Kaskaskia Morphology Study
Headwaters to Lake Shelbyville

KWA Mini Summit

5 March 2012

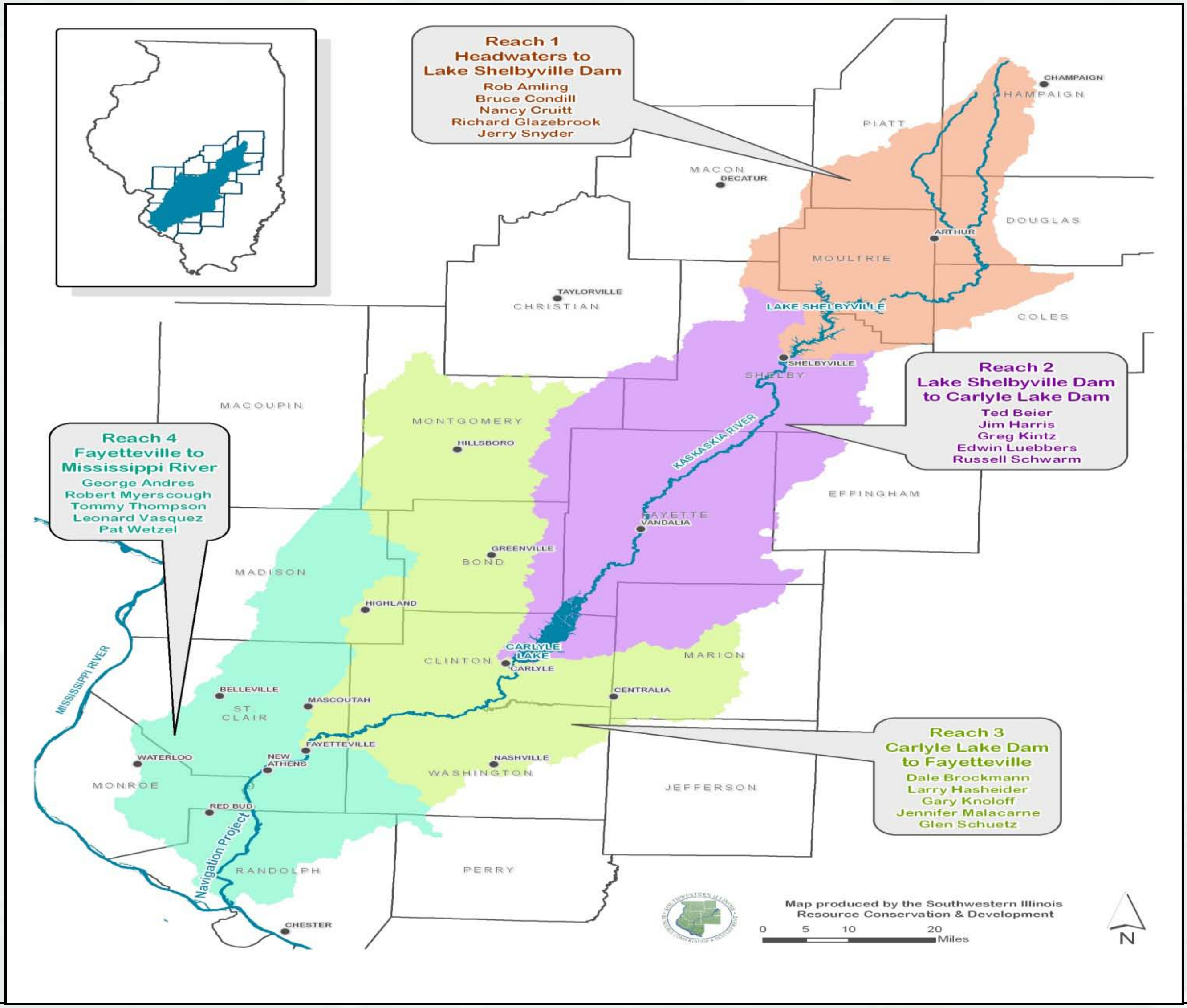
Kaskaskia Morphology Study Headwaters to Lake Shelbyville

- Conducted by U.S. Army Corps of Engineers, St. Louis District and Co-Sponsored by the Upper Kaskaskia LPC and the Illinois Department of Natural Resources under the Conservation 2000-Ecosystem Program
- The study transpired between September 2007 and June 2010

Study Reach

- Documented the status of 75 miles of main channel Kaskaskia River, from the headwaters in Champaign County to the upper end of Lake Shelbyville
- Incorporated 678,000 acres of total drainage area including portions of Champaign, Coles, Douglas, Macon, Moultrie, Piatt, and Shelby Counties.
- Includes 25 miles of Lake Fork and West Okaw Rivers that IEPA has listed as impaired
- Determine the impacts that the Kaskaskia and West Okaw siltation has on the Lake Shelbyville Reservoir

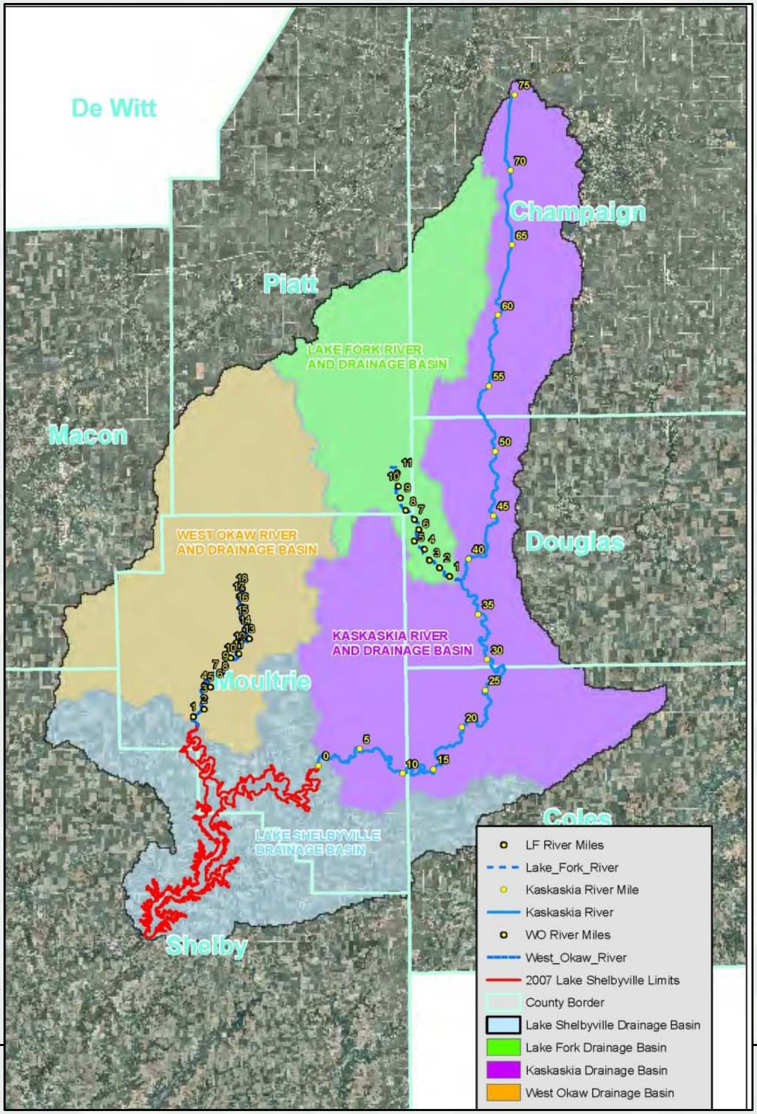
Study Reach


Reach 1
Headwaters to
Lake Shelbyville Dam
Rob Amling
Bruce Condill
Nancy Cruitt
Richard Glazebrook
Jerry Snyder
Reach 2
Lake Shelbyville Dam
to Carlyle Lake Dam
Ted Beier
Jim Harris
Greg Kintz
Edwin Luebbers
Russell Schwarm
Reach 3
Carlyle Lake Dam
to Fayetteville
Dale Brockmann
Larry Hasheider
Gary Knoloff
Jennifer Malacarne
Glen Schuetz
Reach 4
Fayetteville to
Mississippi River
George Andres
Robert Myerscough
Tommy Thompson
Leonard Vasquez
Pat Wetzel
CHAMPAIGN
PIATT
MACON
DECATUR
DOUGLAS
ARTHUR
MOULTRIE
TAYLORVILLE
CHRISTIAN
LAKE SHELBYVILLE
COLES
SHELBYVILLE
SHELBY
MACOUPIN
MONTGOMERY
HILLSBORO
KASKASKIA RIVER
EFFINGHAM
FAYETTE
VANDALIA
GREENVILLE
BOND
MADISON
HIGHLAND
CARLYLE LAKE
CARLYLE
CLINTON
MARION
MISSISSIPPI RIVER
BELLEVILLE
MASCOUTAH
ST. CLAIR
CENTRALIA
FAYETTEVILLE
WATERLOO
NEW ATHENS
NASHVILLE
WASHINGTON
MONROE
JEFFERSON
RED BUD
Navigation Project
RANDOLPH
PERRY
CHESTER
Map produced by the Southwestern Illinois Resource Conservation & Development
0 5 10 20 Miles
N

Study Reach


LAKE MICHIGAN
MICH
IOWA
Rock R.
Green R.
Fox R.
Des Plaines R.
Kankakee R.
Edwards R.
Senachwine Lake
Spoon R.
Upper Peoria Lake
Illinois R.
Mackinaw R.
INDIANA
Sangamon R.
Lake Springfield
Lake Shelbyville
Illinois R.
Mississippi R.
Kaskaskia R.
Little
Embarras R.
Wabash R.
Carlyle Reservoir
MISSOURI
Rend Lake
Big Muddy R.
Wabash R.
Crab Orchard Lake
KENTUCKY
Ohio R.

