KANSAS WATERSHED RESTORATION AND PROTECTION STRATEGY (WRAPS) PROJECT

BIG HILL CREEK/ BIG HILL LAKE WATERSHED ASSESSMENT

FINAL REPORT

KDHE Project No. 2006-0073

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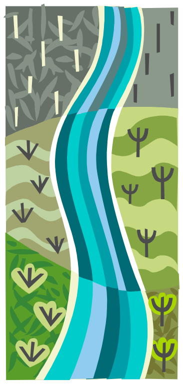

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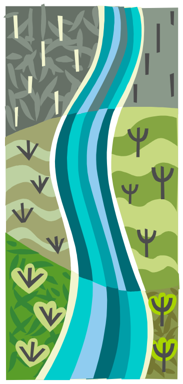

Acknowledgements

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

- Aleksey Y. Sheshukov, Watershed Modeler
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- Josh Roe, Watershed Economist
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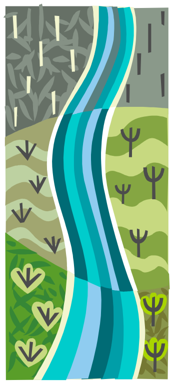
- Sue P. Brown, Watershed Communication
- John C. Leatherman, Professor, Agricultural Economics
- William Hargrove, past KCARE Director



Executive Summary

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

Initiated in June 2007, most project activities were completed by May 2009. This WRAPS Assessment Phase project has completed about 60% of its initial goals. The remaining portion of the project will require engagement with the Stakeholder Leadership Team, which has yet to be formed.

Project accomplishments include:

- *Watershed Assessment*: We compiled existing information related to the Big Hill watershed, culminating in development and publication of a Watershed Atlas.
- *Watershed Modeling*: We completed a SWAT modeling analysis of baseline 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 Big Hill Lake.

Once a Stakeholder Leadership Team is established, further work is needed to engage this team 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.

Introduction

Geographic Scope/Location

The Big Hill Creek/Big Hill Lake Watershed (HUC 11070103010) encompasses all or parts of Montgomery, Neosho, and Labette Counties in southeast Kansas. The Big Hill Creek/Big Hill Lake Watershed is located within Middle Verdigris River watershed (11070103 8-digits HUC) and occupies one 10-digit watershed (1107010301) or three 12-digits HUC watersheds (110701030106, 110701030107, 110701030108). The watershed is primarily the drainage area for Big Hill Creek and its tributaries. At the outlet of the watershed, the Big Hill Creek flows into Verdigris River. Main drainage area of the watershed is 81,126 acres or 127 mi^2. Major lakes in the watershed include Big Hill Lake.

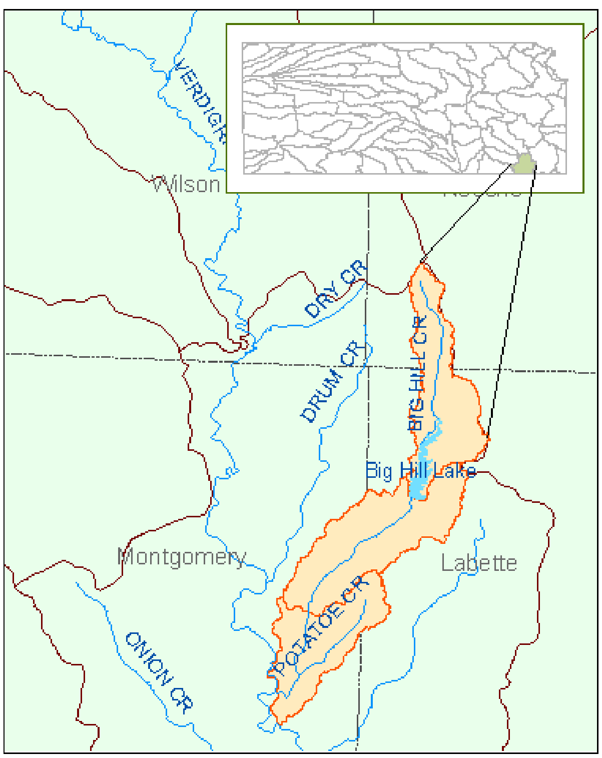


Figure 1: Big Hill Lake Watershed Map

Population
The Big Hill Creek/Big Hill Lake watershed is a rural agricultural area. The population is sparse; most homeowners are located around the lake itself and are seasonal homeowners. The only big town in the watershed is Liberty. According to the 2000 census data from the U.S. Census Bureau (http://quickfacts.census.gov/qfd/index.html), the population of Liberty is approximately 95 people. According to the U.S. Census Bureau, the estimate population within the Big Hill Creek/Big Hill Lake watershed in 2008 is 3,699 people (32.1 people/square mile).

Surface Water Resources
The Big Hill Lake collects water from a 35.4 mi^2 watershed. Big Hill Creek is the only major stream that feeds the lake. Mean precipitation for the watershed is 37.9 inches and mean runoff is 9.64 inches. The lake averages 51.5 inches of evaporation and 15,800 ac-ft/yr outflow, but year-to-year variations in outflow have ranged from <1000 ac-ft/yr to >33,000 ac-ft/yr.

