US Army Corps
of Engineers
St. Louis District

TECHNICAL REPORT M30

BANK EROSION AND HISTORICAL RIVER MORPHOLOGY STUDY OF THE KASKASKIA RIVER

LAKE SHELBYVILLE SPILLWAY TO UPPER END OF CARYLE LAKE

By
Robert D. Davinroy
Michael T. Rodgers
Edward J. Brauer
Dawn M. Lamm

U.S. ARMY CORPS OF ENGINEERS
ST. LOUIS DISTRICT
HYDROLOGIC AND HYDRAULICS BRANCH
APPLIED RIVER ENGINEERING CENTER
FOOT OF ARSENAL STREET
ST. LOUIS, MO 63118

Prepared for:

U.S. Army Corps of Engineers, St. Louis District
and Illinois Department of Natural Resources

In Cooperation with:

Fayette County Soil and Water Conservation District
and Concerned Citizens and Landowners along the Kaskaskia River

Final Report

January 2003

APPLIED
RIVER
ENGINEERING CENTER

Technical Report M30

BANK EROSION AND HISTORICAL RIVER MORPHOLOGY STUDY OF THE KASKASKIA RIVER

LAKE SHELBYVILLE SPILLWAY TO UPPER END OF CARYLE LAKE

By
Robert D. Davinroy
Mike T. Rodgers
Edward J. Brauer
Dawn M. Lamm

U.S. Army Corps of Engineers
St. Louis District
Hydrologic and Hydraulics Branch
Applied River Engineering Center
Foot of Arsenal Street
St. Louis, MO 63118

Prepared for:

U.S. Army Corps of Engineers, St. Louis District
And Illinois Department of Natural Resources

In Cooperation with:

Fayette County Soil and Water Conservation District
And Concerned Citizens and Landowners along the Kaskaskia River

Final Report
January 2003

INTRODUCTION

A bank erosion and historical river morphology study of the Kaskaskia River, between Lake Shelbyville and Lake Carlyle, was conducted by the U.S. Army Corps of Engineers, St. Louis District, and co-sponsored by the Illinois Department of Natural Resources. The study transpired between the period June 2001 and Dec 2002 and was prepared by Mr. Robert Davinroy, District Potamologist, Mr. Michael Rodgers, Hydraulic Engineer, Ms. Dawn Lamm, Hydraulic Engineer, and Mr. Edward Brauer, Hydraulic Engineering Intern.

Other Corps personnel involved in the study included Ms. Deanne Strauser, Project Study Manager, Mr. Claude Strauser, Chief of the Hydrologic and Hydraulics Branch, Mr. Dave Busse, Chief of the Potamology Section, and Mr. Dennis Fenske, Project Manager for Strategic Initiatives. Information and technical assistance was also provided by Mr. Steve Redington, Civil Engineer, Mr. Dave Gordon, Hydraulic Engineer, Ms. Linda Campbell, Hydraulic Engineer, Ms. Joan Stemler, Hydraulic Engineering Technician, Mr. Greg Dyn, Civil Engineering Technician, Mr. Joe Schwenk, Chief of the Geotechnical Branch, Ms. Andrea Lewis, Manager at Lake Shelbyville, Mr. Steve Summers, Park Ranger at Lake Shelbyville, Mr. Bob Wilkens, Manager at Carlyle Lake, and Ms. Norma Hall, Park Ranger at Carlyle Lake.

Ms. Mary Ann Hoeffliger, NRCS-USDA District Conservationist, participated in several meetings and was instrumental in the acquisition of historical photos and the coordination of public meetings. Personnel from the Fayette County Soil and Water Conservation District who organized and participated in technical and public meetings, performed detailed land use computations, and assisted in the gathering and scanning of aerial photography included Mr. Tony Pals, Resource Conservationist, Ms. Chrissy Marley, GIS Specialist, Mr. Nelson Torbeck, Administrative Assistant, and Ms. Karen Sanders, Administrative Coordinator.

Personnel from the Illinois Department of Natural Resources attending meetings and providing input include Mr. Dan North, C2000 Ecosystem Program Administrator, Mr. Marvin Hubbell, Ecosystems Division Manager, and Mr. Randy Sauer, State Stream Biologist.

Special credit is given to Mr. Jim Harris, Carlyle Lake Association, for being instrumental in making the study a reality and for actively participating in both the initial coordination meetings and the public meetings that followed.

The primary goal of this report was to examine the extent of bank erosion on this particular stretch of the Kaskaskia River, determine the problem causes and factors, forecast future conditions, and develop possible remedial measures for erosion abatement or river restoration. This was not a simple task as it involved the study of many variables in the watershed, including climate, geology, hydrology, river morphology changes, historical land use changes, modifications to floodplain drainage, reservoirs, road and bridge construction, levees, river engineering, and sediment transport. This particular reach of the river has been influenced or impacted to some degree by a combination of all of the above factors.

The success of the study hinged upon a collaborative effort between the St. Louis District Corps of Engineers, the Illinois Department of Natural Resources, the Fayette County Soil and Water Conservation Service, the NRCS-USDA, the Carlyle Lake Association, and the many participating local citizens who live, farm, and recreate on the Kaskaskia River and the adjacent floodplain.

TABLE OF CONTENTS

STUDY REACH

Approximately 98 miles of the main channel of Kaskaskia River were analyzed in this study, from the spillway below Lake Shelbyville, Illinois to the upper end of Carlyle Lake, Illinois. Plate 1 is a vicinity and location map of the area. Plate 2 is a study reach map outlining the main river channel of the Kaskaskia River in 5-mile increments. For accurate analysis and ease of reference, river miles were labeled according to the position of the river in 1938, which at that time, was approximately 102 miles long. For comparative study purposes, these river miles were superimposed as section references to the river in 1966 and 1998. Thus, river miles as observed on the study reach map of Plate 2 are historical mileages and do not represent actual modern day distances. Mile 0.0 was located approximately 30 miles downstream of Vandalia, Illinois, along the upper northern sub-impoundment area of Carlyle Lake. Mile 102 was located near the spillway below Shelbyville Lake. It should be noted that because the river length and position has changed over the years. The original river-mile labeling system associated with the river gages and prior Corps of Engineers projects no longer represented actual river distances.

The study reach incorporated approximately 1,370,000 acres (2,140 sq. miles) of total drainage area. Plate 3 is a drainage basin map showing the Kaskaskia River study reach and all of its major tributaries. Primary tributaries included Hurricane Creek, Richland Creek, Robinson Creek, Hickory Creek, Ash Creek, Becks Creek, Big Creek, and Shady Run. The drainage area supplying runoff to the study reach covered 14 Illinois counties including Champaign, Piatt, Macon, Douglas, Coles, Christian, Effingham, Macoupin, Marion, Moultrie, Montgomery, Bond, Shelby, and Fayette.

BASIN GEOLOGY AND GENERAL STREAM AND RIVER CHARACTERISTICS

The basin geology within the study limits generally consists of flat to gently sloping glacial till plains crossed by low, broad end moraines. The highest elevation is 885 feet above sea level in Champaign County to 440 feet above sea level at the start of the study reach at Mile 0.0. Generally, most of the upland relief is not great, and water drainage along the upper end of the tributaries is poor. As a result, channelization (ditching) by private landowners has been performed to improve water drainage along the upper ends of many of the major tributaries and feeder creeks of the Kaskaskia River. This is discussed in more detail in the proceeding section.

The tributary streams flowing into the main stem of the Kaskaskia River generally flow in either a southwest or southeast direction. The streams can be characterized as gently sloping streams.   Field observation indicated that the riverbeds consist primarily of course to medium graded sands and gravels. There was also evidence of a fair amount of fine material in the form of sand, silt, and clay intermixed with the course material. The streambed was generally finer the closer the proximity to the mouth and confluence with the Kaskaskia River.

The main stem of the Kaskaskia River flows in a general southeast direction in a tortuous, meandering pattern. Bed samples and field observation indicated an abundance of silt, sand, and fine to medium graded gravels. The average slope of the Kaskaskia River in the study reach is approximately 1.5 feet per mile.

TRIBUTARY CHANNEL CONDITIONS

Upper Reaches.

As stated previously, the tributaries of the Kaskaskia River drain over relatively flat glacial till plains. From field observations, it was evident that most of the tributaries and feeder creeks in the upper one third of the sub basins had been channelized to improve drainage over these flat plains. This channelization has caused widespread deposition of fine material and development of new floodplains within the excavated drainage ditches. The deposition is a result of historical channel degradation or headcutting. Plates 4 through 6 are photos that illustrate examples of the upper reach channelization and associated deposition. These observations were recorded during repeated site visits to the basin.

The phenomenon of headcutting is complex. In simple terms, headcutting can be described as an underwater landslide or an immediate and pronounced downward shift in the stream or riverbed profile. The channel bottom profile deepens or scours because of a disruption in the flow or sediment balance of the river or stream. The scouring of the channel bottom translates along the stream in an upstream direction. This phenomena can be caused by a variety of natural or man-induced influences, including deepening or widening of the natural channel dimensions from channelization, and by changing the slope of the river from constructing channel cutoffs. Once headcutting is initiated, the headcut or “degradation” may migrate upstream for several miles above the point of disruption. As the river profile scours or degrades, the surrounding channel banks fail, and deposition within the channel results. A new, lower floodplain is also developed (Plate 5)

Middle Reaches.

