KANSAS WATERSHED RESTORATION AND PROTECTION STRATEGY (WRAPS) PROJECT

COTTONWOOD WATERSHED ASSESSMENT

FINAL REPORT

KDHE Project No. 2007-0028

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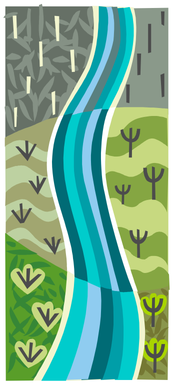


Introduction

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 Cottonwood 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 Cottonwood River were assessed based on stream bank erosion study conducted by the Kansas Water Office and 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.

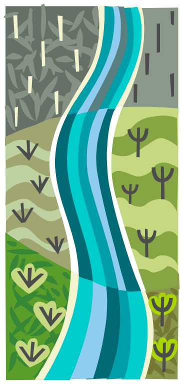
Provide Technical Information to Support Implementation Decisions

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:

Upper and Lower Cottonwood and Neosho Headwaters Watersheds Assessment – Preliminary Report. K-State Research & Extension Publication #EP-137. 72 pages.
http://www.ksre.ksu.edu/library/h20ql2/EP137.pdf

This publication included the following topics:



Acknowledgments

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) – Elk City Lake Watershed Assessment project (2007-0061).

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
- Rohith Gali, Graduate Student, Watershed Modeler
- Josh Roe, Watershed Economist
- 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

TMDLs in the Watershed

A Total Maximum Daily Load (TMDL) designation sets the maximum amount of pollutant that a specific body of water can receive without violating the surface water-quality standards, resulting in failure to support their designated uses. TMDLs provide a tool to target and reduce point and nonpoint pollution sources. TMDLs established by Kansas may be done on a watershed basis and may use a pollutant-by-pollutant approach or a biomonitoring approach or both as appropriate. TMDL establishment means a draft TMDL has been completed, Watershed Review there has been public notice and comment on the TMDL, there has been consideration of the public comment, any necessary revisions to the TMDL have been made, and the TMDL has been submitted to EPA for approval. The desired outcome of the TMDL process is indicated, using the current situation as the baseline. Deviations from the water quality standards will be documented. The TMDL will state its objective in meeting the appropriate water quality standard by quantifying the degree of pollution reduction expected over time. Interim objectives will also be defined for midpoints in the implementation process. In summary, TMDLs provide a tool to target and reduce point and nonpoint pollution sources. The goal of the WRAPS process is to address high priority TMDLs.

Pollutants are assigned “categories” depending on stage of TMDL development:

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

TMDLs in the watershed are listed in the table below.

Table 7. TMDLs in the Cottonwood Watershed

Waterbody	Impairment	Priority	Station	Approval Status
Subbasin: Upper Cottonwood (HUC 11070202)				
COTTONWOOD RIVER,SOUTH	FCB	Medium	SC635	12/13/2002
DOYLE CREEK	NH3	Cat 3	NPDES Permit	12/18/08, Further Evaluate in 2012
DOYLE CREEK	FCB	Cat 3	NPDES Permit	12/18/08, Further Evaluate in 2012
DOYLE CREEK	DO	Cat 3	NPDES Permit	12/18/08, Further Evaluate in 2012
FRENCH CREEK	DO	Medium	SC676	12/13/2002
MUD CREEK	FCB	High	SC691	12/13/2002
NORTH COTTONWOOD RIVER	Cu	Low	SC636	2/25/2005
SOUTH COTTONWOOD RIVER	Hg	Cat 2	SC635	Delisted 8/12/2010
COTTONWOOD RIVER	FCB	Medium	SC625, SC627	12/13/2002

COTTONWOOD RIVER (SO4)	SO4	Low	SC635, SC676, SC690, SC627	12/13/2002
Subbasin: Lower Cottonwood (HUC 11070203)				
COTTONWOOD RIVER (Chl)	Chl	Cat 2	SC120	Delisted 8/12/2010
COTTONWOOD RIVER	FCB	Cat 3	NPDES Permit	12/18/08, Further Evaluate in 2012
FOX CREEK	Bio	Medium	SB718,SC718	1/6/2005
SOUTH FORK COTTONWOOD R	Bio	Medium	SB357,SC582	1/6/2005
Subbasin: Upper Cottonwood (HUC 11070202)				
MARION CO LAKE	DO	Medium	LM012101	9/30/2002
MARION CO LAKE	EU	Medium	LM012101	9/30/2002
MARION LAKE	EU	High	LM020001	9/30/2009

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

Input data and their online sources were:

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

Delineation

Cottonwood River with its tributaries is the primary waterway of Cottonwood Watershed. The Cottonwood River drainage area includes the area that drains the Cottonwood River and its tributaries from the dam at Marion Lake to the confluence of the Cottonwood and Neosho Rivers.

The Cottonwood Watershed WRAPS project is composed of two HUC8s (meaning an 8 digit identifier code): the Upper Cottonwood and the Lower Cottonwood. The Upper Cottonwood HUC-8 number is 11070202 and the Lower Cottonwood HUC number is 11070203. Thirty six sub-watershed creeks based on HUC 12 delineation are shown in Figure 1.

