Marais des Cygnes Basin High Priority Issue
Watershed Restoration and Protection
September 2011 Update

Issue

There are a variety of water quality and water resource concerns such as achieving Total Maximum Daily Loads (TMDL), Nutrient Reduction goals, development of Source Water Protection Plans, reduction of sedimentation in reservoirs and lakes, and protection or restoration of wetland and riparian habitats. These concerns are addressed through a combination of restoration and protection efforts using both voluntary incentive-based approaches and regulatory programs. The restoration and protection of watersheds, particularly those watersheds above public water supply reservoirs, is a priority in the Marais des Cygnes Basin.

Description

There are three federal reservoirs, Pomona, Melvern and Hillsdale, in the Marais des Cygnes basin. All of these reservoirs are operated by the U.S. Army Corps of Engineers (Corps). The federal reservoirs are used for public water supply that serve numerous cities and rural water districts in the basin. These reservoirs are also managed by the Corps for flood control and recreation. There are additional water supply reservoirs in the basin that provide localized water supply and have additional benefits including recreation.

Hillsdale and Pomona reservoirs and many streams within the basin are experiencing water quality impairments. Fecal coliform bacteria and low levels of dissolved oxygen are the most prevalent stream impairments. Sedimentation and eutrophication (nutrient loading) are the primary water quality problems affecting reservoirs in this basin.

Reservoir sedimentation is a major water quantity concern, particularly in reservoirs where the state owns storage for the Water Marketing Program, or where a Water Assurance District owns storage. See the Surface Water Management Policy for a description of these programs. As sediment accumulates in a reservoir's multipurpose pool, the capacity for water supply storage is reduced. Figure 1 shows the estimated capacity lost, including water supply storage, to sediment deposition in federal reservoirs in the basin since construction.

Reservoir sedimentation is a result of soil erosion from the land surface and from stream channels and banks. In most Kansas watersheds, this natural process has been accelerated due to changes in land cover and the modification of stream channels to accommodate agricultural, urban and other land uses. Growing evidence shows that a significant source of sediment in streams is generated from stream channels and edge of field gullies. Streambank erosion can contribute nutrients, such as phosphorus, which can cause water quality impairments. Programs are available through state and federal agencies to restore riparian areas and streams. However, more targeted planning is needed to restore the areas with the greatest potential to improve the health of the watershed and extend the life of our reservoirs.

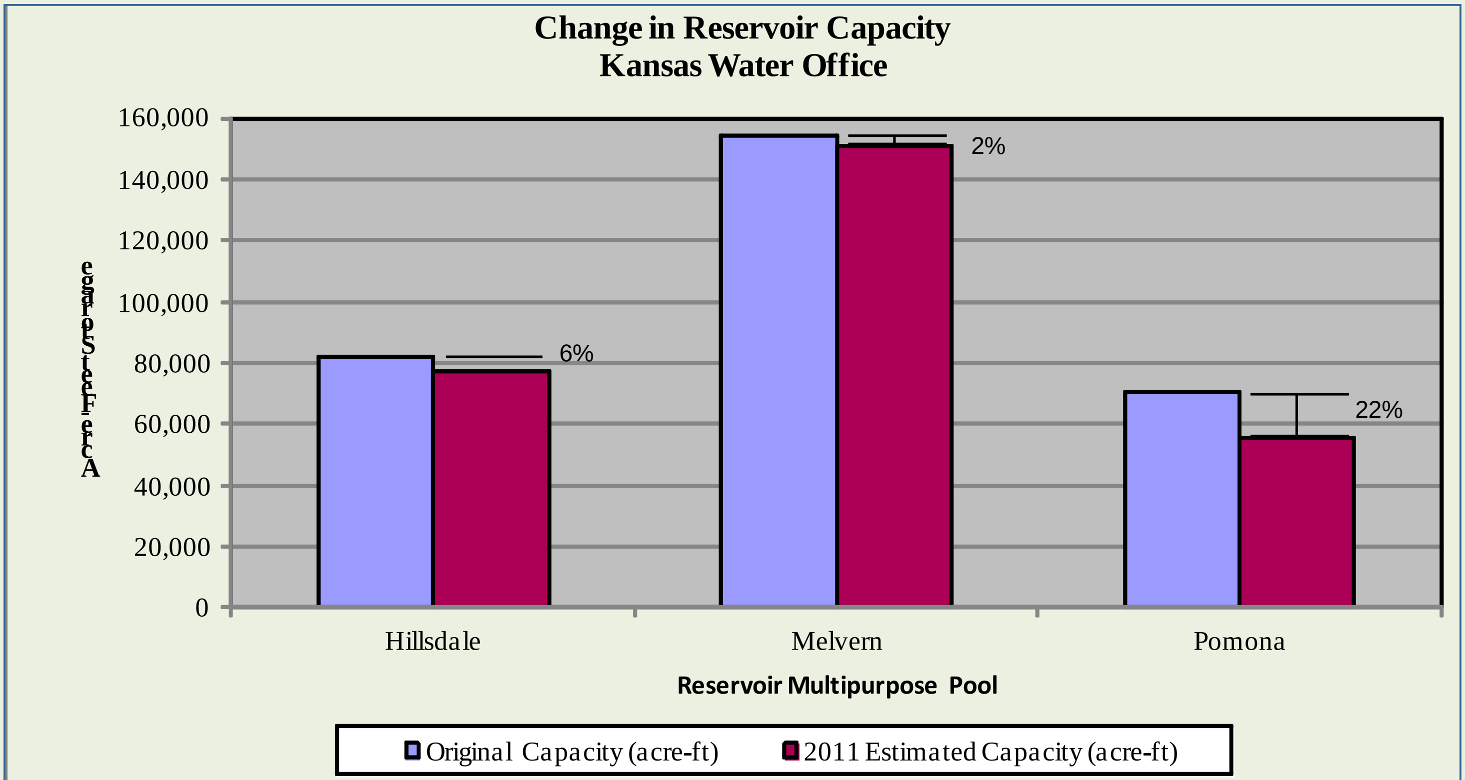

Figure 1.

When this basin priority issue was approved in 2009, the following recommendations were made to address watershed restoration and protection needs in the Marais des Cygnes basin.

Recommended Actions

1. Work with stakeholder groups to incorporate TMDL implementation, nutrient and sediment reduction, and urban stormwater management goals into applicable WRAPS projects.

2. Target technical and financial assistance programs for water quality protection and restoration to implement TMDLs and WRAPS action plans.

Since 2009, substantial progress has been made in the implementation of these recommendations, especially in the assessment of streambank condition. This update provides additional information about recent activities and data acquisition.

Recommendation: Work with stakeholder leadership groups to incorporate TMDL implementation, nutrient and sediment reduction, and urban stormwater management goals into applicable Watershed Restoration and Protection Strategies (WRAPS) projects.

Water quality protection and improvement is most effectively addressed at the watershed level using regulatory and non-regulatory programs. Surface water quality monitoring is conducted to assess the level of pollutants in the water and the health of the biological community. If monitoring indicates that a river segment or other water body is consistently violating surface water quality standards, the water is deemed water quality impaired. Water bodies not meeting water quality standards for their designated uses are identified on the 303(d) list. The 303(d) list is used to identify those waters targeted for the development of TMDLs. A TMDL is the maximum amount of a pollutant that a water body can receive without exceeding water quality standards. Since pollution can arrive via point and nonpoint sources, the TMDL process distributes responsibility for the pollutant load reductions among those contributing sources. High Priority TMDL watersheds are used to target technical and financial assistance for implementation of nonpoint source pollution management practices that can address designated pollutants.