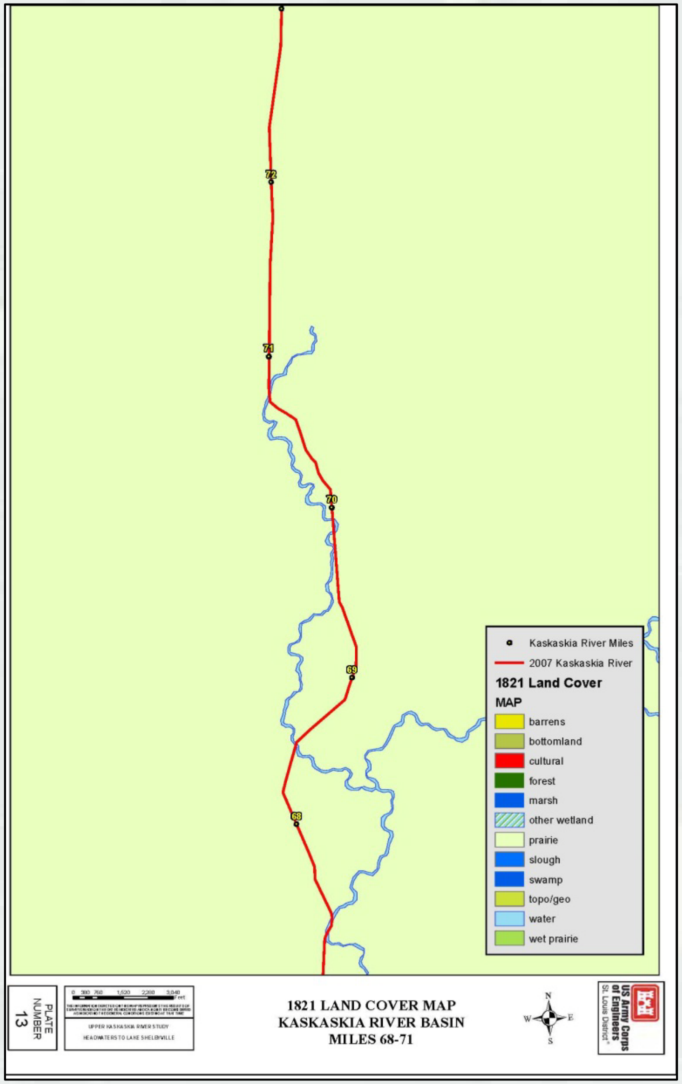
Study Reach
Drainage Basins

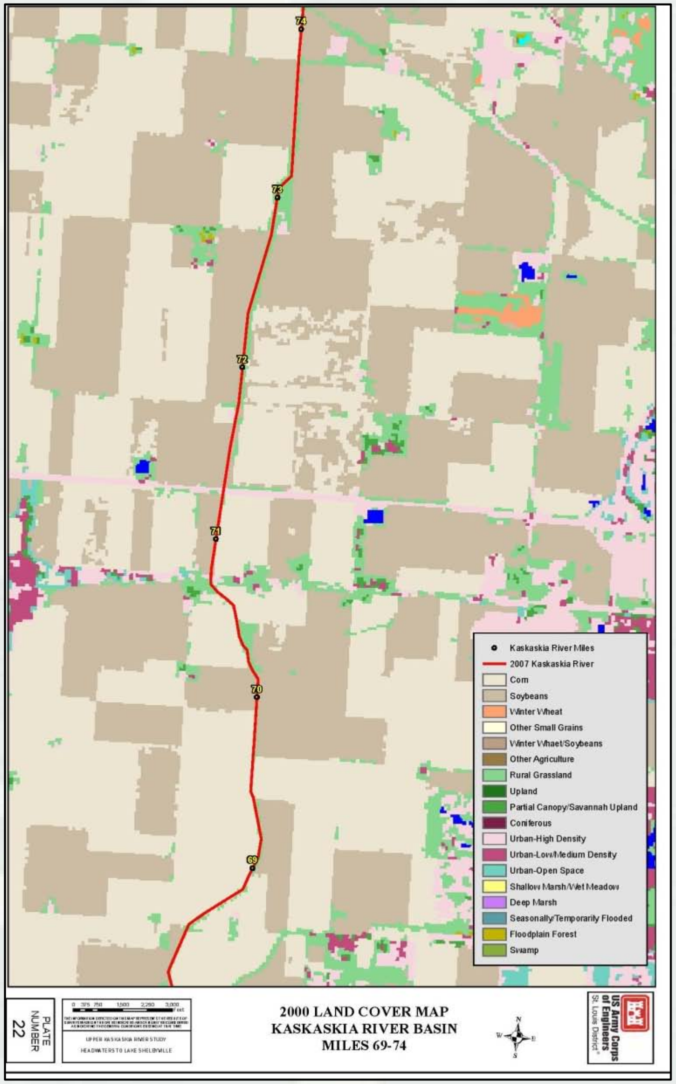


Land Use Changes

- Historical land cover maps (1821) indicate that the majority of the land within the Kaskaskia River Basin was made up of prairies and forests
- During the time period from the mid 19th century through the early 20th century major land use changes occurred. Fertile prairie lands were converted to croplands and the forested lands were logged and use for timber and fuel.
- During this time frame segments of the upper Kaskaskia River were straightened to increase channel conveyance and increase drainage rate of croplands to maximize productive land use

Land Use Changes

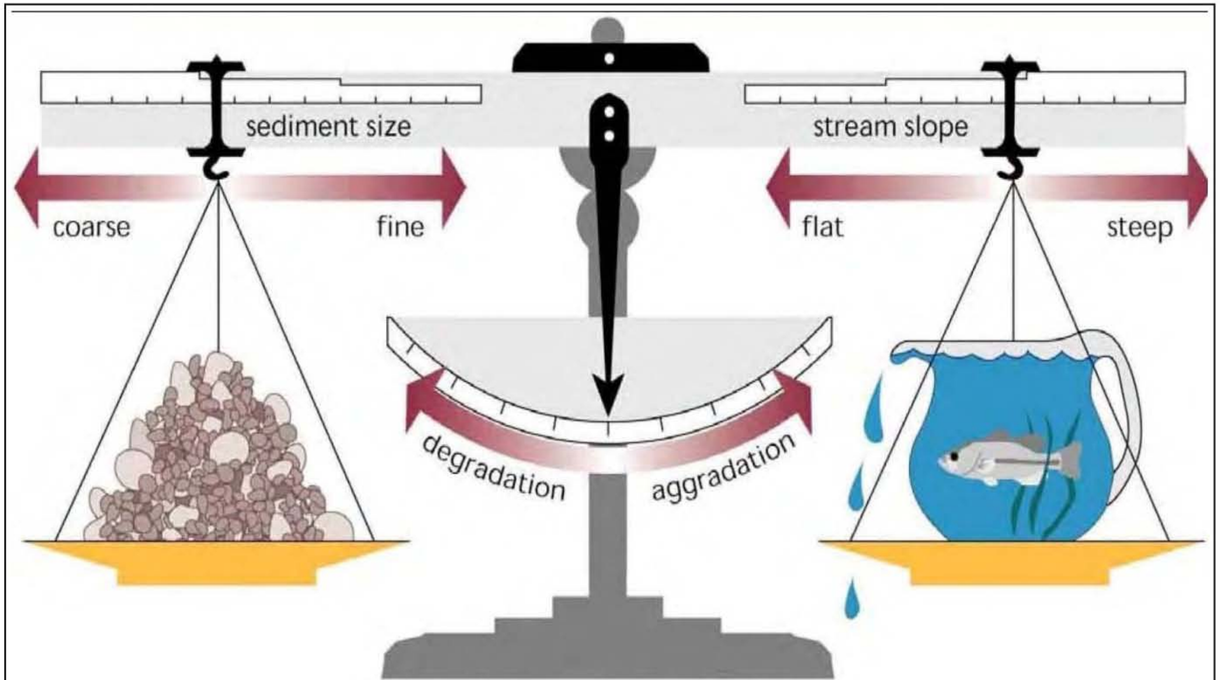




Land Use Changes

- The impacts of land use change can lead to river instability
- Development of croplands from prairies to can increase rill and sheet erosion associated with exposed soils within the basin
- Loess soils that predominantly make up the basin are easily entrained and transported by water and wind.
- Added soils that enter the river system as sediment can imbalance the natural processes of the channel
- Lane’s equation explains the relationship between stream power and discharge of bed material
- The land use changes and effects on the river are consistent with other studies completed within the Kaskaskia Basin in 2000, 2003, and 2006

Lane's Equation



$$Q_s \cdot D_{50} \propto Q_w \cdot S$$

From Rosgen (1996), from Lane, Proceedings, 1955.
Published with the permission of American Society of Civil Engineers.

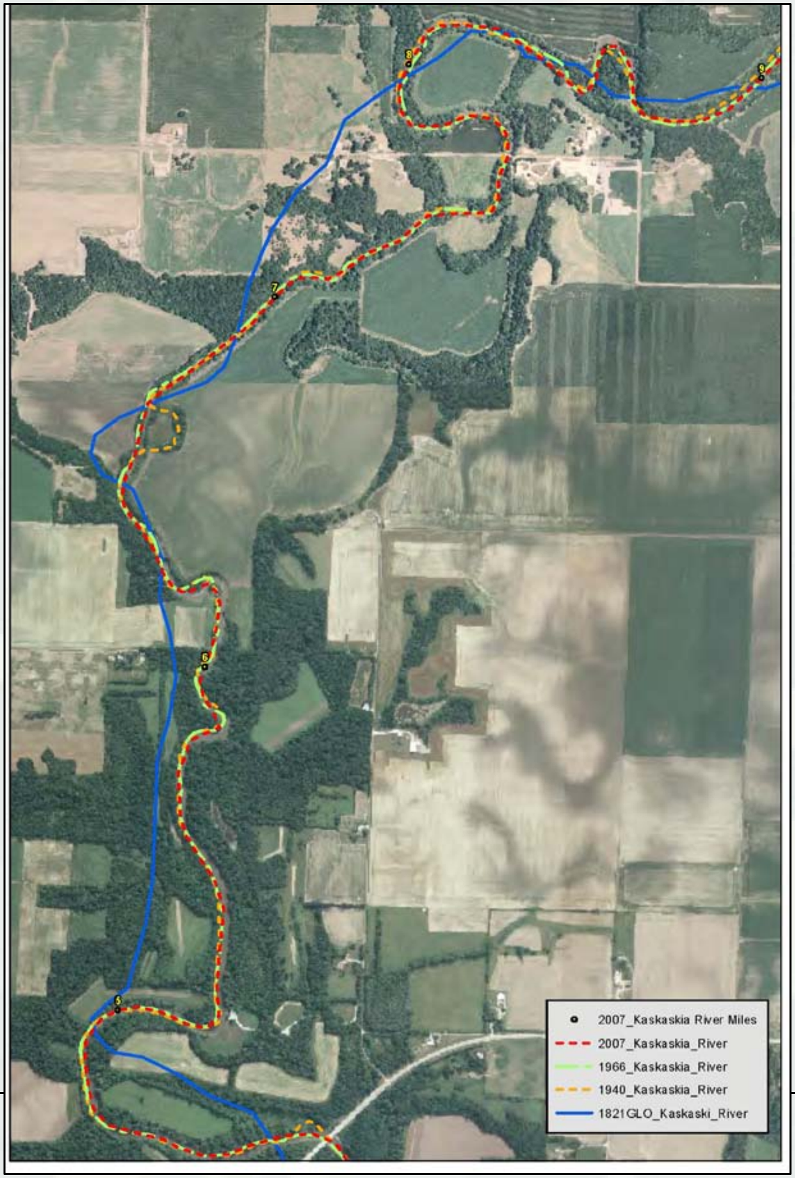
River Morphology

- This analysis included channel morphology, which channel **pattern, dimension, and profile** were studied.
- Patter – refers to the **planform** or physical geometry of the river channel, the number of bends, radius of curvature
- Dimension – refers to the **width and depth** of the channel cross section
- Profile – refers to the **gradient or slope** of the channel throughout the study length.