Designated Uses
Designated uses for the surface water resources in this watershed generally include: expected aquatic life support, food procurement, livestock watering, industrial water supply, and primary contact recreation.

Public Water Supplies
Big Hill Lake is a critical resource in managing instream flow for downstream public water suppliers. Public Wholesale Water Supply District #4, in the Big Hill Creek watershed, pulls water from just below the Big Hill Lake dam.

Land Uses/Activities
Grassland (considered grazingland for livestock) is the predominant land use, covering 57% of the watershed. Row crop agriculture makes up 33%, wooded areas 7%, urban areas 1%, and water resources occupy the remaining 2% of the watershed. There are no state-registered or federally permitted confined animal feeding operations or wastewater treatment plants in the Big Hill Creek watershed.

Wildlife Habitat
Species common to the area included white-tailed deer, wild turkey, quail, squirrel, rabbit, dove, and raccoon, as well as a rich variety of songbirds.

Recreational Areas
Big Hill Lake was identified as the “Top Tier” federal reservoir for outdoor recreation in 2005 by the Kansas Water Office. Recreational amenities in the Big Hill Lake Recreation Area (maintained by the U.S. Army Corps of Engineers) include 3 campgrounds, 3 equestrian trails (totaling 17 miles), 4 day-use areas, and access to the reservoir for fishing, boating, and swimming. Big Hill Lake, considered by the U.S. Army Corps of Engineers to be a “trophy fishing lake”, is one of the most popular and productive fishing areas in Southeast Kansas, where fishermen can catch largemouth and smallmouth bass, walleye, bluegill and catfish.

Watershed / Water Quality Conditions

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.

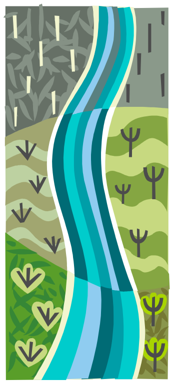
Big Hill Lake has a high priority TMDL for eutrophication (approved 9/30/09). The upper portion of Big Hill Creek currently has a medium priority TMDL for dissolved oxygen and a medium priority TMDL for fecal coliform bacteria (approved 9/30/02).

Verdigris Basin TMDL. Waterbody: Big Hill Lake. Water Quality Impairment: Eutrophication. <www.kdheks.gov/tmdl/ve/Big_Hll_Lake_TMDL.pdf>

Verdigris Basin TMDL. Waterbody: Big Hill Creek. Water Quality Impairment: Dissolved Oxygen. <www.kdheks.gov/tmdl/ve/BigHillCr_DO.pdf>

Verdigris Basin TMDL. Waterbody: Big Hill Creek. Water Quality Impairment: Fecal Coliform Bacteria. <www.kdheks.gov/tmdl/ve/BigHillCr_FCB.pdf>

These impairments can be attributed to agricultural and rural homeowner use activities. Contact recreation in surface waters are being impacted by the presence of fecal coliform bacteria. Public water supplies for rural water districts and private wells are indirectly threatened by water quality impairments. Overgrazing is a problem in certain areas in addition to brush and invasive non-native species introduction. Oil and gas production does occur in this area and therefore brine scars are evident. Flash flooding occurs during storm events primarily in the spring.



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 project was to develop models and tools to evaluate alternative farm and non-farm land use practices in relation to water quality and economics and to document the impact of water restoration and preservation strategies.

Objectives

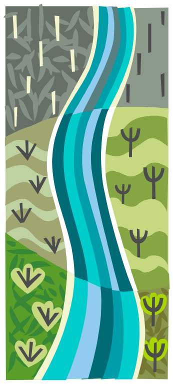
The objectives of this WRAPS Assessment Phase Project were to

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.



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

The WRAPS Development phase project (beginning April 2006) failed to identify, recruit, and engage a Stakeholder Leadership Team for the Big Hill Lake watershed. This outcome was not anticipated at the outset of this WRAPS Assessment phase project, but significantly impacted the final results and impact of the project. No Assessment-focused meetings with stakeholders were held in the watershed.

On June 11, 2008, project staff met with KDHE and SEEKAN RC&D to discuss the status of stakeholder development efforts in the Middle Verdigris and Big Hill watersheds. Staff agreed that given the size and other characteristics of the Big Hill watershed, it would be appropriate to have a single Stakeholder Leadership Team to cover both the Oologah (Middle Verdigris) and Big Hill watersheds, effectively combining the two projects. Also, in response to a lack of interest on the part of local agency staff, SEEKAN agreed to sponsor some information and education activities/events over the following few months to help generate local interest in the WRAPS project.

Project staff met with SEEKAN staff in August 2008 to follow up on plans for I&E activities in the fall. Five potential I&E activities were identified, including a streambank tour, a presentation at the Montgomery County Farm Bureau district meeting in September, a riparian management tour and workshop in October, a River Friendly Farms workshop in November, and a meeting with municipal Public water suppliers in December. Under sub-contract to K-State, SEEKAN ultimately organized/sponsored two information/education events: a streambank/riparian area workshop and a grazing/livestock workshop. These events were identified as being the most relevant to local landowners/producers in the watersheds.

