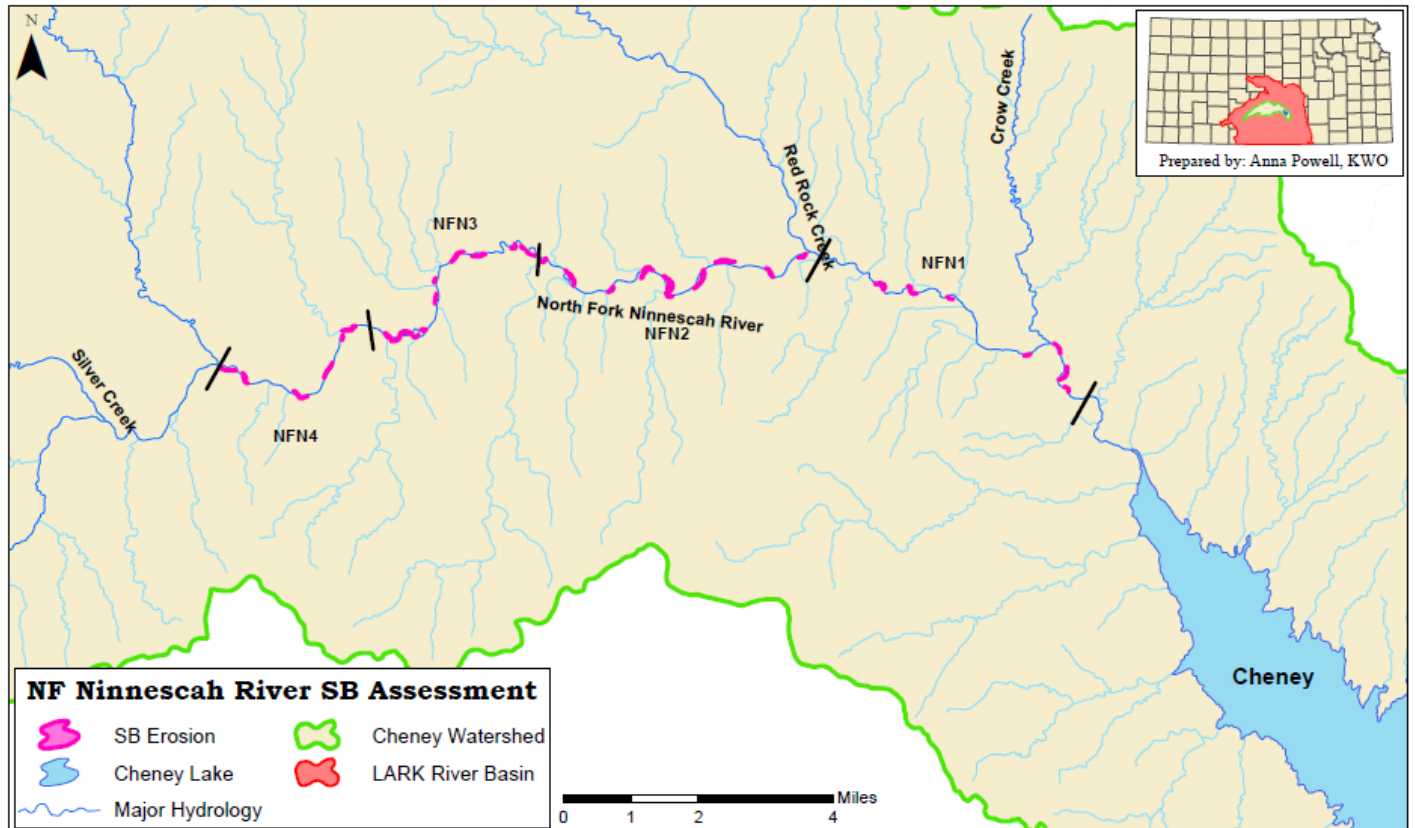


MAINSTEM NORTH FORK NINNESCAH RIVER STREAMBANK EROSION ASSESSMENT

ArcGIS® Comparison Study: 1991 vs. 2008 Aerial Photography

DRAFT: April 2011



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Executive Summary

Federal reservoirs are an important source of water supply in Kansas for approximately two-thirds of Kansas' citizens. The ability of a reservoir to store water over time is diminished as the capacity is reduced through sedimentation. In some cases reservoirs are filling with sediment faster than anticipated. Whether sediment is filling the reservoir on or ahead of schedule, it is beneficial to take efforts to reduce sedimentation to extend the life of the reservoir.

The Kansas Water Authority has established a *Reservoir Sustainability Initiative* that seeks to integrate all aspects of reservoir input, operations and outputs into an operational plan for each reservoir to ensure water supply storage availability long into the future. Reduction of sediment input is part of this initiative.

The Mainstem North Fork Ninescah River Assessment, an ArcGIS® Comparison Study, was initiated to partially implement the *Reservoir Sustainability Initiative*. This assessment identifies areas of streambank erosion to provide a better understanding of the Cheney Lake Watershed for streambank restoration purposes and to increase understanding of streambank erosion to reduce excessive sedimentation in reservoirs across Kansas. The comparison study was designed to guide prioritization of streambank restoration by identifying reaches of streams where erosion is most severe in the watershed above Cheney Lake.

