KANSAS WATERSHED RESTORATION AND PROTECTION STRATEGY (WRAPS) PROJECT

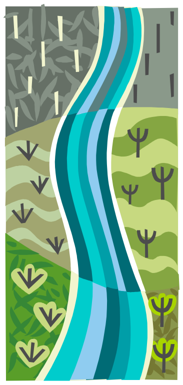
UPPER VERDIGRIS / TORONTO LAKE WATERSHED ASSESSMENT

FINAL REPORT

KDHE Project No. 2007-0063

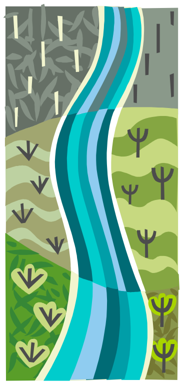
March 2012

Prepared and Submitted by:
Dr. Kyle R. Douglas-Mankin, Principal Investigator
Dr. Aleksey Y. Sheshukov
Department of Biological and Agricultural Engineering
Kansas State University
129 Seaton Hall
Manhattan KS 66506
785-532-2911
krdm@ksu.edu



Contents

Figures and Tables

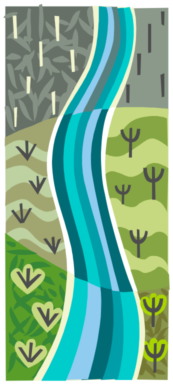


Acknowledgements

This project was made possible with financial support provided by State Water Plan funds administered by the Kansas Department of Health and Environment – Watershed Management Section, granted to K-State Research and Extension through the Kansas WRAPS (Watershed Restoration and Protection Strategy) – Upper Verdigris/Toronto Lake Assessment project (2007-0063).

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

- Aleksey Y. Sheshukov, Watershed Modeler
- Amir Pouyan Nejadhashemi, Watershed Modeler
- Josh Roe, Watershed Economist
- Sumathy Sinnathamby, Graduate Student, Watershed Modeler
- Craig M. Smith, Watershed Economist
- Robert M. Wilson, Watershed Planner
- Sue P. Brown, Watershed Communication
- John C. Leatherman, Professor, Agricultural Economics
- William Hargrove, past KCARE Director



Executive Summary

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

Initiated in June 2007, this WRAPS Assessment Phase project was completed by May 2009. Project accomplishments include:

- *Watershed Assessment*: We compiled existing information related to the Upper Verdigris/Toronto Lake Watershed, culminating in development and publication of a Watershed Atlas.
- *Watershed Modeling*: We completed a 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; and completed an analysis of recreational benefits of Upper Verdigris/Toronto Lake Watershed.

The stakeholder leadership team (SLT) was established in 2008 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

Geographic Scope/Location

Toronto Lake Watershed encompasses parts of Chase, Lyon, Greenwood, Coffey and Woodson counties in southeastern Kansas (Figure 1). Majority of the drainage falls within Greenwood County. It covers approximately one-half of the HUC 8 numbered 11070101 (named Upper Verdigris). Environment (KDHE) and the United States Department of Agriculture (USDA) designated the Upper Verdigris Watershed as Category I watershed indicating that it is in need of restoration. As a Category I watershed, Upper Verdigris does not meet state WQS or fails to achieve aquatic system goals related to habitat and ecosystem health. It is also ranked fifty-eighth in priority out of ninety-two watersheds in the state. Toronto Lake Watershed drains into the Verdigris River and its tributaries into Oklahoma and finally empties into the Gulf of Mexico.

The Toronto Watershed is comprised of 3 HUC 10 delineations (1107010101, 1107010102, and 1107010103) and 17 HUC 12 (110701010101, 110701010102, 110701010103, 110701010104, 110701010105, 110701010106, 110701010107, 110701010108, 110701010201, 110701010202, 110701010203, 110701010301, 110701010302, 110701010303, 110701010304, 110701010305, and 110701010306) delineations. It covers 458,395 acres. Toronto watershed contains Toronto Reservoir (2,800 acre), located in the Cross Timbers Region of Kansas, but drains from the Flint Hills and Osage Cuestas Regions, has a maximum depth of approximately 18 feet and a mean depth of 7 feet. USACE completed the reservoir completion in 1960 by damming the Verdigris River. This watershed area included numerous towns and cities in addition to developed areas surrounding Toronto Reservoir.

Population

Population of Toronto Lake Watershed ranges from 0 to 72 per census tract (Figure 2). Population density of Toronto Lake watershed is 3.1 person/sq. mi. The main populated county is Greenwood County with most populated towns of Madison, Hamilton, and Virgil (Table 1).

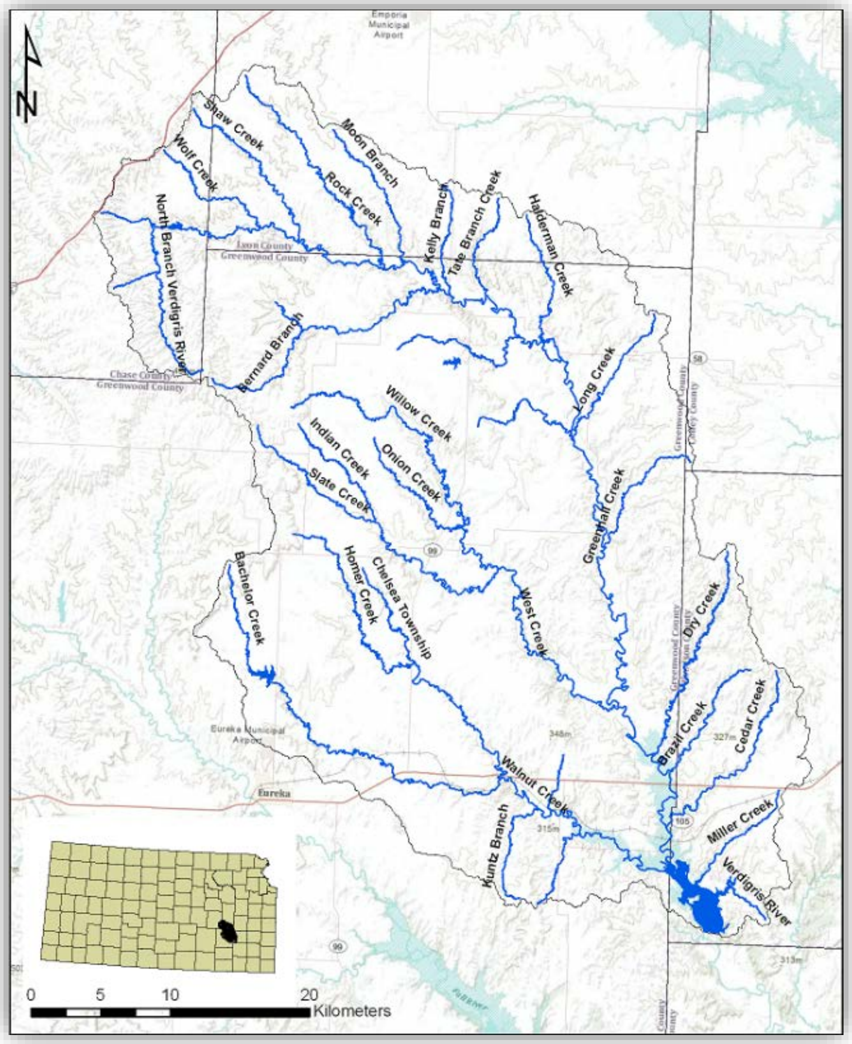


Figure 1 Toronto Reservoir Watershed map

Table 1 Main populated areas in Toronto Reservoir Watershed

COUNTY	POP2000	MALES	FEMALES	HOUSEHOLDS	FAMILIES
Chase	24	14	10	13	7
Coffey	8	5	3	5	3
Greenwood	2586	1295	1291	1063	748
Lyon	360	190	170	133	110
Woodson	709	380	329	322	181
Total	3687	1884	1803	1536	1049