The riparian workshop was held on October 27, 2008 with approximately 18 people participating, 12 of whom were non-agency stakeholders. The grazing/livestock workshop was held on December 11, 2008 and included presentations about the River Friendly Farms program offered by the Kansas Rural Center and information about rangeland best management practices. Approximately 17 people participated, 12 of whom were non-agency stakeholders.

Project staff met with KDHE staff and SEEKAN RC&D staff in February 2009 to discuss the status of the WRAPS Development Phase and Assessment Phase activities for the now combined Oologah/Big Hill WRAPS project and prospects for launching a viable stakeholder leadership team. The group also reviewed the discussion/outcomes of the joint Kansas-Oklahoma meeting in June 2008, reviewed the preliminary SWAT watershed modeling results produced by the Corps, discussed the status of the Corp's watershed management plan for the entire Verdigris/Oologah basin, and reviewed the status of TMDLs in the watershed. All parties agreed that:

- The Corps watershed plan was expected to be on hold indefinitely pending continuation of federal funding for the project.
- Because Lake Oologah is located on the Oklahoma side of the watershed, it was not currently a high priority for Kansas and future WRAPS funding.
- It was unclear as to what progress, if any, Oklahoma agency staff made in organizing stakeholders above Lake Oologah.
- There were no high-priority TMDLs requiring attention on the Kansas side of the watershed.
- There was insufficient interest/support on the part of local agency staff (primarily county Extension offices and conservation districts and NRCS) as well as local residents to reasonably support a viable stakeholder leadership team.
- All stakeholder development activities would be put on hold indefinitely pending completion of the Corps watershed management plan. If/when the Corps plan is completed, project staff would meet with KDHE and SEEKAN to discuss possible plans for I&E activities to publicize the Corps plan and to seek public input. If public input suggested that the Corps plan was unacceptable to watershed residents, project staff would offer assistance is drafting a revised plan (i.e., WRAPS planning phase assistance).

Project staff followed up with Corps staff in April 2009 – no additional work had been completed on the watershed plan, and the Corps could not provide a realistic timeframe for completing the plan.

In the end, these efforts failed to materialize the local engagement needed to support a WRAPS project.

As a result, much of the WRAPS Assessment Project effort was geared to anticipating and preparing the watershed assessment information that would be needed by the Stakeholder Leadership Team early in their WRAPS assessment phase.

This Final Report provides the information that will be needed to get a WRAPS Stakeholder Leadership Team started at some time in the future.

Establish Assessment Criteria

Without a Stakeholder Leadership Team, this project assumed that the preliminary assessment information needed for this WRAPS project would be similar to those needed by other similar Stakeholder Leadership Teams.

A future WRAPS project would be needed to review existing data, determine data gaps, and refine assessment needs. These stakeholders should be involved in establishing the assessment criteria that will be given priority, developing potential land management strategies for assessment, and recommending and reviewing monitoring strategies to support assessment and evaluate implementation

Inventory Existing Information

Again, without a Stakeholder Leadership Team, this project assumed that the preliminary assessment information needed for this WRAPS project would be similar to those needed by other similar Stakeholder Leadership Teams.

A future WRAPS project would be needed 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 Assessment

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:

> Oologah Watershed Assessment: Preliminary Report. K-State Research & Extension Publication #EP-136. 58 pages. <www.ksre.ksu.edu/library/h20ql2/EP136.pdf>

This publication included the following topics:

- 1.0. Oologah 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 Oologah 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 Big Hill 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: Big Hill Lake. Water Quality Impairment: Eutrophication. < www.kdheks.gov/tmdl/ve/Big_Hll_Lake_TMDL.pdf>

Verdigris Basin TMDL. Waterbody: Big Hill Creek. Water Quality Impairment: Dissolved Oxygen. <www.kdheks.gov/tmdl/ve/BigHillCr_DO.pdf>

Verdigris Basin TMDL. Waterbody: Big Hill Creek. Water Quality Impairment: Fecal Coliform Bacteria. <www.kdheks.gov/tmdl/ve/BigHillCr_FCB.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). <www.kdheks.gov/tmdl/>

Watershed Modeling

There are few water-quality watershed models, simple and complex, that can be used for Big Hill watershed assessment. Simple models like STEPL and REGION5 developed by the Environmental Protection Agency (EPA) use mainly empirical equations to model hydrologic and water-quality processes. The complex models like Soil and Water Assessment Tool (SWAT) incorporate multiple submodules which primarily use physically based distributed equations to model various processes in the watershed. The use of complex models requires specific knowledge of physical processes as well as technical skills to run the model.

For Big Hill watershed, the project team used SWAT and geographic information system (GIS) databases to model the watershed and identify critical areas with higher potential for sediment and nutrients to reach the stream.

SWAT model

The Soil and Water Assessment Tool (SWAT) model is a physically based, deterministic, continuous, watershed-scale simulation model developed by the USDA Agricultural Research Service (Arnold et al., 1998; Neitsch et al., 2005). 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.

The Big Hill watershed was divided spatially into subwatersheds using digital elevation data according to the drainage area specified by the user. Subwatersheds 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 subwatershed having similar soil, land use, and slope characteristics. The use of HRUs allows slope, soil, and land-use heterogeneity to be simulated within each subwatershed, but ignores pollutant attenuation between the source area and stream within a given HRU, and limits spatial representation of wetlands, buffers, and other BMPs within a subwatershed.