The Kansas Department of Health and Environment (KDHE) completed the first round of TMDLs within the Marais des Cygnes basin based on the 1998 and 2004 303(d) list. There are 35 approved TMDLs within the Marais des Cygnes basin

TABLE 1
MARAIS DES CYGNES BASIN HIGH PRIORITY TMDLS

MAP ID	WATERBODY	IMPAIRMENTS	HUC 11 WATERSHEDS
STREAM SEGMENTS			
1	Hundred and Ten Mile Creek	DO	10290101030
2	Upper Marais des Cygnes River	FCB	10290101040 10290101070
3	One Hundred Forty Two Mile Creek	DO, FCB	10290101010
4	Pottawatomie Creek	DO	10290101050 10290101060
5	Dragoon Creek	DO	10290101030
6	Ottawa Creek	DO	10290101070
7	Middle Creek	DO	10290102060
8	Marmaton River	DO, BIO	10290104010 10290104020
LAKES			
9	Pomona Lake	E, Silt	10290101030
10	Hillsdale Lake	E	10290102010
11	Marais des Cygnes Wildlife Mgt. Area	DO, E, pH, Silt	10290102060 10290102070 10290102080
12	Rock Creek Lake	E	10290104010
13	Louisburg State Fishing Lake	E	10290102060

Key:
DO: Low dissolved oxygen in upper 3 meters of water column over deepest location in water body
BIO: Biology
E: Eutrophication, biological community impacts and excessive nutrient/organic loading
FCB: Fecal Coliform Bacteria
HUC: U.S. Geologic Survey Hydrologic Unit Code
pH: A measure of the hydrogen ion concentration.
Silt: Observed siltation and/or chronic turbidity that impacts development of trophic state

that describe the strategies and goals to reduce pollution to achieve water quality standards. The 2008 303(d) list submitted to EPA identifies watersheds associated with 12 stream chemistry sampling stations as water quality impaired. There are seven lakes in the Marais des Cygnes basin listed as water quality impaired. Among the streams atrazine, dissolved oxygen depletion, and copper caused the greatest number of impairments. Other pollutants of concern in Marais des Cygnes streams include biological stressors, lead, total suspended solids, and zinc. Among the lakes, eutrophic conditions indicative of excessive algae production were the predominate cause of impairment along with dissolved oxygen depletion. Arsenic, lead, and siltation caused additional lake impairments.

Each parameter causing impairment requires a TMDL. Many of the stream segments configured in a watershed setting have a TMDL applied to them as a whole. KDHE reviewed and revised Marais des Cygnes basin TMDLs and submitted them to EPA in 2008.

Surface Water Nutrient Reduction

The impacts of nutrients originating in Kansas have been well documented. These include Gulf of Mexico hypoxia, excessive productivity in Kansas and downstream reservoirs, and taste and odor problems in drinking water originating from reservoirs. Reduction and control of nutrients is needed to begin mitigating those impacts. Nutrient sources within the basin include both point and nonpoint sources. The major point sources in the basin include large wastewater treatment plants, which are regulated under the National pollutant Discharge Elimination System (NPDES) Program (Figure 2).

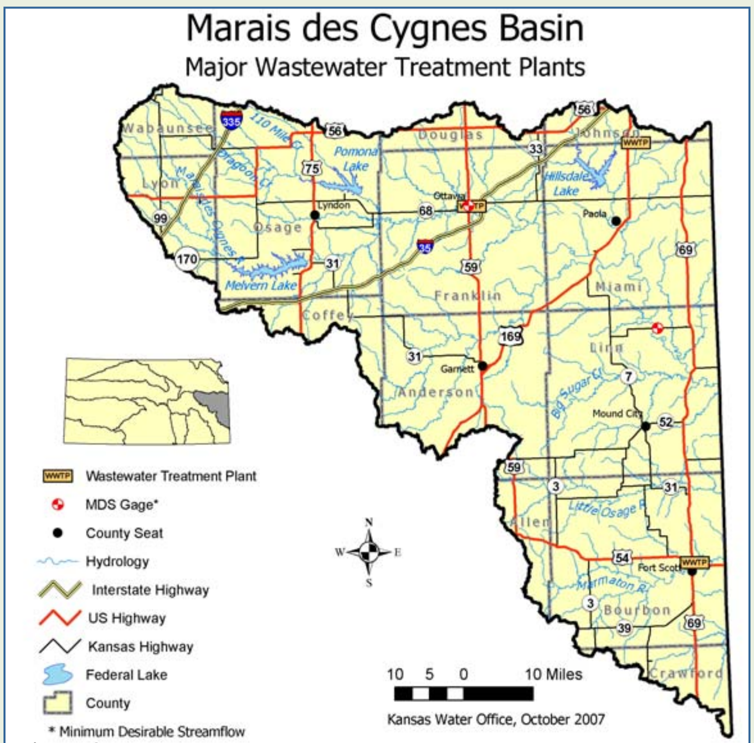

Figure 2

Nonpoint sources of pollution include both agricultural and urban areas. Table 2 shows the relative contribution of point and non-point sources in the Marais des Cygnes basin for total phosphorus (TP) and total nitrogen (TN) leaving the state. The Kansas Surface Water Nutrient Reduction Plan, developed by KDHE, outlines a statewide strategy for reducing the export of TN and TP in surface waters leaving the state. This involves additional reductions in nutrients from point source discharges through the NPDES Program and reductions in nonpoint sources through development and implementation of Watershed Restoration and Protection Strategies (WRAPS). The Nutrient Reduction Plan includes Improvement Potential Index (IPI) maps for Kansas counties for TP and TN reductions (see maps in Water Quality Policy Section). In the Marais des Cygnes basin, Anderson County showed the highest improvement potential for both TP and TN.

Table 2
MDC Nutrient Reduction Data
Source: KDHE Bureau of Water – February 14, 2006

Statewide Perspective

Parameter	State Total	MDC	% of State Total
TN Leaving State (Ton/yr)	51,205	4,751	9%
TP Leaving State (Ton/yr)	7,670	579	8%
Point Source TN (Ton/yr)	10,600	471	5%
Point Source TP (Ton/yr)	2,836	120	4%
Nonpoint Source TN (Ton/yr)	40,605	4,260	10%
Nonpoint Source TP (Ton/yr)	4,834	459	9%

Basin Perspective

Parameter	Total	PS	PS %	NPS	NPS%
TN (Ton/yr)	4,751	491	10%	4,260	90%
TP (Ton/yr)	579	120	21%	459	79%

Source Water Protection

All public water suppliers in the basin completed Source Water Assessments in cooperation with KDHE in 2004. The next step, which is voluntary, is the development of source water protection plans. For communities using groundwater, development of a wellhead protection program is recommended. For communities using surface water, the development of a WRAPS is the best mechanism to ensure water quality protection for their public water supply. WRAPS are stakeholder-driven watershed management plans designed to address multiple water resource issues within a specific sub-watershed within a river basin.

Waterbody	Impairment	Priority	Station	Approval Status
Subbasin: Upper Marais Des Cygnes (HUC 10290101)				
DRAGOON CREEK	DO	High	SC577, SC687	8/28/01
HUNDRED AND TEN MILE CREEK	DO	High	SC633	8/28/01
MARAIS DES CYGNES RIVER	Se	Cat 2	SC555, SC244	8/28/01, Delisted 08/12/2010
MARAIS DES CYGNES RIVER (FCB)	FCB	High	SC270	8/28/01
MARAIS DES CYGNES RIVER	NH3	Cat 2	NPDES Permit	12/18/08, Delisted
MARAIS DES CYGNES RIVER/142 MILE CREEK	DO	High	SC579	8/28/01
MARAIS DES CYGNES RIVER/142 MILE CREEK (FCB)	FCB	High	SC579	8/28/01
OTTAWA CREEK	DO	High	SC616	8/28/01
POTTAWATOMIE CREEK	DO	High	SC556	8/28/01
POTTAWATOMIE CREEK	FCB	Cat 2	NPDES Permit	12/18/08, Delisted
POTTAWATOMIE CREEK/SOUTH FORK	FCB	Cat 2	NPDES Permit	12/18/08, Delisted
SALT CREEK	ECB	Cat 5	SC578 - NPDES Permit	12/18/08
SALT CREEK	NH3	Cat 5	SC578 - NPDES Permit	12/18/08
SWITZLER CREEK	Se	Cat 2	SC687	8/28/01, Delisted 08/12/2010
TAUY CREEK,EAST FORK	FCB	Cat 2	NPDES Permit	Delisted 08/12/2010
WALNUT CREEK	NH3	Cat 2	NPDES Permit	Delisted 08/12/2010
Subbasin: Lower Marais Des Cygnes (HUC 10290102)				
BIG SUGAR CREEK	DO	Medium	SC558	2/28/08
MIDDLE CREEK	DO	High	SC697	8/28/01
Subbasin: Little Osage (HUC 10290103)				
LITTLE OSAGE RIVER	FCB	Medium	SC207	8/28/01
Subbasin: Marmaton (HUC 10290104)				
DRYWOOD CREEK. W. FORK	DO	Low	SC617	2/28/08
MARMATON RIVER	DO	High	SC208, SC559	8/28/01
MARMATON RIVER (Bio)	Bio	High	SC208, SB325	8/28/01
MARMATON RIVER	FCB	Cat 2	NPDES Permit	Delisted 08/12/2010
MARMATON RIVER	NH3	Cat 2	NPDES Permit	Delisted 08/12/2010