The Kansas Water Office (KWO) 2011 assessment quantifies annual tons of sediment eroding from the mainstem North Fork Ninescah River over a 17 year period between 1991 and 2008 within the Cheney Lake Watershed in Kansas. A total of 41 streambank erosion sites were identified, covering 33,336 feet of unstable streambank and transporting 34,740 tons of sediment downstream per year; accounting for roughly 35 acre-feet per year of sediment accumulation in Cheney Lake. It should be noted that the identified streambank erosion locations are only a portion of all streambank erosion occurrences in the watershed. Only those streambank erosion sites covering an area 1,500 sq. feet, or more, were identified. Streambank erosion sites were analyzed by stream reach and six 12-digit Hydrologic Unit Codes (HUC12). A substantial quantity of the identified eroded sediment in the watershed is transported annually from the mainstem North Fork Ninescah River reach two (NFN2) and North Fork Ninescah River reach three (NFN3); at roughly 17,927 and 7,640 tons annually, respectively. These identified reaches account for an estimated 74 percent or \$1.5 million of total stabilization cost needs in the watershed. Results by HUC12 identified 11030014303 as the most active hydrologic unit code for streambank degradation, accounting for 14,960 feet of unstable streambank, 20,897 tons of sediment per year, and 42 percent of total stabilization costs. Based on the average stabilization costs of \$71.50 per linear foot, conducting streambank stabilization practices for the entire watershed would cost approximately \$2.5 million.

The KWO completed this assessment for the Cheney Lake Watershed Restoration and Protection Strategy (WRAPS) Stakeholder Leadership Team (SLT). Information contained in this assessment can be used by the Cheney Lake Watershed WRAPS SLT to target streambank stabilization and riparian restoration efforts toward high priority stream reaches or HUC12s in the Cheney Lake Watershed. Similar assessments are ongoing in selected watersheds above reservoirs throughout Kansas and are available on the KWO website at www.kwo.org, or may be made available upon request to agencies and interested parties for the benefit of streambank and riparian restoration projects.

Introduction

Wetlands 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. 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).

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 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 significant aggregation or degradation (Rosgen, 1997). Streams significantly impacted by land use changes in their watersheds or by modifications to streambeds 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. Many streams in Kansas are incised (SCC, 1999).

Streambank erosion is often a symptom of a larger, more complex problem requiring solutions that may 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.

Additional 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. Forested riparian areas are superior to grassland in holding banks during high flows, when most sediment is transported. When riparian vegetation is changed from woody species to annual grasses and/or forbs, sub-surface internal strength is weakened, causing acceleration of mass wasting processes (extensive sedimentation due to sub-surface instability) (EPA, 2008). The primary threats to wetlands and forested riparian areas are agricultural production and suburban/urban development.

Study Area

Cheney Lake Watershed covers 633,000 acres, 933 sq-miles, which drain into Cheney Lake via the North Fork Ninescah River (Figure 1). Cheney Lake was constructed at the lower, east end of the North Fork Ninescah River between 1962 and 1965 by the Bureau of Reclamation, providing a reliable municipal water supply system for the City of Wichita, wildlife habitat, recreational opportunities and downstream flood control. The original conservation-pool storage of the lake was roughly 152,000 acre-ft, with an additional flood-control capacity of about 81,000 acre-ft. As of 1998, sediment had filled 27 percent of the lake's conservation pool (Mau, 2001). The North Fork Ninescah River is the major source of inflow to Cheney Lake, contributing 70 percent of the water flowing into the Lake. The lake currently supplies 60 to 70 percent of Wichita's daily water supply (Christensen, 2006).

Cheney Lake watershed encompasses land in five counties including Sedgwick, Reno, Kingman, Pratt, and Stafford, with the majority in Reno County. Six twelve-digit hydrologic unit codes (HUC12s) lie within the study area (Figure 2). Land use is predominantly agricultural (greater than 98 percent) and consists mainly of pasture and cropland. Crops produced on 72 percent of the land area include corn, grain sorghum, soybeans and wheat (KSU, 2008). Topography in the Cheney Lake watershed ranges from flat to gently sloping hills. Soils in the watershed generally are classified as clayey loam on the uplands to sand or sandy loam in low-lying areas or where slopes are less than about three percent. Many of the soils in the watershed are subject to erosion by wind and rainfall runoff.