In the middle reaches of the tributaries, there appeared to be moderate to substantial bank erosion along some tributaries. In some reaches, bank stabilization measures were applied, in other reaches they were not. Plates 7 through 9 illustrate typical bank erosion observed on middle reaches of tributaries. The channel bed in the middle reaches appeared to contain primarily fine silt, sand, and gravel.

Lower Reaches.

The lower one-third of most of the tributaries seemed to contain moderately erodible to highly stable banks. One apparent reason for the stability of the lower part of most of the tributaries was the fact that there was an abundance of large trees along the edge of the banks. The large root mass of the tree roots in relation to the relatively small size of the tributary channels (ranging from a few feet to approximately 20 to 30 feet in width), were clearly acting as stabilizing agents and training or maintaining the banks. With the exception of moderate bank erosion observed along the lower reach of Robinson Creek, minimal erosion was noted on the banks at the lower end of most other tributaries. Within the lower reaches of the tributaries, the bed material consisted primarily of fine silt, sand, and gravel.

MAIN CHANNEL CONDITIONS

Reconnaissance.

The present day condition of the main channel of the Kaskaskia River was accessed by conducting both aerial and “on the ground” reconnaissance. The river reach was inspected via helicopter reconnaissance on August 16 of 2001. Flow conditions were 220 cfs at Shelbyville, Ill. During the reconnaissance, several landowners were met at various points along the river to discuss individual erosion problems.

In addition, field recon trips were conducted in 2001 and 2002 by Corps personnel. During some of these trips, interested landowners were met individually to discuss site-specific problems. Moderate to substantial bank erosion, channel blockages from thousands of downed trees, and large depositional areas within the channel were observed during these trips.

Plates 10 through 38 document video photo captures taken from helicopter video and ground photos taken during the field trips. The photos highlight the fact that widespread bank erosion was evident along most bends within the entire study reach. Loss of private land and destruction of large trees were evident throughout channel as well. Within the Vandalia area, endangerment of the adjacent agricultural flank levee from the nearby eroding river was observed in several areas. Historical bank erosion and meandering of the river in this area had already caused costly levee setbacks. Future levee setbacks due to continued bank erosion are imminent.

Bank Failure Mechanisms.

Plate 39 is a photo with graphics describing the typical bank failure mechanisms contributing to the bank erosion observed on the Kaskaskia River. Careful field inspection indicated there were several observed erosion processes that have been at work over the years, including;

1. Parallel Hydraulic Erosion Forces. Bank material had been removed by parallel hydraulic sheer forces against the bank during high flow events. This seemed to be the primary dominant force causing bank erosion on the river.

2. Sheet Erosion, Rilling, and Gullying. Some bank material had been removed by adjacent floodplain water drainage flowing back into the river channel. “Return” water during flood recession or during localized rainfall events in the floodplain had drained over the edge of the banks. This was evident by the observance of small rills and gullies along the adjacent floodplain and down the sides of all eroding banks.

3. Freeze-Thaw. While not evident during field reconnaissance, conversations with land owners indicated that some historical bank erosion had occurred during winter months from freeze-thaw action. The climate over the Kaskaskia Basin has historically generated many periods of sub-zero temperatures during the winter months. Landowners had observed bank failure after the freezing and thawing of the riverbanks. One particular landowner stated he visually observed this process occurring on his property several times during one cold and wet winter.

Field observation also indicated that the river banks were generally composed of approximately a 5 to 15 foot conglomerate layer of silt/clay loam, underlain with a 20 to 30 foot layer of fine to medium graded sands. The predominance of sandy banks provides very low resistance to erosion. As a comparison, banks in rivers and streams containing predominantly clays are much more resistant to erosion.

Cross-Section and Water Velocity Data.

Historical research indicated that there was a lack of physical data along this particular reach of the Kaskaskia River. In order to gain a better understanding of existing physical river attributes, a small amount of cross-sectional data in the form of widths, depths, and surface velocity were collected during field reconnaissance.

Plate 40 is a map outlining the field cross-section locations, concentrated in three regions along the river. Region one consisted of 10 sections located approximately 20 miles north of Vandalia, region two consisted of 10 sections located adjacent to Vandalia, and region three consisted of 10 sections located approximately 20 miles south of Vandalia, for a total 30 sections. All data was collected from boats using a distance measuring tape, sounder, and a miniature acoustic Doppler current profiler. Data collection was limited to approximately 40 miles of the river due to limited river access and time and budget constraints.

Data was gathered on June 18 & 19 of 2002. The river had just recently experienced a major flood event, and at the time of data collection, the river was still approximately 60 to 90 percent of bankfull flow. As observed during previous field visits, bank erosion was prevalent along most reaches. Abundant old and new downed trees were observed throughout the channel, making navigation conditions difficult even at the higher river levels. Also observed were several breaches or scour holes in the agricultural flank levees in the Vandalia area (this is documented and discussed later in this report).

Of the ten locations in each of the three regions, five sections were located on river crossings, and five sections were located on river bends. At each location, a minimum of five data points were gathered. Each point consisted of a distance from the bank, river depth expressed as elevation below the water surface, and velocity taken just below the water surface. Plates 41 through 55 are plots of individual cross-sections. Table 1 below summarizes estimated water stage in the channel as a percentage of bankfull stage, maximum surface velocity, average surface velocity, average depth, and average channel width among the three regions.

NORTH VANDALIA	**Bankfull Stage (%)**	**Maximum Surface Velocity (ft/s)**	**Average Surface Velocity (ft/s)**	**Average Depth (ft)**	**Average Width ft)**
CROSSING SECTIONS	60	2.9	2.2	10	110
BEND SECTIONS	60	2.5	1.3	12	120

VANDALIA ADJACENT	**Bankfull Stage (%)**	**Maximum Surface Velocity (ft/s)**	**Average Surface Velocity (ft/s)**	**Average Depth (ft)**	**Average Width (ft)**
CROSSING SECTIONS	60	3.2	2.3	8	130
BEND SECTIONS	60	2.5	1.5	15	125

SOUTH VANDALIA	**Bankfull Stage (%)**	**Maximum Surface Velocity (ft/s)**	**Average Surface Velocity (ft/s)**	**Average Depth (ft)**	**Average Width (ft)**
CROSSING SECTIONS	90	2.1	1.5	15	130
BEND SECTIONS	90	1.8	1.3	15	140

Table 1. Summary of Channel Data for Three Regions along the Kaskaskia River.

Some very general conclusions were surmised from the collected physical data. It was evident that the percent of bankfull stage increased by approximately 30 percent between region two (“Vandalia Adjacent”) and region three (“Vandalia South”) during the reconnaissance flow conditions. Channel stage increases downstream of Vandalia were probably linear or gradual, although no cross-sections were taken between the two regions to determine the general stage profile. The increase in stages was a result of the backwater effects from Carlyle Lake, as reflected by the observed lower maximum surface velocity in the “Vandalia South” region. The maximum surface velocity in this region for crossing sections was 2.1 ft./sec as compared to 3.2 ft/sec in region two and 2.9 ft/sec in region one, or approximately between a 34 to 28 percent reduction in maximum surface velocity.

The velocity data collected along the “Vandalia Adjacent” region and the “Vandalia North” region, which were both well upstream of the backwater effects from Lake Carlyle, contained maximum surface velocities no greater than 3.2 feet per second, and average surface velocities no greater than 2.3 ft/sec. From past river engineering experience on the Mississippi River and tributaries containing similar bank material conditions, these velocities would generate minimal scour or erosion. Since the water level was relatively high at approximately 60 percent of bankfull stage, the majority of bank erosion on the Kaskaskia River probably occurs at bankfull stage and higher. This conclusion was verified by farmers who noted that most bank erosion along the river had taken place after sustained high water events.

Overbank Scour.

During the course of the reconnaissance trips, several areas of floodplain or “overbank” scour were noted. Overbank scour is defined as erosion occurring across the floodplain. The erosion occurs at flows above bankfull stage. In most cases, overbank scour results from the lack of riparian zone located along the outside of channel bends. As stages rise above bankfull flow, hydraulic pressure forces are exerted along the outside of the bend, with the greatest force directed at the “apex” or outer point of the bend. Flood flows are concentrated at this apex. If the floodplain adjacent to the bend is flat or slightly sloped away from the river and bare of established trees or permanent vegetation, concentrated deflection flows from the river can translate across the floodplain unimpeded. The flows may generate large scour areas along the floodplain route and initiate bank failure at the point of entry from the river. If left unchecked, the development of a new river channel may ensue in the adjacent floodplain. Destruction of private lands and property, roads, and levees may occur during this process. As the condition worsens over time, the permanent formation of a new river channel in the floodplain may occur. Once a new river channel route is formed, “headcutting” upstream in the main river channel may occur. The headcutting may cause bank failure and new sediment deposition in the main channel upstream of the overbank scour area. The new channel formed in the floodplain may therefore result in millions of dollars worth of damage, possible negative environmental impacts, and changes in river regime in the main channel that may require decades before full recovery occurs.