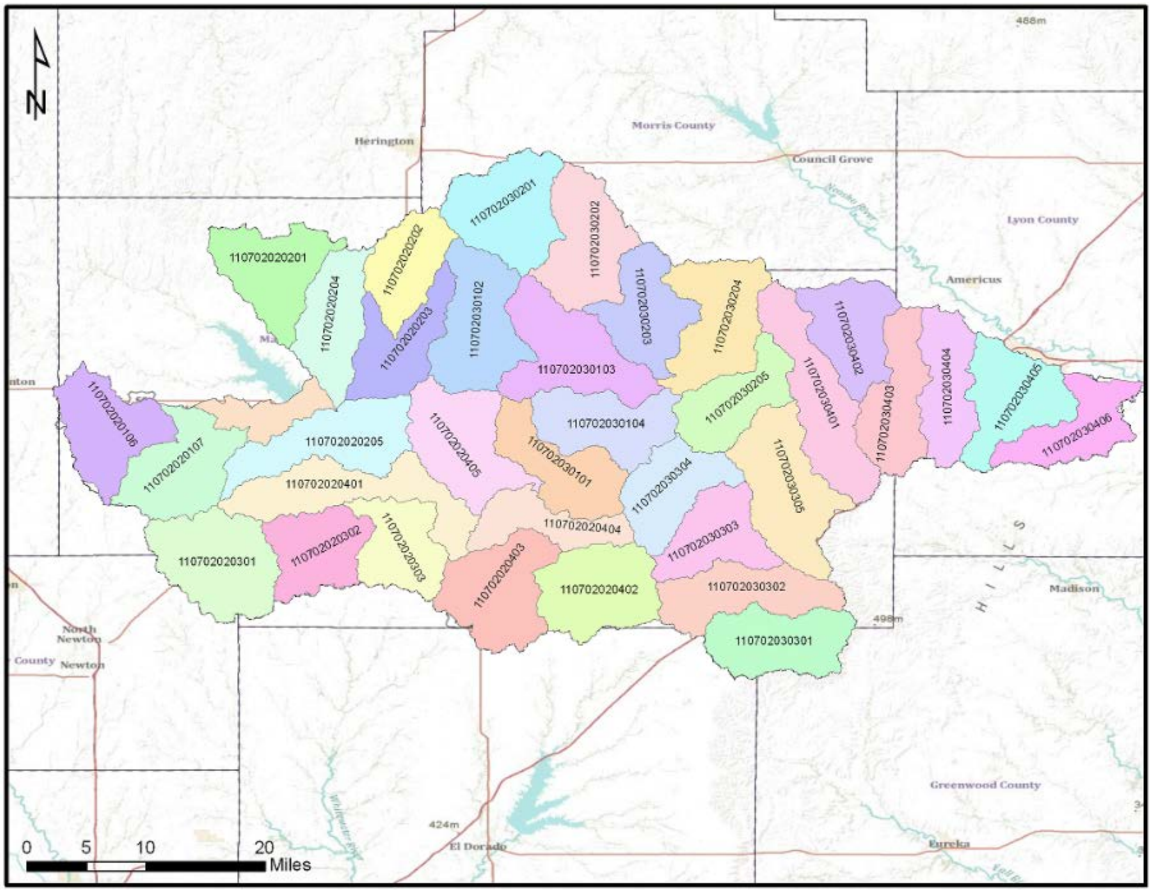


Figure 1. HUC 12 Delineations of Cottonwood Watershed

Topography

The digital elevation map (DEM) for the basin was downloaded from the USGS National Elevation Dataset (NED). Elevations varied from 321 m to 505 m above the sea level (see Figure 2).

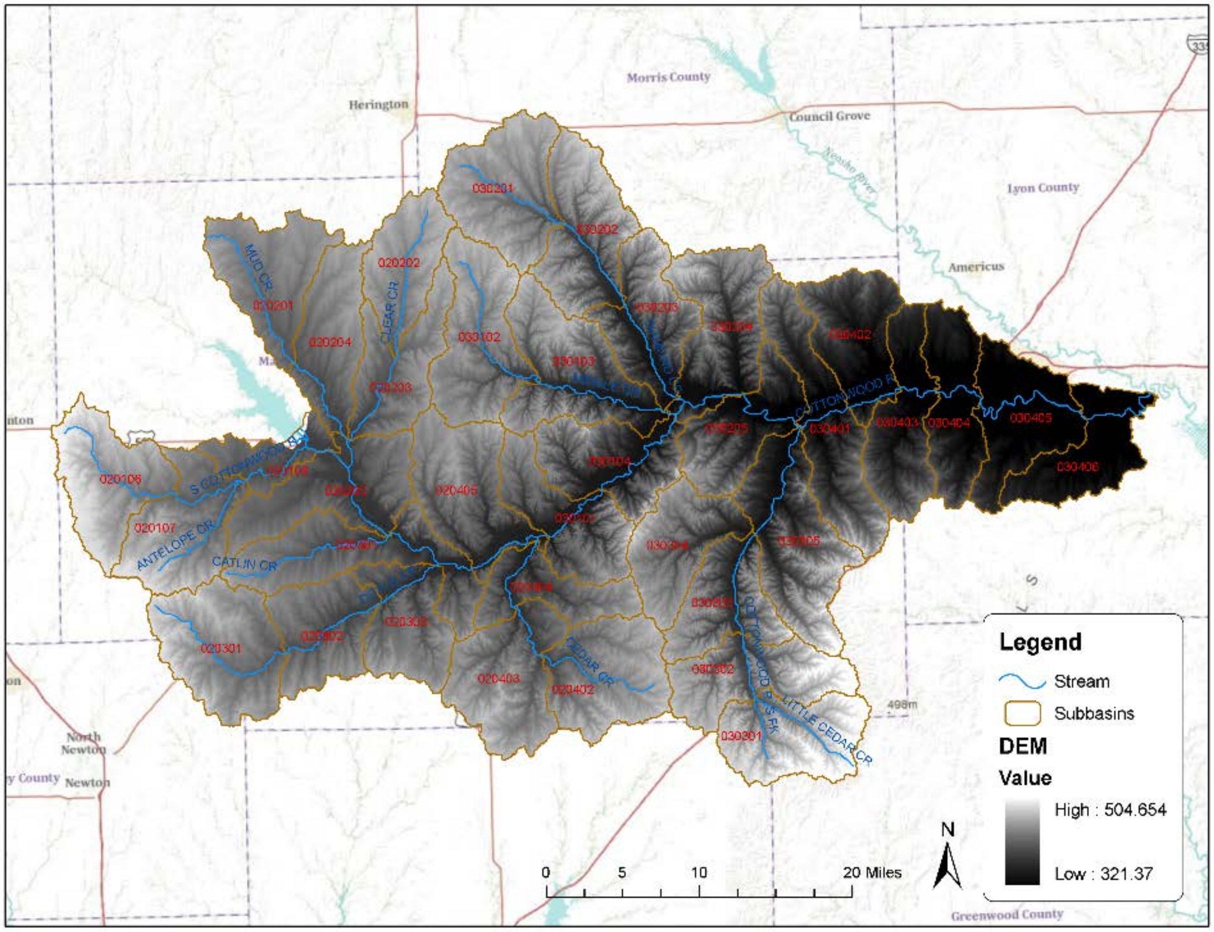


Figure 2. Topography map. Subbasins are labeled by the last 6 digits of the corresponding HUC 12 number.

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 3 and summarized in Table 1 for Cottonwood watershed.

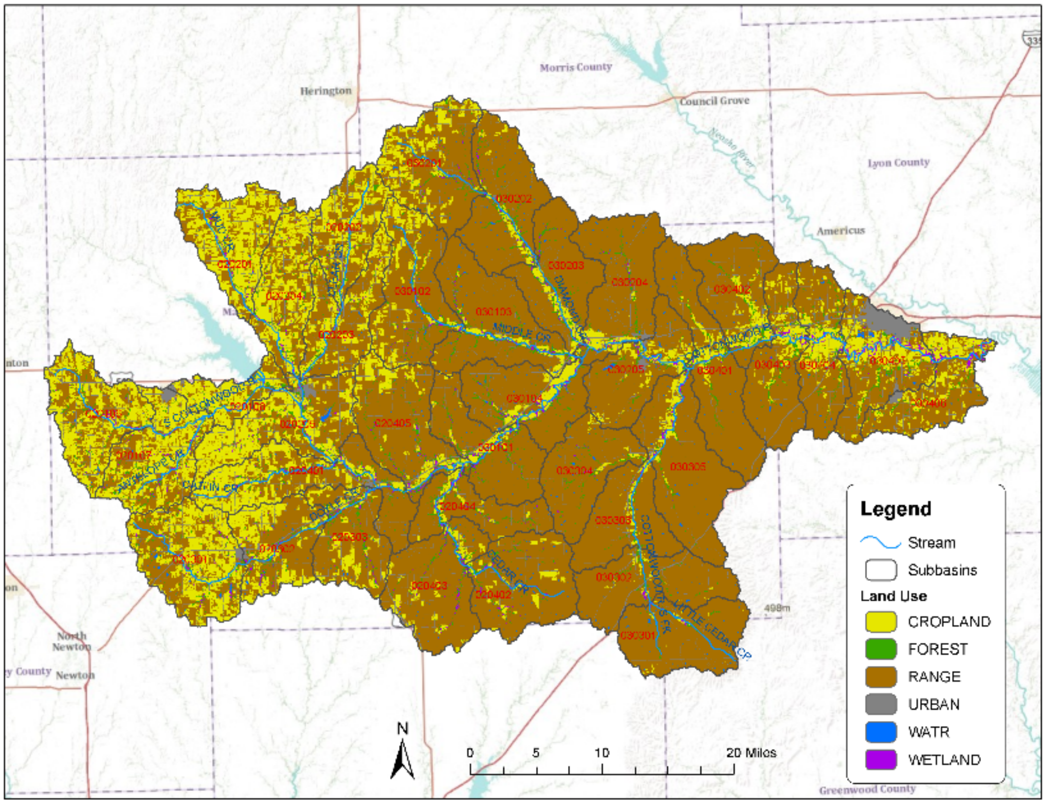


Figure 3. Land use map utilized in the SWAT model. Subbasins are labeled by the last 6 digits of the corresponding HUC 12 number.