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Waterbody	Impairment	Priority	Station	Approval Status
Subbasin: Upper Marais Des Cygnes (HUC 10290101)				
CRYSTAL LAKE	EU	Medium	LM064901	8/28/01
LEBO CITY PARK LAKE	EU	Low	LM065601	8/28/01
OSAGE CITY RES	EU	Low	LM066101	8/28/01
POMONA LAKE	Silt	High	LM028001	8/28/01
POMONA LAKE (EU)	EU	High	LM028001	8/28/01
SPRING CREEK PARK LAKE	EU	Low	LM066801	8/28/01
SPRING CREEK PARK LAKE	AP	Low	LM066801	8/28/01
Subbasin: Lower Marais Des Cygnes (HUC 10290102)				
EDGERTON CITY LAKE	EU	Medium	LM065001	8/28/01
EDGERTON CITY LAKE (Atr)	Atr	Medium	LM065001	8/28/01
HILLSDALE LAKE	EU	High	LM035001, LM035002, LM035003	8/28/01
LOUISBURG SF LAKE	EU	High	LM043801	2/28/08
MARAIS DES CYGNES WMA	DO	High	LM053201	8/28/01
MARAIS DES CYGNES WMA (Silt)	Silt	High	LM053201	8/28/01
MARAIS DES CYGNES WMA	pH	High	LM053201	8/28/01
MARAIS DES CYGNES WMA	EU	High	LM053201	8/28/01
MIAMI CO SFL/ WA	pH	Medium	LM043601	8/28/01
MIAMI CO SFL/ WA	EU	Medium	LM043601	8/28/01
MOUND CITY LAKE	pH	Medium	LM051401	8/28/01
MOUND CITY LAKE	EU	Medium	LM051401	8/28/01
MOUND CITY LAKE	DO	Medium	LM051401	8/28/01
MOUND CITY LAKE	AP	Medium	LM051401	8/28/01
Subbasin: Little Osage (HUC 10290103)				
PRESCOTT CITY LAKE	EU	Low	LM066601	8/28/01
Subbasin: Marmaton (HUC 10290104)				
BOURBON CNTY SF LAKE	EU, DO, pH	Medium	LM013301	2/28/08
BRONSON CITY LAKE	EU	Medium	LM046201	8/28/01
ELM CREEK LAKE	EU	Low	LM044801	8/28/01
LAKE CRAWFORD	EU	High	LM011101	2/28/08
ROCK CREEK LAKE	EU	High	LM045201	2/28/08

Abbreviations

- AP - Aquatic Plants
- Atr - Atrazine
- Bio - Biology
- DO - Dissolved Oxygen
- EU - Eutrophication
- FCB - Fecal Coliform Bacteria
- HUC - Hydrological Unit Code
- NH3 - Ammonia
- pH - pH
- Se - Selenium
- Silt - Siltation

Forty public water suppliers in the basin treat raw water. Twenty-two use surface water and 18 use groundwater. Most residents in the basin get water from the Marais des Cygnes River, one of its major tributaries or one of the three federal reservoirs in the basin.

Each source water assessment included a susceptibility score which can help communities determine which contaminants pose the most significant threat to their water supply. A score, generated from the susceptibility analysis, indicates whether the susceptibility range is low, moderate or high for potential threats of contamination in an assessment area.

KDHE provided public water suppliers susceptibility scores in the following contaminant categories: microbiological, nitrates (applicable for groundwater only), pesticides, inorganic compounds, synthetic organic compounds, volatile organic compounds, sedimentation (surface water only) and eutrophication/phosphorus (surface water only).

Of public water suppliers using groundwater in the Marais des Cygnes basin, 67% had low susceptibility scores and 33% had moderate scores. Of public water suppliers using surface water, 45% had low scores, 45% had moderate scores and nine (figures rounded) percent had high scores. The most commonly identified problems with groundwater were volatile and synthetic organic compounds, pesticides and microbes. The most commonly identified problems with surface water were volatile and synthetic organic compounds, inorganic compounds, sediment and eutrophication/phosphorus.

Development of a wellhead protection program is recommended. The Marais des Cygnes basin has two approved source water protection plan and another in progress.

Recommendation: Target technical and financial assistance programs for water quality protection and restoration to implement TMDLs and WRAPS action plans.

The WRAPS process provides a means to integrate objectives from multiple local, state and federal programs into a comprehensive, coordinated strategy for a specific watershed. This can include TMDL attainment, nutrient reduction, source water protection, reduced reservoir sedimentation, riparian and wetland management, habitat enhancement, and other natural resource objectives.

Watersheds above the three federal reservoirs in the basin that serve public water supply needs have been identified as watersheds of significant state interest for WRAPS development and implementation. WRAPS projects have been initiated in the watersheds above the federal reservoirs. WRAPS have been prepared for the entire basin and the Marmaton watershed.[4] Watersheds with WRAPS projects currently underway in the basin encompass high priority areas for TMDL implementation, areas with a high improvement potential index for nutrient reduction, source water assessment areas and priority areas for wetland and riparian protection.

The Marais des Cygnes WRAPS groups have been modifying their WRAPS plans to include the EPA Nine Elements into their documents. This is a requirement of EPA in order to continue to receive Section 319 grants for plan implementation. This should also result in more effective targeting of resources to the highest priority areas.

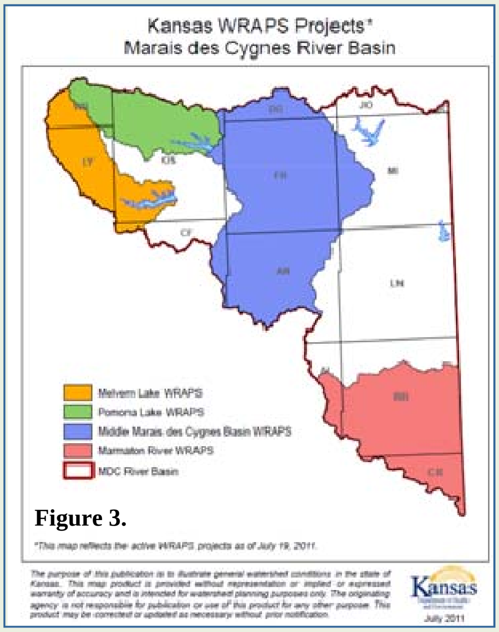

Figure 3.

The Pomona Lake WRAPS group has submitted their Draft EPA Nine Element Plan to KDHE for review. The Melvern WRAPS group is currently working on their draft EPA Nine Element Plan for submission in the near future. The Marmaton River WRAPS group has submitted its final draft to the WRAPS Work Group. The Middle Marais des Cygnes does not currently have a plan or draft submitted.

Recommendation: Complete assessment projects with particular attention to riparian and wetland assessments to target resources. Encourage private landowner efforts to maintain riparian areas to prevent introduction of excess woody debris into the tributary and river system.

Wetland and riparian areas are vital components of proper watershed function that, when wisely managed in context of a watershed system, can moderate and reduce sediment input into reservoirs. There is growing evidence that a substantial source of sediment in streams in many areas of the country is generated from stream channels and edge of field gullies (Balch, 2007). This section evaluates streambank erosion contribution to sedimentation in the three Marais des Cygnes River basin federal reservoirs.

Streambank erosion is a natural process that contributes a large portion of annual sediment yield, but acceleration of this natural process leads to a disproportionate sediment supply, stream channel instability, land loss, habitat loss and other adverse effects. Many land use activities can affect and lead to accelerated bank erosion (EPA, 2008). In most Kansas watersheds, this natural process has been accelerated due to changes in land cover and the modification of stream channels to accommodate agricultural, urban and other land uses.

