KANSAS WATERSHED RESTORATION AND PROTECTION STRATEGY (WRAPS) PROJECT

TUTTLE CREEK LAKE WATERSHED ASSESSMENT

FINAL REPORT

KDHE Project No. 2004-0032

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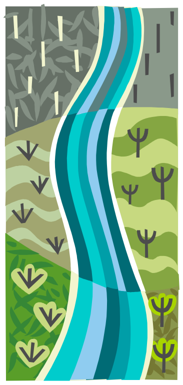

Acknowledgements

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The Assessment phase of this project resulted from the dedicated team effort of these KSU personnel:

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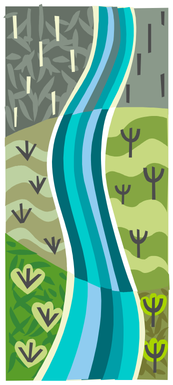


Executive Summary

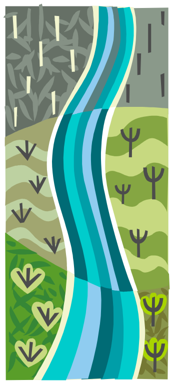
This project served to compile and develop watershed environmental and economic information to assist stakeholders in the Tuttle Creek Lake to develop a Watershed Restoration and Protection Strategy (WRAPS) Plan and Report.

Initiated in June 2006, this WRAPS Assessment Phase project was completed by May 2009. Project accomplishments include:

- *Watershed Assessment*: We compiled existing information related to the Tuttle Creek Lake Watershed, culminating in development and publication of a Watershed Atlas.
- *Watershed Modeling*: We completed the SWAT modeling analysis of current watershed conditions.
- *Economic Analysis*: We developed user-friendly decision tools for stakeholder groups to analyze and compare economic and environmental effects of cropland BMPs, vegetative buffer systems, streambank stabilization systems, and tillage systems.

A stakeholder leadership team (SLT) was established in 2007 for Tuttle Creek Lake Watershed and actively participated in a critical review of the assessment activities including modeling findings of targeted areas, discussions on non-point source pollution areas in the watershed that could not be identified with SWAT, like areas with high concentration of livestock produced nutrient contribution to stream pollution.

The SLT was engaged in the process of clarifying WRAPS objectives and assessment needs, refining watershed information and modeling data, reviewing modeling results, and assessing economic and environmental impacts of various management scenarios. Groundtruthing of SWAT identified targeted areas assisted in identifying current BMP implementation rates in the targeted areas and provided basis for economic analysis of future BMP implementation scenarios.



Introduction

The Tuttle Creek Lake Watershed located in the Kansas Lower Republican Basin includes two watersheds: Lower Big Blue Watershed (HUC 10270205) and Lower Little Blue Watershed (HUC 10270207). Tuttle Creek Lake watershed covers land in Kansas and Nebraska, 98% of Lower Little Blue Watershed lies in Kansas and remaining 2% lies in Nebraska; 79% of Lower Big Blue Watershed has land in Kansas and 21% in Nebraska.

Geographic Scope/Location

The Lower Big Blue Watershed encompasses parts of Clay, Marshall, Nemaha, Pottawatomie, Riley and Washington Counties in Northeast Kansas (Figure 1). The watershed is primarily the drainage area for Tuttle Creek Lake, the second largest lake in Kansas. Major rivers in the watershed include Big Blue River (originates in Nebraska), Black Vermillion River and Spring Creek lakes. Rocky Ford Lake and Centralia Lake are among major lakes in the watershed. The major source of water for Big Blue River is near Grand Island, Nebraska. The Lower Big Blue watershed occupies 9 12-digit HUC watersheds (102702050202, 102702050103, 102702050203, 102702050204, 102702050201, 102702050104, 102702050102, 102702050101, and 102702050401). Total drainage area of the watershed is 1081410 acres (1690 mi^2) (Figure 2).

The Lower Little Blue Watershed encompasses parts of Republic, Washington and Marshall Counties in Northeast Kansas. The watershed is primarily drainage area for the Little Blue River. Major rivers/streams in the watershed are Cook Creek, Camp Creek, and Mill Creek. Tuttle Creek Lake is the major lake in the watershed. The Little Blue River feeds into the Big Blue River and into Tuttle Creek Lake. The Lower Little Blue Watershed occupies 18 12-digit HUC watersheds (102702070303, 102702070304, 102702070207, 102702070201, 102702070202, 102702070203, 102702070405, 102702070502, 102702070206, 102702070302, 102702070101, 102702070102, 102702070104, 102702070105, 102702070301, 102702070204, 102702070205, and 102702070103). Total drainage area of the watershed is 855804 acres (1337 mi^2) (Figure 2).

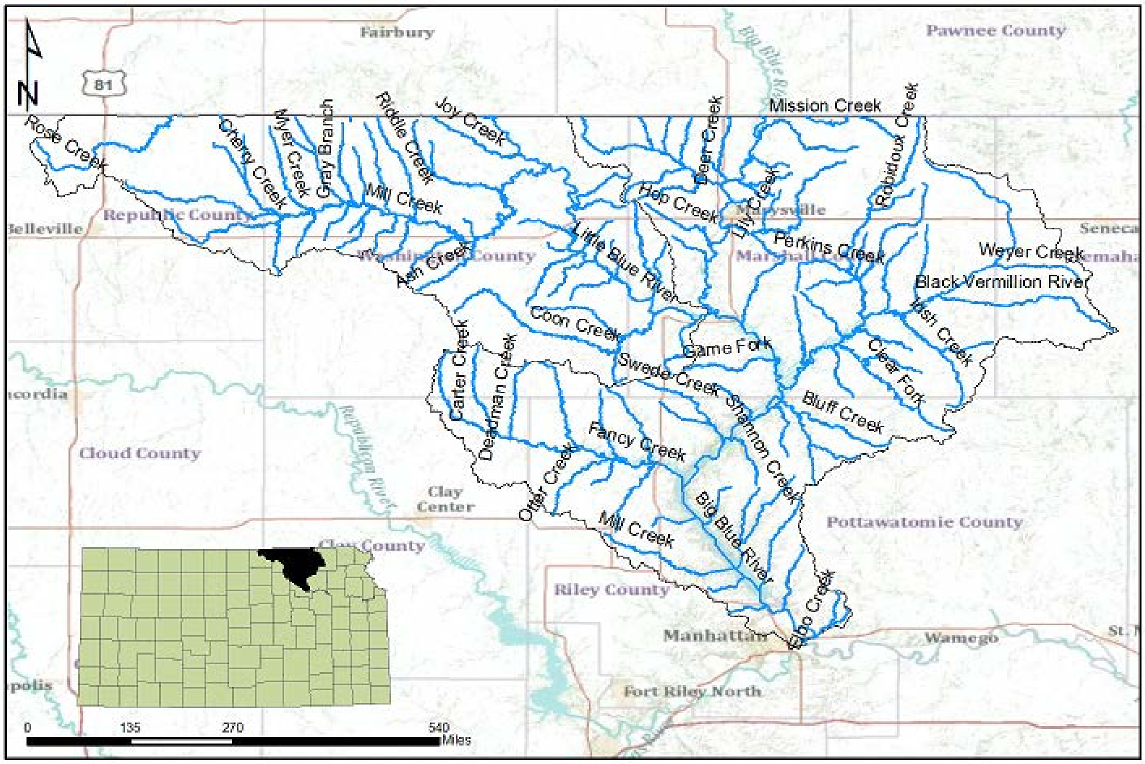


Figure 1 Tuttle Creek Lake Watershed

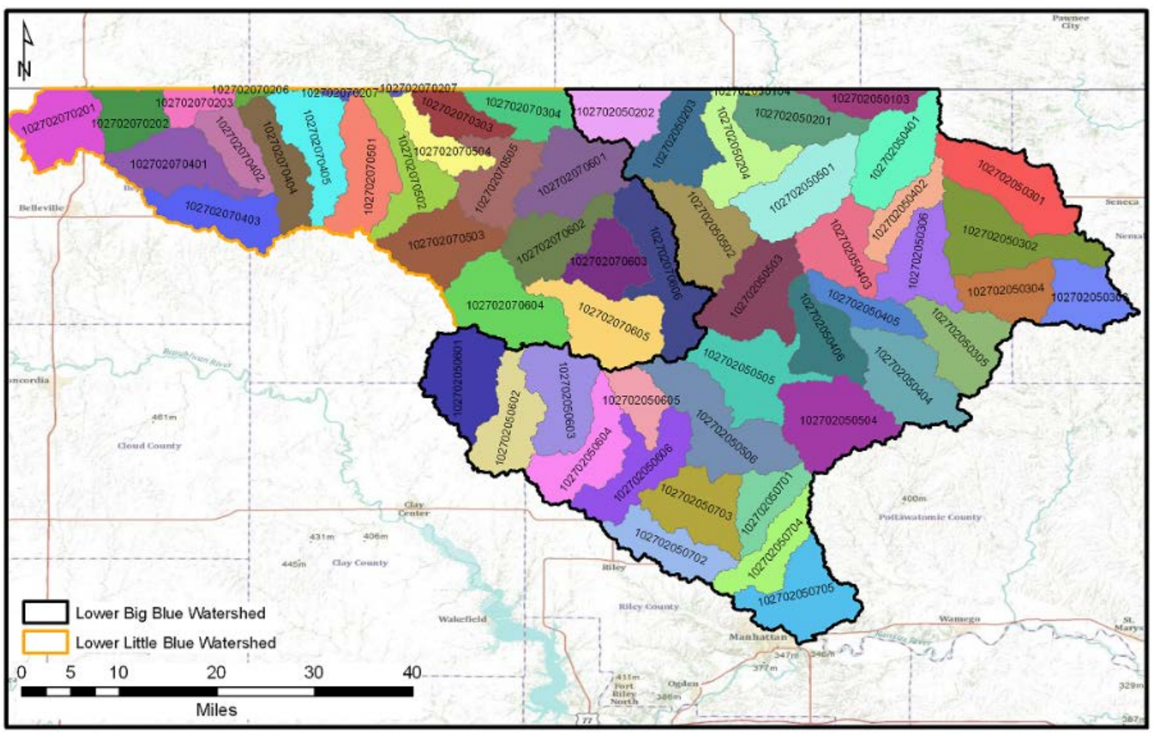


Figure 2 HUC 12 Delineations in the Tuttle Creek Lake Watershed

Population

There are 25 small towns in the Tuttle Creek Lake watershed in Kansas: Green, Axtell, Beattie, Blue Rapids, Frankfort, Marysville, Summerfield, Oketo, Vermillion, Waterville, Centralia, Olsburg, Cuba, Munden, Narka, Leonardville, Randolph, Barnes, Greenleaf, Haddam, Hanover, Hollenberg, Mahaska, Morrowville, and Washington. The smallest town in the watershed is Hollenberg with population of 31 according to the U.S. Census Bureau (http://quickfacts.census.gov/qfd/index.html). The total estimate of population in the Tuttle Creek Lake Watershed is 11,774 (Table 1). Figure 3 shows the spatial distribution of population per 2000 Census block.

Table 1 Main populated areas in the Tuttle Creek Lake Watershed

Area	Population
Green	147
Axtell	445
Beattie	277
Blue Rapids	1088
Frankfort	855
Marysville	3271
Oketo	87
Summerfield	211
Vermillion	107
Waterville	681
Centralia	534
Olsburg	192
Cuba	231
Munden	122
Narka	93
Leonardville	398
Randolph	175
Barnes	152
Greenleaf	357
Haddam	169
Hanover	653
Hollenberg	31
Mahaska	107
Morrowville	168
Washington	1223
Total	**11774**

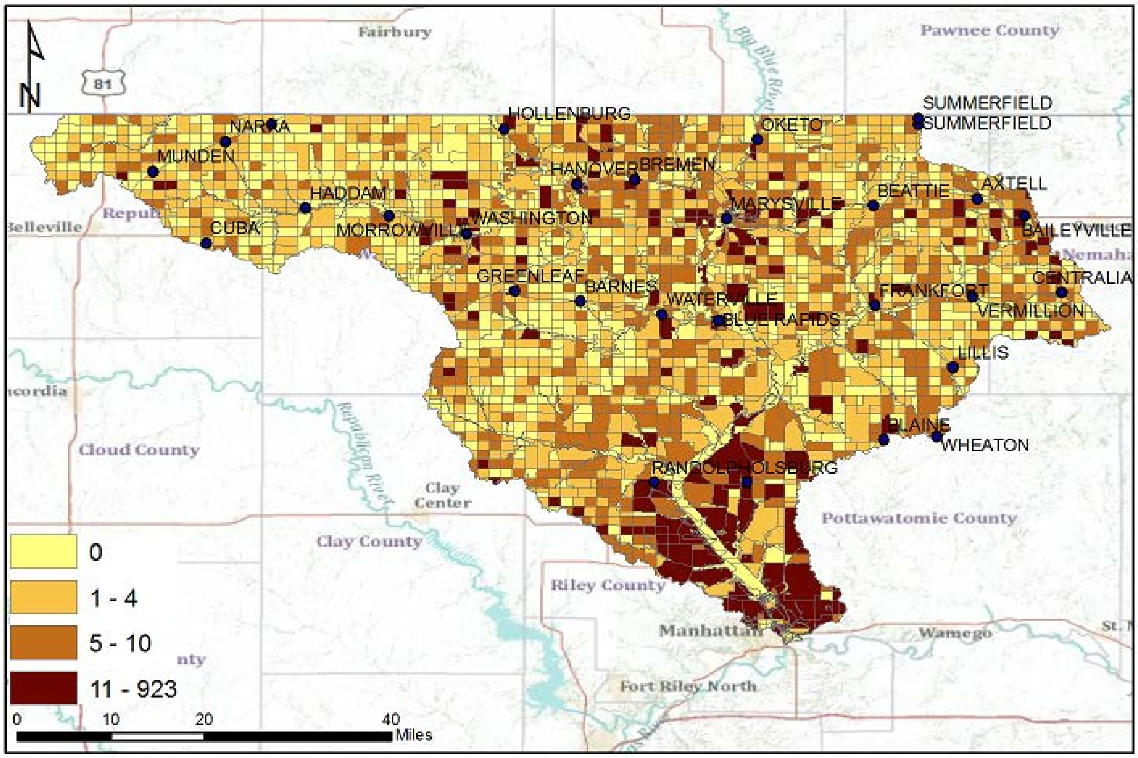


Figure 3 Population density in the Tuttle Creek Lake Watershed

Surface Water Resources

The Tuttle Creek Lake is located at the outlet of Lower Big Blue River Watershed (HUC 10270205) and collects water from the upstream drainage area of approximately 9628 mi^2 above the dam. The surface area of the Tuttle Creek Lake is 15,000 acres (23.43 mi^2) (Figure 1). Big Blue River, Little Blue River and Black Vermillion River are the major streams that feed the lake. Mean precipitation for the watershed ranges from 29 to 35 inches and maximum depth of Tuttle Creek Lake is 15 meters. Storage volume of the Tuttle Creek Lake is 265,000 acre-feet. The storage capacity of sedimentation pool is 179,850 acre-feet and multipurpose pool is 335,100 acre-feet. The dam located on five miles north of Manhattan, Kansas, has an elevation of 1159 ft and total length of dam is 7500 ft. Some small lakes located in the Tuttle Creek Lake Watershed are Lake Elbo, Idlewild Lake and Washington County State Lake.

Aquifers

The Lower Little Blue and Lower Big Blue Rivers along with the tributaries are the primary waterways of the Tuttle Creek Lake Watershed. Three aquifers underlie the watershed: Alluvial aquifer, Glacier Drift, and Dakota aquifer (Figure 4).

- Alluvial Aquifer - The alluvial aquifer is a part of and connected to a river system and consists of sediments deposited by rivers in the stream valleys. The Big and Little Blue and Black Vermillion Rivers have an alluvial aquifer that lies along and below the rivers.

- Glacial Drift - The Glacial Drift aquifer was formed by deposits of rock left by the glacier that covered northeast Kansas 700,000 years ago. These rock deposits of sand and gravel create a porous area that traps and holds water deposits.
- Dakota Aquifer - The Dakota aquifer extends from southwestern Kansas to the Arctic Circle. In recent years, the Dakota aquifer has been used for irrigation purposes in southwest and in north-central Kansas (Cloud, Republic and Washington counties) and continues to present time. The Dakota aquifer also provides water for municipal, industrial, and stock water supplies. A one-mile distance between these wells is the current stipulation for drilling in the Dakota.

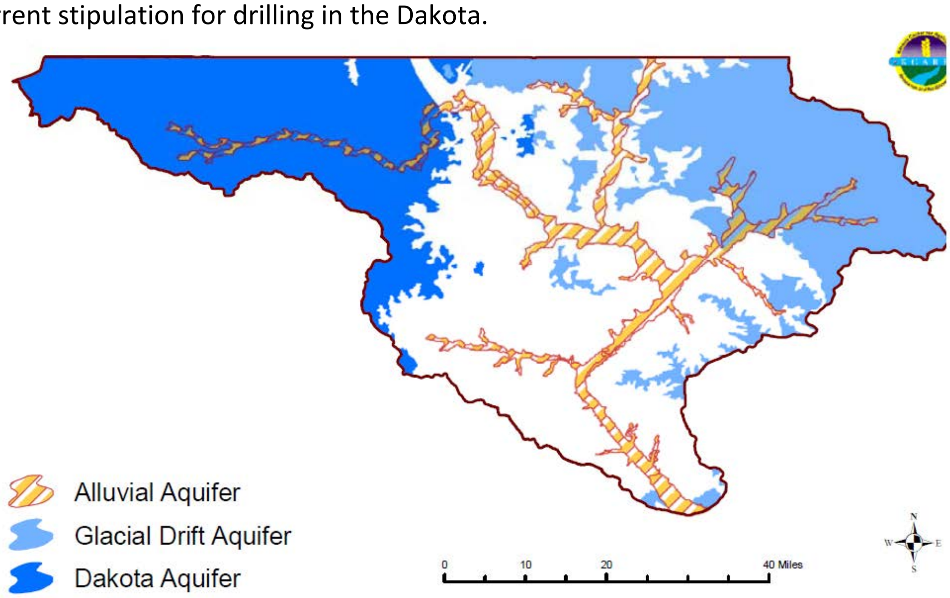


Figure 4 Map of the aquifers underlying the Tuttle Creek Lake Watersheds

Designated Uses

Tuttle Creek Lake was completed in 1962 by the U.S. Army Corps of Engineers at a cost of $80,000,000. Since then, Tuttle Creek Lake has saved approximately six billion dollars in property losses by preventing downstream flood damage. Tuttle Creek Lake collects water from a 10,000 square mile drainage basin, most of which is in Nebraska.