SWAT produces daily results for every subwatershed outlet, each of which can be summed to provide daily, monthly, and annual load estimates.

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

- 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

- The channel component routes flows, settles and entrains sediment, and degrades nutrients, pesticides and bacteria during transport.
- The reservoir component detains water, sediments, and pollutants, and degrades nutrients, pesticides and bacteria during detention.

Throughout the years 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.

<u>Data collection</u>

Data for the SWAT model of Big Hill watershed were collected from a variety of online and printed data sources and knowledgeable people within the watershed. The primary sources of input data are 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 have been developed to process the input data, enter it into the SWAT model, and analyze the output results. We used Visual Basic, Visual Basic for Applications and Visual Studio C++ as main programming languages to develop the data processing utilities.

The digital elevation map (DEM) for the basin was downloaded from the USGS National Elevation Dataset (NED). Elevations vary from 209 m to 329 m above the sea level. The watershed is delineated into 26 subwatersheds (see Figure 2).

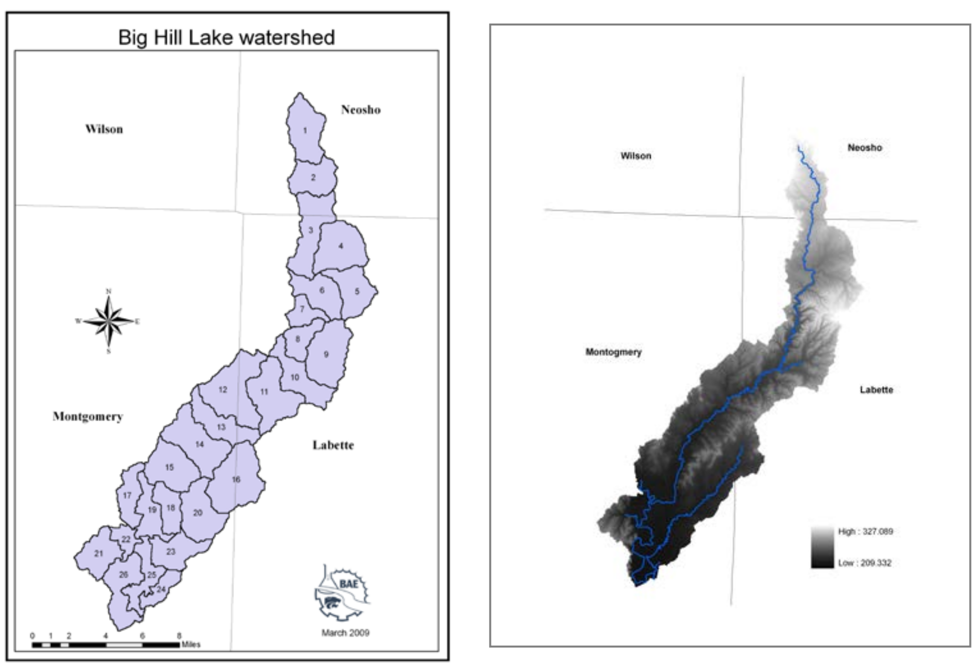


Figure 2: Big Hill Watershed showing 26 subwatersheds and topography

The land use dataset used in the model is the USDA National Land Cover Dataset (NLCD) prepared in 2001 (see Figure 3). NLCD 2001 has 10 standardized categories that are presented for Big Hill watershed, as summarized in Table 1.