Figure 1: Cheney Lake Watershed Assessment Area

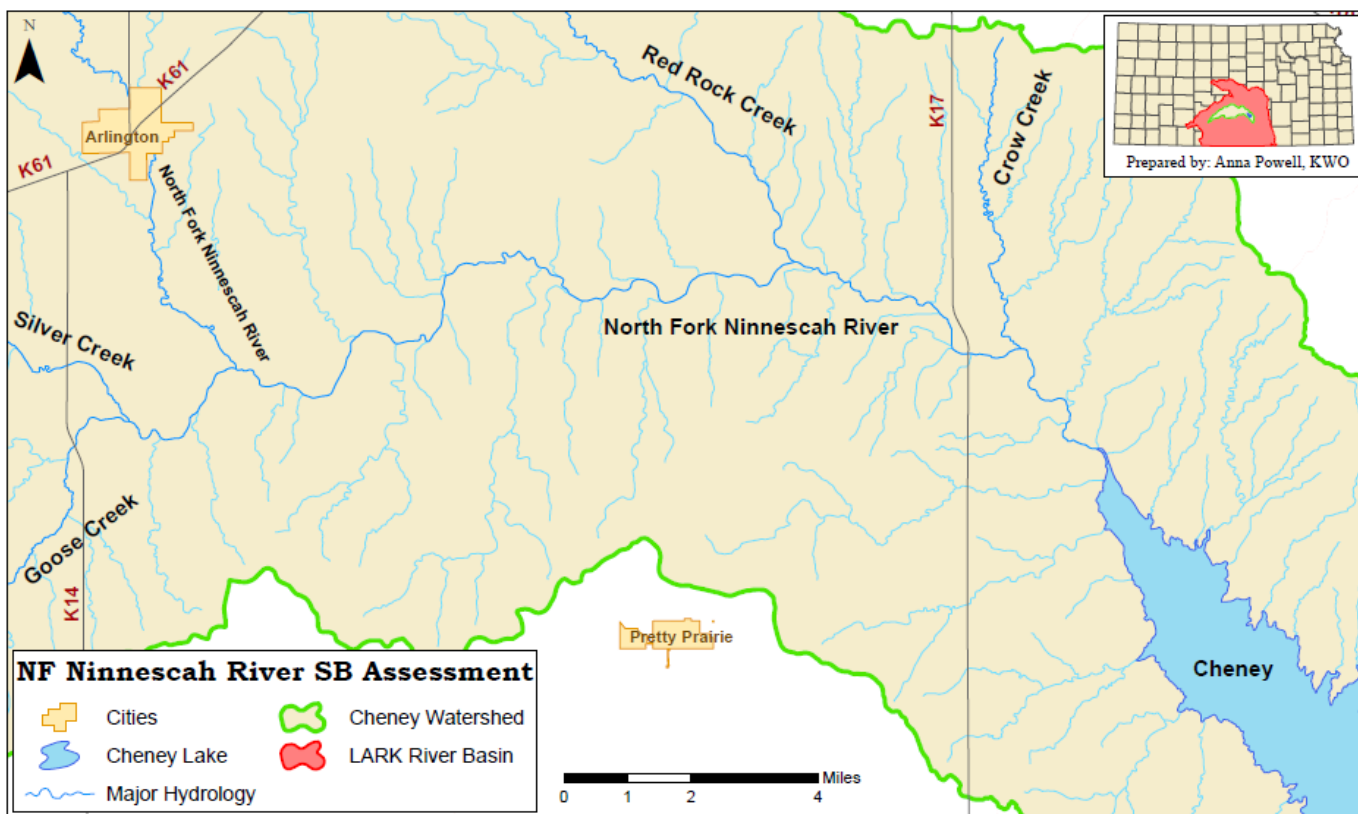
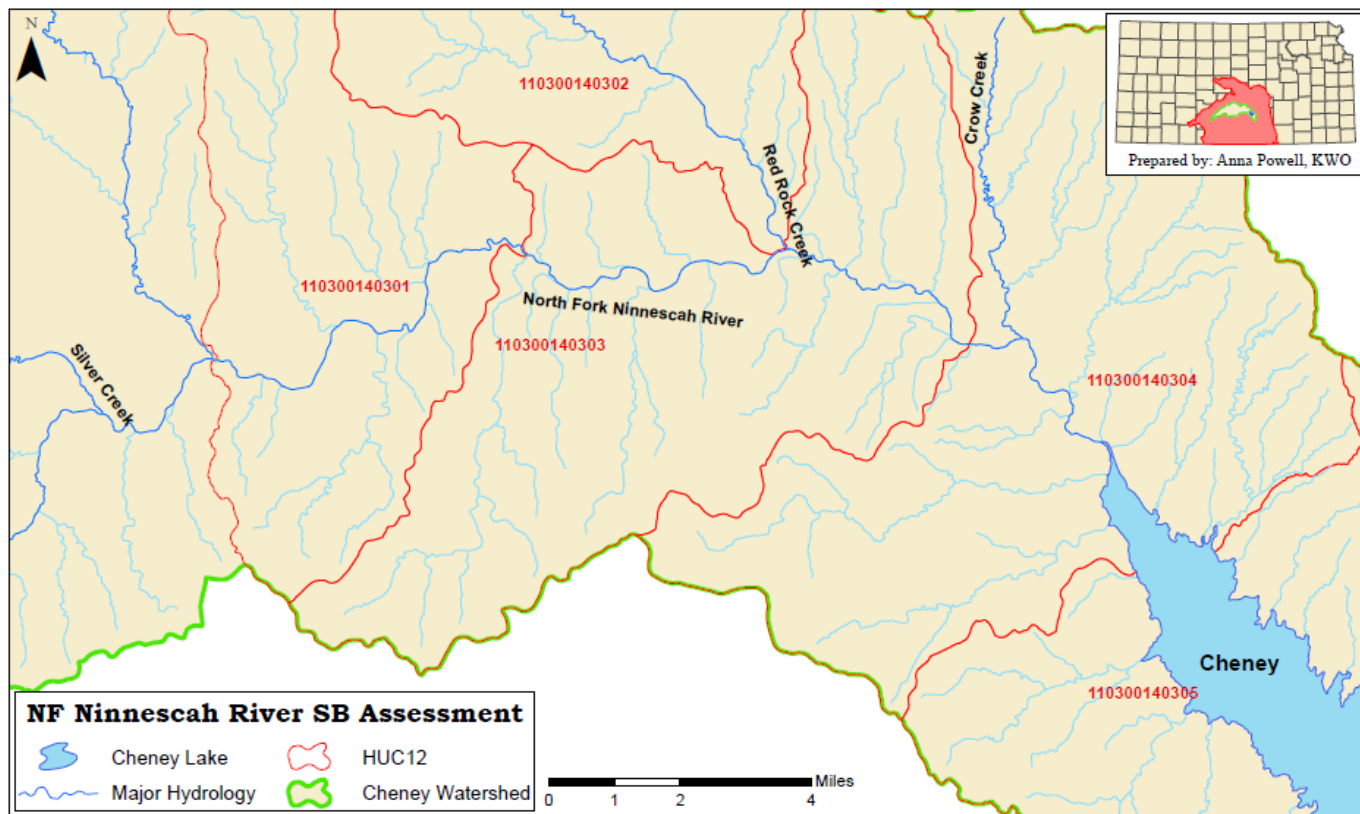