During wet periods the lake can swell from 12,000 surface acres to over 54,000 acres to protect property along the Kansas, Missouri and Mississippi Rivers from flooding. Conversely, during dry periods, water may be released from Tuttle Creek Lake to improve water quality for downstream municipalities' drinking water, and to aid river navigation.

Tuttle Creek Lake was built for flood control, water supply, water quality, navigation, recreation, and fish and wildlife. The lake is used to support aquatic life and secondary contact recreation (Table 2).

Table 2 Designated Water Uses

Stream Name	AL	CR	DS	FP	GR	IW	IR	LW
Lower Big Blue								
Ackerman Creek	E	B						
Big Blue River, Segment 2	E	B						

Big Blue River, Segment 1, 17, 18	E	B	X	X	X	X	X	X
Big Blue River, Segment 7, 20, 21	E	C	X	X	X	X	X	X
Black Vermillion R, Segment 11, 13, 14	E	b	X	X	X	X	X	X
Black Vermillion R, Segment 8, 10	E	C	X	X	X	X	X	X
Black Vermillion R Clear Fork	E	C	X	X	X	X	X	X
Black Vermillion R N Fk, S Fk	E	B	X	X	X	X	X	X
Bluff Cr	S	B						
Bommer Cr, Carter Cr, Cedar Cr, Corndodger Cr, De Shazer Cr, Deadman Cr, Deer Cr, Dog Walk Cr, Elm Cr N, Hop Cr, Indian Cr, Jim Cr, Johnson Fk, Kearney Br, Lily Cr, Little Indian Cr, Meadow Cr, Murdock Cr, Perkins Cr, Pheil Cr, Raemer Cr, Schell Cr, School Br, Scotch Cr, Weyer Cr	E	b						
Bucksnort Cr	S	B						
Dutch Cr	E	b	X					
Elm Cr N, Fancy Cr N	E	B		X				
Fancy Cr W, Horseshoe Cr	E	C		X				
Game Fk	E	B	X					
Timber Cr, Mission Cr	E	C						
Mill Cr	E	C	X	X				
Otter Cr	E	B	X	X				
Otter Cr N	E	B	X	X				
Roubidoux Cr, Spring Cr	E	B		X				
Spring Cr, Segment 65	S	B	X	X				
Timber Cr	E	B	X					
Lower Little Blue								
Ash Creek, Bowman Cr, Cherry Cr, Mill Cr, Myer Cr, Salt Cr, Spring Cr	E	b		X				
Beaver Cr, Bolling Cr, Buffalo Cr, Camp Cr, Cedar Cr, Fawn Cr, Gray Br, Humphrey Br, Iowa Cr, Jones Cr, Joy Cr, Lane Br, Malone Cr, Melvin Cr, Mercer Cr, Mill Cr S Fk, Riddle Cr, Rose Cr,	E	b						
Coon Cr. Mill Cr	E	C	X	X				
Mill Cr	E	a	X					
Little Blue River, Segments 1,2,3	E	C	X	X	X	X	X	X
Little Blue River, Segment 4	E	b	X	X	X	X	X	X

School Cr, Silver Cr	E							
Walnut Cr	E	C						

where

AL Aquatic Life Support
GR Groundwater Recharge
CR Contact Recreation Use
IW Industrial Water Supply
DS Domestic Water Supply
IR Irrigation Water Supply
FP Food Procurement
LW Livestock Water Supply
A Primary contact recreation lakes that have a posted public swimming area
B Primary contact recreation stream segment is by law or written permission of the landowner open to and accessible by the public
b Secondary contact recreation stream segment is not open to and accessible by the public under Kansas law
C Primary contact recreation lakes that are not open to and accessible by the public under Kansas law
S Special aquatic life use water
E Expected aquatic life use water
X Referenced stream segment is assigned the indicated designated use
O Referenced stream segment does not support the indicated beneficial use
Blank Capacity of the referenced stream segment to support the indicated designated use has not been determined by use attainability analysis

Public Water Supplies (PWS) and National Pollutant Discharge Elimination System (NPDES)

There are numerous public waters supplies in Tuttle Creek Lake watershed in Kansas and these sites are distributed across the watershed, slightly concentrated along the streams and around the lake (Table 3). Most of the public water supplies in this watershed use groundwater. Public water supplies can be affected by atrazine concentrations in the spring and summer months. High atrazine concentrations cause an increase in cost to public water suppliers in treatment costs. A public water supply that derives its water from a surface water supply can be affected by sediment – either in difficulty at the intake in accessing the water or in treatment of the water prior to consumption. Nutrients and fecal coliform bacteria will also affect surface water supplies. Public Water Supply locations (PWS) and Rural Water Districts (RWD) in Tuttle Creek Lake Watershed are shown in Figure 5.

Table 3 PWS Serving the Tuttle Creek Lake Watershed

Public Water Suppliers	County	Source of Water	Population	Comments	KWO 2010 Projections
Clay Co. RWD #1 *	CY	1 well	103		

Axtell	MS	1 well, MS Co. RWD #3, NM Co. RWD #3	417		
Beattie	MS	MS Co. RWD #3	264		
Blue Rapids	MS	3 wells	1,022		
Frankfort	MS	3 wells	795		
Marshall Co. RWD #1	MS	MS Co. RWD #3	172		
Marshall Co. RWD #2	MS	Marysville	NA	Included in Marysville's population; annexed in 2003	
Marshall Co. RWD #3	MS	5 wells	1,135		
Marysville	MS	3 wells, water rights on Big Blue not used	3,179		
Oketo	MS	2 wells	81		
Summerfield	MS	3 wells (in Nebraska)	208		
Vermillion	MS	2 wells	115		
Waterville	MS	2 wells	627		
Winifred	MS	MS Co. RWD #3	NA	Included in MS Co. RWD #3 population	
Centralia	NM	NM Co. RWD #3	NA	Included in Seneca's population	486
Nemaha Co. RWD #2 *	NM	Seneca (7 wells (5), 3 springs)	NA	Included in Seneca's population	309
Nemaha Co. RWD #3 *	NM	4 wells, NM Co. RWD #2	1,850		
Olsburg	PT	1 well, PT Co. RWD #2	212		
Pottawatomie Co. RWD #1 *	PT	7 wells	3,927		
Pottawatomie Co. RWD #2 *	PT	3 wells, PT Co. RWD #1	610		
Pottawatomie Co. RWD #3 *	PT	3 wells, Onaga	1,426		
Cuba	RP	2 wells, RP Co. RWD #2	191		

Munden	RP	RP Co. RWD #2	NA	Included in RP Co. RWD #2 population	116
Narka	RP	RP Co. RWD #2	NA	Included in RP Co. RWD #2 population	92
Republic Co. RWD #2 *	RP	2 wells	1,250		
Randolph	RL	RL Co. RWD #1	184		
Riley Co. RWD #1 *	RL	Ogden (3 wells)	NA	Included in Ogden's population	1374
Barnes	WS	2 wells	140		
Greenleaf	WS	4 wells (2)	335		
Haddam	WS	4 wells	151		
Hanover	WS	WS Co. RWD #1	592		
Mahaska	WS	2 wells	96		
Morrowville	WS	WS Co. RWD	152		
Washington	WS	3 wells (1)	1,134		
Washington Co. RWD #1	WS	10 wells	1,368		
Washington Co. RWD #2 *	WS	4 wells	655		
			22,391		
Seneca and Ogden are not located in Tuttle Creek Watershed.					
*** Only portions of these rural water districts are located in Tuttle Creek Watershed**					

KDHE regulates wastewater treatment facilities fail rate within this watershed. Maximum amount of point source pollutants allowed to be discharged is controlled by National Pollutant Discharge Elimination System (NPDES). In Tuttle Creek Lake Watershed, there are approximately 27 municipal and industrial wastewater treatment facilities (Table 4). These facilities were monitored by KDHE and they may be a significant source of nutrients but no fecal coliform bacteria. Public water supply diversion points and rural water districts in addition to countless private wells within this watershed are shown in Figure 5.

Table 4 NPDES Sites

Facility Name	Ownership	Description	Industrial Classification	City	County
Ga-Pacific Corp Blue Rapids	Private	Gypsum Products	Not On El	Blue Rapids	Marshall
Blue Rapids City Of Stp	Public	Sewerage Systems	Municipal	Blue Rapids	Marshall

City Frankfort W Stab Lagoon	Public	Sewerage Systems	Municipal	Frankfort	Marshall
Summerfield City Of Stp	Public	Sewerage Systems	Municipal	Summerfield	Marshall
Randolph City Of Wwtf	Public	Sewerage Systems	Municipal	Randolph	Riley
Axtell City Of Stp	Public	Sewerage Systems	Municipal	Axtell	Marshall
Beattie, City Of Wwt Fac	Public	Sewerage Systems	Municipal	Beattie	Marshall
Rocky Ford Trailer Court	Public	Sewerage Systems	Not On El	Manhattan	Riley
University Park Wwtp	Public	Sewerage Systems	Municipal	Manhattan	Riley
Centralia City Of Wwtp	Public	Sewerage Systems	Municipal	Centralia	Nemaha
Baileyville Impr. Dist. #1 Wwt	Public	Sewerage Systems	Municipal	Baileyville	Nemaha
Vermillion Wwt Facility	Public	Sewerage Systems	Municipal	Vermillion	Marshall
Super 8 Motel	Pub Pri			Marysville	Marshall
Mccall Pattern Company	Pub Pri			Manhattan	Riley
Marysville - Proposed	Pub Pri			Marysville	Marshall
Olsburg	Pub Pri			Olsburg	Pottawatomie
Timber Creek Development	Pub Pri	Contractors-Single Family Hous	Not On El	Manhattan	Riley
Brownawell Terry	Private	Beef Cattle Feedlots	On Elg	Wymore	Gage
Burchard Wwtf	Public	Sewerage Systems	Municipal	Burchard	Pawnee
Barneston Wwtf	Public	Sewerage Systems	Municipal	Barneston	Gage
Leonardville City Of		Gypsum Products	Not On El	Blue Rapids	Marshall
Winifred Feedlots	Private	Sewerage Systems	Municipal	Frankfort Blue Rapids	Marshall
Diller Wwtf		Sewerage Systems	Municipal	Frankfort	Marshall

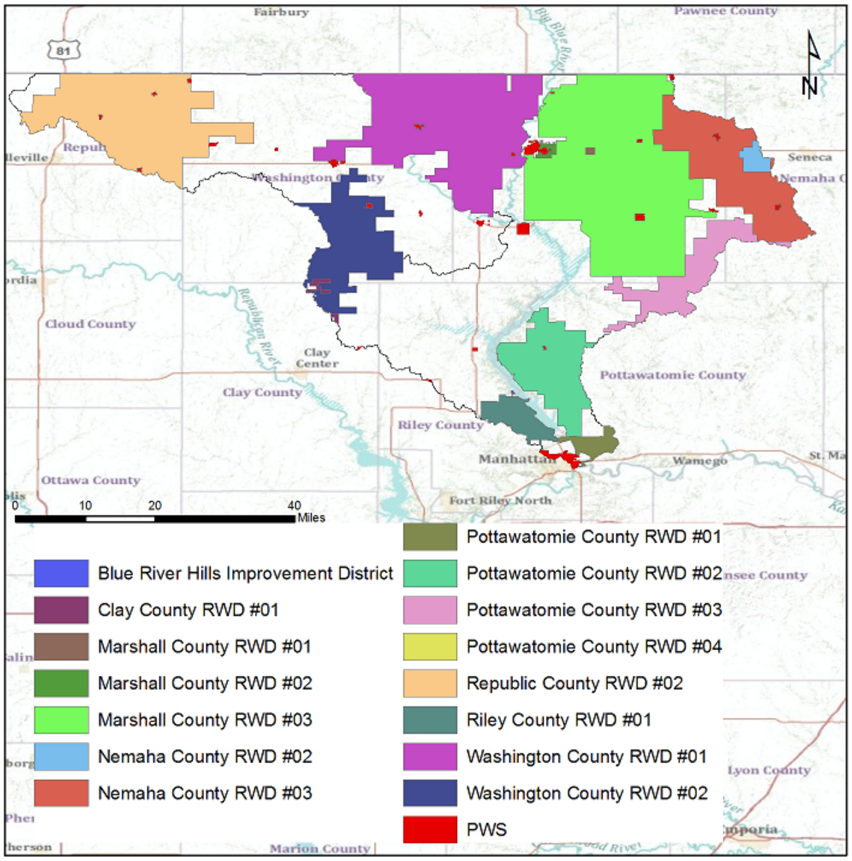


Figure 5 Rural Water Districts (RWD) and Public Water Supply (PWS) Diversion Points

Land Uses / Land Cover

Crop production is the dominant land use in both HUC 8 watersheds in Tuttle Creek Lake Watershed (Figure 6). The majority of croplands lie above the floodplain of the Tuttle Creek Lake Watershed. Approximately 32% of crop land in Lower Little Blue River Watershed is used for row cropping and approximately 27% of crop land in Lower Big Blue River Watershed is used for row cropping. Different land use in watershed is given in Figure 5.

Table 5 shows the percentage land uses in three land use databases as historical changes from 1980 to 2001. The farm size distribution in the watershed is presented in Figure 7. The harvested crop areas are mainly occupied by four main crops in Kansas: wheat, corn, sorghum, and soybeans (Figure 8).

Common Cropland BMPs in Tuttle Creek Lake Watershed

BMPs help reduce the amount of soil and nutrients that run off of cropland fields. Keeping these valuable inputs (soil and nutrients) in the field can be of benefit to both the landowner/producer and to society as a whole. Here are just a couple of the benefits:

- Top soil savings can result in higher yields and lower fertilizer costs
- Certain BMPs can offer both water quality protection and wildlife habitat

Below are some of the more popular BMPs in use in the Tuttle Creek Lake watershed.

- Contour farming is farming the land, tillage and planting of the crop, on the level around the hill. By doing this, each furrow or ridge left by the different implements acts as miniature dams, trapping water, allowing more to soak into the ground. Each row of crop also slows the water. Combined, less water runs off. Soil is erosion reduced. Crop yields are increased in arid areas.

- Grassed waterways are used as outlets to prevent silt and gully formation. The vegetation cover slows the water flow and minimizes channel surface erosion. They can also be used as outlets for water from terraces.

- Vegetative buffers are areas of land that are maintained in permanent vegetation to help reduce nutrient and sediment loss from agricultural fields, improve runoff water quality, and provide habitat for wildlife. Because of these societal benefits, there are several federal and state programs that encourage the installation and maintenance of vegetative buffers.

- No-till is a form of conservation tillage in which chemicals are used in place of tillage for weed control and seedbed preparation. In other words, the soil surface is never disturbed except for planting or drilling operations in a 100 percent no-till system. Two other forms of tillage, reduced tillage and rotational no-till, involve a light to moderate use of tillage equipment. These forms of tillage also control erosion and nutrient runoff, but are not as effective as 100 percent no-till.

- Terraces are embankments constructed perpendicular to the slope of the field and are designed to reduce the length of a field slope and catch water flowing off the slope. Terraces reduce the rate of runoff and allow soil particles to settle out.

- Conservation crop rotations involve growing various crops in the same field in a planned sequence. This may involve growing high residue crops (e.g., corn for grain) in rotation with lower residue crops (e.g., soybeans) or forage/silage crops. The effectiveness of conservation crop rotations depends on many field, climatic, and management factors.

Table 5 Summary of land use changes from 1980 to 2001

Lanuse Type	Agriculture			Barren Land	Forest Land	Grassland	Urban	Wet-lands/ Water	Shrub
	Cropland	Pasture	Total						
GIRAS 1980s	89.3	0.0	89.3	0.1	0.4	7.6	1.1	1.6	0.0
NLCD 1992	48.8	10.3	59.1	0.0	4.6	32.6	0.8	2.5	0.4
NLCD 2001	49.7	0.8	50.5	0.0	4.9	36.4	5.3	2.9	0.0

Common Livestock Operations

Confined Animal Feeding Operations (CAFOs) with more than 300 animal units must register with KDHE. In Tuttle Creek Watershed, there are approximately 288 CAFOs registered with KDHE and majority of CAFOs are located in the central part of the Lower Little Blue watershed. KDHE monitors the quality of wastewater and waste disposal practices from registered CAFOs, but the small unregistered CAFOs in Kansas, may contribute nutrients and fecal coliform bacteria to the nearest water resources. CAFOs are designed to retain a 25-year, 24-hour rainfall/runoff event as well as an anticipated two weeks of normal wastewater from their operations. Typically, this rainfall event coincides with streamflow that is less than 1-5% of the time. However, since the watershed is dominated by grassland and pasture the number of smaller animal feeding operations that are not registered is presumably high, particularly during seasonal feeding months in the winter.

Distribution of livestock is presented in Figure 9 with beef cattle and hogs occupying more than 97%.