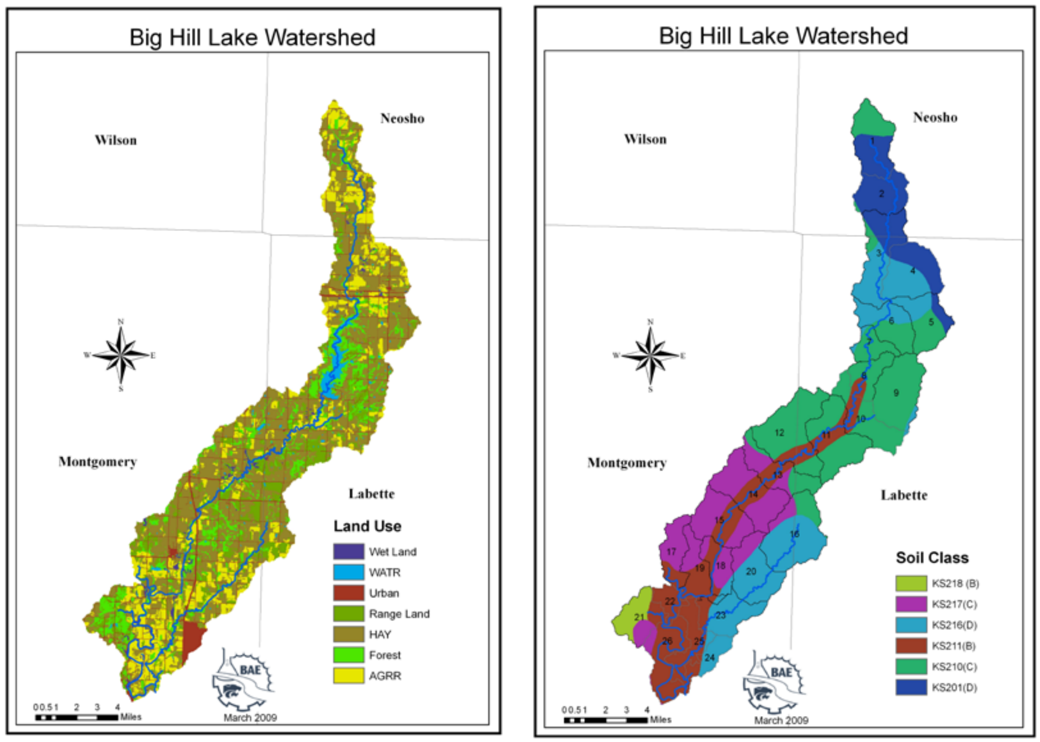


Figure 3: Land use and soil maps for Big Hill watershed

Table 1: Areas of land uses and its classification used in SWAT model

Landuse	Area[ha]	Area[acres]	% watershed area
Water	751.05	1,855.88	2.29
Residential- Low Density	1,571.40	3,883.01	4.79
Residential -Medium Density	304.02	751.25	0.93
Residential- High Density	53.10	131.21	0.16
Southwestern US (arid range)	20.16	49.82	0.06
Forest- Deciduous	4,069.53	10,056.01	12.4
Forest- Mixed	151.47	374.29	0.46
Range- grasses	3,338.73	8,250.17	10.17
Hay	15,889.32	39,263.30	48.4
Agricultutral land- Row crops	6,088.77	15,045.66	18.55
wet lands- Forested	507.42	1,253.86	1.55
Range- Brush	30.15	74.50	0.09
Wet lands- Non Forsted	28.08	69.39	0.09
Industrial	27.72	68.50	0.08

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 3 and Table 2 show soil distribution in the watershed.

Table 2: Soil characteristics used in SWAT model

Soil Class	Area [ha]	Area [acres]	% Watershed Area	Soil Hydro Group
KS201	3657.87	9038.7797	11.14	D
KS210	9897.21	24456.5	30.15	C
KS216	6889.59	17024.5214	20.99	D
KS211	6437.61	15907.6562	19.16	B
KS217	5306.67	13113.0469	16.16	C
KS218	641.97	1586.34	1.96	B

Weather data was collected and downloaded from NOAA National Climatic Data Center (NCDC, 2009). There are total 7 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.

Targeted subwatersheds

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 4 presents maps of such loads in a scale of graduated colors (darker color indicates higher load).

Table 3 lists annual loads for each subwatershed calculated by SWAT. Subwatersheds 2, 4, 10, 22, 24, 25, 26 (with highest annual loads) were identified and selected as targeted subwatersheds (see Figure 5). The targeted subwatersheds were selected as subwatersheds that produce top 20% of the nitrogen, phosphorous and sediment loads. Without local knowledge from the Stakeholder Leadership Team, these targeted subwatersheds should be considered as preliminary, representative results.