Within the study reach, observed overbank scour areas that were of greatest severity occurred along the upper 30 miles of the river. Overbank scour and the early stages of new channel development in the floodplain were documented at Mile 71.5 just south of Cowden, Mile 88.5, Mile 89.5, and Mile 90.8. Plates 56 through 61 document these areas. One of the possible reasons overbank scour seemed to be less prevalent along the lower 70 miles of river was that more riparian corridor was evident. Also, in the Vandalia area, most of the flood flows are contained by levees and therefore scour development out in the floodplain is minimized.

Vandalia Levee Systems and Future Concerns.

During recon, the Vandalia Levee System was inspected. From observation it was clear that two major river related problems existed concerning maintaining the future integrity of the levee system. The first problem involved the bank erosion occurring along the river bends. Substantial bank erosion was noted along the outside of all major bends adjacent to the Vandalia Levee System. There were floodplain areas that contained riparian buffer zones between the levee and the river, and there were areas that contained no buffer zones, yet in both cases the river seemed to be eroding considerably. Because of this severe erosion, several levee setbacks have already taken place, and several more are imminent in the near future.

The second problem concerning future levee maintenance associated with the river involved flood flows and the alignment of the levee system. Because of the highly sinuous channel alignment or planform of the Kaskaskia River, the Vandalia Levee System was constructed as a levee flanking the river, containing many irregular loops and abrupt transition points. During floods, water will flow uniformly or parallel across the floodplain in a general north to south direction. The levee system acts as the “new” bankline of the river. Where abruption points occur along the levee alignment, scour may develop along the riverward toe of the levee. This could ultimately lead to levee failure. In hindsight, the most efficient and maintenance-free levee alignments are those that run parallel along the floodplain and not parallel along the river. However, this is an ideal situation and can be economically impractical in many cases. Farm acreage may have to be reduced in the process.

The flood of 2002 produced several levee failures. Each of these failures was associated with the levee being adjacent to the outside of an erosional river bend, or the levee alignment being irregular and abrupt. Plates 62 through 70 highlight levee failures that occurred in 2002 and suggest possible future levee failure locations associated with both river erosion and non-parallel levee alignment. Reduction of the duration and height of floods on the Kaskaskia River by Lake Shelbyville releases reduces the probability and number of levee failures along the Vandalia Reach.

Another type of erosion associated with the river is bridge scour. Bridge scour along the Kaskaskia River was not accessed in this study due to time and budget constraints. However, of special note was the observation of a bridge failure occurring at Highway 185 in Vandalia during the flood of 2002. Plate 71 documents the bridge failure and highlights the scouring energy supplied by the river during flood flows.

HISTORICAL RIVER MORPHOLOGY

Introduction.

“River morphology” may be defined as the study of the planform or topographic feature of the river in relation to its floodplain. “Historical” river morphology is the study of the river planform of the past. By conducting a historical river morphology study, documentation and an understanding of the physical changes experienced by the river over time may be developed. Combined with other important information such as land use, hydrology, and climatic changes, knowledge may be gained on the “how” and “why” of the present physical condition of the river. Insight may also be provided for making a prediction or a forecast of the future condition of the river.

To conduct a historical river morphology study, maps and aerial photographs are used. The challenge is to piece together and list these vital pieces of information in a comparative way in order that meaningful data can be developed and analyzed.

Today’s first tool of choice or process for developing and analyzing map and photo information is a geographical information system (GIS). Unfortunately, the budget of this study did not allow for the purchase of GIS software or the time required for GIS analysis. Instead, a methodology similar to a GIS but within the study time and budget was developed by using a flatbed scanner, image process software, computer aided design and drafting (CADD), a digital planimeter, a digital micrometer, map mosaic construction, and mathematical spreadsheet analysis.

For this particular study, the available historical mediums gathered for the Kaskaskia River were 1820 Government Land Office Maps (GLO), and aerial photography developed in 1938, 1966, and 1998. Historical research and searches discovered no other historical maps or complete aerial photo sets available for this stretch of the Kaskaskia River.

1820 Government Land Office Maps (GLO).

The first complete survey of the State of Illinois was conducted by the Government Land Office between 1820 and 1830. These maps are referred to as the GLO. The maps were a result of a land survey conducted in many states of the country as a means of making federal lands available for private purchase. The selling of land by the government during this period of history was necessary for reclaiming debt accumulated by the United States after the War of 1812.

The GLO contains the original township and section boundary lines that are still referenced and used today. Associated with the maps are individual field survey notes outlining further details of the survey, including sketches and drawings.

The individual township maps of the GLO were available from the Illinois State Archives Office in Springfield, Illinois. Engineers and technicians arranged meetings with curators of the GLO in Springfield whereby the maps were then scanned into the computer. Once in the computer, a map mosaic was made of the GLO, containing a 50-mile reach of the Kaskaskia River and its floodplain.

Plate 72 is a scaled down version of the completed map mosaic of the 1820 GLO of the Kaskaskia River, between Miles 0 and 50. The maps of the remaining 52 miles of the river were temporarily missing and thus could not be scanned. The mosaic was enlarged to a scale of 1 inch = 2900 feet. The map was then used to identify comparative river planform position and land use. This larger mosaic was also used as reference for presentations at the public meetings held during the study. The mosaic generated much interest at the meetings from landowners who for the first time could see where the Kaskaskia River was on their property in 1820.

It should be noted the GLO surveys were conducted with a chain and a compass. For the completed line drawing of the river, it was observed on the mosaic that depending upon the particular township or surveyor, both the color depiction and the scale size of the river varied. The Kaskaskia River width was greater than the largest chain size available and could not be physically measured from bank to bank. Thus, when surveyors approached the river, the only way to make a distance measurement across the channel was by triangulation using the compass. The inaccuracy or distance provided by triangulation with a compass can be substantial and in the order of 10 to 30 percent if the river is 50 to 100 feet wide. Thus, although the GLO served as a valuable historical reference for the general position or the configuration of the Kaskaskia River.   Accurate measurements such as river length and channel width could not be made with confidence because of surveying method limitations. The large GLO mosaic is available for reference and future use at the St. Louis District.

1938, 1966, and 1998 Aerial Photographs.

Aerial photographs covering the entire main channel and floodplain of the Kaskaskia River were gathered for the years 1938, 1966, and 1998. The photos were made available by the Soil Conservation Service, Fayette County Office, and by the Farm Service Agency. The photos were scanned into the computer as high-resolution images, and then digitally pieced together to create complete large mosaics of the river and the floodplain. The mosaics were plotted from the computer at original photo scales of 1 inch = 1760 feet for 1938, 1 inch = 1320 feet for 1966, and 1 inch = 1338 feet for 1998. Attempts were made to plot all photos to the same scale, but too much scale distortion existed in the photo images.

Each photo mosaic was also used for presentations at the public meetings and for detailed measurements and analysis.   Plots of scaled down segments of the mosaics are shown in Plates 73 through 78 for 1938, Plates 79 through 87 for 1966, and Plates 88 through 93 for 1998. These scaled down segment plots were intended to only serve as reference for landowners, as the large mosaics used for computational analysis were too large to fit within the format of the report. The large mosaics are also available for reference and future use at the St. Louis District.

1985 USGS Quad Maps.

Complete USGS quadrangle map coverage of the entire area was available on the computer. A basin mosaic was created from the quadrangle images and then plotted to a scale of 1 inch = 3,400 feet. The mosaic was used for reference in the office, out in the field, and at the public meetings.

Analysis and Computational Methodology.

The analysis of the historical river morphology study involved determining what type of information could be extracted from the mediums available. Some information would be qualitative and some information would be quantitative in nature. For this particular study, the following analysis plan was developed:

1. The GLO was used for qualitative comparison of the relative position of the river in 1820 versus 1998. It also was used for quantitative comparison of land use changes of the floodplain in 1820 versus 1938, 1966, and 1998.

2. The 1938, 1966, and 1998 aerial photos were used for qualitative comparison of the relative position of the river and for quantitative comparison of physical river attributes such as width, length, wetted edge, etc. and also for land use changes, feet of bare bank, etc.

In the measurement and interpretation of aerial photographs, certain difficulties arise that may effect the accuracy of data. Slight variance and distortion in scale may arise from the airplane flight line, the altitude variance, and the curvature of the earth. Shadows of trees extending out across the channel may obscure the exact location of banks. The contrast, sharpness, and hue quality of the original photographs may make physical features difficult to interpret. Finally, slight distortion of scale may arise during the scanning and plotting process.

The photos were scanned as images and then plotted as large mosaics to the original photo scales. As stated previously, an attempt to plot the mosaics to one common scale failed because substantial image distortion resulted. The three finalized mosaics were carefully checked for scale accuracy by cross-comparing the measurements of common physical features such as field parcels and roads. In addition, each of the mosaics common feature measurements was compared directly to the USGS Quad map mosaic. This whole process was repeated several times. Adjustments in image size were made when necessary.

The computational methodology involved measuring the physical river attributes and land use changes gathered from the large mosaics using a digital micrometer and planimeter, storing the information in a database, and then using Microsoft Excel for analysis. The width of the channel was measured at sections perpendicular to the flow of the river every 0.25 miles along the study reach.