Figure 2: Cheney Lake Watershed Assessment Area HUC12s

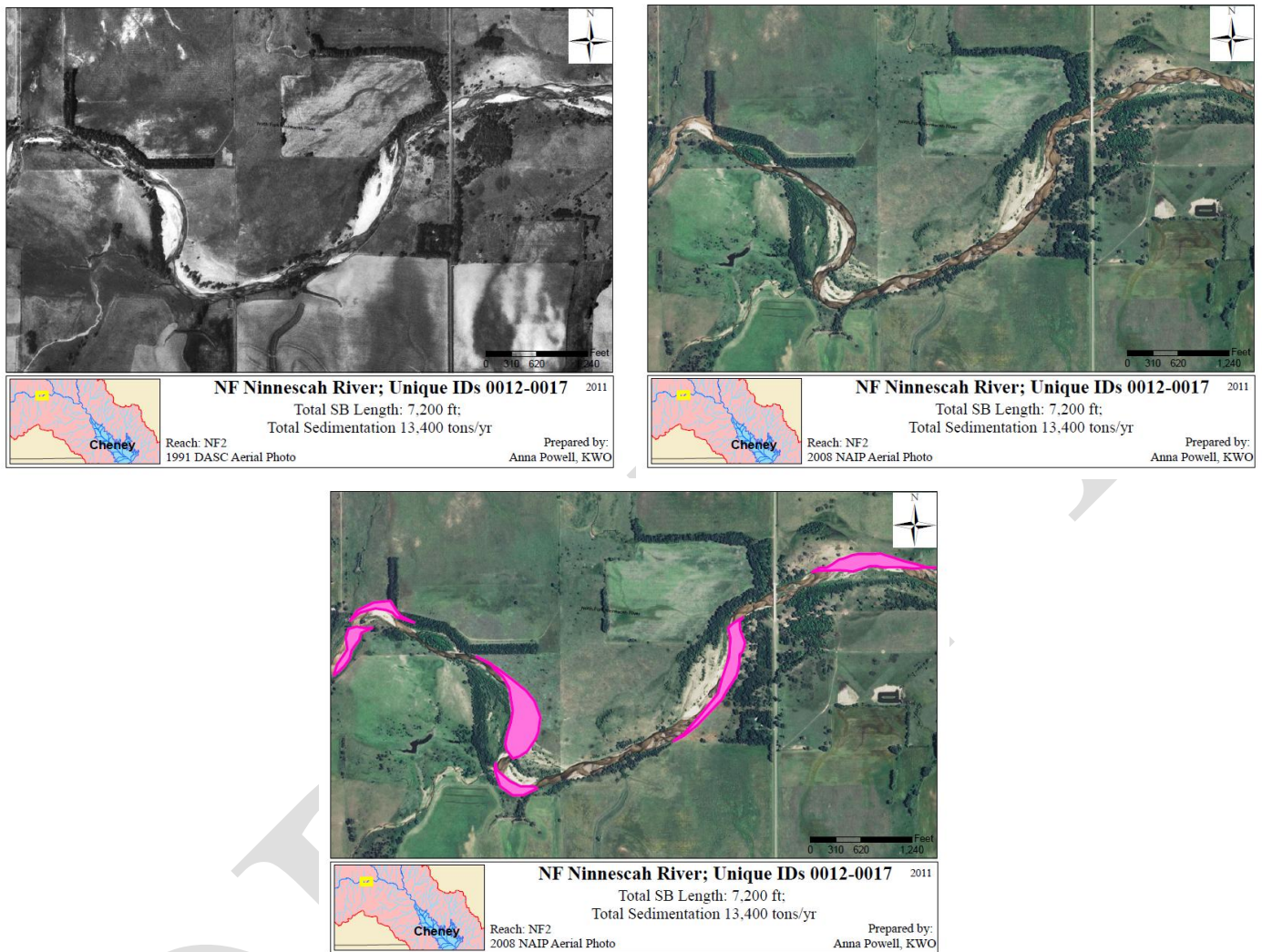


Data Collection Methodology

The Mainstem North Fork Ninescah River streambank erosion assessment was performed using ArcGIS® software. The purpose of the assessment is to identify locations of streambank instability to prioritize restoration needs and slow sedimentation rates on the Mainstem North Fork Ninescah River. ArcMap®, 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 photography, provided by the State of Kansas GIS Data Access & Support Center (DASC).

The streambank erosion assessment was performed by overlaying 2008 NAIP county aerial imagery onto 1991 DASC county aerial imagery (Figure 3). Using ArcMap® tools, “aggressive movement” of the streambank between 1991DASC 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 DASC and 2008 NAIP aerial photos. Streambank erosion sites were denoted by geographic polygons features “drawn” into the ArcGIS® software program through the ArcMap® editor tool. 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 the geographic polygon sites include: watershed location, unique ID, stream name, type of stream and type of riparian vegetation.