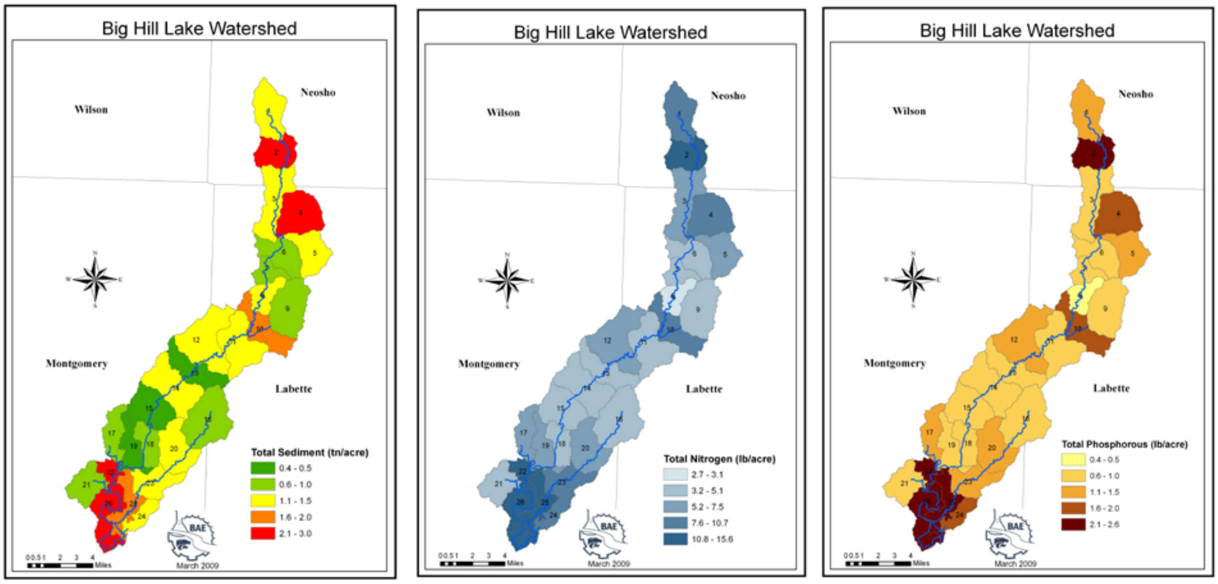


Figure 4: Maps of total sediment, nitrogen, and phosphorous subwatershed loads

Table 3: Total pollutant loads for each subwatershed

SUB	Total Nitrogen (lb/acre)	Total Phosphorous (lb/acre)	Total Sediment (tn/acre)
1	8.28	1.48	1.39
2	11.14	2.19	2.36
3	5.41	0.99	1.22
4	9.15	1.73	2.20
5	6.18	1.07	1.30
6	4.64	0.80	0.80
7	3.74	0.62	0.78
8	2.72	0.45	1.01
9	4.08	0.71	1.00
10	8.59	1.56	1.94
11	4.94	0.85	1.01
12	5.76	1.04	1.22
13	3.64	0.59	0.50
14	4.23	0.66	1.04
15	3.56	0.54	0.39
16	3.37	0.57	0.53
17	6.83	1.07	0.89
18	5.05	0.80	0.63
19	5.20	0.79	0.47
20	6.41	1.06	1.02
21	3.66	0.58	0.81
22	15.62	2.62	2.10
23	7.56	1.28	1.11
24	9.71	1.66	1.38
25	14.24	2.37	1.53
26	13.51	2.23	3.04

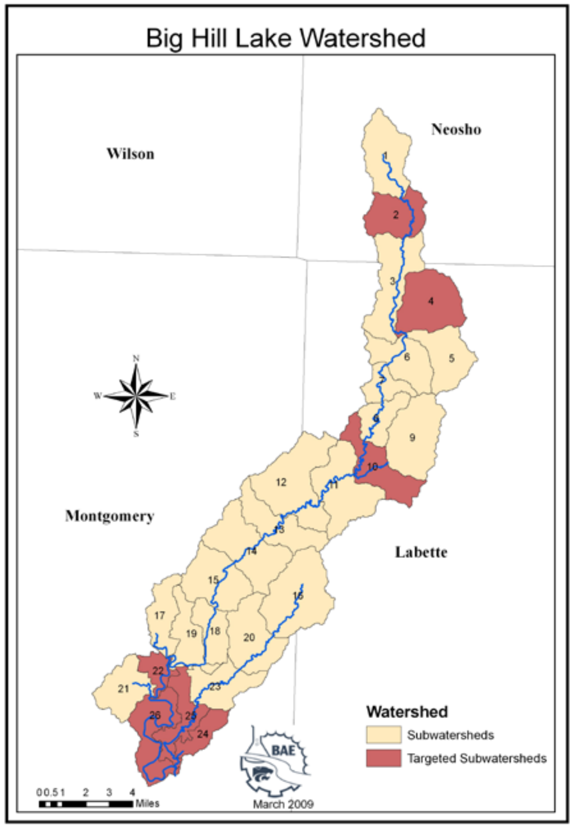


Figure 5: Targeted subwatersheds identified by the SWAT model

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.

Without a Stakeholder Leadership Team, this project was not able to complete the critical stakeholder engagement process needed to make the modeling results truly relevant for the WRAPS planning process.

A future WRAPS project would be needed to work with stakeholders to assure that the watershed model is using appropriate local data and that results address local concerns.

Economic Analysis

General Economic Research

Cost-return budgets have been developed for the Big Hill watershed by working with data from the Kansas Farm Management Association (Tables 4 through 8). The budgets are specific to Big Hill watershed and vary by inputs and yields. Specific BMP budgets have been developed for vegetative buffers, terraces, streambank stabilization, and reduced/no-till.

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.

Table 4: Cost return projection for Corn in the Big Hill watershed.

	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%

Data acquired from: Sarah L. Fogleman and Gary L. Kilgore, Corn Cost-Return Budget in Southeast Kansas, Kansas State University, October 2006.

Table 5: Cost return projection for Soybeans in the Big Hill watershed.

	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%

Data acquired from: Sarah L. Fogleman and Gary L. Kilgore, Soybean Cost-Return Budget in Southeast Kansas, Kansas State University, October 2006.

Table 6: Cost return projection for Wheat in the Big Hill watershed.

	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%

Data acquired from: Sarah L. Fogleman and Gary L. Kilgore, Wheat Cost-Return Budget in Southeast Kansas, Kansas State University, October 2006.

Table 7: Cost return projection for Grain Sorghum in the Big Hill watershed.

	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%

Data acquired from: Sarah L. Fogleman and Gary L. Kilgore, Grain Sorghum Cost-Return Budget in Southeast Kansas, Kansas State University, October 2006.

Table 8: Cost return projection for Alfalfa in the Big Hill watershed.

	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%

Data acquired from: Sarah L. Fogleman and Gary L. Kilgore, Alfalfa Cost-Return Budget in South Central and Southeast Kansas, Kansas State University, October 2006.

Work Products Created (spreadsheet based decision tools)
K-State Watershed Manager Decision-Making Tool 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 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 Big Hill 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-StreambankStabilization Decision-Making 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 (including Big Hill 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 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 Big Hill 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 Big Hill Lake, so this will be the main focus of the economic analysis. The economic impacts and benefits of recreation at Big Hill Lake was be estimated using an input-output impact analysis and non-market valuation techniques.

