watershed for almost 15 years and development of a WRAPS plan, using information contained in the report, will allow more targeted use of resources.

In Cowley County, the City of Winfield provides cost share funds to landowners in the Timber Creek watershed above Winfield City Lake to install BMPs to reduce pollution entering the lake, especially sediment and nutrients. A bathymetric survey completed in 2007 indicates that the lake has lost approximately 4% of its water storage capacity. Raw water from the lake experiences blue-green algae blooms that result in taste and odor occurrences in the finished drinking water. These blooms occur when excess nutrients are present in the water and other environmental conditions exist that lead to algae production.

An important consideration for watershed restoration and protection in this basin, particularly in the northern portion of the watershed, is urbanization. Butler County is growing rapidly due to eastward expansion of the Wichita metropolitan area. This growth is affecting water supply infrastructure, water quality, natural resource conservation, and land use decisions. For example, as the amount of impervious surface in a watershed (i.e. rooftops, roads, parking lots, etc.) increases, water resources can be adversely impacted from increases in runoff volume and additional pollutants associated with urban environments. Efforts made by local governments and urban residents to minimize these adverse impacts through sound land use planning and stormwater management help to address this issue.

Local land use planning and zoning authorities provide cities and counties effective tools to minimize the potential impacts of development on water resources. Urban stormwater management programs can be implemented to manage the amount of impervious surface in urbanizing watersheds and properly control increased runoff . Programs that provide technical assistance and education to urban residents regarding actions that can reduce or eliminate potential pollution sources also play an important role. These programs can be integrated with WRAPS projects to ensure a comprehensive approach to watershed management in urban areas.

Another consideration for watershed restoration and protection in the basin will be the potential for conversion of Conservation Reserve Program (CRP) acreage back to production agriculture as contracts expire. Contracts on 4,476 acres expired on September 30, 2007 in Butler and Cowley counties. If land is taken out of permanent grass cover, implementation of BMPs will be needed to minimize potential adverse impacts to water resources within the basin.

Stone bridge over Badger Creek, Cowley, County.
Photo courtesy Kansas Geological Survey.

Other Watershed Related Activities

- Both Cowley and Butler counties have adopted local sanitary/environmental codes and participate in the Local Environmental Protection Program (LEPP).
- Butler County has countywide planning and zoning programs but Cowley County does not.
- Both conservation districts in the basin have adopted nonpoint source pollution management plans. A grant under the State Water Quality Buffer Initiative has also been awarded in Cowley County in the basin supporting buffer coordinators and facilitating enrollment of stream buffers in continuous CRP.
- Of cities in the basin, Arkansas City, El Dorado, and Winfield are subject to the Phase II Permitted Municipal Separate Storm Sewer System under the NPDES Stormwater Program.
- As of December 2007, there were six active contamination sites being remediated through the State Water Plan Contamination Remediation Program. Most of

the contamination is a result of hydrocarbon contamination by refineries.

- There are eight organized watershed districts in the basin.

Recommended Actions

1. Begin formation of a WRAPS group above El Dorado Reservoir. Work with stakeholders to incorporate TMDL implementation, nutrient and sediment reduction, and urban stormwater management goals into the WRAPS project. Coordinate with development of source water protection plans.

2. Continue to provide cost-share funds through the City of Winfield to landowners in the Winfield City Lake watershed to install BMPs to protect water quality.

3. Continue efforts to prevent the spread of Zebra mussels from infected water bodies.

4. Complete assessment of riparian and wetland areas and target resources to restoration or installation of grass filter strips along streams.

5. Coordinate with surrounding counties on urban growth issues.

6. Continue public outreach efforts to educate the public and landowners about the benefits of BMPs. Encourage other agencies and entities in partnerships and participation to support WRAPS initiatives, activities and funding.

Resources

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2. Kansas Department of Health and Environment, Bureau of Environmental Remediation.. December 2007. *Basin Updates and Site Accomplishments.*

3. Kansas Department of Health and Environment, Bureau of Water. 2004. *Kansas Source Water Assessment Report*, www.kdheks.gov/nps/swap

4. Kansas Department of Health and Environment, Bureau of Water. 2007.*Kansas Watershed Restoration and Protection Strategy*, www.kdheks.gov/nps/wraps

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8. U.S. Army Corps of Engineers, Tulsa District. January 2008. Walnut River Basin, Kansas. *Feasibility Report – El Dorado Lake, Kansas Watershed Management Plan.*

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10. Kansas Water Office. Reports and Publications.

Walnut Basin High Priority Issue
Water Supply Management and Conservation
January 2009

Issue

The western part of the Walnut and the eastern part of the Lower Arkansas basins have experienced population growth at an increasingly high rate over the last few years, resulting in increasing demands placed on existing water supplies. While surface water and ground water supplies are available to meet current and future (2050) demands in the area and are generally of good quality, supplies are not necessarily located in the immediate area of demand. A complete understanding of the capability of meeting future demand is needed.

For water supply issues, it is necessary to evaluate the above concerns on a regional rather than a basin scale. For this issue, the region is defined as the five-county area that includes Butler, Cowley, Harvey, Sedgwick and Sumner counties. In order to improve sustainability and address the availability of adequate public water supply to meet long-term needs, evaluation of surface and ground water management and conservation, including supply and demand analysis and aquifer characterization are needed.

Description

Communities in this region have long been aware of potential water shortages in the future and have taken proactive steps to secure supplies for current and future uses. The City of El Dorado manages the public water supply storage capacity in El Dorado Reservoir and is a regional supplier of raw and potable water**.** The City of Winfield owns a water supply reservoir, Winfield City Lake, which will be adequate to provide water to the city and surrounding area for many years. Augusta City Lake can serve as a short-term back up supply for the city. Additional small community lakes serve localized areas. The City of Wichita is a major regional water supplier and has adopted a plan of action to ensure adequate supplies to the year 2050. This plan utilizes both surface and ground water sources and includes the innovative aquifer storage and recharge project. See the Lower Arkansas Basin Section for more description of this project**.**

Water Supply

Understanding of water supply and demand in the Walnut basin has improved over the last ten years. A study completed by the Kansas Water Office (KWO) in November of 1998[10] found that in the five county region, because of existing water supply in El Dorado Reservoir and Winfield City Lake, the development of additional water supply storage was not warranted. The study recommended that the focus for water supply planning be the development and improvement of the infrastructure of the public water utilities in the region in order to provide adequate service to their customers.

A January 2000 report, *Butler County Public Wholesale Water Supply District Feasibility Study*,[9] evaluated the potential for El Dorado Reservoir to serve as a regional supply for the area and concluded that regionalization is both possible and recommended, with modifications to existing delivery infrastructure.

El Dorado Reservoir

In 2004, a proposal was made by a group of private developers to construct a new 7,000 surface-acre reservoir at the confluence of Grouse and Silver Creeks in southern Cowley County. The KWO updated the population and demand projections and current water supply storage available in that portion of the Walnut basin to determine if a state interest in participating in the proposed project existed. This study found that adequate supplies were available and that the infrastructure to deliver the water where it was needed was the main impediment to providing water supply most efficiently.[1]

In 1997, the Regional Economic Area Partnership (REAP)[11] was formed that includes nine counties in the region. In addition to the five counties listed above, McPherson, Reno, Harper, and Kingman counties are included in REAP. The South Central Water Coalition was formed in 2003 through an inter-local agreement, to collaboratively engage in regional water studies and planning. This area takes in nearly all the Walnut River basin and generally the east half of the Lower Arkansas

basin. The area also includes the Equus Beds aquifer and all of the Wichita Metropolitan Area. This is a geographically and economically integrated area. The Coalition has now been merged into the REAP organization, to be carried on by a special Water Resources Committee of REAP. Through this merger, a paid staff member has been added to assist in the initiatives and work previously undertaken by the Coalition. To address the issue of water supply management and conservation, it is important that public works and planning staffs in the five county area described above, which contains parts of both the Walnut and Lower Arkansas basins, participate in REAP planning efforts. The Water Resources committee of REAP is well positioned to provide leadership in developing a long-term regional water management plan.

In 2005, the U.S. Department of Interior, Bureau of Reclamation (Bureau), through a Planning Assistance to States grant, began a process of gathering, interpreting and consolidating water supply and demand information throughout the nine county region covered by REAP. In March 2008, the Bureau released a draft report of the study titled *"Walnut and Lower Arkansas River Basins Water Supply Special Study – Kansas"*.[8] The purpose of the study was to provide information for the formulation of strategies for supply sources and associated water treatment and distribution alternatives to meet the future municipal and industrial demands and usage within the study area. The draft report recommended that local water users explore inter-local efforts to meet future water demands in the most cost effective manner.

The following strategies were evaluated in the report: enhanced water conservation, existing surface water supplies, use of river water while in flood stage, water reuse, desalination of brackish water, development of existing ground water supply sources, and cost sharing opportunities. The report is still draft and is undergoing external review by participating partners; it is expected to be released in the near future.