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

Land Use	Area, ha	Area, sqmi	%
Water	2691.72	10.39	0.61
Residential-Low Density	13878.63	53.59	3.16
Residential-Low Density	3845.25	14.85	0.87
Residential-Medium Density	989.37	3.82	0.23
Residential-High Density	266.22	1.03	0.06
Rangeland	91.71	0.35	0.02
Forest-Deciduous	13179.33	50.89	3.00
Forest-Mixed	267.66	1.03	0.07
Range-Brush	32.31	0.12	0.01
Range-Grasses	283030.74	1092.79	64.40
Hay	20443.77	78.93	4.65
Agricultural Land-Row Crops	96237.90	371.58	21.90
Wetlands-Forested	4386.42	16.94	1.00
Wetlands-Non-Forested	135.54	0.52	0.03
Total	**439476.57**	**1696.83**	**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 4 and Table 2 show 15 soils, their distribution and characteristics in the watershed.

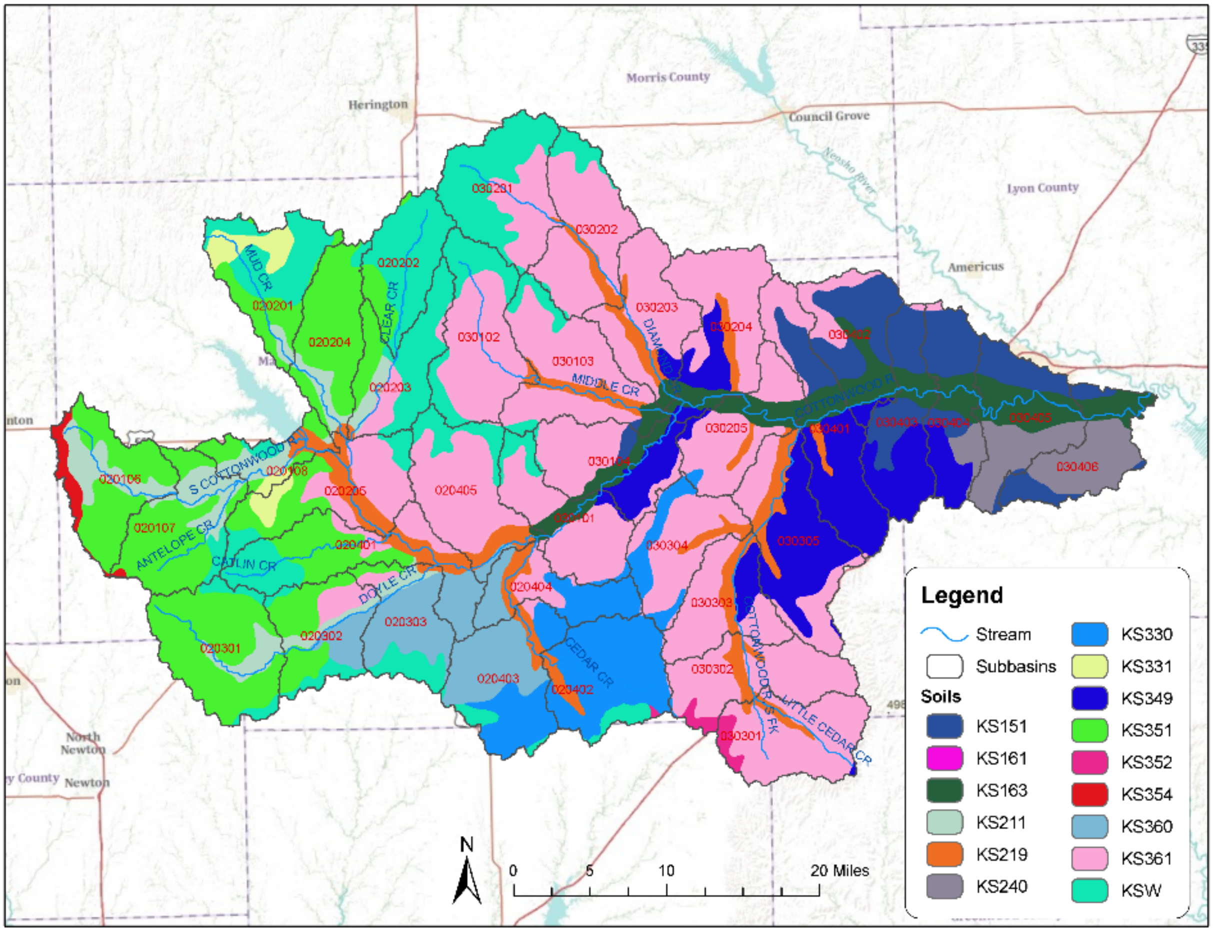


Figure 4. Soil map used in the SWAT model

Table 2. Soil characteristics used in the SWAT model

Soil	Area, ha	Area, sqmi	%
KS351	61097.67	235.90	13.90
KS151	23575.68	91.03	5.36
KS161	17.19	0.07	0.00
KS219	23152.05	89.39	5.27
KSW	52764.66	203.73	12.01
KS211	14998.14	57.91	3.41
KS361	145792.08	562.91	33.17
KS349	34044.57	131.45	7.75

KS354	1660.23	6.41	0.38
KS163	21451.23	82.82	4.88
KS331	3963.87	15.30	0.90
KS330	23755.95	91.72	5.41
KS352	1640.61	6.33	0.37
KS360	19323.00	74.61	4.40
KS240	12239.64	47.26	2.79
Total	**439476.57**	**1696.83**	**100**

Other inputs

Weather data was collected and downloaded from NOAA National Climatic Data Center (NCDC, 2009). There are total 21 weather stations around the watershed; 19 stations with precipitation data and 12 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 was conducted in targeted areas in Marion and Lyon counties (Figure 5) and 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:

Marion County

- Conservation Crop Rotation – current adoption rate not able to determine

- Grassed waterways – current adoption rate of 38 percent
- No-till cultivation – current adoption rate of 29 percent
- Vegetative buffer strips – current adoption rate of 0 percent
- Grassed terraces – current adoption rate of 25 percent
- Permanent vegetation – current adoption rate of 9 percent

Lyon County

- Conservation Crop Rotation – current adoption rate not able to determine
- No-till cultivation – current adoption rate of 8 percent
- Vegetative buffer strips – current adoption rate of 0 percent
- Permanent vegetation – current adoption rate of 0 percent