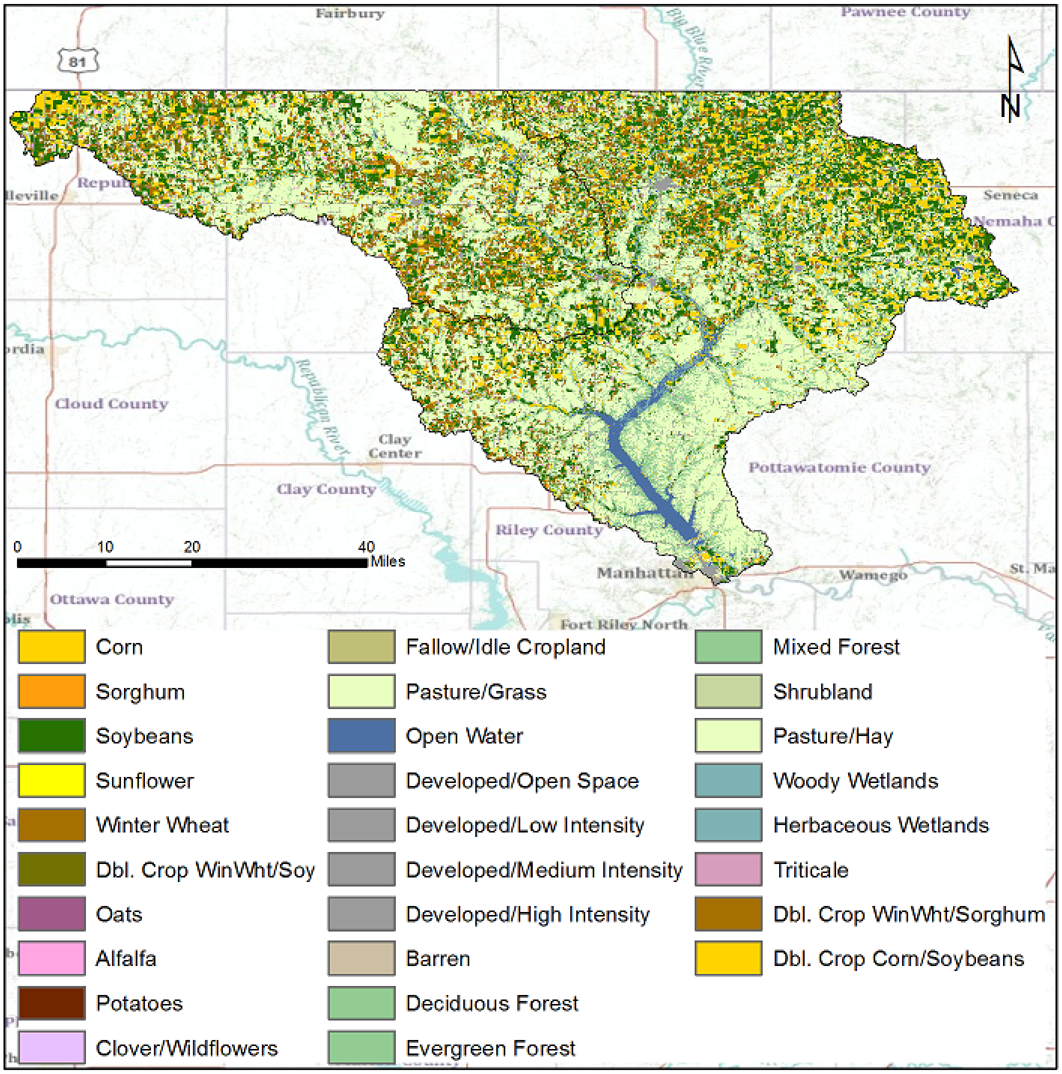


Figure 6 Land cover map (2010 NASS Crop Data Layer)

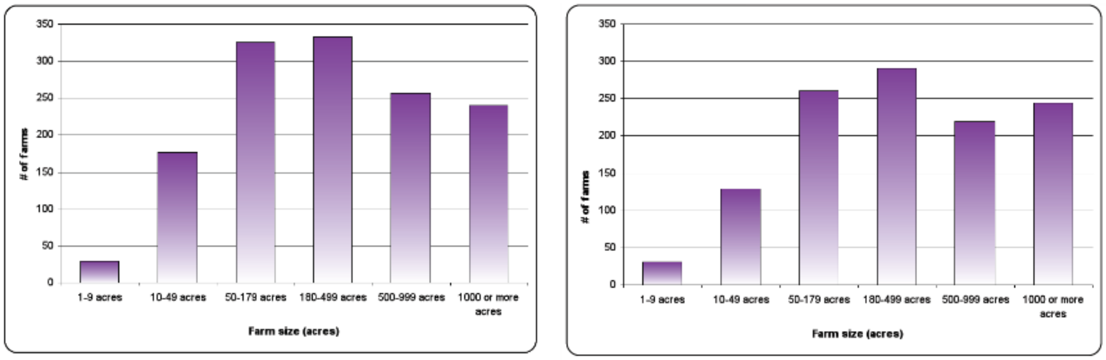


Figure 7 Farm size distribution in Lower Big Blue River Watershed and Lower Little Blue River Watershed

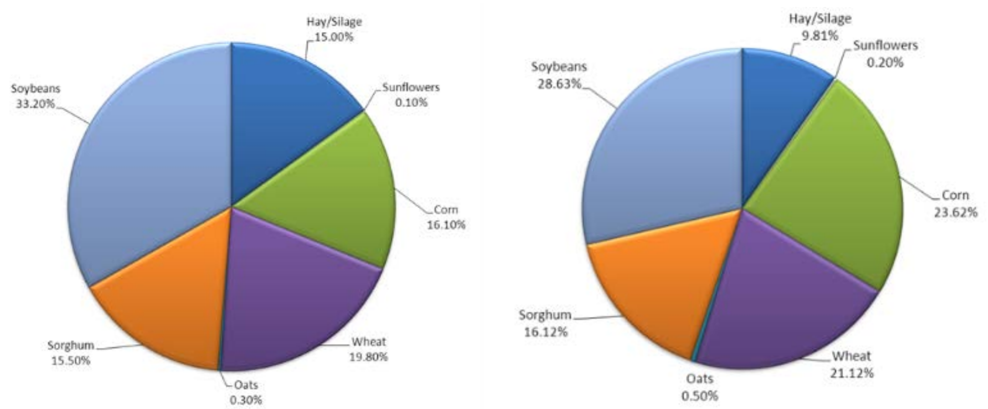


Figure 8 Percentage harvested crop areas (Based on 2010 Crop Data Layer) in in Lower Big Blue River Watershed and Lower Little Blue River Watershed

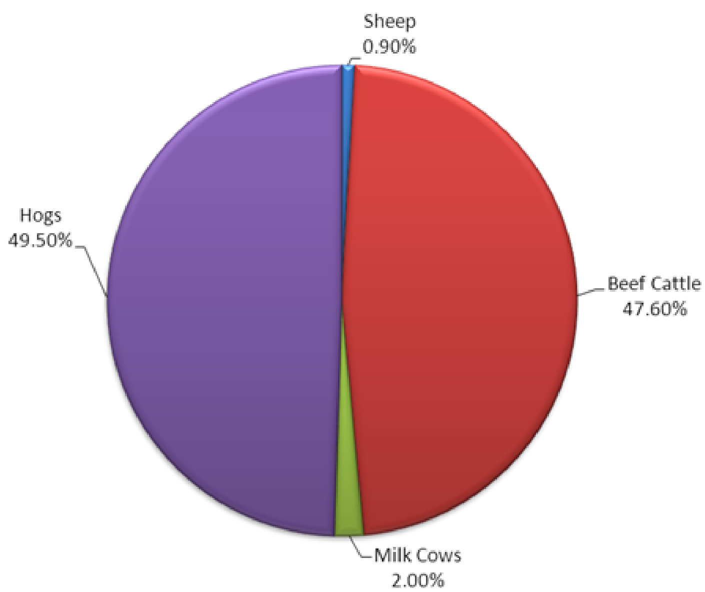


Figure 9 Livestock Distribution in Lower Little Blue River Watershed

Wildlife Habitat

Tuttle Creek Watershed area has several vertebrate (Southern Redbelly Dace, Topeka Shiner, Great Egret, Blue Sucker, Southern Flying Squirrel, Nothern Myotis, Bald Eagle, etc.), invertebrate (Fatmucket, Wallace's Deepwater Mayfly, Fatmucket, Creeper) and Vascular plant (Water Sedge, Pale Goosefoot, Western Hairy Rock-cress, Greater Canadian St. John's, Hooked Agrimony) rare species (Figure 10).

Species common to the area include Bald eagles, white-tailed deer, Canada geese, wild turkey, crappie, walleye, and channel catfish.

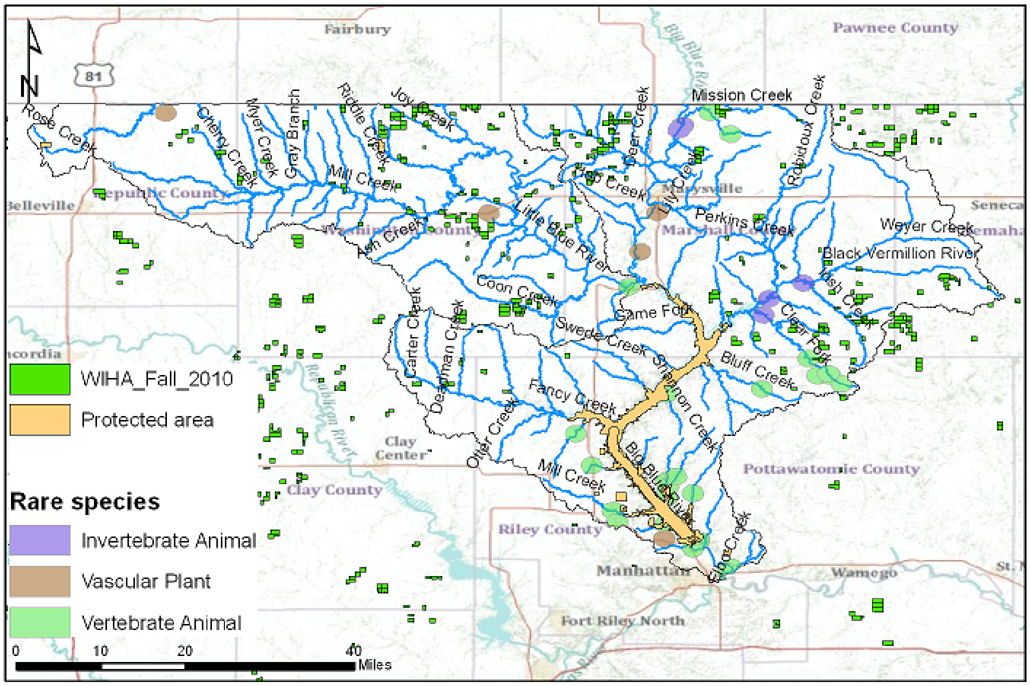


Figure 10 Map of rare species, protected areas, and areas with walk-in hunting access

Recreational Areas

Main recreational area in the watershed is River Pond State park which is located at downstream of Tuttle Creek Dam. A total of 11 parks were developed for recreational purposes and 6 are maintained by US Army Corps of Engineers, 4 are maintained by Kansas Department of Wildlife and parks, and one park by Pottawatomie County. Some of the famous parks are Randolph State Park, Stockdale State Park, Spillway State Park, Tuttle Creek Cove Park, Carnahan Creek Park, and Fancy Creek State Park. Campgrounds, boat ramps, courtesy docks, swim beaches, picnic areas and marina services were some recreational facilities at Tuttle Creek Lake. The Carnahan Creek Park, a 245 acre park maintained by Pottawatomie County located on east side of the lake is primarily a horseback and hiking trail park. A 12-mile horseback riding trail is the main features of the park.

Watershed / Water Quality Conditions

When river segments or lakes that are monitored by Kansas Department of Health and Environment (KDHE) have experienced poor quality, a Total Maximum Daily Load (commonly referred to as a TMDL) is established. A TMDL is the maximum amount of pollution that a surface water body can receive and still meet water quality standards.

The Clean Water Act sets water quality goals for the U.S. Section 303(d) of the Clean Water Act requires states to submit to the U.S. EPA a list of impaired water bodies (303(d) list). For each water body listed, the state must develop a Total Maximum Daily Load (TMDL), which defines both the water-quality objective and the strategy needed to meet that objective. In Kansas, the Kansas Department of Health and Environment (KDHE), Division of Environment, Bureau of Water, Watershed Planning Section has responsibility to develop the 303(d) list of impaired water bodies and develop TMDLs to address each concern. The list of impaired waterways is updated by the states every two years. This can be used to identify specific stream segments and lakes for which, in accordance with their priority ranking, TMDLs may need to be developed.

Total Maximum Daily Loads (TMDLs)

KDHE established streams and lakes experienced poor quality as TMDLs. TMDLs within the watershed are mapped in Figure 11 and listed in Kansas Lower Republican Basin TMDL. Tuttle Creek Lake Watershed has High priority TMDL for eutrophication, Siltation, Alachlor, Atrazine, and FCB (Table 6).

- Kansas Lower Republican Basin TMDL. Tuttle Creek Lake. Water Quality Impairment: Eutrophication. < http://www.kdheks.gov/tmdl/klr/TuttleE.pdf>
- Kansas Lower Republican Basin TMDL. Tuttle Creek Lake. Water Quality Impairment: Siltation. < http://www.kdheks.gov/tmdl/klr/TuttleSILT.pdf>
- Kansas Lower Republican Basin TMDL. Tuttle Creek Lake. Water Quality Impairment: Alachlor. < http://www.kdheks.gov/tmdl/klr/TuttleAl.pdf>
- Kansas Lower Republican Basin TMDL. Tuttle Creek Lake and the watershed. Water Quality Impairment: Atrazine. < http://www.kdheks.gov/tmdl/klr/Tuttle_ATR.pdf>

Table 6 TMDLs in the Watershed

Water Segment	TMDL Pollutant	Endgoal of TMDL	Priority	Sampling Station
Big Blue River above Tuttle Cree	FCB	No more than 10% of samples over applicable criteria	High	SC233, SC 240, SC717
Black Vermillion River	FCB	No more than 10% of samples over applicable criteria	High	SC128, SC129, SC130, SC131, SC132, SC133, SC134, SC141, SC505
Fancy Creek	FCB	No more than 10% of samples over applicable criteria	Medium	SC502
Tuttle Creek Lake Watershe	Atrazine	Monthly average exceedance over 3 ppb occur no more than once in three years. Annual concentrations < 3ppm in Tuttle Creek Lake, its outlet and streams.	High	LM021001, SC502, SC505, SC240, SC232, SC233, SC507, SC712, SC717, SC741

		No individual sample >170ppb.		
Little Blue River	FCB	FCB No more than 10% of samples over applicable criteria	High	SC232, SC240, SC507
Centralia Lake	Aquatic Plants	Summer chlorophyll a concentrations = or < 12ug/l. pH between 6.5 and 8.5	Medium	LM073701
Centralia Lake	Eutrophication	Summer chlorophyll a concentrations = or < 12ug/l. pH between 6.5 and 8.5	Medium	LM073701
Centralia Lake	pH	Summer chlorophyll a concentrations = or < 12ug/l. pH between 6.5 and 8.5	Medium	LM073701
Tuttle Creek Lake	Eutrophication	Average concentrations of total phosphorus in conservation pool <50 ppb.	High	LM021001
Tuttle Creek Lake	Atrazine	Managed pool (<1078') <3ppb at all times. Seasonal flood pool (1078' to 1083') >3ppb once in 3 years. Critical flood pool (>1082') >3ppb will be <10% during spring flood conditions.	High	LM021001
Tuttle Creek Lake	Siltation	Storage in conservation pool will remain within 90% of 1996 storage: 270,000-275,000 acre ft.	High	LM021001
Tuttle Creek Lake	Alachlor	Managed pool <1078' below 0.70 tons/day. Flood pool above 1078' = or <0.92 tons/day.	High	LM021001
Tuttle Creek Lake and Watershed	Atrazine	Managed pool (<1078') <3ppb at all times.	High	LM021001, SC502, SC505, SC240, SC232,

		Seasonal flood pool (1078' to 1083') >3ppb once in 3 years. Critical flood pool (>1082') >3ppb will be <10% during spring flood conditions.		SC233, SC507, SC712, SC717, SC741
Lake Idlewild	Eutrophication	Summer chlorophyll a concentration = or <20ug/l.	Low	LM061201
Washington County State Fishing Lake	Dissolved Oxygen	DO = or >5mg/l over 80% of water column	Low	LM010901
Washington County State Fishing Lake	Aquatic Plants	Maintain 50% open water in lake.	Low	LM010901
Washington Wildlife Area	Eutrophication	Summer chlorophyll a concentration = or <20ug/l.	Low	LM010941
Washington Wildlife Area	Siltation	TSS in conservation pool <7.65 tons or 60mg/l.	Low	LM010941

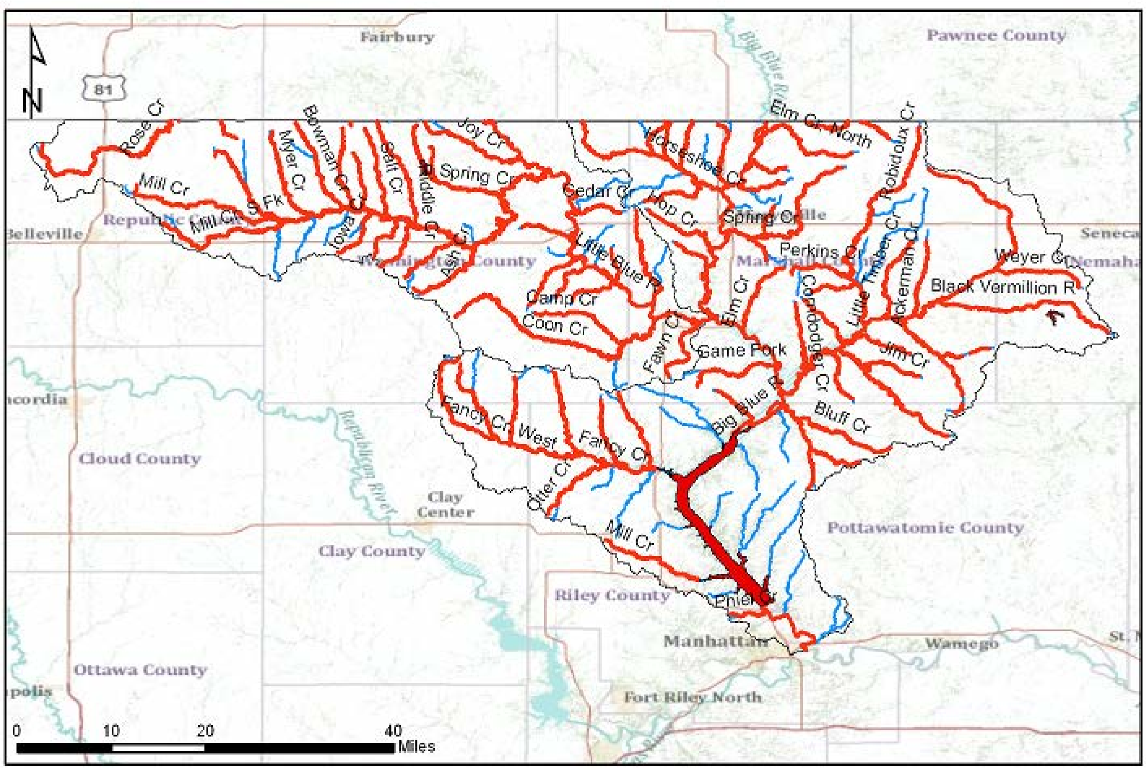


Figure 11 TMDL streams in the Tuttle Creek Lake Watershed

The 303d List of Impaired Water Bodies

The Tuttle Creek Lake Watershed has numerous listings on the "303d list" (Table 8). A 303d list of impaired waters is developed biennially and submitted by KDHE to EPA. To be included on the 303d list, samples taken during the KDHE monitoring program must show that water quality standards are not being met (Table 7). This in turn means that designated uses are not met. TMDLs will be revised and developed over the following years for "high" priority impairments. Priorities are set by work schedule and TMDL development timeframe rather than severity of pollutant. If it will be greater than two years until the pollutant can be assessed, the priority will be listed as "low". Water bodies are assigned "categories" based on impairment status:

- Category 5 – Waters needing TMDLs
- Category 4a – Waters that have TMDLs developed for them and remain impaired
- Category 4b – NPDES permits addressed impairment or watershed planning is addressing atrazine problem
- Category 4c – Pollution (typically insufficient hydrology) is causing impairment
- Category 3 – Waters that are indeterminate and need more data or information
- Category 2 – Waters that are now compliant with certain water quality standards
- Category 1 – All designated uses are supported, no use is threatened.