Figure 3: 1991 DASC & 2008 NAIP of a Streambank Erosion Site



The streambank erosion assessment data also includes approximations of tons of soil loss from the erosion site. This portion of the assessment is performed by utilizing the identified erosion site polygon features. Tons of soil loss was estimated by incorporating perimeter, area and streambank length of the polygons into a regression equation. Perimeter and area were calculated through the *field calculator* application within the ArcGIS® software. The streambank length of identified erosion sites was computed through the application of a regression equation formulated by the KWO office. 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 = .999) is $([Area_SqFt]*-.00067) + ([Perimtr_ft]*.5089609)$. The intercept of the model was forced to zero.

Tons of soil loss was estimated by first calculating the volume of sediment loss and then applying a bulk density estimate to that volume for the typical soil type of identified sites. The volume of sediment was found by multiplying bank height

and surface area lost over the 17 year period between the 1991 and 2008 aerial photos 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 (Avg Soil Loss Rate(Tons/yr)=[Area_SqFt]*[BankHgtFt]*SoilDensity(lbs/ft³)/2000(lbs/ton)/([NAIP_ComparisonPhotoYear]-[BaseAerialPhotoYear])).

To complete the analysis for the equation above for tons of soil lost, streambank height measurements of select identified erosion sites were needed. Streambank height measurements were obtained from a USDA-Natural Resources Conservation Service assessment, Mainstem North Fork Ninescah River Streambank Erosion Analysis. Based on this work, streambank heights were available from several surveyed locations on the Mainstem North Fork Ninescah River. These locations were the basis for extrapolating streambank height measurements on the Mainstem North Fork Ninescah River.

Analysis

To adequately analyze streambank erosion sites, stream reach sections were delineated to better accommodate streambank rehabilitation project focus. Streambank erosion prioritization by stream reach sections include: NFN1, NFN2, NFN3 and NFN4 (Figure 4). Stream reach sections were identified by the stream name and in numerical order from downstream to upstream. Streambank erosion sites were also analyzed by six 12-digit Hydrologic Unit Codes (HUC12s) (Figure 5). Streambank erosion sites were analyzed for: streambank length (feet) of the eroded bank; annual soil loss (tons); percent of streambank length with poor riparian condition (riparian area identified as having cropland or grass/crop streamside vegetation); estimated sediment reduction through the implementation of streambank stabilization 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*; \$71.50 per linear foot was used to calculate average streambank stabilization costs (Figure 6).

Figure 4: Mainstem North Fork Ninescah River Streambank Assessment by Stream Reach