Big Hill Annual Recreation Benefits *(High Bound)*

Actual Expenditures:

The 2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation conducted by the U.S. Fish and Wildlife Service (USFWS) found that 1,091,000 people in Kansas spent 11,725,000 days and $591,123,000 (2001$) for these activities.

Calculation:

$$\frac{\$591{,}123{,}000}{11{,}725{,}000\,\text{days}} = \$50.42 \rightarrow \textbf{Present Value (2005\$) = \$53.68/user-day}$$

According to the Corps of Engineers, 182,995 user-hours were spent at Big Hill in 2005.

Calculation:

$$\frac{182{,}995\,\text{hrs}}{24\,\text{hrs / day}} = \textbf{7,625 user-days}$$

(7,625 user-days) x ($53.68/user-day) = **<u>$409,310 recreation expenditures</u>**

Consumer Surplus:

Activity	% Participation in Activity [1]	Days spent in Activity	Activity value per day (1996 dollars) [2]	Average Annual Recreation Inflation	Present activity value per day (2005 dollars)	Total value per day
Fish	42.2%	3,218	$39.31	1.58%	$45.27	$145,656
Swim	22.8%	1,739	$25.54	1.58%	$29.41	$51,129
Camp	12.2%	930	$35.86	1.58%	$41.29	$38,413
Motorboat	8.2%	625	$46.40	1.58%	$53.43	$33,408
Picnic	4.7%	358	$44.92	1.58%	$51.73	$18,538
Other	9.9%	755	$31.74	1.58%	$36.55	$27,590
Total	100.0%	7,625				$314,734

[1] Gaunt, Philip M. "Water Recreation Needs Assessment Report to the Kansas Water Office." Wichita State University (2001).

[2] Rosenberger, Randall S. "Benefit Transfer of Outdoor Recreation Use Values." USDA Forest Service (2001). For the *High Bound* estimate, the standard errors were added to the mean of estimates.

Total Annual Recreation Benefits (Actual Expenditures + Consumer Surplus):

Calculation:

<u>Total Annual Recreation Benefits</u> = $409,310 + $314,734 = <u>$724,044/yr *(High Bound)*</u>

Big Hill Annual Recreation Benefits *(Low Bound)*

Actual Expenditures:

The 2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation conducted by the U.S. Fish and Wildlife Service (USFWS) found that 1,091,000 people in Kansas spent 11,725,000 days and $591,123,000 (2001$) for these activities.

Calculation:

$$\frac{\$591{,}123{,}000}{11{,}725{,}000\,\text{days}} = \$50.42 \rightarrow \textbf{Present Value (2005\$) = \$53.68/user-day}$$

According to the Corps of Engineers, 182,995 user-hours were spent at Big Hill in 2005.

Calculation:

$$\frac{182{,}995\,\text{hrs}}{24\,\text{hrs / day}} = \textbf{7,625 user-days}$$

(7,625 user-days) x ($53.68/user-day) = **<u>$409,310 recreation expenditures</u>**

Consumer Surplus:

Activity	% Participation in Activity [1]	Days spent in Activity	Activity value per day (1996 dollars) [2]	Average Annual Recreation Inflation	Present activity value per day (2005 dollars)	Total value per day
Fish	42.2%	3,218	$32.47	1.58%	$37.39	$120,312
Swim	22.8%	1,739	$16.62	1.58%	$19.14	$33,272
Camp	12.2%	930	$24.86	1.58%	$28.63	$26,630
Motorboat	8.2%	625	$23.10	1.58%	$26.60	$16,632
Picnic	4.7%	358	$25.60	1.58%	$29.48	$10,565
Other	9.9%	755	$16.78	1.58%	$19.32	$14,586
Total	100.0%	7,625				**$221,997**

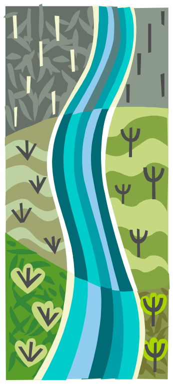
[1] Gaunt, Philip M. "Water Recreation Needs Assessment Report to the Kansas Water Office." Wichita State University (2001).

[2] Rosenberger, Randall S. "Benefit Transfer of Outdoor Recreation Use Values." USDA Forest Service (2001). For the *Low Bound* estimate, the standard errors were subtracted from the mean of estimates.

Total Annual Recreation Benefits (Actual Expenditures + Consumer Surplus):

Calculation:

<u>Total Annual Recreation Benefits</u> = $409,310 + $221,997 = <u>$631,307/yr *(Low Bound)*</u>



Next Steps / Transition into Planning Phase

This WRAPS Assessment Phase project is about 60% complete. The remaining portion of the project will require engagement with the Stakeholder Leadership Team.

A key step is to use the assessment information (as revised through collaboration with the Stakeholder Leadership Team) to refine the watershed model. The revised model would then be used to define critical areas, quantify the impacts of potential BMPs on pollutant loads to the streams, 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.