Measurement errors can result from using the digital micrometer. To check the accuracy of measurement, width and length measurements were made over a twenty-mile sample stretch of the river. The measurements were made at 0.25-mile increments from comparative sections drawn on each of the three mosaics. These measurements were repeated three times, and the data was then averaged. The accuracy of measurement using the micrometer was determined to be within + or – 6.3 feet.

Land use was measured within individual survey sections and then added as units for area totals. This method was used to eliminate or reduce errors often produced by making single larger area measurements with the planimeter.

Historical River Meandering.

Most rivers meander or move across their floodplains. Meandering is a natural process. The rate of river meandering may change over time depending upon many influences. The rate is an indicator of the natural erosive power of the river. To determine qualitatively the extent of river meandering that has occurred on the Kaskaskia River within the study reach, the position of the river as drawn on the 1820 GLO was superimposed over the position of the river in 1938 and 1998 (Plates 94 through 99). The position of the river in 1996 was very similar to 1998 and was thus omitted on the plates so as not to obscure the view of the 1998 position.

When observing the historical positions of the river on the plates, it was noted that there was very little indication that any channelization had taken place over the period. The biggest change in river position occurred between 1820 and 1938, where a section of the river captured a man-made drainage ditch located in the floodplain. This floodplain ditch, which was apparently constructed to drain a swamp, was observed on the 1820 GLO between Mile 25 and Mile 20, approximately 5 miles south of Vandalia. The ditch was located in the floodplain approximately 1 to 2 miles west of the main river channel and ran primarily parallel to the river (Plate 96).

An average meandering rate was calculated between 1820 and 1938 and between 1938 and 1998. The average meandering rate was calculated by measuring and averaging the lateral position movement of the river across the floodplain in 0.25-mile increments, between Miles 0 and 50 (the length of river reach available for analysis on the GLO). A river actually meanders in all directions across the floodplain, but measuring all directions is much more complex and labor intensive. Therefore, for relative comparison purposes, this study focused on the average lateral movement of the river in either an east or west direction.

Plate 100 is a bar graph illustrating the results. The greatest movement of the river occurred between 1820 and 1938, approximately 3 feet per year, as opposed to 1.9 feet per year between 1938 and 1998.

Historical River Sinuosity.

River Sinuosity can be defined as the length of the river divided by the length of the floodplain. Sinuosity is another way of examining changes of the river. The sinuosity of the entire study reach of the river was computed as 1.8 in 1938 and 1.7 in 1998 (Plate 101).

Changes in River Length and Wetted Edge.

Changes in river length and wetted edge (the length of bankline) may also provide insight on river morphology. The river length was measured as approximately 102 miles in 1938, 100 miles in 1966, and 98 miles in 1998 (Plate 102). Wetted edge was measured as approximately 205 miles in 1938 and 197 miles in 1998 (Plate 103).

Average Channel Widths and Widening Rates.

Using the computational methodology discussed previously, the average channel width of the Kaskaskia River was computed for each of the three years along the entire study reach. The average channel width was approximately 92 feet in 1938, 111 feet in 1966, and 141 feet in 1998 (Plate 104). This equated to an average increase in channel width of approximately 19 feet between the 28 year period of 1938 and 1966, an additional 30 feet increase between the 32 year period of 1966 and 1998, and a 49 feet increase between the entire 60 year period of 1938 to 1998 (Plate 105). Plates 106 and 107 are blown up aerial photos of the river showing river width changes between the 1938 and 1966 period, and between the 1938 and 1998 period. The river experienced approximately a 21 percent increase in average channel width between 1938 and 1966, an additional 30 percent increase between 1966 and 1998, or an additional 54 percent increase of average channel width between 1938 and 1998 (Plate 108).

Incorporating the number of years between each of the three photo mosaics, the average channel-widening rate of the river was computed as 0.7 ft/yr between 1938 and 1966, 0.9 ft/yr between 1966 and 1998, and 0.8 ft/yr for the entire period between 1938 and 1998

(Plate 109). It should be noted that the widening rates do not represent erosion rates because the computations do not take into consideration the lateral movement or meandering of the river across the floodplain.

Plate 110 is a profile graph that displays the width of the river channel measured every 0.25 miles along the entire study reach for 1938, 1966, and 1998. The extremes were a minimum width of 50 feet occurring at Mile 11 in 1938 and a maximum width of 260 feet occurring in 1998 at Mile 41.

To better examine the general trends of river widening along the study reach, a moving average was computed. Plate 111 is a plot of the moving average of channel width versus river mile for 1938, 1966, and 1998. The plot shows that the river width generally increased in a downstream direction along the river, between the period 1938 and 1966, between 1966 and 1998, and between the entire period 1938 to 1998. Plate 112 contains comparative bar graphs that also illustrate that the average widening rate has increased in a general downstream direction between each of the three periods.

Historical Land Use Changes in the Floodplain.

Historical land use changes in the floodplain were measured following the computational methodology discussed previously. Major floodplain land use changes can significantly alter or influence river morphology. The total floodplain area between Miles 0 and 50 was measured as approximately 39,493 acres. In 1820, 99.9 percent of the floodplain was forested. Approximately 26,020 acres were cleared by 1938, or 66 percent of the total floodplain, 28,220 acres were cleared by 1966, or 71 percent, and 31,637 acres were cleared by 1998, or 80 percent of the total floodplain (Plates 113 and 114).

Above Mile 50, no GLO maps were available for this study. Using the aerial photograph sets, changes in land use for the entire floodplain were also determined for 1938, 1966, and 1998. The total floodplain area between Miles 0 and 102 was measured as approximately 60,313 acres. Approximately 44,867 acres were cleared by 1966, or 73 percent of the total floodplain, 46,750 acres were cleared by 1966, or 78 percent, and 50,584 acres were cleared by 1998, or 84 percent of the total floodplain (Plates 115 and 116).

Changes in land use directly adjacent to the riverbanks were documented by measuring the original forested and deforested linear riverbank in 1938, 1966, and 1998. Approximately 466,443 feet of linear forested bank and 54,181 feet of linear deforested bank existed in 1938. In 1966, 450,551 feet of forested bank and 71,427 feet of deforested bank existed, and by 1998, 450,160 feet of forested bank and 82,590 feet of deforested bank existed (Plates 117 and 118).

Riparian Corridor Effects.

Although much of the floodplain adjacent to the riverbanks had been historically cleared of forests and vegetation, there were still large tracks of forested floodplain corridors adjacent to the river that existed within the study reach in 1998, especially along the lower 40 miles. These corridors varied between a few hundred feet wide to more than 1000 feet wide. The 1938 photo mosaic was graphically overlaid with the 1998 river alignment (Plates 127 through 223). Examination of several bends along the lower 40 miles indicated that in many locations, erosion was actually greater along bends adjacent to forests than bends adjacent to cleared lands. The two bends just below Mile 3 on Plate 127 illustrated this fact. The bend along the right descending bank, near Mile 2.6, was adjacent to cleared land in 1938. Along this bend, approximately 50 feet of bank had eroded by 1998. However, the bend located just upstream along the left descending bank, near Mile 2.7, contained a wide adjacent riparian zone in both 1938 and 1998 yet had eroded between 100 feet and 200 feet by 1998. Examination of all bends within the lower 40 miles indicated that the planform movement of the river did not seem to be influenced by external floodplain land cover. Apparently, the channel depth of the Kaskaskia River within the study reach is large enough (between 20 and 30 feet deep) to minimize or negate the positive effects usually provided by trees and other vegetation located along the adjacent floodplain.

Historical Land Use Changes outside the Floodplain.

It should be noted that the total floodplain area (60,313 acres) within the study reach is approximately 4 percent of the total basin area of the study reach (1,360,000 acres). The scope and budget of this report did not allow for detailed land use analysis beyond the floodplain. However, as reflected by the Fayette County Land Cover Map (Plate 119), which was produced from the 1820 GLO, the basin area beyond the floodplain historically consisted of forests along the tributaries and prairies across the upland plains. Observation during field visits and study of the 1985 USGS basin mosaic indicated that approximately 70 to 80 percent of the original forests and approximately 99 percent of the prairies had been cleared within the basin.

Historical Flow Trends.

Historical flow trends were examined at the Vandalia and Shelbyville gages. To gain an understanding of historical trends, daily flows recorded at the two gages were converted to average yearly flows. Plate 120 is a graph of the average yearly flowrate of the river at Vandalia between 1915 and 1999. The trend line on the graph was produced from regression analysis of the data points. An upward trend in the average yearly flowrate was observed over the 84 years of record.

Plate 121 is a 20-year moving average graph of the yearly average flowrates between 1935 and 2000 at Vandalia. The moving average trend also verified that there has been an upward trend in historical yearly average flows at Vandalia.

Plate 122 is a graph of the average yearly flowrate of the river at Shelbyville between 1940 and 2000. The regression analysis trend line also indicated an upward trend in the historical average flowrate at Shelbyville.