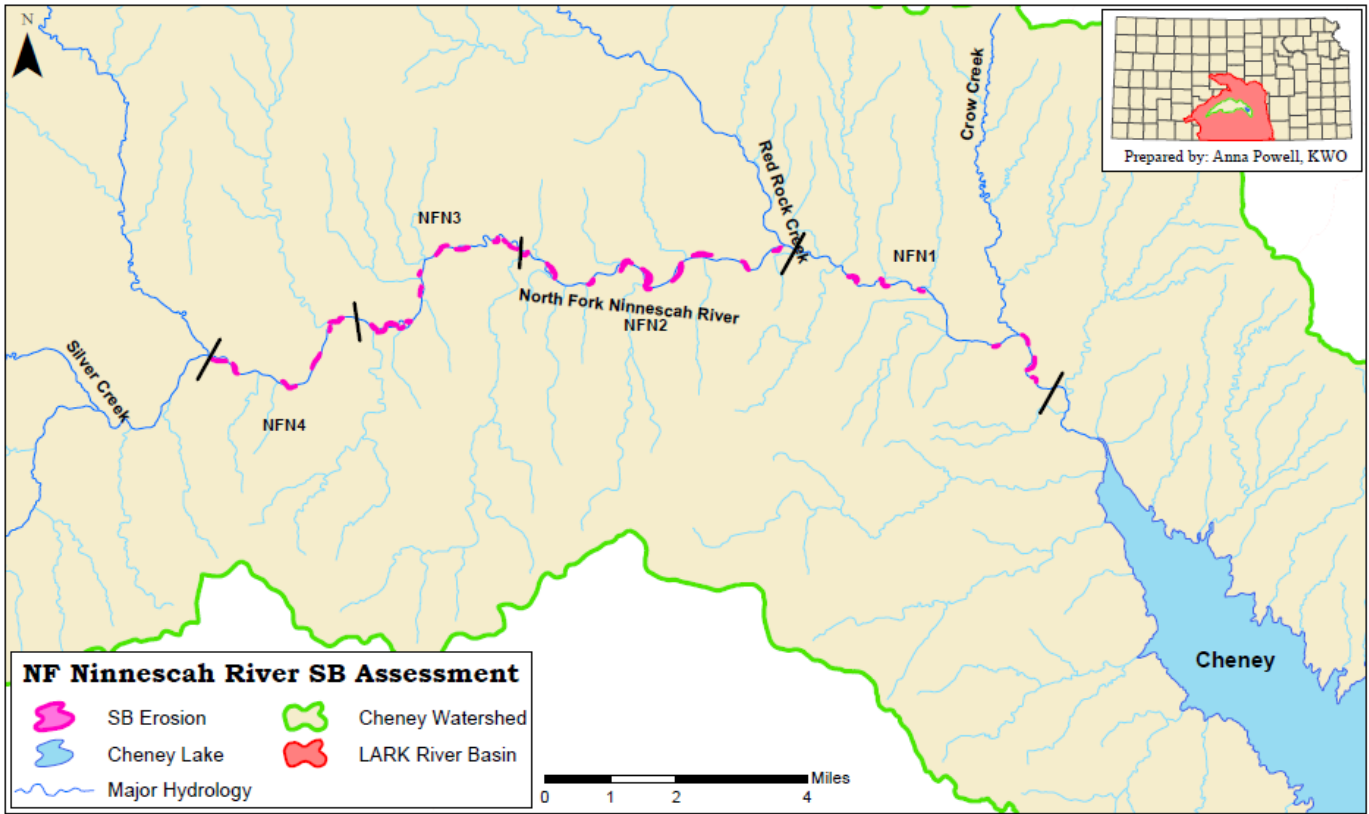


Figure 5: Mainstem North Fork Ninescah River Streambank Assessment by HUC12

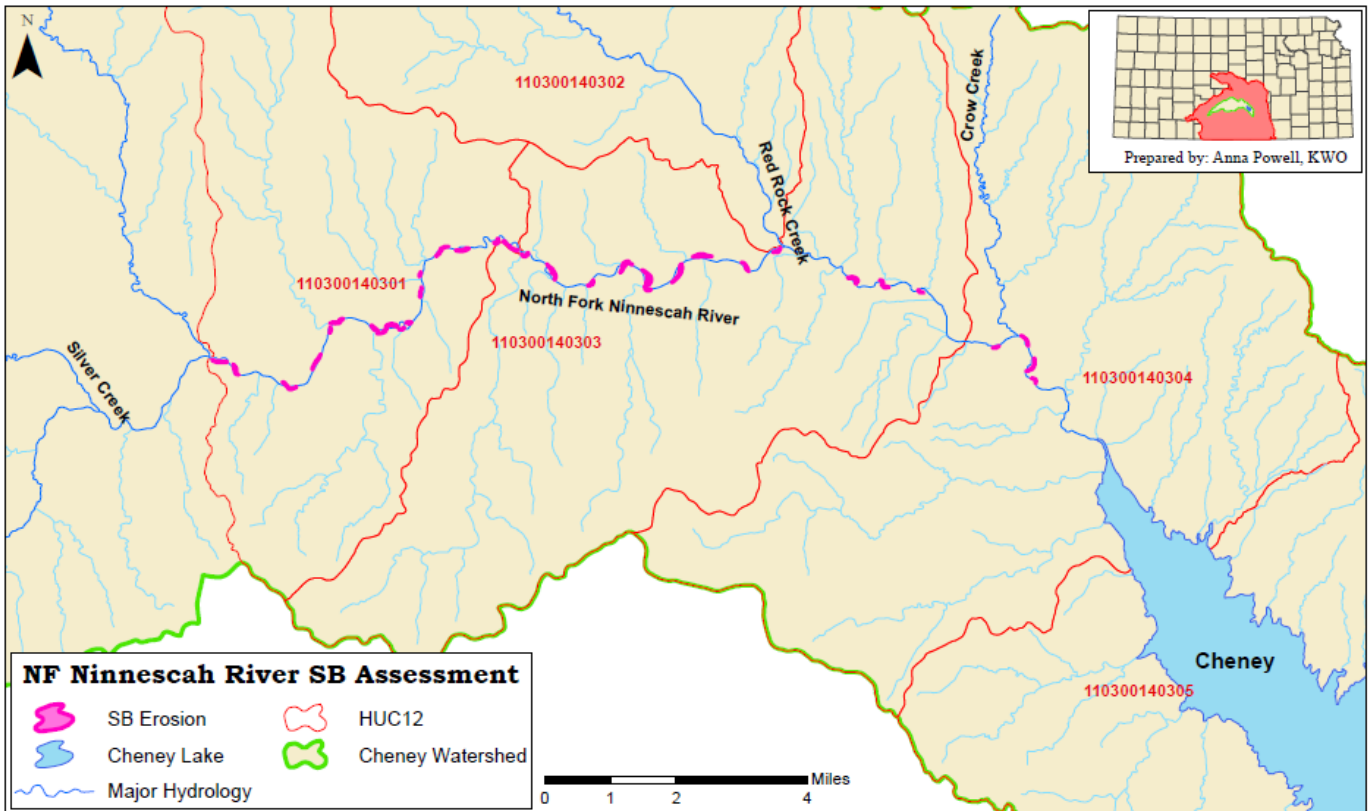


Figure 6: TWI Estimated Costs to Implement Streambank Stabilization BMPs

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

Results

The KWO 2011 assessment quantifies annual tons of sedimentation from streambank erosion between 1991 and 2008 on the Mainstem North Fork Ninescah River within the Cheney Lake Watershed. A total of 41 streambank erosion sites, covering 35,336 feet of unstable streambank were identified and 87 percent of the unstable streambanks were identified as having poor riparian condition (riparian area identified as having cropland or grass/crop streamside vegetation). Sediment transport from identified streambank erosion sites accounts for 34,740 tons of sediment per year transported from the Mainstem North Fork Ninescah River streams to Cheney Lake annually; accounting for roughly 35 acre-feet per year of sediment accumulation in Cheney Lake.

A substantial quantity of the identified eroded sediment in the watershed is transported annually from the mainstem North Fork Ninescah reach two (NFN2) at roughly 17,927 tons annually, and from mainstem North Fork Ninescah reach three (NFN3) at roughly 7,640 tons annually (Table 1 & Figure 7). These identified reaches account for an estimated 74 percent or \$1.5 million of total stabilization cost needs in the watershed. Results by HUC12 identified 11030014303 (HUC12 (303)) as the most active HUC12 for streambank degradation, accounting for 14,960 ft of unstable streambank and 20,897 tons of sediment per year (Table 2 & Figure 8). HUC12 (303) also accounted for roughly 42 percent of unstable streambank, 60 percent of sedimentation and 42 percent of total stabilization costs. Based on the average stabilization costs of \$71.50 per linear foot, conducting streambank stabilization practices for the mainstem North Fork Ninescah River would cost approximately \$2.5 (Table 1).