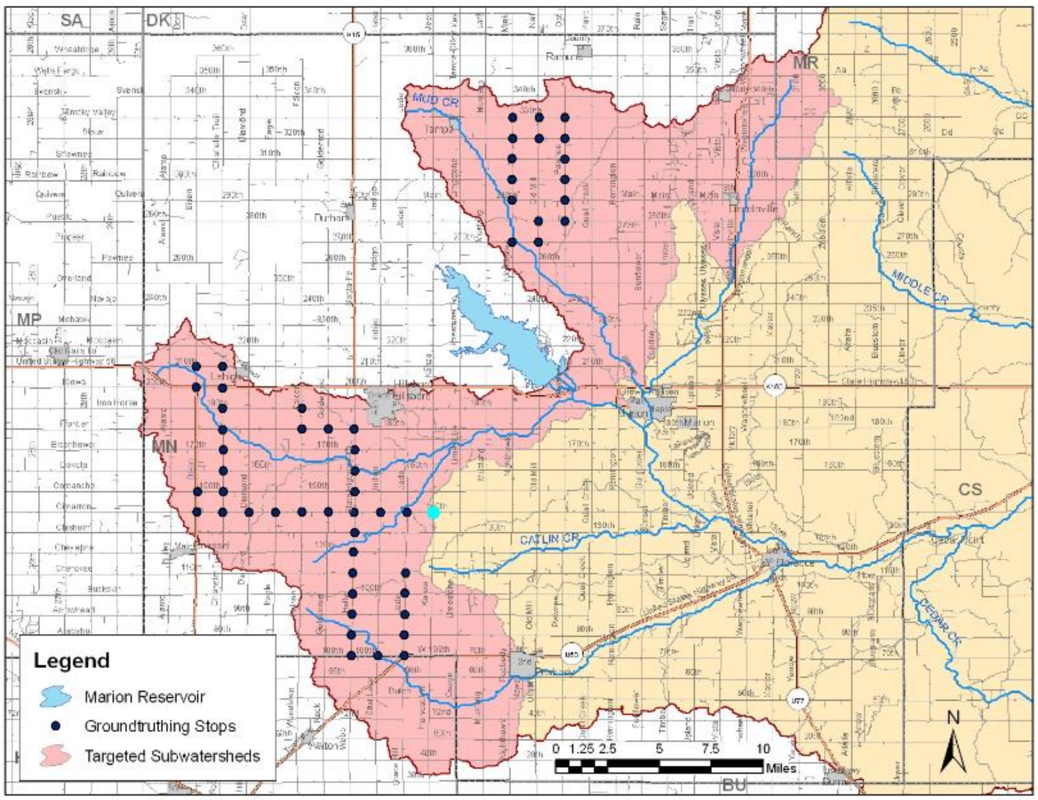
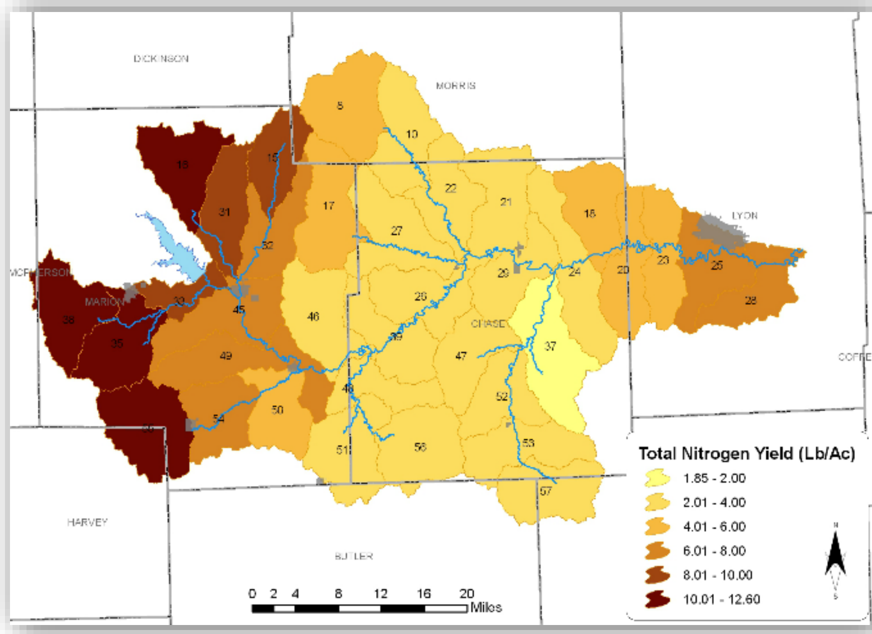
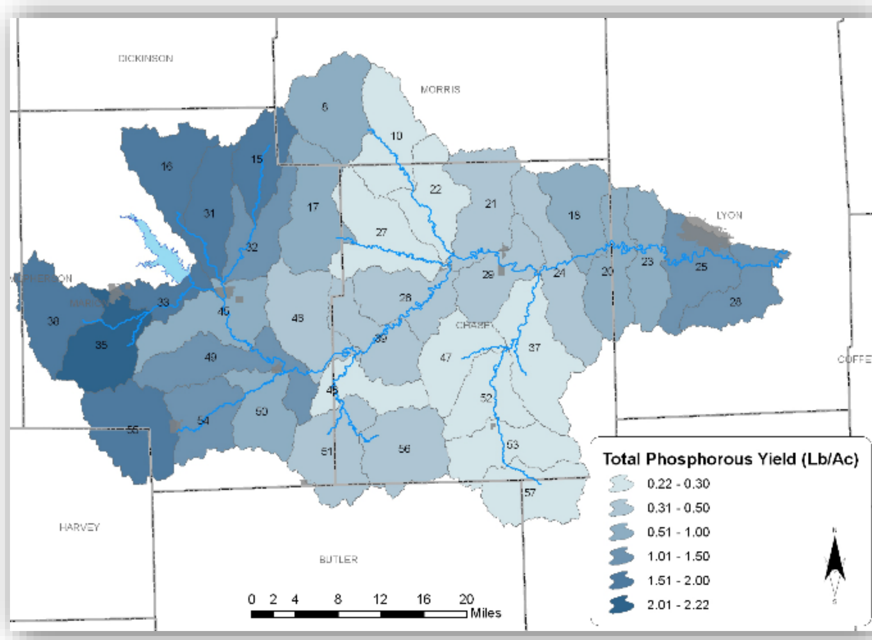


Figure 5. Groundtruthing spots in the Cottonwood Watershed.

This allows the SWAT model to develop a more accurate determination of appropriate targeted areas. The SWAT model then determined number of acres needed to be implemented for each BMP. The maps produced by the modeling are displayed below. It is noted that the areas are characterized by low, medium, medium-high and high. The subwatersheds at the western and eastern ends 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.