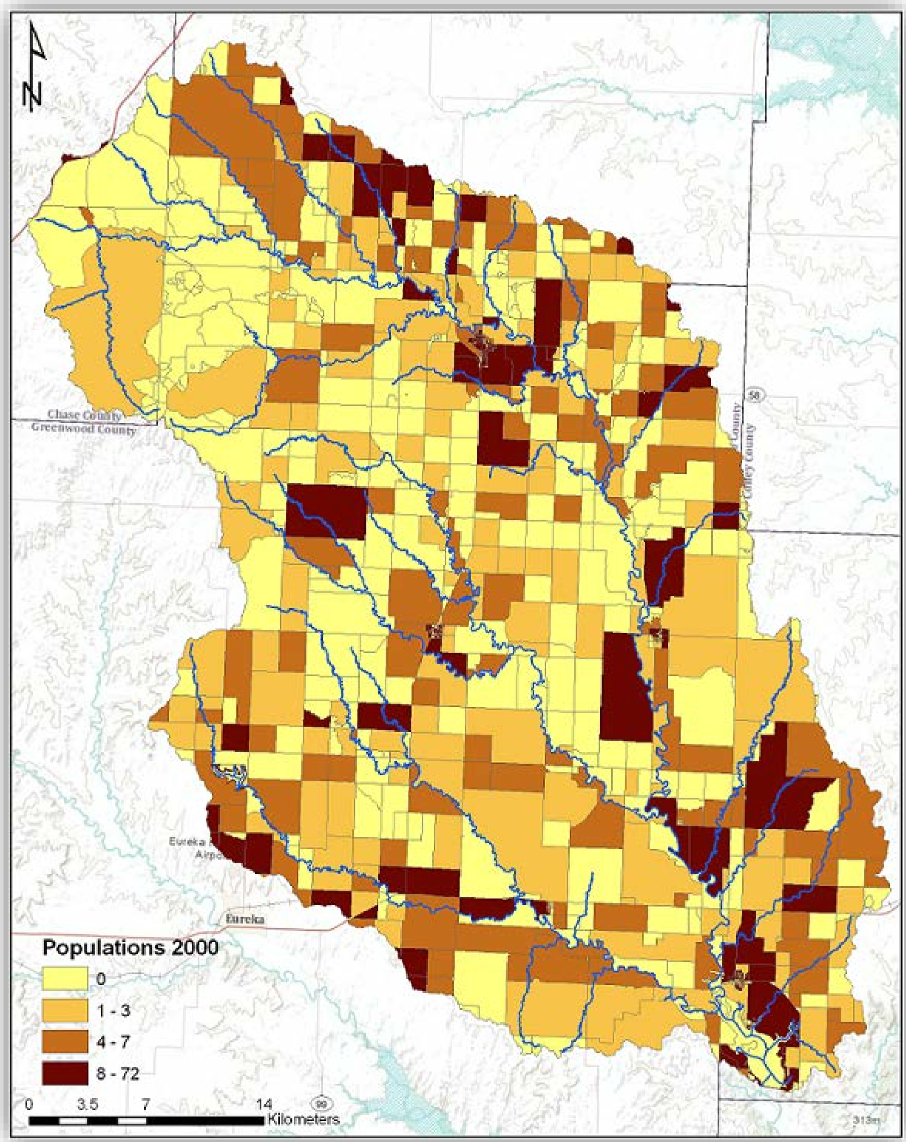
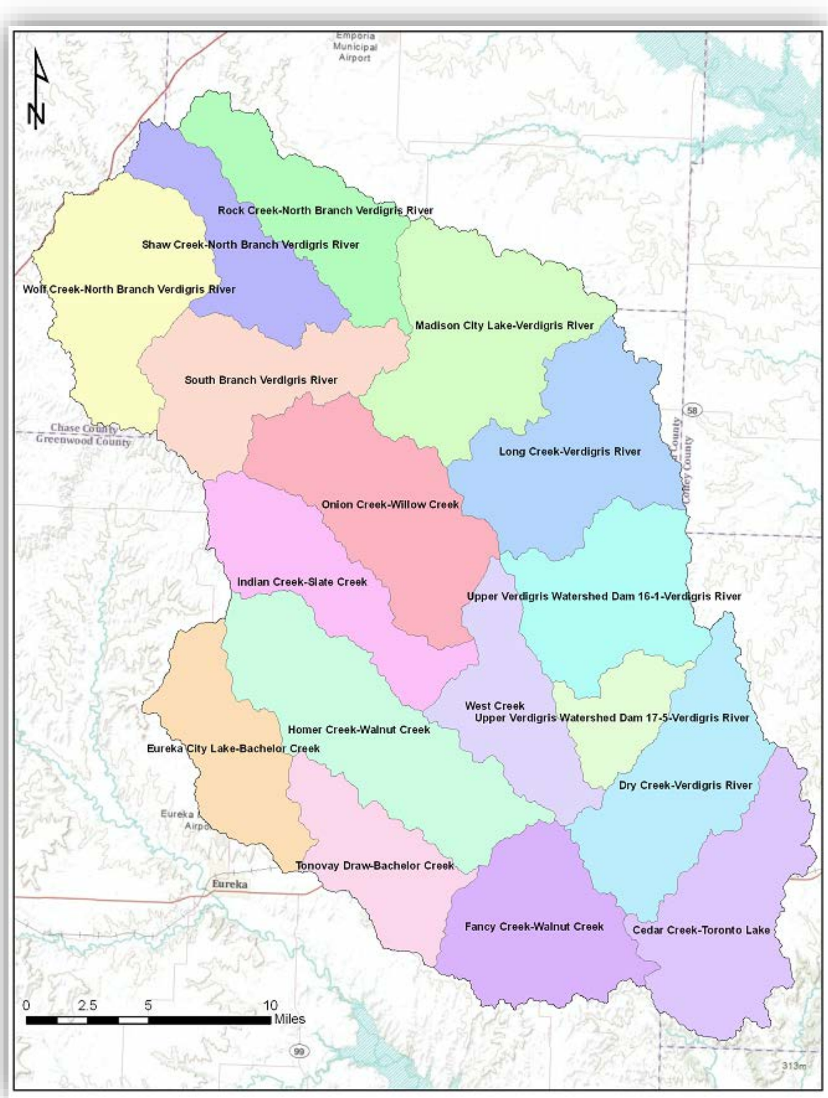


Figure 2 Population density in Toronto Reservoir Watershed

Surface Water Resources

Verdigris River along with its tributaries and Walnut and West creeks are the primary waterways of Toronto Lake Watershed. The Verdigris River drainage includes the headwaters of the river to the upper end of Toronto Lake. Four major lakes within the watershed are: Toronto Lake, Eureka City Lake, Minger Lake, and Madison City Lake. Seventeen sub-watershed creeks based on HUC 12 delineation are shown in Figure 3.

For the purpose of mainly flood control Toronto Reservoir was built in 1960 by the U.S. Army Corps of Engineers, Tulsa District (USACE). The storage capacity of reservoir in 1960 was 27,320 acre feet and it was reduced to 15,010 acre feet in 1990 due to sedimentation. Toronto Reservoir is listed as the highest percentage of capacity loss reservoir in the State of Kansas.



4

Figure 3 HUC 12 Delineations of the Toronto Reservoir Watershed

The Verdigris River has a single alluvial aquifer that lies along and below the rivers (Figure 4). The alluvial aquifer is a part of and connected to a river system and consists of sediments deposited by rivers in the stream valleys.

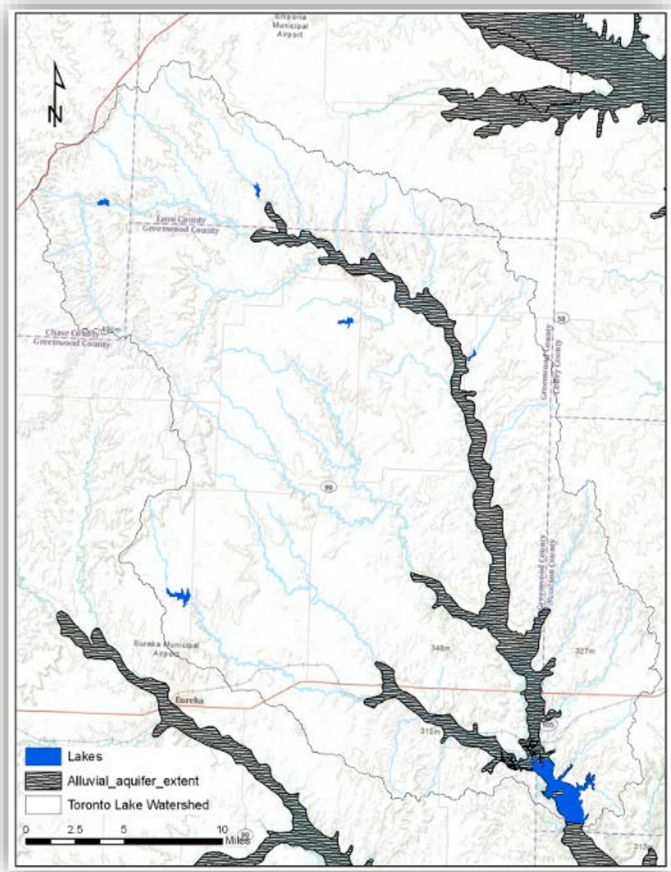


Figure 4 Alluvial Aquifer map

Designated Uses

Toronto Reservoir is primarily used for public swimming. Designated uses (Kansas Surface Water Register, KDHE, 2004) other surface waters in this watershed are aquatic life support (fish), human health purposes, domestic water supply, recreation (fishing, boating, swimming), groundwater recharge, industrial water supply, irrigation and livestock watering (Table 2).

Table 2 Designated Water Uses

Stream Name	AL	CR	DS	FP	GR	IW	IR	LW
Bachelor Cr, Bernard Cr, Homer Cr	E		X	X				
Brazil Cr, Dry Cr, Greenhall Cr, Kelly Br, Kuntz Br, Long Cr, Miller Cr, Moon Br, Onion Cr, Shaw Cr, Tate Branch Cr, Van Horn Cr, Wolf Cr E	E							
Holderman Cr	E		X					
Rock Cr, Slate Cr, Walnut Cr, West Cr	E			X				
Verdigris R	E	C	X	X	X	X	X	X
Verdigris R, N Br	E		X	X	X	X	X	X
Madison City Lake, Toronto Reservoir, Eureka City Lake	E	A	X	X		X		
Toronto Wildlife Area	E			X				

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)

Public water supplies are shown in Table 3. Toronto Reservoir is the major source of drinking water to the town of Toronto, whereas it is groundwater for Madison. Presence of sediment, nutrient and fecal coliform in surface water and reservoir will affect water supplies causing excess cost in treatment prior to public consumption.

Table 3 Public Water Supplies

Water Supplier	County	Source of Water	Population Served
Greenwood County RWD 01	GW	Eureka	1,271
Greenwood County RWD 02	GW	Eureka	1,000
Greenwood County RWD 03	GW	Madison	310
Hamilton	GW	Madison	328
Madison	GW	2 Wells, City Lake	834
Toronto	GW	Toronto Reservoir, Yates Center Lake	300
Virgil	GW	2 Wells	120
Total Population Served			**4,163**

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). The watershed has three NPDES facilities (Table 4). All three NPDES sites have PWS sites (Figure 5). Additionally there are numerous onsite wastewater systems within this watershed.

Table 4 NPDES Sites

NPDES	Facility Name	Ownership	Description	Industrial Classification	City	County
KS0021890	Toronto, City Of, Stp	Public	Sewerage Systems	Municipal	Toronto	WO
KS0030538	Madison, City Of, Wwtf	Public	Sewerage Systems	Municipal	Madison	GW
KS0046001	Hamilton, City Of, Stp	Public	Sewerage Systems	Municipal	Hamilton	GW