Table 7 Impaired streams and lakes and water-quality sampling visits and times in the Tuttle Creek Lake Watershed

Watershed and Impairment	Sampling Sites	Sampling Times	Excursions Seen	Baseline Condition
Big Blue FCB	Barnes	Spring	42%	Nonsupport of designated uses
		Summer/Fall	40%	
		Winter	None	
	Marysville	Spring	5 of 18 samples	Nonsupport of designated uses
		Summer/Fall	6 of 23 samples	
		Winter	None	
Little Blue FCB	Blue Rapids	Spring	42%	Nonsupport of designated uses
		Summer/Fall	40%	
		Winter	None	
	Hollenburg	Spring	5 of 12 samples	
		Summer/Fall	6 of 13 samples	
		Winter	None	
	Mill Creek	Spring	3 of 11 samples	
		Summer/Fall	4 of 13 samples	
		Winter	None	
Black Vermillion FCB	Frankfort	Spring	40%	Partial support of designated uses
		Summer/Fall	15%	
		Winter	13%	
Fancy Creek FCB	Winkler	Spring	50%	Partial support of designated uses
		Summer/Fall	13%	
		Winter	11%	

Tuttle Creek Watershed Atrazine	There are three things to note from the monthly distribution of atrazine in Tuttle Creek Lake. First, there is a definite seasonality to atrazine in the lake with the maximum concentrations occurring in May and June, mirroring in-stream concentrations occurring with runoff events in the drainage. Second, atrazine travels down the lake over time, degrading and becoming dilute as the initial slug flows toward the dam, much like a plug flow loading event. High concentrations at the upper lake decline with time at lower lake stations. Furthermore, initial low concentrations at the lower lake increase through the summer, albeit, remaining below the criterion. Later in summer, concentrations at the lower lake exceed those found in the upper lake. Finally, the earliest data were collected in the mid-1980's by USGS. Subsequent sampling by KDHE and KC-COE have shown reduced levels of atrazine later in the summer than those recorded by USGS. The months of digression are restricted to May and June, an improvement over USGS samples over 3 µg/l collected in July through October. This third observation is indicative of improved pesticide management in the drainage, with further application restrictions on atrazine labels since 1993.
Centralia Lake Eutrophication, Aquatic Plants, pH	Summer Chlorophyll-a 48.31 ppb (very eutrophic) Total phosphorus average 157.1 ppm (elevated) pH high 21% of the time, average 7.88 Inorganic turbidity is low and light availability in the water column is high
Tuttle Creek Lake Eutrophication	Total phosphorus 185 ppb (high levels) Chlorophyll-a averages 2.81 ppb Trophic State Index 40.7
Tuttle Creek Lake and Watershed Atrazine	Lake consistently has elevated pesticides, notably atrazine during spring time conditions. Atrazine levels drop below the 3 ppb criterion in summer and winter. Most excursions have been associated with water in flood pool above 1078'. Sixty-seven percent of samples taken in 1993 or before were over 3 ppb. The percentage of excursions dropped to 27% from 1994-1998. The percentages demonstrated nonsupport of the designated uses. Sampling also occurred in the watershed at the lake headwaters (240); major intra-Kansas tributaries (502, 505, 507); and the stateline (232 ,233). Additionally, biweekly samples for atrazine were taken over 1996-1998 in the Black Vermillion watershed (stations 128-134, 141).
Tuttle Creek Lake Siltation	Lake has consistently high levels of turbidity and siltation. The lake has seen a 30% loss of its original storage since the dam closed in 1962. Based on trend analysis of sediment survey data from the Corps of Engineers, projections to 2008 indicate a loss of 48,000 acre-feet of storage from 1996 surveyed levels. Siltation within the headwaters and arms of the lakes coincidentally reduces the surface area of the lake, as well. KWO estimates there is a current loss of multi-purpose pool of 40.45%.
Tuttle Creek Lake Alachlor	Lake consistently has elevated pesticides, occasional detects of alachlor above the 2 ppb criterion were noted in June of 1991 (2.7 ppb) and 1994 (2.7 and 3.0 ppb). Summer samples taken in 1996-1998 detected alachlor below the water quality standard(.88, 1.3 and 1.2 ppb). The excursion in water quality occurred while the pool was above 1075'. Numerous samples taken by the Corps of Engineers in 1996 and 1997 showed alachlor levels above 2 ppb from June to early September.
Lake Idlewild Eutrophication	Total phosphorus 165 ppb (high levels) Chlorophyll-a averages 109 ppb Inorganic turbidity is low and light availability in the water column is high

Washington County SFL Dissolved Oxygen, Aquatic Plants	DO levels 5.8 mg/L at surface, 2.2 mg/L at bottom of lake The high macrophyte cover does not come with a corresponding high density The dissolved oxygen regime is “marginal” rather than a hard impairment
Washington WA Eutrophication, Siltation	Chlorophyll a concentration 80 ppb (hypereutrophic) Total phosphorus concentration 218 ppb (elevated) Inorganic turbidity is low and light availability in the water column is high Total Suspended Solids 57,5 mg/L

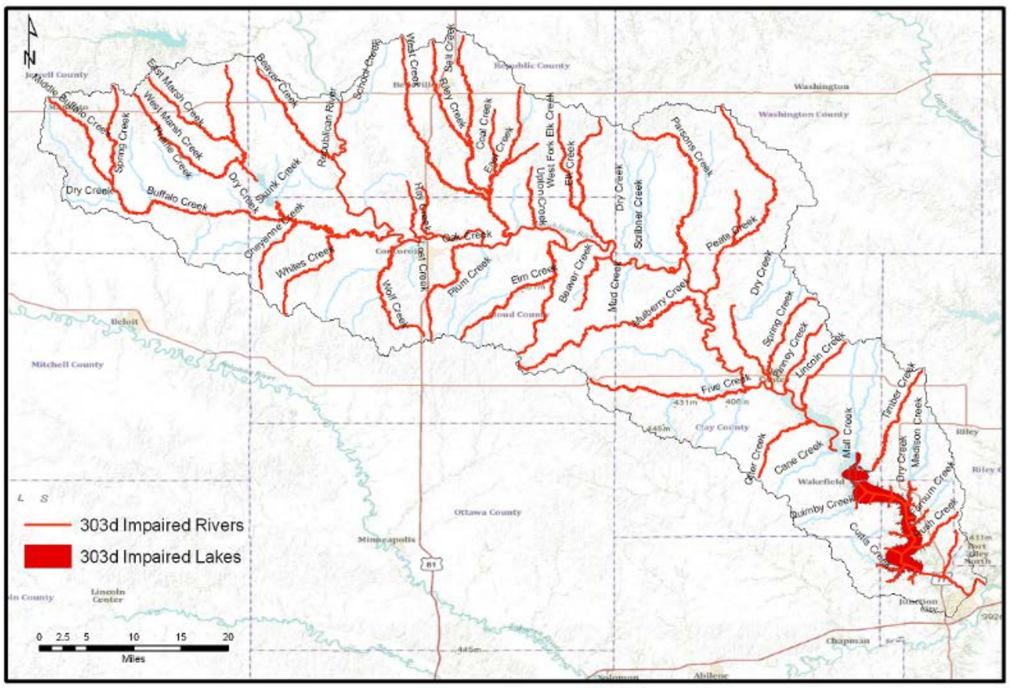


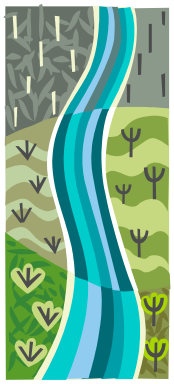
Figure 12 Streams on 303d list in Tuttle Creek Lake Watershed

Table 8 303d List of Impaired Waters in Tuttle Creek Lake Watershed

Water Segment	Impairment	Priority	Sampling Station
Big Blue River near Blue Rapids	Phosphorus	High	SC240
Big Blue River near Oketo	Phosphorus	High	SC233
Black Vermillion River near Frankfort	Phosphorus	High	SC505
Horseshoe Creek near Marysville	Phosphorus	High	SC717
North Elm Creek near Oketo	Phosphorus	High	SC731
Big Blue River near Blue Rapids	Total Suspended Solids	High	SC240

Big Blue River near Oketo	Total Suspended Solids	Low	SC233
Black Vermillion River near Frankfort	Total Suspended Solids	Low	SC505
Horseshoe Creek near Marysville	Total Suspended Solids	Low	SC717
Big Blue River near Oketo	Biology	Low	SC233
Big Blue River near Blue Rapids	Copper	Low	SC240
Big Blue River near Oketo	Copper	Low	SC233
Black Vermillion River near Frankfort	Copper	Low	SC505
Big Blue River near Blue Rapids	Lead	Low	SC240
Big Blue River near Oketo	Lead	Low	SC233
Black Vermillion River near Frankfort	Lead	Low	SC505
Horseshoe Creek near Marysville	Lead	Low	SC717
Big Blue River near Blue Rapids	pH	Low	SC240
Big Blue River near Oketo	pH	Low	SC233
Horseshoe Creek near Marysville	Sulfate	Low	SC717
Black Vermillion River near Frankfort	Biology	Unable to make a definitive determination due to a small number of samples analyzed	SC505
Rocky Ford Wildlife Area	Mercury	Unable to make a definitive determination due to a small number of samples analyzed	LM020601
Little Blue River near Hollenberg	Phosphorus	High	SC232
Little Blue River near Waterville	Phosphorus	High	SC741
Rose Creek near Narka	Phosphorus	High	SC712

Little Blue River near Hollenberg	Total Suspended Solids	High	SC232
Little Blue River near Waterville	Total Suspended Solids	High	SC741
Mill Creek near Hanover	Total Suspended Solids	High	SC507
Rose Creek near Narka	Total Suspended Solids	High	SC712
Little Blue River near Hollenberg	Biology	Low	SC232
Little Blue River near Hollenberg	Copper	Low	SC232
Little Blue River near Waterville	Copper	Low	SC741
Mill Creek near Hanover	Copper	Low	SC507
Rose Creek near Narka	Copper	Low	SC712
Washington County State Fishing Lake	Eutrophication	Low	LM010901
Little Blue River near Hollenberg	Lead	Low	SC232
Little Blue River near Waterville	Lead	Low	SC741
Mill Creek near Hanover	Lead	Low	SC507
Rose Creek near Narka	Lead	Low	SC712
Washington Wildlife Area	Lead	Low	LM010901
Little Blue River near Hollenberg	pH	Low	SC232
Washington Wildlife Area	Dissolved Oxygen	Unable to make a definitive determination due to a small number of samples analyzed	LM010941



Goals, Objectives, and Tasks

Goals

The goal of this project was to provide the watershed environmental and economic information needed for the development of a stakeholder-led Watershed Restoration and Protection Strategy (WRAPS) Plan and Report.

A primary goal of this Tuttle Creek Lake Watershed project was to develop models and tools to evaluate alternative farm and non-farm land use practices in relation to water quality and to document the impact of water restoration and preservation strategies.

Objectives

The objectives of this WRAPS Assessment Phase project were to:

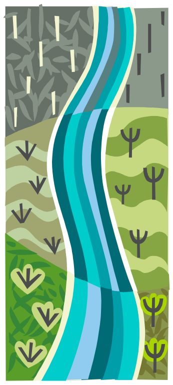
1. characterize watershed conditions,
2. identify needs and opportunities for watershed information to support stakeholder decisions, and
3. understand how the watershed responds to various management scenarios.

Tasks/Activities

The major tasks/activities implemented to achieve project objectives involved:

1. Inform and educate watershed stakeholders.
2. Establish assessment criteria.
3. Inventory existing information.
4. Provide technical information to support implementation decisions.
    a. Watershed Assessment
    b. Watershed Modeling
    c. Economic Analysis
5. Prepare watershed assessment project report.

The completed activities that address the established goals and objectives are presented in the following sections.



Summary of Project Activities and Accomplishments

Timeframe

The activities implemented as part of this WRAPS Assessment Phase project were ongoing for approximately two years, starting in January 2007 and ending in July 2009.

Inform and Educate Watershed Stakeholders

A Stakeholder Leadership Team (SLT) was recruited and established in the watershed. The team was active during the assessment project and provided critical stakeholder engagement that resulted in modeling results truly relevant for the WRAPS planning process. Watershed modeling and economic analysis results were presented to the SLT during several meetings, critically discussed, and the final critical areas were approved.

Activities

The following assessment activities took place during the time span of the project:

Date	Type	#Atten-dees	# Materials Distributed	Description
1/1/2007	Other	N/A	N/A	The move toward integrated, holistic watershed assessment has meant that more attention must be paid to factors beyond the water body itself—how land is used, what type of vegetative or other cover it has, and how it is managed. Such an approach requires the involvement of landowners, developers, farmers, urban governments, homeowners, and other constituents in the watershed if real progress is desired. Stakeholders need to be involved at each stage of the watershed planning process. Their knowledge of local social, economic, political, and ecological conditions provides the yardstick against which proposed solutions must be measured. Also, the goals, problems, and remediation strategies generated by stakeholders define what's desirable and achievable. In this regard, watershed specialists were asked to help in data collection and analysis procedure. Series of forms and maps were prepared and distributed. Their inputs will be directly incorporated in modeling procedure. KSU (Mankin, Nejadhashemi) have developed a draft factsheet ("Adaptive Watershed Modeling") to present the watershed modeling selection and revision process. This is an interactive process between KSU WRAPS Technical Team, the SLT, and other local watershed stakeholders, with the final product representing substantial commitment and consensus of all parties. A concurrent, joint KS-NE effort is underway in the Blue River Basin. Modeling and assessment efforts have not been coordinated to date. This will be addressed and reported upon in future reports. The following activities have been accomplished:
				1. Characterize existing agricultural activity: Working with the modeler, we have begun to identify cropping and management practices in the Tuttle Creek Watershed based on previous research performed at Kansas State University. We will also rely on expert opinion and local leadership team input to categorize existing cropping and tillage practices in the watershed. The technical team has worked with the modeler to develop and refine a Watershed Inventory survey that was completed by the Watershed Specialists.

				2. Develop BMP budgets specific to watershed, consistent with watershed modeling: Working with data from the Kansas Farm Management Association, cost-return budgets are being developed for Tuttle Creek Watershed. The budgets vary by crop rotations, management practices, inputs, and yields. Specific BMP budgets have been or are currently being developed for vegetative buffers, terraces, streambank stabilization, and reduced/no-till. Due to site and field specificity, developing reduced/no-till budgets have proved most difficult. Considerable research has shown that adopting conservation tillage practices such as no-tillage systems that reduce the rate of soil erosion can reduce labor costs, fuel costs, and machinery repair and ownership costs, and in some cases increase crop yields and the net returns from cropping activities. An examination of the research literature also shows a range of results for the profitability of no-tillage systems. We have summarized these results (available upon request).
				3. Create a list of financial incentives/programs available for BMPs: We have compiled lists of financial incentives/programs available through EQIP for both water quality and quantity conservation practices. These lists include both average costs and cost share percentages. We have also identified other programs which offer funding for conservation practices. Since vegetative and riparian forest buffers are supported through multiple funding programs, separate lists have been created to help producers calculate the amount of cost share and annual incentive payments that are available.
				4. Develop Land-Owner/Municipal BMP Decision Making tools: K-State Vegetative Buffer Decision-Assistance Tool has been developed with assistance and input from KSU Ag Economics faculty, NRCS, and Conservation District personnel (buffer coordinators). A marketing brochure has been developed to accompany this tool. This tool allows producers and land-managers across the state of Kansas (including Tuttle Creek Watershed) to evaluate the economic benefits and costs of vegetative buffers, and will help them decide if a buffer makes sense for their operation. This tool also incorporates the funding incentives information gathered previously. This tool should be placed on the web in the next few months.
				6. Construct a model to evaluate the onsite (on-farm) economic effects of field runoff and erosion: Initial work has been done to evaluate the onsite economic effects of soil and nutrient loss. There is a lacking of research in this area, and the little research that has been done has occurred in the Corn Belt. So, we will likely have to

				extrapolate these values in order to estimate "loss of productivity" values for the Tuttle Creek Watershed.
				7. Construct a model to evaluate the off-site (off-farm) economic effects that field runoff and erosion has on the local and regional economy in terms of: a. Lake Recreation, b. Water treatment, c. Lake Maintenance and longevity: Up to this point, most of the off-site economic effects evaluation has focused on Tuttle Creek Lake. Once we feel like we have refined our evaluation techniques with Tuttle Creek, we will then apply these lessons and processes to other watersheds – the technical process should be much more efficient by that time. Thorough research is being performed for the benefits-cost estimation of watershed management. Initial research has shown sedimentation as the main cause of future economic loss to Tuttle Creek Lake, so this will be the main focus of the economic analysis. The economic impacts and benefits of recreation at Tuttle Creek Lake are being estimated using an input-output impact analysis and non-market valuation techniques. A poster and oral presentation are being developed to report the results to Water and the Future of Kansas (WFK) conference attendees. This information will also be presented to the WRAPS local leadership team. The State of Kansas owns water in Tuttle Creek Lake under the Water Assurance Plan and the Water Marketing Plan. Current economic work is focusing on assigning a value to that water storage. Background research is also being performed on the onsite crop productivity (and value) loss to erosion in the watershed. Contact has been made with the Army COE regarding the options for sedimentation remediation from their perspective (dredging, raise the dam, remove the dam, etc.). Conference calls have been made with sedimentation experts at USGS, Kyle Juracek and Waite Ostercamp. Estimates of dredging have been made based on previous Army COE projects. This information is being documented in the form of a sedimentation economics white paper, which will be presented at the WFK conference and to the WRAPS local leadership team. This information is critical to the benefit-cost analysis. A program for estimating the Net Present Value of benefits and costs in the future has also been developed.
				8. With input from the Local Leadership Team, identify nonagricultural land use issues and develop a basic economic model addressing these concerns: Initial contact has been made with Reid Christianson, KSU Extension Assistant in the Biological and Agricultural Engineering Department, whose area of focus is Urban Stormwater BMPs. If the local leadership team identifies urban stormwater as an issue in the Tuttle Creek