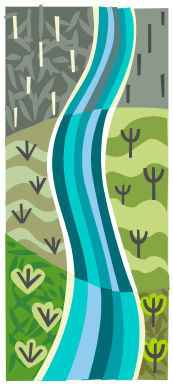
Because a Stakeholder Leadership Team was not successfully established for the Big Hill watershed during the WRAPS Development Phase project, this Assessment Phase project did not accomplish all of its objectives. Nonetheless, many objectives toward the project goal were achieved:

- Compiled an inventory of existing information and reports related to Big Hill watershed.
- 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.
- Set up and completed detailed SWAT modeling analysis of baseline watershed conditions.
- 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.
- Completed an analysis of recreational benefits of Big Hill Lake.

The following objectives were note achieved, and will require engagement of the Stakeholder Leadership Team so that the resulting information is relevant and applicable to the WRAPS planning process.

- The Stakeholder Leadership Team must clarify WRAPS objectives and assessment needs (an outcome of a successful Development Phase project).
- The Stakeholder Leadership Team must identify informational and data gaps needed to address their objectives and assessment needs.
- Baseline watershed assessment data must be refined using local data in collaboration with the Stakeholder Leadership Team.
- The watershed model must be revised to reflect the refined watershed data.
- The watershed model must be used to assess watershed responses to various management scenarios.
- Watershed model and economic results must be communicated to the Stakeholder Leadership Team.

We have made substantial progress toward accomplishing the project goals. Once a Stakeholder Leadership Team is established, the results of this project will allow rapid progress toward completion of a WRAPS Report.



Conclusions, Recommendations, and Lessons Learned

Conclusions

A solid foundation of watershed assessment information was prepared by this project. From their experience with other successful WRAPS Assessment Phase projects in other watersheds, the project team has a clear understanding of the typical steps remaining to complete the assessment project. It is clear that further progress toward completion of a successful Assessment project, and ultimately a WRAPS Plan and Report, will require establishment of an engaged Stakeholder Leadership Team.

Lessons Learned

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

- Although a WRAPS Assessment Phase project can and should (for timely progress of the overall WRAPS process) begin before the completion of a WRAPS Development Phase project, it cannot be completed until the Stakeholder Leadership Team (that results from the Development project) is in place and fully engaged in the assessment process.
- 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.

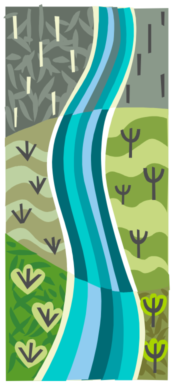
Watershed modeling remains highly sophisticated.

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. Amer. Water Resources Assoc. 34(1): 73-89.

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

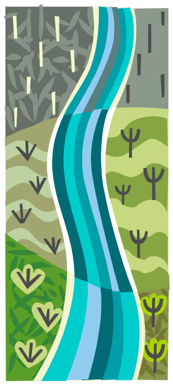
KDHE. 2009. Watershed planning section: TMDLs. Topeka, Kansas: Kansas Department of Health and Environment. <www.kdheks.gov/tmdl>

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.

Nejadhashemi, A.P., R.K. Gali, C.M. Smith, K.R. Mankin, R.M. Wilson, S.P. Brown, and J.C. Leatherman. 2009. Oologah Watershed Assessment: Preliminary Report. Kansas State Research and Extension Publication #EP-136. 58 pages. <www.ksre.ksu.edu/library/h20ql2/EP136.pdf>

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



Appendix A

Watershed Atlas

Nejadhashemi, A.P., R.K. Gali, C.M. Smith, K.R. Mankin, R.M. Wilson, S.P. Brown, and J.C. Leatherman. 2009. Oologah Watershed Assessment: Preliminary Report. Kansas State Research and Extension Publication #EP-136. 58 pages. http://www.ksre.ksu.edu/library/h20ql2/EP136.pdf

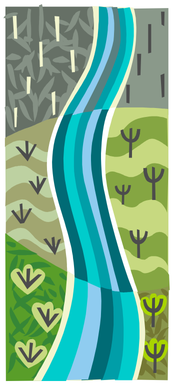
Appendix B

TMDLs

Verdigris Basin TMDL. Waterbody: Big Hill Lake. Water Quality Impairment: Eutrophication. < http://www.kdheks.gov/tmdl/ve/Big_Hll_Lake_TMDL.pdf >

Verdigris Basin TMDL. Waterbody: Big Hill Creek. Water Quality Impairment: Dissolved Oxygen. < http://www.kdheks.gov/tmdl/ve/BigHillCr_DO.pdf >

Verdigris Basin TMDL. Waterbody: Big Hill Creek. Water Quality Impairment: Fecal Coliform Bacteria. < http://www.kdheks.gov/tmdl/ve/BigHillCr_FCB.pdf >



Appendix C

Financial Summary

Category	Budget	Actual	Match	Total
Salaries	24,409.00	19,221.61	5,389.00	24,610.61
Fringe Benefits	4,909.00	3,204.68	1,990.00	5,194.68
Travel	1,750.00	5,248.11	1,698.85	6,946.96
Supplies	3,000.00	791.40	-	791.40
Contractual Services	-	-	-	-
Other	6,932.00	12,534.20	2,800.00	15,334.20
Project Indirect Costs	-	-	-	-
Waived Indirect Costs	-	-	14,965.00	14,965.00
Total	41,000.00	41,000.00	26,842.85	67,842.85