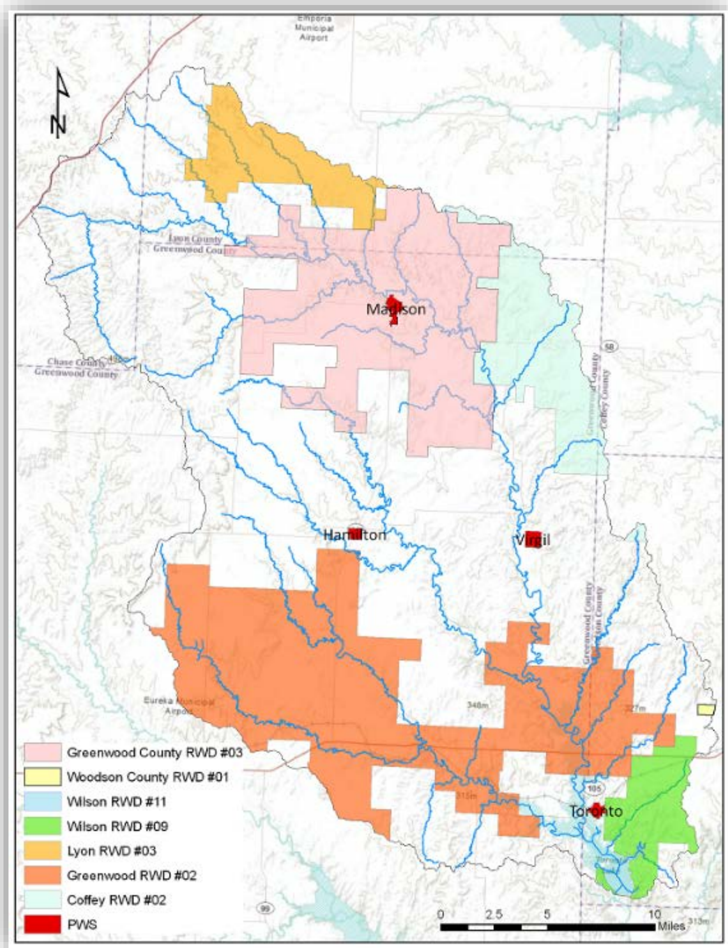


Figure 5 Rural Water Districts (RWD) and Public Water Supply (PWS) Diversion Points

Land Uses / Land Cover

Grassland is the predominant land usage (82.6 percent) for the watershed. As it is used for grazing, grassland can be a major contributor of sediment, nutrients and *E. coli* bacteria. Crop production is the second largest land usage at 5.6 percent (Figure 6 and Figure 7). Woodland, water, deciduous forest and urban areas constitute the remaining land cover. Toronto Lake Watershed has been experienced significant change in land cover historically from pasture to cultivated crops. Most cultivation is found along the river side. Soybeans is the major cultivated crop (3.9%) followed by Corn (1.5%).

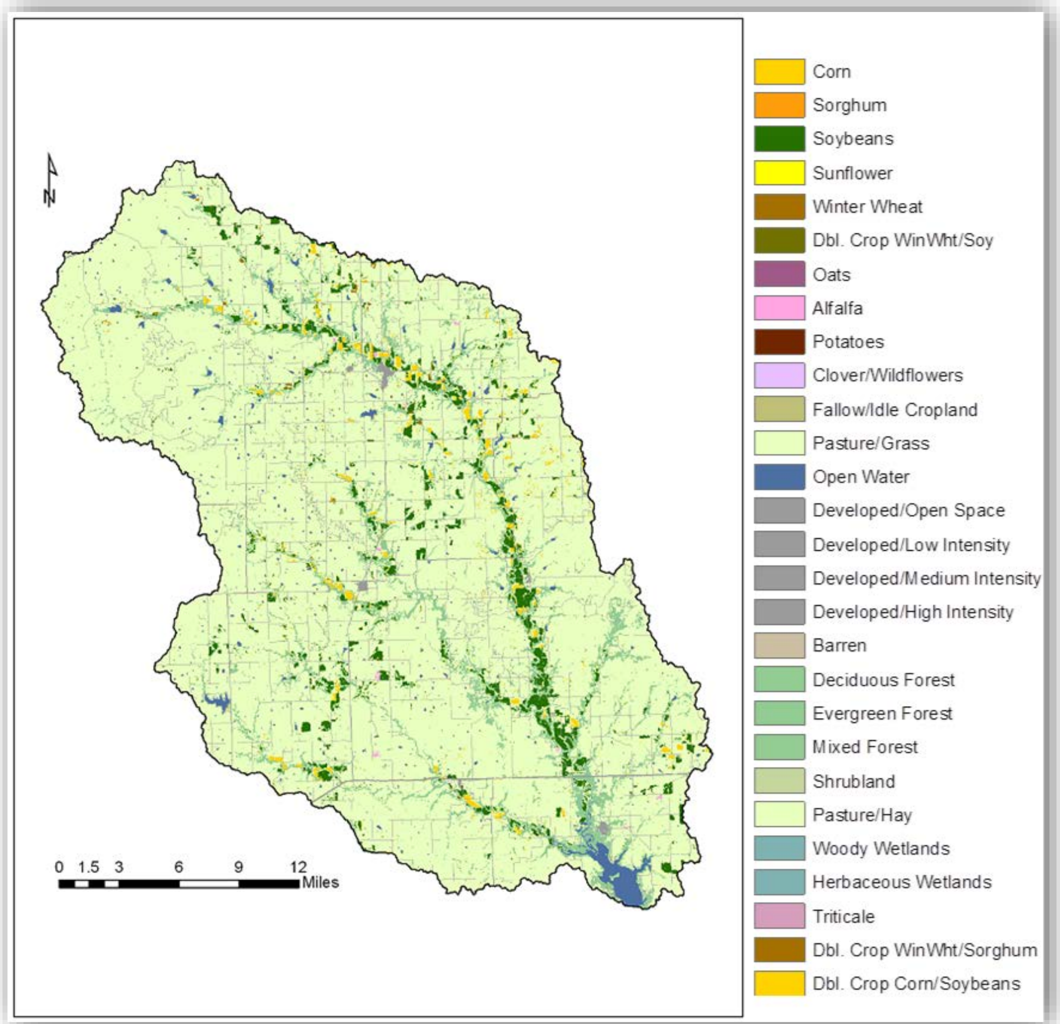


Figure 6 Land cover map (2010 NASS Crop Data Layer)

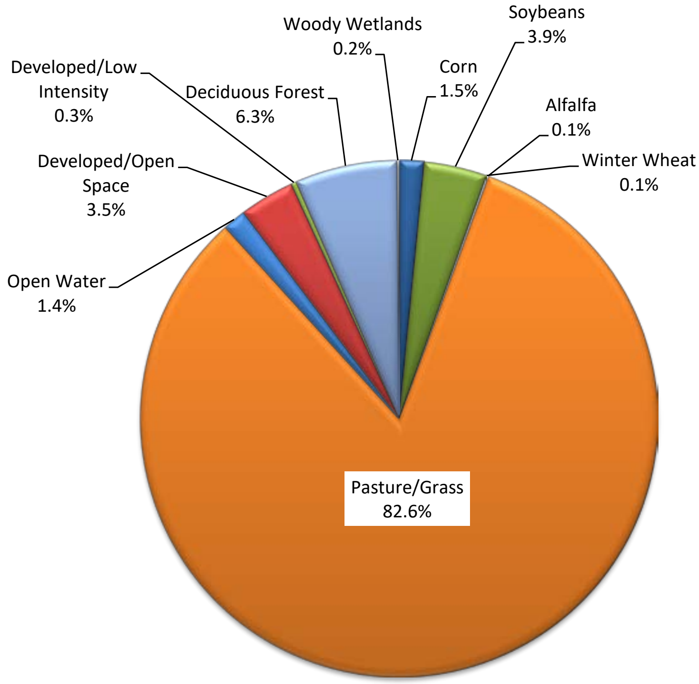


Figure 7 Percentage of individual land uses (Based on 2010 Crop Data Layer)

Wildlife Habitat

Toronto Reservoir was completed in 1960 by the U.S. Army Corps of Engineers. In 1964 license agreement was made between Kansas Department of Wildlife and Parks and Corps of Engineers for fish and wildlife management of 4700 acres of land and water in the upper reaches. Toronto Lake Watershed wildlife area includes riparian timbered areas, grasslands, cropland, and wetland communities. This wildlife area is open to public hunting (Figure 8) and has a wide variety of game and non-game animals including white-tailed deer, turkey, bobwhite quail, squirrel, waterfowl, rabbits and furbearers. Marshes of this area provide excellent habitat for migratory birds and excellent viewing for non-game species of shore birds. White bass, crappie, channel catfish and flathead catfish are the widely available fish species in the reservoir, Walnut Creek, and the Verdigris River. The numerous brush piles are also excellent places to pursue black bass, bluegill and sunfish. There are boat ramps around the reservoir, on Walnut Creek and the Verdigris River to provide boat access.

Native plant restoration, prescribed burning, timber management and farming to provide food and habitat for wildlife are some examples of managements practices have been adopted in this area.

Endangered Species

The Toronto Reservoir Watershed has presence of a threatened or endangered species of mussels in the Verdigris River (Figure 8) and due to that it has been selected as the special aquatic life use waters.

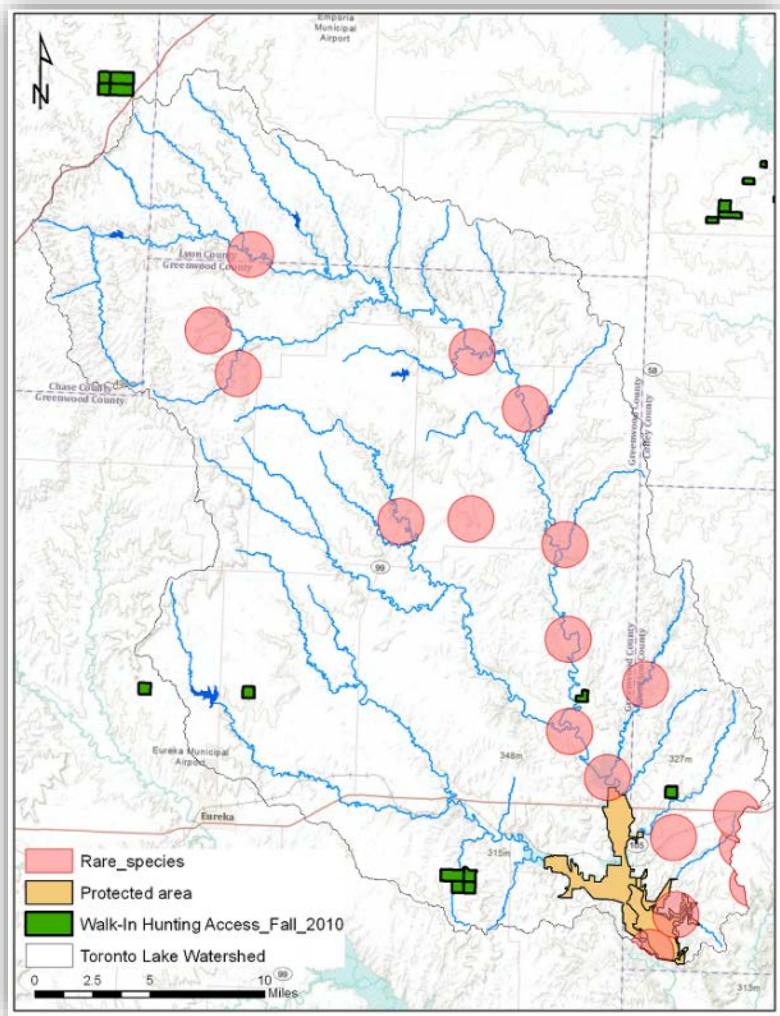


Figure 8 Map of rare species, protected areas, and areas with walk-in hunting access

Recreational Areas

Toronto Lake was built in 1960 by the U.S. Army Corps of Engineers (USACE) for flood control, water supply, water quality, recreation, and fish and wildlife.