River Morphology Analysis

- Historical data was limited for this study, the utilization of historical surveys and aerial photos were the main source of data
- 1821 General Land Office (GLO) maps, 1940 aerial photos, 1966 aerial photos, and 2007 aerial photos were used
- The 1821, 1940, and 1966 maps and photos were scanned in are georeferenced to NAD 1927 State Plane Illinois West Coordinates using ARC-GIS 9.3.
- 2007 aerial photos were georectified and were immediately able to use

Kaskaskia Channel Location



River Morphology Analysis Pattern

- Rivers are rarely straight and typically follow a sinuous course.
- Sinuosity is defined as the rivers **channel length divided by its valley length** and quantifies the meandering rate of the channel.
- The Kaskaskia River pattern was analyzed for the years 1821, 1940, 1966, and 2007. The results obtained were number of bends, radius of curvature, and sinuosity.

River Morphology Analysis Pattern

- The present day channel condition was assessed by aerial photos and ground reconnaissance
- Channel cross-section data was collected to identify the channel pattern, dimension, and profile
- 11 Kaskaskia River cross sections were taken at riffle locations intermittently throughout the basin
- Riffle locations were used to maintain uniform geometry for analysis purposes
- Cross section data collection consisted of using a laser level, rod, and tape to measure topography change and water depth in 5 feet increments

River Morphology Analysis Pattern Results

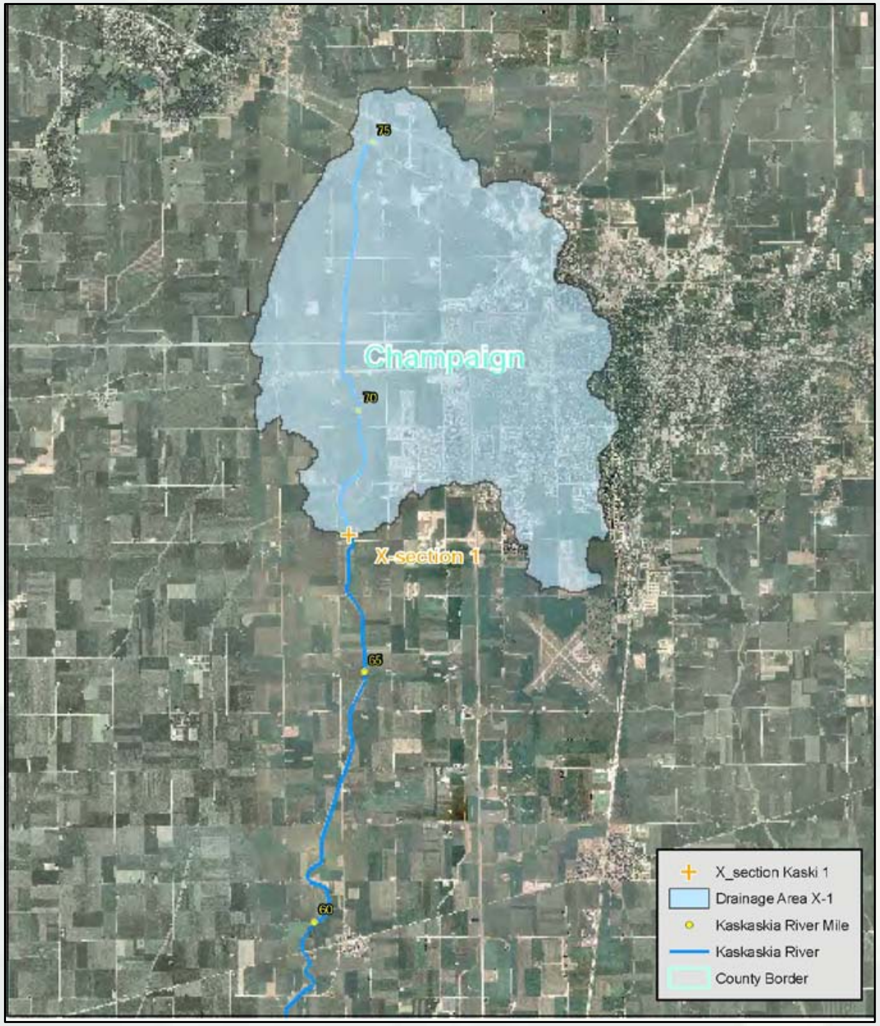
Year	Sinuosity RM (0-22)	Number of Bends RM (0-22)	Average Radius of Curvature RM (0-22)	Sinuosity RM (22-71)	Number of Bends RM (22-71)	Average Radius of Curvature RM (22-71)
1821	1.61	35	800	1.32	89	890
1940	2.06	88	371	1.41	134	538
1966	2.06	80	344	1.37	127	435
2007	2.06	80	344	1.37	127	435

- The Kaskaskia River was broken into 2 reaches based on valley slope.
- Overall a very stable channel, sinuosity increased slightly on the lower reach from 1821 – 1940
- The increase in number of bends can be attributed to added energy in the system due to increased runoff due to land use practices

River Morphology Analysis Dimension

- River channel width and representative cross section is a function of the channel hydrograph, suspended sediments, bed load, and bank materials.
- 11 cross sections were taken at riffles to evaluate Kaskaskia River dimensions
- Stream Stabilization I&E form the Illinois NRCS was used to populate the cross section data.
- Post 1940 analysis revealed a very stable channel
- Sinuosity on the upper end (22-71) was stable from 1821 to 1940 , increased on the lower end and decreased on upper where channel was straightened.
- Post 1940 analysis revealed a stable channel

River Morphology Analysis Dimension



River Morphology Analysis Dimension Stream Stabilization I&E Form

Stream Stabilization I & E Form

ILLINOIS NRCS - Version 2.05- modified 9/12/04 R.Book

County Champaign T. 19n R. 8e Sec. sw 1/4 30

Date 5/21/2010 By Mike Rodgers

Stream Name Kaski shelbyville to headwater UTM Coord.
Landowner Name Cross-Section 1

Drainage Area 36.7 sq. mi. Clear Cells

Regional Curve Predictions:

Bankfull dimensions Width 61 ft. Cross Sectional Area 259 sq. ft.
Depth 4.3 ft.

Reference Stream Gage:

Kaskaskia River near Pesotum Station No. 05590400 Gage Q_2 1810 cfs
Drainage Area 109 sq.mi Regression 1790 cfs
Douglas County, IL **REFERENCE STREAM DATA ONLY**

USGS Flood-Peak Discharge Predictions:

Valley Slope: 9.9 *ft./mi. (user-entered)* Regression Q_2 1316 cfs
ft/mi (from worksheet) Rainfall 3.00 in *(2 yr, 24 hr)* Adjusted Q_2 1331 cfs
0.0019 *ft./ft.* Regional Factor 1.057 Typical Range for Bankfull Discharge
530 to 1070 cfs

Local Stream Morphology.

Channel Description: (a) Clean, straight, no deep pools
Manning's "n" 0.03

Basic Field Data:
Bankfull Width 47 ft.
Mean Bankfull Depth 4.04 ft.
Width/Depth Ratio 11.63

Max. Bankfull Depth 4.6 ft.
Width at twice max. depth 56 ft.
(9.2 ft.)
Entrenchment Ratio 1.19

Stream Length ft.
Valley Length ft.
Contour Interval feet
Estimated Sinuosity

Channel Slope:
Surveyed: 0.000657 ft./ft.
Estimated: ft./ft.

Bankfull Q from:
Cross-Section 586 cfs
Basic field data 613 cfs
Selected Q 600 cfs

Radius of Curvature (Rc) ft.
Rc/Bankfull width: 0.00

Bankfull Velocity Check: *(typical Illinois streams will have average bankfull velocity between 3 and 5 ft/sec.)*

Bedload: D_{90} 1 *in.* Velocity required to move D_{90}: 2.1 *ft./sec.*
D_{50} *in.* Velocity from Cross-Section data 3.09 *ft./sec.*
GOAL: Develop confidence by matching velocities from different sources. Velocity from basic field data: 3.23 *ft./sec.*
Velocity from selected Q: 3.2 *ft./sec.*

Channel Evolution Stage III Stream Type (Rosgen) G6

Notes

Cross-section completed on 01/21/08

Natural Open Channel Flow

back to I&E form Clear Cells

Project: Cross-Section 1
Assisted by: Mike Rodgers
Date: 4/15/2010
Channel Slope (**S**): 0.000657 ft/ft
Manning's ***n***: 0.030
Flow Depth: 5.1 ft

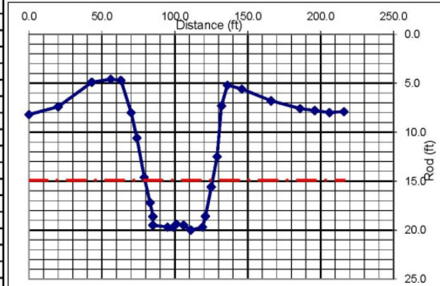
$$Q = \frac{1.486}{n} A R^{\frac{2}{3}} S^{\frac{1}{2}}$$

assuming uniform, steady flow

		Trial Depth 2	*Trial Depth 3*
Selected Flow Depth:	5.1 ft	14.8	
Channel Flow (**Q**):	586.0 cfs	3,325.3	
Channel Velocity:	3.1 ft/sec	3.1	
Cross-Sectional Area (**A**):	189.8 sq.ft.	1,066.4	
Hydraulic Radius (**R**):	3.8 ft	3.8	

Survey Data:

Rod *(ft)*	Distance *(ft)*
8.2	0.0
7.4	20.0
4.9	43.0
4.6	56.0
4.7	63.0
8.0	70.0
10.6	74.0
14.6	79.0
17.2	83.0
18.60	85
19.50	85
19.70	95
19.70	99
19.40	101
19.50	106
20.0	111
19.7	119
18.6	121
15.6	125
12.5	129
7.3	132
5.2	136
5.6	146
6.8	166
7.6	186
7.8	196
8.0	206
7.9	216