In 2007, KWO initiated an analysis of water supply and demand in five Kansas river basins. The analysis utilized historic climate and streamflow, along with current census information to predict the total water supply and demand in the basin over time. The preliminary finding in the Walnut basin was that in Butler County, which is primarily served by El Dorado Reservoir, demand could exceed supply during a 2 percent probability drought by the year 2025 (Figure1). If other sources of water in the basin are included, the projection for shortages in Butler County is in the year 2052. This evaluation did not include ground water availability from the Wellington formation, or sources from outside of the basin that are or could be used to supply water in the Walnut basin.

The 2007 KWO analysis did not account for water that is used in the Walnut basin that originates in the Lower Arkansas basin and is distributed across basin boundaries by the City of Wichita and rural water districts (RWDs). Because the northern part of the Walnut basin is strongly influenced by regional growth patterns to the west, long-term water supply issues will be best addressed by planning with the cities and RWDs in the eastern part of the Lower Arkansas basin. The groundwork exists to build on the information in these studies to develop long-term water supply plans for the region.

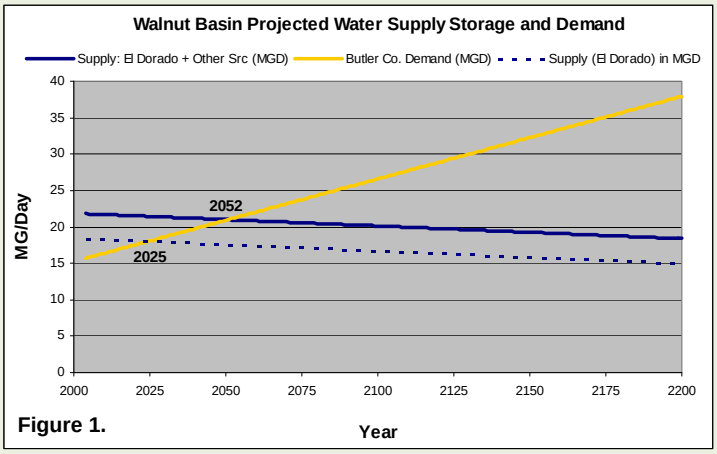

Figure 1.

The major sources of surface water storage in the Walnut basin are El Dorado Reservoir, Winfield City Lake, and Augusta City Lake. Cities in the southern part of the basin get their water from the Walnut River and alluvial wells. Numerous watershed dams have been built in the basin for rural flood control and these have not been considered as either back up or primary sources for water supply and no infrastructure is currently in place to distribute water stored in these structures. Another potential source is ground water from the Wellington formation. Preliminary evaluation of this aquifer indicates that it may be suitable for a short-term supply but long-term needs in this area of the basin cannot be met due to limited storage in the aquifer.

According to the 1981 bathymetric survey[9] of El Dorado Reservoir, the water supply storage pool had lost about 4 percent of its original storage capacity due to sedimentation. A more recent survey was conducted by the Corps in 2004. Due to changes in technology, it was not possible to compare the two surveys to derive a current sedimentation rate that could be used to project storage

capacity loss to sedimentation in the future. However, the 2004 survey does provide current baseline information for future evaluations. See the El Dorado Reservoir Fact Sheet for additional storage information.

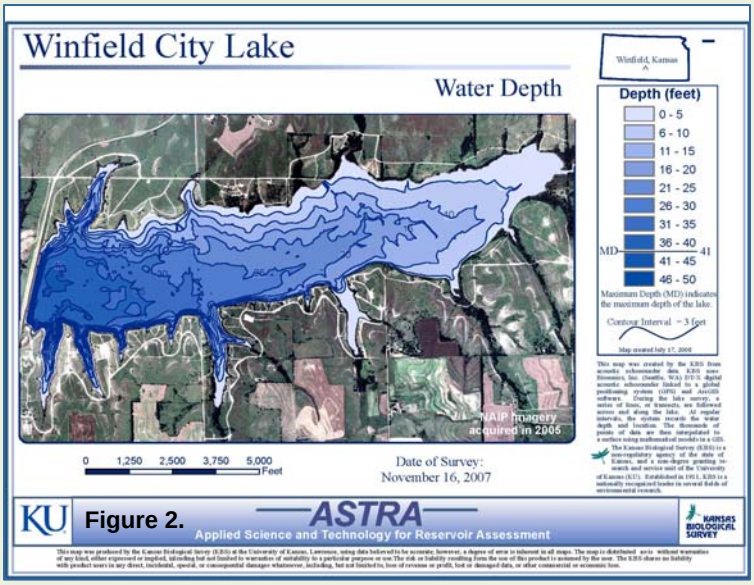

Figure 2.

A bathymetric survey (Figure 2) was completed for Winfield City Lake in 2007. According to this survey, the lake has lost only approximately 4 percent of its original storage capacity and is projected to be able to continue to supply water to the Winfield area for many years. The city has taken steps to reduce sedimentation and maintain water quality in the lake by providing cost-share funds to land owners in the watershed to install best management practices (BMPs) to reduce nutrients and sediment carried in runoff.

The current status of contracts of water suppliers who sell water to other cities and/or RWDs is summarized in the Bureau feasibility study report cited above.[8]

Water Demand

Understanding of water demand in this basin has grown in the past ten years. The most comprehensive information is available in the Bureau report cited above. Fundamental to the recommendations included in the report is the need to manage demand for water. Managing or reducing demand effectively creates additional supply available for essential uses and extends the life of the supply. Actions taken by individuals can have a positive cumulative effect in reduction of water demand. These include low flush toilets, low flow water faucets, hot water on demand water heaters and other water efficient appliances, and xeriscaping. City utilities can implement rate structures that encourage water conservation and demand management.

Municipal and Industrial Demand

In the 2007 KWO supply and demand analysis, all population projections were developed from the county level, so entire counties were assigned to the basin based upon predominance of area *and* existence of larger incorporated areas. The Walnut River corridor in the analysis included Butler and Cowley counties. This demand analysis does not include the larger region recommended for water supply planning purposes.

Water demand associated with the population projections is based on municipal water use as gallons per capita per day (gcpd) usage reported to the Kansas Department of Agriculture-Division of Water Resources (DWR) for 2000 through 2004 by suppliers in the basin.[2] The quantity of water that municipalities sold for non-domestic use is not included in gpcd calculations and was added to the total. To develop the total projected water use from industry, commerce, agriculture and recreation, all non-municipal surface water points of diversion within five miles of the main stem of each basin were selected.

The projected surface water demand increase on the Walnut River corridor and El Dorado Reservoir is primarily associated with the anticipated demand increase of Butler County. As discussed above, further evaluation of future water supply and demand should be done in a regional context rather than a basin context.

Walnut Basin High Priority Issue
Water Supply Management and Conservation
January 2009

Recommended Actions

1. Continue to support collaborative efforts of the REAP to provide leadership in regional planning for water including urban growth issues (see Regional Planning for Urbanization Basin Priority Issue).

2. Develop inter-basin hydrologic models with location specific supply and demand information.

3. Identify options for supply and demand management including: interconnections between public water suppliers, better use of existing supplies, dredging, development of new supplies, modification of reservoir operations, conservation measures, and individual responsible use of water through residential activities. Refine plans to reflect outcomes of identified options. Implement the most beneficial and cost-effective options.

4. Begin incorporating demand management into utility operations. Demand management should also include education of and interaction with the development community and include existing local authorities.

Resources

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2. Kansas Water Office. 2006. *Kansas Municipal Water Use.*

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5. Kansas Department of Health and Environment. 2006. *Public Water System Capacity Development Assessment.*

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8. Bureau of Reclamation. 2008. *"Walnut and Lower Arkansas River Basins Water Supply Special Study – Kansas"*.

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Walnut Basin High Priority Issue
Regional Planning for Urbanization
January 2009

Issue

Demographic shifts in the Walnut basin are influencing land use patterns, water supply and distribution infrastructure, wastewater treatment and disposal, flood damage management, and natural and biological resources. The Walnut basin is strongly influenced by demographic changes in the eastern portion of the Lower Arkansas basin which is experiencing similar demographic impacts. Municipalities seek to guide development within their boundaries or designated growth areas to maximize efficiency of providing services. Unplanned rural subdivisions can challenge the provision of services when municipal boundaries reach rural water district (RWDs) boundaries.

Description

Since settlement, land use in the Walnut basin has been primarily farming and agriculture, dominated by beef cattle production. Oil was discovered in the area in 1915 resulting in a rapid increase in population.

The northern part of the basin, generally in Butler County, is one of the fastest growing areas in the state, with Butler County as a whole ranked ninth in population growth between 2000 and 2005. While the rural farm based population is generally declining, there has been considerable growth of non-farm residences in rural areas outside of city limits in which residents generally commute to employment in El Dorado, Wichita, or the surrounding suburban communities.