DICKINSON
MORRIS
LYON
MARION
CHASE
COFFEY
HARVEY
BUTLER
Total Nitrogen Yield (Lb/Ac)
1.85 - 2.00
2.01 - 4.00
4.01 - 6.00
6.01 - 8.00
8.01 - 10.00
10.01 - 12.60
0 2 4 8 12 16 20 Miles


DICKINSON
MORRIS
LYON
CHASE
COFFEY
HARVEY
BUTLER
Total Phosphorous Yield (Lb/Ac)
0.22 - 0.30
0.31 - 0.50
0.51 - 1.00
1.01 - 1.50
1.51 - 2.00
2.01 - 2.22
0 2 4 8 12 16 20 Miles

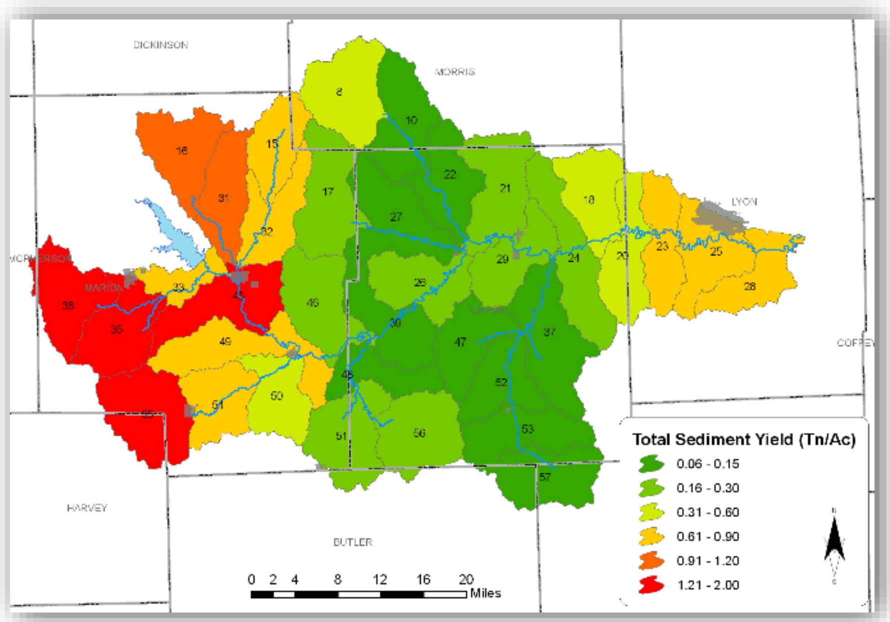


Figure 6. Maps of (a) total phosphorous, (b) nitrogen, and (c) sediment yields in 36 subbasins

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 6 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 3. Subwatersheds 15, 16, 31, 33, 35, 38, 55 (western end) and 25, 28 (eastern end) 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 3 Total pollutant loads for each subwatershed

Subbasin	HUC-12 Last 5 Digits	Total Nitrogen Yield (lb/ac)	Total Phosphorous Yield (lb/ac)	Total Sediment Yield (tn/ac)
8	30201	5.94	0.92	0.48
10	30202	2.53	0.26	0.09
15	20202	8.95	1.51	0.86
16	20201	11.49	1.96	1.08
17	30102	4.95	0.65	0.29
18	30402	4.12	0.62	0.43
20	30403	4.01	0.65	0.52

21	30401	2.72	0.35	0.16
22	30203	2.46	0.26	0.09
23	30404	5.22	0.87	0.70
24	30401	2.56	0.38	0.24
25	30405	6.05	1.03	0.71
26	30104	3.21	0.43	0.23
27	30103	2.35	0.25	0.09
28	30406	6.88	1.15	0.83
29	30205	3.10	0.40	0.16
31	20204	9.82	1.68	0.96
32	20203	6.99	1.13	0.62
33	20108	9.17	1.60	0.89
35	20107	12.60	2.22	1.63
37	30305	1.85	0.24	0.10
38	20106	10.66	1.77	1.42
39	30101	2.88	0.34	0.14
44	20205	7.88	1.21	0.61
46	20405	3.73	0.47	0.20
47	30304	2.12	0.22	0.06
48	20404	2.20	0.28	0.11
49	20401	7.31	1.19	0.65
50	20303	4.46	0.70	0.35
51	20403	2.91	0.43	0.19
52	30303	2.37	0.26	0.11
53	30302	2.46	0.24	0.09
54	20302	7.59	1.25	0.71
55	20301	11.04	1.92	1.30
56	20402	2.68	0.40	0.19
57	30301	2.45	0.24	0.08

Stream Bank Area Assessment

Kansas Water Office provided the Kansas State University watershed management team with the soil volume losses from stream bank erosion along the Neosho River, the Cottonwood River, and primary tributaries. The surficial change between the streambank location in 1991 to the 2006 or 2008 multiplied by the estimated bank heights provided an estimate of the soil volume loss from stream banks for that period. All hotspots are shown in Figure 7, while 19 main segments were identified along the Neosho River (9 spots) and Cottonwood River (10 spots) (see Figure 8). All hotspots are located above the inlet of John Redmond reservoir. The detailed information about each segment with the number of hotspots, stream bank length and erosion losses are provided in Table 4.

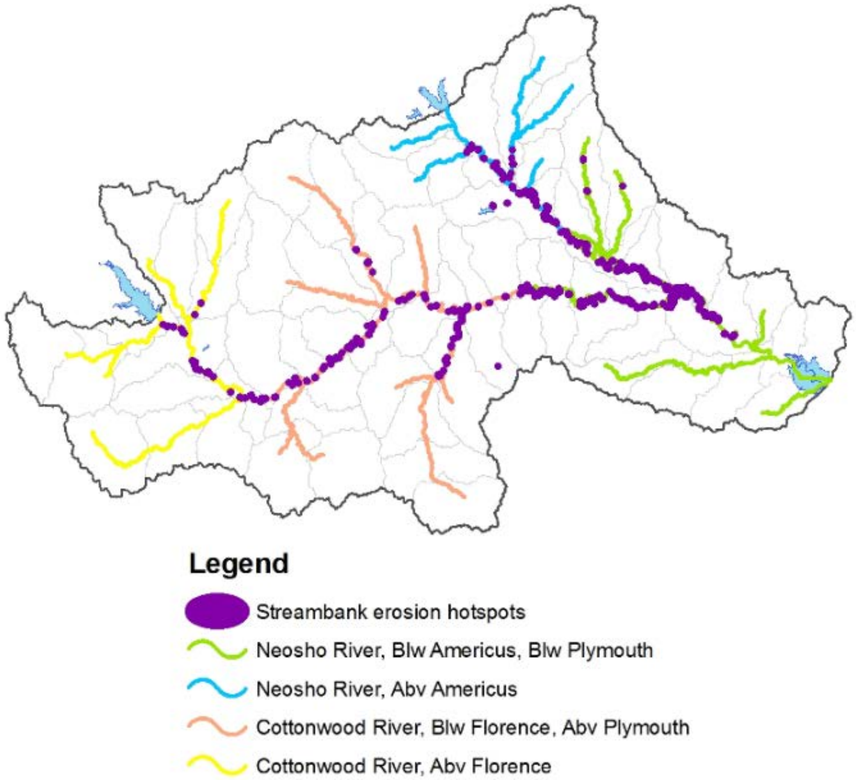


Figure 7. Streambank erosion hotspots along Neosho and Cottonwood Rivers and main tributaries