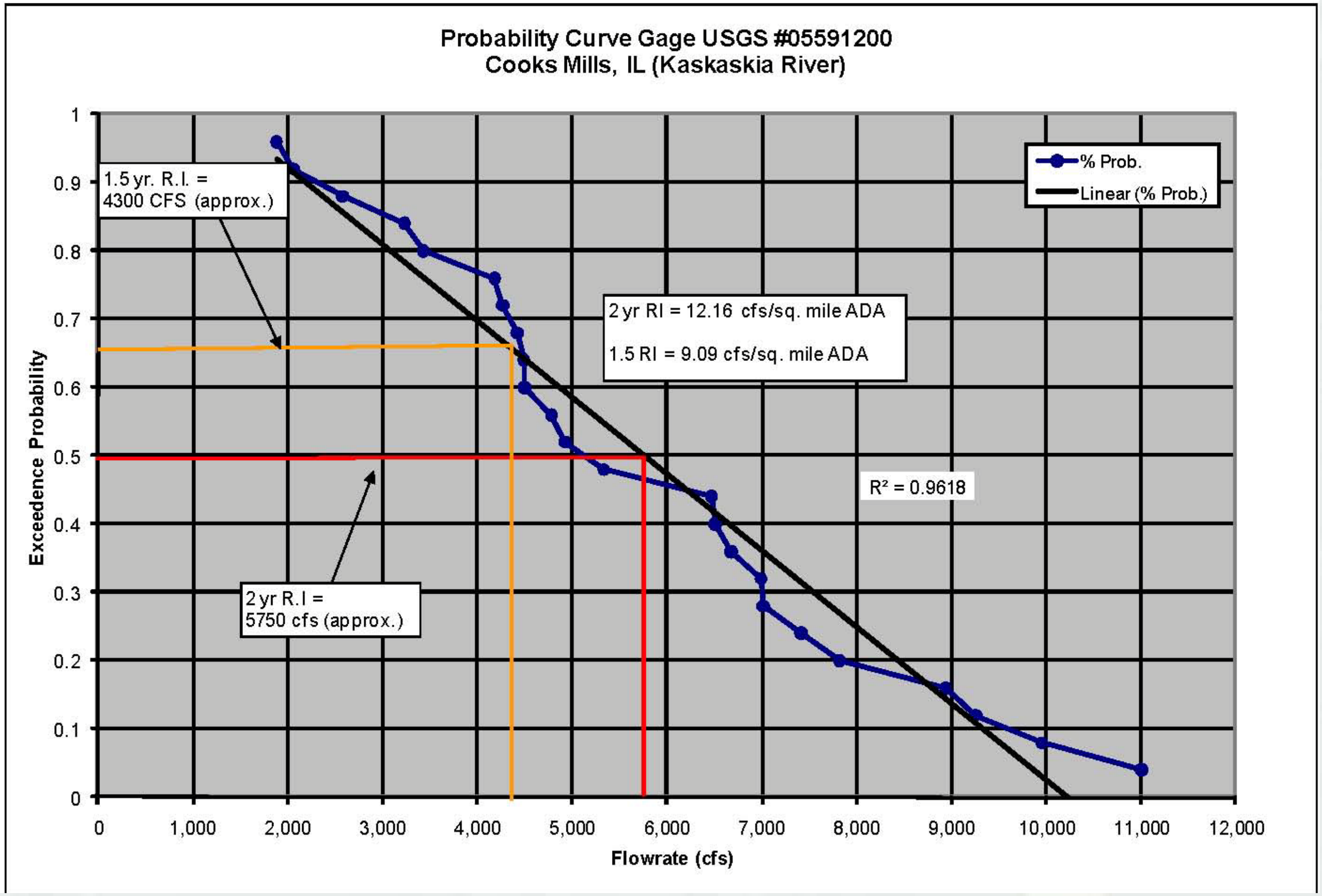


COMMENTS:

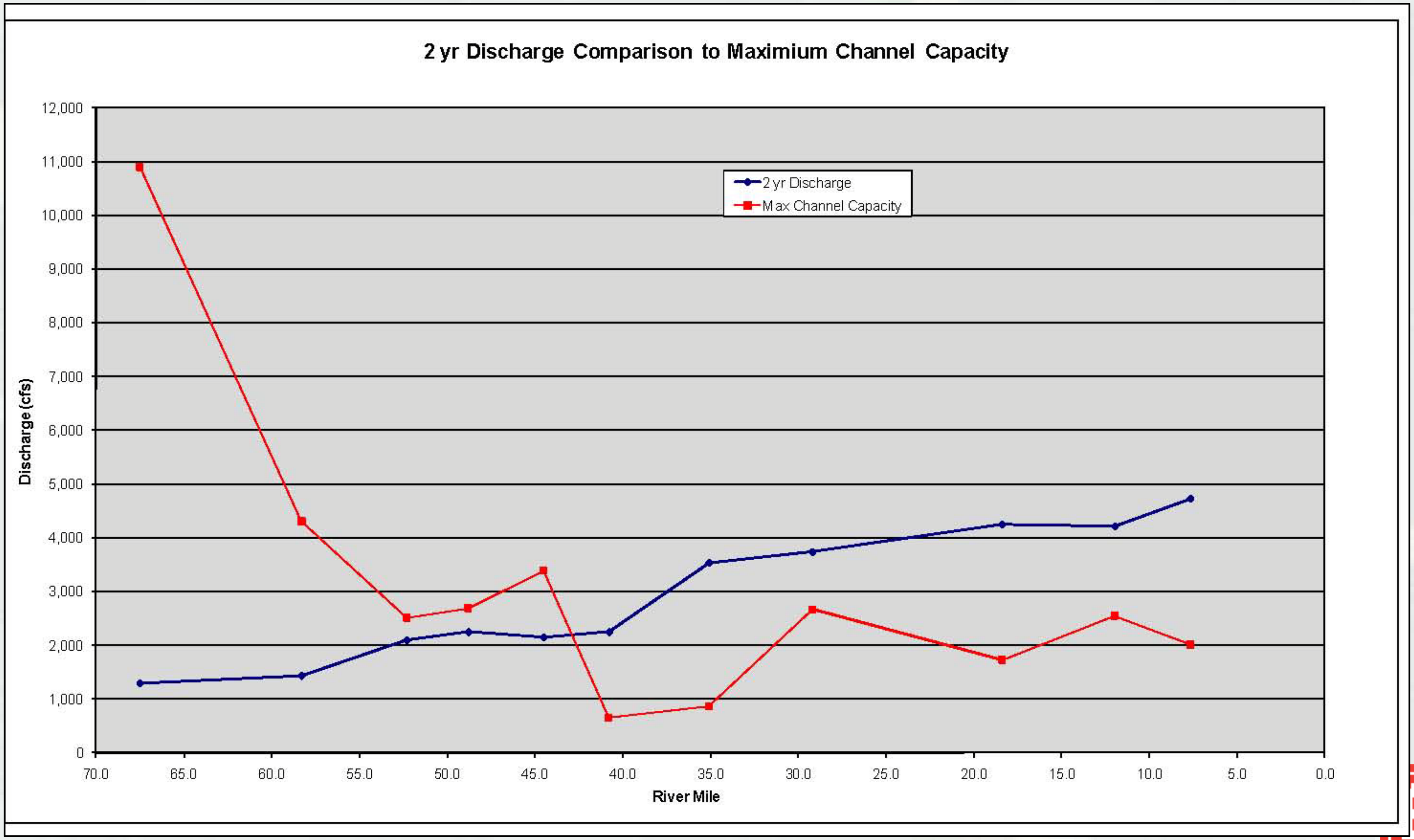
River Morphology Analysis Dimension Probability Curves

- Maximum floe probability curves were developed at two USGS gages, Cooks Mill and Chesterville to predict the 1.5 and 2 year Return Interval (RI)
- 2 year return interval is traditionally termed **“Channel Forming Discharge” or “Bankfull”**
- Cooks Mill 4,300 cfs at 1.5 RI and 5,750 cfs at 2.0 RI
- Chesterville 3,025 cfs at 1.5 RI and 4,500 cfs at 2.0 RI

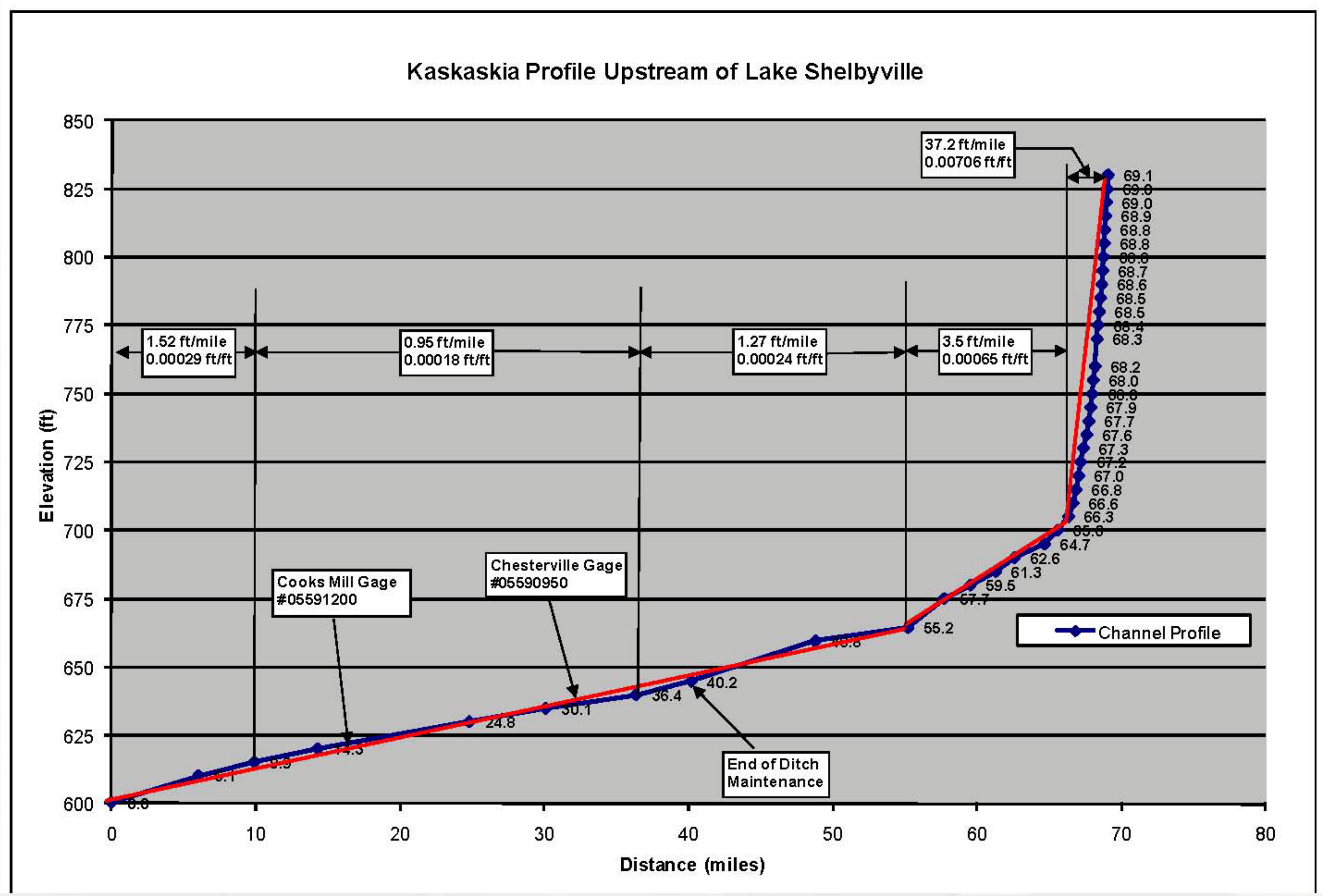
River Morphology Analysis Dimension
Cooks Mill Probability Curve