Although Sedgwick County and Wichita are in the Lower Arkansas River basin the western part of the Walnut basin is influenced by the Wichita metropolitan area economy, land use patterns, and population. The influence of the Wichita metropolitan area on population in the Walnut basin, especially in Butler County, has been apparent since the 1950s. Growth in the western parts of the counties can be attributed to an eastward expansion of the Wichita industrial and metropolitan area. This is enhanced by the well developed transportation system which makes the area accessible via a network of roads and highways. Several railroad lines and municipal airports, including the Wichita municipal airport, also provide accessibility.

Although these areas are economically and demographically connected, no integrated plan for management of water and wastewater and natural resources has been developed for the area.

Population Trends

Figure 1 shows population trends and projections in Butler and neighboring counties from 1990 projected to 2020.

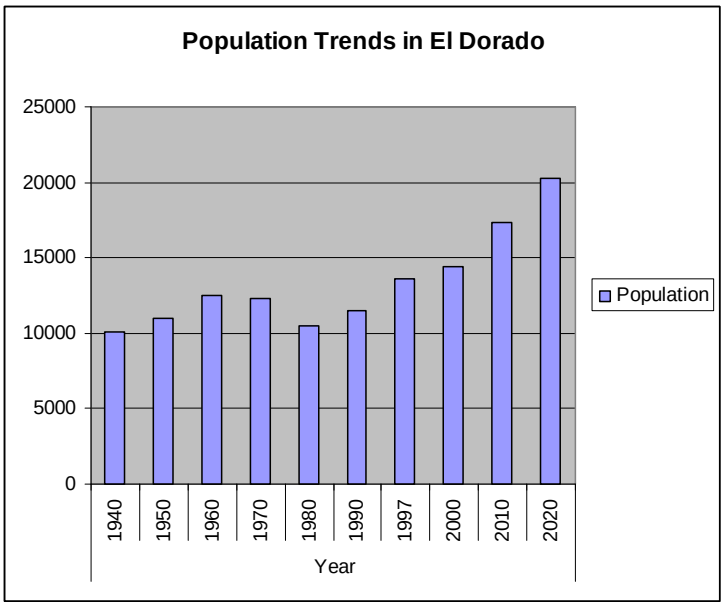

Figure 1. Population Projections for Butler and Neighboring Counties

Regionally, the population of the Wichita Metropolitan Area, which includes Butler, Sumner, Harvey and Sedgwick counties, has been both positive and steady. The population of El Dorado has increased at rates faster than the metropolitan area and the state during the past decade: 17.9% compared to 7.7 percent and five percent. The growth rate in the Wichita metropolitan area was also greater than the growth rate for the State of Kansas between 1980 and 1990.

The population of El Dorado grew by 4,387 persons between 1940 and 2000 (Figure 2). Between 1960 and 1980, El Dorado saw its largest population decrease of the past fifty years as it lost over 2,000 persons, nearly 20% of its population. Since that time, El Dorado's population has steadily increased, growing by 9.5% during the decade of the 1980's. From 1990 to 1997, it is estimated that El Dorado grew by 18%, increasing by 2,064 persons. El Dorado is projected to continue growing. It is in one of the fastest growing counties of the region and is expected to grow by about 5,847 persons in the next twenty years.[1]

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Regional Planning for Urbanization
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Urbanization Impacts

Community officials are interested in growth of their respective communities. Scattered subdivisions outside of municipal service areas in this region often develop around urban centers with little or no long range planning to provide permanent, economical water and wastewater services and to avoid the creation of nuisance conditions and public health problems. Common results include failing onsite wastewater systems, overloaded sewer lines, inadequate water distribution pressure and overloaded or undersized water and wastewater treatment facilities.

Conflicts have arisen between RWDs and municipalities concerning water supply service areas and distribution systems. Availability of utilities outside municipal boundaries supports growth of isolated subdivisions, contributing to unmanaged growth, and the need for enhanced transportation system and other infrastructure development to move people and goods. Impacts on the efficacy of fire protection services have occurred. Unmanaged suburban development has resulted in subdivisions using onsite wastewater systems because municipal wastewater treatment is not available outside of municipal service areas.

Rural Water Tower.
Photo courtesy KGS.

Changes in land use from agricultural use to roads, homes and businesses have resulted in increased runoff and nonpoint source pollution into receiving waters, and fragmented habitat and natural areas. Valuable wetlands and riparian areas that buffer streams from pollutants have been lost.

In the Walnut basin, due to lack of widespread quantities of high quality ground water, development of housing in a non-dense manner is facilitated by the development and presence of rural water systems. Many rural subdivisions could not be viable if they were solely dependent upon ground water supplied water wells. Also facilitating the ability of isolated subdivisions to be viable is the availability of other utilities including electricity and phone service. Due to the remoteness of some of the outlying subdivisions that cannot be served by municipal wastewater systems, onsite systems are sometimes constructed in sensitive alluvial ground water areas, subjecting them to possible pollution from wastewater.

Local Planning Authorities

In the League of Kansas Municipalities publication "Kansas Local Government Law"[2], an entire chapter is devoted to Kansas Planning and Zoning Laws. The document states *"The statutory scheme for planning and zoning by local governments in Kansas reflects a smorgasbord of laws that authorize cities, counties, townships, improvement districts, metropolitan planning commissions, regional planning commissions, and airport and port authorities to engage in some form of planning and zoning."* A cornerstone of city and county planning is development of a Comprehensive Plan. These plans are to provide for the coordinated development of the city or county regarding the use of land, population and building intensity standards, public facilities, public improvement priorities, capital improvement plans, conservation of natural resources, and other elements deemed necessary to the proper development of the area. Plans are implemented by city and county zoning and subdivision regulations. In the counties most influenced by growth patterns in this region, Butler, Harvey, Reno and Sedgwick counties have zoning ordinances. Cowley County does not, except for in a small area around the community of Udall.

Most counties in the area, and particularly Sedgwick and Butler counties, operate under different regulations for planning and development. Within counties, regulations also vary among cities. Subdivision regulations that could impact water and wastewater, stormwater runoff, and maintenance of valuable or sensitive open space also differ. Long range comprehensive plans stop at county lines and do not include regional considerations. Cities can control development within a three mile radius of their boundary through inter-local agreements between the city and county. Many rural subdivisions are outside of these boundaries.

Regional Planning

Community leaders recognized the benefits of and need for integrated planning in 1997 when the Regional Economic Area Partnership[4] (REAP), was formed. REAP is comprised of thirty-four city and county governments in

nine counties of South Central Kansas, which include Butler, Cowley, Harper, Harvey, Kingman, McPherson, Reno, Sedgwick and Sumner counties. These jurisdictions have voluntarily joined together for two primary purposes: first, to guide state and national actions that affect economic development in the region; and second, to consider and adopt joint actions among member governments that enhance the regional economy. Figure 1 shows the member counties of REAP.

Recognizing that the availability of adequate quantities of good quality water is essential to economic growth, and that comprehensive planning is necessary to protect water and natural resources, a Water Resources Committee was established in 2003. One of the REAP goals for 2008 was to "Review progress of the REAP Water Resources Committee to ensure appropriate action that will encourage collaboration among local governments on regional issues of water quality and water supply."

Goals of the Water Resource Committee for 2008 are established in the annual work plan. These are:

- Serve as a regional conduit for dissemination to members of information and education regarding the various activities, programs, funding and initiatives as to the various federal, state, regional and local agencies involved in water quality and supply issues in the South Central Kansas Region;
- Serve as a regional voice on behalf of the members before federal, state, regional and local agencies and organize member involvement in the activities of those agencies;
- Develop and implement a regional water plan;
- Organize and coordinate collaborative efforts on regional issues of water quality and water supply; and
- Develop or organize services to member water utility operations.

Water Supplies

As land was settled in the past centuries by families and entities that farmed the land, private water wells and location of residences in proximity to reliable surface or ground water were the primary mechanisms of obtaining a safe drinking water supply. Most homesteads were located on a sufficient tract of land to be able to provide enough food for the family and to sell the excess as cash crops, along with livestock production. As time progressed, the rural residents periodically experienced drought conditions which led to dry wells and/or creeks for some period of time. Some wells, if they were capable of reliable production, produced poor quality water. Innovations such as cisterns to store water provided some back up infrastructure during times of scarce water availability. Even so, the reliable availability of adequate water for normal domestic use remained inconsistent.