A United States Geological Survey (USGS) study in the Perry Reservoir watershed in northeast Kansas showed that stream channels and banks are a significant contributor of reservoir sedimentation in addition to land surface erosion (Juracek, 2007). A naturally stable stream has the ability, over time, to transport the water and sediment of its watershed in such a manner that the stream maintains its dimension, pattern, and profile without either aggrading or degrading (Rosgen, 1997). Streams that have been significantly impacted by land use changes in their watersheds or by modifications to stream beds and banks go through an evolutionary process to regain a more stable condition. This process generally involves a sequence of incision (downcutting), widening and re-stabilizing of the stream. Most streams in Kansas are in some stage of this process (SCC, 1999).

Streambank erosion is often a symptom of a larger more complex problem requiring solutions that frequently involve more than just streambank stabilization (EPA, 2008). It is important to analyze watershed conditions and understand the evolutionary tendencies of a stream when considering stream stabilization measures. Efforts to restore and re-stabilize streams should allow the stream to speed up the process of regaining natural stability along the evolutionary sequence (Rosgen, 1997). A watershed-based approach to developing stream stabilization plans can accommodate the comprehensive review and implementation.

Other research in Kansas documents the effectiveness of forested riparian areas on bank stabilization and sediment trapping (Geyer, 2003; Brinson, 1981; Freeman, 1996; Huggins, 1994). Vegetative cover based on rooting characteristics can mitigate erosion by protecting banks from fluvial entrainment and collapse by providing internal bank strength. Riparian vegetative type is an important tool that provides indicators of erosion occurrence from land use practices. The riparian area is the interface between land and a river or stream. Riparian areas are significant in soil ecology, environmental management and because of their role in soil conservation, habitat biodiversity and the influence they have on aquatic ecosystems overall health. Forested riparian areas are superior to grassland in holding bank stabilization during high flows, when most sediment is transported. When riparian vegetation is changed from woody species to annual grasses and/or forbs, subsurface internal strength is weakened, causing acceleration of mass wasting processes (extensive sedimentation due to subsurface instability) (EPA, 2008). The primary threats to wetlands and forested riparian areas are agricultural production and suburban/urban development.

Reservoir sedimentation is a major water quantity concern, particularly in reservoirs where the state owns water supply storage. Reservoirs are a vital source of water supply, provide recreational opportunities, support diverse aquatic habitat, and provide flood protection throughout Kansas. Excessive sediment can alter the aesthetic qualities of reservoirs and affect their water quality and useful life (Christensen, 2000). Sediment deposition in reservoirs can be attributed to many factors, including precipitation, topography, contributing-drainage area of the watershed and differing soil types. Decreases in reservoir storage capacity from sediment deposition can affect reservoir allocations used for flood control, drinking-water supplies, recreation and wildlife habitat. Land use has considerable effect on sediment loading in a reservoir. Intense agricultural use in the watershed, with limited or ineffective erosion prevention methods, can contribute large loads of sediment along with constituents (such as phosphorus) to downstream reservoirs (Mau, 2001).

Another form of erosion contributing to sedimentation in many watersheds in Kansas is the development of gullies alongside streams. Streambank gullies develop from the wearing away of the surface soil along drainage channels by surface water runoff. These gullies are associated with the loss of vegetation on the soil and down cuts forming deep widening channels. The potential for surface erosion is associated in part with the amount of bare, compacted soil exposed to rainfall and runoff. Increased risk of erosion and sediment delivery is associated with high soil erodability; little ground cover; steep, long, continuous slopes; high intensity storms; high drainage density of the slope; and close proximity to streams.

Gully erosion can contribute a tremendous amount of sediment at the watershed scale and can occur in both cropland and grassland. The amount of sediment input is based on rainfall/runoff and gully frequency within a given watershed. In each case, the gullies observed are unstable and will continue to be unless best management practices (BMPs) are implemented. A common BMP for gully erosion is the rock chute. Rock chute designs require bank shaping and the placement of erosion control fabric and sorted rock. Rock chutes are designed to direct flow down through the chute center. The rock creates flow resistance slowing down water velocities.

Streambank Erosion Hotspot Identification

Streambank erosion assessments were performed using desktop ArcGIS® ArcMap® 10 software and on-the-ground field data verification and collection. The purpose of these assessments are to identify locations of streambank instability and estimate erosion rates to prioritize restoration needs along streambanks to slow sedimentation rates in Melvern, Pomona and Hillsdale Reservoirs and into the Marmaton River. ArcMap® 10, an ArcGIS® geospatial processing program, was utilized to assess color aerial photography from 2008, provided by National Agriculture Imagery Program (NAIP), and compare it with 1991 black and white aerial provided by Data Access & Support Center (DASC). These assessments did not include rangeland gullies, salt scars or other landscape level sources of sediment.

The streambank gully erosion assessment was performed with similar techniques as the streambank erosion assessment. However, calculating tons of soil erosion was not part of this assessment.

Data Collection Methodology

Streambank erosion assessments were performed by overlaying 2008 NAIP county aerial imagery onto 1991 DASC county aerial imagery. Using ArcMap® tools, "aggressive movement" of the streambank between 1991 DASC and 2008 NAIP aerial photos, were identified at a 1:6,000 scale, as a site of streambank erosion. "Aggressive movement" represents areas of 1,500 sq. feet or more of streambank movement between 1991 and 2008 aerial photos. Note that the identified streambank erosion sites are only a portion of all streambank erosion occurrences. Erosion sites identified in these assessments are limited to locations of streambank erosion and covering an area of streambank movement roughly equal to or greater than 1,500 sq. feet. Any erosion that covers an area smaller than roughly 1,500 sq. feet incurs a high margin of error, making calculations unreliable and is not included. This error can be attributed to some distortions between years when aerial photos are taken and then digitally georeferencing. Error can also be attributed to shading interference from leafing of trees in aerial photos when photos are taken in spring, summer and early fall months. Leafing can affect the ability to locate streambanks.

Streambank erosion sites were denoted by geographic polygons features "drawn" into the ArcGIS® software program using ArcMap® editor tools. The polygon features were created by sketching vertices following the 2008 streambank and closing the sketch by following the 1991 streambank, at a 1:2,500 scale. Data provided, based on geographic polygon sites include: watershed location, unique ID, stream name, type of stream and type of riparian vegetation.

The streambank erosion assessment data also includes estimates of the average volume of soil loss, in tons per year, from streambank erosion sites. Estimation of average soil loss is performed utilizing the identified erosion site polygon features and calculating perimeter, area and streambank length into a regression equation. Perimeter and area were calculated through the *field calculator* application within the ArcGIS® software. Streambank length of identified erosion sites were computed through the application of a regression equation, formulated by the Kansas Water Office (KWO). This equation was developed by taking data from the *Enhanced Riparian Area/Stream Channel Assessment for John Redmond Feasibility Study*, a report prepared by The Watershed Institute (TWI) and Gulf South Research Corporation (GSCR), and relating the erosion area (in sq. feet) and perimeter length of that erosion area (in feet) to the unstable stream bank length (in feet). The multiple regression formula of that fit (R-square = 0.999) is:

Estimated SB Length = ([Area_SqFt]*-.00067) + ([Perimtr_ft]*.5089609)

The intercept of the model was forced to zero.

Average volume of soil loss was estimated by first calculating the volume of sediment loss and applying a bulk density estimate to that volume for the typical soil type of the eroding area. The volume of sediment was found by multiplying bank height, surface area lost over the 17 year period between the 1991 and 2008 and soil bulk density. This calculated volume is then divided by the 17 year period to get the average rate of soil loss in mass/year:

Average Soil Loss Rate (Tons/yr) = [Area_SqFt]* [BankHgtFt]*SoilDensity(lbs/ft^3)/2000(lbs/ton)/ ([NAIP_ComparisonPhotoYear]-[BaseAerialPhotoYear])

Soil bulk density, used in the average soil loss rate equation, was calculated by first determining the moist bulk density of the predominant soil in the study area, using the USDA Web Soil Survey website. The predominant soil type found at all erosion location in the three reservoirs within the Marais des Cygnes River basin was Ivan silt loam in the Melvern Reservoir watershed and Verdigris silt/silty loam in the Pomona and Hillsdale Reservoir watersheds.