Additional concerns observed on the Mainstem North Fork Ninescah River visual assessment include rangeland gullies, extensive stream meandering and poor riparian conditions throughout the watershed. During the visual assessment, widespread rangeland gully erosion was found in the Crow Creek Watershed specifically and more generally throughout the watershed within one mile of streams. Extensive stream meandering was observed in Goose Creek Watershed and in the area of the Silver Creek and North Fork Ninescah River continuing upstream in a westward direction. Due to the

high erodibility of the sandy soils within streams in the Cheney Lake Watershed, meandering is extensive throughout the watershed causing a significant portion of the erosion and sedimentation in Cheney Lake.

Table 1: Mainstem North Fork Ninescah River Streambank Erosion Assessment Table by Stream Reach

STREAM REACH	SB LENGTH (FT)	SB SITE SED (T/YR)	STABIL. COST ESTIMATE	SB EROSION SITES (NO.)	YIELD LOSS/BANK LENGTH	POOR RIPARIAN COND/SB LENGTH (FT)	EST. SED REDUCTION (T/YR)	% SB LENGTH W/ POOR RIPARIAN COND.
NFN1	6891	5184	\$492,758	9	0.8	5753.61	4,406.99	83.49%
NFN2	11862	17927	\$848,162	11	1.5	9352.07	15,238.31	78.84%
NFN3	9429	7640	\$674,176	13	0.8	7522.67	6,494.45	79.78%
NFN4	7152	3987	\$511,433	8	0.6	6583.84	3,389.62	92.04%
TOTAL	35,336	34,740	\$2,526,530	41	3.6	29,212	-29,529	82.67%
Est Stabilization Cost/Linear Ft.			\$71.50	Stabilization/Restoration Efficiency			0.85	

Figure 7: Mainstem North Fork Ninescah River Streambank Erosion Assessment Graph by Stream Reach