River Morphology Analysis
Dimension
2 Year Maximum Channel Capacity



River Morphology Analysis
Profile



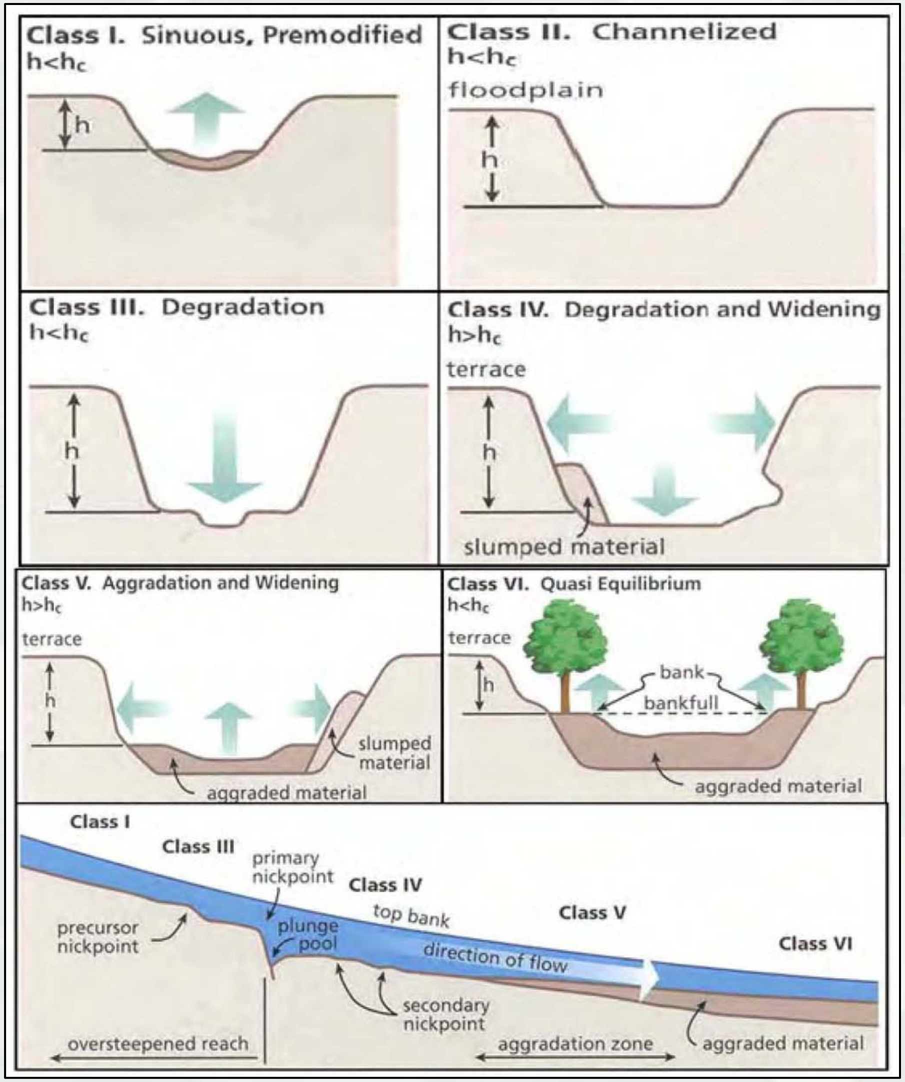
River Morphology Analysis Table

Cross Section	River Mile	Drainage Area (mi^2)	Slope (ft/mile)	Q2 (cfs)	B-full Q (cfs)	B-full Width (ft)	B-full Depth (ft)	W/D Ratio	B-full Velocity (fps)	B-full Q/ Q2	Channel Evolution Stage
1	67.5	36.7	3.5	1,331	600	47	4.0	11.6	3.2	0.5	III
2	58.3	61.5	3.5	1,454	831	45	5.1	8.8	3.6	0.6	III
3	52.3	111.2	1.27	2,147	1,248	69	6.8	10.2	2.7	0.6	III
4	48.8	122	1.27	2,297	1,274	80	6.8	11.7	2.3	0.6	IV
5	44.5	129.8	1.27	2,203	915	54	7.2	7.5	2.4	0.4	VI
6	40.8	137	1.27	2,299	448	69	4.3	15.9	1.5	0.2	I
7	35.1	362	1.27	3,975	972	87	6.0	14.6	1.9	0.2	I
8	29.2	406	0.95	4,199	561	103	3.9	26.6	1.4	0.1	I
9	18.4	478	0.95	4,778	1,678	170	5.5	31.0	1.8	0.4	I
10	12	496	0.95	4,919	2,508	119	7.6	15.6	2.8	0.5	IV
11	7.7	504	1.52	5,521	2,096	92	8.1	11.4	2.8	0.4	VI

Channel Evolution Model (CEM)

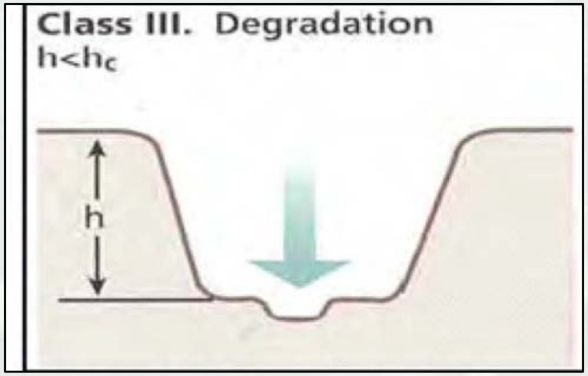
- Conceptual model that describes channel changes and adjustments over time.
- Based on the channel response to disturbance as it occurs, broken into stages dependent on previous stages
- CEM provides scientist and engineers a better understanding of the cause and effect of channel change, guidance in historical analysis, a template of current and future conditions, and a foundation for restoration procedures.
- CEM was used in this study to describe the status of the river channel and provide recommendations for remedial actions

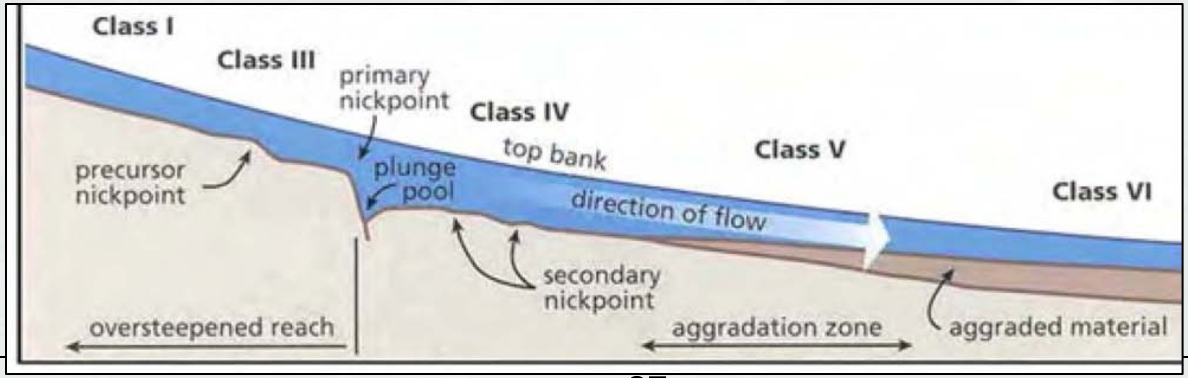
Channel Evolution Model



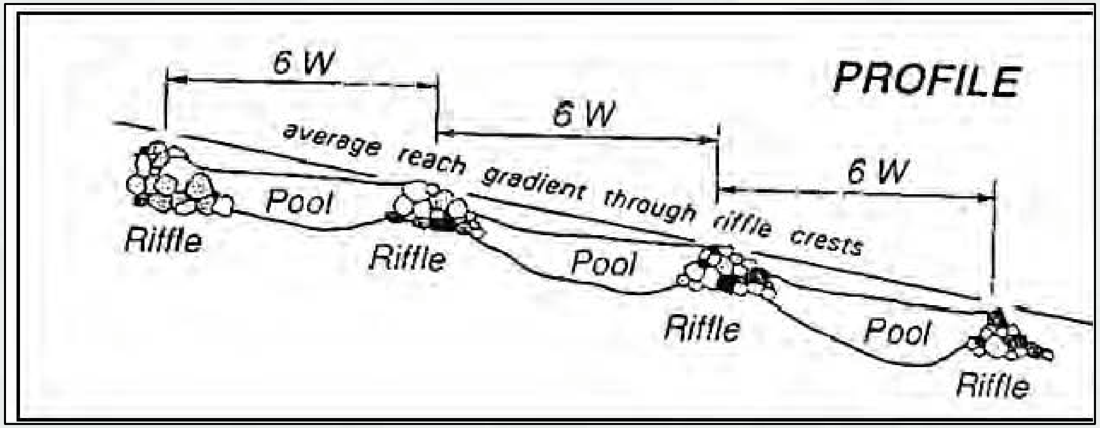
Kaskaskia River
Results and Recommendations