				Watershed, then future work will involve the addition of economics to his work on the engineering side.
				9. Evaluate the benefits and costs of alternative watershed management plans for producers, local governments, and aggregate. Provide an expected completion time (month / year format) for each of the listed items: Using the BMP budget information, we are calculating the annualized costs of the most common BMPs (e.g., vegetative buffers, terraces, no-till, and streambank stabilization). This information will be applied to the alternative watershed management plans. Since the progression and completion of the economic analysis depends greatly on the local leadership team and the watershed modeling, many of the outputs and outcomes cannot have an accurate expected completion date assigned to them.
				Accomplishments to date: The stakeholders have already been introduced to the idea of the economic impact of watershed quality. When the stakeholders have a chance to hear the results of the benefit-cost analysis, they will be aware of the economic impact of water quality within and outside of the watershed. Tracking the number of Decision-Assistance tools distributed via the internet or compact discs will give us some idea of the impact of economic tool development. When the stakeholders develop their management plan or method of distributing implementation funding (e.g., through a BMP Auction, etc.) we will be able to determine if they considered economics in their decisions. Using adaptive management strategies, we can compare their plan to other conventional or less cost-effective plans and determine the overall cost-savings.
9/1/2007	Other	N/A	N/A	A sakeholder leadership team (SLT) was provided with a preliminary understanding of a situation from an outsider's perspective. Two comprehensive preliminary watershed assessment reports were provided. One for the Lower Little Blue and the other for Lower Big Blue Watersheds.
9/13/2007	SLT Meeting	25	25	Watershed modeler met with the stakeholder group for the Tuttle Creek Watershed. Two comprehensive Preliminary Watershed Assessment Reports were presented to the Lower Little Blue and the Lower Big Blue stakeholder leadership teams (SLTs). We also distributed the field data entry sheet to the representatives of counties. In addition, modeler provided two power point presentations about results of modeling for the Lower Little Blue and the Lower Big Blue watersheds. Watershed economist presented "Watershed Economics and Modeling Working Together" to the SLT which explained how we will use

				the results of the analysis to help develop cost-effective watershed management plans.
9/26/2007	E-mail	1	1	E-mail regarding upcoming SLT meetings
9/26/2007	E-mail	4	4	E-mail regarding upcoming SLT meetings
9/26/2007	E-mail	2	2	E-mail regarding upcoming SLT meetings
10/10/2007	SLT Meeting	3	3	Watershed modeler met with 3 representatives from Washington and Republic counties. In this meeting modeler went over the field data entry sheet and answered their questions about this form.
10/15/2007	E-mail	33	33	E-mail regarding upcoming SLT meetings
10/30/2007	SLT Meeting	20	20	Watershed modeler met with the Tuttle creek stakeholder leadership team. In this meeting modeler answered their questions regarding the field data entry sheet.
12/12/2007	E-mail	41	41	Two preliminary assessment reports were provided to about 8 other members of the stakeholder group. An email was sent to all members of the Tuttle Creek stakeholder groups (41 member) to encourage them in collecting additional information and refining the national database information
2/5/2008	SLT Meeting	15	15	Watershed modeler attended the WRAPS SLT meeting at the Waterville Community Center. STEPL model results were presented and input data used by the model was discussed. A process was coordinated, both at the meeting and through outside work by the SLT, to complete a worksheet that allowed the SLT to provide specific numerical revisions to model input data derived from national databases.
3/11/2008	SLT Meeting	15	15	Watershed modeler attended the WRAPS SLT meeting at the Waterville Community Center. The model results were presented to and discussed by the SLT.
3/12/2008	Other	N/A	N/A	The Tuttle stakeholders indicated an interest early on in knowing more about what's going on on the Nebraska side of the watershed. A survey was mailed to farmers in Marshall and Washington Counties in Kansas and Gage and Jefferson Counties in Nebraska in conjunction with the Targeted Watershed Grant. Gary D. Lynne, an Ag Econ Professor at University of Nebraska-Lincoln is leading this project. The Tuttle stakeholders have requested that we provide them with the results of this survey for use in the planning phase of the WRAPS project. They are also thinking that they may be able to use this information in ground-truthing the watershed model. KSU will be contacting Gary Lynne about the

				possibility of presenting the survey results at a future stakeholder meeting. We will also be asking someone from Nebraska's conservation agency to present on the targeted watershed grant and also address the question about watershed protection efforts in the upper portion of the watershed.
5/15/2008	SLT Meeting	15	15	Meeting in Blue Rapids. Watershed modeler presented the SWAT modeling results for sediment loads and targeting with the Lower Little Blue and Lower Big Blue watersheds. The SLT requested further modeling results for nutrient loads and targeting. Watershed economist presented economic modeling and planning tool results.
5/22/2008	Meeting	100	1	KDHE WRAPS Regional Watershed Seminar, Lawrence, KS. WRAPS Adaptive Modeling presentation (Mankin)
6/17/2008	Meeting	85	1	USDA-CSREES Heartland Regional Workshop: Impact Assessment and Achievements in Water Quality Protection, Nebraska City, NE. June 17-19, 2008. Using Watershed Models to Assess Watershed Needs and Project Impacts: What Models Are, When to Use Them, Shortcomings and Strengths. (Mankin, Invited Presentation) Posted at: http://www.oznet.ksu.edu/waterquality/2008%20Assessment/Workshop/Presentations/Mankin 3.pdf
6/17/2008	Meeting	85	1	USDA-CSREES Heartland Regional Workshop: Impact Assessment and Achievements in Water Quality Protection, Nebraska City, NE. June 17-19, 2008. Case Study: Using Watershed Models to Target Best Management Practices in the Pomona Lake Watershed in Kansas. (Mankin, Invited Presentation) Posted at: http://www.oznet.ksu.edu/waterquality/2008%20Assessment/Workshop/Presentations/Mankin 3.pdf
7/10/2008	SLT Meeting	15	15	Meeting in Blue Rapids. The revised SWAT modeling results were presented to the SLT. Watershed economist presented economic modeling and planning tool results.
9/23/2008	E-mail	50	50	
9/30/2008	SLT Meeting	30	30	The SLT was presented with two examples of the economic importance of targeting BMPs within areas of their watershed that have the highest potential for soil erosion.
10/23/2008	E-mail	50	50	
10/30/2008	SLT Meeting	30	30	After the first presentation on 9/30/08 the watershed economist took suggestions from the SLT on additional targeting strategies and alternative BMPs. He then created these scenarios and evaluated the alternative BMP suggestions and presented it to them on 10/30/08.

11/3/2008	Workshop	14	0	During 11/03/2008-11/07/2008, Aleksey Sheshukov attended a SWAT/APEX workshop at the Texas A&M University in College Station, TX. The purpose of attending the workshop was to learn about the advanced watershed modeling tools - SWAT and APEX, and train to be proficient applying these tools in the WRAPS projects. This workshop was designed to introduce new version of SWAT (ArcSWAT), review necessary and optional inputs, and familiarize the user with the new ArcGIS interfaces. It also covered sensitivity analysis, model calibration, and uncertainty analysis using the 2005 version of SWAT with an ArcGIS interface.
11/9/2008	SLT Meeting	30	30	Josh Roe presented a set of targeted, cost-effective BMP implementation scenarios to the SLT. The SLT desired more information on additional scenarios and the effectiveness of cover crops when used in tandem with no-till farming.
11/9/2008	SLT Meeting	30	30	Aleksey Sheshukov presented an approach to identify additional targeted areas in Tuttle Creek watershed. In the presentation we compared the current targeted areas identified in subwatershed scale to more detailed potential areas that can be identified by providing a higher resolution watershed modeling analysis with SWAT. We proposed to do additional modeling analysis within the targeted watersheds by incorporating current management practices, adopted BMPs, and other area features protocoled during the groundtruthing survey performed a week before the meeting by the members of SLT. Advantages of this field-scale modeling approach would include a collection of detailed output GIS maps with potential areas highlighted and accompanied with a corresponding ranking table. Following the presentation, the SLT discussed a possibility to consider this modeling approach as a basis for potential future funding.
11/12/2008	E-mail	40	40	
12/8/2008	E-mail	40	40	
12/15/2008	SLT Meeting	60	60	Josh created the desired set of scenarios and consulted faculty in Agricultural Economics and Agronomy on Cover Crops, he presented this information to the SLT at the December, 15 2008 meeting.
1/8/2009	E-mail	40	40	
1/15/2009	SLT Meeting	60	60	Josh presented what appears to be their final BMP implementation plan as well as a BMP cost-effectiveness matrix that allows stakeholders to compare the cost-effectiveness of BMPs.
2/10/2009	Email	50	50	
2/17/2009	SLT Meeting	60	60	Watershed economist presented cost and effectiveness information for livestock BMPs pertinent to the watershed. The planning for the BMP auction also began with Josh giving a presentation on auction mechanics.

				Powerpoint presentation and fact sheets were distributed to the SLT members.
3/25/2009	Email	50	50	
4/1/2009	SLT Meeting	30	30	Watershed economist assisted the SLT in selecting their top 5 livestock BMPs. The dates for the BMP auction were set and a sub committee consisting of SLT members was created. Dan Devlin gave a presentation on Atrazine BMPs and Phil Barnes presented updated loadings and monitoring data from the watershed.
4/13/2009	Meeting	1	1	Josh Roe and Robert Wilson met with Josh Lloyd from No-Till on the Plains to discuss further opportunities for no-till adoption in Tuttle Creek Watershed.
4/20/2009	SLT Meeting	6	6	The subcommittee for the BMP auction met in Marysville to determine dates and a marketing strategy for the auction. It has been decided that the auction will commence in July, last 3 months, and two producer workshops will take place throughout the watershed to promote it.

Establish Assessment Criteria

With assistance of the Stakeholder Leadership Team, the assessment criteria were established based on the pollutant loads calculated with the watershed assessment models and/or monitoring data information in the Lower Big Blue and Lower Little Blue Rivers and tributaries. The assessment criteria were given priorities in the sediment producing agricultural areas and the areas with heavy livestock grazing facilities. Stream banks along the Lower Big Blue and Lower Little Blue Rivers were assessed based on available GIS information revised according to local knowledge.

Inventory Existing Information

The watershed assessment team compiled the preliminary assessment information needed for this WRAPS project and revised it with the Stakeholder Leadership Team. Inventory included topographical information, land uses, soil types, weather data, surface water resources, designated uses, public and rural water supplies, recreational areas, TMDL, agricultural and management practices, etc. This WRAPS project was able to identify relevant information regarding watershed conditions, natural resources, culture, customs, institutions, etc.

The project team inventoried watershed informational resources, TMDL needs inventories, previous watershed assessment reports, water-quality studies, USGS monitoring data, wildlife reports, riparian assessments, etc. Details about this process and the data compiled are presented in the *Watershed Assessment* section, below.

Provide Technical Information to Support Implementation Decisions

Watershed Atlas

Extensive information about the Tuttle Creek Lake Watershed and surrounding area was collected, compiled, and published as two Preliminary Assessment Reports (often called the "Watershed Atlas"). This information was published as a K-State Research and Extension publication, thus making it available digitally online:

Lower Big Blue Watershed Assessment: Preliminary Report. K-State Research & Extension Publication #EP-140. 54 pages. http://www.ksre.ksu.edu/library/h20ql2/ep140.pdf

Lower Little Blue Watershed Assessment: Preliminary Report. K-State Research & Extension Publication #EP-141. 52 pages. http://www.ksre.ksu.edu/library/h20ql2/ep141.pdf

These publications included the following topics:

- 1.0. Watershed Assessment
  - 1.1. Watershed Summary
  - 1.2. Overview of Water Quality Issues and Potential Pollution Sources
- 2.0. Climate Mapping System
  - 2.1. Precipitation Map
  - 2.2. 30-Year Average Daily Maximum Temperature Map
  - 2.3. 30-Year Average Daily Minimum Temperature Map
- 3.0. Land Use/ Land Cover
  - 3.1. Land Use (GIRAS 1980s)
  - 3.2. Land Use (NLCD 1992)
  - 3.3. Land Use (NLCD 2001)
- 4.0. River Network
- 5.0. Hydrologic Soil Groups
- 6.0. Water Quality Conditions
  - 6.1. The 303d List of Impaired Waterbodies
  - 6.2. Water Quality Observation Stations
  - 6.3. USGS Gage Stations
  - 6.4. Permitted Point Source Facilities
  - 6.5. Confined Animal Feeding Operations (CAFOs)
  - 6.6. 1990 Population and Sewerage by Census Tract
- 7.0. Agricultural Economy
  - 7.1. Corn Cost-Return Budget
  - 7.2. Soybean Cost-Return Budget
  - 7.3. Wheat Cost-Return Budget
  - 7.4. Grain Sorghum Cost-Return Budget
  - 7.5. Alfalfa Cost-Return Budget
  - 7.6. Common Cropland BMPs in Tuttle Creek Lake Watershed
    - 7.6.1. Vegetative Buffer: Economic Analysis and Discussion
    - 7.6.2. Streambank Stabilization: Economic Analysis and Discussion
  - 7.7. Economic Contributions of Recreation at Tuttle Creek Lake
  - 7.8. Census Data
- 8.0. Modeling

8.1. Subbasin Map
8.2. Input Data
8.3. Model Output

9.0. Acknowledgment

10.0. Footnotes/Bibliography

TMDL Reports

- The TMDL documents provide a rich source of watershed information. Priority categories and a detailed list of impairments were provided in Kansas Lower Republican Basin TMDL. Tuttle Creek Lake. Water Quality Impairment: Eutrophication. < http://www.kdheks.gov/tmdl/klr/TuttleE.pdf>

- Kansas Lower Republican Basin TMDL. Tuttle Creek Lake. Water Quality Impairment: Siltation. < http://www.kdheks.gov/tmdl/klr/TuttleSILT.pdf>

- Kansas Lower Republican Basin TMDL. Tuttle Creek Lake. Water Quality Impairment: Alachlor. < http://www.kdheks.gov/tmdl/klr/TuttleAl.pdf>

- Kansas Lower Republican Basin TMDL. Tuttle Creek Lake and the watershed. Water Quality Impairment: Atrazine. < http://www.kdheks.gov/tmdl/klr/Tuttle_ATR.pdf>

- Kansas Lower Republican River Basin, Tuttle Creek Lake Watershed TMDL

    - http://www.kdheks.gov/tmdl/klr/BigBlueFCB.pdf
    - http://www.kdheks.gov/tmdl/klr/BlackVermillionFCB.pdf
    - http://www.kdheks.gov/tmdl/klr/FancyCkFCB.pdf
    - http://www.kdheks.gov/tmdl/klr/LittleBlueFCB.pdf
    - http://www.kdheks.gov/tmdl/klr/centraliaE.pdf
    - http://www.kdheks.gov/tmdl/klr/TuttleE.pdf
    - http://www.kdheks.gov/tmdl/klr/TuttleATR.pdf
    - http://www.kdheks.gov/tmdl/klr/TuttleSILT.pdf
    - http://www.kdheks.gov/tmdl/klr/TuttleAl.pdf
    - http://www.kdheks.gov/tmdl/klr/idlewild.pdf
    - http://www.kdheks.gov/tmdl/klr/washsflDO.pdf
    - http://www.kdheks.gov/tmdl/klr/washsflAP.pdf
    - http://www.kdheks.gov/tmdl/klr/WashWAE.pdf
    - http://www.kdheks.gov/tmdl/klr/WashWASILT.pdf
    - http://www.kdheks.gov/tmdl/klr/Tuttle_ATR.pdf

Within these documents are descriptions and discussions of key water quality conditions and sources, and guidance for potential action. Major topics include:

1. Introduction and problem identification – basic waterbody and watershed data
2. Current water quality condition and desired endpoint – summary of available stream and lake data
3. Source inventory and assessment – data on land uses, point sources
4. Allocation of pollutant reduction responsibility – modeling-based load allocations

5. Implementation – potential activities, state and federal educational and funding support programs, milestones
6. Monitoring – plans for future efforts
7. Feedback – process used by KDHE during TMDL development

More information about KDHE's TMDL process can be found at the KDHE, Division of Environment, Bureau of Water, Watershed Planning Section web site:

Kansas Total Maximum Daily Loads (TMDLs). http://www.kdheks.gov/tmdl/

Watershed Modeling

Soil and Water Assessment Tool (SWAT)

The Tuttle Creek Lake Watershed was assessed using the Soil and Water Assessment Tool (SWAT) by Kansas State University Department of Biological and Agricultural Engineering. SWAT was used as an assessment tool to estimate annual average pollutant loadings such as nutrients and sediment that are coming from the land into the stream. At the end of simulation runs the average annual loads are calculated for each sub watershed. Some subbasins have higher loads than the others. All subbasins are ranked based on the values of an average annual load, sorted from highest to lowest, and form the ranking list. Subbasins within the top 20 to 30 percent of the list are selected as critical (targeted) areas for cropland and livestock BMPs implementation.