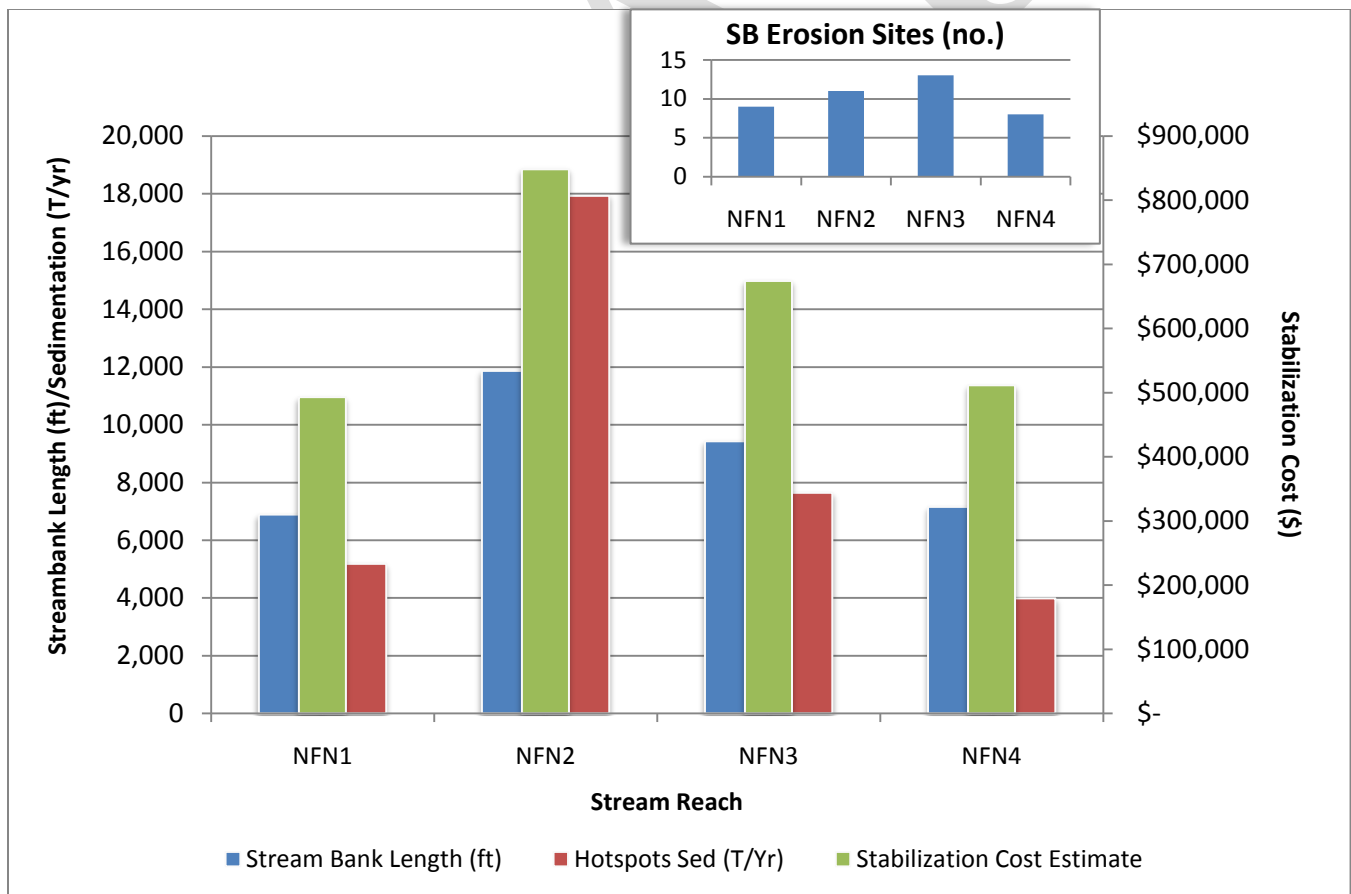
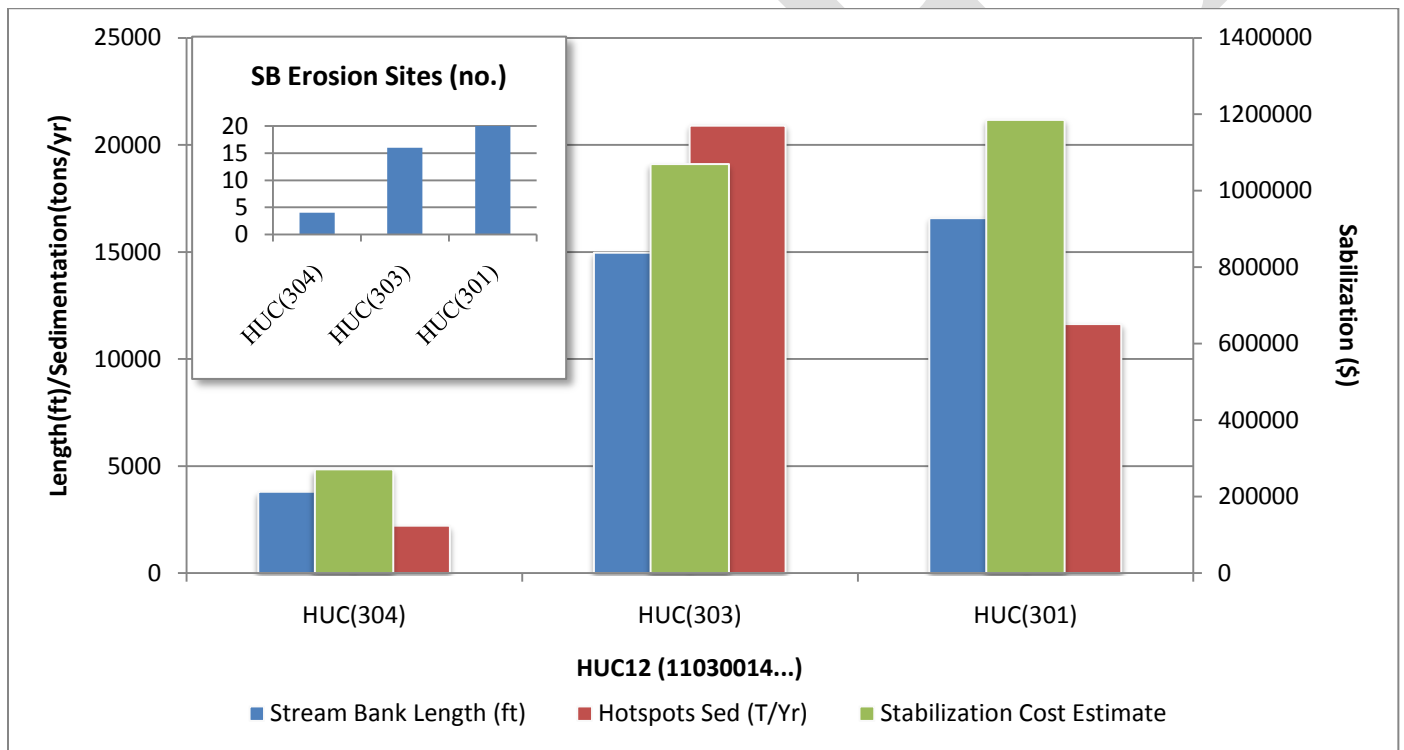


Table 2: Mainstem North Fork Ninescah River Streambank Erosion Assessment Table by HUC12

REACH HUC12 (11030014...)	SB LENGTH (FT)	SB SITE SED (T/YR)	STABIL. COST ESTIMATE	SB EROSION SITES (NO.)	YIELD LOSS/ BANK LENGTH	POOR RIPARIAN COND/SB LENGTH (FT)	EST. SED REDUCTION (T/YR)	% SB LENGTH W/ POOR RIPARIAN COND.
HUC(304)	3,794	22,15	\$271,270	4	0.6	3120	1883	82.23%
HUC(303)	14,960	20,897	\$1,069,650	16	1.4	11986	17763	80.12%
HUC(301)	16,582	11,628	\$1,185,609	21	0.7	15583	9884	93.98%
TOTAL	35,336	34,740	\$2,526,530	41	2.7	30,689	-617,082,421	86.85%
Est Stabilization Cost/Linear Ft.			\$71.50	Stabilization/Restoration Efficiency			0.85	

Figure 8: Mainstem North Fork Ninescah River Streambank Erosion Assessment Graph by HUC12



Conclusion

The KWO completed this assessment for the Cheney Lake Watershed Restoration and Protection Strategy (WRAPS) Stakeholder Leadership Team (SLT). The Draft and Final report will be submitted for internal review at KWO. After internal review, the Draft and Final Report will be submitted to the Cheney Lake WRAPS SLT. Information contained in the assessment can be used by the Cheney Lake WRAPS SLT to target streambank stabilization and riparian restoration efforts toward high priority stream reaches on the mainstem North Fork Ninescah River within Cheney Lake Watershed.

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