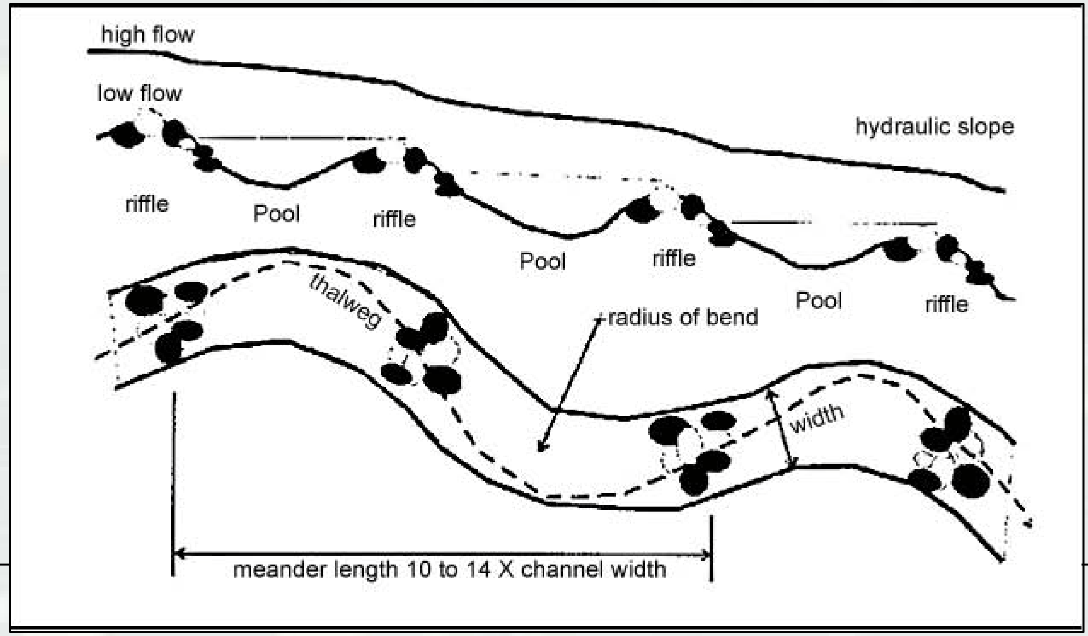
- The analysis of the channel dimension, pattern, and profile identified 3 distinct river reaches
- River Miles 45-70 denoted by a channelized section





Kaskaskia River
Results and Recommendations
Engineered Rock Riffles

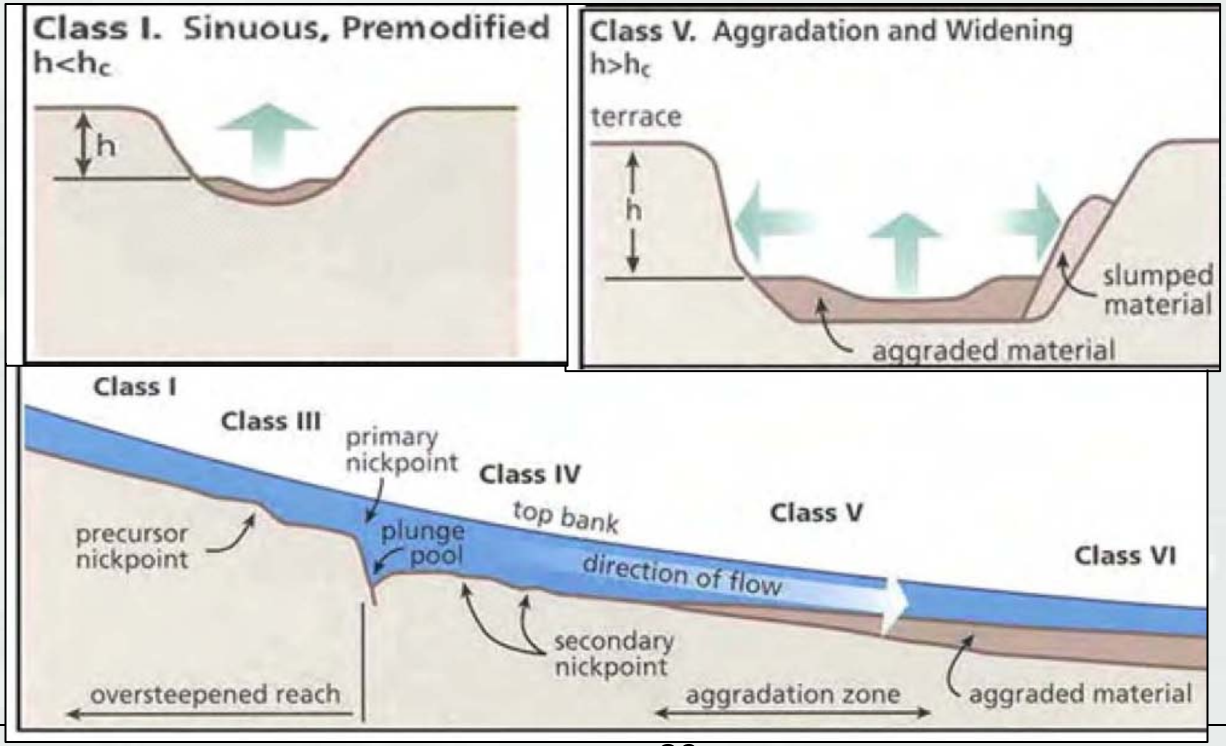




Kaskaskia River
Results and Recommendations

Kaskaskia River
Results and Recommendations

- River Miles 10 – 45 denoted by an aggradated reach
- Only recommendation is to stabilize upper reach to reduce sediment within middle reach

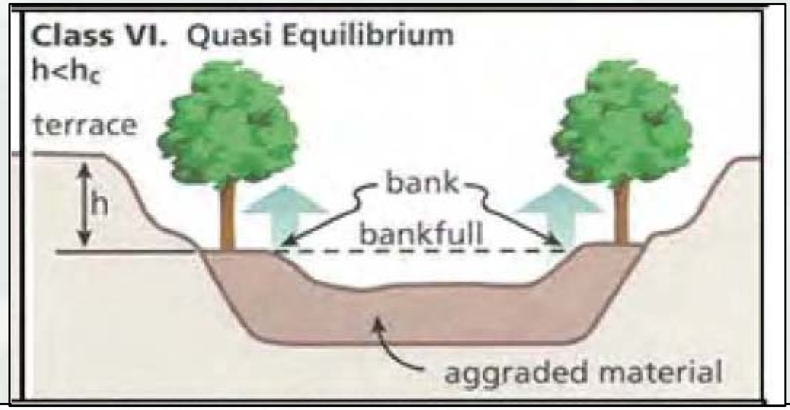


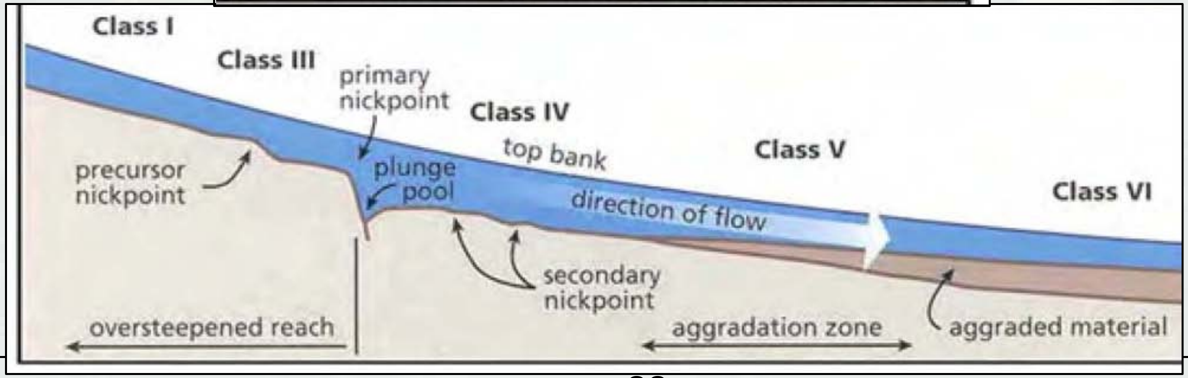
Kaskaskia River
Results and Recommendations

Picture of middle reach

Kaskaskia River
Results and Recommendations

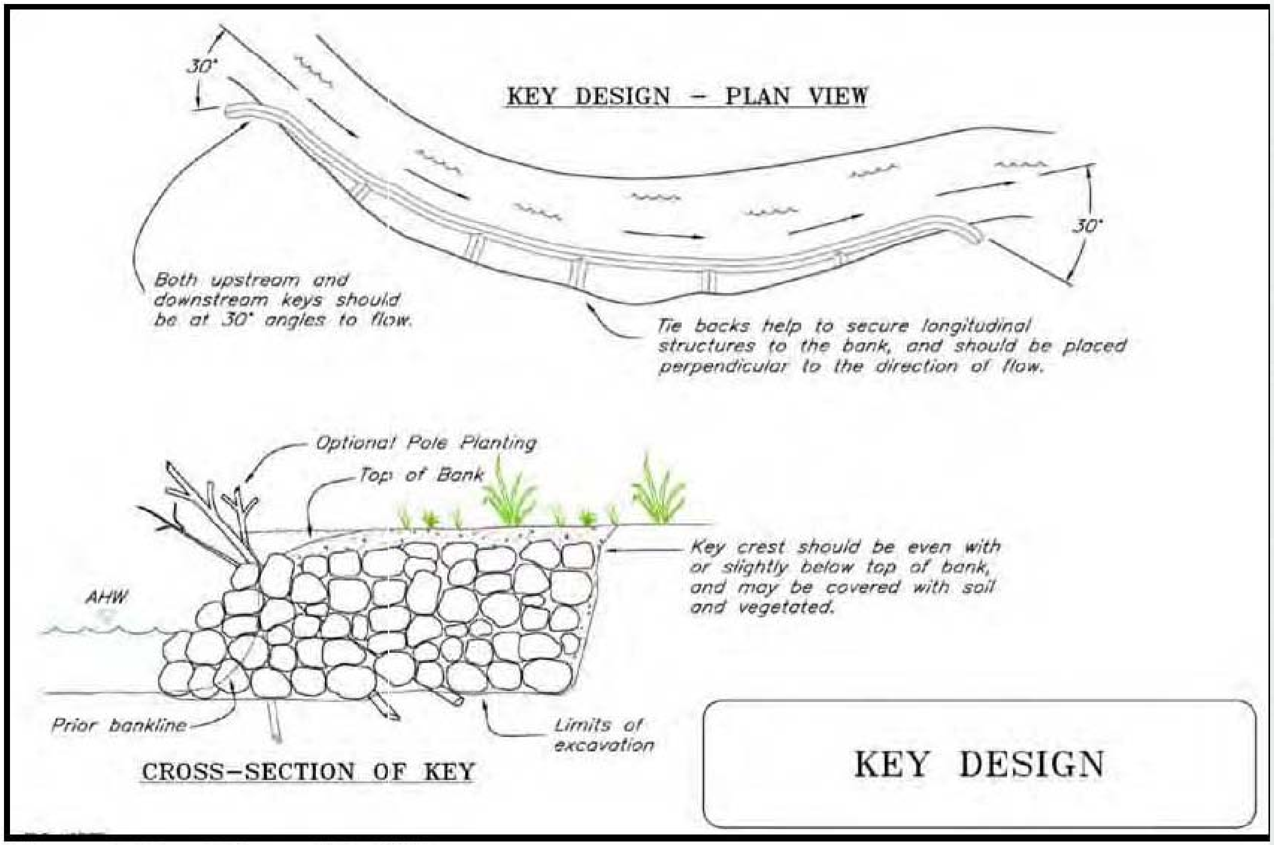
- Lower reach river miles 0-10
- Behaves like a natural channel, out of bank every 1-2 years
- Stable channel with localized locations of bank erosion