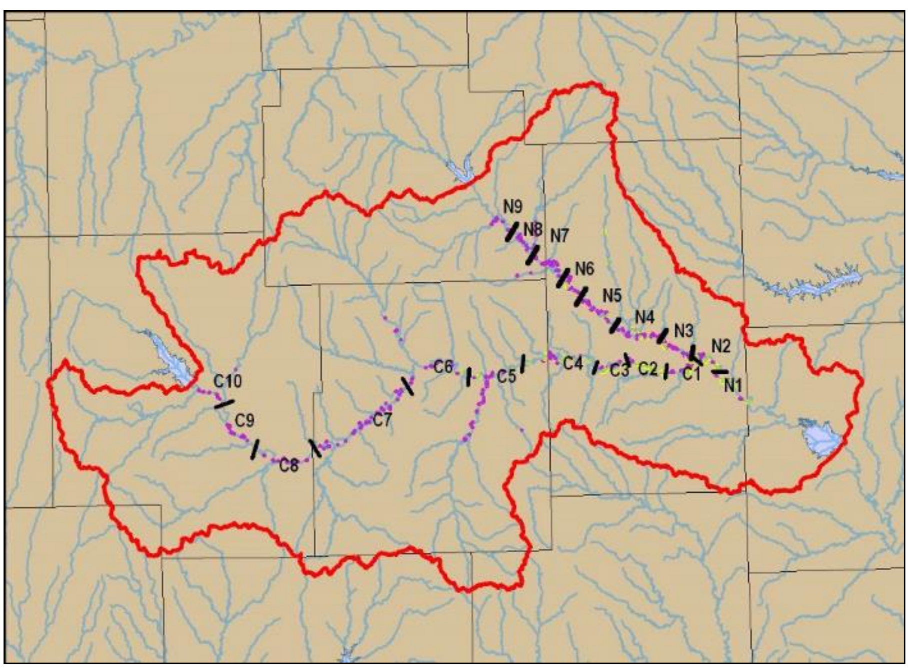


Figure 8. Stream bank erosion hotspots divided into river segments.

Table 4. Soil losses and main characteristics of streambank erosion hotspots along the Cottonwood River.

Reach	Number of hotspots	Total Erosion (tons/year)	Total Length (feet/year)	Tons of Sediment /Foot/Year
C1	18	26,541	9,402	2.82
C2	16	31,977	12,311	2.6
C3	22	13,918	8,014	1.74
C4	27	26,341	13,468	1.96
C5	10	7,095	4,916	1.44
C6	12	5,064	3,302	1.53
C7	32	17,652	10,503	1.68
C8	14	10,303	5,179	1.99
C9	11	11,591	4,253	2.73
C10	7	4,948	2,335	2.12
Total	**169**	**155,429**	**73,683**	

Critical Targeted Areas

The pollutant yields maps produced by the modeling are displayed in Figure 5. As stated earlier, this model accounts for land use, soil type, slope, and current conservation practices. 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, stream bank and TMDL targeted areas are displayed below. An identification of rangeland and livestock critical areas was conducted by the SLT, and locations of the stream bank critical areas were developed by Kansas Water Office. Map of all targeted areas and TMDL streams is shown in Figure 9.

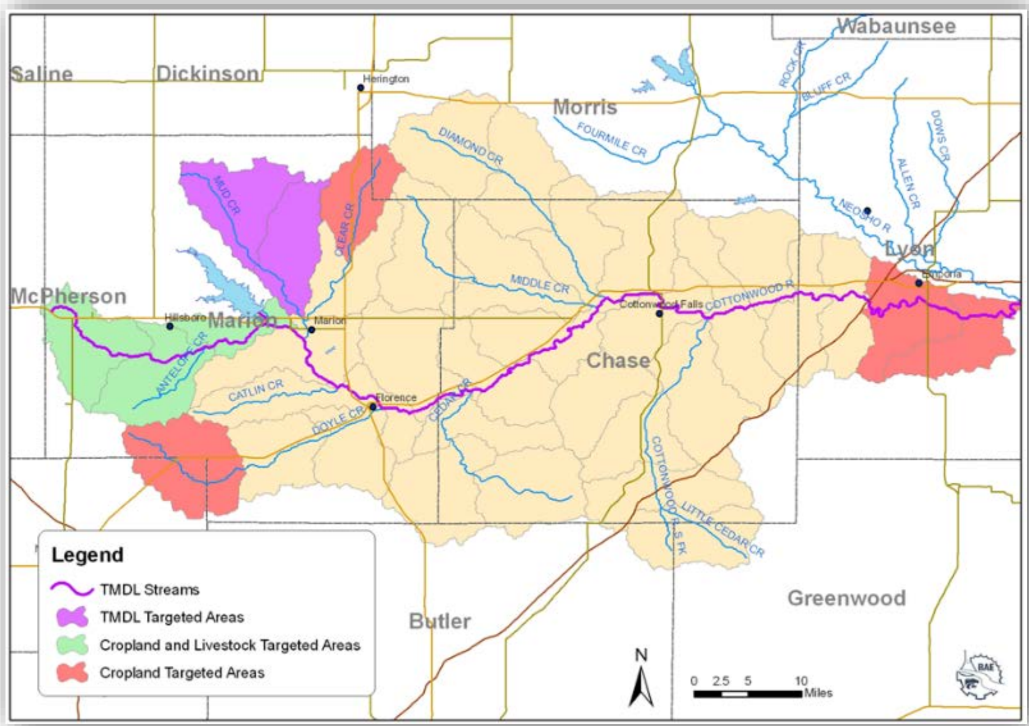


Figure 9. Critical targeted subwatersheds and TMDL streams

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 South Cottonwood River, Mud Creek, Clear Creek, and Doyle Creek at the Western part of the watershed, and Upper End of the Cottonwood River at the Eastern part of the watershed. The targeted areas contain the following HUC-12 numbers:

- 110702020106
- 110702020107
- 110702020108
- 110702020201
- 110702020202
- 110702020204
- 110702020301
- 110702030405
- 110702030406

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 encompass Mud Creek and South Cottonwood River and contain the following HUC-12 numbers:

- 110702020106
- 110702020107
- 110702020108
- 110702020201
- 110702020204

Stream bank Erosion

A study funded by the Kansas Water Office was conducted to determine the reaches of the Cottonwood River that need riparian and streambank stabilization. This assessment along the main channel of the Cottonwood River determined the targeted area for streambank restoration. The Cottonwood River was divided into ten “reach” areas which each contain numerous sites of degradable stream banks. Cottonwood River segments are labeled as C1 through C10 (Figure 7). It has been decided that the restoration projects will begin with Reach C1 and all streambank projects will be completed in this Reach Area before new projects are begun in the subsequent Reach Areas.