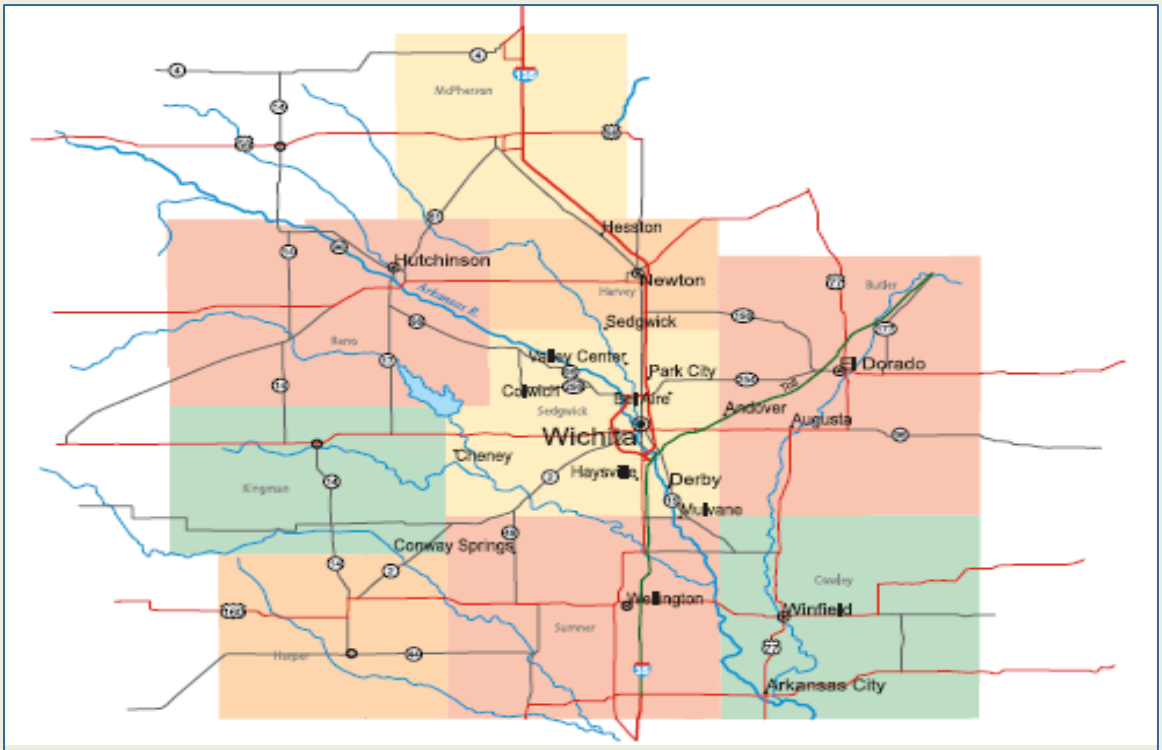

Figure 1. Regional Economic Area Partnership Participating Counties

Kansas state law established the authority of county commissioners to form RWDs in 1941. RWDs were intended to make available safe drinking water throughout the rural landscape, to residences that were typically spaced widely apart. Because the original districts served residences that were not densely located and many miles of delivery lines had to be laid, standards for pipes were less than in more densely populated urban areas.

Once formed, management of the rural water systems is generally performed by the RWD Board

of Directors, and the Boards have no mandate for planning; rather they are service agencies that supply water within their territories where there is a need for a reliable supply of safe drinking water for domestic purposes. RWDs were not intended to support urban densities and demands. Building permits, zoning requirements and subdivision regulations are the responsibility of city and county governments. If a development is approved within the boundaries of a RWD, the district simply provides the domestic water supply. Lack of regional comprehensive planning can lead to case by case decision making for approval of rural subdivisions and other development that may not be in the best interest of the water and natural resources of the area.

Federally indebted RWDs have protection from competition from adjacent municipalities under Title 7, United States Code, Section 1926(b)2. Federally indebted rural water districts are those with a federal loan used to finance aspects of the system. The U.S. Congress intended §1926(b) to protect "federally" indebted water districts from competition for two reasons: (1) Congress wanted to better insure that the federal debt would be repaid, and (2) Congress desired to promote the development of rural water systems to make water available to rural residents that is both economical and safe. This federal law protects RWDs from being incorporated into municipal boundaries, If a RWD is incorporated into a municipality, the law requires cities to pay for lost future revenue of the RWD plus the infrastructure that is often incompatible with city standards. A key element of these standards is fire protection and RWDs infrastructure is often inadequate to perform this function.

City boundaries in the region continue to expand to meet the demands of new residents, businesses and industries. Some cities may be unable to expand their boundaries when they intersect RWD territorial boundaries. Municipalities are required to provide fire protection services and standards for pipes and other infrastructure to insure that they have sufficient capacity.

In recent years there has been an increase in rural residences and subdivisions that are not agriculturally based. Some urban residents desire a more rural experience and migrate outside of city limits to tracts of land covering from one acre to ten or more acres. Often the size of rural single family development lots is dictated by county sanitary codes that prescribe a minimum lot size for which onsite wastewater systems can be utilized. These developments are likely to be served by RWDs that are already established, rather than by private water wells. The districts were historically established to provide water to widely spaced residents, and as agricultural land is sub-divided, the new developments are added to the service lines.

RWDs serve a much needed purpose: to insure that rural residents have access to clean water for domestic purposes. Keeping RWDs viable to fulfill that purpose is vital to rural community health and well being. Municipal water systems are designed to bring the full range of water utility services to urban density and/or commercial/industrial development including water for domestic use, fire protection and high level commercial/industrial demands. In many cases RWDs may not be able to meet those requirements as they were designed to provide basic domestic level services only. Recognizing the difference in the missions of RWDs and municipal utility systems is key to successful resolution of the boundary concerns.

Cowley County Courthouse, Winfield, KS
Photo courtesy Kansas Geological Survey.

County Water and Wastewater Management Plans [5]

In 1979, by adoption of Senate Concurrent Resolution No. 1640, the State of Kansas adopted the Kansas Water Quality Management Plan. One of the specific plan elements called for the control of pollutants from municipal and domestic sources and included a program requiring the development of water and wastewater management plans in urban or high growth counties. In 1980, and again in 1981, the Kansas Legislature passed statutes that required counties to develop countywide water/wastewater management plans to address the provision of acceptable wastewater management contingencies in developing areas of the respective counties.

Counties with populations less than 30,000 could apply to the Secretary of the Kansas Department of Health and Environment (KDHE) for an exemption from preparing a plan. Coordination of water and sewage service was required both by statutes and by regulations developed by the Kansas Department of Health and Environment (K.A.R. 28-16-80). The statutes also included a provision that the plans were required only if federal funds were available to assist local governments in their preparation. In addition to the 75% federal share for plan preparation, the Kansas Legislature provided 12.5% state money to assist the counties, leaving a 12.5% local share.

As a result of the statutory screening process conducted in 1980 which addressed both population and potential water and sewerage problems, 19 counties were identified with immediate needs to prepare plans. Of the counties in the REAP area, Butler, Cowley, Harvey, Reno, and Sedgwick counties were included. Of the 19 counties identified, only eight received federal grants and began their planning efforts. In the REAP area, these included Butler, Cowley and Harvey counties. No planning was started in the others. The 1981 amendments to the Federal Clean Water Act removed the availability of federal planning money from the Act. Therefore, the unavailability of federal funds negated the state requirement to prepare the plans.

Confluence of Little Arkansas & Arkansas River at Wichita.
Photo courtesy Kansas Geological Survey.

The countywide water/wastewater management plans were required to include population projections for 25 years beginning in 1980, and to define areas where water and wastewater systems would be constructed to meet the population growth. The plans were also to define areas where onsite wastewater systems would not be allowed. The regulations also required that the plans be updated every five years. No permits for discharge of waste and no permits for construction of wastewater facilities would have been issued in the county unless the improvements were consistent with the approved plan. This, in effect, required the county and municipal officials to coordinate provision of water and wastewater services with other county development planning.

In a 1985 policy issue of the *Kansas Water Plan* adopted by the Kansas Water Authority, it is noted that the state statute made the development of countywide water/wastewater management plans contingent upon federal funding. A lack of federal funds essentially stopped the program, but the need for planning still existed. The policy recommended modification of the statute to remove the provision requiring plans only if federal funds are available. It further recommended careful review of the statute and regulations to determine if further revisions were necessary. The final recommendation in the policy was that K.S.A. 65-3308 should be revised by the legislature to require preparation of countywide water/wastewater management plans without federal financial support. All counties with populations greater than 30,000 without a plan would be required to prepare a plan. The state would participate in 50-50 cost sharing with amendment of the statute.

After several unsuccessful attempts at legislative action on amending the statute, the policy section was withdrawn from the Kansas Water Plan in 1993 without being implemented.

Across the country, several examples exist in which comprehensive water and wastewater planning and implementation has been successfully implemented. Two of these are in the Baltimore Metropolitan Area and the Durham North Carolina Metropolitan Area.

Water Supply and Demand

See the Surface Water Supply and Conservation Issue in this basin section. In 2005, the Bureau of Reclamation (Bureau), through a Planning Assistance to States grant, began a process of gathering, interpreting and consolidating water supply and demand information throughout the nine county region contained as part of the REAP, which includes Butler and Cowley counties. In March 2008, the Bureau released a draft report of the study titled *"Walnut and Lower Arkansas River Basins Water Supply Special Study-Kansas.*[3] The purpose of the study was to provide information for the formulation of

alternative opportunities to meet the future municipal and industrial demands and usage within the study area by investigating various supply sources and associated water treatment and distribution alternatives and opportunities. Local water users are encouraged to explore inter-local efforts to meet future water demands in the most cost effective manner. The information contained in this report is comprehensive and generally follows the requirements of the County Water and Wastewater Management Plans described earlier.