Kaskaskia River
Results and Recommendations

Longitudinal Peak Stone Toe Protection (LPSTP)



Kaskaskia River
Results and Recommendations

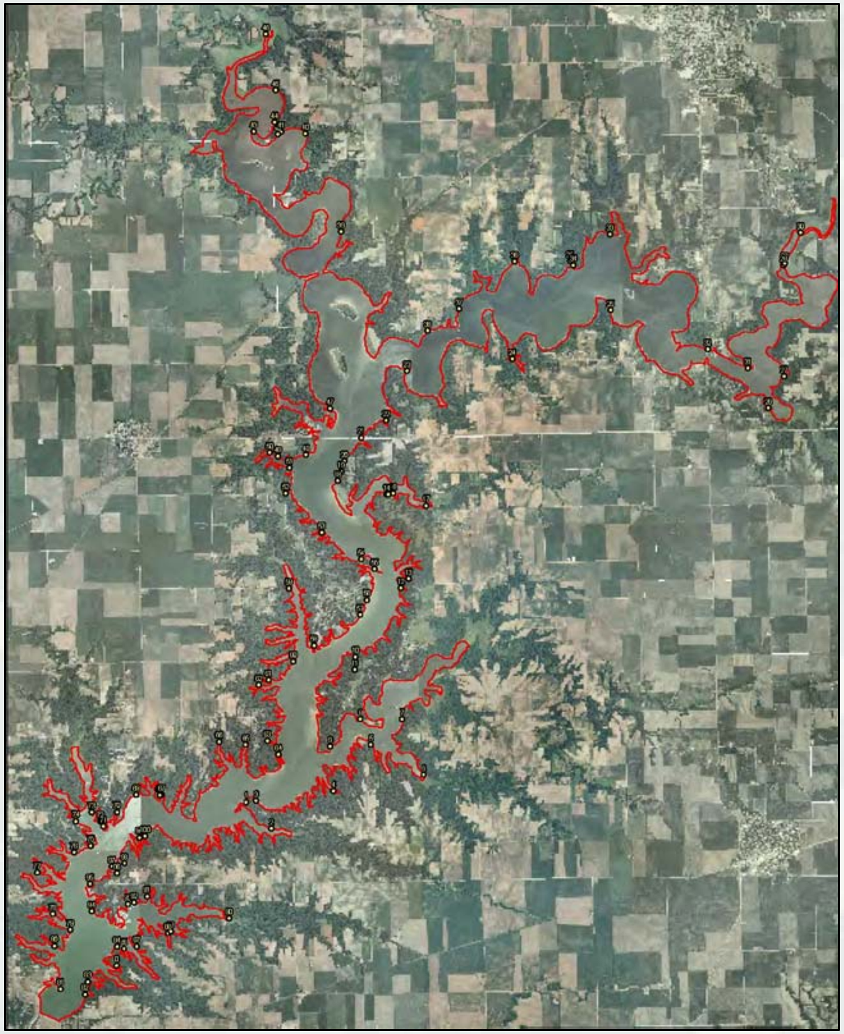
Longitudinal Peak Stone Toe Protection (LPSTP)

Kaskaskia River
Results and Recommendations

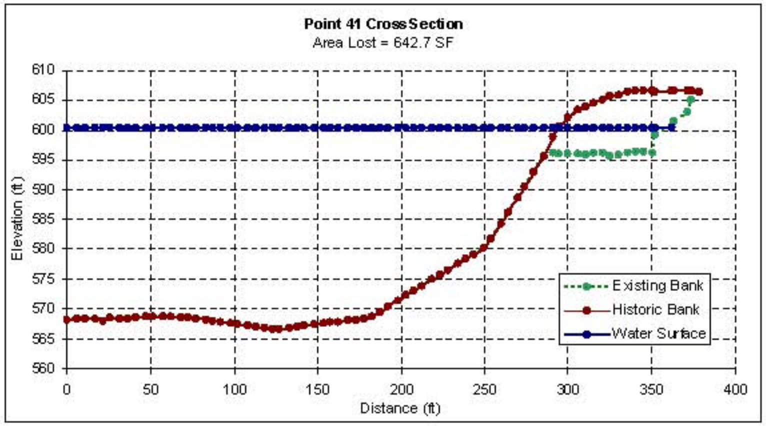
Longitudinal Peak Stone Toe Protection (LPSTP)

Lake Shelbyville Siltation
Wind Fetch Erosion

- 100 points were identified and surveyed for ban erosion.
- This was done by measuring the eroded bank and resulting bench



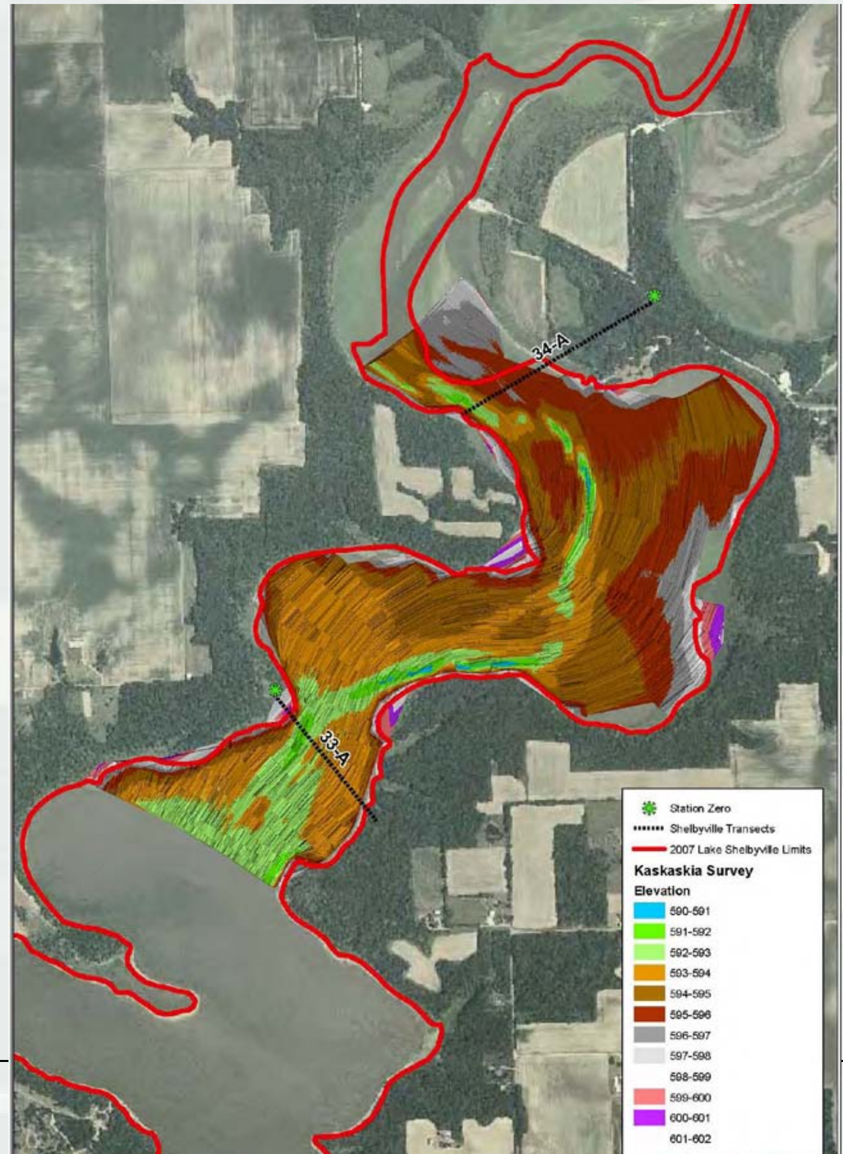
Lake Shelbyville Siltation
Wind Fetch Erosion



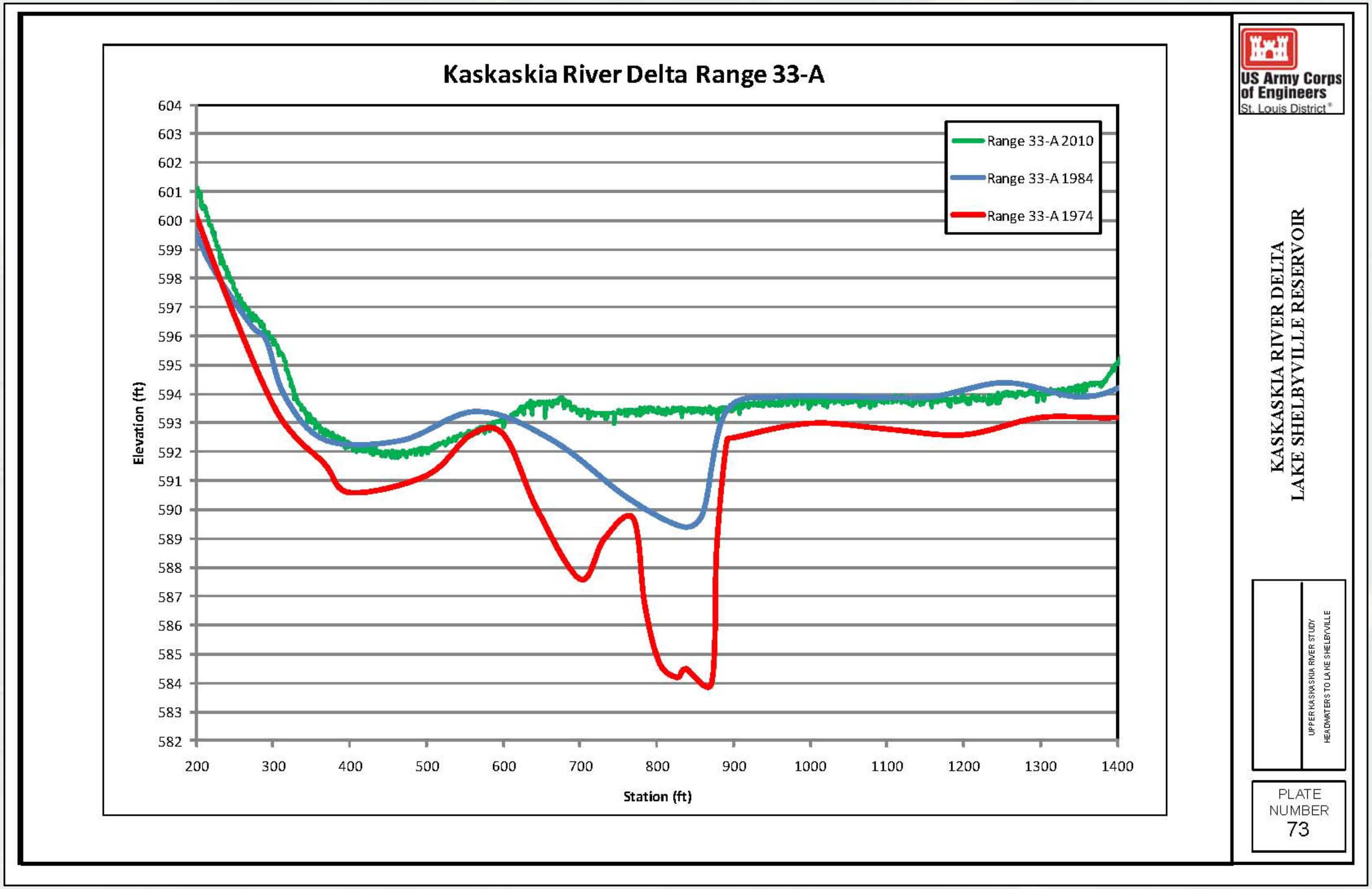
Lake Shelbyville Siltation Kaskaskia and West Okaw Siltation