Plate 122B are two comparison graphs further describing flow trends of the Kaskaskia River at Vandalia. The average annual flow rate has increased approximately 17 percent between the period 1972 to 1999 (1,841 cfs) as compared to the period 1842-1969 (1,532 cfs). It should be noted that the average annual flowrate represents the average total volume of water flowing along the river per year. This is directly related to the amount of total water flowing off the drainage basin and has nothing to do with reservoir releases at Shelbyville. Reservoirs can only influence the shape of the flow hydrograph but have no effect on the total volume of flow coming from the basin. The increase in average annual flow therefore is a reflection of increased annual rainfall and possible land use changes.

The second graph of Plate 122B shows that the average peak flow at Vandalia has decreased approximately 20 percent between 1972 to 1999 as compared to 1942 to 1969. The decrease in average peak flow, even though the total flow has increased historically over the basin, is directly the result of managed flow release at Lake Shelbyville.

Historical Precipitation Trends.

Historical precipitation trends were examined at the two nearest recording rainfall gages, Pana and Urbana, Illinois. Plate 123 is a graph of the annual precipitation at Pana, between 1951 and 1994. The trend line analysis indicated and upward trend in precipitation for the 43 years of record.

Plate 124 is a graph of the annual precipitation at Urbana, between 1900 and 2001. The trend line analysis also indicated and upward trend in precipitation for the 101 years of record.

SUMMARY OF RESULTS

- The present day conditions of the Kaskaskia River and its major tributaries between Shelbyville and the upper end of Carlyle Lake were studied via reconnaissance. In addition, a historical river morphology study was performed, utilizing historical maps and aerial photographs to determine historical river meandering and sinuosity, changes in river length and wetted edge, average channel widths and widening rates, and historical land use changes within and outside of the floodplain. Finally, gage records of flow and precipitation data were analyzed to determine historical flow and precipitation trends.

- Most of the tributaries have been channelized or ditched in the upper plains of the basin. Headcutting has occurred along most of these channels, with widespread deposition of fine material and the formation of new meandering channels and floodplains observed. The middle reaches of the tributaries have experienced moderate to substantial bank erosion. The lower reaches seemed to be moderately stable.

- In the main channel of the Kaskaskia River, bank erosion was prevalent throughout the study reach. Most bend channels were actively eroding, containing vertical banks, large sandbars, and thousands of downed trees and channel blockages.

- Collected field data in the form of channel cross-sections containing depth, width, and surface velocity indicated that the backwater effects of Carlyle Lake decrease channel velocities and increase stages along the lower 20 miles of the study reach. Field measurements and observations by landowners indicated that scouring or erosional velocities for bank erosion along most of the river probably occur at bankfull stages and above.

- Overbank scour and the formation of new river channels were occurring in several areas of the floodplain, primarily along the upper one third of the study reach. These areas pose future threats for erosion of private lands and property and for the initiation of headcutting or channel degradation in the main river channel.

- Several breaches occurred along the Vandalia Levee System during the flood of 2002. Irregular alignment of the levee system, combined with eroding river bends located near or against the levee, will continue to be the primary cause for future breaches and associated repetitive maintenance repair.

- The historical river morphology study provided a record of some of the physical changes that have taken place on the river. The study also provided insight into why these changes have taken place.

- The overall meandering or movement of the river was greater between 1820 and 1938 as compared to the period 1938 to 1998.

- The average meandering and sinuosity of the river has decreased historically over the years, while the channel width has substantially increased.

- The length of the river over the study reach in 1998 was approximately 4 miles shorter than in 1938. The wetted edge has also decreased by 3 miles.

- The river channel in 1998 was on the average approximately 49 feet or 54 percent wider than in 1938. Although the average channel width increased, the average widening rate throughout the historical period remained essentially the same, approximately 0.7 ft/year for the first 28-year period (1938 to 1966), and 0.9 ft/year for the second 32-year period (1966 to 1998).

- The historical channel-widening rate has always had a tendency to become greater as one moves downstream along the river.

- The majority of forest cleared on the floodplain occurred between 1820 and 1938. After 1938, only about 10 to 20 percent more additional land was cleared.

- The amount of forest in 1998 located along the riverbank within this particular reach of the Kaskaskia River was slightly less than what was observed in 1938.

- Comparison of the river in 1938 versus 1998 indicated that large riparian tracts adjacent to the river channel have not reduced bank erosion or river widening.

- Visual observation of modern day maps (USGS quad) versus historical maps (1820 GLO) indicated that approximately 70 to 80 percent of the basin within the study reach had been cleared of forests and prairies. Following the trend observed within the floodplain, the majority of this clearing probably occurred between 1820 and 1938.

- Both the precipitation and volume of water or runoff in the basin have increased over time.

CONCLUSIONS AND FUTURE CONDITIONS

Problem Causes.

The historical meandering of the river has decreased over time. The meandering calculations conducted in this study were qualitative in nature. The meandering rate gives an estimation of the erosion rate and is not to be confused with the widening rate. A reduction in the meandering or the erosion rate implies that the natural equilibrium of the river has been disrupted. The river is still clearly eroding as it has always done historically, but has been widening instead of maintaining a uniform width. Analysis of all the data indicated that the widening has most probably been the result of two primary factors:

1. Major land use changes. Major land use changes that have occurred over the entire 1,370,000 acres of the basin, including the adjacent floodplain, have changed and increased the sediment and flow delivery rate to the Kaskaskia River. When one considers the total amount of forests and prairies that have been cleared over the basin and floodplain, combined with the extensive amount of channelization that has been conducted in the upper plains of the basin, the flow and sediment delivered into the river today is far more efficient than in the natural, undisturbed condition and may be far above the equilibrium threshold. In response to these changed conditions, the river channel has been widening over time.

2. Increased Flowrate and Precipitation. The average flowrate of the river and the precipitation over the basin have both gradually increased over time. The flowrate has probably increased from a combination of the major land use changes and the increased precipitation. The precipitation has increased from climatic changes. Both of these trend increases have influenced the flow and sediment transport balance of the river. A greater amount of water and sediment introduced into the channel can disrupt the equilibrium of the river over time, which may initiate channel widening and braiding.

Changing River Type.

The physical changes that have taken place on the Kaskaskia River imply that the physical type or physical classification of the river has changed. The river has been transformed to a wider channel with an associated increase in channel sediment (sand bars). The physical characteristics of the original river may be classified as a “sinuous canaliform”. A sinuous canaliform is defined as a river containing a predominantly single channel displaying a sinuous or meandering planform.

Historical maps or photos were not available between 1820 and 1938. Since the channel width could not be measured with confidence from the 1820 GLO (see previous discussion on GLO measurements), it was unclear when channel widening first started to occur on the Kaskaskia River. The river in 1938 still appeared to be in a somewhat sinuous canaliform condition, however, even by this time physical changes could have been taking place. The widening of the river probably was slow and imperceptible at first. The river started to widen significantly sometime after 1938. By 1966, significant widening had occurred, and by 1998, the river condition had been transformed from a sinuous canaliform to a sinuous “braided” canaliform. A braided canaliform may be described as a canaliform that contains a wider channel with increased sandbars or depositional areas. The river of 1998 contained a lower sinuosity than in 1938. The river length was shorter in 1998 by approximately 4 miles, and had less wetted edge or bankline. These changes were all indicative of a transformation to a braided canaliform condition. Plate 125 is an illustration showing the two different river classifications.

When studying the historic meandering of the river, it was apparent that the river was still moving across the floodplain but at a slower rate. In the canaliform stage, the river was able to maintain a uniform width, but in the braided caniliform stage, a non-uniform width has developed. In essence, the river has been “stalling” within its floodplain, with more and more energy being applied to widening and less and less energy being applied to meandering.

As stated previously, it was evident from the examination of the historical pattern and position of the river since 1938 that bank erosion on the Kaskaskia River has not been diminished by riparian corridor. The main channel has been apparently large enough that adjacent vegetation has not provided stabilization. While this fact was noted on the Kaskaskia River, it was apparent that on the smaller tributaries, trees were definitely providing bank stabilization.

Reservoir Effects

Reservoir effects and flood protection provided downstream of Lake Shelbyville first started to take effect along the river in the early 1970s. Unfortunately, the only photo sets available for the river in the study reach were from 1938, 1966, and 1998. Photo sets taken both prior to and after the construction of the dam, especially in the 1970's, would have been required to determine any detailed erosion effects associated with the dam.

However, the data of this study did suggest that widening rates were very similar between 1938 and 1966 (approximately 0.7 feet /year) and between 1966 and 1998 (0.9 feet/year). Both of these rates were very close to the average rate of 0.8 feet/year for the entire period. It appeared then that the historic widening rate has been about the same over history. Since the flow and precipitation in the basin has increased over history, a case can be made that Lake Shelbyville has at least held the widening rate constant.

Reservoirs are designed to reduce the amount of peak flows that occur during flood events (Plate 122 B), which can substantially reduce the amount of erosive energy supplied to the river. This fact was verified by a study conducted on the Salt River in Missouri in 1995. The Salt River is similar in both physical size and planform (canaliform) to the Kaskaskia River. The typical bank material along the Salt River is also very similar, containing primarily a top layer of silt followed by a predominant layer of sands.

In 1983, Clarence Cannon Dam started to provide downstream flood protection on the Salt River. To determine the dam's influence on erosion, periodic aerial photography sets were taken along the river both prior to and after dam construction. The photos extended over a 26-year period. Channel measurements indicated that erosion was substantially reduced along the river after dam construction.