In 2007, the Kansas Water Office (KWO) initiated an analysis of water supply and demand in five Kansas river basins. The analysis utilized historic climate and flow, and current census information to predict the total water supply and demand in the basin over time. The preliminary finding for the Walnut basin counties is that in Butler County, which is primarily served by El Dorado Reservoir, demand could exceed supply during a 2 percent probability drought by the year 2025. If other sources of water in the basin are included, the projection for shortages is in the year 2052. This evaluation did not include ground water availability from the Wellington formation, or sources from outside of the basin that are or could be used to supply water in the Walnut basin. However, the Bureau study concluded that ground water in the Wellington formation is not of sufficient quality or quantity to provide a reliable long term source of water supply. Groundwater does occur in alluvial aquifers of the basin.

The KWO analysis did not account for water that is used in the Walnut Basin that originates in the Lower Arkansas basin and is distributed across basin lines by the City of Wichita and RWDs. Because the northern part of the Walnut basin is strongly influenced by regional growth patterns to the west, long term water supply issues will be best addressed by planning with cities and RWDs in the eastern part of the Lower Arkansas basin. The foundation exists to build on the information in these studies to develop long term water supply plans for the region.

Coordination with Priority Issues in the Lower Arkansas Basin

The Lower Arkansas Basin Advisory Committee has also identified water supply as a concern and has developed two issues related to this: *The Role of Reuse in Water Conservation* and *Long Term Public Water Supply*. The City of Wichita and Sedgwick County are developing a regional Watershed Restoration and Protection Strategy (WRAPS) to address water quality and natural resource issues in the area. This group can provide additional resources and expertise for development of a regional comprehensive plan to avoid negative impacts of urbanization and preserve the quality and quantity of water supplies and other resources. Coordination with activities, studies, and planning in the Lower Arkansas basin will complement efforts in the Walnut basin.

Recommended Actions

1. The KWO, the KDHE, and other resource agencies should support local stakeholders in providing leadership in developing a comprehensive regional watershed based plan to manage urbanization and minimize impacts on water resources in the area.

2. Plan development should seek consensus among regional stakeholders, including RWDs, on needed changes to local authorities to implement a comprehensive regional watershed based plan.

3. Determine the feasibility of using the model of County Comprehensive Water and Wastewater plans as a template for plan development. Consider recommending modification of existing, or development of new state legislation to provide additional appropriate state oversight in plan development and or implementation.

4. Coordinate planning efforts with the Lower Arkansas basin to assure that these issues are addressed in a comprehensive manner.

5. Include consideration of the impacts of urbanization on water quality, public water supply, inter-basin transfers, flooding, resource protection and related issues.

Resources

1. City of Eldorado. 2001. City of Eldorado Comprehensive Plan. http://www.eldoks.com/compch5b.html

2. Michael R. Heim. 2001. Kansas Local Government Law. Second Edition. League of Kansas Municipalities.

3. United States Bureau of Reclamation. 2008. *"Walnut and Lower Arkansas River Basins Water Supply Special Study – Kansas.*

4. Regional Economic Area Partnership. 2008.

www.reap-ks.org

5. Kansas Water Authority. 1985. *Kansas Water Plan Quality Section. Sub-section: Countywide Water/ Wastewater Management Plans.*

6. KDHE. 2006. *Kansas Source Water Assessment Report*

Walnut Basin High Priority Issue
Comprehensive Flood Assessment
January 2009

Issue

Persistent flood damages in the Walnut basin indicate a need for a comprehensive evaluation of existing flood control infrastructure and storage to determine current status, mapping funding needs, and opportunities for flood management plans and flood damage reduction actions in the future.

Description

Summer 2007 Flooding

During the weekend of June 30 - July 1, 2007 heavy rains that had been occurring for two weeks caused the Walnut River to overflow its banks from Augusta to Arkansas City, and the Whitewater River from Towanda to Augusta. Rainfall during June in Cowley County totaled 23.17 inches and nine inches fell in just four hours in Winfield on the afternoon of June 29th. The Walnut River crested at 35.79 ft. in Winfield on July 1st, almost 18 ft. above flood stage. Highway 77 was closed in areas and residents in many small communities were affected. Butler and Cowley counties were declared federal disaster areas.

Nearly $40 million dollars in twenty southeast Kansas counties, including the Walnut Basin, was approved by the Federal Emergency Management Agency (FEMA) and the U.S. Small Business Administration (SBA) to assist the state of Kansas and the Kansas Division of Emergency Management (KDEM) in the recovery from the severe storms and flooding during the summer of 2007. Watershed district flood control structures in the basin sustained a conservative estimate of $212,500 in damages during the 2007 summer flood.

Although the upstream federal flood control reservoir functioned properly, and numerous smaller watershed dams also detained water, this catastrophic event served as a reminder that even with extensive structural efforts to control flooding, excessive rainfall over successive days will overcome the ability of the system to prevent damage.

Rivers and streams in the Walnut basin have been historically prone to flooding during high rainfall events. Most of the basin land cover is native prairie with fairly steep slopes and shallow soils making it unsuitable for crop production. As a result, row crop agriculture occurs mainly in the fertile floodplains of rivers and streams. Most communities and cities are sited near stream channels and several, including Augusta and Arkansas City ,are located at the confluence of major rivers in the basin, making them vulnerable to flood damage.

Construction of El Dorado Reservoir by the U.S. Army Corps of Engineers (Corps) began in October 1973 and gates were closed in June 1981 to begin filling. Principal purposes of the reservoir, constructed in the upper part of the basin, are to manage flooding and provide reliable water supply. The eight watershed districts in the basin have constructed 215 water retention structures on tributaries within the basin. Several levees have also been constructed in Butler and Cowley counties.

Expansion of urban development in floodplains increases the potential for flood damage. Future flood damages may be reduced by preventing inappropriate development in flood prone areas and by converting land uses subject to flood damage in existing flood prone areas to other more compatible uses. Local governments can implement floodplain management through use of planning and zoning authority and in some cases through requirements of county sanitary codes. There is no state requirement for local units of government to implement floodplain management. The Kansas Department of Agriculture-Division of Water Resources (DWR) provides technical assistance to local governments and offers the following publication for landowners: Floodplain Management Guide: Floodplain Management in

Flooding in the Walnut Basin, July 2007

Kansas. Quick Guide.[1] There is a requirement for cities and counties identified as flood prone to be participants in the Federal Emergency Management Agency (FEMA) National Flood Insurance Program (NFIP) if their residents want access to subsidized flood insurance and to obtain federally backed loans on buildings in flood prone areas.

By minimizing structural development in floodplains, the floodplain area is available to allow flood waters to spread out on the floodplain, slowing the water, allowing sediment to settle out, and reducing its erosive potential.

Flooding in the Walnut Basin, July 2007

Culverts and bridges can be designed to minimize flood damage by allowing adequate space for floodwater conveyance through them which also reduces backwater effects and damage to upstream areas. Design of these structures can consider total anticipated build out flows. Total build out represents the land use that would develop if the county comprehensive plan is fully implemented. Consideration can be given to allowing enough space in stream structures to allow adequate movement of floodwater through them without backing up. Roads can be designed to be at elevations high enough to minimize floodwater encroachment. Increased watershed storage of floodwater in key areas can also reduce the volume of runoff. This can lessen the amount of time it takes to convey the water through structures, reducing localized flooding.

In 2002 legislation was passed that directed the Secretary of Agriculture and the Chief Engineer, Division of Water Resources (DWR) to evaluate the Department of Agriculture's (KDA) current policies regarding stream obstructions (roads, bridges, culverts, levees) and present a report outlining the strengths and weaknesses of a watershed approach to the permitting of dams and other stream obstructions. The Secretary and the Chief Engineer were to make recommendations to the Legislature with regard to clarifying the obligations of the Water Structures Program to upstream and downstream landowners. A questionnaire was sent to city and county governments, the Kansas Department of Transportation (KDOT) and other interest groups to gather their input on pros and cons of a watershed based approach to permitting of stream obstructions. The approach would have required more rigorous hydrologic and hydraulic modeling to evaluate the effect of structures further upstream and downstream of proposed projects than was currently required. Several alternatives were evaluated that would have imposed various levels of increased requirements.

Two public hearings were held. As a result of the evaluation and public input, the approach was not adopted due largely to concerns of local governments about increased costs and time to process permits. In addition, local governments did not recognize that the current procedures were causing problems and the benefits did not seem to justify the increased cost and work load. Some changes were made to the program including increased notification of upstream and downstream land owners of pending permits. An in-house evaluation was conducted on several streams with permitted structures to determine the downstream flooding impact resulting from the structures.

Accumulation of debris within and behind bridges, culverts and other structures is another concern. These accumulations obstruct the flow of water and can exacerbate the ability of the stream to carry flood water through permitted stream obstructions. It is important that permitted obstructions be kept clear of log jams caused by trees, utility poles and other debris washing into streams during high flows. Management of riparian areas to prevent debris from entering the system and causing blockages is an important part of a preventive and routine maintenance program. Well managed and healthy riparian and wetland areas along streams also benefit flood

reduction by storing water on floodplains.