The SWAT model was developed by USDA- Agricultural Research Service (ARS) from numerous equations and relationships that have evolved from years of runoff and erosion research in combination with other models used to estimate pollutant loads from animal feedlots, fertilizer and agrochemical applications, etc. The SWAT model has been tested for a wide range of regions, conditions, practices, and time scales. Evaluation of monthly and annual streamflow and pollutant outputs indicate SWAT functioned well in a wide range of watersheds. The model directly accounts for many types of common agricultural conservation practices, including terraces and small ponds; management practices, including fertilizer applications; and common landscape features, including grass waterways. The model incorporates various grazing management practices by specifying the amount of manure applied to the pasture or grassland, grazing periods, and the amount of biomass consumed or trampled daily by the livestock. Septic systems, NPDES discharges, and other point-sources are considered as combined point-sources and applied to inlets of sub watersheds. These features made SWAT a good tool for assessing rural watersheds in Kansas.

The SWAT model is a physically based, deterministic, continuous, watershed scale simulation model developed by the USDA-ARS. ArcGIS interface of ArcSWAT version 9.2 was used. It uses spatially distributed data on topography, soils, land cover, land management, and weather to predict water, sediment, nutrient, and pesticide yields. A modeled watershed is divided spatially into sub watersheds using digital elevation data according to the drainage area specified by the user. Sub watersheds are modeled as having non-uniform slope, uniform climatic conditions determined from the nearest weather station, and they are further subdivided into lumped, non-spatial hydrologic response units (HRUs) consisting of all areas within the sub watershed having similar soil, land use, and slope characteristics. The use of HRUs allows slope, soil, and land-use heterogeneity to be simulated within each sub watershed, but ignores pollutant attenuation between the source area and stream and limits spatial representation of wetlands, buffers, and other BMPs within a sub watershed.

The model includes subbasin, reservoir, and channel routing components.

1. The subbasin component simulates runoff and erosion processes, soil water movement, evapotranspiration, crop growth and yield, soil nutrient and carbon cycling, and pesticide and bacteria degradation and transport. It allows simulation of a wide array of agricultural structures and practices, including tillage, fertilizer and manure application, subsurface drainage, irrigation, ponds and wetlands, and edge-of-field buffers. Sediment yield is estimated for each subbasin with the Modified Universal Soil Loss Equation (MUSLE). The hydrology model supplies estimates of runoff volume and peak runoff rates. The crop

management factor is evaluated as a function of above ground biomass, residue on the surface, and the minimum C factor for the crop that is provided in the crop database.

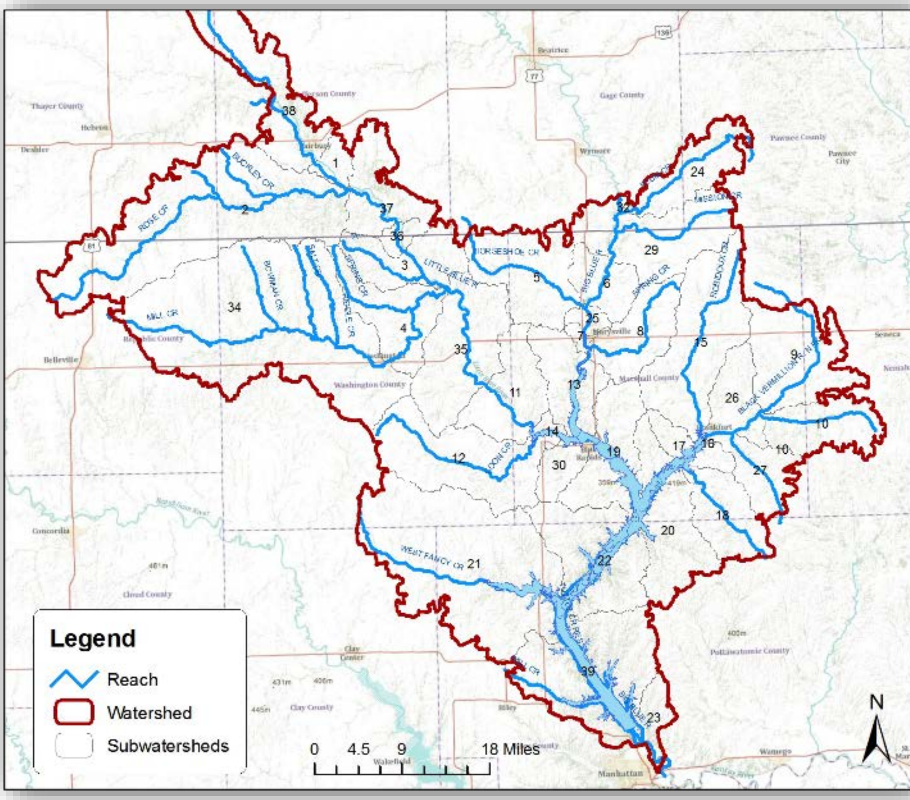
2. The reservoir component detains water, sediments, and pollutants, and degrades nutrients, pesticides and bacteria during detention. This component was not used during the simulations.
3. The channel component routes flows, settles and entrains sediment, and degrades nutrients, pesticides and bacteria during transport. SWAT produces daily results for every sub watershed outlet, each of which can be summed to provide daily, monthly, and annual load estimates. The sediment deposition component is based on fall velocity, and the sediment degradation component is based on Bagnold's stream power concepts. Bed degradation is adjusted by the USLE soil erodibility and cover factors of the channel and the floodplain. This component was utilized in the simulations but not used in determining the critical areas.

Data Collection

Data for the Tuttle Creek Lake Watershed SWAT model were collected from a variety of reliable online and printed data sources and knowledgeable agency personnel within the watershed. The primary sources of input data were in the form of thematic GIS layers. Such layers include topography, land use/land cover, and soil spatial distribution. Other input data can also be available in a form of GIS layers, but these were loaded into the model as tables with items manually distributed over subwatersheds or HRUs. Multiple programming utilities had been developed to process the input data, enter it into the SWAT model, and analyze the output results: Visual Basic, Visual Basic for Applications and Visual Studio C++ were used as main programming languages to develop the data processing utilities.

Input data and their online sources were:

1. 30 meters DEM (USGS National Elevation Dataset)
2. 30m NLCD 2001 Land Cover data layer (USDA-NRCS)
3. STATSGO soil dataset (USDA-NRCS)
4. NCDC NOAA daily weather data (NOAA National Climatic Data Center)
5. Point sources (KDHE on county basis)
6. Septic tanks (US Census)
7. Crop rotations (local knowledge)
8. Grazing management practices (local knowledge)



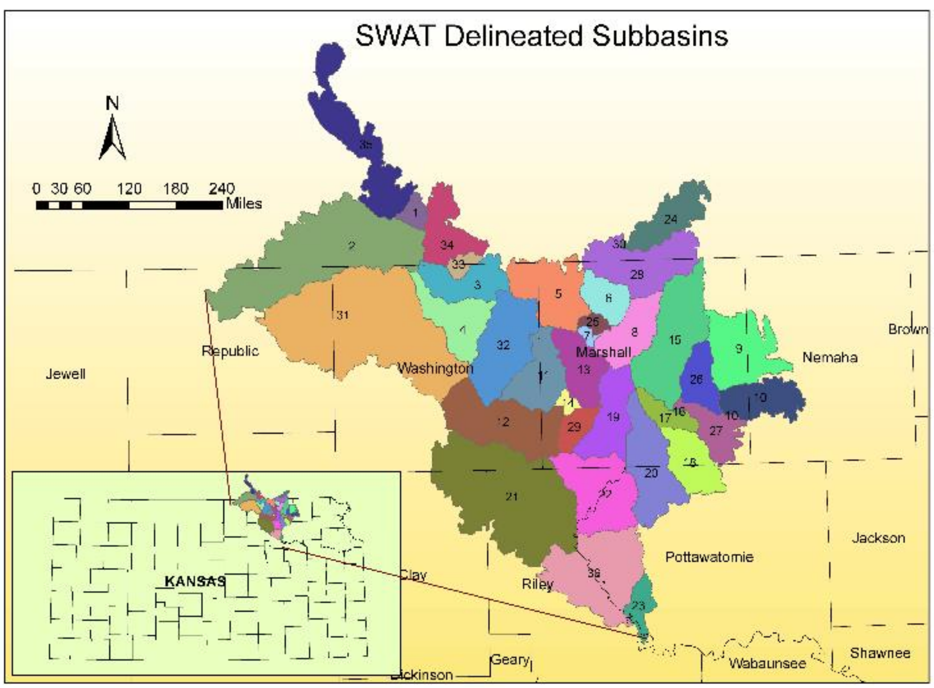


Figure 13 Tuttle Creek Lake Watershed delineated with SWAT

Topography

The digital elevation map (DEM) for the basin was downloaded from the USGS National Elevation Dataset (NED). Elevations varied from 310 m to 570 m above the sea level (see Figure 14). The watershed was delineated into 50 subwatersheds (see Figure 13).

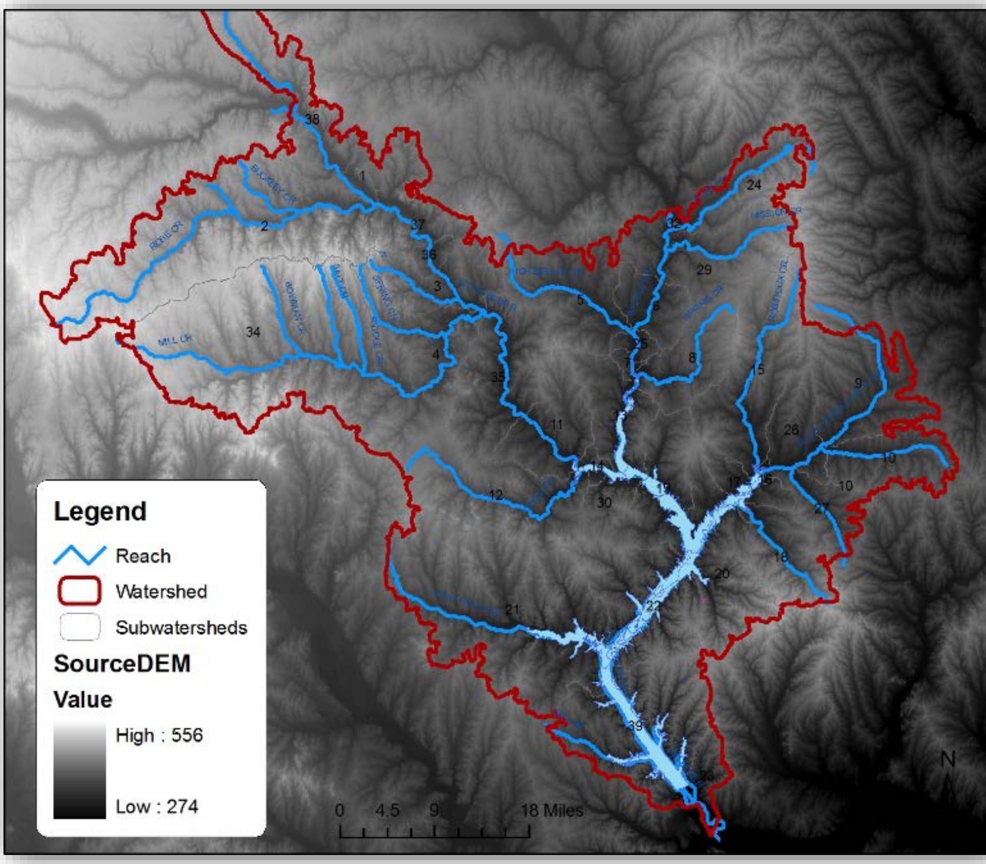


Figure 14 Topography map

Land Use

The land use dataset used in the model was the USDA National Land Cover Dataset (NLCD) prepared in 2001. NLCD 2001 has 10 standardized categories with 6 main categories presented in Figure 15 and summarized in Table 9 for the Upper Republican River Basin and Tuttle Creek Lake Watershed.

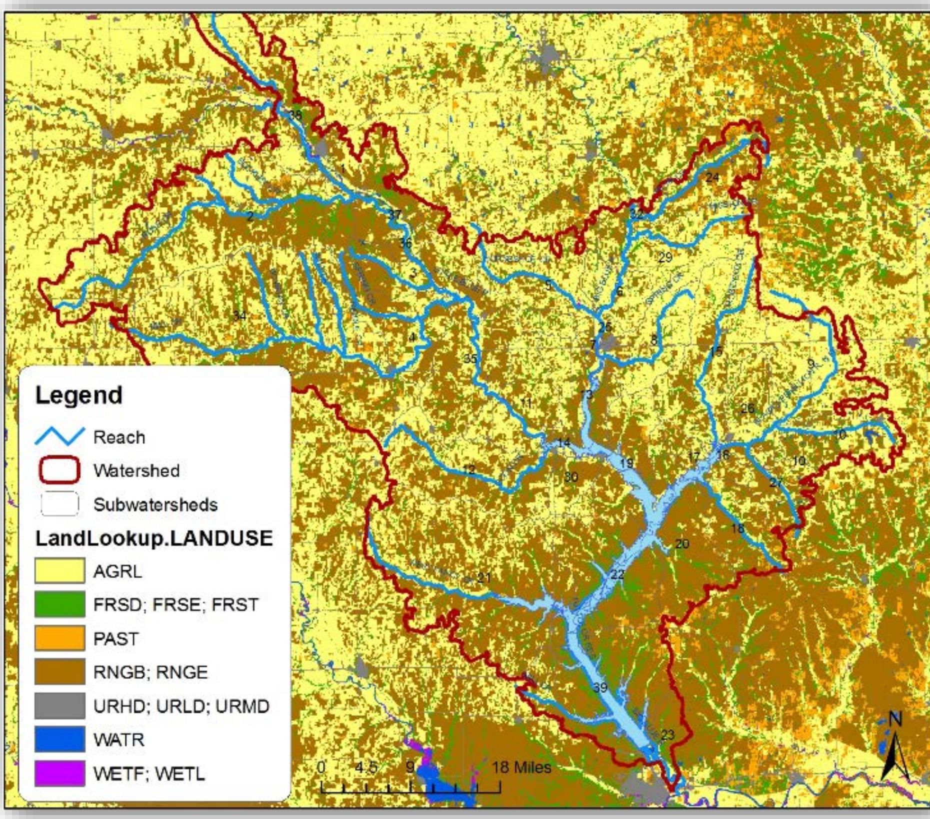


Figure 15 Land use map utilized in the SWAT model

Table 9 Areas of land uses and its classification used in SWAT model

Land Use	Acres	Percentage
Urban Industrial/Commercial	2,394	0.15
Urban Residential	5,187	0.33
Urban open land	4,593	0.3
Urban Woodland	996	0.06
Urban Water	27	0
Cropland	737,540	47.4
Grassland	612,488	39.36
CRP	63,207	4.06
Woodland	109,020	7.01
Water	20,119	1.29
Other	509	0.03
Total	1,556,081	100

Soils

The Natural Resources Conservation Service (NRCS) State Soil Geographic (STATSGO) soils database and its geo-spatial coverage were used as an input for the SWAT model. Groups A, B, C, and D represent different soil textures and commonly vary from sandy soils in Group A to clay soils in Group D. High percentage of C and D group soils present higher soil erosion potential. Figure 16 and Table 10 show 20 soils, their distribution and characteristics in the watershed.

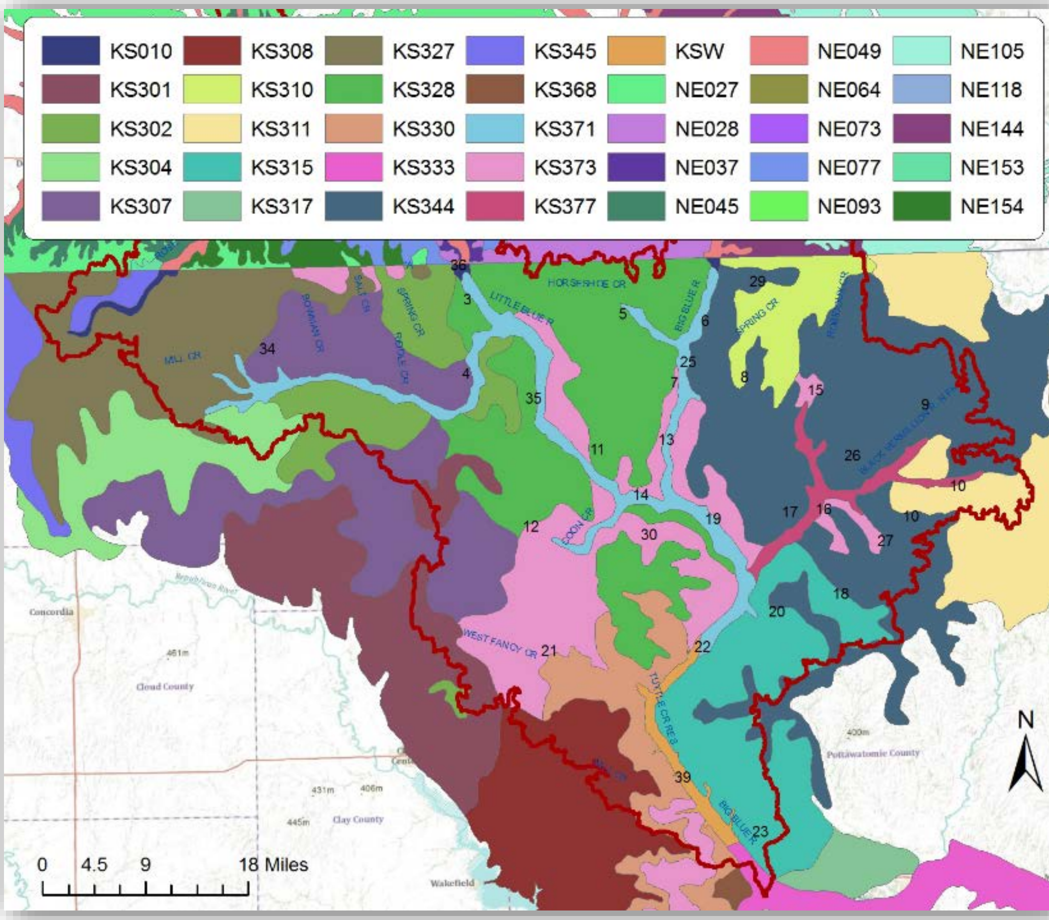


Figure 16 Soil map used in the SWAT model

Table 10 Soil characteristics used in the SWAT model for Kansas portion of the watershed