High Priority TMDL Targeted Area

The High Priority TMDL Targeted Area is driven from a high priority TMDL in the watershed. Mud Creek has a high priority TMDL for FCB. The BMPs that will be implemented for the High Priority Targeted Area are contained in the Livestock Targeted Area BMPs. This is due to geographic overlap of the two targeted areas. The high priority TMDL area is delineated into two subbasins. The HUC 12s that are included in these subbasins are:

- 110702020201
- 110702020204

Stakeholder engagement

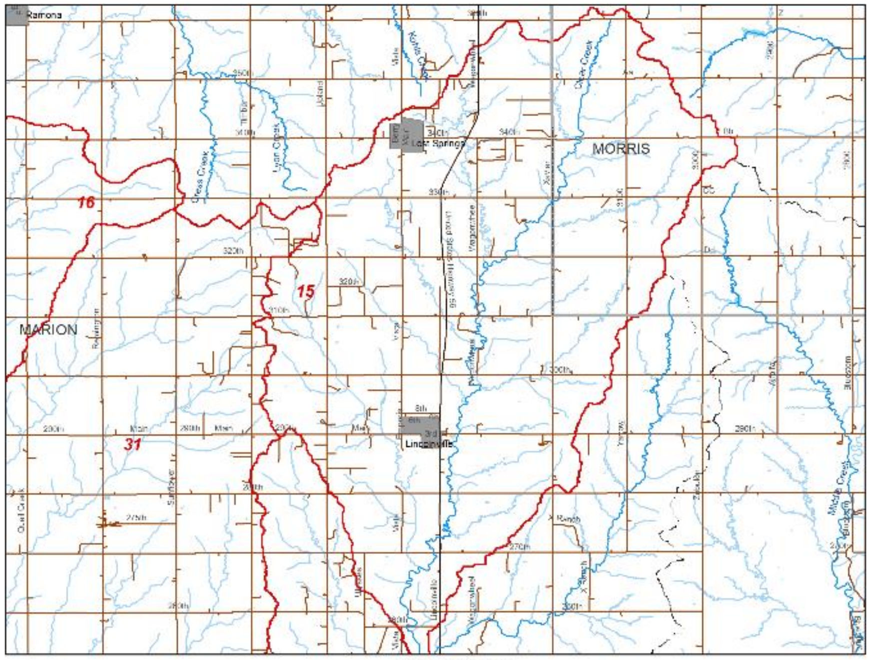
A critical element of the WRAPS watershed modeling process is to engage stakeholders in the collection and verification of watershed data (Mankin, 2008). This process assures that we are modeling “their watershed” using the best local data available. Over a period of several meetings, the watershed modeler 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.

Work Products

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

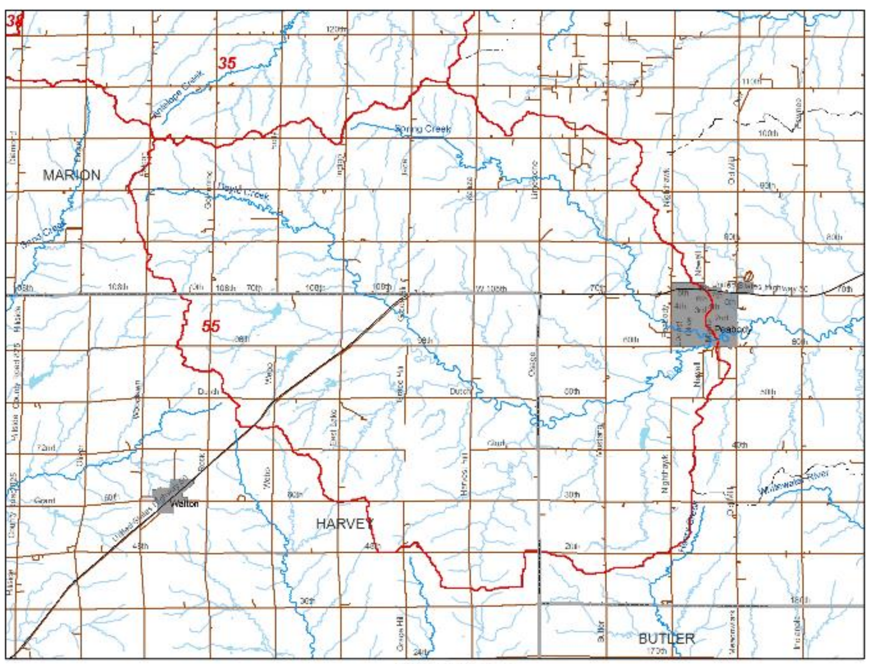
Maps of Clear Creek, Doyle Creek, Mud Creek, South Cottonwood River areas, and areas near Emporia City that assisted in groundtruthing efforts are shown in Figure 10. Results of baseline assessment of the watershed erosion conditions are presented in Figure 11.



Targeted Subbasins

Marion County
Clear Creek Subwatershed

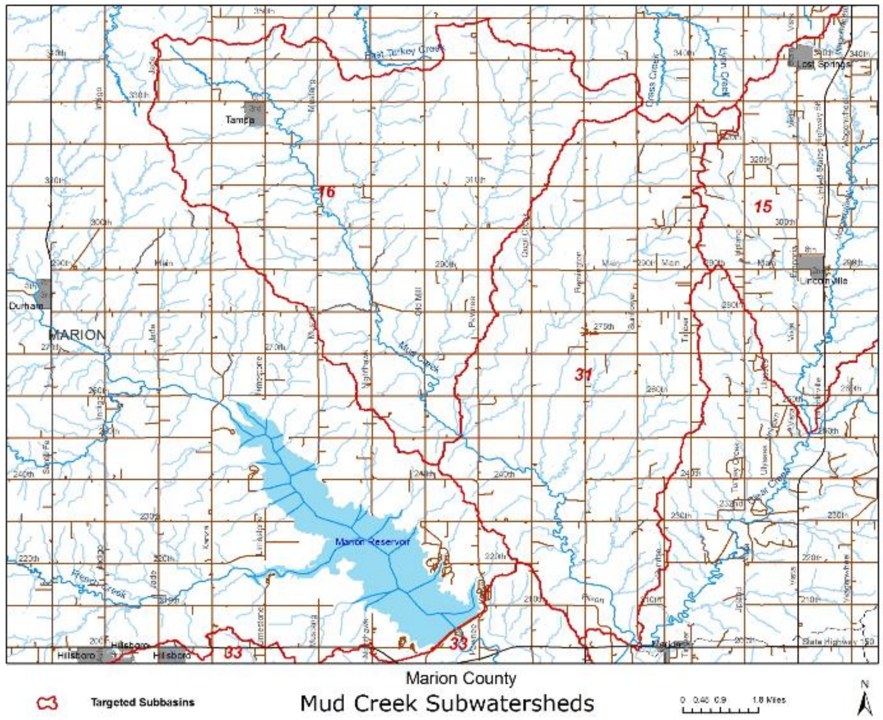
0 0.5 1 2 Miles

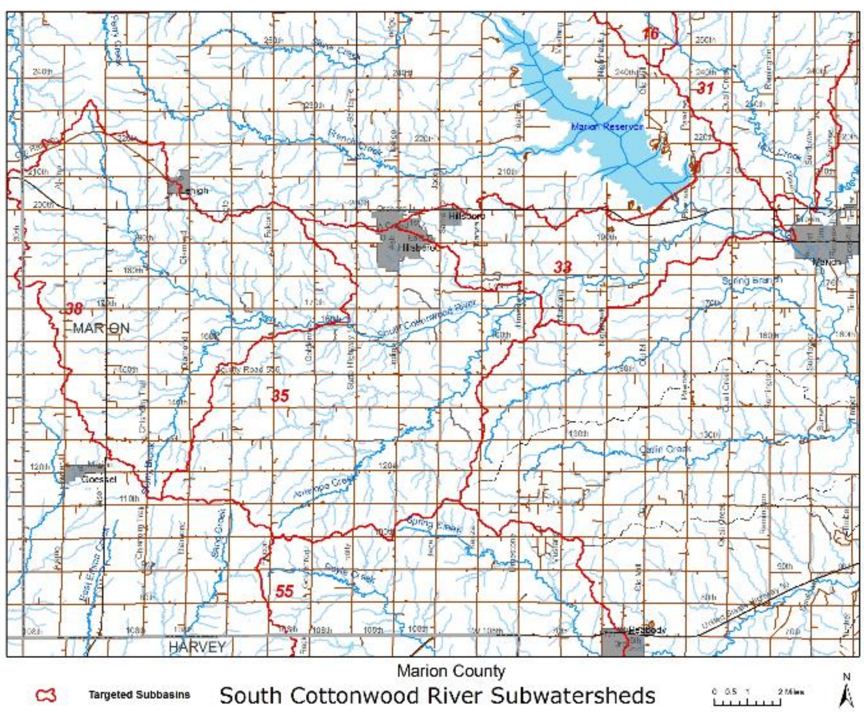


Targeted Subbasins

Marion County
Doyle Creek Subwatershed

0 0.5 1 2 Miles


Marion County
Targeted Subbasins
Mud Creek Subwatersheds
Marion Reservoir
Mud Creek
Tampa
Lost Springs
Lincolnville
Durham
MARION
Hillsboro
16
15
31
33


