Kansas-Lower Republican River Basin

January 2009

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.

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.

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.

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.

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.

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]

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.

Resources

1. Kansas Water Office. 1998. *Kansas-Lower Republican Basin Resource Inventory and Assessment, Volume 4.*

2. U.S. Census Bureau. 2000.

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

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

5. Kansas Department of Agriculture-Division of Water Resources, December 13, 2007. Water Right Information System (WRIS).

6. Natural Resources and Conservation Service. Accessed January 2009. Resource Conservation and Development Information.

Kansas-Lower Republican River Basin Management Categories

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

- 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.

- 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. 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.

Applicable *Kansas Water Plan* Objectives

- All non-domestic points of diversion meeting predetermined criteria will be metered, gaged, or otherwise measured.
- 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.

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.

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

- 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.
- Less than five percent of public water suppliers will be drought vulnerable.
- 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

- 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.
- Ensure that water quality conditions are maintained at a level equal to or better than year 2000 conditions.
- Reduce the average concentration of dissolved solids, metals, nitrates, pesticides and volatile organic chemicals that adversely affect the water quality of Kansas ground water.
- Maintain, enhance, or restore priority wetlands and riparian areas.
- Mutrient reduction goals will be included in all Watershed Restoration and Protection Strategies (WRAPS) projects within the basin.
- 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

- 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

- 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

- 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.

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.

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.

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.

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, Lawrence 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 degradation 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.

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.

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.

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).

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.

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.

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

- 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.
- Ensure that water quality conditions are maintained at a level equal to or better than year 2000 conditions.
- Reduce the average concentration of dissolved solids, metals, nitrates, pesticides and volatile organic chemicals that adversely affect the water quality of Kansas ground water.
- Maintain, enhance or restore priority wetlands and riparian areas.

Basin Specific Objectives

- 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.
- All public water suppliers will complete and implement a source water protection plan.
- All WRAPS projects within the basin and sediment reduction goals included in WRAPS projects above the four federal priority reservoirs.
- 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
5. Kansas Department of Health and Environment, Bureau of Water. 2006. *Kansas Watershed Restoration and Protection Strategy*. www.kdheks.gov/nps/wraps
6. Kansas Department of Health and Environment, Bureau of Water. December 2004. *Surface Water Nutrient Reduction Plan*, www.kdheks.gov/water
7. Kansas Department of Health and Environment, Bureau of Water. 2006. *Watershed Planning and TMDL Program*, www.kdheks.gov/tmdl

8. USDA Farm Service Agency. 2006. *Summary of Active and Expiring CRP Crop land Acres by County.* www.fsa.usda.gov

9. Kansas Water Office. 2003. Kansas Wetland and Riparian Areas Protection and Restoration Plan.

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.

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.

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 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.

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.

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).

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*.

4. Kansas Water Office. 2002. *Status Report: State of Kansas, Water Marketing and Assurance Programs, Multipurpose Small Lakes Program.*

5. Kansas Water Office, Kansas State University. 2008. *Sedimentation in Our Reservoirs: Causes and Solutions, Kansas Center for Agriculture and the Environment*.

6. Kansas Department of Agriculture - Division of Water Resources. 2006. *Public Water Suppliers: Sources and Purchasers.*