This analysis estimated two types of regional recreation effects associated with Toronto Lake. The first type includes the economic impact to the region arising from direct recreation expenditures in the area and the associated indirect effects which occur as the money "ripples" throughout the region. This impact is modeled using an economic accounting system that charts the financial connections between businesses, governments and households in the region.

In 2007, the Army COE reported 141,109 visits to Toronto Lake for a total of 3,036,266 visitor-hours from 10/2006 to 9/2007. Using this data (together with visitor-type and expenditure profiles shown in Table 5, Table 6, and Figure 9) and accounting for imported purchases, it was estimated that visitor expenditures generated $1.89 million (in year 2007) in direct economic activity (sales) within the regional economy, $0.85 million in all types of income associated with the production of economic activities, and 45 area full- and part-time jobs. After calculating the indirect economic impacts, it was estimated that visitor expenditures were closely associated with $2.43 million (in 2007) in overall economic activity, $1.15 million in total income, and 51 jobs in the region. The total economic contributions to the local region are displayed in Table 4.

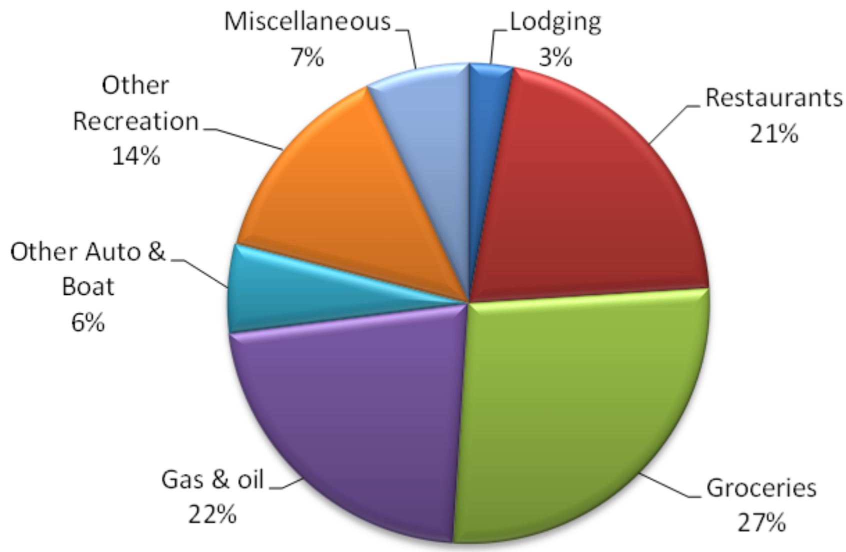


Figure 9 Visitation spending by category ($ per visit in 2007)

Table 5 Visitation and spending for visits made to Toronto Lake in 2007

Visitation	Camper		Day User		Other Overnight		Total
	Boater	Non-boater	Boater	Non-boater	Boater	Non-boater	
Percent of Total	0.7%	16.4%	3.2%	77.3%	0.1%	2.3%	100.0%
2007 Toronto visits	970	23,138	4,543	109,068	135	3,256	141,109
Spending	$71,463	$1,446,313	$101,805	$1,470,094	$12,782	$180,553	$3,283,010

Table 6 Toronto Lake total economic contributions

Impact Measure	Direct	Indirect	Total
Output	$1,887,333	$545,201	$2,432,534
Total Value Added	$846,958	$307,661	$1,154,619
Employment	45	6	51

Not all of the economic effects of recreation are captured by observable market transactions. A second type of economic effect considered here includes certain non-market benefits derived through the self-reported value of participation in recreation activities. This notion acknowledges the value of benefit an individual experiences through participation in an activity exceeds what it actually costs, thereby motivating participation. These benefits are estimated through a process known as non-market valuation. Through surveys, economists have developed general estimates of what people report being willing to pay over and above what they actually are required to spend. This net willingness-to-pay value represents the additional incremental value of benefits afforded to the recreation participant. Net willingness-to-pay has been acknowledged by a U.S. governmental interagency committee as an appropriate measure of the economic benefits associated with outdoor recreation programs. Accepting the legitimacy of purported and generalized willingness-to-pay values and applying them to Toronto Lake recreation, it was estimated that Toronto Lake visitors receive up to $7.60 million (in 2007) in additional non-market recreation benefits annually. The values by recreation activity are reported in **Error! Not a valid bookmark self-reference.**.

Table 7 Non-market benefits of Toronto Lake recreation in 2007

Activity	Days Spent in Activity	Activity Value per Day (in 2007 $)	Total Value per Year
Fish	106,775	$38.58	$4,119,491
Swim	57,689	$19.75	$1,139,239
Camp	30,869	$29.54	$911,821
Boat	20,748	$27.45	$569,475
Picnic	11,892	$30.42	$361,732
Other	25,049	$19.94	$499,432
Total	**253,022**	-------	**$7,601,190**

Watershed / Water Quality Conditions

Total Maximum Daily Loads (TMDLs)

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.

The 303d List of Impaired Water Bodies

The impaired water bodies in the watershed are shown in Figure 10 and listed in Table 8. West Creek and Walnut Creek are impacted by low dissolved oxygen. This has resulted in KDHE issuing a high priority TMDL in West Creek and a medium priority TMDL in Walnut Creek. These TMDLs are aimed at increasing dissolved oxygen concentrations to provide full support of aquatic life. The goal of the TMDL is a dissolved oxygen rate of greater than 5 milligrams of oxygen per liter of water. Low dissolved oxygen levels typically occur with an abundance of algae. This causes the population of decomposers to increase, which in turn depletes oxygen in the stream or river. To discourage an overpopulation of algae, nutrient runoff must be minimized. Additionally, low dissolved oxygen is a naturally occurring event in the hot days of summer when there are low water levels and little water movement. Integrating best management practices (known as BMPs) help prevent nutrient runoff. Some examples of BMPs are riparian area restoration, grass buffer strips along streams, proper manure storage and distribution, ensuring adequately functioning septic systems, and applying proper chemical fertilizer rates. The desired end point for water-quality in Toronto reservoir is presented in Table 9.

Toronto Reservoir has a high priority TMDL for eutrophication, dissolved oxygen, and siltation (approved 9/30/09). West Creek, including tributaries of Onion Creek and Slate Creek currently has a medium priority TMDL for dissolved oxygen (approved 9/30/02).

- Verdigris Basin TMDL. Waterbody: Toronto Lake. Water Quality Impairment: Eutrophication/Dissolved Oxygen/Siltation. Priority: High http://www.kdheks.gov/tmdl/ve/Toronto_TMDL.pdf
- Verdigris Basin TMDL. Waterbody: Walnut Creek. Water Quality Impairment: Dissolved Oxygen. Priority: Medium http://www.kdheks.gov/tmdl/ve/WalnutCr_DO.pdf
- Verdigris Basin TMDL. Waterbody: West Creek. Water Quality Impairment: Dissolved Oxygen. Priority: Medium http://www.kdheks.gov/tmdl/ve/WestCr_DO.pdf

Table 8 TMDLs in the Watershed

Water Segment	TMDL Pollutant	End goal of TMDL	Priority	Sampling Station
Toronto Reservoir	Eutrophication/Dissolved Oxygen/Siltation	Summer chlorophyll a concentrations < 10 ug/L Secchi disk depth >0.7 m DO > 5mg/L	High	LM24001
Walnut Creek (with Homer Creek)	Dissolved Oxygen	BOD<2.7mg/l under critical flow conditions DO>5mg/l	Medium	SC576
West Creek	Dissolved Oxygen	DO>5mg/l BOD< or =3.1mg/l	Medium	SC290

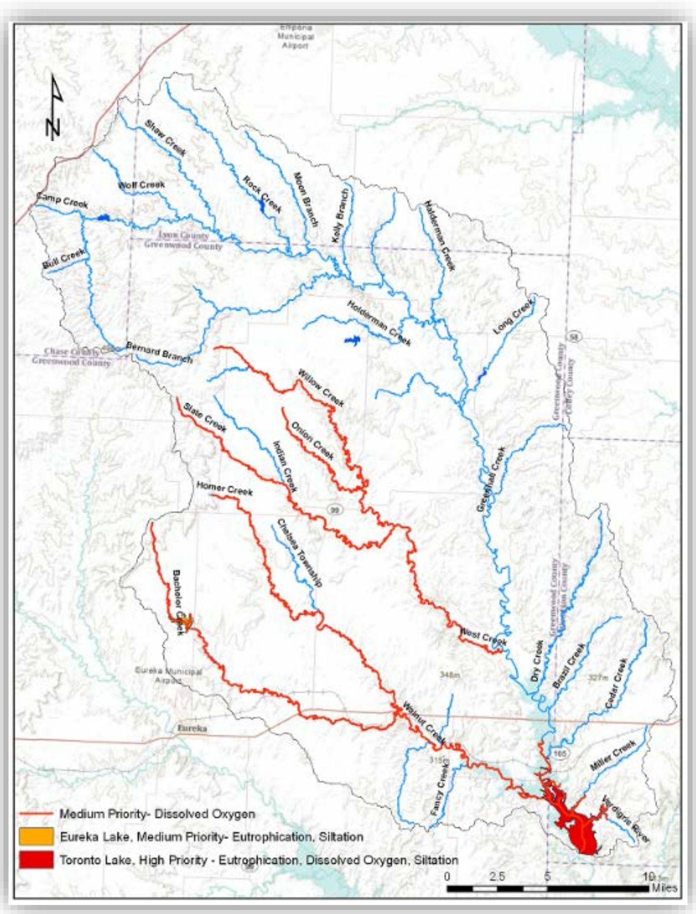
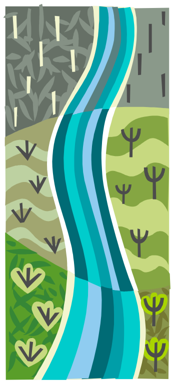


Figure 10 Impaired water bodies based on the 303d List

Table 9 Desired water-quality endpoint for Toronto Reservoir

Parameter	Current Avg. Condition	TMDL	Percent Reduction
Total Phosphorus Annual Load (lbs/year)	71,686	50,585	29.4%
Total Phosphorus Daily Load (lbs/day)*	373.2	263.3	29.4%
Total Nitrogen Annual Load (lbs/year)	691,437	490,450	29.1%
Total Nitrogen Daily Load (lbs/day)*	5077	3601	29.1%
Total Phosphorus Main Basin (µg/L)	73.0	52.4	28%
Total Nitrogen Main Basin (µg/L)	636.0	492.3	23%
Secchi Depth (m)	0.4	> 0.70	75% Increase



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 Upper Verdigris/ Toronto Reservoir 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:

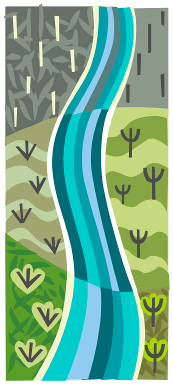
1. characterize watershed conditions,
2. identify needs and opportunities for watershed information to support stakeholder decisions, and
3. understand how the watershed responds to various management scenarios.