Non-structural management measures also include flood forecast and warning systems. The National Weather Service provides river stage and flood forecasts for the basin through its River Forecast Center located at the Arkansas-Red River basin office in Tulsa. The Kansas Mesonet Steering Committee selected priority counties for new weather stations in 2008. River Forecast Center needs were considered in this process and an additional near real-time hourly precipitation data station is planned for Butler County. This network will become increasingly informative and valuable if the developing trend towards increased frequency of heavy rainfall continues. This information may prove valuable for future design standards for permitted stream obstructions.

Existing Programs and Activities

Federal Emergency Management Act and National Flood Insurance Program

The Flood Management Policy Section of the *Kansas Water Plan* describes flood related activities of the FEMA and the NFIP. The DWR provides coordination and technical assistance for the NFIP in Kansas.

To be eligible to participate in the NFIP, communities must enact flood control ordinances designed to limit floodplain development and to protect those buildings that are constructed in the floodplain from flood damage. Management of floodplain development is the first priority to prevent flood damage.

The DWR assists communities with the development of flood control ordinances and is responsible for approving them. In the Walnut basin, nine communities (Andover, Arkansas City, Augusta, Dexter, El Dorado, Rose Hill, Towanda, Whitewater and Winfield) and both Cowley and Butler counties have enacted flood plain ordinances. Property owners in these communities are eligible to buy flood insurance through the NFIP program. Table 1 details flood damage claims since 1978.

Butler County is in the top ten list of counties in the state for flood insurance dollars paid from 1978-2007 and has received the most flood insurance money in the basin. Butler County also shows the highest amount of claims filed.

In 1997, FEMA initiated a plan to modernize the flood mapping program. The plan proposed a seven-year upgrade to the flood map inventory and an enhancement of the associated products and services. Most existing FEMA flood maps were produced using now outdated manual cartographic techniques. The desire was to produce digital maps compatible with computerized geographic information system software. Federal funding to implement the map modernization plan has not been made available as of 2008.

Butler and Cowley counties are in the technical review phase of having FEMA floodplain maps updated. Butler County is the highest priority for these updates.

Kansas Hazard Mitigation Plan

The Kansas Hazard Mitigation Plan (Plan) was updated in 2007 by the KDEM.[2] In the prioritization of risk associated with 22 hazards that was conducted as part of the planning process, flooding and winter storms ranked second behind only tornadoes in the degree of risk present. The updated plan contains the following in the Mitigation Action Strategy Summary (Table 4.7, p. 4.53): "Integrate flood mitigation into KDOT construction projects. Lead agency: KDOT; Support Agency: KDA". This is shown as having a medium planning priority. It is noted that this action applies to all new construction projects and that more coordination with other agencies is needed.

In the Plan, KDEM included a summary of high and significant risk dams. A high hazard dam (Class C Dam) is a dam located in an area where failure could result in any of the following: extensive loss of life, damage to more than one home, damage to industrial or commercial facilities, interruption of a public utility serving a large number of customers, damage to traffic on high volume roads that meet the requirements for hazard class C dams or a high volume railroad line, inundation of a frequently used recreation facility serving a relatively large number of persons, or two or more individual hazards described in hazard class B. A significant hazard dam (Class B) is a dam located in an area where failure could endanger a few lives, damage an isolated home, damage traffic on moderate volume roads that meet the requirements for hazard class B dams, damage low volume railroad

Table 1

County	Number Policies	Total Coverage	Total Premium	Total Claims Since 1978	Total Paid Since 1978
BUTLER COUNTY	433	$ 64,007,100	$ 237,541	394	$ 7,940,777
COWLEY COUNTY	136	$ 13,214,300	$ 85,123	129	$ 1,540,588

tracks, interrupt the use or service of a utility serving a small number of customers, or inundate recreation facilities, including campground areas intermittently used for sleeping and serving a relatively small number of persons. Dam hazard ratings are based on the risk for loss of life and/or property damage and are not related to the condition of the structure. DWR requires emergency action plans to be developed for high hazard dams. In May 2007, this requirement was extended to include significant hazard dams.

Development downstream of some small dams has resulted in changes in hazard class and necessitated upgrade of the structures. Since 1983, any dam classified as high hazard is required to have a breach inundation map prepared to identify the extent of downstream flooding that would occur if the dam were breached during a catastrophic event. These maps are available to be used by local governments to limit development of houses or other structures in these inundation zones. In the Walnut basin, there are 23 high hazard dams (Table 2), of which 15 are in need of breach inundation mapping. There are 31 significant hazard dams.

Table 2

Significant or High Hazard Dams in the Walnut Basin

County*	Population	Total dams	High Hazard (w/out plans)	Significant Hazard
Butler	63,147	232	11 (5)	9
Cowley	34,931	128	4 (3)	14
Harvey	33,643	29	3 (2)	3
Marion	12,760	25	1 (1)	1
Sedgwick	470,895	78	4 (4)	4

*Counties either wholly or partly within the Walnut basin

The Plan also includes a summary of known flood control levees in Kansas (Table 3). Levees, along with dams, are engineered to withstand floods with a computed risk of occurrence (100-year flood). The condition of many of these levees is unknown.

Table 3

Levees in the Walnut Basin

County*	Levee Design Standard	Flooding Source	Protected Community	Federal Levee?
Butler	100-yr	West Branch Walnut River	El Dorado	unknown
Butler	unknown	Whitewater River	Augusta	unknown
Butler	unknown	Whitewater River	Unincorporated areas	unknown
Butler	unknown	Walnut River	Augusta	unknown
Butler	unknown	Walnut River	Unincorporated areas	unknown
Cowley	100-yr	Timber Creek	Winfield	yes
Cowley	100-yr	Walnut River	Winfield	yes

* includes only counties subject to flooding by Walnut River and tributaries

Watershed Districts

The eight watershed districts in the basin have developed general plans, approved by the DWR, that describe the location and floodwater storage capacity of flood control retention and detention structures recommended to address rural flooding. Most impound water even during non-flood conditions and may have benefits in addition to flood control. Several are available as back up sources of drinking water and some also provide recreational opportunities. Many are used for livestock watering and also protect local roads and bridges. General plans include watershed protection actions including construction of terraces, grassed waterways, and grade control structures to control sediment delivery to the structures.

These general plans have been developed, modified and updated over the 55 years since the program was authorized in Kansas in 1953. Modifications to plans generally occur when structures are de-authorized or relocated, or when structures are added to the plan. Funding for construction comes from federal, state and local sources and there has been a downward trend in funding in recent years as shown in Figures 1 and 2.

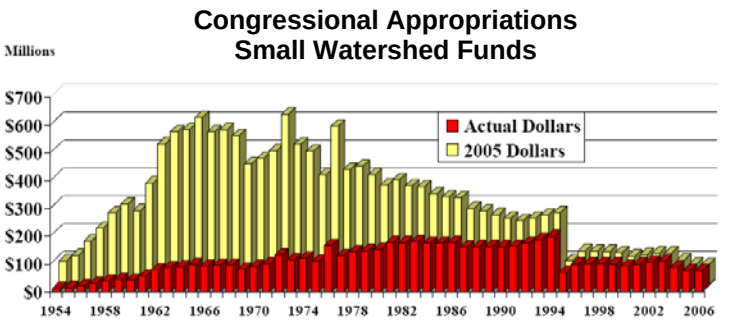

Figure 1. Federal Funding Trends

Construction under the Natural Resource Conservation Service (NRCS) P.L. 566 Program ended in the Walnut basin in 1994 with 139 structures built that drain 1,286,939 acres. There has been no funding in Kansas under the program since 2006. Fifty one additional

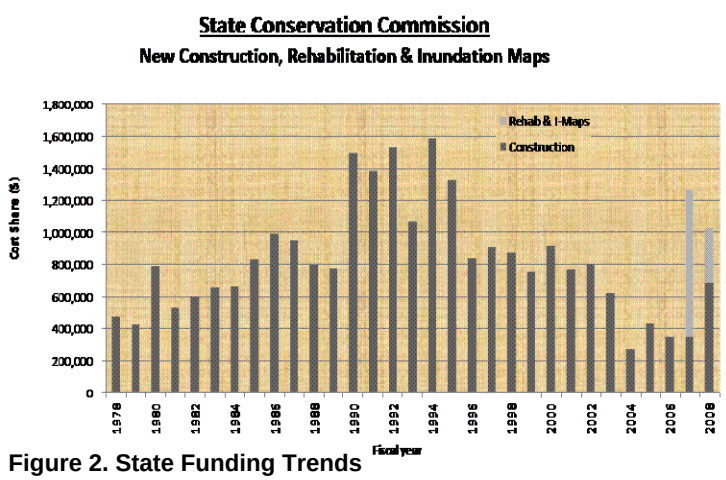

Figure 2. State Funding Trends

structures have been funded with State Conservation Commission (SCC) funding. SCC statewide funding for watershed structures through the Watershed Dam Construction Program peaked in 1994 at about 1.6 million.