Soils	Hydrologic Group	Area (acres)	Area (ha)
KS373	D	1101.85	445.92
KS328	C	127296.84	51517.03
KS302	B	30010.71	12145.33
KS327	C	1135.36	459.48
KS310	D	47977.98	19416.69
KS010	B	900.82	364.56
KS010	B	556.64	225.27
KS344	D	95486.69	38643.46
KS371	B	73638.38	29801.45
KS328	C	7527.79	3046.50

KS327	C	110377.54	44669.79
KS373	D	5027.45	2034.61
KS345	B	8847.93	3580.76
KS010	B	4235.49	1714.10
KS373	D	1064.26	430.71
KS311	D	22787.31	9222.03
KS302	B	11621.26	4703.13
KS373	D	112494.35	45526.46
KS301	C	19029.44	7701.21
KS344	D	66191.29	26787.62
KS328	C	63567.27	25725.67
KS373	D	9416.54	3810.87
KS302	B	30895.25	12503.31
KS373	D	3045.89	1232.67
KS304	B	14106.06	5708.72
KS373	D	19604.41	7933.90
KS377	D	21494.32	8698.75
KS307	C	51673.38	20912.22
KS311	D	7255.89	2936.46
KS301	C	11607.99	4697.75
KS344	D	118380.70	47908.67
KS307	C	65371.94	26456.03
KS373	D	16452.95	6658.51
KS373	D	7038.35	2848.42
KS328	C	6600.77	2671.33
KS328	C	35604.57	14409.17
KS315	C	121145.90	49027.75
KS330	C	60070.42	24310.50
KS373	D	7901.25	3197.64
KS330	C	2802.35	1134.11
KS302	B	336.99	136.38
KS308	D	35310.91	14290.33
KSW	D	14808.63	5993.05
KS333	B	3222.25	1304.04

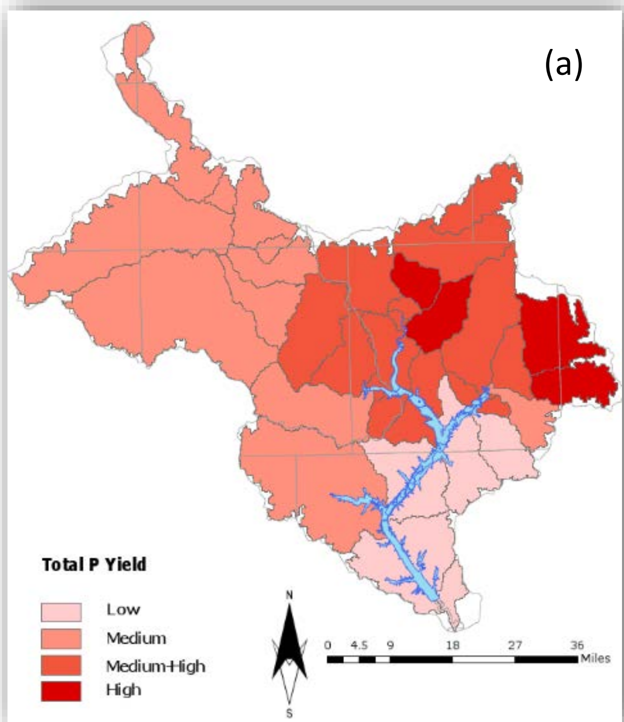
Other inputs

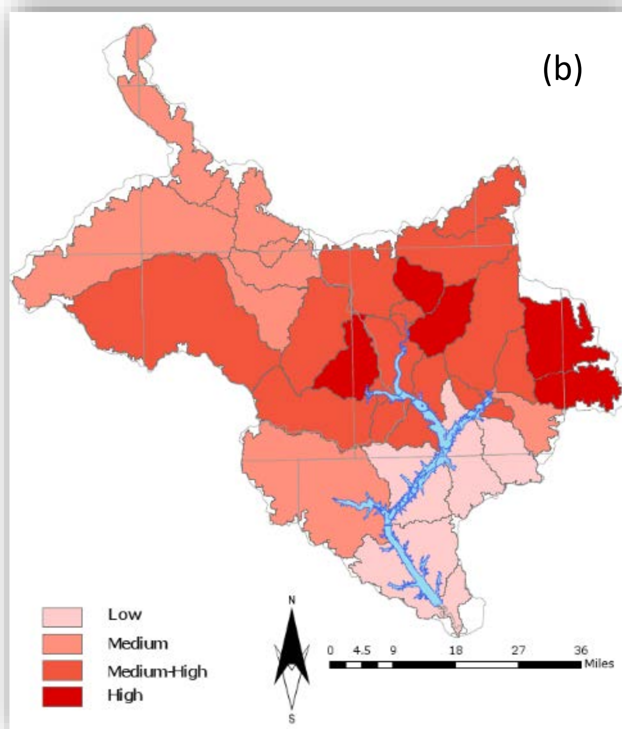
Weather data was collected and downloaded from NOAA National Climatic Data Center (NCDC, 2009). There are total 19 weather stations around the watershed; 16 stations with precipitation data and 10 stations with non-precipitation data.

Among other input information entered into the SWAT model, we can list crop rotations, grazing management operations, confined animal feeding operations (CAFO), permitted point source facilities, and septic systems. From prior experience, these data should be confirmed and revised using local stakeholder knowledge and information.

In every watershed, there are specific locations that contribute a greater pollutant load due to soil type, proximity to a stream and land use practices. By focusing BMPs in these areas; pollutants can be reduced at a more efficient rate. Through research at the University of Wisconsin, it has been shown that there is a "bigger bang for the buck" with streamlining BMP placement in contrast to a "shotgun" approach of applying BMPs in a random nature throughout the watershed. Therefore, the SLT has targeted areas in the watershed to focus BMP placement for sediment runoff, nutrients and E. coli bacteria from livestock production and stream bank erosion. Targeting for this watershed will be accomplished in three different areas:

1. Cropland will be targeted for sediment,
2. Rangeland will be targeted for sediment and the same geographic area will be targeted for livestock related phosphorus, and
3. Stream banks will be targeted for sediment.





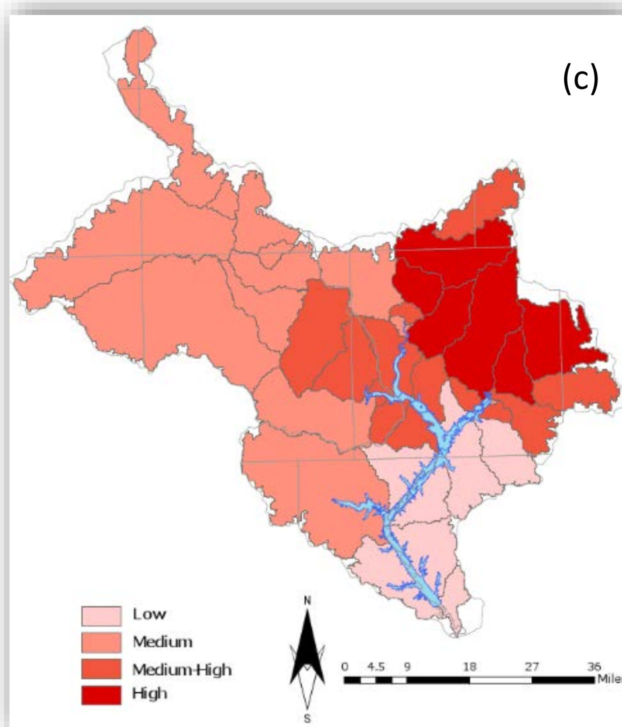


Figure 17 Maps of (a) Phosphorous (lb/acre), (b) Nitrogen (lb/acre), and (c) Sediment (tons/acre) Loads as Determined by SWAT in 50 subbasins of the Tuttle Creek Lake Watershed

After locating initial critical targeted areas, the area was groundtruthed. Groundtruthing is a method used to determine what BMPs are currently being utilized in the targeted areas. It involves conducting windshield surveys throughout the targeted areas identified by the watershed models to determine which BMPs are currently installed. These surveys are conducted by local agency personnel and members of the SLT that are familiar with the area and its land use history. Groundtruthing provides the current adoption rate of BMPs, pictures of the targeted areas, and may bring forth additional water quality concerns not captured by watershed modeling. In 2009, the groundtruthing provided the current adoption rates for four common BMPs (buffers, no-till, grassed waterways, and nutrient management plan) in the cropland targeted area of the watershed averaged across counties.

The results are as follows:

- Grassed waterways – current adoption rate of 57 percent
- No-till cultivation – current adoption rate of 5 percent
- Vegetative buffer strips – current adoption rate of 19 percent
- Nutrient management plans - current adoption rate of 21 percent
- Subsurface fertilizer application – current adoption rate of 5%

This allows the SWAT model to develop a more accurate determination of appropriate targeted areas. The SWAT model then determined number of acres needed to be implemented for each BMP. The maps produced by the modeling are displayed below. It is noted that the areas are characterized by different color with darker colors indicating higher loads.

Pollutant Yields

The SWAT model was setup to run for 15 years from 1993 to 2008 with the first 5 years dedicated for a model warm-up period, to allow model parameters to adjust from the default initial condition. The results were collected on an annual basis for each subwatershed and then averaged out over the simulation period. Model output variables, such as sediment yield, organic, mineral and soluble phosphorous concentrations, and nitrate and organic nitrogen concentrations, were collected and combined in the forms of total sediment, phosphorous, and nitrogen loads. Figure 17 presents maps of the loads for Tuttle Creek Lake Watershed in a scale of graduated colors (darker color indicates higher load).

Average annual yields for each subwatershed are listed in Table 11. All subwatersheds produced relatively high pollutant loads with subwatersheds 6, 8, 9, 15, 26, and 29 produced the highest annual yields, with at least 20% or higher of the total watershed nitrogen, phosphorous, and sediment yields.

Table 11 Total pollutant loads for each subwatershed

Subbasin	Total Sediment Yield (tn/ac)	Total Phosphorous Yield (lb/ac)	Total Nitrogen Yield (lb/ac)
1	2.03	1.51	8.88
2	2.58	1.75	10.24
3	2.84	1.75	10.53
4	2.62	1.66	9.89
5	3.00	2.35	14.42

6	6.12	3.40	19.37
7	3.06	1.97	11.94
8	5.66	3.01	16.38
9	5.96	3.11	16.75
10	4.35	2.87	17.11
11	4.45	2.61	15.77
12	2.85	1.88	11.34
13	4.20	2.28	13.68
14	3.54	2.12	12.59
15	4.94	2.42	13.32
16	3.14	2.29	13.26
17	4.44	2.05	11.70
18	0.47	0.51	3.89
19	4.58	2.03	11.87
20	0.52	0.58	4.36
21	2.53	1.44	8.41
22	0.45	0.52	3.88
23	0.42	0.70	5.15
24	3.61	2.06	12.27
25	3.87	2.45	14.25
26	5.10	2.36	13.27
27	4.53	1.80	10.26
28	5.01	2.46	13.68
29	3.66	2.00	12.18
30	0.72	0.81	4.67
31	2.61	1.88	11.58
32	3.53	1.99	12.07
33	2.22	1.50	8.79
34	1.81	1.25	7.30
35	1.90	1.58	9.15
36	0.60	0.66	4.80

Stream Bank Area Assessment

Stream bank area assessment was based on the 1991 1:24000 USDA/NRCS GIS Riparian GIS layer Inventory originating from the Kansas Geospatial Community Commons. Areas of unprotected land with no riparian cover (barren land, crop land, grass land) were considered susceptible for bank erosion and therefore being selected as targeted critical areas.

The layer contained the following categories:

Table 12 Categories in the riparian inventory layer (AAAA)

Land Cover	Description
Forest Land	Areas adjacent to a stream that contains trees with a canopy cover greater than 51% of the 100 foot buffer zone.
Crop Land	Areas adjacent to a stream where no trees area present and in which 51% of the 100 foot buffer is planted or was planted during the previous growing season for the production of adapted crops

	for harvest, including row crops, small-grain crops, legume, hay crops, nursery crops, and other specialty crops.
Crop/Tree Mix	Cropland land use areas that contain a tree canopy cover of less than 50% of the 100 foot buffer zone.
Grass Land	Areas adjacent to a stream in which 51% or more of the 100 foot buffer contains pastureland, native pasture, or rangeland.
Grassland/Tree Mix	Grassland land use areas that contain a tree canopy cover of less than 50% of the 100 foot buffer zone.
Urban Land	Areas adjacent to a stream where 51% or more of the 100 foot buffer contains dwellings or is located in an urban area without trees adjacent to the stream. Highways, railroads, and other transportation facilities are considered to be part of the urban & built-up land base if the area surrounded by other urban and built-up areas.
Urban/Tree Mix	Urban land use areas that contain a tree canopy cover of less than 50% of the 100 foot buffer zone.
Shrub/Scrub Land	Areas adjacent to a stream that contain shrubs or brush/scrub vegetation with a canopy cover greater than 51% of the 100 foot buffer zone. Areas are composed of multi-stemmed woody plants, shrubs, and vines. Including areas that contain a wide diversity of vegetative cover that are not distinguishable.
Animal Production Area	Areas adjacent to a stream that include barns, pens, or corrals used for the storage, feeding, processing, and production of livestock animals with a land use cover of greater than 51% of the 100 foot buffer zone.
Barren Land	An area adjacent to a stream where 51% of the 100 foot buffer contains land without any discernible vegetative cover, including quarries, borrows pits, and dry ponds.

The conducted GIS analysis included a 30 ft buffer along main stem of the Big Blue and Little Blue Rivers with an intersected riparian coverage (Figure 18). There were approximately 618 acres of a 30 foot buffer along the rivers. After consulting with the SLT, these areas were identified as being targeted for streambank restoration. This riparian area can be vulnerable to runoff and erosion from livestock induced activities. Buffers and filter strips along with forested riparian areas can be used to impede erosion and streambank sloughing. Livestock restriction along the stream will prevent livestock from entering the stream and degrading the banks.

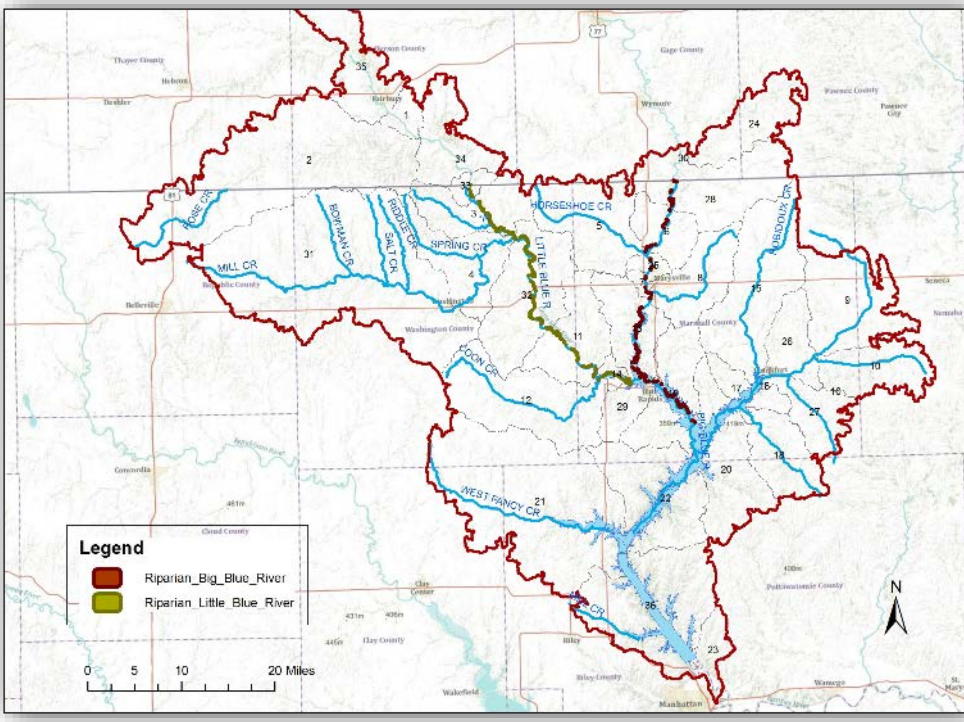


Figure 18 Map of stream bank areas (30 ft) along main stem of Big Blue and Little Blue Rivers

Critical Targeted Areas

The pollutant yields maps produced by the modeling are displayed in Figure 17. The subwatersheds6, 8, 9, 15, 26, and 29 show the highest potential for erosion, phosphorous, and nitrogen runoff. As stated earlier, this model accounts for land use, soil type, slope, and current conservation practices. This is the area of the watershed with the greatest percentage of cropland, which leads to a higher potential for erosion compared to areas that are mainly composed of grassland. Subbasins HUC-12: 102702070304, 102702070601, 1027020700602, 102702070603, 102702070606, 102702050503, 102702050502, 102702050204, and 1027020502011, along mainstem of Big Blue and Little Blue Rivers were selected for livestock BMP implementation.

Cropland and Livestock Targeted Areas

The SWAT delineated (primary ranked) Cropland Targeted Area of this project will be used for the implementation of sediment and nutrient reduction agricultural BMPs. The SLT has also chosen this same area for targeted livestock BMPs. The top five livestock BMPs were selected by need, cost-effectiveness, and producer acceptability. Adoption rate goals were set for the next 20 years based on their overall need and what can be feasibly adopted.