Streambank height measurements, also used in the average soil loss rate equation, were obtained through on the ground field verification in several locations throughout the watersheds in each reservoir. These field verified streambank height measurements were the basis for extrapolating streambank height measurements for identified streambank erosion sites (Figure 4).

The streambank gully erosion assessment was performed with similar techniques as the streambank erosion assessment. Using ArcMap® tools, streambank gully erosion was indicated by point features in the ArcGIS® software program. Gully data was compiled and categorized by high, medium or low priority as another effort in rehabilitation prioritization. The identification of a low priority gully indicates that sheet erosion has been identified and a gully could form in the area that is perpendicular to the stream. A low priority gully does not indicate visible channel cutting or any visible streambank riparian erosion. A medium priority gully identifies visible channel cutting perpendicular to the streambank but no visible erosion of the riparian area of the streambank. High priority gullies identify a deeply incised channel cutting perpendicular to the stream, including a significant portion of the riparian area eroded from the streambank. In some instances, gullies were increased to a medium or high priority, even if they exhibit “low priority” gully identifiers, if there was a visibly identified sizeable amount of land erosion or gullies present in the same vicinity.

As was found with the streambank erosion assessment, limiting factors were also found when performing the streambank gully erosion visual assessment. These limiting factors can be attributed to shading interference from leafing of trees in aerial photos when photos are taken in spring, summer and early fall months. Leafing can affect the ability to locate streambank gully erosions. In the case of Hillsdale Reservoir, riparian areas for a large portion of the watershed exhibited dense woodlands, making it difficult to locate gullies visually.

Figure 4. Streambank Height Measurement at Melvern Reservoir on Elm Creek

Analysis

Streambank erosion sites were analyzed for: streambank length (in feet) of the eroded bank; annual soil loss (in tons/year); percent of streambank length with poor riparian condition (riparian area identified as being cropland, grassland or a grassed buffer for cropland for riparian vegetation); estimated sediment reduction through the implementation of streambank stabilization Best Management Practices (BMPs) at an 85% efficiency rate; and streambank stabilization cost estimates for eroded streambank sites. Streambank stabilization costs were derived from an average cost to implement streambank stabilization BMPs, as reported in the TWI *Kansas River Basin Regional Sediment Management Section 204 Stream and River Channel Assessment*; at $71.50 per linear foot (Figure 5). Streambank stabilization costs vary based on soil type and materials used for streambank stabilization BMPs and may differ from the estimates developed for the *Kansas River Basin Regional Sediment Management Section 204 Stream and River Channel Assessment* BMP estimates. Due to the lack of sufficient information to accurately develop streambank stabilization average costs in the Marais des Cygnes River basin, TWI estimates were used. To accommodate streambank rehabilitation project focus, study areas were delineated into stream reaches and Hydrologic Unit Codes.

Figure 5. TWI Estimated Costs to Implement Streambank Stabilization

BMP Cost Description	**Cost estimate per linear foot (in dollars)**
1. Survey and design Rock delivery and placement As-built certification design Bank shaping	$50 - $75
2. Vegetation (material and planting) Cover crop Mulch Willow Stakes Bare root seedlings Grass filter strip	$5
3. Contingencies Unexpected site conditions requiring extra materials and construction time	$3 - $5.5
TOTAL	$58 - $85.5

Streambank gullies were assessed based on the proportion of high, medium and low priority identifications and can be used as supporting data for streambank erosion or streambank gully erosion rehabilitation prioritization. Explanation of prioritization is found in the data collection and methodology above. No further assessment was performed.

Results

Melvern Reservoir

Melvern Reservoir was constructed on the Upper Marais des Cygnes River in Osage County at river mile 175.4. The watershed drains about 349 square miles and includes portions of Coffey, Lyon, Osage and Wabaunsee counties, with the majority in Osage County. The Corps began construction of the reservoir in 1967 for flood control, water supply, recreation, fish and wildlife and water quality control. Gates were closed in October of 1970 and the conservation pool filled in April of 1975. The original conservation pool and designed sedimentation rate of the reservoir were 154,370 acre-feet and 170 acre-feet per year, respectively. Melvern Reservoir is situated on the eastern edge of Kansas' Flint Hills Region. Major tributaries in the watershed include Mud Creek, Hill Creek, Duck Creek, 142 Mile Creek, Elm Creek and Chicken Creek. The most recent survey bathymetric survey performed by KBS in 2009 reports the conservation storage capacity at 151,256 acre-feet and yields a mean annual sedimentation rate of 86 acre-feet per year.

The watershed above Melvern Reservoir is dominated by deep upland soils and nearly level to moderate slopes, with the lowland terraces and floodplains dominated by deep soils with nearly level slopes. Soils in the watershed vary between well to poorly drained and in general are subject to water erosion during high flow events due to moderate to slow permeability and moderate slopes in the majority of the “prime farmland” cultivated areas (Ingle, 2001). Land use in the watershed is dominated by grasslands, roughly 80%, and is primarily used for grazing purposes, while the remaining 20% is broken into cropland and urban land uses. Precipitation in the watershed averages 35 inches per year, with average annual runoff ranging from seven to eight inches.

Melvern Reservoir currently has no water quality impairments. This is most likely attributed to the predominant land use in the watershed being comprised of grasslands. However, some streams upstream of the reservoir have water quality impairments for dissolved oxygen and fecal coliform bacteria, and TMDLs have been developed for the One Hundred and Forty Two Mile Creek/Upper Marais des Cygnes River (KDHE, 2001).

In 2011, the Kansas Water Office (KWO) performed a GIS based analysis of streambank erosion and riparian condition in the Melvern Reservoir watershed. A total of 68 streambank erosion sites, covering 30,419 feet of unstable streambank were identified through the assessment, with only 46% of the unstable streambanks identified as having poor riparian condition (Figure 6). The assessment also identified estimates totaling approximately 26,671 tons of sediment being transported from the streambank erosion sites annually. Assuming a bulk density of 40 lbs/cubic foot sediment in Melvern Reservoir; streambank sources account for 31 of the 86 acre-feet (36%) of sediment annually deposited in Melvern Reservoir. Based on estimated stabilization costs of $71.50 per linear foot from an assessment conducted by TWI, streambank stabilization for the entire watershed from the 2011 assessment would cost approximately $2.2 million. Of these 68 sites identified, 10 sites were selected, spread throughout the watershed, for field verification and streambank height measurements. Measurements were used to estimate the amount of sediment originating from streambank sites.

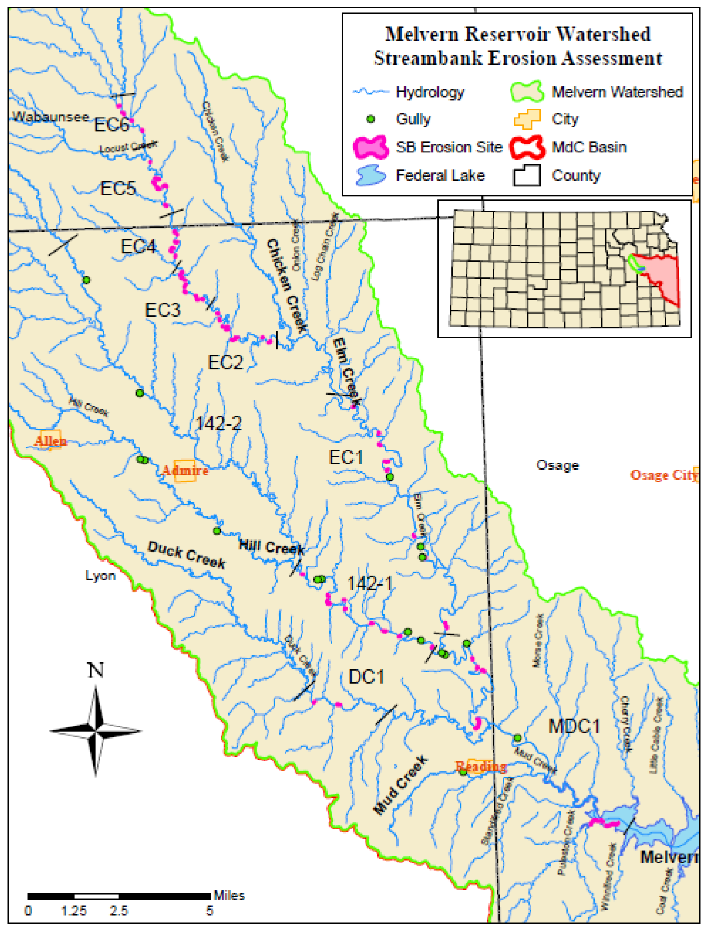

Figure 6. Melvern Reservoir Watershed Streambank Erosion Assessment Map

The majority of the 26,671 tons of sediment is transported each year from the mainstem Marais des Cygnes River; 142 Mile Creek and certain reaches on Elm Creek (Figure 7); contributing approximately 5,110; 4,340; 4,340 and 4,097 tons of sedimentation annually, respectively. The Marais des Cygnes mainstem accounts for an estimated 26% of the total stabilization cost needs in the watershed totaling $572,900. Costs and percentages for 142 Mile Creek are $277,800 (13%); for certain reaches on Elm Creek $240,260 (11%) and $282,200 (13%), respectively.