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 June 2007 and ending in May 2009.

Inform and Educate Watershed Stakeholders

A Stakeholder Leadership Team (SLT) was recruited and established in the watershed. The SLT was very 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	# Att	# Mat	Description
6/5/2007	Watershed Tour / Field Day	25	25	A variety of in place conservation practices were stops along the tour. During the stops, tour participants were provided descriptions of the BMPs as well as information about the financial incentives available through conservation programs. The tour also included a trip around Madison City Lake where the impacts of sedimentation were discussed. After the tour, the group participated in a working dinner where they learned about the WRAPS process as well as the economic analysis and modeling work that will take place during the process. The economic considerations of a streambank stabilization project were discussed and served as an example of the types of decision-making tools that will be available to producers and landowners in the watershed. Watershed modeler provided one PowerPoint slide presentation for the SLT group about watershed modeling and its application for watershed planning and management.
6/9/2007	PMT Meeting	8	8	Cost-return budgets for Toronto Reservoir Watershed were discussed in the meeting. Data from the Kansas Farm Management Association were used. The budgets are specific to Toronto Watershed and vary by inputs and yields. Specific BMP budgets have been or are currently being developed for vegetative buffers, terraces, streambank stabilization, and reduced/no-till.

10/2/2007	Other	11	11	The Toronto Lake preliminary assessment report was sent to the stakeholder leadership team. This helped the WRAPS team to get the feedback about the quality of data. Their inputs also helped to modify the report and incorporate more information as needed.
10/16/2008	PMT Meeting	20	20	The watershed modeler (Aleksey Sheshukov) presented a Toronto Lake Watershed assessment summary report including main land characteristics (topography, soil types, and land cover), current TMDL stream concerns, HUC-12 subwatershed map, and county map. The revised STEP-L results were presented to the stakeholders, and the changes from initial STEP-L run were discussed. The modeler presented maps of total sediment and nutrients loadings, and a map with targeted areas (subwatersheds 3 and 5 in Lyon and Coffey counties) identified by SWAT. Further steps of what needs to be done including the "groundtruthing" were also suggested and discussed. Discussion of further modeling was taken place, stressing the fact that it would be very helpful to pursue a more detailed analysis within the targeted areas to identify the fields of the greatest potential. Stakeholders also expressed their concern about the streambank erosion and its contribution toward the total sediment loading. The process of publishing the Preliminary Assessment Report (i.e., Watershed Atlas) as a K-State Research and Extension publication has begun, and thus making it available digitally online. This process should take about 3 more months for the whole set of 10 Watershed Atlases. Josh Roe (watershed economist) introduced the concept of cost-effective BMP implementation through targeting. Using past projects as a template, he showed how through the use of watershed modeling and optimization techniques, twice the nutrient and sediment runoff can be prevented using the same amount of funds as randomly installing BMPs throughout the watershed. A handout was made showing ten of the most popular crop land BMPs and the SLT was instructed to begin the process of estimating what the current BMP adoption rates were in the targeted areas identified by the modeling. Josh also spent time in calibrating and installing new features on the Watershed Manager. (BMP cost-effectiveness optimization spreadsheet.)
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.
12/9/2008	SLT Meeting	15	90	Josh Roe presented 10 common cropland and 10 common livestock BMPs for the reduction of soil erosion and phosphorus runoff, respectively. The SLT was instructed to think about the BMPs presented and get an idea of which ones they will want to focus on in implementing in the Watershed. Aleksey Sheshukov presented an approach to identify additional targeted areas in Toronto Lake 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. WRAPS team proposed to conduct 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 was engaged in active 15 minute discussion and advised to consider this modeling approach as a basis for potential future funding.
1/21/2009	PMT Meeting	12	12	On the agenda were steps to conduct upcoming field days and public events. Josh Roe presented the BMP cost-effectiveness matrix and the PMT ranked cropland and livestock BMPs in terms of their opinion of how well received they will be within the watershed along with cost-effectiveness.
4/23/2009	SLT Meeting	30	90	Josh presented an optimal set of cropland BMPs and showed the increase in "bang for the buck" that occurs if the BMPs are placed in the targeted area compared to random locations throughout the watershed. The SLT was educated on the cost-effectiveness of 12 cropland BMPs and through a dynamic voting procedure, selected their top five.

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 Upper Verdigris River and its 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 Verdigris River 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 watershed and surrounding area was collected, compiled, and published as a Preliminary Assessment Report (often called the "Watershed Atlas"). This information was published as a K-State Research and Extension publication, thus making it available digitally online:

Toronto Lake Watershed Assessment: Preliminary Report. K-State Research & Extension Publication #EP-139. 42 pages. http://www.ksre.ksu.edu/library/h20ql2/ep139.pdf

This publication included the following topics:

1.0. Toronto Lake 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 Toronto 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 Toronto Lake
  7.8. Census Data
8.0. Modeling
  8.1. Subbasin Map
  8.2. Input Data
  8.3. Model Outputs

TMDL Reports

The TMDL documents provide a rich source of watershed information:

- Verdigris Basin TMDL. Waterbody: Toronto Lake. Water Quality Impairment: Eutrophication/Dissolved Oxygen/Siltation. Priority: High http://www.kdheks.gov/tmdl/ve/Toronto_TMDL.pdf
- Verdigris Basin TMDL. Waterbody: Walnut Creek. Water Quality Impairment: Dissolved Oxygen. Priority: Medium http://www.kdheks.gov/tmdl/ve/WalnutCr_DO.pdf
- Verdigris Basin TMDL. Waterbody: West Creek. Water Quality Impairment: Dissolved Oxygen. Priority: Medium http://www.kdheks.gov/tmdl/ve/WestCr_DO.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 Toronto 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 Toronto 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)

Topography

The digital elevation map (DEM) for the basin was downloaded from the USGS National Elevation Dataset (NED). Elevations varied from 247 m to 513 m above the sea level (see Figure 11). The watershed was delineated into 17 subwatersheds (see Figure 3).

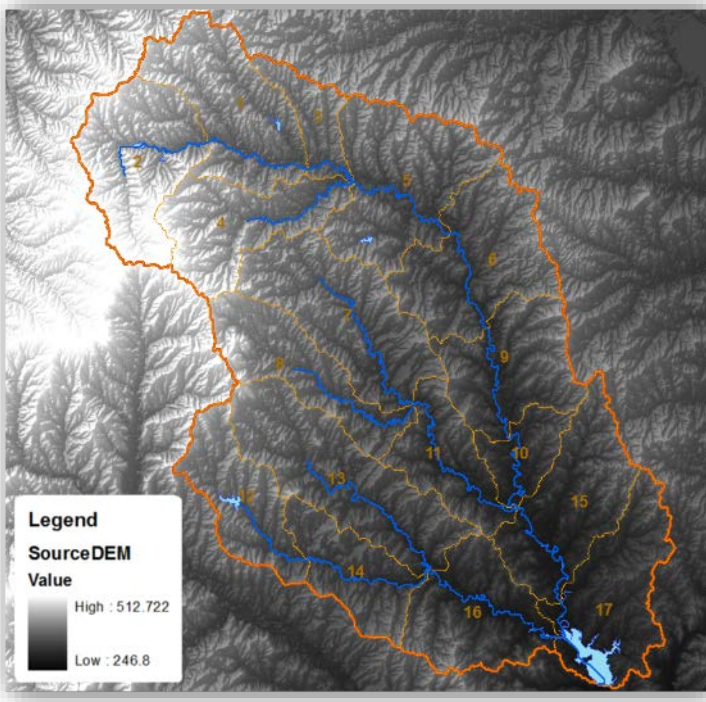


Figure 11 Topography map

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 12 and summarized in Table 10 for Toronto Reservoir watershed.