The channel widening along the Kaskaskia River was generally lower the closer one moved upstream toward the Lake Shelbyville Spillway and greater the closer one moved toward Carlyle Lake. The moving average graph of Plate 111 indicated this trend existed between 1938 and 1966 before the dams were constructed. If the reservoir were to have a negative effect, erosion would be much greater directly downstream of the dam as compared to other areas further downstream. This was not the observed trend. In fact, a case can be made that the widening rates have been actually reduced by the reservoir.

Along the lower end of the study reach, the backwater effects from Carlyle Lake most probably have incurred some additional sedimentation within the channel, thereby encouraging channel widening. The moving average analysis of channel widening along the profile of the study reach (Plate 111) seemed to indicated an upward trend in channel widening the closer the river's proximity to the upper end of the lake. This trend will probably continue along the lower study reach as the reservoir continues to fill with sediment.

Future Land Use Changes.

In all probability the existing land use will not undergo any major changes over the basin in the future. There have been land management practices put in place as recommended by USDA and SCS for erosion control, and this effort should continue to be encouraged. However, considering approximately 70 to 80 percent of the original forests have been cleared in the basin, approximately 99 percent of the original prairies are gone, and the majority of the uplands have been ditched or channelized to improve drainage, the river may experience change for generations to come.

Future Planform of 2050.

It is impossible to predict when the river will fully adjust and reach a state of equilibrium, but all signs indicate that if historical trends persist, it would be conservative to assume that the river will continue to widen at the historical average rate experienced between 1938 and 1998. Thus, it was predicted that that the river will widen an additional 50 feet, on the average, by the year 2050. The probable planform or alignment pattern of the river in 2050 was projected graphically on Plates 126 through 218. The plates contain the 1938 aerial photos with the 1998 river overlaid in red and the projected 2050 river overlaid in peach.

The 2050 graphical planform projection was based upon river engineering judgment and experience. Obviously, many unknown physical factors will influence the ultimate planform configuration in 2050. Some areas will widen more or less than the average, as evident by the comparative width comparisons of 1938, 1966, and 1998 (Plate 110). The projection was made to provide a general idea of what the river may look like in the future and to provide a means to estimate future erosion of land.

Channel Capacity Changes.

There was a strong indication that the channel capacity of the river throughout the study reach has been reduced. No historical cross-sections existed to verify the reduction in depth associated with the widening river channel. However, observations in the field indicated no signs of increases in channel depth from channel degradation or headcutting. No major channelization of the main channel was noted to have occurred historically, although there were a few stretches where natural cutoffs have occurred. No stretch of the river displayed the formation of a new, lower floodplain level, which can be a key indicator for major channel degradation. Some older landowners recalled a deeper river back in the 1930s, while two particular landowners, located a few miles south of

Shelbyville, had observed that the bankfull capacity of flow in the channel had decreased over time.

Assuming no major channel degradation or headcutting, a computational procedure was conducted to determine a typical cross-section and depth that was probable in 1938 and could be probable in 2050 near Vandalia. A series of cross-sections were collected in the field and averaged to produce a typical representative cross-section of the river channel in 2002 near Vandalia (Plate 219).

The cross-section area was then entered into the Manning's equation, along with an estimated average slope and an estimated channel roughness. The discharge from this typical section was computed as 7,380 cfs. This value was approximate to the discharge value at bankfull flow of 7500 cfs. measured at the Vandalia gage (Plate 221).

Using the average width computations of the river near Vandalia in 1938 from the river morphology study, and assuming no change in cross-sectional area, average depths and cross-sectional shape of the channel was estimated in 1938. In the same manner, the conditions of the channel in 2050 were estimated using the projected average width (Plate 219).

Plates 220 and 222 are graphs estimating the historical and future channel capacity changes of the river in the Vandalia area. These estimates show that approximately 16 percent of the channel capacity may have been lost between 1938 and 1998, and an additional 18 percent could be lost by 2050. A detailed hydraulic engineering study along the entire study reach is recommended to determine more accurately the historical and future changes in channel flow capacity.

Environmental Impacts

The focus of this study was directed toward bank erosion and river morphology, yet cursory comments are in order for summarizing the possible environmental impacts associated with the changing conditions of the river. The fact that the river has evolved from a canaliform to a braided canaliform may have environmental consequences that impact fish and wildlife.

The widening and shallowing of the river produces a greater amount of deposition in the channel in the form of sand, silts, and clays. This was evident at low water when much of the bars were exposed and completely dry. There was also an abundant amount of "large woody debris" in the channel in the form of submerged logs, trees, root wads, etc. The wood provides beneficial cover and habitat for a variety of river fish and serves as attachment sites for macro and micro invertebrates. However, the observed woody debris was so prevalent in all parts of the channel cross-section that much of the debris was merely trapping sediment. At normal and low flows, most of the debris either was completely out of the water or partially submerged and buried in just a few inches of water. From conclusions provided by the Illinois State stream biologist on the lower Kaskaskia River, the value of this type of habitat is questionable.

A wider and shallower channel choked with debris and sediment may mean that during low water, especially during the summer months, elevated water temperatures and lower dissolved oxygen levels could occur. During the winter months, the elimination or reduction in depth of the channel may mean a reduction in thermal refugia for over-wintering fish.

Probably of even greater environmental impact is the fact that the river was approximately 4 miles shorter in 1998 than 1938, and contained approximately 6 miles less of wetted edge or bankline. A shorter river with less wetted edge could mean a reduction in habitat diversity.

A suitable definition of a general "fix" for the impacted river would be to adjust the river so that it supports a biological function similar to what it supported before the watershed was developed. Restoring the river along the entire study reach to its original canaliform condition would increase depth, sinuosity, river length, and wetted edge, which may result in habitat gains and diversity for many species of fish. A detailed environmental assessment study of the Kaskaskia River is encouraged in the future to fully address environmental impacts, restoration benefits, and costs.

Remedial Plans and Cost Estimates

Several plans for erosion remediation or river restoration were formulated as part of this study. Plans were listed and discussed in regards to their viability, regardless of merit. Cost estimates were prepared for construction based upon 2002 rates. In addition, a measure for a reduction in levee failures was also highlighted.

Plan A: No Action.

The "no action" plan, whereby no actions are taken for improvement, will lead to continued channel widening and bank erosion along the river, with endangerment of private lands, levees, and properties imminent. Assuming that the river may widen an additional 50 feet on the average by the year 2050, approximately 600 acres of additional floodplain lands may be eroded over the 98 mile study reach of the Kaskaskia River. Plates 126 through 218 show the 1938, 1998, and 2050 predicted planform of the river, illustrating the lands that may be impacted from future channel widening.

Some infrastructure will be affected by this continued erosion. It is impossible to clearly identify the total possible infrastructure damage impacts associated with bridges, roads, levees, etc. within the study reach. Most likely continued change in position of the river upstream and downstream of the bridges will cause concern for abutment erosion. Substantial abutment erosion may cause the river to completely flank or erode around a bridge. All of the alignment approaches to the bridges across the Kaskaskia River face compromise or change from river erosion, thereby leading to future bridge and road maintenance concerns. Several roads located near the outside of bends may also be impacted from river erosion. These roads will either have to be setback and re-constructed, or the eroding bank near the road will have to be stabilized with revetment. Finally, with the continued widening of the river, levee damage or failure associated with river erosion is imminent in several places along the Vandalia Levee system. As with the roads, segments of the levee will have to be re-located or the bankline of the river will have to be stabilized. The economic cost of these types of infrastructure impacts along the 98 miles of river could well run into the millions of dollars by the year 2050.

As the river widens, the resulting loss of channel capacity in the river may mean increased flooding. This increased flooding may equate to a sizable economic impact along the study reach by the year 2050. A detailed hydraulic engineering study of the river would be required in the future in order to provide a better understanding of flood impacts associated with channel capacity changes. Similar losses of channel capacity and reduction in flood protection benefits have been studied and verified on other rivers in the United States, including several projects in the State of Mississippi. These projects economically justified construction expenditures for increased channel capacity and environmental river restoration.

The environmental impact of the no action plan has briefly been discussed. An estimated total dollar amount associated with environmental impacts is extremely hard to develop, and a more detailed environmental analysis or assessment would be required to achieve this. The environmental impact cost along the 98 miles of river could be substantial.

Plan B: Stabilize the River with Bank Protection.

Stabilizing the river, or ensuring that the river remains in its present day planform and no longer widens, would require revetment works along eroding bends and downstream of bends to prevent new channel planform migration. This plan would maintain present day sinuosity, and most probably slightly increase channel depths. Plate 223 is an illustration showing the extent of revetment required for ensuring complete stabilization of the river.

The large size of the river and the low resistance of the banks, combined with the fact that reservoir releases tend to keep the lower elevations of the banks wetter over the course of the year, make vegetative bank stabilization methods such as willow plantings or root wads highly unattractive, with the probability of success extremely low.

Rock revetment (typical C-Stone) provides the most sound and failsafe method of bank stabilization for this particular reach of the Kaskaskia River. Plate 224 is a representative segment reach of the river in 1998, between Miles 17 and 19, illustrating the typical revetment locations and lengths required for complete bank stabilization. Plate 225 illustrates the typical revetment design recommended on the river.