Marion County
Targeted Subbasins
South Cottonwood River Subwatersheds
Marion Reservoir
South Cottonwood River
Lehigh
Hillsboro
Marion
Goessel
Peabody
MARION
HARVEY
16
31
33
38
35
55

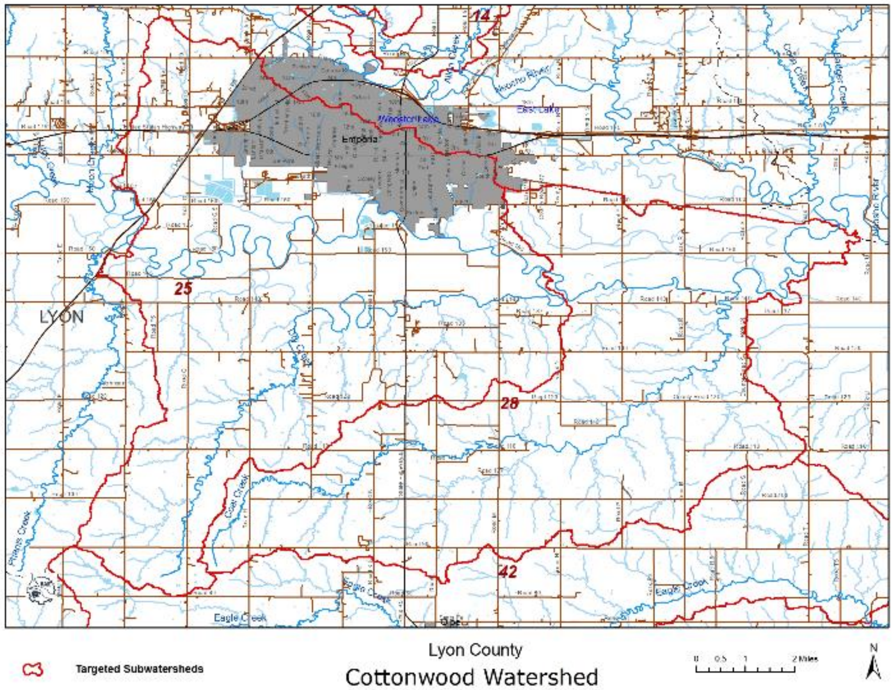


Figure 10. Maps of various groundtruthing areas.

Upper and Lower Cottonwood Watershed
(Results generated by the L-THIA Model)

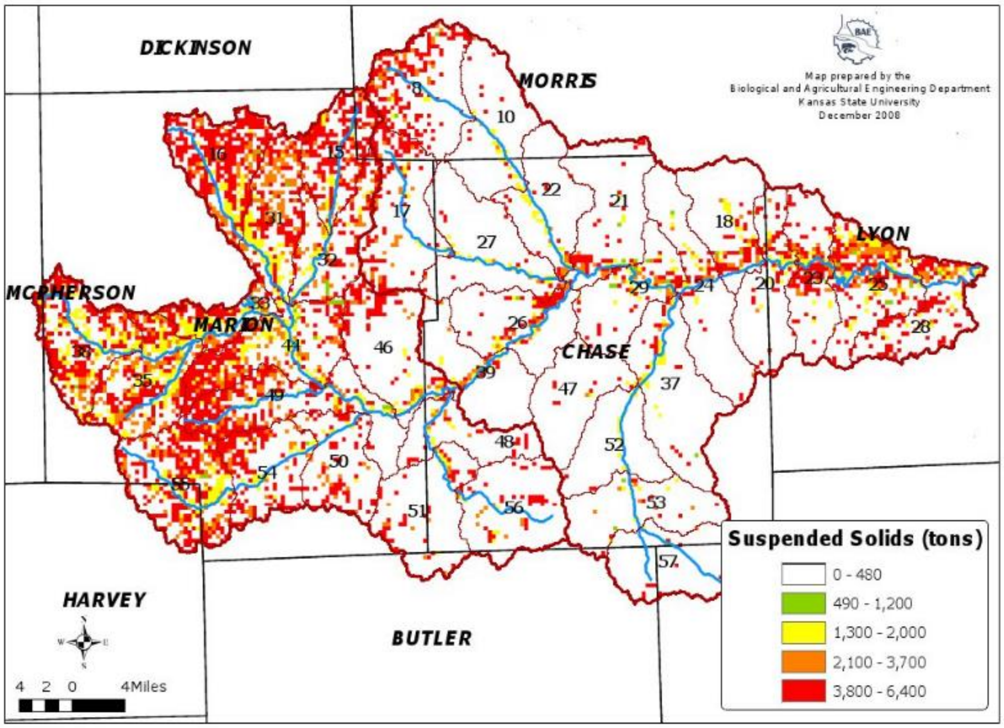
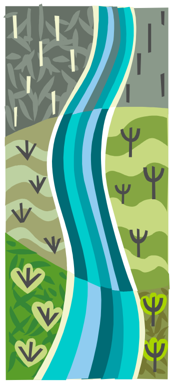


Figure 11. Results of the L-THIA model.

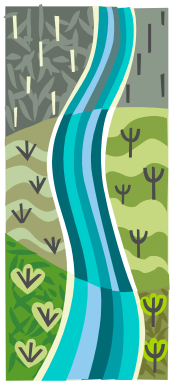


Evaluation of Project Goal, Objectives, and Tasks

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 a middle range assessment using the L-THIA modeling tool.
- 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.
- Watershed model and economic results were delivered, discussed, and approved by the Stakeholder Leadership Team.



Conclusions, Recommendations, and Lessons Learned

Conclusions

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

Lessons Learned

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

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

Recommendations

Watershed modeling is important to the WRAPS Assessment process.

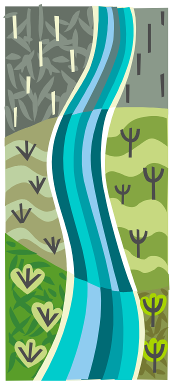
- One Kansas individual skeptical of watershed modeling suggested that K-State should instead simply show real data about how various agricultural management practices impact water quality in each locale. He and I discussed how soil types, rainfall patterns, growing seasons, and management practices,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

Watershed modeling remains highly sophisticated.

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

Believable watershed modeling requires technical skill and social connection.

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



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