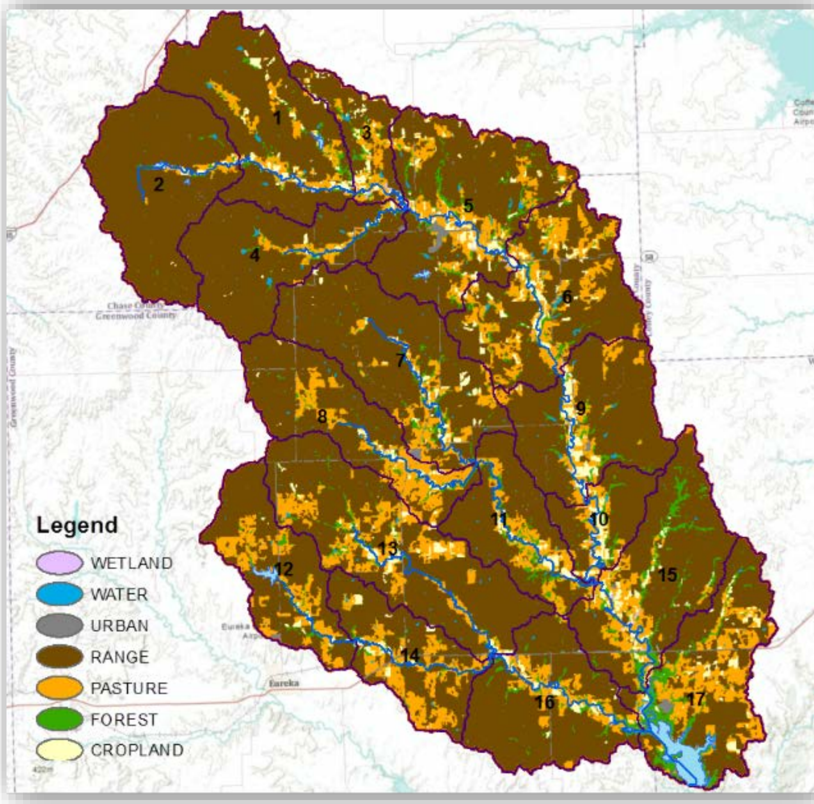


Figure 12 Land use map utilized in the SWAT model

Table 10 Areas of land uses and its classification used in SWAT model

Land Use	Area [ha]	Area [acres]	% Wat.Area
Water	2497.59	6171.6698	1.35
Residential-Low Density	6491.07	16039.7585	3.5
Residential-Medium Density	535.68	1323.6921	0.29
Residential-High Density	50.58	124.9857	0.03
Forest-Deciduous	8564.76	21163.9502	4.62
Forest-Mixed	155.52	384.2977	0.08
Range-Brush	42.21	104.303	0.02
Range-Grasses	131461.47	324847.8654	70.88
Hay	27745.47	68560.4436	14.96
Agricultural Land-Row Crops	7236.63	17882.0746	3.9
Wetlands-Forested	617.13	1524.9591	0.33
Wetlands-Non-Forested	39.69	98.076	0.02
Southwestern US (Arid) Range	31.05	76.7261	0.02
Industrial	2.16	5.3375	0
Total	**185471.01**	**458308.1393**	**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 13 and Table 11 show 17 soils, their distribution and characteristics in the watershed.

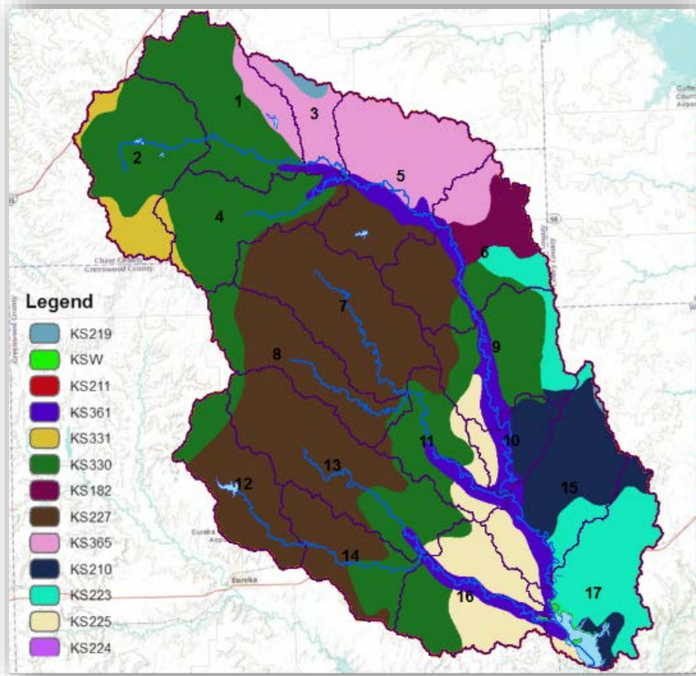


Figure 13 Soil map used in the SWAT model

Table 11 Soil characteristics used in the SWAT model

Soils	Area [ha]	Area [acres]	% Wat.Area
KS330	55,930.32	138,206.62	30.16
KS365	16,902.27	41,766.35	9.11
KS361	11,011.77	27,210.63	5.94
KS331	3,699.81	9,142.42	1.99
KS219	692.10	1,710.21	0.37
KS227	55,902.51	138,137.90	30.14
KS182	3,435.66	8,489.69	1.85
KS223	13,686.75	33,820.64	7.38
KS225	11,395.71	28,159.37	6.14
KS210	11,695.68	28,900.61	6.31
KSW	1,067.49	2,637.82	0.58
KS211	38.61	95.41	0.02
KS224	12.33	30.47	0.01
Total	**185,471.01**	**458,308.14**	**100.00**

Other inputs

Weather data was collected and downloaded from NOAA National Climatic Data Center (NCDC, 2009). There are total 8 weather stations around the watershed; 7 stations with precipitation data and 4 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.

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 five common BMPs (buffers, no-till, terraces, conservation crop rotation and grassed waterways) in the cropland targeted area of the watershed averaged across counties.

The results are as follows:

- Vegetative buffer strips – current adoption rate of 30 percent
- No-till cultivation – current adoption rate of 20 percent
- Grassed terraces – current adoption rate of 70 percent
- Conservation Crop Rotation – current adoption rate of 95 percent
- Grassed waterways – current adoption rate of 10 percent The SWAT model was revised using the groundtruthing information.

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. This information is provided in Tables 17 and 25. The maps produced by the modeling are displayed below. It is noted that the areas are characterized by low, medium, medium-high and high. The subwatersheds at the northern end of the basin 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.

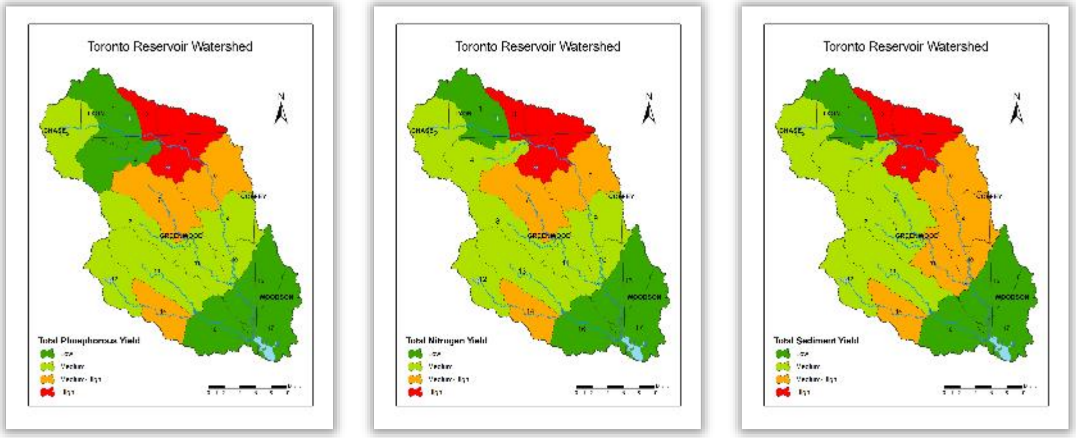


Figure 14 Maps of total phosphorous, nitrogen, and sediment yields in 17 subbasins

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 nitrogen concentrations, were collected and combined in the forms of total sediment, phosphorous, and nitrogen loads. Figure 10 presents maps of such loads in a scale of graduated colors (darker color indicates higher load).

Average annual yields for each subwatershed are listed in Table 12**Error! Not a valid bookmark self-reference.**. Subwatersheds 3 and 5 produced the highest annual yields with at least 20% or higher of the total watershed nitrogen, phosphorous, and sediment yields. The pollutant yields maps produced by the modeling are displayed above. It is noted that the areas are characterized by low, medium, medium-high and high.

Table 12 Total pollutant loads for each subwatershed

Subbasin	Total Sediment Yield (tn/ac)	Total Phosphorous Yield (lb/ac)	Total Nitrogen Yield (lb/ac)
1	2.08	0.29	0.19
2	5.02	0.75	0.81
3	11.45	1.79	2.14
4	4.70	0.69	0.60
5	9.76	1.46	1.54
6	6.98	1.11	1.07
7	7.46	1.19	0.97
8	5.81	0.99	0.83

9	5.68	0.91	0.98
10	5.63	0.97	1.13
11	4.99	0.83	0.85
12	4.97	0.85	0.68
13	5.34	0.90	0.71
14	7.02	1.20	1.04
15	2.48	0.41	0.22
16	3.31	0.48	0.32
17	1.25	0.23	0.12

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 13 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.

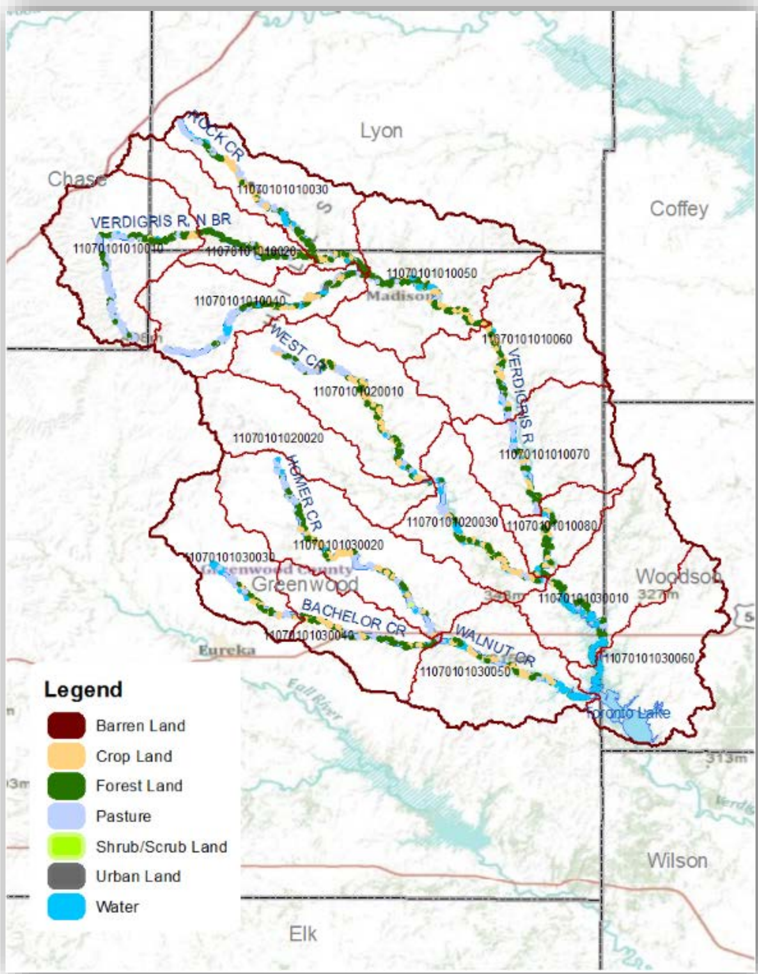


Figure 15 Map of stream bank areas (100 ft) along main stem of rivers

The conducted GIS analysis included a 100 ft buffer along main stems of the Verdigris River and main tributaries with an intersected riparian coverage (Figure 15). After consulting with the SLT, four subbasins (Homer Creek and West Creek) were identified as being targeted for streambank restoration by the SLT team. In the targeted area, the predominant land use in the riparian areas is pastureland at 57 percent (Table 14). 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.