Using CADD and the 1998 photo mosaic, complete stabilization of 98 miles of the river would require approximately 490,000 linear feet of revetment. This equated to the following cost estimate:

Item	Cost Estimate
Mobilization and Demobilization	$250,000.00
Intermediate Mobilization and Demobilization	$300,000.00
Clearing and Grubbing	$1,250,000.00
Miscellaneous Earthwork	$1,000,000.00
Graded C-Stone (4.4 million tons@$20/ton)	$88,000,000.00
Subtotal	$90,800,000.00
Add 25 % Contingency	$22,700,000.00
TOTAL	**$113,500,000.00**

Plan C: Restore the River to Approximate 1938 Planform with Dike and Revetments.

A restoration of the river, whereby the width and depth of the river is re-established to an approximate 1938 condition, may be achieved through a traditional river engineering approach utilizing dikes and revetments. This plan would regain both lost channel sinuosity and lost channel capacity, thereby providing flood protection and environmental benefits.

Typical C-Stone is the material of choice for dike and revetment construction on the Kaskaskia River. Plate 226 is a representative segment reach of the river in 1998, between Miles 17 and 19, illustrating the typical dike and revetment locations and lengths required for restoration of the river to an approximate 1938 condition. Plate 227 shows a typical dike design section on the river.

Using CADD and the 1998 photo mosaic, restoration of 98 miles of the river would require approximately 1,000,000 linear feet of revetment, which would provide both bank protection on banks opposite the dike fields and bank protection upstream and downstream where dikes are tied into the bank. In addition, approximately 8,040 dikes, at 505,420 linear feet, would be required along the 98 miles. This includes grade control structures located at the entrance to each of the tributaries to prevent headcutting up the tributaries from the deepening of the main channel. This equated to the following cost estimate:

Item	Cost Estimate
Mobilization and Demobilization	$250,000.00
Intermediate Mobilization and Demobilization	$300,000.00
Clearing and Grubbing	$2,000,000.00
Miscellaneous Earthwork	$2,000,000.00
Graded C-Stone Revetment (9 million tons @$20/ton)	$180,000,000.00
Graded C-Stone Dikes (12 million tons@$20/ton)	$240,000,000.00
Subtotal	$424,550,000.00
Add 25 % Contingency	$106,138,000.00

TOTAL	**$530,688,000.00**

Plan D: Dredging.

An investigation was conducted into the viability of restoring the river to an approximate 1938 condition employing land based equipment or hydraulic dredging. Similar restoration has been accomplished on a few other rivers and streams utilizing dredging, as the cost compared to using rock can be substantially less. These rivers and streams were composed of either hard clay or coarse cobbles and gravels. Dredging is a viable option only if an abundance of non-erodible materials such as these is available locally for excavation and placement. Erosion resistant materials are necessary for ensuring a long-lived river channel.

Field observations of banks and river bottom during recon trips and the study of boring logs available from construction of the navigation project near New Athens, Ill (Plate 228) provided an indication of the predominant soils and bed materials located on the Kaskaskia River. It was surmised that the majority of material located along the river and floodplain consisted of approximately a 5 to 15 feet layer of silt and clay followed by a 10 to 20 feet layer of sand and fine gravel. Unfortunately, it was determined that these available materials would not provide sufficient resistance or non-erodibility against normal river forces, even with compaction. The life of a new channel created by either excavation or disposal of river material would be very short lived because of the abundance of sand. Therefore, this plan is not recommended.

Plan E: Establishment of Riparian Corridor or Buffer Strips for Overbank Scour.

Comparison of the 1938, 1966, and 1998 aerial mosaics indicated that large areas of riparian corridor have not slowed down or halted bank erosion on the Kaskaskia River. In fact, there were areas of the river within the study reach that actually eroded more in riparian zones as compared to non-riparian zones. However, riparian corridors or buffer strips are still encouraged along the river in areas where overbank floodplain scour development is an issue.

Remedial measures for the alleviation or elimination of overbank scour are two-phased. First, the compromised or degraded bank area along the bend should be restored to shape and grade. Material should be filled and compacted. The preferred material of choice is clay because of its high resistance to erosion or scour. If clay is not available, topsoil may be used, but it is recommended that a blanket of revetment or riprap (C-stone) be used on the riverside of the fill according to the recommended typical design suggested in Plate 225.

The second stage of overbank scour remediation is to discourage future floodplain scour and channel development by the establishment of a riparian zone adjacent to the river bend. A minimum 25 ft riparian buffer strip is highly recommended to minimize or dissipate floodplain flow velocities and scour. Willows or cottonwoods are the trees of choice because of their fast growing potential. These buffer zones in the floodplain, referred to as tree screens on the Mississippi River (Rapp, et. al), can drastically discourage future overbank scour formation and encourage deposition of material along the floodplain scour path.

Plan F: Measures outside the Floodplain.

Measures outside the floodplain to reduce flow and sediment contributions to the river were beyond the scope of this study. However, continued land management practices in the basin for the reduction of erosion is encouraged. In addition, the construction of sediment traps in the form of lakes and small reservoirs along the tributaries and feeder creeks could greatly improve conditions on the Kaskaskia River. Considering the size of the drainage basin within the study reach (1,370,000 acres) and the historical changes that have taken place in the basin and on the river, these measures would have to be substantial in scope to provide any positive impact on conditions occurring in the river.

The costs could well run into the tens of millions of dollars. An engineering study on these type basin measures is recommended in the future.

Plan G: Demonstration Erosion Control Measures

Other measures for bank erosion control beyond revetments were researched as part of this study effort. However, it became clear that the majority of stabilization methods that have been developed in this country have been applied to smaller rivers and streams.

In 1981, many of these other techniques were evaluated and discussed in the "Streambank Erosion Control Evaluation and Demonstration Act of 1974, Section 32, Public Law 93-251, Final Report to Congress". A number of small streams were set up as demonstration erosion control projects in the Yazoo Basin in Mississippi as part of this Act. Since 1981, new and innovative bank stabilization techniques have been developed as part of this initial effort from a variety of government and state agencies as well as universities and local contractors. The list is extensive and includes techniques such as willow plantings, tree revetments, hardpoints, barbs, longitudinal peak revetments, tire revetments, and gabions, to name a few.

Unfortunately, only a small fraction of these techniques have been used or attempted on bigger rivers such as the Kaskaskia River. Some of the methods that have been tried on big rivers, such as bendway weirs and hardpoints, have only recently been implemented and their success for use as a bank stabilization technique on big rivers is not yet known. As a direct example, a series of bendway weirs were placed in one bend of the Kaskaskia River within the study reach by NRCS, but the rock structures had only been in the river just a few years prior to this report evaluation. During reconnaissance, it was evident that some stabilization was being achieved with these structures, yet their full success for bank stabilization and future use on other sections of the river remains to be evaluated.

Because it is unknown how effective other techniques would be on a river of this size, and because traditional revetment is so expensive, a demonstration erosion control project for larger rivers is warranted, and the Kaskaskia River would be an excellent candidate. This project could be of significant benefit not only to the Kaskaskia River, but also to other larger rivers within the United States.

A demonstration erosion control project would enable experimentation and evaluation of a variety of the new techniques that have been used primarily on smaller rivers and streams. In addition, new techniques could be innovated that may not only be cost effective, but also environmentally friendly. Of the approximately 100 miles of study reach of the Kaskaskia River, individual small reaches could be set up for experimentation, preferably along the upstream reach of the river just below Shelbyville.

A collaborative effort between the Corps of Engineers, the Illinois Department of Natural Resources, the NRCS, the local citizens and organizations, and the political representatives at both the state and local government s would be required to garner the support and money required for this type of project. The justification would be based not only upon the need for bank erosion control, but also upon the need for environmental restoration of a large river. The physical changes that have taken place in the Kaskaskia River have also no doubt taken place on other rivers of the Midwest and abroad. Learning how to cost-effectively restore both the physical and environmental attributes of the Kaskaskia River could serve as a reference blueprint for larger rivers that are in need of similar restoration.

Plan H: Elimination of Future Levee Setbacks and Levee Failure Discouragement

The elimination of future levee setbacks along the Vandalia Levee system can be achieved by lining the banks along the eroding bends near the levee with revetment as outlined in the recommended typical design suggested in Plate 225. These steps should be initiated far in advance of the migrating channel, since some grading of the banks may be required. Action to stabilize the river should take place by at least the time the river has reached a minimum of “one” channel width away from the levee. Stabilization of the bank may be initially expensive, but the elimination of several levee setbacks in the future may make the measure cost effective in the end. Bank stabilization plans and cost estimates should therefore be incorporated as part of the future operation and maintenance plan of the levee system.

Channel re-routing or man-made cutoffs to eliminate levee setbacks are not encouraged. Headcutting and channel degradation may result upstream of the cutoff which may accelerate bank erosion and threaten adjacent levees upstream.