- This methodology analyzed historical cross sections from 1974, 1984, and compared to 2010 bathymetric data
- Focal point was to identify the deltaic formation caused by the Kaskaskia River entering the reservoir and quantify the sediment.
- Mean siltation rate of 0.1 to 0.15 feet per year for the entire cross section and averaged 0.2 to 0.5 feet per year at the location of the historical channel from 1974 to 1984. Mean siltation rate .03 feet per year for the entire cross section and averaged 0.13 to 0.25 feet per year at the location of the historical channel from 1984 to 2010. **This is for the Kaskaskia River Delta Only**
- **<u>This data set is strictly qualitative and should not be extrapolated to the entire reservoir</u>**

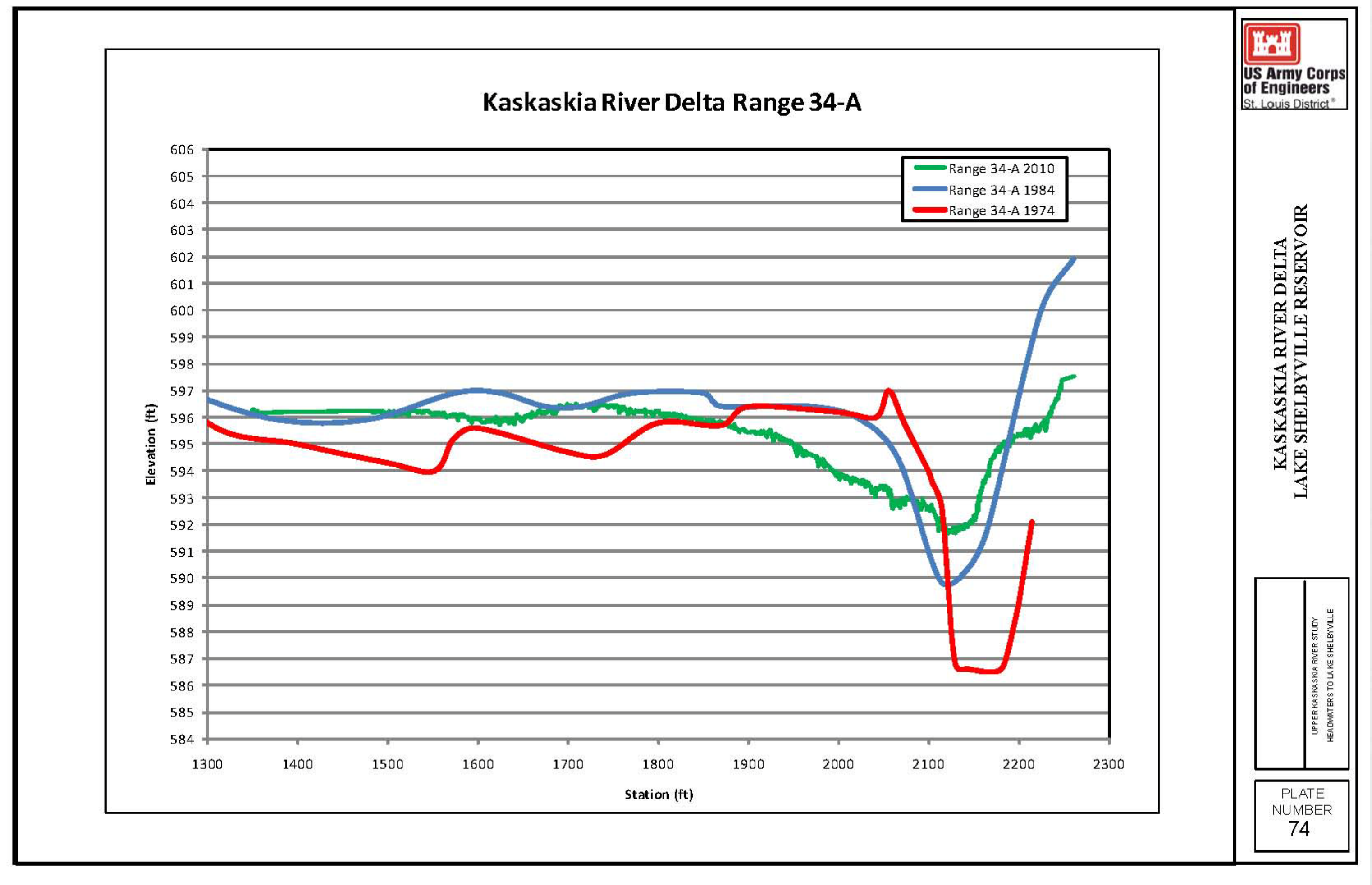
Lake Shelbyville Siltation
Kaskaskia River Delta



Lake Shelbyville Siltation
Kaskaskia River Delta



Lake Shelbyville Siltation
Kaskaskia River Delta



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Questions?

Impaired Stream Analysis

- As part of the initial SOW, 55 miles of streams identified by the IEPA were to analyzed
- Based on the causes of stream impairment, stream restoration efforts would best served within the channelized sections of Lake Fork River

Stream	Assessment ID	Length (miles)	Category	Causes	Sources
Asa Creek	IL-OZZT01	9.05	5	DO, TSS, N	Source Unknown, Crop Production
Coon Creek N.	IL-OZZU	4.78	5	Impairment Unknown	NA
Dry Fork	IL-OZZW	11.89	5	Impairment Unknown	NA
Lake Fork	IL-OW-01	9.37	5	Alteration in stream-side or littoral vegetative covers, Sedimentation, TDS, N, Polychlorinated biphyenyls	Channelizatoin, Source Unknown, Crop Production
	IL-OW-02	4.79	5	Alteration in stream-side or littoral vegetative covers, Sedimentation, TDS, N, Polychlorinated biphyenyls	Channelizatoin, Source Unknown, Crop Production
W. Okaw	IL-OT-02	4.96	5	DO, TDS, pH, N, P, Fecal Coliform	Source Unknown, Crop Production
	IL-OT-04	4.77	5	DO, TDS, pH, N, P	Source Unknown, Crop Production

Impaired Stream Analysis

- Data was gathered from the West Okaw of comparison purposes between Dry Fork
- Six cross sections were taken at riffle locations on the Lake Fork and West Okaw Rivers

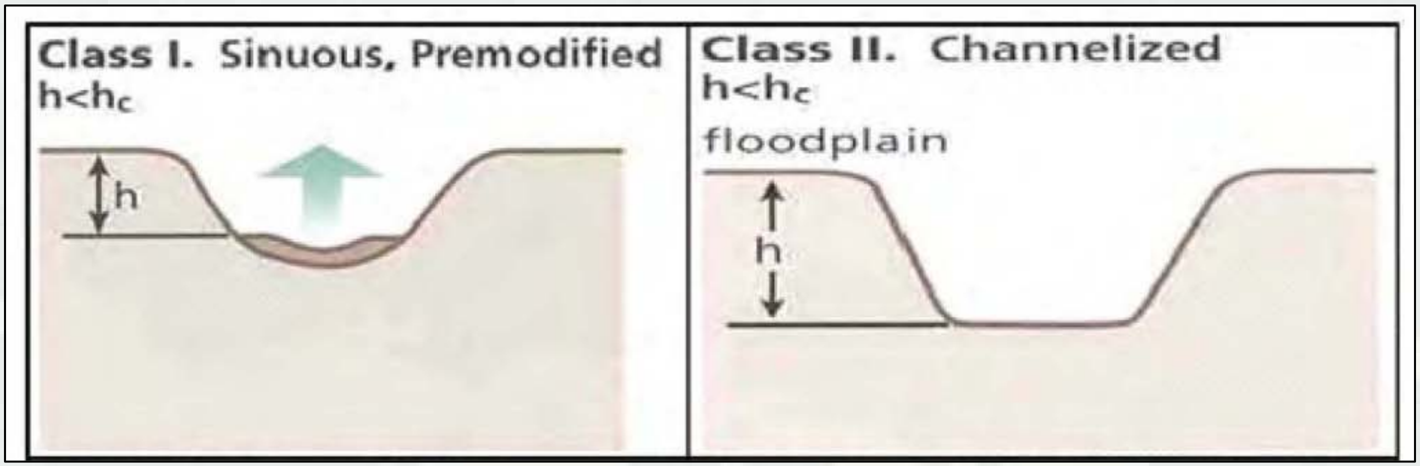
Pattern Comparison

River	Channel Length (ft)	Valley Length (ft)	Sinuosity	Number of Bends	Average Radius of Curvature
Lake Fork	62,380	44,420	1.4	52	404
West Okaw	98,400	51,750	1.9	87	275

- Lower sinuosity on the Dry Fork is evidence of channelization

Impaired Stream Analysis

LAKE FORK RIVER											
Cross Section	River Mile	Drainage Area (mi^2)	Slope (ft/mile)	Q2 (cfs)	B-full Q (cfs)	B-full Width (ft)	B-full Depth (ft)	W/D Ratio	B-full Velocity (fps)	B-full Q/ Q2	Channel Evolution Stage
1	8.8	155	1.09	1,720	755	75	5.2	14.4	1.9	0.4	II
2	5.5	160	1.09	1,880	785	78	5.6	13.9	1.8	0.4	I
3	1.2	165	1.09	1,938	926	120	4.8	25.0	1.6	0.5	I



Impaired Stream Analysis

WEST OKAW RIVER											
Cross Section	River Mile	Drainage Area (mi^2)	Slope (ft/mile)	Q2 (cfs)	B-full Q (cfs)	B-full Width (ft)	B-full Depth (ft)	W/D Ratio	B-full Velocity (fps)	B-full Q/ Q2	Channel Evolution Stage
1	18.1	113	3.26	2,143	968	121	3.9	31.0	2.0	0.5	I
2	14.6	137	3.26	2,451	545	75	3.6	20.8	2.0	0.2	I
3	9.2	162	3.26	2,759	1,088	73	5.7	12.8	2.6	0.4	IV