Table 14 Riparian Land use in the streambank targeted areas of a 100 foot buffer

Land Use	Acres	Percent
Pasture	8,664	57.54
Forest Land	2,197	14.59
Pasture/Tree Mix	1,621	10.76
Water	948	6.30
Crop Land	820	5.44
Crop/Tree Mix	698	4.63
Urban Land	44	0.29
Shrub/Shrub Land	32	0.21
Urban/Tree Mix	29	0.19
Barren Land	7	0.05
	15,059	100.00

Critical Targeted Areas

The pollutant yields maps produced by the modeling are displayed in Figure 14. The subwatersheds 3 and 5 at the northern end of the basin shown in 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.

The critical cropland, livestock and stream bank targeted areas are displayed below. An identification of rangeland and livestock critical areas was conducted by the SLT, while locations of the stream bank critical areas were developed with the use of the riparian GIS layer repository.

Cropland Erosion Targeted Areas

The SWAT delineated (primary ranked) targeted area of this project is to be used for the determination of BMP placement for sediment (overland origin). This area includes a portion of the Verdigris River, Moon Branch, Kelly Branch and Tate Branch. This area contains HUC numbers:

- 110701010105 (subbasin 3),
- the lower portion of HUC 110701010103 (subbasin 5).

Rangeland and Livestock Targeted Areas

The SLT has determined an area for targeting rangeland erosion in the watershed. This area will also be targeted for livestock related phosphorus pollutants. Rangeland BMPs will be placed in this area. These SWAT areas are HUC numbers:

- 110701010201 (subbasin 7),
- 110701010304 (subbasin 14),
- 110701010305 (subbasin 16).

Stream bank Erosion

In addition to the GIS based stream bank assessment, the SLT has determined that the targeted area for stream bank restoration will be Homer Creek and West Creek along with their tributaries. It will be targeted for sediment that originates from stream bank failures and lack of riparian cover. These areas are contained in HUC numbers:

- 110701010201 (subbasin 7),
- 110701010202 (subbasin 8),
- 110701010203 (subbasin 11),
- 110701010302 (subbasin 13).

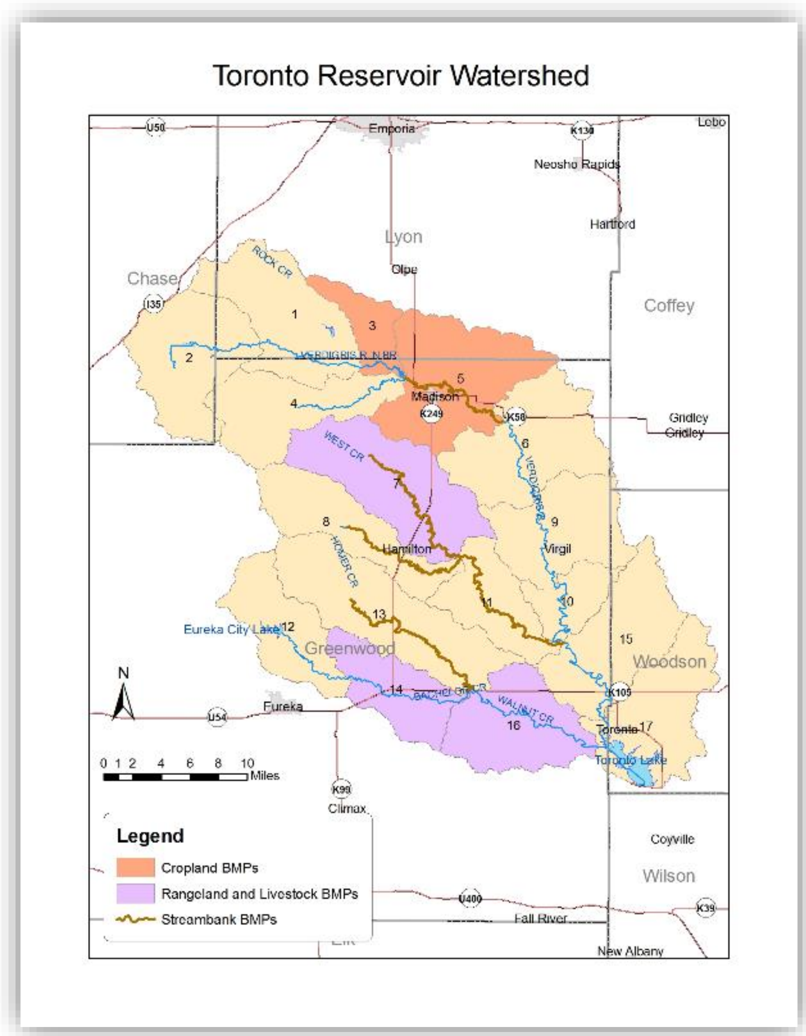


Figure 16 Critical targeted subwatersheds

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.

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.

Economic Analysis

General Economic Research

Cost-return budgets have been developed for the Toronto Reservoir watershed by working with data from the Kansas Farm Management Association (Table 15 through Table 19). The budgets are specific to Toronto Reservoir 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 Toronto Reservoir 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.

Corn Cost-Return Budget

Table 15 Cost-return projections for corn crops in the Toronto Watershed, 2006.

CORN	Yield Level (bu)		
	80	110	140
INCOME PER ACRE			
A. Yield per acre	80	110	140
B. Price per bushel	$2.70	$2.70	$2.70
C. Net government payment	$10.48	$11.39	$12.30
D. Indemnity payments			
E. Miscellaneous income			
F. Returns/acre ((AxB)+C+D+E)	$226.48	$308.39	$390.30
COSTS PER ACRE			
1. Seed	$32.43	$32.43	$36.66
2. Herbicide	33.85	33.85	33.85
3. Insecticide/Fungicide	0.27	0.27	0.27
4. Fertilizer and Lime	37.48	45.40	53.32
5. Crop Consulting			
6. Crop Insurance			
7. Drying			
8. Miscellaneous	7.00	7.00	7.00
9. Custom Hire / Machinery Expense	90.16	98.83	107.50
10. Non-machinery Labor	10.19	11.17	12.15

11. Irrigation			
12. Land Charge / Rent	34.40	43.00	51.60
G. SUB TOTAL	$245.77	$271.94	$302.34
13. Interest on ½ Nonland Costs	9.51	10.30	11.28
H. TOTAL COSTS	$255.28	$282.25	$313.63
I. RETURNS OVER COSTS (F-H)	-$28.81	$26.14	$76.68
J. TOTAL COSTS/BUSHEL (H/A)	$3.19	$2.57	$2.24
K. RETURN TO ANNUAL COST (I+13)/G	**-7.85%**	**13.40%**	**29.09%**

Soybean Cost-Return Budget

Table 16 Cost-return projections for soybean crops in the Toronto Watershed, 2006.

SOYBEANS	**Yield Level (bu)**		
	25	35	45
INCOME PER ACRE			
A. Yield per acre	25	35	45
B. Price per bushel	$6.08	$6.08	$6.08
C. Net government payment	$10.48	$11.39	$12.30
D. Indemnity payments			
E. Miscellaneous income			
F. Returns/acre ((AxB)+C+D+E)	$162.48	$224.19	$285.90
COSTS PER ACRE			
1. Seed	$30.60	$30.60	$32.95
2. Herbicide	8.86	8.86	8.86
3. Insecticide/Fungicide			
4. Fertilizer and Lime	16.41	17.70	21.20
5. Crop Consulting			
6. Crop Insurance			
7. Drying			
8. Miscellaneous	7.00	7.00	7.00
9. Custom Hire / Machinery Expense	73.03	77.25	80.22
10. Non-machinery Labor	8.25	8.75	9.06
11. Irrigation			
12. Land Charge / Rent	34.40	43.00	51.60
G. SUB TOTAL	$178.55	$193.14	$210.89
13. Interest on ½ Nonland Costs	6.49	6.76	7.17
H. TOTAL COSTS	$185.03	$199.89	$218.06
I. RETURNS OVER COSTS (F-H)	-$22.56	$24.30	$67.84
J. TOTAL COSTS/BUSHEL (H/A)	$7.40	$5.71	$4.85

K. RETURN TO ANNUAL COST (I+13)/G	-9.00%	16.08%	35.57%

Wheat Cost-Return Budget

Table 17 Cost-return projections for wheat crops in the Toronto Watershed, 2006.

WHEAT	Yield Level (bu)		
	35	45	55
INCOME PER ACRE			
A. Yield per acre	35	45	55
B. Price per bushel	$4.41	$4.41	$4.41
C. Net government payment	$10.48	$11.39	$12.30
D. Indemnity payments			
E. Miscellaneous income			
F. Returns/acre ((AxB)+C+D+E)	$164.83	$209.84	$254.85
COSTS PER ACRE			
1. Seed	$9.90	$9.90	$9.90
2. Herbicide	2.75	2.75	2.75
3. Insecticide/Fungicide			
4. Fertilizer and Lime	36.65	43.71	52.06
5. Crop Consulting			
6. Crop Insurance			
7. Drying			
8. Miscellaneous	7.00	7.00	7.00
9. Custom Hire / Machinery Expense	60.61	63.62	66.63
10. Non-machinery Labor	6.85	7.19	7.53
11. Irrigation			
12. Land Charge / Rent	34.40	43.00	51.60
G. SUB TOTAL	$158.16	$177.17	$197.47
13. Interest on ½ Nonland Costs	5.57	6.04	6.56
H. TOTAL COSTS	$163.73	$183.20	$204.04
I. RETURNS OVER COSTS (F-H)	$1.10	$26.64	$50.81
J. TOTAL COSTS/BUSHEL (H/A)	$4.68	$4.07	$3.71
K. RETURN TO ANNUAL COST (I+13)/G	4.22%	18.44%	29.06%

Grain Sorghum Cost-Return Budget

Table 18 Cost-return projections for grain sorghum crops in the Toronto Watershed, 2006.