Figure 7. Elm Creek Streambank Erosion Site; Estimated sedimentation rate at 766 tons/yr

Several streambank gully erosion problems in areas adjacent to the stream reaches were identified through the streambank erosion assessment. The assessment of streambank gullies identified certain reaches of 142 Mile Creek as contributing the highest amount of total streambank gullies (six), while certain reaches of the Marais des Cygnes River contributed a total of five gullies.

Pomona Reservoir

Pomona Reservoir was constructed on the One Hundred and Ten Mile Creek, 8.3 miles above the confluence with the Marais des Cygnes River north of the town of Pomona in Osage County. The watershed drains about 322 square miles and includes portions of Franklin, Lyon, Osage and Wabaunsee Counties, with the majority in Osage County. The Corps began construction of the reservoir in 1959 for flood control, low flow supplementation, water quality, recreation, domestic water supply and fish and wildlife enhancement. Gates were closed in July of 1962 and the conservation pool filled in June of 1965. The original conservation pool and designed sedimentation rate of the reservoir were 70,603 acre-feet and 294 acre-feet per year, respectively. Major tributaries in the watershed include Dragoon Creek, Valley Brook and Soldier Creek. The most recent survey bathymetric survey performed by KBS in 2009 reports the conservation storage capacity at 55,670 acre-feet and yields a mean annual sedimentation rate of 330 acre-feet per year.

The watershed above Pomona Reservoir is dominated by gently rolling uplands, with hilly areas along the streams, average annual rainfalls at 36 inches with the majority of the precipitation falling in late spring and early summer. Soils in the watershed along the flood plains are generally associated with the Verdigris-Osage association with deep, nearly level, well drained and poorly drained soils that have silty or clayey subsoil. Land use in the watershed is comprised of 42% grassland, 41% cropland and the remaining 16% divided into woodland and urban development.

The KDHE has developed two TMDLs for Pomona Reservoir; eutrophication and siltation. Excess nutrient loading from the watershed creates conditions favorable for algae blooms and aquatic plant growth resulting in low dissolved oxygen rates and an unfavorable habitat for aquatic life. Eutrophication from nitrogen and phosphorous is mostly due to runoff from agricultural lands, animal waste runoff from confined animal feeding operations and septic systems situated near the lake. A majority of the nutrient load has been found to come from the Dragoon Creek subwatershed, based on the Kansas Biological Survey data collected in 1999 and 2000 at Pomona Reservoir. Agricultural producers in the watershed implement best management practices (known as BMPs) to prevent nutrient runoff. Some common BMPs include: the use of conservation tillage and cover crops, maintaining buffer strips along field edges, and proper timing of fertilizer application (Nejadheshemi, 2009).

Pomona Reservoir is also impaired by siltation. Silt or sediment accumulation in lakes and wetlands reduces reservoir volume and limits recreational access to the lake. The reservoir is also light limited, with an average transparency (Secchi Disc depth) of 44.0 cm, an average turbidity of 38.2 formazin turbidity units and the average total suspended solid concentration is 30.5 mg/L. Siltation impairment is most likely due to cropland sediment runoff from exposed soils, increasing sedimentation during high flow events and causing an increase in the turbidity and concentration of total suspended solids and decreasing the water column transparency. Reducing erosion is necessary for a reduction in sediment. Agricultural best management practices similar to the practices for nutrient reduction, such as conservation tillage, grass buffer strips around cropland and reducing activities within the riparian areas will reduce erosion and improve water quality (Nejadheshemi, 2009).

In 2011, the KWO performed a GIS based analysis of streambank erosion and riparian condition in the Pomona Reservoir watershed. A total of 23 streambank erosion sites, covering 6,043 feet of unstable streambank were identified through the assessment, with 96% of the unstable streambanks identified as having poor riparian condition (Figure 8). The assessment also identified estimates totaling approximately 2,869 tons of sediment being transported from the streambank erosion sites annually. Assuming a bulk density of 40 lbs/cubic foot sediment in Pomona Reservoir; streambank sources account for only 3.3 of the 330 acre-feet (1%) of sediment annually deposited in Pomona Reservoir. Based on estimated stabilization costs of $71.50 per linear foot from an assessment conducted by TWI, streambank stabilization for the entire watershed from the 2011 assessment would cost approximately $432,060. Of these 23 sites identified, seven sites were selected, spread throughout the watershed, for field verification and streambank height measurements. Measurements were used to estimate the amount of sediment originating from streambank sites.

The majority of the 2,869 tons of sediment is transported each year from One Hundred and One Mile Creek and certain reaches of Dragoon Creek; contributing approximately 901 and 800 tons of sedimentation annually, respectively. One Hundred and One Mile Creek accounts for an estimated 25% of the total stabilization cost needs in the watershed totaling $110,000, while selected reaches of Dragoon Creek accounts for 19% of the total stabilization cost needs in the watershed totaling $83,000.

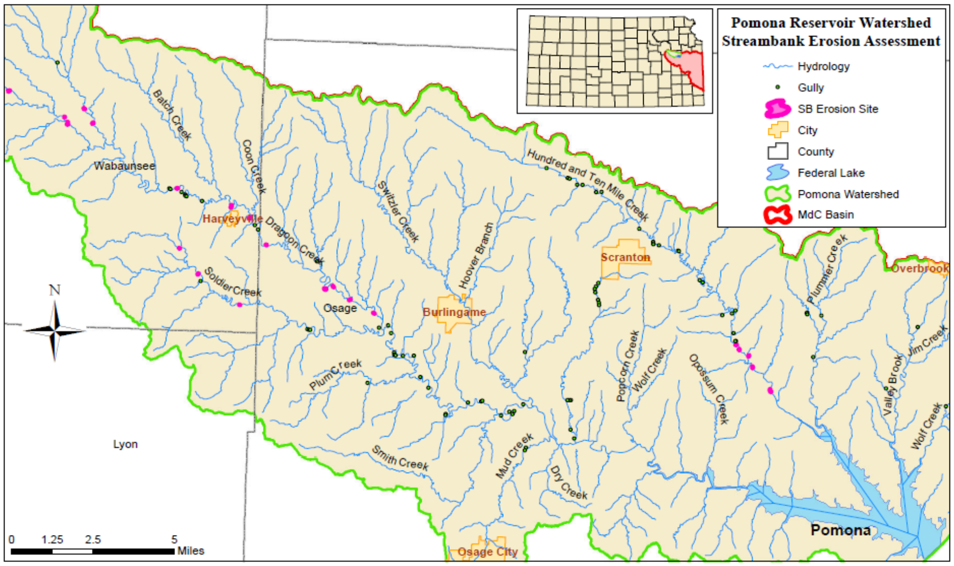

Figure 8. Pomona Reservoir Watershed Streambank Erosion Assessment Map

Several streambank gully erosion problems in areas adjacent to the stream reaches were identified through the streambank erosion assessment. The streambank gully assessment concluded 82 identified streambank gullies, of which all but six were found to be from adjoining, cultivated fields. From the 82 streambank gullies identified, Dragoon Creek (Figure 9) and One Hundred and Ten Mile Creek were found to be contributing the highest number streambank gullies. Dragoon Creek was identified as having 31 gullies, four of which were high priority, 25 were medium priority and two were low priority; while the One Hundred and Ten Mile Creek contributed a total of 21 gullies, two of which were high priority, 12 were medium priority and seven were low priority gullies. The other 26 gullies are distributed throughout the watersheds tributaries with 10 high priority, 14 medium priority and six low priority gullies.