Watershed districts have the authority to levee taxes on residents within the district to be used for operating expenses, new structures and routine maintenance of infrastructure. Local funding can also be used to implement best management practices (BMPs) such as wetlands and riparian areas that also provide flood detention benefits. Figure 3 shows the boundaries of existing watershed districts within the basin.

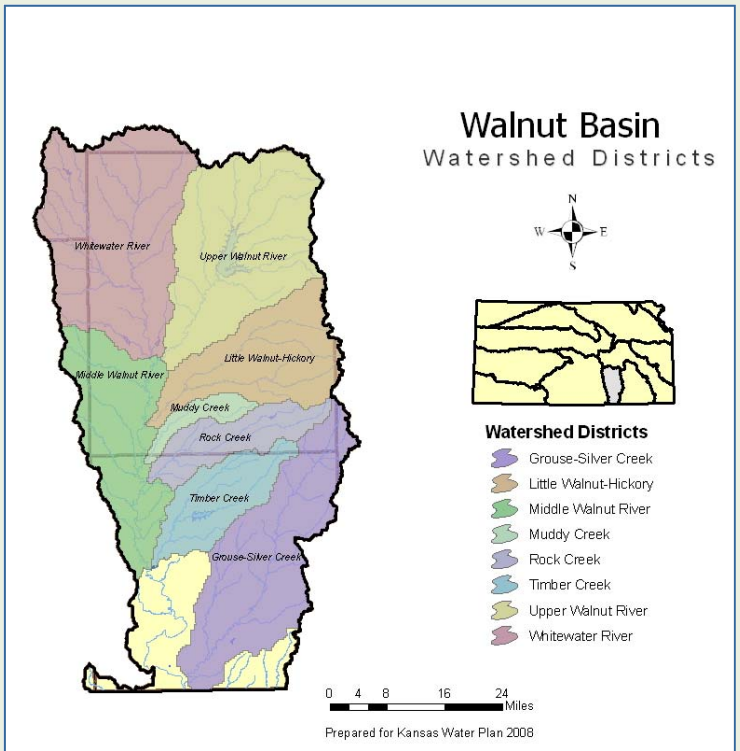

Figure 3.

Because of recent changes in permitting procedures for new dams by the Corps, environmental issues have emerged that must be addressed before a permit can be issued. These issues are becoming increasingly challenging to address and construction of new dams has slowed in the past ten years. It is unlikely that all dams proposed in the general plans will be constructed due to these challenges and decreased funding.

Local Floodplain Development and Management and Watershed Restoration and Protection Coordination

The 2005 Flood Management Policy Section in the *Kansas Water Plan* recommends multi-objective management of flood prone areas. Incorporation of nonstructural measures into watershed district plans can further enhance the reduction of damages from floods while also providing other benefits. The 2007 Kansas Hazard Mitigation Plan also supports incorporating nonstructural measures into watershed plans, such as those being developed as part of the Watershed Restoration and Protection Strategy (WRAPS).

Since 2005, the state has coordinated the development of WRAPS. Local WRAPS groups develop management plans to address locally identified priority issues. Watershed Districts and WRAPS groups can work together to address multiple resource concerns through implementation of BMPs. Actions taken to address total maximum daily load concerns, such as establishing or maintaining healthy riparian areas, can also positively impact flood flows. A one acre wetland has the potential to provide storage for 1.5 million gallons of floodwater, while also filtering pollutants before discharge. Management of riparian areas to prevent debris accumulation can also be address by WRAPS. By sharing resources and expertise, multiple objectives can be achieved.

A WRAPS group has been formed in the Grouse Creek watershed and non-structural activities are being evaluated in their planning. A WRAPS group is being formed in the watershed above El Dorado Reservoir. These efforts present an opportunity to integrate planning efforts.

Recommended Actions

1. Assess the effectiveness of existing flood control infrastructure and develop plans to reduce flood damage to this infrastructure. Ensure that infrastructure is maintained and free of debris accumulation.

2. Complete repairs of damaged flood control structures and deferred maintenance needs.

3. Determine the current floodplain status and promote NFIP participation, model ordinances and best management practices to local units of government. Limit development in the 100 year floodplain using Flood Insurance Rate Maps to delineate prohibited areas.

4. Engage in WRAPS to integrate comprehensive watershed based flood management with existing floodplain and riparian programs. Assess and inventory watersheds to identify potential locations for non-structural flood control measures.

5. Minimize the amount of land owned by the government when purchasing land by involving the private sector and offering the land for sale for appropriate uses.

6. Complete development of emergency plans for high hazard dams.

7. Complete breach zone mapping.

8. Coordinate with the DWR Water Structures Program to determine if increased hydrologic and hydraulic evaluation of stream obstructions should be considered in the Walnut basin or in parts of the basin particularly prone to flooding. Identify and evaluate flood prone areas that may be attributed to permitted stream obstructions. Consider costs to repair damages against costs to implement the program.

Resources

1. Kansas Department of Agriculture, Division of Water Resources. Floodplain Management Guide. 2008. http://www.ksda.gov/includes/document_center/structures/Floodplain/ksgg_web.pdf

2. Kansas Division of Emergency Management Adjutant General's Department. November 2007. *Kansas Hazard Mitigation Plan*.

3. Federal Emergency Management Agency. August 1, 2002. *National Flood Insurance Program: Program Description.*

4. Kansas Water Office. July 2005. *Small Dam Safety and Rehabilitation*. *Kansas Water Plan* Background Paper No. 76.

5. Kansas Water Office. 2003. The *Kansas Water Plan* Fiscal Year 2005 Update; July 2003. Final Draft. *Flood Management Policy Section*

6. USDA Natural Resources Conservation Service. 2006. *Kansas 2006 Update: Watershed Protection and Flood Prevention Program (PL-566)*. Salina, Kansas: March 23, 2006.

Walnut Basin High Priority Issue
Recreational Use of the Walnut River
January 2009

Issue

Increasing public access to the state's lakes, rivers and streams, and recognizing the associated economic, social, and quality of life benefits to be derived from fishing, boating and other water-related recreational activities is an objective of the *Kansas Water Plan*. The Walnut River is not open for public access under Kansas law. However, the river and its tributaries do present numerous opportunities for recreation including boating, hunting, hiking, fishing, wildlife viewing, and camping. The entire extent of current opportunities and access areas is unknown and opportunities to consolidate areas with access have not been evaluated.

Description

The Kansas State Comprehensive Outdoor Recreation Plan (SCORP)[1] states that evaluation of recreation needs of the Walnut basin area indicates that there is an historic and current demand for additional water based recreation in the Walnut basin. These include needs for outdoor, water oriented, recreational activities such as swimming beaches, picnicking areas, camping areas, boating (including kayaking and canoeing), fishing, and water skiing. The report documents increasing perception by the public of the value of natural areas. Activities associated with these areas include hiking, horseback riding, recreational walking, birding and other wildlife viewing, and open space experiences. Recently there has been increased interest in canoeing/kayaking on navigable rivers in Kansas.

The FY 2005 *Kansas Water Plan* states that although the Walnut Basin has two major reservoirs on the river system that have recreation components (El Dorado and Winfield City), there is still a demand for more water-based recreation facilities. The Walnut River and its tributaries are not among the three rivers in the state considered available for public access and use. On tributaries to El Dorado Reservoir, river/stream access does exist in public lands included in the flood control pool. The same is true for Grouse Creek, in the area of the flood control pool of Kaw Reservoir in Oklahoma.

Walnut River near Arkansas City, Kansas

A survey asking why people do not participate more in outdoor recreation, completed during development of the SCORP, found that "not enough time" or "not interested", ranked #1 and #2 . Consistently ranking 3rd was the difficulty of gaining access to private areas. When coupled with not enough public facilities, the primary barrier to outdoor experiences that can be addressed by suppliers becomes clear: Inadequate access. The barrier is even more apparent where rivers are not even open to the public whether or not access points are available.[2]

Despite restricted access due to water laws of the state, canoeing and other float type activities have become increasingly popular in Kansas, with reported participation increasing by 80% in the last decade.[1] Public access is generally provided only on navigable rivers and the upper reaches of public reservoirs. In general the *Stream Access Program of the Kansas Department of Wildlife and Parks*[4] (KDWP*)* is used to provide a systematic approach to implementing general access to navigable Kansas streams. The system is developed by identifying candidate sites, prioritizing their potentials, and scheduling development when funding is available. The Walnut River is not considered to be navigable so is not eligible for this program.

Existing Opportunities for Walnut River/Stream Access

The Walnut River and four of its tributaries are impounded to form El Dorado Reservoir in the northern part of the basin. In the flood control pool and the area within it managed for wildlife, the river and three of the tributaries have access for boating on them. Put-in and take-out for access to the Walnut River above El Dorado Reservoir are at the Chelsea Boat Ramp. The round trip distance from the access point is six miles. Cole Creek, Durechen Creek and Satchel Creek all have useable canoe access at their respective bridges on Highway 177. The Cole Creek access provides an eight mile round trip float. The Durechen Creek access point provides a round trip float of four miles. The Satchel Creek access provides a two mile round trip float.