Future levee failures may be discouraged by constructing new levee alignments that are parallel rather than abrupt along the floodplain (as discussed on page 14). If this measure is not possible, the revetment may be provided along levee alignment sections that are abrupt or intruding into flood flows (plates 62 through 70). The revetment should be placed along the riverside face from the levee toe to the levee crown. Graded C or B Stone may be used. Detailed cost estimates, plans, and specifications for revetment levee design were outside the scope of this report, but information may be provided to local interests from the St. Louis District Soils and Foundations Branch.

FINAL COMMENTS

The primary goal of this report was to investigate the causes of bank erosion on this stretch of the Kaskaskia River and develop remedial measures. It should be noted that to date nowhere in this country has such a large stretch (100 miles) of an eroding river the size of the Kaskaskia been studied or accessed. All other studies have been limited to smaller rivers and streams generally covering very short study reaches.

Even though the effort and costs for restoration were found to be extensive with alternatives A and B, the formulation and development of these alternatives were necessary to serve as an engineering and economic benchmark. This benchmark may serve as a comparative reference for other environmentally friendly and cost effective initiatives carried out in a future demonstration erosion control project. Under this type of project, a variety of bank stabilization techniques never before attempted on a large river may be tested and evaluated for performance.

REFERENCES

1. Bates, Ken. Integrated Bank Protection; Ecology Concepts of Streambank Protection. Published discussion from the ASCE Wetlands Engineering & River Restoration Conference, Adams Mark Hotel, Denver, Colorado, 23 March 1998.

2. Busse, David, Robert Davinroy, Dave Gordon, David Derrick, Wayne Kinney, and Steve Redington, eds. Bank Erosion Study of the Kaskaskia River, Carlyle Lake to New Athens, Illinois. Applied River Engineering Center, U.S. Army Corps of Engineers, St. Louis District, St. Louis, Missouri, 2002.

3. Caverly, Jill, Jon Fripp and Margaret Burns. Stream Restoration – Getting to Design. Published discussion from the ASCE Wetlands Engineering & River Restoration Conference, Adams Mark Hotel, Denver, Colorado, 23 March 1998.

4. Critical Trends Assessment Program. Kaskaskia River Area Assessment. Vol.1, Vol. 2. Illinois State Water Survey, Springfield, Illinois, DNR Clearinghouse, 1999.

5. Edwards, Rick, David J. Miller, R. Steve Dial and D. Eric Somerville. Ecosystem Restoration Under the WRDA of 1996. Published discussion from the ASCE Wetlands Engineering & River Restoration Conference, Adams Mark Hotel, Denver, Colorado, 23 March 1998.

6. Hayes, Donald F., eds. Wetlands Engineering & River Restoration Conference 1998. Virginia: American Society of Civil Engineers, 1998.

7. Horner & Shifrin, Inc. Salt River Erosion Study, Hamilton Property. Missouri: Horner & Shifrin, Inc., U.S. Army Corps of Engineers, St. Louis District, 1995.

8. Meier, Claudio I. The Ecology Basis of River Restoration, River Ecology for Hydraulic Engineers. Published discussion from the ASCE Wetlands Engineering & River Restoration Conference, Adams Mark Hotel, Denver, Colorado, 23 March 1998.

9. Petersen, Margaret S. River Engineering. New Jersey: Prentice-Hall, 1986.

10. Resource Technology, Inc., Report of Sedimentation, 1999 Resurvey, Carlyle Reservoir, Upper Mississippi River Basin, Kaskaskia River, Illinois New Mexico: Resource Technology, Inc., 2000.

11. Rosgen, Dave and Hilton Lee Silvey, illustrated. Applied River Morphology. Minnesota: Printed Media Companies, 1996.

12. Sauer, Randy. Written Environmental Comments to Bank Erosion Study of the Lower Kaskaskia River, Carlyle to New Athens, 2002

13. Schwar, Michael T. and Jerry Bernard. What Level of Engineering is Needed for Restoration Projects? Published discussion from the ASCE Wetlands Engineering & River Restoration Conference, Adams Mark Hotel, Denver, Colorado, 23 March 1998.

14. Simons, Daryl B. Ph.D., P.E., and Fuat Senturk Ph.D. Sediment Transport Technology, Water and Sediment Dynamics. Colorado: Water Resources Publications, 1992.

15. Southwestern Illinois RC&D, Inc. Kaskaskia River Watershed, an Ecosystem Approach to Issues & Opportunities. Illinois: 2002.

16. U.S. Army Corps of Engineers. Carlyle Lake Watershed Plan. Illinois: U.S. Army Corps of Engineers, St. Louis District 2000.

17. U.S. Army Corps of Engineers. The Streambank Erosion Control Evaluation and Demonstration Act of 1974 Section 32, Public Law 93-251, Appendix A thru H, December 1981

FOR MORE INFORMATION

All large mosaics of the Kaskaskia River for the years 1820, 1933, 1966, and 1998 are stored and available for reference at the Applied River Engineer Center in St. Louis. For more information about the Applied River Engineering Center, please contact Robert Davinroy, David Gordon or Dawn Lamm at:

Applied River Engineering Center
U.S. Army Corps of Engineers - St. Louis District
Hydrologic and Hydraulics Branch
Foot of Arsenal Street
St. Louis, Missouri 63118

Phone: (314) 263-4714, (314) 263-4230, or (314) 263-8090
Fax: (314) 263-4166

E-mail: Robert.D.Davinroy@mvs02.usace.army.mil
David.Gordon@mvs02.usace.army.mil
Dawn.Lamm@mvs02.usace.army.mil

Or you can visit us on the World Wide Web at:

http://www.mvs.usace.army.mil/engr/river/river.htm

APPENDIX OF PLATES

Plates 1 through 228 follow:

1. Shelbyville to Carlyle Vicinity Map
2. Study Reach Map
3. Drainage Basin Map Within Study Reach
4. Channelization and Sedimentation Effects on Upper Robinson Creek
5. Channelization and Historical Headcutting Effects of Upper Robinson Creek
6. Channelization and Historical Headcutting Effects on Hickory Creek
7. Bank Erosion on Robinson & Richland Creeks
8. Revetment of Middle Robinson Creek
9. Bank Erosion on Otter Branch Creek
10. River Widening Lower Kaskaskia Mile 12.5
11. Mile 25 & Mile 26
12. Mile 27
13. Mile 28 & Mile 29
14. Mile 29.4 & Mile 29.7
15. Mile 30 & Mile 31
16. Mile 32 & Mile 32.5
17. Mile 33 & Mile 33.9
18. Mile 34.2 & Mile 34.5
19. Mile 35.5 & Mile 38
20. Mile 39.5 & Mile 39.6
21. Mile 39.7 & Mile 39.9
22. Mile 40.5 & Mile 42.4
23. Mile 47 & Mile 49.1
24. Mile 53 & Mile 63.1
25. Mile 65.5 & Mile 69.5
26. Erosion / Deposition Mile 68.9
27. Bank Erosion Mile 69.8
28. Mile 70 & Mile 75
29. Channel Constriction at Mile 70.8
30. Bank Erosion / Widening Mile 70.8
31. Channel Widening Mile 71.5

66. Possible Location for Levee Failures Vandalia Levee District Mile 27
67. Levee Failures Vandalia Levee District Mile 30.5 & 31
68. Levee Failures & Possible Future Levee Failures Vandalia Levee District Mile 32 –33.5
69. Possible Location for Levee Failures Vandalia Levee District Mile 40
70. Possible Location for Levee Failures Vandalia Levee District Mile 44
71. Bridge Failure Hwy. 185 Vandalia, IL
72. 1820 GLO Map
73. 1938 Aerial Photograph Mile 102 to 79
74. 1938 Aerial Photograph Mile 79 to 62
75. 1938 Aerial Photograph Mile 65 to 46
76. 1938 Aerial Photograph Mile 50 to 31
77. 1938 Aerial Photograph Mile 31 to 14
78. 1938 Aerial Photograph Mile 18 to 0
79. 1966 Aerial Photograph Mile 102 to 93
80. 1966 Aerial Photograph Mile 95 to 78
81. 1966 Aerial Photograph Mile 82 to 71
82. 1966 Aerial Photograph Mile 71 to 60
83. 1966 Aerial Photograph Mile 69 to 59
84. 1966 Aerial Photograph Mile 63 to 46
85. 1966 Aerial Photograph Mile 46 to 31
86. 1966 Aerial Photograph Mile 30 to 14
87. 1966 Aerial Photograph Mile 14 to 0
88. 1998 Aerial Photograph Mile 102 to 79
89. 1998 Aerial Photograph Mile 80 to 62
90. 1998 Aerial Photograph Mile 64 to 46
91. 1998 Aerial Photograph Mile 50 to 31
92. 1998 Aerial Photograph Mile 31 to 14
93. 1998 Aerial Photograph Mile 17 to 0
94. Meandering of the Kaskaskia River 1820 – 1998 Mile 0 to 10
95. Meandering of the Kaskaskia River 1820 – 1998 Mile 10 to 20
96. Meandering of the Kaskaskia River 1820 – 1998 Mile 20 to 25
97. Meandering of the Kaskaskia River 1820 – 1998 Mile 30
98. Meandering of the Kaskaskia River 1820 – 1998 Mile 35
99. Meandering of the Kaskaskia River 1820 – 1998 Mile 40 to 50