Figure 9. Gully Erosion on Dragoon Creek

Hillsdale Reservoir

Hillsdale Reservoir was constructed on Big Bull Creek, at river mile 18.2, west of Hillsdale, Kansas and northwest of Paola, Kansas. The watershed drains about 144 square miles and includes portions of Douglas, Franklin, Johnson and Miami Counties. The Corps began construction of the reservoir in 1976 for flood control, navigation, water supply, water quality, recreation and fish and wildlife; navigation is not currently an operating purpose. Gates were closed in September 1981 and the conservation pool filled in February of 1985. The original conservation pool and designed sedimentation rate of the reservoir were 82,207 acre-feet and 83 acre-feet per year, respectively. Major tributaries in the watershed include Rock Creek, Smith Branch, Spring Creek, Little Bull Creek and Spring Creek. The most recent survey bathymetric survey performed by KBS in 2009 reports the conservation storage capacity at 77,665 acre-feet and calculated sedimentation rate at 166 acre-feet per year.

Land use in the Hillsdale Reservoir watershed consists of 50% grassland, 35% cropland, with the remaining 15% used for feedlots and urban and residential development. Gently rolling uplands, with hilly areas along the streams, characterize the topography with average annual rainfalls at 39 inches. The majority of the precipitation falls in late spring and early summer.

There is one TMDL developed by KDHE for Hillsdale Reservoir, eutrophication. Excess nutrient loading from the watershed creates conditions favorable for algae blooms and aquatic plant growth resulting in low dissolved oxygen rates and an unfavorable habitat for aquatic life. Eutrophication from nitrogen and phosphorous is mostly due to runoff from agricultural lands, animal waste runoff from confined animal feeding operations and septic systems situated near the lake. According to modeling done by Kansas State University and the Hillsdale Water Quality Project, Big Bull Creek contributes 40 - 50% of the nonpoint source pollutants while Little Bull Creek contributes only 25% of the nonpoint source pollutants (KDHE, 2001). Agricultural producers in the watershed implement best management practices (known as BMPs) to prevent nutrient runoff. Some common BMPs include: the use of conservation tillage and cover crops, maintaining buffer strips along field edges and proper timing of fertilizer application (Nejadheshemi, 2009). In order to improve the trophic condition of the lake from its current fully eutrophic status, the desired endpoint will be summer chlorophyll a concentrations at or below 12 ug/l (KDHE, 2001).

In 2011, the KWO performed a GIS based analysis of streambank erosion and riparian condition in the Hillsdale Reservoir watershed. A total of 11 streambank erosion sites, covering 6,965 feet of unstable streambank were identified through the assessment, with 73% of the unstable streambanks identified as having poor riparian condition (Figure 10). The assessment also identified estimates totaling approximately 1,073 tons of sediment being transported from the streambank erosion sites annually. Assuming a bulk density of 40 lbs/cubic foot sediment in Hillsdale Reservoir; streambank sources account for only 1.2 of the 166 acre-feet (1%) of sediment annually deposited in Hillsdale Reservoir. Based on estimated stabilization costs of $71.50 per linear foot from an assessment conducted by TWI, streambank stabilization for the entire watershed from the 2011 assessment would cost approximately $76,700. Of these 11 sites identified, six sites were selected, spread throughout the watershed, for field verification and streambank height measurements. Measurements were used to estimate the amount of sediment originating from streambank sites.

The majority of the 1,073 tons of sediment is transported each year from Bull Creek and Rock Creek; contributing approximately 395 and 382 tons of sedimentation annually, respectively. Bull Creek accounts for an estimated 37% of the total stabilization cost needs in the watershed totaling $28,200, while Rock Creek accounts for 36% of the total stabilization cost needs in the watershed totaling $27,300.

Several streambank gully erosion problems in areas adjacent to the stream reaches were identified through the streambank erosion assessment. The assessment of streambank gullies in the Hillsdale Reservoir watershed concluded seven total gullies alongside streambanks, four in croplands and three in grasslands; all demonstrated identifications of high priority gullies but were still in the beginning stages of headcutting. Locations of gullies included one in the upper headwaters of Bull Creek, three located on Wade Creek and three located on Scott Creek. Both Wade and Scott Creek are located in the southwestern portion of Hillsdale Reservoir watershed.

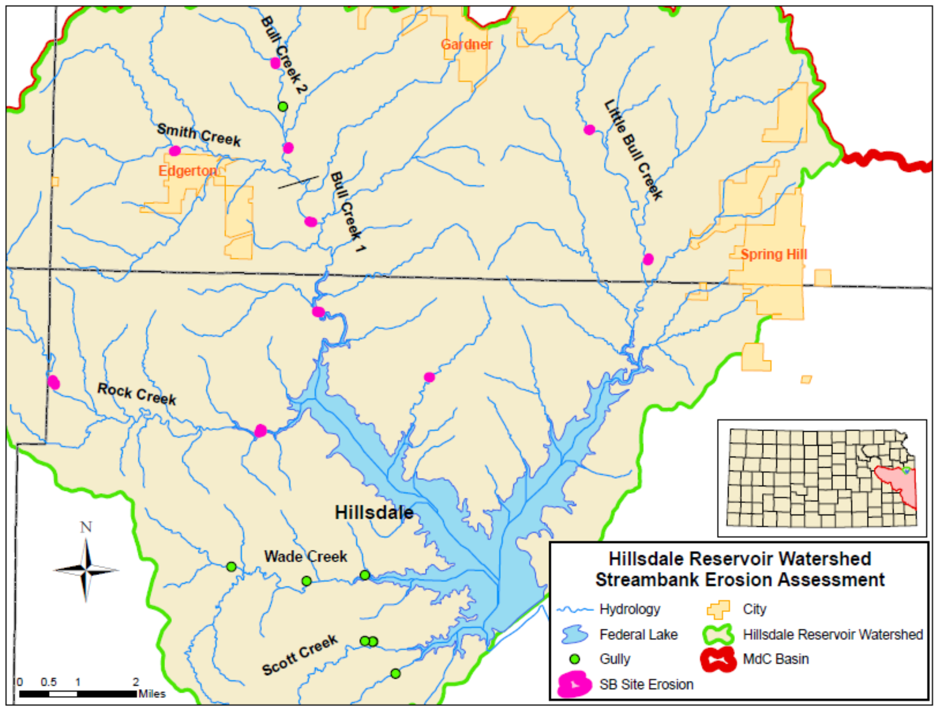

Figure 10. Hillsdale Reservoir Watershed Streambank Erosion Assessment Map

Marmaton River

The Marmaton Watershed is located in the Marais des Cygnes River basin. In Missouri, the Marmaton River flows into the Little Osage River and the Little Osage River joins the Marais des Cygnes River to create the Osage River. This river eventually flows into the Missouri River in eastern Missouri. The entire Marmaton Watershed drains the Marmaton River and its tributaries in Kansas and Missouri. However, this assessment only focused on the portion of the Marmaton Watershed that includes the Marmaton River and its tributaries upstream of the Kansas border to the confluence of the Marmaton River with Paint Creek in central Bourbon County.

Land use in the Marmaton Watershed consists mainly of grasslands at 49%, with croplands at 40%, woodlands at 9% and the rest of the land use in urban development at 1%. Surface water use in the watershed is generally used for aquatic life support, domestic water supply, recreation, groundwater recharge, industrial water supply, irrigation and livestock watering. Rainfall in the watershed averages 42 inches annually with the high intensity rainfall events occurring in late spring and early summer when cropland is either bare, in the early stages of biomass growth or has residual biomass from harvest.

The KDHE currently has two TMDLs developed for the Marmaton River, dissolved oxygen (DO) and nutrients and oxygen demand impact on aquatic life. The KDHE has set a required load reduction goal for Biochemical Oxygen Demand (BOD) concentrations to remain below 2.9 mg/l. This desired endpoint should improve DO concentrations. The KDHE has also set a required load reduction goal for phosphorus at 4,380 lbs, nitrogen at 18,980 lbs and sediment at 840 tons for the Marmaton River Nutrient and Oxygen Demand TMDL originating from nonpoint sources.