GRAIN SORGHUM	Yield Level (bu)		
	70	85	110
INCOME PER ACRE			

A. Yield per acre	70	85	110
B. Price per bushel	$2.82	$2.82	$2.82
C. Net government payment	$10.48	$11.39	$12.30
D. Indemnity payments			
E. Miscellaneous income			
F. Returns/acre ((AxB)+C+D+E)	$207.88	$207.88	$207.88
COSTS PER ACRE			
1. Seed	$12.29	$12.29	$12.29
2. Herbicide	20.34	20.34	20.34
3. Insecticide/Fungicide	5.90	5.90	5.90
4. Fertilizer and Lime	39.68	43.64	50.24
5. Crop Consulting			
6. Crop Insurance			
7. Drying			
8. Miscellaneous	7.00	7.00	7.00
9. Custom Hire / Machinery Expense	82.39	86.92	94.47
10. Non-machinery Labor	9.31	9.82	10.68
11. Irrigation			
12. Land Charge / Rent	34.40	43.00	51.60
G. SUB TOTAL	$211.30	$228.90	$252.51
13. Interest on ½ Nonland Costs	7.96	8.37	9.04
H. TOTAL COSTS	$219.26	$237.27	$261.55
I. RETURNS OVER COSTS (F-H)	-$11.38	$13.82	$60.95
J. TOTAL COSTS/BUSHEL (H/A)	$3.13	$2.79	$2.38
K. RETURN TO ANNUAL COST (I+13)/G	**-1.62%**	**9.69%**	**27.72%**

Alfalfa Cost-Return Budget

Table 19 Cost-return projections for alfalfa crops in the Toronto Watershed, 2006.

ALFALFA		**Yield Level (ton)**	
	3.0	3.5	4.0
INCOME PER ACRE			
A. Yield per acre	3.0	3.5	4.0
B. Price per bushel	$101.00	$101.00	$101.00
C. Net government payment	$12.30	$13.37	$14.44
D. Indemnity payments			
E. Miscellaneous income			
F. Returns/acre ((AxB)+C+D+E)	$315.30	$366.87	$418.44
COSTS PER ACRE			

1. Seed	$10.17	$10.17	$10.17
2. Herbicide	2.51	2.51	2.51
3. Insecticide/Fungicide	7.08	7.08	7.08
4. Fertilizer and Lime	19.90	26.89	33.88
5. Crop Consulting			
6. Crop Insurance			
7. Drying			
8. Miscellaneous	6.38	6.38	6.38
9. Custom Hire / Machinery Expense	109.42	118.08	126.61
10. Non-machinery Labor	12.36	13.34	14.31
11. Irrigation			
12. Land Charge / Rent	31.60	39.50	47.40
G. SUB TOTAL	$199.43	$223.96	$248.34
13. Interest on ½ Nonland Costs	7.55	8.30	9.04
H. TOTAL COSTS	$206.98	$232.26	$257.38
I. RETURNS OVER COSTS (F-H)	$108.32	$134.61	$161.06
J. TOTAL COSTS/BUSHEL (H/A)	$68.99	$66.36	$64.35
K. RETURN TO ANNUAL COST (I+13)/G	**58.10%**	**63.81%**	**68.50%**

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 Toronto Reservoir 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

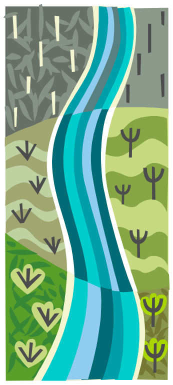
This tool was developed with assistance and input from KSU Ag Economics faculty, Watershed Institute, and KAWS. This tool allows producers and land-managers across the state of Kansas (Toronto Reservoir Watershed) to evaluate the economic benefits and costs of streambank stabilization projects, and will 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 Toronto Reservoir 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 Toronto Reservoir, so this will be the main focus of the economic analysis. The economic impacts and benefits of recreation at the Toronto Reservoir were being estimated using an input-output impact analysis and non-market valuation techniques.



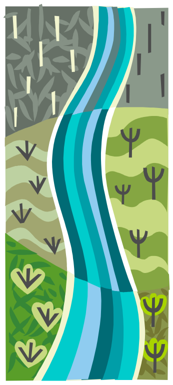
Next Steps / Transition into Planning Phase

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.

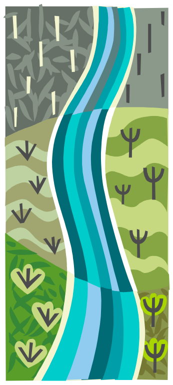


Evaluation of Project Goal, Objectives, and Tasks

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 Toronto Reservoir 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 Toronto 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.

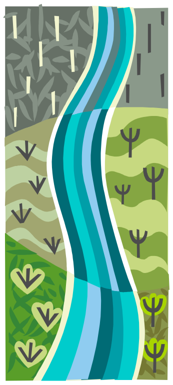
- One Kansas individual skeptical of watershed modeling suggested that K-State should instead simply show real data about how various agricultural management practices impact water quality in each locale. He and I discussed how soil types, rainfall patterns, growing seasons, and management practices, 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.



References

Arnold, J.G., R. Srinivasan, R.S., Muttiah, and J.R. Williams. 1998. Large area hydrologic modeling and assessment Part I: Model development. J. Am. Water Resour. Assoc. 34(1): 73-89.

Gaunt, P.M. 2001. Water Recreation Needs Assessment Report to the Kansas Water Office. Wichita State University.

Kansas Geospatial Community Commons. http://www.kansasgis.org/catalog/catalog.cfm

KDHE. 2009. Watershed planning section: TMDLs. Topeka, Kansas: Kansas Department of Health and Environment. www.kdheks.gov/tmdl

Kansas Department of Health and Environment. The Basics of TMDLs. http://www.kdheks.gov/tmdl/basic.htm#tmdl

Kansas Department of Health and Environment, 2000.

Verdigris Basin TMDL. Waterbody: Toronto Lake. Water Quality Impairment: Eutrophication/Dissolved Oxygen/Siltation. Priority: High Http://Www.Kdheks.Gov/Tmdl/Ve/Toronto_Tmdl.Pdf

Verdigris Basin TMDL. Waterbody: Walnut Creek. Water Quality Impairment: Dissolved Oxygen. Priority: Medium Http://Www.Kdheks.Gov/Tmdl/Ve/Walnutcr_Do.Pdf

Verdigris Basin TMDL. Waterbody: West Creek. Water Quality Impairment: Dissolved Oxygen. Priority: Medium Http://Www.Kdheks.Gov/Tmdl/Ve/Westcr_Do.Pdf

Kansas Department of Health and Environment, 2010. http://www.kdheks.gov/tmdl/download/2010_303_d_List_of_All_Imaired_Waters.pdf

Kansas Department of Health and Environment, 2010. http://www.kdheks.gov/tmdl/download/2010_303_d_Delistings.pdf

Kansas Department of Health and Environment, 2010. http://www.kdheks.gov/tmdl/download/2010_303_d_List_of_All_Imaired_Waters.pdf

Kansas Water Office. Reservoir Fact Sheets. http://www.kwo.org/reservoirinformation/reservoir%20information.htm

Mankin, K.R. 2008. WRAPS Adaptive Modeling. Presentation at the KDHE WRAPS Regional Watershed Seminar, Lawrence, KS. May 22, 2008.

Neitsch, S.L., J.G. Arnold, J.R. Kiniry, and J.R. Williams. 2005. Soil and Water Assessment Tool (SWAT), Theoretical documentation. Temple, Texas: USDA-ARS Grassland Soil and Water Research Laboratory.

Permitted Point Source Facilities: BASINS. Online reference information available at: http://www.epa.gov/waterscience/basins/index.htm

Rosenberger, R.S. 2001. Benefit Transfer of Outdoor Recreation Use Values. USDA Forest Service.

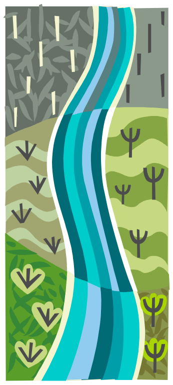
U.S. Census of Agriculture. 2002 http://www.nass.usda.gov/Census_of_Agriculture/index.asp

U.S. Census Bureau, 2000. http://quickfacts.census.gov/qfd/states/2000.html

USDA-NASS. 2007. Cropland Data Layer. http://www.nass.usda.gov/research/Cropland/SARS1a.htm

USDA-NRCS. 1994. Soil data mart. Washington, D.C.: USDA Natural Resources Conservation Service. http://soildatamart.nrcs.usda.gov/Default.aspx

USDA-NRCS. 2004. Geospatial data gateway. Fort Worth, Texas: USDA Natural Resources Conservation Service. http://datagateway.nrcs.usda.gov

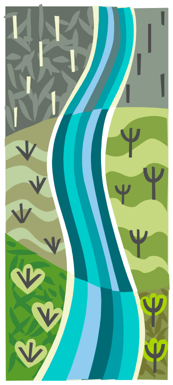


Appendix A: Watershed Atlas

Nejadhashemi, A.P., C.M. Smith, K.R. Mankin, R.M. Wilson, S.P. Brown, and J.C. Leatherman. 2009. Toronto Lake Watershed Assessment: Preliminary Report. Kansas State Research and Extension Publication #EP-139. 57 pages . http://www.ksre.ksu.edu/library/h20ql2/EP139.pdf

Appendix B: TMDLs

- Verdigris Basin Tmdl. Waterbody: Toronto Lake. Water Quality Impairment: Eutrophication/Dissolved Oxygen/Siltation. Priority: High http://www.kdheks.gov/tmdl/ve/toronto_tmdl.pdf
- Verdigris Basin Tmdl. Waterbody: Walnut Creek. Water Quality Impairment: Dissolved Oxygen. Priority: Medium http://www.kdheks.gov/tmdl/ve/walnutcr_do.pdf
- Verdigris Basin Tmdl. Waterbody: West Creek. Water Quality Impairment: Dissolved Oxygen. Priority: Medium http://www.kdheks.gov/tmdl/ve/westcr_do.pdf



Appendix C: Financial Summary

Summary of Financial Expenditures and Matching Funds				
Category	Budget	Actual	Match	Total
Salaries	44,045.00	54,713.48	9,596.04	64,309.52
Fringe Benefits	11,155.00	9,957.13	2,280.91	12,238.04
Travel	1,750.00	1,981.69	-	1,981.69
Supplies	2,500.00	1,088.70		1,088.70
Contractual Services	-	-		-
Other	8,550.00	259.00		259.00
Project Indirect Costs	-	-	-	-
Waived Indirect Costs	-	-	36,743.40	36,743.40
Total	$ 68,000.00	$ 68,000.00	$ 48,620.35	$ 116,620.35