Within the Kaw Reservoir Wildlife area there are four access points on Grouse Creek. From Silverdale to Traders Bend in Oklahoma, the northernmost access points provides a four and a half mile stretch of Grouse Creek that when combined with a float on the Arkansas River

to Traders Bend in Oklahoma makes a total of 13.5 miles. Intermediate access points are available along the entire stretch. The Silverdale Boat Ramp south of Silverdale provides a float of four and a half miles to the confluence with the Arkansas River. The 2nd Street Bridge Access point provides a float of three miles to the confluence with the Arkansas River. The 3rd Street Bridge Boat Ramp includes two miles to the confluence with the Arkansas River. There is a take out at the Lower Grouse Creek boat ramp.

Depending on the flow conditions within both the river and the impounded water, canoeing/kayaking in these areas can vary from being much like on a still water reservoir with little flow, to high rushing water during high runoff conditions. The canoeing/kayaking experience sought by participants is usually on fast flowing water more typical of un-impounded conditions.[3]

Kansas Department of Wildlife and Parks Programs

KDWP has developed some innovative programs to enhance public access to private lands.

Walk-in Hunting Access Program[4] The Walk-in Hunting Access (WIHA) program was established in 1995 in an effort to enhance the strong Kansas hunting heritage by providing hunting access to private property. The program has grown to one of the most successful access programs in the country. By 2004, over one million acres in Kansas were enrolled in the program providing numerous opportunities for sportsmen to pursue their favorite game at no additional charge. Although the majority of the acreage provides good to excellent upland game bird hunting, some areas provide opportunities for deer, waterfowl and squirrel hunting as well.

Landowners receive a modest payment in exchange for allowing public hunting access. Payments vary by the amount of acres enrolled and length of the contract period. Contract dates can be established from September 1 or November 1 through January 31 of each year. In addition, other lands are leased for spring turkey hunting only (April 1- May 31). Land enrolled can be in the Conservation Reserve Program (CRP) native rangeland, wheat or milo stubble and riparian or wetland areas. The area is posted with signs designating it as a WIHA, regularly patrolled, and safety zones are clearly marked. Liability is waived from private individuals who lease land to the state for recreational purposes. State law provides immunity from damages or injuries resulting from ordinary negligence. Maps showing areas enrolled in the WIHA can be found at the KDWP website listed in the resources.

Fishing Impoundments and Stream Habitats Program.[5] The Fishing Impoundments and Stream Habitats (F.I.S.H.) program is patterned after the WIHA Program with a goal of increasing public fishing opportunities in Kansas. The F.I.S.H. Program was first introduced to Kansas anglers and landowners in 1998. KDWP leases private waters from landowners for public fishing. Landowners participating in F.I.S.H. receive payments, which vary according to the number of water acres enrolled in impoundments or the length and quality of the streams. Annual payments are based on $40 per acre for impoundments and from $500 - $1000 per stream mile. Waters need to be available for public access from March 1 to October 31.

El Dorado Reservoir

F.I.S.H. provides anglers with a place to fish while leaving the land in private ownership, contributing to the strengthening of rural-urban ties. KDWP officials periodically patrol F.I.S.H. areas. Violators are ticketed or arrested for vandalism, littering or failing to comply with fishing regulations. Access is limited to foot traffic, except on roads designated by the landowner in the case of very large tracts of land.

Each year, the KDWP publishes a fishing atlas outlining each body of water enrolled in the program and anglers are asked not to contact landowners. The atlas also contains information about the species of fish present for each water type. This program is made possible by the Federal Aid in Sport Fish Restoration Act, a federal aid project funded by purchase of fishing equipment. Landowners have the option to withdraw from the program at any time. They will be paid a prorated portion of the agreed payment and provided with signs denoting that

the water has been removed from the program.

Regulations related to the F.I.S.H. Program area listed in the Resources section of this document.

Liability is a valid concern. However, state law provides that private individuals who lease their land to the state for recreational purposes are immune from ordinary negligence.

Opportunities with the Kansas Department of Transportation

The Kansas Department of Transportation (KDOT) allows river access at some areas on which they own easements and rights of way for bridges and other river/stream structures. While the land upstream and downstream of these public access points is privately owned, if landowner permission could be secured between the points, reasonably large stretches of the river for boating could be developed.

Increasing Access through Private Lands

The Walnut River and tributaries are not open to public use by state law. Landowner permission on both sides of the stream is required for recreational use to be on the water. When canoeing is the preferred activity, canoeists/kayakers like to have reasonable lengths of stream to float to compensate for the effort of getting the boat in the water at sometimes difficult access points. Obtaining permission on stretches long enough to provide for a reasonable length float trip is difficult, and access is not always readily available even if landowner permission is granted. Many landowners whose land borders the streams have concerns about allowing access due to potential noise, trash, and general degradation of the area. A suggestion has been made that a licensing program be developed for groups or individuals to be authorized to lead groups of people on float trips on private lands. A licensing program would ensure responsibility and include acceptable standards for conduct on public and private lands. Restrictions similar to those related to the F.I.S.H. Program could be part of the license.

Table 1 summarizes publicly accessible water based recreation in the Walnut River basin. Clearly most access is associated with community and state fishing lakes with little available on flowing water in the Walnut basin.

Table 1
Water Based Recreation Opportunities by Basin and Category
Kansas, December 1999[1]

River Basin	Category	Name of Facility	County	Water Surface Acres	Hunting Acres	Number of Facilities with Selected Activities						
						Boat	Camp	Fish	Hiking Trails	Hunt	Picnic	Swim
WAL	Community Lake	Lake George	Butler	4.0	0		yes	yes	yes		yes	
WAL	Community Lake	Sixth Street Pond	Cowley			yes		yes	yes		yes	
WAL	Community Lake	Winfield City Lake	Cowley	1,130.0	800	yes	yes	yes	yes	yes	yes	yes
WAL	Community Lake	Winfield Island Park Lake	Cowley	7.0			yes	yes			yes	
WAL	Large Reservoir	El Dorado	Butler	8,000.0	4,100	yes	yes	yes	yes	yes	yes	yes
WAL	River Access	Arkansas River at Arkansas City	Cowley					yes				
WAL	River Access	Arkansas River - Kaw Wildlife Area	Cowley				yes	yes				
WAL	River Access	Grouse Creek - upper end of Kaw River	Cowley			yes		yes				
WAL	River Access	Walnut River - upper end of El Dorado Reservoir	Butler					yes				
WAL	River Access	Walnut River at Winfield	Cowley					yes				
WAL	State Fishing Lake	Butler	Butler	124.0	351	yes	yes	yes		yes	yes	
WAL	State Fishing Lake	Cowley	Cowley	84.0		yes	yes	yes			yes	
WAL	State Fishing Lake	Kaw WA	Cowley	14.0		yes		yes				

Walnut Basin High Priority Issue
Recreational Use of the Walnut River
January 2009

Recommended Actions

1. Inventory existing access points along the Walnut River and tributaries outside of authorized public use areas that have access provided by KDOT, WIHA or F.I.S.H. programs. Determine the feasibility of developing additional access points that could be linked together to provide reasonably long float experiences.

2. Encourage the use of conservation easements by private landowners with stream frontage that would be willing to allow public recreation in target areas to link with access points identified above. Conservation easements on riparian lands have multiple benefits.

3. Continue to promote participation in the WIHA Program and target areas containing stream segments with potential access development.

4. Continue to promote the F.I.S.H. program especially on contiguous tracts of land with potential for access development.

5. Explore the possibility of establishing a stream access program with the KDWP that would provide payment to private landowners who allow boaters to float through their properties.

6. Explore the possibility of a sponsored licensed tour/float guide to raise confidence in landowners concerned with nuisance and liability issues. The license could have similar restrictions as the F.I.S.H. program to ensure responsible use of the streams.

Resources

1. Kansas Department of Wildlife and Parks. 2008. "State Comprehensive Outdoor Recreation Report". http://www.oznet.ksu.edu/Stevenson/SCORP.pdf

2. Wichita State University. 2001. "Water Recreation Needs Assessment."

3. Dave Murphy. 2008. Paddling Kansas. Trails Books.

4. Kansas Department of Wildlife and Parks. 2008. http://www.kdwp.state.ks.us/news/Other-Services/Private-Landowner-Assistance/Wildlife/Walk-in-Hunting.

5. Kansas Department of Wildlife and Parks. 2008. http://www.kdwp.state.ks.us/news/Fishing/Special-Fishing-Programs-for-You/Fishing-Impoundments-and-Stream-Habitats-F.I.S.H.-Program.

6. Kansas Department of Wildlife and Parks Regulations for the F.I.S.H. Program. K.A.R. 115-8-1; 115-8-4; 115-8-5; 115-8-9; 115-8-11; 115-8-12; 115-8-14; 115-8-15; 115-8-18; 115-8-19; 115-8-20.