In 2011, the KWO performed a GIS based analysis of streambank erosion and riparian condition in the Marmaton watershed upstream of the Kansas border to the confluence of the Marmaton River with Paint Creek in central Bourbon County. A total of seven streambank erosion sites, covering 3,445 feet of unstable streambank were identified through the assessment, with 57% of the unstable streambanks identified as having poor riparian condition. The assessment also identified estimates totaling approximately 1,239 tons of sediment being transported from the streambank erosion sites annually. Based on estimated stabilization costs of $71.50 per linear foot from an assessment conducted by TWI, streambank stabilization for the entire watershed from the 2011 assessment would cost approximately $246,300. Of these seven sites identified, three sites were selected, spread throughout the watershed, for field verification and streambank height measurements. Measurements were used to estimate the amount of sediment originating from streambank sites.

Figure 11. KAWS Level 1 Assessment of the Marmaton River - Photo of an unstable streambank on the Marmaton River

Of the 1,239 tons of sediment is transported each year from the Marmaton River (Figure 11) and Mill Creek; each contributes approximately 729 and 510 tons of sedimentation annually, respectively. The Marmaton River accounts for an estimated 52% of the total stabilization cost needs in the watershed totaling $126,900, while Mill Creek accounts for 48% of the total stabilization cost needs in the watershed totaling $119,400.

A streambank gully assessment found no clear indication of streambank gullies within the assessment area.

For the Marais des Cygnes River basin watersheds above Melvern, Pomona and Hillsdale Reservoirs, along with a portion of the Marmaton Watershed, KWO continues to recommend streambank stabilization/riparian restoration projects as an effective method of reducing sediment delivery to these reservoirs from streambank sources. Continued land treatment as described in WRAPS plans and streambank protection with buffers is recommended for all three reservoirs and the Marmaton River watershed. Additional evaluations of gullies are needed to determine the magnitude of sediment contribution from these sources.

Recommendation: Continue efforts to prevent the spread of Zebra mussels from infected water bodies.

Zebra mussels were confirmed in Melvern Reservoir in July 2011. This is the first reservoir in the Marais des Cygnes basin to be infested. However, infestations downstream of Melvern Reservoir are inevitable.

Zebra mussels have invaded Kansas lakes and streams and expanded populations continue to be discovered in Kansas aquatic environments. They are not only detrimental to native species in Kansas; they also cause problems for recreational activities, such as boating and fishing, municipal and industrial users and even agricultural producers. The negative impacts, background, and policy recommendations to manage Zebra mussels can be found in the Kansas Water Plan Aquatic Nuisance Species Management Policy.

Recommendation: Continue public outreach efforts to educate the public and landowners about the benefits of best management practices. Encourage other agencies and entities in partnerships and participation to support WRAPS initiatives, activities, and funding.

Local Authorities for Water Quality Management

The 2010 census projections were reviewed in May 2011 and found that Anderson, Franklin, and Linn Counties were experiencing growth greater than that projected in 2006, but projected growth in Miami and Osage counties, was less than previously expected in the 2006 projections. Even with the adjustment to

Miami County from the 2010 census, it continues to trend as the county with the greatest growth in population for the basin. While no substantial unexpected growth is occurring in the basin, those communities experiencing growth and expansion will have an increase in impervious areas. As the amount of impervious surface in a watershed (i.e. rooftops, roads, parking lots, etc.) increases, water resources can be adversely impacted from increases in runoff volume and additional pollutants associated with urban environments, unless efforts are made by local governments and urban residents to minimize these adverse impacts through sound land use planning and stormwater management.

Local land use planning and zoning authorities provide cities and counties effective tools to minimize the potential impacts of development on water resources. Urban stormwater management programs can be implemented to manage the amount of impervious surface in urbanizing watersheds and properly control increased runoff resulting from urbanization. Programs that provide technical assistance and education to urban residents regarding actions that can reduce or eliminate potential pollution sources also play an important role. These programs can be integrated with WRAPS projects to ensure a comprehensive approach to watershed management in urban areas.

An important consideration for watershed restoration and protection in the basin will be the potential for conversion of Conservation Reserve Program (CRP) acreage back to production agriculture as contracts expire. One thousand three hundred eight contracts on 59,930.7 acres enrolled in the 13 Kansas counties contained wholly or partly in the Marais des Cygnes basin expired on September 30, 2007. If land is taken out of permanent grass cover, implementation of best management practices will be needed to minimize potential adverse impacts to water resources within the basin.

Recommendation: Complete an inventory and assessment of gullies and salt scars in the basin, with priority in the federal reservoir watersheds, to determine their contribution to sediment in those watersheds.

Erosion sites that were identified in the streambank assessment were limited to locations of streambank erosion and did not include gullies, salt scars, or other landscape level sources. No specific attempt was made to locate and characterize gullies within these watersheds during the desktop assessment.

However, when completing field measurements of identified streambank hotspots, numerous gullies were found adjacent to streams. It is likely that gullies are also a substantial source of sediment in these watersheds and therefore additional efforts are needed to quantify their contribution.

Other Watershed Related Activities

- The 13 counties either wholly or partly within the basin have adopted local sanitary/environmental codes or participate in the Local Environmental Protection Program.
- All counties have countywide planning and zoning programs.
- All conservation districts in the basin have adopted nonpoint source pollution management plans. Grants under the State Water Quality Buffer Initiative have also been awarded in nine counties in the basin supporting buffer coordinators and facilitating enrollment of stream buffers in continuous CRP.
- Of cities in the basin, only Ottawa is subject to the Phase II Permitted Municipal Separate Storm Sewer System under the NPDES Stormwater Program.
- As of December 2010, there were two active contamination sites being remediated through the *State Water Plan (*Contamination Remediation Program).
- There are eight organized watershed districts in the basin.

RECOMMENDED ACTIONS

1. Continue work with stakeholder leadership groups to incorporate TMDL implementation, nutrient and sediment reduction, and urban stormwater management goals into applicable WRAPS projects.

2. Target technical and financial assistance programs for water quality protection and restoration to implement TMDLs and WRAPS action plans. Coordinate with development of Source Water Protection Plans. Complete development of nine element plans for all WRAPS documents.

3. Complete assessment projects with particular attention to streambank, riparian and wetland assessments to target resources. Encourage private landowner efforts to maintain riparian areas to prevent introduction of excess woody debris into the tributary and river system.

4. Continue efforts to prevent the spread of Zebra mussels from infected water bodies.

5. Continue public outreach efforts to educate the public and landowners about the benefits of best management practices. Encourage other agencies and entities in partnerships and participation to support WRAPS initiatives, activities and funding.

6. Complete an inventory and assessment of gullies and salt scars in the basin, with priority in the federal reservoir watersheds, to determine their contribution to sediment in those watersheds.

Resources

1. Kansas Water Office. 2009. *Kansas Water Plan Water Quality Policy and Institutional Framework Section, 2009*.

2. Kansas Department of Health and Environment, Bureau of Environmental Remediation. December 2010. *Basin Updates and Site Accomplishments. http://www.kdheks.gov/remedial/swp/download/SWP_Basin_Report_2010.pdf*

3. Kansas Department of Health and Environment, Bureau of Water. March, 2004. *Kansas Source Water Assessment Report*. www.kdheks.gov/nps/swap

4. Kansas Department of Health and Environment, Bureau of Water. 2007. *Kansas Watershed Restoration and Protection Strategy*. www.kdheks.gov/nps/wraps

5. Kansas Department of Health and Environment, Bureau of Water. December 2004. *Surface Water Nutrient Reduction Plan*, www.kdheks.gov/water

6. Kansas Department of Health and Environment, Bureau of Water. 2007. *Watershed Planning and TMDL Program*. Accessed Jan. 2008. www.kdheks.gov/tmdl

7. USDA Farm Service Agency. 2007. *Summary of Active and Expiring CRP Cropland Acres by County*. Accessed Jan. 2008. www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=crt

8. Kansas Department of Health and Environment TMDL website accessed Jan. 2008. http://www.kdheks.gov/tmdl/index.htm .