The SWAT model has delineated the targeted area into six sub basins. The HUC 12s that are included in these sub basins are (Figure 19):

- Sub basin #6: 102702050201, 102702050204
- Sub basin #8: 102702050501

- Sub basin #9: 102702050301, 102702050302
- Sub basin #15: 102702050401, 102702050402, 102702050403
- Sub basin #26: 102702050306
- Sub basin #29: 102702050201, 102702050103

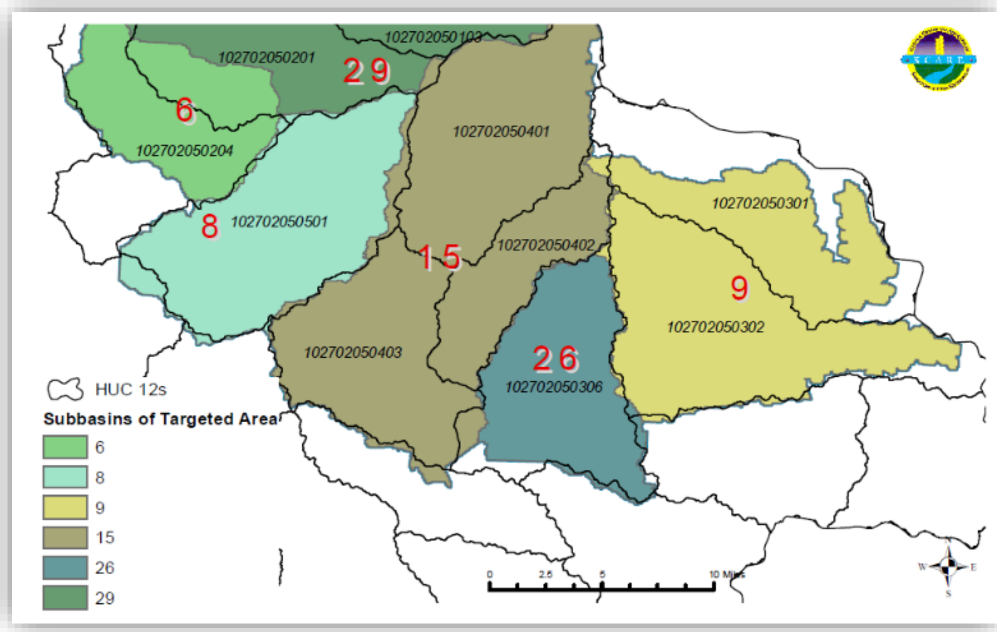


Figure 19 Cropland and Livestock targeted areas identified by SWAT. SWAT Areas are overlaid with HUC-12 areas.

Streambank Erosion

Targeting streambank areas were identified after the riparian buffer analysis along the Big Blue and Little Blue Rivers was conducted with GIS, and presented to SLT. Approximately 618 acres of a 30 foot buffer along the river were considered a targeted area. The HUC 12s included in this area are: 102702070304, 102702070601, 1027020700602, 102702070603, 102702070606, 102702050503, 102702050502, 102702050204, and 102702050201.

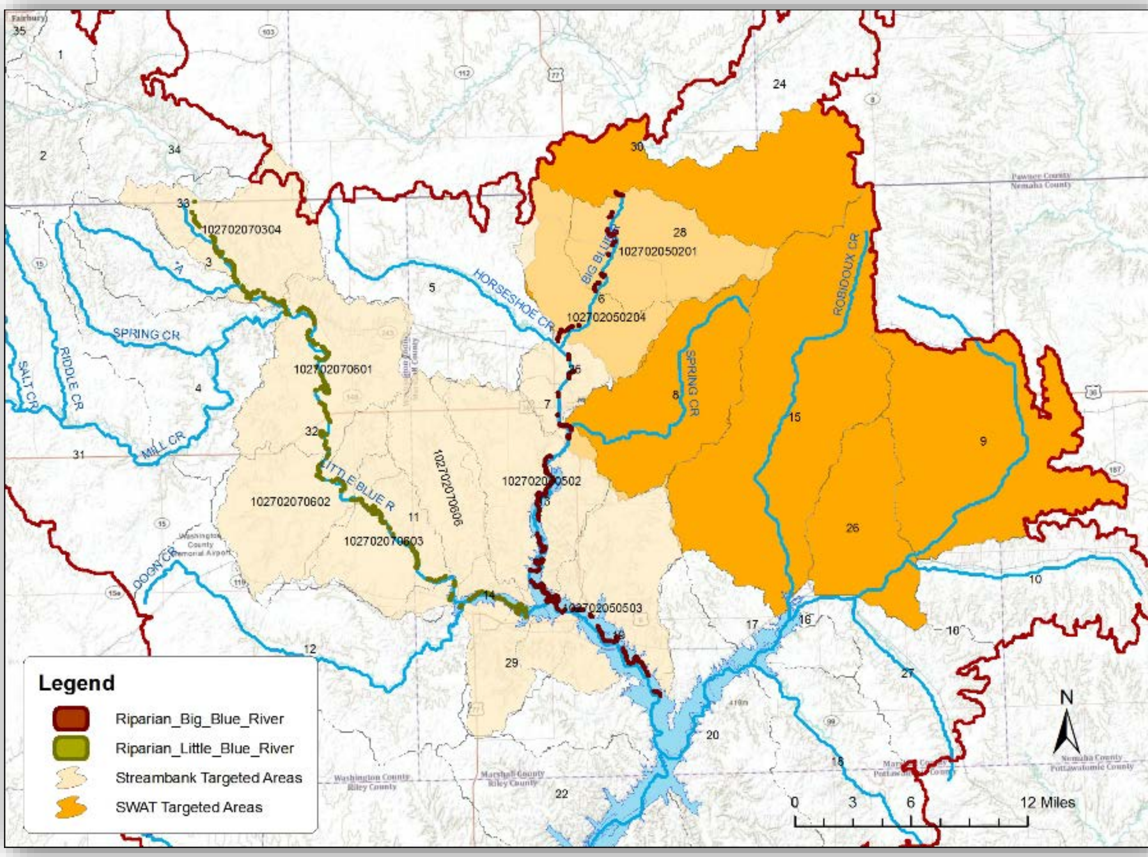


Figure 20 Critical targeted subwatersheds in Tuttle Creek Lake Watershed

Stakeholder engagement

A critical element of the WRAPS watershed modeling process is to engage stakeholders in the collection and verification of watershed data (Mankin, 2008). This process assures that we are modeling “their watershed” using the best local data available. Over a period of several meetings, the watershed modeler meets with stakeholders, presents baseline data, receives feedback and corrections on these data, revises model inputs to represent local data, and re-runs the model using these stakeholder-modified input data.

Work Products

During the iterative engagement process, the stakeholders develop an understanding of how the assessment data and modeling results can be used to inform, but not dictate, their watershed planning decisions. Various maps were provided to stakeholders that helped in understanding watershed water-quality problems, and also assisted in decision-making and identification of potential critical areas not captured by SWAT modeling.

Economic Analysis

General Economic Research

Cost-return budgets have been developed for Tuttle Creek Lake Watershed by working with data from the Northeast Kansas Farm Management Association. The budgets are specific to Tuttle Creek Lake Watershed and vary by inputs and yields. Specific BMP budgets have been developed for vegetative buffers, terraces, stream bank stabilization, and reduced/no-till and available in the Tuttle Creek Lake Watershed Atlas. The cost-return budgets are compiled for corn, soybean, wheat, grain, and alfalfa crops and presented in the Watershed Atlas (see Appendix A: Watershed Atlas).

We compiled lists of financial incentives/programs available through EQIP for both water quality and quantity conservation practices. These lists include both average costs and cost share percentages. We have also identified other programs which offer funding for conservation practices. Since vegetative and riparian forest buffers are supported through multiple funding programs, separate lists have been created to help producers calculate the amount of cost share and annual incentive payments that are available.

Work Products

The following spreadsheet based decision tools were created to assist with economic analysis in support of the development of watershed management plans.

K-State Watershed Manager Decision-Making Tool

This is a spreadsheet program that can support the development of watershed management plans. Using this program, watershed stakeholder groups & technical assistance providers can estimate, optimize, and compare the economic and environmental effects of various watershed management scenarios. This includes cost estimates and estimates of (sediment, phosphorus, and nitrogen) load reductions for a variety of cropland Best Management Practices (BMPs). *K-State Watershed Manager* was developed by a group of agricultural economists at Kansas State University. The goal was to provide a user-friendly tool which could aid watershed groups in developing cost-effective watershed management plans. The tool development was funded in part through the Kansas Department of Health and Environment by U.S. EPA Section 319 Funds in support of Kansas Watershed Restoration and Protection Strategies (WRAPS).

KSU-Vegetative Buffer Decision-Making Tool

This tool was developed with assistance and input from KSU Ag Economics faculty, NRCS, and Conservation District personnel (buffer coordinators). This tool allows producers and land-managers across the state of Kansas (including Tuttle Creek Lake Watershed) to evaluate the economic benefits and costs of vegetative buffers, and will help them decide if a buffer makes sense for their operation. This tool also incorporates the funding incentives information gathered previously. This tool is on the KSU Agricultural Economics website, AgManager.

KSU-Streambank Stabilization Decision-Making Tool

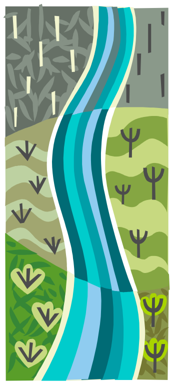
This tool was developed with assistance and input from KSU Ag Economics faculty, Watershed Institute, and KAWS. This tool allows producers and land-managers across the state of Kansas (Tuttle Creek Lake Watershed) to evaluate the economic benefits and costs of streambank stabilization projects, and will help them decide if stabilizing an eroding streambank makes sense for their operation. This tool also incorporates the funding incentives information gathered previously. This tool is on the KSU Agricultural Economics website, AgManager.

KSU-Tillage Decision-Making Tool

This tool was developed with assistance and input from KSU Ag Economics faculty and Agricultural Extension agents across the state. This tool allows producers and land-managers across the state of Kansas (including Tuttle Creek Lake Watershed) to evaluate the economic benefits and costs of alternative tillage management strategies, and helps them decide if reducing tillage is a feasible option for their operation. This tool incorporates enterprise budgets so that the user can make their decision based on a comprehensive analysis. This tool is on the KSU Agricultural Economics website, AgManager.

Non-market valuation and input-output impact analysis

Thorough research was performed for the benefits-cost estimation of watershed management. Initial research has shown sedimentation as the main cause of future economic loss to Tuttle Creek Lake, so this will be the main focus of the economic analysis. The economic impacts and benefits of recreation at the Tuttle Creek Lake were being estimated using an input-output impact analysis and non-market valuation techniques.



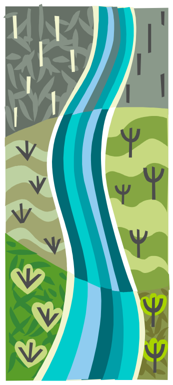
Next Steps / Transition into Planning Phase

This WRAPS Assessment Phase project was completed and all tasks were finished. For transition into the Planning phase, the identified critical areas (cropland, livestock, and stream bank targeted areas) and calculated pollutant loads to the streams will be used to quantify the impacts of potential, and assist the Stakeholder Leadership Team in prioritizing this list of BMPs. The Stakeholder Leadership Team would use model results along with local knowledge about the BMPs that most likely will be accepted by the farmers and implemented on the ground.

The economic aspects of the BMP implementation would also be discussed with the Stakeholder Leadership Team. A variety of decision-making tools that have been developed by K-State would be applied to provide the Stakeholder Leadership Team with the most cost-efficient BMP implementation plan.

For each individual impairment or combination of impairments, a list of recommended BMPs and the cost of implementation would be presented, discussed, and approved by the Stakeholder Leadership Team. The list may include buffers, continuous no-till, nutrient management, and waterways for cropland, riparian and native grass habitat buffers for streambanks, and off-stream watering sites, vegetative filter strips, and relocation of pasture feeding sites for livestock.

To facilitate the transition into the planning phase, an overview of the watershed assessment findings, including the targeted areas, the lists of potential BMPs for each impairment, and the approximate cost of the implementation, should be provided to the Stakeholder Leadership Team.

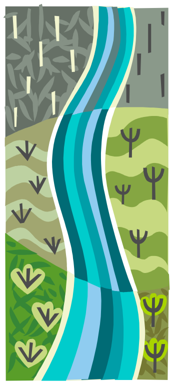


Evaluation of Project Goal, Objectives, and Tasks

The goal of this project was to characterize watershed conditions, identify needs and opportunities for watershed information to support stakeholder decisions, and understand how the watershed responds to various management scenarios.

This Assessment Phase project accomplished all of its objectives, in particular:

- The Stakeholder Leadership Team clarified WRAPS objectives and assessment needs in the watershed and identified informational and data gaps needed to address the objectives and assessment needs
- The assessment team compiled an inventory of existing information and reports related to Tuttle Creek Lake watershed.
- The assessment team published a Watershed Atlas online, summarizing watershed climate, soil, topographic, and land use data; economic analyses of agricultural cropping systems and best management practices (BMPs); and STEPL modeling results.
- The assessment team set up and completed detailed SWAT modeling analysis of baseline and SLT revised using local knowledge watershed conditions.
- The assessment team developed user-friendly decision tools for stakeholder groups to analyze and compare economic and environmental effects of cropland BMPs, vegetative buffer systems, streambank stabilization systems, and tillage systems.
- The assessment team completed an analysis of recreational benefits of Tuttle Creek Lake.
- Watershed model and economic results were delivered, discussed, and approved by the Stakeholder Leadership Team.



Conclusions, Recommendations, and Lessons Learned

Conclusions

Watershed assessment information was prepared by this project including watershed inventory, watershed modeling, identification of critical areas, and economic analysis. A Stakeholder Leadership Team was created and fully engaged in all activities throughout the assessment phase of the WRAPS project. The identified targeted areas were divided into three categories: cropland BMPs, livestock BMPs, and stream bank BMPs. This division was based on the restoration needs and specifics of the watershed. SLT contribution along with the assessment management team was instrumental in identification of livestock and stream bank erosion sites.

Lessons Learned

Several important lessons were learned through the implementation of this Assessment Phase project:

- Watershed data available through various Internet sources should be considered to be “generalized” information and should be confirmed and revised through interactions with stakeholders having local knowledge and data.
- Successful watershed modeling as part of a WRAPS planning process, requires the active engagement of a Stakeholder Leadership Team in a process we have called *Adaptive Watershed Modeling*, where modelers and stakeholders interact iteratively throughout creation of watershed data, development of scenarios, and analysis of results.
- It is helpful to begin discussions of watershed modeling using simple modeling tools (such as STEPL) to allow discussions with stakeholders to focus on important watershed conditions and local information rather than becoming bogged down in discussion of model intricacies.
- Stakeholders benefit from the use of decision tools that integrate economic and environmental impacts of various field and watershed management decisions, and allow them to compare various scenarios.

Recommendations

Watershed modeling is important to the WRAPS Assessment process.

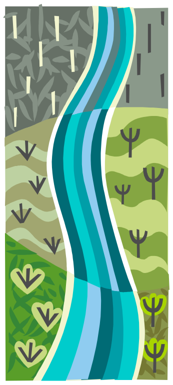
- One Kansas individual skeptical of watershed modeling suggested that K-State should instead simply show real data about how various agricultural management practices impact water quality in each locale. He and I discussed how soil types, rainfall patterns, growing seasons, and management practices, among other factors, could impact results, in addition to how expensive it would be to study even a small number of combinations. In a very short time, this individual began to see how models could be used to extend data from specific combinations of these factors to other combinations where water quality data was not available.

Watershed modeling remains highly sophisticated.

- The project team has been involved with watershed assessment activities in Kansas for more than 12 years. Over this time, watershed assessment tools and models have evolved. Watershed information can now be accessed in digital format for watershed topography, soils, and land-cover. Watershed models have evolved from dedicated research tools to become more user-friendly both in data input and post-processing of results. However, running watershed models remains a highly sophisticated task; correct results are never guaranteed

Believable watershed modeling requires technical skill and social connection.

- The integration of watershed modeling results in the watershed planning process is not a simple endeavor. Once watershed stakeholders lose confidence in the watershed model or modeler, they will not believe the results and will not use these results in their planning. Watershed models generally are not "correct", but their results can be highly instructive and useful to the WRAPS planning process. Helping stakeholders understand how model results should, and should not, be used requires a committed engagement over a long period of time, and often requires an intermediary, like an Extension Agent or Watershed Specialist, who can help the modeler and the stakeholder bridge the communication gap.
- In short, watershed environmental and economic modeling is critical to success of a WRAPS project, but requires technical staff with a special set of skills and dedication to the enterprise of stakeholder engagement and partnership.



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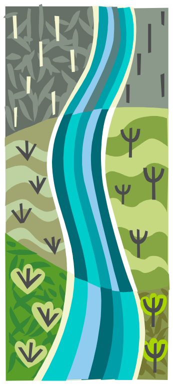

Appendix A: Watershed Atlas

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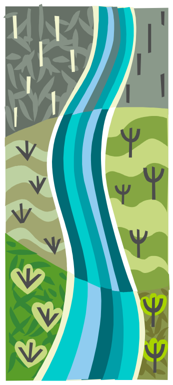


Appendix B: TMDLs

Tuttle Creek Lake:

http://www.kdheks.gov/tmdl/klr/TuttleE.pdf
http://www.kdheks.gov/tmdl/klr/TuttleATR.pdf
http://www.kdheks.gov/tmdl/klr/TuttleSILT.pdf
http://www.kdheks.gov/tmdl/klr/TuttleAl.pdf

Big Blue River:

http://www.kdheks.gov/tmdl/klr/BigBlueFCB.pdf

Black Vermillion River:

http://www.kdheks.gov/tmdl/klr/BlackVermillionFCB.pdf

Fancy Creek:

http://www.kdheks.gov/tmdl/klr/FancyCkFCB.pdf

Little Blue River:

http://www.kdheks.gov/tmdl/klr/LittleBlueFCB.pdf

Centralia Lake:

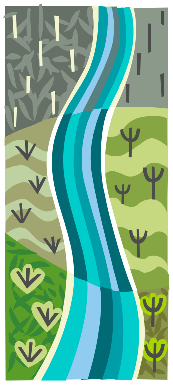
http://www.kdheks.gov/tmdl/klr/centraliaE.pdf

Lake Idlewild:

http://www.kdheks.gov/tmdl/klr/idlewild.pdf

Washington County State Fishing Lake:

http://www.kdheks.gov/tmdl/klr/washsflDO.pdf
http://www.kdheks.gov/tmdl/klr/washsflAP.pdf
http://www.kdheks.gov/tmdl/klr/WashWAE.pdf
http://www.kdheks.gov/tmdl/klr/WashWASILT.pdf



Appendix C: Financial Summary

Summary of Financial Expenditures and Matching Funds				
Category	Budget	Actual	Match	Total
Salaries	102,485.00	111,376.03	17,620.34	128,996.37
Fringe Benefits	29,997.00	22,294.57	3,775.58	26,070.15
Travel	3,000.00	5,735.55	-	5,735.55
Supplies	3,413.00	3,487.80		3,487.80
Contractual Services	-	-		-
Other	8,650.00	4,651.05	32,478.31	37,129.36
Project Indirect Costs	14,755.00	14,755.00	-	14,755.00
Waived Indirect Costs	-	-	62,958.00	62,958.00
Total	$ 162,300.00	$ 162,300.00	$ 116,832.23	$ 279,132.23